ICES WGEF REPORT 2018

ICES ADVISORY COMMITTEE

ICES CM 2018/ACOM:16

Report of the Working Group on Elasmobranch Fishes (WGEF)

19–28 June 2018

Lisbon, Portugal

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Recommended format for purposes of citation:

ICES. 2018. Report of the Working Group on Elasmobranch Fishes (WGEF), 19–28 June 2018, Lisbon, Portugal. ICES CM 2018/ACOM:16. 1306 pp.

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Executive Summary

The ICES Working Group on Elasmobranch Fishes (Co-chairs, Samuel Shephard, Ireland and Paddy Walker, Netherlands) was held at IPMA, Lisbon, Portugal from 19th to 28th June 2018.

Twenty-five Expert Group members attended, with five other members contributing via correspondence. One representative of the ICES Secretariat also attended the meeting. Ten ICES Member States were represented at the meeting. A member from Greece attended the meeting for the first time.

ICES WGEF meets annually, with advice for a subset of stocks drafted in alternating years. Work in 2018 focused on those stocks for which it was an advisory year: Evaluate the stock status for the provision of biennial advice due in 2018 for: (i) spurdog in the NE Atlantic; and (ii) skates in the Celtic Seas and Bay of Biscay and Iberian Coast ecoregions.

Sixteen Working Documents (WD, Annex 3) were presented to the Group, mainly relating to recent results from fishery-independent trawl surveys, or from national projects exploring the stock dynamics and biology of assessed species, including the use of MSY proxies.

Some of the data used in 2018 were submitted following the ICES Data Call. Discard data for selected stocks were also made available following the advice of the Workshop on Discards (ICES, 2017). Data checks of some national data were undertaken prior to the meeting, following the guidance developed during WKSHARKS 2016, with further data checks undertaken during the meeting. Whilst much progress was made towards developing a single source for estimated elasmobranch landings, data checks focused on those stocks being addressed in 2018 and further examination and data checks for more generic landings categories are on-going.

Skates in the Celtic Seas and Bay of Biscay and Iberian Coast ecoregions were assessed mostly using time series data from fishery-independent trawl surveys, with species-specific landings data also used when developing advice. Fishery-dependent data, such as DCF length sampling, effort data and landings information were the main data sources considered for those species for which fishery-independent data are limited or lacking.

An assessment was also carried out for spurdog (*Squalus acanthias*) in the Northeast Atlantic.

WGEF had a Term of Reference (ToR) on further developing a proposed joint meeting with ICCAT for the assessment of the thresher shark (*Alopias vulpinus*); and updating life-history parameters for elasmobranchs. However, ICCAT has had a change in their planning of the stock assessments and will now be concentrating on the shortfin mako (*Isurus oxyrinchus*) in 2019. This change means that the joint porbeagle assessment has been postponed, likely until 2020. The ToR for this meeting will be further developed once a date has been set.

In 2018, WGEF further developed MSY proxy reference points relevant for elasmobranchs and explored/applied MSY Proxies analyses for selected stocks. Between 6th and 9th February 2018, a Workshop on Length-Based Indicators and Reference Points for Elasmobranchs (WKSHARK4) was held in Nantes, France (ICES, 2018). And the issue was further addressed at the WGEF meeting (Section 26.2).

Many elasmobranch stocks are considered to be data-limited, owing to incomplete species-specific catch data, inaccurate species identification and incomplete knowledge of life-history parameters. In addition, fishery-independent surveys only sample comparatively few elasmobranch species with any degree of effectiveness (ICES, 2017). This status precludes the analytical stock assessment process that is used for many commercial teleost stocks, with only one elasmobranch species (spurdog) within ICES assessed as Category 1 using analytical models. WGEF further explored the application of proxy MSY RPs to elasmobranch fishes. Full information on each analysis is available in associated WD.

Case studies were compared and the use of input parameters such as M/k ratio, L_c (length at first capture) and life-history parameters was explored. WGEF recommends that a standard process is defined for how to select values for these parameters for use in models. Appropriate values should be agreed before WGEF 2019 for the stocks for which advice will be provided in that year.

The group recommends different approaches for each ICES stock assessment category:

- Category 3: Further development of the LBIs and RPs - see above
- Category 5/6 and bycatch: demographic analyses; occupancy; frequency of occurrence.

Each of these approaches would be served by data collection programmes that account for spatial and temporal distribution of different elasmobranch life history stages.

The working group dealt with a special request from France to revise the advice provided in 2016 on fishing opportunities for 2018 for the stocks of undulate ray (*Raja undulata*) in 7.de and in 8.ab. This outcome has been reported separately (Annex 8), but the work highlighted that the group does not have a standard procedure by which to include information from industry self-sampling programmes and observer programmes into the assessment process. The conclusion of WGEF was that a 'benchmark' process should be carried out to determine how industry and on-board observation data (including discard data) can be incorporated in the advisory process, with undulate ray as an example. The benchmark should address the issue of raising method when a species is mostly discarded, as standard raising procedures are not applicable.

Another issue that has to be addressed is how to advise on fishing opportunities that ensure that exploitation is sustainable when a species has been under moratorium, as is the case with the undulate ray.

There was also a special request to ICES from the European Commission in which ICES was *requested to analyse for a list of stocks the role of the TAC instrument. ICES was asked to assess the risks of removing TAC for each case, analysed in light of the requirement to ensure that the stock concerned remains within safe biological limits in the short and middle term. ICES is further requested to assess the potential contribution of the application of other conservation tools in absence of TACs to the requirement that the stock concerned remains within safe biological limits.*

In cases where the uses of TAC should be continued, ICES is asked to analyse a possible approach to contribute to inter-annual stability of TACs.

Skates and rays and spurdog were included in this request and the information has been reported separately together with the other stocks (Annex 9). The main conclusion was that for the stocks of the skates and rays in all areas, and spurdog (picked dogfish), it is considered that removing the TACs would generate a high risk of the stocks being exploited unsustainably and not in accordance with the objectives of the Common Fisheries Policy (CFP).

The following stocks sections were addressed at the 2017 WGEF meeting:

Section	Species/Assemblage	Area	Assessment type
2	Spurdog	Northeast Atlantic	Updated assessment and advice
3	Leafscale gulper shark and Portuguese dogfish	Northeast Atlantic	Updated information
4	Kitefin shark	Northeast Atlantic	Updated information
5	Other deepwater sharks	Northeast Atlantic	Updated information
6	Porbeagle	Northeast Atlantic	Updated information
7	Basking shark	Northeast Atlantic	Updated information
8	Blue shark	North Atlantic (North of 5ºN)	Updated information
9	Shortfin mako	North Atlantic (North of 5ºN)	Updated information
10	Tope	Northeast Atlantic and Mediterranean	Updated information
1	Thresher sharks	Northeast Atlantic and Mediterranean	Updated information
12	Other Pelagic sharks	Northeast Atlantic	Updated information
13	Skates and rays	Barents Sea	Updated information
14	Skates and rays	Norwegian Sea	Updated information
15	Skates and rays	North Sea, Skagerrak, Kattegat and eastern Channel	Updated information
16	Skates and rays	Iceland and East Greenland	Updated information
17	Skates and rays	Faroes Islands	Updated information
18	Skates and rays	Celtic Seas (ICES Subareas 6 and 7 except Division 7.d)	Updated assessment and advice
19	Skates and rays	Bay of Biscay and Iberian waters (ICES Subarea 8 and Division 9.a)	Updated assessment and advice
20	Skates and rays	Azores and Mid-Atlantic Ridge	Updated information
21	Smooth-hounds	Northeast Atlantic	Updated information
22	Angel shark	Northeast Atlantic	Updated information

Section	Species/Assemblage	Area	Assessment type
23	White skate	Northeast Atlantic	Updated information
24	Greenland shark	Northeast Atlantic	Updated information
25	Catsharks	Northeast Atlantic	Updated information

1 Introduction

1.1 Terms of Reference

2017/2/ACOM16 The **Working Group Elasmobranch Fishes** (WGEF), chaired by Paddy Walker (Netherlands) and Samuel Shephard (Ireland), will meet at IPMA, Lisbon from 19–28 June 2018 to:

a) Address generic ToRs for Regional and Species Working Groups.

b) Update the description of elasmobranch fisheries for deep-water, pelagic and demersal species in the ICES area and compile landings, effort and discard statistics by ICES Subarea and Division, and catch data by NEAFC Regulatory Area. Describe and prepare a first Advice draft of any emerging elasmobranch fishery with the available data on catch/landings, fishing effort and discard statistics at the finest spatial resolution possible in the NEAFC RA and ICES area(s);

c) Evaluate the stock status for the provision of biennial advice due in 2018 for: (i) spurdog in the NE Atlantic; and (ii) skates in the Celtic Seas and Bay of Biscay and Iberian Coast ecoregions

d) Conduct exploratory analyses and collate relevant data in preparation for the evaluation of other stocks (skate stocks in the North Sea ecoregion, the Azores and MAR; catsharks (*Scyliorhinidae*) in the Greater North Sea, Celtic Seas and Bay of Biscay and Iberian Coast ecoregions; smooth-hounds in the Northeast Atlantic and tope in the Northeast Atlantic) in preparation for more detailed biennial assessment in 2018;

e) Conduct exploratory analyses and collate relevant data in preparation for the evaluation of the stock status for the provision of quadrennial advice due in 2019 for the following widely-distributed shark stocks: (i) Portuguese dogfish; (ii) Leafscale gulper shark; (iii) Kitefin shark; (iv) Porbeagle, and the following species that are on the prohibited species list: (v) angel shark, (vi) basking shark and (vii) white skate;

f) Collate discard data from countries and fleets according to the ICES data call to: (i) address the following issues: data quality and onboard coverage; raising factors; discard retention patterns between fleets and countries; discard survival; and (ii) advise on how to include discard information in the advisory process;

g) Further develop MSY proxy reference points relevant for elasmobranchs and explore/apply in MSY Proxies analyses for selected stocks;

h) Classify the elasmobranch stocks currently assessed by ICES as target or bycatch stocks. A target stock is in this context a stock for which the TAC is a main driver for the regulation of fishing activities, and a bycatch stock a stock which is mainly caught as a bycatch and for which the TAC has no or very limited influence on the fishing activities. Explore the possibility of identifying elasmobranch stocks (or species) that can be used as community state indicators within the context of managing mixed fisheries

i) Further develop the ToR for the proposed joint ICCAT-ICES meeting in 2019 to (i) assess porbeagle shark and (ii) collate available biological and fishery data on thresher sharks in the Atlantic;

j) Work intersessionally to draft/update stock annexes to be made available by 31st January 2018, and then develop a procedure and schedule for subsequent reviews.

k) Address the special request from France to revise the advice provided in 2016 on fishing opportunities for 2018 for the stocks of undulate ray (*Raja undulata*) in 7.de and in 8.ab by:

i) Validating new data provided by France from:

- o industry self-sampling programme
- o observer programme

ii) Update the catch advice for 2018 based on the results of the data validation, the STECF report on survivability and updated assessment. Prepare a draft advice document for these two stocks

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group no later than 14 days prior to the starting date.

WGEF will report by 12 July for the attention of ACOM.

1.2 Participants

The following WGEF members attended the meeting:

Ole Thomas Albert	Norway
Jurgen Batsleer	The Netherlands
Loic Baulier	France
Gérard Biais	France
Noémi Van Bogaert	Belgium
Wouter van Broekhoven	The Netherlands
Jose De Oliveira	UK
Guzmán Diez	Spain (Basque Country)
Jim Ellis	UK
Ivone Figueiredo	Portugal
Hélène Gadenne	France
Klara Jakobsdottir	Iceland
Graham Johnston	Ireland
Claudia Junge	Norway
Pascal Lorance	France
Catharina Maia	Portugal
Inigo Martínez	ICES Secretariat
Sophy McCully Philips	UK
Teresa Moura	Portugal
Anastasius Papodopolous	Greece
Mário Rui Pinho	Portugal (Azores)
Cristina Rodríguez-Cabello	Spain
Barbara Serra-Pereira	Portugal
Samuel Shephard (Co-chair)	Ireland
Paddy Walker (Co-chair)	The Netherlands

The following WGEF members assisted by correspondence:

Armelle Jung	France
Tanja Miethe	UK
Harriët van Overzee	The Netherlands
Jan-Jaap Poos	The Netherlands
Joana Silva	UK
Nicola Walker	UK
Francisco Velasco	Spain

1.3 Background and history

The Study Group on Elasmobranch Fishes (SGEF), having been first established in 1989 (ICES, 1989), was re-established in 1995 and had meetings or met by correspondence in subsequent years (ICES, 1995–2001). Assessments for elasmobranch species had been hampered by a lack of data. The 1999 meeting was held concurrently with an EC-funded Concerted Action Project meeting (FAIR CT98-4156) allowing greater participation from various European institutes. Exploratory assessments were carried out for the first time at the 2002 SGEF meeting (ICES, 2002), covering eight of the nine case-study species considered by the EC-funded DELASS project (CT99-055). The success of this meeting was due largely to the DELASS project, a three-year collaborative effort involving 15 fisheries research institutes and two subcontractors (Heessen, 2003). Though much progress was made on methods, there was still much work to be done, with the paucity of species-specific landings data a major data issue.

In 2002, SGEF recommended the group be continued as a working group. The medium-term remit of this group being to extend the methods and assessments for elasmobranchs prepared by the EC-funded DELASS project; to review and define data requirements (fishery, survey and biological parameters) for stock identification, analytical models and to carry out such assessments as are required by ICES customers.

In 2003, WGEF met in Vigo, Spain and worked to further the stock assessment work carried out under DELASS. In 2003, landings data were collated for the first time. This exercise was based on data from ICES landings data, the FAO FISHSTAT database, and data from national scientists (ICES, 2003). In 2004, WGEF worked by correspondence to collate and refine catch statistics for all elasmobranchs in the ICES area. This task was complicated by the use (by many countries) of generic reporting categories for sharks, dogfish, skates and rays. WGEF evaluated sampling plans and their usefulness for providing assessment data (ICES, 2004).

In 2005, WGEF came under ACFM and was given the task of supporting the advisory process. This was because ICES has been asked by the European Commission to provide advice on certain species. This task was partly achieved by WGEF in that preliminary assessments were provided for spurdog, kitefin shark, thornback ray (North Sea) and deep-water sharks (combined). ACFM produced advice on these species, as well as for basking shark and porbeagle, based on the WGEF Report. A standard reporting and presentation format was adopted for catch data and best estimates of catch by species were provided for the first time (ICES, 2005).

In 2006, work continued on refining landings data and collating available biological data (ICES, 2006). Work was begun on developing standard reporting formats for length–frequency, maturity and CPUE data.

In 2007, WGEF met in Galway, with the demersal elasmobranchs of three ecoregions (North Sea, Celtic Seas and Bay of Biscay/Iberian waters) subject to more detailed study and assessment (ICES, 2007), with special emphasis on skates (given that these are generally the more commercially valuable demersal elasmobranchs in shelf seas). It should be noted, however, that though there have been some historical tagging studies (and indeed there are also on-going tagging and genetic studies), current knowledge of the stock structure and identity for many of these species is poor, and in most instances the assumed stock area equates with management areas.

WGEF met twice in 2008, firstly in parallel with WGDEEP (March 2008) to update assessments and advice for deep-water sharks and demersal elasmobranchs, and then with the ICCAT shark subgroup in Madrid (September 2008) to address North Atlantic stocks of shortfin mako and blue shark, and to further refine data available for the NE Atlantic stock of porbeagle (ICES, 2008).

In June 2009 WGEF held a joint meeting with the ICCAT SCRS Shark subgroup at ICES headquarters (Copenhagen). This meeting successfully pooled all available data on North Atlantic porbeagle stocks (ICES, 2009). In addition, updated assessments were carried out for North Sea, Celtic Seas, and Biscay and Iberian demersal elasmobranchs and for the deep-water sharks *Centrophorus squamosus* and *Centroscymnus coelolepis*. A three-year assessment schedule was also agreed.

In June 2010 WGEF met in Horta, Portugal. This meeting was a full assessment meeting and stock updates were carried out for 19 species or species groups (ICES, 2010b), with draft advice provided for eight stocks. In addition, three special requests from the EC, relating to new advice on five elasmobranch species, were answered.

In June 2011, WGEF met at ICES Headquarters Copenhagen. Although this was not an advice year, advice was provided for *Squalus acanthias*. This was the result of a benchmark assessment of this species carried out via correspondence during spring 2011. The updated model was used to provide F_{MSY}-based advice for the first time. A special request from NEAFC, on sharks and their categorisation by habitat was also addressed (ICES, 2011b).

In June 2012, WGEF met at IPMA in Lisbon (ICES, 2012b). This meeting was a full assessment meeting during which both stock updates and draft advice were provided. Two special requests, one from NEAFC and the other from the NWWRAC (via the EC), were also answered. WGEF also met in Lisbon the following year (ICES, 2013a) with preparatory work and exploratory analyses conducted, in addition to addressing some special advice requests from the EU.

From 2014, it was decided with ICES that advice would be staggered, with the main stocks divided across alternating years and with advice for prohibited and most of the zero-TAC stocks done once every four years. In 2014, WGEF assessed and provided draft advice for skates (Rajidae) in the Celtic Seas and Biscay-Iberian ecoregions (ICES, 2014), and the following year WGEF examined skates in the North Sea ecoregion and Azorean waters, as well as various sharks: Portuguese dogfish, leafscale gulper shark, kitefin shark, smooth-hounds, tope, catsharks, angel shark, porbeagle and basking shark (ICES, 2015).

Overall the working group has been successful in maintaining participation from a wide range of countries, although the number of active participants declined slightly in 2016, for various reasons. Nevertheless, over the longer-term, attendance at WGEF has been stable level in recent years, with participation from quantitative assessment scientists, fishery managers, survey scientists and elasmobranch biologists.

Interest in the work of WGEF from other RFMOs has increased, with regular contact and cooperation between WGEF and the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the General Fisheries Commission for the Mediterranean (GFCM). Since 2009, WGEF members have been involved in some of the stock assessments carried out by ICCAT and the GFCM. As many elasmobranch species and stocks range outside the ICES area, WGEF encourages co-operation between ICES and such RFMOs, both in providing information, and in sharing resources for stock assessment.

Stock assessments for many elasmobranchs are particularly difficult owing to incomplete (or lack of) species-specific catch data, the straddling and/or highly migratory nature of some of these stocks (especially with regards deep-water and pelagic sharks), and that internationally-coordinated fishery-independent surveys only sample a small number of demersal elasmobranchs with any degree of effectiveness.

1.4 Planning of the work of the group

Given the large number of stocks that WGEF addresses, WGEF and the ICES Secretariat have developed the following timeframe for advice (Table 1.1).

In 2018, the following species and stocks were assessed and advice drafted. These stocks will be addressed again in 2020:

- Spurdog in the Northeast Atlantic;
- Skates and rays (Rajidae) in the Celtic Seas (ICES subareas 6 and 7 except Division 7.d);[1]
- Skates and rays (Rajidae) in the Bay of Biscay and Iberian Coast (ICES Subarea 8 and Division 9.a);

[1] Note: Skate stocks that straddle divisions 7.d and 7.e are included within the Celtic Sea section and advice. Skate species that straddle Division 4.c. and Division 7.d are included within the North Sea section and advice.

In 2017, the following species and stocks were addressed for advice (Table 1.2). These stocks will be addressed again in 2019:

- Skates and rays (Rajidae) in the Greater North Sea, (including Skagerrak, Kattegat and eastern Channel) (seven stocks and 'other skates');
- Skates and rays (Rajidae) in the Azores and Mid-Atlantic Ridge (mainly *R. clavata*);
- Smooth-hounds in the Northeast Atlantic;
- Tope in the Northeast Atlantic;
- Catshark stocks in the Northeast Atlantic (seven nominal management units);

In 2015 (or 2014 in the case of white skate), the following species and stocks were also addressed for advice (Table 1.2). These stocks will be addressed again in 2019:

- Leafscale gulper shark in the Northeast Atlantic;
- Kitefin shark in the Northeast Atlantic;
- Portuguese dogfish in the Northeast Atlantic;
- Angel shark in the Northeast Atlantic;
- Porbeagle in the Northeast Atlantic;
- Basking shark in the Northeast Atlantic;
- Thresher sharks in the Northeast Atlantic;
- White skate in the Northeast Atlantic.

Table 1.1. Elasmobranch stocks scheduled for assessments and advice in 2018.

ICES Stock code	Stock name	EcoRegion	Advice updated	Advice
dgs-nea	Spurdog (*Squalus acanthias*) in the Northeast Atlantic	Widely distributed	2018	Biennial
rjb-89a	Common skate (*Dipturus batis*-complex) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	Bay of Biscay and Iberian coast	2018	Biennial
rjn-8c	Cuckoo ray (*Leucoraja naevus*) in Division 8.c (Cantabrian Sea)	Bay of Biscay and Iberian coast	2018	Biennial
rjn-pore	Cuckoo ray (*Leucoraja naevus*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2018	Biennial
rjh-pore	Blonde ray (*Raja brachyura*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2018	Biennial
rjc-bisc	Thornback ray (*Raja clavata*) in Subarea 8 (Bay of Biscay and Cantabrian Sea)	Bay of Biscay and Iberian coast	2018	Biennial
rjc-pore	Thornback ray (*Raja clavata*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2018	Biennial
rjm-bisc	Spotted ray (*Raja montagui*) in Subarea 8 (Bay of Biscay and Cantabrian Sea)	Bay of Biscay and Iberian coast	2018	Biennial
rjm-pore	Spotted ray (*Raja montagui*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2018	Biennial
rju-8ab	Undulate ray (*Raja undulata*) in Divisions 8.a.b (Bay of Biscay)	Bay of Biscay and Iberian coast	2018	Biennial
rju-8c	Undulate ray (*Raja undulata*) in Divisions 8.c (Cantabrian Sea)	Bay of Biscay and Iberian coast	2018	Biennial
rju-9a	Undulate ray (*Raja undulata*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2018	Biennial
raj-89a	Other skates and rays in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	Bay of Biscay and Iberian coast	2018	Biennial
rjb-celt	Common skate (*Dipturus batis*) complex (flapper skate (*Dipturus* cf. *flossada*) and blue skate (*Dipturus* cf. *intermedia*)) in Subareas 6 and 7 (excluding 7.d)	Celtic Seas	2018	Biennial
rji-celt	Sandy ray (*Leucoraja circularis*) in Subareas 6 and 7 (Celtic Sea and West of Scotland)	Celtic Seas	2018	Biennial
rjf-celt	Shagreen ray (*Leucoraja fullonica*) in Subareas 6 and 7 (Celtic Sea and West of Scotland)	Celtic Seas	2018	Biennial
rjn-678abd	Cuckoo ray (*Leucoraja naevus*) in Subareas 6 and 7 (Celtic Sea and West of Scotland) and Divisions 8.a.b.d (Bay of Biscay)	Celtic Seas/Biscay	2018	Biennial
rjh-7afg	Blonde ray (*Raja brachyura*) in Divisions 7.a.f.g (Irish and Celtic Sea)	Celtic Seas	2018	Biennial
rjh-7e	Blonde ray (*Raja brachyura*) in Division 7.e (western English Channel)	Celtic Seas	2018	Biennial

ICES Stock code	Stock name	EcoRegion	Advice updated	Advice
rjc-7afg	Thornback ray (*Raja clavata*) in Divisions 7a.f.g (Irish and Celtic Sea)	Celtic Seas	2018	Biennial
rjc-echw	Thornback ray (*Raja clavata*) in Division 7.e (Western English Channel)	Celtic Seas	2018	Biennial
rjc-VI	Thornback ray (*Raja clavata*) west of Scotland (Subarea 6)	Celtic Seas	2018	Biennial
rje-7ech	Small-eyed ray (*Raja microocellata*) in the English Channel (Divisions 7.d.e)	Celtic Seas	2018	Biennial
rje-7fg	Small-eyed ray (*Raja microocellata*) in Divisions 7.f.g (Bristol Channel)	Celtic Seas	2018	Biennial
rjm-67bj	Spotted ray (*Raja montagui*) in Subarea 6 and Divisions 7.b.j (west of Scotland and Ireland)	Celtic Seas	2018	Biennial
rjm-7aeh	Spotted ray (*Raja montagui*) in Divisions 7.a.e.f.g.h (southern Celtic seas)	Celtic Seas	2018	Biennial
rju-7bj	Undulate ray (*Raja undulata*) in Divisions 7.b.j (Southwest of Ireland)	Celtic Seas	2018	Biennial
rju-ech	Undulate ray (*Raja undulata*) in Divisions 7.d.e (English Channel)	Celtic Seas	2018	Biennial
raj-celt	Other skates and rays in Subareas 6 and 7 (excluding 7.d)	Celtic Seas	2018	Biennial

Table 1.2. Elasmobranch stocks with assessments and advice in 2015 and 2014 (white skate).

ICES Stock code	Stock name	EcoRegion	Advice updated	Advice
sho-89a	Black-mouth dogfish (*Galeus melastomus*) in in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	Bay of Biscay and Iberian seas	2015	Biennial
syc-8c9a	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Divisions 8.c and 9.a (Atlantic Iberian waters)	Bay of Biscay and Iberian seas	2015	Biennial
syc-bisc	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Divisions 8.a,b,d (Bay of Biscay)	Bay of Biscay and Iberian seas	2015	Biennial
sho-celt	Black-mouth dogfish (*Galeus melastomus*) in Subareas 6 and 7 (Celtic Sea and West of Scotland)	Celtic Seas	2015	Biennial
syc-celt	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 6 and Divisions 7.a–c. e–j (Celtic Seas and west of Scotland)	Celtic Seas	2015	Biennial
syt-celt	Greater-spotted dogfish (*Scyliorhinus stellaris*) in Subareas 6 and 7 (Celtic Sea and West of Scotland)	Celtic Seas	2015	Biennial
rjb-34	Common skate (*Dipturus batis*-complex) in Subarea 4 and Division 3.a (North Sea and Skagerrak)	North Sea	2015	Biennial
rjn-34	Cuckoo ray (*Leucoraja naevus*) in Subarea 4 and Division 3.a (North Sea and Skagerrak and Kattegat)	North Sea	2015	Biennial
rjh-4aVI	Blonde ray (*Raja brachyura*) in Division 4a and Subarea 6 (Northern North Sea and west of Scotland)	North Sea	2015	Biennial
rjh-4c7d	Blonde ray (*Raja brachyura*) in Divisions 4c and 7.d (Southern North Sea and eastern English Channel)	North Sea	2015	Biennial
rjc-347d	Thornback ray (*Raja clavata*) in Subarea 4, and Divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat and eastern English Channel)	North Sea	2015	Biennial
rjm-347d	Spotted ray (*Raja montagui*) in Subarea 4, and Divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and Eastern English Channel)	North Sea	2015	Biennial
rjr-234	Starry ray (*Amblyraja radiata*) in Subareas 2, 3.a and 4 (Norwegian Sea, Skagerrak, Kattegat and North Sea)	North Sea	2015	Biennial
raj-347d	Other skates and rays in the North Sea ecoregion (Subarea 4, and Divisions 3.a and 7.d)	North Sea	2015	Biennial
syc-347d	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 4, and Divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and Eastern English Channel)	North Sea	2015	Biennial
agn-nea	Angel shark (*Squatina squatina*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial

ICES Stock code	Stock name	EcoRegion	Advice updated	Advice
bsk-nea	Basking shark (*Cetorhinus maximus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
cyo-nea	Portuguese dogfish (*Centroscymnus coelolepis*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
gag-nea	Tope (*Galeorhinus galeus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Biennial
guq-nea	Leafscale gulper shark (*Centrophorus squamosus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
por-nea	Porbeagle (*Lamna nasus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
raj-mar	Rays and skates (mainly thornback ray) in the Azores and Mid-Atlantic Ridge	Widely distributed and migratory stocks	2015	Biennial
sck-nea	Kitefin shark (*Dalatias licha*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
trk-nea	Starry smooth-hound (*Mustelus* spp.) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Biennial
rja-nea	White skate (*Rostroraja alba*) in the Northeast Atlantic	Widely distributed	2014	Quadrennial

1.5 ICES approach to F_{MSY}

Most elasmobranch species are slow growing, with low population productivity. Some species (e.g. basking shark) are on several lists of 'threatened' or 'endangered' species. They may also be listed under international trade agreements such as the Convention on the International Trade on Endangered Species (CITES), which may place limitations on fishing for or trade in these species. Because of this, it is not believed that F_{MSY} is an appropriate or achievable target in all cases, particularly in the short term. However, the ICES F_{MSY} methodology has evolved in recent years. For example, new methods that are more appropriate for data-deficient stocks have been developed, and there is a greater interest in considering generation time into such methods and for the provision of advice. The generation time of elasmobranchs is often much longer than most teleosts. For each assessed stock the ICES precautionary approach is considered, and the group's approach and considerations are outlined in the stock summary sheets. In 2017, WGEF applied two data-poor assessment methods to three selected ray stocks. These methods produced promising results, but will require some adjustment to account for elasmobranch life history and fisheries dynamics. In 2018 progress was made with applying MSY proxies to elasmobranch stocks and a series of recommendations have been made (Section 26.2).

1.6 Community plan of action for sharks

An Action Plan for the Conservation and Management of Sharks (EU, 2009) was adopted by the European Commission in 2009. Further details on this plan and its relevance to WGEF can be found in an earlier report (ICES, 2009).

1.7 Conservation advice

Several terms are used to define stock status, particularly at low levels. Some of these terms mean different things to different people. Therefore, WGEF takes this opportunity to define how terms are used within this report, and also how WGEF believe these terms should be used when providing advice.

In addition, several elasmobranch species are listed as 'prohibited species' or as species that cannot be retained in European Council Regulations fixing annual fishing opportunities (CEC, 2016a, b). Although this may be appropriate, WGEF believes that this status should only be used for long-term conservation, whilst a (near) zero TAC may be more appropriate for short-term management.

These ideas are discussed in detail below.

Extinction vs. extirpation

Extinction is defined as "*The total elimination or dying out of any plant or animal species, or a whole group of species, worldwide*" (Chambers Dictionary of Science and Technology), yet increasingly the term 'extinct' is used in conservation and scientific literature to highlight the disappearance of a species from a particular location or region, even if the area is at the periphery of the main geographical range.

Additionally, some of the studies that have reported a species to be (locally or regionally) 'extinct' can be based on limited data, with supporting data often neither spatially nor temporally comprehensive enough to confirm the loss, especially with regards to species that are wide-ranging, small-bodied and/or cryptic, or distributed in habitats that are difficult to survey.

In terms of a standardized approach to the terminology of lost species, WGEF consider the following:

Extinct: When an animal or plant species has died out over its entire geographical range.

Extirpated: When an animal or plant species has died out over a defined part of its range, from where it was formerly a commonly occurring species. This loss should be due, whether directly or indirectly, to anthropogenic activities.

If anthropogenic activities are not considered to have affected the loss of the species, then the species should be considered to have 'disappeared' or been lost from the area in question. The term 'extirpated' should also be used to identify the loss of the species from part of the main geographical range or habitat, and therefore be distinguished from a contraction in the range of a species, where it has been lost from the fringes of its distribution or suboptimal habitat.

Additionally, the terms 'extinct' and 'extirpated' should be used when there has been sufficient, appropriate survey effort (i.e. operating at the relevant temporal and spatial scale and with an appropriate survey or census method) to declare the species extinct/extirpated. Prior to this time, these terms could be prefixed near- or presumed.

Presumed extinct/extirpated should be used when the species has not been recorded in available survey data (which should operate at an appropriate temporal and spatial scale), but when dedicated species-specific surveys have not been undertaken.

Near extinct/extirpated should be used when there are isolated reports of the species existing in the geographical area of interest.

In terms of ICES advice, the term 'extinct' was used in both 2005 and 2006 to describe the status of angel shark in the North Sea; although since 2008 the term 'extirpated' has been used.

The utility of the Prohibited species list on TAC and quotas regulations

The list of prohibited species on the TACs and quotas regulations (e.g. CEC, 2016a) is an appropriate measure for trying to protect the marine fish of highest conservation importance, particularly those species that are also listed on CITES and various other conservation conventions. Additionally, there should be sufficient concern over the population status and/or impacts of exploitation that warrants such a long-term conservation strategy over the whole management area.

There are some species that would fall into this category. For example, white shark and basking shark are both listed on CITES and some European nations have given legal protection to these species. Angel shark has also been given legal protection in UK.

It should also be recognized that some species that are considered depleted in parts of their range may remain locally abundant in some areas, and such species might be able to support low levels of exploitation. From a fisheries management viewpoint, advice for a zero or near-zero TAC, or for no target fisheries, is very different from a requirement for 'prohibited species' status, especially as a period of conservative management may benefit the species and facilitate a return to commercial exploitation in the short term.

Additionally, there is a rationale that a list of prohibited species should not be changing regularly, as this could lead to confusion for both the fishing and enforcement communities. The STECF meeting on management of skates and rays has recommended issuing guidelines for the inclusion and removal of species on the prohibited species list (STECF, 2017)

In 2009 and 2010, undulate ray, *Raja undulata* was moved on to the prohibited species list. This had not been advised by ICES. Following a request from commercial fishers, the European Commission asked ICES to give advice on this listing. ICES reiterated that undulate ray would be better managed under local management measures and that there was no justification for placing undulate ray on the prohibited species list. There have been subsequent changes in the listing of this species. It was removed from the Prohibited Species List for Subarea 7 in 2014 (albeit as a species that cannot be retained or landed). In 2015, undulate ray was only maintained in the prohibited species list in subareas 6 and 10. Small TACs were established for stocks in the English Channel and Bay of Biscay in 2015 and for the stock in the Iberian ecoregion in 2016. During the

2018 meeting the advice for 2016–2017 was recalculated following a request from France (ICES, 2018b).

1.8 Sentinel fisheries

ICES advice for several elasmobranch stocks suggests that their fisheries should, for example "*consist of an initial low* (level) *scientific fishery*". In discussions of such fisheries, WGEF would suggest that a 'sentinel fishery' is a science-based data collection fishery conducted by commercial fishing vessel(s) to gather information on a specific fishery over time using a commercial gear but with standardized survey protocols. Sentinel fisheries would:

- Operate with a standardized gear, defined survey area, and standardized index of effort;
- Aim to provide standardized information on those stocks that may not be optimally sampled by existing fishery-independent surveys;
- Include a limited number of vessels;
- Be subject to trip limits and other technical measures from the outset, in order to regulate fishing effort/mortality in the fishery;
- Carry scientific observers on a regular basis (e.g. for training purposes) and be collaborative programmes with scientific institutes;
- Assist in biological sampling programmes (including self-sampling and tagging schemes);
- Sampling designs, effort levels and catch retention policy should be agreed between stakeholders, national scientists and the relevant ICES assessment expert group.

1.9 Mixed fisheries regulations

Apart from TAC regulations, several ICES divisions have fish stocks subject to recovery plans, including the cod recovery plan, hake recovery plan, etc.

As several elasmobranch stocks, particularly skates and rays, are caught in mixed fisheries within these areas catches of elasmobranchs may be limited by restrictive effort limitations because of these plans. In general, these are not referred to within the text, but must be taken into consideration when looking at landings trends from within these areas.

1.10 Current ICES expert groups of relevance to the WGEF

Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)

Several elasmobranchs are taken in North Sea demersal fisheries, including spurdog (Section 2), tope (Section 10), various skates (Section 15) and starry smooth-hound (Section 21).

WGNSSK should note that the Greater Thames Estuary is the main part of the North Sea distribution of thornback ray *Raja clavata* and may also be an important nursery ground for some small shark species, such as tope and starry smooth-hound. Thornback ray is an important species in ICES Division 4.c, and is taken in fisheries targeting sole (e.g. trawl and gillnet), cod (e.g. trawl, gillnet and longline), as well as in targeted fisheries.

The Wash may also be an area of ecological importance for some elasmobranchs, including thornback ray and tope.

Working Group for the Celtic Seas Ecoregion (WGCSE)

Several elasmobranchs are taken in the waters covered by WGCSE, including spurdog (Section 2), tope (Section 10), various skates and rays (Section 18) and starry smooth-hound (Section 21).

WGCSE should note that common skate *Dipturus batis*-complex, which has declined in many inshore areas of northern Europe, may be locally abundant in parts of ICES Division 6.a and the deeper waters of the Celtic Sea (Division 7.h-j). Thornback ray is abundant in parts of the Irish Sea, especially Solway Firth, Liverpool Bay and Cardigan Bay. The Lleyn Peninsula is an important ground for greater-spotted dogfish *Scyliorhinus stellaris*. WGSCE should also note that the Bristol Channel is of high local importance for small-eyed ray *Raja microocellata*, as well as being an important nursery ground for some small sharks (e.g. starry smooth-hound and tope) and various skates.

Angel shark (Section 22) was formerly abundant in parts of Cardigan Bay, the Bristol Channel and Start Bay, and is now observed very rarely. Similarly, white skate (Section 23) was historically present in this ecoregion, and may be near-extirpated from most parts of the ecoregion.

Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP)

In 2008, WGEF met in parallel with WGDEEP in order to assess and provide advice on deep-water sharks (see Sections 3–5). In February 2010, WGDEEP held a benchmark assessment of deep-water stocks (WKDEEP; ICES 2010a). Two WGEF members attended in order to carry out an assessment of the deep-water shark species *Centrophorus squamosus* and *Centroscymnus coelolepis*. Considerable progress was made in robust construction of a plausible catch and effort history for both species. A novel approach to assessing such species as deep-water sharks was presented at the meeting using a subset of the data on Portuguese dogfish and was agreed by WKDEEP to be a highly promising approach, pending the acceptable reconstruction of the aforementioned catch and effort data. Further development and possible future application of the method is to be encouraged. Several members of WGEF also attend WGDEEP, so facilitating the exchange of knowledge between the two expert groups.

International Bottom-trawl Survey Working Group (IBTSWG) and Working Group on Beam Trawl Surveys (WGBEAM)

IBTSWG continue to provide maps of the distribution of a variety of demersal elasmobranchs from the IBTS surveys in the North Sea and western areas. WGEF consider that these plots provide useful information and hope that IBTSWG will continue to provide these plots as routine outputs in the future. WGBEAM carries out some analysis of catch rates and distribution of certain skate species from beam trawl surveys in the North Sea and Celtic Seas ecoregions. Such analyses are very useful for WGEF.

There are some inaccuracies in the identifications of some skates in various trawl surveys, as well as some recent taxonomic revisions. Hence, more collaborative studies and exchange between WGEF and WGBEAM to address such issues is encouraged.

Workshop on Sexual Maturity Staging of Elasmobranchs (WKMSEL)

The first workshop met in October 2010, following a recommendation from PGCCDBS. Its objectives were to agree on a common maturity scale for both oviparous and viviparous elasmobranchs across laboratories, compare existing scales and standardize maturity determination criteria (ICES, 2010c). Although WGEF agrees that standardization across laboratories is important, there are concerns over some of the new scales proposed. In particular, the increase in the number of stages compared with other scales used could lead to some problems if introduced. These include:

- Comparison of new and more historic data;
- Training requirements for all staff who stage elasmobranchs;
- Adoption of new systems and/or software adjustments for survey/other databases, such as IBTS, DATRAS, etc.

A second workshop was held in December 2012, following a recommendation by ICES, to revise and update the maturity scales proposed by WKMSEL. The new macroscopic scales for males and females of oviparous and viviparous species have simple descriptions that facilitate the assignment of maturity stages, as was recommended by WGEF in 2012. The adoption of sub-stages (e.g. 3a and 3b) allow for an optional simplified version of the scale, useful for rapid data collection by less experienced staff.

Following WGEF recommendations, previous scales were reanalysed to make a correspondence between them and the new scales. The correspondence was adequate for most of the stages proposed except for the later ones, e.g. post-laying for oviparous females and regenerating for both oviparous and viviparous. These new stages were considered essential to fully understand the reproductive strategies of the species and get better estimates for life-history parameters, needed in demographic and other assessment models (ICES, 2013b).

1.11 Other meetings of relevance to WGEF

1.11.1 ICCAT

WGEF have conducted joint-meetings and assessments with ICCAT in 2008 (Madrid) and 2009 (ICES headquarters). These meetings were useful in pooling information on highly migratory pelagic shark species, including porbeagle, blue shark and shortfin mako. It is intended that these collaborations continue to usefully assess and update knowledge of pelagic shark species. ICCAT shark specialist subgroup also recommends maintaining links and sharing data with WGEF.

In 2012 a representative of WGEF attended the ICCAT Ecological Risk Assessment and shortfin mako stock assessment in Faro, Portugal. Data from this meeting were used in the WGEF account of shortfin mako (Section 9). In 2015, representatives of WGEF participated at the ICCAT blue shark stock assessment that was held in Lisbon, Portugal.

In 2016 representatives of ICCAT and WGEF attended the ICES Workshop to compile and refine catch and landings of elasmobranchs (WKSHARKS; ICES, 2016).

The ICCAT Shark Species Group held an intercessional meeting at Madeira in April 2016 (ICCAT, 2016). The ICCAT Shark Species Group intends to update stock assessments of Atlantic stocks of shortfin mako in 2017. ICCAT (2016) also suggested that updated porbeagle assessments should be undertaken in 2019.

WGEF considers that further collaborative meetings with the ICCAT Shark Species Group should continue and recommend that the ICES Secretariat should approach ICCAT and propose a joint ICCAT-ICES meeting to assess porbeagle in 2019. Such a meeting could also usefully address thresher shark *Alopias* spp. This issue was addressed at the 2017 meeting and documented in this report.

1.11.2 General Fisheries Commission for the Mediterranean (GFCM)

From 2010 to 2013, the GFCM carried out a programme to improve the knowledge and assess the status of elasmobranchs in the Mediterranean and the Black Sea. The main outcomes of this four-year programme were three meetings and two publications:

1) Expert Meeting on the status of elasmobranchs in the Mediterranean and Black Sea (Sfax, Tunisia, 20–22 September 2010);

2) Workshop on stock assessment of selected species of elasmobranchs (Brussels, Belgium, 12–16 December 2011);

3) Workshop on age determination (Antalya, Turkey, 8–12 October 2012);

4) Bibliographic review to sum up the information gathered during the above mentioned meetings (Bradai *et al.*, 2012); and

5) Publication of a technical manual on elasmobranch age determination (Campana, 2014).

In 2013, the GFCM decided to develop a three-year extension of this programme including the:

1) Preparation of a draft proposal on practical options for mitigating bycatch for the most impacting gears in the Mediterranean and Black Sea;

2) Production and dissemination of guidelines on good practices to reduce the mortality of sharks and rays caught incidentally by artisanal fisheries;

3) Development of studies on growth, reproduction, population genetic structure and post-released mortality and identification of critical areas (nurseries) at national or regional level;

4) Preparation of factsheets and executive summaries for some commercial species presenting identification problems;

5) Assessment of the impact of anthropogenic activities other than fisheries on the observed decline of certain sharks and ray populations;

6) Implementation of a pilot tagging programme for pelagic sharks.

WGEF consider that ICES and the GFCM would benefit from improved interaction due to the overlap in the distribution of certain stocks, and also in comparing stock assessment methods for data-limited stocks.

1.12 Relevant biodiversity and conservation issues

ICES work on elasmobranch fish is becoming increasingly important as a source of information to various multilateral environmental agreements concerning the conservation status of some species. Table 1.3 lists species occurring in the ICES area that are considered within these fora. An increasing number of elasmobranchs are now ‘prohibited’ species in European fisheries regulations (CEC, 2016a), and these are summarised in Table 1.4.

Additionally, whilst not forming the basis of a legal instrument, the International Union for Conservation of Nature (IUCN) conduct Red List assessments of many species, including elasmobranchs, which has been undertaken at North-East Atlantic (Gibson *et al.*, 2008), Mediterranean (Cavanagh and Gibson, 2007; Abdul Malak *et al.*, 2011) and European scales (Nieto et al., 2015). IUCN listings are summarised in the relevant species sections and are not discussed further in this section of the report.

1.12.1 OSPAR Convention

The OSPAR Convention (www.ospar.org) guides international cooperation on the protection of the marine environment of the Northeast Atlantic. It has 15 Contracting Parties and the European Commission represents the European Community. The OSPAR list of Threatened and/or Declining Species and Habitats, developed under the OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area, provides guidance on future conservation priorities and research needs for marine biodiversity at risk in the region. To date, eleven elasmobranch species are listed (Table 1.3), either across the entire OSPAR region or in areas where they were perceived as declining. Background Documents summarizing the status of these species are available (OSPAR Commission, 2010).

1.12.2 Convention on the Conservation of Migratory Species (CMS)

CMS recognizes the need for countries to cooperate in the conservation of animals that migrate across national boundaries, if an effective response to threats operating throughout a species' range is to be made. The Convention actively promotes concerted action by the range states of species listed on its Appendices. The CMS Scientific Council has determined that 35 shark and ray species, globally, meet the criteria for listing in the CMS Appendices (Convention on Migratory Species, 2007). Table 1.3 lists Northeast Atlantic elasmobranch species that are currently included in the Appendices.

CMS Parties should strive towards strict protection of endangered species on Appendix I, conserving or restoring their habitat, mitigating obstacles to migration and controlling other factors that might endanger them. The range states of Appendix II species (migratory species with an unfavourable conservation status that need or would significantly benefit from international cooperation) are encouraged to conclude global or regional agreements for their conservation and management.

CMS now has a Sharks MOU, comprising an Advisory Committee (AC) and Intercessional Working Group (IWG).

1.12.3 Convention on International Trade in Endangered Species (CITES)

CITES was established in recognition that international cooperation is essential to the protection of certain species from overexploitation through international trade. It creates an international legal framework for the prevention of trade in endangered species of wild fauna and flora, and for the effective regulation of international trade in other species which may become threatened in the absence of such regulation.

Species threatened with extinction can be listed on Appendix I, which basically bans commercial, international trade in their products. Appendix II includes "*species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival*". Trade in such species is monitored closely and allowed if exporting countries can provide evidence that such trade is not detrimental to wild populations of the species.

Resolution Conf. 12.6 encourages parties to identify endangered shark species that require consideration for inclusion in the Appendices if their management and conservation status does not improve. Decision 13.42 encourages parties to improve data collection and reporting of catches, landings and trade in sharks (at species level where possible), to build capacity to manage their shark fisheries, and to take action on several species-specific recommendations from the Animals Committee (CITES, 2009).

1.12.4 Convention on the Conservation of European Wildlife and Natural Habitats (Bern convention)

The Bern Convention is a regional convention that provides a binding, international legal instrument that aims to conserve wild flora, fauna and natural habitats. Appendix II (or III) lists strictly protected (or protected) species of fauna (sometimes identified for the Mediterranean Sea only). Contracting Parties should "*take appropriate and necessary legislative and administrative measures to ensure the special protection of the wild fauna species specified in Appendix II*" and "*protection of the wild fauna species specified in Appendix II*".

Table 1.3. Elasmobranch species listed by Multilateral Environmental Agreements. Source; OSPAR (http://www.ospar.org/), CITES (https://cites.org/), CMS (http://www.cms.int/) and Bern Convention (http://www.coe.int/t/dg4/cultureheritage/nature/bern/default_en.asp).

Family	Species	Multilateral Environmental Agreement			
		OSPAR	CMS	CITES	Bern
Squalidae	Spurdog *Squalus acanthias*	✓	App II (northern hemisphere populations		
Centrophoridae	Gulper shark *Centrophorus granulosus*	✓			
	Leafscale gulper shark *Centrophorus squamosus*	✓			
Somniosidae	Portuguese dogfish *Centroscymnus coelolepis*	✓			
Squatinidae	Angel shark *Squatina squatina*	✓			App III (Med)
Rhincodontidae	Whale shark *Rhincodon typus*		App II	App II	
Alopiidae	Pelagic thresher *Alopias pelagicus*		App II	App II	
	Bigeye Thresher *Alopias superciliosus*		App II	App II	
	Common Thresher *Alopias vulpinus*		App II	App II	
Cetorhinidae	Basking shark *Cetorhinus maximus*	✓	App I and II	App II	App II (Med)
Lamnidae	White shark *Carcharodon carcharias*		App I and II	App II	App II (Med)
	Shortfin mako shark *Isurus oxyrinchus*		App II		App III (Med)
	Longfin mako shark *Isurus paucus*		App II		
	Porbeagle shark *Lamna nasus*	✓	App II	App II	App III (Med)
Carcharhinidae	Silky shark *Carcharhinuns falciformis*		App II	App II	
	Oceanic white-tip *Carcharhinus longimanus*			App II	
	Blue shark *Prionace glauca*				App III (Med)
Sphyrnidae	Scalloped hammerhead *Sphyrna lewini*		App II	App II	
	Great hammerhead *Sphyrna mokarran*		App II	App II	
	Smooth hammerhead *Sphyrna zygaena*			App II	

Table 1.3. (continued). Elasmobranch species listed by Multilateral Environmental Agreements.

Family	Species	Multinational Environmental Agreement			
		OSPAR	CMS	CITES	Bern
Pristidae	Sawfish *Pristidae*		App I and II	App I	
Rajidae	Common skate (*Dipturus batis*) complex	✓			
	Thornback ray *Raja clavata*	✓ North Sea			
	Spotted ray *Raja montagui*	✓ North Sea			
	White skate *Rostroraja alba*	✓			App III (Med)
Mobulidae	Reef manta ray *Manta alfredi*		App I and II		
	Giant manta ray *Manta birostris*		App I and II		
	Manta rays *Manta* spp.			App II	
	Longhorned mobula *Mobula eregoodootenkee*		App I and II	App II	
	Lesser devil ray *Mobula hypostoma*		App I and II	App II	
	Spinetail mobula *Mobula japanica*		App I and II	App II	
	Shortfin devil ray *Mobula kuhlii*		App I and II	App II	
	Giant devil ray *Mobula mobular*		App I and II	App II	App II (Med)
	Munk's (or pygmy) devil ray *Mobula munkiana*		App I and II	Ap II	
	Lesser Guinean devil ray *Mobula rochebrunei*		App I and II	App II	
	Chilean (or sicklefin) devil ray *Mobula tarapacana*		App I and II	App II	
	Smoothtail mobula *Mobula thurstoni*		App I and II	App II	

Table 1.4. Elasmobranch taxa listed as Prohibited Species on EU fisheries regulations. It is prohibited for EU vessels "*… to fish for, to retain on board, to tranship or to land …*" these species in certain areas within EU waters (Article 13) or, for certain species listed in Article 22, within the ICCAT Convention area. Adapted from CEC (2016a).

Family	Species	Area
Centrophoridae	Leafscale gulper shark *Centrophorus squamosus*	EU waters of Division 2.a and subarea 4; EU and international waters of subareas 1 and 14
	Birdbeak dogfish *Deania calcea*	EU waters of Division 2.a and subarea 4; EU and international waters of subareas 1 and 14
Etmopteridae	Smooth lantern shark *Etmopterus pusillus*	EU waters of Division 2.a and subarea 4; EU and international waters of subareas 1, 5–8, 12 and 14
	Great lantern shark *Etmopterus princeps*	EU waters of Division 2.a and subarea 4; EU and international waters of subareas 1 and 14
Somniosidae	Portuguese dogfish *Centroscymnus coelolepis*	EU waters of Division 2.a and subarea 4; EU and international waters of subareas 1 and 14
Dalatiidae	Kitefin shark *Dalatias licha*	EU waters of Division 2.a and subarea 4; EU and international waters of subareas 1 and 14
Squatinidae	Angel shark *Squatina squatina*	EU waters
Alopiidae	Bigeye thresher shark *Alopias superciliosus*	ICCAT convention area
Cetorhinidae	Basking shark *Cetorhinus maximus*	All waters
Lamnidae	White shark *Carcharodon carcharias*	All waters
	Porbeagle shark *Lamna nasus*	All waters
Triakidae	Tope *Galeorhinus galeus*	When taken by longline in EU waters of Division 2.a and subarea 4, and EU and international waters of subareas 1, 5–8, 12 and 14.
Carcharhinidae	Silky shark *Carcharhinus falciformis*	ICCAT convention area
	Oceanic whitetip shark *Carcharhinus longimanus*	ICCAT convention area
	Hammerheads (Sphyrnidae), except for *Sphyrna tiburo*)	ICCAT convention area
Pristidae	Narrow sawfish *Anoxypristis cuspidata*	All waters
	Dwarf sawfish *Pristis clavata*	All waters
	Smalltooth sawfish *Pristis pectinata*	All waters
	Largetooth sawfish *Pristis pristis*	All waters
	Green sawfish *Pristis zijsron*	All waters
Rhinobatidae	All members of family	EU waters of subareas 1–12

Table 1.4. (continued). Elasmobranch taxa listed as Prohibited Species on EU fisheries regulations.

Family	Species	Area
Rajidae	Starry ray *Amblyraja radiata*	EU waters of Divisions 2.a, 3.a, 7.d and subarea 4
	Common skate (*Dipturus batis*) complex (*Dipturus cf. flossada and Dipturus cf. intermedia*)	EU waters of Division 2.a and subareas 3–4, 6–10.
	Norwegian skate *Dipturus nidarosiensis*	EU waters of subarea 6 and Divisions 7.a-c and 7e–h and 7.k
	Thornback ray *Raja clavata*	EU waters of Division 3.a
	Undulate ray *Raja undulata*	EU waters of subareas 6 and 10
	White skate *Rostroraja alba*	EU waters of subareas 6-10
Mobulidae	Reef manta ray *Manta alfredi*	All waters
	Giant manta ray *Manta birostris*	All waters
	Longhorned mobula *Mobula eregoodootenkee*	All waters
	Lesser (or Atlantic) devil ray *Mobula hypostoma*	All waters
	Spinetail mobula *Mobula japanica*	All waters
	Shortfin devil ray *Mobula kuhlii*	All waters
	Giant devil ray *Mobula mobular*	All waters
	Munk's (or pygmy) devil ray *Mobula munkiana*	All waters
	Lesser Guinean devil ray *Mobula rochebrunei*	All waters
	Chilean (or sicklefin) devil ray *Mobula tarapacana*	All waters
	Smoothtail mobula *Mobula thurstoni*	All waters

1.13 ICES fisheries advice

ICES advice is now provided under the Maximum Sustainable Yield framework (MSY).

Maximum sustainable yield is a broad conceptual objective aimed at achieving the highest possible yield over the long term (an infinitely long period of time). It is non-specific with respect to: (a) the biological unit to which it is applied; (b) the models used to provide scientific advice; and (c) the management methods used to achieve MSY.

The MSY concept can be applied to an entire ecosystem, an entire fish community, or a single fish stock. The choice of the biological unit to which the MSY concept is applied influences both the sustainable yield that can be achieved and the associated management options. Implementation of the MSY concept by ICES will first be applied to individual fish stocks. Further information on the background to MSY and how it is applied to fish stocks by ICES can be found in the General Context to ICES Advice.

1.14 Data availability

General considerations

WGEF members agree that future meetings of WGEF should continue to meet in June, as opposed to meeting earlier in the year, as (a) more refined landings data are available; (b) meeting outside the main spring assessment period should provide national laboratories with more time to prepare for WGEF, (c) it will minimize potential clashes with other assessment groups (which could result in WGEF losing the expertise of stock assessment scientists) and (d) given that there are not major year-to-year changes in elasmobranch populations (cf. many teleost stocks), the advice provided would be valid for the following year.

The group agreed that CPUE from surveys should be provided as disaggregated raw data, and not as compiled data. The group agreed that those survey abundance estimates that are not currently in the DATRAS database are also provided as raw data by individual countries.

WGEF recommends that MS provide detailed explanations of how national data for species and length compositions are raised to total catch, especially when there may be various product weights reported (e.g. gutted or dressed carcasses and livers and/or fins).

Landings data

Since 2005, WGEF has collated landings data for all elasmobranchs in the ICES area, although this task has been hampered by the use by so many countries of "nei" (not elsewhere identified) categories. Landings data (as extracted from ICES FishStat Database) have been collated in species-specific landings tables and stored in a WG archive. These data have been corrected as follows:

- Replacement with more accurate data provided by national scientists;
- Expert judgements of WG members to reallocate data to less generic categories (usually from a "nei" category to a specific one).

The data in these archives are considered to be the most complete data and are presented in tabular and graphical form in the relevant sections of this Report and on the ICES WGEF SharePoint.

WGEF aims to allocate progressively more of the "nei" landings data over time, and some statistical approaches have been presented to WGEF (see Johnston *et al.*, 2005; ICES, 2006, 2011a). However, the Working Group's best estimates are still considered inaccurate for a number of reasons:

i) Quota species may be reported as elasmobranchs to avoid exceeding quota, which would lead to over-reporting;

ii) Fishers may not take care when completing landings data records, for a variety of reasons;

iii) Administrations may not consider that it is important to collect accurate data for these species;

iv) Some species could be underreported to avoid highlighting that bycatch is a significant problem in some fisheries;

v) Some small inshore vessels may target (or have a bycatch of) certain species and the landings of such inshore vessels may not always be included in official statistics.

The data may also be imprecise as a result of revisions by reporting parties. WGEF aims to arrive at an agreed set of data for each species and will document any changes to these datasets in the relevant working group report. A Workshop to compile and refine catch and landings of elasmobranchs (WKSHARKS) was held in January 2016 (ICES, 2016), and following this the 2016 Data Call requested a standardised approach to data submission, including for a longer period.

ICES Data Call for landings data

Some of the data used in 2015 were submitted following the ICES Data Call. WGEF concluded that the format of the Data Call in that year, whereby some nations submitted individual files for each of the named stocks, was problematic, as it resulted in generic landings categories not being submitted by all nations and increased the workload of the group.

In 2016, the Data Call requested that nations submit a single file for all categories of elasmobranch in their national data for the period 2005–2015. The 2016 Data Call was viewed as successful and facilitated landings data (supplied by nearly all nations operating in the area of interest) to be supplied in a common format.

WGEF considered that the 2017 Data Call for landings data should be in the same format, but requesting only data for 2015 and 2016. It was also suggested that the 2017 Data Call request data earlier in the year (e.g. by the end of April), so that WGEF could undertake more data checks prior to the meeting. This format was followed in 2017 and 2018, but there were still considerable issues with data collation, formatting and QA that had to be addressed in the early stages of the meetings. WGEF propose that an earlier data call (ideally using InterCatch format) would facilitate members to conduct initial assessments prior to the meeting and remove a serious time-constraint.

Discards data

The EU requires Member States to collect discard data on elasmobranchs. This discarding may include both regulatory discarding, when quota is limited, as well as the discarding of smaller and less marketable individuals. Whilst WGEF want to make progress from 'landings' to 'catch'-based advice, data from discard observer programmes has, to date, only been used in exploratory and descriptive analyses.

EU countries have implemented national on-board observer programs to estimate discards of abundant commercially important species (e.g. hake, *Nephrops*, cod, sole, and plaice). The adopted sampling designs have been defined considering the métiers, seasons and areas relevant for those species. As a consequence, national sampling programmes might not be optimal for estimating precise and unbiased discards for elasmobranchs.

Discard data were available to WGEF in 2018 but their raising to national catch levels are uncertain and procedures are not standardized. Particularly problematic are the cases of species which are not landed, being either not commercial or being subject to conservation measures (e.g. zero TAC).

In 2017, ICES WKSHARK3 reviewed i) the suitability of national sampling programs to estimate elasmobranch discards (including rare species), ii) the discard information available and iii) the procedures/methods to calculate population level estimates of discards removals for different countries (UCES, 2017).

The main issues concerning the estimation of elasmobranch total discards are:

1. **Data quality**

Species identification, in particular that for rare species or species rarely seen in a particular area/national fleet or metier is a problematic issue. There are also suspected errors on species identification in various national datasets.

2. **Insufficient sampling effort**

As, in each fishing haul or set, elasmobranchs constitute a small and highly variable fraction of the catch the uncertainty of the mean discards rate is intrinsically high. This uncertainty can only be addressed by a significant increase in the coverage of on-board observations.

As an example, IPMA updated the work presented at the WKSHARKS3 (Figueiredo *et al.*, 2017 WD). A classical ratio estimator (deGraft-Johnson, 1969), under a two-phase sampling scheme, was used to estimate the annual total discarded weight of *Raja clavata*, (period 2011-2014) from commercial vessels operating at ICES Division 9.a (Portugal mainland), with LOA larger than 12 m and with fishing permit to set gillnets or trammel nets. Using the variances of the estimates obtained, the optimum sample sizes to subsample in each phase were determined by considering the two variables (number of hauls with nets and total number/weight of *R. clavata* discards) and on the strength of the ratio relationship between them. Under a fixed cost function and the minimum MSE of the mean ratio estimate, the optimal sample size for second phase of the sampling scheme (i.e. on-board observations) should be increased from 256 to 678 times in relation to the sampling size levels of the years analysed in order to reduced uncertainty in discard estimates.

3. **Raising factor**

The discard estimators used varied between countries (ICES, 2017). While some are based on the fraction of fishing effort to the total effort in the metier, others are based on the fraction of the landings of the focal species to the total landings of that species in the metier, or on the landings of all or a number of commercially important species to the total landings of those species. The discard estimator adopted by each country is dependent upon the sampling plan and characteristics of the particular country, fleet or metier. It is thus extremely unlikely that a one-for-all estimator can be adopted. Nevertheless, reliable discard estimates need to be available to WGEF, so minimum levels of estimate precision should be agreed.

Considering the example of French fisheries, it was possible to compare the estimated discards using two raising methods: the raising to the landings of the same species (referred to as standard method in Table 1.5) and the raising to the landings of all species. See WKSHARK3 for details of the latter method (ICES, 2017)

For some stocks, estimates are similar and consistent. In particular for the stock rjc.27.3a4d, which is caught mostly in Division 7.d by French fisheries, both methods suggest discards of about 100 t per year until 2014 and a recent increase. Similar estimates were also obtained for greater-spotted dogfish in the Celtic sea. However, for two stocks of lesser-spotted dogfish, a species where identification is not a problem and which is abundant in the areas considered and marketed in France, estimates are very different with higher estimates derived from the standard method. These estimated high levels seem unrealistic and require more investigation. It may be that lesser-spotted dogfish is 100% discarded in some fishing operations and retained at various levels depending on other factors, amongst which the catch of more valuable species. This effect might not apply to the greater-spotted dogfish, a larger more coastal species, caught predominately in small-scale fisheries.

Table 1.5. Discards estimates from different methods in French fisheries for one stock of thornback ray, two stocks of lesser spotted dogfish and three stocks of greater-spotted dogfish.

Stock	Method	2011	2012	2013	2014	2015	2016
rjc.27.347d	Standard	78	128	266	63	313	799
rjc.27.347d	All species	124	85	81	45	330	NA
syc.27.67	Standard*	3700	7372	3448	3770	4414	9600
	All species	2007	3527	2460	1728	2708	NA
* includes 7.d							
syc.27.8abd	Standard	3342	4835	2497	4432	8616	8822
	Allspecies	1182	1624	865	1266	2279	
	Allspecies*	1371	1739	528	1255	2468	
	* metiers combined						
syt.27.67	Standard	23	49	17	154	26	51
	All species	31	16	56	61	27	NA

Discards estimates convey important information, for example estimates in the order of 1000 tonnes were obtained for the undulate ray in 7de, compared to 20–70 tonnes per year of blonde ray in the western Channel. This broad comparison of the range of discards supports other evidence of much higher abundance of undulate ray compared to blonde ray in the English Channel.

4. Discard retention patterns

Discards-retention patterns change other time and between fleets and countries, and these changes can be associated with several different factors.

Biological communities are complex networks of species that change through time and space. Due to this, the spatial overlap between the target and secondary, or by-catch, species, caught by a certain fishery, is an important aspect that needs to be considered when estimating discards. In fact, as both target and non-target species are dynamic, the level of spatial overlap is likely to change with time even at small spatial scales.

Such spatial and temporal dynamics of fishing resources render estimates/predictions of catch and discard rates quite variable. This is exemplified by a Dutch (industry) study funded by the European Maritime and Fisheries Fund (2016–2018). In this study, vessels register and retain discards of quota regulated species by haul on-board. In the auction, the discards are sorted by species, measured and weighed. The results show that for the Dutch pulse fishery 80 to 90% of the rays are discarded. This high discard rate is mainly due to restrictive Dutch quota s for skate and ray.

In the case of elasmobranchs, some species may show highly seasonal variations in abundance or changes in local abundance. Single fishing vessels can show high variability in catch and discard rates between days of the week. Adding fishing fleet dynamics to the natural dynamics of target resources, the situation becomes even more complex and predictions of potential by-catch becomes even more uncertain. Given the restrictive quota for rays, Producer Organisations often take measures, e.g. setting a MLS limit the amount that can be landed per trip, to avoid an early exhaustion of the quota. Such measures may influence discard decisions in the fleet - especially in the context of the Landing Obligation. Difficulties in accounting for decision making process on board undermine the accuracy and quality of discard estimates. This situation requires the development of adequate estimators that take those aspects in consideration, under penalty of obtaining highly imprecise discard estimates which in turn, may have significant social and economic impacts on fishing communities.

Market demand and management measures are important drivers for elasmobranch discards. For example, WHSKARK3 estimated that the retention of smoothhound probably increased over time in UK fisheries and the discarding of thornback ray in the Channel increased in recent years (ICES, 2017). These behaviours are probably a consequence of market opportunities for smoothhound and limited TAC for thornback ray.

5. Discard survival

Owing to the apparent high survival of elasmobranchs after capture it is important to obtain separate estimates for dead and surviving discards. As a proportion of the discards would be alive, catch data (landings and estimated discards) do not equate with "dead removals" in terms of population dynamics. Understanding the survival rates of discarded individuals is therefore fundamental for informing potential exemptions from the EU landings obligation.

To date there have been only limited scientific studies on the discard survival of skates in European fisheries, and data on the immediate, short-term survival and longer-term discard survival of these species are lacking for most fisheries. A summary of those studies was compiled in WKSHARKS3. To inform discussions on the future EU landing obligation and to improve the quantification of dead discards, WGEF recommend the need to implement scientific studies to better assess and quantify the discard survival of the main commercial skates caught by the trawl fleets, especially otter trawlers operating in the Bay of Biscay and Iberian waters, beam trawl fleets operating in northern Europe and for gill- and trammel net fisheries used by the inshore polyvalent fleet.

Stock structure

This report presents the status and advice of various demersal, pelagic and deep-water elasmobranchs by individual stock component. The identification of stock structure has been based upon the best available knowledge to date (see the stock-specific sections for more details). However, it has to be emphasized that overall, the scientific basis underlying the identity of many of these stocks is currently weak. In most cases, stock identification is based on the distribution and relative abundance of the species, current knowledge of movements and migrations, reproductive mode, and consistency with management units.

WGEF considers that the stock definitions proposed in the report are limited for many species, and in some circumstances advice may refer to 'management units'.

WGEF recommends that increased research effort be devoted to clarifying the stock structure of the different demersal and deep-water elasmobranchs being investigated by ICES.

Length measurements

Further information on the issues of different types of length measurement can be found in earlier reports (see Section 1.15 of ICES, 2010b). WGEF recommends that length–frequency information both commercial and survey be made available to the group for those species for which length-based assessments could be considered.

Taxonomic problems

Incorrect species identifications or coding errors affect many relevant data sets, including commercial data and even some scientific survey data. WGEF consistently attempt to correct and report these errors when they are found. The FAO recently produced an updated guide to the chondrichthyan fish of the North Atlantic (Ebert and Stehmann, 2013).

Other issues-*Dipturus* complex

Two publications (Iglésias *et al*., 2010; Griffiths *et al*., 2010), demonstrated that *Dipturus batis*, frequently referred to as common skate, is in fact a complex of two species, that were erroneously synonymised in the 1920s. Hence, much of the data for *Dipturus batis* is a confusion of blue skate *D. batis* and flapper skate *D. intermedia*.

In 2012 a special request was received from the European Commission to determine whether these species could be reliable identified and whether they have different distributions, with regard to the possible setting of separate TACs for the two species. This special request is dealt with in Annex IV of 2012 WGEF report. Where possible, this report refers to the species separately, with the confounded data referred to as the *Dipturus batis* complex.

Currently labs can only upload data to DATRAS for *D. batis*, as TSN codes are not available for provisionally-titled species. The Secretariat and IBTSWG are attempting to enable species-specific data to be input. In 2012, the case was submitted to the International Commission on Zoological Nomenclature (ICZN) with *Dipturus batis* proposed for the smaller species (ex. *Dipturus batis cf. flossada*) and *Dipturus intermedia* for the larger one. Pending on the decision of this commission, ICES is unable to progress this issue further.

This issue is further discussed in Section 21.1 of the 2010 WGEF report.

1.15 Methods and software

Many elasmobranchs are data-limited, and the paucity of data can extend to:

- Landings data, which are often incomplete or aggregated;
- Life-history data, as most species are poorly known with respect to age, growth and reproduction;
- Commercial and scientific datasets that are compromised by inaccurate species identification (with some morphologically similar species having very different life-history parameters);
- Lack of fishery-independent surveys for some species (e.g. pelagic species) and the low and variable catch rates of demersal species in existing bottom-trawl surveys.

Hence, the work undertaken by WGEF often precludes the formal stock assessment process that is used for many commercial teleost stocks. The analysis of survey, biological and landings data are used in most cases to evaluate the status of elasmobranch species/stocks. This limitation may be eased by new data-poor assessment approaches, which have the potential to allow some ray stocks to be moved from assessment category 3 to category 2.

Analytical assessment models are only used in the stock assessments of two species; porbeagle and spurdog. In 2011, WGEF updated and refined the model last used for the spurdog assessment in 2008 and 2010. A benchmark assessment of spurdog was carried out prior to, and during WGEF 2011. Further information can be found in Section 2 of 2011 WGEF report. In 2017, WGEF used two new data poor methods to conduct exploratory assessments for the following ray stocks:

Thornback ray (*Raja clavata*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel): RJC-347d.

Cuckoo ray (*Leucoraja naevus*) in Subarea 4 and Division 3.a (North Sea, Skagerrak, and Kattegat): RJN-34.

Cuckoo ray (*Leucoraja naevus*) in subareas 6 and 7 and divisions 8.ab and 8.d: RJN-678abd.

The first assessment approach applied the WKLIFE set of length-based indicators (LBI) to screen the length composition of catches and classify the three ray stocks according to conservation and sustainability, yield optimization and Maximum Sustainable Yield (MSY) considerations. The Surplus Production in Continuous Time (SPiCT) model (Pedersen and Berg, 2017) was then also applied to provide estimates of biomass, fishing mortality and MSY. These exercises were informative, highlighting the need to adjust LBI and associated reference points (RP) to account for elasmobranch life history and fisheries dynamics. The SPiCT modelling was also encouraging, providing assessment outputs with surprisingly low uncertainty. WGEF considers that there is scope in the future to move some of the category 3 skate and ray stocks into category 2. In 2018, further exploratory data-poor assessments were undertaken (see 2018 WD and summary in this report). WGEF made recommendations for future application of these approaches to elasmobranchs.

For other species WGEF followed the latest ICES guidelines on the assessment of data-limited stocks (ICES, 2012a). For most species survey data was available. For certain low-abundance species, only landings information is available. For demersal elasmobranchs in the Celtic and North Sea, a 'survey status' is provided for each species. For Bay of Biscay and Iberia Coast besides survey data for more frequently caught species there is also fishery-dependent information. Survey data quickly illustrate the relative abundance of each species in each survey, as well as a visual indication of trends in abundance and mean length. Further details are outlined in each section.

1.16 InterCatch

To date, WGEF has not used InterCatch for its landings figures. Landings figures are supplied by individual members. These are considered to be superior to official statistics as regional laboratories can better provide information on local fisheries and interpretation of nominal records of various species (including errors in species coding). In addition, the problems of the use of generic categories and species misidentification can be better evaluated in advance by WGEF members.

In 2016 and 2017, landings data were requested in the InterCatch SI format. However, as the data formatting undertaken by WGEF (e.g. allocation to stock, quality assurance, reallocation of misidentified species) are not standard routines in InterCatch, data are maintained separately.

1.17 Transparent Assessment Framework (TAF)

TAF is a new framework, currently in development, to organize all ICES stock assessments. Using a standard sequence of R scripts, it makes the data, analysis, and results available online, and documents how the data were preprocessed. Among the key potential benefits of this structured and open approach are improved quality assurance and peer review of ICES stock assessments. Furthermore, a fully scripted TAF assessment is easy to update and rerun later with a new year of data. As of spring 2018, the first assessments are being scripted in standard TAF scripts. See http://taf.ices.dk for more information.

During the WGEF 2018 meeting, the following progress was made getting stocks into TAF:

1. NE Atlantic spurdog (dgs.27.nea) assessment has been scripted in TAF. It was decided to leave certain pre-analytical steps (to find appropriate values for fixed model parameters) outside of the TAF analysis. The TAF analysis contains the final model run from 2018, from data to results.

2. NE Atlantic spurdog (dgs.27.nea) survey data preprocessing has been scripted in TAF, in a separate repository from the assessment (see item 1 above). This turned out be a practical separation, as the survey analysis for this stock is rather extensive, and because the survey preprocessing and the stock assessment are conducted by two different experts.

3. North Sea thornback ray (rjc.27.3a47d) has been fully scripted in TAF for the 2017 assessment. No advice is released for this stock in 2018, and the analysis will be updated on TAF next year.

The above analyses will become publicly available on https://github.com/ices-taf after ACOM has released the advice.

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2 Spurdog in the Northeast Atlantic

2.1 Stock distribution

Spurdog *Squalus acanthias* has a worldwide distribution in temperate and boreal waters, and occurs mainly in depths of 10–200 m. In the NE Atlantic, this species is found from Iceland and the Barents Sea southwards to the coast of Northwest Africa (McEachran and Branstetter, 1984).

WGEF considers that there is a single NE Atlantic stock ranging from the Barents Sea (Subarea 1) to the Bay of Biscay (Subarea 8), and that this is the most appropriate unit for assessment and management within ICES. Spurdog in Subarea 9 may be part of the NE Atlantic stock, but catches from this area are likely to consist of a mixture of *Squalus* species, with increasing numbers of *Squalus blainville* further south.

Genetic microsatellite analyses conducted by Verissimo *et al.* (2010) found no differences between east and west Atlantic spurdog. The authors suggested this could be accomplished by transatlantic migrations of a very limited number of individuals. Further information on the stock structure and migratory pattern of Northeast Atlantic spurdog can be found in the Stock Annex.

2.2 The fishery

2.2.1 History of the fishery

Spurdog has a long history of exploitation in the Northeast Atlantic (Pawson *et al.*, 2009) and WGEF estimates of total landings are shown in Figure 2.1a and Table 2.1. Spurdog has historically been exploited by France, Ireland, Norway and the UK (Figure 2.1b and Table 2.2). The main fishing grounds for the NE Atlantic stock of spurdog are the North Sea (Subarea 4), West of Scotland (Division 6.a) and the Celtic Seas (Subarea 7) and, during the decade spanning the late 1980s to 1990s, the Norwegian Sea (Subarea 2) (Table 2.3). Outside these areas, landings have generally been low. In recent years the fishery has changed significantly in line with restrictive management measures, which have included more restrictive quota, a maximum landing length and bycatch regulations.

Further details of the historical development of the fishery are provided in the Stock Annex. Further general information on the mixed fisheries exploiting this stock and changes in effort can be found in ICES (2009, ab) and STECF (2009).

2.2.2 The fishery in 2017

The zero TAC for spurdog for EU vessels has resulted in a major change in the magnitude and spatial distribution of reported landings. Landings have declined across all ICES subareas in recent years, although there are some landings in the northern parts of the ICES area.

Since 2011 the annual Norwegian landings have been stable at 216–313 tonnes. Preliminary reported landings of spurdog from Norwegian fisheries were 222 t in 2017.

In July 2016, an in-year amendment to EU quota regulations saw the introduction of a small TAC (270 t) for Union and international waters of subareas 1, 5–8, 10 and 12 (see

Section 2.2.4). In 2017, UK reported landings of 37 tonnes spurdog. For UK, traditionally one of the major exploiters of the spurdog stock, this was a major increase from a level close to zero that has been seen since the zero TAC was introduced in 2011. Apart from Spain, Iceland, France and Portugal, that reported 5, 4, 3 and 1.4 tonnes spurdog for 2017 respectively, no other countries reported any significant catch.

Commercial fishermen in various areas, including the southern North Sea, the Celtic Sea, and in the south- and mid-Norwegian coastal areas, continue to report that spurdog can be seasonally abundant on their fishing grounds.

2.2.3 ICES advice applicable

In 2018, ICES advised that "*when the precautionary approach is applied, there should be no targeted fisheries on this stock in 2019 and 2020. Based on medium-term projections, annual catches at the recent assumed level (2468 tonnes) would allow the stock to increase at a rate close to that estimated with zero catches. Any possible provision for the landing of bycatch should be part of a management plan, including close monitoring of the stock and fisheries*".

2.2.4 Management applicable

The following table summarizes ICES advice and actual management applicable for NE Atlantic spurdog during 2001–2017:

Year	Single-stock exploitation boundary (tonnes)	Basis	TAC (IIa(EC) and IV) (tonnes)	TAC IIIa, I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes)	TAC IIIa(EC) (tonnes)	TAC I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes)	WG landings (NE Atlantic stock) (tonnes)
2000	No advice	-	9470				15 890
2001	No advice	-	8870	-	-	-	16 693(1)
2002	No advice	-	7100	-	-	-	11 020
2003	No advice	-	5640	-	-	-	12 246
2004	No advice	-	4472	-	-	-	9365
2005	No advice	-	1136	-	-	-	7100
2006	F=0	Stock depleted and in danger of collapse	1051	-	-	-	4015
2007	F=0	Stock depleted and in danger of collapse	841 [2]	2828	-	-	2917
2008	No new advice	No new advice	631 [2,3]	-	-	2004 (2)	1798
2009	F=0	Stock depleted and in danger of collapse	316 [3,4]	-	104 (4)	1002 (4)	1980
2010	F=0	Stock depleted and in danger of collapse	0 [5]		0 (5)	0 (5)	892
2011	F=0	Stock depleted and in danger of collapse	0 [6]		0	0 (6)	435
2012	F=0	Stock below possible reference points	0 [6]		0	0 (6)	453
2013	F=0	Stock below possible reference points	0		0	0	335
2014	F=0	Stock below possible reference points	0		0	0	383

Year	Single-stock exploitation boundary (tonnes)	Basis	TAC (IIa(EC) and IV) (tonnes)	TAC IIIa , I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes)	TAC IIIa(EC) (tonnes)	TAC I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes)	WG landings (NE Atlantic stock) (tonnes)
2015	F=0	Stock below possible reference points	0		0	0	237
2016	F=0	Stock below possible reference points	0		0	0 (270)	349
2017	F-0	Stock below possible reference points	0		0	0	273

([1]) The WG estimate of landings in 2001 may include some misreported deep-sea sharks or other species.

([2]) Bycatch quota. These species shall not comprise more than 5% by live weight of the catch retained on board.

([3]) For Norway: including catches taken with longlines of tope shark (*G. galeus*), kitefin shark (*D. licha*), bird beak dogfish (*D. calcea*), leafscale gulper shark (*C. squamosus*), greater lantern shark (*E. princeps*), smooth lanternshark (*E. spinax*) and Portuguese dogfish (*C. coelolepis*). This quota may only be taken in zones IV, VI and VII.

([4]) A maximum landing size of 100 cm (total length) shall be respected.

([5])Bycatches are permitted up to 10% of the 2009 quotas established in Annex Ia to Regulation (EC) No. 43/2009 under the following conditions:catches taken with longlines of tope shark (*G. galeus*), kitefin shark (*D. licha*), bird beak dogfish (*D. calceus*), leafscale gulper shark (*C. squamosus*), greater lantern shark (*E. princeps*), smooth lantern shark (*E. pusillus*) and Portuguese dogfish (*C. coelolepis*) and spurdog (*S. acanthias*) are included (Does not apply to IIIa); a maximum landing size of 100 cm (total length) is respected; the bycatches comprise less than 10% of the total weight of marine organisms on board the fishing vessel. Catches not complying with these conditions or exceeding these quantities shall be promptly released to the extent practicable.

([6]) Catches taken with longlines of tope shark (*G. galeus*), kitefin shark (*D. licha*), bird beak dogfish (*D. calcea*), leafscale gulper shark (*C. squamosus*), greater lanternshark (*E. princeps*), smooth lanternshark (*E. pusillus*), Portuguese dogfish (*C. coelolepis*) and spurdog (*S acanthias*) are included. Catches of these species shall be promptly released unharmed to the extent practicable.

In all EU regulated areas, a zero TAC for spurdog was retained for 2017. In July 2016, an in-year amendment to EU quota regulations (Council Regulation (EU) 2016/1252 of 28 July 2016) saw the introduction of a small TAC (270 t) for Union and international waters of subareas 1, 5–8, 10 and 12, with this TAC to be allocated to vessels participating in bycatch avoidance programmes. This regulation states that "*a vessel engaged in the by-catch avoidance programme that has been positively assessed by the STECF may land not more than 2 tonnes per month of picked dogfish that is dead at the moment when the fishing gear is hauled on board. Member States participating in the by-catch avoidance programme shall ensure that the total annual landings of picked dogfish on the basis of this derogation do not exceed the amounts indicated below. They shall communicate the list of participating vessels* *to the Commission before allowing any landings. Member States shall exchange information about avoidance areas"*.

This derogation was not denoted for TAC areas for EU waters of 3.a or EU waters of 2.a and 4. In these areas, no EU landings were permitted.

In 2007, Norway introduced a general ban on target fisheries for spurdog in the Norwegian economic zone and in international waters of ICES subareas 1–14, with the exception of a limited fishery for small coastal vessels. Bycatch could be landed and sold as before. All directed fisheries were banned from 2011, although there is still a bycatch allowance. From October 2011, bycatch should not exceed 20% of total landings on a weekly basis. Since 4 June 2012, bycatch must not exceed 20% of total landings over the period 4 June–31 December 2012. From 1 January 2013, bycatch must not exceed 15% of total landings on a half calendar year basis. Live specimens can be released, whereas dead specimens must be landed. From 2011, the regulations also include recreational fisheries. Norway has a 70 cm minimum landing size (first introduced in 1964).

Since 1st January 2008, fishing for spurdog with nets and longlines in Swedish waters has been forbidden. In trawl fisheries, there is a minimum mesh size of 120 mm and the species may only be taken as a bycatch. In fisheries with hand-held gear only one spurdog was allowed to be caught and kept by the fisher during a 24-hour period.

Many of the mixed fisheries which caught spurdog in the North Sea, West of Scotland and Irish Sea are subject to effort restrictions under the cod long-term plan (EC 1342/2008).

2.3 Catch data

2.3.1 Landings

Total annual landings of NE Atlantic spurdog are given in Table 2.1 and illustrated in Figure 2.1a. Preliminary estimates of landings for 2017 were 273 t.

2.3.2 Discards

Estimates of total amount of spurdog discarded are not routinely provided although some discard sampling does take place.

Data from Scottish observer trips in 2010 were made available to the WG. Over 1200 spurdog (raised to trip level and then summed across trips) were caught over 29 trips (across Divisions 4.a and 6.a), but on no occasion were any retained.

At the 2010 WG, a working document was presented on the composition of Norwegian elasmobranch catches, which suggested significant numbers of spurdog were discarded.

Preliminary observations on the discard-retention patterns of spurdog as observed on UK (English) vessels were presented by Silva *et al.* (2013 WD; Figure 2.2).

No attempts to raise observed discard rates to fleet level have been undertaken as yet, and given the aggregating nature of spurdog, such analyses would need to be undertaken with care.

Further information on discards can be found in the Stock Annex.

2.3.3 Discard survival

Low mortality has been reported for spurdog caught by trawl when tow duration was <1 h, with overall mortality of about 6% (Mandelman and Farrington, 2007; Rulifson, 2007), with higher levels of mortality (ca. 55%) reported for gillnet-caught spurdog (Rulifson, 2007).

Only limited data on at-vessel mortality are available for European waters (Bendall *et al.*, 2012), and there are no published data on post-release mortality.

2.3.4 Quality of the catch data

In addition to the problems associated with obtaining estimates of the historical total landings of spurdog, due to the use of generic dogfish landings categories, anecdotal information suggests that widespread misreporting by species may have contributed significantly to the uncertainties in the overall level of spurdog landings.

Underreporting may have occurred in certain ICES areas when vessels were trying to build up a track record of other species, for example deep-water species. It has also been suggested that over-reporting may have occurred where stocks with highly restrictive quotas have been recorded as spurdog. However, it is not possible to quantify the amount of under and over-reporting that may have occurred. The introduction of UK and Irish legislation requiring registration of all fish buyers and sellers should mean that such misreporting problems have declined since 2006.

It is not known whether the 5% bycatch ratio (implemented in 2008) or the maximum landing length (in 2009) led to misreporting (although the buyers and sellers legislation should deter this) or increased discarding.

Given the zero TAC in place, recent catch data are highly uncertain. Whilst data from discard observer programmes may allow catches to be estimated, the estimation of dead discards will be more problematic.

Some nations may now be reporting landings of spurdog under more generic codes (e.g. *Squalus* sp., Squalidae and Squaliformes) as well as for *Squalus acanthias*.

2.4 Commercial catch composition

2.4.1 Length composition of landings

Sex disaggregated length–frequency samples are available from UK (E&W) for the years 1983–2001 and UK (Scotland) for 1991–2004 for all gears combined. The Scottish length–frequency distributions appear to be quite different from the length–frequency distributions obtained from the UK (E&W) landings, with a much larger proportion of small females being landed by the Scottish fleets. Figure 2.2 shows landings length–frequency distributions averaged over five year intervals. The Scottish data have been raised to total Scottish reported landings of spurdog while the UK (E&W) data have only been raised to the landings from the sampled boats, a procedure which is likely to mean that the latter length frequencies are not representative of total removals by the UK (E&W) fleet. For this reason, the UK (E&W) length frequencies are assumed to be representative only of the landings by the target fleet from this country.

Raw market sampling data were also provided by Scotland for the years 2005–2010. However, sampled numbers have been low in recent years (due to low landings) and use of these data was not pursued.

2.4.2 Length composition of discards

There are no international estimates of discard length frequencies.

Discard length–frequency data were provided by the UK (Scotland) for 2010. Length frequencies raised to trip level and pooled over all trips and areas by gear type are shown in Figure 2.3. These have not been raised to fleet level.

Discard length–frequency data were provided by the UK (England) for four broad gear types (Figure 2.4). In general, beam trawlers caught relatively few spurdog, and these were comprised mostly of juveniles, gillnets catches were dominated by fish 60–90 cm TL and otter trawlers captured a broad length range. Data for larger fish sampled across the whole time-series were most extensive for gillnetters operating in the Celtic Seas (Silva *et al.,* 2013 WD). The discarding rates of commercial sized fish (80–100 cm TL) from these vessels increased from 7.5% (2002–2008) to 18.7% (2009–2010), whereas the proportion of fish >100 cm LT discarded increased from 6.2% (2002–2008) to 34.1% (2009–2010), indicating an increased proportion of larger fish were discarded in line with the maximum landing length regulations that were in force during 2009–2010. The zero TAC with no bycatch allowance resulted in the discarding of all observed spurdog in 2011.

2.4.3 Sex ratio

No recent data.

2.4.4 Quality of data

Historically, length–frequency samples were only available for UK landings and these were aggregated into broader length categories for the purpose of assessment. No data were available from Norway, France or Ireland, which were the other main nations exploiting this stock. For the 20 years prior to restrictive measures, UK landings accounted for approximately 45% of the total. However, there has been a systematic decline in this proportion since 2005 and the UK landings in 2008 represented 15% of the total. In 2010, UK landings were just above 5% of the total, and <1% in 2011. It is not known to what extent the available commercial length–frequency samples are representative of the catches by these other nations. In addition, there are only limited length–frequency data from recent years.

2.5 Commercial catch-effort data

No commercial CPUE data were available to the WG.

The outline of a Norwegian sentinel fishery on spurdog was presented to the 2012 WG (Albert and Vollen, 2012 WD). This potential provider of an abundance index series has not been initiated yet.

A UK Fishery Science Partnership (FSP) study carried out by CEFAS examined spurdog in the Irish Sea (Ellis *et al*., 2010), primarily to (a) evaluate the role of spurdog in longline fisheries and examine the catch rates and sizes of fish taken in a longline fishery; (b) provide biological samples so that more recent data on the length-at-maturity and fecundity can be calculated; and (c) tag and release a number of individuals to inform on the potential discard survivorship from longline fisheries. Survey stations were chosen by the fishermen participating in the survey.

This survey undertook studies on a commercial, inshore vessel that had traditionally longlined for spurdog during parts of the year. Four trips (nominally one in each quarter), each of four days, were undertaken over the course of the year. The spurdog caught were generally in good condition, although the bait stripper can damage the jaws, and those fish tagged and released were considered to be in a good state of health.

Large numbers of spurdog were caught during the first sampling trip, of which 217 were tagged with Petersen discs and released. The second sampling trip yielded few spurdog, although catches at that time of year are considered by fishermen to be sporadic. Spurdog were not observed on the first three days of the third trip, but reasonable numbers were captured on the last day, just off the Mull of Galloway. The fourth trip (spread over late October to early December, due to poor weather) yielded some reasonably large catches of spurdog from the grounds just off Anglesey.

2.6 Fishery-independent information

2.6.1 Availability of survey data

Fishery-independent survey data are available for most regions within the stock area. Beam trawl surveys are not considered appropriate for this species, due to the low catchability of spurdog in this gear type. The surveys coordinated by IBTS have higher catchability and the gears are considered suitable for this species. Spatial coverage of the North and Celtic Seas represents a large part of the stock range (Figure 2.5). For further details of these surveys and gears used see ICES (2010). The following survey data have been used in earlier analyses by WGEF:

- UK (England & Wales) Q1 Celtic Sea groundfish survey: years 1982–2002.
- UK (England & Wales) Q4 Celtic Sea groundfish survey: years 1983–1988.
- UK (England & Wales) Q3 North Sea groundfish survey 1977–present.
- UK (England & Wales) Q4 SWIBTS survey 2004–2009 in the Irish and Celtic Seas.
- UK (NI) Q1 Irish Sea groundfish survey 1992–2008.
- UK (NI) Q4 Irish Sea groundfish survey 1992–2008.
- Scottish Q1 west coast groundfish survey: years 1990–2010 (ScoGFS-WIBTS-Q1) and 2011-2015 (UKSGFS-WIBTS-Q1).
- Scottish Q4 west coast groundfish survey: years 1990–2009 (ScoGFS-WIBTS-Q4) and 2011-2015 (UKSGFS-WIBTS-Q4).
- Scottish Q1 North Sea groundfish survey: years 1990–2010.
- Scottish Q3 North Sea groundfish survey: years 1990–2009.
- Scottish Rockall haddock survey: years 1990–2009.
- Irish Q3 Celtic Seas groundfish survey: years 2003–2009.
- North Sea IBTS (NS-IBTS) survey: years 1977–2010.

A full description of the current groundfish surveys can be found in the Stock Annex.

Norwegian data on spurdog from the Shrimp survey (NO-shrimp-Q1) and the Coastal survey (NOcoast-Aco-Q4) were presented to the WGEF in 2014 and 2018 (Vollen, 2014 WD). The survey coverage is shown in Figure 2.6, and general information on the surveys can be found in Table 2.4.

The annual shrimp survey (1998–2018) covers the Skagerrak and the northern parts of the North Sea north to 60°N. The timing of the survey changed from quarter 4 (1984–2003), via quarter 3 (2002–2004), to quarter 1 from 2005. Mesh size was not specified for the first years, 35 mm from 1989–1997, and 20 mm from 1998. Trawl time was one hour from 1984–1989, then 30 minutes for later years.

The coastal survey (1996–2017) yearly covers the areas from 62°N to the Russian border in the north in October–November. Only data south of 66°N were used, as very few spurdog were caught north of this latitude. Length data were available from 1999 onwards. A Campelen Shrimp trawl with 40 mm mesh size was used from 1995–1998, whereas mesh size was 20 mm for later years. Trawl time was 20–30 minutes.

Spurdog catches in these surveys are not numerous. Number of stations with spurdog catches ranged from one to 35 per year in the shrimp survey; and from 0 to 8 per year in the coastal survey. The total number of spurdog caught ranged from one to 341 individuals per year in the shrimp survey, and from 0 to 106 individuals per year in the coastal survey (Table 2.4).

2.6.2 Length–frequency distributions

Length–frequency distributions (aggregated overall years) from the UK (E&W), Scottish and Irish groundfish surveys are shown in Figures 2.7–2.8.

The UK (E&W) groundfish survey length–frequency distribution (Figure 2.7a) consists of a high proportion of large females, although this is influenced by a single large catch of these individuals. Mature males are also taken regularly and juveniles often caught on the grounds in the northwestern Irish Sea.

The Irish Q4 GFS also catches some large females (Figure 2.7b), but the majority of individuals (both males and females) are of intermediate size, in the range 50–80 cm.

The Scottish West coast groundfish surveys demonstrate an almost complete absence of large females in their catches (Figure 2.8). These surveys show a high proportion of large males and also a much higher proportion of small individuals, particularly in the Q1 survey. However, it should be noted that length frequency distributions exhibit high variability from year to year (not shown) with a small number of extremely large hauls dominating the length–frequency data.

In the UK FSP survey, the length range of spurdog caught was 49–116 cm (Figure 2.9), with catches in Q1 and Q3 being mainly large (>90 cm) females. Catches in Q4 yielded a greater proportion of smaller fish. The sex ratio of fish caught was heavily skewed towards females, with more than 99% of the spurdog caught in Q1 female. Although more males were found in Q3 and Q4, females were still dominant, accounting for 87% and 79% of the spurdog catch, respectively. Numerically, between 16.5 and 41.9% of spurdog captured were >100 cm, the Maximum Landing Length in force at the time.

In the Norwegian Shrimp and Coastal surveys the length–frequency distribution was rather uniform overall years, with the length groups 60–85 cm being the most abundant (Figure 2.10).

Previously presented length frequencies are displayed in the Stock Annex.

2.6.3 CPUE

Spurdog survey data are typically characterised by highly variable catch rates due to occasional large hauls and a significant proportion of zero catches. Average catch rates (in numbers per hour) from the NS-IBTS are shown in Figure 2.11. Although the time-series is noisy, it appears that spurdog are now being seen in a greater proportion of hauls in the Q3 survey, with average catch rates also increasing in Q3.

Time-series plots of frequency of occurrence (proportion of non-zero hauls) for the Irish surveys are shown in Figure 2.12. This short time-series shows stability on the frequency of occurrence and on the catch rates. For UK surveys, previously presented data (either discontinued or not updated this year) have indicated a trend of decreasing occurrence and decreasing frequency of large catches with catch rates also decreasing (although highly variable) (Figures 2.16–2.17).

Time-series plots of frequency of occurrence (five year running mean) for both Norwegian surveys is shown for >20 years in Figure 2.13; shrimp survey (1985–2018) and coastal survey (1995–2017). Frequency of occurrence (five year running mean) and average catch rate (in number per hour zero hauls not included, with five-year running mean) from the Norwegian Survey trends from the Norwegian Shrimp and Coastal surveys are shown in Figures 2.14–2.15. The frequency of occurrence declined for the Shrimp survey from late 1980s and reached a low in late 1990s. Since then, the Shrimp survey shows an increasing trend, whereas the Coastal survey shows a decreasing trend. With regards to average catch range, numbers are variable but a decrease can be seen from the 1980s to the late 1990s for the Shrimp survey. For the Coastal survey, a peak could be seen around 2004, but it should be noted that results are generally based on very few stations.

Future studies of survey data could usefully examine surveys from other parts of the stock area, as well as sex-specific and juvenile abundance trends. In the absence of accurate catch data, fishery-independent trawl surveys will be increasingly important to monitor stock recovery.

2.6.4 Statistical modelling

As at previous WG meetings a biomass index was derived from an analysis of Scottish survey data. Data from four Scottish surveys listed above (1990–2015) were considered in the analysis (Rockall was not included due to the very low numbers of individuals caught in this survey). The dataset consists of length–frequency distributions at each trawl station (over 7000 in total), together with the associated information on gear type, haul time, depth, duration and location. For each haul station, catch-rate was calculated: total weight caught (derived from length using the length-weight relationship) divided by the haul duration to obtain a measure of catch-per-unit of effort in terms of g/30 minutes.

The objective of the analysis was to obtain standardized annual indices of CPUE (on which an index of relative abundance can be based) by identifying explanatory variables which help to explain the variation in catch rate and which is not a consequence of changes in population size. Due to the highly skewed distribution of catch rates and the presence of the large number of zeros, a 'delta' distribution approach was taken to the statistical modelling. Lo *et al*., 1992 and Stefansson, 1996 describe this method which combines two generalized linear models (GLM): one which models the probability of a positive observation (binomial model) and the second which models the catch rate conditioned on it being positive assuming a lognormal distribution. The overall year effect (annual index) can then be calculated by multiplying the year effects estimated by the two models.

The aim of the analysis was to obtain an index of temporal changes in CPUE and therefore year was always included as a covariate (factor) in the model. Other explanatory variables included were area (Scottish demersal sampling area, see Dobby *et al*. (2005) for further details) and month or quarter. Variables which explained greater than 5% of the deviance in previous analysis were retained in the model. All variables were included as categorical variables.

The model results, in terms of retained terms and deviance values are presented in Table 2.5. Estimated effects are shown in Figure 2.18. The diagnostic plot for the final lognormal model fit is shown in Figure 2.19, indicating that the distributional assumptions are adequate: the residuals show a relatively symmetrical distribution, with no obvious departures from normality, and the residual variance shows no significant changes through the range of fitted values.

The estimated year effects for the binomial component of the model demonstrate a significant decline over the first part of the time period with an increase in more recent years (with the exception of 2015). The year effects for the catch rate given that it is positive show a general increasing trend since around 2005. Although this index is used within the assessment, there are a number of weaknesses associated with the analysis which should be highlighted:

- The survey data analysed only covers a proportion of the stock distribution;
- The two Scottish west coast surveys underwent a redesign in 2011, including the use of new ground-gear. No consideration has been given to potential changes in catchability due to the new ground-gear in this analysis.
- A sex-specific abundance index would potentially be more informative.

2.7 Life-history information

Maturity and fecundity data were collected on the UK FSP surveys. The largest immature female spurdog was 84 cm, with the smallest mature female 78 cm. The smallest mature and active female observed was 82 cm. All females ≥90 cm were mature and active. The observed uterine fecundity was 2–16 pups, and larger females produced more pups. In Q1, the embryos were either in the length range 11–12 cm or 14–18 cm, and no females exhibited signs of recently having given birth. In Q3, near-term pups were observed at lengths of 16–21 cm. During Q4, near-term and term pups of 19–24 cm were observed, and several females showed signs of recently having pupped.

This further suggests that the Irish Sea may be an important region in which spurdog give birth during late autumn and early winter, although it is unclear if there are particular sites in the area that are important for pupping.

The biological parameters used in the assessment can be found in the Stock Annex. Updated life history data have also been collected (Silva *et al*., 2015; see Section 2.14), which should be investigated for any update to the benchmark assessment.

2.8 Exploratory assessments and previous analyses

2.8.1 Previous assessments

Exploratory assessments undertaken in 2006 included the use of a delta-lognormal GLM-standardized index of abundance and a population dynamic model. This has been updated at subsequent meetings. The results from these assessments indicate that spurdog abundance has declined, and that the decline is driven by high exploitation levels in the past, coupled with biological characteristics that make this species particularly vulnerable to such intense exploitation (ICES, 2006).

2.8.2 Simulation of effects of maximum landing length regulations

Earlier demographic studies on elasmobranchs indicate that low fishing mortality on mature females may be beneficial to population growth rates (Cortés, 1999; Simpfendorfer, 1999). Hence, measures that afford protection to mature females may be an important element of a management plan for the species. As with many elasmobranchs, female spurdog attain a larger size than males, and larger females are more fecund.

Preliminary simulation studies of various Maximum Landing Length (MLL) scenarios were undertaken by ICES (2006) and suggested that there are strong potential benefits to the stock by protecting mature females. However, improved estimates of discard survivorship from various commercial gears are required to better examine the efficacy of such measures.

2.9 Stock assessment

2.9.1 Introduction

A benchmark assessment of the model was carried out in 2011. A summary of review comments and response to it were provided in Appendix 2a of the 2011 WGEF report (ICES, 2011), and is reproduced in an Appendix to the Stock Annex. The model is described in detail in the Stock Annex, and in De Oliveira *et al*. (2013).

In 2011 WGEF updated the model based on the benchmark assessment. Subsequent update assessments were carried out in 2014 and 2016, and the results presented here are for a further update to include data up to 2017.

Life-history parameters and input data

Calculation of the life-history parameters M_a (instantaneous natural mortality rate), l_a^s (mean length-at-age for animals of sex s), w_a^s (mean weight-at-age for animals of sex s), and P_a'' (proportion females of age a that become pregnant each year) are summarised in Table 2.6, and described visually in Figure 2.20.

Landings data used in the assessment are given in Table 2.7. The assessment requires the definition of fleets with corresponding exploitation patterns, and the only information currently available to provide this comes from Scottish and English & Wales databases. Two fleets, a "non-target" fleet (Scottish data) and a "target" fleet (England & Wales data), were therefore defined and allocated to landings data. Several targeting scenarios were explored in order to show the sensitivity of model results to these allocations (ICES, 2011), and these results are included here. In order to take the model back to a virgin state, the average proportion of these fleets for 1980–1984 were used to split landings data prior to 1980, but two of the targeting scenarios assume historic landings were only from "non-target" or "target" fleets.

The Scottish survey abundance index (biomass catch rate) was derived on the basis of applying a delta-lognormal GLM model to four Scottish surveys over the period 1990–2017, and is given in Table 2.8 along with the corresponding CVs. The proportions-by-length category data derived from these surveys, along with the actual sample sizes these data are based on, are given in Table 2.9 separately for females and males.

Table 2.10 lists the proportion-by-length-category data for the two commercial fleets considered in the assessment, along with the raised sample sizes. Because these raised sample sizes do not necessarily reflect the actual sample sizes the data are based on (as they have been raised to landings), these sample sizes have been ignored in the assessment (by setting $n_{pcom,j,y} = \bar{n}_{pcom,j}$ in equation 10b of the Stock Annex); a sensitivity test conducted in ICES (2010) showed a lack of sensitivity to this assumption.

The fecundity data (see Ellis and Keable, 2008 for sampling details) are given as pairs of values reflecting length of pregnant female and corresponding number of pups, and are listed in Tables 2.11a and b for the two periods (1960 and 2005).

2.9.2 Summary of model runs

Category	Description	Figures	Tables
•Base case run		2.21–27, 2.31–33	2.12–15
•Retrospective	A 6-year retrospective analysis, using the base case run and omitting one year of data each time	2.28	
•Sensitivity			
Q_{fec}	A comparison with an alternative Q_{fec} values that fall within the 95% probability interval of Figure 2.21, with a demonstration of the deterioration in model fit to the survey abundance index for higher Q_{fec} values	2.22, 2.29	
Targeting scenarios	A comparison of alternative assumptions about targeting (taken from ICES, 2011): Tar 1: the base case (each nation is defined "non-target", "target" or a mixture of these, with pre-1980s allocated the average for 1980–1984) Tar 2: as for WGEF in 2010 (Scottish landings are "non-target", E&W "target", and the remainder raised in proportion to the Scottish/E&W landings, with pre-1980s allocated the average for 1980–1984) Tar 3: as for Tar 2 but with E&W split 50% "non-	2.30	

	target" and 50% "target"
	Tar 4: as for Tar 1, but with pre-1980 selection entirely non-target
	Tar 5: as for Tar 1, but with pre-1980 selection entirely target

2.9.3 Results for base case run

Model fits

Fecundity data available for two periods present an opportunity to estimate the extent of density-dependence in pup-production (Qfec). However, estimating this parameter along with the fecundity parameters afec and bfec for the two time-periods was not possible because these parameters are confounded. The approach therefore was to plot the likelihood surface for a range of fixed afec and bfec input values, while estimating Qfec, and the results are shown in Figure 2.21. The two periods of fecundity data are essential for the estimation of Qfec, and further information that would help with the estimation of this parameter would be useful. Figure 2.21d indicates a near-linear relationship between Qfec and MSYR (defined in terms of the biomass of all animals $\geq l^{f}_{mat00}$), so additional information about MSYR levels typical for this species could be used for this purpose (but has not yet been attempted).

The value of Qfec chosen for the base case run (2.086) corresponded to the lower bound of the 95% probability interval shown in Figure 2.21. Lower Qfec values correspond to lower productivity, so this lower bound is more conservative than other values in the probability interval. Furthermore, sensitivity tests presented below show that higher Qfec values are associated with a deterioration in the model fit to the Scottish survey abundance index.

Figure 2.22 shows the model fit to the Scottish surveys abundance index for the base case value of Qfec and for alternative values that still fall within the 95% confidence interval of Figure 2.21c; Figure 2.22 indicates a deterioration in the model fit to the Scottish surveys abundance index as Qfec increases. Figure 2.23a shows the model fit to the Scottish and England & Wales commercial proportion-by-length-category data, and Figure 2.23b to the Scottish survey proportion-by-length-category data, the latter fitted separately for females and males. Model fits to the survey index and commercial proportion data appear to be reasonably good with no obvious residual patterns, and a close fit to the average proportion-by-length-category for the commercial fleets. Figure 2.23b indicates a poorer fit to the survey proportions compared to the commercial proportions, and given the residual patterns (a dominance of positive residuals for females, and, more weakly, the opposite for males) that it may be possible to estimated sex ratio (not attempted).

Figure 2.24a compares the deterministic and stochastic versions of recruitment, and plots the estimated recruitment residuals normalised by σ_r. The fits to the two periods of fecundity data are shown in Figure 2.25, highlighting the difference in the fecundity relationship with female length for the two periods, this difference being due to Qfec.

Estimated parameters

Model estimates of the total number of pregnant females in the virgin population $(N_0^{f,preg})$, the extent of density-dependence in pup production (Qfec), survey catchability (qsur), and current (2018) total biomass levels relative to 1905 and 1955 (Bdepl05 and Bdepl55), are shown in Table 2.12a (for the "base case" and alternative Qfec values) together with estimates of precision. Estimates of the natural mortality parameter Mpup, the fecundity parameters afec and bfec, and MSY parameters (Fprop,MSY, MSY, B_{MSY}, MSY $_{Btrigger}$ and MSYR) are given in Table 2.12b. Table 2.13 provides a correlation matrix for some of the key estimable parameters (only the last five years of recruitment deviations are shown). Correlations between estimable parameters are generally low, apart from the commercial selectivity parameters associated with length categories 55–69 cm and 70–84 cm, and Qfec vs. qsur.

Estimated commercial- and selectivity-at-age patterns are shown in Figure 2.26, and reflect the relatively lower proportion of large animals in the survey data when compared to the commercial catch data, and the higher proportion of smaller animals in the Scottish commercial catch data compared to England & Wales (see also Figure 2.23). It should be noted that females grow to larger lengths than males, so that females are able to grow out of the second highest length category, whereas males, with an L_∞ of <85 cm (Table 2.6) are not able to do so (hence the commercial selectivity remains unchanged for the two largest length categories for males). The divergence of survey selectivity for females compared to males is a reflection of the separate selectivity parameters for females/males in the largest length category (70+ for surveys).

A plot of recruitment vs. the number of pregnant females in the population, effectively a stock–recruit plot, is given in Figure 2.24b together with the replacement line (the number of recruiting pups needed to replace the pregnant female population under no harvesting). This plot illustrates the importance of the Qfec parameter in the model: a Qfec parameter equal to 1 would imply the expected value of the stock–recruit point lies on the replacement line, which implies that the population is effectively incapable of replacing itself. A further exploration of the behaviour of Qy and Npup,y (equations 2a and b in the Stock Annex) is shown in Figure 2.27.

Time-series trends

Model estimates of total biomass (By) and mean fishing proportion (Fprop5-30,y) are shown in Figure 2.32 together with observed annual catch ($C_y = \sum_j C_{j,y}$). They indicate a strong decline in spurdog total biomass, particularly since the 1940s, to a low around 2000 (18% of pre-exploitation levels), which appears to be driven by relatively high exploitation levels, given the biological characteristics of spurdog. Fprop5-30,y appears to have declined in recent years, with By increasing again to 24% of pre-exploitation levels in 2018 (Bdepl05 in Table 2.12a). Figure 2.32 also shows total biomass (By), recruitment (Ry) and mean fishing proportion (Fprop5-30,y) together with approximate 95% probability intervals. The fluctuations in recruitment towards the end of the time-series are driven by information in the proportion-by-length-category data. Table 2.14 provides a stock summary (recruitment, total biomass, landings and Fprop5-30,y).

2.9.4 Retrospective analysis

A six year retrospective analysis (the base case model was re-run, each time omitting a further year in the data) was performed, and is shown in Figure 2.28a for the total biomass (By), mean fishing proportion (Fprop5-30,y) and recruitment (Ry). A retrospective pattern appears to have developed since the last assessment (ICES, 2016; the retrospective pattern from the last assessment is shown in Figure 2.28b for comparison). Although a worrying development, the retrospective patterns are still well within the 95% confidence limits of the assessments estimates (compare Figure 2.28a with Figure 2.32), and the retrospective pattern is in the conservative direction (underestimating stock size and overestimating fishing pressure), so not an immediate concern.

2.9.5 Sensitivity analyses

Two sets of sensitivity analyses were carried out, as listed in the text table above.

a) Q_{fec}

The afec and bfec values that provided the lower bound of the 95% probability interval (Qfec=2.086; Figure 2.21a-c) was selected for the base case run. This sensitivity test compares it to the runs for which the afec and bfec input values provide the optimum (Qfec=2.532) and upper bound (Qfec=3.358). Model result are fairly sensitive to these options (Figure 2.29, Table 2.12a and b), but higher Qfec values, although still within the 95% probability interval, lead to a deterioration in the fit the Scottish survey abundance index, as demonstrated in Figure 2.22b. This is part justification for selecting the more conservative lower bound as the base case value.

b) Alternative targeting scenarios

Alternatives targeting scenarios for both the post-1980s landings data (for which data are available by nation) and the pre-1980s landings data (not available by nation) were explored in this set of sensitivity analyses presented in ICES (2011) and shown again here. The alternative scenarios are listed in Section 2.9.2, and results shown in Figure 2.30. These results indicate a general lack of sensitivity to alternative assumptions about targeting.

2.9.6 *MSY $B_{trigger}$*

The current estimates of B_{MSY} for spurdog is 956 676 t ("Base case" in Table 2.12b). MSY $B_{trigger}$ was previously set to B_{MSY} (ICES, 2016). However, this is before current guidelines for calculating reference points for Category 1 and 2 stocks were published (ICES, 2017); according to these guidelines, MSY $B_{trigger}$ represents the 5th percentile of the distribution of B_{MSY} in cases where B_{MSY} is estimable and has been "observed" by the assessment; this is indeed the case for spurdog (with the model stretching back to the virgin state), so we approximate the 5th percentile of the B_{MSY} distribution by setting MSY $B_{trigger}$ = B_{MSY}/1.4 = 683 340 t (see second bullet on page 16 of ICES, 2017, for the approach).

2.9.7 Projections

The base case assessment is used as a basis for future projections under a variety of catch options. These are based on:

- The ICES MSY rule, which assumes that $F_{prop,\mathrm{MSY}} = 0.032$ and $MSY\ B_{trigger}$ = 683 340 t (Table 2.12b and Section 2.9.6; this rule fishes at $F_{prop,\mathrm{MSY}} = 0.032$ for total biomass values at or above $MSY\ B_{trigger}$, but reduces fishing linearly when total biomass is below $MSY\ B_{trigger}$ by the extent to which total biomass is below $MSY\ B_{trigger}$),;
- Zero catch (for comparison purposes);
- TAC_{2009} = 1422 t, the last non-zero TAC set for spurdog in 2009;
- Average landings for 2007–2009 = 2468 t, an amount that could accommodate bycatch in mixed fisheries;
- Fishing at $F_{prop,\mathrm{MSY}} = 0.032$ (the MSY harvest rate).

Results are given in Table 2.15a, expressed as total biomass in future relative to the total biomass in 2018, and are illustrated in Figure 2.31. Results relative to MSY $_{\mathrm{Btrigger}}$ are given in Table 2.15b. Recovery to MSY $_{\mathrm{Btrigger}}$ for the most conservative catch options (zero, TAC 2009, ave catch 2007–9) from 2018 are 22, 24 and 26 years respectively, with the remaining options (MSY approach and MSY harvest rate) taking longer than 30 years (point estimates in Table 2.15b).

2.9.8 Conclusion

Since this is an update assessment, results for the base case model are presented as the final assessment. Although this assessment has developed a slight retrospective pattern compared to the last assessment (ICES, 2016), it is still well within the 95% confidence limits of the assessment and the model provides reasonable fits to most of the available data. Sensitivity tests show the model to be sensitive to the range of Qfec values that fall within the 95% probability interval for corresponding fecundity parameters. However, results show a deterioration of the model fit to the Scottish survey abundance index as Qfec increases, thereby justifying the selection of the more conservative lower bound as the base case value (Qfec = 2.086). The model is relatively insensitivity to alternative targeting scenarios, including assumptions about selection patterns prior to 1980. A summary plot of the final assessment (the base case run), showing landings and estimates of recruitment, mean fishing proportion (with F_{prop},MSY=0.032) and total biomass (with MSY $_{\mathrm{Btrigger}}$ = 683 340 t), together with estimates of precision, is given in Figure 2.32 and Table 2.14.

Results from the current model confirm that spurdog abundance has declined, and that the decline is driven by high exploitation levels in the past, coupled with biological characteristics that make this species particularly vulnerable to such intense exploitation. The assessment also confirms that the stock is starting to recover from a low in the mid-2000s.

A comparison with the 2016 assessment is provided in Figure 2.33 and shows an upward adjustment in recruitment and total biomass in recent years..

2.10 Quality of assessments

WGEF has attempted various analytic assessments of NE Atlantic spurdog using a number of different approaches (see Stock Annex and ICES, 2006). Although these exploratory models did not prove satisfactory (as a consequence of the quality of the assessment input data), they all indicated a decline in spurdog, as did previous analyses of survey data.

Whilst the current assessment model has been both benchmarked and published, there are a number of issues to consider, as summarised below.

2.10.1 Catch data

The WG has provided estimates of total landings of NE Atlantic spurdog and has used these, together with UK length–frequency distributions in the assessment of this stock. However, there are still concerns over the quality of these data as a consequence of:

- Uncertainty in the historical level of catches because of landings being reported by generic dogfish categories;
- Uncertainty over the accuracy of the landings data because of species misreporting;
- Lack of commercial length–frequency information for countries other than the UK (UK landings are a decreasing proportion of the total and therefore the length frequencies may not be representative of those from the fishery as a whole);
- Low levels of sampling of UK landings and lack of length–frequency data in recent years when the selection pattern may have changed due to the implementation of a maximum landing length (100 cm);
- Lack of discard information.

2.10.2 Survey data

Survey data are particularly important indicators of abundance trends in stocks such as this where an analytical assessment is not available. However, it should be highlighted that:

- The survey data used by WGEF cover only part of the stock distribution and analyses should be extended to other parts of the stock distribution;
- Spurdog survey data are difficult to interpret because of the typically highly skewed distribution of catch-per-unit of effort;
- Annual survey length–frequency distribution data (aggregated over all hauls) may be dominated by data from single large haul.

2.10.3 Biological information

As well as good commercial and survey data, the analytical assessments require good information on the biology of NE Atlantic spurdog. In particular, the WG would like to highlight the need for:

- Updated and validated growth parameters, in particular for larger individuals;
- Better estimates of natural mortality.

2.10.4 Assessment

As with any stock assessment model, the assessment relies heavily on the underlying assumptions; particularly with regard to life-history parameters (e.g. natural mortality and growth), and on the quality and appropriateness of input data. The inclusion of two periods of fecundity data has provided valuable information that allows estimation of Qfec, and projecting the model back in time is needed to allow the 1960 fecundity dataset to be fitted. Nevertheless, the model has difficulty estimating both Qfec and the fecundity parameters simultaneously, and additional information, such as on appropriate values of MSYR for a species such as spurdog, and possibly also additional fecundity data (which are now available but have not been included), would help with this problem. Further refinements of the model are possible, such as including variation in growth. Selectivity curves also cover a range of gears over the entire catch history, and more appropriate assumptions (depending on available data) could be considered. A check should be kept on the recent development of a retrospective pattern, although this is still well within the 95% confidence limits of assessment estimates.

In summary, the model is considered appropriate for providing an assessment of spurdog, though it could be further developed in future if the following data were available:

- Selectivity parameters disaggregated by gear for the main fisheries (i.e. for various trawl, longline and gillnets);
- Appropriate indices of relative abundance from fishery-independent surveys, with corresponding estimates of variance;
- Improved estimates for biological data (e.g. growth parameters, reproductive biology and natural mortality);
- Inclusion of additional fecundity data;
- Information on likely values of MSYR for a species such as spurdog.

2.11 Reference points

MSY considerations: In 2017 the exploitation status of the stock was considered to be below F_{prop},MSY, as estimated from the results of the assessment. However, biomass has declined to record low levels in recent years and therefore to allow the stock to rebuild, catches should be reduced to the lowest possible level in 2019 and 2020. Projections assuming application of the average landings for 2007–9 (which would accommodate bycatch in mixed fisheries) suggest that the stock will rebuild by 5–10% of its 2018 level by 2021 (Table 2.15a).

Fprop,MSY=0.032, as estimated by the current assessment, assuming a non-target selection pattern.

2.12 Conservation considerations

In 2006, the IUCN categorised Northeast Atlantic spurdog as ‘Critically Endangered’, although the most recent assessment of spurdog in European waters lists spurdog as ‘Endangered’ (Nieto *et al*., 2015).

2.13 Management considerations

Perception of state of stock

All analyses presented in previous reports of WGEF have indicated that the NE Atlantic stock of spurdog declined over the second half of the 20th Century, but now appears to be increasing. The current stock size is thought to be ca. 24% of virgin biomass.

Although spurdog are less frequently caught in groundfish surveys than they were 20 years ago, there is some suggestion that spurdog are now being more frequently seen in survey hauls, and survey catch rates are starting to increase (Figure 2.12).

Stock distribution

Spurdog in the ICES area are considered to be a single stock, ranging primarily from Subarea 1 to Subarea 8, although landings from the southern end of its range may also include other *Squalus* species. There should be a single TAC area.

Biological considerations

Spurdog is a long-lived and slow growing species which has a high age-at-maturity, and is particularly vulnerable to high levels of fishing mortality. Population productivity is low, with low fecundity and a protracted gestation period. In addition, they form size- and sex-specific shoals and therefore aggregations of large fish (i.e. mature females) are easily exploited by target longline and gillnet fisheries.

Updated age and growth studies are required.

Fishery and technical considerations

Those fixed gear fisheries that capture spurdog should be reviewed to examine the catch composition, and those taking a large proportion of mature females should be strictly regulated.

During 2009 and 2010, a maximum landing length (MLL) was established in EC waters to deter targeting of mature females (see Section 2.10 of ICES, 2006 for simulations on MLL). Those fisheries taking spurdog that are lively may have problems measuring fish accurately, and investigations to determine an alternative measurement (e.g. preoral length) that has a high correlation with total length and is more easily measured on live fish are required. Dead dogfish may also be more easily stretched on measuring, and understanding such post-mortem changes is required to inform on any levels of tolerance, in terms of enforcement.

There is limited information on the distribution of gravid females with term pups and new-born spurdog pups, though they have been reported to occur in Scottish waters, in the Celtic Sea and off Ireland. The lack of accurate data on the location of pupping and nursery grounds, and their importance to the stock, precludes spatial management for this species at the present time.

The survivorship of discarded spurdog is unknown, and data on the at-vessel mortality and post-release mortality (by fishing gear and size of spurdog) are required to inform on the landing obligation.

2.14 Additional recent information

2.14.1 Developing an abundance index for spurdog in Norwegian waters

Input data to the assessment model have so far been restricted to the British sector, and data from other areas have been requested. In Norwegian waters, from where more than 80% of the current landings originate, there is no dedicated survey for spurdog, but data are recorded on all regular surveys, as well as by the Norwegian Reference fleet, and during official controls of commercial catches and landings. Two WDs were presented at 2016 WGEF meeting to indicate the potential for establishing one or several new tuning fleets in Norwegian waters to inform future assessments of this stock.

Here are shown the updated trends from the Shrimp Survey in South-Norway (Divisions 3.a and 4.a) the Coastal Survey in North-Norway (Division 2.a) and from samples from the commercial fleet in Norwegian waters. Details of the calculations were given in Albert and Vollen (2015), Albert (2016) and Vollen and Albert (2016).

The Shrimp Survey shows a rather clear pattern, with relatively high and fluctuating survey indices in the 1980s, low and decreasing values throughout the 1990s, reaching the lowest values in 2002, and then a return to high an variable values since 2003 (Figure 2.34). The Coastal Survey shows highly variable survey indices, with slight tendencies of higher values between 2000–2010 than in both the preceding and the following years (Figure 2.34). The frequency of occurrence of spurdog in sampled catches from Norwegian commercial gillnetters shows an increasing trend throughout the most recent decade, and similar trends are also present from other fleets (Figure 2.35).

All of these time series are crude estimates without proper stratification, and should only be regarded as preliminary indications of overall trends. Before next benchmarking process of spurdog, more elaborated indices of abundance and composition should preferably be documented for this northern part of the distribution range.

2.14.2 Recent life-history information

Recent collection of contemporary biological data for *S. acanthias* was possible as part of a Defra-funded project aiming to better understand the implications of elasmobranch bycatch in the southwest fisheries around the British Isles (Silva and Ellis, 2015 WD). A total of 1112 specimens were examined, including 805 males (53–92 cm LT) and 307 females (47–122 cm LT), as well as associated pups (n = 935, 98–296 mm LT). Conversion factors were calculated for the overall relationships between total length and total weight by sex and maturity stage and gutted weight by sex only.

Preliminary results suggested there may be no changes of length-at-maturity of females in comparison to earlier estimates of Holden and Meadows (1962), indicating that this life-history parameter may not have changed in relation to recent overexploitation. However, the maximum fecundity observed (n = 19 pups) reported in this recent study is higher than reported in earlier studies (e.g. Ford, 1921; Holden and Meadows, 1964; Gauld, 1979), and provides further support to the hypothesis that there has been a density-dependent increase in fecundity (see Ellis and Keable, 2008 and references therein).

2.14.3 Occurrence in commercial fishing operations: A case study of French on-board observations

The occurrence of spurdog in French on-board observations was calculated as the proportion of fishing operations (trawl haul or net set) with catch (discards, landings or both) of spurdog in areas where the species is observed regularly in French fisheries, namely Subarea 6 and divisions 7.b-cc and 7.f-k from 2007–2015. Other areas, such as the Bay of Biscay (Subarea 8) where occurrences are rare in French Fisheries were excluded. Fishing operations were aggregated by DCF level 5 métier. The time-series of the proportion of fishing operations encountering spurdog is shown for the four top ranking métiers (Figure 2.36). No trend was observed in the two main métiers (OTB-DEF and OTT-DEF), with the two other métiers (with lower numbers of observed fishing operations) showing contrasting signals.

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Table 2.1. Northeast Atlantic spurdog. WG estimates of total landings of NE Atlantic spurdog (1947–2017).

Year	Landings (tonnes)	Year	Landings (tonnes)	Year	Landings (tonnes)
1947	16 893	1972	50 416	1997	15 347
1948	19 491	1973	49 412	1998	13 919
1949	23 010	1974	45 684	1999	12 384
1950	24 750	1975	44 119	2000	15 890
1951	35 301	1976	44 064	2001	16 693
1952	40 550	1977	42 252	2002	11 020
1953	38 206	1978	47 235	2003	12 246
1954	40 570	1979	38 201	2004	9 365
1955	43 127	1980	40 968	2005	7 101
1956	46 951	1981	39 961	2006	4 015
1957	45 570	1982	32 402	2007	2 917
1958	50 394	1983	37 046	2008	1 798
1959	47 394	1984	35 193	2009	1 980
1960	53 997	1985	38 674	2010	893
1961	57 721	1986	30 910	2011	435
1962	57 256	1987	42 355	2012	453
1963	62 288	1988	35 569	2013	336
1964	60 146	1989	30 278	2014	383
1965	49 336	1990	29 906	2015	286
1966	42 713	1991	29 562	2016	382
1967	44 116	1992	29 046	2017	273
1968	56 043	1993	25 636		
1969	52 074	1994	20 851		
1970	47 557	1995	21 318		
1971	45 653	1996	17 294		

Table 2.2. Northeast Atlantic spurdog. WG estimates of total landings by nation (1980–2017). Data from 2005 onwards revised during WKSHARKS2. From 2005 Scottish landings data are combined with those from England and Wales, and presented as UK (combined)

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Belgium	1097	1085	1110	1072	1139	920	1048	979	657	750	582	393	447	335	396	391
Denmark	1404	1418	1282	1533	1217	1628	1008	1395	1495	1086	1364	1246	799	486	212	146
Faroe Islands	0	22	0	0	0	0	0	0	0	6	2	3	25	137	203	310
France	17 514	19 067	12 430	12 641	8356	8867	7022	11 174	7872	5993	4570	4370	4908	4831	3329	1978
Germany	43	42	39	25	8	22	41	48	27	24	26	6	55	8	21	100
Iceland	36	22	14	25	5	9	7	5	4	17	15	53	185	108	97	166
Ireland	108	476	1268	4658	6930	8791	5012	8706	5612	3063	1543	1036	1150	2167	3624	3056
Netherlands	217	268	183	315	0	0	0	0	0	0	0	0	0	0	0	0
Norway	5925	3941	3992	4659	4279	3487	2986	3614	4139	5329	8104	9633	7113	6945	4546	3940
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portugal	2	0	0	0	0	0	1	5	3	2	128	188	250	323	190	256
Russia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	8	653	0	0	0	0	0	0	0	0	0	0	0	0
Sweden	399	308	398	300	256	360	471	702	733	613	390	333	230	188	95	104
UK (E&W)	9229	9342	8024	6794	8046	7841	7047	7684	6952	5371	5414	3770	4207	3494	3462	2354
UK (Sc)	4994	3970	3654	4371	4957	6749	6267	8043	8075	8024	7768	8531	9677	6614	4676	8517
Total	40 968	39 961	32 402	37 046	35 193	38 674	30 910	42 355	35 569	30 278	29 906	29562	29046	25636	20851	21318

Table 2.2 (continued). Northeast Atlantic spurdog. WG estimates of total landings by nation (1980–2016). Data from 2005 onwards revised during WKSHARKS2. From 2005 Scottish landings data are combined with those from England and Whales, and presented as UK (combined)

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Belgium	430	443	382	354	400	410	23	11	13	21	17	11	12	7	1	0	0	0	-	-
Denmark	142	196	126	131	146	156	107	232	219	150	121	76	78	82	14	26	30	19	10	26
Faroe Islands	51	218	362	486	368	613	340	224	295	225	271	241	144	462	179	104				
France	1607	1555	1286	998	4342	4304	2569	1705	1062	946	702	505	368	412	164	84	34	13	19	2
Germany	38	21	31	54	194	304	121	98	138	141	8	3	6	2	1	1	1	1	1	+
Iceland	156	106	80	57	107	199	276	200	142	76	82	43	68	102	62	53	51	6	19	8
Ireland	2305	2214	1164	904	905	1227	1214	1416	1076	1022	859	651	137	175	26	13	37	34	18	2
Netherlands	0	0	0	0	28	39	27	10	25	31	23	25	18	5	7	1	4	3	0	1
Norway	2748	1567	1293	1461	1643	1424	1091	1119	1054	1016	790	615	711	543	540	247	285	250	313	217
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portugal	120	100	46	21	2	3	4	4	9	5	9	10	4	3	2	3	2	2	1	2
Russia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	28	95	372	363	306	135	17	43	47	85	42	23	7	7	6	2	1	27
Sweden	154	196	140	114	123	238	0	275	244	169	147	93	75	80	5	0	-	-	-	-
UK (combined)*	2670	3066	4480	4461	3654	4516	2823	3109	1729	3481	1209	799	280	546	64	1	3	6	0	-
UK (Sc)*	6873	5665	4501	3248	3606	2897	2120	3708	3342											
Total	17 294	15 347	13 919	12 384	15 890	16 693	11 020	12 246	9365	7101	4015	2917	1798	1980	893	435	453	336	383	286

Table 2.2 (continued). Northeast Atlantic spurdog. WG estimates of total landings by nation (1980–2016). Data from 2005 onwards revised during WKSHARKS2. From 2005 Scottish landings data are combined with those from England and Whales, and presented as UK (combined)

COUNTRY	2016	2017
Belgium	.	.
Denmark	24	.
Faroe Islands		
France	1	3
Germany	2	+
Iceland	8	4
Ireland	34	1
Netherlands	1	1
Norway	270	222
Poland		
Portugal	1	1
Russia		
Spain	10	5
Sweden	+	+
UK (combined)*	30	37
UK (Sc)*		
Total	382	273

Table 2.3. Northeast Atlantic spurdog. WG estimates of landings by ICES Subarea (1980–2016). Data from 2005 onwards revised during WKSHARKS2.

Subarea or Division	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Baltic	0	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0	0	0
1 and 2	138	20	28	760	40	120	137	417	1559	2808	4296	6614	5063	5102	3124	2725	1853	582
3 and 4	20 544	16 181	11 965	11 572	10 557	11 136	8986	11 653	10 800	10 423	11 497	9264	10 505	6591	4360	7347	5299	4977
5	45	27	18	27	5	22	9	41	6	73	182	133	336	335	364	484	217	320
6	4590	4011	5052	7007	8491	12422	8107	9038	7517	6406	5407	6741	6268	5927	5622	5164	4168	3412
7.a	2722	4013	4566	4001	6336	6774	6458	7305	5569	3389	2801	2527	2669	2700	2313	1185	1650	1534
7.b-c	704	925	424	1777	2178	1699	1197	2401	1579	893	369	293	316	2009	1175	1004	603	450
7.d-f	6693	8210	5989	4664	2450	1280	1644	2892	2120	1634	1339	1122	852	785	800	760	852	646
7.g-k	4793	5479	3881	6924	4902	4965	3864	8106	6175	4477	3736	2495	2622	1745	2680	2034	2229	2984
8	739	1095	479	312	234	257	507	497	242	174	273	367	406	435	406	602	408	418
9	0	0	0	0	0	0	1	4	1	2	4	4	2	5	7	5	2	2
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	12
14	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0
Other or unspecified	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	12	10
Total	40 968	39 961	32 402	37 046	35 193	38 674	30 910	42 355	35 569	30 278	29 906	29 562	29 046	25 636	20 851	21 318	17 294	15 347

Table 2.3 (continued) Northeast Atlantic spurdog. WG estimates of landings by ICES Subarea (1980–2016). Data from 2005 onwards revised during WKSHARKS2.

Subarea or Division	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Baltic	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 and 2	607	779	894	462	357	440	423	682	499	312	337	230	190	93	131	74	122	105
3 and 4	3895	2705	2475	2516	1904	2395	2163	1177	789	628	642	635	400	183	189	198	203	140
5	442	545	879	1406	808	583	677	244	204	161	86	103	63	53	51	6	28	8
6	2831	2715	5977	5624	3169	3398	2630	1581	830	619	169	263	69	3	1	0	0	+0
7.a	1771	2153	1599	1878	1529	2021	938	589	413	272	73	97	3	1	10	4	2	+
7.b-c	854	1037	1028	816	527	588	432	332	268	299	48	97	7	1	1	0	0	1
7.d-f	443	411	438	555	295	268	278	285	168	172	124	196	78	71	33	17	8	+
7.g-k	2656	1822	2161	2846	2130	2339	1739	2005	746	386	245	288	63	14	29	30	16	5
8	308	171	405	469	269	134	56	138	87	58	70	65	15	12	3	3	2	17
9	2	3	19	8	11	5	14	5	10	11	5	6	5	5	5	3	2	8
10	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	104	22	14	41	22	74	12	4	1	0	0	0	0	0	0	0	0	0
14	0	0	0	63	0	0	0											
Other or unspecified	6	4	1	2	0	0	0	59	0	0	0	0	0	0	0	0	0	0
Total	13 919	12 384	15 890	16 693	11 020	12 246	9365	7101	4015	2917	1798	1980	893	435	453	336	383	286

Table 2.3 (continued) Northeast Atlantic spurdog. WG estimates of landings by ICES Subarea (1980–2016). Data from 2005 onwards revised during WKSHARKS2.

Subarea or Division	2016	2017
Baltic	0	0
1 and 2	150	127
3 and 4	165	98
5	8	4
6	5	1
7.a	2	0
7.b-c	3	+
7.d-f	1	14
7.g-k	44	24
8	1	1
9	2	5
10	0	0
12	0	0
14	0	0
Other or unspecified	0	0
Total	382	273

Table 2.4. Northeast Atlantic spurdog. Norwegian Shrimp and Coastal survey, 1984–2017. Month of survey, mean duration of tows, total number of stations, number of stations with spurdog, total number of spurdog caught, and mesh size used. Source: Vollen and Albert (2016 WD).

Year	Survey	Month of survey	Mean duration (h)	# of stations	# of stations with spurdog	# spurdogs caught	Mesh size	Survey	Month of survey	Mean duration (h)	# of stations	# of stations with spurdog	# spurdogs caught	Mesh shze
1984	S	10–11	0.96	59	10	67								
1985	S	10–11	1.00	86	29	303								
1986	S	10–11	0.96	57	26	341								
1987	S	10–11	0.99	93	29	90								
1988	S	10–11	0.97	102	29	87								
1989	S	10–11	0.50	89	11	18	35							
1990	S	10–11	0.49	77	19	130	35							
1991	S	10–11	0.52	101	11	38	35							
1992	S	10–11	0.50	99	12	22	35							
1993	S	10–11	0.50	106	10	14	35							
1994	S	10–11	0.47	101	10	18	35							
1995	S	10–11	0.48	102	8	15	35	C	9–10	0.43	29	6	22	40
1996	S	10–11	0.50	103	4	15	35	C	9–10	0.45	22	5	9	40
1997	S	10–11	0.49	93	10	18	35	C	8–9	0.42	44	1	2	20
1998	S	10–11	0.49	95	9	14	20	C	10–11	0.47	33	8	106	20
1999	S	10–11	0.50	97	4	7	20	C	10–11	0.44	34	2	4	20
2000	S	10–11	0.50	98	5	18	20	C	10–11	0.47	28	6	12	20
2001	S	10–11	0.50	70	2	3	20	C	10–11	0.42	17	5	64	20
2002	S	10–11	0.50	77	1	1	20	C	10–11	0.46	37	4	43	20
2003	S	10–11	0.53	68	12	34	20	C	10–11	0.44	23	4	21	20
2004	S	5–6	0.50	60	7	48	20	C	10–11	0.37	33	5	104	20
2005	S	5–6	0.51	86	7	12	20	C	10–11	0.46	18	2	17	20

Year	Survey	Month of survey	Mean duration (h)	# of stations	# of stations with spurdog	# spurdogs caught	Mesh size	Survey	Month of survey	Mean duration (h)	# of stations	# of stations with spurdog	# spurdogs caught	Mesh shze
2006	S	1–2	0.49	43	9	33	20	C	10–11	0.30	34	8	52	20
2007	S	1–2	0.50	64	14	27	20	C	10–11	0.35	36	7	35	20
2008	S	1–2	0.51	73	13	52	20	C	10–11	0.56	7	0	0	20
2009	S	1–2	0.47	92	16	39	20	C	10–11	0.39	19	0	0	20
2010	S	1–2	0.47	95	20	34	20	C	10–11	0.36	26	3	25	20
2011	S	1–2	0.49	97	18	43	20	C	10–11	0.33	20	5	6	20
2012	S	1–2	0.47	63	14	71	20	C	10–11	0.36	31	5	9	20
2013	S	1–2	0.38	100	35	177	20	C	10	0.42	19	1	1	20
2014	S	1	0.47	68	18	99	20	C	10	0.39	30	3	4	20
2015	S	1	0.49	88	18	62	20	C	10-11	0.37	28	5	10	20
2016	S	1	0.50	105	19	51	20	C	10	0.37	27	2	37	20
2017	S	1	0.50	108	35	90	20	C	10-11	0.41	33	3	26	20

Table 2.5. Northeast Atlantic spurdog. Analysis of Scottish survey data. Summary of significance of terms in final delta-lognormal CPUE model.

Binomial model	Df	Deviance	Resid df	Resid dev	%	P(>|Chi|)
			7257	8128.6		
as.factor(year)	27	96.65	7230	8032	5%	9.07E-10
as.factor(month)	11	1189.86	7219	6842.1	66%	< 2.2e-16
as.factor(roundarea)	19	518.59	7200	6323.5	29%	< 2.2e-16

Lognormal model	Df	Deviance	Resid df	Resid dev	%	Pr(>F)
			1798	5194.3		
as.factor(year)	27	296.35	1771	4898	31%	1.39E-13
as.factor(Q)	3	434.6	1768	4463.4	45%	< 2.2e-16
as.factor(roundarea)	17	232.49	1751	4230.9	24%	1.10E-12

Table 2.6. Northeast Atlantic spurdog. Description of life-history equations and parameters.

Parameters	Description/values	Sources
M_a	Instantaneous natural mortality at age *a*: $M_a = \begin{cases} M_{pup} e^{-a \ln(M_{pup}/M_{adult})/a_{M1}} & a < a_{M1} \\ M_{adult} & a_{M1} \le a \le a_{M2} \\ M_{til} / [1 + e^{-M_{gam}(a-(A+a_{M2})/2)}] & a > a_{M2} \end{cases}$	
a_{M1}, a_{M2}	4, 30	expert opinion
M_{adult}, M_{til}, M_{gam}	0.1, 0.3, 0.04621	expert opinion
M_{pup}	Calculated to satisfy balance equation 2.7	
l_a^s	Mean length-at-age a for animals of sex *s* $l_a^s = L_\infty^s (1 - e^{-\kappa^s (a - t_0^s)})$	
L_∞^f, L_∞^m	110.66, 81.36	average from literature
κ^f, κ^m	0.086, 0.17	average from literature
t_0^f, t_0^m	-3.306, -2.166	average from literature
w_a^s	Mean weight at age *a* for animals of sex *s* $w_a^s = a^s (l_a^s)^{b^s}$	
a^f, b^f	0.00108, 3.301	Bedford *et al*. (1986)
a^m, b^m	0.00576, 2.89	Coull *et al*. (1989)
l_{mat00}^f	Female length at first maturity 70 cm	average from literature
P_a''	Proportion females of age a that become pregnant each year $P_a'' = \dfrac{P_{\max}''}{1 + \exp\left[-\ln(19)\dfrac{l_a^f - l_{mat50}^f}{l_{mat95}^f - l_{mat50}^f}\right]}$ where $P_{\max}''$ is the proportion very large females pregnant each year, and l_{matx}^f the length at which *x*% of the maximum proportion of females are pregnant each year	
$P_{\max}''$	0.5	average from literature
l_{mat50}^f, l_{mat95}^f	80 cm, 87 cm	average from literature

Table 2.7. Northeast Atlantic spurdog. Landings used in the assessment, with the allocation to "Non-target" and "Target". Estimated Scottish selectivity (based on fits to proportions by length category data for the period 1991–2004) is assumed to represent "non-target" fisheries, and estimated England and Wales selectivity (based on fits to proportions by length category data for the period 1983–2001) "target" fisheries. The allocation to "Non-target" and "Target" shown below is based on categorising each nation as having fisheries that are "non-target", "target" or a mixture of these from 1980 onwards. An average for the period 1980–1984 is assumed for the "non-target"/"target" split prior to 1980, while all landings from 2008 onwards are assumed to come from "non-target" fisheries. Landings from 2010 onwards are assumed to be the average for 2007–2009. Landings are used as catch in the assessment.

Year	Non-target	Target	Total	Year	Non-target	Target	Total	Year	Non-target	Target	Total
1905	3503	3745	7248	1943	3954	4227	8181	1981	20953	19009	39962
1906	1063	1137	2200	1944	3939	4212	8151	1982	16075	16327	32402
1907	690	738	1428	1945	3275	3501	6776	1983	17095	19951	37046
1908	681	728	1409	1946	5265	5630	10895	1984	15047	20147	35194
1909	977	1045	2022	1947	8164	8729	16893	1985	17048	21626	38674
1910	755	808	1563	1948	9420	10071	19491	1986	15138	15772	30910
1911	946	1011	1957	1949	11120	11890	23010	1987	19558	22798	42356
1912	1546	1653	3199	1950	11961	12789	24750	1988	17292	18277	35569
1913	1957	2093	4050	1951	17060	18241	35301	1989	15355	14924	30279
1914	1276	1365	2641	1952	19597	20953	40550	1990	14390	15516	29906
1915	1258	1344	2602	1953	18464	19742	38206	1991	14034	15529	29563
1916	258	276	534	1954	19607	20963	40570	1992	15711	13335	29046
1917	164	175	339	1955	20843	22284	43127	1993	12268	13369	25637
1918	218	233	451	1956	22691	24260	46951	1994	9238	11613	20851
1919	1285	1374	2659	1957	22023	23547	45570	1995	12104	9214	21318
1920	2125	2271	4396	1958	24355	26039	50394	1996	10026	7269	17295
1921	2572	2749	5321	1959	22905	24489	47394	1997	9158	6190	15348
1922	2610	2791	5401	1960	26096	27901	53997	1998	8509	5410	13919
1923	2733	2922	5655	1961	27896	29825	57721	1999	7233	5152	12385
1924	3071	3284	6355	1962	27671	29585	57256	2000	9283	6608	15891
1925	3247	3472	6719	1963	30103	32185	62288	2001	9513	7180	16693
1926	3517	3760	7277	1964	29068	31078	60146	2002	6169	5001	11170
1927	4057	4338	8395	1965	23843	25493	49336	2003	7167	5080	12247
1928	4602	4920	9522	1966	20642	22071	42713	2004	5718	3648	9366
1929	4504	4816	9320	1967	21320	22796	44116	2005	4234	4192	8426
1930	5758	6156	11914	1968	27085	28958	56043	2006	2670	1439	4109
1931	5721	6117	11838	1969	25166	26908	52074	2007	1846	1083	2929
1932	8083	8643	16726	1970	22983	24574	47557	2008	1836	0	1836
1933	9784	10460	20244	1971	22063	23590	45653	2009	2640	0	2640
1934	9848	10530	20378	1972	24365	26051	50416	2010	2468	0	2468
1935	10761	11505	22266	1973	23880	25532	49412	2011	2468	0	2468
1936	10113	10812	20925	1974	22078	23606	45684	2012	2468	0	2468
1937	11565	12365	23930	1975	21322	22797	44119	2013	2468	0	2468
1938	8794	9402	18196	1976	21295	22769	44064	2014	2468	0	2468
1939	9723	10396	20119	1977	20420	21832	42252	2015	2468	0	2468
1940	4556	4872	9428	1978	22828	24407	47235	2016	2468	0	2468
1941	4224	4516	8740	1979	18462	19739	38201	2017	2468	0	2468
1942	5135	5490	10625	1980	20770	20198	40968				

Table 2.8. Northeast Atlantic spurdog. Delta-lognormal GLM-standardised index of abundance (with associated CVs), based on Scottish groundfish surveys.

Year	Index	CV
1990	153.7	0.31
1991	89.5	0.30
1992	76.2	0.30
1993	143.2	0.30
1994	127.1	0.34
1995	49.5	0.45
1996	84.2	0.34
1997	52.2	0.33
1998	82.5	0.33
1999	172.9	0.32
2000	73.9	0.34
2001	94.2	0.32
2002	94.6	0.32
2003	89.0	0.33
2004	63.1	0.35
2005	78.5	0.34
2006	62.6	0.33
2007	86.2	0.30
2008	75.6	0.33
2009	62.1	0.34
2010	89.3	0.45
2011	84.4	0.37
2012	73.3	0.36
2013	72.8	0.37
2014	160.8	0.31
2015	63.8	0.36
2016	154.6	0.31
2017	203.5	0.31

Table 2.9. Northeast Atlantic spurdog. Scottish survey proportions-by-length category for females (top) and males (bottom), with the actual sample sizes given in the second column.

	$n_{psur,y}$	16–31	32–54	55–69	70+
Females					
1990	539	0.0112	0.2685	0.1265	0.1272
1991	962	0.0636	0.1218	0.1092	0.1123
1992	145	0.1430	0.1514	0.2055	0.0424
1993	398	0.1259	0.1635	0.0788	0.1296
1994	1656	0.0744	0.2426	0.0519	0.0352
1995	2278	0.0572	0.3087	0.0779	0.1520
1996	230	0.0722	0.2381	0.0831	0.0684
1997	167	0.0438	0.2011	0.0955	0.0815
1998	446	0.0361	0.2404	0.1201	0.1731
1999	186	0.0316	0.0787	0.0331	0.1079
2000	1994	0.0962	0.2136	0.0456	0.1149
2001	118	0.0132	0.2060	0.0735	0.1363
2002	148	0.0428	0.0789	0.1773	0.1879
2003	224	0.0123	0.1578	0.0788	0.1898
2004	63	0.0412	0.0834	0.1240	0.0597
2005	121	0.0243	0.1434	0.1568	0.0756
2006	92	0.0360	0.1130	0.1727	0.0413
2007	152	0.0287	0.1773	0.1075	0.1657
2008	232	0.0708	0.1590	0.0127	0.1047
2009	233	0.0427	0.1175	0.2547	0.1167
2010	3495	0.1787	0.2687	0.1127	0.0002
2011	130	0.0183	0.1565	0.0684	0.1812
2012	808	0.0364	0.2320	0.0855	0.1316
2013	65	0.1713	0.2228	0.0146	0.1513
2014	608	0.0463	0.1701	0.0848	0.0873
2015	139	0.0535	0.1617	0.1744	0.1353
2016	670	0.0975	0.1383	0.1383	0.1456
2017	941	0.0758	0.1728	0.0817	0.1280
Males					
1990	1044	0.0204	0.1300	0.0575	0.2587
1991	1452	0.0711	0.1273	0.0824	0.3123
1992	154	0.2324	0.0534	0.0504	0.1215
1993	644	0.0503	0.1202	0.1555	0.1762
1994	2467	0.0832	0.1809	0.1472	0.1847
1995	1905	0.0566	0.1259	0.0478	0.1738
1996	453	0.0597	0.1480	0.1237	0.2068
1997	270	0.0228	0.1033	0.0803	0.3716
1998	436	0.0207	0.0974	0.0969	0.2155
1999	503	0.0269	0.2437	0.1136	0.3646
2000	2045	0.0100	0.1144	0.0799	0.3255
2001	221	0.0141	0.1045	0.0753	0.3771
2002	264	0.0252	0.0654	0.1209	0.3016
2003	392	0.0209	0.0818	0.1257	0.3328
2004	190	0.0045	0.1397	0.1250	0.4225
2005	225	0.0297	0.0572	0.1506	0.3622
2006	180	0.0846	0.0992	0.1027	0.3505
2007	264	0.0044	0.1786	0.1423	0.1954
2008	395	0.0699	0.1482	0.0669	0.3678
2009	417	0.0252	0.1247	0.0719	0.2466
2010	2478	0.0028	0.1863	0.0644	0.1861
2011	567	0.0170	0.0896	0.0836	0.3853
2012	1278	0.0434	0.1249	0.0495	0.2968
2013	59	0.0242	0.1673	0.0639	0.1847
2014	1438	0.0463	0.1412	0.0668	0.3572
2015	207	0.0069	0.1532	0.0973	0.2177
2016	1095	0.0733	0.1134	0.1014	0.1922
2017	1581	0.0717	0.1194	0.1082	0.2423

Table 2.10. Northeast Atlantic spurdog. Commercial proportions-by-length category (males and females combined), for each of the two fleets (Scottish, England & Wales), with raised sample sizes given in the second column.

	$n_{pcom,j,y}$	16–54	55–69	70–84	85+
Non-target (Scottish) commercial proportions					
1991	6167824	0.0186	0.4014	0.5397	0.0404
1992	6104263	0.0172	0.1844	0.7713	0.0272
1993	4295057	0.0020	0.2637	0.7106	0.0236
1994	3257630	0.0301	0.3322	0.5857	0.0520
1995	5710863	0.0112	0.2700	0.6878	0.0309
1996	2372069	0.0069	0.4373	0.5416	0.0142
1997	3769327	0.0091	0.3297	0.5909	0.0702
1998	3021371	0.0330	0.4059	0.5286	0.0325
1999	1869109	0.0145	0.3508	0.5792	0.0556
2000	1856169	0.00001	0.1351	0.7683	0.0967
2001	1580296	0.0021	0.2426	0.7022	0.0531
2002	1264383	0.0529	0.3106	0.5180	0.1186
2003	1695860	0.0011	0.2673	0.5729	0.1587
2004	1688197	0.0106	0.2292	0.6893	0.0708
Target (England & Wales) commercial proportion					
1983	243794	0.0181	0.4010	0.4778	0.1030
1984	147964	0.0071	0.2940	0.4631	0.2359
1985	97418	0.0015	0.1679	0.6238	0.2068
1986	63890	0.0004	0.1110	0.6410	0.2476
1987	116136	0.0027	0.1729	0.5881	0.2362
1988	168995	0.0085	0.0973	0.5611	0.3332
1989	109139	0.0011	0.0817	0.5416	0.3757
1990	39426	0.0168	0.1349	0.5369	0.3115
1991	42902	0.0013	0.1039	0.5312	0.3637
1992	23024	0.0003	0.1136	0.4847	0.4013
1993	15855	0.0012	0.1741	0.4917	0.3331
1994	14279	0.0026	0.2547	0.3813	0.3614
1995	48515	0.0007	0.1939	0.4676	0.3378
1996	16254	0.0082	0.3258	0.4258	0.2402
1997	22149	0.0032	0.1323	0.4082	0.4563
1998	21026	0.0007	0.1075	0.4682	0.4236
1999	9596	0.0037	0.1521	0.5591	0.2851
2000	10185	0.0001	0.0729	0.4791	0.4480
2001	17404	0.0024	0.1112	0.4735	0.4128

Table 2.11a. Northeast Atlantic spurdog. Fecundity data for 1960 (Ellis and Keable, 2008), given as length of pregnant female (l f) and number of pups (P'). Total number of samples is 783.

l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'
73	3	84	4	86	3	87	7	88	3	89	4	90	1	91	7	93	3	94	5	96	10	101	11
73	3	84	6	86	3	87	8	88	5	89	4	90	3	91	8	93	4	94	5	96	10	101	7
75	3	84	6	86	3	87	9	88	5	89	5	90	3	91	8	93	5	94	6	96	7	102	5
77	3	84	3	86	4	87	2	88	6	89	7	90	5	91	3	93	5	94	6	96	7	102	10
78	3	84	3	86	4	87	5	88	6	89	8	90	6	91	4	93	5	94	7	96	8	102	3
79	2	84	4	86	4	87	5	88	6	89	8	90	8	91	4	93	5	94	8	97	4	103	14
79	3	84	4	86	4	87	5	88	7	89	5	90	5	91	7	93	5	94	8	97	4	103	9
79	4	84	4	86	5	87	5	88	8	89	6	90	6	91	4	93	6	94	8	97	7	103	15
79	4	84	5	86	5	87	6	88	6	89	6	90	6	91	5	93	8	94	9	97	2	103	9
79	3	84	6	86	5	87	5	88	6	89	8	90	7	91	7	93	9	94	9	97	3	103	15
80	4	84	6	86	5	87	5	88	8	90	1	90	7	91	7	93	5	94	9	97	3	105	11
80	3	84	4	86	6	87	6	88	9	90	2	90	9	91	8	93	5	94	11	97	3	110	8
80	4	84	4	86	2	87	7	89	3	90	3	90	10	92	2	93	5	94	3	97	4	117	9
80	5	84	6	86	3	87	7	89	3	90	3	91	2	92	4	93	6	94	3	97	4		
80	2	84	6	86	4	87	7	89	4	90	3	91	3	92	5	93	6	94	8	97	4		
80	3	84	6	86	4	87	8	89	4	90	3	91	4	92	7	93	7	94	9	97	5		
80	3	84	6	86	5	87	9	89	4	90	5	91	5	92	2	93	8	94	9	97	6		
80	5	84	3	86	5	88	2	89	6	90	5	91	5	92	2	93	9	94	9	97	6		
81	1	84	4	86	5	88	2	89	2	90	5	91	6	92	2	93	9	94	11	97	7		
81	3	84	4	86	5	88	2	89	2	90	6	91	6	92	2	93	4	95	3	97	3		
81	3	84	4	86	6	88	4	89	3	90	7	91	7	92	2	93	6	95	6	97	5		
81	3	84	6	86	6	88	4	89	3	90	1	91	2	92	2	93	6	95	6	97	6		
81	6	84	6	86	7	88	5	89	3	90	2	91	2	92	3	93	6	95	8	97	7		
81	3	84	6	86	5	88	5	89	3	90	2	91	2	92	3	93	7	95	3	97	4		
81	3	84	6	86	6	88	5	89	3	90	3	91	2	92	3	93	9	95	4	97	6		
82	3	85	3	86	7	88	5	89	3	90	3	91	2	92	3	93	9	95	4	97	8		
82	4	85	3	86	7	88	6	89	4	90	3	91	3	92	3	93	9	95	4	97	9		
82	4	85	4	86	7	88	1	89	4	90	3	91	3	92	4	93	9	95	5	97	9		
82	4	85	5	86	8	88	2	89	4	90	4	91	4	92	4	93	9	95	7	97	4		
82	5	85	5	86	1	88	3	89	4	90	4	91	4	92	5	93	10	95	7	97	6		
82	6	85	5	86	2	88	3	89	4	90	4	91	4	92	5	93	11	95	7	97	7		
82	1	85	5	86	2	88	3	89	4	90	4	91	4	92	6	93	1	95	9	97	7		
82	4	85	5	86	3	88	3	89	4	90	4	91	4	92	6	93	4	95	6	97	9		
82	4	85	7	86	4	88	3	89	4	90	4	91	4	92	6	93	7	95	9	97	6		
82	6	85	1	86	5	88	3	89	4	90	5	91	4	92	6	93	4	95	7	97	8		
82	6	85	3	86	6	88	4	89	4	90	5	91	5	92	7	93	6	95	8	97	9		
82	5	85	3	86	7	88	4	89	5	90	5	91	5	92	7	93	6	95	10	98	1		
82	6	85	3	86	7	88	4	89	5	90	5	91	5	92	8	93	6	95	11	98	5		
82	5	85	4	86	7	88	4	89	5	90	5	91	5	92	9	93	7	95	11	98	6		
82	6	85	4	86	8	88	5	89	5	90	6	91	6	92	4	93	9	95	11	98	9		
82	5	85	4	87	2	88	5	89	5	90	6	91	6	92	5	93	9	95	4	98	9		
83	3	85	5	87	3	88	5	89	5	90	6	91	6	92	6	93	9	95	7	98	8		
83	2	85	5	87	4	88	5	89	6	90	8	91	6	92	6	93	9	95	8	98	8		
83	2	85	3	87	5	88	5	89	6	90	9	91	6	92	6	93	10	95	11	98	9		
83	3	85	4	87	6	88	5	89	6	90	4	91	7	92	7	93	11	95	11	98	12		
83	4	85	4	87	3	88	5	89	6	90	4	91	7	92	8	94	5	95	11	98	8		
83	5	85	5	87	4	88	5	89	6	90	4	91	7	92	6	94	6	96	4	98	8		
83	4	85	5	87	4	88	6	89	6	90	5	91	7	92	6	94	6	96	4	98	9		
83	4	85	5	87	4	88	6	89	7	90	5	91	4	92	7	94	6	96	9	99	6		
83	5	85	6	87	5	88	6	89	4	90	5	91	4	92	10	94	7	96	4	99	6		
83	5	85	6	87	5	88	6	89	4	90	6	91	4	92	3	94	9	96	5	99	8		
83	5	85	6	87	5	88	6	89	4	90	6	91	4	92	3	94	3	96	5	99	4		
83	6	85	7	87	7	88	6	89	4	90	6	91	4	92	4	94	3	96	5	99	8		
83	4	85	4	87	3	88	4	89	4	90	6	91	5	92	5	94	3	96	5	99	15		
83	4	85	5	87	4	88	5	89	4	90	7	91	6	92	6	94	4	96	6	99	8		
83	4	85	7	87	5	88	5	89	5	90	7	91	6	92	6	94	4	96	6	100	6		
83	6	85	8	87	5	88	5	89	5	90	7	91	6	92	7	94	4	96	6	100	9		
83	4	85	3	87	5	88	6	89	6	90	7	91	6	92	7	94	5	96	6	100	10		
83	4	85	4	87	6	88	6	89	6	90	9	91	6	92	7	94	5	96	8	100	14		
83	4	85	5	87	6	88	6	89	6	90	9	91	7	92	10	94	5	96	5	100	7		
83	6	85	6	87	7	88	5	89	6	90	5	91	7	92	6	94	6	96	5	100	10		
84	3	85	7	87	7	88	5	89	7	90	6	91	7	93	1	94	6	96	6	100	14		
84	3	85	4	87	7	88	6	89	3	90	6	91	8	93	4	94	6	96	6	101	4		
84	3	86	2	87	5	88	6	89	5	90	6	91	8	93	5	94	7	96	8	101	6		
84	4	86	3	87	5	88	6	89	6	90	7	91	8	93	6	94	7	96	8	101	6		
84	6	86	3	87	5	88	6	89	6	90	7	91	8	93	7	94	7	96	7	101	10		
84	3	86	4	87	6	88	7	89	8	90	8	91	4	93	8	94	7	96	7	101	7		
84	3	86	5	87	6	88	8	89	8	90	9	91	5	93	1	94	7	96	8	101	9		
84	3	86	2	87	7	88	8	89	3	90	10	91	7	93	2	94	8	96	10	101	11		
84	4	86	2	87	7	88	9	89	3	90	1	91	7	93	2	94	4	96	10	101	9		

Table 2.11b. Northeast Atlantic spurdog. Fecundity data for 2005 (Ellis and Keable, 2008), given as length of pregnant female (l f) and number of pups (P'). Total number of samples is 179.

l_f	P'	l_f	P'	l_f	P'	l_f	P'	l_f	P'	l_f	P'	l_f	P'	l_f	P'	l_f	P'	l_f	P'	l_f	P'	l_f	P'
84	6	92	9	94	11	97	5	98	12	100	7	101	14	102	13	103	11	105	16	107	11	109	18
87	8	92	5	95	7	97	12	98	7	100	12	101	9	102	12	103	11	105	15	107	12	109	13
89	6	92	8	95	9	97	7	98	13	100	11	101	14	102	13	103	11	105	15	107	15	109	16
89	6	92	9	95	10	97	12	98	13	100	12	101	10	102	5	103	16	105	5	107	16	110	15
89	5	92	3	95	11	97	14	98	10	100	8	101	10	102	13	104	14	105	16	107	17	110	10
89	3	93	5	96	11	97	14	98	7	100	9	101	10	102	12	104	11	105	19	107	12	110	13
89	8	93	3	96	10	97	7	98	12	100	10	101	12	102	17	104	12	105	11	108	16	111	19
89	5	93	9	96	7	97	7	98	12	100	9	102	17	102	13	104	14	105	8	108	13	112	17
90	9	93	4	96	7	98	12	98	10	100	9	102	3	103	14	104	14	105	17	108	16	112	12
90	7	93	11	96	11	98	12	99	10	100	12	102	15	103	11	104	15	105	13	108	14	112	16
90	9	94	8	96	10	98	7	99	11	100	14	102	16	103	14	104	13	106	16	108	14	113	15
90	4	94	6	97	12	98	16	99	8	101	17	102	13	103	14	104	14	106	16	108	12	113	21
91	6	94	9	97	6	98	8	99	11	101	13	102	10	103	13	104	17	106	14	109	15	114	14
91	6	94	5	97	8	98	11	99	12	101	13	102	12	103	16	105	15	106	7	109	13	116	16
92	8	94	9	97	8	98	5	99	11	101	6	102	13	103	15	105	12	107	12	109	10		

Table 2.12a. Northeast Atlantic spurdog. Estimates of key model parameters, with associated Hessian-based estimates of precision (CV expressed as a percentage and given in smaller font size) for the base-case run, and two sensitivity tests for alternative values of Qfec.

	Q_{fec}=2.086 base case		Q_{fec}=2.532		Q_{fec}=3.538	
$N_0^{f,preg}$	94983	2.1%	82484	2.0%	64648	2.1%
Q_{fec}	2.086	2.1%	2.532	2.6%	3.538	3.5%
q_{sur}	0.00053	22%	0.00052	21%	0.00045	17%
B_{depl05}	0.235	24%	0.307	25%	0.551	20%
B_{depl55}	0.288	24%	0.366	25%	0.610	19%

Table 2.12b. Northeast Atlantic spurdog. Estimates of other estimates of interest for the base case run, and two sensitivity tests for alternative values for Qfec. MSY Btrigger is calculated as Bmsy/1.4.

	Q_{fec}=2.086 base case	Q_{fec}=2.532	Q_{fec}=3.538
M_{pup}	0.741	0.653	0.509
a_{fec}	-12.222	-9.903	-7.384
b_{fec}	0.179	0.147	0.111
$F_{prop,msy}$	0.0319	0.0398	0.0546
MSY	22027	26290	32814
B_{msy}	956676	876281	767713
MSY $B_{trigger}$	683340	625915	548366
MSYR	0.0321	0.0433	0.0655
$-\ln L_{tot}$	2148.11	2146.21	2148.08

Table 2.13. Northeast Atlantic spurdog. Correlation matrix for some key estimable parameters for the base-case. Correlations with absolute values greater than 0.5 are shaded.

	$N_0^{f,preg}$	$S_{c2,non\text{-}tgt}$	$S_{c2,tgt}$	$S_{c3,non\text{-}tgt}$	$S_{c3,tgt}$	$S_{c4,non\text{-}tgt}$	$S_{c4,tgt}$	S_{s1}	S_{s2}	S_{s3}	S_{s4}	Q_{fec}	$\varepsilon_{r,11}$	$\varepsilon_{r,12}$	$\varepsilon_{r,13}$	$\varepsilon_{r,14}$	$\varepsilon_{r,15}$	q_{sur}
$N_0^{f,preg}$	1																	
$S_{c2,non\text{-}tgt}$	-0.11	1																
$S_{c2,tgt}$	-0.01	0.00	1															
$S_{c3,non\text{-}tgt}$	-0.23	0.41	0.01	1														
$S_{c3,tgt}$	-0.04	0.01	0.08	0.05	1													
$S_{c4,non\text{-}tgt}$	-0.29	0.43	0.01	0.88	0.07	1												
$S_{c4,tgt}$	-0.19	0.06	0.10	0.16	0.54	0.20	1											
S_{s1}	0.04	-0.04	-0.01	-0.10	-0.07	-0.11	-0.11	1										
S_{s2}	0.07	-0.05	-0.01	-0.12	-0.08	-0.14	-0.13	0.46	1									
S_{s3}	0.08	-0.04	-0.01	-0.09	-0.04	-0.10	-0.09	0.38	0.50	1								
S_{s4}	0.03	-0.03	-0.01	-0.08	-0.06	-0.09	-0.09	0.30	0.40	0.34	1							
Q_{fec}	0.03	0.05	0.01	0.17	0.17	0.17	0.22	-0.08	-0.07	0.00	-0.05	1						
$\varepsilon_{r,11}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.01	0.00	-0.01	1					
$\varepsilon_{r,12}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.05	-0.03	0.00	0.00	0.00	0.00	1				
$\varepsilon_{r,13}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.04	0.00	0.00	0.00	0.00	-0.01	1			
$\varepsilon_{r,14}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	1		
$\varepsilon_{r,15}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.06	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	1	
q_{sur}	-0.33	0.02	0.00	-0.03	-0.14	-0.02	-0.12	-0.13	-0.25	-0.34	-0.33	-0.68	0.01	0.00	0.00	0.00	0.00	1

Table 2.14. Northeast Atlantic spurdog. Summary table of estimates from the base case assessment: recruitment (number of pups), total biomass (t) and fishing proportion or harvest rate (with selectivity averaged over ages 5–30); and WG estimates of landings (t) used in the assessment. The final recruitment value is taken directly from the estimated stock-recruit relationship.

	R (pups)	B_{tot} (t)	Catch (t)	F_{prop} (5–30)
1980	202625	609481	40968	0.096
1981	186839	587959	39962	0.097
1982	176935	566822	32402	0.081
1983	175460	552782	37046	0.095
1984	165147	532885	35194	0.094
1985	155023	513628	38674	0.106
1986	153482	490234	30910	0.088
1987	150583	473895	42356	0.125
1988	144398	445362	35569	0.111
1989	146803	423601	30279	0.100
1990	138411	406453	29906	0.103
1991	146485	390089	29563	0.107
1992	137034	373544	29046	0.110
1993	122168	356717	25637	0.102
1994	118461	343187	20851	0.087
1995	105962	333689	21318	0.090
1996	106847	323652	17295	0.075
1997	107086	317346	15348	0.068
1998	106083	312486	13919	0.062
1999	104271	308481	12385	0.056
2000	104904	305589	15891	0.072
2001	104265	298820	16693	0.077
2002	105999	291183	11170	0.053
2003	110748	289246	12247	0.059
2004	112643	286266	9366	0.045
2005	114572	286268	8426	0.041
2006	112924	287127	4109	0.020
2007	117170	292562	2929	0.014
2008	122576	299457	1836	0.009
2009	129610	307801	2640	0.012
2010	143201	316111	2468	0.011
2011	127799	323654	2468	0.011
2012	128511	331270	2468	0.010
2013	134192	339268	2468	0.010
2014	133675	347248	2468	0.010
2015	138188	355467	2468	0.010
2016	146238	364039	2468	0.009
2017	150114	372728	2468	0.009
2018	152138	381466		

Table 2.15a. Northeast Atlantic spurdog. Assessment projections under different future catch options. Estimates of begin-year total biomass relative to the total biomass in 2018 are shown, assuming that the catch in 2018 is 2486 tons (average landings for 2007–2009). Point estimates are given in the upper third of the table with corresponding lower and upper values (reflecting ±2 standard deviations) given in the middle and bottom third of the table. All landings from 2008 onwards are assumed to be taken by non-target fisheries only. The "+x yrs" in the first column is relative to 2018 (so "+3 yrs" indicates 2021).

	Medium-term projections				
	MSY approach	zero	TAC 2009	Ave catch 2007–9	MSY harvest rate
average catch*	7962	0	1422	2468	10102
Point estimates					
+ 3 yrs	1.06	1.08	1.08	1.07	1.04
+ 5 yrs	1.09	1.15	1.13	1.12	1.05
+ 10 yrs	1.18	1.32	1.29	1.26	1.10
+ 30 yrs	1.51	2.16	2.05	1.96	1.30
Point estimates - 2 standard deviations					
+ 3 yrs	1.03	1.06	1.05	1.05	1.01
+ 5 yrs	1.04	1.11	1.10	1.09	1.01
+ 10 yrs	1.08	1.25	1.22	1.19	1.03
+ 30 yrs	1.20	1.90	1.83	1.76	1.13
Point estimates + 2 standard deviations					
+ 3 yrs	1.08	1.11	1.10	1.10	1.06
+ 5 yrs	1.14	1.19	1.17	1.16	1.09
+ 10 yrs	1.28	1.39	1.36	1.33	1.17
+ 30 yrs	1.82	2.43	2.27	2.16	1.47

*"ave Catch" is the average for the projection period 2019-2047

Table 2.15b. Northeast Atlantic spurdog. As for Table 2.15a, but this table shows estimates of begin-year total biomass relative to MSY Btrigger (see Table 2.12b).

	Medium-term projections				
	MSY approach	zero	TAC 2009	Ave catch 2007–9	MSY harvest rate
average catch*	7962	0	1422	2468	10102
Point estimates					
+ 3 yrs	0.59	0.61	0.60	0.60	0.58
+ 5 yrs	0.61	0.64	0.63	0.63	0.59
+ 10 yrs	0.66	0.74	0.72	0.70	0.61
+ 30 yrs	0.84	1.21	1.14	1.10	0.73
Point estimates - 2 standard deviations					
+ 3 yrs	0.56	0.58	0.58	0.57	0.55
+ 5 yrs	0.56	0.60	0.60	0.59	0.55
+ 10 yrs	0.56	0.66	0.65	0.63	0.54
+ 30 yrs	0.53	0.94	0.92	0.90	0.55
Point estimates + 2 standard deviations					
+ 3 yrs	0.62	0.63	0.62	0.62	0.60
+ 5 yrs	0.66	0.68	0.67	0.66	0.63
+ 10 yrs	0.76	0.81	0.79	0.77	0.68
+ 30 yrs	1.15	1.47	1.36	1.29	0.90

*"ave Catch" is the average for the projection period 2019–2047

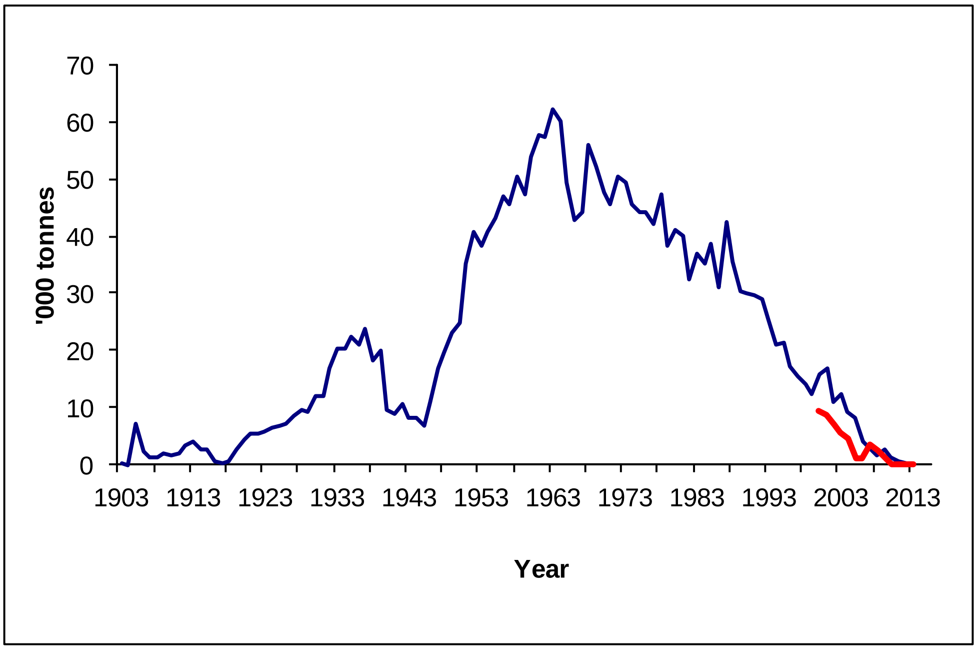


Figure 2.1a. Northeast Atlantic spurdog. WG estimates of total international landings of NE Atlantic spurdog (1903–2013, blue line) and TAC (red line). Restrictive management (e.g. through quotas and other measures) is only thought to have occurred since 2007.

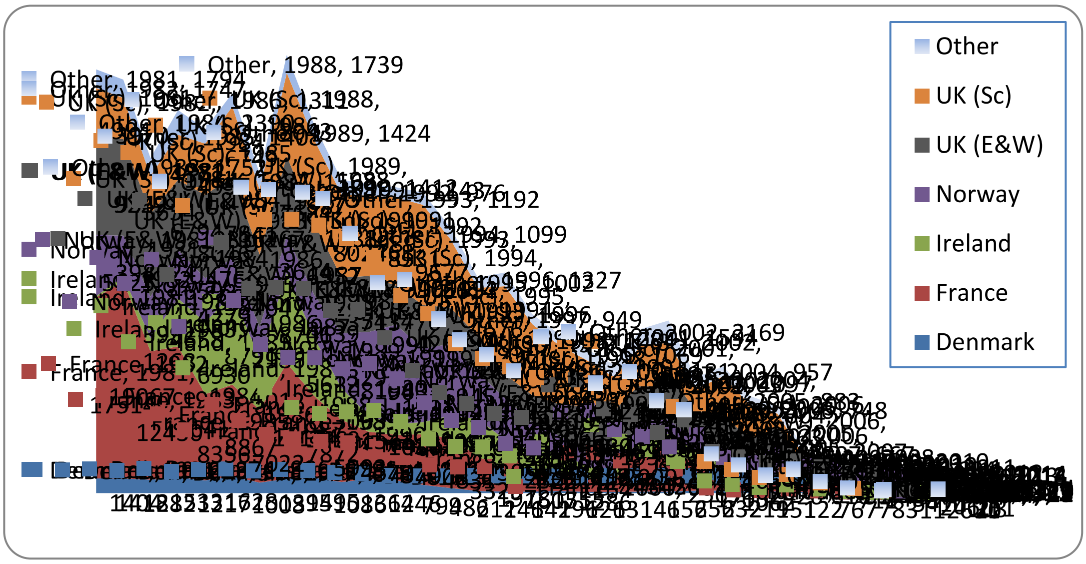


Figure 2.1b. Northeast Atlantic spurdog. WG estimates of landings by nation (1980–2014).

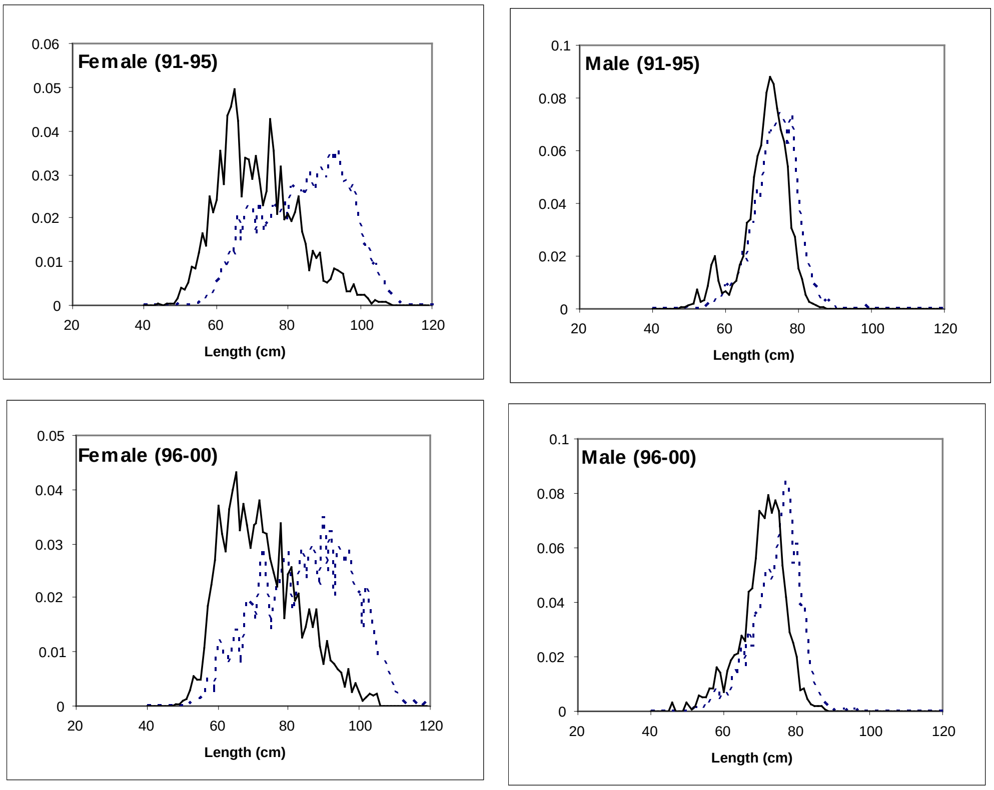


Figure 2.2. Northeast Atlantic spurdog. Comparison of length–frequency distributions (proportions) obtained from market sampling of Scottish (solid line) and UK (E&W) (dashed line) landings data. Data are sex-disaggregated, but averaged over five-year intervals.

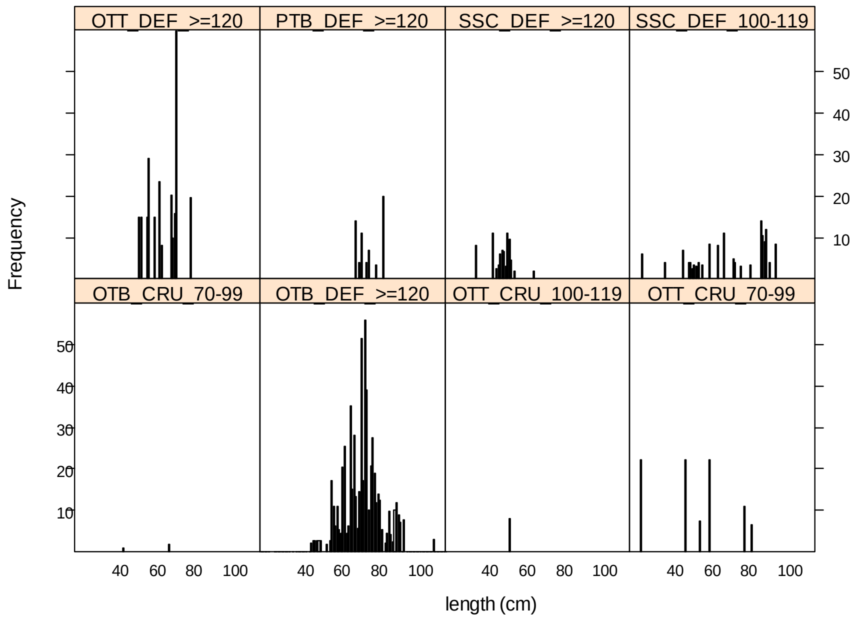


Figure 2.3. Northeast Atlantic spurdog. Length distributions of spurdog caught on Scottish observer trips in 2010. Data are aggregated across trips for each gear category. Gear codes relate to gear type, target species and mesh size. OTT – Otter trawl twin; PTB – Pair trawl bottom; SSC – Scottish Seine; OTB – Otter trawl bottom; DEF – demersal fish; CRU – crustacean.

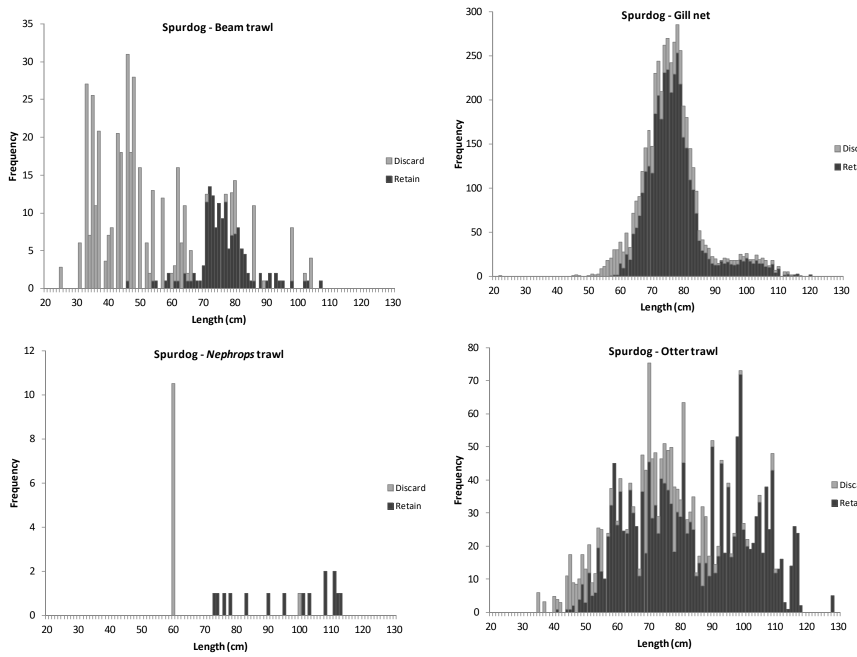


Figure 2.4. Northeast Atlantic spurdog. Discard-retention patterns of spurdog taken in UK (English) vessels using beam trawl, gillnet, *Nephrops* trawl and otter trawl.

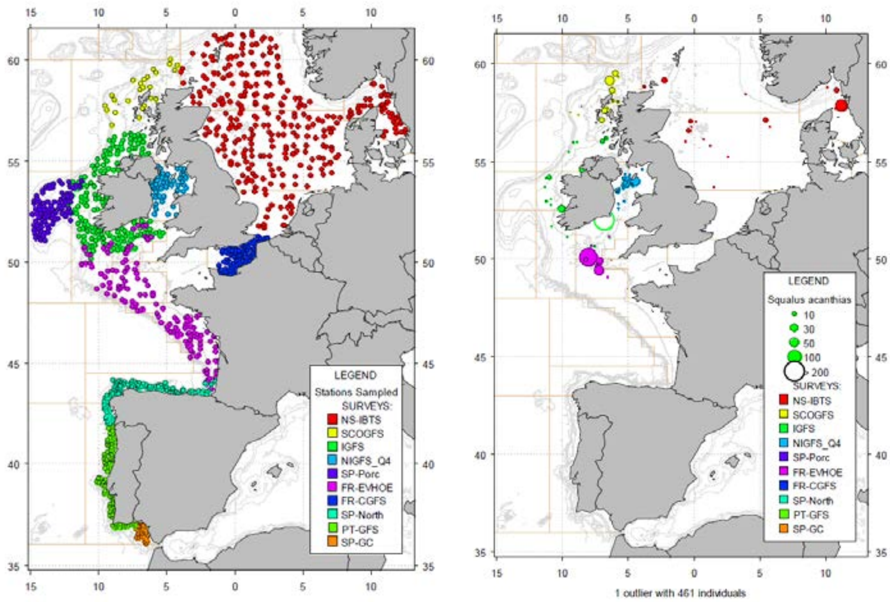


Figure 2.5. Northeast Atlantic spurdog. Overall spatial coverage of the IBTS (left) all surveys combined and (right) captures of spurdog (number per hour, bottom) as reported in the 2013 summer/autumn IBTS. The catchability of the different gears used in the NE Atlantic surveys is not constant; therefore the map does not reflect proportional abundance in all the areas but within each survey (From ICES, 2014).

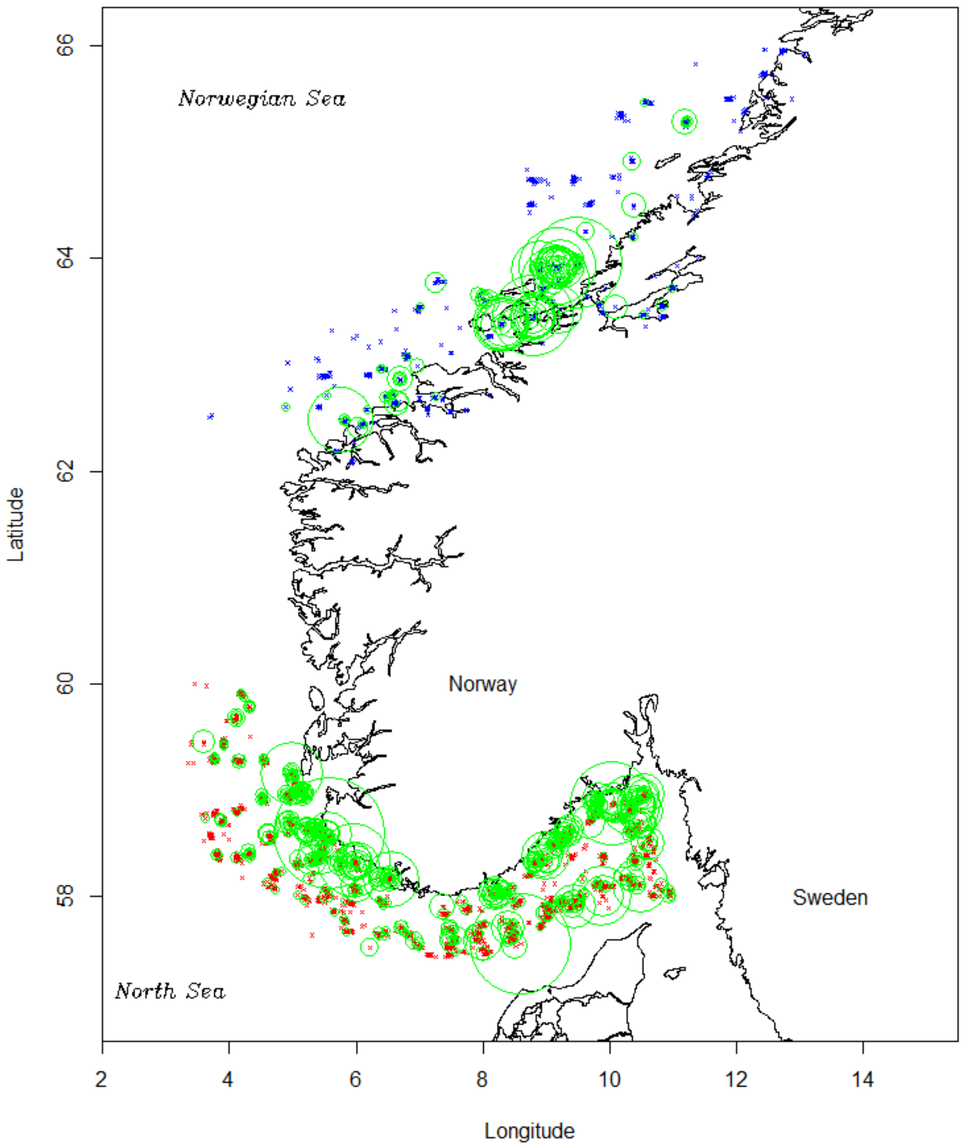


Figure 2.6. Northeast Atlantic spurdog. Map of survey areas with stations 1996–2017/18 for Coastal survey (blue) and Shrimp survey (red) for area 58-66°North. Green circles indicate catches of spurdog; circle area is proportional to catch in number of individuals.Source: Vollen (2014 WD), plus additional data from 2014 onwards.

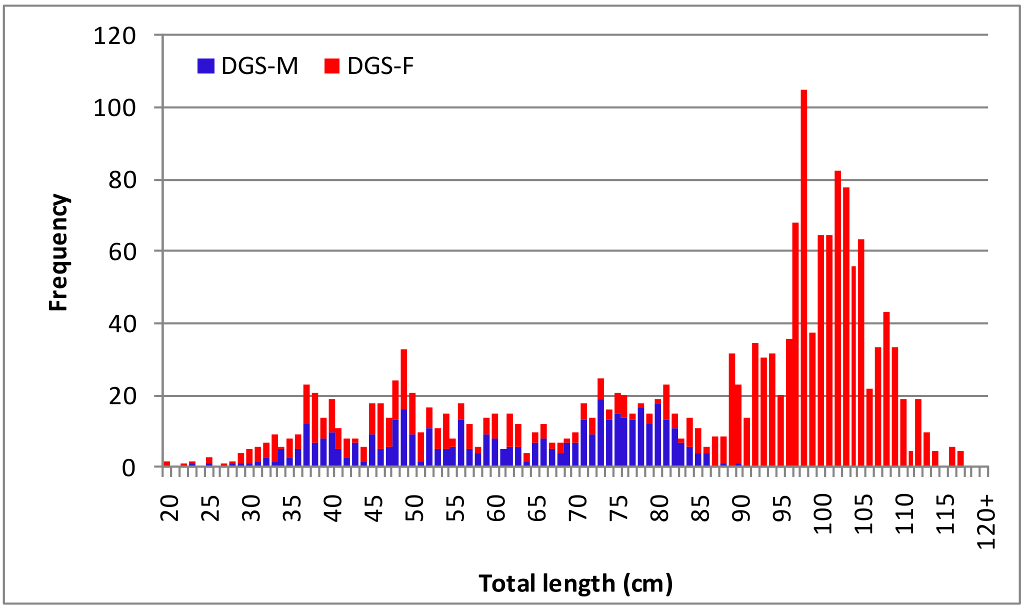


Figure 2.7a. Northeast Atlantic spurdog. Length distribution of spurdog captured in the UK (England and Wales) westerly IBTS in Q4 (2004–2009, all valid and additional tows). Length distribution highly influenced by a single haul of large females.

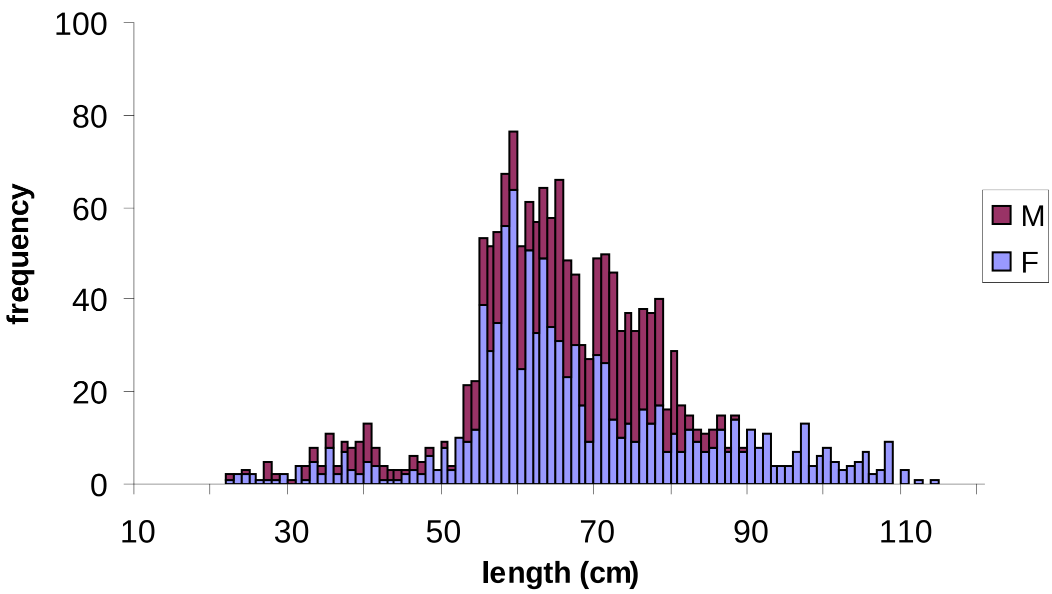


Figure 2.7b. Northeast Atlantic spurdog. Length distribution of spurdog captured in the Irish Q3 Celtic Seas groundfish survey (2003–2009).

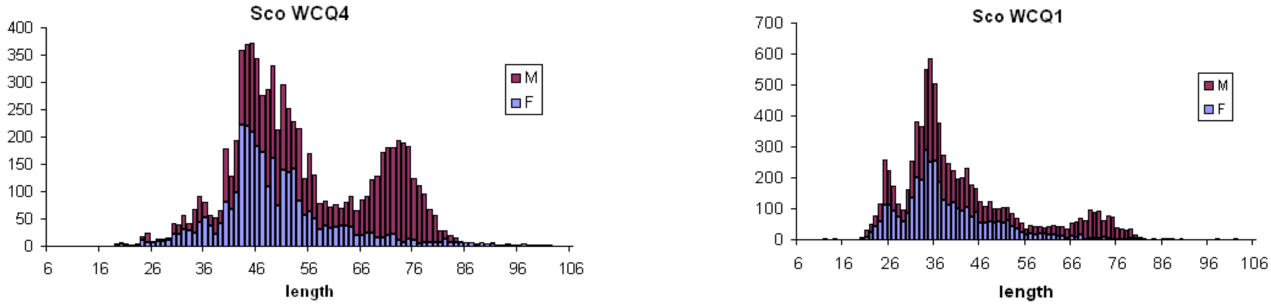


Figure 2.8. Northeast Atlantic spurdog. Length distribution of spurdog captured in the Scottish Q1 and Q4 groundfish surveys (1990–2010). Length–frequency distributions highly influenced by a small number of hauls containing many small individuals.

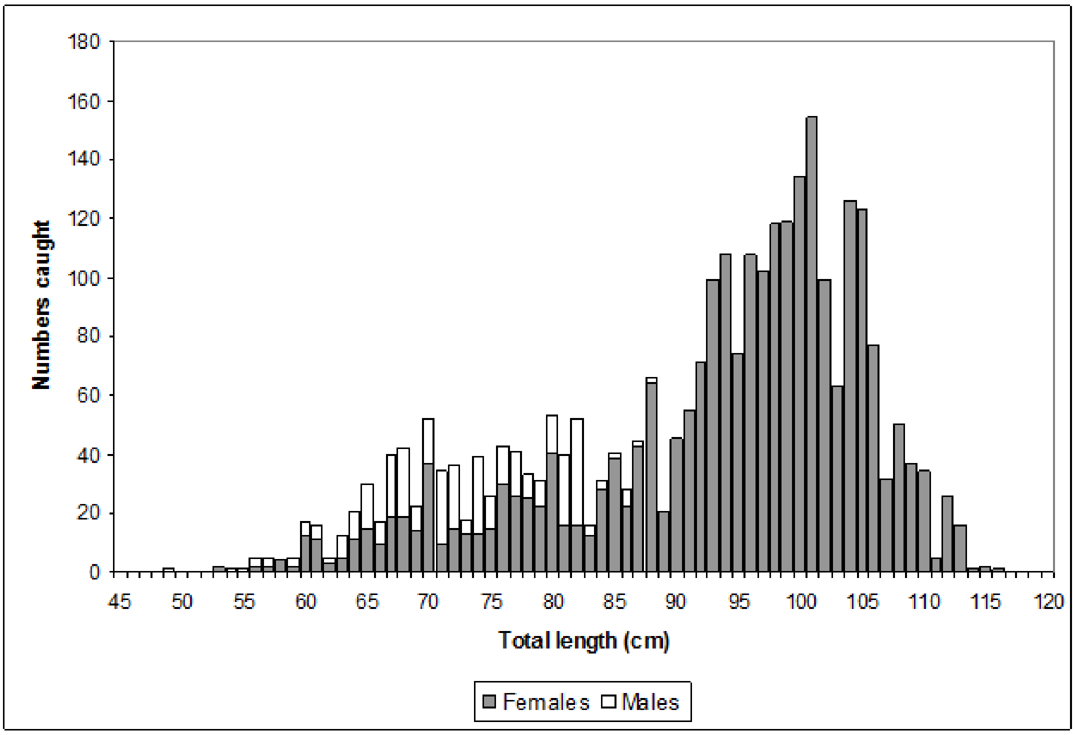


Figure 2.9. Northeast Atlantic spurdog. Total length–frequency of male and female spurdog taken during the UK(E&W) FSP survey, raised for those catches that were sub-sampled (n = 2517 females and 356 males).

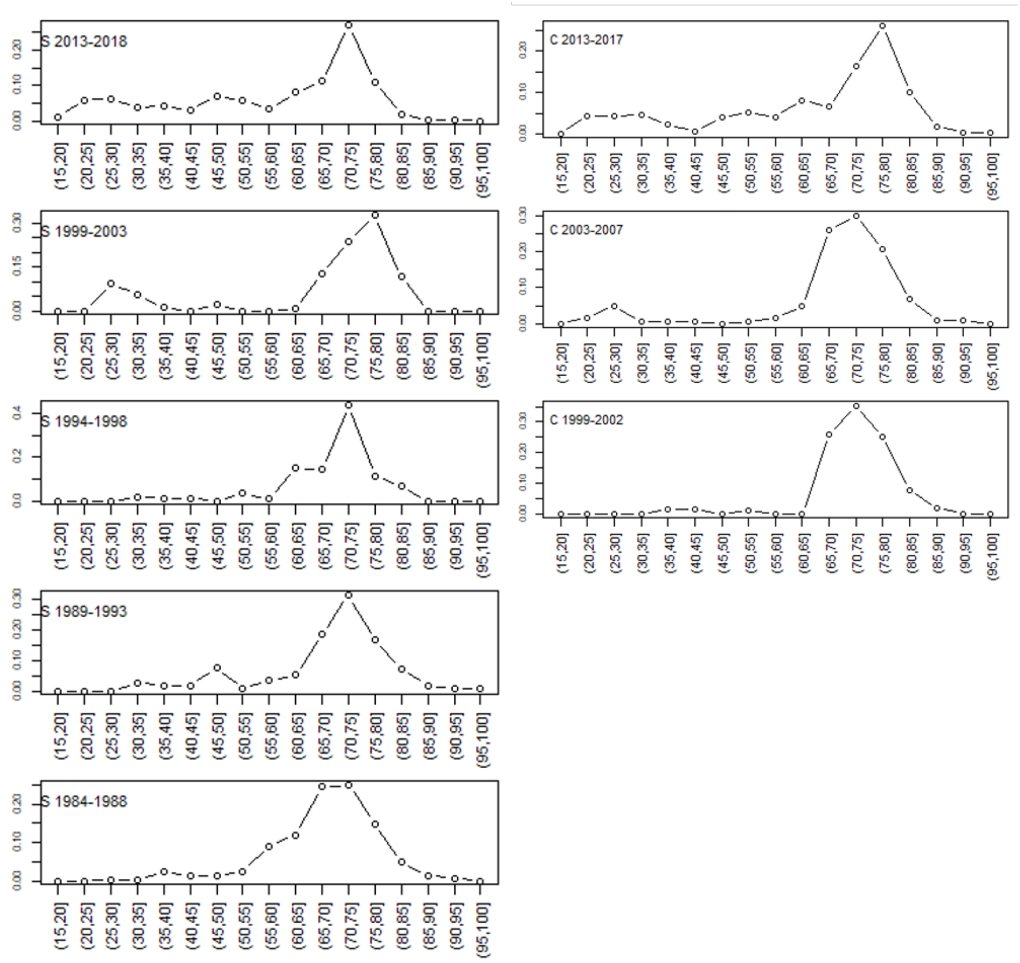
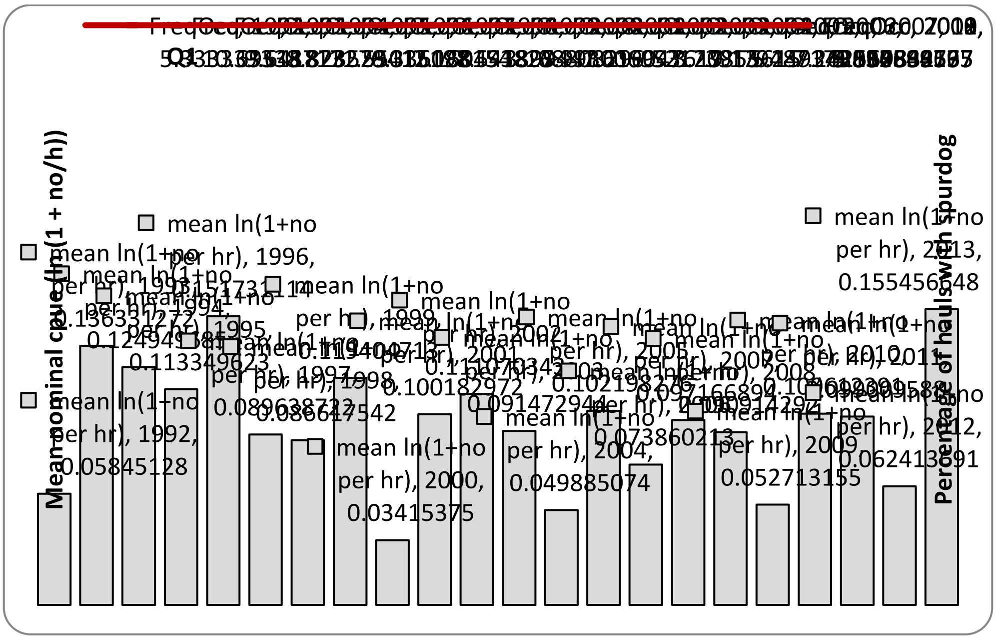


Figure 2.10. Northeast Atlantic spurdog. Relative length–frequency distributions (5 cm length groups and five-year periods) for the Shrimp survey 1985–2018 (left) and Coastal survey 1999–2017 (right).



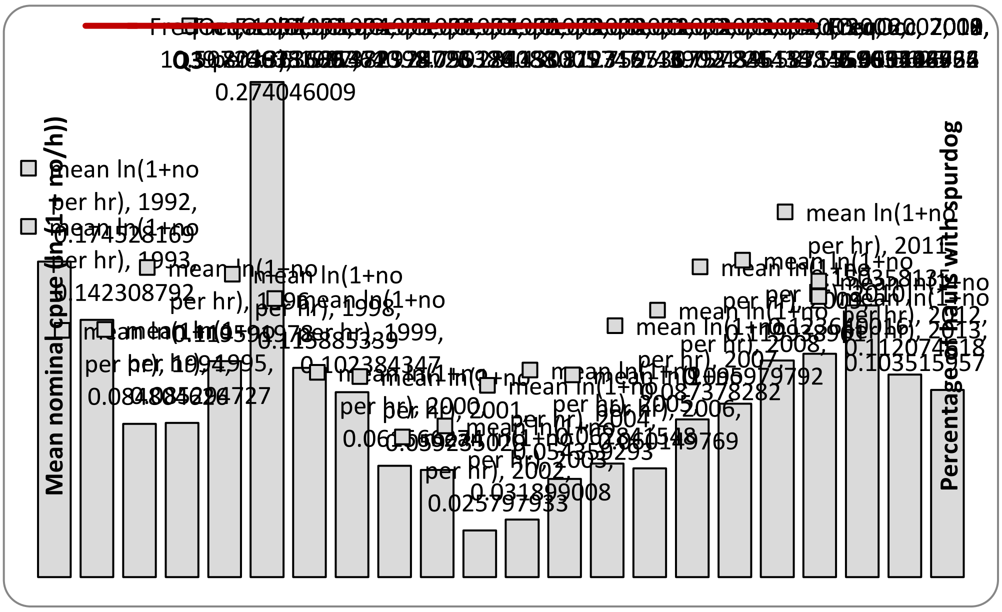


Figure 2.11. Northeast Atlantic spurdog. Nominal catch per unit of effort (grey bars) and frequency of occurrence (red line) of spurdog in the Q1 and Q3 North Sea IBTS (1992–2013). Catch per unit of effort is mean ln(1+n/h) for all stations in roundfish areas 1–9. Data accessed from DATRAS (19 June 2014).

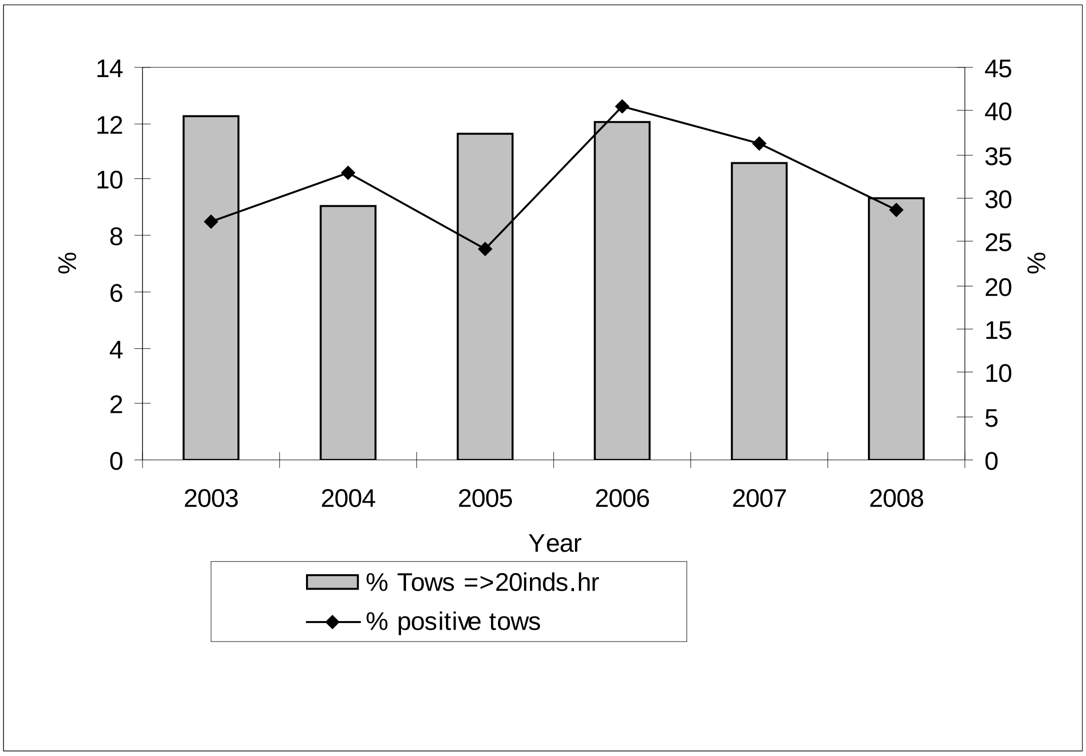


Figure 2.12. Northeast Atlantic spurdog. Proportion of survey hauls in Irish Q3 groundfish survey 2003–2008, ICES Area 7, in which nominal CPUE was ≥20 per one hour tow, and percentage of tows in which spurdog occurred.

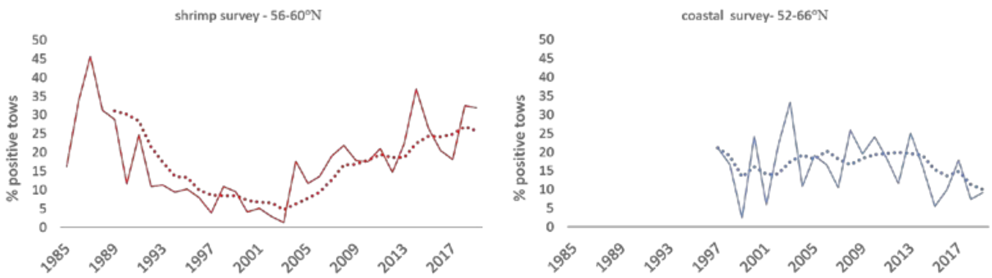


Figure 2.13. Northeast Atlantic spurdog. Percentage of tows in shrimp (left) and coastal (right) survey in which spurdog occurred by year, with moving average (dotted, 5 yrs).

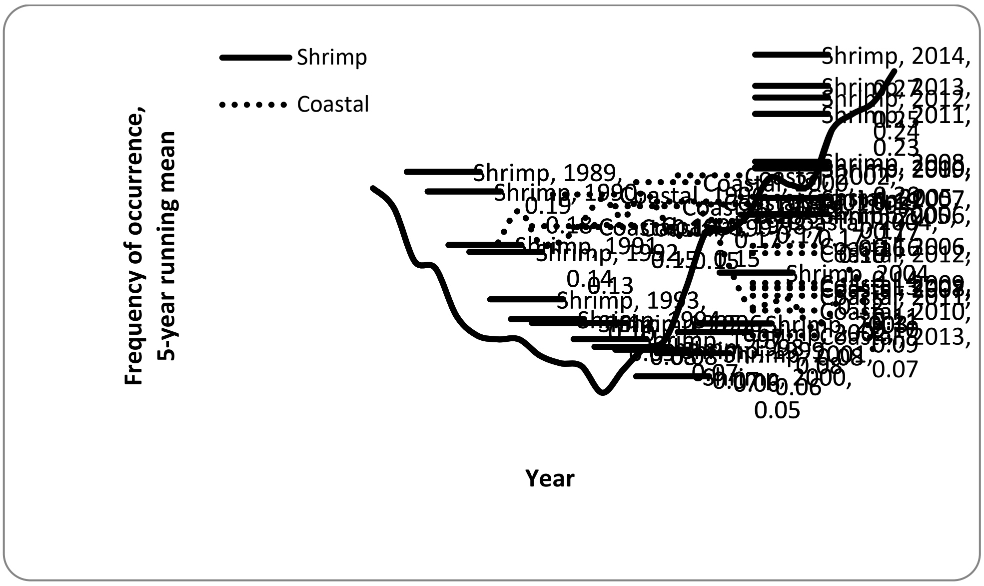


Figure 2.14. Northeast Atlantic spurdog. Frequency of occurrence of spurdog in the Norwegian Coastal survey and Shrimp survey. A five year running mean is used. Source: Vollen (2014 WD).

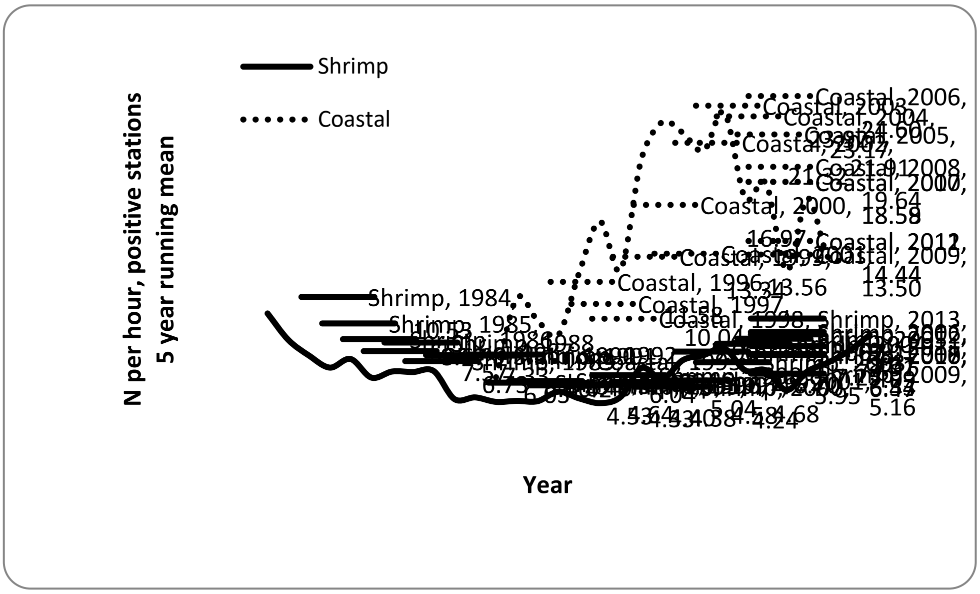
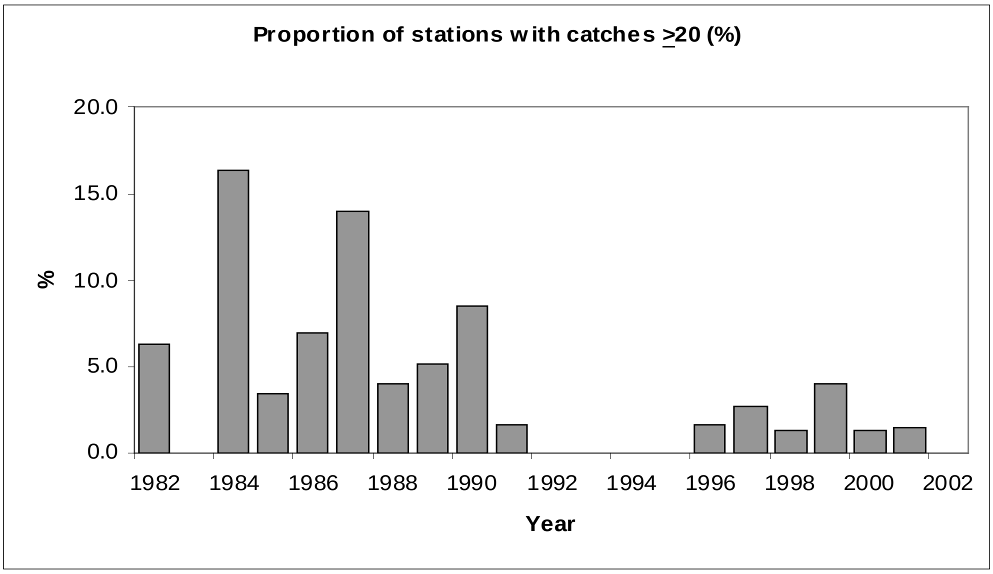


Figure 2.15. Northeast Atlantic spurdog. Mean number of spurdog caught per hour in the Norwegian Coastal survey and Shrimp survey. A five year running mean is used. Source: Vollen (2014 WD).



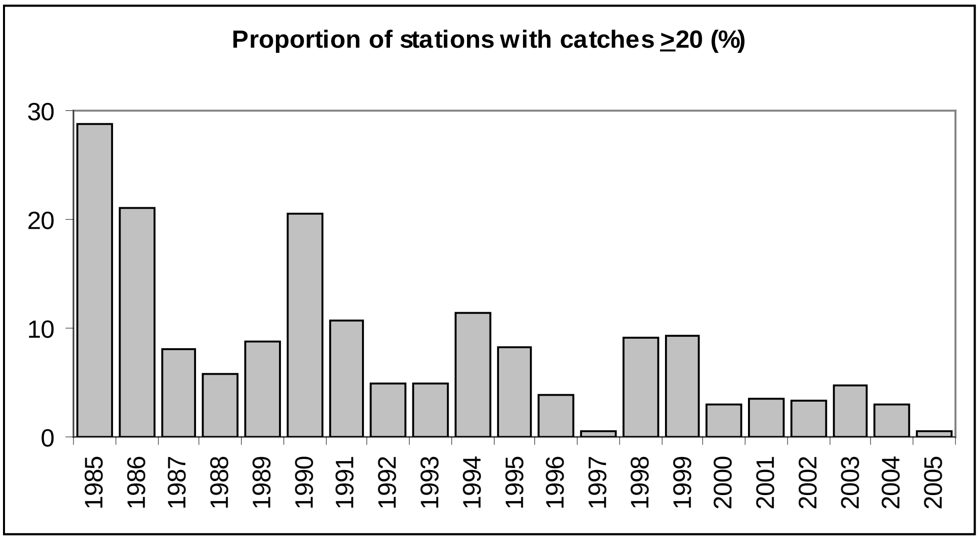
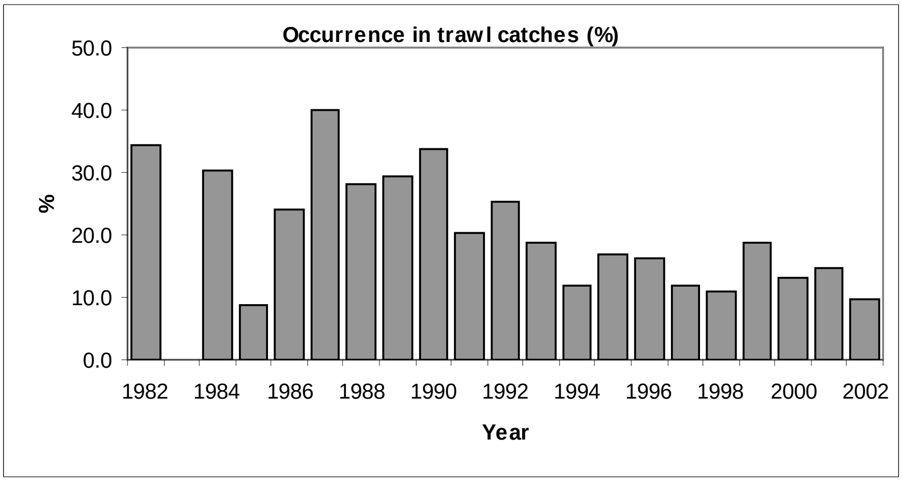


Figure 2.16. Northeast Atlantic spurdog. Proportion of survey hauls in the English Celtic Sea groundfish survey (1982–2002, top) and Scottish west coast (VIa) survey (Q1, 1985–2005, bottom) in which CPUE was ≥20 ind.h–1. (Source: ICES, 2006).

a)



b)

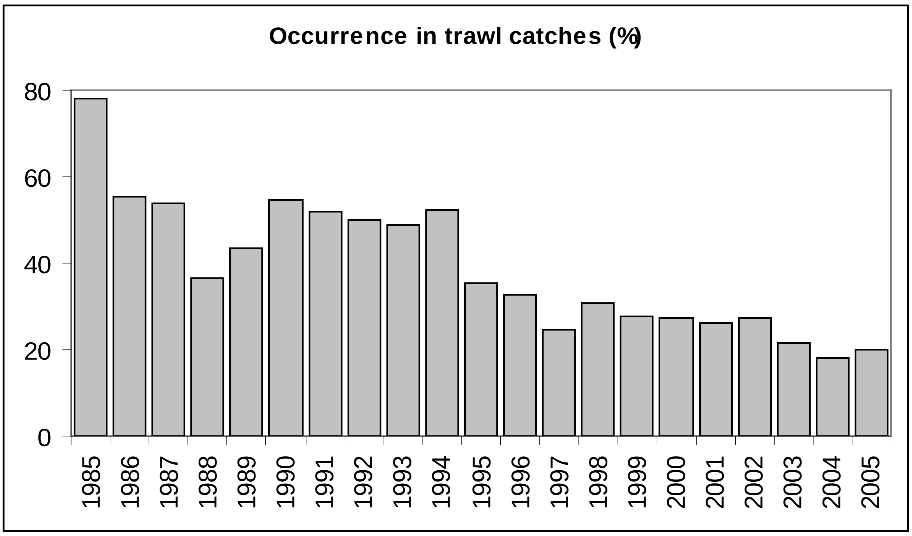


Figure 2.17. Northeast Atlantic spurdog. Frequency of occurrence in survey hauls in a) the English Q1 Celtic Sea groundfish survey (1982–2002), and b) the Scottish west coast (VIa) survey (Q1, 1985–2005).

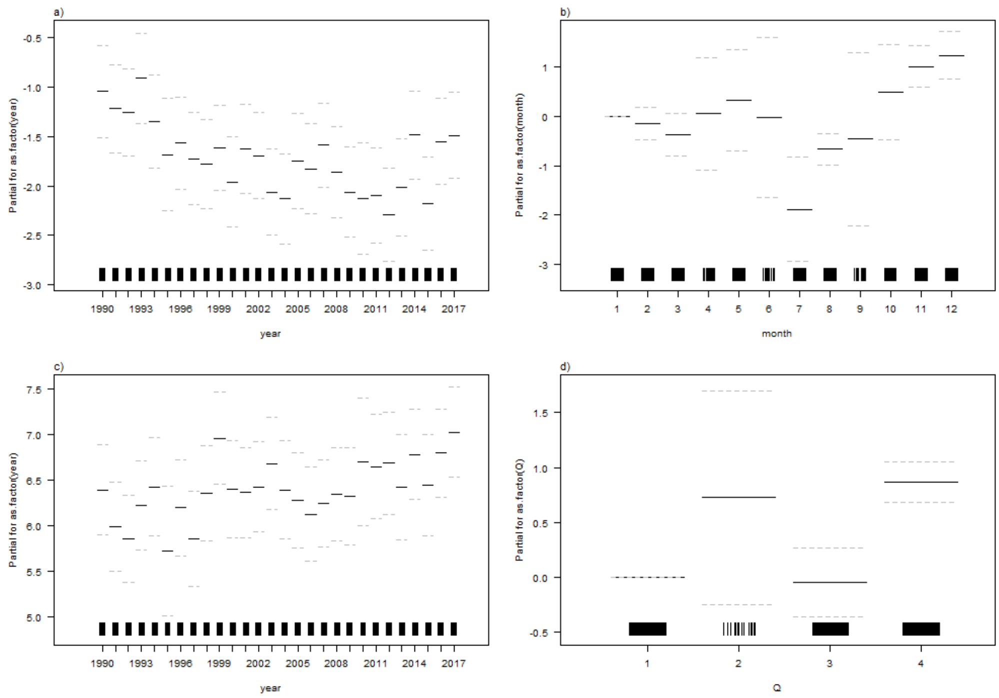


Figure 2.18. Northeast Atlantic spurdog. Estimated year and quarter effects (± 1 s.e.) from the delta-lognormal GLM: binomial model shown in a) and b), and lognormal results in c) and d) (log scale).

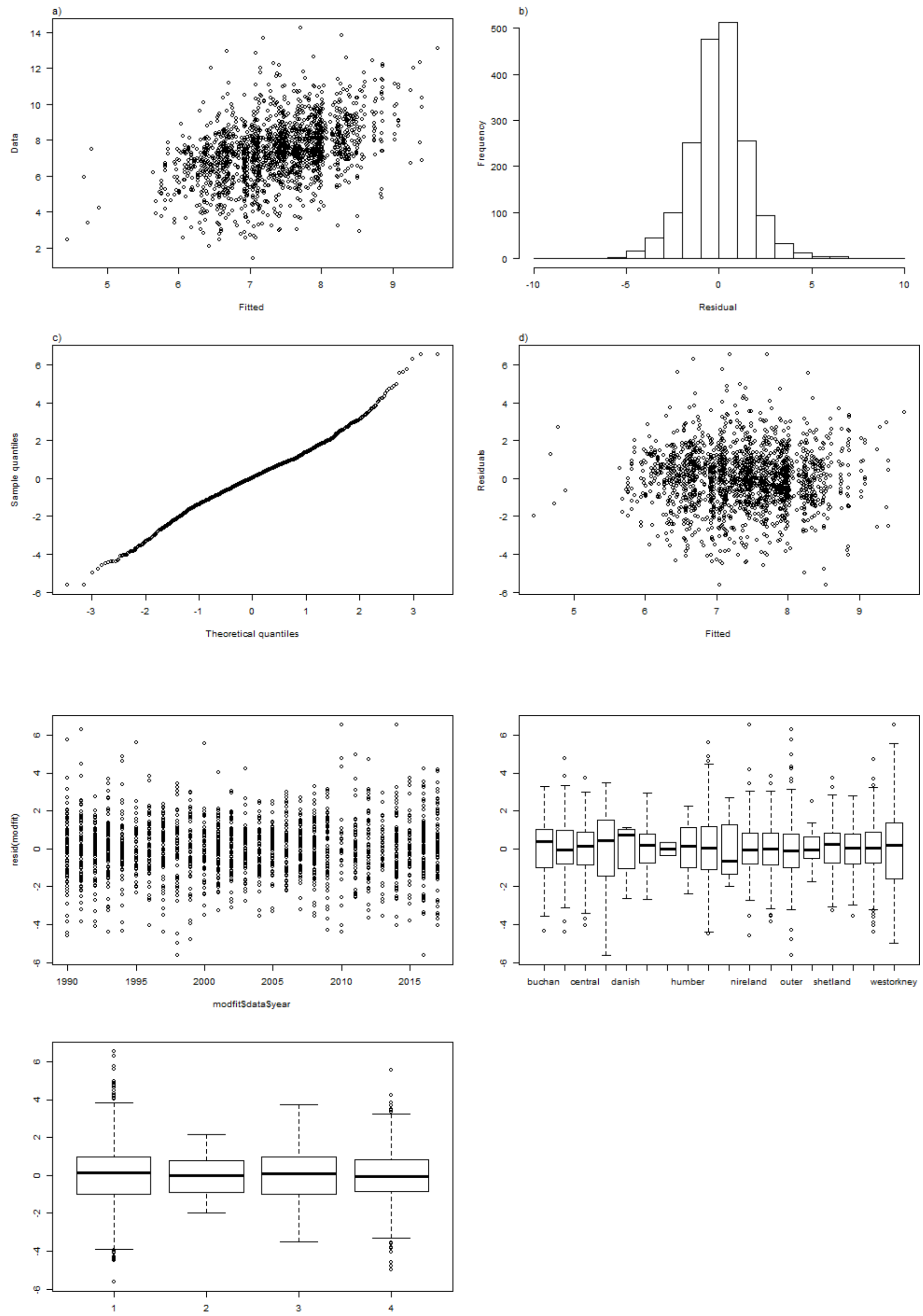


Figure 2.19. Northeast Atlantic spurdog. Analysis of Scottish survey data. Residual plot of final lognormal model fit: a) observed vs. fitted values, b) histogram of residuals, c) normal Q-Q plot, d) residuals vs. fitted values and e), f) and g) residuals vs. year, area and quarter.

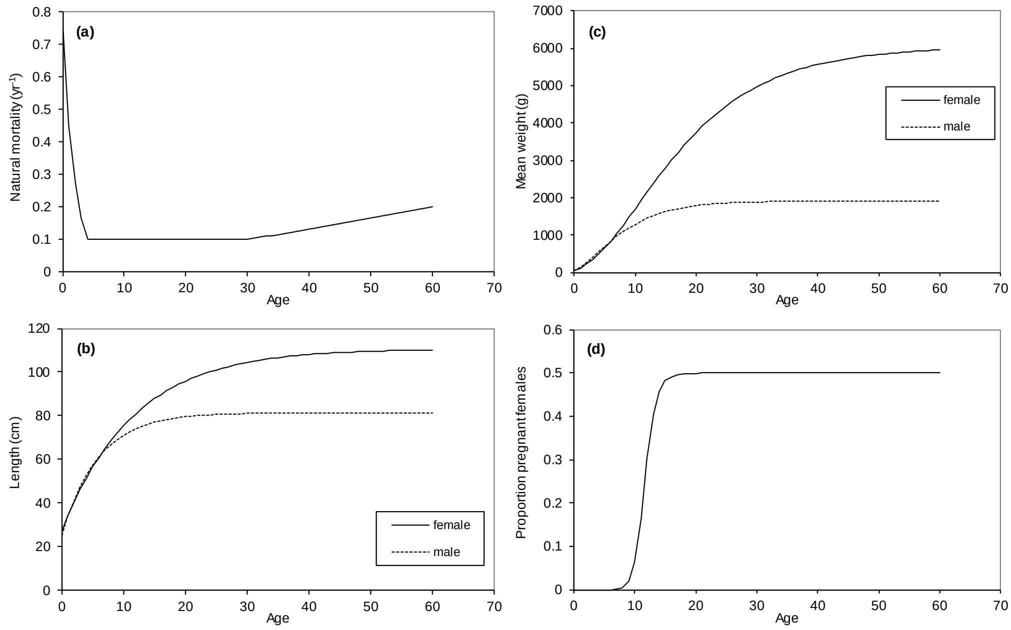


Figure 2.20. Northeast Atlantic spurdog. A visual representation of the life-history parameters described in Table 2.5. [Note, the value of natural mortality-at-age 0 is a parameter derived from the assessment.]

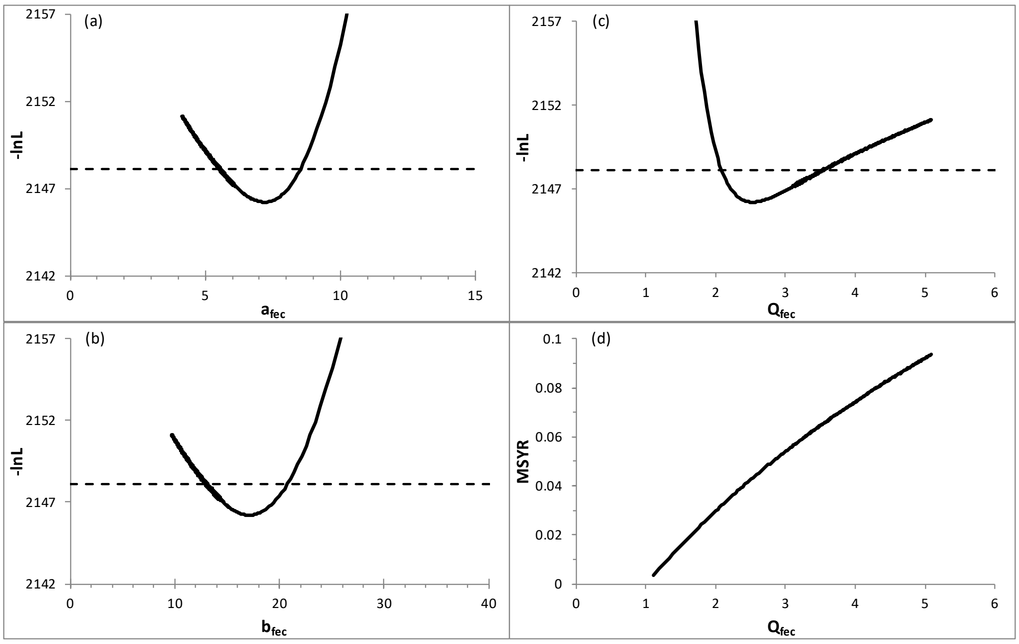


Figure 2.21. Northeast Atlantic spurdog. Negative log-likelihood (-ln*L*) for a range of (a) a_{fec} and (b) b_{fec} values, with (c) corresponding Q_{fec}. Plot (d) shows MSYR (MSY/B_{MSY}) vs. Q_{fec}. Using the likelihood ratio criterion, the hashed line in plots (a)–(c) indicate the minimum –ln*L* value + 1.92, corresponding to 95% probability intervals for the corresponding parameters for values below the line.

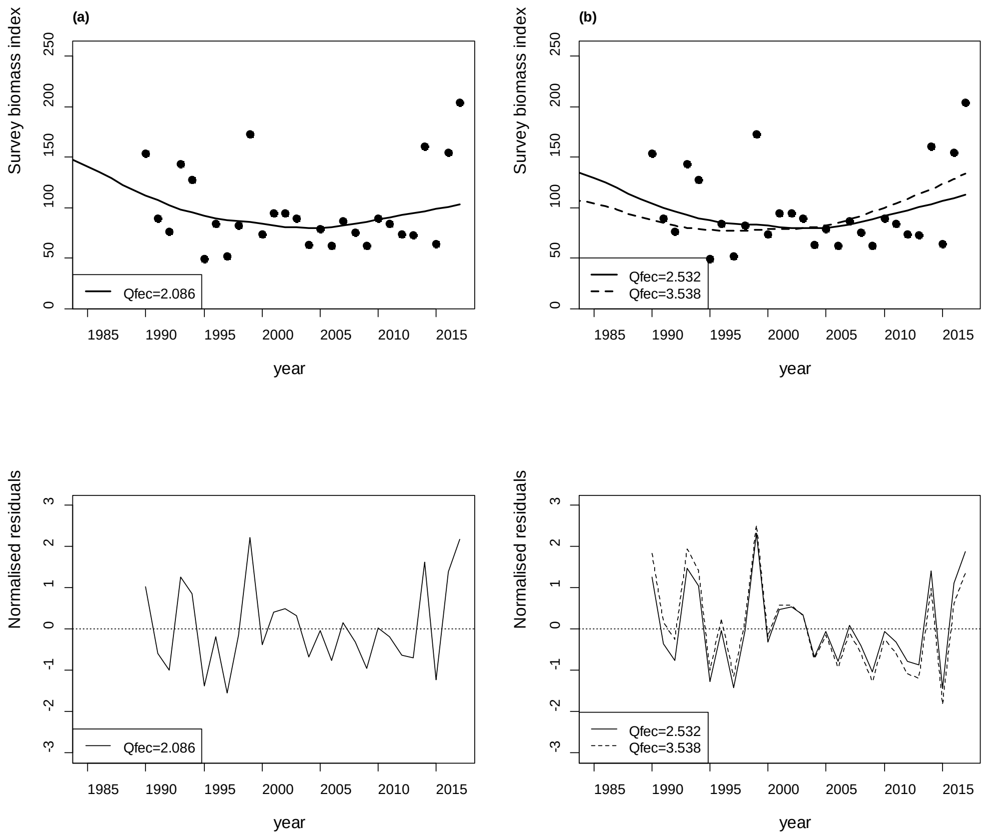


Figure 2.22. Northeast Atlantic spurdog. Model fits to the Scottish surveys abundance index (top panel), with normalised residuals ($\varepsilon_{sur,y}$ in Stock Annex equation 9b) (bottom) for (a) the base-case Qfec=2.000 (the more conservative lower bound in Figure 2.21c) and (b) for two alternatives (the optimum and upper bounds in Figure 2.21c) that fall within the 95% confidence bounds.

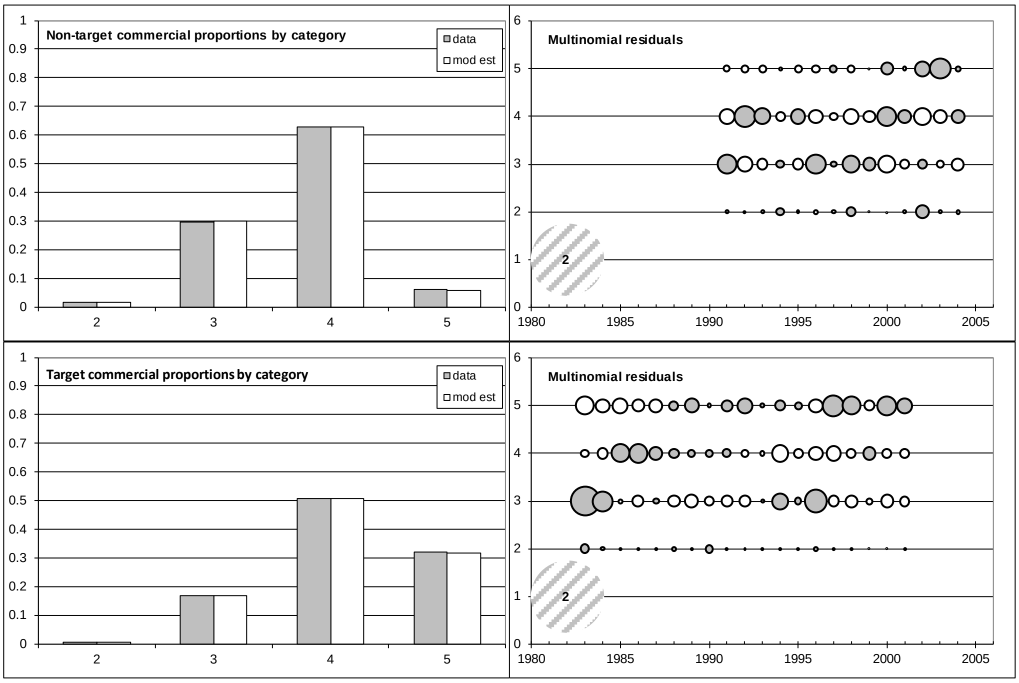


Figure 2.23a. Northeast Atlantic spurdog. Model fits to the non-target (Scottish; top row) and target (England & Wales; bottom row) commercial proportions-by-length category data for the base case run. The left-hand side plots show proportions by length category averaged over the time period for which data are available, with the length category given along the horizontal axis. The right-hand side plots show multinomial residuals ($\varepsilon_{pcom,j,y,L}$ in Stock Annex equation 10b), with grey bubbles indicating positive residuals, bubble area being proportional to the size of the residual (the light-grey hashed bubble indicates a residual size of 2, and is shown for reference), and length category indicated on the vertical axis. The length categories considered are 2: 16–54 cm; 3: 55–69 cm; 4: 70–84 cm; 5: 85+ cm.

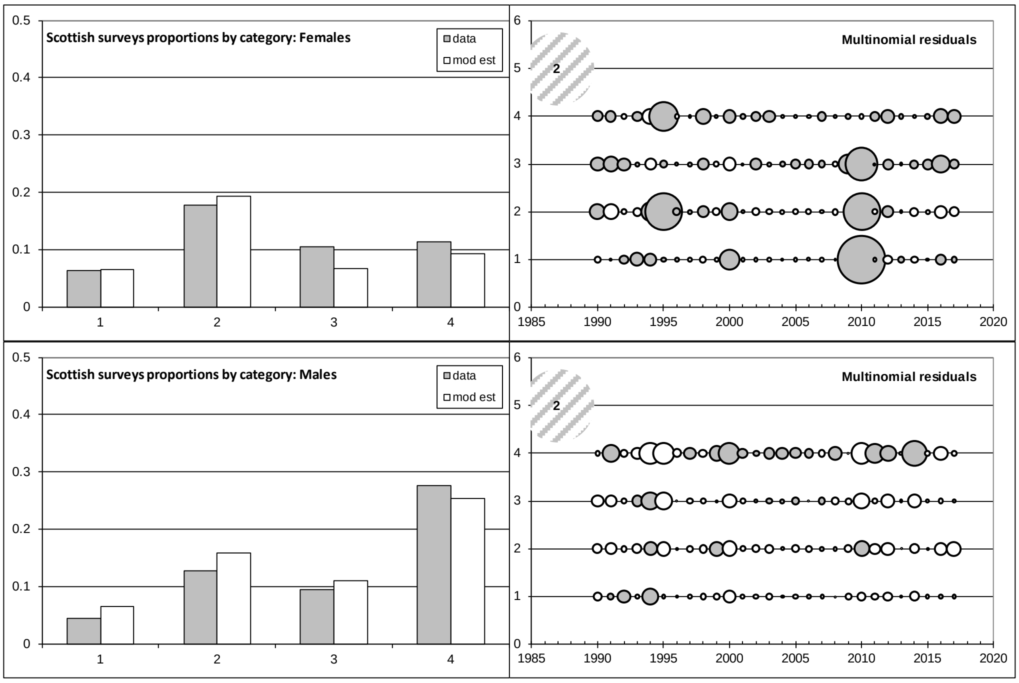


Figure 2.23b. Northeast Atlantic spurdog. Model fits to the Scottish survey proportions-by-length category data for the base-case run for females (top row) and males (bottom row). A further description of these plots can be found in the caption to Figure 2.23a. Length categories considered are 1: 16–31 cm; 2: 32–54 cm; 3: 55–69 cm; 4: 70+ cm.

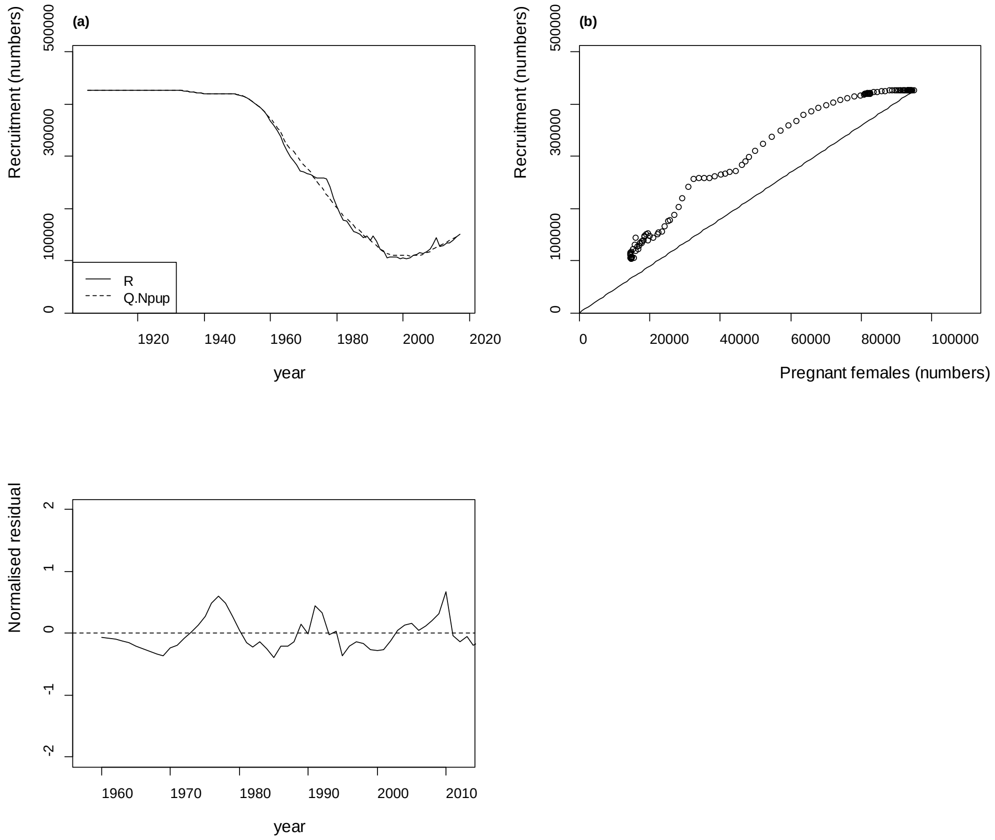


Figure 2.24. Northeast Atlantic spurdog. (a) A comparison of the deterministic (N_{pup}) and stochastic (*R*) versions of recruitment (Stock Annex equations 2a–c) (top-left panel) with normalised residuals ($\varepsilon_{r,y}/\sigma_r$, where $\varepsilon_{r,y}$ are estimable parameters of the model) (bottom); and (b) a plot of recruitment (R) vs. number of pregnant females (open circles), together with the replacement line (number of recruiting pups needed to replace the pregnant female population under no harvesting).

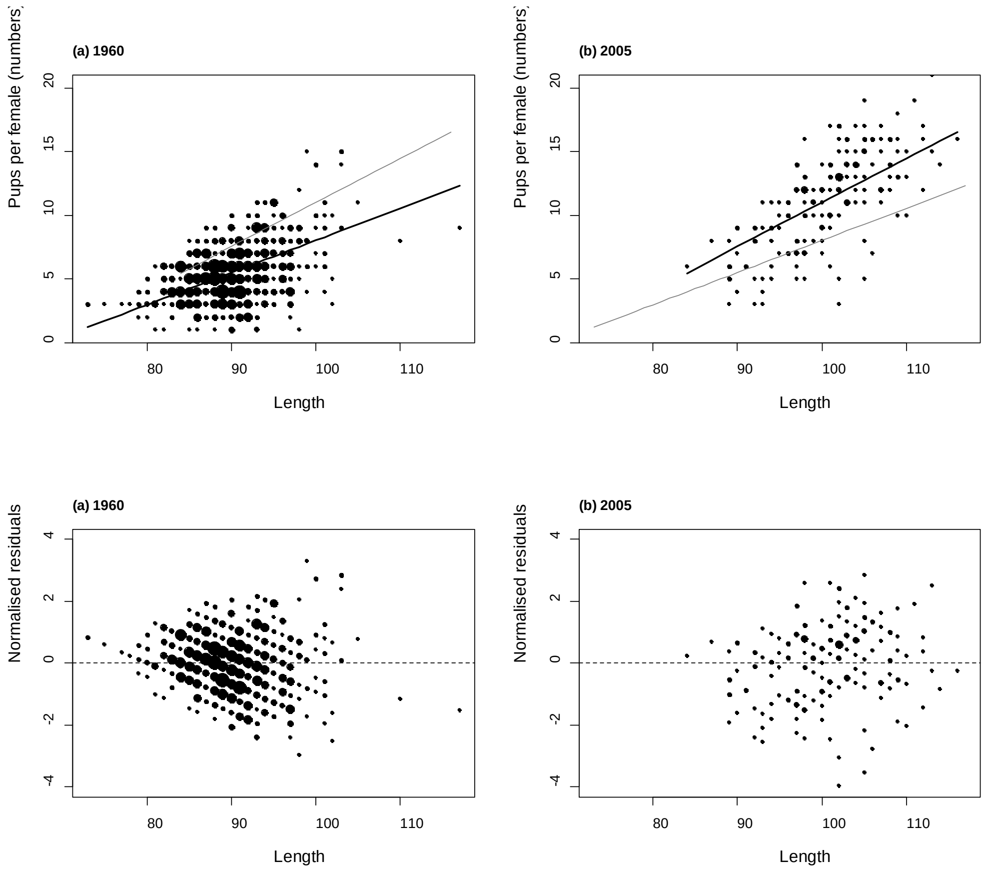


Figure 2.25. Northeast Atlantic spurdog. Fit to fecundity data from two periods (top row) for (a) 1960 and (b) 2005, with associated normalised residuals ($\varepsilon_{fec,k,y}$ in Stock Annex equation 11b) (bottom row). For the top plots, the heavy black lines reflect the model estimates for the given points, while the light grey ones, reflecting the model estimates for the points in the adjacent plot, are given for comparison. For all plots, the diameter of each point is proportional to $\sqrt{n}$, where n is the number of samples with the same number of pups for a given length.

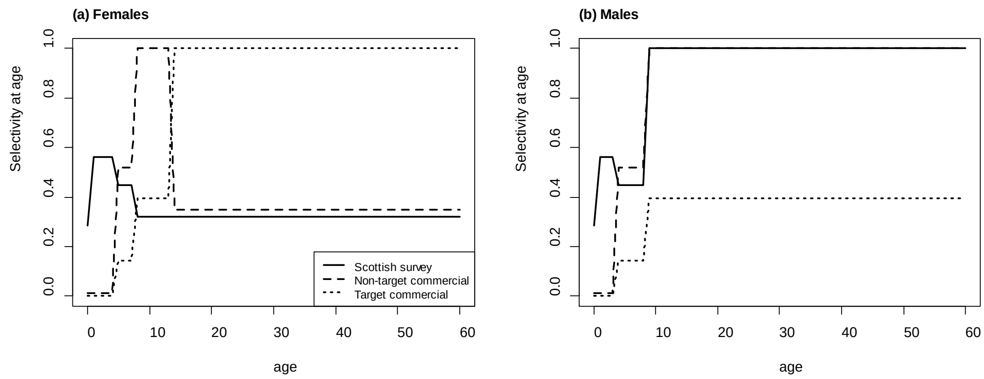


Figure 2.26. Northeast Atlantic spurdog. Estimated selectivity-at-age curves for the base case run for (a) females and (b) males. The two commercial fleets considered have non-target (Scottish) and target (England & Wales) selectivity, which differ by sex because of the life-history parameters for males and females (Table 2.6). The survey selectivity relies on Scottish survey data.

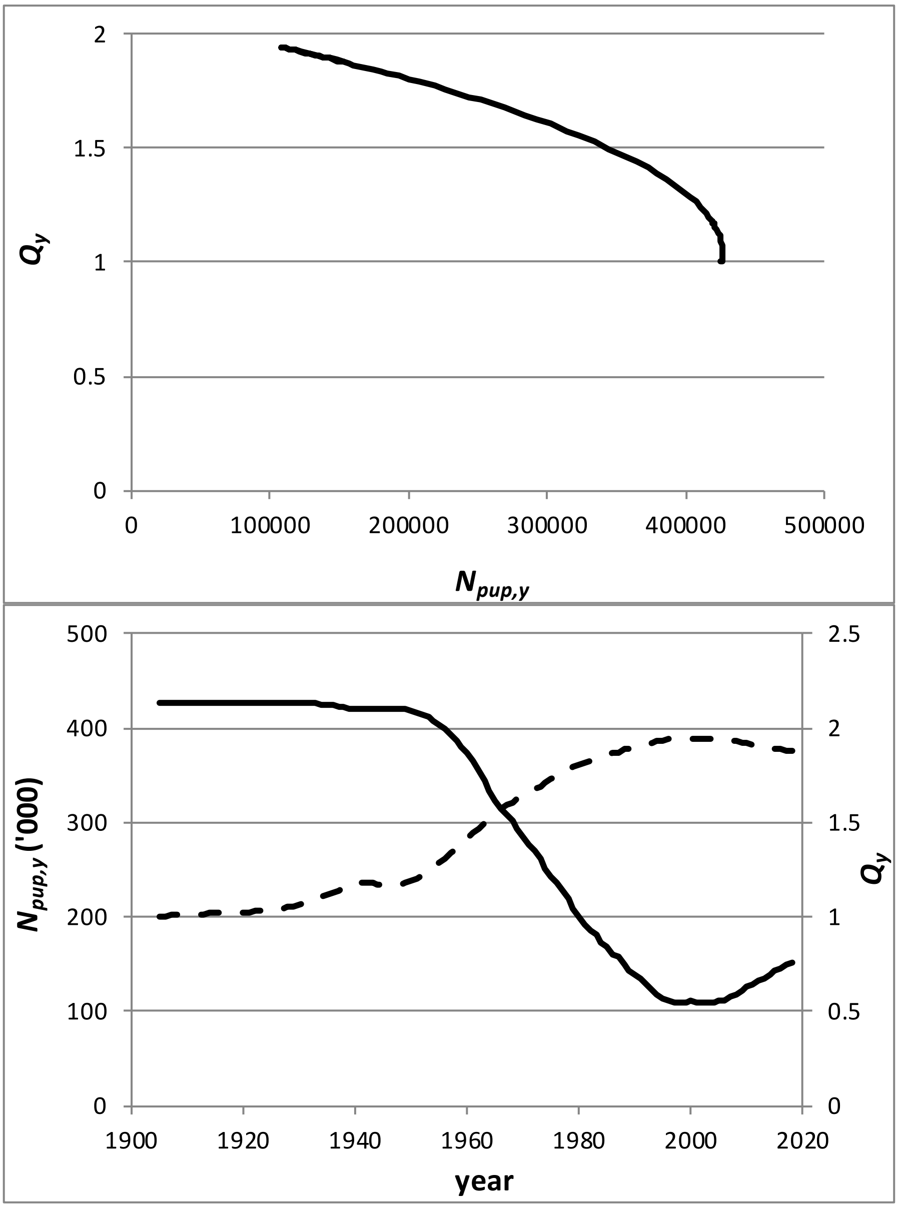


Figure 2.27. Northeast Atlantic spurdog. A plot of the density-dependent factor Q_y (Stock Annex equation 2b) against the number of pups $N_{pup,y}$ (top), and both plotted against time (bottom; solid line for $N_{pup,y}$, and hashed line for Q_y).

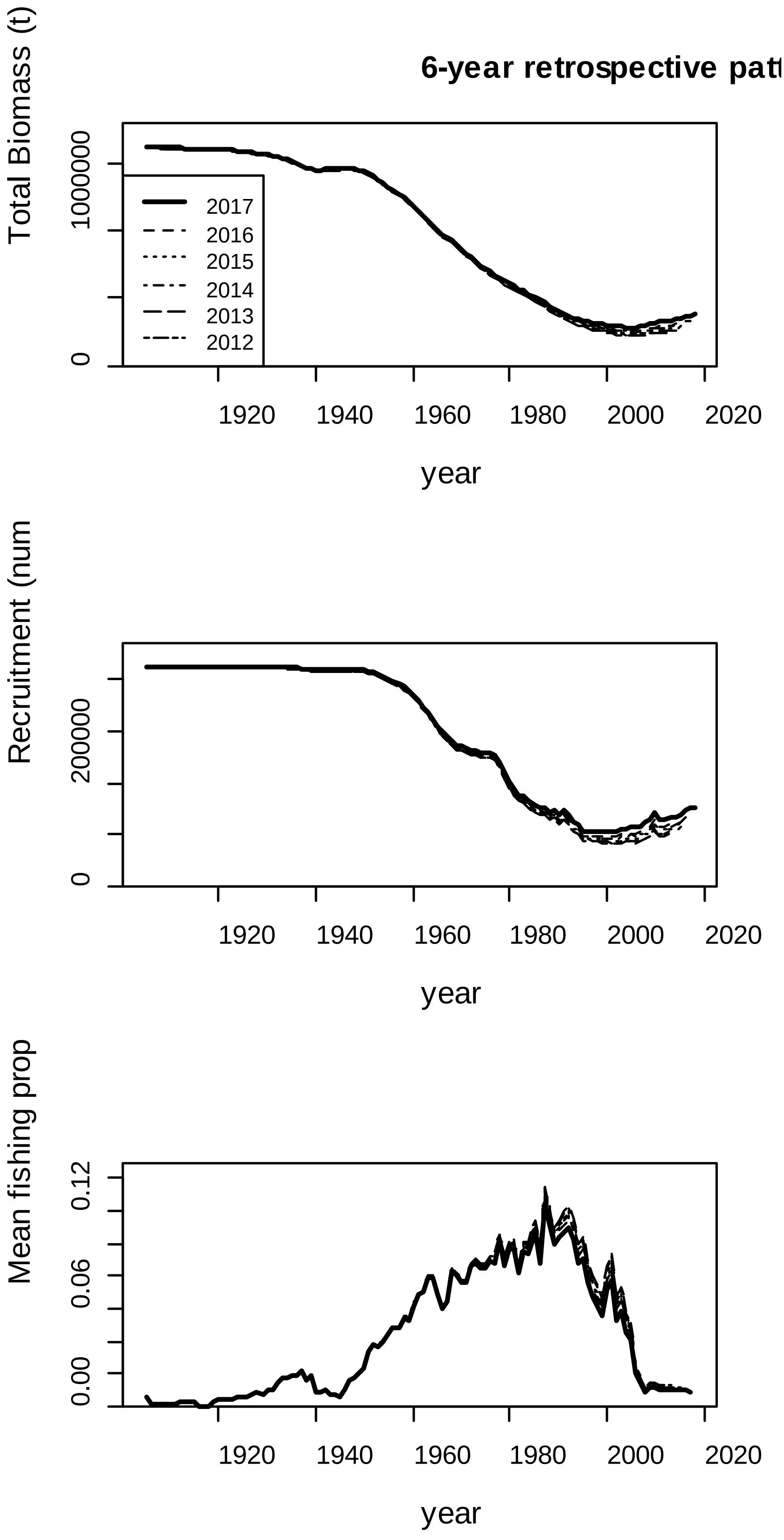


Figure 2.28a. Northeast Atlantic spurdog. Six-year retrospective plots (omitting probability intervals for clarity; the model was re-run, each time omitting a further year in the data).

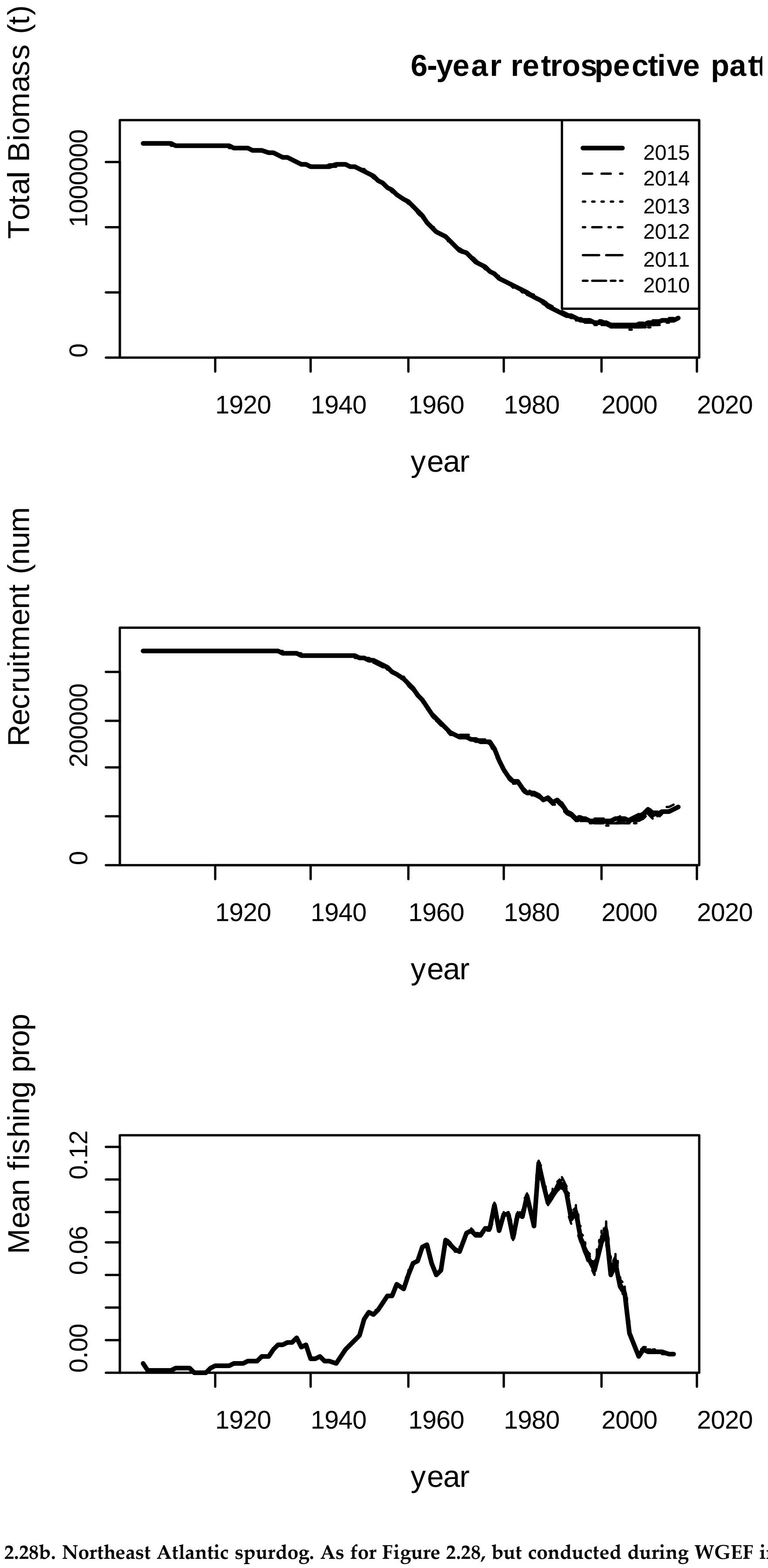


Figure 2.28b. Northeast Atlantic spurdog. As for Figure 2.28, but conducted during WGEF in 2016 (ICES, 2016) with an appropriate adjustment of years.

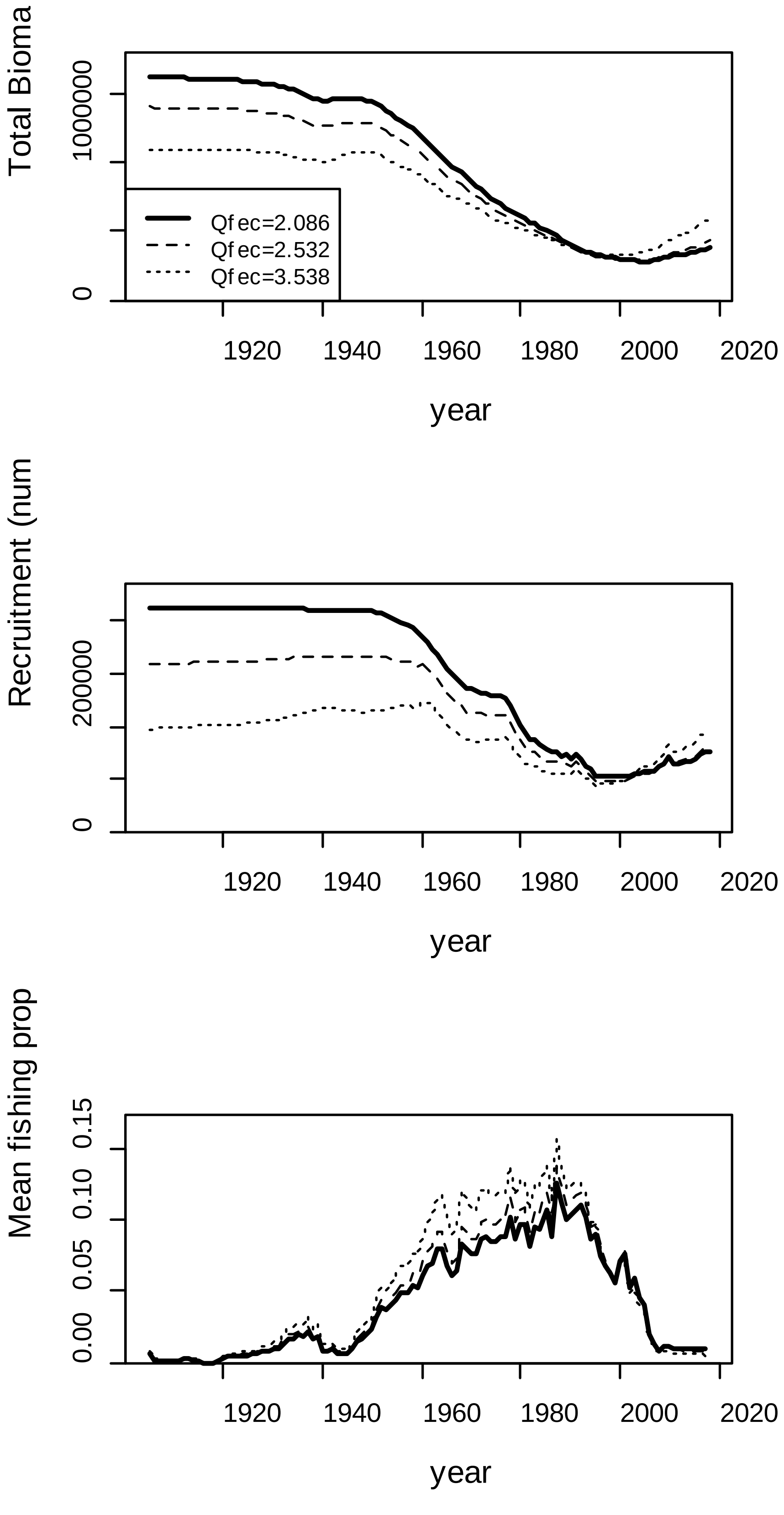


Figure 2.29. Northeast Atlantic spurdog. A sensitivity analysis of the parameter that determines the extent of density-dependence in pup production (Q_{fec}). Three alternative values are considered, related to the smallest, optimum (in terms of lowest –ln*L*) and largest value of Q_{fec} below the hashed line in Figure 2.21c (respectively 2.086 [base case], 2.532 and 3.538).

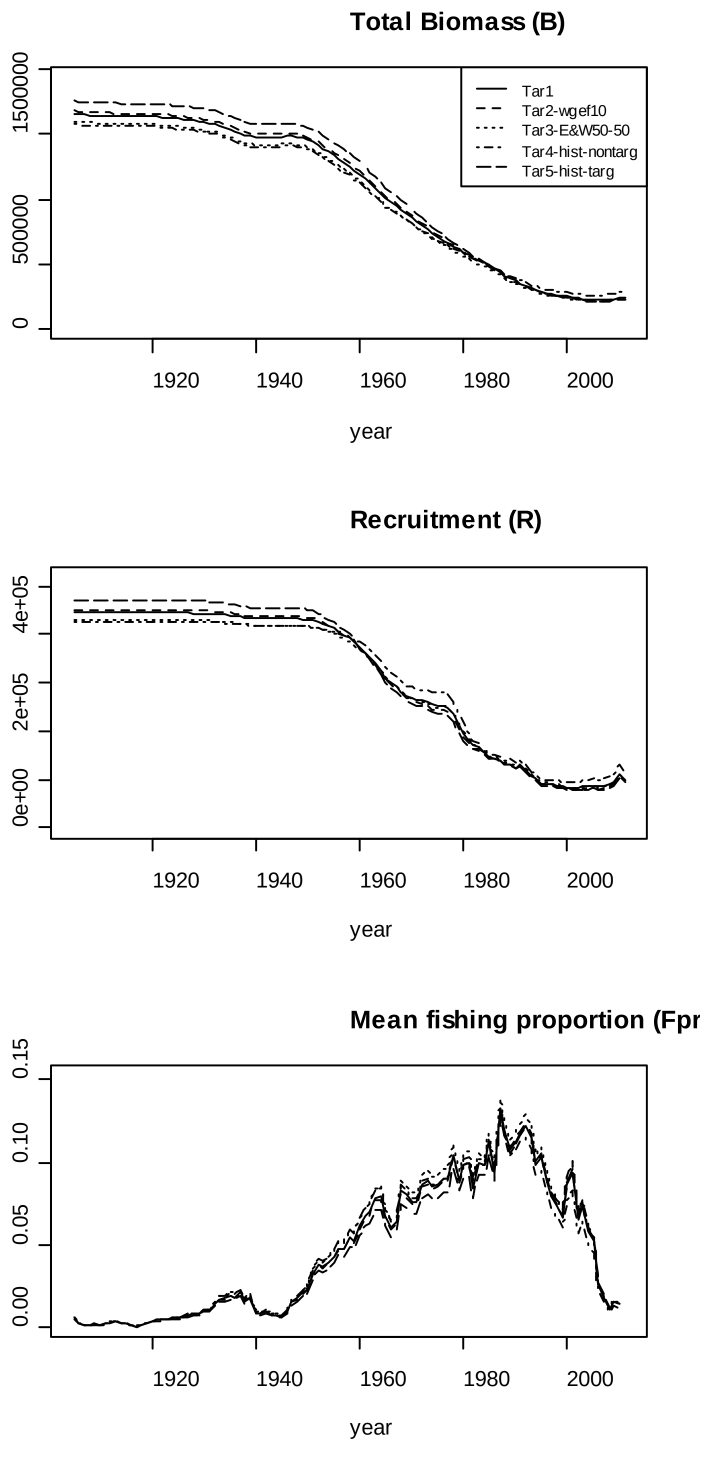


Figure 2.30. Northeast Atlantic spurdog. A comparison of the alternative targeting scenarios, where fishing is defined as either "non-target" (Scottish selectivity) or "target" (England & Wales selectivity). Tar 1 is the base case (each nation is defined "non-target", "target" or a mixture of these, with pre-1980s allocated the average for 1980–1984), Tar 2 is as for WGEF in 2010 (Scottish landings are "non-target", E&W "target", and the remainder raised in proportion to the Scottish/E&W landings, with pre-1980s allocated the average for 1980–1984), Tar 3 as for Tar 2 but with E&W split 50% "non-target" and 50% "target", and Tar 4 and 5 as for Tar 1, but with pre-1980 selectivity entirely non-target (former) or target (latter). This figure is taken from WGEF (2011; i.e. not updated with subsequent data) to illustrate sensitivity to assumptions about historic selection.

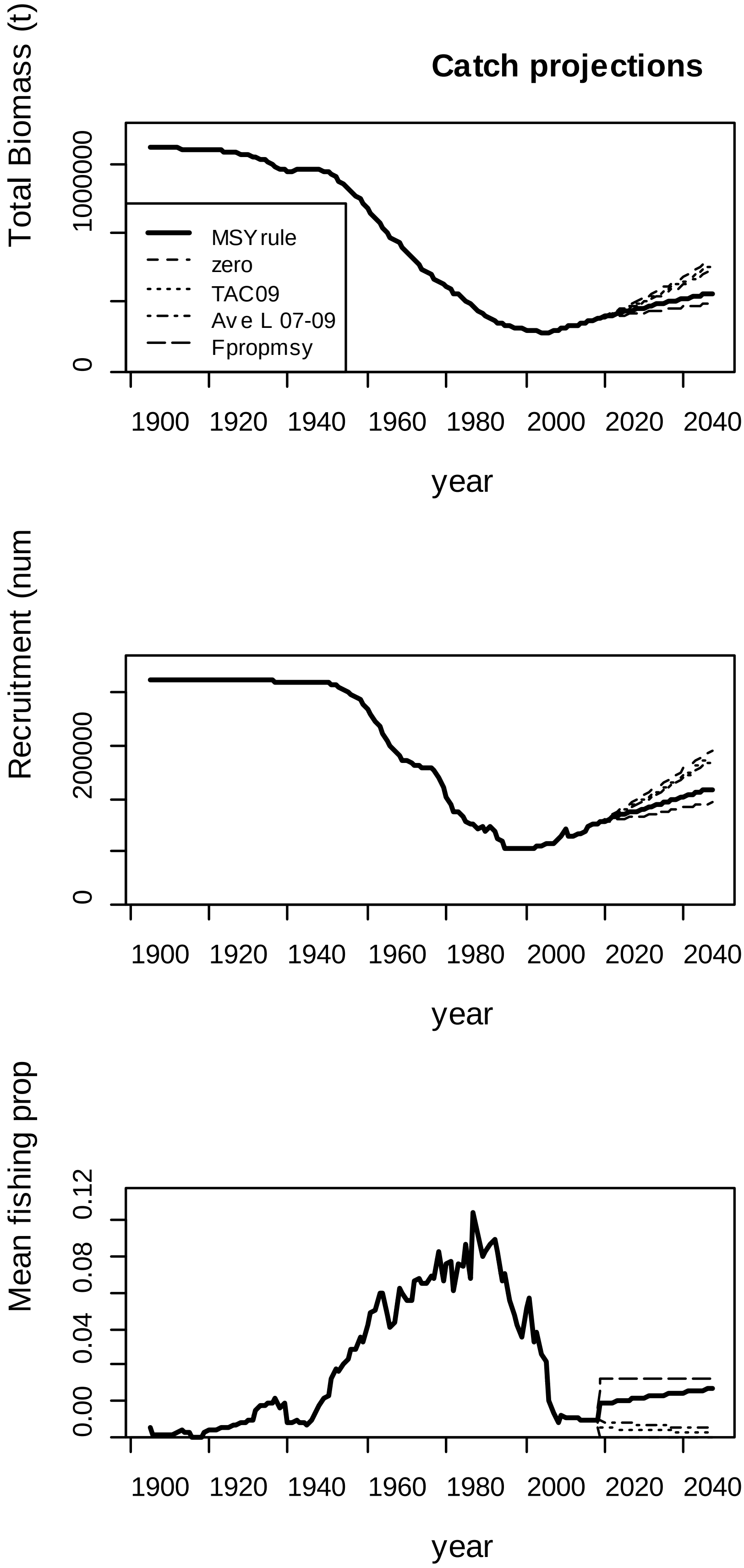


Figure 2.31. Northeast Atlantic spurdog. 30-year projections for different levels of future catch, including zero catch for reference.

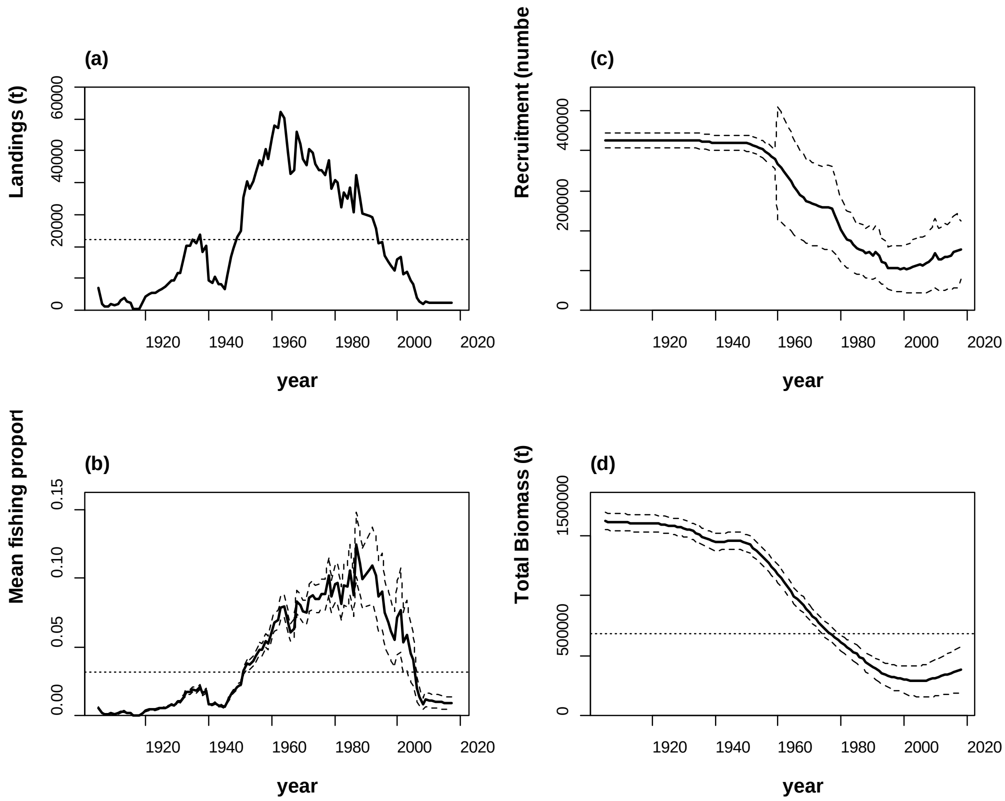


Figure 2.32. Northeast Atlantic spurdog. Summary four-plot for the base-case, showing long-term trends in landings (tons; dotted horizontal line=*MSY*=22 027 t), recruitment (number of pups), mean fishing proportion (average ages 5–30; dotted horizontal line=$F_{prop,MSY}$=0.032) and total biomass (tons; dotted horizontal line= *MSY* $B_{trigger}$=683 340 t). Hashed lines reflect estimates of precision (±2 standard deviations).

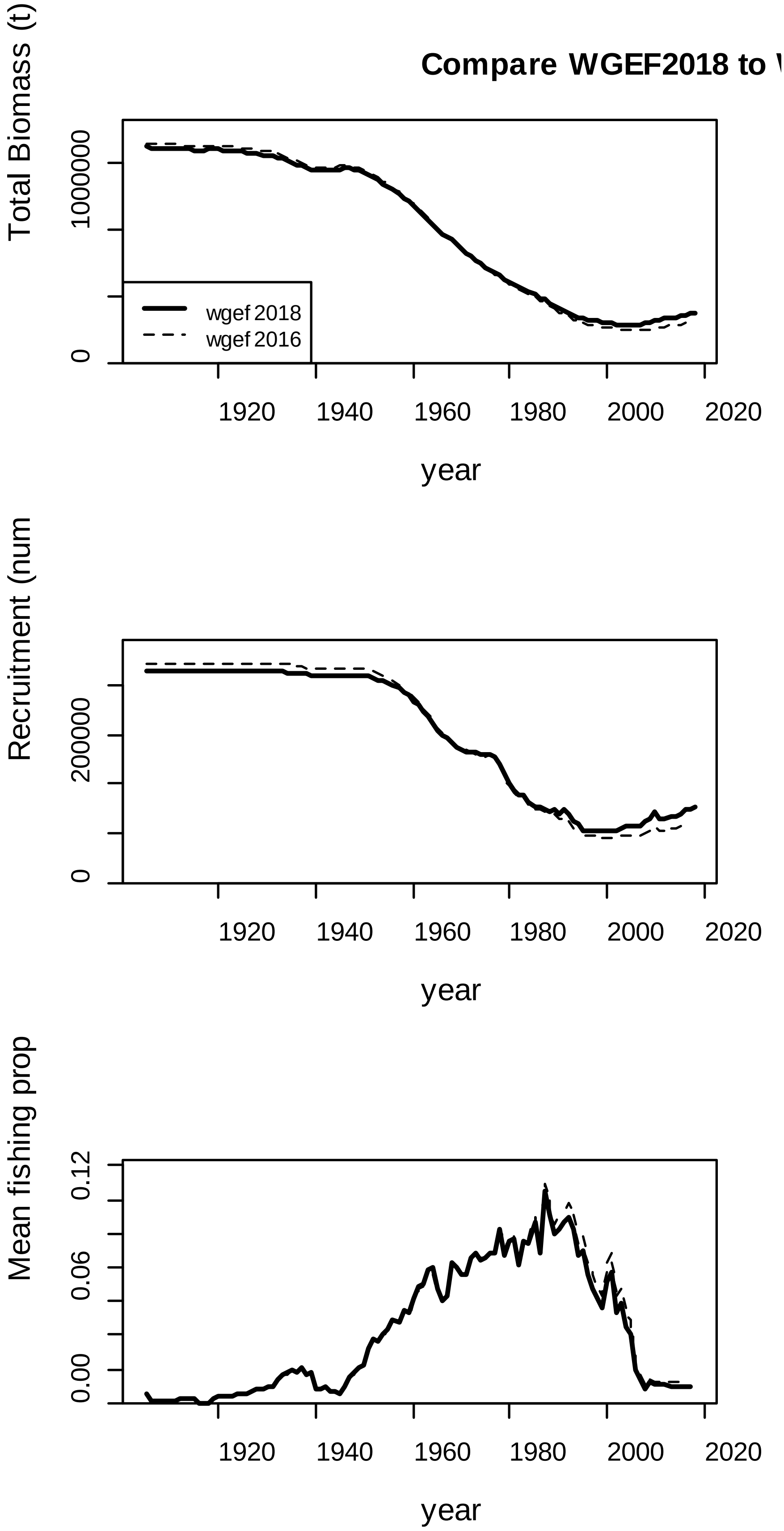


Figure 2.33. Northeast Atlantic spurdog. Comparison with the assessment from WGEF (2016).

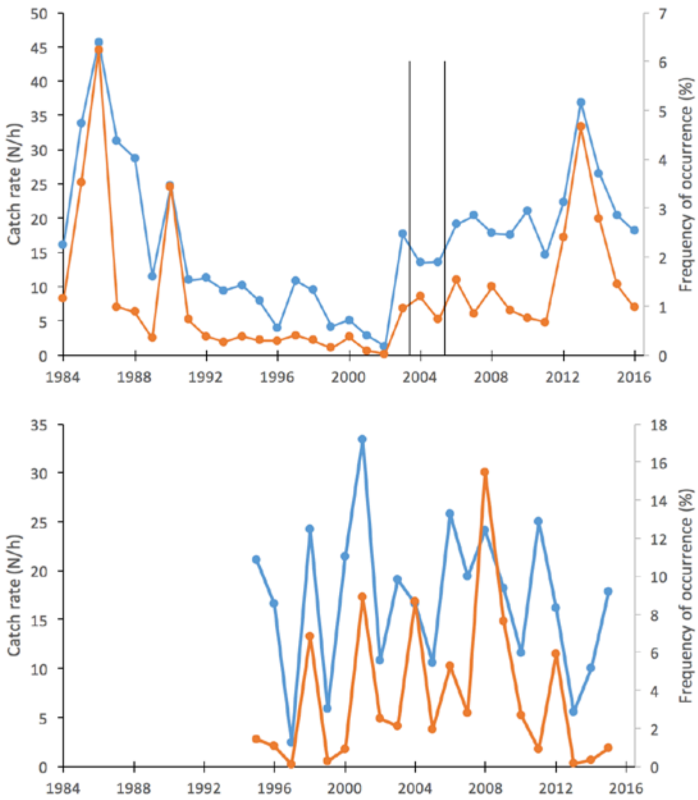


Figure 2.34. Northeast Atlantic spurdog. Survey indices of spurdog in terms of catch rates (orange lines) and frequency of occurrence (blue lines) from the Norwegian Shrimp Survey in South-Norway (top panel) and the Norwegian Coastal Survey in North-Norway (bottom panel). The two vertical lines indicate changes in seasonal coverage of the shrimp survey, being in fourth quarter from 1984, in second quarter from 2004, and in first quarter from 2006.

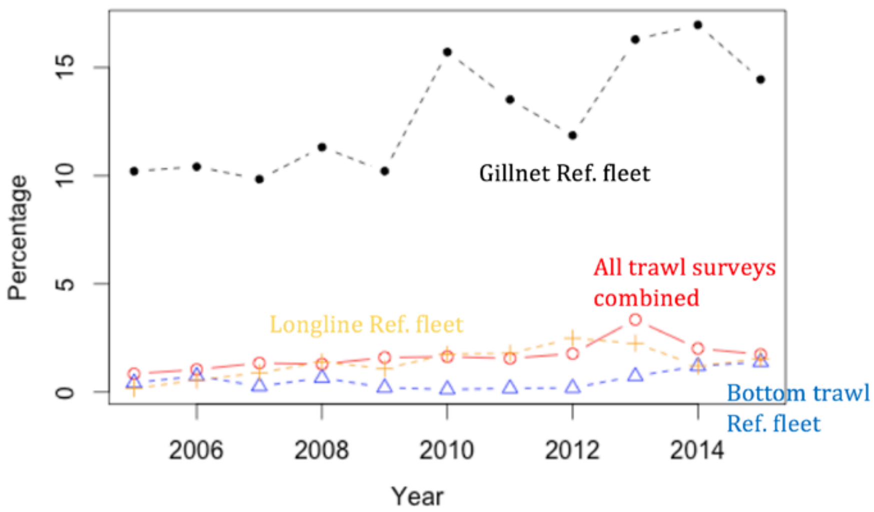


Figure 2.35. Northeast Atlantic spurdog. Percentage occurrence of spurdog in sampled Norwegian commercial catches from each year and from each major fishery groups.

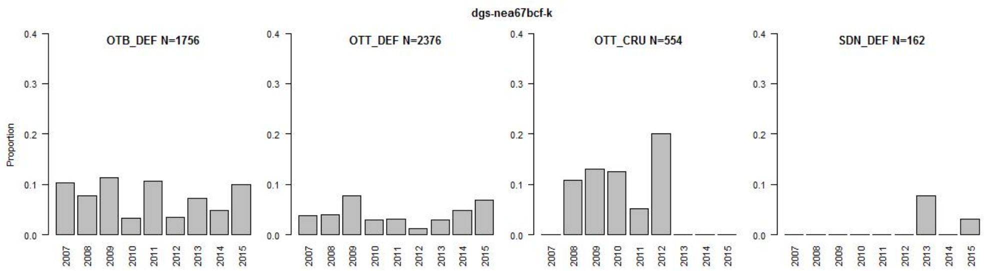


Figure 2.36. Northeast Atlantic spurdog. Proportion of commercial hauls encountering spurdog in French fisheries (main level 5 metiérs catching spurdog) in Subarea 6 and Divisions 7.b-c and 7.f-k for the period 2007–2015. N: total number of fishing operations sampled for the métier.

3 Deep-water sharks; Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14)

ICES provides advice for these species on a quadrennial basis, and only minor editorial changes were made to this chapter in 2018.

3.1 Stock distribution

A number of species of deep-water sharks have been exploited in the ICES area. This section deals with leafscale gulper shark *Centrophorus squamosus* and Portuguese dogfish *Centroscymnus coelolepis*, which have been the two species of greatest importance to commercial fisheries.

In the past in some of European fisheries, landings data for the two species were combined for most of the period since the beginning of the fishery, under a generic term "siki".

3.1.1 Leafscale gulper shark

Leafscale gulper shark has a wide distribution in the NE Atlantic, from Iceland and Atlantic slopes south to Senegal, Madeira and the Canary Islands. On the Mid-Atlantic Ridge, it is distributed from Iceland to the Azores (Hareide and Garnes, 2001). The species can be demersal on the continental slopes (at depths of 230–2400 m) or have a more pelagic behaviour, occurring in the upper 1250 m of oceanic areas with seafloor around 4000 m (Compagno and Niem, 1998).

Available information suggests that this species is highly migratory (Clarke *et al.*, 2001; 2002; Moura *et al.*, 2014). In the NE Atlantic, the distribution pattern formerly assumed considered the existence of a large-scale migration, where females would give birth off the Madeira Archipelago, as there were reports of pregnant females (Severino *et al.*, 2009) in that region. Geo-referenced data show that pregnant females also occur off Iceland, indicating another potentially important reproductive area in the northern part of the NE Atlantic (Moura *et al.*, 2014). Juveniles are only caught rarely. Segregation by sex, size and maturity seems to occur, likely linked to factors such as depth and temperature. Post-natal and mature females tend to occur in relatively shallower sites. Pregnant females are distributed in warmer waters compared to the remaining maturity stages, particularly immature females, which are usually found at greater depths and lower temperatures (Moura *et al.*, 2014). Although based on a small sample size, tagging studies have observed movements from the Cantabrian Sea to the Porcupine Bank (Rodríguez-Cabello and Sánchez, 2014; Rodríguez-Cabello *et al.*, 2016).

Results from a molecular study, using six nuclear loci, did not reject the null hypothesis of genetic homogeneity among NE Atlantic collections (Verissimo *et al.*, 2012). The same study showed that females are less dispersive than males and possibly philopatric. In the absence of more clear information on stock identity, a single assessment unit of the Northeast Atlantic has been adopted.

3.1.2 Portuguese dogfish

Portuguese dogfish is distributed widely in the NE Atlantic. Stock structure and spatial dynamics are poorly understood. Specimens below 70 cm have been recorded rarely.

The absence of small fishes in the NE Atlantic may be a consequence of their concentration in nurseries outside the sampling areas, movement to pelagic or deeper waters, gear selectivity or to different habitat and/or prey choices, with juveniles being more benthic (Moura *et al.*, 2014). Consistent results among different studies show that females move to shallower waters for parturition (Girard and Du Buit, 1999; Clarke *et al.*, 2001; Moura and Figueiredo, 2012 WD; Moura *et al.*, 2014). Similar size ranges and different maturity stages exist in both the northern and southern European continental slopes. The occurrence of all adult reproductive stages within the same geographical area and, in many cases in similar proportions among different areas, suggests that this species is able to complete its life cycle within these areas (Moura *et al.*, 2014).

Population structure studies developed so far using microsatellites and mitochondrial DNA show no evidence of genetic population structure among collections in the NE Atlantic (Moura *et al.*, 2008 WD; Verissimo *et al.*, 2011; Catarino *et al.*, 2015). In the absence of more clear information on stock identity, a single assessment unit of the Northeast Atlantic has been adopted.

3.2 The fishery

3.2.1 History of the fishery

Fisheries taking these species are described in stock annexes for leafscale gulper shark and Portuguese dogfish.

Since 2010, EU TACs for deep-water sharks have been set at zero. Consequently, reported landings for since then were very low or zero. As most of these species are taken as bycatch in mixed fisheries, it is likely that discarding has increased. French vessels operating in Faroese waters reported landings of 10 t in 2015.

3.2.2 The fishery in 2017

No new information.

3.2.3 ICES advice applicable

Leafscale gulper shark: In 2015, ICES advised that "when the precautionary approach is applied for leafscale gulper shark in the Northeast Atlantic, fishing mortality should be minimized and no targeted fisheries should be permitted. This advice is valid for 2016 to 2019".

Portuguese dogfish: In 2015, ICES advises that "when the precautionary approach is applied for Portuguese dogfish in the Northeast Atlantic, fishing mortality should be minimized and no targeted fisheries should be permitted. This advice is valid for 2016 to 2019".

3.2.4 Management applicable

The EU TACs that have been adopted for deep-sea sharks in European Community waters and international waters at different ICES subareas are summarized in the table below. The deep-sea shark category includes the following species (Council regulation (EC) No 1182/2013): Deep-water catsharks *Apristurus spp.*, frilled shark *Chlamydoselachus anguineus*, gulper sharks *Centrophorus spp.*, Portuguese dogfish *Centroscymnus* *coelolepis*, longnose velvet dogfish *Centroscymnus crepidater*, black dogfish *Centroscyllium fabricii*; birdbeak dogfish *Deania calcea*; kitefin shark *Dalatias licha*; greater lantern shark *Etmopterus princeps*; velvet belly *Etmopterus spinax*; mouse catshark *Galeus murinus*; six-gilled shark *Hexanchus griseus*; sailfin roughshark *Oxynotus paradoxus*; knifetooth dogfish *Scymnodon ringens* and Greenland shark *Somniosus microcephalus*.

Since 2015, the two species, leafscale gulper shark and Portuguese dogfish, have been included on the EU prohibited species list for Union waters of Division 2.a and Subarea 4 and in all waters of Subareas 1 and 14 (Council Regulation (EC) No 2014/0311, Art. 13:1(e)).

Council Regulation (EC) No 1568/2005 banned the use of trawls and gillnets in waters deeper than 200 m in the Azores, Madeira and Canary Island areas.

Council Regulation (EC) No 41/2007 banned the use of gillnets by Community vessels at depths greater than 600 m in ICES Divisions 6.a-b, 7.b-c, 7.j-k and Subarea 12. A maximum bycatch of deep-water shark of 5% is allowed in hake and monkfish gillnet catches.

A gillnet ban in waters deeper than 200 m is also in operation in the NEAFC regulatory Area (all international waters of the ICES Area). NEAFC also ordered the removal of all such nets from these waters by the 1st February 2006.

NEAFC Recommendation 7: 2013 requires Contracting Parties to prohibit vessels flying their flag in the Regulatory Area from directed fishing for deep-sea sharks on the following list: *Centrophorus granulosus, Centrophorus squamosus, Centroscyllium fabricii, Centroscymnus coelolepis, Centroscymnus crepidater, Dalatias licha, Etmopterus princeps, Apristurus spp, Chlamydoselachus anguineus, Deania calcea, Galeus melastomus, Galeus murinus, Hexanchus griseus, Etmopterus spinax, Oxynotus paradoxus, Scymnodon ringens* and *Somniosus microcephalus*.

In accordance with EC Regulation 43/2009, "rasco (gillnet)" fishing gear was banned at depths lower than the 600 m isobath. The regulation affected 4–6 boats in the Basque Country that used this technique. The "rasco" fleet targets anglerfish *Lophius spp*., which represents around 90% of catch weight. This métier is highly seasonal, with the highest activity occurring during winter months. Catches during these months tend to occur in deeper waters, where the nets are sunk to depths down to 1000 m. From 2013–2015, a study to characterize the "rasco" métier used by the Basque fleet was carried out. It aimed to assess the impact of this fishery on the bycatch of deep-water species, especially sharks, to manage these fishing activities sustainably. The fishing grounds of this study were located in ICES Division 8.c at more than 12 nm from the coast according to the regulations that prevent fishing within this limit.

Council regulation (EU) 2016/2285 fixed a restrictive by-catch allowance for 2017 and 2018, introduced on a trial basis, permitting limited landings of unavoidable by-catches of deep-sea sharks in directed artisanal deep-sea longline fisheries for black scabbardfish. Specifically, 10 tonnes were allowed for deep-sea sharks in Union and international waters of ICES subareas 5, 6, 7, 8 and 9, in Union and international waters of ICES Subarea 10 and in Union waters of CECAF 34.1.1, 34.1.2 and 34. 2. This allowance was based on ICES indications that the currently applicable restrictive catch limits lead to misreporting of unavoidable by-catches of deep-sea sharks. Directed artisanal deep-sea longline fisheries for black scabbardfish (recognised as a selective fishing gear in such fisheries) have unavoidable bycatches of deep-sea sharks, which are currently discarded dead. According to the council regulation, Member States concerned should develop regional management measures for the fishing of black scabbardfish and establish specific data-collection measures for deep-sea sharks to ensure close monitoring of the stocks.

This regulation affects specifically the Portuguese deep-water longline fishery targeting black scabbardfish in ICES Division 9.a and Subarea 10. A coordinated action plan has already been proposed by Portugal to evaluate management measures to be adopted.

	ICES subareas		
YEAR	5–9	10	12 (includes also *Deania histricosa* and *Deania profondorum)*
2005 and 2006	6763	14	243
2007	2472[(1)]	20	99
2008	1646[(1)]	20	49
2009	824[(1)]	10[(1)]	25[(1)]
2010	0[(2)]	0[(2)]	0[(2)]
2011	0[(3)]	0[(3)]	0[(3)]
2012	0	0	0
2013	0	0	0
2014	0	0	0
2015	0	0	0
2016	0	0	0
2017	10[(4)]	10[(4)]	10[(4)]
2018	10[(4)]	10[(4)]	0[(4)]

[(1)] Bycatch only. No directed fisheries for deep-sea sharks are permitted.

[(2)] Bycatch of up to 10% of 2009 quotas is permitted.

[(3)] Bycatch of up to 3% of 2009 quotas is permitted.

[(4)] Exclusively for bycatch in longline fishery targeting black scabbardfish. No directed fishery shall be permitted.

3.3 Catch data

No new information.

During 2011–2012, the project "Reduction of deep-sea sharks bycatches in the Portuguese longline black scabbard fishery" (Ref. MARE C3/IG/re ARES (2011) 1021013) was carried out to study the bycatch of deep-water sharks, mainly leafscale gulper shark and Portuguese dogfish, in the Portuguese longline fisheries targeting black scabbardfish (mainland Portugal, Azores and Madeira) with the following objectives: i) evaluate the species distributions; ii) evaluate the overlap between deep-sea sharks and black scabbardfish; and iii) evaluate the testing modification of the fishing gear.

WGEF considers that this study does not provide representative information on the distribution of deep-water shark species and on their stocks, as it was restricted to the exploited areas of the deep-water longline fisheries targeting black scabbardfish. Sampling levels were low and did not provide sufficient spatial coverage to allow evaluation of the spatial overlap between deep-sea sharks and black scabbardfish. The trends in estimated biomass indices presented combine quite distinct data sources, logbooks and on-board observations conducted during the project, both sources have substantial caveats. No relevant technical modifications on the fishing gear were evaluated that could contribute to minimize the deep-sea sharks bycatch levels.

Geostatistical studies (Veiga *et al*., 2013; Veiga *et al*., 2015 WD) used fishery-dependent data (vessel monitoring systems, logbooks and official daily landings) to evaluate the spatial distribution and overlap between black scabbardfish and leafscale gulper shark and between black scabbardfish and Portuguese dogfish taken by the longline fishery operating off mainland Portugal (Division 9.a). Results indicated that in fishing grounds where black scabbardfish is more abundant, the relative occurrence of both deep-water shark species are reduced. These findings have implications for alternative management measures to be adopted in this particular fishery, particularly where it concerns the minimization of deep-water shark bycatch.

3.3.1 Landings

Landings of leafscale gulper shark and Portuguese dogfish have historically been included by many countries in mixed landings categories (e.g. sharks 'nei' and dogfish 'nei'). Where possible, WGEF has used the experience of WG participants to assign mixed landings by species. The assumptions that have been made are described in the Stock Annex. For a significant proportion of landings, it was not possible to determine identity to species level and hence the landings presented here are of "siki" sharks are a mixed category comprising mainly *C. squamosus* and *C. coelolepis* but also including unknown quantities of other species.

Figure 3.1 shows the Working Group estimates of combined landings of the two species by country and Figure 3.2 shows Working Group estimates of combined landings of the two species by ICES area. The Working Group estimates of total landings of mixed deep-water sharks, believed to be mainly Portuguese dogfish and leafscale gulper shark but possibly also containing a small component of other species, are presented in Tables 3.1–3.2 by country and ICES area respectively. From 2010 onwards landings are presented by species.

Landings have declined from around 10 000 t in 2001–2004 to one tonne in 2012. The recent decrease in landings is mostly related to the imposition of the EU TAC, which has been set at zero catch since 2010.

3.3.2 Discards

Since 2010, the EU TACs for deep-water sharks have been set at zero, and consequently it is believed that the discarding in mixed deep-water fisheries has increased. Discard data have been previously provided by Portugal (Division 9.a), Spain (Subareas 6, 7 and Divisions 8.c and 9.a), France (Subareas 6–7) and Ireland (Divisions 7.b-c and 7.j-k).

Portugal. The IPMA on-board sampling programme of Portuguese commercial vessels that operate deep-water longlines to target black scabbardfish (métier LLD_DWS_0_0_0), started in mid-2005. Sampling effort was fixed at three trips per quarter and sampled trips and vessels were selected in a quasi-random way (Fernandes *et al*., 2001 WD). However, it is considered that spatial coverage is insufficient to allow discards to be raised to the whole fleet.

To evaluate the level of shark bycatch and discards, and to increase knowledge of the fishery, a pilot study on the Portuguese trammel net fishery targeting anglerfish in Division 9.a (200–600 m deep) took place, under the PNAB/DCF from 2012–2014. Results showed that the fishery targeting anglerfish at depths of 200–600 m had a low frequency of occurrence of Portuguese dogfish. No specimens of leafscale gulper shark were sampled. Higher frequencies are likely to be observed at depths >600 m.

Spain. The Spanish Discards Sampling Programme for Otter and Pair Bottom Trawl (OTB and PTB) fleets, covering ICES subareas 6–7 and divisions 8.c and 9.a was started in 1988; however, it did not have annual coverage until 2003. The sampling strategy and the estimation methodology used follows the "Workshop on Discard Sampling Methodology and Raising Procedures" guidelines (ICES, 2003) and more details of this applied to this area were explained in Santos *et al*. (2010 WD).

Discards of *Centrophorus spp*. are presented in Table 3.3. The estimates are not species-specific; it is unknown whether observers have the necessary identification skills and experience to reliably identify the various species. It should also be noted that observer coverage in this fishery is very low and thus a very large raising factor has been applied. The species composition of discards suggests that the fishery operates at depths shallower than the usual depth range for *Centrophorus spp*. As a consequence, it is admitted that *Centrophorus* contribute only a small percentage to total discards. It does not appear that the sampling has been stratified to account for this depth effect and this probably explains the high inter-annual variation. The results presented in Table 3.3 can therefore not be considered reliable estimates of the quantities discarded. They are included in this report as indicative that some discarding of this genus does occur, and this may be of relatively large magnitude.

France. In 2012 (10 vessels), 2013 (12 vessels) and 2014 (11 vessels) landed >10 t of roundnose grenadier *Coryphanoides rupestris*, black scabbardfish *Aphanopus carbo* and blue ling *Molva dypterygia*. The catch of these 10–12 vessels represented 99% of the total French landings per year of these three species. In the three years (2012–2014), on-board observers boarded seven, 10 and eight of these vessels respectively. The deep-water fishery for these three species is carried out to the west of Scotland, Ireland and in Faroese waters. The majority of the landings are from divisions 6.a, 5.b and 7.c, with an additional 2–3% coming from 7.j. In 2014, all on-board observations of this fishery came from divisions 6.a and 7.b-c. Landings of other deep-water species by French vessels are mostly bycatch in demersal fisheries.

The depth distribution of French on-board observation was assessed by selecting all hauls where a catch of roundnose grenadier, black scabbardfish or blue ling was recorded. Over this eleven-year period, the proportion of deep hauls sampled has reduced (Figure 3.3). In 2014, no hauls deeper than 1200 m were sampled, although the on-board observations covered more than 350 hauls. WGDEEP made the same observation based upon logbooks reported by deep-water fishing vessels, which cover a larger number of hauls (logbooks are not used here since they only include data on landed species and not on deep-water elasmobranchs).

French bycatch of Portuguese dogfish and leafscale gulper shark occurs mainly, if not only, in the deep-water fishery to the West of Scotland. The frequency of occurrence of the two deep-water shark species in French on-board observations does not show clear trends. Variations, including lower occurrence of Portuguese dogfish in recent years or the higher occurrence in 2009–2014 of leafscale gulper shark, may result from the shallower distribution of the fishing grounds (Table 3.4).

French discards were raised using the standard procedure developed in the COST project (Anon., 2009; Jansen *et al*., 2009). The raising of discards to the total fleet activity is problematic. In addition to difficulties identified for several species, Portuguese dogfish and leafscale gulper shark are not landed so that discards cannot be raised to the discards-to-landings ratio and raising should be done using an effort measure. Raising can be done by fishing time, number of trips, number of fishing operations and number of fishing days. Raising to these effort variables returned different estimates of discards, ranging from 13–200 t of Portuguese dogfish and from 40–700 t of leafscale gulper shark.

WGEF 2013 presented an exploratory technique for estimating total catch of Portuguese dogfish and leafscale gulper shark (equivalent to discards since the introduction of the 0 TAC in 2010) using CPUE from onboard sampling raised to fleet level with VMS data. Due to limitations on VMS data availability, the analysis was restricted to the period 2003–2007. It was not possible to further extend this analysis; however it is expected that improved data availability in the future will allow this method to be used to produce estimates of discards from the French fleet in future years.

The approach was applied to leafscale gulper shark and Portuguese dogfish combined. Results by species are not yet fully available, although species were reliably identified at least from 2009 onwards. CPUE was estimated from observer data and these were aggregated spatially through the use of a “nested grid” following the approach used for VMS point data presented by Gerritsen *et al*. (2013). Effort data derived from VMS were then used to raise the gridded CPUE data to estimate total catch. The resulting estimates are given in Table 3.5 together with reported landings in those years. A full description of the method used can be found in an earlier report (ICES, 2013).

3.3.3 Quality of the catch data

Historically, very few countries have provided landing data disaggregated by species. Portugal has supplied species-specific data for many years. Since 2003 onwards, other countries have increased species-specific reporting of landings but some of these data may contain misidentifications.

Furthermore, it is believed that immediately prior to the introduction of quotas for deep-water species in 2001, some vessels may have logged deep-water sharks as other species (and vice versa) in an effort to build up track record for other deep-water species (or deep-water sharks). It was also likely that, before the introduction of quotas for deep-water sharks, some gillnetters may have logged monkfish as sharks.

Misreporting is likely to have increased as a reaction to the EU restrictive measures adopted for deep-water sharks. Data provided as a result of the DCF landing sampling programme at Sesimbra landing port in 2009 and 2010 revealed the existence of misidentification problems (Lagarto *et al*., 2012 WD). Data collected in 2014 indicates that the misidentification problems persist. Sampling data derived from 13 trips on deep-water longliners (a small proportion of the total number of trips) indicate that nearly 50% of the sampled specimens landed as *Galeorhinus galeus* corresponded to leafscale gulper shark and Portuguese dogfish. Despite the limited data available, interquartile ranges of estimated proportion (in weight) of leafscale gulper shark and Portuguese dogfish were 0.01–0.51 and 0.15–0.46, respectively. The wide range obtained is probably associated with differences in catch values between fishing grounds which are, in turn, associated with differences in the spatial distribution pattern of both deep-water sharks (Veiga *et al*., 2013, 2015 WD).

IUU fishing is thought to take place, especially in international waters.

3.3.4 Discard survival

No information is available for commercial fishing operations. Scientific studies have recently tagged leafscale gulper sharks caught by longline at depths of 900–1100 m, indicating that they are capable of surviving capture by that gear (Rodríguez-Cabello and Sánchez, 2014; Rodríguez-Cabello and Sánchez, 2017). According to this study, catch or at-vessel mortality for *C. squamosus* and *C. coelolepis* was lower than expected: 1.2%, and 4.5%, respectively, however, these values increased to 18.9%, and 38.6%, respectively, if the specimens in poor condition were also considered.

It is important to remark that soaking times in these studies were restricted to 2–3 hours and the lines were hauled back at a slower speed (0.4–0.5 m s–1) than under normal fishing practices.

3.4 Commercial catch composition

3.4.1 Species composition

Between 2006 and 2011, WGEF made a number of attempts to split mixed landings data by species using catch ratios from various historical sources. The benchmarked procedure agreed by WKDEEP 2010 is described in the Stock Annex. This methodology was further explored by a dedicated workshop on splitting of deep-water shark historical catch data in 2011 (ICES, 2011). Results from this meeting indicated that the ratio between leafscale gulper shark and Portuguese dogfish varied considerably both temporally and spatially and that further work would be required to reliability split the landings.

In the absence of reliable spatial data at a higher resolution than is currently available to national institutes, no further work has been carried out and no species level landings estimates are presented.

During WKSHARK2, landing data provided by each country was revised in relation to data quality (including taxonomic categories) and protocols to better document the decisions to be made when estimating WG landings were developed (ICES, 2016). Data since 2005 was revised to WGEF 2017 according to WKSHARK2 outcomes and the same format was adopted to submit data in 2018. As a consequence, more reliable new landing figures are available by species since 2005.

3.4.2 Length composition

No new information is available.

3.4.3 Quality of catch and biological data

Despite past efforts to improve the quality of data, particularly on species composition, considerable uncertainties persist on historical data.

Since the reduction of EU TACs to zero, it is expected that significant quantities of both these species are discarded by deep-water fisheries. Although some sampling of discarding has been undertaken, these data are not adequate to estimate the quantities caught.

3.5 Commercial catch–effort data

No new data.

3.6 Fishery-independent surveys

Since 1996, Marine Scotland Science has conducted a monitoring deep-water survey in Subarea 6 at depths ranging from 300–2040 m. This survey can be considered to be standardised in terms of depth coverage since 1998.

Ireland carried out a deep-water survey each year in subareas 6 and 7, concentrating off north-western Ireland and west of Scotland, and the Porcupine Bank area to the west of Ireland. Fishing took place at 500 m, 1000 m, 1500 m and 1800 m. The survey took place in September from 2006–2008 and in December 2009. No further surveys have since taken place.

These and other surveys were part of a planned coordinated survey in the ICES area, through the Planning Group on Northeast Atlantic Continental Slope Surveys (WGNEACS). WGNEACS 2012 was dedicated mainly to the design of a longline survey in Bay of Biscay and Iberian waters. One of its main objectives would be to clarify the distribution of all the deep-water sharks and to provide data to monitor their stock status, in the absence of commercial fisheries data.

3.7 Life-history information

No new information.

3.8 Exploratory assessments

3.8.1 Analyses of Scottish deep-water survey data

A Generalized Additive Model (GAM) with a negative binomial distribution was used to standardise abundance indices for leafscale gulper shark and Portuguese dogfish caught in the Scottish deep-water survey for the period from 2000 to 2017 (Campbell, 2018 WD). The survey covered depths of 300–2040 m and the continental slope between approximately 55°N and 59°N (Figs 3.4–3.5). The survey has occasionally carried out hauls at Rockall and Rosemary Bank, which could potentially bias the results. Therefore, those stations have been excluded from the GAM analysis and data are exclusively derived from hauls on the continental slope. The majority of hauls were made at the following strata: 500, 1000, 1500 and 1800 m. In any one year, there were usually around 5–6 hauls for each of these depth strata. Data used in the model were restricted to the "core" depth range for each species, established through visual inspection of the data. Core depth ranges for Portuguese dogfish and leafscale gulper shark were considered to be 700–1900 m and 500–1800 m, respectively. The percentages of hauls within the expected depth range in which both deep-water sharks were caught are presented in Figures 3.6–3.7. The model took the form:

No ~ duration+ depth+ latitude + year

Depth, latitude and duration entered in the model as smoothed terms and year as a factor. Summaries of the model fits for both species are presented in Table 3.7 and Figures 3.8–3.9.

The abundance index was standardised to a fixed duration of 60 minutes for both species, and to a depth of 1000 m and latitude 57°N for leafscale gulper shark, and 1600 m and 56°N for Portuguese dogfish. These reference depths and latitudes were selected to reflect highest catch rates and low standard deviation in the fitted GAMs. Standardised abundance indices are plotted in Figures 3.10–3.11.

Abundance estimates show no clear trend for Portuguese dogfish, while for leafscale gulper shark abundance appeared to increase and stabilize in recent years after a decreasing trend from 2005 to 2011 (Figures 3.10 and 3.11). The proportion of positive (with catch of the species) hauls shows no temporal trend for Portuguese dogfish, while for leafscale gulper shark have stabilized at medium level in recent years after an initial decreasing trend (Figures 3.6 and 3.7).

3.8.2 Analyses of Portuguese data

To evaluate the spatial overlap between Portuguese dogfish and leafscale gulper shark with the targeted black scabbardfish, IPMA conducted a pilot survey on board commercial fishing vessels from the Portuguese mainland black scabbard fishery (Veiga, 2015 WD). Ten fishing hauls were sampled, half of them located at the fishing grounds exploited by the black scabbardfish fleet (BSF fishing grounds) and the other half located at deeper areas adjacent to these fishing grounds; each pair carried out by one vessel (five vessels in the total). For each fishing haul, the proportion of each shark species was estimated as the quotient between the caught weight of the deep-water shark under analysis and the sum of the caught weight of black scabbardfish and of that deep-water shark. Table 3.8 shows the proportion values obtained for Portuguese dogfish and leafscale gulper shark by fishing trip. Within vessels, the proportions differed between the BSF fishing grounds from those located deeper, with values being higher at the latter. The Wilcoxon rank sum was used to test the equality between paired samples. For the two species, the p-values were significant (p-value = 0.01 and 0.08 for Portuguese dogfish and leafscale gulper shark, respectively) at 0.1 significance level, suggesting important differences in the proportion between BSF fishing grounds and deeper fishing grounds.

3.9 Stock assessment

No new assessments were undertaken in 2016.

Previous work applied the Category 3 approach to these stocks (ICES, 2012). The indicator used for each species was GAM standardized CPUE derived from the Scottish deep-water survey (2000–2013, see Section 3.8.1). The stock size indicator was assessed using the ratio between the mean value for 2012–2013 and the mean of the preceding five-year period (2007–2011, noting that there was no survey in 2010). For both stocks, as current landings are (near) zero, the application of the category 3 approaches gives advice of zero.

The application of the benchmarked model requires historical data discriminated by species from the different areas within the stock NE Atlantic. Such data is unavailable as historical data is not split by species. Efforts so far (e.g. WKSHARKS) were not able to split the historical data. Current discard estimates are not standardized yet so it cannot be used for further catch estimates.

3.10 Quality of the assessments

In the absence of fishery-dependent data, the status of these species can only be ascertained from fishery-independent data. Abundance indices used in previous assessments were exclusively derived from the Scottish deep-water survey. However there are concerns of applying this survey to infer stock status as it takes place in a small proportion of the management area. Furthermore, these data are only available for the period after the development of the fishery. There are no fishery-independent data for areas further south, which prevents understanding of trends in abundance in these areas.

The absence of landings data as a result of the reduction of EU TACs to zero creates difficulties for assessing stock status for both species. Many countries formerly reported landings of Portuguese dogfish and leafscale gulper shark combined with other deep-water sharks in categories such as “siki sharks”. Unless suitable data can be found to enable splitting of the catch data, historical catch levels will remain uncertain. Discards are known to occur, but have not been fully quantified, and survival is expected to be very low.

3.11 Reference points

WGEF was not able to propose appropriate reference points for advice under the MSY framework. Methods for establishing MSY reference points and/or proxies for similar data-poor stocks are continuing and WGEF will use this work as a basis to develop reference points for deep-water sharks.

3.12 Conservation considerations

The recent Red List of European marine fish considered both leafscale gulper shark and Portuguese dogfish to be Endangered (Nieto *et al*., 2015).

3.13 Management considerations

Some species of deep-water shark are considered to have very low population productivity.

On the basis of the precautionary approach, ICES has routinely advised against targeted fisheries on leafscale gulper shark and Portuguese dogfish.

Whilst the zero TAC for deep-water sharks has prevented targeted fisheries for deep-water sharks, these species can still be a bycatch in other deep-water fisheries. The level of bycatch in these fisheries is uncertain.

There are limited data to evaluate the stocks of these species. The Scottish deep-water survey provides a meaningful time-series of species-specific data, but this survey commenced after the fishery was already established, and only covers a parts of the stock ranges for both the leafscale gulper shark and the Portuguese dogfish. Fishery-independent data from other areas of the stock range are limited or lacking.

3.14 References

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Table 3.1. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Working Group estimate of combined landings of Portuguese dogfish and leafscale gulper shark (t) by ICES area. Landings are combined until 2009; from 2010 onwards landings are presented by species (leafscale gulper shark - Portuguese dogfish). UA, unknown area.

	4.a	5.a	5.b	6	7	8	9	10	12	14	UA	Total
1988	0	0	0	0	0	0	560	0	0	0	0	560
1989	12	0	0	8	0	0	507	0	0	0	0	527
1990	8	0	140	6	0	6	475	0	0	0	0	635
1991	10	0	75	1013	265	70	1075	0	1	0	0	2509
1992	140	1	123	2013	1171	62	1114	0	2	0	0	4626
1993	63	1	97	2781	1232	25	946	0	7	0	0	5152
1994	98	0	198	2872	2087	36	1155	0	9	0	0	6455
1995	78	0	272	2824	1800	45	1354	0	139	0	0	6512
1996	298	0	391	3639	1168	336	1189	0	147	0	0	7168
1997	227	0	328	4135	1637	503	1311	0	32	9	0	8182
1998	81	5	552	4133	1038	605	1220	0	56	15	0	7705
1999	55	0	469	3471	895	531	972	0	91	0	0	6484
2000	1	1	410	3455	892	361	1049	0	890	0	0	7059
2001	3	0	475	4459	2685	634	1130	0	719	0	0	10105
2002	10	0	215	3086	1487	669	1198	0	1416	12	0	8093
2003	16	0	300	3855	3926	746	1180	0	849	4	0	10876
2004	5	0	229	2754	3477	674	1125	0	767	0	0	9031
2005	4	0	239	1102	842	376	1033	1	134	0	1323	5054
2006	4	0	195	638	323	208	1325	0	0	0	34	2727
2007	3	0	590	737	94	23	517	0	1	61	0	2025
2008	1	0	171	621	111	27	463	0	0	0	0	1393
2009	1	0	24	54	4	105	33	0	0	0	0	220
2010	1 - 0	0 – 0	38 - 8	21 - 22	4 - 0	4 - 1	4 - 1	0 - 0	0 - 0	0 - 0	0 - 0	71 - 33
2011	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	1 - 0	1 - 1	0 - 0	0 - 0	0 - 0	0 - 0	2 - 1
2012	0 - 0	0 - 0	51 - 0	0 - 0	0 - 0	0 - 0	1 - 0	0 - 0	0 - 0	0 - 0	0 - 0	52 - 1
2013	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
2014	0 - 0	0 - 0	32 - 5	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	33 - 5
2015	1-0	0 - 0	9-0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	10-0
2016	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0-0
2017	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	3 – 7	0 - 0	0 - 0	0 - 0	0 - 0	0-0

Table 3.2. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Working Group estimate of combined landings of Portuguese dogfish and leafscale gulper shark (t) in the Northeast Atlantic by country. Landings are combined until 2009; from 2010 onwards landings are presented by species (leafscale gulper shark - Portuguese dogfish).

	France	UK (Scot)	UK (E&W)	Ireland	Iceland	Spain (Basque)	Portugal	Germany	Estonia	Latvia	Lithuania	Poland	Russia	Spain (Galicia)	Faeroe Island	Norway	Total
1988	0	0	0	0	0	0	560	0	0	0	0	0	0	0	0	0	560
1989	0	20	0	0	0	0	507	0	0	0	0	0	0	0	0	0	527
1990	140	14	0	0	0	0	481	0	0	0	0	0	0	0	0	0	635
1991	1288	24	104	0	0	0	1093	0	0	0	0	0	0	0	0	0	2509
1992	3104	165	80	0	1	0	1128	148	0	0	0	0	0	0	0	0	4626
1993	3468	469	174	0	1	0	946	91	0	0	0	0	0	0	3	0	5152
1994	3812	743	387	0	0	0	1155	358	0	0	0	0	0	0	0	0	6455
1995	3186	801	986	33	0	0	1354	92	0	0	0	0	0	0	60	0	6512
1996	3630	576	1036	5	0	286	1189	164	0	0	0	0	0	0	282	0	7168
1997	3095	766	2202	0	0	473	1314	106	0	0	0	0	0	0	226	0	8182
1998	3177	1007	1494	3	5	561	1260	40	0	0	0	0	0	0	158	0	7705
1999	3079	625	1019	2	0	450	1036	214	0	0	0	0	0	0	54	5	6484
2000	3519	623	413	138	0	280	1108	265	0	0	0	0	0	572	23	118	7059
2001	3684	2429	320	454	0	608	1151	431	0	0	14	0	0	615	0	399	10105
2002	2103	1184	335	577	0	621	1198	518	53	0	40	8	0	1381	0	75	8093
2003	1454	1594	4027	493	0	719	1180	640	4	0	28	0	0	737	0	0	10876
2004	1189	1135	3610	764	0	563	1125	0	0	0	0	0	0	626	0	19	9031
2005	866	802	1533	381	0	359	1033	79	0	0	0	0	0	0	0	0	5053
2006	744	184	537	113	0	78	1072	0	0	0	0	0	0	0	0	0	2727
2007	855	86	23	36	0	0	522	0	0	0	1	0	500	0	0	0	2023
2008	802	49	7	8	0	0	463	0	0	0	62	0	0	0	3	0	1393

	France	UK (Scot)	UK (E&W)	Ireland	Iceland	Spain (Basque)	Portugal	Germany	Estonia	Latvia	Lithuania	Poland	Russia	Spain (Galicia)	Faeroe Island	Norway	Total
2009	52	30	0	0	0	84	54	0	0	0	0	0	0	0	0	0	220
2010	63 - 10	1 - 20	0 - 0	0 - 0	0 - 0	0 - 0	7 - 2	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	71 - 33
2011	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	1 - 1	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	2 - 1
2012	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	1 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	51 - 0	0 - 0	52 - 1
2013	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
2014	33 - 5	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	33 - 5
2015	10-0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	10-0
2016	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0-0
2017	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	7 - 3	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0-0

Table 3.3. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Spanish discard data for Centrophorus spp. Numbers of sampled trips and total trips are not yet available for the years 2010 onward.

Year	Celtic Sea (Subareas (VI-VII))			Iberian Waters (Divisions (VIIIc–IXa))		
	Sampled trips	Total trips	Raised discards (t)	Sampled trips	Total trips	Raised discards (t)
2003	9	1172	0	51	18 036	0
2004	11	1222	0	53	20 819	0
2005	10	1194	0	97	11 693	4.5
2006	13	1152	3.2	75	18 352	4.1
2007	12	1233	0	95	17 750	0
2008	11	1206	67.3	103	15 114	0
2009	15	1304	61.1	116	14 486	85.9
2010			0			29.2
2011			0			0.9
2012			173.4			0.7
2013			0			0

Table 3.4. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Total number of fishing trips, number of hauls and number of hauls with catch of Portuguese dogfish and leafscale gulper shark in French on-board observations (2005–2014).

Year	Country	Total number of		Portuguese dogfish (positive hauls)		Leafscale gulper shark (positive hauls)	
		Trips	Hauls	Number	Proportion	Number	Proportion
2005	France	18	212	26	0.12	9	0.04
2006	France	9	106	18	0.17	1	0.01
2007	France	6	15	1	0.07	35	0.14
2008	France	18	245	12	0.05	143	0.24
2009	France	42	605	89	0.15	120	0.24
2010	France	48	504	93	0.18	71	0.16
2011	France	29	443	67	0.15	93	0.21
2012	France	32	449	35	0.08	79	0.18
2013	France	36	447	27	0.06	72	0.20
2014	France	31	365	34	0.09	9	0.04

Table 3.5. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Catch of "siki" sharks per year estimated from on-board observation cpue (average 2004–2012) multiplied by VMS effort in 2003–2007 compared to logbook landings (all French landings) in the same years.

Year	Nested grid estimate	Logbook landings
2003	1492.8	1454
2004	1543.2	1189
2005	1321.4	866
2006	926.0	744
2007	866.8	855

Table 3.6. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Data included in the GAM analysis of Scottish deep-water survey data: numbers of hauls within the specified depth range, numbers of individuals caught and numbers caught per hour.

	Portuguese Dogfish			Leafscale gulper shark		
Year	No. Hauls	No. Fish	Mean NpH	No. Hauls	No. Fish	Mean NpH
2000	22	103	4.68	29	70	2.41
2002	20	63	3.15	26	65	2.50
2004	14	26	1.86	23	18	0.78
2005	14	39	2.79	19	46	2.42
2006	20	35	1.75	28	34	1.21
2007	13	35	2.69	19	16	0.84
2008	20	40	2.00	28	11	0.39
2009	28	31	1.11	35	19	0.54
2011	20	30	1.50	25	0	0.00
2012	21	31	1.48	26	4	0.15
2013	21	49	2.33	21	16	0.76
2015	23	90	3.91	28	15	0.54
2017	29	25	0.86	30	28	0.93

Table 3.7. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Summary of model fit GAM analysis of Portuguese dogfish in Scottish deep-water surveys (2000–2017).

Portuguese dogfish	Estimate	Standard Error	T value	Pr(>|t|)	Significance
(Intercept)	0.1119	0.22665	0.494	0.62149	
as.factor(year)2002	-0.06629	0.17584	-0.377	0.706167	
as.factor(year)2004	-0.69668	0.22947	-3.036	0.002397	**
as.factor(year)2005	-0.33847	0.20229	-1.673	0.094284	.
as.factor(year)2006	-0.75307	0.20518	-3.67	0.000242	***
as.factor(year)2007	-0.32088	0.23816	-1.347	0.177871	
as.factor(year)2008	-0.45577	0.21325	-2.137	0.032579	*
as.factor(year)2009	-0.36289	0.40541	-0.895	0.370725	
as.factor(year)2011	-0.76982	0.45908	-1.677	0.093564	.
as.factor(year)2012	-0.08749	0.37911	-0.231	0.817492	
as.factor(year)2013	-0.25891	0.39541	-0.655	0.5126	
as.factor(year)2015	0.57163	0.35286	1.62	0.105236	
as.factor(year)2017	-1.14578	0.39895	-2.872	0.004079	**

	e.d.f	Reference degrees of freedom	Chi squared	p-value	Significance
s(duration)	7.963	8.705	33.73	8.58E-05	***
s(depth)	8.430	8.893	405.63	2.00E-16	***
s(latitude)	8.734	8.973	126.52	2.00E-16	***

Leafscale gulper shark	Estimate	Standard Error	T value	Pr(>|t|)	Significance
(Intercept)	-0.0135	0.2125	-0.063	0.949452	
as.factor(year)2002	0.0557	0.1810	0.308	0.7582	
as.factor(year)2004	-1.0090	0.2695	-3.742	0.000182	***
as.factor(year)2005	-0.1612	0.2087	-0.772	0.439892	
as.factor(year)2006	-0.5580	0.2168	-2.574	0.01005	*
as.factor(year)2007	-0.7916	0.2871	-2.757	0.005834	**
as.factor(year)2008	-1.4150	0.3379	-4.188	2.81E-05	***
as.factor(year)2009	-1.1090	0.4138	-2.679	0.00738	**
as.factor(year)2011	-43.8600	13420000	0	0.999997	
as.factor(year)2012	-2.2270	0.5898	-3.777	0.000159	***
as.factor(year)2013	-0.7001	0.3925	-1.784	0.074485	.
as.factor(year)2015	-0.8465	0.3958	-2.139	0.032454	*
as.factor(year)2017	-0.5225	0.3536	-1.478	0.13947	

	e.d.f	Reference degrees of freedom	Chi squared	p-value	Significance
s(duration)	3.524	4.273	5.458	0.242	
s(depth)	7.288	8.112	187.766	2.00E-16	***
s(latitude)	5.47	6.53	32.831	2.05E-05	***

Table 3.8. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Fishing hauls depth and proportion values of both species from the pilot study conducted onboard of commercial fishing vessels from the Portuguese mainland black scabbard fishery. PCYO, proportion of Portuguese dogfish; PGUQ proportion of leafscale gulper shark.

	BSF fishing grounds (depth, m)	Deeper fishing grounds (depth, m)	BSF fishing ground		Deeper fishing ground	
			P_{CYO}	P_{GUQ}	P_{CYO}	P_{GUQ}
Vessel 1	1170	1463	---	0.026	0.884	0.881
Vessel 2	1357	1461	---	0.148	0.893	0.334
Vessel 3	1180	1376	0.224	0.074	0.720	0.267
Vessel 4	1198	1382	0.122	0.112	0.820	0.734
Vessel 5	1189	1445	0.058	0.110	0.279	0.044

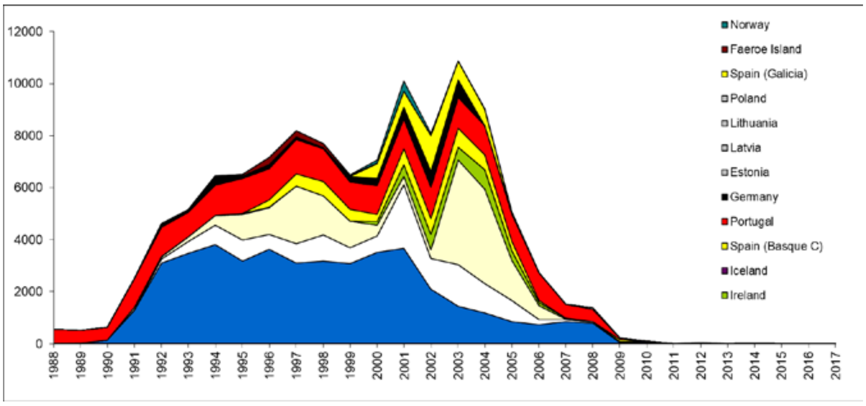


Figure 3.1. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Working Group estimates of combined landings of the two species, by country.

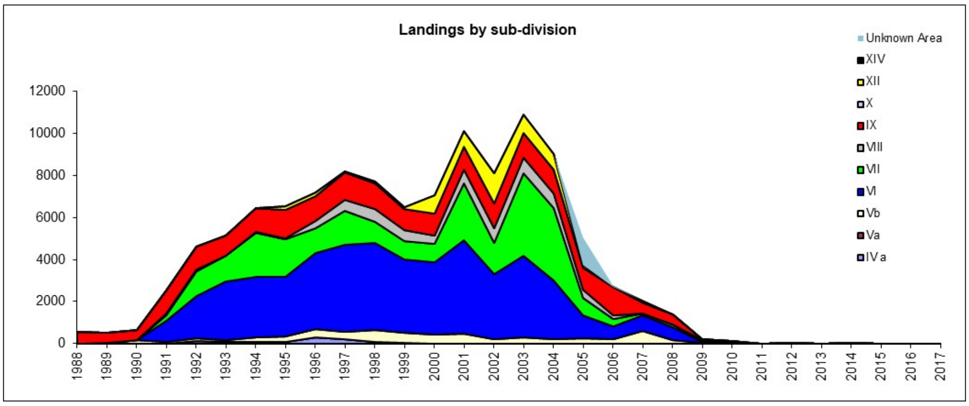


Figure 3.2. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Working Group estimates of combined landings of the two species, by ICES Subarea.

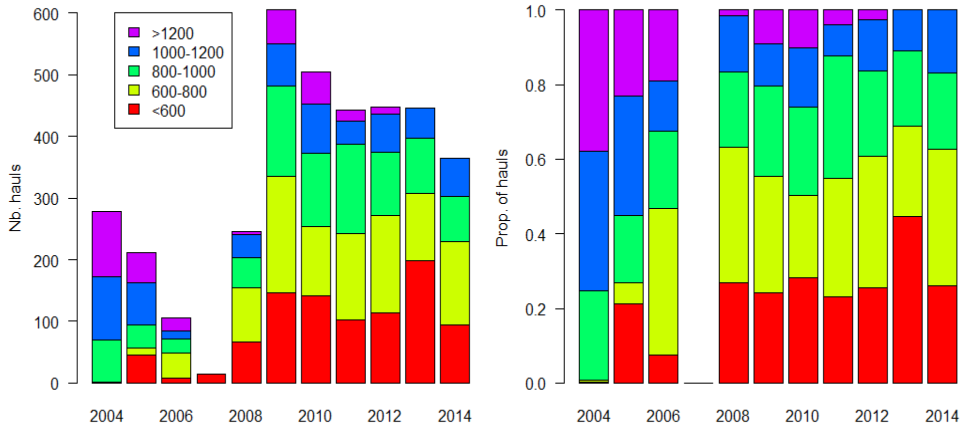
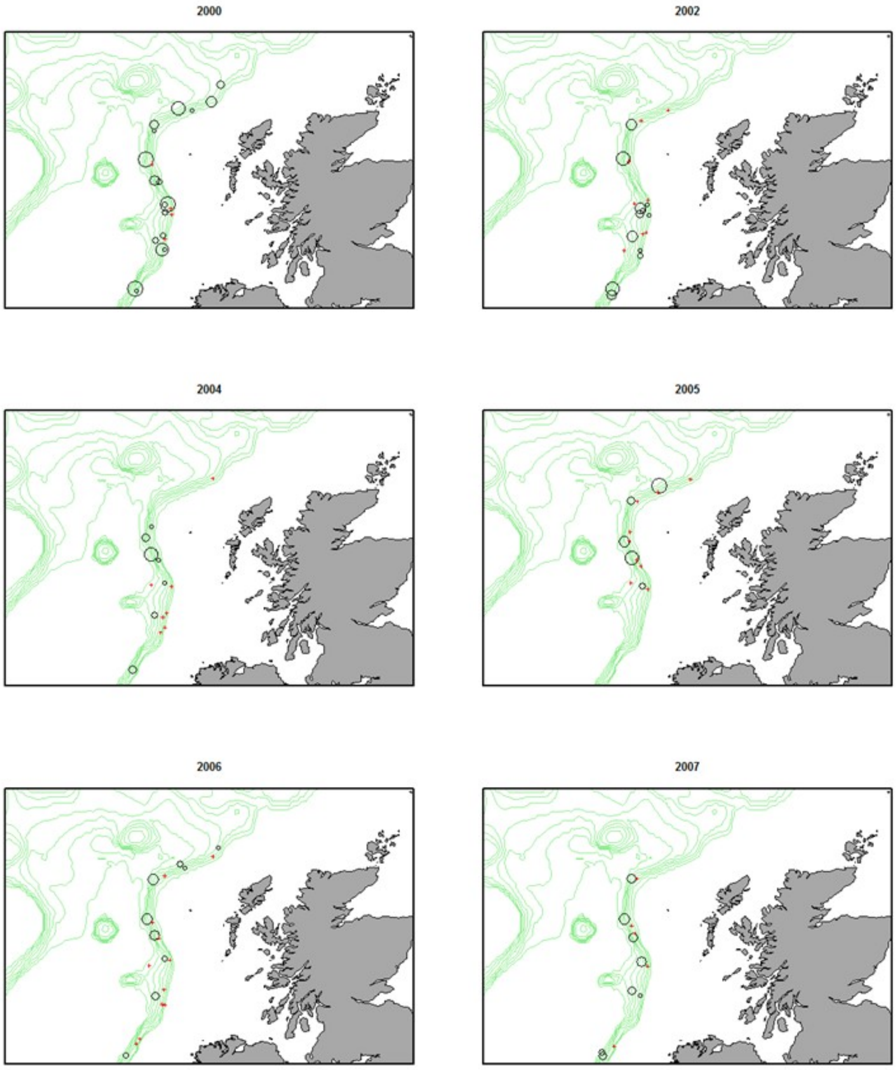


Figure 3.3. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Depth distribution of on-board observation of French deep-water fisheries 2004–2014, number of hauls per 200 m depth range (left) and proportions (right), proportions in 2007 where there was no sampling dedicated to deep-water fisheries are not given.


2000
2002
2004
2005
2006
2007

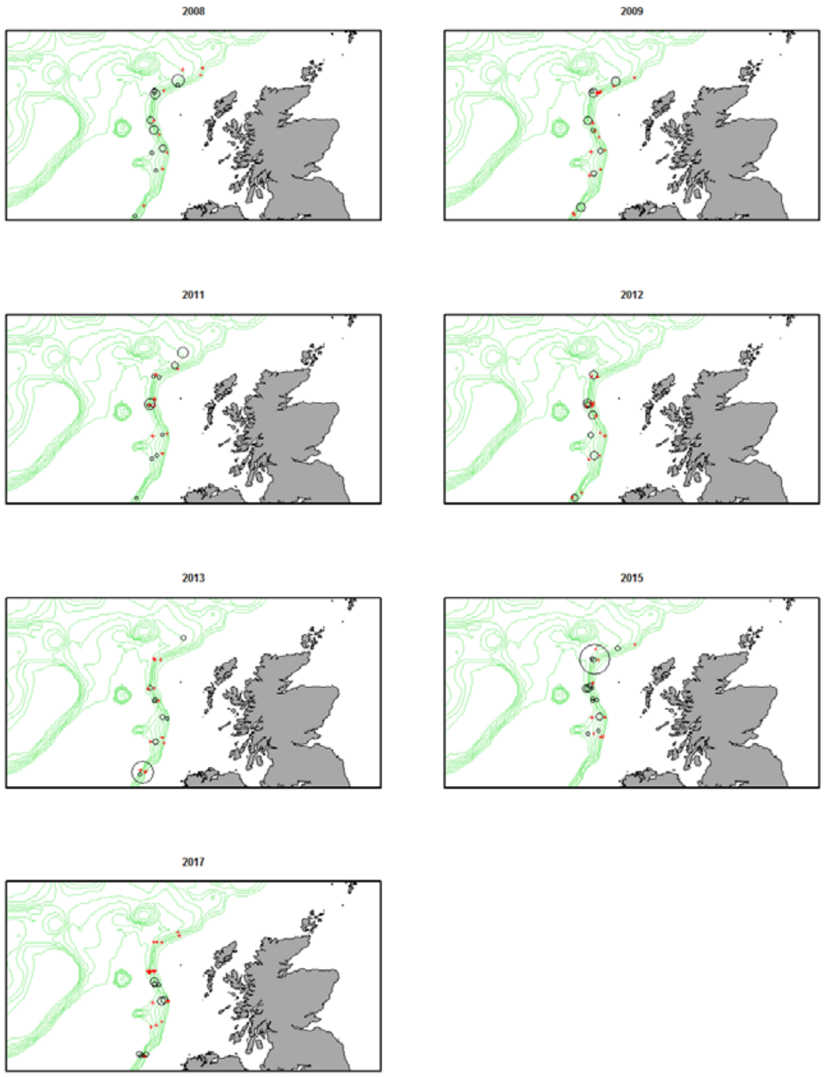
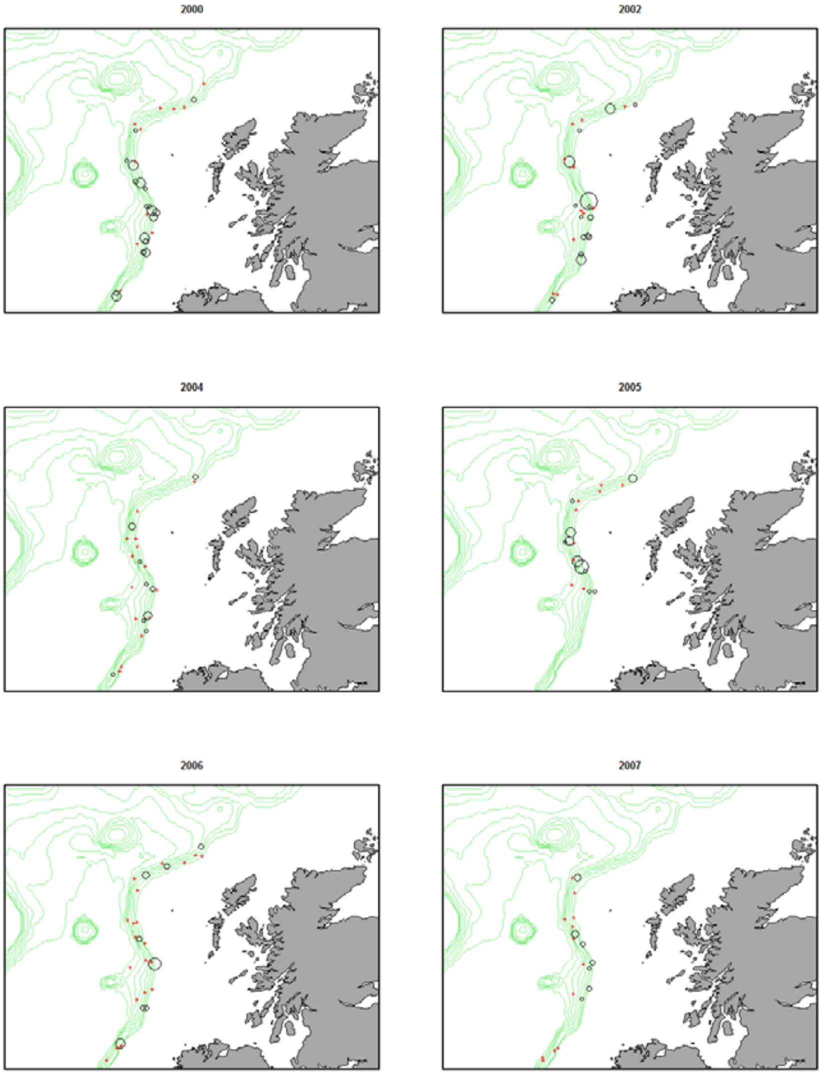


Figure 3.4. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Distribution of catches of Portuguese dogfish within the expected depth range (700 to 1900 m) in Scottish deep-water surveys 2000 to 2017. Solid circles indicate catches of one or more individuals, open circles hauls with no catch of this species.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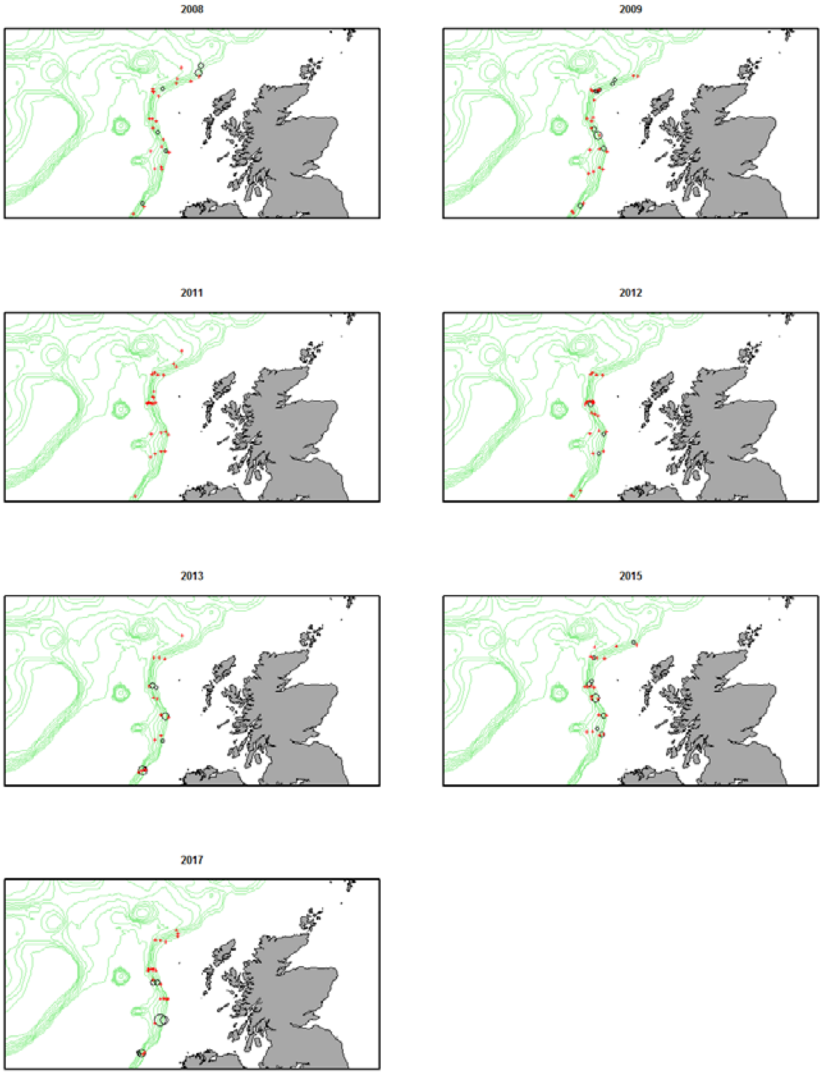

Figure 3.5. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Distribution of catches of leafscale gulper shark within the expected depth range (500 to 1800 m) in Scottish deep-water surveys 2000 to 2017. Solid circles indicate catches of one or more individuals, open circles hauls with no catch of this species.

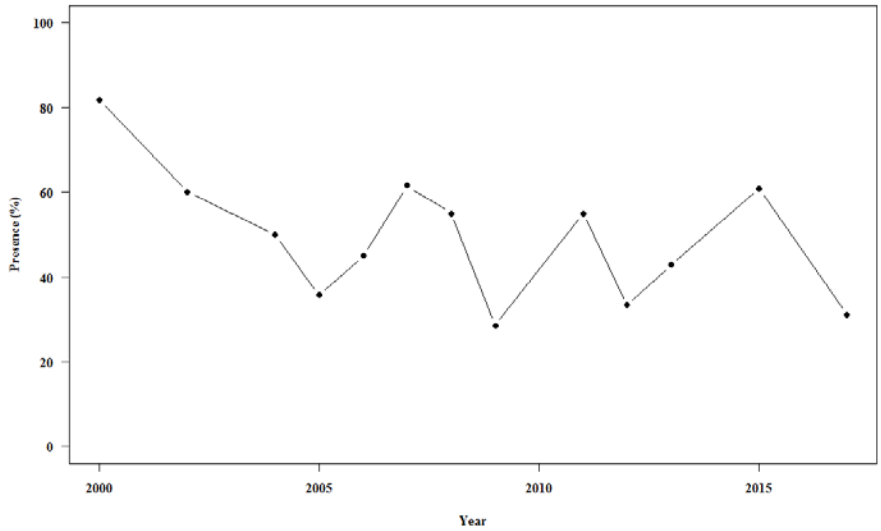

Figure 3.6. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Percentage of hauls within the expected depth range (700 to 1900 m) in which Portuguese dogfish were caught. Scottish deep-water surveys 2000 to 2017 slope stations only.

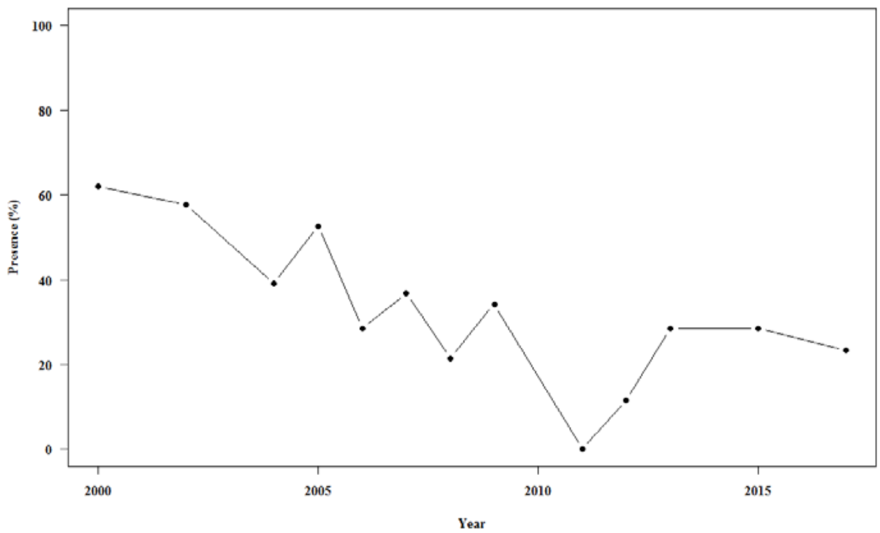

Figure 3.7. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Percentage of hauls within the expected depth range (500–1800 m) in which Leafscale gulper shark were caught. Scottish deep-water surveys 2000 to 2017 slope stations only.

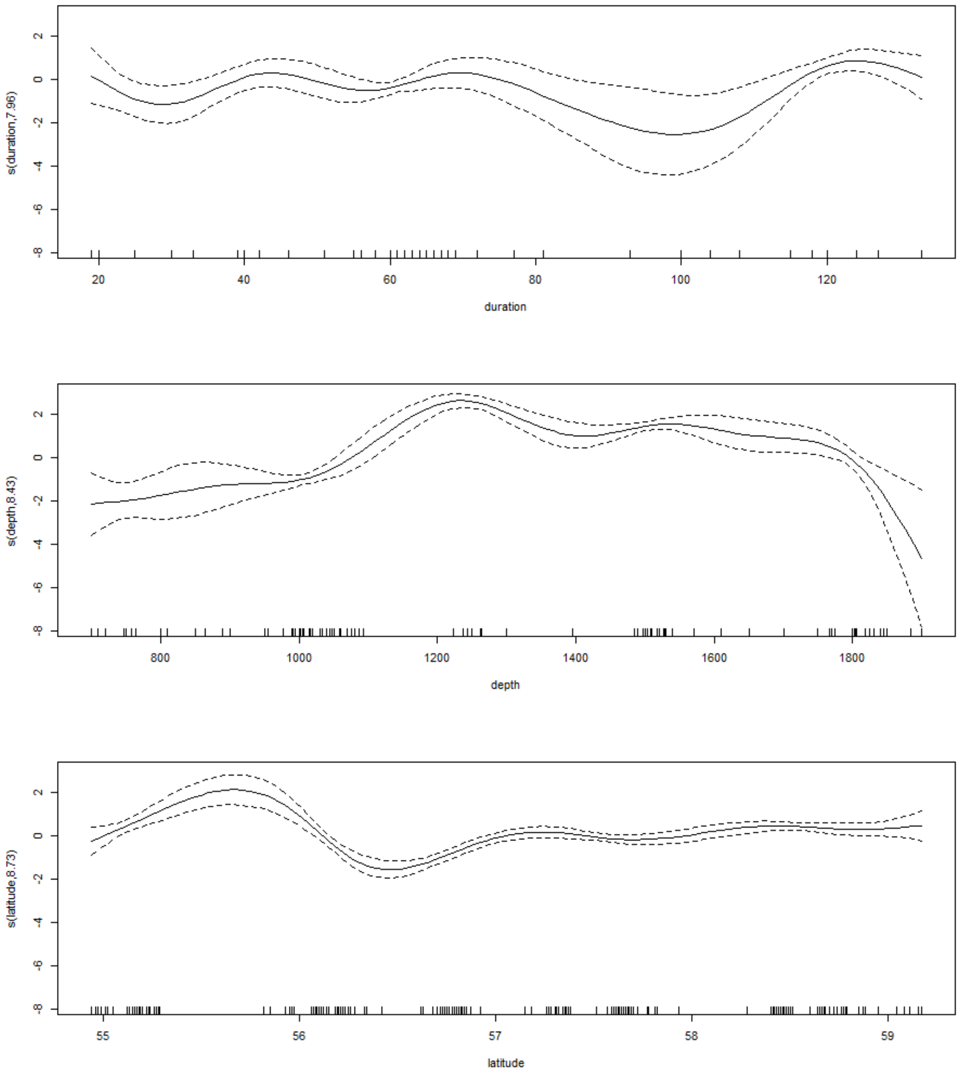

Figure 3.8. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Model fits for smoothed terms in GAM analysis of Portuguese dogfish in Scottish deep-water surveys 2000 to 2017.

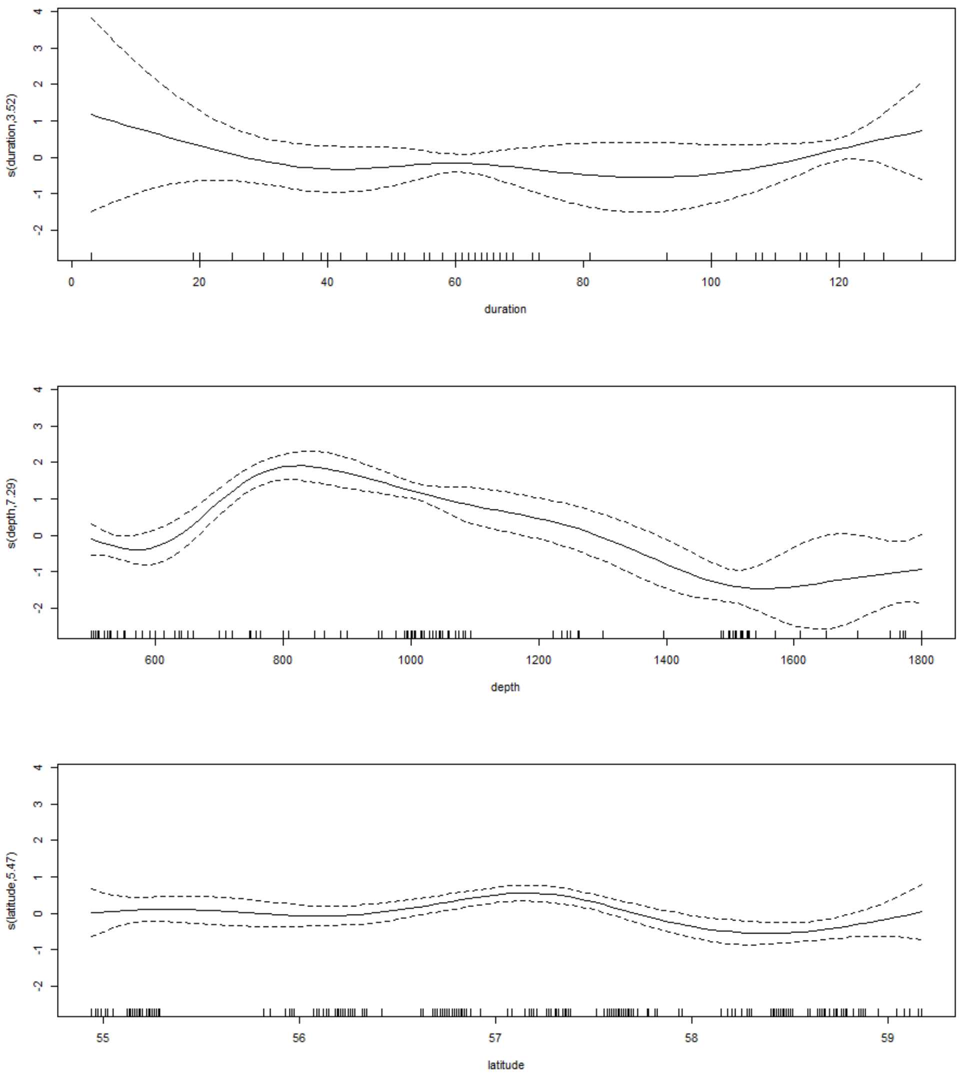

Figure 3.9. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Model fits for smoothed terms in GAM analysis of leafscale gulper shark in Scottish deep-water surveys 2000 to 2017.

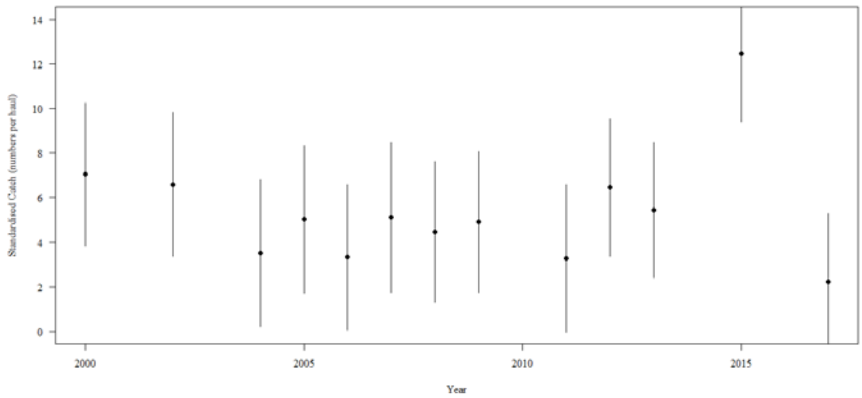

Figure 3.10. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Standardized abundance index for Portuguese dogfish in Scottish deep-water surveys 2000 to 2017.

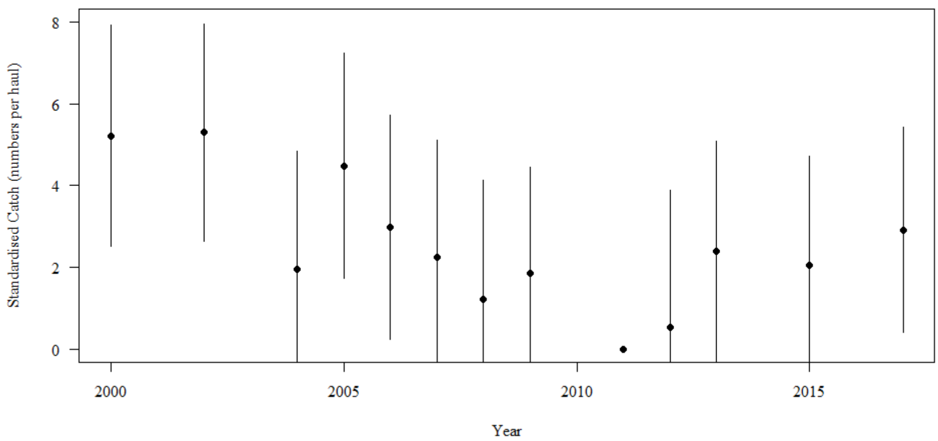

Figure 3.11. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Standardized abundance index for leafscale gulper shark in Scottish deep-water surveys 2000 to 2017.

4 Kitefin shark in the Northeast Atlantic (entire ICES Area)

4.1 Stock distribution

Kitefin shark *Dalatias licha* is distributed widely in the deeper waters of the northeast Atlantic, from Norway to northwest Africa and the Gulf of Guinea, including the Mediterranean Sea and NW Atlantic.

The stock identity of kitefin shark in the NE Atlantic is unknown. However, the species seems to be more abundant in the southern area of the Mid-Atlantic Ridge (Subarea 10). Elsewhere in the NE Atlantic, kitefin shark is recorded infrequently. The species is caught as bycatch in mixed deep-water fisheries in Subareas 5–7, although at much lesser abundance than the main deep-water sharks (see Section 3), and the species composition of the landings is not accurately known.

For assessment purposes, the Azorean stock (Subarea 10) is considered as a management unit.

4.2 The fishery

4.2.1 History of the fishery

A detailed description of historical fisheries can be found in Heessen (2003) and ICES (2003). The Azorean target fishery stopped at the end of the 1990s. Elsewhere in the North Atlantic, it is a frequent bycatch in various deep-water fisheries.

Historically, Azorean landings of kitefin shark began in the early 1970s and increased rapidly to over 947 t in 1981, fluctuating considerably thereafter, at least in part due to market fluctuations. Landings peaked at 937 t in 1984 and 896 t in 1991. Since 1991, the reported landings have declined, possibly as a result of economic problems related to markets.

4.2.2 The fishery in 2016 and 2017

Currently there are no target fisheries for kitefin shark. Landings in the northeast Atlantic have been at low levels since 2005, with most of the catches reported from Subareas 7, 8 and 10 (Table 4.1 and Figure 4.1).

4.2.3 ICES advice applicable

ICES advised in 2015 that "*when the precautionary approach is applied for kitefin shark in the Northeast Atlantic, fishing mortality should be minimized and no targeted fisheries should be permitted. This advice is valid for 2016 to 2019*".

This is similar to the 2006 advice where ICES advised: "*This stock is managed as part of the deep-sea shark fisheries. No targeted fisheries should be permitted unless there are reliable estimates of current exploitation rates and sufficient data to assess productivity. It is recommended that exploitation of this species should only be allowed when indicators and reference points for future harvest have been identified and a management strategy, including appropriate monitoring requirements has been decided upon and is implemented*".

4.2.4 Management applicable

The EU TACs that have been adopted for deep-sea sharks in European Community waters and international waters at different ICES subareas are summarized in the table below. The deep-sea shark category includes the kitefin shark *Dalatias licha* (Council regulation (EC) No 2285/2016).

Year	Subareas 5–9	Subarea 10	Subarea 12 (includes also *Deania histricosa* and *Deania profondorum*
2005 and 2006	6763	14	243
2007	2472(1)	20	99
2008	1646(1)	20	49
2009	824(1)	10(1)	25(1)
2010	0(2)	0(2)	0(2)
2011	0(4)	0(4)	0(3)
2012	0	0	0
2013	0	0	0
2014	0	0	0
2015	0	0	0
2016	0	0	0
2017	10	10	0

(1) Bycatches only. No directed fisheries for deep-sea sharks are permitted.

(2) Bycatches of up to 10% of 2009 quotas are permitted.

(3) Bycatches of up to 3% of 2009 quotas are permitted.

(4) Bycatch only for bottom longline fisheries targeting black scabbardfish

Council Regulation (EC) No 1568/2005 banned the use of trawls and gillnets in waters deeper than 200 m in the Azores, Madeira and Canary Island areas.

Council Regulation (EC) No 41/2007 banned the use of gillnets by Community vessels at depths greater than 600 m in divisions 6.a-b, 7.b-c, 7.j-k and Subarea 12. A maximum bycatch of deep-water shark of 5% is allowed in hake and monkfish gillnet catches and 10% on the bottom longline fisheries targeting black scabbardfish.

A gillnet ban in waters deeper than 200 m is also in operation in the NEAFC regulatory Area (all international waters of the ICES Area). NEAFC also ordered the removal of all such nets from these waters by the 1st February 2006.

In 2009 the Azorean Regional Government introduced new technical measures for the demersal/deep-water fisheries (Portaria n.º 43/2009 de 27 de Maio de 2009) including area restrictions by vessel size and gear, and gear restrictions (hook size and maximum number of hooks on the longline gear). These measures have been adapted thereafter. In Azorean waters, there is a network of closed areas (summarized in Section 20). The Condor seamount has been closed to demersal/deep-water fisheries since 2010.

4.3 Catch data

4.3.1 Landings

The annual landings reported from each country are given in Table 4.1 and in Figure 4.1.

4.3.2 Discards

No new data were presented this year.

Discard rates of 15–85% of the kitefin shark caught per set were reported from the sampled Azorean longliners during 2004–2010 (ICES, 2012). Since 2011, discards may have increased due to management restrictions, or been landed as unspecified elasmobranchs.

Sporadic and low levels of kitefin shark discards were reported from the Spanish trawl fleets operating in divisions 8.c and 9.a in 2010–2012.

4.3.3 Quality of catch data

Historic landings of deep-water sharks taken in the Azores were commonly gutted, finned, beheaded and also skinned. Only the trunks and, in some cases, the livers were landed. Misidentification problems were likely to occur with other deep-water shark species in ICES Division 10.a.

The reported Azorean landings data come exclusively from the commercial first sale of fresh fish at auctions and so landings data (Table 4.1) may be underestimated.

4.4 Commercial catch composition

No new information.

4.5 Commercial catch–effort data

No new information.

4.6 Fishery-independent surveys

Existing research surveys rarely catch kitefin shark, as the surveys are not designed for the species, and thus will not provide relevant information for the assessment.

Relative abundances of kitefin shark (ind.h–1) from the Scottish deep-water trawl survey (depth range 500–1000 m) were submitted in 2016 to the group (Table 4.2). These data confirm that only low numbers are caught (< 10 specimens are caught each survey). For the entire survey period, a total of 34 specimens (8 males of 60–110 cm, and 26 females of 40–140 cm) have been caught.

Relative biomass estimates of kitefin shark (kg.haul-1) from the Spanish trawl survey on the Porcupine Bank are presented (Figures 4.2–4.4; Ruiz-Pico *et al*. 2018 WD). Few individuals were caught over the 12-year survey period (177 until 2014).

In 2017, the biomass of *D. licha* followed the increasing trend from 2016, whereas the abundance decreased (Figure 4.2). This contrast is explained by a large (129 cm) specimen that was caught north of the bank. This individual was the largest specimen in the time series, and contributed more to biomass than to abundance. Other sites of occurrence were found in the western area, with a few specimens also caught in the south and east of the study area (Figure 4.3). All were caught in the deepest strata, particularly from 463–754 m in this last survey. Eight of the twelve specimens were from 42–70 cm in length and three around 100 cm (Figure 4.4).

The Azorean longline survey (ARQDACO(P)-Q1) has on average of 495 fishing stations per survey, covering a depth range 50–1200 m. During the period 1996–2016, a total of 68 kitefin sharks were caught, averaging about four individuals per year (WD-10-Pinho, 2017). Over the entire time period, specimens were caught at depths of 300–800 m and their total length ranged from 43–150 cm.

4.7 Life-history information

There is no new information available.

In Azorean waters, individuals smaller than 98 cm are scarce, suggesting that spawning and juveniles probably occur in deep-water or in non-exploited areas. Males are more available to the fishery at 100 cm (age 5) and females at 120 cm (age 6).

4.8 Exploratory assessment models

Exploratory kitefin shark stock assessments were conducted during the 1980s, using an equilibrium Fox production model (Silva, 1987). The stock was considered intensively exploited with the average observed total catches (809 t) near the estimated maximum sustainable yield (MSY = 933 t). An optimum fishing effort of 281 days fishing bottom nets and 359 trips fishing with handlines was proposed, corresponding approximately to the observed effort.

During the DELASS project (Heessen, 2003), a Bayesian stock assessment approach using the Pella-Tomlinson biomass dynamic model was applied to two fisheries, handline and bottom gillnet (ICES, 2003, 2005). Based on the probability of the Biomass 2001 be less than B_{MSY}, the stock was considered depleted.

The next assessment will be in 2019, with available data to be reviewed and presented to next year's WG meeting.

4.9 Stock assessment

No new assessment was undertaken, because no new data were available.

4.10 Quality of assessments

No new assessment was undertaken.

4.11 Reference points

No reference points have been proposed for this stock.

4.12 Conservation considerations

Kitefin shark is listed as 'Near threatened' on the IUCN Red List (Blasdale *et al*., 2009)

4.13 Management considerations

Preliminary assessment results suggested that the stock might have been depleted to about 50% of virgin biomass. However, further analysis is required to better understand the actual status of the stock. Fisheries for kitefin shark have been affected by fluctuations in the price of shark liver oil. An analysis of liver oil prices may provide some information on historical exploitation levels of this species.

There are no adequate fishery-independent surveys to monitor the stock. WGEF recommends that the development of a fishery should not be permitted unless data on the level of sustainable catches become available. If an artisanal sentinel fishery is established, it should be accompanied by a data collection programme.

The Condor seamount, in Division 10.a, has been closed to fishing, accompanied by a multidisciplinary research project (ecological, oceanography and geological) that may contribute for the future characterization of the dynamics of the stock in the area (Portaria n.º 48/2010 de 14 de Maio de 2010).

4.14 References

Blasdale, T., Serena, F., Mancusi, C., Guallart, J. and Ungaro, N. 2009. *Dalatias licha*. The IUCN Red List of Threatened Species. Version 2014.1. <www.iucnredlist.org>. Downloaded on 23 July 2014.

Heessen, H. J. L. 2003. Report of the DELASS Project.

ICES. 2003. Report of the Working Group on Elasmobranch Fishes. ICES CM 2003/G:09, 155 pp.

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Pinho, 2017. Resuming elasmobranchs survey data from the Azores (ICES 27.10a). ICES WD WGEF 2017.

Ruiz-Pico, Fernández-Zapico, O S., Baldó, F., Velasco, F. and Rodríguez-Cabello, C. 2018 Results on main elasmobranches species from 2001 to 2017 Porcupine Bank (NE Atlantic) bottom trawl surveys. Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon 18–28 June 2018, 34 pp.

Silva, H. M. Da. 1987. An assessment of the Azorean stock of kitefin shark, *Dalatias licha*. ICES Copenhagen, ICES CM 1987/G:66, 10 pp.

Table 4.1. Kitefin shark in the Northeast Atlantic. Working Group estimates of landings (t) of kitefin shark *Dalatias licha*.

Country	Area	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Germany	7j	6												
	7k	15												
France	27						1							
	5b		1											
	7b						0							
	7e											0		
	7g						0							
	8a		0			0					0		0	
	8b	1	1	1	1	0	0	1	0	0	0		0	0
	8c		0	0				0						
UK	5b													
	6a	19	25	2										
	6b													
	7b	0		0										
	7c	11	0											
	7h													
	7j	26	4	1										
	7k	32		1										
	8c		1											
	8d		0	0										
	8e		1											
	9b		4											
Ireland	7b	0	0											
	7c	5	5											
	7j	0	1											
	7k	2	2											
	10	0												
Portugal	9a	3	6	3	1	1	0	0	0	0	0		0	0
	10a	14	10	7	10	6	2	1					0	0
Total		**137**	**63**	**15**	**12**	**8**	**4**	**2**	**0**	**0**	**0**	**0**	**0**	**0**

Table 4.2. Kitefin shark in the Northeast Atlantic. Relative abundance of kitefin shark (number per hour trawling) from Scottish deep-water survey (depth range 500–1000 m: Only one fish has been caught outside this core depth range) in ICES Subarea 6.

Year	Nº hauls	Nº positive hauls	Nº fish	Mean Nph
1998	17	2	2	0.05
2000	13	0	0	0.00
2002	16	2	4	0.13
2004	14	2	2	0.07
2005	13	1	4	0.15
2006	20	3	8	0.20
2007	15	2	7	0.23
2008	20	3	5	0.13
2009	27	1	1	0.06
2011	15	1	1	0.07
2012	18	0	0	0.00
2013	11	1	1	0.09

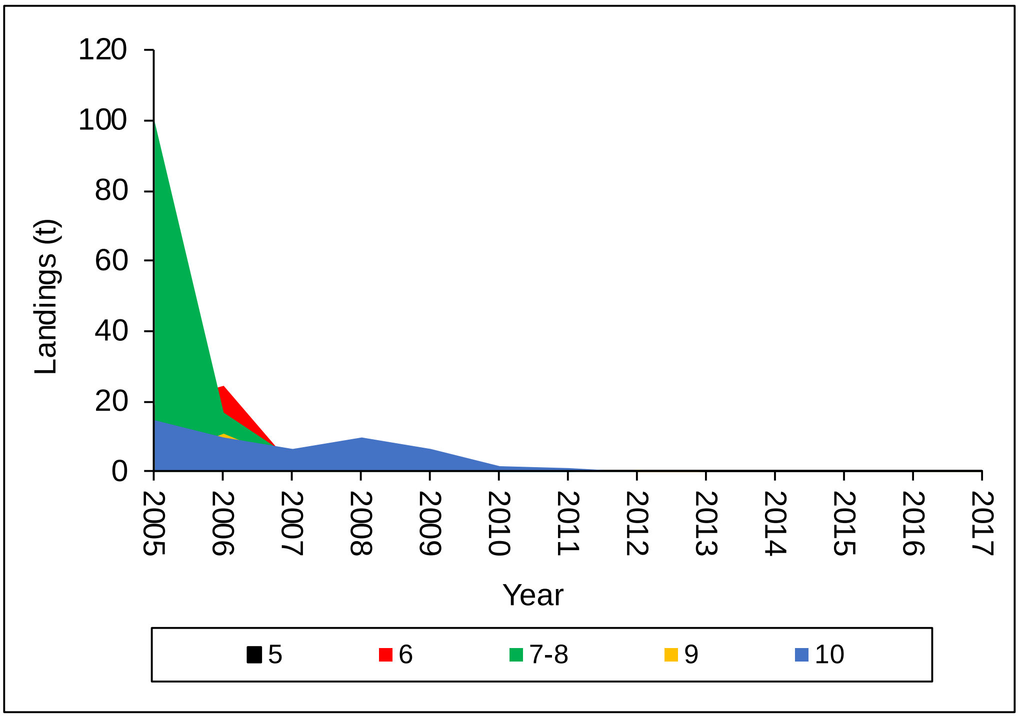

Figure 4.1. Kitefin shark in the Northeast Atlantic. Total landings of kitefin shark by ICES division. Management information is given on the graph.

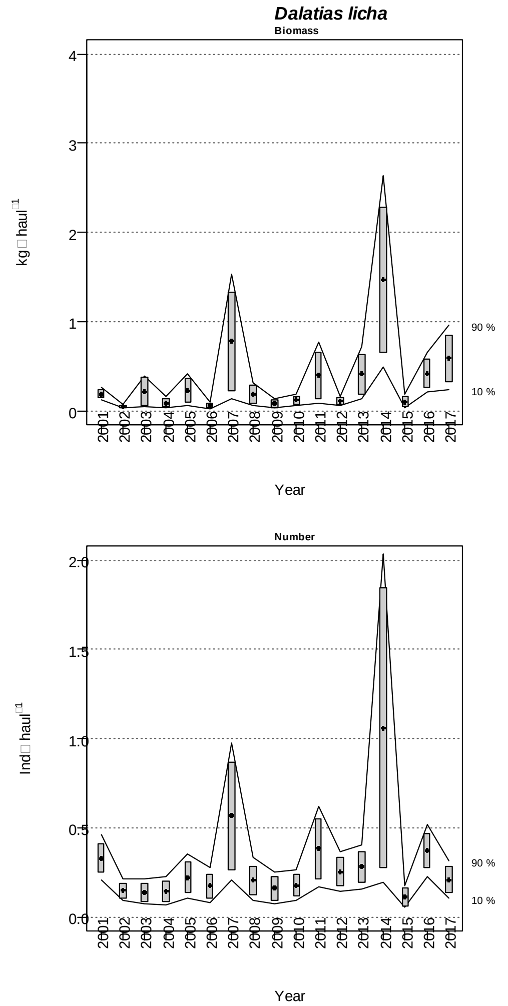

Figure 4.2. Kitefin shark in the Northeast Atlantic. Relative abundance of kitefin shark, in weight (kg/haul) and number from the Spanish groundfish survey on the Porcupine bank. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). Source: Ruiz-Pico *et al.* (2018 WD)

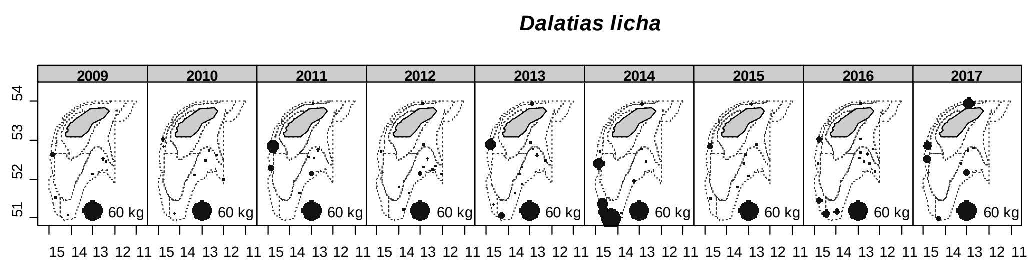

Figure 4.3. Kitefin shark in the Northeast Atlantic. Annual (2009–2017) spatial distribution of kitefin shark (kg/haul) on the Porcupine bank survey. Source: Ruiz-Pico *et al.* (2018 WD)

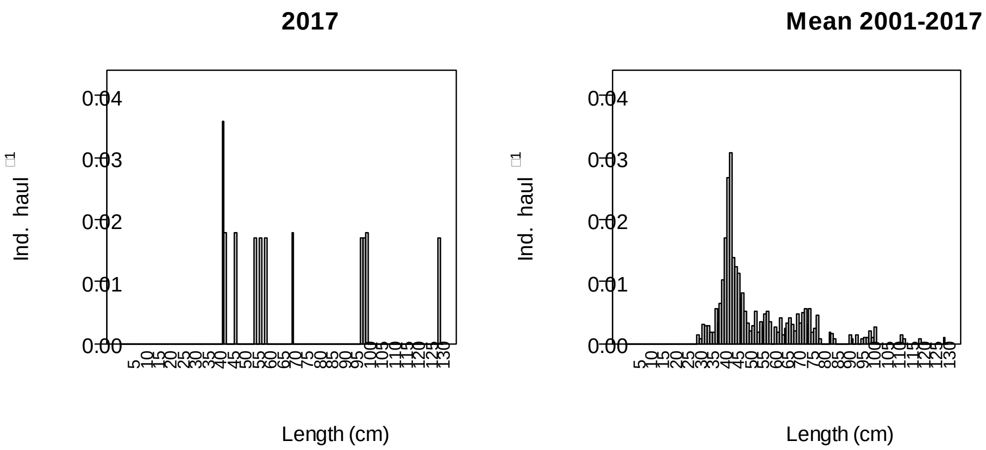

Figure 4.4. Kitefin shark in the Northeast Atlantic. Annual length composition of kitefin shark from the Spanish groundfish survey on the Porcupine Bank. **Ruiz-Pico *et al.* (2018 WD).**

5 Other deep-water sharks and skates from the Northeast Atlantic (ICES Subareas 4–14)

5.1 Stock distributions

This section includes information about deep-water elasmobranch species other than Portuguese dogfish and leafscale gulper shark (see Section 3), kitefin shark (see Section 4) and Greenland shark (see Section 24). Limited information exists on the majority of the deep-water elasmobranchs considered here, and the stock units for these species are unknown.

The species and generic landing categories for which landing data are presented are: gulper sharks *Centrophorus spp*., birdbeak dogfish *Deania calcea*, longnose velvet dogfish *Centroscymnus crepidater*, black dogfish *Centroscyllium fabricii*, lanternsharks *nei Etmopterus spp*., knifetooth dogfish *Scymnodon ringens*, arrowhead dogfish *Deania profundorum*, bluntnose sixgill shark *Hexanchus griseus* and mouse catshark *Galeus murinus*. Historical catches of velvet belly lanternshark *Etmopterus spinax* and 'aiguillat noir' (which may include *C. fabricii, C. crepidater* and *Etmopterus spp*.) are also presented. Other deep-water sharks in the ICES area include: deep-water catsharks *Apristurus spp*., frilled shark *Chlamydoselachus anguineus*, great lanternshark *Etmopterus princeps* and sailfin roughshark (sharpback shark) *Oxynotus paradoxus.*

Fiveteen species of skate (Rajidae) are known from deep water in the NE Atlantic: Arctic skate *Amblyraja hyperborea*, Jensen's skate *Amblyraja jenseni*, Krefft's skate *Malacoraja kreffti*, roughskin skate *Malacoraja spinacidermis*, deep-water skate *Rajella bathyphila*, pallid skate *Bathyraja pallida*, Richardson's skate *Bathyraja richardsoni*, Bigelow's skate *Rajella bigelowi*, round skate *Rajella fyllae*, Mid-Atlantic skate *Rajella kukujevi*, spinytail skate *Bathyraja spinicauda*, sailray *Rajella lintea*, Norwegian skate *Dipturus nidarosiensis,* blue pygmy skate *Neoraja caerulea* and Iberian pygmy skate *Neoraja iberica*.

Species such as common skate complex, shagreen skate *Leucoraja fullonica*, starry ray *Amblyraja radiata* and longnose skate *Dipturus oxyrinchus* may also be found in deep water, but their main areas of distribution are in shallower waters down to 500 m and they are not considered in this sectionThe electric ray *Torpedo nobiliana* may also occur in deep waters.

Eight species of rabbitfish (Chondichthyes; Holocephali), including members of the genera *Chimaera, Hariotta* and *Rhinochimaera* are a bycatch of some deep-water fisheries and are sometimes marketed. The current zero-TACs for deep-water sharks, whose livers were used to extract squalene, may have led to the increased retention of rabbitfish, particularly common chimaera *Chimaera monstrosa* in Norway (114 t in 2012, 177 t in 2013, 217 t in 2017) to produce "ratfish oil". Catches of Chimaeridae are included in the report of the ICES Working Group on Deep-water Fisheries Resources (WGDEEP).

5.2 The fishery

5.2.1 History of the fishery

Most catches of other deep-water shark and skate species are taken in mixed trawl, longline and gillnet fisheries together with Portuguese dogfish, leafscale gulper shark and deep-water teleosts.

5.2.2 The fishery in 2016

Since 2010, EU TACs for deep-water sharks have been set at zero (see Section 5.2.4). Consequently, reported landings of most of the species covered in this chapter in 2016 were very low or zero. As most of these species are taken as bycatch in mixed fisheries, it is likely that discarding has increased.

5.2.3 ICES advice applicable

No species-specific advice is given for the shark and skate species considered here.

The ICES Advice for 2013 also included an "*Opinion on modification to the list of deep-sea sharks*" (ICES Advice 2013, Book 11, Section 11.2.2.1).

5.2.4 Management applicable

Prior to 2010 in EC waters, a combined TAC was set for a group of deep-water sharks. These include Portuguese dogfish *Centroscymnus coelolepis*, leafscale gulper shark *Centrophorus squamosus*, birdbeak dogfish *Deania calcea*, kitefin shark *Dalatias licha*, greater lanternshark *Etmopterus princeps*, velvet belly lanternshark *Etmopterus spinax*, black dogfish *Centroscyllium fabricii*, gulper shark *Centrophorus granulosus*, blackmouth catshark *Galeus melastomus*, mouse catshark *Galeus murinus*, longnose velvet dogfish *Centroscymnus crepidater*, frilled shark *Chlamydoselachus anguineus*, bluntnose six-gill shark *Hexanchus griseus*, sailfin roughshark *Oxynotus paradoxus*, Greenland shark *Somniosus microcephalus*, knifetooth dogfish *Scymnodon ringens* and deep-water catsharks *Apristurus spp*. In Subarea 12, rough longnose dogfish *Deania histricosa* and arrowhead dogfish *Deania profundorum* are also included on the list.

In 2010, TACs in all areas were reduced to zero with an allowance for bycatch of 10% of 2009 TACs. For 2011, the bycatch allowance was reduced to 3% of 2009 TACs and in 2012 no allowance for bycatch was permitted. This remained the *status quo* in 2013 and 2014. In 2014, the list of sharks was updated to include all *Centrophorus* species and blackmouth catshark was removed, following comments from ICES (See Section 5.2.3). The zero-TAC for deep-water sharks continued until 2016.

Council regulation (EU) 2016/2285 fixed a restrictive by-catch allowance for 2017 and 2018, introduced on a trial basis, permitting limited landings of unavoidable by-catches of deep-sea sharks in directed artisanal deep-sea longline fisheries for black scabbardfish. Specifically, 10 tonnes were allowed for deep-sea sharks in Union and international waters of ICES subareas 5, 6, 7, 8 and 9, in Union and international waters of ICES Subarea 10 and in Union waters of CECAF 34.1.1, 34.1.2 and 34. 2. This allowance was based on ICES indications that the currently applicable restrictive catch limits can lead to misreporting of unavoidable by-catches of deep-sea sharks. Directed artisanal deep-sea longline fisheries for black scabbardfish (recognised as a selective fishing gear in such fisheries) have unavoidable by- catches of deep-sea sharks, which are currently discarded dead. According to the council regulation, Member States concerned should develop regional management measures for the fishing of black scabbardfish and establish specific data-collection measures for deep-sea sharks to ensure close monitoring of the stocks.

This regulation affects specifically the Portuguese deep-water longline fishery targeting black scabbardfish in ICES Division 9.a and Subarea 10. A coordinated action plan has already been proposed by Portugal to evaluate management measures to be adopted.

Deep-water skates are included in EU TACs for “Skates and Rays Rajidae”. In EU waters of Divisions 6.a-b, 7a-c and 7e-k, Norwegian skate *Dipturus nidarosiensis* is one of a group of species which may not be retained on board and must be promptly released unharmed to the extent practicable.

5.3 Catch data

5.3.1 Landings

Landings in 2017 were very low due to the management measures in force for deep-water sharks (Tables 5.1–5.9).

During WKSHARK2, landing data provided by country was revised in relation to data quality (including taxonomic categories). Protocols to better document the decisions to be made when estimating WG landings were also developed (ICES, 2016).

In WGEF 2017, landings data was revised according to WKSHARK2, but the landing data tables from 2005 onwards were not updated until WGEF 2018.

Gulper sharks *Centrophorus spp.* (not *C. squamosus*)

Almost all landings of gulper sharks (other than leafscale gulper shark) have been from the Portuguese longline fishery in Subarea 9 (Tables 5.1, 5.8 and 5.9). Until 2008, annual landings from this fishery were around 100 t, but in 2009, Portuguese landings reduced to 2 t. In 2017, under the 10 t TAC, 2 t were landed. However, misidentification problems were detected in mainland Portuguese landing ports with two different species of *Centrophorus* being observed in catches: *Centrophorus granulosus* and *Centrophorus uyato*. Other countries reported very small landings of *C. granulosus* from subareas 6 and 7 since 2002. Reported landings of this species by UK vessels in subareas 6 and 7 are considered to be misidentified and these data are included in the Working Group estimates of “siki sharks”.

Birdbeak dogfish *Deania calcea*

WGEF landings estimates of birdbeak dogfish are presented in Tables 5.2, 5.8 and 5.9. It is likely that landings reported as this species include other species in the same genus, particularly in Portuguese landings from Subarea 10 (Pinho, 2010 WD). Misidentification problems were detected in mainland Portuguese landing ports with two different species of *Deania* being observed in catches: *D. calcea* and *D. profundorum*. However, mostly correspond to *D. calcea* .

Five European countries landings of birdbeak dogfish: Norway, Ireland, UK), Spain and Portugal. In 2005, the total reported landings for all subareas reached 195 t; however this declined over the years due to the zero TAC

Catches of this species by Russian deep-water longline fisheries in the Faroese Fishing Zone and other Northeastern Atlantic areas were reported in working documents to WGEF (Vinnichenko and Fomin, 2009 WD; Vinnichenko *et al*., 2010 WD). Landings data from this fishery were not subsequently available to the working group.

Longnose velvet dogfish *Centroscymnus crepidater*

WGEF landings estimates of longnose velvet dogfish are presented in Tables 5.3, 5.8 and 5.9. It is likely that some landings of this species are also included in data for "siki sharks" (see Section 3) and in other mixed categories.

European countries that have reported landings from subareas 6–9 are: UK, France, Ireland and Portugal. Highest landings (420 t) were recorded in 2006 and were principally derived from the UK registered deep-water gillnet fleet. Reported landings have since declined to zero, probably as a result of the ban on deep-water gillnet fishing and reduced EU TACs for deep-water sharks.

Black dogfish *Centroscyllium fabricii*

Reported landings of black dogfish are presented in Tables 5.4, 5.8 and 5.9. Landings of this species may also be included in the grouped category "*Aiguillat noir*" and other mixed categories, including siki sharks.

Four European countries have reported landings, from divisions 4.a, 5.b and subareas 7 and 12: UK, Iceland, France and Spain.

France reported the majority of the landings of black dogfish in the ICES area, starting to report landings in 1999. French annual landings peaked at about 400 t in 2001 and have since declined. These landings are mainly from Division 5.b and Subarea 6. Iceland reported few landings, all from Division 5.a. The largest annual landings reported by Spain came from Subarea 12 in 2000 (85 t) and 2001 (91 t), but recent data are lacking.

Since 2009, only Iceland has reported catches of black dogfish, mainly from Subarea 5, but always in small amounts (1 t in 2013).

Lanternsharks *Etmopterus spp.*

Reported landings of velvet belly lanternshark *Etmopterus spinax* are presented in Tables 5.5 until 2004. Revised landing data provided to WGEF from 2005 onwards indicates that landings assigned to *E. spinax* should be considered as *Etmopterus spp*. Those figures are provided in Table 5.6. Six countries have reported landings of *Etmopterus spp*.: Denmark, Norway, UK, France, Spain and Portugal. Until 2001, the greatest landings were from Denmark. In recent years, Norway has the highest catches reaching 129 t in 2017.

Portuguese landings mainly referred to *Etmopterus spinax* and *Etmopterus pusillus*, however only a very small proportion of the catches of these species is retained.

Catches of this species by Russian deep-water longline fisheries in the Faroese Fishing Zone and other Northeastern Atlantic areas were reported in working documents to WGEF (Vinnichenko and Fomin, 2009 WD; Vinnichenko *et al*., 2010 WD). Landings data from this fishery were not subsequently available to the working group.

"Aiguillat noir"

This is a generic category only used by France (Tables 5.7, 5.8 and 5.9) to record landings on small, deep-water squaliform sharks, mainly black dogfish *Centroscyllium fabricii* with smaller quantities of longnose velvet dogfish and lanternsharks. Reported landings started in 2000 (249 t) then declined from 266 t in 2001 to 1 t in 2007, since when there have been no reported landings.

Norwegian skate *Dipturus nidarosiensis*

The species is occasionally landed in three French ports mostly under the landing name "*D. oxyrinchus*" with the code RJO. The length–frequency distribution of *Dipturus nidarosiensis* observed in the 2012–2014 French landing are presented in Figure 5.1, individuals landed mostly come from the ICES Division 6.a.

Other skates

Surveys of French fish markets show that *Rajella lintea*, *Rajella kukujevi*, *Rajella fyllae*, *Bathyraja spinicauda* and *Dipturus nidarosiensis* are occasionally landed from ICES Division 6.a, but without specific landing names.

5.3.2 Discards

Portugal (Azores): Discards data from the Azorean observer programme were provided in Pinho and Canha (2011 WD; Table 5.10). Since then, this information has not been updated.

Portugal (mainland): Discards data from the Portuguese longline fishery were presented. *Etmopterus spp*. and *C. crepidater* are the species with higher percentages of discards along the time-series (although *C. crepidater* was not sampled in 2013). Other elasmobranchs were rarely discarded (Prista *et al.*, 2014 WD). Estimates of percentage discarded by species from deep-water longlines and demersal bottom trawls are given in Table 5.11.

To evaluate the level of bycatch and discards of deep-water sharks in the Portuguese trammelnet fishery, a pilot study was undertaken in ICES Division 9.a (Moura *et al.*, 2015 WD). Results show that the fishery targeting anglerfish and operating at depths of 200–600 m has a low frequency of occurrence of deep-water sharks (Table 5.12). Results further suggest that relatively higher frequencies of occurrence are likely to be observed deeper than 600 m, according to the depth ranges reported for most of these species.

Spain: The Spanish Discards Sampling Programme for Otter and Pair Bottom Trawl (OTB and PTB) fleets, covering ICES subareas 6, 7, Division 8.c and 9 (North), started in 1988; however, it did not occur annually until 2003. The sampling strategy and the estimation methodology used follows the "Workshop on Discard Sampling Methodology and Raising Procedures" guidelines (ICES, 2003) and more detail of this applied to this area was explained in Santos *et al*. (2010). Preliminary estimates of Spanish deep-water elasmobranch discards (2003–2014) are presented in Table 5.13.

5.3.3 Quality of the catch data

Data provided to WGEF in 2017 and 2018 followed WKSHARKS2 guidelines. Despite the decisions taken regarding the assignment of landings to species or higher *taxa* some problems persist. For example, some quantities of deep-water species are maintained grouped in generic categories such as "sharks indetermined", "unidentified deepwater sharks" or "Squaliformes".

Landings reported by UK vessels for 2003/2004 were considered to be unreliably identified and were therefore amalgamated into a mixed deep-water shark (siki) category together with Portuguese dogfish and leafscale gulper shark. Since 2005/2006, UK landings for most species were considered to be more reliably identified; however, reported landings of gulper shark are still considered to be unreliable and have been added to landings of siki sharks.

As result of restrictive quotas for deep-water sharks, landings of these species may have been misidentified.

5.3.4 Discard survival

No data available to the Working Group.

5.4 Commercial catch composition

No new information is available.

5.5 Commercial catch and effort data

No new information is available.

5.6 Fishery-independent surveys

5.6.1 ICES Subarea 6

The Scottish deep-water trawl survey has operated from 1996 to 2015 at depths of 300–2000 m along the continental slope between approximately 55˚N and 59˚N (see Neat *et al.*, 2010 for details). Neat *et al.* (2015) analysed catches of deep-water elasmobranch species from Scottish deep-water trawl survey.

5.6.2 ICES Subarea 7

The Spanish survey on the Porcupine Bank (SppGFS-WIBTS-Q4) in ICES divisions 7.c and 7.k covers an area from longitude 12°W to 15°W and from latitude 51°N to 54°N following the standard IBTS methodology for the western and southern areas (ICES, 2010). The sampling design is a random stratified (Velasco and Serrano, 2003) with two geographical sectors (North and South) and three depth strata (<300 m, 300–450 m and 450–800 m). Haul allocation is proportional to the strata area following a buffered random sampling procedure (as proposed by Kingsley *et al.*, 2004) to avoid the selection of adjacent 5×5 nm rectangles. More details on the survey design and methodology are presented in Ruiz-Pico *et al.* (2014 WD) and Fernández-Zapico *et al.* (2015 WD). Results for 2017 are presented in Ruiz-Pico *et al.* (2018 WD)

The most abundant deep-water shark species in biomass in these surveys were *Deania calcea* (birdbeak dogfish), *Deania profundorum* (arrowhead dogfish), *Scymnodon ringens* (Knifetooth dogfish), *Etmopterus spinax* (velvet belly lantern shark), *Dalatias licha* (Kitefin shark), and *Hexanchus griseus* (bluntnose six-gill shark).

5.6.3 ICES divisions 8.c and 9.a

The Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters has covered this area annually since 1983 (except 1987), obtaining abundance indices and length distributions for the main commercial species and elasmobranchs. More details on the survey design, methodology and results can be found in Ruiz-Pico *et al.* (2015

WD; Ruiz-Pico *et al*. 2018 WD). In 2017, elasmobranchs made up ca. 11% of the total fish catch (14% if considering the additional hauls, at deeper waters). All species showed an increase in biomass with regard to 2015., A new vessel (R/V Miguel Oliver) is in use since 2013.

In the Portuguese survey (PtGFS-WIBTS-Q4) taking place off southwestern and southern coasts, the deep-water elasmobranch with highest catches is *D. profundorum*. This survey is designed for crustacean species and operates to depths of 700 m.

5.6.4 ICES Subarea 10

Data from the Azorean bottom longline survey (ARQDACO(P)-Q1) in Division 10.a2 were given in Pinho (2017 WD). *Deania spp*. were the most representative (abundant) species in the survey. *C. crepidater* was common, but much less abundant. Other species occurred in very low numbers (averaging 1–4 individuals per year). Depth range sand length composition data are available. It should be noted that the gear configuration used is not adequate for sampling all the species (Pinho, 2017 WD).

5.7 Life-history information

Several recent studies have provided relevant biological information:

Moore *et al.* (2013) provide length of first maturity of *Centroscymnus crepidater* (57.2 cm total length (TL) for males and 75.4 cm TL for females) and of *Apristurus aphyodes* (49.0 cm TL for males and 56.9 cm TL for females) from the Rockall Trough.

Rodriguez-Cabello *et al*. (2013) showed that the distribution of *Galeus murinus* extended southward, to Cantabrian Sea, and *Neoraja caerulea* and northwards the distribution of *Neoraja iberica.*

Coelho *et al.* (2014) conducted demographic analysis of *E. spinax* using an age-based model. They found that the population should be stable if there is a two year reproductive cycle, but would be declining if there is a three year cycle, highlighting why an accurate knowledge of reproductive periodicity is important.

Moura *et al.* (2014) found that *Deania calcea* was spatially segregated by size, sex and maturity. Pregnant females inhabit shallower and warmer waters; large immature specimens were deeper, and mature males were more broadly distributed than mature females, supporting the possibility of sex-biased dispersal.

5.8 Exploratory assessments analyses of relative abundance indices

The exploratory assessments below are all based on analyses of relative abundance indices in fishery-independent surveys.

5.8.1 Spanish Porcupine Bank (SppGFS-WIBTS-Q4) and Spanish IEO Q4-IBTS survey

Abundance indices for some deep-water elasmobranchs caught in the Spanish survey on the Porcupine Bank (SppGFS-WIBTS-Q4) and the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters are presented below.

Information for *E. spinax*, *H. griseus*, *S. ringens*, *D. calcea* and *D. profundorum* is presented however the majority of these species are usually found at deeper waters than those covered by the Spanish IEO Q4-IBTS survey (additional hauls) and thus the abundance indices must be treated with caution.

5.8.2 Scottish deep-water trawl survey in Division 6.a

Neat *et al*. (2015) analysed catches of deep-water elasmobranch species from the Scottish deep-water trawl survey in Division 6.a. Selected results are presented below.

Scientific dual-warp bottom-trawls with rock-hopper ground gear (for details see Neat *et al*., 2010) were carried out at 527 sites along the deep-water slopes, banks and seamounts of the Rockall Trough, to the west of Scotland. Surveys were carried out from 1996–2013 at depths of 300–2030 m. In 1996 FRV Scotia IV was in service, but was replaced by FRV Scotia V in 1998. Most of the records in the database derive from Scotia V and in particular from surveys carried out in September that used the Jackson BT-184 deep-water bottom trawl. For species distribution mapping all data were used, but for statistical analyses over time only data from 1998 onwards (Scotia V only) and only data collected with the same trawl net (Jackson BT184) from the continental slope during the month of September were used. For some species of the genus *Apristurus* there has been an ongoing taxonomic debate, for example *A. melanoasper* was only formally described in 2004. Therefore time-series analyses were restricted to two of the more common *Apristurus* species (*A. aphyodes* and *A. microps*) that did not pose identification problems or nomenclature changes during the survey period.

For each species, the relationship between number caught per hour of trawling and depth were visually inspected and a core depth range established that included >99% of individuals. All hauls within this range (including those with zero catch of that species) were used to generate estimates of catch per unit of effort. As a consequence of variable depth ranges of each species, the sample sizes (number of hauls) vary from species to species.

Distribution maps for each species were produced using ARC GIS. To assess areas of relatively high abundance in close proximity to each other, the 'Hot Spot Analysis' tool in ARC GIS was used. This calculates the 'Getis-Ord Gi' statistic for each feature in a dataset. The resultant values indicate where features with either high or low values cluster spatially based on the proximity of neighbouring features. The analysis highlights samples with a high value that are surrounded by other features with high values as well. It is a useful tool for visualising the spatial distribution of high abundance data.

Generalized additive models (Zuur *et al*., 2009) were used to analyse trends over time, as the relative abundance of most species showed non-linear relationships with depth and over time. The GAM uses a smoothing function to account for non-linear relationships. Latitude was also included in the model as a continuous variable as there was often a weak but significant relationship. Negative binomial or Tweedie variance structures were used to account for the variable occurrence of hauls with zero catch. GAMs were applied to eleven species that were regularly encountered from year-to-year. Several species were too infrequently sampled to analyse.

5.8.3 Summary of trends by species

Birdbeak dogfish *Deania calcea* and Arrowhead dogfish *Deania profundorum*

In the SppGFS-WIBTS-Q4 survey series, these two species were traditionally registered together, but have been better separated since 2012, as reported in previous documents (Ruiz-Pico *et al*., 2014). The biomass and abundance of *Deania spp*. (mainly *D. calcea*) have been following an up and down trend during the last decade. In 2017, the values decreased but remained among the average values of the time series and high to the previous five years (Figure 5.2). Particularly, *D. calcea* decreased whereas D. profundorum increased reaching the highest values of the time series (Ruiz-Pico *et al*., 2018 WD).

In the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters, *D. calcea* and *D. profundorum* were recorded together until 2009. *D. profundorum* was first separately recorded in 2009 (Sanjuan *et al*., 2012). To avoid confounding effects between the two species results previous to 2009 combine the two species and were referred as *Deania spp*. (Figure 5.3). Both species are usually common in additional deeper hauls (> 500 m) and scarce or absent on the standard hauls (70–500 m). *Deania calcea*, that used to be commonly captured in additional hauls, was absent in 2017 survey for the first time since 2009. *Deania profundorum* biomass was reduced almost to the half of 2016 (Fernández-Zapico *et al*., 2018 WD).

The abundance of *Deania calcea* in hauls within the core depth range of 400–1500 m on the Scottish slope has fluctuated generally between 0.7 and 2.2ind.h–1 with no evident trend (since 1998; Table 5.14). The catch rate in 2013 was anomalously high at 5 ind.h–1, the highest in the series. Preliminary analyses by Neat *et al*. (2015) showed a significant positive trend (p = 0.001) over time (Figure 5.4). The results of this analysis should be considered as preliminary and indicative only of general trends.

Knifetooth dogfish *Scymnodon ringens*

In the Spanish Porcupine survey (SppGFS-WIBTS-Q4) the biomass and abundance of *S. ringens* in 2017 decreased but remained among the average values of the time-series (Figure 5.5) (Ruiz-Pico *et al*., 2018 WD).

Biomass values in the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters are very low. In 2017, the biomass of S. ringens decreased to nearly the half of 2016 values in additional hauls and was not captured in standard hauls during the last four years. These values have fluctuated since 2004 with no evident trend (Figure 5.6) (Fernández-Zapico *et al*., 2018 WD).

Velvet belly lanternshark *Etmopterus spinax*

Both the biomass and abundance indexes of *E. spinax* in the Spanish Porcupine survey (SppGFS-WIBTS-Q4) decreased in 2017, after the remarkable increase of the previous year. The values have been following an up and down trend throughout the time series, but with the mean biomass of the last two years remained slightly higher than the five previous years (Figure 5.7; Ruiz-Pico *et al*., 2018 WD).

In the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters, the biomass index shows an increasing trend since 1996. In 2017, about 70% of the biomass of this scarce elasmobranch was found in hauls deeper than 500 m. The biomass of this species has remained constant since last year in standardized hauls but has increased considerably in the additional deep hauls (Figure 5.8). During the last two years, the biomass of this species has doubled when compared to the previous five years (Fernández-Zapico *et al*., 2018 WD).

The relative abundance of *Etmopterus spinax* derived from Scottish deep-water survey at depths from 300 to 1100 m has varied with no overall trend (between 3–10 ind.h–1) since 1998 (Table 5.15 and Figure 5.9). Preliminary analyses using GAM with Tweedie distribution suggest no significant trend over time (Neat *et al*., 2015).

Greater lantern shark *Etmopterus princeps*

The relative abundance of this species between depths of 800–1800 m from Scottish deep-water survey has been variable (averaging 3 ind.h–1), for the past 14 years (Table 5.16; Figure 5.10). Preliminary analyses using GAM with Tweedie distribution suggest no trend over time (Neat *et al*., 2015).

Bluntnose six-gill shark *Hexanchus griseus*

Stratified biomass indicex of *H. griseus* in the Spanish Porcupine survey (SppGFS-WIBTS-Q4) decreased in 2017. The biomass remained among the average values of the time-series whereas the abundance among the lowest values (Figure 5.11) (Fernández-Zapico *et al*., 2018 WD).

In the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters the biomass of *H. griseus* biomass decreased in standard hauls and is absent since 2015 in additional deeper ones (Figure 5.12) (Ruiz-Pico *et al*., 2018 WD).

The relative abundance of *H. griseus* between depths of 300–800 m from Scottish deep-water survey averaged <1 ind.h–1 over the past 14 years (Table 5.17). There was an anomalously high catch of 15 individuals in 2008.

Black dogfish *Centroscylium fabricii*

The relative abundance of *C. fabricii* between depths of 800–1800 m from Scottish deep-water survey has fluctuated with no trend (ca. 5 ind.h–1) since 1998 (Table 5.18; Figure 5.13). Variability of the catch rates is high, wityh occasional large catches recorded. Preliminary analyses using GAM with Tweedie distribution suggest no significant trend over time (Neat *et al*., 2015).

Longnose velvet dogfish *Centroscymnus crepidater*

The relative abundance of this species between depths of 500–1800 m from Scottish deep-water survey has been variable (averaging 5 ind.h–1, but with occasional very high catches) for the past 14 years (Table 5.19; Figure 5.14). Preliminary analyses using GAM with Tweedie distribution suggest a significant negative trend ($p < 0.001$) over time (Neat *et al*., 2015).

Small-eye cat shark *Apristurus microps*

The relative abundance of this species at depths of 500–1500 m from Scottish deep-water survey was, on average, 1 ind.h–1 over the past 14 years (Table 5.20; Figure 5.15).

Pale catshark *Apristurus aphyodes*

The relative abundance of this species between depths of 800–2030 m from Scottish deep-water survey was on average 4 ind.h–1 for the past 14 years (Table 5.21; Figure 5.16). Preliminary analyses using GAM with Tweedie distribution suggest an increasing trend over time ($p < 0.001$) (Neat *et al.*, 2015).

Deep-water skates and rays

Skates are caught infrequently in the Scottish deep-water survey, and the total numbers of each species (blue pygmy skate *Neoraja caerulea*, Mid-Atlantic skate *Rajella kukujevi*, round skate *Rajella fyllae*, deep-water skate *Rajella bathyphila*, Bigelow's skate *Rajella bigelowi*, Richardson's skate *Bathyraja richardsoni*, Jensen's skate *Amblyraja jenseni* and Krefft's skate *Malacoraja kreffti*) each year are shown in Table 5.22.

5.9 Stock assessment

No formal assessments are undertaken for these stocks.

5.10 Quality of assessments

No assessments undertaken.

5.11 Reference points

No reference points have been proposed for any of these species.

5.12 Conservation considerations

The recent European Red List of marine fishes considers *Centrophorus granulosus* to be Critically Endangered, *Centrophorus lusitanicus*, *Echinorhinus brucus*, *Deania calcea* and *Dalatias licha* as Endangered; and *Centrophorus uyato* and *Oxynotus centrina* as Vulnerable (Nieto *et al.*, 2015).

5.13 Management considerations

No management advice is given in 2016.

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Table 5.1. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of gulper sharks (*Centrophorus granulosus* and *Centrophorus spp.*) in tonnes. Portuguese landings (1) are assigned to *Centrophorus spp.* (not *C. squamosus*) whereas French and Irish landings (2) are assigned to *C. granulosus*. Estimates from 2005 onwards were revised following WKSHARKS2.

	UK	PORTUGAL[1]	SPAIN	FRANCE[2]	IRELAND[2]	TOTAL
1990		1056				1056
1991		801				801
1992		958				958
1993		886				886
1994		344				344
1995		423				423
1996		242				242
1997		291				291
1998		187				187
1999		95				95
2000		54				54
2001		96				96
2002		159	8			167
2003	643	203				846
2004	481	89	n.a.			570
2005		49	n.a.		14	64
2006		100				100
2007		62				62
2008		56		+		56
2009		17		1		18
2010		7		+		7
2011		2	+			2
2012		1		1		1
2013		0				+
2014		+				+
2015		+				+
2016		+				+
2017		2				2

+ catch under 0.5 tonnes

Table 5.2. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of birdbeak dogfish (*Deania calcea*). Estimates from 2005 onwards were revised following WKSHARKS2.

	Ireland	Spain	UK (England and Wales)	UK(Scotland)	France	Portugal	Norway	Total
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000						13		13
2001				1		37		38
2002		5		+		67		72
2003		n.a.	+	3		72		75
2004		n.a.	+	38		157		195
2005			50			146		195
2006			22			75		96
2007						37		37
2008					5	57		62
2009					2	22		25
2010					+	3		3
2011						1		1
2012	2					1		3
2013						0	+	+
2014							+	+
2015						0	+	+
2016							+	+
2017						2	+	3

+ catch under 0.5 tonnes

Table 5.3. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of longnose velvet dogfish (*Centroscymnus crepidater*). Estimates from 2005 onwards were revised following WKSHARKS2.

	France	Ireland	UK	Portugal	Spain	Total
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999*	+		+			+
2000*	+		+	1	85	86
2001*	+		+	3	68	71
2002*	13		+	4	n.a.	17
2003*	10		21	2	n.a.	33
2004*	8		7	1	n.a.	16
2005	10		209	3		222
2006	4		409	7		420
2007	2	2	109	18		131
2008	4		0	33		37
2009	6			27		33
2010	40			+		40
2011						
2012						
2013						
2014				+		+
2015				+		+
2016	+			+		+
2017				1		1

+ catch under 0.5 tonnes

Table 5.4. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of black dogfish (*Centroscyllium fabricii*). Estimates from 2005 onwards were revised following WKSHARKS2.

	France	Iceland	UK	Spain	Total
1990					
1991					
1992		1			
1993					
1994					
1995		1			
1996		4			
1997					
1998					
1999	+				
2000	382			85	467
2001	395			91	486
2002	47	+		n.a.	47
2003	90	+	+	n.a.	90
2004	49	n.a.	+	n.a.	49
2005	12		5		17
2006	3				3
2007	6				6
2008	136				136
2009	99	1			101
2010	85	10			95
2011	+	1			1
2012	1	3			3
2013	+	1			1
2014	9	+			9
2015	+	2			2
2016	+	+			+
2017	+				+

+ catch under 0.5 tonnes

Table 5.5. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of velvet belly lanternshark (*Etmopterus spinax*).

	Norway	Denmark	UK (Scotland)	UK (England and Wales)	Spain	France	Total
1990							
1991							
1992							
1993		27					27
1994		+					+
1995		10					10
1996		8					8
1997		32					32
1998		359					359
1999		128					128
2000		25					25
2001		52					52
2002					85		85
2003							
2004							

Table 5.6. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of lanternsharks NEI (*Etmopterus spp*.). Estimates from 2005 onwards were revised following WKSHARKS2.

	Danmark	Norway	France	Spain	Portugal	UK	total
1990							
1991							
1992							
1993							
1994			846		+		846
1995			2388		+		2388
1996			2888		+		2888
1997			2150		+		2150
1998			2043				2043
1999			+				+
2000			+	38	+		38
2001			+	338			338
2002			+	99			99
2003			+				+
2004			+		+		+
2005	16			2	+	9	27
2006	17			27	+		44
2007	9			87		8	103
2008	46		+	6		20	72
2009			1	9			9
2010	4	9	2				15
2011		4	1	1*	+	+	5
2012		13	+	2*	+		13
2013		19	+			+	19
2014		47				+	47
2015		27	1		+	+	28
2016		59	+				59
2017		129	+				129

*** assigned to *Etmopterus pusillus***

Table 5.7. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of "*aiguillat noir*".

	France	total
2000	123	123
2001	165	165
2002	11	11
2003	37	37
2004	21	21
2005	5	5

Table 5.8. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings by species (1990-2004).

Species	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Gulper shark	1056	801	958	886	344	423	242	291	187	95	54	96
Birdbeak dogfish											13	38
Black dogfish											467	486
Longnose velvet dogfish											86	71
Velvet belly lanternshark				27	+	10	8	32	359	128	25	52
Lanternshark NEI					846	2388	2888	2150	2043	+	38	338
Aiguillat noir											123	165
Angular roughshark												
TOTAL	1127	876	1042	974	1269	2893	3238	2588	2708	303	894	1340

Table 5.8. Continued.

Species	2002	2003	2004
Gulper shark	167	203	89
Birdbeak dogfish	72	75	195
Black dogfish	47	90	49
Longnose velvet dogfish	17	33	16
Velvet belly lanternshark	85		
Lanternshark nei	99		
Aiguillat noir	11	37	21
Angular Roughshark			75
TOTAL	641	523	562

Table 5.9. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings by species since 2005, after revision following WKSHARKS2.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Gulper shark	64	100	62	56	18	7	2	1	+	+	+	+	2
Birdbeak dogfish	195	96	37	62	25	3	1	3	+	+	+	+	3
Longnose velvet dogfish	222	420	131	37	33	40				+	+	+	1
Black dogfish	17	3	6	136	101	95	1	3	1	9	2	0	0
Lanternshark NEI	27	44	103	72	9	15	5	13	19	47	28	59	129
Knifetooth dogfish	65	56	161	156	36	53	2	3	+	+			
Arrowhead dogfish			1		+	1	2	1			+		1
Bluntnose sixgill shark	13	13	54	2	5	2	2	1	2	+	1	+	0
Mouse catshark			+	+	3	2	5	1	4	4	2	3	
TOTAL	603	732	555	521	230	218	20	26	26	60	33	62	136

Table 5.10. Other deep-water sharks and skates from the Northeast Atlantic. Discards of deep-water shark species (numbers) recorded by Azores observers 2005–2010.

Species	Damaged	Non commercial	Undersized	Not identified	Total
Centrophorus granulosus		2			2
Dalatias licha		41	3		44
Deania calcea	6	254	1		261
Etmopterus spinax	8	6302	8	1	6319
Hexanchus griseus		2	1	2	5

Table 5.11. Other deep-water sharks and skates from the Northeast Atlantic. Frequency of occurrence (%) of deep-water sharks in the discards of the hauls sampled on board the Portuguese fisheries by gear type: crustacean bottom otter trawl - OTB_CRU; demersal fish bottom otter trawl - OTB_DEF; deep-water set longline fishery that targets black scabbardfish LLS_DWS (2004–2013). "---" indicates no occurrence; NA, information not available by species.

Fishery	YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
OTB_CRU	*Deania calcea*	5	5	3	4	9	2	2	2	4	NA
	Centrophorus granulosus	---	---	---	---	---	---	1	---	1	NA
	Deania profundorum	---	---	---	---	---	---	---	2	---	NA
	Etmopterus spp.	36	24	50	22	17	8	11	23	29	7
OTB_DEF	*Deania calcea*	1	---	---	---	---	---	---	---	---	NA
	Etmopterus spp.	4	3	1	---	---	2	---	---	---	---
LLS_DWS	*Centroscymnus crepidater*	---	---	80	67	25	17	22	17	11	---
	Centroscymnus cryptacanthus	---	---	---	---	25	---	---	---	---	NA
	Deania calcea	---	---	---	---	25	17	11	---	22	NA
	Squalus spp.	---	---	---	---	---	---	---	---	11	NA
	Deep-water sharks nei	---	---	---	---	---	---	22	---	---	NA
	Deania profundorum	---	---	---	---	---	---	---	---	11	NA
	Etmopterus spp.	---	100	100	100	100	100	100	100	100	100
	Scymnodon ringens	---	67	---	67	---	17	---	---	---	NA

Table 5.12. Other deep-water sharks and skates from the Northeast Atlantic. Number and catch weight of anglerfish (*Lophius spp.*) and number of sharks by 100 m depth strata sampled from the pilot study on the trammelnet fishery targeting anglerfish in Portuguese waters (Division 9.a) (2012–2014). *Lophius spp.* combines *Lophius piscatorius* and *Lophius budegassa*. N = number of sampled specimens; W_{est}, estimated weight (based on length–weight relationships). From Moura *et al.* (2015 WD).

		Depth stratum (m)					
	Total	100–	200–	300–	400–	500–	>600
Species	**n**	n	n	n	n	n	n
*Centroscymnus crepidater**	**2**		1				1
*Scymnodon ringens**	**3**					1	2
*Chlamydoselachus anguineus**	**8**			2		1	5
*Dalatias licha**	**6**		1			1	4
*Centrophorus granulosus**	**1**			1			
*Deania calcea**	**13**			3		2	9
*Etmopterus spinax**	**4**			4			
Etmopterus pusillus	**3**		1	2			
Squaliformes NI	**1**					1	
Mitsukurina owstoni	**2**				2		
Galeus atlanticus	**1**			1			
Galeus spp.	**50**	3	6	12	12	5	12
Scyliorhinus canicula	**177**	29	107	40	1	0	0
Mustelus spp.	**1**		1				
Isurus oxyrhinchus	**1**	1					
Prionace glauca	**5**	4		1			
Galeorhinus galeus	**3**		3				
Lophius spp. (n)	**3229**	344	2040	716	13	25	91
Lophius spp. (weight, kg)	**11 711.1**	1254.4	6564.7	2416.5	149.9	187.9	1137.8
No hauls	**90**	**16**	**50**	**14**	**2**	**2**	**6**

*** sharks included in the EU deep-water shark list.**

Table 5.13. Other deep-water sharks and skates from the Northeast Atlantic. Spanish discard data of deep-water shark species. In bold weight discarded (tons.) of demersal elasmobranches and below in italics. CV of estimations by fishing ground. For detailed information see Santos *et al*. (2010).

Fishing Ground Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Celtic Sea (Subareas 6–7)												
Dalatias licha	0	90.9	13.9	1.3	0	0	2.9	0.5	47.7	0.4		
	-	99.7	99.7	98.8	-	-	99.3	99.5	99.7	99.6		
Deania calcea	0	9.8	87.3	17.3	22.2	6.1	2.6	3.6	0	6.2		
	-	99.7	76	49.5	99.7	62.1	99.3	99.5	-	72		
Etmopterus spinax	16.2	296.1	117.7	2.8	6.6	653.6	60.1	206.1	167.2	16.9		
	63.5	94.4	59.5	84.7	99.7	92.9	39.1	76.3	80.5	96.8		
Galeus melastomus	90.1	504.4	169.5	12.8	220.7	456.6	984.6	1045.7	737.1	395.1		6.3
	95.1	64.3	57.1	36.6	47.8	73.5	81.3	77	44.6	89.7		
Iberian Waters (Divisions 8.c–9.a)												
Dalatias licha	0	0	1.3	2.6	0	0	0	3.8	0	0.1	2.0	
	-	-	102.6	100.2	-	-	-	99.7	-	99.7	84.3	
Deania calcea	10.8	51.4	5.5	22.8	1.8	17.9	27.6	157.4	32.4	39.5	164	
	54.9	81.3	61.4	84.5	69.9	96.6	53.9	62.1	43.4	49.9	47.7	
Etmopterus spinax	0.5	332.1	5.6	1.8	1.7	19.5	37.9	28.8	23.3	78.5	14.7	
	90.5	90.8	49.5	68.5	59.4	58.9	75.6	58.6	79.5	72.7	58.1	
Galeus melastomus	588.8	243.5	527.3	553.2	1063.4	225.8	903.7	1271.9	730.7	1433	749	1123
	31.4	54.8	36	60.7	36.7	28.5	62.8	51.1	34.8	40.5	31.8	

Table 5.14. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for Birdbeak dogfish *D. calcea* from Scottish deep-water survey. (N hauls- number of hauls; N fish- number of fishes; Mean NpH – mean number per hour).

Year	N hauls	N fish	Mean NpH	proportion of positive hauls
1998	19	28	0.7	0.63
2000	31	134	2.2	0.9
2002	27	79	1.6	0.84
2004	24	73	1.7	0.63
2005	18	35	1.0	0.47
2006	28	109	2.1	0.68
2007	18	59	1.7	0.47
2008	25	41	1.0	0.26
2009	31	19	0.7	0.42
2011	21	14	0.6	0.37
2012	21	34	1.8	0.58
2013	23	109	5.0	0.63

Table 5.15. Other deep-water sharks and skates from the Northeast Atlantic Summary data for velvet belly lanternshark *Etmopterus spinax* from Scottish deep-water survey. (N HAULS- number of hauls; N FISH- number of fishes; MEAN NPH – mean number per hour).

Year	N hauls	N fish	Mean NpH	proportion of positive hauls
1998	18	319	8.5	0.39
2000	22	360	8.4	0.36
2002	20	137	3.8	0.55
2004	19	137	4.1	0.32
2005	13	98	3.8	0.31
2006	21	201	5	0.33
2007	12	221	9.4	0.42
2008	17	257	8.7	0.53
2009	24	91	4.6	0.13
2011	13	66	5	0.38
2012	27	176	7.6	0.52
2013	37	367	10.5	0.46

Table 5.16. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for greater lanternshark *Etmpterus princeps* from Scottish deep-water survey. (N HAULS- number of hauls; N FISH- number of fishes; MEAN NPH – mean number per hour).

Year	N hauls	N fish	Mean NpH	proportion of positive hauls
2000	20	148	3.70	0.63
2002	16	247	8.33	0.81
2004	14	123	4.48	0.54
2005	14	77	2.75	0.58
2006	19	102	3.97	0.56
2007	15	163	5.62	0.69
2008	22	57	1.74	0.55
2009	29	149	5.62	0.48
2011	21	68	2.96	0.61
2012	22	74	3.46	0.36
2013	23	118	5.2	0.52

Table 5.17. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for bluntnose six-gill shark *Hexanchus griseus* from Scottish deep-water survey. (N HAULS- number of hauls; N FISH- number of fishes; MEAN NPH – mean number per hour).

Year	N hauls	N fish	Mean NpH	proportion of positive hauls
1998	18	1	0.03	0.06
2000	16	0	0	0
2002	13	3	0.13	0.15
2004	14	0	0	0
2005	7	2	0.14	0.14
2006	11	1	0.05	0.09
2007	6	8	0.68	0.33
2008	8	15	1.09	0.25
2009	8	1	0.14	0.13
2011	8	0	0	0
2012	8	1	0.14	0.13
2013	11	3	0.31	0.18

Table 5.18. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for black dogfish *Centroscymnus fabricii* from Scottish deep-water survey. (N HAULS- number of hauls; N FISH- number of fishes; MEAN NPH – mean number per hour).

Year	N hauls	N fish	Mean NpH	proportion of positive hauls
2000	20	372	9.3	0.75
2002	15	107	3.8	0.53
2004	13	104	4.0	0.46
2005	12	158	6.6	0.58
2006	17	180	5.6	0.53
2007	12	109	4.6	0.5
2008	19	175	5.7	0.58
2009	25	138	6.4	0.56
2011	14	214	14.1	0.64
2012	14	119	9.9	0.64
2013	13	71	5.4	0.62

Table 5.19. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for long-nosed velvet dogfish *Centroscymnus crepidater* from Scottish deep-water survey. (N HAULS- number of hauls; N FISH- number of fishes; MEAN NPH – mean number per hour).

Year	N hauls	N fish	Mean Nph	proportion of positive hauls
1998	18	1054	27.2	0.78
2000	28	524	9.6	0.75
2002	23	276	6.6	0.74
2004	20	341	9.3	0.7
2005	17	248	7.3	0.71
2006	25	271	5.8	0.72
2007	15	213	7.1	0.67
2008	18	499	16.2	0.72
2009	25	192	9.1	0.64
2011	17	183	10.1	0.47
2012	16	103	7.3	0.56
2013	21	223	11.0	0.48

Table 5.20. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for mouse catshark *Galeus murinus* from Scottish deep-water survey. (N HAULS- number of hauls; N FISH- number of fishes; MEAN NPH – mean number per hour).

Year	N hauls	N fish	Mean NpH	proportion of positive hauls
1998	7	16	0.984615	0.57
2000	15	38	1.271612	0.6
2002	10	56	3.146067	0.6
2004	8	18	1.142857	0.5
2005	8	2	0.125	0.12
2006	10	30	1.578947	0.6
2007	6	33	2.8125	0.83
2008	9	12	0.75	0.56
2009	16	38	3.064516	0.75
2011	7	4	0.541761	0.43
2012	8	12	1.773399	0.75
2013	9	10	1.149425	0.22

Table 5.21. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for pale catshark *Apristurus aphyodes* from Scottish deep-water survey. .(N HAULS- number of hauls; N FISH- number of fishes; MEAN NPH – mean number per hour)

YEAR	N HAULS	N FISH	MEAN NPH	PROPORTION OF POSITIVE HAULS
2000	20	43	1.08	0.2
2002	16	49	1.55	0.44
2004	14	81	2.89	0.57
2005	14	96	3.43	0.54
2006	19	174	5.03	0.61
2007	15	89	2.94	0.46
2008	22	100	3.16	0.6
2009	29	64	2.22	0.3
2011	21	178	7.80	0.56
2012	26	105	4.32	0.58
2013	18	88	5.0	0.39

Table 5.22. Other deep-water sharks and skates from the Northeast Atlantic. Total number of deep-water skates caught in the Scottish deep-water survey across all depths by year (blue pygmy skate *Neoraja caerulea*, Mid-Atlantic skate *Rajella kukujevi*, round skate *Rajella fyllae*, deep-water skate *Rajella bathyphila*, Bigelow's skate *Rajella bigelowi*, Richardson's skate *Bathyraja richardsoni*, Jensen's skate *Amblyraja jenseni* and Krefft's skate *Malacoraja kreffti*).

YEAR	N. CAERULEA	R. KUKUKUJEVI	R.FYLLAE	R.BATHYPHILA	R.BIGELOWI	B. RICHARDSONI	A. JENSENI	M. KREFTI
1998	1	0	11	0	0	0	0	0
2000	1	0	6	2	2	0	0	0
2002	4	1	9	4	0	0	1	1
2004	0	1	7	1	0	0	0	0
2005	0	0	2	0	1	0	0	0
2006	0	0	7	2	1	0	0	0
2007	1	0	4	1	1	0	6	2
2008	0	0	6	0	0	0	3	0
2009	0	0	8	0	2	2	1	1
2011	0	4	4	0	1	0	1	0
2012	5	0	6	0	1	2	6	0
2013	0	0	1	0	3	10	6	2
Total	12	6	71	10	12	14	24	6

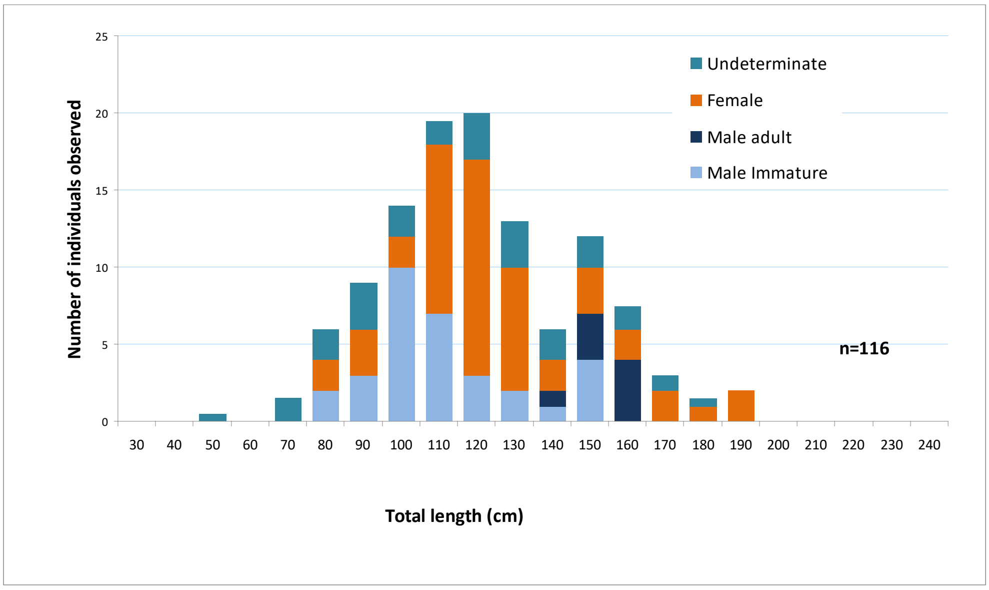

Figure 5.1. Other deep-water sharks and skates from the Northeast Atlantic. Length–frequency distribution of *Dipturus nidarosiensis* observed in the 2012–2014 French landing and coming from ICES subareas 6–7.

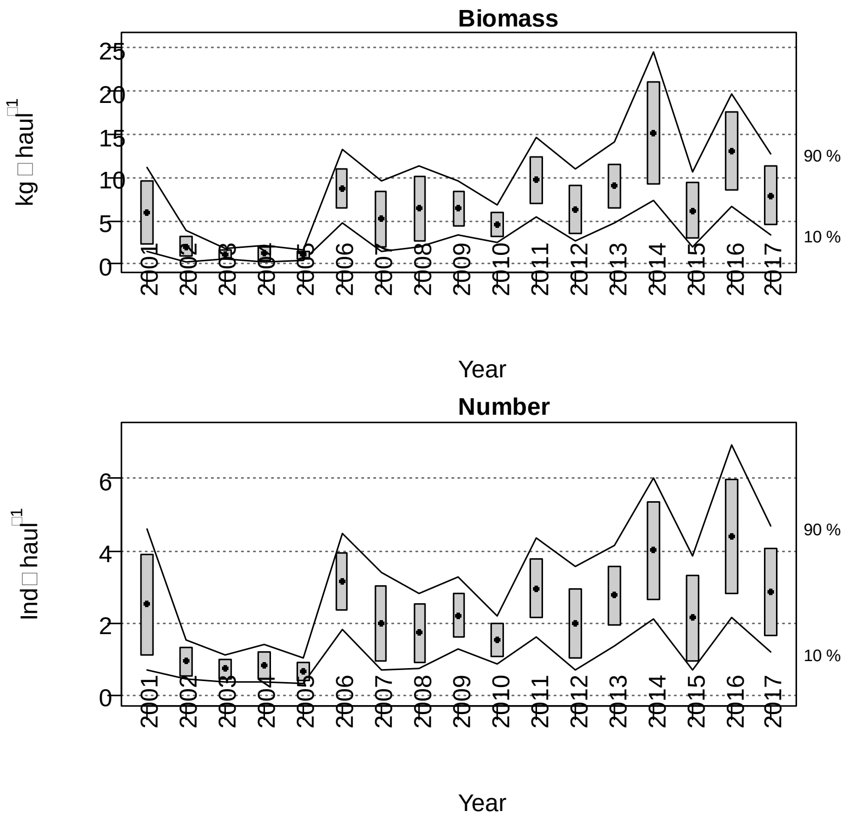

Figure 5.2. Other deep-water sharks and skates from the Northeast Atlantic. *Deania spp.* ,mainly Birdbeak dogfish *Deania calcea* biomass index (Kg haul^{-1}) from the Spannish Porcupine survey (*Spp*GFS-WIBTS-Q4) time-series (2001–2016). Boxes show parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al.* (2018 WD).

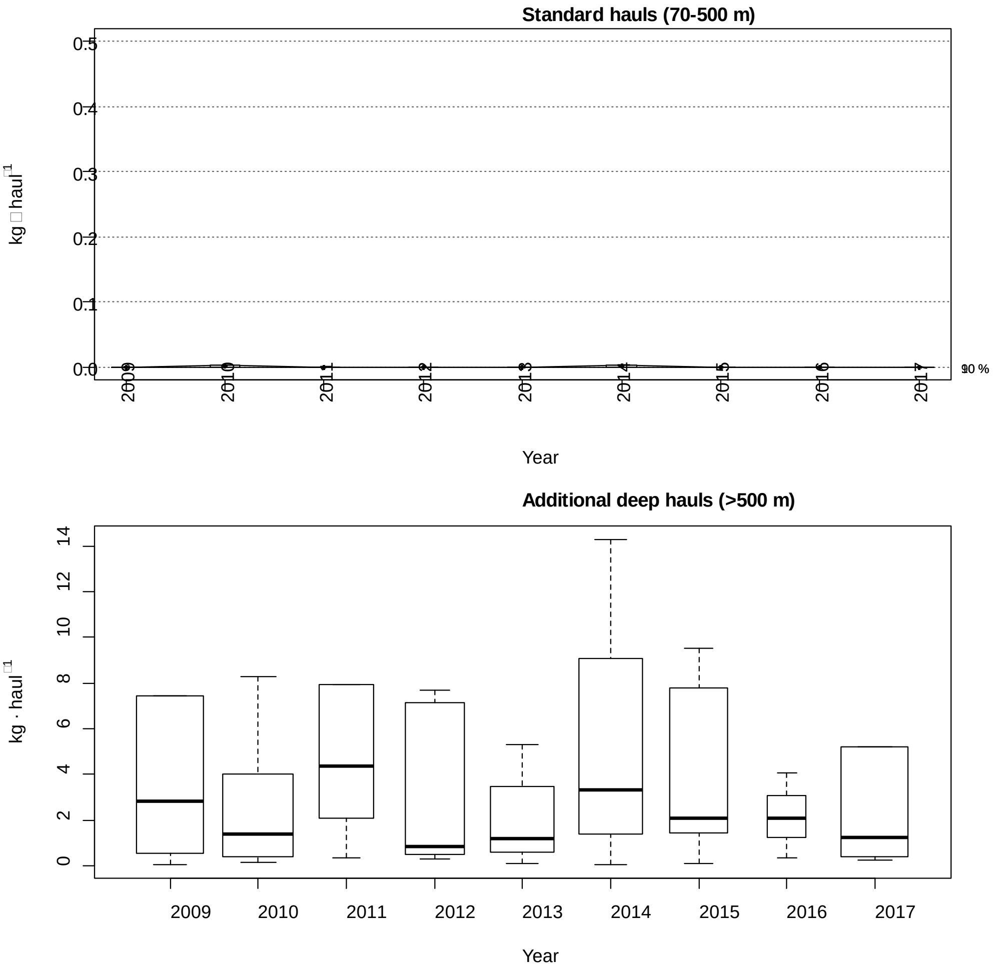

Figure 5.3. Other deep-water sharks and skates from the Northeast Atlantic. Evolution of *Deania calcea* and *Deania profundorum* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). From Fernández-Zapico *et al.* (2018 WD).

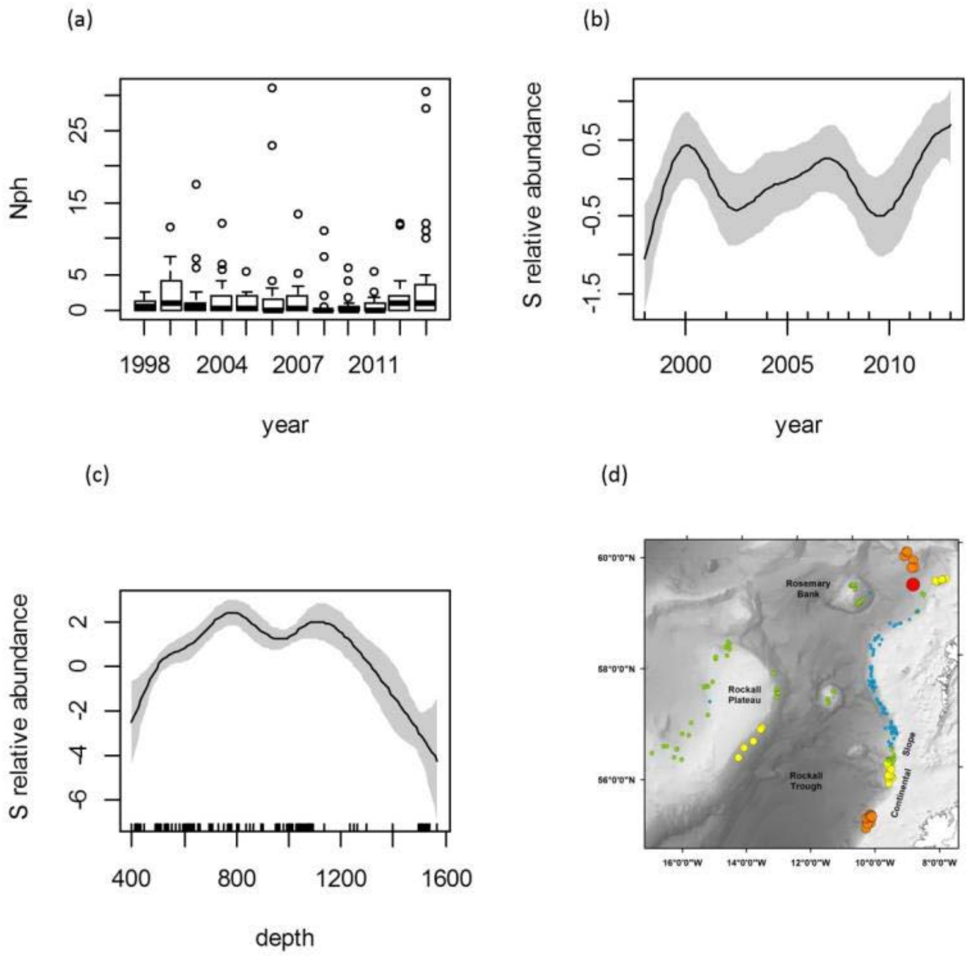

Figure 5.4. Other deep-water sharks and skates from the Northeast Atlantic. Results of GAM analysis of catches of birdbeak dogfish *Deania calcea* in Scottish deep-water trawl survey from Neat *et al.* (2015) showing (a) Box-whisker plot of numbers per hour for each year. (b) Smoothed function of relative abundance of across years. (c) Smoothed function of relative abundance of across depths. (d) Distribution of abundance across the survey area graded from large red dots that indicate hauls of high abundance in close proximity to other hauls of high abundance to small blue dots that indicate hauls of low abundance in close proximity to other hauls of low abundance.

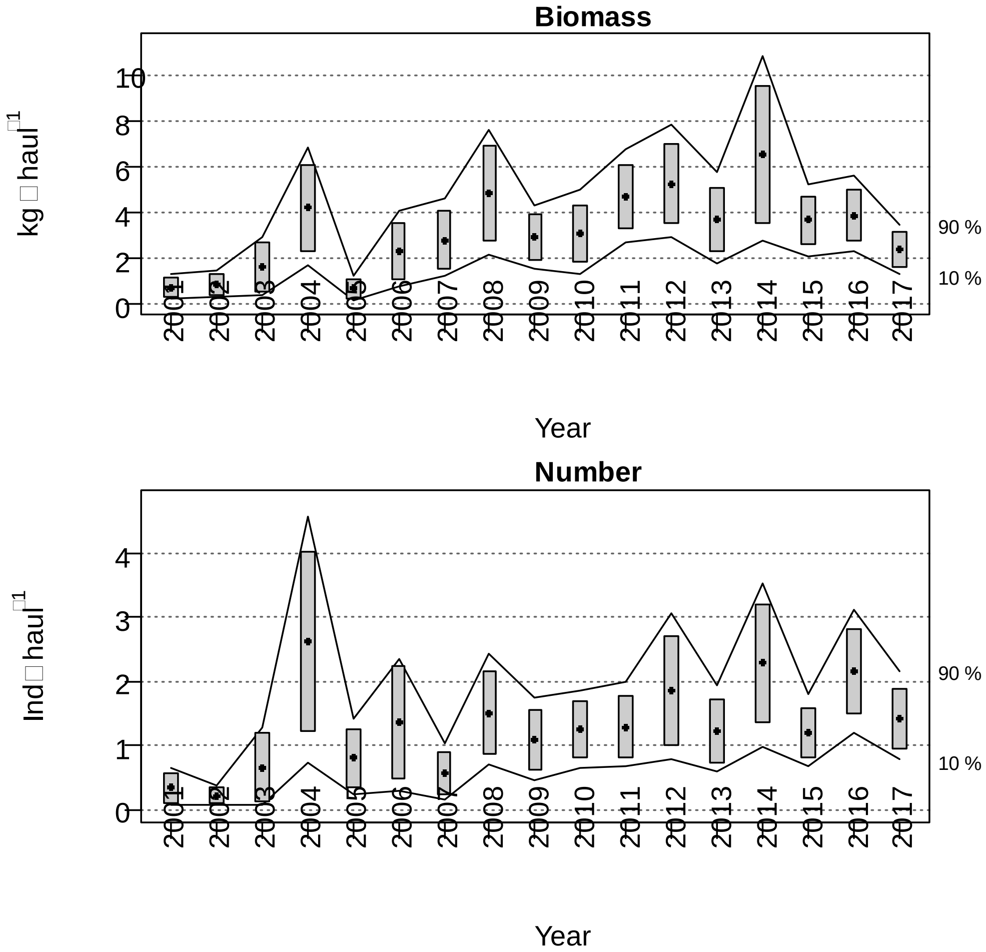

Figure 5.5. Other deep-water sharks and skates from the Northeast Atlantic. Knifetooth dogfish *Scymnodon ringens* biomass index (top, kg·haul^{-1}) and abundance index (bottom, numbers. Haul in the Spanish Porcupine survey (SppGFS-WIBTS-Q4) time-series (2001–2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al.* (2018 WD).

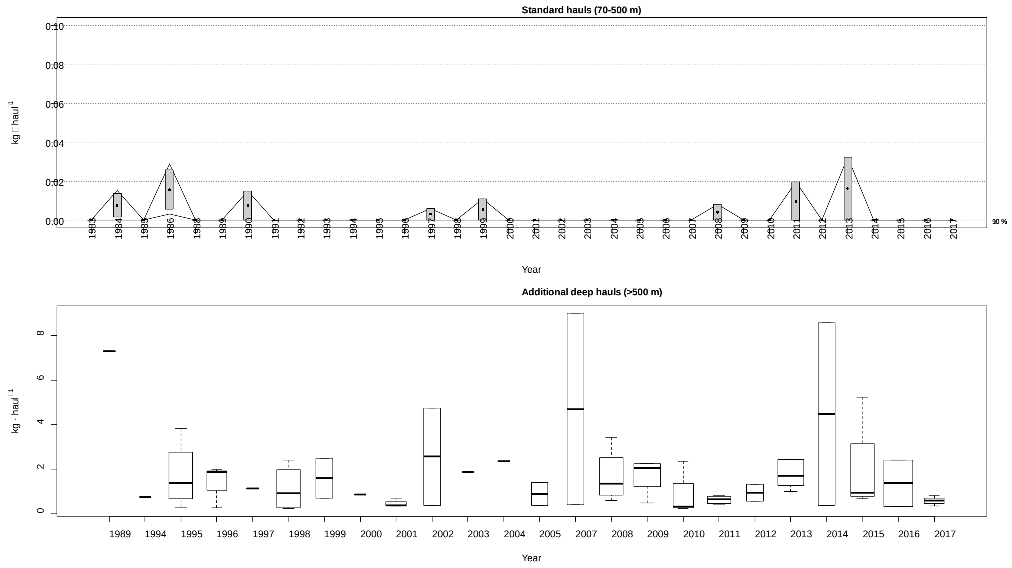

Figure 5.6. Other deep-water sharks and skates from the Northeast Atlantic. Evolution of *Scymnodom ringens* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). From Fernández-Zapico *et al.* (2018 WD).

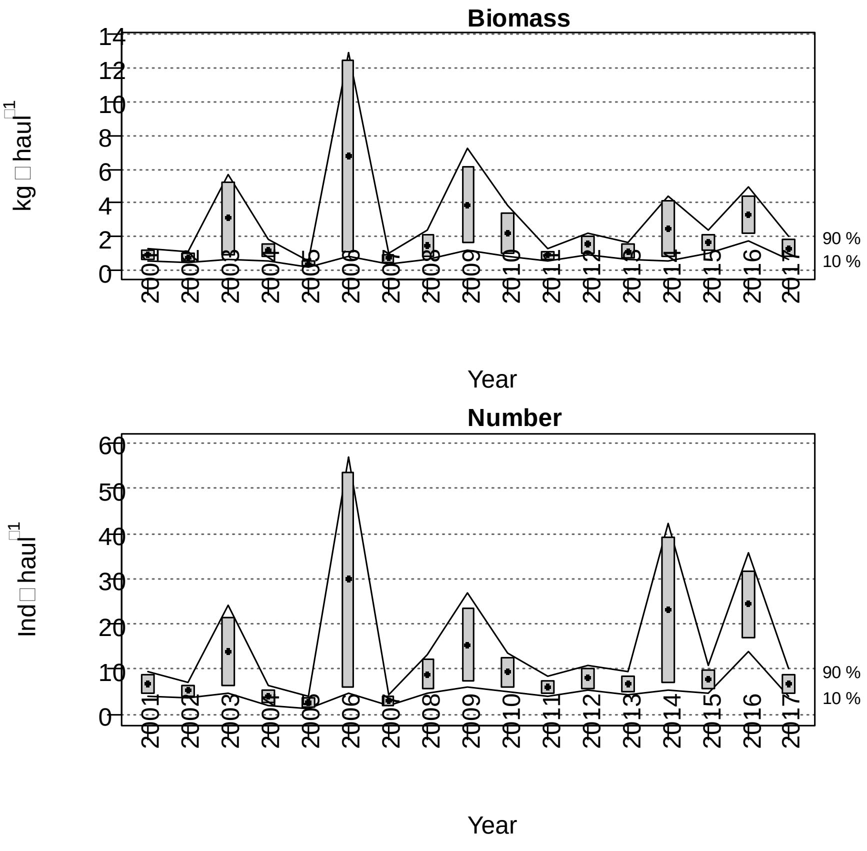

Figure 5.7. Other deep-water sharks and skates from the Northeast Atlantic. *Etmopterus spinax* biomass index (top, kg·haul–1) and abundance index (bottom, numbers. haul–1) during Porcupine survey time-series (2001–2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al.* (2018 WD).

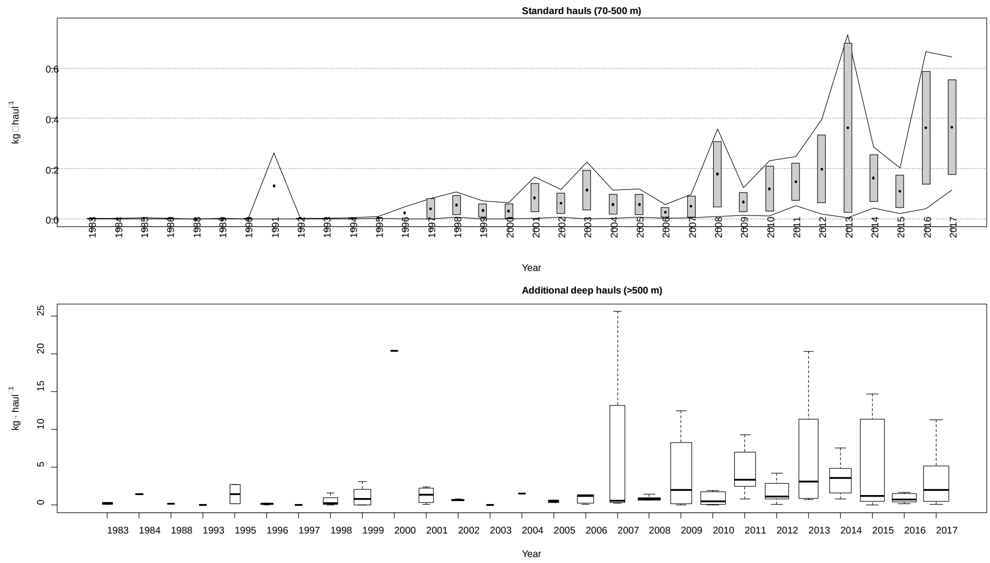

Figure 5.8. Other deep-water sharks and skates from the Northeast Atlantic. Evolution of *Etmopterus spinax* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). From Fernández-Zapico *et al.* (2018 WD).

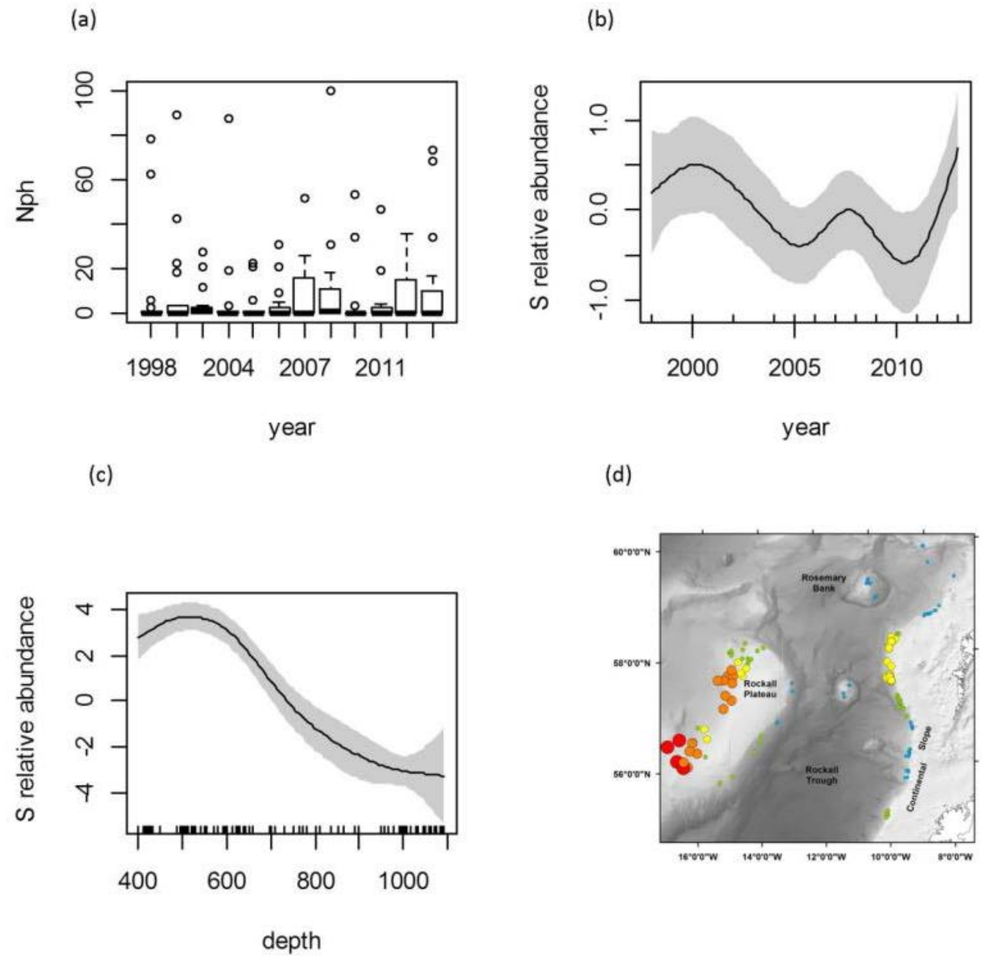

Figure 5.9. Other deep-water sharks and skates from the Northeast Atlantic. Results of GAM analysis of catches of velvet belly *Etmopterus spinax* in Scottish deep-water trawl survey from Neat *et al.* (2015) showing (a) Box-whisker plot of numbers per hour for each year. (b) Smoothed function of relative abundance of across years. (c) Smoothed function of relative abundance of across depths. (d) Distribution of abundance across the survey area graded from large red dots that indicate hauls of high abundance in close proximity to other hauls of high abundance to small blue dots that indicate hauls of low abundance in close proximity to other hauls of low abundance.

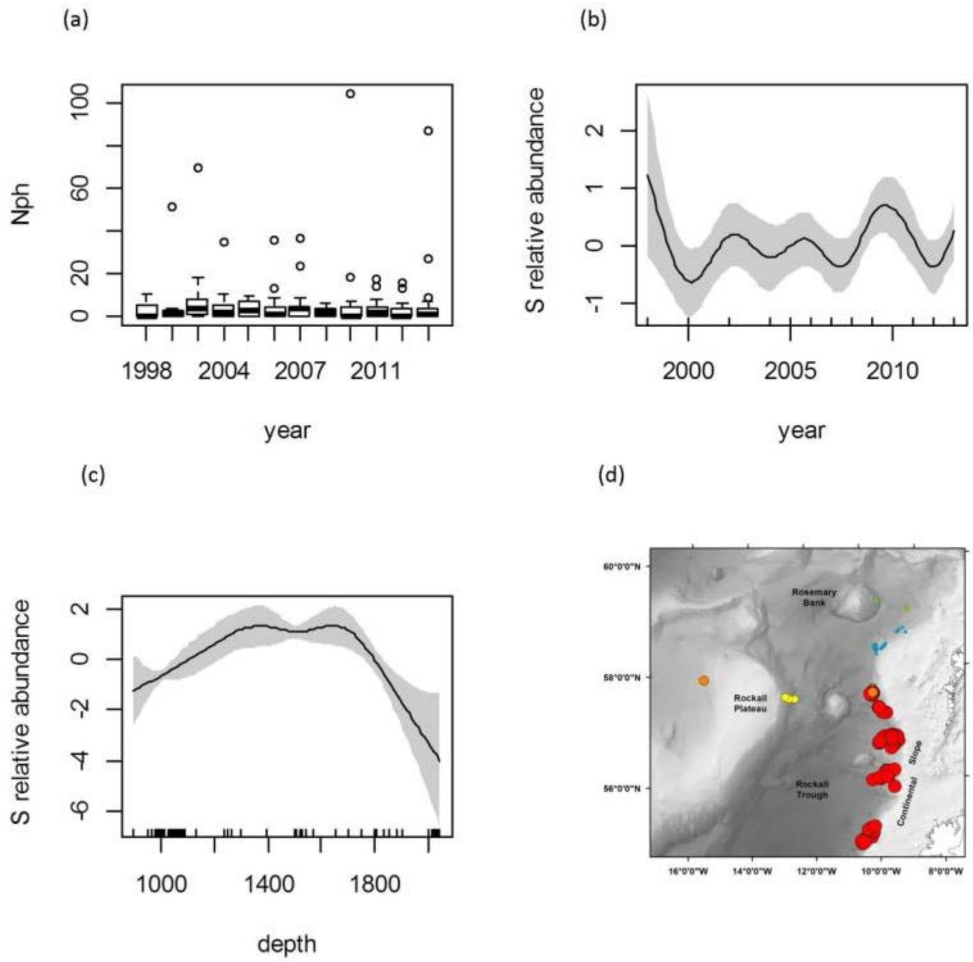

Figure 5.10. Other deep-water sharks and skates from the Northeast Atlantic. Results of GAM analysis of catches of greater lantern shark *Etmopterus princeps* in Scottish deep-water trawl survey from Neat *et al.* (2015) showing (a) Box-whisker plot of numbers per hour for each year. (b) Smoothed function of relative abundance of across years. (c) Smoothed function of relative abundance of across depths. (d) Distribution of abundance across the survey area graded from large red dots that indicate hauls of high abundance in close proximity to other hauls of high abundance to small blue dots that indicate hauls of low abundance in close proximity to other hauls of low abundance.

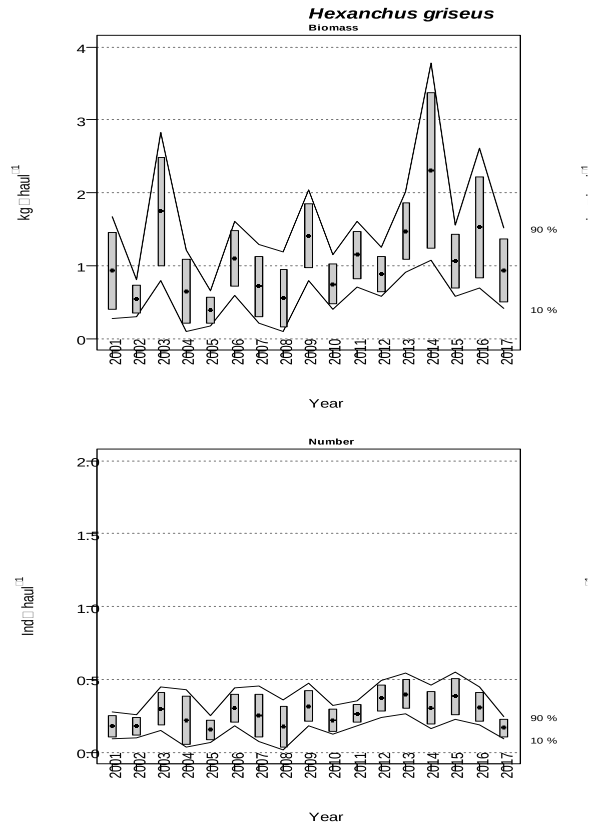

Figure 5.11. Other deep-water sharks and skates from the Northeast Atlantic. Changes in bluntnose six-gill shark *Hexanchus griseus* biomass index (Kg haul^{-1}) during Porcupine survey (*Spp*GFS-WI-BTS-Q4) time-series (2001–2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al.* (2018 WD).

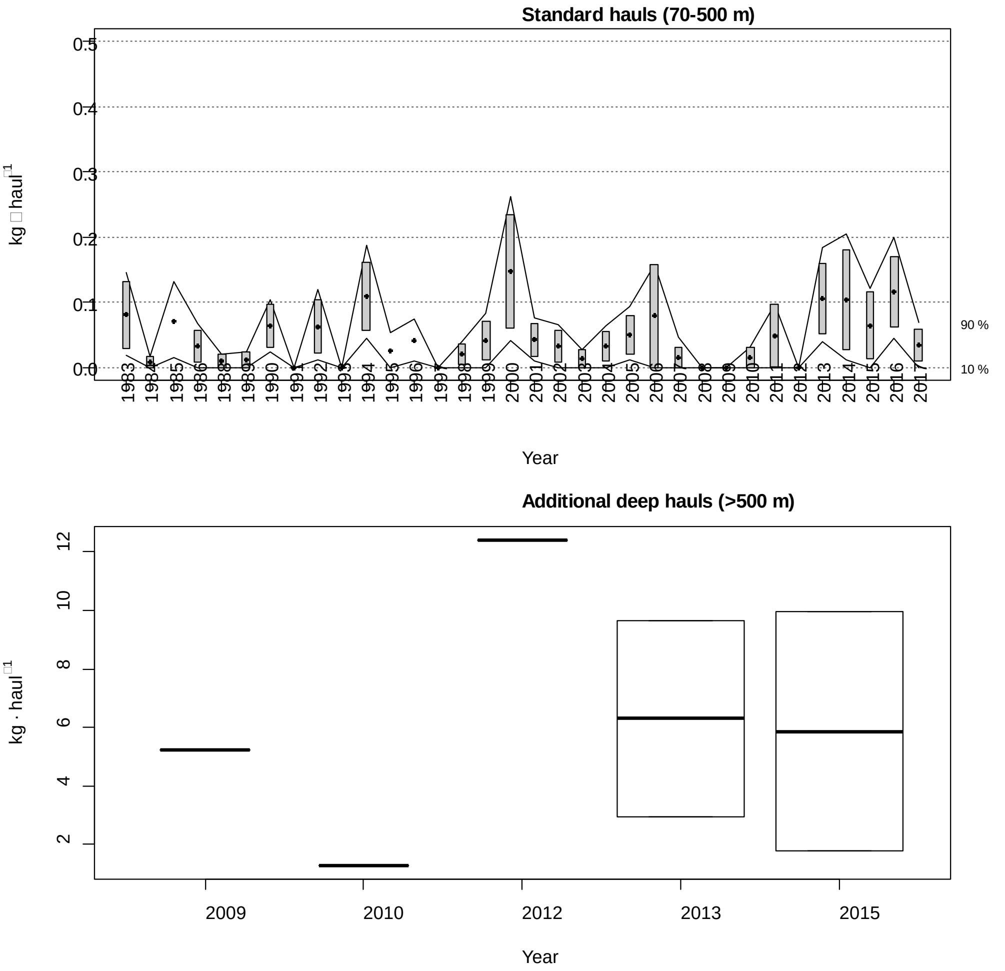

Figure 5.12. Other deep-water sharks and skates from the Northeast Atlantic. Evolution of *Hexanchus griseus* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). From Fernández-Zapico *et al.* (2018 WD).

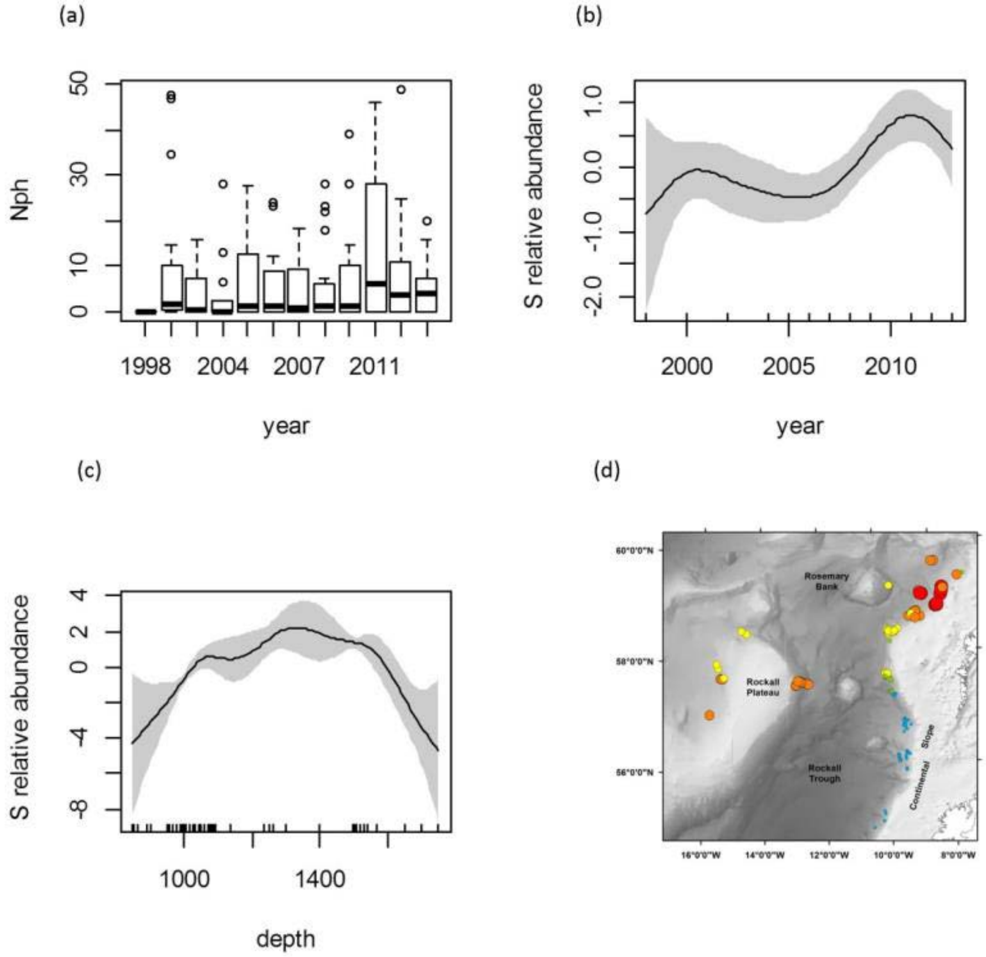

Figure 5.13. Other deep-water sharks and skates from the Northeast Atlantic. Results of GAM analysis of catches of black dogfish *Centroscymnus fabricii* in Scottish deep-water trawl survey from Neat *et al.* (2015) showing (a) Box-whisker plot of numbers per hour for each year. (b) Smoothed function of relative abundance of across years. (c) Smoothed function of relative abundance of across depths. (d) Distribution of abundance across the survey area graded from large red dots that indicate hauls of high abundance in close proximity to other hauls of high abundance to small blue dots that indicate hauls of low abundance in close proximity to other hauls of low abundance.

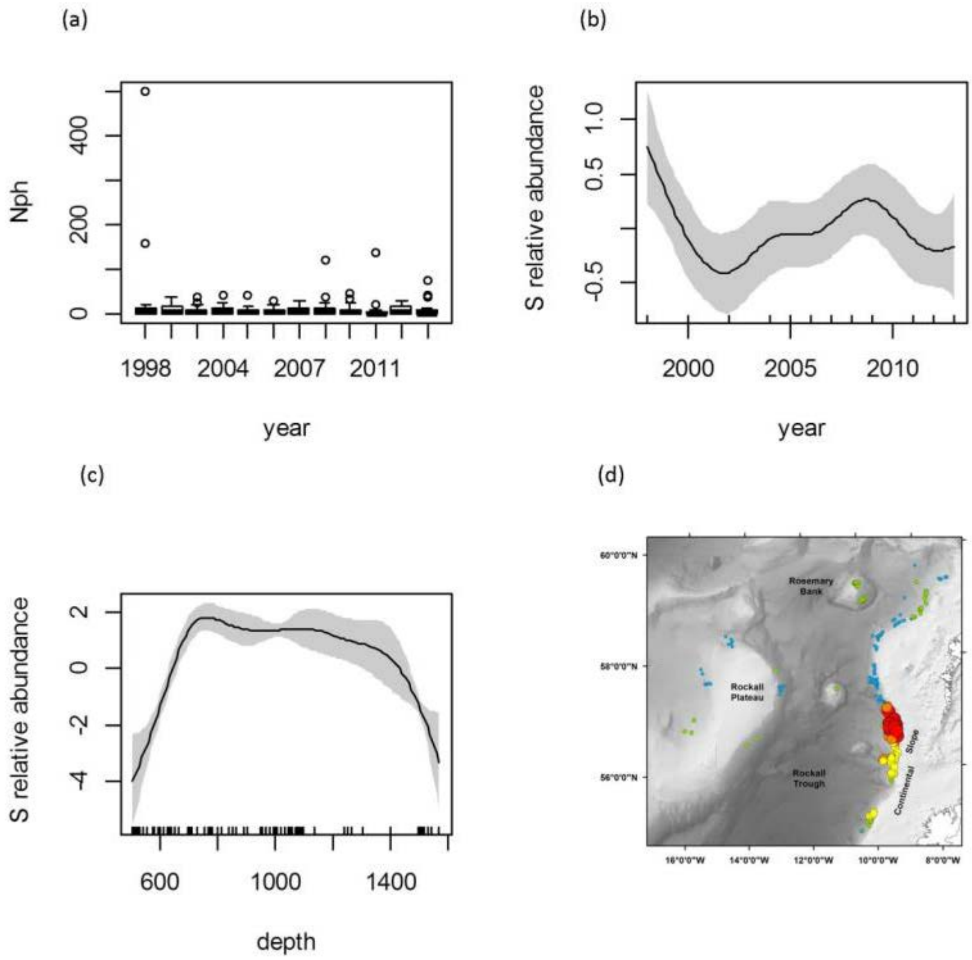

Figure 5.14. Other deep-water sharks and skates from the Northeast Atlantic. Results of GAM analysis of catches of *Centroscymnus crepidater* in Scottish deep-water trawl survey from Neat *et al.* (2015) showing (a) Box-whisker plot of numbers per hour for each year. (b) Smoothed function of relative abundance of across years. (c) Smoothed function of relative abundance of across depths. (d) Distribution of abundance across the survey area graded from large red dots that indicate hauls of high abundance in close proximity to other hauls of high abundance to small blue dots that indicate hauls of low abundance in close proximity to other hauls of low abundance.

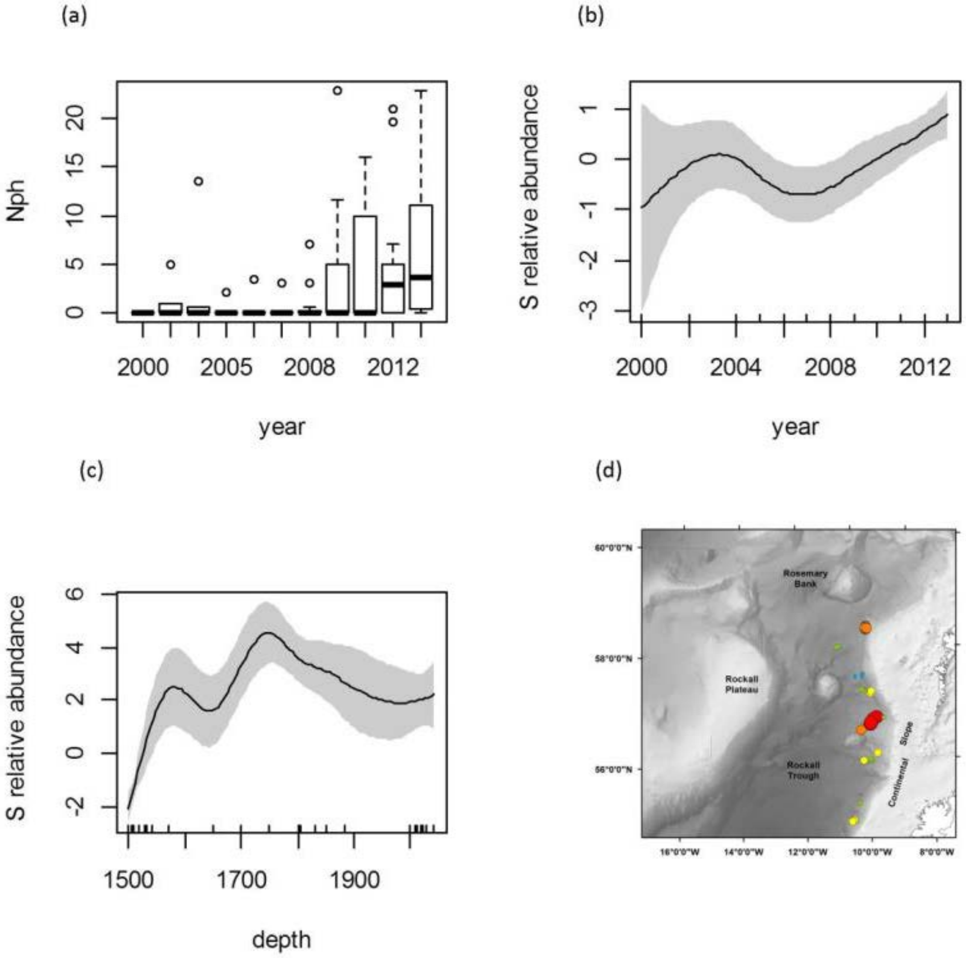

Figure 5.15. Other deep-water sharks and skates from the Northeast Atlantic. Results of GAM analysis of catches of *Apristurus microps* in Scottish deep-water trawl survey from Neat *et al.* (2015) showing (a) Box-whisker plot of numbers per hour for each year. (b) Smoothed function of relative abundance of across years. (c) Smoothed function of relative abundance of across depths. (d) Distribution of abundance across the survey area graded from large red dots that indicate hauls of high abundance in close proximity to other hauls of high abundance to small blue dots that indicate hauls of low abundance in close proximity to other hauls of low abundance.

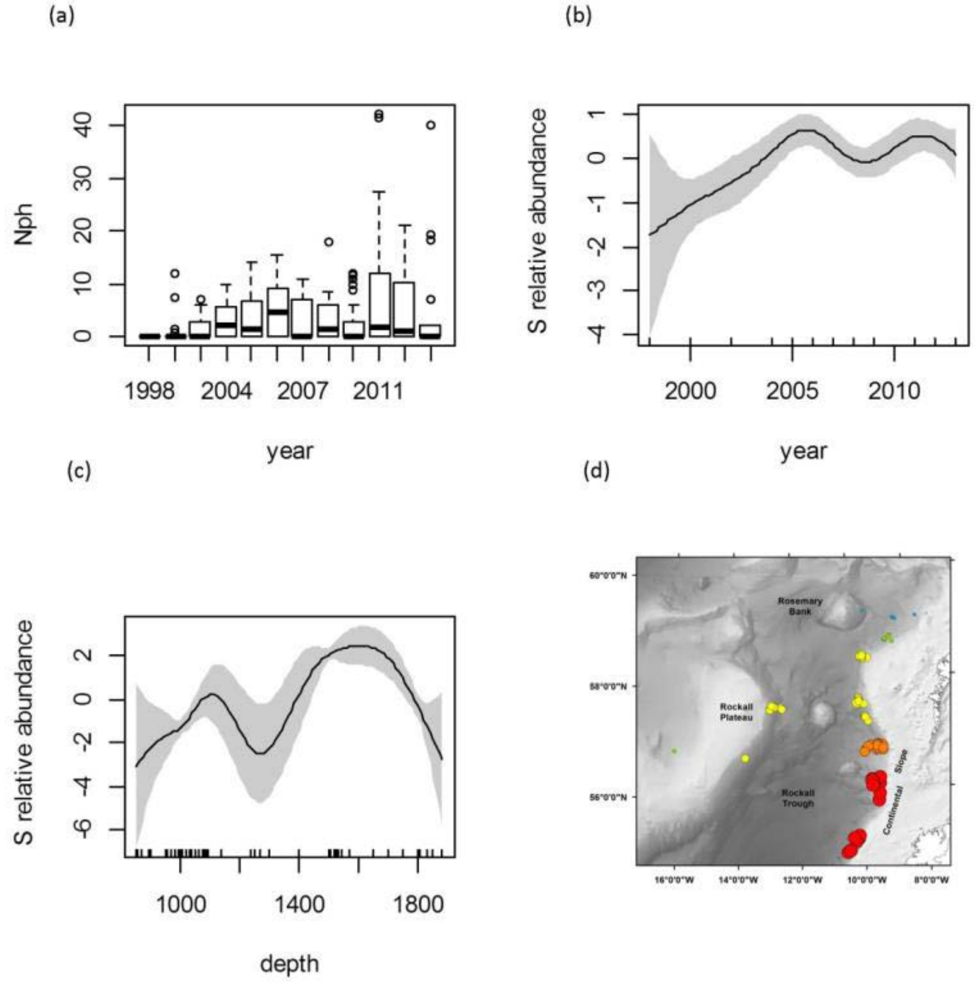

Figure 5.16. Other deep-water sharks and skates from the Northeast Atlantic. Results of GAM analysis of catches of *Apristurus aphyodes* in Scottish deep-water trawl survey from Neat *et al.* (2015) showing (a) Box-whisker plot of numbers per hour for each year. (b) Smoothed function of relative abundance of across years. (c) Smoothed function of relative abundance of across depths. (d) Distribution of abundance across the survey area graded from large red dots that indicate hauls of high abundance in close proximity to other hauls of high abundance to small blue dots that indicate hauls of low abundance in close proximity to other hauls of low abundance.

6 Porbeagle in the Northeast Atlantic (Subareas 1–14)

6.1 Stock distribution

WGEF has traditionally considered that there is a single stock of porbeagle *Lamna nasus* in the Northeast Atlantic. The stock occupies the entire ICES area (Subareas 1–14) and extends from the Barents Sea to Northwest Africa. For management purposes the southern boundary of the stock is 36°N and the western boundary at 42°W. The information to identify the stock unit is provided in the Stock Annex (ICES, 2011).

Evidence available from studies using pop-up satellite archival tags (PSATs) around the British Isles and along the Bay of Biscay shelf edge, however, indicates that porbeagle can cross the North Atlantic to at least the Mid-Atlantic Ridge in autumn-winter. However, when the archival tags transmit data after the winter, they show a return to the European spring-summer feeding areas, providing evidence of site fidelity (Biais *et al.*, 2017). Figures 6.1a and 6.1b show the movements of individual porbeagle tagged in Ireland and in the Bay of Biscay that have reached the Mid-Atlantic Ridge. Additionally, there is one record of one porbeagle that was tagged off Ireland and recaptured in American waters in November (Cameron *et al.*, 2018). Genetic studies have suggested that gene flow has occurred across the North Atlantic (Pade, 2009). However, of about 2000 conventional tags that have been deployed in the NW Atlantic and the 209 recaptures made (up to 2012), none showed any transatlantic migration (Campana *et al.*, 2013).

6.2 The fishery

6.2.1 History of the fishery

The main country catching porbeagle in the last decade was France and, to a lesser extent, Spain, UK and Norway. The only regular target fishery that has existed recently was the French fishery (although there have been seasonal target fisheries in the UK). However, historically there were important Norwegian and Danish target fisheries. Porbeagle is also taken as a bycatch in mixed fisheries, mainly in UK, Ireland, France and Spain. A detailed history of the fishery is in the Stock Annex (ICES, 2011).

Information presented to WGEF 2015 indicated that the Norwegian catch decline in the 1950s and 1960s did not simply reflect a decline in abundance, but also has been influenced by a decrease in effort (Biais *et al.*, 2015a WD). The discovery of good fishing grounds off Ireland in 1960 and the failure to find the same abundance on these grounds in the two following years had an important role in the 1960–1963 catch decline (Figure 6.2). Available data on the mean weights of fish indicate that this fishery off Ireland was located on nursery areas (Biais *et al.*, 2015b WD). Analyses of long-term landings data need to be interpreted in relation to catch per unit of effort experienced by this fleet in both the Northeast and Northwest Atlantic fishing grounds, as well as other factors (e.g. other fishing opportunities).

6.2.2 The fishery in 2017

No EU fishery has been allowed since the implementation of a zero TAC in 2010. However, some limited landings are reported for 2017, as well in the previous five years (Table 6.1). The 2018 WGEF estimate is 10 t in 2017 and since the zero TAC was implemented in 2010, the mean WGEF estimate is 31 t per year. However, data since 2010 must be considered as unrepresentative of removals, as dead discards are not quantified.

6.2.3 ICES advice applicable

The 2015 advice is valid for 2015–2019, and stated: "*ICES advises that when the precautionary approach is applied for porbeagle in the Northeast Atlantic, fishing mortality should be minimized and no targeted fisheries should be permitted*".

6.2.4 Management applicable

It has been forbidden to catch and land porbeagle in Sweden since 2004.

EC Regulation 1185/2003 prohibits the removal of shark fins and subsequent discarding of the body of this species. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

EC Regulation 40/2008 first established a TAC (581 t) for porbeagle taken in EC and international waters from ICES Subareas 1–12 and 14 for 2008. The TAC was reduced by 25% in 2009 and a maximum landing length of 210 cm (fork length) was implemented.

From 2010–2014, successive EC Regulations (23/2010, 57/2011, 44/2012, 39/2013 and 43/2014) had established a zero TAC for porbeagle in EU waters of the ICES area and prohibited EU vessels to fish for, to retain on board, to tranship and to land porbeagle in international waters.

Since 2015 it has been prohibited for EU vessels to fish for, to retain on board, to tranship or to land porbeagle, with this applying to all waters (Council Regulation (EU) 2015/104, 2016/72, 2017/127 and 2018/120).

In 2007, Norway banned all direct fisheries for porbeagle but bycatch could be landed up to 2011. Since that year, live specimens must be released, whereas dead specimens can be landed, but this was not mandatory. The species is therefore exempt from the general Norwegian landings obligation, and the payment is therefore withdrawn, except for 20% to cover the cost of landing.

In 2017, a regulation was issued to ban all targeted fishing in Icelandic waters for spurdog, porbeagle and basking shark and stipulating that all viable catch in other fisheries must be released.

6.3 Catch data

6.3.1 Landings

Tables 6.1a, b and Figures 6.3–6.4 show the historical landings of porbeagle in the Northeast Atlantic. From 1971 onwards, France remained the major contributor. The Danish time-series for 1946–1949 was completed at the 2015 WGEF, using the information collected for analysing the trends in the Northern European porbeagle fishery (Biais *et al*., 2015a WD).

More detailed information on landings is presented in the Stock Annex.

6.3.2 Discards

Because of the high value of this species, it is likely that specimens caught incidentally were landed prior to quota becoming restrictive. Historical discards are consequently thought to be low. The EU adoption in 2009 of a maximum landing size for this species likely led to increased discarding of large fishes by vessels from the French directed fishery, although the proportion of large fish was low in the landing of this fishery (<5%; Hennache and Jung, 2010).

Current levels of discarding are uncertain, and may seasonally occur in some métiers. For example, observations on porbeagle bycatch have been made for some gillnetters operating in the Celtic Sea (Bendall *et al.*, 2012a, b; Ellis and Bendall, 2015 WD), but there are no estimates of total dead discards.

Anecdotal information indicates that porbeagle is a regular bycatch in the Norwegian pelagic trawl fishery for blue whiting in the Norwegian Sea. Due to the fishing method, whereby the catch is pumped on board, all specimens are reportedly dead when caught. It was also suggested that there is an increased occurrence of porbeagle in this fishery since 2014/2015. The lack of observer coverage on these vessels means that such observations have not been independently verified.

6.3.3 Quality of catch data

Some EU nations have incomplete recording of porbeagle (e.g. they have been reported as generic sharks; have been captured by <10 m LOA vessels). Although catch data for this stock are considered to be underestimated, these are mostly for nations catching small quantities, and more comprehensive data are available for the main fishing nations. Since the zero TAC / prohibited listing was introduced, reported landings are not representative of catch. There are no estimates of recent catches, as only limited data from discard observer trips are available for porbeagle (and it is unclear as to whether these data would be sufficiently representative to provide robust estimates of dead removals). 2005–2015 EU Member States, Norwegian and Icelandic landing have been revised in 2016. Major revisions are in 2008 and 2009 for France and Spain.

6.3.4 Discard survival

Data on discard survival are limited. Bendall *et al.* (2012a) examined the vitality of porbeagle caught in gillnet fisheries, and only four (20%) of the 20 fish captured were alive. It is important to recognise that this study was based on a small sample size and the soak time was shorter than that adopted by normal fishing operations. Survival on longlines is likely to be much higher, but would depend on soak time. Fishers have reported mortality of porbeagle caught in pelagic trawl fisheries, but this has not been quantified.

6.4 Commercial catch composition

Only limited length data are available. However, length-distributions by sex are available for 2008 and 2009 for the French target fishery (Hennache and Jung, 2010; Figure 6.5). These distributions are considered representative of international catches because during that period France was the major contributor to catch figures.

The composition by weight class (<50 kg and ≥50 kg) of the French fishery catches reveals that the proportion of large porbeagle in the landings was higher before 1998 than after 2003 but with large inter-annual changes (Table 6.2).

Catch data derived from the target French fishery highlighted the dominance of porbeagle (89%) on the total catch. Other species included blue shark (10%), common thresher (0.6%) and tope (0.3%).

6.4.1 Conversion factors

Length–weight relationships are available for different geographic areas and for time periods (Table 6.3). Relationships between alternative length measurements with total length in porbeagle were recently presented (Table 6.4; Ellis and Bendall, 2015 WD).

6.5 Commercial catch and effort data

A new CPUE series from Norwegian porbeagle longliners (1950–1972 was presented in 2015 (Biais *et al.*, 2015b WD). Personal logbooks of three fishermen (covering periods of three, 10 and 15 years) were used to get this new series. Data were reported for each fishing day of the trip, including days with zero catch. Most of the fishing days were in northern European waters (Divisions 2.a, 4.a-b, 5.a and 6.a (north of 59°N)), the historical Norwegian fishing zone, but some data were also available for fishing days west of the British Isles, including the Celtic Sea.

The time-series trend in this area was explored by carrying out a GLM on log transformed values fitted with a gamma link function. The annual index series provided by this analysis showed no significant temporal trend (Figure 6.6).

A CPUE series based on data collected from 17 boats belonging to the French targeted fishery was presented by Biais and Vollette (2009). These boats landed more than 500 kg of porbeagle per year during more than six years after 1972 and more than four years from 1999 onwards (to include a boat that had entered the fishery towards the end of the time-series, given the limited number of boats in recent years).

At the 2009 ICCAT-ICES meeting, standardized catch rates were also presented for North Atlantic porbeagle during the period 1986–2007, caught as low prevalent bycatch in the Spanish surface longline fishery targeting swordfish in the Atlantic Ocean (Mejuto *et al.*, 2009). The analysis was performed using a GLM approach that considered several factors such as longline type, quarter, bait and also spatial effects by including seven zones.

The nominal and the standardized catch rate series of the French fleet show that higher values occurred by the late 1970s (Figure 6.7). Since then, CPUE has varied between 400–900 kg per day without showing a trend.

The caution with which trends over short periods must be considered was shown by an analysis of the effect of porbeagle aggregating behaviour, as well as an effect of cooperation between skippers. The analysis was carried out for years 2001–2008 for which detailed data were available (Biais and Vollette, 2010). The analysis showed that inter-annual variation in local abundance may be higher than indicated by catch by trip or catch by day.

Spanish data showed a higher variability than the French (Figure 6.8), possibly as they were based on bycatch data and derived from fishing fleet that operate in areas with lower abundance of porbeagle.

6.6 Fishery-independent surveys

An abundance survey was carried out in May-June 2018 by France (Ifremer) on board a chartered longliner. The longline was the same as that formerly used by commercial vessels, but shorter (336 hooks per set; 1 or 2 sets per day). A sampling protocol with fixed stations was adopted, as in the Western Atlantic (Campana *et al*, 2013). The survey area stretches from latitudes 45° to 48° N along the shelf edge (depths from 700 to 4000 m). 32 stations must be covered. Preliminary results show that the station distribution relates well to the spring porbeagle abundance distribution in the Bay of Biscay and in the South-West of the Celtic Sea in 2018. The renewal of this survey is planned in 2019 but the further time gap between surveys remains to be defined.

6.7 Life-history information

Life-history information (including habitat description) is presented in Stock Annex.

Nicolaus *et al.* (2015 WD) reported high levels of mercury (Hg) in both the red and white muscle of porbeagle (n = 33) caught in the Celtic Sea. Hg concentrations in either the red or white muscle that exceeded the maximum levels established in European regulations for seafood were observed in a third of specimens. Hg concentration, however, increased with length, and all fish >195 cm total length had concentrations >1.0 mg kg^{-1}, with a maximum observed value of 2.0 mg kg^{-1}.

6.7.1 Movements and migrations

Migrations of three porbeagle tagged off Ireland with archival pop-up tags (PAT) in 2008 and 2009 are described by Saunders *et al.* (2011). One specimen migrated 2400 km to the northwest off Morocco, residing around the Bay of Biscay for about 30 days. The other two remained in off-shelf regions around the Celtic Sea/Bay of Biscay and off western Ireland. They occupied a vertical distribution ranging from 0–700 m and at temperatures of 9–17°C, but during the night they preferentially stayed at upper layers. The Irish tagging programme is ongoing.

The UK (CEFAS) launched a tagging program in 2010 to address the issue of porbeagle bycatch and to further promote the understanding of porbeagle movement patterns in UK marine waters. Altogether, 21 satellite tags were deployed between July 2010 and September 2011, and 15 tags popped off after two to six months. However, four tags failed to communicate. The tags attached to sharks in the Celtic Sea generally popped off to the south of the release positions while those to sharks off the northwest coast of Ireland popped off in diverse positions. One tag popped off in the western part of the North Atlantic, one close to the Gibraltar Straits and another in the North Sea. Several tags popped off close to the point of release (Bendall *et al.*, 2012b).

In June–July 2011, France (IFREMER and IRD) joined the international tagging effort in cooperation with CEFAS by undertaking a survey on the shelf edge in the West of Brittany. A second survey was carried out in 2013 by Ifremer. Three PATs were deployed by IFREMER-IRD and three by CEFAS (results in Bendall *et al.*, 2012a) during the 2011 survey, and nine during the 2013 survey. Pop-off dates were set at twelve months for the PSATs deployed by France which were all used to tag large females (L_T >2 m). Eight PSATs popped up after four months and four at twelve months. Track reconstructions, based on Grid Filtering, were carried out for these eight tags (Biais *et al.*, 2017). They revealed large migrations of the sharks; going from the Bay of Biscay northward to the Arctic Circle, southward to Madeira and three fish moved westwards to the Mid-Atlantic Ridge. A general circular migration pattern was observed with a return to the Bay of Biscay or the SW Celtic Sea shelf edge when PSATS popped up at 12 months. In these cases, the small observed distances between tagging and pop-up positions (mean 190 km) are remarkable given that movements could be of several thousand km.

An exploratory abundance survey for porbeagle in the Bay of Biscay was undertaken by France in summer 2016, including the deployment of 7 PATs. One PAT never transmitted, three premature pop-ups (<1 month) were observed and one PAT transmitted in February just off the northwest coast of Spain. The two remaining PATs popped up on schedule at 12 months. The corresponding estimated tracks show again that porbeagle has an annual circular migration pattern. These PAT deployments were completed in 2018 by the tagging of 32 porbeagle during the 2018 French abundance survey.

6.7.2 Reproductive biology

A research programme carried out by the NGO APECS (Hennache and Jung, 2010) provided information based on a large sampling (n = 1770) on the French catch in 2008–2009. Spatial sex-ratio segregations are documented and information is provided on the likelihood of a nursery ground in St George's Channel and of a pupping area in the grounds along the western Celtic Sea shelf edge. Further evidence of parturition close to the western European shelf was provided by the captures of 9 newborn pups on the Bay of Biscay shelf break in May 2015 and July 2016 (Biais *et al*., 2017) as well as by the captures of pregnant females during the 2018 abundance survey.

6.7.3 Genetic information

A preliminary study of the genetic diversity (mitochondrial DNA haplotype and nucleotide diversities) was carried by Pade (2009). This study was based on 156 individuals caught both on the Northeast and Northwest Atlantic; the results obtained show no significant population structure across the North Atlantic. However, while the mtDNA haplotype diversity was very high, sequence diversity was low, which suggests that most females breed in particular places, which also indicates the stock is likely to be genetically robust (Pade, 2009).

A recent genetic study examined 224 specimens from eight sites across the North Atlantic and the Southern Hemisphere (Testerman, 2014). Results support previous findings of no genetic differentiation between the Northeast and Northwest Atlantic. However, results showed strong genetic difference between the North Atlantic and Southern Hemisphere. This indicates two genetically distinct populations (Testerman, 2014). Further studies examining genetic structure of Mediterranean Sea porbeagle are still required.

6.8 Exploratory assessment models

6.8.1 Previous studies

The first assessment of the Northeast Atlantic stock was carried out in 2009 by the joint ICCAT/ICES meeting (ICCAT, 2009; ICES, 2009) using a Bayesian Surplus Production (BSP) model (Babcock and Cortes, 2009) and an age-structured production (ASP) model (Porch *et al*., 2006). The 2009 assessments have not been updated since.

Using the French CPUE series as well as the Spanish CPUE series, stock projections based on the BSP model demonstrated that low catches (below 200 t) may allow the stock to increase under most credible model scenarios and that the recovery to B_{MSY} could be achieved within 25–50 years under nearly all model scenarios. However, it is important to recognise both the uncertainty in the input parameters for this assessment and the low productivity of the stock. More detailed results from these are detailed in the Stock Annex.

6.8.2 Population dynamics model

A recent analysis by Campana *et al*. (2013), utilising a forward-projecting age- and sex-structured population dynamics model found that the Canadian porbeagle population could recover from depletion, even at modest fishing mortalities. The population was projected forward from an equilibrium starting abundance (assumed an un-fished equilibrium at the beginning of 1961 prior to directed commercial fisheries) and age distribution by adding recruitment and removing catches. All model projections predicted recovery to 20% of spawning stock numbers before 2014 if the fishing mortality rate was kept at or below 4% of the vulnerable biomass. Under the low productivity model, recovery to spawning stock numbers at maximum sustainable yield was predicted to take over 100 years at exploitation rates of 4% of the vulnerable biomass. The results of this study may need to be re-appraised, depending on improved knowledge of the stock unit(s).

6.8.3 The SPiCT model

A working document (Albert, 2018) was presented describing different exploratory runs of the SPiCT model based on a French CPUE long-line index from the Bay of Biscay, as well as on total international landings, both available in the last working group report (ICES, 2017). The CPUE index was available for the years 1972–2007 (Figure 6.7) and landings data from 1950–2016 (Table 6.1a and 6.1b).

To investigate the sensitivity of the SPiCT model towards varying quality throughout the time-series, the model was fitted for a series of different start and stop years for both the CPUE index and the landings data. As recommended (Pedersen and Berg, 2016), various choices were also made of which parameters to be estimated by the model and which that were set by the user. Fixing n=2 implies that the symmetric Schaefer model is used, and fixing alpha=1 means that the process and observation noise are equal.

Tables 6.5a and 6.5b summarize settings, diagnostics and results from ten different runs, Run1-Run10. In a few cases, there were significant violations of some of the underlying assumptions, but the implications of this were not further investigated. The model output also includes precision estimates of the parameters K, MSY, Fmsy, B and F.

Figure 6.9 shows the results plots for Run 6. More detailed results are presented in the working document.

In assessing the individual model runs, emphasis was placed on the extent to which the historical development, as it appears in the KOBE plots, seems in line with what is known with regard to fishing history. The KOBE plots from all the runs except the first one, showed more or less realistic trajectories. However, the runs with landings data only starting in 1971 (Run 1-3) gave extremely imprecise estimates, with confidence intervals covering large parts of the plots. This is probably due to the fact that they covered a period of relatively small contrast in the landings data, and only the left side of the production curve was supported by data points.

The best results were therefore from runs where the catch data dates back to 1950. In runs 4, 5 and 10, the catch series was truncated where the fishing ban was implemented. These runs all show that the stock was in the red zone at that time. The runs that continue until 2016 (Run 6, 7, 8 and 9) show that fishing mortality fell below Fmsy in 2010 and that the stock is on its way up again. Pedersen and Berg (2016) points out that the shape of the production curve is important for unbiased reference points and recommends not fixing the shape parameter n if it is well estimated by the model. In Run 6, the n-parameter was allowed to be estimated, while in Run 7 it was fixed at n=2 (Schaefer) while all other input data were the same. The results from these two runs were largely similar, but Bmsy was smaller and Fmsy higher when n was estimated. This resulted in estimated present biomass of 60% above Bmsy, compared to slightly below Bmsy (86%) when n was fixed.

Apart from Run1, which is considered largely unreliable, all the runs until 2016 (Run6 - Run9) indicate that the stock biomass is now either above or not too far below Bmsy. With the present F far below Fmsy, a commercial porbeagle fishery may therefore again become advisable in the near or medium-term future. This requires however a reestablishing of reliable data series on removals, as well as on stock size and composition. However, these exploratory runs need to be further scrutinized before the results can be considered as indicative of the present status of the stock.

6.9 Stock assessment

Since the closure of the fishery and the designation of porbeagle as a prohibited species, there are insufficient commercial data (and no fishery-independent data) with which to ascertain the current status of the stock. In order to close data gaps and identify important areas for life-history stages (e.g. mating, pupping and nursery grounds), ICCAT has encouraged research and monitoring projects at stock level to start in 2017 for the results to be used in the joint ICCAT/ICES stock assessment in 2019 (ICCAT, 2016).

6.10 Quality of assessments

The assessments (and subsequent projections) conducted at the joint ICCAT/ICES meeting that are summarized in the Stock Annex were considered exploratory assessments, considering the assumptions (carrying capacity for the SSB model, F in the historic period in the ASP model) and available data, (particularly a lack of CPUE data for the peak of the fishery; uncertainty in some of the landings data).

The CPUE index used in the ICCAT/ICES assessment included catch per day from the French fleet for the years 2001–2008. This showed that catch rates could vary a lot between consecutive years, and so may not be reflective of stock abundance.

Consequently, the model outputs were considered highly uncertain (ICCAT, 2009) and in 2009 and subsequent years, WGEF considered that there was insufficient new information to inform on current stock status.

Available CPUE from Norwegian vessels showed no consistent trend from 1950 to 1972. This information, provided at the 2015 WGEF, also suggests that the northern fisheries ceased partly because of the attraction of other fisheries. It underlines also that economic and social factors are important considerations in explaining why a fishery may not operate or resume even if the abundance does not decline. An update of the ICES/ICCAT assessment should consider these new data during the next ICCAT porbeagle assessment scheduled for 2019.

6.11 Reference points

ICCAT uses F/F_{MSY} and B/B_{MSY} as reference points for stock status of pelagic shark stocks. These reference points are relative metrics rather than absolute values. The absolute values of B_{MSY} and F_{MSY} depend on model assumptions and results and are not presented by ICCAT for advisory purposes.

6.12 Conservation considerations

At present, the porbeagle shark subpopulations of the Northeast Atlantic and Mediterranean are listed as Critically Endangered in the IUCN red list (Stevens *et al*., 2006).

In 2013, a renewed proposal to list porbeagle shark on Appendix II of CITES was accepted at the Conference of Parties (16) Bangkok, and it has been listed since September 2014.

6.13 Management considerations

WGEF/ICCAT considered all available data in 2009. This included updated landings data and CPUE from the French and Spanish fisheries. Collation of historical information, as provided in 2015, supports the need to update the ICCAT/ICES assessment.

The new CPUE series provided for the Norwegian fishery from 1950 to 1972 further highlights the difficulties in interpreting stock trends with contrasting trends in CPUE and landings.

In the absence of target fisheries and reliable information on bycatch and discards, one or several dedicated longline surveys covering the main parts of the stock area would be needed if stock status is to be monitored appropriately. Surveys carried out by France in 2019 and 2020 are therefore an initiative that is important to continue with renewals at relevant time intervals (3–5 years) for future assessments. Consideration should be given to launching similar series in other areas.

This species has low population productivity, and is thus highly susceptible to overexploitation. Consequently, WGEF considers that target fishing should not proceed without a programme to monitor stock abundance. WGEF also highlight that the present fishing ban hampers any quantitative assessment of current stock status.

A maximum landing length (MLL) was adopted by the EC in 2009. It constituted a potentially useful management measure in targeted fisheries, as it should deter targeting areas with mature females. However, there are also potential benefits from limiting fishing mortality on juveniles. Given the difficulties in measuring (live) sharks, other body dimensions (e.g. height of the first dorsal fin or pre-oral length) that could be pragmatic surrogate measurements could usefully be identified. The correlation of some measurements with fork length is high (Bendall *et al.*, 2012a) but further studies, so as to better account for natural variation (e.g. potential ontogenetic variation and sexual dimorphism) in such measurements, are needed to identify the most appropriate options for managing size restrictions.

Further ecological studies on porbeagle, as highlighted in the scientific recommendations of ICCAT (2009), would help to further develop management measures for this species. Such work could usefully build on recent and on-going tagging projects, and various Member States have undertaken increasing studies on porbeagle.

Studies on porbeagle bycatch should be continued to develop operational ways to reduce bycatch, to decrease at-vessel mortality and to improve the post-release survivorship of discarded porbeagle.

All fisheries-dependent data should be provided by the Member States having fisheries for this stock, as well as other countries longlining in the ICES area.

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Table 6.1a. Porbeagle in the Northeast Atlantic. Working Group estimates of porbeagle landings data (tonnes) by country (1926–1970). Data derived from ICCAT, ICES and national data. Data are considered an underestimate.

Year	Estimated Spanish data	Denmark	Norway (NE Atl)	Scotland
1926			279	
1927			457	
1928			611	
1929			832	
1930			1505	
1931			1106	
1932			1603	
1933			3884	
1934			3626	
1935			1993	
1936			2459	
1937			2805	
1938			2733	
1939			2213	
1940			104	
1941			283	
1942			288	
1943			351	
1944			321	
1945			927	
1946			1088	
1947			2824	
1948			1914	
1949			1251	
1950	4	1900	1358	
1951	3	1600	778	
1952	3	1600	606	
1953	4	1100	712	
1954	1	651	594	
1955	2	578	897	
1956	1	446	871	
1957	3.	561	1097	
1958	3	653	1080	7
1959	3	562	1183	9
1960	2	362	1929	10
1961	5	425	1053	9
1962	7	304	444	20
1963	3	173	121	17
1964	6	216	89	5
1965	4	165	204	8
1966	9	131	218	6
1967	8	144	305	7
1968	11	111	677	7
1969	11	100	909	3
1970	10	124	269	5

6.1b. Porbeagle in the Northeast Atlantic. Working Group estimates of porbeagle landings data (tonnes) by country (1971–2017). Data are considered an underestimate for some (minor) fishing countries. Data are derived from ICCAT, ICES and FAO data and 2015-2017 EU Data calls.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Denmark	311	523	158	170	265	233	289	112	72	176	158	84	45	38	72
Faroe Is	1		5			1	5	9	25	8	6	17	12	14	12
France	550	910	545	380	455	655	450	550	650	640	500	480	490	300	196
Germany			6	3	4	.	.	.	.	.	.	.	.	.	.
Iceland			2	2	4	3	3	.	1	1	1	1	1	1	1
Ireland			.	.	.	.	.	.	.	.	.	.	.	.	.
Netherlands			.	.	.	.	.	.				.	.	.	.
Norway	111	293	230	165	304	259	77	76	106	84	93	33	33	97	80
Portugal			.	.	.	.	.	.	.	.	.	.	.	.	.
Spain	11	10	12	9	12	9	10	11	8	12	12	14	28	20	23
Spain (Basque Country)															
Sweden		4			3			5	1	8	5	6	5	9	10
UK (E,W, NI)	7	15	14	15	16	25			1	3	2	1	2	5	12
UK (Scot)			13												
Japan	991	1755													NA
TOTAL	1971	1972	985	744	1063	1185	834	763	864	932	777	636	616	484	406

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Denmark	114	56	33	33	46	85	80	91	93	86	72	69	85	107	73
Faroe Is	12	33	14	14	14	7	20	76	48	44	8	9	7	10	13
France	208	233	341	327	546	306	466	642	824	644	450	495	435	273	361
Germany	.	.	.	.	.	.	.	1	.	.	.	.	2	0	17
Iceland	1	1	1	1	.	.	1	3	4	5	3	2	3	3	2
Ireland	.	.	.	.	.	.	.	.	.	.	.	.	.	8	2
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
Norway	24	25	12	27	45	35	43	24	26	28	31	19	28	34	23
Portugal	.	3	3	2	2	1	0	1	1	1	1	1	1	0	15
Spain	26	30	61	40	26	46	15	21	49	17	39	23	22	15	11
Spain (Basque Country)											20	12	27	41	1
Sweden	8	5	3	3	2	2	4	3	2	2	1	1	1	1	38
UK (Eng,Wal & NI)	6	3	3	15	9					0			1	6	7
UK (Scot)															.
Japan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	2	NA	NA	NA
TOTAL	399	389	471	462	690	482	629	862	1047	827	628	633	612	498	563

Table 6.1b. (continued). Working Group estimates of porbeagle landings data (tonnes) by country (1971–2017). Data are considered an underestimate for some (minor) fishing countries. Data are derived from ICCAT, ICES and FAO data and 2015-2017 ICES Data calls.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Denmark	76	42	21	20	3	3	2	2	4	0	2	3	0	0	0
Faroe Is	8	10	14	5	18	21	14	10	13	14	18	25	17	15	11
France	339	439	394	374	295	226	371	330	337	10	2	27	13	2	3
Germany	1	3	5	6	5	<1	2	2	<1	0	<1	<1	0	0	0
Iceland	4	2	0	1	<1	1	<1	1	1	1	1	1	1	<1	<1
Ireland	6	3	11	18	3	4	8	7	3	<1	0	0	0	0	0
Netherlands			0		<1	0	<1	0	0	<1	0	0	0	0	<1
Norway	17	14	19	24	12	27	10	12	10	12	11	17	9	5	4
Portugal	4	11	4	57	<1	<1	<1	<1	0	<1	<1	0	0	<1	0
Spain	68	65	44	19	18	87	52	269	150	<1	<1	<1	0	0	0
Sweden	1			5	<1	0	<1	<1	<1	0	0	0	0	0	0
UK	1	10	7	25	24	12	26	15	11	<1	<1	<1	0	0	0
Japan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TOTAL	525	599	519	554	379	381	484	648	529	37	34	74	40	22	19

Table 6.1b. (continued). Working Group estimates of porbeagle landings data (tonnes) by country (1971–2017). Data are considered an underestimate for some (minor) fishing countries. Data are derived from ICCAT, ICES and FAO data and 2015-2017 ICES Data calls.

	2016	2017
Denmark	<1	
Faroe Is	5	2
France	<1	1
Germany	0	0
Iceland	2	1
Ireland	0	0
Netherlands	0	0
Norway	6	6
Portugal	0	0
Spain	0	0
Sweden	0	0
UK	0	0
Japan	NA	NA
TOTAL	14	10

Table 6.2. Porbeagle in the Northeast Atlantic. Proportion of small (<50 kg) and large (≥50 kg) porbeagle taken in the French longline fishery 1992–2009. Source: Hennache and Jung (2010).

	% Weight of in the catches of porbeagle:	
Year	< 50 kg	>50 kg
1992	26.0	74.0
1993	29.7	70.3
1994	33.1	66.9
1995	49.9	53.1
1996	31.9	68.1
1997	39.2	60.8
1998	Data not available by weight category	
1999		
2000		
2001		
2002		
2003	53.7	46.3
2004	44.0	56.0
2005	40.0	60.0
2006	44.3	55.7
2007	44.9	55.1
2008	45.9	54.1
2009	51.8	48.2

Table 6.3. Porbeagle in the Northeast Atlantic. Length–weight relationships of porbeagle from scientific studies.

Stock	L-W relationship	Sex	n	Length range	Source
NW Atlantic	$W = (1.4823 \times 10^{-5})\ L_F\ 2.9641$	C	15	106–227 cm	Kohler *et al.*, 1995
NE Atlantic (Bristol Channel)	$W = (1.292 \times 10^{-4})\ L_T\ 2.4644$	C	71	114–187 cm	Ellis and Shackley, 1995
NE Atlantic (N/NW Spain)	$W = (2.77 \times 10^{-4})\ L_F\ 2.3958$	M	39		Mejuto and Garcés, 1984
	$W = (3.90 \times 10^{-6})\ L_F\ 3.2070$	F	26		
NE Atlantic (SW England)	$W = (1.07 \times 10^{-5})\ L_T\ 2.99$	C	17		Stevens, 1990
NE Atlantic (Biscay / SW England/W Ireland)	$W = (4 \times 10^{-5})\ L_F\ 2.7316$	M	564	88–230 cm	Hennache and Jung, 2010
	$W = (3 \times 10^{-5})\ L_F\ 2.8226$	F	456	93–249 cm	
	$W = (4 \times 10^{-5})\ L_F\ 2.7767$	C	1020	88–249 cm	

Table 6.4. Porbeagle in the Northeast Atlantic. Relationships between alternative length measurements with total length in porbeagle (n = 53), where total length refers to the total length with the upper lobe of the caudal fin flexed down (L_{T_under}) and measured under the body. Relationships given as an equation and in proportional terms (percentage of L_{T_under}). Source: Ellis and Bendall (2015 WD).

Measurement	Equation	R^2
Total length (depressed), measured over body (L_{T_over})	L_{T_over} = 1.0279.L_{T_under} – 0.3109	0.99
Total length (natural), measured under body (L_{N_under})	L_{N_under} = 0.9906.L_{T_under} – 3.9749	0.99
Total length (natural), measured over body (L_{N_over})	L_{N_over} = 0.9979.L_{T_under} – 1.0713	0.99
Fork length, measured under body (L_{F_under})	L_{F_under} = 0.877.L_{T_under} – 3.6981	0.99
Fork length, measured over body (L_{F_over})	L_{F_over} = 0.8919.L_{T_under} – 1.4538	0.99
Standard length, measured under body (L_{S_under})	L_{S_under} = 0.7688.L_{T_under} – 2.1165	0.99
Standard length, measured over body (L_{S_over})	L_{S_over} = 0.7849.L_{T_under} – 0.2599	0.99
Measurement	% of L_{T_under} (mean ± SD and range)	
Total length (depressed), measured over body (L_{T_over})	102.6 ± 1.31 (100.0–106.7)	
Total length (natural), measured under body (L_{N_under})	96.7 ± 1.72 (91.9–101.9)	
Total length (natural), measured over body (L_{N_over})	99.1 ± 1.82 (95.3–102.6)	
Fork length, measured under body (L_{F_under})	85.5 ± 0.99 (83.3–88.9)	
Fork length, measured over body (L_{F_over})	88.3 ± 1.34 (85.2–92.5)	
Standard length, measured under body (L_{S_under})	75.6 ± 1.07 (74.1–79.1)	
Standard length, measured over body (L_{S_over})	78.3 ± 1.34 (75.6–82.2)	

Table 6.5a. Porbeagle in the Northeast Atlantic. Input and output to/from the different SPiCT model runs. The coloured cells represent changes in input relative to the previous run. See Albert (WD, 2018).

	Run_1	Run_2	Run_3	Run_4	Run_5	Run_6	Run_7	Run_8	Run_9	Run_10
Catch_start	1971	1971	1971	1950	1950	1950	1950	1950	1950	1950
Catch_stop	2016	2009	1995	1995	2007	2016	2016	2016	2016	2009
Ind_start	1972	1972	1972	1972	1972	1972	1972	1972	1972	1972
Ind_stop	2007	2007	1995	1995	2007	2007	2007	2007	2007	2007
Restriction							n=2	n=2, alf=1	n=2, alf=4	n=2, alf=4
Convergens	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
C_shapiro	***	ns	ns	ns	ns	***	***	***	***	ns
C_bias	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C_acf	ns	ns	ns	ns	*	*	ns	*	*	*
C_Lbox	ns	ns	ns	ns	*	*	ns	*	ns	**
I_shapiro	ns	ns	**	**	ns	*	ns	ns	ns	ns
I_bias	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
I_acf	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
I_Lbox	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
K	17561	10154	12290	9789	9903	9700	12848	13454	12256	10429
K_low	313	816	752	7576	5686	4855	7224	5630	7766	6969
K_high	984770	126225	208194	12648	17247	19382	22852	32151	19341	15610
q	0,00095	0,00046	0,00044	0,00046	0,00047	0,00038	0,00028	0,00026	0,00029	0,00041

Table 6.5b. Porbeagle in the Northeast Atlantic. More output from the different SPiCT model runs. Estimates of Bfinal/Bmsy and of Ffinal/Fmsy are colour coded according to whether the estimates indicate that the stock was severely overfished and if overfishing was occurring at the final year (the greener the better, the redder the worse). The next-to-last line indicates the author's subjective evaluation of how well the trajectory describes the history of the fishery. The last line gives the rate of the upper and lower estimate of K, an indicator of carrying capacity, and the colour coding refers to the precision of the estimated K. See Albert (WD, 2018).

	Run_1	Run_2	Run_3	Run_4	Run_5	Run_6	Run_7	Run_8	Run_9	Run_10
Bmsys	4946	3797	3801	3610	3203	3232	6319	6266	6080	5185
Bmsys_low	111	817	690	2348	1122	862	3634	2794	3875	3477
Bmsys_high	220592	17641	20930	5550	9145	12123	10989	14054	9541	7730
Fmsys	0,2	0,18	0,17	0,19	0,21	0,19	0,12	0,12	0,12	0,17
Fmsys_low	0,02	0,06	0,04	0,13	0,07	0,05	0,05	0,04	0,06	0,08
Fmsy_high	2,1	0,6	0,7	0,27	0,63	0,72	0,28	0,33	0,27	0,38
MSYs	1001	694	652	676	664	622	741	730	757	892
MSYs_low	216	367	390	507	463	460	506	468	536	572
MSYs_high	4645	1308	1091	900	951	842	1084	1138	1069	1394
Bfinal/Bmsy	0,0004	0,4	0,4	0,4	0,5	1,6	0,86	0,82	0,91	0,32
Ffinal/Fmsy	43,5	1,8	3,2	3,4	1,3	0,016	0,025	0,026	0,023	2,1
Final year	**2016**	2009	1995	1995	2007	**2016**	**2016**	**2016**	**2016**	2009
Reasonable trajectory?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
K_high/K_low	3146	155	277	2	3	4	3	6	2	2

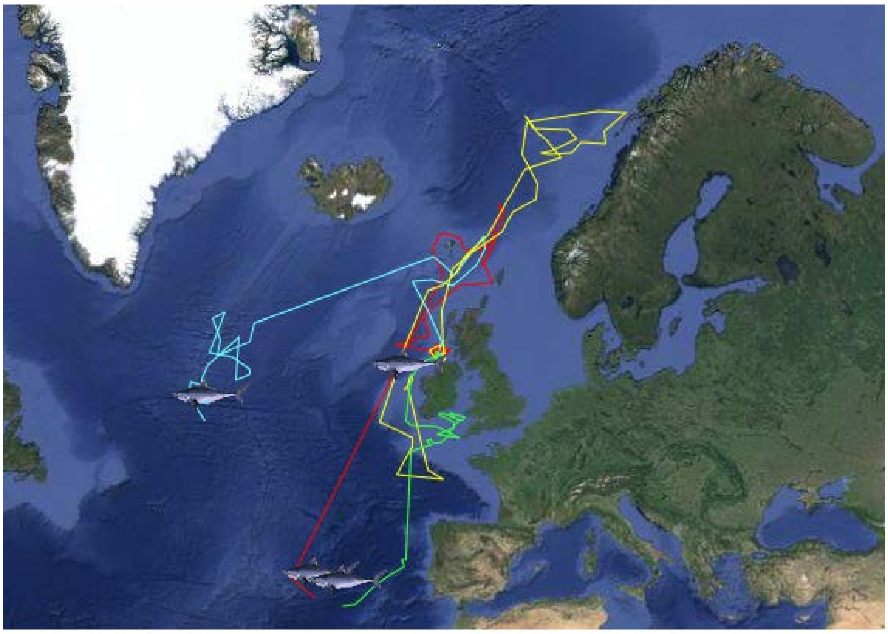

Figure 6.1a. Porbeagle in the Northeast Atlantic. Movement of porbeagle tagged in Irish porbeagle archival tagging programme.

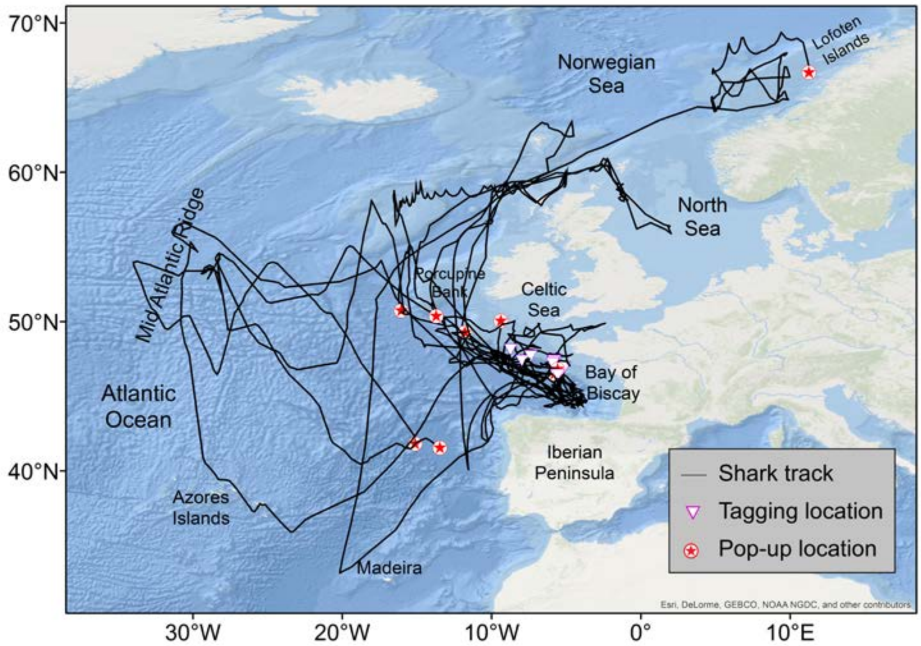

Figure 6.1b. Porbeagle in the Northeast Atlantic. Movement of porbeagle tagged in French porbeagle archival tagging programme (Biais *et al.*, 2017).

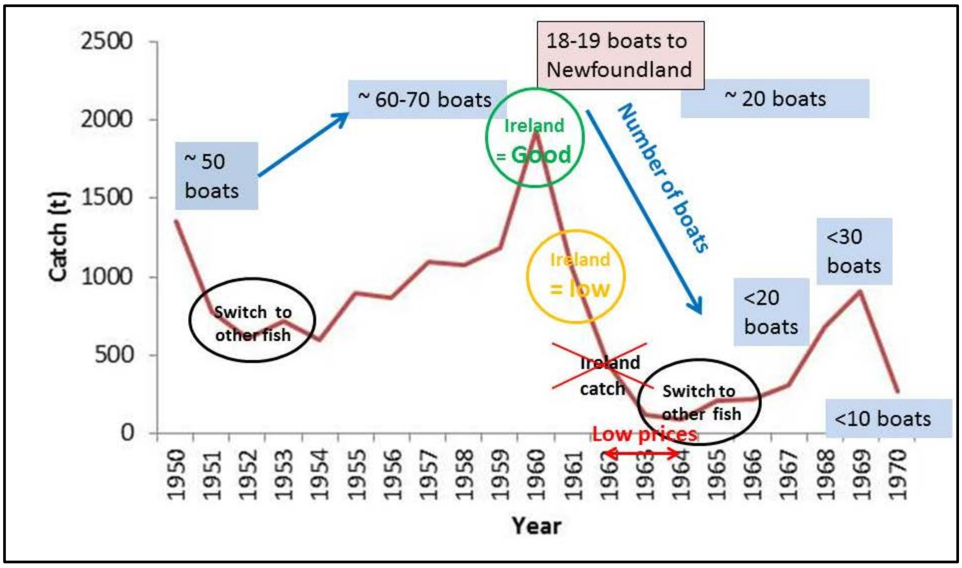

Figure 6.2 Porbeagle in the Northeast Atlantic. Trend in Norwegian catch and information on the fishery. Source: Biais *et al.* (2015a WD).

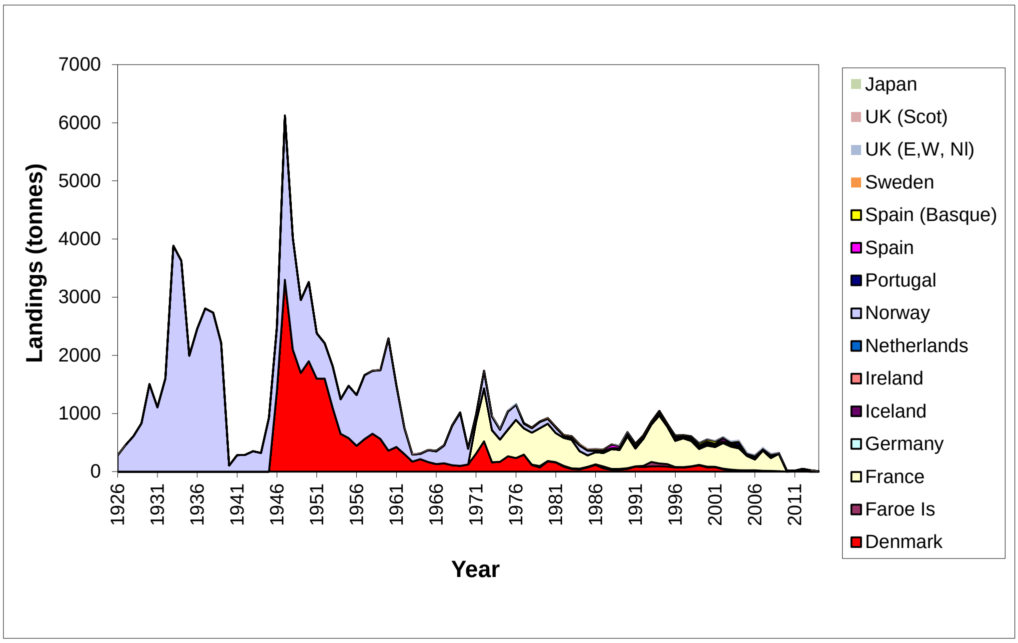

Figure 6.3. Porbeagle in the Northeast Atlantic. Working Group estimates of longer term trend in -landings of porbeagle in the Northeast Atlantic

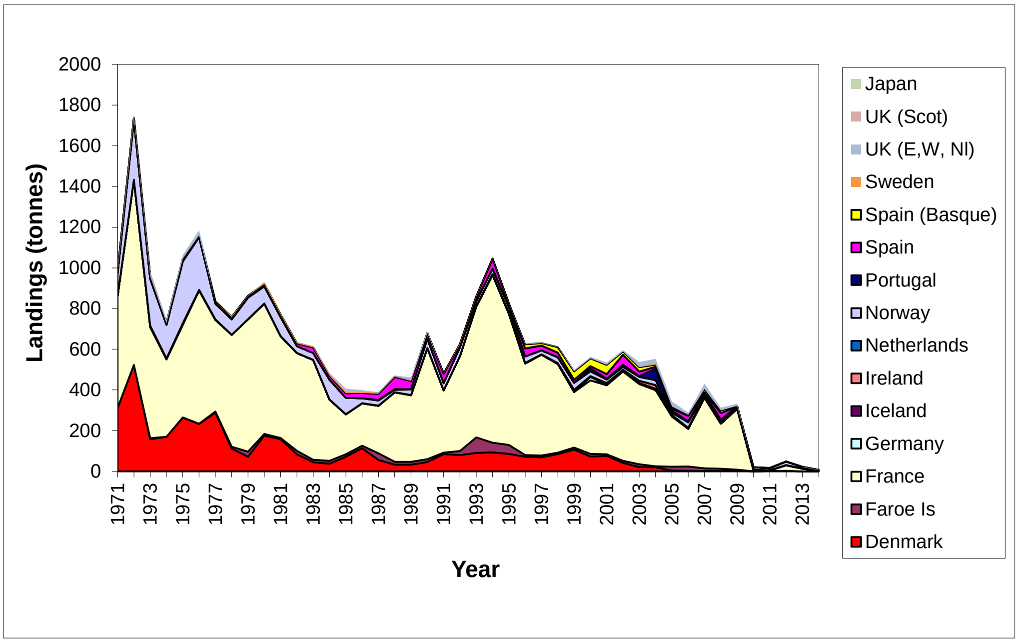

Figure 6.4. Porbeagle in the Northeast Atlantic. Working Group estimates of landings of porbeagle in the Northeast Atlantic for 1971–2014 by country.

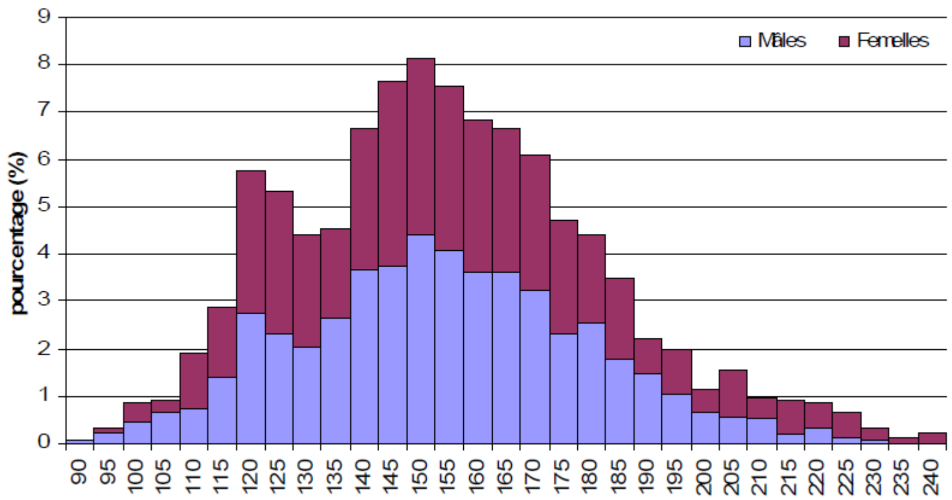

Figure 6.5. Porbeagle in the Northeast Atlantic. Length–frequency distribution of the landings of the Ile d'Yeu target fishery for porbeagle (2008–2009; n =1769). Source: Hennache and Jung (2010).

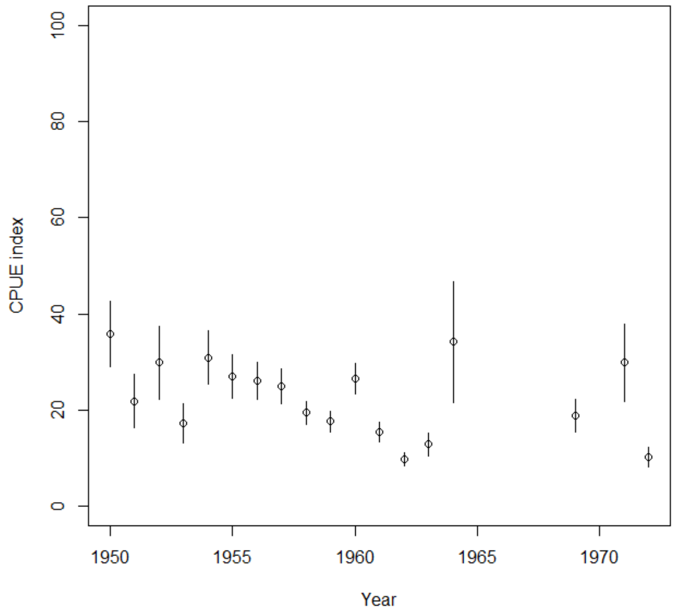

Figure 6.6. Porbeagle in the Northeast Atlantic. Temporal trends in a CPUE index for the Norwegian target longline fishery for porbeagle (1950–1972) in the northern European waters (Divisions 2.a, 4.a-b, 5.a and 6.a (North of 59°N)). Source: Biais *et al.* (2015b WD).

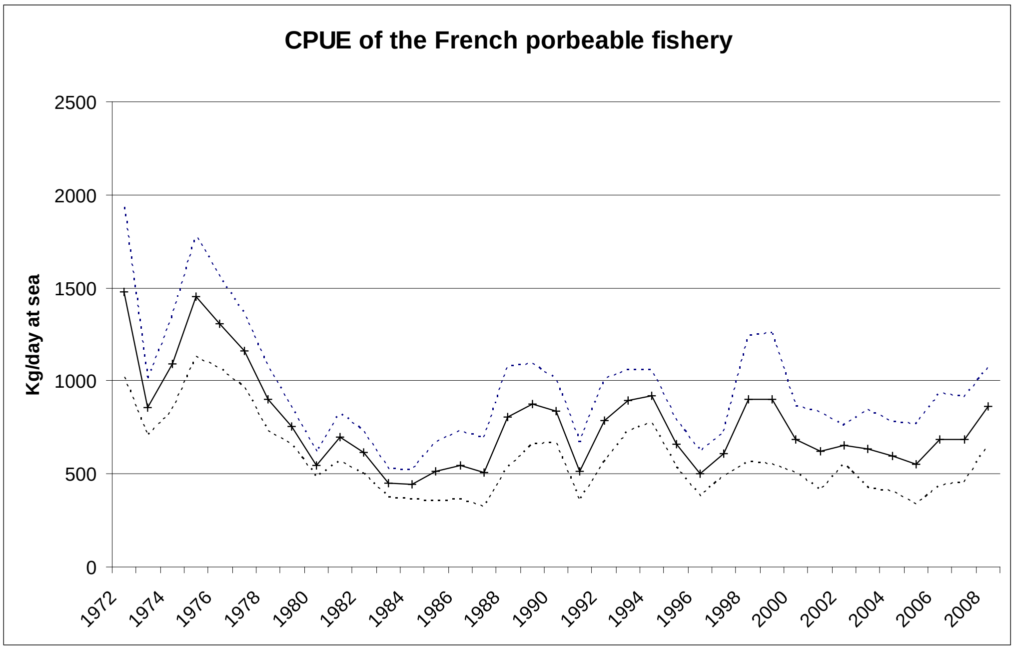

Figure 6.7. Porbeagle in the Northeast Atlantic. Nominal CPUE (kg/day at sea) for porbeagle taken in the French fishery (1972–2008) with confidence interval (± 2 SE of ratio estimate). From Biais and Vollette (2009 WD).

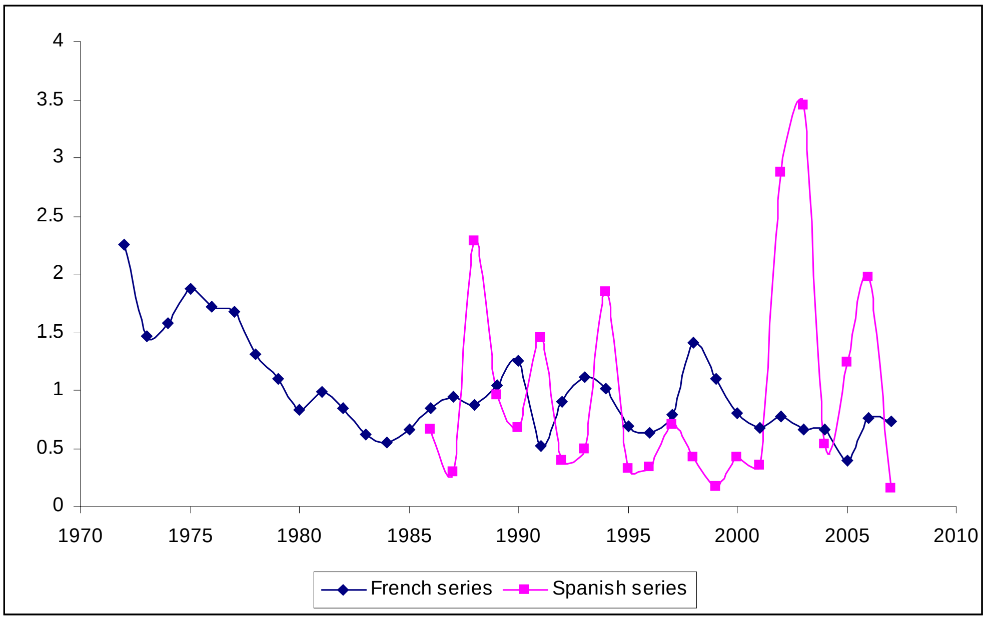

Figure 6.8. Porbeagle in the Northeast Atlantic. Temporal trends in standardized CPUE for the French target longline fishery for porbeagle (1972–2007) and Spanish longline fisheries in the Northeast Atlantic (1986–2007). Source: ICCAT (2009).

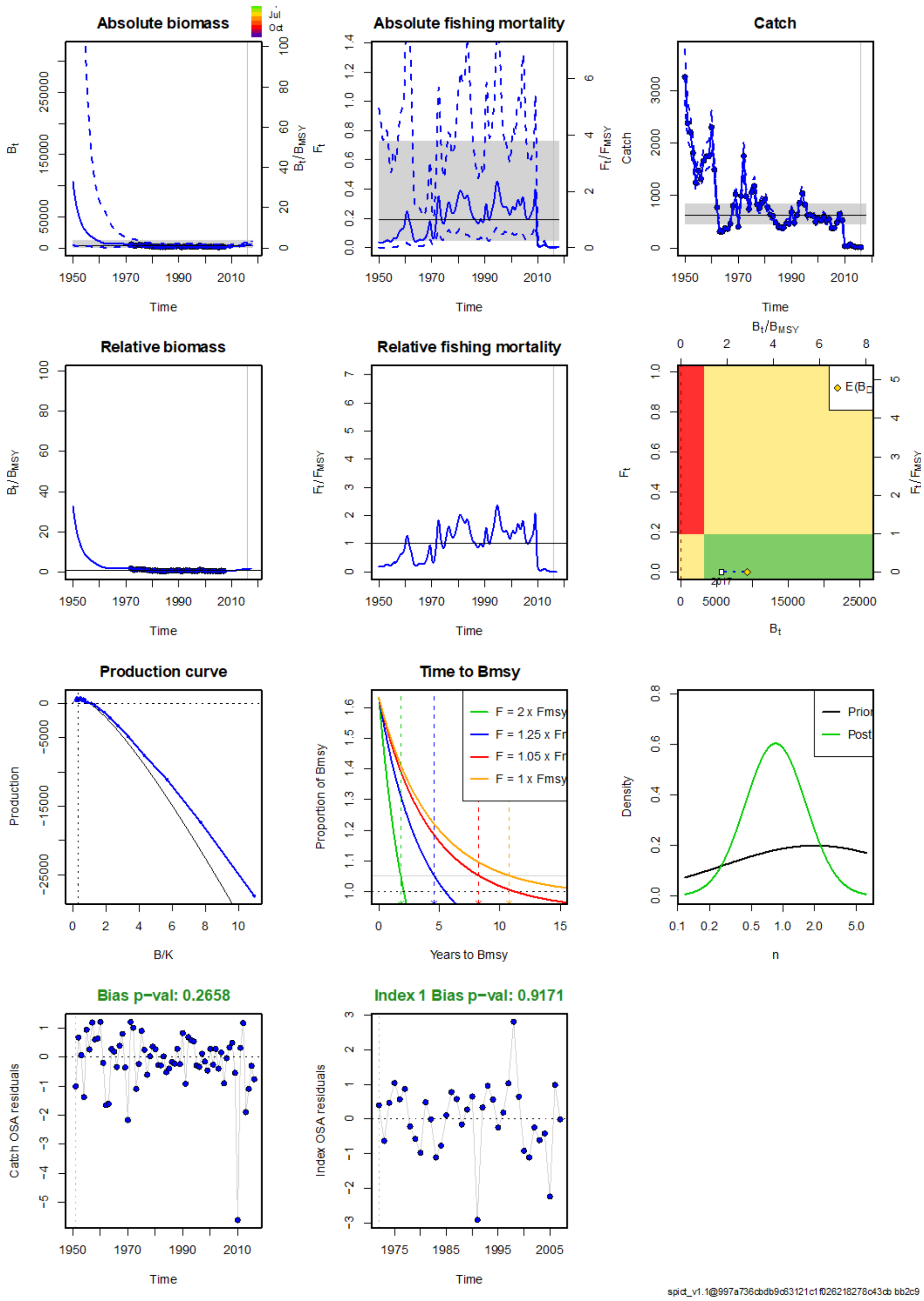

Figure 6.9. Porbeagle in the Northeast Atlantic. Output plots from Run 6 (conf. Table 6.5a and b), see Albert (WD, 2018).

7 Basking Shark in the Northeast Atlantic (ICES areas 1–14)

7.1 Stock distribution

In the Northeast Atlantic, the basking shark *Cetorhinus maximus* is present from Iceland, and the White Sea (southern Barents Sea) southwards to the Mediterranean Sea and north-west Africa (Compagno, 1984; Konstantinov and Nizovtsev, 1980). WGEF considers that the basking shark in the ICES area exists as a single stock and management unit. However, the WGEF is aware of recent tagging studies showing both transatlantic and transequatorial migrations, as well as migrations into tropical areas and mesopelagic depths (Braun *et al*., 2018; Gore *et al*., 2008; Skomal *et al*., 2009).

Marked interannual and intra-annual variability of basking shark sightings have been reported, with significant correlation between the duration of the sightings season in each year and environmental/climatic factors like the North Atlantic Oscillation (Couto *et al*., 2017; Witt *et al*., 2012). A genetic study by Hoelzel *et al*. (2006) indicates no differentiation between ocean basins, whereas Noble *et al*. (2006) suggested little gene flow between the northern and southern hemisphere. A rough estimate of the population size was given by Hoelzel *et al*. (2006). A recent study west of the UK, using photo identification (Gore *et al.,* 2017), showed very few re-sightings after one year (0.5%), and satellite tracking showed that basking shark show behavioural plasticity and that most individuals use only a small fraction of the time feeding in the surface (Gore *et al.,* 2017; Dohety *et al*., 2017). These results point to a relatively large stock, and/or that the stock size may not be adequately traced by surface sightings.

7.2 The fishery

7.2.1 History of the fishery

The fishery for basking shark goes back as far as the middle or end of the 1700s, in Norwegian, Irish and Scottish waters (Strøm, 1762; Moltu, 1932; Parker and Stott, 1965; Myklevoll, 1968; McNally, 1976; Fairfax, 1998; See also the Stock Annex). Up to 1000 individuals may have been taken in Irish waters each year at the height of the fishery. Such intensive fisheries stopped during the mid-1800s when the species became very scarce.

The Norwegian fleet resumed the fishery in 1920. The landings increased during the 1930s as the fishery gradually expanded to offshore waters across the North Sea and south and west of Ireland, Iceland and Faroes. During 1959–1980, landings ranged between 1266 and 4266 individuals per year, but subsequently declined (Kunzlik, 1988). The geographical and temporal distribution of the Norwegian domestic basking shark fishery changed markedly from year to year, possibly as a consequence of the unpredictable nature of the shark's inshore migration (Stott, 1982).

In Irish waters, the basking shark fishery started again in 1947. Between 1000 and 1800 individuals were taken each year from 1951 to 1955 (an average of 1475 per year), but there was a decline in recorded landings from 1956. Average annual landings were 489 individuals from 1956–1960, 107 individuals from 1961–1965, then about 50–60 individuals per year for the remaining years of the fishery (Parker and Stott, 1965; McNally, 1976).

The Scottish fishery started in the 1940s. In all, around 970 sharks were taken between 1946 and 1953 (during a period when Norwegian vessels were also catching basking sharks in these waters).

From 1977–2007, an estimated total of 12 347 basking sharks were landed by Norway and Scotland, and of these Norway landed 12 014 individuals with an annual maximum of 1748 individuals landed in 1979.

There is no longer any directed fishery for basking shark within the ICES area. Since 2007, the species has been listed as a prohibited species on EU fisheries regulations and EU vessels should release/discard any individuals caught. Norwegian vessels may land dead specimens but should release live specimens. Since 2013, reported landings have been <500 kg.

7.2.2 The fishery in 2017

No new information.

7.2.3 ICES advice applicable

ICES advice has been for a zero TAC since 2006. In 2012, ICES advised on the basis of the precautionary approach that there should be no landings of basking shark and that it should remain on the Prohibited Species List. In 2015, ICES advised that "*when the precautionary approach is applied for basking shark in the Northeast Atlantic, no targeted fisheries should be permitted and bycatch should be minimized. This advice is valid for 2016 to 2019*".

7.2.4 Management applicable

Article 13 of Council Regulation (EU) 2016/72 prohibits Union fishing vessels from fishing for, retaining on board, transhiping or landing basking shark in all waters. Article 46 of Council Regulation (EU) 2016/72 prohibits third-country vessels fishing for, retaining on board, transhiping or landing basking shark from EU waters.

Based on ICES advice, Norway banned all directed fisheries and landing of basking shark in 2006 in the Norwegian Economical Zone and in ICES subareas 1–14. The ban has continued since. During this period, live specimens caught as bycatch had to be released immediately, although dead or dying specimens could be landed. Since 2012, bycatch that is not landed should also be reported, and landings of basking sharks are not remunerated. Bycatch should be reported both in number of individuals and weight (since 2009).

Basking shark has been protected from killing, taking, disturbance, possession and sale in UK territorial (twelve nautical miles) waters since 1998. They are also protected in two UK Crown Dependencies: Isle of Man and Guernsey (Anon., 2002).

Sweden has forbidden fishing for or landing basking shark since 2004.

7.3 Catch data

7.3.1 Landings

Landings data within ICES subareas 1–14 from 1977–2014 are presented in Table 7.1, and Figure 7.1–7.2, since 2014: <0.1 t landed. Landings of basking shark peaked in 1979 at a total of 5266 t, and declined rapidly towards 1988. Another peak in landings (1697 t) occurred in 1992. After the ban on directed fisheries in 2006–2007, annual landings declined to <30 t and are currently <1 t.

Reported landings data come from UK (Guernsey) in 1984 and 2009, Portugal (1991–2007, 2010–2013, 2016), France (1990–2010 and 2014) and Norway (1977–2008, 2011–2012). Most landings are from Subarea 2 and are taken by Norway. For Portugal and

France, the reported landings were between 0.1 and 1.5 t. Landings for France in 2005 were higher, with 3.5 t.

Landings in numbers from Scotland and Norway (1977–2014) are presented in Figure 7.3. The trends are very similar to those of landings in biomass, with a first maximum of 1748 individuals in 1979, a second maximum of 573 individuals in 1992, and less than ten individuals after 2006.

The conversion factors used for Norwegian landings (liver and fin weight to live weight) were revised during WGEF 2008. Data from the Norwegian Directorate of Fisheries revealed that the nominal value of fins increased dramatically from 1979 to 1992, was variable during 1993–2005, and decreased after 2005. Table 7.2 shows old and revised numbers.

Table 7.3 shows the proportions (%) of landed basking sharks caught by various gears as reported to the Norwegian Directorate of Fisheries (1990–2011). During most of the 1990s, harpoon was the main gear, but remained at a relatively low level from 2000, except for 2005 which was the last year with a directed fishery. After the ban on directed fisheries in 2006, bycatch has been taken primarily in gillnets.

Further information on Norwegian landings of liver and fins, and corresponding official and revised landings in live weight and numbers are given in the Stock Annex.

7.3.2 Discards

Limited quantitative information exists on basking shark discarded bycatch. However, anecdotal information indicates that this species is an incidental bycatch in gillnet and trawl fisheries and may be entangled in potting ropes. Most bycatch events occur in the summer as the species moves inshore. Total bycatch has not been estimated.

Normal discard observer programmes, such as DCMAP may not record bycatch of large animals such as basking sharks, if they fall or are removed from gear before the catch is brought on board the vessel. Fisheries observer programmes are not designed to account for rare species. (ICES, 2018).

Berrow and Heardman (1994) estimated 77–120 sharks were caught annually in the gillnet fishery in the Celtic Sea. These authors received 28 reports of specimens being entangled in fishing gear around the Irish coast in 1993. In the Isle of Man, bycatch in herring and pot fishery (entanglement in ropes) is estimated at 14–20 sharks annually. Bonfil (1994) estimated that 50 specimens were taken annually by the oceanic gillnet fleet in the Pacific Ocean. Fairfax (1998) reported that basking sharks are sometimes brought up from deep-water trawls near the Scottish coast during winter, and Valeiras *et al.* (2001) reported that of twelve basking sharks being incidentally caught in fixed entanglement nets in Spanish waters between 1988 and 1998, three sharks were sold at landing markets, three live sharks were released, and three dead sharks were discarded at sea. More detailed information can be found in the Stock Annex.

The French NGO APECS reported on 15 accidental catches from the Irish Sea, Atlantic Ocean and Mediterranean Sea (Jung *et al.*, 2012). More detailed information (catch location, gear, and biological data) are given in Table 7.4. This table also includes data on eleven bycatch events from the Norwegian coast, published in the Norwegian media (prior to 2013).

Accidental bycatch of three basking shark were reported from The Smalls, Ireland (Division 7.g) in 2005. These sharks were released alive (Johnston, pers. comm. 2015). There are no other records of basking sharks in the Irish discard observer programme.

In 2009, observers from French national observer programmes reported three accidentally caught, but released, basking sharks (*ca.* 4 m long). Two basking shark were recorded in Division 6.a and one in Division 4.a. One individual (*ca.* 8 m long) was recorded in 2010 from Division 6.a.

In April 2014, two basking sharks were stranded on south Brittany beaches: one male (5 m L_T, 650 kg) and one female (4 m L_T, 250 kg estimated). The female had a third of its dorsal body lacerated with a propeller.

Five basking sharks were caught and discarded by the Norwegian Coastal Reference Fleet in 2007–2009 (Vollen, 2010 WD). All specimens were caught in gillnets by vessels <15 m in ICES Subarea 2.

The requirement for EU fleets to discard all basking sharks accidentally caught results in a lack of information on these catches. Similarly for Norway, although reporting of released basking sharks is mandatory, there is currently no operative mechanism to facilitate such reporting. A protocol for the standardised recording of bycatch and biological information from bycatch would benefit any future assessments of the stock.

7.3.3 Quality of the catch data

The official Norwegian conversion factor used to convert from liver weight and fin weight to live fish was revised in 2008 (Table 7.2). The official Norwegian landing statistics were unchanged from 1977 to 1999, but from 2000–2008 the revised landings figures are applied. Further information on the revision of the conversion factor is included in the Stock Annex.

7.3.4 Discard survival

Limited information available, and national observer programmes could usefully collect data on fate (released alive/released dead) of basking shark specimens caught.

7.4 Commercial catch composition

There is some information on minimum, maximum and median weight of livers and fins, and corresponding live weights of individual basking sharks landed in Norway during 1992–1997. This information is included in the Stock Annex.

7.5 Commercial catch-effort data

There are no effort or CPUE data available for recent years. Historical CPUE data from the Norwegian fishery (1965–1985) are given in the Stock Annex.

7.6 Fishery-independent surveys

Several countries, e.g. Norway, Denmark, Ireland, conduct scientific whale-counting surveys. Observations of basking sharks are normally recorded in these surveys.

The Norwegian whale-counting survey observed a total of 87 basking shark in the Norwegian Sea during the period 1995–2014. Sightings seem to be heavily dependent on weather conditions, and 82 of the 87 sightings were made within nine short time periods (hours or 1–2 d). No apparent trends could therefore be identified. A number of Norwegian commercial vessels regularly report observations of whales, and a request to report basking shark sightings might yield useful effort-related data. The Norwegian Shark Alliance (HAI Norge) have collected online public sightings of basking sharks since 2011.

A national sightings program also exists along French coastlines, including all scientific survey reports (managed by APECS). Between 40 and 270 sightings are recorded each year, mostly reported by sailors and fishers. Sightings occur mainly from April to June, and the major area is the southern and western coasts of Brittany. Early sightings are reported off the island of Corsica in February–March; in 2011 one basking shark was reported in Saint Pierre et Miquelon.

There are sightings programmes in the UK (Marine Conservation Society, 2003; Southall *et al.*, 2005), and in Ireland through the Irish Basking Shark Study Group and the Irish Whale and Dolphin Group.

In Scotland, Whale and Dolphin Trust for Hebrides and North West Scotland, runs a sighting progamme; Sea Watch Foundation is doing so for the Northern islands and north-east Scotland coasts. Basking Shark Scotland collates public sightings data.

7.7 Life-history information

A summary of the knowledge of basking shark habitat, reproduction, growth and maturity, food and feeding, and behaviour can be found in the Stock Annex.

Habitat

In a study from 2008, the Irish Basking Shark Study Group tagged two basking sharks with archival satellite tags (Berrow and Johnston, 2010 WD). Both sharks remained on the continental shelf for most of the tagging period; 'Shark A' spent most time in the Irish and Celtic Seas with evidence of a southerly movement in winter to the west coast of France, whilst the movements of 'Shark B' were more constrained, remaining off the southwest coast for the whole period with locations off-the-shelf edge and in the Porcupine Bight (Figure 7.4). The greatest depths recorded were 144 m and 136 m, respectively, demonstrating that although 'Shark B' was located over deep water off-the-shelf edge, it was not diving to large depths. The sharks were within 8 m of the surface for 10% and 6% of the time. The study demonstrated that basking sharks were present and active in Irish waters throughout the winter period.

Skomal *et al.* (2009) shed further light on apparent winter 'disappearance' of basking shark. Through satellite archival tags and a novel geolocation technique they demonstrated that sharks tagged in temperate feeding areas off the coast of southern New England moved to the Bahamas, the Caribbean Sea, and onward to the coast of South America and into the southern hemisphere. When in these areas, basking sharks descended to mesopelagic depths (200–1000 m) and in some cases remained there for weeks to months at a time. The authors concluded that basking sharks in the western Atlantic Ocean, which is characterized by dramatic seasonal fluctuations in oceanographic conditions, migrate well beyond their established range into tropical mesopelagic waters. In the eastern Atlantic Ocean, however, only occasional dives to mesopelagic depths have been reported in equivalent tagging studies (Sims *et al.*, 2005). It is hypothesized that in this area, the relatively stable environmental conditions mediated by the Gulf Stream may limit the extent to which basking sharks need to move during winter to find sufficient food.

The NGO APECS and the Manx Basking Shark Watch tagged ten basking sharks in 2009 (Stéphan *et al.*, 2011). The sharks were tagged with pop-up archival tags (MK10PAT, Wildlife Computers). Eight tags were deployed around the Isle of Man in the Irish Sea and two in the Iroise Sea (West Brittany, France). All the sharks tagged in the Irish Sea moved south, within the Irish Sea or Celtic Sea, and one to the southern Bay of Biscay (Figure 7.5). One of the tags set in the Irish Sea in 2009 popped off after five days but the second after 38 days. During this short period, the shark moved quickly northwards past the west coast of Ireland to western Scotland. This study confirmed that at least some sharks are present in coastal waters during the cold season (October to March). They are then found in deeper waters, while continuing to perform daily vertical migrations. However, one particularly significant sector of winter distribution does emerge: the northwestern part of the Celtic Sea where basking sharks are especially distributed at depths of 50–100 m during the cold season (Figure 7.5). The track of one shark tagged in Brittany confirms that some sharks sighted at the entrance to the Channel can swiftly reach the waters of the Hebrides via the west of Ireland (Figure 7.5).

Since 2011, APECS have tagged two further sharks off south Brittany, a 7.5 m male in April 2011 and a 6.5 m female in June 2013. These tags popped off after 35 and 76 days, respectively. The first one moved about 150 nm west of the tagging location to the northern Bay of Biscay, and the second one in the Celtic Sea, about 40 nm south of Ireland. In May 2016 two SPOT tag were deployed on adults animal south of Brittany ; the 6.5 m female showed up in May 2017 in the southern of Bay of Biscay after spending the winter off the Moroccan coast.

The Manx Basking Shark Watch also deployed tags in 2008 and 2011–2013 and have four basking sharks equiped with SPOT5 tags that can be tracked on the WildlifeTracking website. The Irish Basking Shark Study Group also performed tagging in 2012 and 2013.

SPOT Tagging technology has been successfully applied in the Inner Hebrides (West Scotland) on basking shark since 2012: nine SPOTs were deployed in July 2012 (Witt *et al*., 2013). Recent analyses (Witt *et al*., 2016), revealed various spatio-temporal patterns in habitat use, from coastal movements to movements of thousands of kilometers (Figure 7.6). Long-distance movements of three adult basking shark from the Hebridean Sea to Madeira, Canary Islands and North African coasts were observed from SPOT and SPLASH-F tags. These represented movements of >3300 km (straight-line distance) over periods of 132–322 days. In contrast, other sharks demonstrated a degree of site fidelity to the Inner Hebrides (at various spatial scales) during the summer months (Figure 7.7). This study also lighted the importance of the Irish and Celtic Seas and important migration corridors for sharks moving from NW Scotland to the Isle of Man and southwest England.

7.8 Exploratory assessment models

No exploratory assessments have been undertaken.

7.9 Stock assessment

No stock assessment has been undertaken.

7.10 Quality of assessments

No assessments have been undertaken.

7.11 Reference points

No reference points have been proposed for this stock.

7.12 Conservation considerations

Basking shark is listed as "Endangered" on the Red List of European marine fish (Nieto *et al*., 2015) and on the Norwegian Red List (Sjøtun *et al*., 2010).

Basking shark was listed on Appendix II of the Convention on International Trade in Endangered Species (CITES) in 2002.

Basking shark was listed on Appendices I and II of the Convention on the Conservation of Migratory Species (CMS) in 2005.

Basking shark is listed on Annex I, Highly Migratory Species, of the UN Convention on the Law of the Sea (UNCLOS).

Basking shark was listed on the OSPAR (Convention on the protection of the marine environment of the Northeast Atlantic) list of threatened and/or declining species in 2004.

7.13 Management considerations

The current status of the stock is unknown. At present there is no directed fishery for this species. WGEF considers that no directed fishery should be permitted unless a reliable estimate of a sustainable exploitation rate is available.

Proper quantification of bycatch, fate and discarding, in numbers and estimated weight, is required.

Where national legislation prohibits landing of bycaught basking sharks, measures should be put in place to ensure that incidental catches are recorded by (estimated) weight and number, and carcasses or biological material made available for research.

7.14 References

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Table 7.1. Basking shark in the Northeast Atlantic. Total landings (t) of basking sharks in ICES subareas 1–14 (1977–2017). "."=zero catch, "+" = <0.5 t. Data for 2017 updated following Data Call.

	1 & 2	3 &4	5A	5B	6	7	8	9	10	12	14	TOTAL
1977	3680	.	.	.	.	.	.	.	.	.	.	3680
1978	3349	.	.	14	.	278	.	.	.	.	.	3641
1979	5120	.	.		.	139	7	.	.	.	.	5266
1980	3642	.	.	83	.	.	.	.	.	.	.	3725
1981	1772	.	.	28	.	.	.	.	.	.	.	1800
1982	1970	.	.	.	.	186	.	.	.	.	.	2156
1983	967	734	.	.	.	60	.	.	.	.	.	1761
1984	873	1188	.	.	.	1	.	.	.	.	.	2062
1985	1465	.	.	.	.	.	.	.	.	.	.	1465
1986	1144	.	.	.	.	.	.	.	.	.	.	1144
1987	164	.	.	.	.	.	.	1	.	.	.	165
1988	96	10	.	.	.	.	.	.	.	.	.	106
1989	593	.	.	.	.	.	.	+	.	.	.	593
1990	781	116	.	.	.	.	1	.	.	.	.	897
1991	533	220	.	.	.	.	+	+	.	.	.	753
1992	1613	84	.	.	.	.	+	+	.	.	.	1697
1993	1374	.	.	.	.	.	.	+	.	.	.	1374
1994	920	157	.	.	.	.	+	1	.	.	.	1078
1995	604	23	.	.	.	.	1	1	.	.	.	629
1996	792	.	.	.	.	.	+	1	.	.	.	793
1997	425	43	.	.	.	.	2	1	.	.	.	471
1998	55	.	.	.	.	.	1	.	.	.	.	56
1999	31	.	.	.	.	.	1	1	.	.	.	33
2000	117	.	.	.	.	.	1	1	.	.	.	119
2001	80	.	.	.	.	.	.	2	1	.	.	83
2002	54	+	.	.	.	.	.	1	.	.	.	55
2003	128	.	.	.	.	.	.	1	.	.	.	129
2004	72	.	.	.	.	.	.	1	26	.	.	99
2005	218	+	.	.	.	1.9	1.5	1.5	0.1	0.6	.	224
2006	16	.	.	.	.	+	+	+	.	+	.	17
2007	26	.	.	.	.	.	.	+		+	.	26
2008	4	.	.	.	.	.	1.1	.	0.1		.	5
2009	.	.		1.3	+	.	+	.	0.1	1.4	.	2.9
2010	.	.		+	1.2	.		+	+	0.7	.	2.1
2011	2	.	.	.	.	.	.	+	0.1	0.8	.	3
2012	22	.	.	.	.	.	.	1.1	+	0.2	.	23
2013	.	.	.	.	.	.	.	+	.	.	+	+
2014	.	.	.	.	.	+	.	.	+	.	.	+
2015	.	.	.	.	.	.	.	.	.	+	.	+
2016	.	.	.	.	.		.	+	.	.	.	+
2017	.	.	.	.	.	0.6	.	.	.	.	.	0.6.

Table 7.2. Basking shark in the Northeast Atlantic. Norwegian landings of liver (kg) and fins (kg) of basking shark (*Cetorhinus maximus*) during 1977–2008, estimated landings in live weight (conversion factors of 4.64 for liver and 40.0 for fins), estimated numbers of landed individuals (from landings of both liver and fins using an average weight per individual of 648.5 kg for liver and 71.5 kg for fins), ICES and Norwegian official landings (applying conversion factors of 10.0 for liver (1977–1995), 100.0 fins (1996–1999), 100.0 for fins (ICES 2000–2008), and 40.0 for fins (Norway 2000–2008)), and landings recommended used by ICES WGEF 2008. In 1995 and 1997, landings of whole individuals measuring 3760 kg (one individual) and 7132 kg (two individuals), respectively, were reported. These weights are included in the official and revised landings and in the estimation of landed numbers.

Year	Liver (kg)	Fins (kg)	Catch from liver (tonnes)	Catch from fins (tonnes)	Landed numbers (livers – fins)	ICES official landings (tonnes)	Norway official landings (tonnes)	Recommended by ICESWGEF 2008
1977	793 153	0	3680.2	0.0	1223	7931.5	7931.5	3680.2
1978	784 687	0	3640.9	0.0	1210	7846.9	7846.9	3640.9
1979	1 133 477	95 070	5259.3	3802.8	1748–1330	11 334.8	11 334.8	5259.3
1980	802 756	60 851	3724.8	2434.0	1238–851	8027.6	8027.6	3724.8
1981	387 997	27 191	1800.3	1087.6	598–380	3880.0	3880.0	1800.3
1982	464 606	31 987	2155.8	1279.5	716–447	4646.1	4646.1	2155.8
1983	379 428	24 847	1760.5	993.5	585–348	3794.3	3794.3	1760.5
1984	444 171	23 505	2061.0	940.2	685–329	4441.7	4441.7	2061.0
1985	315 629	16 699	1464.5	668.0	487–234	3156.3	3156.3	1464.5
1986	246 474	12 138	1143.6	485.5	380–170	2464.7	2464.7	1143.6
1987	35 244	3148	163.5	125.9	54–44	352.4	352.4	163.5
1988	22 761	1927	105.6	77.1	35–27	227.6	227.6	105.6
1989	127 775	10 367	592.9	414.7	197–145	1277.8	1277.8	592.9
1990	193 179	18 110	896.4	724.4	298–253	1931.8	1931.8	896.4
1991	162 323	18 337	753.2	733.5	250–256	1623.2	1623.2	753.2
1992	365 761	37 145	1697.1	1485.8	564–520	3657.6	3657.6	1697.1
1993	291 042	34 360	1350.4	1374.4	449–481	2910.4	2910.4	1374.4
1994	176 220	26 922	817.7	1076.9	272–377	1762.2	1762.2	1076.9
1995	10 450	15 571	52.2	626.6	17–219	108.3	108.3	626.6
1996	41 283	19 789	191.6	791.6	64–277	1978.9	1978.9	791.6
1997	57 184	11 520	272.5	467.9	90–163	1159.1	1159.1	467.9
1998	3	1366	0.0	54.6	19	136.6	136.6	54.6
1999	20	770	0.1	30.8	11	77.0	77.0	30.8
2000	51	2926	0.2	117.0	41	292.6	117.0	117.0
2001	0	1997.5	0.0	79.9	28	199.7	79.9	79.9
2002	0	1351.5	0.0	54.1	19	135.2	54.1	54.1
2003	0	3191.5	0.0	127.7	45	319.2	127.7	127.7
2004	0	1808.3	0.0	72.3	25	180.8	72.3	72.3
2005	0	2180.5	0.0	87.2	30	218.1	87.2	87.2
2006	0	160	0.0	6.4	2	16.0	6.4	6.4
2007	0	653	0.0	26.1	9	65.3	26.1	26.1
2008	0	98	0.0	3.9	1	9.8	3.9	3.9

Table 7.3. Basking shark in the Northeast Atlantic. Proportions (%) of landed basking sharks caught in different gears as reported to the Norwegian Directorate of Fisheries from 1990–2011.

YEAR	DIVISION 2.A							DIVISION 4.A	
	Harpoon	Gillnet	Driftnet*	Undefined nets	Bottom trawl	Danish seine	Hook and lines	Harpoon	Gillnet
1990	84.0		3.1					12.9	
1991	69.7		1.0					29.3	
1992	83.1		6.0		5.6		0.4	4.9	
1993	99.1	0.8			0.1				
1994	85.4							14.6	
1995	89.8	6.5							3.7
1996	89.1	10.3		0.2		0.4	0.1		
1997	66.7	23.7					0.5	9.1	
1998	67.2	28.5					4.4		
1999	9.1	81.8		7.8	1.3				
2000	33.4	58.7			7.8				
2001		96.0			4.0				
2002	16.3	78.5			5.2				
2003	3.4	89.7			7.2				
2004		100.0							
2005	54.1	44.5		0.5	1.4				
2006		100.0							
2007		100.0							
2008		100.0							
2009									
2010									
2011		50.0					50.0		

*** These driftnets for salmon were banned after 1992.**

Table 7.4. Basking shark in the Northeast Atlantic. Summary details of bycatch reported from France and Norway.

Nation	Day	Month	Year	Geog. area	Lat	Lon	Gear	Depth	Length	Weight (kg)	Comment	Source
France	25	Jan	2010	Iroise Sea	48.549	5.124	Gillnet		4–5 m		Released alive	Unpublished data - APECS
France	8	May	2010	Atlanic	46.236	1.592	Gillnet		4.6 m		Discarded	Unpublished data - APECS
France	27	May	2010	Atlantic	47.247	2.964	Gillnet		3.4 m		Discarded, samples, museum collection	Unpublished data - APECS
France		May	2009	Mediterranean	42.935	3.063	Gillnet		6–7 m			Unpublished data - APECS
France		May	2009	Mediterranean	42.935	3.063	Gillnet		6–7 m			Unpublished data - APECS
France		May	2009	Mediterranean	42.935	3.063	Gillnet		6–7 m			Unpublished data - APECS
France	31	May	2009	Atlantic	47.768	4.211			2.5–3 m		Released alive	Unpublished data - APECS
France	18	Nov	2009	Atlantic	43.427	1.695			3.5–4 m		Discarded	Unpublished data - APECS
France	27	Apr	2009	Mediterranean	45.841	1.531	Bottom trawl	20 m			Discarded	Unpublished data - APECS
France	20	May	2009	Mediterranean	43.051	-3.391	Pelagic trawl	45 m	5 m		Discarded	Unpublished data - APECS
France	30	May	2011	Mediterranean	43.328	-5.203	Gillnet		3–6 m		Released alive	Unpublished data - APECS
France	3	Aug	2011	Iroise Sea	48.233	4.483	Gillnet		3–6 m		Discarded, samples	Unpublished data - APECS
France	19	Apr	2011	Atlantic	47.760	4.205	Gillnet	30 m	3–6 m		Discarded, samples, immature	Unpublished data - APECS
France	6	May	2011	Atlantic	47.745	4.218	Gillnet		3–6 m		Released alive, genetic sample	Unpublished data - APECS
France	4	Nov.	2011	Celtic Sea					4 m		Genetic sample	Obsmer data
France	17	May	2013	Atlantic	47.780	4.210	Gillnet		3.3 m		Discarded, samples, immature male	Unpublished data - APECS
France	15	April	2014	Atlantic	47.78	3.77			5 m	650	Discarded	Media
Norway		Dec	2006	Atlantic	59.03	9.80	Gillnet	50 m	3.5 m	350	Approx. position	Media
Norway		Sep	2006	Atlantic	58.81	9.90	Gillnet		~4 m	500	Discarded, approx. position	Media
Norway		Aug	2007	Atlantic	61.97	5.02	Gillnet		4.5 m	250	Discarded, approx. position	Media
Norway			2007	Atlantic	64.13	8.20	Gillnet		4 m	500	Approx. position	Media

Nation	Day	Month	Year	Geog. area	Lat	Lon	Gear	Depth	Length	Weight (kg)	Comment	Source
Norway		Sep	2007	Atlantic	58.45	8.86	Gillnet		4–5 m		Approx. position	Media
Norway		July	2008	Atlantic	68.11	14.18					Approx. position	Media
Norway		July	2008	Atlantic	62.36	47.00	Gillnet				Released alive, approx. position	Media
Norway		July	2011	Atlantic	70.29	27.28	Gillnet		~10 m		Discarded, approximate position	Media
Norway		July	2011	Atlantic	71.11	23.96	Gillnet				Released alive, approx. position	Media
Norway		May	2012	Atlantic	68.78	11.86	Gillnet		~10 m	~1 t	Landed, approx. position	Media
Norway		May	2012	Atlantic	62.48	5.86	Gillnet				Landed, approx. position	Media
Norway	13	Sept	2014	Atlantic	65.60	12.10	Gillnet		12 m		Approx. position	Media

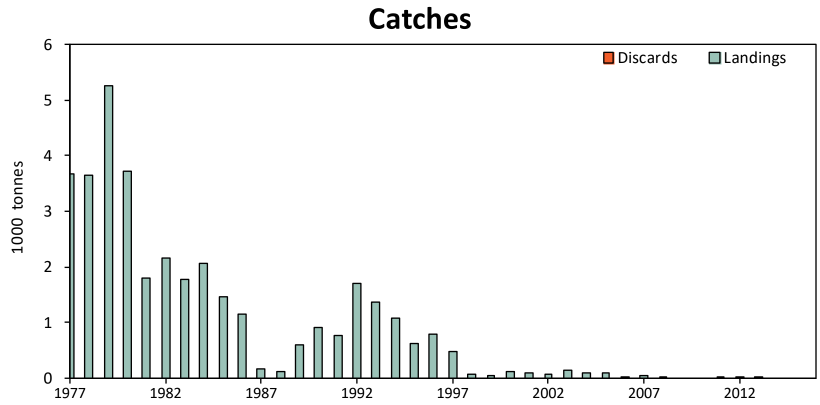

Figure 7.1. Basking shark in the Northeast Atlantic. Total landings (1000 t) of basking sharks in ICES subareas 1–14 from 1977–2014, , since 2014: <0.1 t landed (not shown).

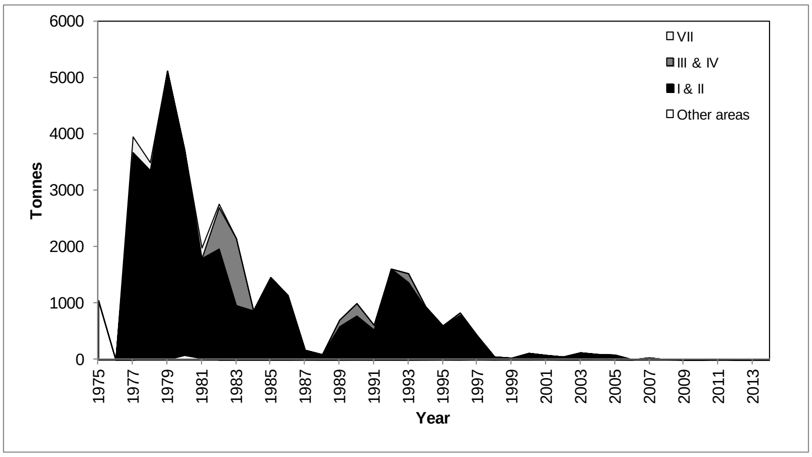

Figure 7.2. Basking shark in the Northeast Atlantic. Total landings (t) of basking sharks in ICES subareas 1–14 from 1975–2014, since 2014: <0.1 t landed in "Other areas" (not shown).

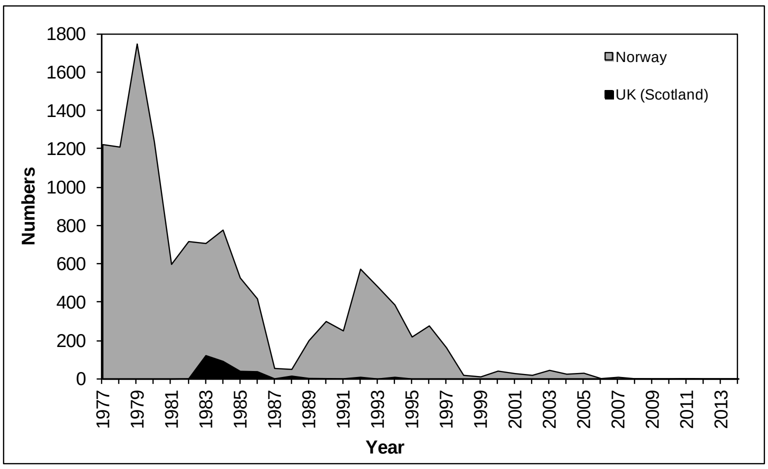

Figure 7.3. Basking shark in the Northeast Atlantic. Numbers of basking sharks landed by Norway and Scotland in ICES subareas 1–14 from 1977–2014.

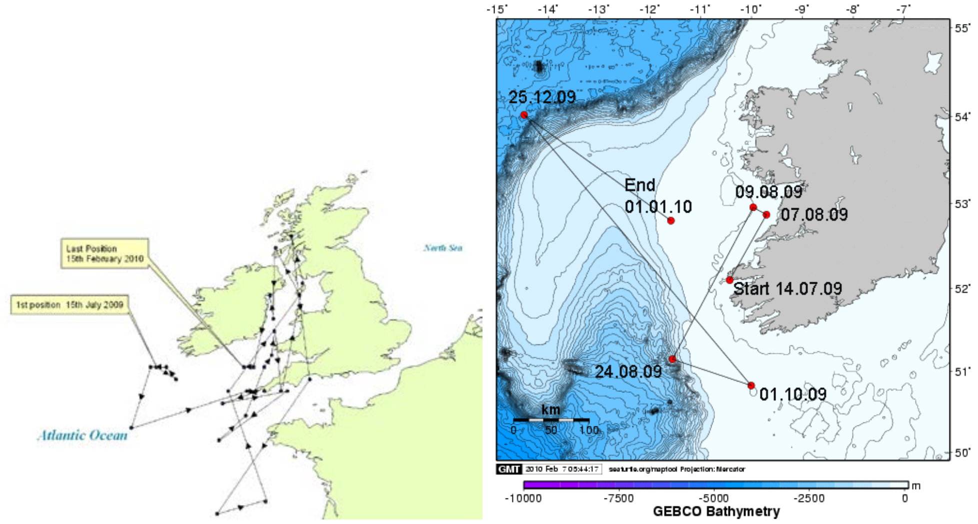

Figure 7.4. Basking shark in the Northeast Atlantic. Geolocations from basking shark A (left, sex=male) and B (right, sex=unknown). Source: Berrow and Jackson (2010 WD).

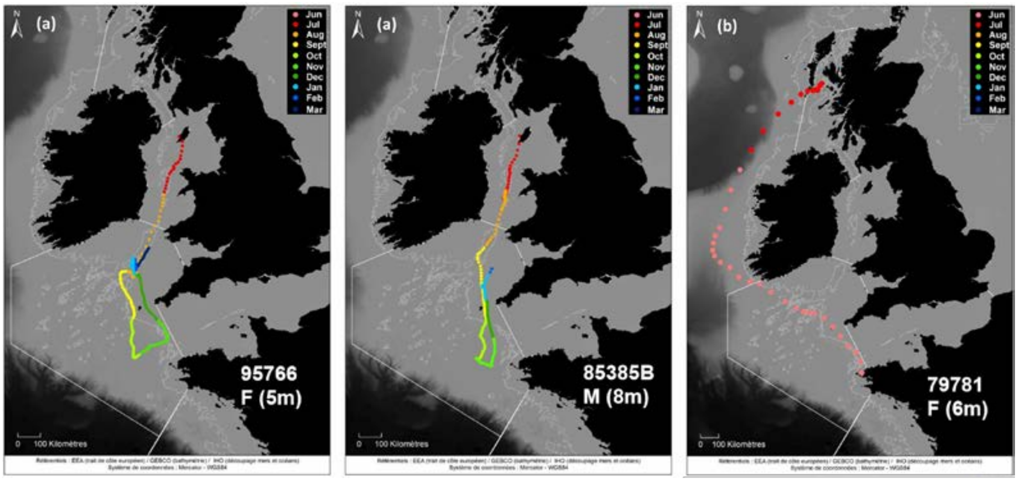

Figure 7.5. Basking shark in the Northeast Atlantic. Most probable tracks for (left) shark 95766 (5 m female) and (centre) shark 85385 (8 m male), tracked for more than 200 days and which stayed in the Irish Sea and Celtic Seas, and (right) most probable track for shark 79781 (6 m female) tracked for 38 days. Source: Stéphan *et al.* (2011).

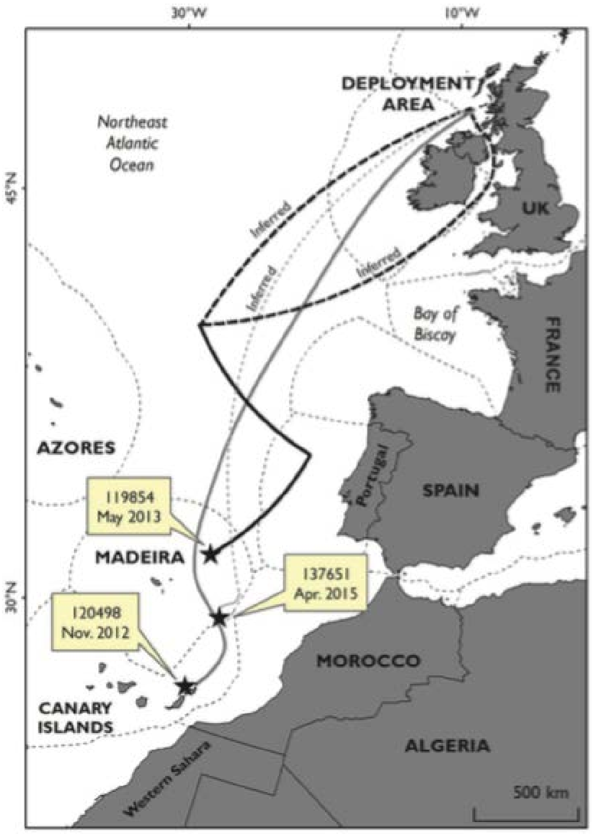

Figure 7.6. Basking shark in the Northeast Atlantic. Long-range movements of basking sharks from Scotland revealed by Argos satellite tracking. Two SPOT-tagged basking sharks in 2012 (119854, 120498) and one SPLASH-F tagged shark in 2014 (137651). Source: Witt *et al.* (2016).

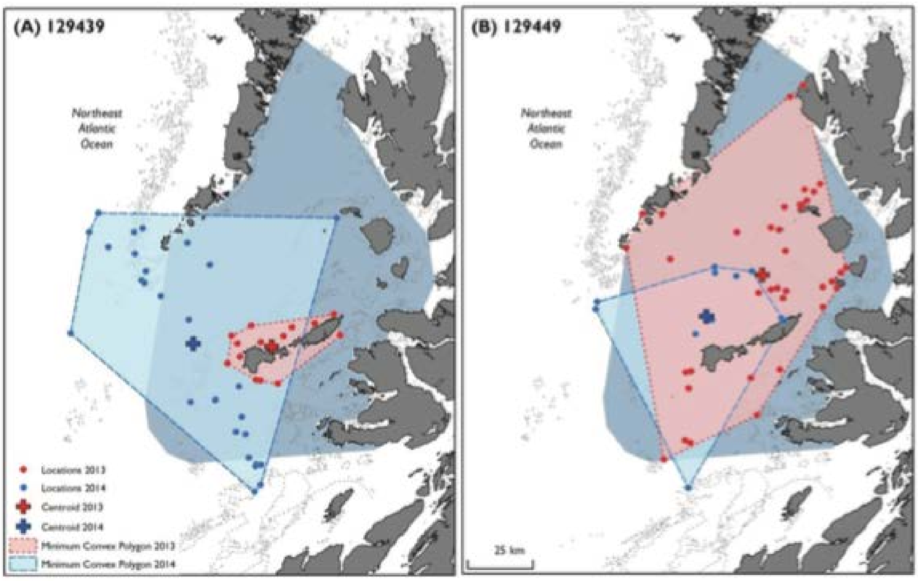

Figure 7.7. Basking shark in the Northeast Atlantic. Example distribution of two sharks showing inter-annual fidelity to the Hebridean Sea. Single highest quality Argos locations per day (red and blue circles for 2013 and 2014 respectively). Minimum convex polygons for data gathered in 2013 and 2014 (red and blue polygons respectively), geographic mean centroid of Argos locations for 2013 and 2014 (red and blue crosses respectively). Source: Witt *et al.* (2016).

8 Blue shark in the North Atlantic (North of 5ºN)

8.1 Stock distribution

There is a discrete North Atlantic stock of blue shark *Prionace glauca* (Heessen, 2003; Fitzmaurice *et al.*, 2005; ICCAT, 2008), with 5°N latitude the southern stock boundary, and a separate South Atlantic stock (ICCAT, 2008). This is based on mark-recapture data and oceanographic features, and it also facilitates comparison with fisheries statistics from tuna-like species, as other North Atlantic stocks have this southern stock boundary. Hence, the ICES area is only part of the stock area.

Recent genetic studies on blue shark reveal genetic homogeneity across whole ocean basins in Atlantic (Verissimo *et al.*, 2017) and Pacific oceans (Ovenden *et al.*, 2009; Taguchi *et al.*, 2015). These are at odds with the currently assumed distinction of northern and southern stocks within each ocean basin. The bulk of the evidence gathered thus far indicates that the blue shark exhibits dispersal with gene flow over very large spatial scales, and little to no philopatry to the sampled nursery areas or to distinct ocean basins. However, in cases as in blue sharks where effective populations sizes are ~1,000s, the levels of genetic divergence associated with migration rates which could lead to demographic connectivity (~10%; Hastings, 1993) may be difficult to detect using traditional molecular markers. In these cases, the precautionary approach in conservation and fisheries management would be to consider each nursery area as independent, with potentially different demographic parameters and vulnerability to fishing pressure. If each nursery area currently exchanges only a few migrant individuals per generation with other nurseries, the replenishment of each stock would be mostly dependent on recruit survival rather than on immigration from adjacent stocks.

8.2 The fishery

8.2.1 History of the fishery

In recent years, more information has become available about fisheries taking blue shark in the North Atlantic. Although available data are incomplete, they offer information on the situation in fisheries and trends. There are no large-scale target fisheries for blue shark, it is a major bycatch in tuna and billfish fisheries, where it can comprise up to 70% of the total catches and even exceed the catch of target species (ICCAT, 2005). In the North Atlantic, the EU fleets (Portugal and Spain) are responsible for approximately 82% of the total landings (Anon, 2015).

Observer data indicates that substantially more blue shark are caught as bycatch than reported in landings statistics. Blue sharks are also caught, in considerable numbers, in recreational fisheries, including in the ICES area (Campana *et al.*, 2005).

Since 1998, there has been a Basque artisanal longline fishery targeting blue shark and other pelagic sharks in the Bay of Biscay from June to November (Díez *et al.*, 2007). Initially 3–5 vessels were involved but, as a consequence of changes in local fishing regulations, the number of vessels has reduced to two since 2008.

In the North Atlantic, thirteen fisheries (in descending order of volume: EU-Spain, EU-Portugal, Japan, Canada, USA_LL, Chinese Taipei, EU-France, Belize, Panama, USA_SP., China PR, Korea and, Venezuela) accounted for 99% of the total removals (1990–2014). The majority (except: USA sport fishery, EU-France unclassified gear) are longline fisheries (Anon., 2015). There are also blue shark landings in Mediterranean fisheries (Anon., 2015).

8.2.2 The fishery in 2017

In 2015, prior to their most recent stock assessment, ICCAT nominal catch statistics of blue shark (by stock, flag and gear) were reviewed. No major updates were made to the historical catch series, and only recent years of official catches were updated. Before 1997, there is a lack of official catches statistics for some of the main fishing nations operating in the stock area. No change in 2018.

8.2.3 Advice applicable

ACOM has never provided advice for blue shark in the ICES area. Assessment of this stock is considered to be the responsibility of ICCAT. In July 2015, members of WGEF participated in the ICCAT blue shark stock assessment meeting that took place in Lisbon, Portugal (ICCAT, 2015).

In 2015, ICCAT considered that the status of the North Atlantic stock is unlikely to be either overfished or subject to overfishing. However, due to the level of uncertainty in the assessment results no specific management recommendations were provided (ICCAT, 2015).

8.2.4 Management applicable

There are no measures regulating the catches of blue shark in the North Atlantic.

EC Regulation No. 1185/2003 (updated by EU Regulation No 605/2013) prohibits the removal of shark fins of these species, and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

8.3 Catch data

8.3.1 Landings

It is difficult to accurately quantify landings of blue shark in the North Atlantic. Data are incomplete, and the generic reporting of shark catches has resulted in underestimations. Landing data from different sources (ICCAT, FAO and national statistics) can vary (Figures 8.1– 8.3). Table 8.1 gives the catch data (total landings and discards by stock, flag and major gears) collated by ICCAT, which appears to provide the most complete catch data for this stock. ICCAT considers that reported landings of blue shark were underestimated in the early part of the time-series (prior to 1997), with official landings and estimates of a comparable magnitude since 1997, when annual landings have been *ca.* 20 000–40 000 t. In the North Atlantic, blue shark is reported predominantly by Spain, Portugal, Japan, USA and Canada (Figure 8.2.

In 2015, alternative approaches to estimate catch series were discussed by ICCAT (Anon., 2015), including (i) ratios between blue shark catches and species-specific catches derived from ICCAT Task I data; (ii) catch/effort and standardised CPUE; and (iii) shark fin trade data. Figure 8.4 shows the catch series (1971–2013) for North Atlantic blue shark available for the 2015 stock assessment (SA2015), the 2008 stock assessment catches (SA2008), and the catch series obtained using shark-fin ratios (three different series, see for example Clarke *et al.,* 2006). Both stock assessment series followed a similar trend (but with large differences in some years) with catches oscillating several times between 15 000 t and 55 000 t. The three shark-fin series show a completely different tendency (continuous upward trend) with catches starting around 10 000 t in the 1980s and growing to nearly 60 000 t in 2011 (Anon., 2015). Generally, the overall data for blue shark (and sharks in general) reported to ICCAT has improved slightly over time (more complete series by species, lesser quantities of unclassified sharks, less weight of unclassified gears in the shark series, etc.). However, many unclassified shark species, mostly grouped by family (e.g. Lamnidae, Carcharhinidae, Sphyrnidae) and genera (e.g. *Rhizoprionodon, Carcharhinus, Sphyrna* and *Alopias* spp.) were reported to ICCAT in the past. The largest portion of unclassified sharks (1982–2013) is concentrated in longline and gillnet fisheries (Anon., 2015).

Japanese catches (landings and discards) from tuna longliners in the North Atlantic are estimated to have fluctuated between 1400–2400 t in 2006–2014, but a large increase to about 8200 t is observed in 2015. These are higher than reported landings of the target species (bluefin tuna) from Japanese longliners in this period (ICCAT, 2008). Another study of Japanese bluefin tuna longline fisheries showed that the ratio of blue shark to the target species was about 1:1 (Boyd, 2008). Data from observations onboard a Chinese Taipei (Taiwanese) vessel targeting bluefin tuna in the southern North Atlantic showed that blue shark accounted for 76% of shark bycatch, though no information was presented on the percentage of blue shark in the total catch (Dai and Jang, 2008). Together, blue shark and shortfin mako account for between 69% and 72% of catches from Spanish and Portuguese surface longliners in the North Atlantic (Oceana, 2008).

8.3.2 Discards

Historically, the relative low value of blue shark meant that it was not always retained for the market, with the fins the most valuable body part. In some fisheries the fins were retained and the carcasses discarded. In 2013, EU prohibited this practice (see section 8.2.4).

Accurate estimates of discarding are required to quantify total removals from the stock. Currently no such estimates are available. Differences between estimated and reported catch in various fisheries (ICCAT, 2008 and references cited therein) suggest that discarding is widespread in fisheries taking blue shark.

Discard estimates are available for fisheries from Chinese Taipei, Korea Rep., USA, and UK (Bermuda) in recent years and from 2000 onwards from USA. However, they represent likely a limited part of total discards. The full extent of blue shark bycatch cannot be assessed using the data available, but evidence suggests that longline operations can catch more blue shark than target species. There is considerable bycatch of blue sharks in Japanese and Taiwanese tuna longliners operating in the Atlantic. However, it is not possible, to estimate discard rates from these fleets from the information available. Discards can be assumed to be far higher than reported (Campana *et al*., 2005), especially in high seas fisheries.

Information on elasmobranchs discards in demersal otter trawl, deep-water set longlines, set gillnet and trammel net fisheries for ICES Division 9.a (2004–2013) showed that blue shark was caught infrequently and discarded in the longline fishery but not in the other fisheries (Prista *et al*., 2014).

8.3.3 Discard survival

Blue shark is one of the most frequent shark species captured in pelagic longline fisheries, and there are several estimates of survival (Boggs, 1992; Francis *et al*., 2001; Campana *et al*., 2005; Diez and Serafy, 2005). It is thought that most discards of whole sharks would be alive on return to the sea. For instance, discard survival rate is estimated to be about 60% in longline fisheries and 80% in rod and reel fisheries (Campana *et al*., 2005). More generally, the at-vessel mortality of longline-caught blue shark ranges from about 5–35% (summarised in Ellis *et al.,* 2014 WD). Discard survival in such fisheries can be influenced by several factors, including hook type, soak time and size of shark. However, discarding can increase overall mortality attributable to fisheries: a study conducted on Canadian pelagic longliners targeting swordfish in the Northwest Atlantic (Campana *et al*., 2009) showed that "*overall blue shark bycatch mortality in the pelagic longline fishery was estimated at 35%, while the estimated discard mortality for sharks that were released alive was 19%. The annual blue shark catch in the North Atlantic was estimated at about 84 000 t, of which 57 000 t is discarded. A preliminary estimate of 20 000 t of annual dead discards for North Atlantic blue sharks is similar to that of the reported nominal catch, and could substantially change the perception of population health if incorporated into a population-level stock assessment*". The survival rate at hauling for blue shark was estimated to be 49% for the French pelagic longliners targeting swordfish in the southwest Indian Ocean. Experiments conducted with gear equipped with hook timers indicated that 29% were alive 8 h after their capture (Poisson *et al*., 2010). The survival rate of blue shark (at haul back) after a nighttime soak may be lower than that during daytime soaks.

8.3.4 Quality of catch data

Catch data are incomplete, and the extent of finning in high seas fisheries is unclear. The historical use of generic shark categories is also problematic, although European countries now report more species-specific data.

In 2012, the ICCAT secretariat noted some large discrepancies between the data in the EUROSTAT database and that of the ICCAT database, with EUROSTAT records showing captures almost double those of ICCAT in recent years.

Methods developed to identify shark species from fins (Sebastian *et al*., 2008; Holmes *et al*., 2009) could help to gather data on species targeted by illegal fishers, this information will greatly assist in management and conservation.

The variability of blue shark mortality estimates, relating to the proportion of live discards, hampers the estimation of total removals, although there are improving approaches to reporting of live discards to the ICCAT SCRS (Anon., 2015).

Given the uncertainty on the 2015 assessment of blue shark North Atlantic stock, ICCAT recommended continued monitoring of the fisheries by observer and port sampling programmes (ICCAT, 2015).

8.4 Commercial catch composition

No new information.

8.4.1 Conversion factors

Information on the length–weight relationship is available from several scientific studies (Table 8.2), as are the relationships between various length measurements (Table 8.3). Campana *et al*., 2005 calculated the conversion relationships between dressed weight (W_D) and live weight or round weight (W_R) for NW Atlantic blue shark (n = 17) to be $W_R = 0.4 + 1.22\ W_D$ and $W_D = 0.2 + 0.81\ W_R$.

For French fisheries, the proportion of gutted fish to round weight is 75.19%. There is also a factor for landed round weight to live weight (96.15%), meaning that there is a 4% reduction in weight because of lost moisture (Hareide *et al*., 2007). Various estimates of fin weight to body weight are available (Mejuto and García-Cortés, 2004; Santos and Garcia, 2005; Hareide *et al*., 2007; Santana-Garcon *et al*., 2012; Biery and Pauly, 2012).

8.5 Commercial catch and effort data

For the North Atlantic stock, catches show a peak in 1987, a decline until 2002 and then an increase (Figure 8.3).

The CPUE input data available are comprehensively described and presented in the 2015 blue shark data preparatory meeting report (Anon., 2015). Following the work conducted for the 2008 SCRS blue shark stock assessment, CPUE were combined through a GLM with two choices of weighting: by the catch of the flag represented by each index and by the area of the flag represented by each index. Additionally, a hierarchical index of abundance that combines all available indices into a single series was also developed. However, it was noted that the process of combining CPUE indices was discouraged as they tend to mask the individual trends of the series and the underlying reasons as to why the series are different. It also indicated that some models can stochastically make use of the different series without need to combine these indices. It was suggested that it may be more useful to group CPUEs according to similar trends, and to include these as separate scenarios as was discussed during the 2015 bigeye tuna assessment.

Table 8.4 shows the various CPUE indices currently available (EU-Portugal, EU-Spain, USA_LL, Japan, Chinese Taipei, and Venezuela), which have been considered for use in the assessment. These CPUE indices show a relatively flat trend throughout the time-series, but with high variance (Table 8.4 and 8.5; Figure 8.5).

8.6 Fishery-independent surveys

No fishery-independent data are available for the NE Atlantic, although such data exist for parts of the NW Atlantic (Hueter *et al*., 2008). A survey from 1977–1994 conducted by the US NMFS documented a decline among juvenile male blue sharks by 80%, but not among juvenile females, which also occur in fewer numbers in the area, the western North Atlantic off the coast of Massachusetts (Hueter *et al*., 2008). The authors concluded that vulnerability to overfishing in blue sharks is present despite their enhanced levels of fecundity relative to other carcharhinid sharks.

8.7 Life-history information

The blue shark is common in pelagic oceanic waters throughout the tropical and temperate oceans worldwide. It has one of the widest ranges of all the shark species. It may also be found close inshore.

In a satellite telemetry study, Queiroz *et al.* (2010) described complex and diverse types of behaviour depending on water stratification and/or depth (Figure 8.6). Females tagged in the Western channel were able to spend up to 70 days in this shelf edge area in the Bay of Biscay; whereas tagged juveniles showed relatively extensive vertical movements away from the southern nursery areas. Results indicated that the species inhabits waters with a wide temperature range from 10–20°C.

The US National Marine Fisheries Service also conducts a Cooperative Shark Tagging Programme (CSTP; Kohler *et al*., 1998; NMFS, 2006), with tagging in the NE Atlantic also being undertaken under the auspices of the Inshore Fisheries Ireland (formerly the Irish Central Fishing Board) Tagging Programme (Green, 2007 WD) and UK Shark Tagging Programme, and there have been other earlier European tagging studies (e.g. Stevens, 1976). Figure 8.7 shows the tag and release results presented by ICCAT (2012), highlighting the large number tagged to date, and the vast horizontal movements undertaken by blue shark in the Atlantic.

In Australian waters, blue sharks exhibit oscillatory dive behaviour between the surface layers to as deep as 560–1000 m. Blue sharks mainly occupied waters of 17.5–20.0°C and spent 35–58% of their time in <50 m depths and 10–16% of their time in >300 m (Stevens *et al*., 2010). The distribution and movements of blue shark are strongly influenced by seasonal variations in water temperature, reproductive condition, and availability of prey. The blue shark is often found in large single-sex schools containing individuals of similar size.

Adult blue sharks have no known predators, although sub-adults and juveniles are eaten by both shortfin mako and white shark as well as by sea lions. Fishing is likely to be a major contributor to adult mortality. A recent first estimation of fishing mortality rate via satellite tagged sharks being recaptured by fishing vessels ranged from 9 to 33% (Queiroz *et al*., 2010).

Various studies have compiled data on biological information on this species in the North Atlantic and other areas. Some of these data are summarized in Table 8.2 (length–weight relationships), Table 8.6 (growth parameters) and Table 8.7 (other life-history parameters). Based on life-history information, the blue shark is considered to be among the most productive shark species (ICCAT, 2008).

New life history inputs were obtained from data first assembled at the ICCAT 2014 Intersessional Meeting of the Shark Species Group (SCRS/2014/012) and additional information provided during the 2015 blue shark data preparatory meeting (SCRS/2015/142). These included maximum population growth rates (rmax) and steepness (h) values of the Beverton–Holt stock–recruitment relationship for North and South Atlantic stocks of blue shark, based on the latest biological information available gathered at the 2015 blue shark data preparatory meeting. To encompass a plausible range of values, uncertainty in the estimates of life history inputs (reproductive age, lifespan, fecundity, von Bertalanffy growth parameters, and natural mortality) was incorporated through Monte Carlo simulation by assigning statistical distributions to those biological traits in a Leslie matrix approach. Estimated productivity was high (rmax = 0.31–0.44 yr^{-1} for the North Atlantic stock), similar to other stocks of this species. Consequently, analytically derived values of steepness were also high (h = 0.73–0.93 for the North Atlantic stock).

The influence of different biological parameters (e.g. growth coefficients, reproductive periodicity, first maturation age, natural mortality and longevity) on estimated blue shark productivity was assessed. Age at first maturity and growth coefficient substantially influenced the productivity of species (e.g. a low age at first maturity and high growth coefficient results in high productivity). Breeding periodicity also affected productivity (i.e. a longer breeding period decreased productivity). Biological parameters should be carefully considered when they are used in the stock analysis, especially when estimated productivity is inconsistent with trends in abundance indices. The level of depletion experienced by blue shark stocks may affect the productivity or population growth through density dependence, and differences in environmental water temperature may also affect growth rates (Anon., 2015).

8.8 Exploratory assessment models

8.8.1 Previous assessments

In 2004, ICCAT completed a preliminary stock assessment (ICCAT, 2005). Although results suggested that the North Atlantic stock were above biomass in support of MSY, the assessment remained conditional on the assumptions made. These assumptions included (i) estimates of historical shark catch, (ii) the relationship between catch rates and abundance, (iii) the initial state of the stock in 1971, and (iv) various life-history parameters. It was pointed out that the data used for the assessment did not meet the requirements for proper assessment (ICCAT, 2006), and further research and better-resolved data collection was highly recommended.

In 2008, three models were used in stock assessment conducted by ICCAT (ICCAT, 2008 and references cited therein): a Bayesian surplus production model, an age-structured model that did not require catch data (catch-free model), and an age-structured production model. Results with the Bayesian surplus production model produced estimates of stock size well above MSY levels (1.5–2* B_{MSY}), and estimated F to be very low (at F_{MSY} or well below it). The carrying capacity of the stock was estimated so high that the increasing estimated catches (25–62 000 t over the time-series) generated very low F estimates. Sensitivity analyses showed that the stock size estimate was dependent on the weighting assigned to the Irish CPUE series. Equal weighting of this and the other series produced a stock size at around B_{MSY}. Other sensitivity analyses indicated similar results to the base case run, with the stock well above MSY levels.

The age-structured biomass model displayed different results with either a strong decrease in biomass throughout the series to about 30% of virgin levels, or a less pronounced decline. The prior for the virgin biomass assigned high values to a very small number of biomass values but also indicated that the range of plausible values of this parameter has a heavy tail. This is probably because there is not enough information in the data to update the model and thus provide a narrower range of plausible values and thus provide a more precise estimate of the biomass of the stock.

The age-structured model not requiring catch information estimated that F was higher than F_{MSY}, but still low and that the current SSB estimated at around 83% of virgin levels.

As a consequence of the results in 2008, ICCAT concluded that biomass was estimated to be above the level that would support MSY (ICCAT, 2008). These results agreed with earlier work (ICCAT, 2005). Stock status appeared to be close to unfished biomass levels and fishing mortality rates were well below those corresponding to the level at which MSY is reached. However, ICCAT (2008) pointed out that the results were heavily dependent on the underlying assumptions. In particular, the choice of catch data to be used, the weighting of CPUE series and various life-history parameters used as input in the model. ICCAT was unable to conduct sensitivity analyses of the input data and assumptions (ICCAT, 2008).

Owing to those weaknesses, no firm conclusions were drawn from the preliminary assessments conducted by ICCAT. ICCAT, 2008 stated that most models used predicted that this stock was not overfished but did not use these results to infer stock status and to provide management advice.

8.9 Stock assessment

The North Atlantic Blue shark stock was assessed by ICCAT in 2015 using two different approaches (see ICCAT, 2015 for more details): Bayesian Surplus Production Model (BSPM) and length-based age-structured models - Stock Synthesis (SS3).

The Bayesian Surplus Production Models adjusted consistently estimated a posterior distribution for *r* that was similar to the prior, and a posterior for *K* with a long right tail with high mean and CV (ICCAT, 2015). The estimated biomass trajectory stayed close to *K* for most runs, and the harvest rate estimate was low (Figure 8.8). The inclusion of a process error in the model did not improve the results. When each CPUE index was fitted separately, the posterior mean of K varied and the CVs were large, implying that none of the indices were particularly informative about the value of K.

Several SS3 runs were undertaken. Run 4 and 6 (see details below) which utilized multiplication factors to reduce the input sample size assigned to length composition data in the model likelihood resulted in reasonable convergence diagnostics (described below).

Model Run	Model Adjustments				
Preliminary Run 1	Natural weights used in model likelihood Length composition input sample size (n = observed) Abundance indices (inverse CV weighting; SCRS/2015/151)				
Preliminary Run 2 CV adjustment	Same as Preliminary Run 1 + Adjust CV of S9 (ESP-LL-N) Constant CV of 20% applied to S9 (ESP-LL-N)				
Preliminary Run 3 Sample size adjustments	Same as Preliminary Run 2 + Adjust input sample size for length comp Maximum length composition input sample size (n=200)				
Preliminary Run 4	Same as Preliminary Run 2 + Apply variance adjustment to length comp.				
Fleet	F1	F2	F3	F4	F5
Variance adjustments	0.01	0.01	0.1	0.1	0.1
Preliminary Run 5	Same as Preliminary Run 2 + Apply variance adjustment to length comp.				
Fleet	F1	F2	F3	F4	F5
Variance adjustments	0.0184	0.0478	0.0261	0.1373	0.2236
Preliminary Run 6	Same as Preliminary Run 2 + Apply variance adjustment to length comp.				
Fleet	F1	F2	F3	F4	F5
Variance adjustments	0.0019	0.0047	0.0046	0.0573	0.0403

Model fits to CPUE and length composition data were similar for both runs. The fitting to abundance tracked trends well and were within most annual 95% confidence intervals for many abundance indices, including S3 (JPLL-N-e), S4 (JPLL-N-l), S6 (US-Obs-cru), S7 (POR-LL), and S9 (ESP-LL-N) (Figures 8.9–8.10). Model fits tracked trends reasonably well for abundance index S2 (US-Obs), but were often outside annual 95% confidence intervals. Predicted abundance was flat for abundance indices S8 (VEN-LL) and S10 (CTP-LL-N), probably because of large 95% confidence intervals for S8 and high inter-annual fluctuations in the early years for S10. Indices S1 (US-Log) and S5 (IRL-Rec) were only included in the model for exploratory purposes, were not fit in the model likelihood (lambda = 0), and had no influence on model results or predicted values. Model fits to length composition were reasonable for aggregate data (Figure 8.11).

Both run 4 and run 6 resulted in sustainable spawning stock size and fishing mortality rates relative to maximum sustainable yield (Figures 8.12–8.14). However, run 6 (the model run with relatively less weight applied to the length composition data in the model likelihood) resulted in a relatively more depleted stock size, compared to run 4.

Both models suggested sustainable spawning stock size and fishing mortality rates relative to maximum sustainable yield. The model with a relatively lower sample size assigned to the length composition data resulted in a relatively more depleted stock size. However, model fits to length composition were insufficient for annual length composition data, for which a bimodal pattern was evident. This is related to spatial segregation of the population. It was suggested that more work should be done to improve the fits to length composition data before using the model to provide management advice.

8.10 Quality of assessments

At the 2015 ICCAT assessment meeting considerable progress was made on the integration of new data sources (in particular size data) and modelling approaches (in particular model structure). Uncertainty in data inputs and model configuration was explored through sensitivity analyses, which revealed that results were sensitive to structural assumptions of the models. The production models showed a poor fit to the flat or increasing trends in the CPUE series combined with increasing catches. Overall, assessment results are uncertain (e.g. level of absolute abundance varied by an order of magnitude between models with different structures) and should be interpreted with caution.

For the North Atlantic stock, scenarios with the BSPM estimated that the stock was not overfished (B_{2013}/B_{MSY} = 1.50–1.96) and that overfishing was not occurring (F_{2013}/F_{MSY} = 0.04–0.50). Estimates obtained with SS3 varied more widely, but still predicted that the stock was not overfished (B_{2013}/B_{MSY} = 1.35–3.45) and that overfishing was not occurring (F_{2013}/F_{MSY} = 0.15–0.75). Comparison of results obtained in the assessment conducted in 2008 and the current assessment revealed that, despite significant differences between inputs and models used, stock status results did not change drastically (B_{2007}/B_{MSY} = 1.87–2.74 and F_{2007}/F_{MSY} = 0.13–0.17 for the 2008 base runs using the BSP and a catch-free age-structured production model).

8.11 Reference points

ICCAT uses F/F_{MSY} and B/B_{MSY} as reference points for stock status of this stock. These reference points are relative metrics rather than absolute values. The absolute values of B_{MSY} and F_{MSY} depend on model assumptions and results and are not presented by ICCAT for advisory purposes.

8.12 Conservation considerations

Blue shark is listed as 'Near Threatened' by the IUCN.

8.13 Management considerations

Based on the scenarios and models explored, ICCAT considered the status of the North Atlantic stock as unlikely to be overfished nor subject to overfishing. However, due to the level of uncertainty, no specific management recommendations were developed.

Catch data are highly unreliable. Some CPUE series exist, and where data are available, show a relatively flat trend throughout the time-series, but with high variance. Further work is required to explain the downward trends and to better quantify removals from the stock.

Catch data are considered incomplete, and underestimated. There have been unaccounted discards and a substantial occurrence of finning over parts of the time series. Data reported to ICES, ICCAT and FAO can vary.

For accurate stock assessments of pelagic sharks, better fishery data are required. In addition, reporting procedures must be strengthened so that all landings are reported, and that landings are reported to species level, rather than generic "shark nei" categories. In the absence of reliable landings and catch data, catch ratios and market information derived from observers can provide useful information for understanding blue shark fishery dynamics.

For the North Atlantic stock, smaller sized blue sharks have been observed to dominate north of 30ºN, while larger sized blue sharks dominated south of 30ºN. In order to be able to account for the differences in size composition of fish in different areas, future implementations of SS3 should consider this spatial structure in the fleets. This will require estimating fleet and area specific CPUE indices, catch and size distributions. Ideally the model could also be separated by sex.

Blue shark is considered to be one of the most productive sharks in the North Atlantic. As such, it can be expected to be more resilient to fishing pressure than other pelagic sharks. However, the high degree of susceptibility to longline fishing and the poor quality of the information available to assess the stock is a cause for concern. Given the uncertainty of the results and that this species is a significant bycatch, especially in tuna and billfish fisheries, there is a need for continued monitoring of the fisheries by observer and port sampling programmes. There are currently no fishery-independent data available for that part of the stock in the ICES area.

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Table 8.1. Blue shark in the North Atlantic. Landings (t) by country 1978–2015 from ICCAT Task I catch data. These are considered underestimates, especially prior to 1997.

Stock	Country	1978	1979	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
North Atlantic	Belize																					
	Brasil																					
	Canada								320	147	968	978	680	774	1277	1702	1260	1494	528	831	612	547
	Cape Verde																+					
	China P.R.																					
	Chinese Taipei																					
	EU.Denmark											2	2	1	1		1	2	3	1	1	
	EU.España																			24497	22504	21811
	EU.France	4	12		9	8	14	39	50	67	91	79	130	187	276	322	350	266	278	213	163	399
	EU.Ireland																					66
	EU.Netherlands																					
	EU.Portugal												1387	2257	1583	5726	4669	4722	4843	2630	2440	2227
	EU.United Kingdom												1				+	12			1	+
	FR.St Pierre et Miquelon																					
	Japan																1203	1145	618	489	340	357
	Mexico																	+				
	Panama																					9
	Senegal																					
	Trinidad and Tobago																					

Stock	Country	1978	1979	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	U.S.A.			204		605	107	341	1112	1400	776	751	829	1080	399	1816	601	641	987	391	447	317
	UK.Bermuda																	3	1	1	2	8
	Korea Rep.																					
	Namibia																					
	South Africa																					
	Uruguay																					
	Venezuela																					
N.Atlantic TotalTotal		4	12	204	9	613	121	380	1482	1614	1835	1810	3028	4299	3536	9566	8084	8285	7258	29053	26510	25741
Mediterranean	EU.Cyprus																					
	EU.España																			146	59	20
	EU.France																					
	EU.Italy																					
	EU.Malta																1	1	1	+	+	+
	EU.Portugal																				2	
	Japan																5	7	1	1		
Med TOTAL		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	5.581	8.376	1.768	147.95	60.856	20.445
N.ATL AND MED TOTAL		4	12	204	9	613	121	380	1482	1614	1835	1810	3028	4299	3536	9566	8090	8293	7260	29201	26571	25761

Table 8.1. Cont. Blue shark in the North Atlantic. Landings (t) by country 1978–2016 from ICCAT Task I catch data (accessed June 2018). These are considered underestimates, especially prior to 1997.

			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TOTAL			40664	35800	32765	37928	36305	43072	43888	50464	53901	58842	65193	73050	63174	56848	69408	62012	66273
	ATN		28174	21709	20066	22951	21742	22359	23217	26927	30723	35198	37178	38084	36786	37202	39881	39502	42029
	ATS		12444	14043	12682	14967	14438	20642	20493	23487	23097	23459	27799	34926	26347	19545	29292	22172	23938
	MED		45	47	17	11	125	72	178	50	81	185	216	40	42	100	235	85	79
Landings	ATN	Longline	27305	20699	19290	22880	21297	22167	23067	26810	30514	35031	36952	37777	36549	36882	39677	38777	41772
		Other surf.	732	905	708	70	380	126	104	63	80	63	59	100	109	74	205	725	257
	ATS	Longline	12444	14042	12678	14961	14339	20638	20434	23417	22708	23453	27785	34531	25878	19375	27457	21355	23309
		Other surf.	0	1	4	6	99	3	59	10	375	6	14	391	264	0	1835	818	629
	MED	Longline	44	47	17	10	43	71	83	48	81	18	50	40	41	68	190	84	78
		Other surf.	1	1	1	0	81	0	95	2	1	167	165	0	0	32	45	1	2
Discards	ATN	Longline	137	105	68	0	63	66	45	53	129	102	167	205	127	246	122	124	87
		Other surf.	0	0	0	0	1	0	0	0	1	1	1	2	1	0		+	0
	ATS	Longline	0	0	0	0	0	0	0	60	14	0	0	4	206	169	114	122	139
		Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0		6	0
Landings	ATN	Barbados																9	6
		Belize	0	0	0	0	0	0	0	0	0	114	461	1039	903	1216		4	6
		Brazil	7	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
		Canada	624	1162	836	346	965	1134	977	843	0	0	0	0	1	0		0	0
		Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
		China PR	0	185	104	148	0	0	0	367	109	88	53	109	98	327		1	27
		Chinese Taipei	165	59	0	171	206	240	588	292	110	73	99	148	94	121	81	220	266

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	EU.Denmark	2	1	13	5	1	0	0	0	0	0	0	0	0	0		0	0
	EU.Spain	24112	17362	15666	15975	17314	15006	15464	17038	20788	24465	26094	27988	28666	28562	25202	30078	29019
	EU.France	395	207	221	57	106	120	99	167	119	84	122	115	31	216	129	259	352
	EU.Ireland	31	66	11	2	0	0	0	0	0	0	0	1	3	2	1	0	0
	EU.Netherlands	0	0	0	0	0	0	0	0	0	1	0	0	0	0		0	0
	EU.Portugal	2081	2110	2265	5643	2025	4027	4338	5283	6167	6252	8261	6509	3768	3694	2913	3859	7819
	EU.United Kingdom	12	9	6	4	6	5	3	6	6	96	8	10	8	10	10	12	17
	FR.St Pierre et Miquelon	0	0	0	0	0	0	0	0	0	1	0	0	0	0		0	0
	Japan	273	350	386	558	1035	1729	1434	1921	2531	2007	1763	1227	2437	1808	2034	4011	4239
	Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	537	299	327		0	10
	Marocco																873	0
	Mexico	0	6	0	0	0	0	0	0	0	0	0	0	0	0		0	0
	Panama	0	0	0	0	0	0	254	892	613	1575	0	0	0	289		0	0
	Senegal	0	0	456	0	0	0	0	43	134	255	56	0	5	12		13	3
	St.Vincent and Grenadines																0	119
	Suriname	0	0	0	0	0	0	0	0	0	0	0	0	181	281		0	0
	Trinidad and Tobago	0	0	6	3	2	1	1	0	2	8	9	11	11	8		4	2
	U.S.A.	291	39	0	0	7	2	2	1	8	4	9	65	56	32		31	30
	UK.Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
	Venezuela	43	47	29	40	10	28	12	19	8	73	75	118	98	52		129	116
Discards ATN	Candada																0	0
	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	21	14	9	5	16
	Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0		19	27

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
U.S.A.	137	106	68	0	65	66	45	54	130	103	167	206	106	231		18	1
UK.Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0		82	43

Table 8.2. Blue shark in the North Atlantic. Length–weight relationships for blue shark from different populations. Lengths in cm, and weights in kg unless specified in equation. W_R = round weight; W_D = dressed weight.

L (cm) W (kg) relationship	Sex	n	Length range (cm)	Source
WD = (8.04021 x 10–7) LF ^ 3.23189	C	354	75–250 (LF)	García-Cortés and Mejuto, 2002
WR = (3.1841 x 10–6) LF ^ 3.1313	C	4529		Castro, 1983
WR = (3.92 x 10–6) LT ^ 3.41	Male	17		Stevens, 1975
WR = (3.184 x 10–7) LT ^ 3.20	Female	450		Stevens, 1975
WR = (3.2 x 10–6) LF ^ 3.128	C	720		Campana *et al.*, 2005
WD = (1.7 x 10–6) LF ^ 3.205	C	382		Campana *et al.*, 2005

Table 8.3(a). Blue shark in the North Atlantic. Length–length relationships for male, female blue shark and both sexes combined from the NE Atlantic and Straits of Gibraltar (Buencuerpo *et al.*, 1998). L_S = standard length; L_F = fork length; L_T = total length; L_{UC} = upper caudal lobe length.

Females	Males	Combined
LF = 1.076 LS + 1.862 (n = 1043)	LF = 1.080 LS + 1.552 (n = 1276)	LF = 1.079 LS + 1.668 (n = 2319)
LT = 1.249 LS + 7.476 (n = 1043)	LT = 1.272 LS + 4.466 (n = 1272)	LT = 1.262 LS + 5.746 (n = 2315)
LUC = 0.219 LS + 4.861 (n = 1038)	LUC = 0.316 LS + 2.191 (n = 1264)	LUC = 0.306 LS + 3.288 (n = 2302)
LT = 1.158 LF + 5.678 (n = 1043)	LT = 1.117 LF + 2.958 (n = 1272)	LT = 1.167 LF + 4.133 (n = 2315)

Table 8.3(b). Blue shark in the North Atlantic. Length–length relationships for both sexes combined of blue shark from various populations and sources.

Stock	Relationship	n	Source
NW Atlantic	LF = (0.8313) LT + 1.3908	572	Kohler *et al.*, 1995
NE Atlantic	LF = 0.8203 LT –1.061		Castro and Mejuto, 1995
NW Atlantic	LF = –1.2 +0.842 LT	792	Campana *et al.*, 2005
NW Atlantic	LT = 3.8 + 1.17 LF	792	Campana *et al.*, 2005
NW Atlantic	LCF = 2.1 + 1.0 LSF	782	Campana *et al.*, 2005
NW Atlantic	LSF = –0.8 + 0.98 LCF	782	Campana *et al.*, 2005
NW Atlantic	LF = 23.4 + 3.50 LID	894	Campana *et al.*, 2005
NW Atlantic	LID = –4.3 + 0.273 LF	894	Campana *et al.*, 2005

Table 8.4. Blue shark in the North Atlantic. Indices of abundance for North and South Atlantic blue shark stocks. Source: ICCAT (2015).

			North Atlantic					
Year	Usobs	JPLLe	JPLLI	USOLD	PORLL	VENLL	ESPLL	CHTPLL
1957				0.98				
1958				0.48				
1959				1.11				
1960				1.18				
1961				1.13				
1962				1.5				
1963				0.7				
1964				0.87				
1965				1.55				
1966				1.27				
1967				1.43				
1968				1.31				
1969				1.96				
1970				0.97				
1971		0.87		1.08				
1972		1.46		1.93				
1973		1.12						
1974		2.62						
1975		1.85		0.88				
1976		1.07		0.75				
1977		1.89		1.82				
1978		1.58		1.06				
1979		1.3		0.860				
1980		2.21		0.830				
1981		2.19		1.050				
1982		2.08		0.780				
1983		1.81		1.010				
1984		1.22		0.680				
1985		1.51		0.740				
1986		1.52		0.480				
1987		2.13		0.500				
1988		1.21		0.440				
1989		1.51		0.800				
1990		1.34		0.940				
1991		1.26		1.220				
1992	7.455	1.9		0.63				
1993	11.076	2.43		0.95				
1994	9.717		2.33	0.98		0.047		
1995	10.17		2.1	0.73		0.073		
1996	8.208		2.05	0.47		0.017		
1997	14.439		2.05	1.25	158.14	0.154	156.83	
1998	18.408		1.72	1.16	169.02	0.216	154.45	
1999	6.663		1.89	0.76	149.83	0.117	179.91	
2000	9.541		1.58	0.78	201.44	0.151	213.05	
2001	2.306		1.71		222.14	0.133	215.63	
2002	2.277		1.37		200.86	0.074	183.94	
2003	1.876		1.97		238.77	0.044	222.88	
2004	9.503		1.79		266.16	0.034	177.27	0.749
2005	3.193		1.9		218.55	0.006	166.82	2.195
2006	4.674		2.16		212.63	0.013	177.11	1.308
2007	9.645		2.18		241.32	0.060	187.06	0.561
2008	8.512		2.48		225.68	0.088	215.80	0.495
2009	8.322		2.46		228.30	0.045	196.08	0.570
2010	13.545		2.45		276.76	0.040	209.03	0.877
2011	21.806		2.37		233.29	0.044	221.13	0.765
2012	8.128		2.6		305.53	0.107	238.00	0.668
2013	7.374		2.09		304.08	0.044	203.49	1.045

Table 8.5. Blue shark in the North Atlantic. Coefficients of variation (CVs) for North and South Atlantic blue shark stocks. Source: ICCAT (2015).

			North Atlantic					
Year	Usobs	JPLLe	JPLLl	USOLD	PORLL	VENLL	ESPLL	CHTPLL
1957				0.17				
1958				0.16				
1959				0.25				
1960				0.38				
1961				0.35				
1962				0.27				
1963				0.25				
1964				0.17				
1965				0.17				
1966				0.23				
1967				0.21				
1968				0.21				
1969				0.22				
1970				0.32				
1971		0.53		0.23				
1972		0.39		0.21				
1973		0.45						
1974		0.32						
1975		0.34		0.19				
1976		0.47		0.29				
1977		0.27		0.2				
1978		0.32		0.11				
1979		0.24		0.11				
1980		0.29		0.09				
1981		0.36		0.09				
1982		0.36		0.09				
1983		0.37		0.1				
1984		0.50		0.1				
1985		0.44		0.1				
1986		0.39		0.09				
1987		0.35		0.1				
1988		0.49		0.12				
1989		0.44		0.39				
1990		0.49		0.17				
1991		0.47		0.11				
1992	0.31	0.43		0.1				
1993	0.29	0.40		0.09				
1994	0.29		0.50	0.1		1.08		
1995	0.29		0.55	0.1		0.87		
1996	0.50		0.51	0.3		1.90		
1997	0.33		0.52	0.13	0.084	`	0.008	
1998	0.35		0.53	0.15	0.076	0.67	0.008	
1999	0.34		0.49	0.13	0.077	0.84	0.008	
2000	0.32		0.28	0.12	0.083	0.74	0.008	
2001	0.39		0.56		0.089	0.77	0.008	
2002	0.39		0.62		0.086	1.03	0.008	
2003	0.37		0.59		0.082	1.26	0.009	
2004	0.30		0.69		0.084	1.53	0.009	0.12
2005	0.35		0.71		0.087	3.88	0.010	0.19
2006	0.31		0.69		0.084	2.24	0.010	0.06
2007	0.32		0.61		0.085	1.35	0.011	0.22
2008	0.32		0.69		0.085	1.16	0.011	0.28
2009	0.31		0.64		0.086	1.56	0.012	0.17
2010	0.31		0.64		0.089	1.54	0.010	0.10
2011	0.29		0.51		0.079	1.51	0.010	0.12
2012	0.34		0.51		0.081	1.00	0.010	0.11
2013	0.31		0.21		0.085	1.84	0.011	0.14

Table 8.6. Blue shark in the North Atlantic. Von Bertalanffy growth parameters (L_∞ in cm (L_T), k in years–1, t0 in years) from published studies.

Area	L∞	k	t0	Sex	Study
North Atlantic	394	0.133	–0.801	Combined	Aasen, 1966
North Atlantic	423	0,11	–1.035	Combined	Stevens, 1975
NW Atlantic	343	0.16	–0.89	Males	Skomal, 1990
NW Atlantic	375	0.15	–0.87	Females	Skomal, 1990
NE Atlantic	377	0.12	–1.33	Combined	Henderson *et al*., 2001
North Atlantic	282	0.18	–1.35	Males	Skomal and Natanson, 2002
North Atlantic	310	0.13	–177	Females	Skomal and Natanson, 2002
North Atlantic	287	0.17	–1.43	Combined	Skomal and Natanson, 2003
NW Atlantic	300	0.68	–0.25	Combined	MacNeil and Campana, 2002 (whole ages)
NW Atlantic	302	0.58	–0.24	Combined	MacNeil and Campana, 2002 (section ages)

Table 8.7. Blue shark in the North Atlantic. Biological parameters for blue shark.

Parameter	Values	Sample Size	Area	Reference
Reproduction	Placental viviparity			various
Litter size	25–50 (30 average)			various
Size-at-birth	30–50 cm LT			various
Sex ratio (males: females)	1.5:1		NE Atlantic	García-Cortés and Mejuto, 2002
	1:1.44		NE Atlantic	Henderson *et al*., 2001
	1.33:1		NW Atlantic	Kohler *et al*., 2002
	1:2.13		NE Atlantic	Kohler *et al*., 2002
	1:1.07	801	NE Atlantic (N. coast Spain)	Mejuto and García-Cortés, 2005
	1:0.9	158	NE Atlantic (S. coast Spain)	
	1:0.38	2187	N central Atlantic	
	1:0.53	4550	NW Atlantic	
Gestation period	9–12 months			Campana *et al*., 2002
% of females revealing fecundation signs	0.74	415	NE Atlantic (N. coast Spain)	Mejuto and García-Cortés, 2005
	0	76	NE Atlantic (S. coast Spain)	
	36.27	601	N central Atlantic	
	18.15	1573	NW Atlantic	
% of pregnant females	0	415	NE Atlantic (N. coast Spain)	Mejuto and García-Cortés, 2005
	0	76	NE Atlantic (S. coast Spain)	
	14.6	601	N central Atlantic	
	9.8	1573	NW Atlantic	
Male age-at-maturity (years)	4–6			various
Female age-at-maturity (years)	5–7			various
Male length-at-maturity	180–280 cm (LF)		NW Atlantic	Campana *et al*., 2002
	190–195 cm (LF)			Francis and Duffy, 2005
	201 cm (LF; 50% maturity)		NW Atlantic	Campana *et al*., 2005
Female length-at-maturity	220–320 cm (LF)			Campana *et al*., 2002
	170–190 cm (LF)			Francis and Duffy, 2005

Parameter	Values	Sample Size	Area	Reference
	> 185 cm (LF)			Pratt, 1979
Longevity (years)	16–20			Skomal and Natanson, 2003
Natural mortality (M)	0.23		Worldwide	Campana *et al.*, 2005 (mean of various studies)
Productivity (R2m) estimate: intrinsic rebound	0.061 (assuming no fecundity increase)		Pacific	Smith *et al.*, 1998
Potential rate of increase per year	43% (unfished)		NW Atlantic	Campana *et al.*, 2005
Population doubling time TD (years)	11.4 (assuming no fecundity increase)		Pacific	Smith *et al.*, 1998
Trophic level	4.1	14		Cortés, 1999

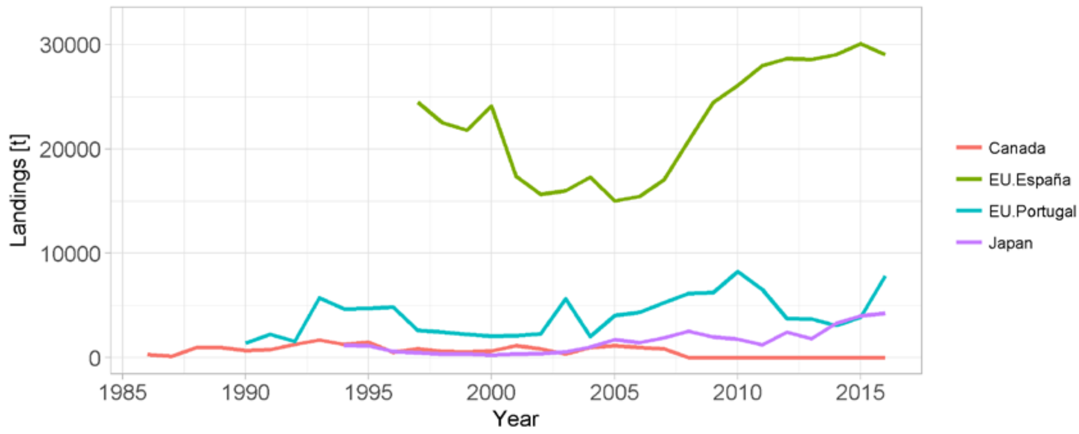


Figure 8.1. Blue shark in the North Atlantic. Preliminary estimates of landings of blue shark in the Atlantic for the four main countries (Source: ICCAT Task I data, Accessed June 2018).

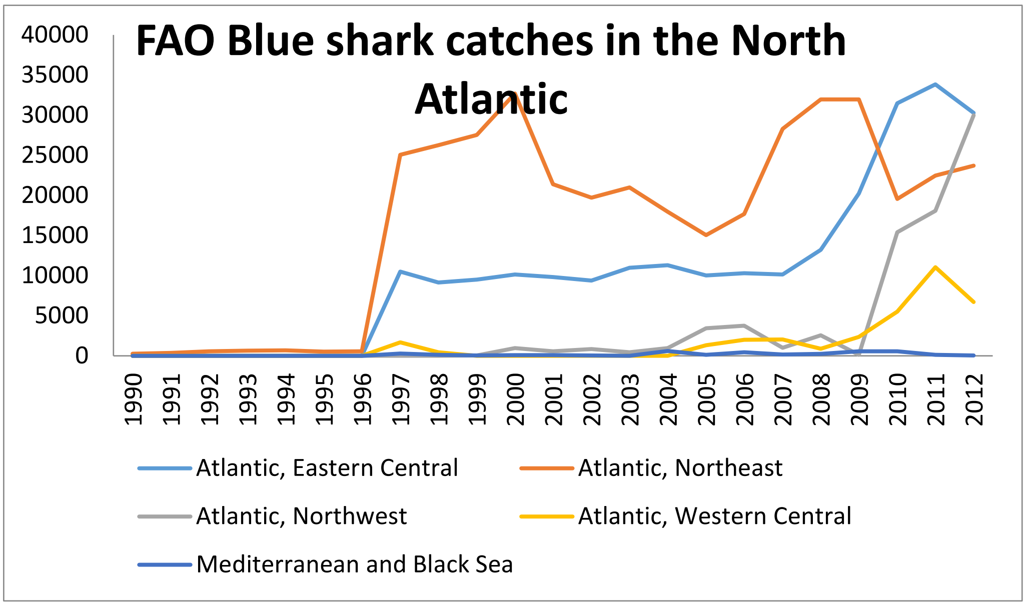


Figure 8.2. Blue shark in the North Atlantic. Preliminary estimates of landings of blue shark in the Atlantic Ocean for the different areas (Source: FAO, 2014).

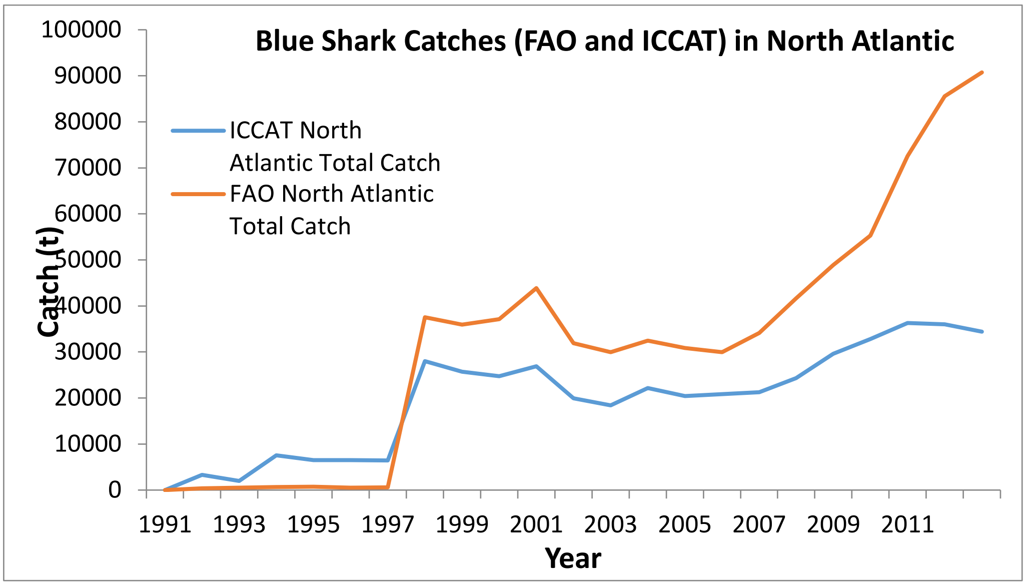


Figure 8.3. Blue shark in the North Atlantic. Blue shark landings in the North Atlantic from FAO and ICCAT data.

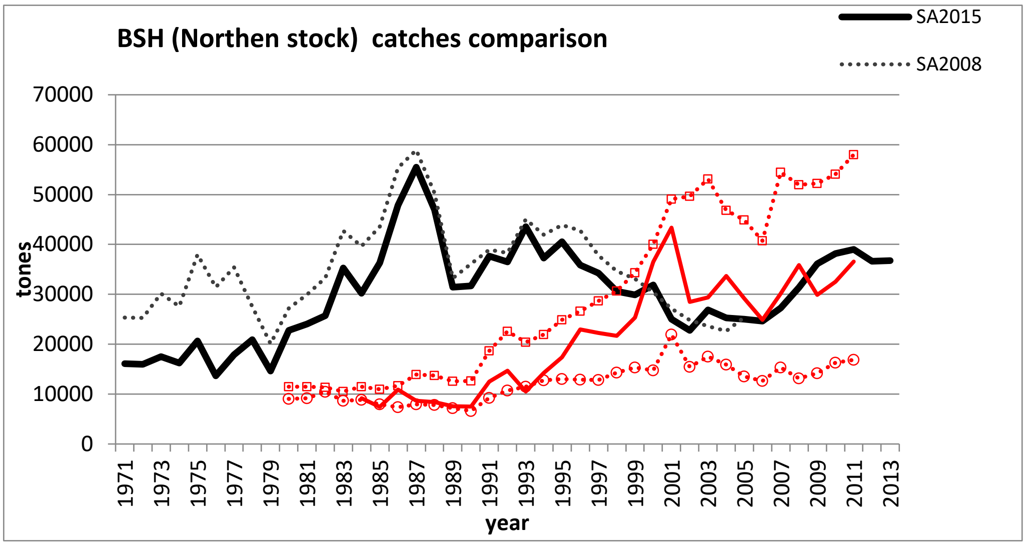


Figure 8.4. Blue shark in the North Atlantic. Comparison of various catch series for the North Atlantic stock of blue shark (1971–2013). In black, the stock assessment catches from the 2008 stock assessment and 2015 estimations. In red, three catch series obtained using shark-fin ratios with three different approaches (area, effort, target level).

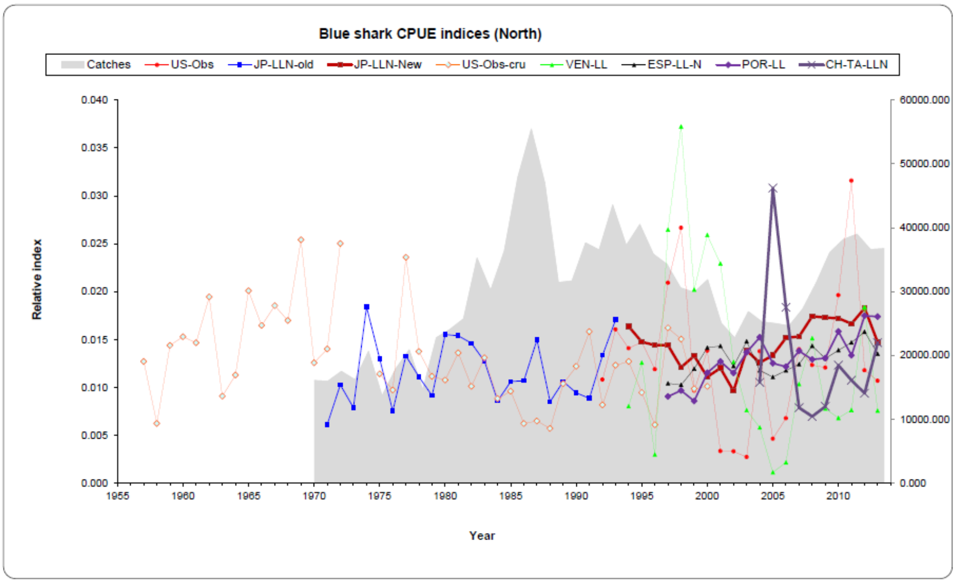


Figure 8.5. Blue shark in the North Atlantic. Indices of abundance and catches. Source: ICCAT (2015).

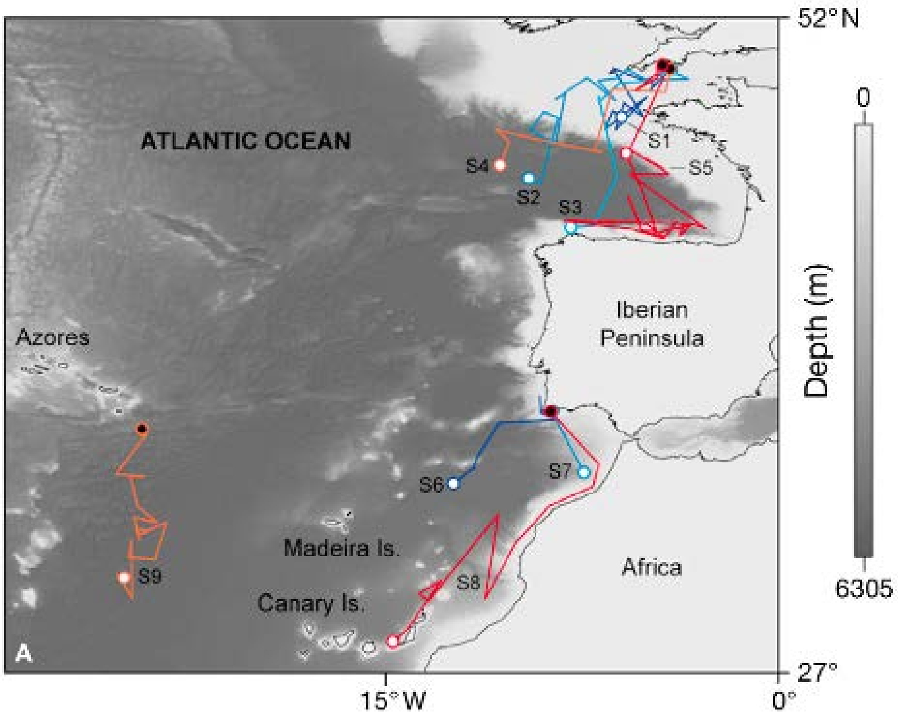
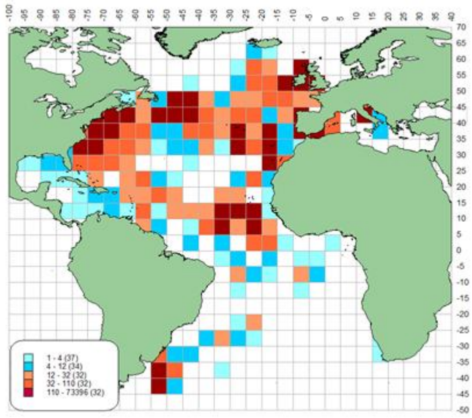
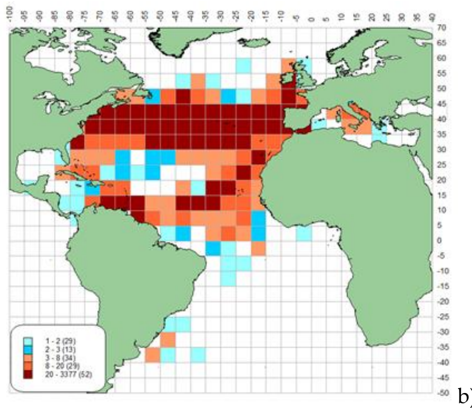


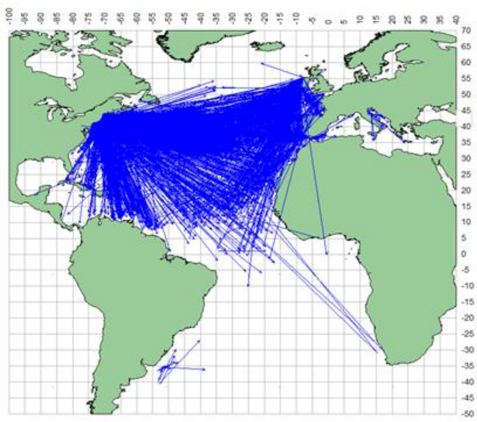
Figure 8.6. Blue shark in the North Atlantic. Pop-off satellite-tagged blue shark movement patterns. (A) General movements overlaid on bathymetry; black circles denote tagging locations and white circles the pop-up/capture locations. (B to J) Individual tracks overlaid on sea surface temperature maps; white circles are geolocated positions with date. Source: Queiroz *et al.* (2010).



a)



b)



c)

Figure 8.7. Blue shark in the North Atlantic. Blue shark tagging maps, presented by ICCAT (2012), showing (a) density of releases, (b) density of recoveries, and (c) straight line displacement between release and recovery locations.

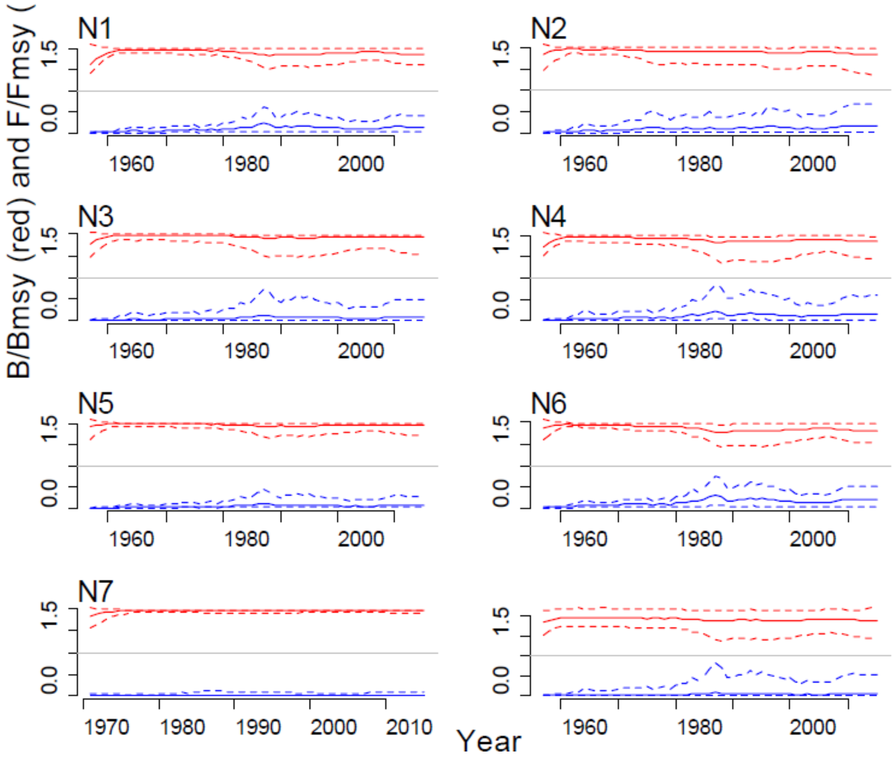


Figure 8.8. Blue shark in the North Atlantic. Estimated biomass relative to B_{MSY} (in red) and harvest rate relative to the MSY level (blue), for the BSP runs. Source: ICCAT (2015).

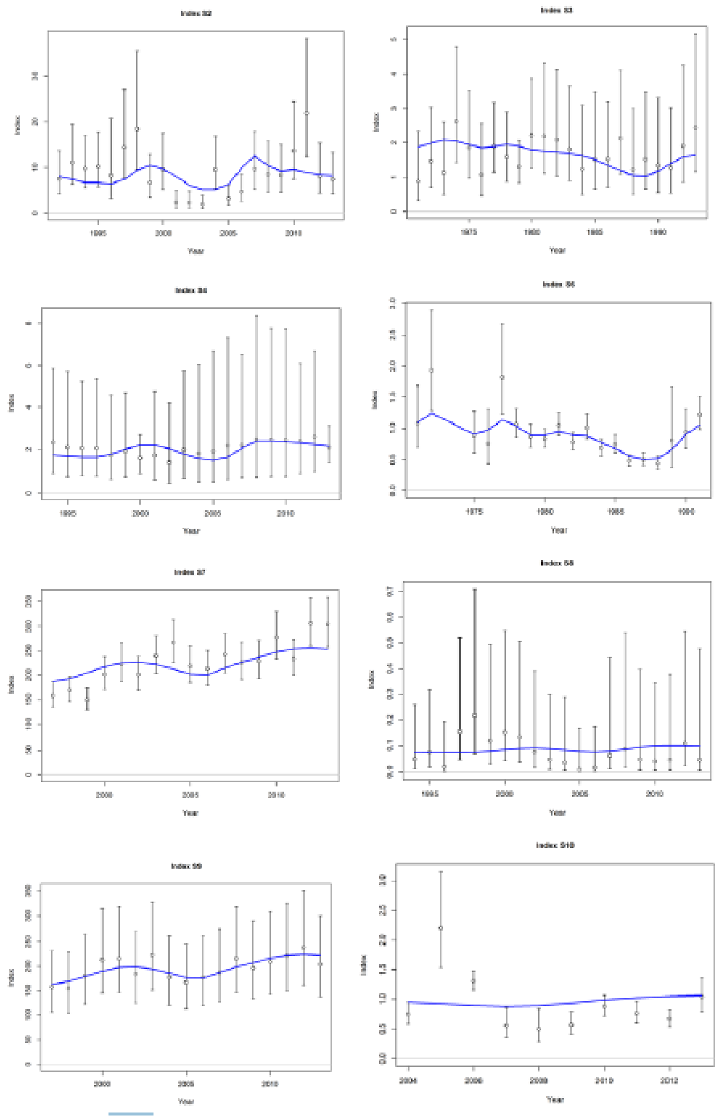


Figure 8.9. Blue shark in the North Atlantic. Preliminary Run 4 observed CPUE (open circles ± 95% confidence intervals assuming lognormal error) and model predicted CPUE (blue line) for abundance indices fit in the model likelihood: S2 (US-Obs, upper left), S3 (JPLL-N-e, upper right), S4 (JPLL-N-l, middle left), S6 (US-Obs-cru, middle right), S7 (POR-LL, middle left), S8 (VEN-LL, middle right), S9 (ESP-LL-N, lower left), and S10 (CTP-LL-N, lower right). Source: ICCAT (2015).

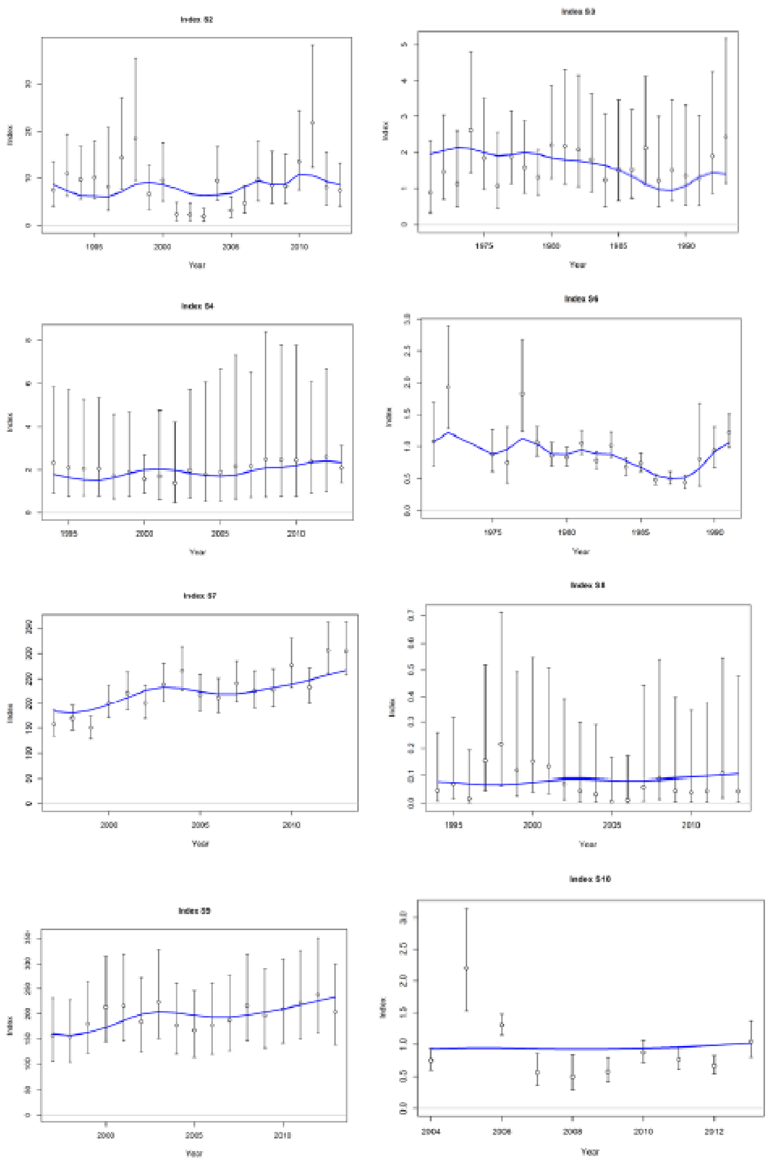
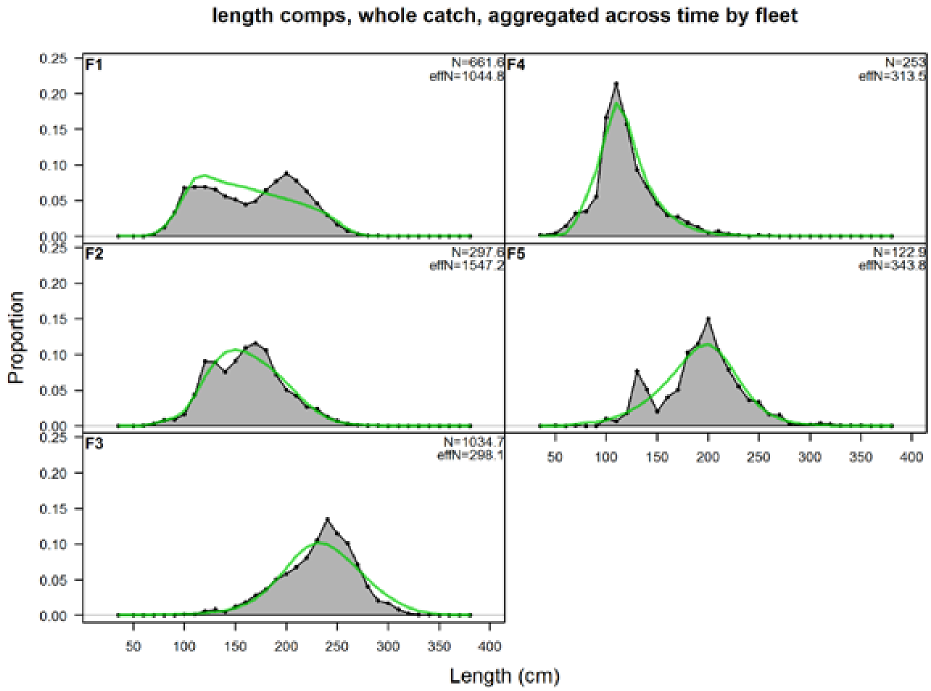


Figure 8.10. Blue shark in the North Atlantic. Preliminary Run 6 observed CPUE (open circles ± 95% confidence intervals assuming lognormal error) and model predicted CPUE (blue line) for abundance indices fit in the model likelihood: S2 (US-Obs, upper left), S3 (JPLL-N-e, upper right), S4 (JPLL-N-l, middle left), S6 (US-Obs-cru, middle right), S7 (POR-LL, middle left), S8 (VEN-LL, middle right), S9 (ESP-LL-N, lower left), and S10 (CTP-LL-N, lower right). Source: ICCAT (2015).



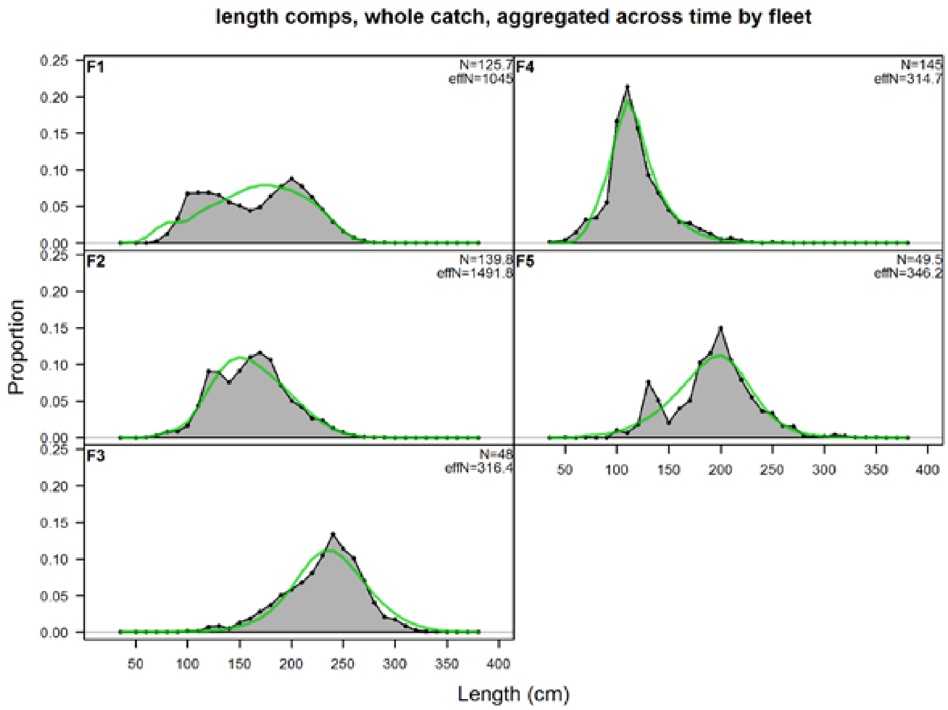


Figure 8.11. Blue shark in the North Atlantic. Model predicted (line) and observed (shaded) aggregated annual length compositions (female + male) for Preliminary Run 4 (upper panel) and Preliminary Run 6 (lower panel). Source: ICCAT (2015).

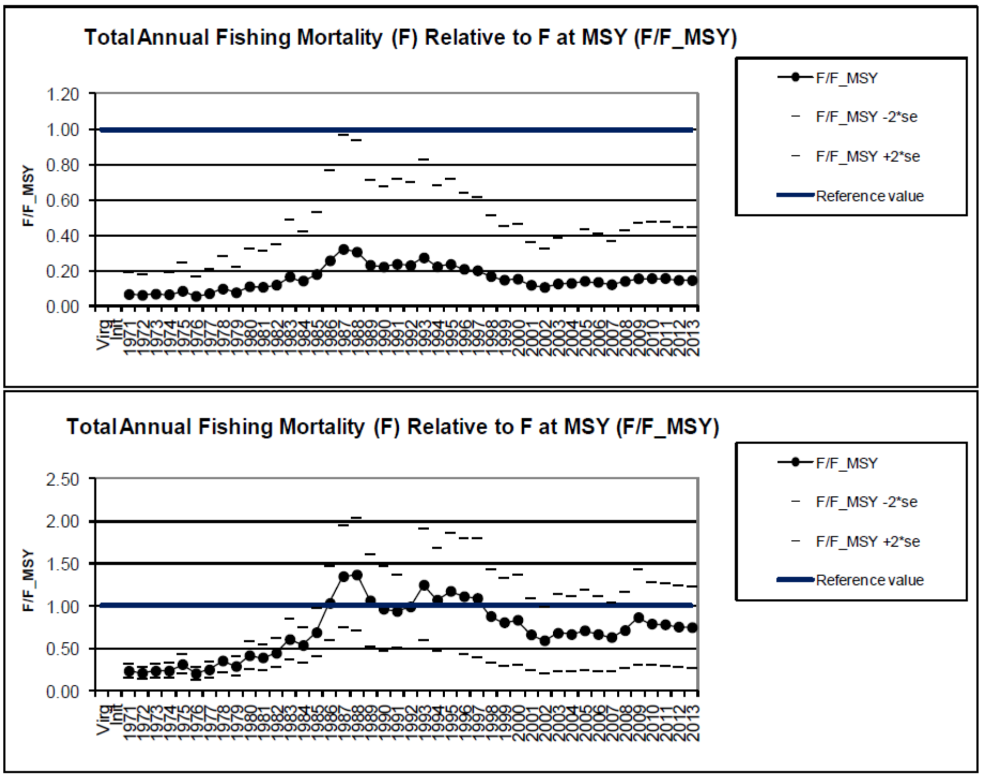


Figure 8.12. Blue shark in the North Atlantic. Estimated annual total exploitation rate in numbers (total fishing mortality for all fleets combined) relative to fishing mortality at MSY (F/F_{MSY}), obtained from Stock Synthesis output for Preliminary Run 4 (upper panel) and Preliminary Run 6 (lower panel). Source: ICCAT (2015).

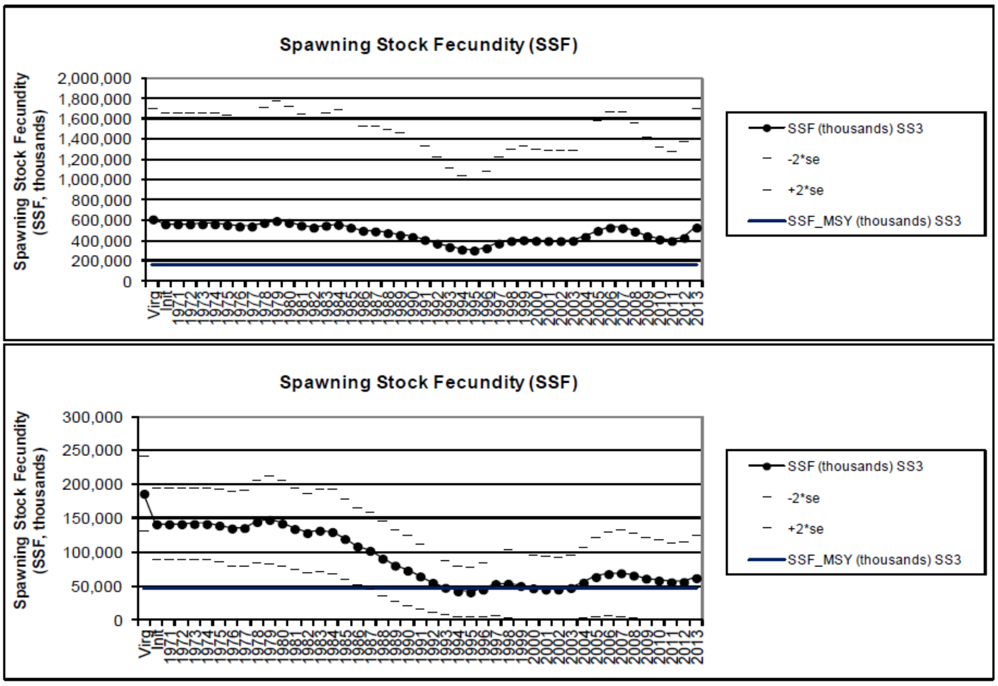


Figure 8.13. Blue shark in the North Atlantic. Estimated spawning stock size (spawning stock fecundity, SSF) along with approximate 95% asymptotic standard errors (+- 2*s.e.) relative to spawning stock size at MSY (SSFMSY) for Preliminary Run 4 (upper panel) and Preliminary Run 6 (lower panel). Source: ICCAT (2015).

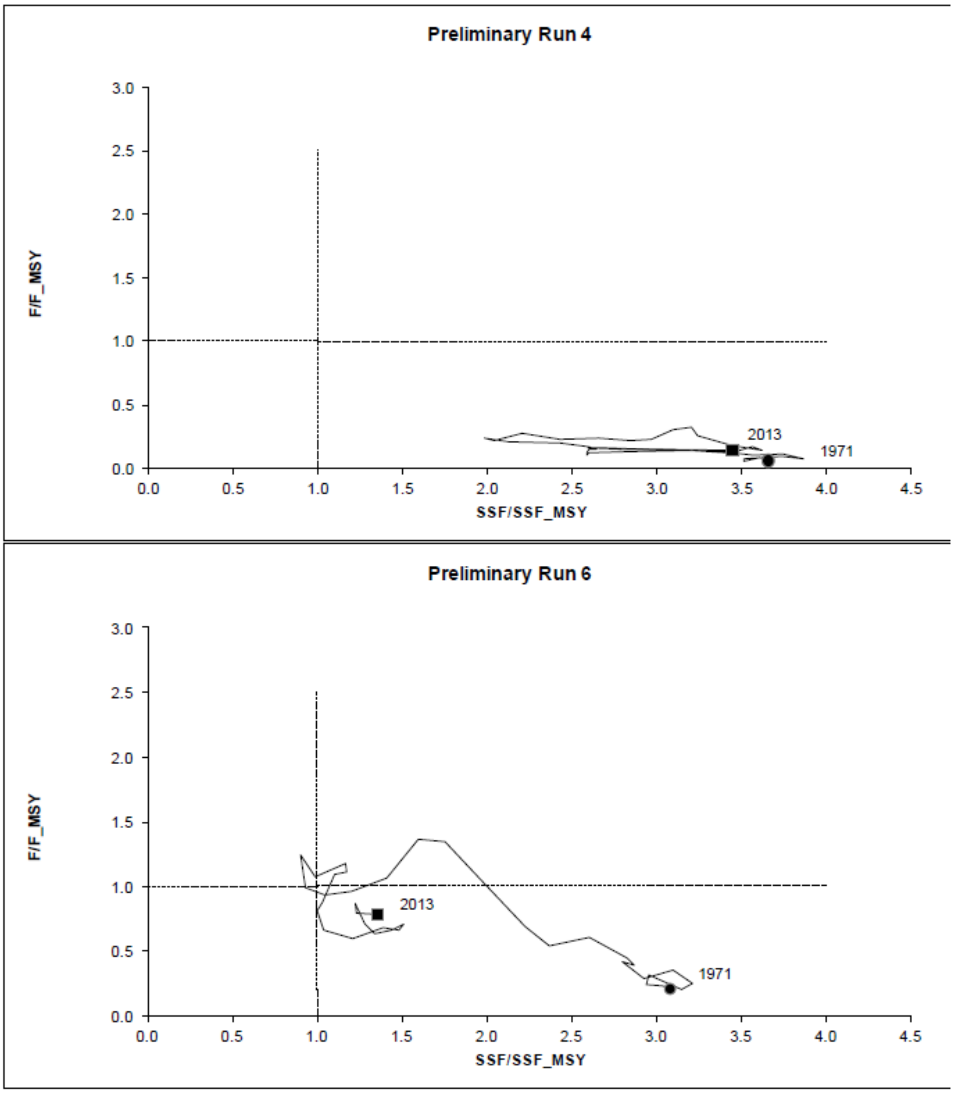


Figure 8.14. Blue shark in the North Atlantic. Kobe Phase plots for Preliminary Run 4 (upper panel) and Preliminary Run 6 (lower panel). The circle indicates the position of the start year of the model (1971) and the square represents the end year of the model (2013). The horizontal (dotted) line identifies the fishing mortality reference at maximum sustainable yield (F_{MSY}). The vertical (dotted) line identifies the reference spawning stock fecundity at maximum sustainable yield (SSF_{MSY}). Source: ICCAT (2015).

9 Shortfin mako in the North Atlantic (North of 5°N)

Shortfin mako sharks *Isurus oxyrinchus* Rafinesque are large, highly mobile, pelagic predators that inhabit tropical and temperate waters circumglobally and are prized in both recreational and commercial fisheries (Campana, Marks and Joyce 2005).

The North Atlantic shortfin mako stock is assessed by the International Commission for the Conservation of Atlantic Tunas (ICCAT). ICCAT conducted a stock assessment for shortfin mako in 2017 (12–16 June). At the previous Data Preparatory meeting, the catch, effort and size data as well as the tagging data were reviewed and the models to be used during the assessment and their assumptions were discussed.

9.1 Stock distribution

One stock of shortfin mako has been considered to exist in the North Atlantic (e.g. Kohler *et al.*, 2002) as genetic studies found no evidence to separate east and west populations in the Atlantic, but indicate differences between the North Atlantic and the South Atlantic and other oceans (Heist *et al.*, 1996; Schrey and Heist, 2002). The relationship between shortfin mako in the North Atlantic and Mediterranean Sea is unclear, and so the North Atlantic stock assessment does not include data from the Mediterranean Sea.

Based on the oceanography of equatorial waters, and that other large pelagic species (e.g. swordfish, blue shark) have a southern stock boundary of 5°N, this location is also suggested to be the southern limit of the North Atlantic shortfin mako stock. The stock area broadly equates with FAO Areas 27, 21, 31 and 34 (in part).

Preliminary results indicate that there is stock mixing, with males moving more between regions while the females seem to show philopatric behaviour (ICCAT, 2016). These population differences may imply different biological parameters between regions. So the study of the biology of the species and further genetic studies are required for the clarification of stock boundaries (ICCAT, 2016).

9.2 The fishery

9.2.1 History of the fishery

Shortfin mako is a highly migratory species that is a frequent bycatch in pelagic longline fisheries targeting tuna and billfish, and in other high seas tuna fisheries. Like porbeagle, it is a relatively high-value species (cf. blue shark, which is of lower commercial value), being normally retained (Campana *et al.*, 2005). Recreational fisheries on both sides of the North Atlantic also catch this species, with relatively large quantities reported from sport (rod and reel) fisheries reported to ICCAT (178 t in 2011). Some specimens are released alive from these fisheries.

Shortfin mako is also taken in Mediterranean Sea fisheries (STECF, 2003). Tudela *et al.* (2005) observed 542 shortfin mako taken as bycatch in 4140 km of driftnets set in the Alboran Sea between December 2002 and September 2003.

Traditionally, minimal catches of this species have been reported to ICES (7 to ~1000 t in the last 20 years). Landings data from ICCAT are given in the catch table (Table 9.1). The main country reporting landings of this species to ICES in 2012 was Portugal (Azores), where catch was 24 t. Small quantities (<2 t) were reported by France and UK.

9.2.2 The fishery in 2015

The shortfin mako is an important shark species captured in pelagic longline fisheries targeting tunas and swordfish. As part of an on-going cooperative program for fisheries and biological data collection, information collected by fishery observers and scientific projects from several fishing nations in the Atlantic (EU-Portugal, Uruguay, Chinese Taipei, USA, Japan, Brazil and Venezuela) were analysed at the 2017 ICCAT shortfin mako data preparatory meeting (ICCAT, 2017).

9.2.3 Advice applicable

ICES does not provide advice for this stock. Assessment of this stock is considered to be the responsibility of ICCAT.

Following the 2012 assessment, ICCAT recommended, as a precautionary approach, that fishing mortality of shortfin mako should not be increased until more reliable stock assessment results became available.

9.2.4 Management applicable

There are no measures regulating the catches of shortfin mako in the North Atlantic. However, there are a number of recommendations from ICCAT on, among others, finning, data collection and species identification (ICCAT, 2015).

EC Regulation No. 1185/2003 (updated by EU Regulation No 605/2013) prohibits the removal of shark fins of these species, and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

9.3 Catch data

9.3.1 Landings

Nominal catch statistics stock, flag and gear, are presented in Table 9.1. Several updates were made to the historical catch series in 2017, namely for EU-Spain LLHB; South Africa; Japan (2014, 2015) and some other minor corrections (ICAT, 2017). For the rest of the flags, only the most recent years of official catches were added/updated and duly incorporated into T1NC. Substantial historical revisions have been made and the current Task I catches (new) were considered acceptable for use in the assessment models. As a result, the historical catches to be used in the 2017 assessment are lower than those documented in the Report of the 2012 Shortfin Mako Stock Assessment (Anon., 2013).

In 2015, 3227 t of shortfin mako catch was reported to ICCAT (Table 9.1) in the North Atlantic (89% from longline fleets, the rest from sport fishing and other fleets). Landings have been relatively stable over recent decades. The main countries reporting catches in the North Atlantic in 2015 are Spain, Morocco, USA and Portugal, accounting for 42, 29, 16 and 7 percent respectively (Table 9.1). National landings reported to ICES for 2015 were 216 t for the northeast Atlantic, with the majority of this from Subarea 9a by the UK. Smaller amounts were reported from areas 4, 6, 7 and 8, by Spain and the UK.

In the Mediterranean Sea, total reported landings to ICCAT were 0 t. Since 2007, reported landings in the Mediterranean Sea have been between 0 and 2 t.

9.3.2 Discards

Discard data are also given in Table 9.1, these are considered largely underestimated, with the USA longline being the fleet with the longest report of small amount of discards from 1987–1996 (1–38 t) and 2007–2015 (7–20 t). There are no reported discards from the Mediterranean Sea. Actual level of shortfin mako bycatch is difficult to estimate, as available data are limited and documentation is incomplete. A report of the US pelagic longline observer programme stated that of the sharks caught alive, 23% were released alive and 61% retained (ICCAT, 2005).

Shortfin Mako shark discards (alive and dead) from Canadian fisheries in the Northwest Atlantic Ocean have been provided in 2017. The report includes records from all fisheries within the Canadian EEZ (both national and ICCAT managed) that capture Shortfin Mako and the data is partitioned into live releases and dead discards (ICCAT, 2017).

Shortfin mako is a high value species, and many European fisheries land shortfin mako gutted (usually with the head on). Although often landed for their meat in some fisheries, finning (the practice of removing the fins of a shark and returning the remainder of the carcass to the sea) may occur for this species as well, which may result in undocumented catches and mortality in some fleets. Finning regulations are in force in various fisheries, but the extent of finning in IUU fisheries is unknown.

9.3.3 Quality of catch data

Catch data are considered underestimates, and the extent of finning in high seas fisheries is unclear. The historical use of generic shark categories is problematic, although many European countries have begun to report species-specific data in recent years. Despite some important recovery of historical catch series in recent years, ICCAT considers that the overall catch is underestimated, particularly before 2000.

There have been major discrepancies between reported landings in databases from ICCAT, FAO and EuroStat. The ICCAT Secretariat consolidated these three data sources into a unique database, and currently progress is being made on its validation and the associated data mining task (analysis of equivalent data series at various aggregation levels; Palma *et al.*, 2012). FAO data have been revised in recent years, and historical catch figures have increased from what was reported previously. The catches by FAO area (Figure 9.4) and the total North Atlantic catch are shown along with ICCAT catch totals (Figure 9.2) for comparison.

Previous ICCAT assessments of shortfin mako used two different estimates of landings for this stock, the tuna ratio (logged observations of shark catches relative to tuna catches) and the fin trade index (shark fin trade observations from the Asian market used to calculate caught shark weights based on catch effort data; Clarke *et al.*, 2006; ICCAT 2005, 2008). These figures were much higher than reported landings.

The methodology adopted to estimate historic catches of blue shark was considered inappropriate for this species. It was noted that unlike the blue shark, shortfin mako has always had commercial value and thus discards have been less. So for shortfin mako, historical estimation of catches will be based on observer data, as well as other potential techniques. And where no additional information is available, catch ratios will be used to make these estimations. The highest priority for this exercise is given to Morocco, before 2011; EU-Spain, before 1997 and Canada, before 1995 (ICCAT, 2017).

9.3.4 Discard survival

Several studies have reported the at-vessel mortality of shortfin mako to broadly range from about 30–50% in longline fisheries (summarised in Ellis *et al.*, 2014 WD). Discard survival in such fisheries can be influenced by several factors, including hook type, soak time and size of shark.

9.4 Commercial catch composition

9.4.1 Conversion factors

Shortfin mako can be landed in various forms (e.g. gutted, dressed, with or without heads). It is therefore important that appropriate conversion factors for these landings are used. FAO (based on Norwegian data) use conversion factors for fresh, gutted, and gutted and headed sharks of 87% and 77%, respectively (Hareide *et al*., 2007). Scientific estimates for various conversion factors for shortfin mako are summarised for length–weight relationships (Table 9.2) and different length measurements (Table 9.3).

9.5 Commercial catch and effort data

Recent CPUE time series were provided for both the North and South Atlantic stocks along with a lowess smoother fitted to CPUE each year using a general additive model (GAM) to compare trends by stock (North Atlantic and South Atlantic) (Figure 9.5.). The overall trend for the Northern indices is an initial decrease followed by an increase from 2000 and a decline in the recent years. Residuals from the lowess fits to CPUE are compared to look at deviations from the overall trends (Figure 9.6.). This comparison allows conflicts between indices (e.g. highlighted by patterns in the residuals) and autocorrelation within indices (which may be due to year-class effects or the importance of factors not included in the standardization of the CPUE) to be identified.

Figure 9.7 presents the correlations between North Atlantic CPUE indices; the lower triangle shows the pairwise scatter plots between indices with a regression line, the upper triangle provides the correlation coefficients, and the diagonal provides the range of observations. The correlation between US observer and Chinese Taipei is high at 0.78; however, this is likely to be due to a single point (i.e. 2009). Also, a strong correlation could be found by chance if two series only overlap for a few years. Figure 9.8 shows the results from a hierarchical cluster analysis evaluated for the North Atlantic using a set of dissimilarities. All series appear to be similar, with the US observer and Chinese Taipei having the greatest similarity, but, as mentioned above, this could be due to one influential point. Cross-correlations for the North Atlantic are plotted in in Figure 9.8; the US logbook (3rd diagonal element) shows strong autocorrelation over 3 years, this could be due to year-class effects. This could also be a reason for strong cross-correlations between series. A strong negative or positive cross-correlation could be due to series being dominated by different age-classes, e.g. Portuguese longline and US observer has a negative lag of 2–3 that could be due to the US series catching younger individuals.

Although the relationship between Atlantic and Mediterranean Sea shortfin mako is unclear, Tudela *et al.* (2005) estimated CPUE based on driftnetters from Al Hoceima and Nador fishing in the Alboran Sea. Di Natale and Pelusi (2000) reported data from the Italian large pelagic longline fishery in the Tyrrhenian Sea (1998–1999), and calculated a mean CPUE of 1.1 kg per 1000 hooks.

9.6 Fishery-independent surveys

No fishery-independent data from the NE Atlantic are available.

Fishery-independent data are available from the NW Atlantic (Simpfendorfer *et al.*, 2002; Hueter and Simpfendorfer, 2008). Babcock (2010) provided an index of abundance of shortfin mako catch rates from the US East Coast from the National Marine Fisheries Service Marine Recreational Fishery Statistics Survey (MRFSS). A total of 711 shortfin mako were reported from 1981–2010. There were 252 686 trips of which about 0.2% caught at least one shortfin mako.

The NMFS (USA) also conducts a Cooperative Shark Tagging Programme (CSTP), which collaborates with the Shark Tagging Programme of Inland Fisheries Ireland (formerly the Irish Central Fisheries Board) (Green, 2007 WD; NMFS, 2006).

At the 2014 ICCAT Inter-sessional meeting of the shark subgroup, a Portuguese research project was presented on mitigation measures for shark bycatch in pelagic longline fisheries. An electronic tagging experiment will be carried out during this research project, so as to evaluate post-release mortality of shortfin mako.

There is a large set of mark-recapture data available at ICCAT for shortfin mako shark, with 9316 individuals tagged since 1962 and 1,255 specimens recaptured (ICCAT, 2016). The ICCAT Shark Species Group suggested that these data could be used to provide information for the growth curve, and proposed an age and growth workshop for shortfin mako in 2017 (ICCAT, 2016).

9.7 Life-history information

Various studies have provided biological information for this species (see also Stevens, 2008). Data available for the North Atlantic stock are given in Table 9.2 (length–weight relationships), Table 9.4 (growth parameters), and Table 9.5 (other life-history parameters).

There was also an update of life-history parameters in the report of the 2014 inter-sessional meeting of the ICCAT shark sub-group (ICCAT, 2014) and again in 2017 (ICCAT, 2016). At the 2017 ICCAT SMA data-preparatory meeting, it was decided that the two phases of the Shark Research and Data Collection Plan were devoted to shortfin mako shark, as the species to be assessed in 2017. While considerable work has been produced, there are still uncertainties on some important biological parameters and it is important to continue the work that has been started on this species. Additionally, ICCAT Recommendation 14–06 on shortfin mako caught in association with ICCAT fisheries supports this in saying that: "Paragraph 3: *CPCs are encouraged to undertake research that would provide information on key biological/ecological parameters, life-history and behavioural traits, as well as on the identification of potential mating, pupping and nursery grounds of shortfin mako sharks. Such information shall be made available to the SCRS*". As such, the Group recommends that it is important to continue the shortfin mako shark work and allocate part of the new funds for this species to continue this work.

9.7.1 Habitat

Shortfin mako is a common, extremely active epipelagic species found in tropical and warm-temperate seas from the surface down to at least 500 m (Compagno, 2001). The species is seldom found in waters <16°C, and in the western North Atlantic they only move onto the continental shelf when surface temperatures exceed 17°C. Observations from South Africa indicate that the species prefers clear water (Compagno, 2001).

9.7.2 Nursery grounds

Published records of potential nursery grounds are lacking. Buencuerpo *et al.* (1998) suggested that the western basin of the Mediterranean Sea was a nursery area. Stevens

(2008) suggested that nursery areas would likely be situated close to the coast in highly productive areas, based on the majority of reports, with nursery grounds potentially off West Africa in the North Atlantic.

9.7.3 Diet

Shortfin mako feed primarily on fish, both pelagic and demersal species, and cephalopods (Compagno, 2001). Shortfin mako sampled off southwest Portugal had teleosts as the principal component of their diet (occurring in 87% of the stomachs and accounting for >90% of the contents by weight), and crustaceans and cephalopods were also relatively important, whilst other elasmobranchs were only present occasionally (Maia *et al*., 2006).

In the NW Atlantic, bluefish *Pomatomus saltatrix* is the most important prey species and comprises about 78% of the diet (Stillwell and Kohler, 1982). These authors estimated that a 68 kg shortfin mako consumes about 2 kg of prey per day, and could eat about 8–11 times its body weight per year. Stillwell (1990) subsequently suggested that shortfin mako may consume up to 15 times their weight per year.

The diet of shortfin mako in South African waters indicated that elasmobranchs could be important prey, and marine mammals can also make up a small proportion of the diet (Compagno, 2001).

9.7.4 Movements

Shortfin mako sharks have a wide distribution and habitat use patterns (Casey and Kohler 1992; Rogers *et al*. 2015; Vaudo *et al*. 2016). The species showed diel diving behavior, with deeper dives occurring primarily during the daytime. A strong influence of thermal habitat on species movement behaviour suggests potentially strong impacts of rising ocean temperatures on the ecology of this highly migratory top predator. Integrating knowledge of fish movements into spatially explicit population dynamics models is being urged for improving stock assessments and management (Braccini, Aires-da-Silva and Taylor 2016).

9.8 Exploratory assessment models

In 2004, ICCAT held an assessment meeting to assess stock status of shortfin mako (ICCAT, 2005). Overall, the quality and availability of data were considered limited and results considered provisional. Based on CPUE data, it was likely that the North Atlantic stock of shortfin mako had been depleted to about 50% of previous levels. Stock capacity was likely be below MSY and a high to full level of exploitation for this stock was inferred from available data. It was considered that further studies were needed and in particularly the underlying assumptions of the model needed to be optimized before stronger conclusions could be drawn (ICCAT, 2005, 2006).

The 2008 ICCAT assessment for North Atlantic shortfin mako used a Bayesian surplus production (BSP) model, an age-structured production model (ASPM) and a catch-free age structured production model. Results indicated that, for most model outcomes, stock depletion was about 50% of biomass estimated for the 1950s. Some model outcomes indicated that the stock biomass was near or below the biomass that would support MSY with current harvest levels above F_{MSY}, whereas others estimated considerably lower levels of depletion and no overfishing (ICCAT, 2011).

The 2012 assessment used the Bayesian Surplus Production Model (BSP). Additionally, as in the 2008 assessment, a Catch-Free Age-Structured Production Model (CFASPM) was applied and a simple length-based method was also employed to check assumptions about selectivity made and for choosing starting or for fixing values of CFASPM model. The results from the BSP model found that the median of the current stock abundance was above B_{MSY} and the median F was smaller than F_{MSY} (except for the run that estimated catches from effort before 1997). The CFASPM base run estimated a relative depletion of 71% of virgin conditions, with current fishing mortality estimated as 41% of what would be required to drive the stock to MSY ($F/F_{MSY} = 0.41$) and current SSB was estimated at 2.04 times that producing MSY ($SSB/SSB_{MSY} = 2.04$) (ICCAT, 2012). Across all scenarios considered, the estimates of SSB/SSB_{MSY} ranged from 1.63–2.04, the estimates of F/F_{MSY} ranged from 0.16–0.62 and the biomass depletion with respect to virgin conditions ranged from 0.55–0.71 (ICCAT, 2012). The results indicated in general that the status of the stock is healthy and the probability of overfishing was low (ICCAT, 2012).

9.9 Stock assessment

An ICCAT assessment for shortfin mako was carried out in 2017 (ICCAT, 2017). The models agreed that the northern stock was overfished and was undergoing overfishing. The results obtained in this evaluation are not comparable with those obtained in the last assessment in 2012 because the input data and model structures have changed significantly. ICCAT considered the stock status results for the South Atlantic to be highly uncertain. Despite this uncertainty, it was not possible for ICCAT to discount that in recent years the stock may have been at, or already below, B_{MSY} and that fishing mortality was already exceeding F_{MSY}.

9.10 Quality of assessment

Assessments undertaken by ICCAT are conditional on several assumptions, including the estimates of historical shark catch, the relationship between catch rates and abundance, the initial state of the stock, as well as uncertainty in some life-history parameters.

9.11 Reference points

ICCAT uses F/F_{MSY} and B/B_{MSY} as reference points for stock status. These reference points are relative metrics. The absolute values of B_{MSY} and F_{MSY} depend on model assumptions and results and are not presented by ICCAT for advisory purposes.

9.12 Conservation considerations

Shortfin mako was listed as 'Near Threatened' until 2008 when it was up listed to 'Vulnerable' both globally and regionally in the North Atlantic in the IUCN Red List (Cailliet *et al*., 2009).

In 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Atlantic population of the shortfin mako as threatened (DFO, 2006).

9.13 Management considerations

Shortfin mako shark is one of the most common species in the global fin trade (Clarke *et al*. 2006). Thus, fishery exploitation is a major source of mortality for mako shark populations, which, because of their life-history characteristics, have a high risk of overexploitation (Cortés *et al*. 2010). Despite this risk, mako shark management is limited as there is a great deal of uncertainty in population estimates because of sparse biological information on the species, including its movement ecology (E. Cortés, pers. comm).

Catch data of pelagic sharks are considered unreliable, as many sharks are not reported on a species-specific basis, and some fisheries may have only landed fins. As already stated, the landings data are unreliable and particularly pre-2000 should be considered an underestimate. Reporting procedures must be strengthened so that all landings are reported, and that landings are reported to species level, rather than generic "*nei*" categories. The consolidation of three databases (ICCAT, FAO and EUROSTAT) by the ICCAT Secretariat should also strengthen the reliability of catch data in the future.

The 2011 Report of the Standing Committee on Research and Statistics (SCRS) stated that, "*Considering the quantitative and qualitative limitations of the information available to the Committee, the results presented in 2008, as those of the 2004 assessment (Anon. 2005), are not conclusive*" (ICCAT, 2011). Furthermore, "*The Commission should consider taking effective measures to reduce the fishing mortality of these stocks. These measures may include minimum or maximum size limits for landing (for protection of juveniles or the breeding stock, respectively); and any other technical mitigation measures such as gear modifications, time-area restrictions, or others, as appropriate*".

In 1995 the Fisheries Management Plan for pelagic sharks in Atlantic Canada established a catch limit of 100 t annually for the Canadian pelagic longline fishery as well as advising release of live catch.

9.14 References

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Table 9.1. Shortfin mako in the North Atlantic (ATN) South Atlantic (STN) and Mediterranean (MED). Available landings (t) of shortfin mako by country from ICCAT Task I catch data. These data are considered underestimates, especially prior to 2000. Landings of <0.5 t are data for 2012, 2013 and 2014 from ICCAT (2015). Landings for ATN Sport and other gear codes are given as one value from 2012 onwards.

			1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
TOTAL			753	1293	2042	1575	2182	4346	4057	3448	3794	3543	3440	3095	4084	5748	5896	8407	7808	5799	5680	4345	5151	4739	5375	7704	6263	6611	6326	6935	5447	6179	6675	7031	7385	5646	6177	5913
	ATN		525	1065	1261	1170	1502	3686	3581	3173	2868	2098	2323	2193	3103	4158	3758	5347	5346	3580	3879	2791	2592	2682	3416	3923	3864	3479	3378	4083	3566	4116	4188	3771	4478	3646	2906	3227
	ATS		228	227	781	405	680	661	476	263	926	1446	1116	902	981	1590	2138	3060	2461	2213	1793	1549	2555	2050	1957	3779	2398	3115	2938	2850	1881	2063	2486	3258	2905	2001	3271	2686
	MED		0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	6	8	5	4	7	2	2	2	17	10	2	1	1	2	2	2	0	0	0
Landings	ATN	Longline	525	680	648	802	573	737	2284	2702	2068	1407	2035	1965	2806	3464	3401	3868	5092	3397	3703	2695	2272	2452	3145	3906	3439	3172	3105	3901	3387	3919	4007	3549	4191	3362	2629	2875
	ATN	Other surf.	0	385	613	368	929	2949	1297	462	795	681	278	217	258	671	335	1450	253	182	176	94	320	230	270	17	425	307	272	176	169	177	178	213	268	278	265	341
	ATS	Longline	228	227	781	405	680	661	476	262	926	1446	1116	847	966	1579	2117	3044	2445	2189	1781	1539	2532	2033	1942	3748	2323	3101	2895	2809	1799	2057	2485	3196	2842	1953	3238	2669
	ATS	Other surf.	0	0	0	0	0	0	0	1	0	0	0	55	15	11	21	15	16	25	12	10	22	18	15	31	76	14	43	30	82	7	1	62	55	47	31	15
	MED	Longline	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	6	8	5	4	7	2	2	2	17	10	2	1	1	2	2	2	0	0	0
	MED	Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Discards	ATN	Longline	0	0	0	0	0	0	0	9	5	9	10	11	38	24	21	29	1	0	0	0	0	0	0	0	0	0	0	7	9	20	2	9	19	5	12	10
	ATN	Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	ATS	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	8	0	2	2
	ATS	Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	MED	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landings	ATN	Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	28	69	114	99	1	1
	ATN	Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	ATN	Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	111	67	110	69	70	78	69	78	73	80	91	71	72	43	53	41	37	29	35	55	85
	ATN	China PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	16	19	29	18	24	11	5	2
	ATN	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	61	21	16	25	31	48	21	7	0	84	57	19	30	25	23	11	14	13	14	8	5	10
	ATN	EU.España	279	293	333	600	389	543	2097	2405	1851	1079	1537	1390	2145	1964	2164	2209	3294	2416	2223	2051	1561	1684	2047	2068	2088	1751	1918	1816	1895	2216	2091	1667	2308	1509	1481	1362
	ATN	EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	2	0	0	0	1	1
	ATN	EU.Portugal	0	0	0	0	0	0	0	0	0	0	193	314	220	796	649	657	691	354	307	327	318	378	415	1249	473	1109	951	1540	1033	1169	1432	1045	1023	820	219	222
	ATN	EU.United Kingdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	1	1	1	0	0	0	1	15	0	0	0	0	0	
	ATN	FR.St Pierre et Miquelon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	4	0	0	4	0	
	ATN	Japan	246	387	273	159	141	142	120	218	113	207	221	157	318	425	214	592	790	258	892	120	138	105	438	267	572	0	0	82	131	98	116	53	56	33	69	47
	ATN	Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	27	15	8	2
	ATN	Maroc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	420	406	667	624	947
	ATN	Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	10	16	0	10	6	9	5	8	6	7	8	8	8	4	4	4
	ATN	Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	49	33	39	0	0	0	19	7	
	ATN	Philippines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
	ATN	Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	17	21	0	0	2	0	2	2
	ATN	St. Vincent and Grenadines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	ATN	Sta. Lucia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	
	ATN	Trinidad and Tobago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	3	1	2	1	1	1	1	1	0	2	1	1	1
	ATN	U.S.A.	0	385	655	410	971	3001	1361	540	896	795	360	315	376	948	642	1710	469	407	347	159	454	395	415	142	521	469	386	375	344	365	392	383	412	406	398	524
	ATN	UK.Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ATN	Venezuela	0	0	0	0	0	0	3	2	3	8	1	6	5	1	7	7	17	9	8	6	9	24	21	28	64	27	14	19	8	41	27	20	33	9	13	7
	ATS	Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0	17	2	0	32	59	78	88	1	15
	ATS	Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	190	0	27	219	409	226	283	238	426	210	145	203	99	128	192	196	93	268	124
	ATS	China PR	0	0	0	0	0	0	0	0	0	0	0	0	0	34	45	23	27	19	74	126	305	22	208	260	0	0	0	77	6	24	32	29	8	9	9	5
	ATS	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	116	166	183	163	146	141	127	63	0	626	121	128	138	211	124	117	144	203	150	157	157	112
	ATS	Côte d'Ivoire	0	0	0	0	0	0	0	0	0	0	0	9	13	10	20	13	15	23	10	10	9	15	15	30	15	14	16	25	0	5	7	0	20	34	19	11
	ATS	EU.España	0	0	0	0	0	0	6	0	378	809	552	327	421	772	552	1084	1482	1356	984	861	1090	1235	811	1158	703	584	664	654	628	922	1192	1535	1207	1083	1077	862
	ATS	EU.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	94	165	116	119	388	140	56	625	13	242	493	375	321	502	336	409	176	132	127	158
	ATS	EU.United Kingdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	11	0	0	0	0	0	
	ATS	Japan	228	206	703	252	462	540	428	234	525	618	538	506	460	701	1369	1617	514	244	267	151	264	56	133	118	398	0	0	72	115	108	103	132	291	114	181	110
	ATS	Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	13	7	7	4	4
	ATS	Namibia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	459	375	509	1415	1243	1002	295	23	307	377	586	9	950	661
	ATS	Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	1	0	0	0	0	0	0	0	10	0	0	0	0	0	0	
	ATS	Philippines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
	ATS	Russian Federation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	ATS	Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	34	23	0	11
	ATS	South Africa	0	0	0	0	0	0	0	1	0	0	0	46	66	45	24	49	37	31	171	67	116	70	12	116	101	111	86	224	137	146	152	218	108	250	476	613
	ATS	U.S.A.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	ATS	UK.Sta Helena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	ATS	Uruguay	0	21	78	153	218	121	43	28	23	19	26	13	20	28	12	17	26	20	23	21	35	40	38	188	249	146	68	36	41	106	23	76	36	1	0	
	ATS	Vanuatu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	12	13	1	0	0	0	0	0	0	0	
	MED	EU.Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	
	MED	EU.España	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	6	7	5	3	2	2	2	2	2	4	1	0	0	1	2	2	0	0	0
	MED	EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	MED	EU.Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	5	0	0	0	15	5	0	0	0	0	0	0	0	0	
	MED	Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	MED	Maroc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Discards	ATN	Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ATN	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	ATN	Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	ATN	Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ATN	U.S.A.	0	0	0	0	0	0	0	9	5	9	10	11	38	24	21	28	1	0	0	0	0	0	0	0	0	0	0	7	10	20	2	9	18	5	11	8
	ATN	UK.Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	ATS	Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	
	ATS	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	2	2
	ATS	EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	MED	EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9.2. Shortfin mako in the North Atlantic. Length–weight relationships for *Isurus oxyrinchus* (sexes combined) from different populations. Lengths in cm, and weights in kg unless specified in equation. W_R = round weight; W_D = dressed weight.

Stock	L (cm) W (kg) relationship	n	Length range (cm)	Source
Central Pacific	log W (lb) = –4.608 + 2.925 x log L_T			Strasburg, 1958
Cuba	$W = 1.193 \times 10^{-6} \times L_T^{3.46}$	23	160–260 (L_T)	Manday, 1975
Australia	$W = 4.832 \times 10^{-6} \times L_T^{3.10}$	80	58–343 (L_T)	Stevens, 1983
South Africa	$W = 1.47 \times 10^{-5} \times L_{PC}^{2.98}$	143	84–260 (L_{PC})	Cliff *et al*., 1990
NW Atlantic	$W_R = (5.2432 \times 10^{-6}) L_F^{3.1407}$	2081	65–338 (L_F)	Kohler *et al*., 1995.
NW Atlantic	$W = 7.2999 \times L_T (m)^{3.224}$	63	2.0–3.7 m (L_T)	Mollet *et al*., 2000
Southern hemisphere	$W = 6.824 \times L_T (m)^{3.137}$	64	2.0–3.4 m (L_T)	Mollet *et al*., 2000
NE Atlantic	$W_D = (2.80834 \times 10^{-6}) L_F^{3.20182}$	17	70–175 (L_F)	García-Cortés and Mejuto, 2002
Tropical east Atlantic	$W_D = (1.22182 \times 10^{-5}) L_F^{2.89535}$	166	95–250	García-Cortés and Mejuto, 2002
Tropical central Atlantic	$W_D = (2.52098 \times 10^{-5}) L_F^{2.76078}$	161	120–185	García-Cortés and Mejuto, 2002
Southwest Atlantic	$W_D = (3.1142 \times 10^{-5}) L_F^{2.7243}$	97	95–240	García-Cortés and Mejuto, 2002

Table 9.3. Shortfin mako in the North Atlantic. Length–length relationships for male, female and sexes combined from the NE Atlantic and Straits of Gibraltar (L_S = standard length; L_F = fork length; L_T = total length; L_{UC} = upper caudal lobe length). Source: Buencuerpo *et al.* (1998).

Females	Males	Combined
$L_F = 1.086\ L_S + 1.630$ (n=852)	$L_F = 1.086\ L_S + 1.409$ (n=911)	$L_F = 1.086\ L_S + 1.515$ (n=1763)
$L_T = 0.817\ L_S + 0.400$ (n=852)	$L_T = 1.209\ L_S + 0.435$ (n=681)	$L_T = 1.207\ L_S + 0.971$ (n=1533)
$L_{UC} = 3.693\ L_S + 13.094$ (n=507)	$L_{UC} = 3.795\ L_S + 10.452$ (n=477)	$L_{UC} = 3.758\ L_S + 11.640$ (n=1054)
$L_T = 1.106\ L_F + 0.052$ (n=853)	$L_T = 1.111\ L_F - 0.870$ (n=911)	$L_T = 1.108\ L_F - 0.480$ (n=1746)

Table 9.4. Shortfin mako in the North Atlantic. Published growth parameters, assuming two vertebral bands formed annually. Data give von Bertalanffy growth parameters (Gompertz growth function) used, t_0 in cm. L_∞ in cm (Fork Length), k in years^{-1}.**

Area	L_∞	k	T_0	Sex	Study
Northwest Atlantic	302	0.266	–1	Male	Pratt and Casey, 1983
Northwest Atlantic	345	0.203	–1	Female	Pratt and Casey, 1983
Atlantic	373.4	–0.203	1.0	Female	Cortés, 2000
Northwest Atlantic	253	0.125	71.6	Male	Natanson *et al.*, 2006**
Northwest Atlantic	366	0.087	88.4	Female	Natanson *et al.*, 2006**

Table 9.5. Shortfin mako in the North Atlantic. Life-history information available from the scientific literature.

Parameter	Values	Sample Size	Area	Reference
Reproduction	Ovoviviparous with oophagy			Campana *et al.*, 2004
Litter size	4–25	35	Worldwide	Mollet *et al.*, 2000
	12–20			Castro *et al.*, 1999
Size at birth (L_T)	70 cm	188+	Worldwide	Mollet *et al.*, 2000
Sex ratio (males: females)	1:1	2188	NW Atlantic	Casey and Kohler, 1992
	1:0.4		NE Atlantic (Spain, Azores)	Mejuto and Garces, 1984
	1:0.9		NE, N central Atlantic and Med	Buencuerpo *et al.*, 1998
	1.0:1.4	17	NE Atlantic	García-Cortés and Mejuto, 2002
Gestation period	15–18	26	Worldwide	Mollet *et al.*, 2000
Male age-at-first maturity (years)*	2.5			Pratt and Casey, 1983
	9			Cailliet *et al.*, 1983
Male age-at-median maturity (years)	7	145	New Zealand	Bishop *et al.*, 2006
Female age-at-first maturity (years)*	5			Pratt and Casey, 1983
Female age maturity (years)	19	111	New Zealand	Bishop *et al.*, 2006
	7			Pratt and Casey, 1983
Male length-at-first maturity (T_L)	195 cm			Stevens, 1983
Male length-at-maturity (T_L)	197–202 cm (median)	215	New Zealand	Francis and Duffy, 2005
	180 cm (L_F)		NE Atlantic (Portugal)	Maia *et al.*, 2007
	200–220		Worldwide	Pratt and Casey, 1983; Mollet *et al.*, 2000
Female length-at-first maturity (T_L)	265–280 cm			Cliff *et al.*, 1990
Female length-at-maturity (T_L)	301–312 (median)	88	New Zealand	Francis and Duffy, 2005
	270–300 cm (L_T)		Worldwide	Pratt and Casey, 1983; Mollet *et al.*, 2000

Parameter	Values	Sample Size	Area	Reference
Age-at-recruitment (year)	0–1			Stevens and Wayte, 1999
Male maximum length (L_T)	296 cm			Compagno, 2001
Female maximum length (L_T)	396 cm 408 cm (estimated)			Compagno, 2001
Lifespan (years)	11.5–17 (oldest aged)			Pratt and Casey, 1983
	45 (estimated longevity)			Cailliet *et al*., 1983
Natural mortality (M)	0.16		Pacific	Smith *et al*., 1998
Annual survival estimate	0.79 (95% C.I. 0.71–0.87)			Wood *et al*. 2007
Growth parameters	61.1 cm year–1 first year 40.6 cm year–1 second year 5.0 cm month–1 in summer 2.1 cm month–1 in winter	262	NE Atlantic (Portugal)	Maia *et al*., 2007
Maximum age (estimated from von Bertalanffy growth eqn.)	28			Smith *et al*., 1998
Productivity (R2m) estimate: intrinsic rebound	0.051 (assuming no fecundity increase)		Pacific	Smith *et al*., 1998
Potential rate of increase per year	8.5%		Atlantic	Cortés, 2000
Population doubling time T_D (years)	13.6 (assuming no fecundity increase)		Pacific	Smith *et al*., 1998
Generation time (years)	~ 9		Atlantic	Cortés, 2000
Trophic level	4.3	7		Cortés, 1999

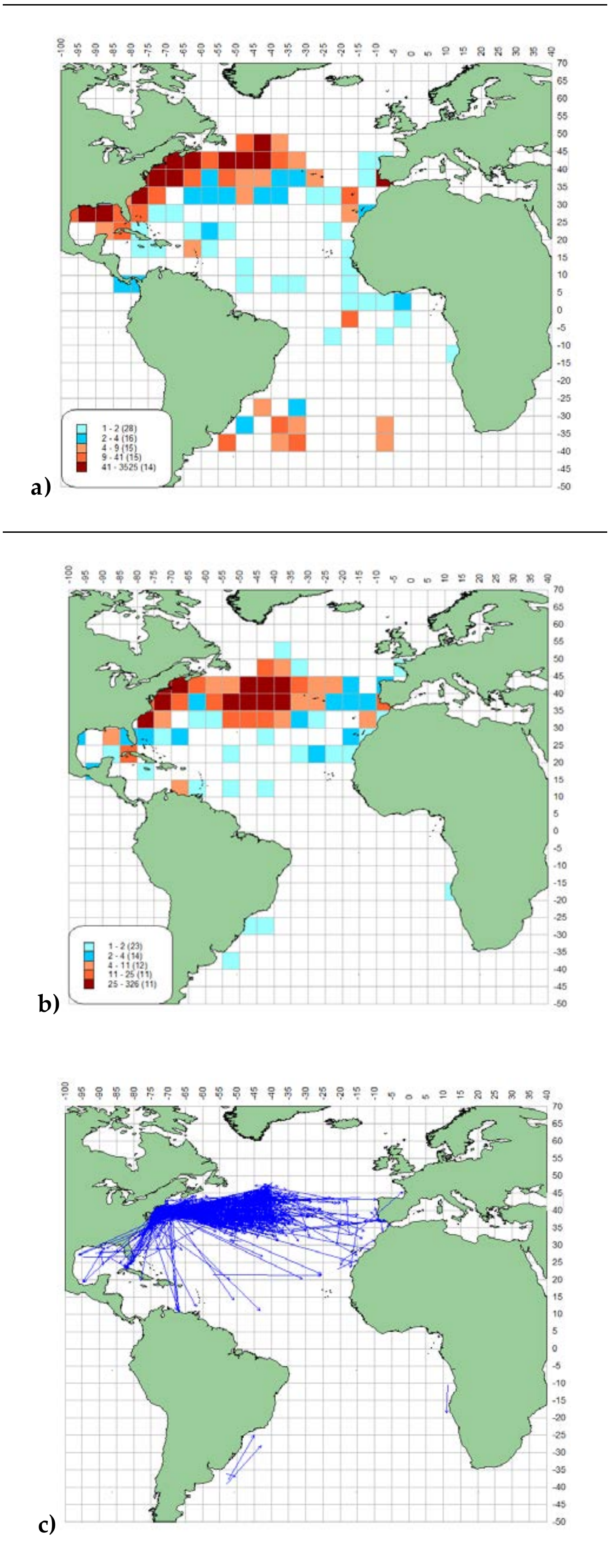

Figure 9.1. Shortfin mako in the North Atlantic. Tag and release distributions for shortfin mako in the Atlantic Ocean showing (a) density of releases, (b) density of recoveries, and (c) straight displacement between release and recovery locations. Recaptures were 13.4%. Source: ICCAT (2014).

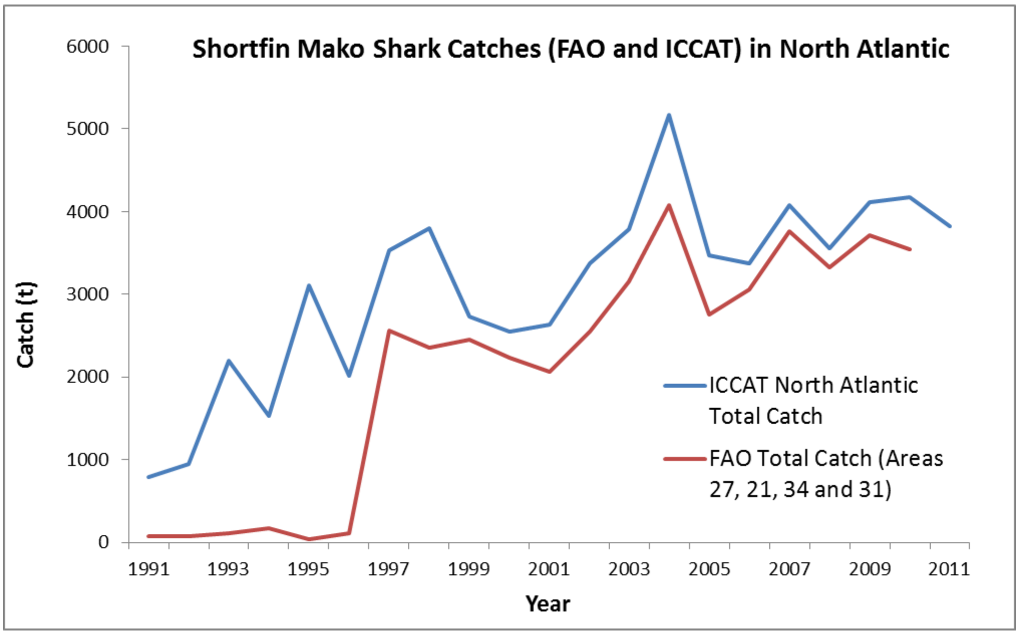

Figure 9.2. Shortfin mako in the North Atlantic. Total catches (t) of shortfin mako in the North Atlantic reported to FAO and ICCAT.

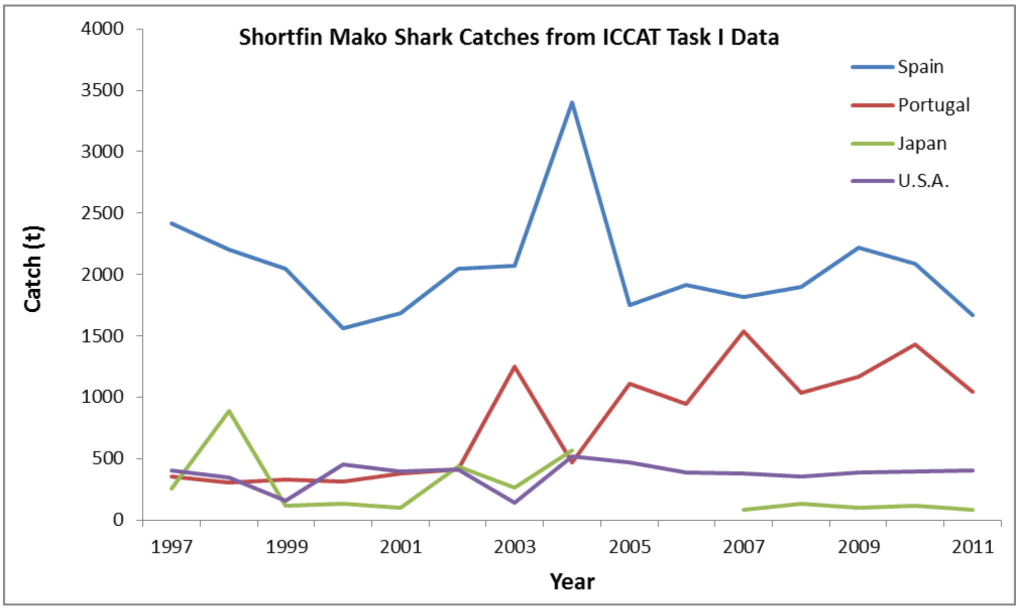

Figure 9.3. Shortfin mako in the North Atlantic. Total catches (t) made by the major countries (accounting for 84% of total landings) landing shortfin mako in the North Atlantic reported to ICCAT.

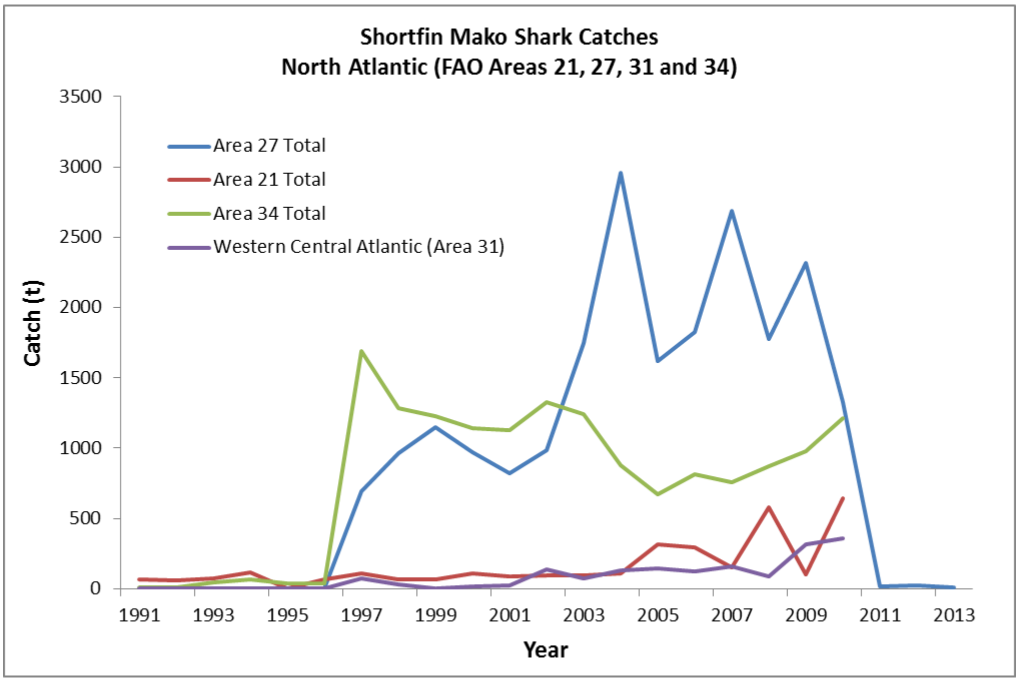

Figure 9.4. Shortfin mako in the North Atlantic. Total catches (t) of shortfin mako reported to FAO by major fishing area.

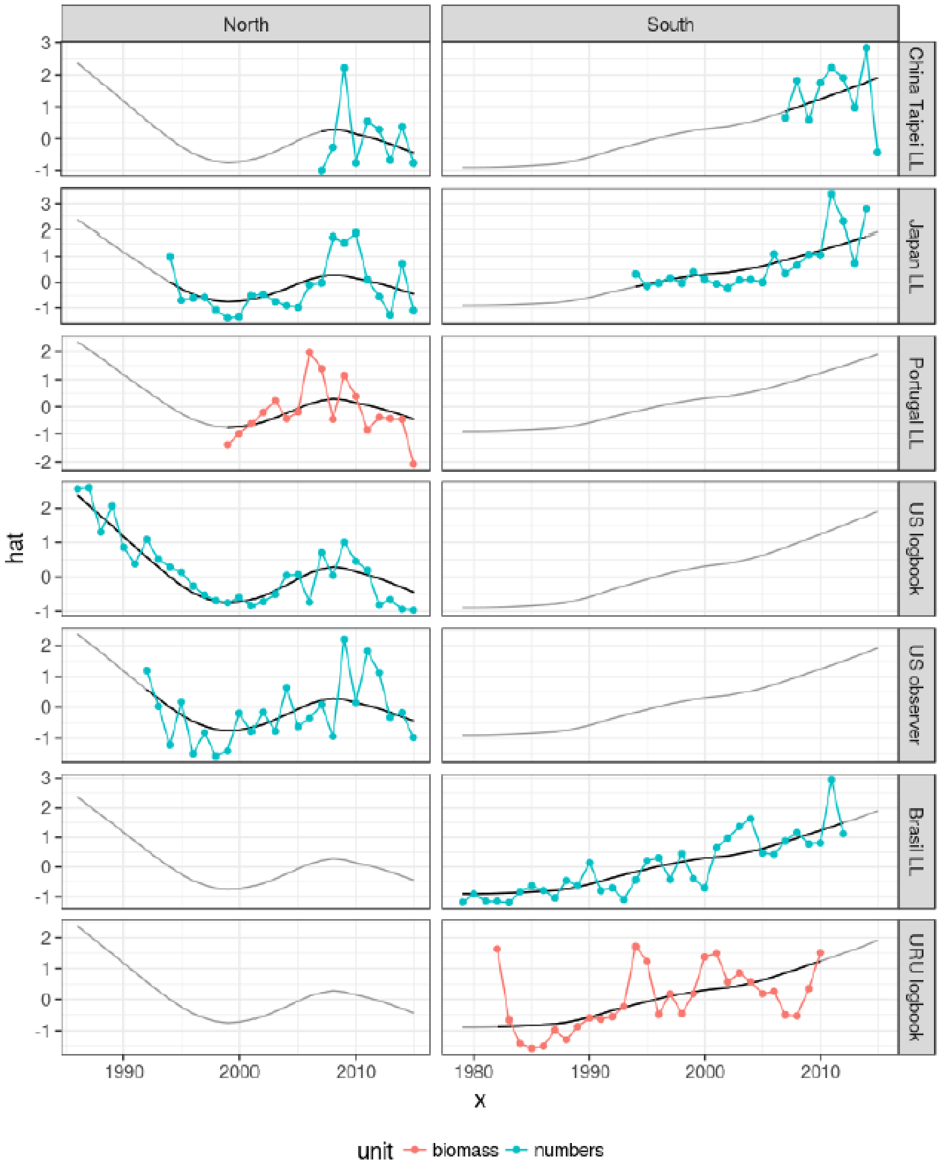

Figure 9.5. Shortfin mako in the North and South Atlantic. Time series of agreed CPUE indices, points are the standardised values, continuous black lines are a loess smoother showing the average trend by area (i.e. fitted to year for each area with series as a factor). X-axis is time, Y-axis are the scaled indices. Source: ICCAT.

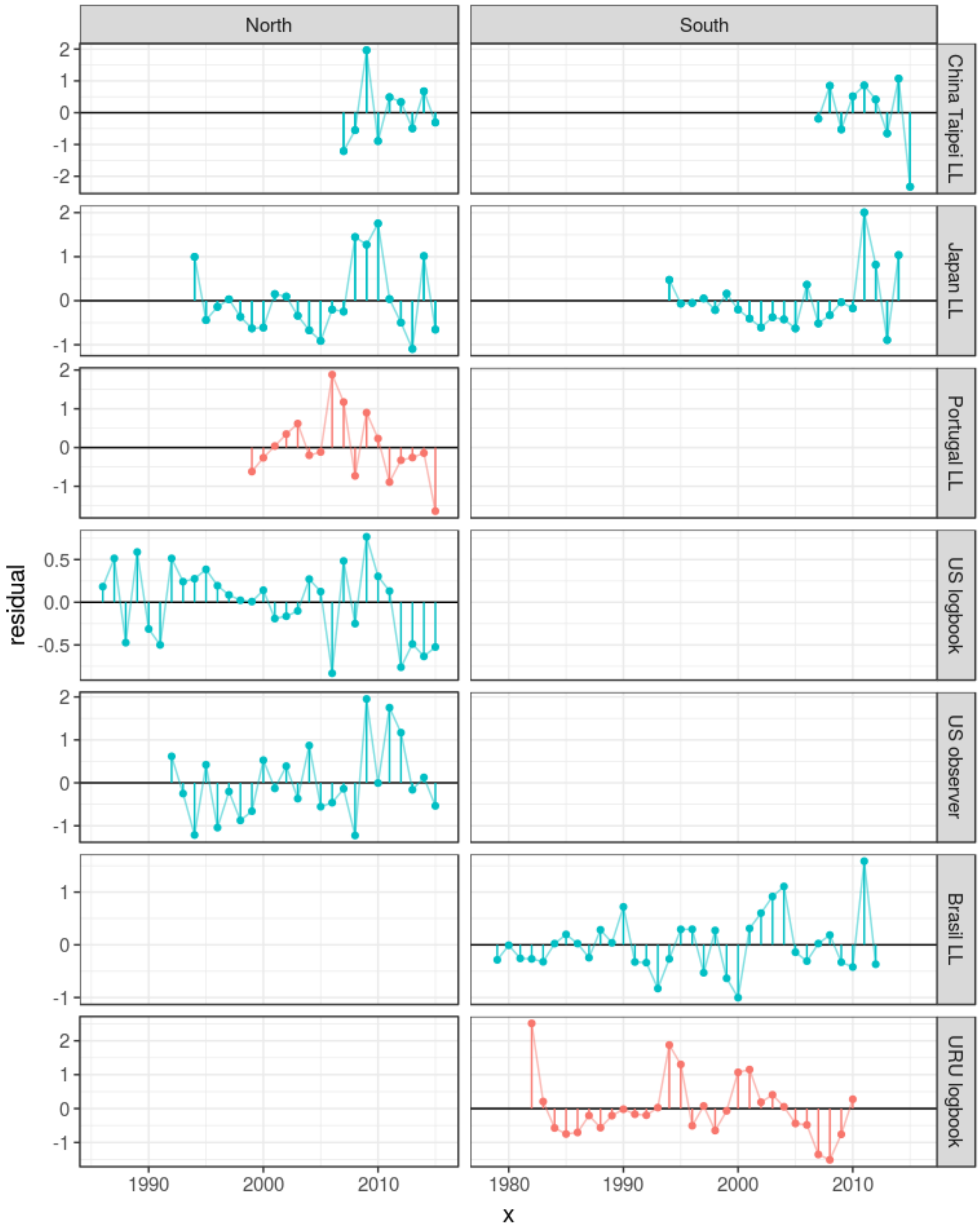

Figure 9.6. Shortfin mako in the North and South Atlantic. North and South Atlantic time series of residuals from the loess fit to agreed indices. X-axis is time, Y-axis are the scaled indices. Source: ICCAT.

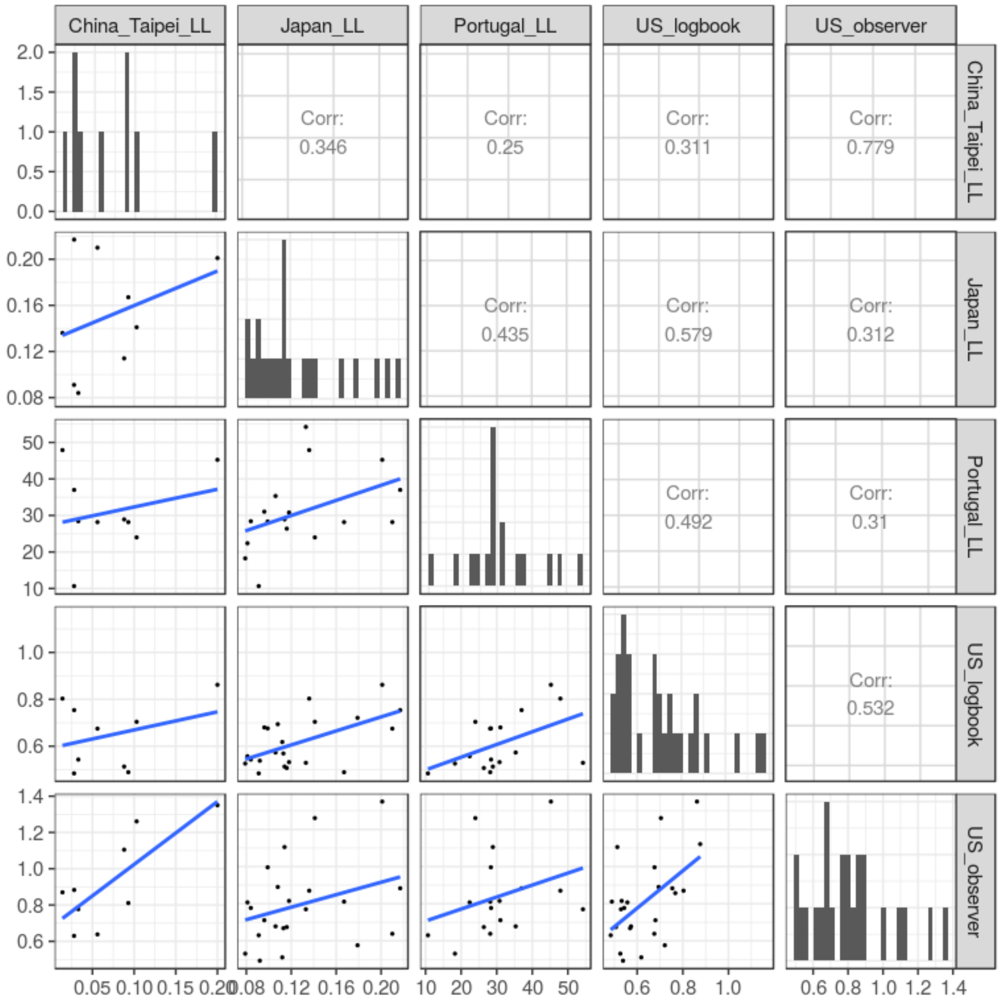

Figure 9.7. Shortfin mako in the North Atlantic. North Atlantic pairwise scatter plots for agreed indices. X- and Y-axis are scaled indices. Source: ICCAT.

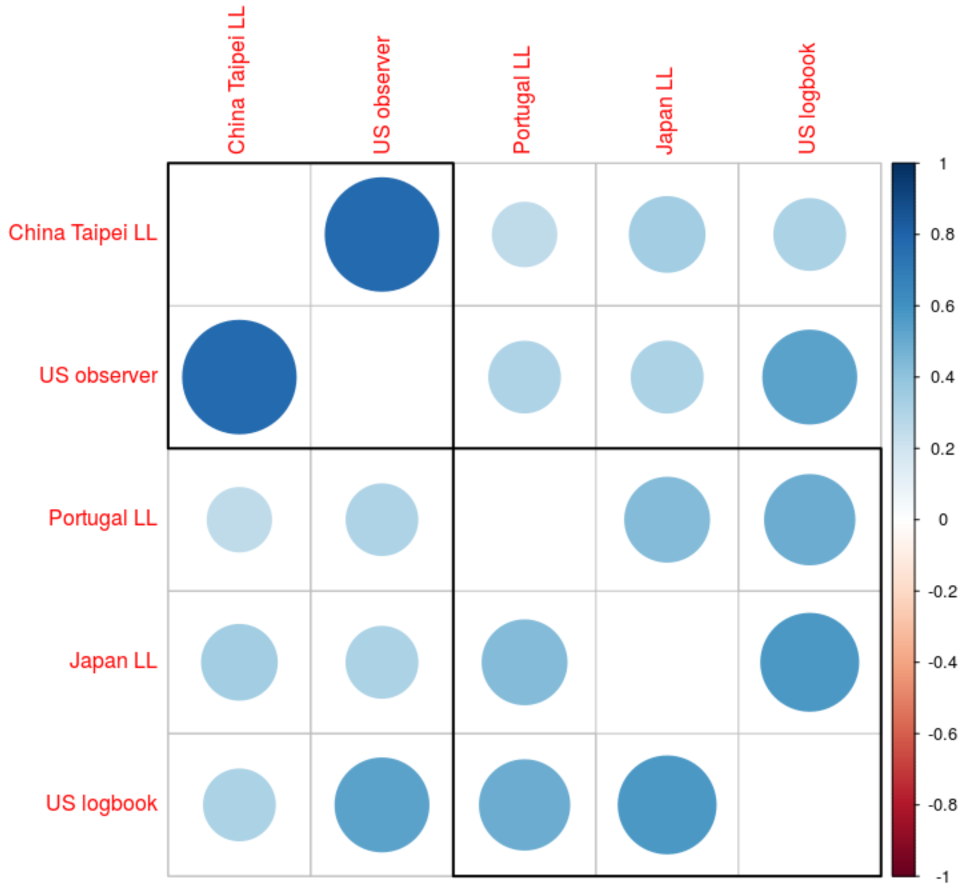

Figure 9.8. Shortfin mako in the North Atlantic. North Atlantic correlation matrix for the agreed indices; blue indicates positive and red negative correlations, the order of the indices and the rectangular boxes are chosen based on a hierarchical cluster analysis using a set of dissimilarities. Source: ICCAT.

10 Tope in the Northeast Atlantic

10.1 Stock distribution

WGEF considers there to be a single stock of tope (or school shark) *Galeorhinus galeus* in the ICES area. This stock is distributed from Scotland and southern Norway southwards to the coast of Northwest Africa and the Mediterranean Sea. The stock area covers ICES subareas 2–10 (where subareas 4 and 6–10 are important parts of the stock range, and subareas 2, 3 and 5 areas where tope tend to be an occasional vagrant). The stock extends into the northern part of the CECAF area and the Mediterranean Sea (Subareas I–III). The information used to identify the stock unit is summarized in the stock annex (ICES, 2009).

10.2 The fishery

10.2.1 History of the fishery

Currently there are no targeted commercial fisheries for tope in the NE Atlantic. Tope is taken as a bycatch in trawl, gillnet and longline fisheries, including demersal and pelagic static gears. Tope is discarded in some fisheries, but landed as a bycatch in other fisheries.

Tope is also an important target species for recreational sea angling in several areas, with anglers, angling clubs and charter boats often having catch and release protocols.

10.2.2 The fishery in 2017

There were no major changes to the fishery noted in 2017.

10.2.3 ICES Advice applicable

ICES provided advice for this stock for the first time in 2012, stating "*Based on ICES approach to data-limited stocks, ICES advises that catches should be reduced by 20%. Because the data for catches of tope are not fully documented and considered unreliable (due to the historical use of generic landings categories), ICES is not in a position to quantify the result. Measures to identify pupping areas should be taken*".

In 2015, ICES advised that "*when the precautionary approach is applied, landings should be no more than 283 tonnes in each of the years 2016 and 2017. Discarding is known to occur, but is variable and quantities of dead discards have not been estimated*".

In 2017, ICES advised that when the precautionary approach is applied, landings should be no more than 376 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches.

10.2.4 Management applicable

It is prohibited for EU vessels to land tope that have been captured on longlines in European Union waters of ICES Division 2.a and Subarea 4 and in Union and international waters of ICES subareas 1, 5–8, 12 and 14 (EU Regulation 2016/72).

The UK's Department for Environment, Food and Rural Affairs (DEFRA) introduced a Statutory Instrument in 2008 (SI Number 2008/691, "The Tope Order") that prohibited fishing for tope other than by rod and line (with anglers fishing using rod and line from boats not allowed to land their catch) and established a tope bycatch limit of 45 kg per day in commercial fisheries.

10.3 Catch data

10.3.1 Landings

No accurate estimates of historical catch are available, as many nations that land tope report an unknown proportion of landings in aggregated landings categories (e.g. dogfish and hounds). In other cases, misidentification/misreporting of other species as tope may have taken place.

Reported species-specific landings, which commenced in 1978 for French fisheries, are given in Table 10.1, based on data collated by WGEF up to and including 2017. Prior to, and at WGEF 2016, landings from 2005–2015 were reassessed, and where possible, erroneous or generic species categories or figures were reassigned following WKSHARKS2 (ICES, 2016a). The data supplied to WGEF are higher than previous data, although of a similar magnitude, and the reasons for these discrepancies are still to be investigated.

Recent estimated landings data from 2005–2016 for tope are shown by fishing area (Table 10.2) and by nation (Table 10.3), following the procedure from WKSHARKS2. Overall, landings data appear relatively stable in recent years (Figure 10.1).

France is one of the main nations landing tope, accounting for ca. 80% in 2017, with the English Channel and Celtic Seas important fishing grounds. UK fisheries also land tope, although species-specific data are lacking for the earlier years, and reported landings have declined since precautionary management measures (trip limits of no more than 45 kg per day) were introduced.

Since 2001, Ireland, Portugal and Spain have also declared species-specific landings. However, it is believed that some of the Portuguese landings recorded as tope may also include unknown proportions of other sharks, including smooth-hounds and deep-water sharks. Portuguese tope landings for 2017 were examined by IPMA scientists and have been corrected. This is why Portuguese tope landings in 2017 are much less than declared in previous years.

There are also landings of tope around the Azores.

Limited species-specific catch data for the Mediterranean Sea and off northwest Africa are available. The degree of possible misreporting or underreporting is not known.

10.3.2 Discards

Though some discard information is available from various nations, data are limited for most nations and fisheries.

Preliminary studies from the UK Discard programme (Silva *et al*., 2013 WD) indicated that juvenile (50–94 cm L_T) tope tended to be discarded in demersal trawl fisheries and larger (>94 cm L_T) individuals were usually retained (Figure 10.2). Tope caught in drift and static gillnet fisheries were usually retained, with retained tope mainly in the 70–124 cm L_T size range.

The small number of tope recorded in some discard observer programmes may be an artefact of limited coverage on those vessels that may encounter them, and the occasional and seasonal occurrence of tope in some areas. Sporadic records of tope in observer data indicate that appropriate methods of raising such discard data to fleet need to be evaluated if catch advice is to be developed.

In 2017, ICES held a workshop (WKSHARKS3) to compile and refine catch and landings of elasmobranchs (ICES, 2017). National data were examined for UK (England), Ireland, France and Spain (Basque country) for two main gear categories: otter trawl and gillnet. Discard data were also provided as part of the 2017 Data Call. However, data available were insufficient to draw a more comprehensive interpretation of any discard/retention patterns.

10.3.3 Quality of catch data

Catch data are of poor quality, and biological data are not collected under the Data Collection Regulations. Some generic biological data are available (see Section 10.7).

10.3.4 Discard Survival

Ellis *et al.* (2014 WD) provided references for discard survival of shark species worldwide. Discard survival of members of the Triakidae family appears to be quite variable. Whilst quantitative data are limited in European waters, Fennessy (1994) reported at-vessel mortality (AVM) of 29% for Arabian smooth-hound *Mustelus mosis* taken in a prawn trawl fishery. AVM ranged from 57–93% for three triakid sharks taken in an Australian gillnet fishery, despite the soak times being <24 hours (Braccini *et al*., 2012). Lower AVM of triakids has been reported in longline fisheries (Frick *et al*., 2010; Coelho *et al*., 2012).

10.4 Commercial catch composition

Tope is one of the main elasmobranch species caught by the Azorean bottom longline fleet and was reported in 29% of the trips, representing up to 2% of the total catch landed along the studied period (Fig. 10.3) (Santos *et al.* 2018 WD).

10.5 Commercial catch and effort data

Standardized CPUE series for tope from the Azorean bottom longline fleet are shown in Table 10.4 and Fig. 10.4. (Santos *et al.* 2018 WD). The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE oscillated over time, with peaks in 1999, 2000 and 2014; while the standardized index gave a more stable trend since 1994. According to Ortiz (2017), it is not necessary that the nominal and standardized trends follow the same trend.

10.6 Fishery-independent information

10.6.1 Availability of survey data

Although several fishery-independent surveys operate in the stock area, data are limited for most of these. Analyses of catch data need to be undertaken with care, as tope is a relatively large-bodied species (up to 200 cm L_T in the NE Atlantic), and adults are strong swimmers that forage both in pelagic and demersal waters. Tope are not sampled effectively in beam trawl surveys (because of low gear selectivity). They are caught occasionally in GOV trawl and other (high-headline) otter trawl surveys in the North Sea and westerly waters, though survey data generally include a large number of zero hauls.

The discontinued UK (England and Wales) Q4 IBTS survey in the Celtic Seas ecoregion recorded small numbers of tope, which were tagged and released where possible (ICES, 2008). UK surveys in this area generally caught larger tope at the southern entrance to St George’s Channel, and in 2011 several juveniles were caught in the Irish Sea.

Southern and western IBTS surveys may cover a large part of the stock range, and more detailed and updated analyses of these data are required.

The Western waters beam-trawl survey in the English Channel and Celtic Sea did not catch any tope (Silva *et. al.*, 2018WD) which is known to occur in the area. However, tope occurs higher up in the water column and is rarely captured by beam trawls.

Data on tope from the Azorean longline survey (ARQDACO(P)-Q1) should be examined in future years.

10.6.2 Trends in survey abundance

Updated data for three trawl surveys were examined by WGEF, as summarised below. Data for the IBTS-Q1 in the North Sea showed a low abundance across countries over the time-series examined (1992–2017), with only 14 positive hauls and a total of 34 individuals per hour. This survey was excluded from further analyses.

IBTS-Q3: The mean CPUE (numbers and biomass) were calculated for the IBTS-Q3 in the North Sea IBTS for the years 1992–2016. During this period, there were large differences in abundance and biomass in earlier years compared to recent years (Figure 10.5), though the frequency of occurrence has increased since 2002 (Figure 10.6).

More detailed investigations of IBTS-Q3 data on DATRAS were undertaken by WGEF in 2017 in terms of the length and spatial distribution by nations (Figure 10.7 and 10.8). Length-frequency distributions indicate that data for *Galeorhinus galeus* and *Mustelus* spp. may have been confounded, with this most evident for Danish survey data (See Section 21.6). Data from DAN are included in the present analysis, but it is likely that larger tope have been attributed to *Mustelus* in some years, and so until further analyses of these data are undertaken, the temporal trends in catch rates are not based on a complete data set. Further analyses on the quality of these data are required.

Furthermore, WGEF note that the apparent 'peak' in tope in 1992 in driven by a single large catch at one station (*RV* Thalassa in 35F1, haul number 15 with CPUE of 182 ind/hr). Further examination of these data are required.

IGFS-WIBTS-Q4: Abundance and biomass estimates were calculated for the time series 2005–2016 (Figure 10.9) and shows an increasing trend since 2012. This survey usually catches small numbers of tope, although one haul (40E2, Division 6.a) in 2006 yielded 59 specimens (Figure 10.9). Most tope caught are now tagged and released.

EVHOE-WIBTS-Q4: Abundance and biomass estimates were calculated for the time series 1997–2016 (Figure 10.10), and fluctuate without trend.

The spatial distribution across the time-series (1997–2014) (Figure 10.4 in ICES, 2016b), showed similar locations reported during UK surveys, with the majority of individuals found at the entrance to St George's Channel and outer Bristol Channel.

WGEF consider that any trend analysis should be viewed with care, due to the low catchability on fishery-independent surveys. Given the low and variable catch rates, WGEF do not consider that catch rates are wholly appropriate for quantitative advice on stock status. The proportion of stations at which tope are captured may be an alternative metric for consideration and could be further investigated for more surveys covering the stock area.

10.6.3 Length distributions

In 2009, data were presented on length distributions found in the Celtic Seas ecoregion during fisheries-independent surveys conducted by England and Ireland in Q4 (Figure 10.7 in ICES, 2016b). Irish surveys recorded 145 tope (2003–2009), of which 110 (76%) were male. English surveys recorded 90 tope (56 (62%) males and 34 (38%) females).

These specimens were 40–163 cm L_T. The length–frequency distributions found between the surveys were noticeably different, with more large males found in the Irish survey; 75% of the males were greater than 130 cm. The English surveys had a more evenly distributed length range.

Length distributions of tope caught in various UK surveys in 2004–2009 were analysed in 2016 (see Figure 10.8 in ICES 2016b). In the beam trawl survey (Figure 10.8a in ICES, 2016b), two peaks were observed, at 30–54 cm L_T and 70–84 cm L_T respectively. In the North Sea survey (Figure 10.8b in ICES, 2016b) a wide range (30–164 cm L_T) was observed, with a main peak at 30–44 cm L_T. Wide ranges were also observed in the Celtic Sea survey (44–164 cm L_T; Figure 10.8c in ICES, 2016b) and in the western IBTS survey (70–120 cm L_T; Figure 10.8d in ICES, 2016b).

10.6.3.1 Recreational length distributions

A Scottish recreational fishery in the Mull of Galloway has recorded sex, length and weight of captured tope since 2009. While the number of tope tagged has declined, the number of mature fish of both sexes appears to have disproportionally declined (Figure 10.11). This area is thought to be a breeding ground for tope (James Thorburn, pers. comm., 2014), so the lack of mature animals is a cause for concern.

10.6.4 Tagging information

159 tope were tagged and released by CEFAS over the period 1961–2013, predominately in the Irish Sea and Celtic Sea (Figure 10.10 in ICES 2016b; Burt *et al*., 2013). Fish were also tagged in the western English Channel and North Sea but in lower numbers (n = 9). Tope were tagged over a wide length range (41–162 cm L_T), the majority being males, with a male to female sex ratio of 1.5:1. A total of four tope were recaptured, and were, on average, at liberty for 1195 days, with a maximum recorded time at liberty of 2403 days. Over the period individual fish had travelled relatively large distances (112–368 km), and all had moved from one ICES division to another. For example, the fish that was at liberty the longest was released in Cardigan Bay (Division 7.a) in November 2003, was later captured in June 2010 just to the east of the Isle of Wight. It is also noted that a tag from a tope was returned to CEFAS from southern Spain, and although release information could not be located, it is thought it may have been tagged in the 1970s.

In 2012, the UK (Scotland) started an electronic (archival data storage tags that record pressure and temperature) and conventional tagging programme for tope. As of June 2013, 13 tope had been tagged and there were two returns reported from France and Portugal (conventional tag). Further releases were planned in 2013. Updated information from this study could usefully be supplied to WGEF.

The Irish Marine Sportfish Tagging Programme has tagged tope off the Irish coast since 1970. Four fish have been recaptured in the Mediterranean Sea (Inland Fisheries Ireland, pers comm. 2013; Fitzmaurice, 1994; cf. nicematin.com, 29 May 2013, "Le long périple d'un requin hâ, de l'Irlande à la Corse). A tope tagged on 38 July 2001 off Greystones (Ireland) as part of this programme, was caught on 9 May 2013 off Bastia, Corsica (Mediterranean Sea), showing a movement of 3900 km in twelve years. One tope tagged off Ireland was recaptured in May 2018, again off the west of Ireland, after 9046 days.

10.7 Life-history information

Much biological information is available for tope in European seas and elsewhere in the world, which are summarized in the stock annex (ICES, 2009).

A genetic study (Chabot and Allen, 2009) on the eastern Pacific population including comparisons with samples from Australia, South and North America and UK, showed that there is little to no gene flow between these populations, indicating a lack of mixing.

The following relationships and ratios were calculated by Séret and Blaison (2010):

$L_T = 0.0119\ W^{2.7745}$ (n = 10; length range of 60–140 cm L_T; weight in g);
Live weight / eviscerated weight = 1.28 (s.d. 0.05);
Live weight / dressed weight (eviscerated, headed, skinned) = 2.81 (s.d. 0.13);
Smallest mature male = 110 cm L_T, smallest mature female 130 cm L_T, fitting with the ranges 120–135 and 134–140 cm L_T observed for other populations.

Additional data from French surveys were presented by Ramonet *et al.* (2012 WD).

The length-weight relationship from tope sampled on UK (E&W) surveys (Silva *et al.*, 2013) was used to convert individual numbers at length to biomass when assessing the Q3 North Sea IBTS survey index.

$L_T = 0.0038\ W^{3.0331}$ (n = 43; length range of 39–155 cm L_T; weight in g)

10.7.1 Parturition and nursery grounds

Pups (24–45 cm L_T) are caught occasionally in groundfish surveys, and such data might be able to assist in the preliminary identification of general pupping and/or nursery areas (see Figure 10.5 of ICES, 2007). Most of the pup records in UK surveys are from the southern North Sea (Division 4.c), though they have also been recorded in the northern Bristol Channel (Division 7.f). The updated locations of pups caught in fisheries-independent surveys across the ICES region could usefully be collated in the near future.

The lack of more precise data on the location of pupping and nursery grounds, and their importance to the stock, precludes spatial management for this species at the present time.

10.8 Exploratory assessment models

Various assessment methods have been developed and applied to the South Australian tope stock (e.g. Punt and Walker, 1998; Punt *et al*., 2000; Xiao and Walker, 2000).

A preliminary capture-recapture model was developed in 2015 using data from the Irish Marine Sportfish Tagging Programme (Bal *et al*., 2015 WD). This approach was re-applied as an exploratory assessment by WGEF in 2016 including additional Irish tagging records from 2014 and 2015. The approach, results and a discussion of the current state of the model are summarized below.

10.8.1 Data used

The capture–mark–recapture database used is based on 7 641 tope caught and released year round by recreational fisheries over the period 1970 to 2015. There were 448 individual recapture records, although some fish were recaptured several times (486 recaptures in total). Observed recaptures come from both recreational and commercial fisheries. The tagging area was around Ireland (concentrated off the southwest coast), with recaptures made from across the ICES area.

The aim of the study was to get preliminary estimates of the size of the population of tope off the southwest Irish coast. It was necessary to estimate capture efficiency and fish survival, so as to use catch numbers (new catch plus recaptures) together with these parameters to support a population dynamic model. This model requires a discrete structure in the data, and so only captures and recaptures that occurred from mid-June to mid-August were considered. This period roughly coincides with the peak seasonal occurrence and is long enough to ensure that enough data were available for analysis. Fish first captured outside this period were used to estimate survival and capture probability only and do not enter type population estimates. As capture data come exclusively from recreational anglers, recapture data from other fisheries were only used to get information about the state of sharks through time (i.e. dead or alive, 443 recaptures). Tope recaptured by fisheries other than recreational angling were assumed to be dead. Fish with unknown recapture gears were assumed to have been recaptured by anglers if the recapture date was between May and September and if the recapture location was near the Irish shore. Remaining unknown recaptures were assumed to correspond to commercial gears. The capture and recapture data used in the study are summarised in Figure 10.12.

10.8.2 Methodology

10.8.2.1 Cormack-Jolly-Seber Model

10.8.2.1.1 Generalities

To disentangle capture probability from survival probability, a Cormack-Jolly-Seber (CJS) model was applied to the capture–recapture data that can be summarized for each fish in capture–recapture histories.

The corresponding state–space model and data structures are summarized in Figure 10.13. State–space models are hierarchical models that decompose an observed time-series of observed response into a process (here survival rate) and an observation error component (here capture probability) (After Kery and Schaub, 2012).

In this exploratory assessment, the authors defined the latent variable $A_{i,y}$ which takes the value 1 if an individual i is alive and value 0 if an individual is dead year y.

Conditionally on being alive at occasion y, individual i may survive until occasion $y+1$ with probability $\Phi_{i,y}(y = 1, ..., Y)$. The following equation defines the state process:

(1) $A_{i,y+1} \mid A_{i,y} \sim \text{Bernouilli}(A_{i,y} * \Phi_{i,y})$

The Bernoulli success is composed of the product of the survival and the state variable z. The inclusion of z insures that an individual dead remain dead and has no further impact on estimates.

If individual i is alive at occasion y, it may be recapture (R) with probability $p_{i,y}(y = 2, ..., Y)$. This can again be modelled as a Bernoulli trial with success probability $p_{i,y}$:

(2) $R_{i,y} \mid A_{i,y} \sim \text{Bernouilli}(A_{i,y} * p_{i,y})$

the inclusion of the latent variable A insures that an individual dead cannot be modelled again afterwards.

10.8.2.1.2 Specific modelling

To allow for more flexibility, survival is assumed to vary per year based on a random walk structure in the logit scale. Equation (2) is changed for the following equation starting on occasion 2:

(3) $A_{i,y+1} \mid A_{i,y} \sim \text{Bernouilli}(A_{i,y} * \Phi_y)$
$\text{logit}(\Phi_y) \sim \text{Normal}(\text{logit}(\Phi_{y-1}), \sigma_\Phi)$

with the following uninformative priors

$\Phi_1 \sim \text{Unif}(0, 1)$ and $\sigma_\Phi \sim \text{Unif}(0, 10)$

The capture probability of individuals as a fixed parameter in equation (1) thus change into the following equation:

(4) $R_{i,y} \mid A_{i,y} \sim \text{Bernouilli}(A_{i,y} * p)$

In the case of the Irish tope data, there is not a well-defined period of tagging and recapture as recreational anglers fish year round. However, the CJS approach needs the data to be discretised and so a reference period over which the population is considered closed is necessary. Not to lose information coming from sharks first caught outside the reference period chosen, they were included in the model to get better estimates of survival and recapture probabilities. To do so, the first year survival is corrected by the deviation (Δd_i) between the date the individual *i* was captured at and the following 15th of July (i.e. middle of the reference period chosen):

(5) $\Phi i,1 = \Phi 1\ \Delta di\ /365$

10.8.2.2 Deriving population size: the Jolly Seber approach

The best way of deriving population size estimates would be to add a third population dynamic component to the model described above and to fit the whole model in one go. This structure is called a Jolly-Seber (JS) model (Kery and Schaub, 2012).

Focusing on untagged fish population sizes (for computation cost only), the population size (*N*) may be derived as follow for occasion 1:

(6) $C_1 \sim \text{Binomial}(p, N_1)$ with uninformative prior for $N_1 \sim \text{Unif}(0, 300\ 000)$

Population dynamics can be built in using the probability of survival coming from the CJS model described above together on top of the estimate of catch probability. For occasions following occasion 1, with *S* referring to survivors from the previous occasion *N* and *E* the new entrants to the population, *N* is estimated as:

(7) $S_y \sim \text{Binomial}(\Phi_y, N_{y-1})$
$N_y = S_y + E_y$

The series of *E* is given a Gamma random walk prior structure (gamma distribution in jags are parameterized with shape (α) and rate (β) to capture relatively smooth evolutions. Starting on occasion 3, the following apply:

(8) $E_y \sim \text{Gamma}(\alpha_{Ey}, \beta_{Ey})$
$\alpha_{Ey} = E_{y-1} \times \beta_{Ey}$
$\beta_{Ey} = E_{y-1} / \sigma_y^2$

with the following uninformative priors:

$E_2 \sim \text{Unif}(0, 300\,000)$ and $\sigma_y \sim \text{Unif}(0, 30\,000)$

Trials made so far to fit the model in one go were unsuccessful, revealing a mismatch between the CJS and dynamic elements of the model. Bal *et al.* (2015 WD) suggested this was due to the fact that a fixed p for the whole time-series is not realistic.

In consequence, preliminary population estimates for 2015 and 2016 were derived in two ways:

a) Omitting the underlying population dynamic and simply deriving N in the Bayesian model using parameter p and the total number of sharks captured the corresponding year;

b) The CJS model was fitted first. Posteriors were then used as informative priors to sequentially fit the population dynamic model described above, breaking feedbacks between the two parts. The figures are provided for illustrative purpose.

10.8.3 Computation details

Bayesian fitting, forecasting and the derivations were implemented using Markov Chain Monte Carlo algorithms in JAGS (Just Another Gibbs Sampler, Plummer, 2003; http://mcmc-jags.sourceforge.net) through the R software (R Development Core Team, 2013). Three parallel MCMC chains were run and 20 000 iterations from each were retained after an initial burn-in of 10 000 iterations. Chain thinning used equalled 5. Convergence of chains was assessed using the Brooks-Gelman-Rubin diagnostic (Gelman *et al.*, 2015).

10.8.4 Results

Results comprise posterior density functions of capture rate (Figure 10.14), annual survival (Figure 10.15) and population size estimates from methods a (Figure 10.16) and b (Figure 10.17).

10.8.5 Discussion

The current estimated population of tope around Ireland has been relatively stable in recent years (although with some annual peaks with high variance in 2005–2007 requiring more detailed examination). The actual population size remains uncertain as shown by the scale difference coming from the two methods used to infer population size (Figures 10.16 and 10.17).

Building a model that accounted for difference between sexes would be interesting, as males and females appear to show captures and recaptures in different locations around Ireland; this spatial difference may mean that capture and survival probabilities differ between sexes. Such a model would require improved recording of individual sex.

Although size and/or weight of sharks were available, they were not considered in the current model as these data require further quality checking.

Preliminary studies have so far been unsuccessful in fitting a complete JS model in one go. Expert opinion on tagging and recapture effort could help address the fitting issues linked to some apparent mismatch between the CJS and population dynamic elements of the full model. In addition, this could result in more realistic model with annual variations in both survival and capture probabilities. Information on variability in fishing effort for commercial fisheries might also be included and should allow separation of natural survival variability and anthropogenic pressure. It is hoped that further model development work will address these issues and support an improved exploratory tope assessment in the future.

10.9 Stock assessment

Landings data (see Section 10.3) and survey data (see Section 10.6) are currently too limited to allow for a quantitative stock assessment of NE Atlantic tope. In 2017, tope was still treated as a Category 5 stock, with advice based on recent estimated landings.

Whilst not used in quantitative advice, WGEF note that available survey trends indicate that catch numbers have been relatively stable or variable in recent years.

10.10 Quality of the assessment

The low catchability of tope in current surveys can lead to variability in catch rates. Trawl surveys are not designed to capture larger pelagic species like tope, and therefore survey catches may not accurately represent population size.

Current surveys do cover a large part of the stock area in northern European waters, but data for other areas are unavailable. The spatial and bathymetric distribution of tope may be influenced by the availability of pelagic prey, which may lead to further variability in catch rates in surveys.

In the absence of any other data sources, surveys with high headline trawls may be the most appropriate species-specific data currently available.

10.11 Reference points

No reference points have been proposed for this stock.

10.12 Conservation considerations

The most recent IUCN Red List Assessment for Europe (Nieto *et al*., 2015) identified tope as Vulnerable, and it is also listed as Vulnerable globally (Gibson *et al*., 2008).

10.13 Management considerations

Tope is considered highly vulnerable to overexploitation, as this species has low population productivity, relatively low fecundity and a protracted reproductive cycle. Unmanaged targeted fisheries elsewhere in the world have resulted in stock collapse (e.g. off California and South America).

Tope is an important target species in recreational fisheries; though there are insufficient data to examine the relative economic importance of tope in the recreational angling sector, this may be high in some regions.

Tope is, or has been, a targeted species elsewhere in the world, including Australia/New Zealand, South America and off California. Evidence from these fisheries (see stock annex and references cited therein) suggests that any targeted fisheries would need to be managed conservatively, exerting a low level of exploitation.

Australian fisheries managers have used a combination of a legal minimum and maximum lengths, legal minimum and maximum gillnet mesh sizes, closed seasons and closed nursery areas. These measures may have less utility in the ICES area as tope is taken here mainly in mixed fisheries.

Following the publication of the GFCM (General Fisheries Commission for the Mediterranean) Report of the Workshop on Stock Assessment of selected species of Elasmobranchs in the GFCM area in 2011, WGEF believes that collaboration should continue between ICES and the GFCM. This will encourage the sharing of information and aid the better understanding of elasmobranch fisheries in the Mediterranean, where WGEF data for this region are often lacking.

10.14 References

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Table 10.1. Tope in the Northeast Atlantic. Reported species-specific landings (tonnes) for the period 1975–2004. These data are considered underestimates as some tope are landed under generic landings categories, and species-specific landings data are not available for the Mediterranean Sea and are limited for Northwest African waters.

ICES Area and Nation	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
ICES Division 3.a, 4																					
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
France	na	na	Na	32	22	na	na	26	26	13	31	13	14	18	12	17	16	10	11	12	8
Netherlands																					
Sweden	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	na	na	Na	na	na	na	na	8	10	31	36	94	28	22	18	14	21	15	15	19	25
UK (Scotland)																-	-	-	-	-	-
Subtotal	0	0	0	32	22	0	0	34	36	44	67	107	42	40	30	31	37	25	26	31	33
ICES Subarea 6–7																					
France	na	na	Na	522	2076	na	na	988	1580	346	339	1141	491	621	407	357	391	235	240	235	265
Ireland	na	na	Na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Netherlands																					
Spain	na	na	Na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Spain (Basque country)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	na	na	Na	na	na	na	na	63	51	28	23	21	21	21	55	45	47	53	48	49	38
UK (Scotland)																					
Subtotal				522	2076	0	0	1051	1631	374	362	1162	512	642	462	402	438	288	288	284	303
ICES Subarea 8																					
France	na	na	Na	na	237	na	na	na	63	119	52	103	97	66	39	34	38	34	40	54	44
Spain	na	na	Na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Spain (Basque country)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ICES Area and Nation	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
UK (E&W)	-	-	-	+	+	+	+	+	+	+	+	1									0
UK Scotland																					
Subtotal				0	237	0	0	0	63	119	52	104	97	66	39	34	38	34	40	54	44
ICES Subarea 9																					
Spain	na	na	Na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Subtotal																					
ICES Subarea 10																					
Portugal	18	na	Na	24	15	51	77	42	24	29	24	24	24	34	23	56	81	80	115	116	124
Subtotal	18			24	15	51	77	42	24	29	24	24	24	34	23	56	81	80	115	116	124
Other/Unknown																					
France	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
CECAF area																					
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL LANDINGS	**18**	**0**	**0**	**578**	**2350**	**51**	**77**	**1127**	**1754**	**567**	**505**	**1397**	**675**	**782**	**554**	**523**	**593**	**427**	**469**	**485**	**504**

Table 10.1. (continued). Tope in the Northeast Atlantic. Reported species-specific landings (tonnes) for the period 1975–2014. These data are considered underestimates as some tope are landed under generic landings categories, and species-specific landings data are not available for the Mediterranean Sea and are limited for Northwest African waters.

ICES Area and Nation	1996	1997	1998	1999	2000	2001	2002	2003	2004
ICES Division 3.a, 4									
Denmark	-	.	.	3	8	4	5	5	5
France	11	5	11		11	11	6	6	3
Netherlands									
Sweden	-	.	.	.	.	.	.	.	.
UK (E&W)	14	22	12	14	13	10	13	11	8
UK (Scotland)	-	.	.	.	.	.	.	.	.
Subtotal	25	27	23	17	32	25	24	22	16
ICES Subareas 6–7									
France	314	409	312		368	394	324	284	209
Ireland	Na	na	na	na	na	4	1	6	4
Netherlands		.	.	.	.	.	.	.	.
Spain	Na	na	na	na	na	+	242	3	na
Spain (Basque country)	-	.	.	.	.	+	+	3	15
UK (E&W)	39	34	41	62	98	72	60	55	65
UK (Scotland)									
Subtotal	353	443	353	62	466	470	627	351	293
ICES Subarea 8									
France	78	40	46	+	71	58	49	60	16
Spain	Na	na	na	na	na	9	13	10	na
Spain (Basque country)	-	.	.	.	.	9	6	10	10

ICES Area and Nation	1996	1997	1998	1999	2000	2001	2002	2003	2004
UK (E&W)	0	0	0	0		1		3	8
UK Scotland									
Subtotal	78	40	46	0	71	77	68	83	34
ICES Subarea 9									
Spain	Na	na	na	na	na	na	na	na	76
Subtotal									
ICES Subarea 10									
Portugal	80	104	128	129	142	82	77	69	51
Subtotal	80	104	128	129	142	82	77	69	51
Other/Unknown									
France	-	.	.	386	.	2	.	.	.
CECAF area									
Portugal	-	.	.	.	2	1	2	98	na
TOTAL LANDINGS	536	615	551	593	713	656	798	622	394

Table 10.2. Tope in the Northeast Atlantic. ICES estimates of tope landings (tonnes) by area 2005-2016 following WKSHARKS2 (ICES, 2016a).

Fishing Area	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
27.2	0.0	0.0	0.0	0.0		0.0	0.0		0.0		0.0		
27.3	1.1	1.3	0.0	0.1		1.0	1.0			1.0	0.4	0.1	
27.4	24.2	26.8	15.6	13.2	9.5	9.2	15.5	6.8	6.4	5.6	6.3	9.2	11.7
27.5b	0.0	0.0	0.5	0.1	0.0	0.0			0.0	0.0	0.0	0.0	
27.6	3.4	4.0	6.7	5.6	8.0	1.3	0.6	0.7	1.2	1.1	6.2	0.5	0.8
27.7	417.8	445.8	366.7	359.9	348.6	311.1	262.6	277.8	279.5	245.5	301.2	233.8	269.8
27.8	113.1	110.9	102.9	123.4	145.8	80.0	85.1	54.6	60.9	52.8	64.5	90.8	96.8
27.9	37.9	54.0	47.3	48.2	72.6	59.7	53.9	45.0	48.8	54.4	51.1	34.2	8
27.10	44.7	45.2	42.6	46.6	33.9	41.3	43.6	47.4	45.7	65.4	71.0	84.9	
27.12			0.0				0.0			0.0	0.0		
27.14							0.0	0.0					
27													
(unspecified, incl. BIL94B)	0.2	0.2	0.0	0.0		0.1	0.1	0.0		0.0			
34*	5.0	10.7	3.2	11.1	5.5	28.4	8.0	5.3	2.4	3.6	0.0	0.3	
37*/BIL95	20.3	16.3	15.6	12.8	25.9	32.4	41.2	28.4	38.4	33.0			
Total	**667.7**	**715.2**	**601.3**	**621.1**	**649.9**	**564.4**	**511.5**	**466.1**	**483.3**	**462.4**	**500.8**	**453.7**	**387.2**

* Landings data from areas 34 and 37 are incomplete and not based on all nations fishing in those areas.**Table 10.3. Tope in the Northeast Atlantic. ICES species-specific estimates of tope landings (tonnes) 2005-2016 following WKSHARKS2 (ICES, 2016a)**

Table 10.3. Tope in the Northeast Atlantic. ICES species-specific estimates of tope landings (tonnes) 2005-2016 following WKSHARKS2 (ICES, 2016a)

NATION	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium												0.1	0.1
Denmark	7.0	6.0	2.0	3.0	2.0	2.0	3.0	1.0		3.0	1.4	0.9	
France	347.8	383.2	301.9	365.1	353.8	319.7	291.4	282.5	308.9	261.1	349.8	302.7	312.8
Germany													0.4
Ireland	5.5	6.8	2.6	2.1	2.9	3.1	0.6	0.3					
Netherlands						2.1	17.7	24.8	11.2	11.4	5.8	8.2	18.7
Norway						0.1	0.2		0.0		0.0		
Portugal	44.73	45.23	42.60	46.57	33.88	41.34	43.52	47.41	45.74	65.41	71.0	85.2	0.2
Spain	181.7	181.8	202.9	163.1	234.0	179.4	138.1	94.0	100.3	101.1	55.7	36.8	41.3
Sweden	0.1	0.3	0.0	0.1									
UK	80.8	91.9	49.4	41.1	23.3	16.8	17.0	16.1	17.1	20.4	17.0	19.8	13.7
Total	**667.7**	**715.2**	**601.3**	**621.1**	**649.9**	**564.4**	**511.5**	**466.1**	**483.3**	**462.4**	**500.8**	**453.7**	**387.2**

Table 10.4. Tope in the Northeast Atlantic. Nominal and standardized CPUE series (kg 10-3 hooks) for tope Galeorhinus galeus catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds.

Year	Nominal CPUE	Standardized CPUE	LCI	UCI
1990	0.37	2.01	1.74	2.29
1991	1.51	1.94	1.62	2.27
1992	0.08	2.86	2.25	3.47
1993	0.62	1.26	1.02	1.49
1994	0.22	0.71	0.57	0.85
1995	0.14	0.81	0.67	0.95
1996	0.20	0.57	0.45	0.69
1997	0.76	0.94	0.72	1.16
1998	1.63	0.95	0.73	1.17
1999	2.43	1.28	0.95	1.62
2000	2.40	1.24	0.93	1.55
2001	1.53	1.06	0.80	1.31
2002	1.08	1.09	0.84	1.35
2003	1.39	0.74	0.59	0.88
2004	0.67	0.64	0.50	0.78
2005	0.39	0.57	0.47	0.67
2006	0.41	0.56	0.47	0.65
2007	0.30	0.49	0.41	0.57
2008	0.62	0.56	0.46	0.65
2009	0.78	0.82	0.69	0.95
2010	1.00	0.74	0.62	0.86
2011	1.09	0.84	0.71	0.97
2012	1.38	0.74	0.62	0.87
2013	1.53	1.01	0.86	1.16
2014	1.59	0.79	0.65	0.94
2015	1.51	0.89	0.72	1.07
2016	1.39	0.88	0.70	1.06

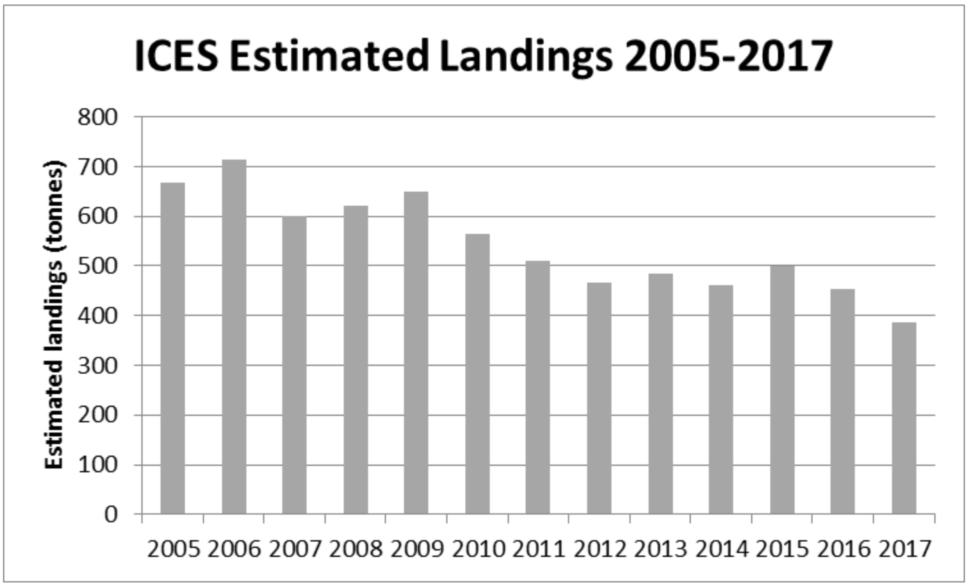

Figure 10.1. Tope in the Northeast Atlantic. ICES species-specific estimated landings 2005–2017.

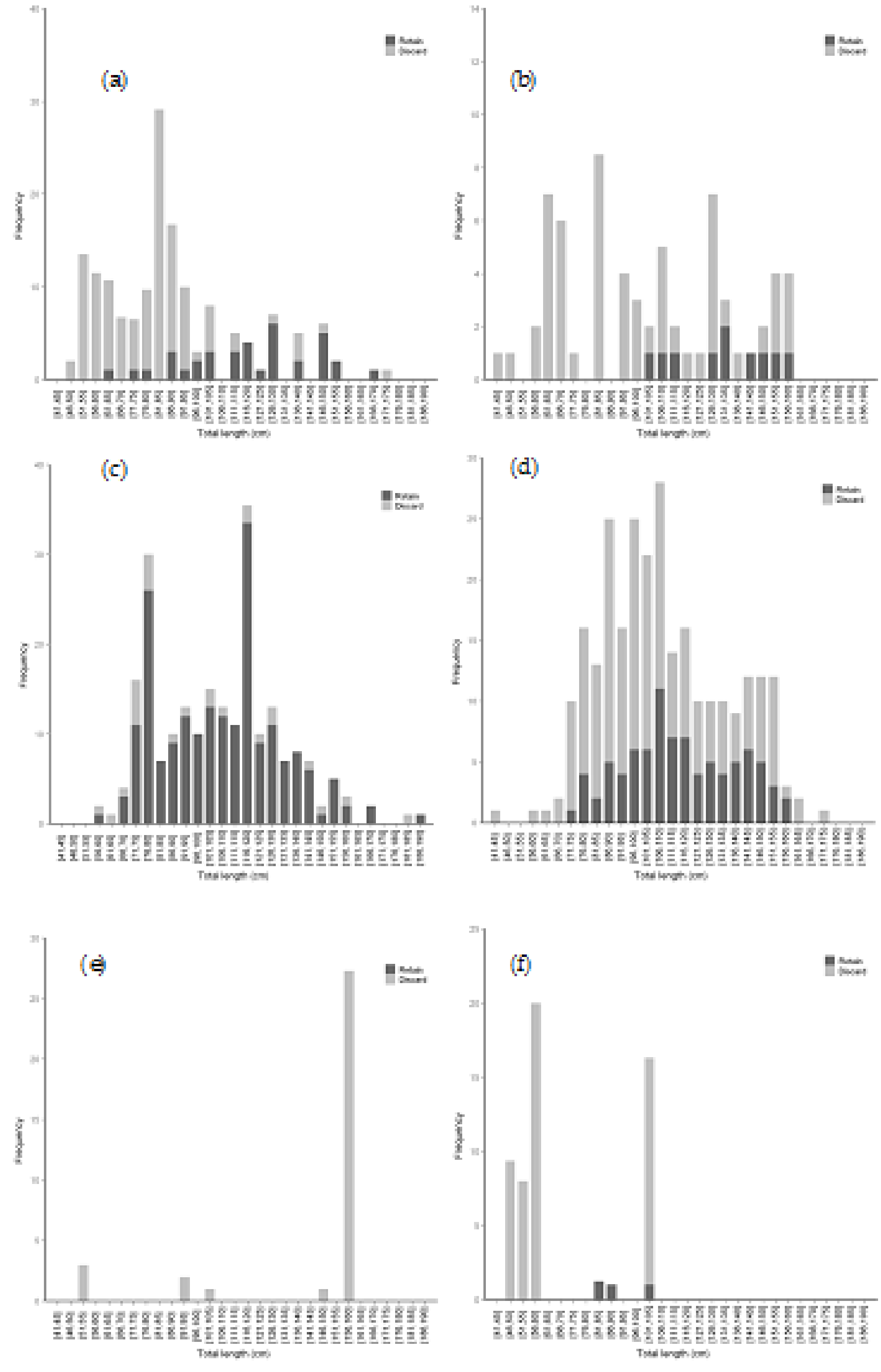

Figure 10.2. Tope in the Northeast Atlantic. Length–frequency of discarded and retained tope *Galeorhinus galeus* by (a) otter trawl (2002–2007), (b) otter trawl (2008–2011), (c) gillnet (2002–2007), (d) gillnet (2008–2011), (e) beam trawl (2002–2011) and (f) *Nephrops* trawl (2002–2011) across both ecoregions, as recorded in the Cefas observer programme. Source: Silva *et al.* (2013 WD).

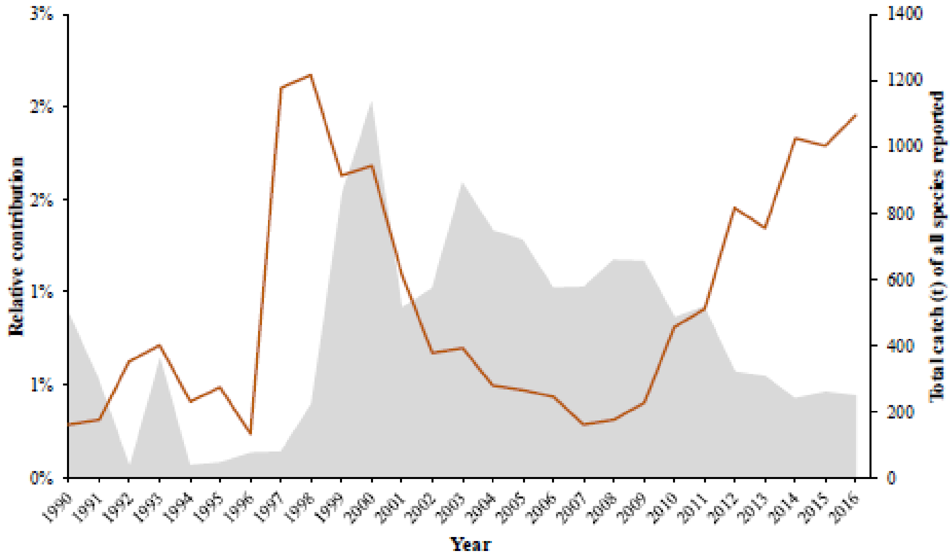

Figure 10.3. Tope in the Northeast Atlantic. Total catch of all species (■) and relative contribution of tope *Galeorhinus galeus* to all species (▬) landed by the Azorean bottom longline fleet and sampled by the DCF inquiries.

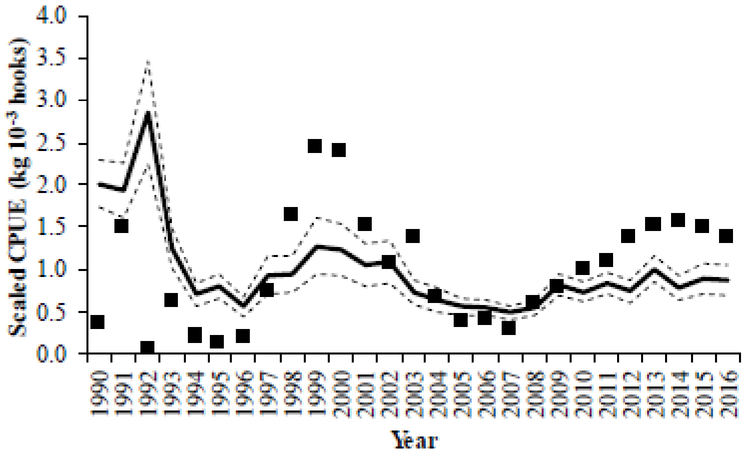

Figure 10.4. Tope in the Northeast Atlantic. Nominal (■) and standardized (—) CPUE (kg 103 hooks) for tope *Galeorhinus galeus* from the Azorean bottom longline fishery, 1990–2016. Dotted lines represent 95% confidence intervals for the standardized CPUE.

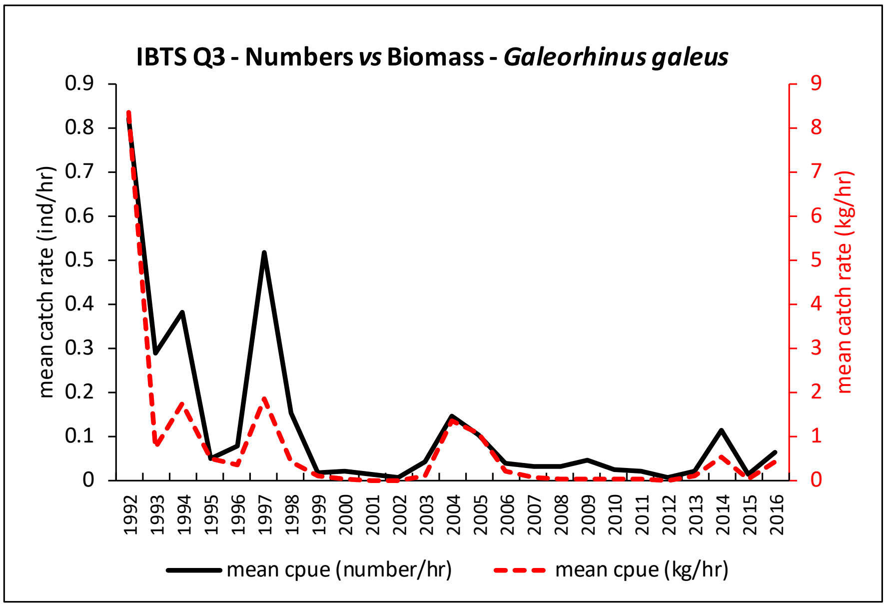

Figure 10.5. Tope in the Northeast Atlantic. Mean catch rate in terms of numbers (ind/hr) and biomass (kg/hr) during the IBTS_Q3 of the North Sea (1992–2016). <u>Note</u>: The large catch in 1992 is largely due to a large catch reported in one haul, and these data should be verified. Some catches of tope are considered to have been reported as *Mustelus* on DATRAS, consequently this time-series does not provide a robust abundance trend.

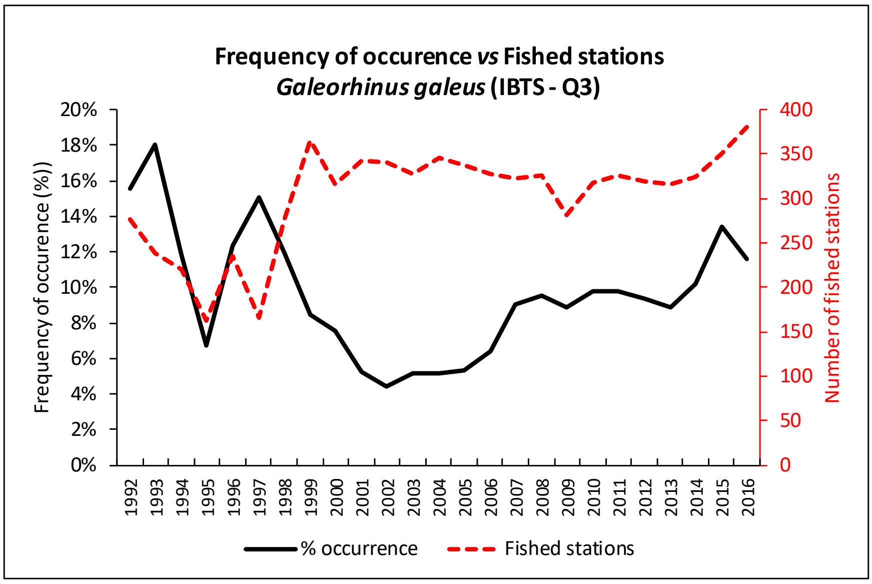

Figure 10.6. Tope in the Northeast Atlantic. Frequency of occurrence and number of fished stations in the IBTS-Q3 of the North Sea (1992–2016).

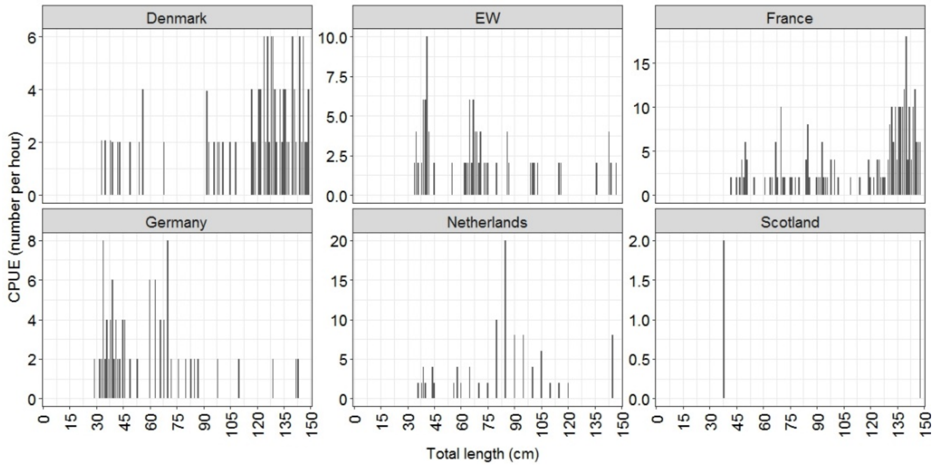

Figure 10.7. Tope in the Northeast Atlantic. Length-frequency distribution of tope by country in the IBTS-Q3 of the North Sea (1992–2016).

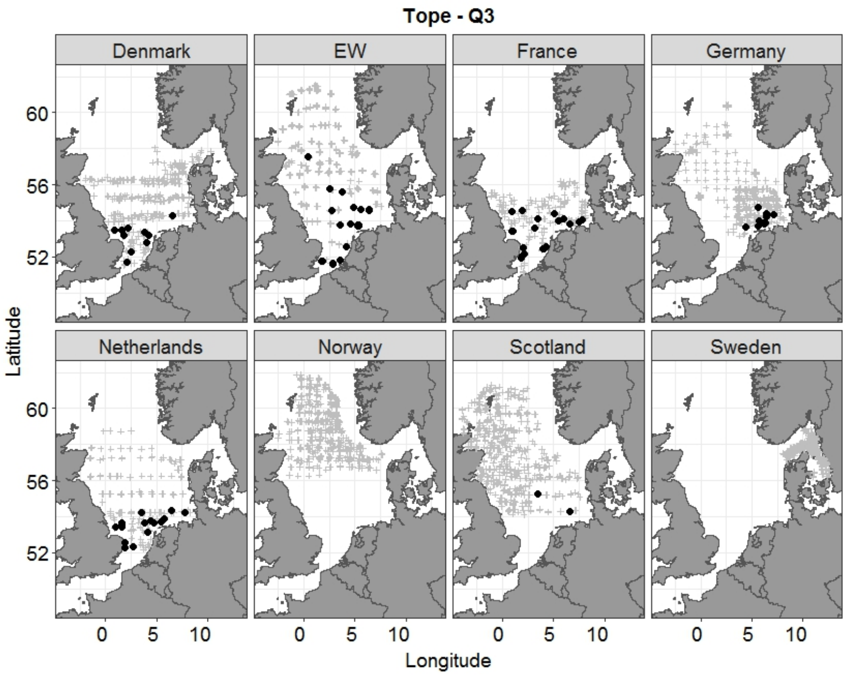

Figure 10.8. Tope in the Northeast Atlantic. Spatial distribution of tope by country in the IBTS-Q3 of the North Sea (1992–2016) (black dots = positive hauls; grey dots = negative hauls).

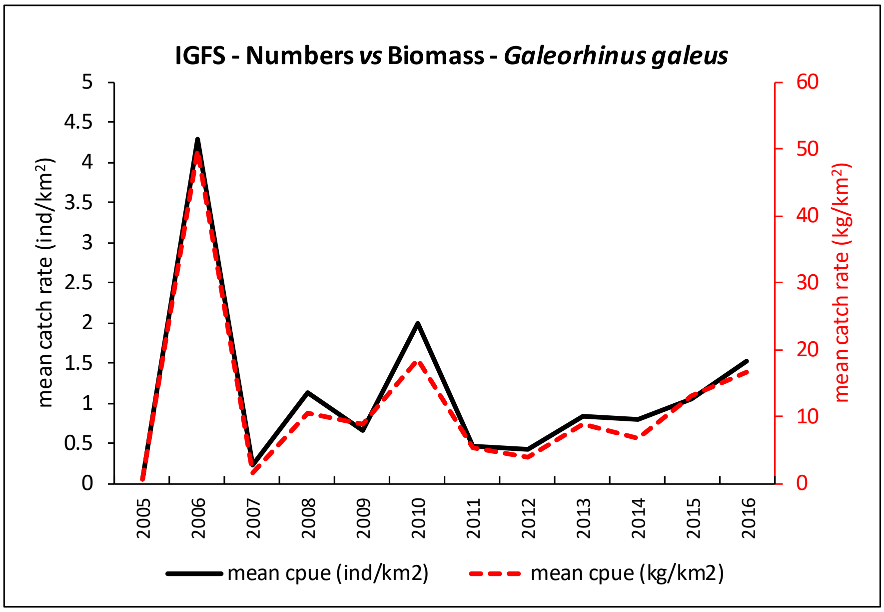

Figure 10.9. Tope in the Northeast Atlantic. Mean catch rate in terms of numbers (ind/km²) and biomass (kg/ km²) during the Irish Ground Fish Survey (IGFS-WIBTS-Q4) 2005–2016.

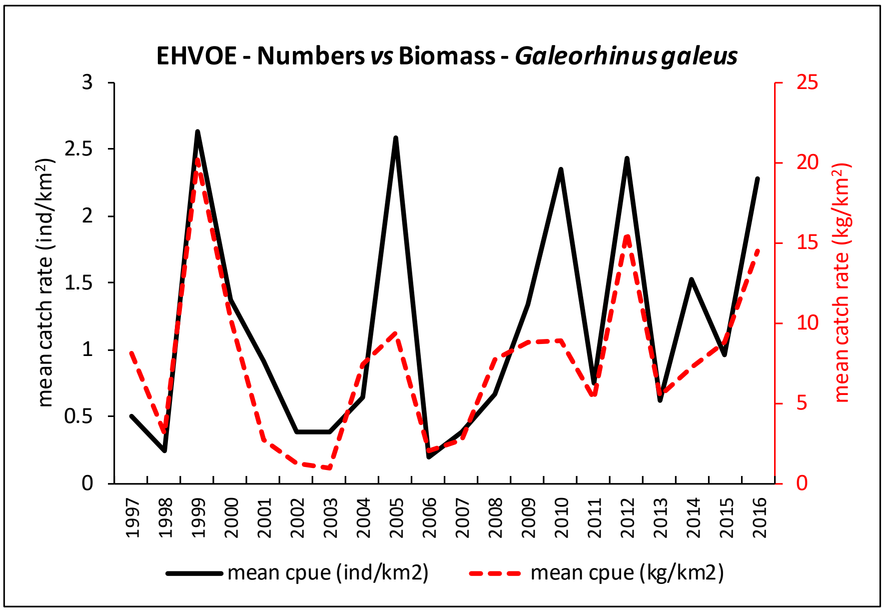

Figure 10.10. Tope in the Northeast Atlantic. Mean catch rate in terms of numbers (ind/km²) and biomass (kg/ km²) during the EHVOE-WIBTS-Q4 (1997–2016).

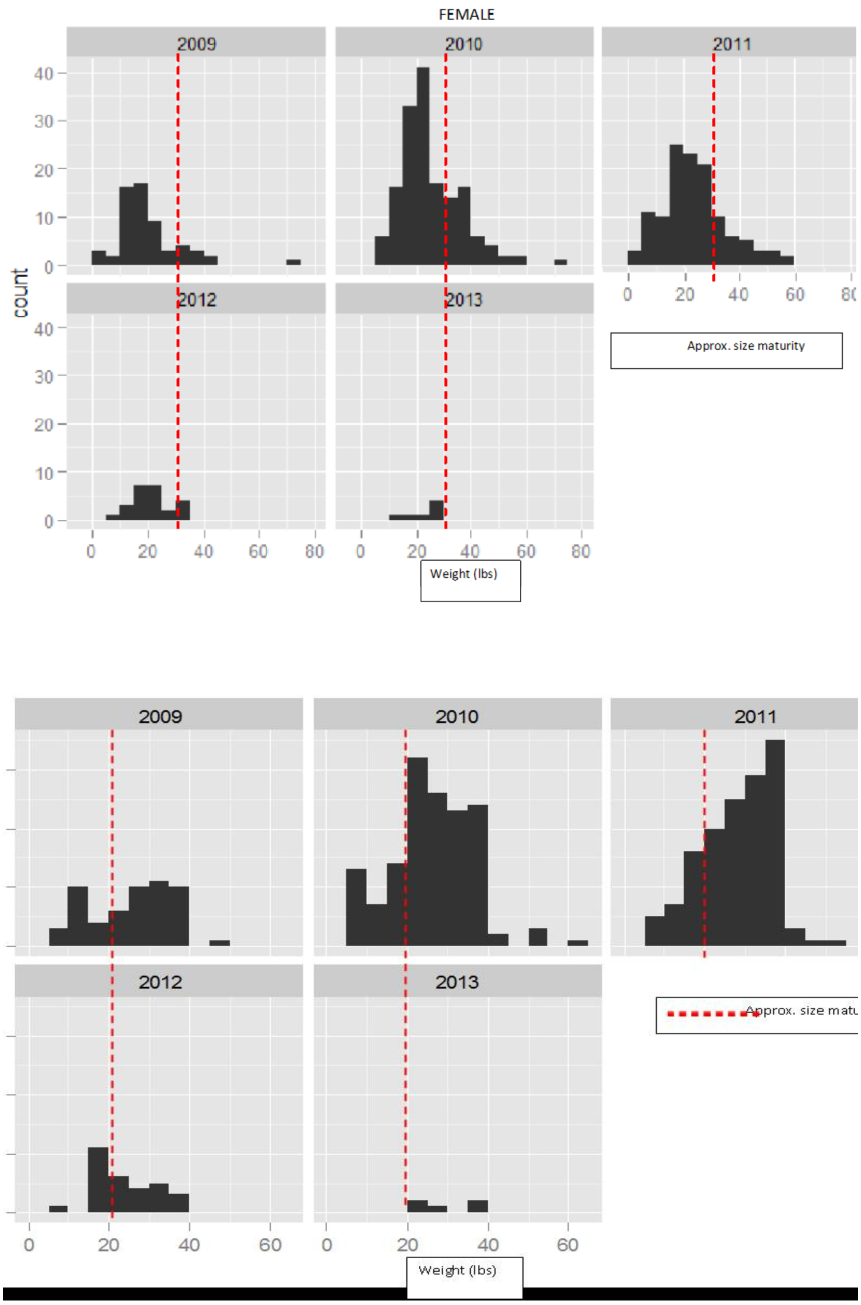

Figure 10.11. Tope in the Northeast Atlantic. Count by year of captures of female (top) and male (bottom) tope by recreational fishery in the Mull of Galloway, Scotland. The red lines show approximate weight-at-maturity. Source James Thorburn, University of Aberdeen. Unpublished data, 2014.

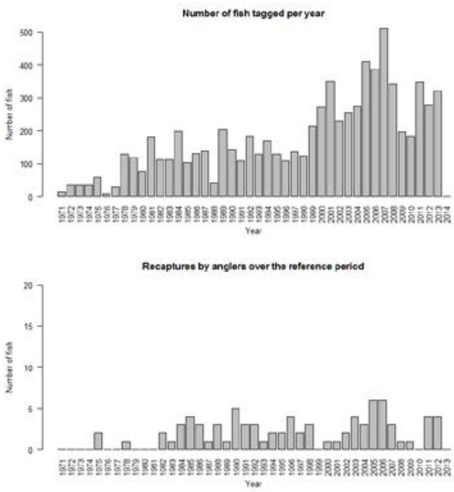

Figure 10.12. Tope in the Northeast Atlantic. Numbers captured, recaptured and newly captured per year. Source: Bal *et al.* (2015 WD).

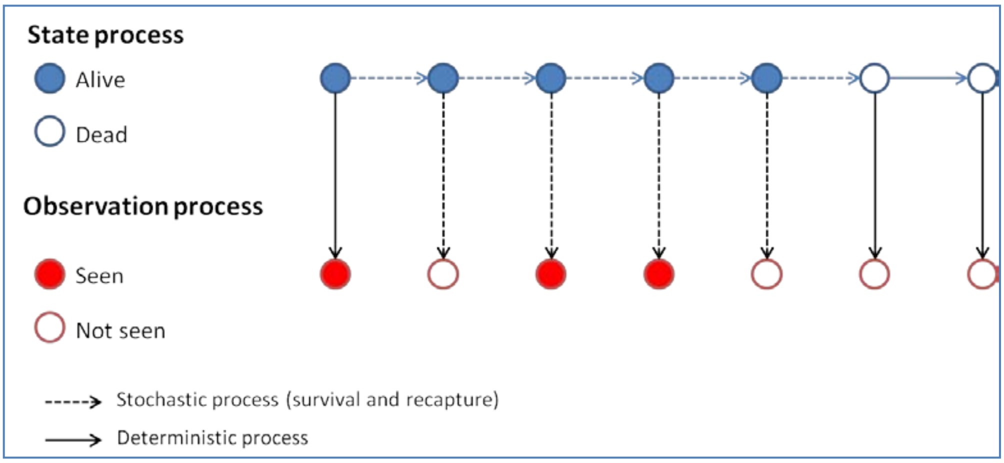

Figure 10.13. Tope in the Northeast Atlantic. Example of the state and observation process of a marked individual over time for the CJS model. The sequence of true states in this individual is A = [1, 1, 1, 1, 1, 0, 0] and the observed capture history is H = [1, 0, 1, 1, 0, 0, 0]. Source: Bal *et al.* (2015 WD).

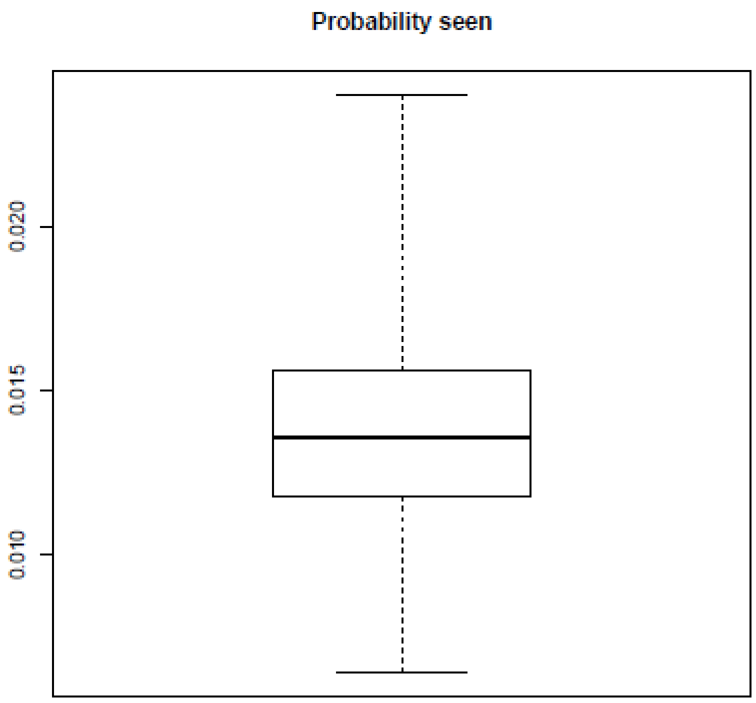

Figure 10.14. Tope in the Northeast Atlantic. Individual capture probability posterior.

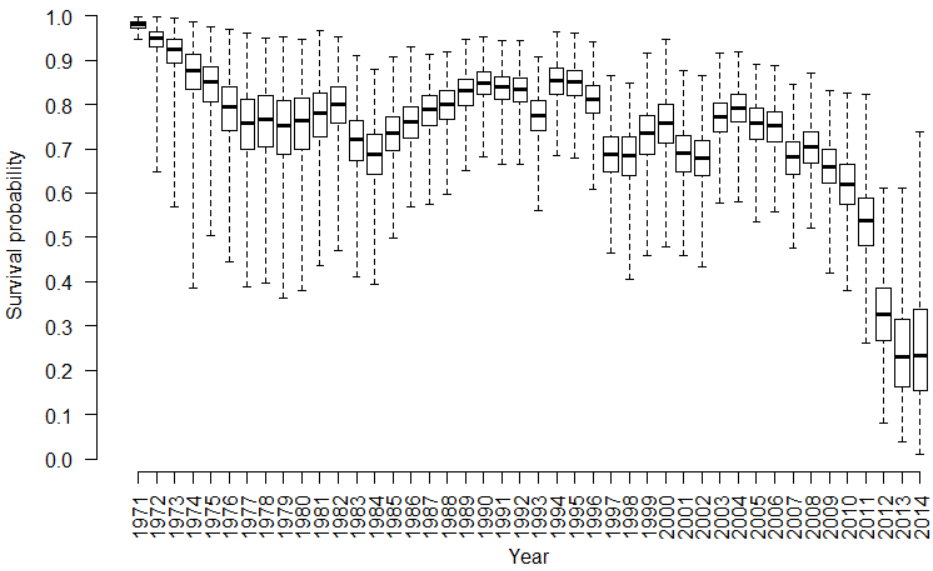

Figure 10.15. Tope in the Northeast Atlantic. Annual survival probabilities posteriors. Source: Bal *et al.* (2015 WD).

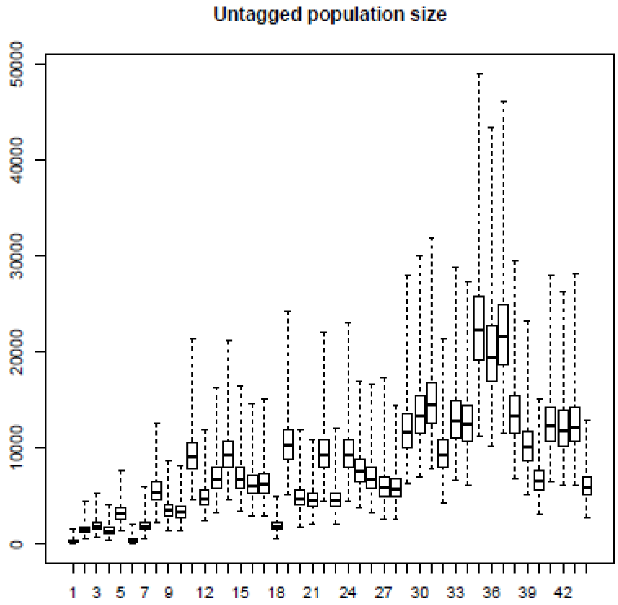

Figure 10.16. Tope in the Northeast Atlantic. Boxplot annual population size posteriors without population dynamics structure, x-axis shows study year (1971–2014).

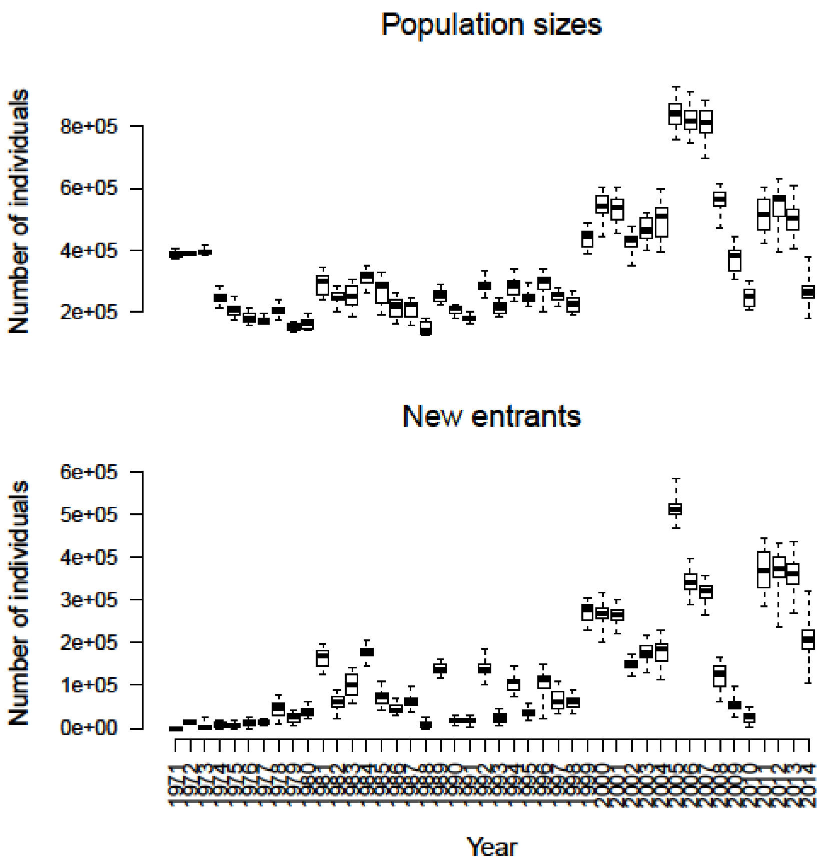

Figure 10.17. Tope in the Northeast Atlantic. Boxplot annual population sizes and number of entrant's posteriors with population dynamics structure (1971–2014).

11 Thresher sharks in the Northeast Atlantic and Mediterranean Sea

11.1 Stock distribution

Two species of thresher occur in the ICES area: common thresher, *Alopias vulpinus* and bigeye thresher, *A. superciliosus.* Of these species, *A. vulpinus* is the main species encountered on the continental shelf of the ICES area.

There is little information on the stock identity of these species, which have a near circumglobal distribution in tropical and temperate waters. WGEF assumes there to be a single stock of *A. vulpinus* in the NE Atlantic and Mediterranean Sea, with this stock extending into the CECAF area. The presence of a nursery ground in the Alboran Sea provides the rationale for including the Mediterranean Sea within the stock area. Further information on stock identity is given in the Stock Annex (ICES, 2009).

11.2 The fishery

11.2.1 History of the fishery

There are no target fisheries for thresher sharks in the NE Atlantic. Both species are a bycatch in longline fisheries for tuna and swordfish, and would have been taken in earlier pelagic drift net fisheries. Common thresher is an occasional bycatch in gillnet fisheries. Fisheries data for the ICES area are limited and unreliable. It is likely that some commercial data for the two species are confounded.

In the Mediterranean Sea where the two thresher sharks species occur, there are no target fisheries. Both are bycatches in various fisheries, including the Moroccan driftnet fishery in the southwest Mediterranean. The two species are also caught in industrial and semi-industrial longline fisheries and artisanal gillnet fisheries. In France, thresher sharks are caught incidentally by trawlers targeting small pelagic fish in the Gulf of Lions and they were landed in two main ports (Sète and Port La Nouvelle).

11.2.2 The fishery in 2017

No new information.

11.2.3 ICES Advice applicable

ICES first provided advice for thresher sharks in 2015, stating that "*ICES advises that when the precautionary approach is applied for common thresher shark Alopias vulpinus and bigeye thresher shark Alopias superciliosus in the Northeast Atlantic, fishing mortality should be minimized and no targeted fisheries should be permitted. This advice is valid for 2016 to 2019*".

11.2.4 Management applicable

Section 23 of Council Regulation (EU) 2016/72 of 22 January 2016 prohibits EU vessels in the ICCAT convention area either "*Retaining on board, transhipping or landing any part or whole carcass of bigeye thresher sharks (Alopias superciliosus) in any fishery*" of "*to undertake a directed fishery for species of thresher sharks of the Alopias genus*". These management measures were continued into 2017.

Council Regulation No. 1185/2003 prohibits the removal of shark fins of these species, and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

11.3 Catch data

11.3.1 Landings

Landings of thresher shark are reported irregularly and are variable; from 11–198 t in the North and Eastern Atlantic and Mediterranean Sea (ICCAT and national data; Tables 11.1–11.4, noting that only Table 11.4 was updated this year). An unknown proportion of landings are reported as generic 'sharks'. The main European nations reporting thresher shark in landings are Portugal, Spain and France, although the large quantities reported by Portugal to ICCAT in 2006 and 2007 still need to be verified.

There can be large inter-annual variation in reported landings, as well as differences in values reported to ICCAT and ICES. Further studies to refine landings data for thresher shark are required, and should be explored in the proposed joint meetings with the ICCAT shark subgroup.

As well as being caught and landed from fisheries for tuna and tuna-like species, thresher sharks are also a bycatch in continental shelf fisheries in the ICES area, including subareas 4, 6–9a.

11.3.2 Discards

Limited data are available.

11.3.3 Quality of catch data

Thresher sharks have not been reported consistently, either at species-specific or generic level. There are also some discrepancies between some data sources. Landings of thresher shark in coastal waters are most likely to represent *A. vulpinus*, but some of these landings may also be reported as 'sharks nei'.

11.3.4 Discard survival

There is limited information on discard survival from European fisheries, but there have been several studies elsewhere in the world. Braccini *et al.* (2012) found that about two thirds of thresher shark captured in gillnets were dead, even with a short soak time, although this was based on a small sample size. Moderate to high levels of mortality have been reported in pelagic longline fisheries, with most studies indicating that about half of the thresher sharks captured are in poor condition or dead (see Ellis *et al.*, 2017 and references therein).

11.4 Commercial catch composition

Length–frequency distributions for *A. vulpinus* were collected under the Data Collection Regulation (DCR) programme by observers on board French vessels (see ICES, 2015). Given the potential problems of how thresher sharks are measured (standard length, fork length, total length), improved standardisation of length-based information is required.

11.5 Commercial catch and effort data

Limited data on landing and effort are available for the ICES area. ICES and ICCAT should cooperate to collate and interpret commercial catch data from high seas and shelf fisheries.

11.6 Fishery-independent surveys

No fishery-independent data are available for the NE Atlantic.

11.7 Life-history information

Various aspects of the life history, including conversion factors, and nursery grounds for these species are included in the Stock Annex.

There have been a few recent published studies on *A. vulpinus*. Cartamil *et al.* (2016) examined the movements of *A. vulpinus* along the western coast of the USA and Mexico; Natanson *et al.* (2016) provided revised growth curves for *A. vulpinus*, in the NW Atlantic; and Finotto *et al.* (2016) commented on the occurrence of *A. vulpinus* in the northern Adriatic Sea. Relevant information from these studies should be reviewed for future work by WGEF.

11.7.1 Movements and migrations

The "Alop" Project tagged two specimens in the Gulf of Lions. The behaviour of one female (135 cm L_T) was recorded for 200 days. Horizontal movements within a restricted area of the Gulf of Lions were observed; the female stayed in coastal shelf areas from July to September, moving to deeper waters afterwards, probably as a response to the seasonal drop in sea surface temperature. Another specimen (120 cm L_T) stayed mostly at depths of 10–20 m with occasional dives to 800 m.

Nakano *et al*. (2003) conducted an acoustic telemetry study to identify the short-term horizontal and vertical movement patterns of two immature female *A. superciliosus* in the eastern tropical Pacific Ocean (summer 1996). Distinct crepuscular vertical migrations were observed; specimens often occurring at 200–500 m depth during the day and at 80–130 m depth at night, with slow ascents and relatively rapid descents during the night, the deepest dive being 723 m. The estimate of the mean swimming speed over the ground ranged from 1.32-2.02 km h^{-1}.

Weng and Block (2004) studied diel vertical migration patterns of two *A. superciliosus* that were caught and tagged with pop-up satellite archival tags in the Gulf of Mexico and near Hawaii. Both showed strong diel movement patterns, spending most of the day below the thermocline (waters of 10°C at 300–500 m and 400–500 m) and occurring in warmer (>20°C) surface mixed layers above the thermocline (10–50 m) at night.

Carlson and Gulak (2012) provided results from a tagging programme with archival tags deployed on *A. superciliosus*. One specimen exhibited a diurnal vertical diving behaviour, spending most of their time between 25 and 50 m depth in waters between 20 and 22°C while the other dove down to 528 m. Deeper dives occurred more often during the day, and by night they tended to stay above the thermocline.

Cao *et al.* (2012) provided data for *A. superciliosus* and *A. vulpinus* around the Marshall Islands, where they occurred at depths of 240–360 m and 160–240 m, temperatures of 10–16°C and 18–20°C and salinities of 34.5–34.7 and 34.5–34.8, respectively.

11.7.2 Nursery grounds

Nursery areas for *A. superciliosus* occur off the southwestern Iberian Peninsula and Strait of Gibraltar (Moreno and Moron, 1992). Juvenile *A. vulpinus* are known to occur in the English Channel and southern North Sea (Ellis, 2004). Further information on potential nursery areas is given in the Stock Annex.

11.7.3 Diet

The two thresher shark species feed mostly on small pelagic fish, including mackerel and clupeids, as well as squid and octopus.

11.8 Exploratory assessments

No assessments have been conducted for thresher sharks in the NE Atlantic.

Both species were included in a Productivity-Susceptibility Analysis (PSA) for the pelagic fish assemblage (ICCAT, 2011). The lack of reliable landings data, and absence of fishery-independent data hampers the assessment of these stocks.

11.9 Stock assessment

No assessments have been undertaken due to insufficient data. Species-specific landings are required. Any assessment will need to be undertaken in collaboration with ICCAT.

11.10 Quality of assessments

No assessment has been undertaken.

11.11 Reference points

No reference points have been proposed for these stocks.

11.12 Conservation considerations

In 2015, a revision of the Red List for European Marine Fishes classified both *Alopias vulpinus* and *A. superciliosus* as Endangered (Nieto *et al.*, 2015).

11.13 Management considerations

There is limited knowledge of the stock structure or the status of the two thresher shark species occurring in the NE Atlantic.

Liu *et al.* (1998) considered *Alopias* spp. to be particularly vulnerable to overexploitation and needing close monitoring because of their high vulnerability resulting from low fecundity and relatively high age of sexual maturity.

Ecological risk assessments undertaken by ICCAT for eleven pelagic sharks indicated that the bigeye thresher has the lowest productivity and highest vulnerability with a productivity rate of 0.010, and that the common thresher was ranked 10th, with a productivity rate of 0.141 (ICCAT, 2011).

In 2009, the International Commission for the Conservation of Atlantic Tuna (ICCAT, 2009) recommended the following:

1) "CPCs (The Contracting Parties, Cooperating non-Contracting Parties, Entities or Fishing Entities) shall prohibit, retaining on board, transhipping, landing, storing, selling, or offering for sale any part or whole carcass of bigeye thresher sharks (*Alopias superciliosus*) in any fishery with exception of a Mexican small-scale coastal fishery with a catch of less than 110 fish;

2) CPCs shall require vessels flying their flag to promptly release unharmed, to the extent practicable, bigeye thresher sharks when brought along side for taking on board the vessel;

3) CPCs should strongly endeavour to ensure that vessels flying their flag do not undertake a directed fishery for species of thresher sharks of the genus *Alopias* spp.;

4) CPCs shall require the collection and submission of Task I and Task II data for *Alopias* spp. other than *A. superciliosus* in accordance with ICCAT data reporting requirements. The number of discards and releases of *A. superciliosus* must be recorded with indication of status (dead or alive) and reported to ICCAT in accordance with ICCAT data reporting requirements;

5) CPCs shall, where possible, implement research on thresher sharks of the species *Alopias* spp. in the Convention area in order to identify potential nursery areas. Based on this research, CPCs shall consider time and area closures and other measures, as appropriate."

Some of these recommendations appear to have been acted on by the EU (see Section 11.2.4).

At the CITES Conference of Parties in September 2016 *Alopias* spp. were included on Appendix II. The species covered are the bigeye thresher *A. superciliosus,* and the look-alike species common thresher *A. vulpinus* and pelagic thresher *A. pelagicus*. This listing will go into effect in October 2017.

11.14 References

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Table 11.1. Thresher sharks in the Northeast Atlantic and Mediterranean Sea. Reported landings of thresher sharks (1997 to 2016; ICCAT data, accessed June 2018). An unknown proportion of thresher sharks are reported in combined sharks. Areas are AZOR: Azores; CVER: Cape Verde; EAST: East Atlantic; ETRO: East Tropical Atlantic; MDRA: Madeira; MEDI: Mediterranean Sea; N.ADR: North Adriatic Sea; N.ION: North Ionian Sea; NE: Northeast Atlantic; NORT: North Atlantic; and S.SIC: Strait of Sicily.

Flag	Area	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Algerie	MEDI																	0		0.4	
China	MEDI														0	0	0	0	0		
	NE														0	0.2	2	2.1	0.2		
Cote	ETRO																			9.5	
Cyprus	MEDI															0					
Spain	MEDI	3.5	7.2	6.7	9.2	9	25.3	0.4	1.1			2.5	2.7	0.2	0	0	0	0			
	NE	190.3	167.4	49.6	42.1	109	48.6	26.1	59.4			43.9	70.4	77.7	0			0			
	NORT	0.1							3.8					0	0	0	0				
France	MEDI											5.7	9.6	5.7	1.6	1	0.5	1.4	0	2.5	
	NE								23.3	18.5		31.2		26	25.3	40.6	6.7	30.9	0	38.8	37.0
Ireland	NE				0.1			0	0.1		0.3										
Italy	MEDI											7.4	5.5	13.9	4.1			21.3			
	N.ADR																		2		0.5
	N.ION																		0		
	S.SIC																		0.7		
Malta	MEDI	0.1	0.7	0.2	1.4	0	0	0	0	0	0	0.2	0.1	0.3	0.1	0.1	0	0	0		
Portugal	AZOR									8.1	11.9	13.6	7.5	21.3	0.6						
	CVER											2.2									
	EAST								0.1			2.3	2								
	MDRA									0.1	1	3.1		0.1							
	MEDI						0.5				0.1										
	NE		0	1.3	1.8	1.6	21.2	17.5	20.9		94.5	81.8	43.8	43.1	15.1		0.6	1.4			
	NORT								0.5												
UK	NE										0	1.1	0.8	0.7	1.6	1.3	0.8	1.1	2	2.5	3
Ghana	ETRO																		58.3	142.9	
Korea	NE																	0.3	0.1		
Russia	ETRO									0.3											
Senegal	NE												2.5	9				0	0		
	NORT																0				
TOTAL		193.9	175.3	57.8	54.6	119.6	95.7	44.1	109.2	27	107.8	195	144.9	198	48.5	43.3	10.6	58.5	63	196.6	40.5

Table 11.2. Thresher sharks in the Northeast Atlantic and Mediterranean Sea. Reported landings of thresher shark by species and nation (ICCAT data, accessed June 2018). An unknown proportion of thresher sharks are reported in combined sharks. ALV = *Alopias vulpinus*, BTH = *Alopias superciliosus*, THR = *Alopias* spp.

	Spain			France			Ireland		Italy	Malta		Portugal			United Kingdom
Year	THR	BTH	ALV	THR	BTH	ALV	THR	ALV	ALV	BTH	ALV	THR	BTH	ALV	THR
1997	33.9	148.1	30.2								0.1				
1998	54.6	113.6	45.1								0.7		0.0		
1999	65.6										0.2			1.3	
2000	48.4	35.9	13.8					0.1			1.4	1.8			
2001	77.1	62.0	25.0								0.0	1.6			
2002	26.6	42.5	13.2								0.0			111.1	
2003	6.9	21.7	12.8				0.0				0.0			17.5	
2004	11.9	38.5	17.8			23.3	0.1				0.0	0.1		23.9	
2005						18.5					0.0		0.6	85.3	
2006								0.3			0.0			107.6	22.9
2007		39.4	16.0			36.9			7.4		0.2	2.8	3.3	97.7	1.1
2008	81.0					9.6			5.5		0.1		2.7	52.7	0.8
2009		59.2	30.9			31.7			13.9		0.3			70.9	0.7
2010		0.0	0.0			27.0			4.1		0.1		0.7	20.2	1.6
2011	0.0			0.2	0.1	41.3					0.1				1.3
2012	0.0					7.2					0.0			0.6	0.8
2013	0.0					32.3			21.3	0.0	0.0		0.1	1.3	1.1
2014									2.7						2
2015	0	0	0			41.3			0						2.5
2016						37.0			0.5						3
TOTAL	405.9	560.8	204.8	0.2	0.1	306.2	0.1	0.4	55.4	0.0	3.2	6.2	7.4	590.2	38

Table 11.3. Thresher sharks in the Northeast Atlantic and Mediterranean Sea. Reported landings of thresher shark (*Alopias* spp.) by country and ICES subarea for the period 1984–2004.

Nation	Subarea	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Denmark	4												
France	6–9	3	6	2	7	12	10	9	13	14	14	11	13
Ireland	6–8												
Portugal	7–9			7	11	103	13	14	31	13	12	16	7
Spain	7–9												
UK(E&W)	4–7												
Total		3	6	9	18	115	23	23	45	27	26	27	20

Nation	Subarea	1996	1997	1998	1999	2000	2001	2002	2003	2004
Azores	10									
Denmark	4						.	.	+	.
France	6-9	17	22	18	13	107	112	4	3	3
Ireland	6-7						.	.	+	+
Portugal	7-9	13	37	24	12	15	25	21	17	33
Spain (Basque Country)	8									
Spain	7-9		53	54	36	1			3	84
UK(E&W)	4-7									
Total		30	113	98	61	123	137	25	23	120

Table 11.4. Thresher sharks in the Northeast Atlantic and Mediterranean Sea. Reported landings of thresher shark (*Alopias* spp.) for the period 2005–2017 (Data following the 2016,2017 and 2018 data calls). Data are considered preliminary and more dedicated studies to refine a time series of thresher shark landings is required.

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France	33.1	36.2	42.1	26.5	38.7	28.0	51.3	34.0	33.6	42.9	38.8	35.2	<0.1
Ireland		0.3											
Netherlands			0.1									<0.1	
Portugal	49.4	78.9	54.8	22.9	27.2	12.7	3.3	0.6	1.3	0.2	0.9	0.6	1
Spain	4.1	17.7	66.8	103.1	96.5	0.2	<0.1	0.1					
UK	0.4	<0.1	1.1	0.8	0.7	1.6	1.3	0.8	1.1	2.0	2.5	3.0	
Total	87.0	133.1	164.8	153.2	163.0	42.6	56.0	35.5	36.0	45.1	42.3	38.8	1

12 Other pelagic sharks in the Northeast Atlantic

12.1 Ecosystem description and stock boundaries

In addition to the pelagic species discussed previously (Sections 6–11), several other pelagic sharks and also rays occur in the ICES area (Table 12.1). Many of these taxa, including hammerhead sharks (*Sphyrna* spp.) and requiem sharks (*Carcharhinus* spp.), are tropical to warm temperate species, and often coastal pelagic species. There are limited data with which to examine the stock structure of these species, and the ICES area would only be the northern extremes of their NE Atlantic distribution range. Other species, including long-fin mako, silky shark and oceanic white-tip are truly oceanic and likely to have either North Atlantic or Atlantic stocks, although data to confirm which are limited. These species are found mostly in the south-western parts of the ICES areas (e.g. Iberian Peninsula), though some may occasionally range further north. Some of these species also occur in the Mediterranean Sea.

12.2 The fishery

12.2.1 History of the fishery

Pelagic sharks and also some ray species are an incidental bycatch in tuna and billfish fisheries (mainly longline, but also purse-seine) and a very occasional bycatch in other pelagic fisheries. Some, like the hammerheads and the requiem sharks, may constitute a noticeable component of the bycatch and were traditionally landed, whilst others are only recorded sporadically (e.g. white shark, tiger shark and devil ray). Although some of these species are an important bycatch in high seas fisheries (e.g. silky shark and oceanic whitetip), others are taken in continental shelf waters of the ICES area (e.g. various requiem sharks and hammerhead sharks).

12.2.2 The fishery in 2017

No new information is available.

12.2.3 ICES advice applicable

ICES does not provide advice on these stocks.

12.2.4 Management applicable

EC Regulation No. 1185/2003 (updated by EU Regulation No 605/2013) prohibits the removal of shark fins of these species, and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

Article 12 of Council Regulation (EU) 2017/127 lists prohibited species which, if caught accidentally, should not be harmed and should be released promptly. It is prohibited for EU vessels to fish for, to retain on board, to tranship or to land species listed in this Article, which include the following pelagic elasmobranchs:

- White shark *Carcharodon carcharias* in all waters;
- Manta rays *Manta birostris* in all waters;
- Mobulid rays *Mobula* spp. in all waters.

ICCAT recommend that Contracting Parties "prohibit, retaining on board, transhipping, landing, storing, selling, or offering for sale any part or whole carcass" of silky shark *Carcharhinus falciformis* (Recommendation 2011–08), oceanic whitetip shark *Carcharhinus longimanus* (Recommendation 2010–07) and all hammerhead sharks (Family Sphyrnidae, except bonnethead shark *Sphyrna tiburo*) (Recommendation 2010–08).

In support of this ICCAT Recommendation, Article 18 of Council Regulation (EU) 2017/127 states that, for EU vessels in the ICCAT convention area, that it is prohibited to retain on board, tranship or land any part or whole carcass of hammerhead sharks (Family Sphyrnidae, except for *Sphyrna tiburo*) or oceanic whitetip shark *C. longimanus,* or to retain on board silky shark *C. falciformis.* taken in any fishery.

12.3 Catch data

12.3.1 Landings

No reliable estimates of landings or catches are available for these species, as many nations that land various species of pelagic sharks have often recorded them under generic landings categories. There can also be differences in the data reported to ICES, ICCAT and FAO, and so the most accurate data sources need to be verified.

Historical species-specific landings reported to ICES were summarised in earlier WGEF reports. Data reported to ICCAT are given in Table 12.2. Spain and Portugal are the main European nations reporting these species from the Northeast Atlantic. Some of these data (e.g. some of the reported landings of 'tiger shark' by the Netherlands) are known coding errors.

Catch data are provided for the Spanish longline swordfish fisheries in the NE Atlantic in 1997–1999 (Castro *et al*., 2000; Mejuto *et al*., 2002). They show that 99% of the bycatch of offshore longline fisheries consisted of pelagic sharks (Table 12.3), although 87% was blue shark.

Available landings data from FAO FishStat for the NE Atlantic (Table 12.4) are considered underestimates, due to inconsistent reporting and use of generic categories. However, this is the only database to report landings of devil ray (17 t by Spain 2004–2011).

More dedicated effort to compile an appropriate time series of landings is required.

12.3.2 Discards

No data are available. Some species are usually retained, but other species, such as the pelagic stingray, are usually discarded. There are now EU regulations to prohibit the retention of some species, and these species should now be discarded.

12.3.3 Quality of catch data

Catch data are of poor quality, except for some occasional studies of the Spanish Atlantic swordfish longline fishery (e.g. Castro *et al*., 2000; Mejuto *et al*., 2002) and of Portuguese pelagic longline fishery in the Atlantic Ocean (e.g. Santos *et al*., 2014). Biological data are not collected under the Data Collection Regulations, although some generic biological data are available (see Section 12.7). Species-specific identification in the field is problematic for some genera (e.g. *Carcharhinus* and *Sphyrna*).

Methods developed to identify shark species from fins (Sebastian *et al*., 2008; Holmes *et al*., 2009) could be used to gather data on species retained in IUU fisheries on the high seas, this information should aid in management and conservation.

12.3.4 Discard survival

There have been several studies on the at-vessel mortality of pelagic sharks in longline fisheries, although more limited data are available for purse-seine fisheries. These studies were reviewed in Ellis *et al.* (2017).

12.4 Commercial catch composition

Data on the species and length composition of these sharks are limited.

12.5 Commercial catch and effort data

No CPUE data are available to WGEF for these pelagic sharks in the ICES area. ICCAT is the main source for appropriate catch and effort data for pelagic sharks, with data also available for the NW Atlantic (e.g. Cramer and Adams, 1998; Cramer *et al*., 1998; Cramer, 1999).

12.6 Fishery-independent data

No fishery-independent data are available for these species.

12.7 Life-history information

Little information is available on nursery or pupping grounds. Silky shark is thought to use the outer continental shelf as primary nursery ground (Springer, 1967; Yokota and Lessa, 2006), and young oceanic whitetip have been found offshore along the SE coast of the USA, suggesting offshore nurseries over the continental shelf (Seki *et al.*, 1998). Scalloped hammerhead nurseries are usually in shallow coastal waters.

The overall biology of several species has been reviewed, including white shark (Bruce, 2008), silky shark (Bonfil, 2008), oceanic whitetip (Bonfil *et al.*, 2008) and pelagic stingray (Neer, 2008). Other biological information is available in Branstetter, 1987; 1990; Stevens and Lyle, 1989; Shungo *et al*., 2003 and Piercy *et al*., 2007. A summary of the main biological parameters is given in Table 12.6.

In relation to *M. mobular*, Fortuna *et al.* (2014) estimated the size of the population of *M. mobular* in the Adriatic Sea as 3255 adults, from 60 field observations and available biological parameters. It was reported that several hundred specimens (estimates varied from 200 to 500) of this species were caught by fishermen of the Gaza Strip on 27 February 2013.

12.8 Exploratory assessments

No assessments have been made of these stocks in the NE Atlantic. Cortés *et al.* (2010) undertook a level 3 quantitative Ecological Risk Assessment (ERA) for eleven pelagic elasmobranchs (blue shark, shortfin and longfin mako, bigeye and common thresher, oceanic whitetip, silky, porbeagle, scalloped and smooth hammerhead, and pelagic stingray). Of these species, silky shark was found to be high risk (along with shortfin mako and bigeye thresher sharks), and oceanic whitetip and longfin mako sharks were also considered to be highly vulnerable.

McCully *et al*. (2012) undertook a level 2, semi-quantitative ERA for pelagic fish in the Celtic Sea area, and of the 19 species considered (eight of which were elasmobranchs), porbeagle and shortfin mako sharks were found to be at the highest risk in longline and setnet fisheries, followed by common thresher. A comparable analysis examining the pelagic ecosystem for the Northeast Atlantic would be a useful exercise.

12.9 Stock assessment

No stock assessments have been undertaken.

12.10 Quality of the assessment

No assessment has been undertaken.

12.11 Reference points

No reference points have been proposed for these stocks.

12.12 Conservation consideration

The recent IUCN red list of European marine fish (Nieto *et al*., 2015) listed white shark as Critically Endangered, and devil ray, oceanic white-tip and sandbar shark as Endangered in European seas. Pelagic stingray, which is generally discarded, was assessed as 'Least Concern'. *Isurus paucus,* most *Carcharhinus* spp., *Sphyrna lewini, S. mokarran* and *S. zygaena spp.* were Data Deficient.

The following species are included in the Memorandum of Understanding for Sharks (MoU-Sharks) of the Convention of Migratory Species (CMS): *Carcharodon carcharias*, *Isurus paucus* and *Manta birostris*.

12.13 Management considerations

There is a paucity of the fishery data on these species, and this hampers the provision of management advice.

Some of the species are specified on various conservation initiatives. For example, white shark is listed on Appendix II of the Barcelona Convention, Appendix II of the Bern Convention, Appendices I/II of the CMS and Appendix I of CITES.

In 2013, *Carcharhinus longimanus*, *Sphyrna lewini*, *Sphyrna mokarran*, *Sphyran zygaena*, *Manta birostris* and *Manta alfredi* were listed on Appendix II of CITES (Conference of Parties 16, Bangkok). The implementation of these listings was delayed by 18 months (14 September 2014) to enable Range States and importing States to address potential implementation issues. Silky shark, thresher shark and Devil rays were included in Appendix II of CITES at the 17th Meeting of the Conference of the Parties (CoP17, Johannesburg) in 2016.

In 2012, a consortium of scientific institutions (AZTI, IEO, IRD and IFREMER) obtained a contract from the EC to review the fishery and biological data on major pelagic sharks and rays. The aim was to identify the gaps that could be filled in the frame of the implementation of the EU shark action plan (EUPOA-Sharks) in order to improve the monitoring of major elasmobranch species caught by both artisanal and industrial large pelagic fisheries on the high seas of the Atlantic, Indian and Pacific Oceans. The consortium reviewed and prioritised the gaps identified to develop a research programme to fill gaps and to support the formulation of scientific advice for management. The main gaps concerned fishery statistics, which are often not broken down by species, a lack of size–frequency data and regional biological/ecological information. The final report was given to the DG-Mare of the EU in May 2013 (DG-Mare, 2013).

In 2013, the shark species group of ICCAT proposed the framework of a Shark Research and Data Collection Program (SRDCP) to fill up the gaps in our knowledge on pelagic sharks that are responsible for much of the uncertainty in stock assessments, and have caused constraints to the provision of scientific advice. The final report is available at ICCAT website (ICCAT, 2013).

12.14 References

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Table 12.1. Other pelagic sharks in the Northeast Atlantic. Summary of the distribution of pelagic elasmobranchs in the ICES area. Species that are resident or caught frequently in an area are denoted ●, species that may occur as occasional vagrants denoted ⦿ and species that have not been recorded in an area are denoted ○. Adapted from Whitehead *et al.* (1989).

Family	Common name	Scientific name	ICES Subarea			
			VII	VIII	IX	Notes
Lamnidae	White shark	*Carcharodon carcharias*	○	⦿	⦿	[1]
	Longfin mako	*Isurus paucus*	○	○	⦿	
Carcharhinidae	Spinner shark	*Carcharhinus brevipinna*	○	○	⦿	
	Silky shark	*Carcarhinus falciformis*	○	○	⦿	
	Blacktip shark	*Carcharhinus limbatus*	○	○	⦿	
	Oceanic whitetip	*Carcharhinus longimanus*	○	⦿	⦿	[2]
	Dusky shark	*Carcharhinus obscurus*	○	○	⦿	
	Sandbar shark	*Carcharhinus plumbeus*	○	⦿	⦿	
	Night shark	*Carcharhinus signatus*	○	○	⦿	
	Tiger shark	*Galeocerdo cuvier*	?	?	⦿	[3]
Sphyrnidae	Scalloped hammerhead	*Sphyrna lewini*	○	○	⦿	
	Great hammerhead	*Sphyrna mokarran*	○	○	?	
	Smooth hammerhead	*Sphyrna zygaena*	⦿	⦿	⦿	
Dasyatidae	Pelagic stingray	*Pteroplatytrygon violacea*	⦿	⦿	⦿	[4]
Mobulidae	Devil ray	*Mobula mobular*	⦿	⦿	⦿	[5]
	Giant manta	*Manta birostris*	○	○	?	

[1] Three records from the Bay of Biscay; [2] One individual stranded in Swedish waters; [3] Some unconfirmed sightings in northern Europe; [4] Two specimens recorded from the North Sea; [5] Individual specimens reported from the Bay of Biscay (capture) and Celtic Sea (stranding).

Table 12.2. Other pelagic sharks in the Northeast Atlantic. Summary of landings data (2000–2016) as reported to ICCAT (Downloaded June 2018) by Spain. ICCAT areas are AZOR: Azores; CVER: Cape Verde; EAST: East Atlantic; ETRO: East Tropical Atlantic; MDRA: Madeira; MEDI: Mediterranean Sea; N.ADR: North Adriatic Sea; N.ION: North Ionian Sea; NE: Northeast Atlantic; NORT: North Atlantic; and S.SIC: Strait of Sicily.

Nation	Category	Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Spain	Carcharhinidae	NE		100	80	86	97				28					6			
Spain	Carcharhinidae	NORT					31							66	8				
Spain	*Carcharhinus brachyurus*	MEDI									1	1						<1	
Spain	*Carcharhinus brachyurus*	NE									0.30	0.36							
Spain	*Carcharhinus falciformis*	NE		1			4			59		20							
Spain	*Carcharhinus galapagensis*	NE										1							
Spain	*Carcharhinus limbatus*	NE		0.03									5						
Spain	*Carcharhinus longimanus*	NE	0.02	4	0.10							18	56						
Spain	*Carcharhinus plumbeus*	NE										4	0						
Spain	*Carcharhinus signatus*	NE		0.03			0.14						2						
Spain	*Galeocerdo cuvier*	NE	1	1	1	0.21	0.10			0.13		1							
Spain	*Galeocerdo cuvier*	NORT												3	0.07				
Spain	*Galeocerdo cuvier*	MEDI												1					
Spain	*Isurus paucus*	NE	4	16	24	24	28			16		37	20			15	4	34	40
Spain	*Isurus paucus*	NORT												43	91				
Spain	Pelagic Sharks nei	NE	326								57								
Spain	Pelagic Sharks nei	MEDI	0								0.04								
Spain	*Sphyrna lewini*	NE				0.02	2												
Spain	*Sphyrna* spp	NE	312	249	363	231	364			103		113							
Spain	*Sphyrna* spp	MEDI	0.38				0.01												
Spain	*Sphyrna* spp	NORT												0.09					
Spain	*Sphyrna zygaena*	NE	1	4	1		12			2		0.22							
Spain	Sphyrnidae	NE									124								

Table 12.2 (continued). Other pelagic sharks in the Northeast Atlantic. Summary of landings data (2000–2016) as reported to ICCAT (Downloaded June 2018) by Portugal. ICCAT areas are AZOR: Azores; CVER: Cape Verde; EAST: East Atlantic; ETRO: East Tropical Atlantic; MDRA: Madeira; MEDI: Mediterranean Sea; N.ADR: North Adriatic Sea; N.ION: North Ionian Sea; NE: Northeast Atlantic; NORT: North Atlantic; and S.SIC: Strait of Sicily.

Nation	Category	Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Portugal	Carcharhinidae	NE				155			18	5			0.18						
Portugal	Carcharhinidae	CVER						14	0.32										
Portugal	Carcharhinidae	ATL				14													
Portugal	Carcharhinidae	AZOR						10	2										
Portugal	Carcharhinidae	MEDI						2											
Portugal	Carcharhiniformes	NE								483									
Portugal	Carcharhiniformes	CVER								5									
Portugal	Carcharhiniformes	EAST								1									
Portugal	Carcharhiniformes	MDRA								0.34									
Portugal	*Carcharhinus falciformis*	NE										0.26	0.01	30	0.37	0.03			
Portugal	*Carcharhinus falciformis*	CVER												26					
Portugal	*Carcharhinus falciformis*	AZOR												0.19					
Portugal	*Carcharhinus limbatus*	NE												0.24		0.04			
Portugal	*Carcharhinus longimanus*	NE							0.05		1	1	18						
Portugal	*Carcharhinus longimanus*	CVER										0.24	0.22						
Portugal	*Carcharhinus plumbeus*	NE											0.07		0.18	1			
Portugal	*Carcharhinus plumbeus*	AZOR						0.14											
Portugal	*Carcharodon carcharias*	CVER						6											
Portugal	*Carcharodon carcharias*	NE														0.02			
Portugal	*Isurus paucus*	NE											1	0.00	5	1	1		
Portugal	*Sphyrna* spp	NE	0.18	0.30		6			17	6	5	10	42		0.11	0.28			
Portugal	*Sphyrna* spp	CVER						26	2	3	6	2	3						
Portugal	*Sphyrna* spp	EAST								9	12								
Portugal	*Sphyrna* spp	NORT					16												
Portugal	*Sphyrna* spp	AZOR				2	1	1	1	3	1	2	0.07						
Portugal	*Sphyrna* spp	ATL				1													
Portugal	*Sphyrna* spp	MDRA									0.32								
Portugal	*Sphyrna zygaena*	NE				1			4			0.12	6			1			
Portugal	*Sphyrna zygaena*	EAST								11	0.08								
Portugal	*Sphyrna zygaena*	CVER						4	1										
Portugal	*Sphyrna zygaena*	AZOR							0.09			0.12			1		0.21		
Portugal	*Sphyrna zygaena*	MEDI						1											
Portugal	*Sphyrna zygaena*	ATL				1													

Table 12.2 (continued). Other pelagic sharks in the Northeast Atlantic. Summary of landings data (2000–2016) as reported to ICCAT (Downloaded June 2018) by other EU nations. Data for tiger shark by the Netherlands were considered coding errors and excluded. ICCAT areas are AZOR: Azores; CVER: Cape Verde; EAST: East Atlantic; ETRO: East Tropical Atlantic; MDRA: Madeira; MEDI: Mediterranean Sea; N.ADR: North Adriatic Sea; N.ION: North Ionian Sea; NE: Northeast Atlantic; NORT: North Atlantic; and S.SIC: Strait of Sicily.

Nation	Category	Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
France	Carcharhinidae	NE									507	2	0.38	3					
France	Carcharhinidae	MEDI										0.36	0.21	0.21					
France	*Carcharhinus albimarginatus*	NE											0.02	0.06					
France	*Carcharhinus brevipinna*	NE										0.00							
France	*Carcharhinus leucas*	NE										0.03							
France	*Carcharhinus limbatus*	NE										0.03							
France	*Carcharhinus longimanus*	MEDI										3	5	1					
France	*Carcharhinus longimanus*	NE										1							
France	*Carcharhinus obscurus*	NE										1	0.14	0.19					
France	*Carcharhinus plumbeus*	MEDI										0.08							
France	*Carcharias taurus*	NE										0.06	1	3					
France	*Carcharodon carcharias*	NE												0.07					
France	*Sphyrna lewini*	NE										0.09							<1
France	*Sphyrna* spp	NE												0.07					
France	Sphyrnidae	NE												0.05					
UK	*Sphyrna lewini*	NE										12	0.33						
UK	*Sphyrna zygaena*	NE													0.03	0.03			<1
Netherlands	*Carcharhinus obscurus*	EAST										1		0.35	0.07				
Netherlands	*Carcharhinus obscurus*	ETRO									0.17								
Netherlands	*Carcharias taurus*	EAST													3				
Italy	*Carcharhinus plumbeus*	MEDI								0.17									
Italy	*Carcharodon carcharias*	MEDI								177									
Italy	*Sphyrna* spp	S.SIC															5		
Italy	*Sphyrna* spp	MEDI														2			<1
Italy	*Sphyrna* spp	TYRR															0.50		
Italy	*Sphyrna zygaena*	MEDI								0.28									

Table 12.2 (continued). Other pelagic sharks in the Northeast Atlantic. Summary of landings data (2000–2016) as reported to ICCAT (Downloaded June 2018) by other nations. ICCAT areas are AZOR: Azores; CVER: Cape Verde; EAST: East Atlantic; ETRO: East Tropical Atlantic; MDRA: Madeira; MEDI: Mediterranean Sea; N.ADR: North Adriatic Sea; N.ION: North Ionian Sea; NE: Northeast Atlantic; NORT: North Atlantic; and S.SIC: Strait of Sicily.

Nation	Category	Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Russia	*Carcharhinus longimanus*	ETRO						0.30											
Russia	*Sphyrna zygaena*	ETRO						0.10											
Korea Rep.	*Sphyrna zygaena*	NE															0.09		
Chinese Taipei	*Carcharhinus falciformis*	ATL				163	22	13											
Chinese Taipei	*Carcharhinus falciformis*	NE									1	3		0.03	0.33				
Chinese Taipei	*Carcharhinus falciformis*	NORT							1	1									
Chinese Taipei	*Carcharhinus longimanus*	NE												0.01	0.02				
Chinese Taipei	*Carcharodon carcharias*	NE												0.00	0.09	0.11			
Chinese Taipei	Sphyrnidae	NE												0.02	0.15	0.05	0.02		
Gabon	Carcharhinidae	ETRO			123														
Ghana	*Carcharhinus longimanus*	ETRO															2	123.0	
Ghana	*Sphyrna* spp	ETRO															10	311	
Guinea Ecuato-rial	*Carcharhinus longimanus*	ETRO															3		
Morocco	Carcharhinidae	NE															238	922	
Morocco	Carcharhinidae	MEDI															32	533	
Morocco	*Carcharhinus obscurus*	NE												6	1	3			
Morocco	*Carcharodon carcharias*	NE												92	11	25	7		
Morocco	*Sphyrna lewini*	NE												1	0				
Morocco	*Sphyrna zygaena*	NE												153	155				
Nigeria	*Sphyrna mokarran*	ETRO											7	0.25	13				
Senegal	Carcharhinidae	CVER																154	
Senegal	Carcharhinidae	NE	1714	1806	1045	1387	1651	5401	1035	1221	1253	375	426	898			728	150	524
Senegal	Carcharhinidae	NORT													0.18				
Senegal	Carcharhiniformes	NE													3649				
Senegal	*Carcharhinus plumbeus*	NE								0.40						0.37			
Senegal	*Carcharhinus signatus*	EAST														6581			
Senegal	*Carcharias taurus*	NE									49								
Senegal	*Carcharodon carcharias*	NE											18						
Senegal	*Sphyrna* spp	EAST																127	
Senegal	*Sphyrna* spp	NE	57	1464	36	71	168	318	173	154	110	101	56	51	101		113	40	
Senegal	*Sphyrna zygaena*	EAST														438		2	
Senegal	*Sphyrna zygaena*	NE						7								1			
Senegal	*Sphyrna zygaena*	NORT													1				
Senegal	Sphyrnidae	NE													1				239

Table 12.3. Other pelagic sharks in the Northeast Atlantic. Shark bycatch in the Spanish swordfish longline fisheries of the NE Atlantic. Data from Castro *et al.*, 2000 and Mejuto *et al.*, 2002.

Shark bycatches of the Spanish longline swordfish fishery								
NE Atlantic	*Carcharhinus* spp.	*Sphyrna* spp.	*Galeocerdo cuvier*	*Isurus paucus*	*Mobula* spp.	Total bycatch	% sharks	% blue shark
1997	148	382	3	8		28 000	99.4	87.5
1998	190	396	5	8	7	26 000	99.4	86.5
1999	99	240	4	18	1	25 000	98.6	87.2

Table 12.4. Other pelagic sharks in the Northeast Atlantic. Reported landings (t) by country (Source FAO Fish-Stat) for Atlantic, northeast fishing area.

FAO FISHSTAT (2014)		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Country	Species																
Portugal	*Sphyrna zygaena*			8	8	4	5	7	20	3	13	9	7	5	4	0	0
Spain	*Mobula mobular*								1	3	3	2	1	3	4	5	0
	Sphyrna zygaena								5	10	< 0,5	3	2	1	< 0,5		
	Galeocerdo cuvier								2	4	5	3	2	-	< 0,5		
France	*Pteroplatytrygon violacea*																1
TOTAL		0	0		8	4	5	7	28	20	21	17	12	9	8	5	1

Table 12.5. Other pelagic sharks in the Northeast Atlantic. Preliminary compilation of life-history information for NE Atlantic sharks.

Species	Distribution Depth range	Max. TL cm	Egg development	Maturity size cm	Age at maturity (years)	Gestation period (months)	Litter size	Size at birth (cm)	Lifespan years	Growth	Trophic level
White shark *Carcharodon carcharias*	Cosmopolitan 0–1280 m	720	Ovoviviparous+ oophagy	372–402	8–10	?	7–14	120–150	36	L∞ = 544 K= 0.065 T0 = –4.40	4.42–4.53
Longfin mako *Isurus paucus*	Cosmopolitan	417	Ovoviviparous	> 245 F			2	97–120			4.5
Silky shark *Carcharhinus falciformis*	Circumtropical 0–500 m	350	Viviparous	210–220 M 225 F	6–7 7–9	12	2–15	57–87	25	L∞ = 291/315 K= 0.153 / 0.1 T0 = –2.2 / –3.1	4.4–4.52
Spinner shark *Carcharhinus brevipinna*	Circumtropical 0–100 m	300	Viviparous	176–212	7.8–7.9	10–12	Up to 20	60–80		L∞ = 214 FL K= 0.210 T0 = –1 .94	4.2–4.5
Oceanic whitetip *Carcharhinus longimanus*	Cosmopolitan 0–180 m	396	Viviparous	175–189	4–7	10–12	1–15	60–65	22	L∞ = 245 / 285 K= 0.103 / 0.1 T0 = 2.7 / – 3.39	4.16–4.39
Dusky shark *Carcharhinus obscurus*	Circumglobal	420	Viviparous	220–280	14–18	22–24	3–14	70–100	40	L∞ = 349 / 373 K= 0.039/ 0.038 T0 = –7.04/ –6.28	4.42–4.61
Sandbar shark *Carcharhinus plumbeus*	Circumglobal 0–1800 m	250	Viviparous	130–183	13–16	12	1–14	56–75	32	L∞ = 186 FL K= 0.046 T0 = –6.45	4.23–4.49

Species	Distribution Depth range	Max. TL cm	Egg development	Maturity size cm	Age at maturity (years)	Gestation period (months)	Litter size	Size at birth (cm)	Lifespan years	Growth	Trophic level
Night shark *Carcharhinus signatus*	Atlantic 0–600 m	280	Viviparous	185–200	8–10	~12	4–12	60		L∞ = 256 / 265 K= 0.124 / 0.114 T0 = –2.54 / – 2.7	4.44–4.5
Tiger shark *Galeocerdo cuvier*	Circumglobal 0–350 m	740	Oviviviparous	316–323	8–10	13–16	10–82	51–104	50	L∞ = 388 / 440 K= 0.18 / 0.107 T0 = –1.13 / –2.35	4.54–4.63
Scalloped hammerhead *Sphyrna lewini*	Cosmopolitan 0–512 m	430	Viviparous	140–250	10–15	9–10	13–31	45–50	35	L∞ = 320 / 321 K= 0.249 / 0.222 T0 = –0.41 / – 0.75	4.0–4.21
Great hammerhead *Sphyrna mokarran*	Circumglobal 1–300 m	610	Viviparous	250–292		11	13–42	60–70		L∞ = 264 / 308 (FL) K= 0.16 / 0.11 T0 = -1.99 / -2.86	4.23–4.43
Smooth hammerhead *Sphyrna zygaena*	Circumglobal 0–200 m	500	Viviparous	210–265		10–11	20–50	50–60			4.32–4.5
Pelagic stingray *Pteroplatytrygon violacea*	Cosmopolitan 37–238	160	Ovoviviparous	35–40 DW	2–3	2–4	4–9	15–25 DW	~10	L∞ = 116 DW K= 0.0180	4.36
Devil ray *Mobula mobular*	NE Atl. + Med. epipelagic	520	Ovoviviparous			25	1	≤ 166 DW			3.71

13 Demersal elasmobranchs in the Barents Sea

13.1 Ecoregion and stock boundaries

The ecology of the Barents Sea ecosystem (ICES Subarea 1, extending into the eastern parts of Subarea 2) has been described comprehensively by Jakobsen and Ozhigin (2012).

Lynghammar *et al*. (2013) reviewed the occurrence of chondrichthyan fish in the Barents Sea ecoregion. Skate species inhabiting offshore areas included thorny skate *Amblyraja radiata*, Arctic skate *Amblyraja hyperborea*, round skate *Rajella fyllae*, spinytail skate *Bathyraja spinicauda*, common skate *Dipturus batis* complex, sailray *Rajella lintea*, long-nose skate *Dipturus oxyrinchus,* shagreen ray *Leucoraja fullonica* and thornback ray *Raja clavata* (Andriashev, 1954; Dolgov, 2000; Dolgov *et al*., 2005a; Wienerroither *et al*., 2011; Knutsen *et al*., 2017 WD), but few occur at high abundance. All skate species occurring in offshore areas also occur in more coastal areas, with the exception of *A. hyperborea, D. oxyrinchus* and *R. lintea* (Williams *et al*., 2008). The spatial distribution of chondrichthyan fishes in the Barents Sea, as observed in recent surveys, has been described by Wienerroither *et al*. (2011; 2013).

Stock boundaries are not known for the skates in this area. Neither are the potential movements of species between the coastal and offshore areas. The adjacent Norwegian coastal area has been included within the Barents Sea ecoregion. Further investigations are necessary to determine potential migrations or interactions of elasmobranch populations within this ecoregion and adjacent areas.

Amblyraja radiata is the dominant species, comprising 96% by number and about 92% by biomass of skates caught in surveys or as bycatch. The next most abundant species are *A. hyperborea* and *R. fyllae* (3% and 2% by number, respectively), and the remaining species are scarce (Dolgov *et al*., 2005a; Drevetnyak *et al*., 2005).

The species composition of skates caught in the Barents Sea differs from those recorded in the Norwegian Deep and northeastern Norwegian Sea (Skjaeraasen and Bergstad, 2000; 2001). Although *A. radiata* is the dominant species in both areas, the proportion of warmer-water species (*B. spinicauda* and *R. lintea*) is lower and the portion of cold-water species (*A. hyperborea*) is higher in the Barents Sea.

In terms of other elasmobranchs, sharks known to occur in the Barents Sea include spurdog (Section 2), velvet belly lanternshark (Section 5), porbeagle shark (Section 6) and Greenland shark (Section 24). One chimaeroid (*Chimaera monstrosa*) also occurs.

13.2 The fishery

13.2.1 History of the fishery

All skate species in the ecoregion may be taken as bycatch in demersal fisheries, but there are at present no fisheries targeting skates in the Barents Sea. Detailed data on catches of skates from the Barents Sea are only available from bycatch records and surveys from 1996–2001 and 1998–2001, respectively (provided by Dolgov *et al*., 2005a; 2005b). Bottom-trawl fisheries targeting cod *Gadus morhua* and haddock *Melanogrammus aeglefinus*, and longline fisheries targeting cod, blue catfish *Anarhichas denticulatus* and Greenland halibut *Reinhardtius hippoglossoides* have a skate bycatch, which is generally discarded. Dolgov *et al.* (2005b) estimated the total catch of skates taken by the Russian fishing fleet operating in the Barents Sea and adjacent waters in 1996–2001, and found that it ranged from 723–1891 t (average of 1250 t per year). *A. radiata* accounted for 90–95% of the total skate bycatch.

13.2.2 The fishery in 2017

No new information. Since 2012, Norwegian declared landings have sharply increased and both in 2015 and 2017 they doubled compared to the previous year. The reason for this increase is unknown.

13.2.3 ICES advice applicable

ICES does not provide advice on the status of skate stocks in this ecoregion.

13.2.4 Management applicable

There are no TACs for any of the skate species in this ecoregion. Norway has a general ban on discarding. Since 2010, all dead or dying skates and other fish in the catches should be landed, whereas live specimens can be discarded.

13.3 Catch data

13.3.1 Landings

For ICES Subarea 1, landings data are limited and only available for all skate species combined (Table 13.1; Figure 13.1). Landings from the most westerly parts of the Barents Sea ecoregion fall within Subarea 2 (see Section 14). Russia and Norway are the main countries landing skates from the Barents Sea. Russian landings are not available since 2011.

Elasmobranch landings from ICES Subarea 1 are low, but there have been large fluctuations in Russian landings. The peak in Russian landings in the 1980s corresponded to an experimental fishery for skates, where the bycatch (mainly comprised of *Amblyraja radiata*) was landed (Dolgov, personal communication, 2006).

Based on data from the Norwegian Reference fleets, and the expert judgement detailed in Albert *et al*. (2016 WD), Norwegian landings by species and species groups from ICES Subarea 1 were estimated (Table 13.2). The main species landed tend to be larger speciemens of *Raja clavata*, *Bathyraja spinicauda* and *Amblyraja hyperborea*.

13.3.2 Discards

Based on interviews of the Norwegian Reference Fleet and landing sites, the expected discards of skates varied extensively between species and is assumed almost 100% for specimens below 50 cm. For *Rajella fyllae* and *Amblyraja radiata*, nearly all specimens are probably discarded, whereas the discards of *Raja clavata* by the coastal fleet is expected to be negligible (Albert *et al*., 2016 WD).

Dolgov *et al.* (2005b) estimated the total annual bycatch of skates from commercial trawl and longline fisheries in the Barents Sea to range from 723–1891 t, with *A. radiata* accounting for 90–95% of the total skate catch. *A. radiata* is also the predominant skate in catches of the Norwegian Reference Fleet operating in ICES Subarea 1, and accounts for around 90% of the catches (Albert *et al*., 2016 WD).

13.3.3 Quality of catch data

Recent data on skate catch and landings in the Barents Sea are almost exclusively from Norway, and species information from the Norwegian Reference Fleet (Table 13.2) may be indicative of the total catch and landings. The estimation of total skate catches and landings by species relied on some strong assumptions, e.g. that data from the Coastal and Oceanic Reference Fleets operating in the Barents Sea are representative for vessels below and above 21 m respectively, and that the relative species composition of skate catches in these two reference fleets has been stable over the last ten years. These assumptions were made due to limited availability of data. With increased data and extended time series, these assumptions should be relaxed by including running averages over shorter time periods, e.g. 3–5 years.

Even after allocating skate landings to species based on data from the Reference Fleet, the generic "Skates and rays" category still accounted for more than 50% of the total skate landings. A further reduction of this proportion should however be achievable. The work on improving species identification by arranging workshops for reference fleet crew and education during visits at sea will continue to further improve data quality in the future.

In addition, the splitting of catches by species should be validated by independent surveys. The best way to do this is probably to include skates on the list of species to sample from selected landing ports. Skates are mostly landed as wings in Norway, which can make conventional species identification more difficult (although skate identification could be confirmed with genetic barcoding). Programmes for market sampling of skate landings could usefully be undertaken.

13.3.4 Discard survival

No data available to WGEF for the fisheries in this ecoregion.

13.4 Commercial catch composition

Generally, larger skates are more often caught in longline fisheries than in trawl fisheries (Dolgov *et al*., 2005b).

Vinnichenko *et al.* (2010 WD) reported that catches of skates in Russian trawl and longline bottom fisheries in 2009 (60–400 m depths) were dominated by *A. radiata* (90–95%). Information on length and sex composition can be found in ICES (2014). Other species occurring were *R. fyllae*, *A. hyperborea*, *B. spinicauda* and *R. lintea*. These findings are supported by data from the Norwegian Reference Fleet (Vollen, 2010 WD; Albert *et al.*, 2016 WD).

Dolgov *et al.* (2005b) reported the mean length and the sex ratio for four species of skate in the Barents Sea. The sex ratio was 1:1 in commercial catches for all skate species except *A. hyperborea*, of which males dominated in the longline fishery (see ICES, 2007 for further information).

13.5 Commercial catch and effort data

Some CPUE data are available for *A. radiata*, *A. hyperborea*, *R. fyllae* and *D. batis* complex in trawl and longline fisheries, respectively. Total catches of skates in Russian fisheries in the Barents Sea and adjacent areas for the years 1996–2001 were summarized in ICES (2007).

Catch data from other nations are limited and analyses of more recent Russian data are required.

13.6 Fishery-independent surveys

13.6.1 Russian bottom trawl survey (RU-BTr-Q4)

For the offshore areas, data from October–December surveys (RU-BTr-Q4) were available for the years 1996–2003 (Dolgov *et al.*, 2005b; Drevetnyak *et al.*, 2005; summarized in ICES, 2007). These studies described the distribution and habitat utilization of skates (*A. radiata*, *A. hyperborea*, *R. fyllae*, *D. batis* complex, *B. spinicauda* and *R. lintea*) in the Barents Sea.

Vinnichenko *et al.* (2010 WD) reported on catches of *A. radiata* from the 2009 Russian bottom-trawl survey in October–December (RU-BTr-Q4). The overall length range was 8–61 cm total length (L_T) with catches comprised mainly males (41–56 cm L_T) and females (31–50 cm L_T). The average length of males (41.6 cm L_T) was greater than that of females (38.8 cm), and the sex ratio was about 1.02:1.

13.6.2 Norwegian coastal survey (NOcoast-Aco-Q4)

The distribution and diversity of elasmobranch species in the northern Norwegian coastal areas were assessed by Williams *et al.* (2008). The results were summarized in ICES (2007; 2008). New data from Norwegian coastal survey should be analysed and presented to the WGEF as species identification improves.

13.6.3 Deep stations from multiple Norwegian surveys (NO-GH-Btr-Q3 and others)

Vollen (2009 WD) reported on elasmobranch catches from deep trawl hauls (400–1400 m) along the continental slope (62–81°N) in 2003–2009. The area investigated covered the Norwegian Sea ecoregion, as well as the border between the Norwegian Sea and Barents Sea ecoregions (see Section 14 of ICES, 2009).

13.6.4 Joint Russian-Norwegian surveys (BS-NoRu-Q1 (BTr), Eco-NoRu-Q3 (Aco)/Eco-NoRu-Q3 (Btr))

Two joint Russian–Norwegian surveys are conducted in the Barents Sea. The surveys run in February (BS-NoRu-Q1 (BTr)), in the southern Barents Sea northwards to the latitude of Bear Island, and August–September (Eco-NoRu-Q3 (Aco)/Eco-NoRu-Q3 (Btr)), covering the whole of the Barents Sea including waters near Spitsbergen and Franz Josef Land. The Norwegian part of the February survey started in 1981, but data on elasmobranchs are missing for some years. The August–September survey started in 2003. All skate species are recorded during these surveys, and length data are collected. Some biological data are also collected on Russian vessels. However, due to initial species identification problems, species-specific data should only be used from the years 2006–2007 onwards (applies also to Norwegian data).

Vinnichenko *et al.* (2010 WD) analysed data on elasmobranch species from the joint surveys in 2009. The results were reported in Section 13 of ICES (2014). Wienerroither *et al*. (2011; 2013) used data from the August–September (Q3) survey (2004–2009) and February (Q1) survey (2007–2012) to describe the spatial distribution of chondrichthyan fishes in the Barents Sea. For some species, length composition area also available. The information on the main elasmobranch species is summarized below. It should be noted that length distributions are not directly comparable between the two surveys due to differences in sampling design and coverage in time and area.

A. radiata: The most common skate species in the Barents Sea. Widely distributed in the surveyed area, except in Arctic waters (Figure 13.2). Size distribution was similar in the two surveys, ranging from 5–65 cm (Figure 13.3). Based on a simple swept area model utilizing the Q3 data, the stock appear to vary in both biomass and number of individuals, without showing any apparent trend (Knutsen, *et al*., 2017 WD).

A. hyperborea: The species was found in deeper waters along the shelf edge towards the Norwegian Sea and Polar basin, and in Arctic water in the deeper parts of the eastern Barents Sea (Figure 13.2). The size ranges from 6 to 85 cm. Only few specimens smaller than 38 cm were caught during the Q1 survey, although this size class was very numerous in the Q3 survey (Figure 13.3). The stock increased in biomass and numbers between 2007 and 2014. For the recent years, the estimates have been on the same level as before 2007 (Knutsen *et al*. 2017 WD).

B. spinicauda: During the Q1 survey, the species was found in larger parts of the central basin. During the Q3 survey, the distribution was more towards the western part of the surveyed area (Figure 13.2). Recorded lengths ranged from 6 to 183 cm (Figure 13.3). The largest specimen exceeded the reported maximum length of 172 cm. Fewer small and more large individuals were caught in the Q1 survey than in the Q3 survey. Generally, the stock appear to be relatively stable in terms of biomass and number of individuals (Knutsen *et al*. 2017 WD).

R. fyllae: The species was found in warm-water areas in the southwestern part of the surveyed area, and along the slope west of Svalbard/Spitsbergen (Figure 13.2). The length distribution ranged from 6–60 cm, with two peaks around 10–15 and 46–50 cm (Figure 13.3). Although there is some annual fluctuations in number of individuals in the Barents Sea, the general trend is stable, as is the trend for biomass (Knutsen *et al*. 2017).

13.6.5 Quality of survey data

Species identification for skates is a major issue, especially with some of the earlier data. Williams (2007) gave a detailed description of identification issues for *A. radiata* vs. *R. clavata* in the Norwegian Sea ecoregion. Also, the occurrence of *D. batis* complex (possibly confused with *B. spinicauda*. The depth distribution of the two species in Dolgov *et al*. (2005a) and *L. fullonica* in the Barents Sea have been questioned by Lynghammar *et al.* (2014), as no specimens could be obtained for genetic analyses since 2007. Consequently, appropriate quality checks of these survey data are required prior to use in assessments.

In order to improve quality of current survey data, better identification practices using appropriate identification literature needs to be put in place. Ongoing work to improve future sampling at IMR includes workshops to educate staff as well as improved field guides and keys used for species identification.

13.7 Life-history information

Length data for *A. radiata*, *A. hyperborea*, *R. fyllae*, *D. batis* complex and *B. spinicauda* are available in Dolgov *et al.* (2005a; 2005b) and Vinnichenko *et al.* (2010 WD; see ICES, 2007; 2010). Some biological information is available in the literature (e.g. Berestovskii, 1994). Sampling of elasmobranch egg cases has been included in Norwegian trawl surveys from mid-2009, and may provide future information on egg-laying (spawning) grounds.

13.8 Exploratory assessment models

No exploratory assessments have been conducted, due to the limited data available. Analyses of survey trends may allow to evaluate the status of the more frequent species, although taxonomic irregularities need to be addressed first.

13.9 Exploratory assessment models

No assessments have been conducted.

13.10 Quality of assessments

No assessments have been conducted.

13.11 Reference points

No reference points have been proposed.

13.12 Conservation considerations

See Section 12.11.

13.13 Management considerations

Landings of skates in this ecoregion have increased by a factor of 20 over the last seven years. There are no TACs for any of the demersal skate stocks in this region.

The elasmobranch fauna of the Barents Sea comprises relatively few species. The most abundant skate in the area is *A. radiata*, which is widespread and abundant in this and adjacent waters. This species dominated the large historical Russian landings, but is otherwise generally discarded.

Data from the Norwegian Reference Fleet indicate that the most commonly landed skates today are larger specimens of *Raja clavata*, *Batyhraja spinicauda* and *Amblyraja hyperborea.* These are not abundant in the Barents Sea and the information on stock status is limited.

Further studies are required, particularly for the larger-bodied skates, which may be more vulnerable to overfishing.

13.14 References

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Table 13.1. Demersal elasmobranchs in the Barents Sea. Total landings (t) of skates from ICES Subarea 1 (1973–2015); "n.a." = no data available, "." = zero catch, "+" = <0.5 tonnes.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Belgium	.	.	.	1	.	.	.	.	.	.	.	.	.	.
France	.	.	.	81	49	44	.	.	.	.	.	.	.	.
Germany	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Iceland	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Norway	.	.	.	1	3	4	8	2	2	2	1	10	11	3
Portugal	.	.	100	11	1	.	.	+	.	.	.	.	.	.
USSR/Russian Fed.	n.a.	n.a.	n.a.	n.a.	n.a.	1126	168	93	3	1	n.a.	563	619	2137
Spain	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UK(E&W)	78	46	49	33	70	9	8	4	+	1	.	+	+	+
UK(Scotland)	.	.	1	2	2	.	.	.	.	.	.	.	.	.
Total	78	46	150	129	125	1183	184	99	5	4	1	573	630	2140

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.	.
France	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Germany	.	.	.	.	.	.	.	2	.	.	.	.	.	.
Iceland	.	.	.	.	.	.	1	.	.	+	1	.	.	4
Norway	14	7	4	1	5	24	29	72	9	27	3	13	21	12
Portugal	.	.	.	.	.	.	.	.	.	.	.	.	.	.
USSR/Russian Fed.	2364	2051	1235	246	n.a.	399	390	369	n.a.	n.a.	399	790	568	502
Spain	.	.	.	.	.	.	.	.	7	.	.	.	.	.
UK(E&W)	2	.	+	.	.	.	.	.	.	.	.	.	+	.
UK(Scotland)	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Total	2380	2058	1239	247	5	423	420	443	16	27	403	803	589	518

Table 13.1 (continued). Demersal elasmobranchs in the Barents Sea. Total landings (t) of skates from ICES Subarea 1 (1973–2015); "n.a." = no data available, "." = zero catch, "+" = <0.5 tonnes.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.	.
France	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Germany	.	.	.	.	.	.	+	.	.	+	.	.	+	+
Iceland	.	.	.	3	3	.	.	.	.	.	.	1	8	.
Norway	30	26	2	1	4	13	4	72	15	9	31	109	171	157
Portugal	.	.	.	+	.	.	.	.	.	.	.	.	.	.
USSR/Russian Fed.	218	173	38	69	37	48	24	6	2	1	n.a.	n.a.	n.a.	n.a.
Spain	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UK(E&W)	.	.	.	.	.	.	.	.	.	.	+	.	.	.
UK(Scotland)	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Total	248	199	40	73	44	61	28	78	17	10	31	109	179	157

	2015	2016	2017
Belgium	.	.	.
France	.	.	.
Germany	.	.	.
Iceland	.	.	.
Norway	369	374	703
Portugal	.	.	.
USSR/Russian Fed.	n.a.	n.a.	n.a.
Spain	.	.	.
UK(E&W)	.	.	.
UK(Scotland)	.	.	.
Total	369	374	703

Table 13.2. Demersal elasmobranchs in the Barents Sea. Estimated Norwegian landings (t) of skates and rays by species in ICES Subarea I. Source: Albert *et al.* (2016 WD).

Species	2012	2013	2014	2015
Amblyraja hyperborea	10	17	2	14
Bathyraja spinicauda	13	22	3	19
Dipturus oxyrinchus	1	1	0	1
Raja clavata	10	13	25	50
Rajidae indet.	76	116	127	285
Total	**108**	**170**	**157**	**368**

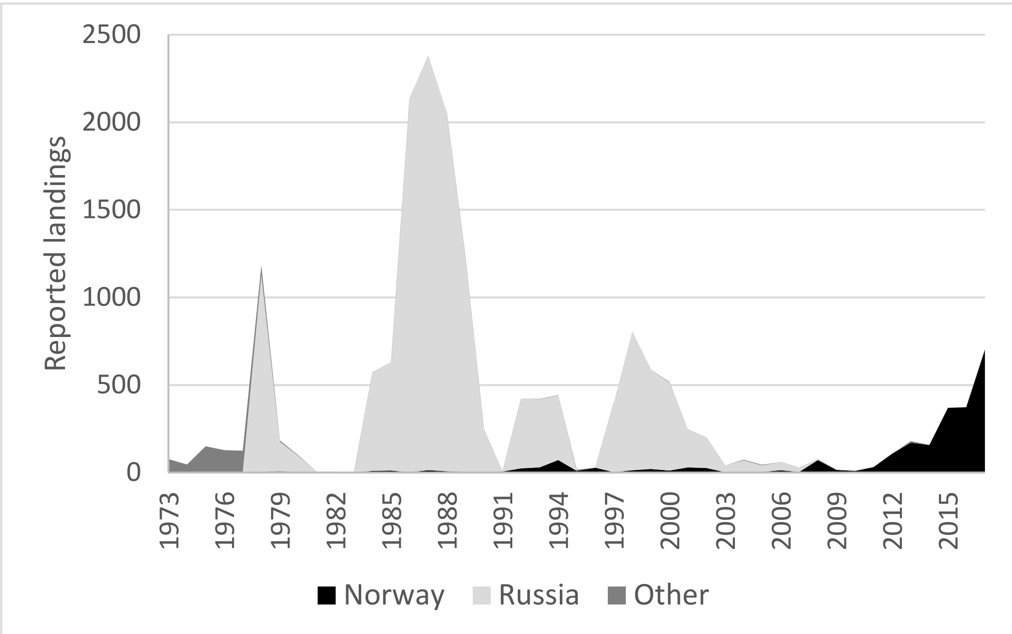

Figure 13.1. Demersal elasmobranchs in the Barents Sea. Reported landings (t) of skates from ICES Subarea 1 (1973–2017).

Q1 Q3

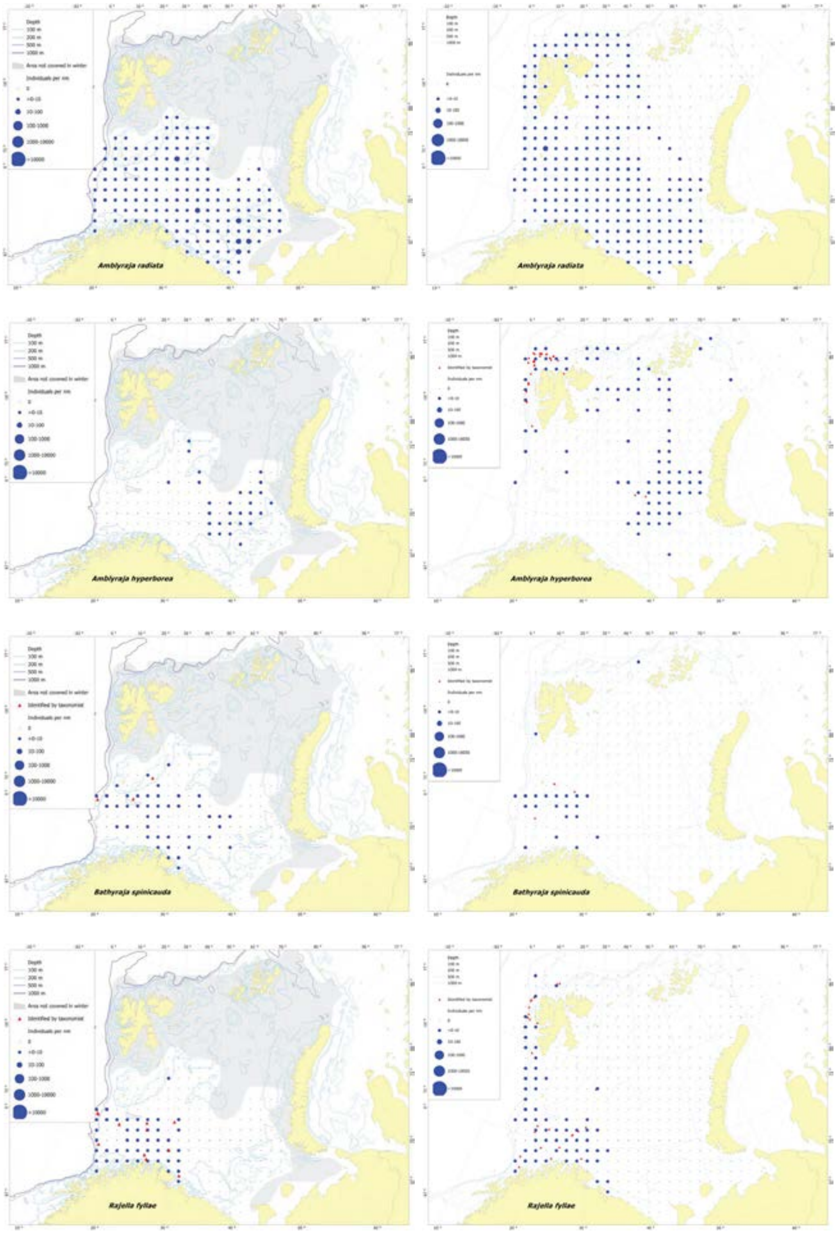

Figure 13.2. Demersal elasmobranchs in the Barents Sea. Spatial distribution of *A. radiata*, *A. hyperborea*, *B. spinicauda* and *R. fyllae* (top to bottom) in Q1 (left) and Q3 (right) Joint Russian–Norwegian surveys. Source: Wienerroither *et al*. (2011, 2013).

Q1 Q3

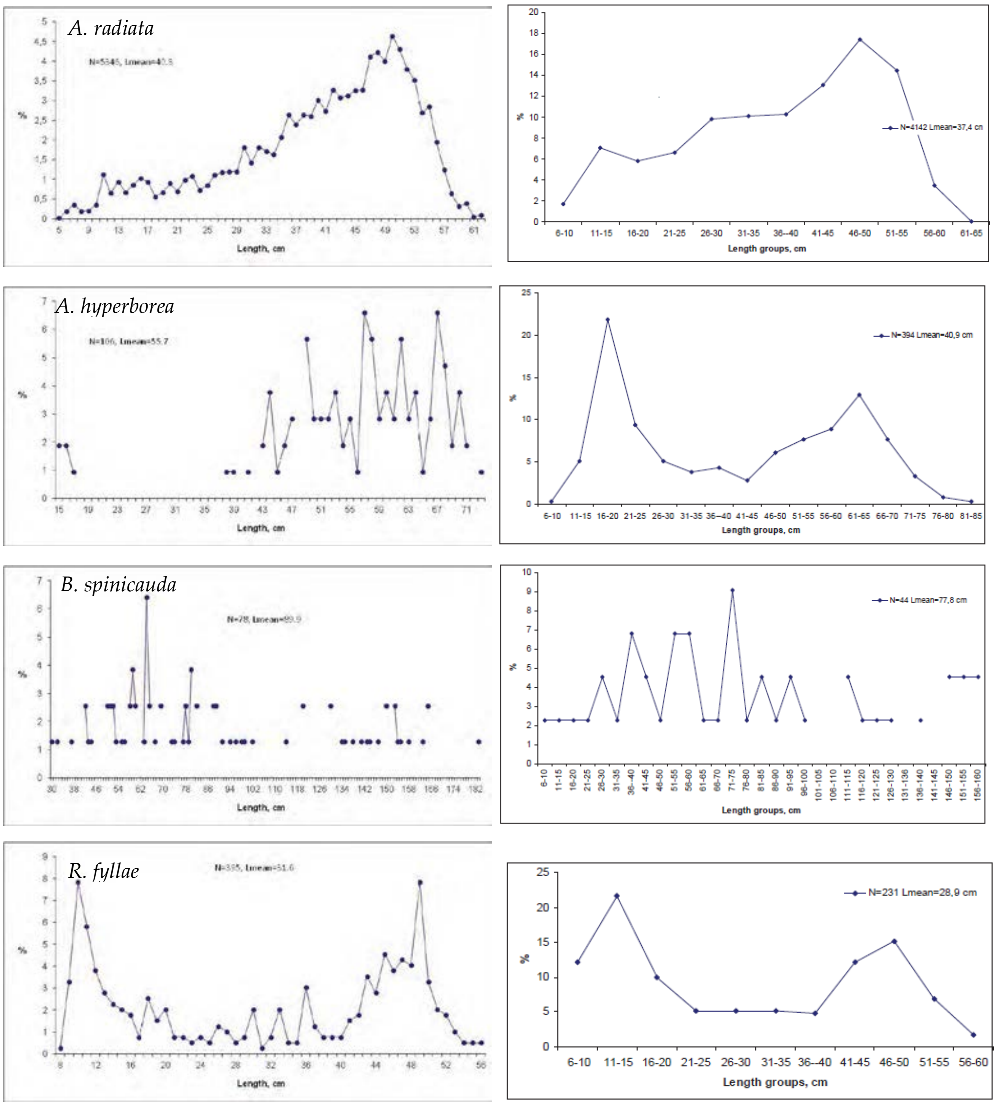

Figure 13.3. Demersal elasmobranchs in the Barents Sea. Length distributions of *A. radiata*, *A. hyperborea*, *B. spinicauda* and *R. fyllae* (top to bottom) in Q1 (left) and Q3 (right) Joint Russian–Norwegian surveys. Note that length distributions are not directly comparable between the two surveys. Source: Wienerroither *et al.* (2011, 2013).

14 Demersal elasmobranchs in the Norwegian Sea

14.1 Ecoregion and stock boundaries

The occurrence of chondrichthyan species in the Norwegian Sea ecoregion was reviewed by Lynghammar *et al*. (2013). In coastal areas, thorny skate *Amblyraja radiata* is the most abundant skate species (Williams *et al*., 2008). While more abundant in the north, this species is common at all latitudes along the Norwegian coast.

Other species that have been confirmed in the coastal area are thornback ray *Raja clavata,* common skate complex, sailray *Rajella lintea,* Norwegian skate *Dipturus nidarosiensis,* sandy ray *Leucoraja circularis*, shagreen ray *Leucoraja fullonica,* round skate *Rajella fyllae*, arctic skate *Amblyraja hyperborea* and spinytail skate *Bathyraja spinicauda*. Long-nose skate *Dipturus oxyrinchus* is distributed mainly along the southern section of the coastline, south of latitude 65°N. Records of blond ray *R. brachyura* and spotted ray *R. montagui* need to be confirmed by voucher specimens, although they are present in catch statistics (Lynghammar *et al.*, 2014).

In deeper areas of the Norwegian Sea, *A. radiata* and *A. hyperborea* are the two most numerous species, but *B. spinicauda* and *R. fyllae* also occur regularly, particularly north of 70°N (Skjaeraasen and Bergstad, 2001; Vollen, 2009 WD).

Sharks in the Norwegian Sea ecoregion include spurdog *Squalus acanthias* (Section 2) velvet belly lanternshark *Etmopterus spinax* (Section 5), porbeagle *Lamna nasus* (Section 6), basking shark *Cetorhinus maximus* (Section 7), Greenland shark *Somniosus microcephalus* (Section 24), black-mouth catshark *Galeus melastomus* and lesser-spotted dogfish *Scyliorhinus canicula* (Section 25).

Stock boundaries are not known for the species in this area, neither are the potential movements of species between the coastal and offshore areas. Further investigations are necessary to determine potential migrations or interactions of elasmobranch populations within this ecoregion and adjacent areas.

14.2 The fishery

14.2.1 History of the fishery

There are no fisheries targeting skates or sharks in the Norwegian Sea, though they are caught in various demersal fisheries targeting teleost species. All skate species in the ecoregion may be taken as bycatch, with only larger individuals thought to be landed (see Section 14.3).

14.2.2 The fishery in 2017

No new information.

14.2.3 ICES advice applicable

ICES does not provide advice for the skate stocks in this ecoregion, although some stocks of North Sea skates may extend into the southern parts of the Norwegian Sea.

14.2.4 Management applicable

There are no TACs for any of the skate stocks in this ecoregion.

Norway has a general ban on discarding. Since 2010, all dead or dying skates in the catches should be landed, whereas live specimens can be discarded.

14.3 Catch data

14.3.1 Landings

Landings data for skates are provided for the years 1973–2017 (Table 14.1; Figure 14.1). For ICES Subarea 2, landings data are limited and, for skates, not species disaggregated. This Subarea covers all of the Norwegian Sea ecoregion, but also includes the most westerly parts of the Barents Sea ecoregion (Section 13).

Overall landings throughout time have been low, ca. 200–300 t per year for all fishing countries, with moderate fluctuations. The peak in the late 1980s resulted from Russian fisheries landing over 1900 t of skates in 1987, subsequently dropping to low levels two years later. This peak was a consequence of an experimental fishery, when skate bycatch was landed, whereas normally they are discarded (Dolgov, pers. comm.). Russia and Norway are the main countries landing skates from the Norwegian Sea.

Landings data (usually not discriminated at species level) have been provided by Norway, France, Germany and the UK in recent years. Russian landings have not been available since 2010.

Based on data from the Norwegian Reference fleets, and the expert judgement detailed in Albert *et al*. (2016 WD), Norwegian landings by species and species groups from ICES Subarea 2 were estimated (Table 14.2). The main species landed tend to be larger specimens of *Dipturus oxyrinchus*, *Bathyraja spinicauda* and *Raja clavata*.

14.3.2 Discard data

Based on interviews of the Norwegian Reference Fleet and landing sites, the expected discards of skates varies extensively between species and is assumed almost 100% for specimens below 50 cm. For *Rajella fyllae* and *Amblyraja radiata,* nearly all specimens are probably discarded, whereas the discarding of *Raja clavata* by the coastal fleet is expected to be negligible (Albert *et al*., 2016 WD).

14.3.3 Quality of catch data

Catch data are not species disaggregated.

Recent data on skate catch and landings in the Norwegian Sea are almost exclusively from Norway, and species information from the Norwegian Reference Fleet (Table 14.2) may be indicative of the total catch and landings. The estimation of total skate catches and landings by species relied on some strong assumptions, e.g. that data from the Coastal and Oceanic Reference Fleets operating in the Norwegian Sea are representative for vessels below and above 21 m respectively, and that the relative species composition of skate catches in either of these two reference fleets has been stable over the last ten years. These assumptions were made due to limited availability of data. With increased data and extended time series, these assumptions should be relaxed by including running averages over shorter time periods, e.g. 3–5 years.

Even after allocating skate landings to species based on data from the Reference Fleet, the generic “Skates and rays” category still accounted for about 30% of the total skate landings. A further reduction of this proportion should however be achievable. The work on improving species identification by arranging workshops for reference fleet crew and education during visits at sea will continue to further improve data quality in the future.

In addition, the splitting by species should also be validated by independent surveys. The best way to do this is probably to include skates on the list of species sampled from selected landing ports. Skates are mostly landed as wings in Norway, which can make conventional species identification more difficult (although skate identification could be confirmed with genetic barcoding). Programmes for market sampling of skate landings could usefully be undertaken.

14.3.4 Discard survival

No data available to WGEF for the fisheries in this ecoregion.

14.4 Commercial catch composition

14.4.1 Species and size composition

In 2009, Russian landings of skates were taken as bycatch during the longline and trawl demersal fisheries at depths ranging from 50–900 m deep in February–November. The main skate caught was *A. radiata*, with A. *fyllae*, *A. hyperborea* and *B. spinicauda* found in minor quantities (Vinnichenko *et al.*, 2010 WD).

A. radiata (27–58 cm L_T) were recorded in the commercial bottom-trawl catches, comprising mostly males of 41–55 cm and females of 36–50 cm (Figure 14.2a). The proportion of small individuals was lower than in the Barents Sea. The mean length of females (43.7 cm) was smaller than that of males (45.0 cm). Males were slightly more abundant in catches (sex ratio of 1.1:1).

Vinnichenko *et al.* (2010 WD) presented data on *A. radiata* compiled from samples taken by scientific observers on commercial fishing vessels, the Russian survey and the joint Russian–Norwegian surveys. These are presented in Section 14.6.4.

14.4.2 Quality of the data

Information on the species composition of commercial catches is required.

Data from the Norwegian Reference Fleet demonstrated that elasmobranch catches in ICES Subarea 2 were dominated by *A. radiata* and *R. clavata* (Table 14.2; Vollen, 2010 WD), although misidentification problems may exist. For vessels in the Oceanic Reference Fleet, elasmobranch bycatch differed between bottom trawl, bottom gillnet and longline. Whereas *A. radiata* made up the bulk of trawl and longline catches (55% and 79% by numbers, respectively), *R. clavata* dominated in gillnet catches (82%). This was probably influenced by the dominance of trawl and longline vessels further north, and more southerly fishing grounds for gillnetters, but potential misidentifications issues should also be investigated. Catches of *A. radiata* were higher in Subarea 2 than in Subarea 1 for trawl catches (61 kg per 100 trawl hours for Subarea 2; 43 kg per 100 trawl hours for Subarea 1), but lower for longline catches (119 kg per 10000 hooks vs. 135 kg per 10000 hooks, respectively).

Data from the Coastal Reference Fleet indicated that the common skate complex (possibly misidentified) and unidentified skates dominated the landed catches in this area (39% and 33% by weight, respectively). Discards were dominated by unidentified skates (32% by weight). As opposed to the Oceanic Reference Fleet, *A. radiata* was only sporadically recorded in this area.

14.5 Commercial catch and effort data

Limited data available (but see above).

14.6 Fishery-independent surveys

14.6.1 Russian bottom trawl survey (RU-BTr-Q4)

Vinnichenko *et al.* (2010 WD) reported that catches from the 2009 survey were dominated by *A. radiata* of 10–56 cm L_T (Figure 14.2b). In the size distribution, different size/age classes of the skate were very distinct. The mean length of males (37.7 cm) and females (37.4 cm) were similar, and males were slightly predominant (sex ratio = 1.05:1).

A. hyperborea of 17–91 cm L_T were recorded in the catches (Figure 14.2d; specimens >131 cm were not considered here as they are thought to be typing errors or species misidentifications). Predominating were males of 46–50 cm and 61–75 cm, and females in the 56–65 cm and 76–80 cm length classes. The mean length of males (65.1 cm) and females (65.8 cm) were similar. Mostly males were caught (sex ratio = 5:1).

14.6.2 Norwegian coastal survey (NOcoast-Aco-4Q)

The distribution and diversity of elasmobranchs in northern Norwegian coastal areas, based on survey data from 1992–2005, were summarized by Williams *et al.* (2008). The southern portion of the coastal area studied was incorporated within the Norwegian Sea ecoregion, and the Barents Sea was defined as the border between Norwegian Directorate of Fisheries Statistical Areas 04 and 05.

Thirteen skate species and four species of shark were recorded inhabiting the coastal region (Table 14.3). Regularly occurring skates were *A. radiata, A. hyperborea,* common skate complex, *D. nidarosiensis, D. oxyrinchus, Raja clavata, Rajella fyllae, L. fullonica*. Occasional or single observations were made of *B. spinicauda*, *R. lintea* and *L. circularis* (also *R. montagui*, *R. brachyura* were nominally recorded, but see Section 14.6.5). Four species of shark were identified: *E. spinax, G. melastomus* and *S. acanthias*, as well as one specimen of *S. microcephalus.*

The *A. radiata* appear to fluctuate in both biomass and numbers, but the stock has had a positive trend for the last nine years (Knutsen *et al*., 2017 WD). *D. oxyrinchus* also fluctuate in biomass, but only slightly in numbers, indicating variance in size composition between years. However, the overall trends in biomass and numbers are positive. The estimates of biomass and abundance of *R. fyllae* remained stable through the time series (2003–2016) (Knutsen *et al*., 2017 WD).

Although no clear shifts in abundance over time were detected for any species, more robust assessment is necessary to better identify temporal trends in abundances.

14.6.3 Deep stations from multiple Norwegian surveys (NO-GH-Btr-Q3 and others)

Vollen (2009 WD) reported on elasmobranch catches from 3185 deep trawl hauls (400–1400 m) along the continental slope (62–81°N) from the Barents Sea to the Skagerrak. Data were combined from multiple deep-water surveys during the period 2003–2009. Data from the Skagerrak are excluded in this section, whereas parts of the Barents Sea ecoregion are included. Overall, nine species (six skates and three sharks) were recorded. *A. radiata* and *A. hyperborea* were the dominant species north of 62°N (ICES Subarea 2), whereas *E. spinax* was most numerous in the Norwegian Deep (Division 3.a). *B. spinicauda* and *R. fyllae* also occurred frequently in the catches in all areas. Reports of *R. clavata* were considered to be misidentifications of other species. Results were reported in more detail in ICES (2009).

14.6.4 Joint Russian-Norwegian survey (BS-NoRu-Q1 (BTr), Eco-NoRu-Q3 (Aco)/Eco-NoRu-Q3 (Btr))

Two joint Russian–Norwegian surveys are conducted in the Barents Sea: one during February (BS-NoRu-Q1 (BTr)), in the southern Barents Sea northwards to the latitude of Bear

Island, and another in August–September (Eco-NoRu-Q3 (Aco)/Eco-NoRu-Q3 (Btr)), covering much of the Barents Sea, including waters near Spitsbergen and Franz Josef Land. The Norwegian part of the February survey started in 1981, but data on elasmobranchs are missing for some years. The August–September survey started in 2003. All skates are recorded during these surveys, and data on length distributions as well as some biological data (on board of Russian vessels) are collected. As a result of initial problems with species identification, species-specific data should only be used from the years 2006–2007 onwards (for Norwegian data). Analyses of data from these surveys are not complete, but some data from the 2009 surveys were presented by Vinnichenko *et al.* (2010 WD).

A. radiata was the dominant species in the August–September survey. Individuals varied from 5–61 cm L_T (Figure 14.2c), with most specimens 33–37 cm (Vinnichenko *et al.*, 2010 WD).

Vinnichenko *et al.* (2010 WD) also presented data on *A. radiata* compiled for samples collected by scientific observers on commercial fishing vessels, the Russian survey and the joint Russian–Norwegian surveys. Males prevailed in the samples (1.7:1). Most males and females (over 70%) were immature, the rest were in developing stages or were mature. Unlike in the Barents Sea, no individuals at the active stage were reported in the area. The main prey (by weight) were crustaceans (spider crab *Hyas* spp.: 33%; northern shrimp *Pandalus borealis*: 14%; amphipods: 6%), fish (capelin *Mallotus villosus*: 14%; Atlantic hookear sculpin *Artediellus atlanticus*: 12%; unidentified fish remains: 6%) and polychaete worms.

14.6.5 Quality of survey data

The difficulties associated in identifying skate species are a concern when considering the validity of the data used for any assessment. Identification problems between *A. radiata* and *R. clavata* were highlighted by Williams (2007) and summarized in ICES (2007). Despite sampling since 2007, Lynghammar *et al.* (2014) did not obtain any specimens of the common skate complex, *L. fullonica*, *R. brachyura* or *R. montagui* in the Norwegian Sea: giving more credence to earlier misidentification issues. The two former species have been confirmed to exist in the area in historical times, whilst the two latter species have never been confirmed. *R. montagui* from central Norway was known from a museum specimen, but Lynghammar *et al.* (2014) identified it as *R. clavata*.

In order to achieve a better quality of survey data, it is important to improve the identification practices, using appropriate identification literature. Ongoing work to improve sampling at the Institute of Marine Research includes workshops to educate staff as well as improved guides and keys used for species identification.

14.7 Life-history information

Some length data are available for *A. radiata* and *A. hyperborea* (Vinnichenko *et al.*, 2010 WD; ICES, 2010). Some biological information is available in the literature (e.g. Berestovskii, 1994). Sampling of elasmobranch egg-cases was included in Norwegian trawl surveys from mid-2009, and may provide future information on nursery grounds.

14.8 Exploratory assessment models

No exploratory assessments have been conducted, due to the limited data available. Analyses of survey trends may allow evaluation of the status of more frequently-caught species, although taxonomic irregularities need to be addressed first.

14.9 Stock assessment

No assessments have been conducted.

14.10 Quality of assessments

No assessments have been conducted.

14.11 Reference points

No reference points have been proposed for any of these skate stocks.

14.12 Conservation considerations

The International Union for Conservation of Nature and Natural Resources (IUCN Red List of Threatened species (IUCN, 2014) listings for species occurring in this area include (assessment year in parentheses):

"Critically endangered": common skate complex (2006);

"Endangered": *L. circularis* (2014);

"Vulnerable": *L. fullonica* (2014);

"Near threatened": *B. spinicauda* (2006), *D. nidarosiensis* (2014), *D. oxyrinchus* (2014) and *R. clavata* (2005).

Demersal elasmobranchs listed on the Norwegian Red List (Nedreaas *et al.*, 2015), excluding species assessed as "Least concern", is only the common skate complex ("Critically endangered").

14.13 Management considerations

There are no TACs for any of the skates in this ecoregion. The demersal elasmobranch fauna of the Norwegian Sea comprises several species that also occur in the Barents Sea (Section 13) and/or the North Sea (Section 15). Further investigations are required, and could also offer valuable additional information for managing the neighbouring ecoregions.

14.14 References

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Table 14.1. Demersal elasmobranchs in the Norwegian Sea. Total landings (t) of skates from ICES Subarea 2 (and Division 2.a and 2.b) from 1973–2016. "n.a." = no data available, "." = means zero catch, "+" = < 0.5 tonnes. Countries with only occasional catches are not included in the landings table: Denmark (1994), Belgium (1 tonne 1975), Sweden (+ in 1975), Netherlands (1979, 2015), Iceland (2001, 2011), Estonia (2002, 2005), and Ireland (2007, 2009). Species included are: *A. radiata, D. licha, D. pastinaca, D. spp., L. circularis, L. fullonica, L. naevus, M. aquila, R. brachyura, R. clavata, R. montagui, R. alba, T. marmorata,* Rajiformes (indet).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Faroe Islands	.	.	.	5	2	1	1	.	.	.	.	.	.	4
France	.	.	1	68	61	18	2	1	12	109	2	6	5	11
Germany	+	1	52	12	59	114	84	85	53	7	2	112	124	102
Norway	201	158	89	34	99	82	126	191	137	110	96	150	104	133
Portugal	.	.	.	34	39	.	.	.	.	.	.	.	.	.
USSR/Russ. Fed.	.	.	.	.	.	302	99	39	.	.	.	537	261	1633
Spain	.	.	.	.	.	.	.	.	.	.	28		17	5
UK – E, W & NI	65	18	14	20	90	10	6	2	+	+	.	5	1	2
UK - Scotland	2	1	.	+	1	+	.	.	.	.	.	.	+	+
Other	.	.	1	.	.	.	2	.	.	.	.	.	.	.
Total	268	178	157	173	351	527	320	318	202	226	128	810	512	1890

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Faroe Islands	.	15	.	42	.	2	.	.	.	.	.	.	.	.
France	21	42	8	56	11	15	9	7	8	6	8	5	.	5
Germany	95	76	32	52	.	+	.	.	.	.	.	.	.	2
Norway	214	112	148	216	235	135	286	151	239	198	169	214	239	244
Portugal	.	.	.	.	.	.	22	11	.	10	28	46	10	6
USSR/Russ. Fed.	1921	1647	867	208	n.a.	181	112	257	n.a.	n.a.	77	139	247	400
Spain	.	9	.	.	.	.	.	.	3	.	3	15	6	.
UK - E, W & NI	4	.	2	1	+	1	+	+	1	4	.	+	1	+
UK – Scotland	2	+	+	+	+	+	+	.	+	+	+	+	1	1
Other	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Total	2257	1902	1057	575	246	334	429	426	251	218	285	419	504	658

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Faroe Islands	.	.	2	12	15	13	9	13	4	3	n.a.	.	n.a.	n.a.
France	4	7	2	7	9	7	2	5	3	6	1	1	+	+
Germany	.	2	2	7	1	.	.	.	+	1	.	.	1	2
Norway	233	118	111	142	133	146	189	259	258	250	197	121	147	105
Portugal	3	.	8	2	1	14	13	2	.	.	.	.	.	.
USSR/Russ. Fed.	113	38	6	50	20	16	20	.	8	2	n.a.	n.a.	n.a.	n.a.
Spain	7	11	32	.	1	.	.	.	.	+	.	+	1	+
UK - E, W & NI*		.	.	.	2	4	1	1	+	+	+	.	1	.
UK – Scotland*	1	3	3	.	.	.	.	.	.	.	.	.	.	.
Other	4	5	.	.	.	.	1	.	+	.	.	.	.	.
Total	365	184	166	220	165	186	226	268	269	259	200	122	149	108

	2015	2016	2017
Faroe Islands	.	.	.
France	.	.	.
Germany	2	1	1
Norway	112	198	111
Portugal	.	.	.
USSR/Russ. Fed.	.	.	.
Spain	.	.	.
UK (combined)*	2	+	.
Other	+	.	.
Total	115	200	112

*From 2005 Scottish landings data are combined with those from England, Wales and Northern Ireland, and presented as UK (combined). + under 0.5 ton

Table 14.2. Demersal elasmobranchs in the Norwegian Sea. Estimated Norwegian landings (tons) of skates and rays by species in ICES Subarea 2. Source: Albert *et al.* (2016 WD).

	2012	**2013**	**2014**	**2015**
Amblyraja hyperborea	9	11	7	10
Bathyraja spinicauda	23	28	19	23
Common skate complex	7	9	7	7
Dipturus oxyrinchus	23	28	23	20
Leucoraja circularis	2	2	2	2
Leucoraja fullonica	1	1	1	1
Raja clavata	14	17	14	12
Rajella lintea	6	7	5	6
Rajidae indet.	36	43	27	32
Total	**121**	**146**	**104**	**112**

Table 14.3. Catch data (number of individuals per species) for the Norwegian Sea ecoregion from the Annual Autumn Bottom-trawl Surveys of the North Norwegian Coast, from 1992 to 2005. Adapted from Williams *et al.* (2007 WD).

Species	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total catch	Total % of positive samples	Catch rate (No. per survey)
Amblyraja radiata	7	44	23	15	8	41	9	16	9	6	10	10	19	9	226	11%	17.4
Bathyraja spinicauda	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0%	0.1
Rajella fyllae	0	4	0	0	0	1	0	0	0	0	5	6	4	0	20	1%	1.5
Raja clavata	0	4	15	1	0	2	3	6	0	0	0	0	2	0	33	2%	2.5
Common skate complex	0	2	0	1	3	7	7	1	1	1	1	0	0	0	24	1%	1.8
Leucoraja fullonica	0	0	0	0	0	0	0	4	3	9	3	0	0	1	20	1%	1.5
Leucoraja circularis	0	0	0	0	0	0	0	0	1	0	1	9	5	7	23	1%	1.8
*Raja montagui**	0	0	0	0	0	0	0	2	1	0	1	0	1	0	5	<1%	0.4
Dipturus oxyrinchus	0	0	54	3	2	30	2	0	0	1	2	6	4	2	106	5%	8.2
Dipturus nidarosiensis	0	0	0	0	1	1	0	0	0	3	1	0	1	0	7	<1%	0.5
Amblyraja hyperborea	0	0	1	0	0	0	0	0	0	0	4	0	1	0	6	<1%	0.5
*Raja brachyura**	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	<1%	0.3
Rajella lintea	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	<1%	0.1
Galeus melastomus	0	24	1883	1197	105	1269	189	480	258	812	1196	275	640	48	8376	24%	644.3
Etmopterus spinax	0	829	8453	473	1061	2733	584	3881	1485	1401	2417	785	2305	1369	27 776	33%	2136.6
Squalus acanthias	0	21	51	26	20	5	106	168	12	68	43	21	104	17	662	8%	50.9
Somniosus microcephalus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	<1%	0.1
Number of samples	17	163	106	77	74	96	78	81	76	56	78	65	77	63			

***Probably misidentifications, the occurrence of the species in the area has not been confirmed (see Section 14.6.5).**

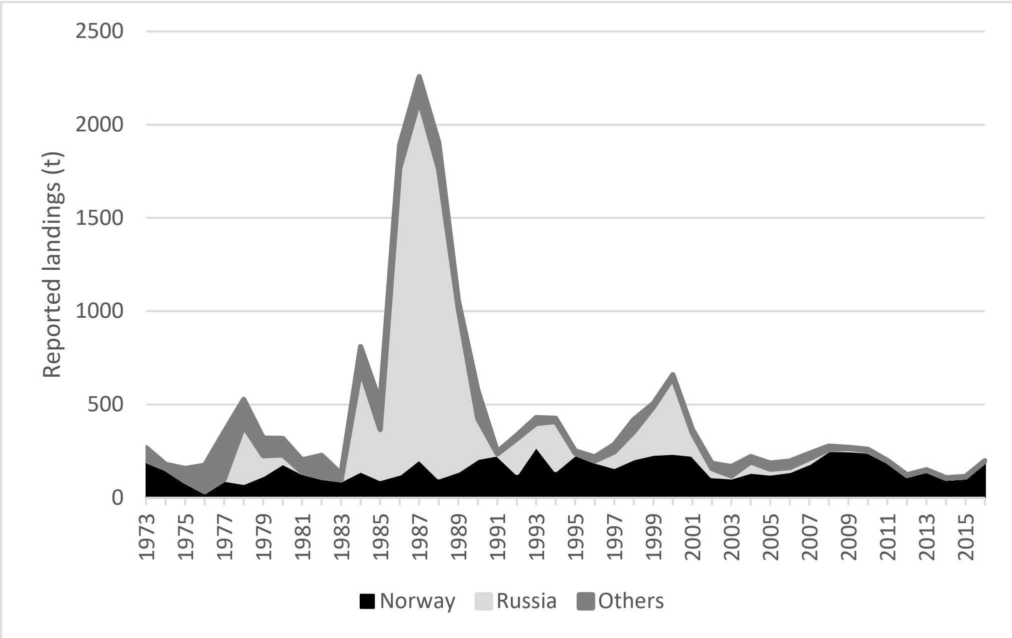

Figure 14.1. Demersal elasmobranchs in the Norwegian Sea. Total landings (t) of skates from ICES Subarea 2 (1973–2016).

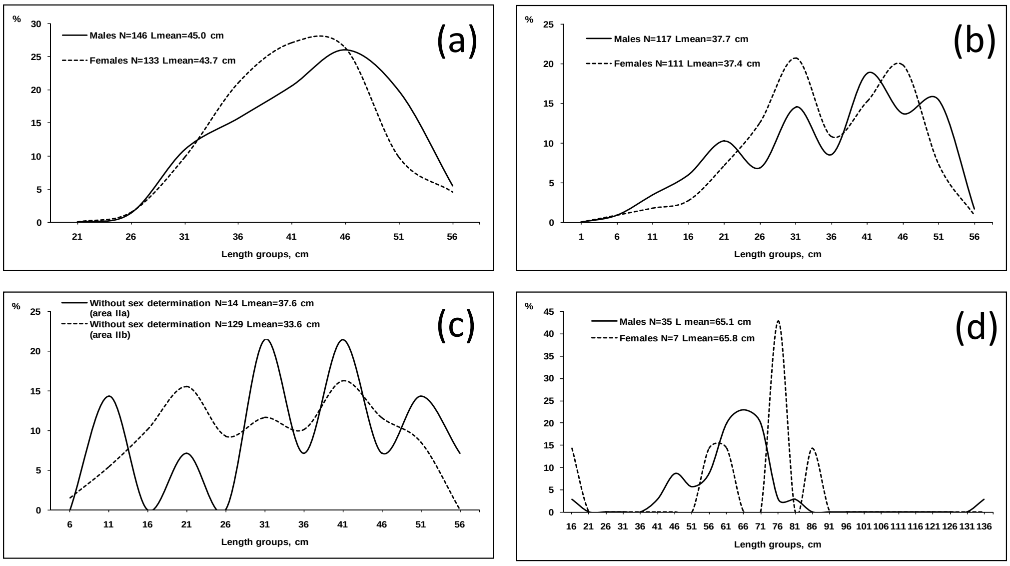

Figure 14.2. Demersal elasmobranchs in the Norwegian Sea showing the length composition of *A. radiata* in (a) commercial bottom-trawl catches in the Norwegian Sea in 2009, (b) Russian demersal survey (October–December 2009) and (c) the Norwegian Sea based on data from the joint Russian–Norwegian ecosystem survey (August–September 2009); and (d) length composition of *A. hyperborea* in the Norwegian Sea (Division 2.b) from the Russian demersal survey (October–December 2009). Specimens exceeding 131 cm are probably typing errors or misidentifications. Source: Vinnichenko *et al*. (2010 WD).

15 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel

15.1 Ecoregion and stock boundaries

In the North Sea, about ten skate and ray species occur, as well as about ten demersal shark species (Daan *et al.*, 2005). Thornback ray *Raja clavata* is probably the most important skate for the commercial fisheries. Preliminary assessments on this species were presented in ICES (2005, 2007), based on research survey data. WGEF is still concerned over the possibility of misidentification of skates in some recent IBTS surveys, especially differentiation between *R. clavata* and starry ray *Amblyraja radiata* .

R. clavata in the Greater Thames Estuary (southern part of Division 4.c) is known to move into the eastern English Channel (Walker *et al.*, 1997; Ellis *et al.*, 2008b). For most other demersal species in the North Sea ecoregions, stock boundaries are not well known. Stocks of cuckoo ray *Leucoraja naevus*, spotted ray *R. montagui* and *R. clavata* (northern North Sea) probably continue into the waters west of Scotland and, in the case of *R. montagui*, also into the eastern English Channel. Blonde ray *Raja brachyura* has a patchy distribution, occurring in the southern North Sea (presumably extending to the eastern English Channel) and north-western North Sea (and this stock may extend to north-west Scotland).

The distribution and stock boundaries of the two species in the common skate complex are uncertain. The larger-bodied flapper skate *Dipturus intermedius* occurs in the north-western North Sea, and this stock is likely the same as occurs of North-west Scotland. The presence and geographical extent of blue skate *Dipturus batis* in this region is uncertain, but this species may have occurred in the southern North Sea historically.

This section focuses primarily on skates (Rajidae). For the main demersal sharks in this ecoregion, the reader is referred to the relevant chapters for spurdog (Section 2), tope (Section 10), smooth-hounds (Section 21) and lesser-spotted dogfish and other catsharks (Section 25).

15.2 The fishery

15.2.1 History of the fishery

Demersal elasmobranchs are caught as a bycatch in the mixed demersal fisheries for roundfish and flatfish. A few inshore vessels target skates and rays with tangle nets and longlines. For a description of the demersal fisheries see the Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (ICES, 2009a) and the report of the DELASS project (Heessen, 2003).

In 2007, the EC brought in a 25% bycatch ratio (see also Section 15.2.4, footnote 1) for vessels over 15 m. This has restrained some fisheries and may have resulted in misreporting, both of area and species composition.

15.2.2 The fishery in 2017

The landings generally peaked in the middle of the 1980s and declined steadily thereafter in the North Sea (see Figure 15.3.1). Since 2008, the TAC appears to have been restrictive for the fisheries in the North Sea. A similar trend is observed for Division 7.d although a slight increase (7%) in landings was observed since 2005.

15.2.3 ICES Advice applicable

ICES provided stock-specific advice for several species/stocks in this region in 2017 (for 2018 and 2019) as summarized below (and Section 15.9).

Stock	Assessment cat.	Landings advice	Implied landings in 2018 and 2019
Common skate *Dipturus batis-complex* Subarea 4 and Division 3.a	6.3.0	There should be no landings for these stocks and measures should be taken to minimize by-catch.	0 t
Thornback ray *Raja clavata* Subarea 4 and Divisions 3.a and 7.d	3.2	Landings should be no more than 2110 tonnes	2574 t
Blonde ray *Raja brachyura* Subarea 6 and Divisions IVa	5.2	Landings should be no more than 6 tonnes	6 t
Blonde ray *Raja brachyura* Divisions 4.c and 7.d	5.2	Landings should be no more than 162 tonnes	195 t
Spotted ray *Raja montagui* Subarea 4 and Divisions 3.a and 7.d	3.2	Landings should be no more than 292 tonnes	291 t
Cuckoo ray *Leucoraja naevus* Subarea 4 and Division 3.a	3.2	Landings should be no more than 128 tonnes	116 t
Starry ray *Amblyraja radiata* Subareas 2, 4 and Division 3.a	3.1.5	There should not be a targeted fishery for this stock and measures should be taken to reduce bycatch	0 t
Other skates and rays Subarea 4 and Divisions 3.a and 7.d	6.2.0	ICES cannot provide advice on the status of these stocks due to a lack of reliable survey and catch data. ICES advises that improved collection of species-specific landings data for more skate taxa be introduced, including for larger-bodied skates of *Dipturus* spp., sandy ray *Leucoraja circularis* and shagreen ray *Leucoraja fullonica,* to help to inform on the status of these stocks.	NA

15.2.3.1 State of the stocks

In 2012, WGEF provided a qualitative summary of the general status of the major species based on surveys and landings. It should be noted that this perception has not changed.

Common skate complex: Depleted. It was formerly widely distributed over much of the North Sea but is now found only rarely, and only in the northern North Sea. The distribution extends into the west of Scotland and the Norwegian Sea [Note: This perception was based on comparisons of historical and contemporary trawl survey data]. In the last 10 years catch rates have increased in the IBTS surveys.

R. clavata: The distribution area and abundance have decreased over the past century, with the stock concentrated in the south-western North Sea where it is the main commercial skate species. Its distribution extends into the eastern Channel. Survey catch trends in divisions 4.c and 7.d have been increasing in recent years. The status of *R. clavata* in divisions 4.a-b is uncertain.

R. montagui: Stable/increasing. The area occupied has fluctuated without trend. Abundance in the North Sea is increasing since 2000, in the eastern Channel a slight increase can be observed during recent years.

***A. radiata*:** Stable/decreasing. Survey catch rates increased from the early 1970s to the early 1990s and have decreased since then.

L. naevus: Stable. Since 1990 the area occupied has fluctuated without trend. Abundance has decreased since the early 1990s. In recent years, catch rates in the IBTS have increased, while they have been stable/decreasing in the BTS Tridens survey.

R. brachyura: Uncertain. This species has a patchy occurrence in the North Sea. It is at the edge of its distributional range in this area. However, several surveys have shown increased catch rates in the last 15 years.

15.2.4 Management applicable

In 1999, the EC first introduced a common TAC for “skates and rays”. From 2008 onwards, the EC has obliged Member States to provide species-specific landings data for the major North Sea species: *R. clavata*, *R. montagui*, *R. brachyura*, *L. naevus*, *A. radiata* and the ‘common skate complex’. WGEF is of the opinion that this measure is ultimately expected to improve our understanding of the skate fisheries in the area.

The TACs (Council Regulation (EU) 2018/120); for skates and rays for the different parts of the area in 2018 are: 1654 t for EU waters of Division 2.a and Subarea 4; 1276 t for Division 7.d; and 47 t for Division 3.a. Some transfer (5%) between Division 7.d TAC area and the Celtic Seas ecoregion is allowed, which may account for some quota overshoot of the TAC in 7.d. Within the overall skate TAC for Division 7.d, a species-specific precautionary TAC of 19 t was set for undulate ray (*Raja undulata*), with a special condition that up to 5% may be fished in Union waters of 7.e and reported under the following code: (RJU/*67AKD).

The original 2016 TAC regulations (Council Regulation (EU) 2016/72), also excluded blonde ray *Raja brachyura* from the TAC for Union waters of Division 2.a and Subarea 4 (along with small-eyed ray *Raja microocellata*) advising “when accidentally caught, these species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species”. Following a scientific rebuttal of the need for this measure for *Raja brachyura* in Subarea 4, it was subsequently amended in Council Regulation (EU) 2016/458, and restricted to *Raja microocellata* only.

The list of prohibited species on EU fisheries regulations (Council Regulation (EU) 2016/72) included the following species within the North Seas ecoregion: White skate *Rostroraja alba* (Union waters of ICES subareas 6–10), thornback ray *Raja clavata* (Union waters of Division 3.a), starry ray *Amblyraja radiata* (Union waters of Divisions 2.a, 3.a and 7.d and Subarea 4) and common skate complex in Union waters of Division 2.a and ICES subareas 3, 4, 6–10.

Year	TAC	TAC for 2.a and 4	TAC for 7.d	TAC for 3.a	Landings*
1999	6060	6060			3997
2000	6060	6060			3992
2001	4848	4848			4011
2002	4848	4848			3904
2003	4121	4121			3797
2004	3503	3503			3237
2005	3220	3220			3264 (3030)
2006	2737	2737			2949 (2845)
2007	2190	2190 (1)			3168 (3141)
2008	1643	1643 (2)			3218 (3025)
2009	2755	1643 (3,4,5)	1044 (i, ii)	68 (a, b)	3094 (3192)
2010	2342	1397 (3,4,5)	887 (i, ii, iii)	58 (a, b)	2908 (2951)
2011	2342	1397 (3,4,5)	887 (i, ii, iii)	58 (a, b)	2726 (2672)
2012	2340	1395 (3,4,5)	887 (i, ii, iii)	58 (a, b)	2844 (2738)
2013	2106	1256 (3,4,5)	798 (ii, iii, iv)	52 (c,d)	2994 (3000)
2014	2101	1256 (4,6,7)	798 (iii,v,vi)	47 (e,f)	2843 (2603)
2015	2227	1382 (4,6,7)	798 (iii, vii, viii)	47 (e)	2526
2016	2326	1313 (6,8,9)	966 (iii, vii, ix)	47 (e)	2702
2017	2488	1378 (6,8,9)	1063 (iii, vii, ix)	47 (e)	2678
2018	2977	1654 (6,8,9,10)	1276 (v,x,xi,xii)	47 (e)	

***Data from 2005 onwards revised following 2016 Data Call, with previous estimates in brackets.**

1) By-catch quota. These species shall not comprise more than 25% by live weight of the catch retained on board.

2) Catches of cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata*, blonde ray *Raja brachyura*, spotted ray *Raja montagui*, starry ray *Amblyraja radiata* and common skate *Dipturus batis* to be reported separately.

3) Catches of cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata*, blonde ray *Raja brachyura*, spotted ray *Raja montagui* and starry ray *Amblyraja radiata* to be reported separately.

4) By-catch quota. These species shall not comprise more than 25% by live weight of the catch retained on board. This condition applies only to vessels over 15 m length overall.

5) Does not apply to common skate *Dipturus batis*. Catches of this species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

6) Catches of cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata*, blonde ray *Raja brachyura* and spotted ray *Raja montagui* to be reported separately.

7) Shall not apply to common skate *Dipturus batis* complex and starry ray *Amblyraja radiata* . When accidentally caught, these species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

8) By-catch quota. These species shall not comprise more than 25% by live weight of the catch retained on board per fishing trip. This condition applies only to vessels over 15 metres' length overall. This condition applies only to vessels over 15 m LOA. This provision shall not apply for catches subject to the landing obligation as set out in Article 15(1) of Regulation (EU) No 1380/2013.

9) Shall not apply to blonde ray *Raja brachyura* in Union waters of 2.a and small-eyed ray *Raja microocellata* in Union waters of 2.a and 4. When accidentally caught, these species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species

10) Special condition: of which up to 10 % may be fished in Union waters of 7d (SRX/*07D2.), without prejudice to the prohibitions set out in Articles 13 and 45 of this Regulation for the areas specified therein. Catches of blonde ray (*Raja brachyura*) (RJH/*07D2.), cuckoo ray (*Leucoraja naevus*) (RJN/*07D2.), thornback ray (*Raja clavata*) (RJC/*07D2.) and spotted ray (*Raja montagui*) (RJM/*07D2.) shall be reported separately. This special condition shall not apply to small-eyed ray (*Raja microocellata*) and undulate ray (*Raja undulata*).

(i) Catches of cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata*, blonde ray *Raja brachyura*, spotted ray *Raja montagui* and starry ray *Amblyraja radiata* to be reported separately.

(ii) Does not apply to common skate *Dipturus batis* and undulate ray *Raja undulata*. Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

(iii) Of which up to 5% may be fished in EU waters of 6.a-b, 7.a-c and 7.e-k

(iv) Catches of cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata*, blonde ray *Raja brachyura*, spotted ray *Raja montagui*, small-eyed ray *Raja microocellata* and starry ray *Amblyraja radiata* to be reported separately.

(v) Catches of cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata*, blonde ray *Raja brachyura*, spotted ray *Raja montagui* and small-eyed ray *Raja microocellata* to be reported separately.

(vi) Does not apply to common skate complex *Dipturus batis*, undulate ray *Raja undulata* and starry ray *Amblyraja radiata* . Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

(vii) Catches of cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata*, blonde ray *Raja brachyura*, spotted ray *Raja montagui*, small-eyed ray *Raja microocellata* and undulate ray *Raja undulata* to be reported separately.

(viii) Undulate ray not to be targeted, with a trip limit of 20 kg live weight per trip, and catches to remain under an overall quota of 11 t

(ix) Undulate ray not to be targeted, with a trip limit of 40 kg live weight per trip, and to remain under an overall quota of 12 t

(x) of which up to 5 % may be fished in Union waters of 6a, 6b, 7a-c and 7e-k. This special condition shall not apply to small-eyed ray *Raja microocellata* and to undulate ray *Raja undulata*.

(xi) of which up to 10 % may be fished in Union waters of 2a and 4. his special condition shall not apply to small-eyed ray *Raja microocellata*.

(xii) Undulate ray not to be targeted. The catches shall remain under an overall quota of 19t.

a) Catches of cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata*, blonde ray *Raja brachyura*, spotted ray *Raja montagui* and starry ray *Amblyraja radiata* to be reported separately.

b) Does not apply to common skate *Dipturus batis*. Catches of this species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

c) Catches of cuckoo ray *Leucoraja naevus*, blonde ray *Raja brachyura*, spotted ray *Raja montagui* and starry ray *Amblyraja radiata* to be reported separately.

d) Does not apply to common skate *Dipturus batis* and thornback ray *Raja clavata*. Catches of this species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

e) Catches of cuckoo ray *Leucoraja naevus*, blonde ray *Raja brachyura* and spotted ray *Raja montagui* to be reported separately.

f) Does not apply to common skate complex *Dipturus batis*, thornback ray *Raja clavata* and starry ray *Amblyraja radiata* . Catches of this species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

Within the North Sea ecoregion, some of the UK's Inshore Fisheries and Conservation Authorities (IFCAs), formerly Sea Fisheries Committees, have a minimum landing size of 40 cm disc width for skates and rays.

In 2013, Dutch Producer Organisations introduced a minimum landings size of 55 cm (total length) for skates and rays. In addition, to keep landings within the national quota, the POs have implemented landing restrictions varying between 100 and 250 kg dead weight.

Since 2009, Norway has had a discard ban that applies to skates and sharks, as well as other fish, in the Norwegian Economic Zone. Whilst some discarding of skates is likely to have continued, the precise quantity is unknown.

15.3 Catch data

15.3.1 Landings

The landings tables for all rays and skates combined (Tables 15.3.1–15.3.3) were updated. Since 2008, EC member states are required to provide species-specific landings data for the main species of rays and skates and these are collated by stock (Table 15.3.4). These data were all based on data submitted in the 2017 Data Call, with appropriate corrections made, following the recommendations of WKSHARKS (ICES, 2016).

Figure 15.3.1 shows the total international landings of rays and skates from Division 3.a, Subarea 4, and Division 7.d since 1973. The figure also includes the combined landings of 3a and 4 plus the TAC for recent years. Data from 1973 onwards are WGEF estimates.

15.3.2 Discard data

Information on discards in the different demersal fisheries is being collected by several Member States, and was submitted to the Expert Group.

Length–frequency distributions of discarded and retained elasmobranchs (for the period 1998–2006) were provided by UK-England (ICES, 2006), with updated information in Ellis *et al*. (2010). Silva *et al*. (2012) investigated the UK skate catches, including those from the North Sea, and using observer data, discussed discarding patterns. In general, 50% retention occurred at 49–51 cm total length (L_T) for the main commercial skate species, and nearly all skates larger than 60 cm L_T were retained. *A. radiata* was generally discarded across the entire length range (12–69 cm L_T).

A Dutch (industry) study funded by the European Maritime and Fisheries Fund (2016–2018) was set up to get a more detailed view on the catch composition. Vessels register and retain discards of quota regulated species by haul on board. In the auction, the discards are sorted by species, measured and weighed. The sorting process includes skates and rays and results show that for the Dutch pulse fishery 80 to 90% of the rays are discarded, with L_T ranging from 20 to >80 cm for the main commercial species (i.e. *Raja clavata*, *Raja montagui* and *Raja brachyura*). This high discard rate is mainly due to restrictive Dutch quotas for skate and rays.

15.3.3 Quality of the catch data

In 2008, the EC asked Member States to start reporting their landings of skates and rays by (major) species. Compliance with this varies from 0–100% by region and Member State (see Section 15.4.1), with a greatly increased proportion of skates now reported at species-level. The quality of the species-specific data is discussed in Section 15.4.2.

Several nations have market sampling and discard observer programmes that can also provide information on the species composition, although comparable information is lacking for earlier periods. Updated analyses of these data are required.

The ongoing French project "RAIMEST", conducted by French fisheries regional committees, aims to improve existing knowledge on skate stocks in Division 7.d, based on fisher knowledge. This work aims to improve knowledge on functional fishery areas and on the spatial characteristics of skate catches (presence of areas, species distribution, seasonality, individual size, etc.). Another goal is to define a correction coefficient to apply to declarative data (logbook) in this area.

15.3.4 Discard survival

Rays will be phased in under the European landing obligation (LO) from 1 January, 2019 onwards, and given the disparity in quota and actual landings, it is expected that at least some species will become "choke" species in certain fisheries. As stated in STECF 2014 "Article 15 paragraph 2(b)" exemptions from the LO are possible for species for which "scientific evidence demonstrates high survival rates" (CEFAS, 2017).

Ellis *et al.* (2017) provided a review of discard survival studies. Skates taken in coastal fisheries using trawls, longlines, gillnets and tangle nets generally show low at-vessel mortality (Ellis *et al*., 2008a, 2018), though it should be noted that the inshore fleet generally have limited soak times and haul durations. Studies for beam trawlers indicate that just over 70% of skates may survive (Depestele *et al*., 2014).

While most studies provided estimates of short-term survival, a Dutch study quantitatively estimated the longer-term discard survival probability of thornback ray. Discard survival was assessed during nine trips with commercial pulse-trawlers, monitoring survival in captivity for 15–18 days (Schram and Molenaar, 2018). The discard survival probability estimates varied among sea trips, resulting in a survival probability estimate of 53% (95%CI 40–65%). Also, during two trips, discard survival probabilities were estimated for spotted ray, resulting in survival probabilities of 21% and 67%. Given the limited numbers of observations per species estimates should be considered and treated as a first indication of the actual discard survival probability for these species in the 80 mm pulse-trawl fisheries. Further quantitative estimates of longer-term survival are required for a variety of elasmobranchs captured in various European fisheries (Ellis *et al*., 2018).

15.4 Commercial landings composition

15.4.1 Species and size composition

From 2008 onwards, all EU countries are obliged to register species-specific landings for the main skate species. In the past, only France and Sweden provided landings data by species based on information from logbooks and auctions. However, the accuracy of some of these data was doubtful. The landings for each country have been analysed to determine the percentage of landings that have been reported to species-specific level. It can be seen that this percentage varies between regions and countries. Belgium, France, the Netherlands, UK-England and UK-Scotland demonstrate consistently high levels of species-specific declaration for Subarea 4 and Division 7.d; in 2014 they all declared > 75% of their landings in Subarea 4 and Division 7.d to species level, respectively. Sweden mainly landed rays and skates from Division 3.a, and 100% of landings were declared at species level. Even though EU nations should declare species-specific landings data for the main species, Denmark, Germany and Norway (Division 3.a and Subarea 4) had lower percentages of landings recorded to species levels, or did not declare any landings to species level. Whilst the Norwegian Reference Fleet provides some information on species composition, this cannot be regarded as representative of the whole Norwegian fishery.

Size composition data for landings by the Dutch beam trawl fleet based on market sampling for 2000–2008 are presented in Table 15.3.5. Figure 15.3.2. shows the length–frequency of sampled Dutch skate and ray landings in 2013–2017.

15.4.2 Quality of data

The WG is of the opinion that analyses of data from market sampling and observer programmes can provide reliable data on the recent species composition of landings and discards, and such data should be used to validate and/or complement reported species-specific landings data.

From 2008 onwards, improved species-specific landings are available. Such data can be compared with market sampling and observer programmes to determine whether species identification has occurred correctly. The market sampling programme of the Dutch beam trawl fishery from 2000–2008 demonstrated that *R. montagui* and *R. clavata* are the most common species landed, followed by *R. brachyura* (Table 15.3.5). Since the species-specific landings data were available (from 2008 onwards), it appears that the percentage of *R. montagui* has decreased in the Dutch landings (ICES, 2009b, 2010, 2011a, 2012, 2014) compared with 2000–2007. It is likely that before 2008 misidentification has occurred (especially between *R. montagui* and *R. brachyura*). Misidentification probably affects most nations reporting these two species.

Data quality issues were addressed in more detail at WKSHARKS (ICES, 2016), and some national data submitted during the 2016 Data Call were amended accordingly.

Landings of white skate *Rostroraja alba* and *R. microocellata* as reported by France in Subarea 4, Arctic skate *Amblyraja hyperborea* as reported by France in subareas 4 and Division 7.d, and *D. oxyrinchus* as reported by the UK (England) in Division 7.d are likely the result of misidentifications or coding errors. Furthermore, landings of *L. circularis* reported by Belgium in Division 7.d are unlikely and are suspected to refer to *R. microocellata*, as both species are sometime known locally as 'sandy ray'. Very low landings (39 kg) of *R. alba* were reported by UK (England) in Subarea 4 and Division 7.d, but the accuracy of this species identification remains unclear.

These examples demonstrate that more robust protocols for ensuring correct identification, both at sea and in the market, and quality assurance of landings data are still needed. The species-specific landings data indicate that some nations still report a considerable proportion of unidentified ray and skate landings or do not report species-specific landing data at all.

In 1981 France reported exceptionally high landings for Subarea 4 and Division 7.d. This is likely to be caused by misreporting. Misreporting may also have taken place in 2007 as a consequence of limited quota and the 25% bycatch limitation.

15.5 Commercial catch-effort data

There are no effort data specifically for North Sea skates and rays.

15.6 Fishery-independent surveys

Time-series of abundance and biomass indices for the most relevant species are available, based on North Sea IBTS, BTS, and CGFS surveys. Data were extracted from the DATRAS database or supplied by national laboratories. A description of the surveys is given below.

15.6.1 International Bottom Trawl Survey North Sea Q1 (IBTS-Q1) and Q3 (IBTS-Q3)

Fishery-independent data are available from the International Bottom Trawl Survey (IBTS), in winter and summer. An overview of North Sea elasmobranchs based on survey data was presented in Daan *et al.* (2005).

Daan *et al.* (2005) also analysed the time-series of abundance for the major species caught for the period 1977–2004 (see Figure 12.3 of ICES, 2006). *A. radiata* appears to have increased from the late seventies to the early eighties, followed by a decline. The reasons for this decline are unknown, but could include changing environmental conditions, multi-species interactions (including with other skates), fishing impacts, or even improved species identification. The same patterns seem to apply to *L. naevus* and *R. montagui*, these species increase in the most recent ten years in the Q1 and Q3 surveys. The 'common skate complex' showed an overall decline, supporting the findings of ICES (2006). Since 2009 an increase of the 'common skate complex' has been observed (Figure 15.6.5). *R. clavata* has been stable, with one outlier in 1991 owing to a single exceptionally large catch (confirmed record), but shows an increasing trend in most recent years (Figure 15.6.3).

15.6.2 Channel groundfish survey

Martin *et al.* (2005) analysed data from the Channel Groundfish Survey (CGFS) and the Eastern Channel Beam Trawl Survey (UK (BTS-Q3)) for the years 1989–2004. Migratory patterns related to spawning and nursery areas were postulated, with the coast of southeast England an important habitat for *R. clavata*. Updated analyses for this survey were recently published by Martin *et al*. (2010, 2012). CGFS continued in 2013, where high indices were noted for *R. clavata* and *R. undulata*. While most species fluctuate without clear trend, *R. clavata* has increased in the last ten years. Information on *R. undulata* is presented in Section 18, as the main part of the stock is considered to occur in Division 7.e.

15.6.3 Beam trawl surveys

The UK (BTS-Q3) started in the late 1980s, although the survey grid was not standardized until 1993 (see Ellis *et al*., 2005a, b and Parker-Humphreys, 2005 for a description of the survey). The primary target species for the survey are commercial flatfish (plaice *Pleuronectes platessa* and sole *Solea solea*) and so most sampling effort occurs in relatively shallow water. *Raja brachyura*, *R. clavata*, *R. montagui* and *R. undulata* are all sampled during this survey.

The NL (BTS-Q3) consists of two parts: the NL BTS ISIS started in the late 1980s, and the NL BTS Tridens started in the 1990s. The primary target species for the survey are commercial flatfish (plaice and sole) the BTS ISIS fishes in the Southern North Sea, and the BTS Tridens fishes in the Southern and central North Sea. Catch rates ($n.h^{-1}$ and $n.ha^{-1}$) are now available for these surveys.

The DE (BTS-Q3) data are available since the late 2000s. Catch rates ($n.h^{-1}$ and $n.ha^{-1}$) are now available for these surveys. Catch rates generally are lower than for the other BTS surveys, with the exception of *A. radiata*.

The Belgian (BTS-Q3) survey data have been uploaded to DATRAS for seven survey years (2010–2017). Catch rates ($n.h^{-1}$ and $n.ha^{-1}$) are available for these surveys. This North Sea survey is organized yearly at the end of August and beginning of September since the early 1990ies on-board of the RV Belgica. During the past seven years, a clear increase for *R. clavata* was observed for most survey stations.

15.6.4 Index calculations

The survey data for the IBTS, BTS, and CGFS surveys were downloaded from DATRAS on 15 June 2018. For the IBTS and BTS data, CPUE per length per haul was downloaded. For the CGFS, exchange data was downloaded. CPUE per length per haul was calculated from the CGFS exchange data.

Starting from the CPUE (in numbers per hour) per length per haul, indices were calculated for $n.hr^{-1}$, $biomass.hr^{-1}$, and exploitable $biomass.hr^{-1}$. This was done by first combining observations for *Dipturus batis* (including for the junior synonym *Dipturus flossada*) and *Dipturus intermedius* as "common skate complex", and to split the observations for *Raja brachyura* for areas 4.a and 4.c.

Then, zero observations were added for all length-haul combinations. Next, the average CPUE per length per ICES statistical was calculated from the CPUE per length per haul. The CPUE per length per ICES statistical rectangle data was combined with the life history information to obtain CPUE per length per ICES statistical rectangle in numbers per hour and in weight per hour.

The CPUE per length per ICES statistical rectangle was summed over lengths to obtain CPUE per ICES statistical rectangle. For the exploitable biomass indices, only individuals > 50 cm were included. The CPUE per ICES statistical rectangle was averaged within IBTS roundfish areas for the IBTS and for the total area for BTS and CGFS. For the subsequent analyses, only IBTS roundfish areas 1–7 were used. In a final step, the CPUE per roundfish area was averaged to obtain an overall index in terms of $n.hr^{-1}$, $biomass.hr^{-1}$, and exploitable $biomass.hr^{-1}$.

It should be noted that owing to a mismatch between the data structure uploaded to DATRAS for the 2016 UK BTS and the DATRAS CPUE per length per haul calculation, the CPUE per length per haul calculation was incorrect (on DATRAS) for the 2016 UK BTS. This index is thus not shown.

The abundance indices in $n.hr^{-1}$ for the different species are presented in tables 15.6.1–15.6.7. The biomass indices in $kg.hr^{-1}$ are presented in tables 15.6.8–15.6.14. The exploitable biomass indices in $kg.hr^{-1}$ are presented in tables 15.6.15–15.6.21. The indices are also given in figures 15.6.1–15.6.7.

In addition to estimating the indices, the annual mean length and range of the individuals caught in the surveys was calculated for the IBTS and BTS surveys (Figure 15.6.8). These can be used to detect possible species misidentifications.

Spatial distribution of the species in the North Sea was estimated by plotting the CPUE information for the IBTS surveys and the CGFS in maps (Figure 15.6.9). These maps were made for 5-year periods, so that changes in spatial distribution can be detected.

15.6.5 Other surveys

French surveys of coastal areas that aim to sample scallops and coastal fish nurseries and communities have bycatch of skates. These surveys include Comor (dedicated to monitoring scallop abundance in 7.d) NourSom (fish nurseries in the Baie de Somme) and NourSeine (fish nurseries in Baie de Seine).

As a part of the biological surveillance of the Penly nuclear power plant, IFREMER surveys the coastal area from Dieppe to the Baie de Somme. Since 1979, the sampling methodology has been standardized, using a stratified sampling scheme relying upon small meshed beam trawls. The surveys are conducted yearly in autumn and juvenile *Raja clavata* are commonly caught (mean length = 28.2 cm L_T; range = 15–45 cm L_T). Catches are mostly in the coastal area between Ault and Cayeux, which may be considered as a nursery ground for the species. Because this survey consists of a long time-series, it would be interesting to describe the evolution of their catches over the last 30 years (Tetard *et al.*, 2015). For more details, see Deschamps *et al.* (1981) and Schlaich *et al.* (2014).

15.7 Life-history information

Elasmobranchs are not routinely aged, although techniques for ageing are available (e.g. Walker, 1999; Serra-Pereira *et al*., 2005). Limited numbers of species have been aged in special studies.

Updated length–weight conversion factors and lengths-at-maturity are available for nine skate species (McCully *et al*., 2012; Silva *et al.,* 2013). The length-weight conversions used for the calculations of the fisheries independent biomass indices are given in Table 15.7.1. Three species had conversion factors specific to the North Sea ecoregion, with the lengths at maturity for both sexes of *L. naevus*, and female *R. clavata*, being significantly smaller in the North Sea than the Celtic Seas ecoregion.

Demographic modelling requires more accurate life-history parameters, in terms of age or length and fecundity. For example, recent studies of the numbers of egg-cases laid by captive female *R. clavata* were 38–66 eggs over the course of the egg-laying season (Ellis, unpublished), whereas other studies using oocyte counts and the proportion of females carrying eggs have suggested that the fecundity may be >100.

15.7.1 Ecologically important habitats

Ecologically important habitats for the skates include (a) oviposition (egg-laying) sites (b) nursery grounds; (c) habitats of the rare species, as well as other sites where there can be large aggregations (e.g. for mating or feeding).

Little is known about the presence of egg-laying grounds, although parts of the southern North Sea (e.g. the Thames area) are known to have large numbers of juvenile *R. clavata* (Ellis *et al.*, 2005a) and egg-laying is thought to occur in both the inshore grounds of the Outer Thames estuary and the Wash.

Trawl surveys could usefully provide information on catches of (viable) skate egg-cases. This recommendation has therefore been put into the offshore and inshore manuals of the trawl surveys (ICES, 2011b). The Netherlands already collects data on viable elasmobranch egg-cases.

Surveys may be able to provide information on the locations of nursery grounds and other juvenile habitats, and these should be further investigated to identify sites where there are large numbers of 0-groups and where these life-history stages are found on a regular basis.

Little is known about the habitats of the rare elasmobranch species, and further investigations on these are required (e.g. Martin *et al*., 2010; 2012; Ellis *et al*., 2012).

15.8 Exploratory assessment models

Given the lack of longer term species-specific data from commercial fleets and limited biological information, the status of North Sea skates and rays have been evaluated based on survey data, including historical information.

15.8.1 GAM analyses of survey trends

In 2016, a GAM analysis focused on *A. radiata* in the IBTS-Q1, IBTS-Q3 and BTS surveys (and also *Scyliorhinus canicula*; see Section 25). The length-based CPUE per haul for the period 1977–2016 were used as input data. These variables were used to predict CPUE in a GAM analysis (Wood, 2006). To estimate the total individuals per length class for the North Sea the predicted spatial distribution of mean CPUE (GAM-outcome) was combined with the swept areas for the NL BTS survey (with the highest catchability estimate in the analysis). The numbers per length were then converted to weights using data from McCully *et al.* (2012). Future work on these analyses could include converting the CPUE indices to numbers per unit area (density estimates) for all surveys (including IBTS), but it should be noted that different ground gears and sweep lengths can be used in some surveys, which may influence catchability.

15.8.2 Exploratory assessment of thornback ray in the Eastern English Channel

An exploratory assessment of *R. clavata* in the eastern Channel (Division 7.d) was made using a Bayesian production model, fitted to total catch and survey biomass indices (see chapter 19, section *R. clavata* in the Bay of Biscay for model description). The modelling is applied here to the eastern Channel only, and therefore not to the stock unit considered for advice. This modelling approach suggests that the biomass has been increasing since the 1990s (ICES, 2017). However, the results are conditioned by strong assumptions, in particular the assumed constant intrinsic population growth rate, which may not be true as seen for spurdog where a clear density dependence in stock fecundity has been observed.

15.8.3 Estimation of abundance and spatial analysis-application of the SPANdex method

In 2007, the SPANdex approach was used to examine changes in abundance and distribution of four more common skate species in the North Sea (*A. radiata, L. naveus, R. clavata* and *R. montagui*) (ICES, 2007). Density surfaces (distribution based strata) were created using potential mapping in SPANS (Anon, 2003). Quarter 1 catch rate data from the North Sea IBTS survey (IBTS-Q1) employing a GOV demersal trawl, from 1980 to 2006 were used for the analysis. The distribution maps of all four skate species examined indicated that these species had been restricted to consistent areas. The area occupied (AO) changed over time, but this may not reflect population changes and should therefore be used with caution when being used as metric for population status.

15.8.4 Previous assessments of *R. clavata*

Under the DELASS project (Heessen, 2003), various analyses of survey data were conducted (ICES, 2002). The high frequency of zero catches in combination with a few, in some cases, high catches were analysed statistically using a two-stage model approach. First, the probability of getting a catch with at least one *R. clavata* was made using a GLM with a binomial distribution and a logit link function. Non-zero catches were then modelled using a Gamma distribution and a log link function.

ICES (2002) concluded the North Sea stock of thornback ray has steadily declined since the start of the 20th century and that the distribution area has been largely reduced. ICES (2002) questioned whether the patches left in the North Sea with stable local populations are self-sustaining and whether the number of patches will remain high enough for a sustained North Sea population. ICES (2005) subsequently undertook GIS analyses of survey data, and these studies also suggested that the stock was concentrated in the south-western North Sea (see sections 10.5 and 10.8 of ICES, 2005) and the stock area had declined.

From comparisons of recent survey data with data for the early 1900s it can be seen that, in the first decade of the 20th century, *R. clavata* was widely distributed over the southern North Sea, with centres of abundance in the south-western North Sea and in the German Bight, north of Helgoland. The area over which the species is distributed in recent years is much smaller than 100 years ago. The species has disappeared from the south-eastern North Sea (German Bight), and catches in the Southern Bight have become limited to the western part only (see also ICES, 2002).

15.9 Stock assessment

Assessment of these species follows the ICES procedure for data-limited stocks. Most stock fall into ICES category 3.2, use of survey trends.

The last assessment was undertaken in 2017 (ICES, 2017), with updated analyses to be undertaken in 2019.

15.10 Quality of assessments

Analyses of survey data for *R. clavata* undertaken by ICES (2002; 2005) may have been compromised by misidentifications in submitted IBTS data, and so the extent of the decline in distribution reported in these reports may be exaggerated. The distribution of *R. clavata* in the southern North Sea has certainly contracted to the south-western North Sea, and they are now rare in the south-eastern North Sea, where they previously occurred (as indicated by historical surveys). The perceived decline in catches in the north-eastern North Sea may have been based, at least in part, on catches of *A. radiata*. Excluding questionable records from analyses still indicates that the area occupied by *R. clavata* has declined, with the stock concentrated in the south-western North Sea, with catch trends in Division 4.c more stable/increasing in recent times (ICES, 2017).

15.11 Reference points

No reference points have been proposed for *R. clavata* or other skate stocks in this ecoregion.

15.12 Conservation considerations

Both members of the 'common skate complex' are considered 'Critically Endangered by the IUCN, and '*D. batis*', *R. montagui*, and *R. clavata* are all on the OSPAR list of Threatened and Declining species.

Various elasmobranchs are contained in the Swedish Red List (Gärdenfors, 2010), with *R. lintea* considered Near Threatened, *R. clavata* and rabbit fish *Chimaera monstrosa* considered Endangered, and '*D. batis*' considered Regionally Extirpated.

The Norwegian Red List (Gjøsæter *et al.*, 2010) included various skates. '*D. batis*' (complex) is considered Critically Endangered, and *B. spinicauda*, *D. nidarosiensis* and *L. fullonica* are all considered Near Threatened.

15.13 Management considerations

Skates are usually caught in mixed fisheries for demersal teleosts, although some inshore longline and gillnet fisheries target *R. clavata* in seasonal fisheries in the south-western North Sea. *Raja brachyura* may be locally and seasonally important for some inshore fisheries.

Up to 2008, skates were traditionally landed and reported in mixed categories such as "skates and rays". For assessment purposes, species-specific landings data are essential. Species-specific reporting for the main skate species has been required since 2008. An increasing proportion of skate landings are now reported to species and, whilst there are some inconsistencies, the overall proportions broadly correspond with what would be expected, given survey information. Nevertheless, some doubt exists as to the quality of some of the data provided, particularly the distinction between *R. montagui* and *R. brachyura.* Continued species-specific reporting is required, and further scientific sampling of commercial catches (to validate species-specific landings) and training are required.

A TAC for skates was first established for Union waters of Division 2.a and Subarea 4 (combined) in 2009. Since 2009, there have been three separate TAC areas in this ecoregion: Union waters of Division 2.a and Subarea 4 (combined); Division 3.a; and Division 7.d).

Landings have been at or above the TAC since 2006 (but slightly above in Division 7.d, possibly due to transfer between 7.d and 7.e) (Figure 15.3.1) and may now be restrictive for some fisheries. Since its introduction, the TAC has gradually been reduced, which may have induced regulatory discarding. In recent years (2016–2018), the TAC slightly increased.

At-vessel mortality is low inshore trawlers in the south-western North Sea, as tow duration tends to be relatively short and longline fisheries also have low at-vessel mortality (Ellis *et al.*, 2008a, b, 2018). At-vessel mortality in gillnets may also be low, depending on soak-time. Preliminary studies of survival from beam trawlers indicated survival of >70% for skates (Depestele *et al.*, 2014).

Effort restrictions and high fuel prices have resulted in reduced effort, but can also result in using different gears with different catchabilities for skates. Also, some fisheries may redirect effort to fishing grounds closer to port, which may affect more coastal species, such as *R. clavata* in the Thames estuary and in the Wash in the south-western North Sea.

Current TAC regulations have a condition so that "*up to 5%* [of the TAC for Union waters of 6.a-b, 7.a–c and 7.e–k] *may be fished in Union waters of 7.d*". Whilst it is pragmatic to allowing vessels in the English Channel (7.d-e) to transfer quota between these divisions, further studies to examine the implications of this needs to be evaluated. For example, 5% of the overall 2014 quota for 6.a-b, 7.a–c and 7.e–k (8032 t) is 401.6 t, which is more than half of the 2014 TAC for 7.d (798 t). Whilst this is a theoretical maximum and unlikely to be realised, further studies of this issue are required.

Technical interactions of fisheries in this ecoregion are demonstrated in Table 15.13.1.

15.14 References

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Table 15.3.1. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Total landings of skates (Rajidae) in ICES Division 3.a (in tonnes). Data from 2005 onwards from the 2016 Data Call. Note that "+" indicates landings <0.05. Danish landings data for 2017 were not available.

Year	DK	DE	NL	NOR	SE	Total
1999	11	0	0	208	2	221
2000	41	0	0	123	2	166
2001	56	0	0	154	12	222
2002	22	0	0	159	13	194
2003	36	0	0	163	9	208
2004	129	0	0	85	20	234
2005	65	0	0	94.2	10.2	169.7
2006	25	1	+	51.5	17.6	94.6
2007	8	0	+	13.0	11.2	32.6
2008	4	0	0	23.0	6.0	33.0
2009	12	0	0	32.9	1.9	46.7
2010	12	0	0	23.7	9.2	44.9
2011	43	0	0	24.7	2.7	70.5
2012	16	0	0	28.0	1.6	45.6
2013	18	0	0	50.1	4.0	72.2
2014	14	0	0	38.9	2.9	55.8
2015	27.4	0	0.3	32.3	0	60.1
2016	39.8	0	0	49.8	0	89.7
2017	-	+	0	55.1	0.2	55.4

Table 15.3.2. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Total landings of skates (Rajidae) in ICES Subarea 4 (in tonnes). Note that "+" indicates landings <0.5. Data from 2005 onwards from the 2016 Data Call. Danish landings data for 2017 were not available.

YEAR	BEL	DK	FRA	DE	NLD	NOR	SE	UK	TOTAL
1999	336	45	41	16	515	152	+	1583	2688
2000	332	93	31	23	693	161	+	1376	2709
2001	370	65	61	11	834	173	+	1298	2812
2002	436	34	62	22	805	83	+	1353	2794
2003	323	33	36	21	686	113	+	1278	2490
2004	276	25	37	17	561	77	+	1062	2055
2005	349.6	25.0	59.8	28.0	492.9	86.8	0.2	833.2	1875.5
2006	345.7	28.0	76.6	16.1	529.6	97.7	0.2	732.2	1826.0
2007	260.5	29.0	65.9	17.1	659.0	71.2	0.1	704.2	1807.2
2008	387.0	24.0	72.3	29.2	505.9	96.6	0.4	762.3	1877.8
2009	302.5	30.0	76.5	22.1	378.5	120.7	0.1	665.7	1596.2
2010	309.8	30.0	95.0	32.4	390.5	105.2	0.3	662.0	1625.2
2011	236.8	38.0	59.3	19.0	211.6	55.8	0.3	788.1	1408.9
2012	187.7	21.0	46.6	16.7	431.1	69.2	0.0	662.4	1434.7
2013	213.9	45.0	51.5	25.1	312.0	73.5	0.2	803.6	1526.2
2014	198.5	44.0	49.1	32.2	225.5	88.3	0.3	778.4	1418.8
2015	245.5	39.9	22.3	25.1	273.7	62.4	0.0	665.7	1334.7
2016	184.0	41.0	39.2	49.6	280.7	69.3	0.0	662.4	1326.1
2017	175.5	-	37.8	41.5	287.2	90.9	0.1	686.9	1320.1

Table 15.3.3. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Total landings of skates (Rajidae) in ICES Division 7.d (in tonnes). "+" indicates landings <0.5. Data from 2005 onwards from the 2016 Data Call.

YEAR	BEL	FRA	DE	NLD	UK	TOTAL
1999	93	558	0	0	437	1088
2000	69	693	+	0	355	1117
2001	79	729	0	0	169	977
2002	113	725	0	0	140	978
2003	153	796	0	0	186	1135
2004	96	695	0	0	157	948
2005	100.5	965.1	0	8.6	144.1	1218.3
2006	112.8	759.4	0	12.1	144.0	1028.3
2007	157.6	949.0	0	18.0	203.6	1328.1
2008	172.4	913.4	0	12.3	209.2	1307.4
2009	120.7	1152.2	0	10.0	164.2	1447.1
2010	107.8	974.1	0	10.5	138.9	1231.4
2011	106.7	972.9	0	12.1	152.9	1244.5
2012	104.9	1070.5	0	14.4	172.1	1361.9
2013	131.3	1065.3	0	4.4	193.2	1394.2
2014	113.2	1055.1	0	5.8	194.0	1368.0
2015	115.2	866.5	0	3.1	146.2	1131.0
2016	136.2	941.8	0	8.2	200.0	1286.1
2017	141.5	922.1	0	8.6	230.0	1302.3

Table 15.3.4. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Landings per stock and country in the North Seas ecoregion (Subarea 4 and Divisions 3.a and 7.d) (in tonnes).

raj.27.3a47d										
Year	**BEL**	**DE**	**DK**	**FRA**	**GBR**	**IRL**	**NLD**	**NOR**	**SE**	**Total**
2005	450.1	28.3	90.0	754.9	977.2	0.1	501.5	180.2	10.4	2992.7
2006	458.4	16.6	53.0	675.1	876.2		541.8	149.2	17.7	2788.0
2007	417.2	17.6	37.0	735.4	907.8		677.1	84.3	11.2	2887.5
2008	186.5	29.3	28.0	806.7	720.9		66.4	119.6	6.4	1963.9
2009	128.0	22.1	40.0	578.1	412.9		4.5	153.6	2.0	1341.2
2010	137.3	32.4	39.0	444.7	210.1		5.2	123.0	9.5	1001.2
2011	93.5	19.0	77.0	378.7	144.3		5.8	80.0	2.8	801.1
2012	50.9	16.8	37.0	248.9	107.5		25.3	95.2	1.6	583.0
2013	15.9	25.1	60.0	107.1	99.0		12.1	120.4	4.2	443.8
2014	25.1	32.2	49.0	40.5	81.5		9.5	126.1	3.2	367.0
2015	31.3	25.1	62.6	17.5	33.2		5.8	94.7		270.4
2016	39.6	11.7	74.8	19.9	27.6		2.4	119.1	0.0	295.1
2017	36.7	8.4		25.6	34.9		1.8	146.0	0.3	253.6

rjb.27.3a4						
Year	**BEL**	**DK**	**FRA**	**GBR**	**NLD**	**SE**	**Total**
2005			0.7				0.7
2006			0.1			0.4	0.5
2007			0.1			0.0	0.1
2008	0.0		0.2	0.5	0.0		0.8
2009		2.0	0.2	7.0			9.2
2010	0.0	2.0	0.5	0.7		0.5	3.7
2011		1.0	0.1	4.2	0.0	0.7	6.0
2012				1.8	0.5	1.4	3.7
2013			0.0	1.0		1.9	2.9
2014			0.0	0.3			0.3
2015		0.7		0.3			1.0
2016		2.0		0.3	0.0	0.0	2.4
2017				0.7	0.0	0.0	0.7

rjc.27.3a47d									
Year	BEL	DE	DK	FRA	GBR	NLD	NOR	SE	Total
2005				196.4	0.0		0.8		197.2
2006				107.8				0.0	107.9
2007	0.6			155.3	0.0			0.0	155.9
2008	214.2			90.1	208.9	196.6	0.0		709.7
2009	153.9			461.9	334.9	178.1			1128.8
2010	175.6		1.0	541.1	409.1	203.2	5.9		1335.8
2011	163.9		1.0	533.8	485.2	97.0	0.5	0.3	1281.6
2012	154.3			769.0	477.5	186.4	2.0	0.0	1589.2
2013	200.7		2.0	940.5	572.7	149.0	3.3		1868.3
2014	205.9		8.0	988.6	570.8	130.8	1.2		1905.3
2015	219.1		3.7	814.2	447.3	160.6			1644.8
2016	33.8		2.7	890.5	516.6	185.2		0.0	1628.8
2017	173.5	27.3		829.6	580.8	162.7			1773.9

rjm.27.3a47d							
Year	BEL	DE	DK	FRA	GBR	NLD	Total
2005				41.9	0.0		41.9
2006				25.9			25.9
2007	0.1			93.4	0.0		93.5
2008	38.7			46.2	9.4	240.4	334.7
2009	34.6			127.8	28.3	199.7	390.3
2010	35.1			32.2	56.2	182.3	305.8
2011	31.2			30.8	93.2	108.0	263.2
2012	10.0			25.5	82.2	180.0	297.7
2013	11.6			28.2	127.1	119.4	286.2
2014	4.3		1.0	35.7	106.7	66.4	214.0
2015	9.4		0.1	15.2	123.6	76.9	225.3
2016	9.9	4.1		15.7	117.2	76.3	223.2
2017	15.4	5.9		36.7	112.3	87.4	257.8

rjh.27.4c7d							
Year	BEL	DE	DK	FRA	GBR	NLD	Total
2005							0.0
2006							0.0
2007	0.2						0.2
2008	115.8				22.4	14.6	152.8
2009	104.3			12.9	35.1	5.9	158.2
2010	63.1			20.9	38.9	9.9	132.8
2011	45.5			26.9	58.5	12.8	143.6
2012	72.4			22.7	45.3	53.1	193.6
2013	109.1			23.9	70.6	35.7	239.4
2014	69.3			30.4	57.4	24.3	181.4
2015	90.2		0.0	30.9	36.1	33.8	191.1
2016	0.0			35.6	21.6	24.8	82.1
2017	75.1	0.0		50.0	29.2	43.9	198.2

rjh.27.4a6							
Year	BEL	DK	ES	FRA	GBR	IRL	Total
2005							0.0
2006							0.0
2007							0.0
2008					6.8		6.8
2009	0.0		0.1	0.9	5.2	0.3	6.4
2010	0.0				6.7	3.7	10.4
2011					16.6	0.9	17.5
2012					4.0	1.4	5.4
2013					0.5	23.6	24.1
2014				0.6	0.7	8.6	10.0
2015		0.0		0.8	3.4	9.3	13.6
2016				0.6	2.3	10.9	13.8
2017				0.2	1.2	5.4	6.9

rjn.27.3a4							
Year	BEL	DE	DK	FRA	GBR	NLD	Total
2005				0.0			0.0
2006				0.0			0.0
2007				0.0			0.0
2008	2.5			0.4	0.2	0.2	3.3
2009	1.0			1.1	4.6	0.4	7.1
2010	3.7			1.0	81.2	0.3	86.3
2011	5.0		2.0	1.0	143.1		151.1
2012	1.1			0.5	115.5		117.1
2013	0.6		1.0	0.0	122.6	0.1	124.4
2014	0.5			0.1	151.7	0.3	152.5
2015	3.1		0.3	0.0	169.0		172.5
2016	0.4	0.0	1.4	0.2	167.6	0.2	169.7
2017	0.4			0.3	149.4		150.1

rjr.27.23a4						
Year	BEL	FRA	GBR	NLD	SE	Total
2005						0.0
2006						0.0
2007						0.0
2008	0.1					0.1
2009			0.1			0.1
2010			0.0			0.0
2011		1.2			0.0	1.3
2012			0.1	0.2		0.3
2013		0.0	0.0			0.0
2014	0.0	0.0	0.0			0.0
2015		0.0				0.0
2016		0.0				0.0
2017		0.1				0.1

Table 15.3.5. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel: North Sea rays and skates. Length–frequency distributions in the Dutch beam trawl fleet (numbers in '000).

Country: the Netherlands
Gear: beam trawl
Category: landings

	Raja clavata						*Raja montagui*						*Raja brachyura*					
length	2000	2001	2005	2006	2007	2008	2000	2001	2005	2006	2007	2008	2000	2001	2005	2006	2007	2008
25																		
30	0.6	1.9	3.0	0.3	1.0	0.5	3.5	0.5	0.9	0.5		0.2						
35	9.4	11.2	7.8	8.6	7.1	3.0	34.2	6.3	4.7	2.5	0.4	0.2	1.2	1.0	0.3	1.5		
40	16.8	19.9	14.2	13.4	30.5	4.0	75.6	33.5	14.0	15.8	9.7	6.3	1.2	1.5	2.1	5.5	3.8	
45	17.5	20.3	11.2	26.2	27.2	8.5	85.9	60.3	36.9	52.5	32.2	16.1	1.2	3.3	6.0	3.9	7.2	0.1
50	23.0	36.4	18.2	40.0	36.0	15.2	58.3	72.5	47.6	59.6	52.6	45.4	2.7	5.6	7.7	3.5	3.8	0.6
55	16.0	35.3	12.9	26.6	30.9	17.7	42.7	54.6	49.9	34.6	50.8	58.9	3.1	4.9	9.6	7.7	5.1	0.7
60	12.1	22.8	14.7	20.0	19.1	16.6	26.1	42.4	44.2	25.3	40.5	71.7	0.6	5.3	6.8	7.5	5.1	0.8
65	5.3	15.3	5.7	16.7	17.5	14.9	10.4	16.1	13.7	4.7	12.4	26.1	1.0	3.6	8.0	7.6	6.1	0.7
70	5.3	5.2	6.2	11.8	12.3	14.6	2.0	2.3	0.9	1.1	0.5	1.2	1.6	2.1	6.1	4.5	5.9	0.5
75	4.7	5.5	5.2	8.1	6.9	9.8	0.3		0.1				1.8	2.7	3.1	5.4	6.8	0.8
80	3.7	3.5	2.2	3.7	5.4	5.0							1.6	1.9	4.2	5.1	8.2	0.5
85	3.4	2.3	1.8	1.9	1.8	2.9							1.1	1.5	3.1	2.3	6.0	0.5
90	1.2	0.6	0.7	0.9	1.0	0.9							0.5	1.9	2.4	2.0	2.8	0.4
95	0.8	0.3	0.1		0.1	0.4							0.1	0.6	1.6	1.2	2.6	0.2
100						0							0.1		0.2	0.3	0.1	0.0
105															0.3			0.0
110	0.1																	
sum	119.8	180.5	103.9	178.2	197	114.0	339.2	288.4	212.9	196.6	199.2	226.1	17.7	35.8	61.5	58.0	63.5	5.8

Table 15.6.1 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates (n/hr) for *Amblyraja radiata* . Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS TRI Q3	BTS GFR Q3	CGFS Q4
1987	3.717	NA	0.101	NA	NA	NA
1988	1.762	NA	0.178	NA	NA	0
1989	7.244	NA	0.382	NA	NA	0
1990	4.964	NA	1.472	NA	NA	0
1991	3.956	7.899	0.447	NA	NA	0.044
1992	7.278	2.280	0.184	NA	NA	0
1993	11.221	1.681	0.053	NA	NA	0
1994	3.792	1.931	0.045	NA	NA	0
1995	8.016	1.852	0.188	NA	NA	0
1996	5.694	2.338	0.118	20.452	NA	0
1997	4.816	2.177	0	16.279	NA	0
1998	5.090	2.193	0	23.308	NA	0
1999	6.725	2.757	0.143	34.190	NA	0.044
2000	7.769	3.088	0	34.000	NA	0
2001	2.692	5.157	0.037	21.217	NA	0
2002	4.173	2.925	0.031	25.459	0.865	0
2003	4.613	3.407	0.067	18.726	0.517	0.024
2004	4.332	1.851	0.071	20.762	0.375	0
2005	3.690	2.102	0.303	19.343	0.098	0
2006	2.288	2.348	0.179	13.729	NA	0
2007	4.231	3.850	0	14.557	17.412	0
2008	3.129	2.516	NA	15.174	15.396	0.023
2009	1.333	2.982	0.897	14.759	10.693	0
2010	1.400	2.204	0	15.478	9.950	0
2011	1.281	2.415	0	13.842	8.783	0
2012	1.670	1.944	0.091	13.239	18.278	0
2013	1.191	1.413	0.069	13.379	13.372	0
2014	1.088	1.539	0.817	12.298	1.462	0
2015	1.941	2.045	0.172	10.101	9.518	0
2016	1.374	1.738	0.469	8.315	11.737	0
2017	0.968	1.209	NA	4.059	8.463	0
2018	0.284	NA	NA	NA	NA	NA

Table 15.6.2 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates (n/hr) for *Leucoraja naevus*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI2 Q3	BTS BEL Q3	CGFS Q4
1987	0.151	NA	0	NA	NA	NA	NA
1988	0.617	NA	0.034	NA	NA	NA	0
1989	0.736	NA	0	NA	NA	NA	0
1990	0.529	NA	0	NA	NA	NA	0.053
1991	0.444	0.292	0	NA	NA	NA	0
1992	0.749	0.414	0	NA	NA	NA	0
1993	0.806	0.108	0	0	NA	NA	0
1994	0.620	0.186	0	0	NA	NA	0.146
1995	0.533	0.087	0	0	NA	NA	0.067
1996	0.432	0.120	0	0	0.905	NA	0.026
1997	0.268	0.416	0	0.015	1.302	NA	0.078
1998	0.458	0.08	0	0	3.115	NA	0.035
1999	0.327	0.38	0	0	3.841	NA	0
2000	0.444	0.433	0	0	2.169	NA	0.016
2001	0.309	0.569	0	0	1.478	NA	0
2002	0.451	0.477	0	0	2.840	NA	0.013
2003	0.250	0.290	0	0	3.015	NA	0
2004	0.330	0.306	0	0	0.972	NA	0.049
2005	0.329	0.404	0	0	1.659	NA	0.022
2006	0.372	0.465	0	0	1.420	NA	0.014
2007	0.449	0.329	0	0	2.507	NA	0
2008	0.431	1.112	NA	0.015	4.400	NA	0
2009	0.352	0.587	0	0	2.013	NA	0.022
2010	0.438	0.65	0	0.853	0.576	0	0
2011	0.407	0.608	0	0.343	0.958	0	0.027
2012	0.658	0.731	0	0.278	1.013	0	0
2013	0.782	0.532	0	0.357	1.22	0	0
2014	0.459	0.435	0	1.343	1.465	0	0
2015	0.765	0.45	0	0.127	0.702	0	0
2016	0.481	0.493	0	NA	1.332	0.128	0.056
2017	0.852	0.674	NA	1.238	1.772	0	0
2018	0.387	NA	NA	NA	NA	NA	NA

Table 15.6.3. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates (n/hr) for 'common skate complex'. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS TRI Q3
1987	0	NA	NA
1988	0.015	NA	NA
1989	0	NA	NA
1990	0	NA	NA
1991	0.031	0.003	NA
1992	0	0	NA
1993	0.010	0	NA
1994	0	0	NA
1995	0	0	NA
1996	0.019	0	0
1997	0	0	0
1998	0.003	0.008	0
1999	0.007	0.089	0
2000	0	0	0
2001	0	0	0
2002	0.004	0.056	0
2003	0	0	0
2004	0	0	0
2005	0.006	0.014	0.035
2006	0	0.002	0
2007	0.046	0	0
2008	0.006	0.020	0
2009	0.013	0.013	0
2010	0.045	0	0
2011	0.052	0.019	0
2012	0.033	0.100	0.053
2013	0.084	0.065	0
2014	0.037	0.052	0.029
2015	0.052	0.013	0.027
2016	0.067	0.051	0
2017	0.048	0.064	0.025
2018	0.105	NA	NA

Table 15.6.4 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates (n/hr) for *Raja clavata*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS	BTS ISI	BTS ENG	BTS TRI	BTS GFR	BTS BEL	CGFS Q4
1987	1.855	NA	0	NA	NA	NA	NA	NA
1988	0.319	NA	0.023	NA	NA	NA	NA	2.680
1989	1.852	NA	0.741	NA	NA	NA	NA	3.398
1990	1.364	NA	0.981	NA	NA	NA	NA	1.608
1991	42.436	1.269	0	NA	NA	NA	NA	0.859
1992	2.165	1.216	0.579	NA	NA	NA	NA	1.604
1993	0.531	1.043	0	3.011	NA	NA	NA	1.155
1994	0.702	0.113	0.030	2.405	NA	NA	NA	0.943
1995	0.124	0.041	0.083	1.693	NA	NA	NA	0.859
1996	0.711	0.687	0.162	2.314	0.048	NA	NA	1.451
1997	1.144	0.270	0.825	2.802	0	NA	NA	3.199
1998	1.106	0.050	0.023	2.344	0.269	NA	NA	1.710
1999	0.399	0.143	2.057	4.317	0	NA	NA	2.871
2000	0.879	0.040	0.357	3.742	0.197	NA	NA	2.593
2001	0.904	0.166	0	4.103	0.087	NA	NA	1.784
2002	1.062	0.721	0.078	2.697	0.972	0	NA	2.217
2003	1.029	0.054	0.100	3.53	0.558	0	NA	5.092
2004	0.475	0.133	0	3.141	0.085	0	NA	2.020
2005	1.034	0.054	0.182	3.913	0.091	0	NA	3.296
2006	1.167	0.640	0	4.870	0.181	NA	NA	2.377
2007	0.519	0.129	0.024	3.115	0.647	0	NA	2.827
2008	2.016	0.623	NA	4.136	0.03	0	NA	3.173
2009	2.576	0.706	0	3.242	0.091	0	NA	3.103
2010	0.550	0.565	0.062	14.516	0.214	0	1.678	2.406
2011	0.194	0.355	0.040	13.302	0.085	0	2.162	4.678
2012	2.926	0.787	0.030	19.409	1.713	0	3.044	4.614
2013	1.063	2.243	0.034	25.38	0.557	0	4.257	6.477
2014	1.310	2.141	0.320	46.729	0.257	0	6.375	8.092
2015	1.822	4.533	0.368	35.292	0.481	0.066	4.775	13.718
2016	1.035	5.796	0.260	NA	1.306	0	5.662	14.608
2017	2.884	0.734	NA	36.462	0.287	0	8.246	8.803
2018	1.200	NA	NA	NA	NA	NA	NA	NA

Table 15.6.5 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates (n/hr) for *Raja montagui*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI Q3	BTS BEL Q3	CGFS Q4
1987	0.105	NA	0	NA	NA	NA	NA
1988	0.130	NA	0	NA	NA	NA	1.213
1989	0.298	NA	0.592	NA	NA	NA	0.543
1990	0.213	NA	0.278	NA	NA	NA	0.615
1991	2.477	0.360	0.579	NA	NA	NA	0.156
1992	0.281	0.396	0.184	NA	NA	NA	0.019
1993	0.302	0.414	0.637	0.543	NA	NA	0.359
1994	0.268	0.650	0	0.493	NA	NA	0.273
1995	0.633	0.211	0	0.879	NA	NA	0.240
1996	0.244	0.253	0.824	0.263	0.667	NA	0.214
1997	0.699	0.003	0.226	0.598	0	NA	0.864
1998	0.314	0.197	0	0.902	1.123	NA	0.451
1999	0.237	0.991	0	0.543	1.079	NA	0.044
2000	0.233	0.032	0.029	0.500	0.648	NA	0.083
2001	0.181	0.098	0	0.248	1.014	NA	0.058
2002	0.528	0.065	0	0.517	0.361	NA	0.180
2003	0.462	0.086	0.033	0.659	0.247	NA	0.163
2004	0.371	0.143	0	0.878	0.359	NA	0.024
2005	0.652	0.364	0	0.071	0.136	NA	0.197
2006	0.182	0.356	0	0.274	0.536	NA	0.097
2007	0.663	0.753	0	0.261	0.239	NA	0.450
2008	1.876	0.269	NA	0.328	0.167	NA	0.011
2009	0.979	0.905	0	0.184	0.242	NA	0
2010	1.111	0.861	0	6.586	0.273	1.117	0.021
2011	0.775	1.009	0	2.500	0.928	1.056	0.217
2012	1.566	1.123	0	4.005	1.305	1.166	0.117
2013	1.502	1.327	0.046	5.089	0.841	0.993	0.159
2014	0.989	2.313	0.160	4.484	0.543	1.899	0.286
2015	1.198	0.510	0.057	6.597	0.550	2.580	0.504
2016	0.975	1.091	0.135	NA	2.444	2.609	0.160
2017	1.274	0.826	NA	12.089	0.911	4.132	0.833
2018	1.312	NA	NA	NA	NA	NA	NA

Table 15.6.6 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates (n/hr) for *Raja brachyura* in 4.a. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3
1987	0	NA
1988	0	NA
1989	0.125	NA
1990	0	NA
1991	0	0
1992	0.312	0
1993	0.021	0
1994	0	0
1995	0	0
1996	0.062	0
1997	0	0
1998	0.004	0
1999	0.062	0
2000	0	0
2001	0	0
2002	0	0
2003	0.088	0
2004	0	0
2005	0	0
2006	0.038	0
2007	0.269	0.045
2008	0.184	0.023
2009	0.179	0.125
2010	0.293	0
2011	0.085	0.209
2012	0.049	0
2013	0.748	0
2014	0.305	0
2015	0.024	0
2016	0.012	0.200
2017	0	0.100
2018	0	NA

Table 15.6.7 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates (n/hr) for *Raja brachyura* in 4.c. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG	BTS TRI Q3	BTS BEL	CGFS Q4
1987	0	NA	0	NA	NA	NA	NA
1988	0	NA	0	NA	NA	NA	0
1989	0	NA	0	NA	NA	NA	0.308
1990	0	NA	0	NA	NA	NA	0.022
1991	0	0	0	NA	NA	NA	0
1992	0.223	0	0	NA	NA	NA	0
1993	0.133	0	0	0.266	NA	NA	0
1994	0	0	0	0.097	NA	NA	0.086
1995	0	0	0	0.049	NA	NA	0.117
1996	0	0	0	0.047	0	NA	0
1997	0	0	0	0.015	0	NA	0.080
1998	0	0	0	0.045	0	NA	0.167
1999	0.030	0	0	0.25	0	NA	0.116
2000	0	0	0.056	0.081	0	NA	0.100
2001	0	0	0	0.168	0	NA	0.086
2002	0	0	0	0.113	0	NA	0.371
2003	0.015	0	0	0.148	0	NA	0.276
2004	0	0	0	0.126	0.242	NA	0.259
2005	0.030	0	0.071	0.128	0	NA	0
2006	0.091	0	0	0.03	0.323	NA	0.133
2007	0.121	0	0	0.092	0.6	NA	0.200
2008	0.333	0	NA	0.059	0	NA	0.021
2009	0.044	0	0	0.131	0	NA	0.23
2010	0.03	0	0	0.757	0	0.414	0.031
2011	0.022	0	0	0.812	0	0.117	0.289
2012	0.212	0.083	0.071	0.517	0	0.379	0.320
2013	0.091	0	0	1.857	0	0.614	0.199
2014	0.756	0	0	1.829	0	0.417	0.853
2015	0.268	0	0	0.922	1.239	0.762	0.448
2016	0.153	0.375	0	NA	0	0.987	0.729
2017	0.333	0.264	NA	3.182	0	0.579	1.141
2018	0.597	NA	NA	NA	NA	NA	NA

Table 15.6.8. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of biomass estimates (kg/hr) for *Amblyraja radiata* . Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS TRI Q3	BTS GFR Q3	CGFS Q4
1987	3.717	NA	0.101	NA	NA	NA
1988	1.762	NA	0.178	NA	NA	0
1989	3.729	NA	0.075	NA	NA	0
1990	2.483	NA	0.387	NA	NA	0
1991	2.001	3.553	0.124	NA	NA	0.087
1992	3.355	1.240	0.038	NA	NA	0
1993	5.677	0.876	0.014	NA	NA	0
1994	1.853	0.966	0.023	NA	NA	0
1995	4.116	0.763	0.102	NA	NA	0
1996	2.853	1.062	0.237	4.493	NA	0
1997	2.333	1.031	0	4.383	NA	0
1998	2.755	1.275	0	6.313	NA	0
1999	2.728	1.182	0.059	8.558	NA	0.042
2000	3.383	1.353	0	8.015	NA	0
2001	1.074	1.724	0.016	4.733	NA	0
2002	1.605	1.035	0.035	5.947	0.179	0
2003	1.973	1.320	0.034	4.486	0.164	0.022
2004	1.569	0.615	0.015	5.140	0.111	0
2005	1.400	0.764	0.171	5.407	0.036	0
2006	0.942	0.865	0.112	4.089	NA	0
2007	1.946	1.667	0	5.191	6.359	0
2008	1.504	1.151	NA	6.182	5.996	0.075
2009	0.753	1.575	0.494	6.321	4.587	0
2010	0.733	1.178	0	6.176	3.765	0
2011	0.664	1.232	0	4.709	2.789	0
2012	0.783	0.802	0.051	3.467	5.721	0
2013	0.488	0.556	0.047	3.253	2.753	0
2014	0.591	0.655	0.318	3.475	0.535	0
2015	0.849	1.094	0.074	4.071	3.039	0
2016	0.667	0.823	0.165	2.700	3.112	0
2017	0.490	0.536	NA	1.558	2.829	0
2018	0.139	NA	NA	NA	NA	NA

Table 15.6.9. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of biomass estimates (kg/hr) for *Leucoraja naevus*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI2 Q3	BTS BEL Q3	CGFS Q4
1987	0.129	NA	0	NA	NA	NA	NA
1988	0.599	NA	0.021	NA	NA	NA	0
1989	0.611	NA	0	NA	NA	NA	0
1990	0.508	NA	0	NA	NA	NA	0.044
1991	0.340	0.161	0	NA	NA	NA	0
1992	0.720	0.434	0	NA	NA	NA	0
1993	0.752	0.085	0	0	NA	NA	0
1994	0.422	0.169	0	0	NA	NA	0.292
1995	0.453	0.108	0	0	NA	NA	0.097
1996	0.385	0.063	0	0	0.496	NA	0.003
1997	0.203	0.600	0	0.001	0.718	NA	0.065
1998	0.369	0.083	0	0	1.382	NA	0.018
1999	0.275	0.261	0	0	0.944	NA	0
2000	0.306	0.331	0	0	0.928	NA	0.002
2001	0.192	0.252	0	0	0.379	NA	0
2002	0.232	0.277	0	0	0.573	NA	0.002
2003	0.141	0.163	0	0	1.08	NA	0
2004	0.160	0.163	0	0	0.453	NA	0.016
2005	0.191	0.253	0	0	0.544	NA	0.032
2006	0.243	0.26	0	0	0.460	NA	0.003
2007	0.254	0.204	0	0	0.854	NA	0
2008	0.238	0.818	NA	0.001	1.473	NA	0
2009	0.175	0.383	0	0	0.795	NA	0.007
2010	0.279	0.455	0	0.269	0.258	0	0
2011	0.276	0.450	0	0.06	0.489	0	0.004
2012	0.471	0.540	0	0.069	0.514	0	0
2013	0.532	0.378	0	0.065	0.449	0	0
2014	0.302	0.266	0	0.658	0.564	0	0
2015	0.633	0.356	0	0.084	0.279	0	0
2016	0.348	0.346	0	NA	0.577	0.013	0.011
2017	0.609	0.470	NA	0.515	0.798	0	0
2018	0.296	NA	NA	NA	NA	NA	NA

Table 15.6.10. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of biomass estimates (kg/hr) for 'common skate complex'. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and BTS survey data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS TRI Q3
1987	0	NA	NA
1988	0.015	NA	NA
1989	0	NA	NA
1990	0	NA	NA
1991	0.139	0.005	NA
1992	0	0	NA
1993	0.022	0	NA
1994	0	0	NA
1995	0	0	NA
1996	0.047	0	0
1997	0	0	0
1998	0.008	0.015	0
1999	0.011	0.027	0
2000	0	0	0
2001	0	0	0
2002	0.008	0.067	0
2003	0	0	0
2004	0	0	0
2005	0.014	0.043	0.015
2006	0	0.004	0
2007	0.047	0	0
2008	0.004	0.039	0
2009	0.003	0.002	0
2010	0.027	0	0
2011	0.165	0.014	0
2012	0.109	0.177	0.043
2013	0.224	0.051	0
2014	0.127	0.074	0.008
2015	0.086	0.011	0.072
2016	0.182	0.095	0
2017	0.411	0.150	1.047
2018	0.425	NA	NA

Table 15.6.11. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of biomass estimates (kg/hr) for *Raja clavata*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS	IBTS	BTS ISI	BTS ENG	BTS TRI	BTS GFR	BTS BEL	CGFS
1987	3.341	NA	0	NA	NA	NA	NA	NA
1988	0.359	NA	0.004	NA	NA	NA	NA	1.169
1989	1.885	NA	0.418	NA	NA	NA	NA	6.306
1990	1.497	NA	0.806	NA	NA	NA	NA	2.764
1991	19.556	1.507	0	NA	NA	NA	NA	1.150
1992	1.760	0.792	0.698	NA	NA	NA	NA	2.641
1993	0.558	0.702	0	1.175	NA	NA	NA	1.371
1994	0.368	0.062	0.008	0.958	NA	NA	NA	2.172
1995	0.140	0.143	0.011	0.895	NA	NA	NA	1.768
1996	0.487	1.273	0.233	1.084	0.111	NA	NA	0.564
1997	1.009	0.440	0.583	2.186	0	NA	NA	2.839
1998	0.246	0.018	0.004	1.274	0.130	NA	NA	2.599
1999	0.232	0.358	1.095	2.116	0	NA	NA	2.204
2000	0.471	0.089	0.298	1.711	0.074	NA	NA	2.610
2001	0.568	0.187	0	2.078	0.053	NA	NA	1.962
2002	0.637	0.690	0.088	1.063	0.831	0	NA	2.807
2003	0.688	0.088	0.055	1.784	0.407	0	NA	3.372
2004	0.285	0.074	0	2.500	0.058	0	NA	1.946
2005	0.787	0.071	0.471	1.519	0.094	0	NA	4.356
2006	1.610	0.653	0	1.968	0.149	NA	NA	3.292
2007	0.371	0.031	0.022	1.472	0.540	0	NA	4.281
2008	3.149	0.655	NA	2.222	0.013	0	NA	4.638
2009	2.293	0.566	0	1.736	0.142	0	NA	4.124
2010	0.501	0.427	0.004	7.129	0.196	0	1.409	3.957
2011	0.093	0.530	0.096	5.980	0.056	0	1.353	4.628
2012	3.553	0.439	0.084	8.558	0.741	0	2.011	5.601
2013	0.973	2.797	0.012	10.81	0.305	0	2.366	10.325
2014	1.506	3.017	0.263	22.046	0.296	0	4.959	12.325
2015	1.811	3.625	0.489	12.405	0.650	0.141	2.766	18.841
2016	0.787	4.522	0.499	NA	0.525	0	3.846	29.397
2017	3.436	1.185	NA	17.034	0.758	0	4.649	15.838
2018	1.018	NA	NA	NA	NA	NA	NA	NA

Table 15.6.12. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of biomass estimates (kg/hr) for *Raja montagui*. Information from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2016. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI Q3	BTS BEL Q3	CGFS Q4
1987	0.142	NA	0	NA	NA	NA	NA
1988	0.139	NA	0	NA	NA	NA	0.439
1989	0.203	NA	0.163	NA	NA	NA	0.438
1990	0.240	NA	0.055	NA	NA	NA	0.534
1991	0.821	0.267	1.125	NA	NA	NA	0.148
1992	0.318	0.373	0.153	NA	NA	NA	0.029
1993	0.286	0.459	0.422	0.172	NA	NA	0.293
1994	0.310	0.820	0	0.175	NA	NA	0.393
1995	0.620	0.247	0	0.170	NA	NA	0.238
1996	0.253	0.175	0.584	0.138	0.401	NA	0.059
1997	0.351	0.002	0.246	0.250	0	NA	0.524
1998	0.418	0.126	0	0.146	0.504	NA	0.290
1999	0.274	1.177	0	0.114	0.638	NA	0.018
2000	0.189	0.029	0.013	0.331	0.063	NA	0.065
2001	0.192	0.061	0	0.067	0.091	NA	0.051
2002	0.393	0.052	0	0.204	0.198	NA	0.132
2003	0.359	0.048	0.058	0.057	0.072	NA	0.124
2004	0.228	0.195	0	0.181	0.215	NA	0.004
2005	0.426	0.317	0	0.086	0.108	NA	0.153
2006	0.086	0.212	0	0.111	0.482	NA	0.175
2007	0.612	0.691	0	0.090	0.215	NA	0.585
2008	1.765	0.244	NA	0.090	0.118	NA	0.003
2009	0.582	0.677	0	0.072	0.103	NA	0
2010	0.901	0.664	0	1.272	0.154	0.287	0.005
2011	0.609	0.818	0	0.827	0.434	0.743	0.130
2012	1.196	1.002	0	0.852	0.873	0.370	0.094
2013	1.110	1.036	0.043	0.983	0.644	0.369	0.215
2014	0.981	2.533	0.128	1.427	0.542	0.621	0.118
2015	1.222	0.566	0.057	1.552	0.566	0.567	0.366
2016	0.862	1.045	0.097	NA	0.798	0.832	0.046
2017	1.028	0.728	NA	2.483	0.500	1.013	0.848
2018	1.316	NA	NA	NA	NA	NA	NA

Table 15.6.13. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of biomass estimates (kg/hr) for *Raja brachyura* 4.a. Information is obtained from the IBTS Q1 and IBTS Q3 (roundfish areas 1–7), survey data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3
1987	0	NA
1988	0	NA
1989	0.194	NA
1990	0	NA
1991	0	0
1992	0.161	0
1993	0.044	0
1994	0	0
1995	0	0
1996	0.014	0
1997	0	0
1998	0.009	0
1999	0.051	0
2000	0	0
2001	0	0
2002	0	0
2003	0.141	0
2004	0	0
2005	0	0
2006	0.034	0
2007	0.562	0.158
2008	0.679	0.084
2009	0.379	0.565
2010	1.150	0
2011	0.416	0.934
2012	0.298	0
2013	1.759	0
2014	1.190	0
2015	0.137	0
2016	0.056	1.148
2017	0	0.318
2018	0	NA

Table 15.6.14 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of biomass estimates (kg/hr) for *Raja brachyura* 4.c. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG	BTS TRI Q3	BTS BEL	CGFS Q4
1987	0	NA	0	NA	NA	NA	NA
1988	0	NA	0	NA	NA	NA	0
1989	0	NA	0	NA	NA	NA	0.200
1990	0	NA	0	NA	NA	NA	0.007
1991	0	0	0	NA	NA	NA	0
1992	0.134	0	0	NA	NA	NA	0
1993	0.38	0	0	0.394	NA	NA	0
1994	0	0	0	0.012	NA	NA	0.035
1995	0	0	0	0.004	NA	NA	0.186
1996	0	0	0	0.006	0	NA	0
1997	0	0	0	0.002	0	NA	0.127
1998	0	0	0	0.005	0	NA	0.274
1999	0.066	0	0	0.084	0	NA	0.162
2000	0	0	0.025	0.013	0	NA	0.074
2001	0	0	0	0.059	0	NA	0.130
2002	0	0	0	0.095	0	NA	0.234
2003	0.027	0	0	0.048	0	NA	0.413
2004	0	0	0	0.085	1.316	NA	0.121
2005	0.080	0	0.062	0.067	0	NA	0
2006	0.019	0	0	0.013	0.224	NA	0.152
2007	0.28	0	0	0.119	1.868	NA	0.454
2008	0.603	0	NA	0.013	0	NA	0.019
2009	0.062	0	0	0.092	0	NA	0.434
2010	0.008	0	0	0.724	0	0.125	0.071
2011	0.005	0	0	0.716	0	0.15	0.424
2012	0.980	0.214	0.062	0.144	0	0.095	1.117
2013	0.339	0	0	0.741	0	0.107	0.290
2014	1.068	0	0	2.014	0	0.108	1.569
2015	0.462	0	0	0.418	0.129	0.169	1.740
2016	0.233	0.257	0	NA	0	0.159	2.413
2017	0.808	0.476	NA	1.070	0	0.113	5.480
2018	1.483	NA	NA	NA	NA	NA	NA

Table 15.6.15 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of exploitable biomass index (kg/hr for individuals >50 cm) for *Amblyraja radiata* . Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS TRI Q3	BTS GFR Q3	CGFS Q4
1987	0.358	NA	0	NA	NA	NA
1988	0.366	NA	0	NA	NA	0
1989	0.258	NA	0	NA	NA	0
1990	0.247	NA	0	NA	NA	0
1991	0.227	0.2	0	NA	NA	0.087
1992	0.28	0.078	0	NA	NA	0
1993	0.214	0.064	0	NA	NA	0
1994	0.172	0.14	0	NA	NA	0
1995	0.524	0.034	0	NA	NA	0
1996	0.147	0.086	0.205	0.167	NA	0
1997	0.273	0.061	0	0.215	NA	0
1998	0.299	0.179	0	0.573	NA	0
1999	0.252	0.052	0	0.48	NA	0
2000	0.34	0.065	0	0.24	NA	0
2001	0.043	0.111	0	0.203	NA	0
2002	0.104	0.033	0.035	0.125	0.037	0
2003	0.215	0.033	0	0.194	0	0.014
2004	0.059	0.044	0	0.146	0	0
2005	0.069	0	0	0.034	0	0
2006	0.006	0.018	0.045	0	NA	0
2007	0.037	0.06	0	0	0	0
2008	0.064	0	NA	0	0.047	0.075
2009	0.021	0	0	0.038	0.056	0
2010	0.007	0.133	0	0.07	0.168	0
2011	0.061	0.022	0	0.102	0.1	0
2012	0.018	0.014	0	0.11	0.056	0
2013	0.025	0	0	0	0	0
2014	0.106	0.046	0	0.04	0	0
2015	0.013	0.027	0	0	0	0
2016	0.028	0	0	0	0	0
2017	0.042	0	NA	0.03	0	0
2018	0.015	NA	NA	NA	NA	NA

Table 15.6.16 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of exploitable biomass index (kg/hr for individuals >50 cm) for *Leucoraja naevus*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI2 Q3	BTS BEL Q3	CGFS Q4
1987	0.113	NA	0	NA	NA	NA	NA
1988	0.518	NA	0	NA	NA	NA	0
1989	0.404	NA	0	NA	NA	NA	0
1990	0.428	NA	0	NA	NA	NA	0.029
1991	0.240	0.081	0	NA	NA	NA	0
1992	0.604	0.359	0	NA	NA	NA	0
1993	0.602	0.074	0	0	NA	NA	0
1994	0.255	0.157	0	0	NA	NA	0.283
1995	0.338	0.099	0	0	NA	NA	0.091
1996	0.300	0.031	0	0	0.384	NA	0
1997	0.141	0.579	0	0	0.409	NA	0.047
1998	0.258	0.060	0	0	0.782	NA	0
1999	0.207	0.177	0	0	0.375	NA	0
2000	0.229	0.239	0	0	0.359	NA	0
2001	0.097	0.085	0	0	0.026	NA	0
2002	0.094	0.114	0	0	0.168	NA	0
2003	0.066	0.080	0	0	0.213	NA	0
2004	0.059	0.037	0	0	0.180	NA	0
2005	0.054	0.106	0	0	0.158	NA	0.032
2006	0.115	0.110	0	0	0.113	NA	0
2007	0.127	0.104	0	0	0.411	NA	0
2008	0.098	0.517	NA	0	0.060	NA	0
2009	0.072	0.249	0	0	0.188	NA	0
2010	0.156	0.271	0	0.155	0.027	0	0
2011	0.137	0.289	0	0	0.190	0	0
2012	0.296	0.360	0	0	0.213	0	0
2013	0.322	0.235	0	0	0.124	0	0
2014	0.128	0.117	0	0.462	0.218	0	0
2015	0.487	0.271	0	0.082	0.097	0	0
2016	0.240	0.215	0	NA	0.186	0	0
2017	0.414	0.318	NA	0.097	0.191	0	0
2018	0.215	NA	NA	NA	NA	NA	NA

Table 15.6.17 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of exploitable biomass index (kg/hr for individuals >50 cm) for 'common skate complex'. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and BTS survey data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS TRI Q3
1987	0	NA	NA
1988	0.015	NA	NA
1989	0	NA	NA
1990	0	NA	NA
1991	0.139	0.005	NA
1992	0	0	NA
1993	0.022	0	NA
1994	0	0	NA
1995	0	0	NA
1996	0.044	0	0
1997	0	0	0
1998	0.008	0.015	0
1999	0.011	0	0
2000	0	0	0
2001	0	0	0
2002	0.008	0.067	0
2003	0	0	0
2004	0	0	0
2005	0.014	0.043	0
2006	0	0.004	0
2007	0.031	0	0
2008	0	0.039	0
2009	0	0	0
2010	0.011	0	0
2011	0.156	0.010	0
2012	0.106	0.160	0.023
2013	0.201	0.027	0
2014	0.122	0.064	0
2015	0.077	0.011	0.072
2016	0.176	0.089	0
2017	0.408	0.142	1.047
2018	0.419	NA	NA

Table 15.6.18. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of exploitable biomass index (kg/hr for individuals >50 cm) for *Raja clavata*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI	BTS ENG	BTS TRI	BTS GFR	BTS BEL	CGFS Q4
1987	3.131	NA	0	NA	NA	NA	NA	NA
1988	0.302	NA	0	NA	NA	NA	NA	0.558
1989	1.538	NA	0.228	NA	NA	NA	NA	5.738
1990	1.119	NA	0.418	NA	NA	NA	NA	2.516
1991	6.674	1.103	0	NA	NA	NA	NA	1.004
1992	1.178	0.429	0.610	NA	NA	NA	NA	2.418
1993	0.452	0.441	0	0.516	NA	NA	NA	1.205
1994	0.123	0.056	0	0.583	NA	NA	NA	2.087
1995	0.124	0.143	0	0.555	NA	NA	NA	1.664
1996	0.293	1.179	0.207	0.675	0.111	NA	NA	0.223
1997	0.711	0.435	0.434	1.655	0	NA	NA	1.989
1998	0	0	0	0.716	0.045	NA	NA	2.336
1999	0.079	0.355	0.599	1.031	0	NA	NA	1.640
2000	0.196	0.077	0.186	0.888	0.031	NA	NA	2.019
2001	0.254	0.164	0	1.399	0.040	NA	NA	1.700
2002	0.271	0.531	0.085	0.423	0.675	0	NA	2.301
2003	0.433	0.081	0	1.049	0.245	0	NA	1.593
2004	0.129	0.065	0	1.757	0.031	0	NA	1.544
2005	0.540	0.070	0.471	0.606	0.072	0	NA	3.721
2006	1.405	0.480	0	1.359	0.129	NA	NA	2.609
2007	0.253	0.018	0.022	0.868	0.374	0	NA	3.775
2008	2.913	0.507	NA	1.398	0	0	NA	4.152
2009	1.687	0.386	0	1.206	0.138	0	NA	3.645
2010	0.417	0.300	0	4.668	0.146	0	1.118	3.552
2011	0.071	0.457	0.096	3.439	0.028	0	0.907	3.179
2012	3.020	0.259	0.084	4.544	0.245	0	1.197	4.638
2013	0.759	2.404	0	6.446	0.213	0	1.344	9.492
2014	1.261	2.741	0.096	13.554	0.252	0	3.831	10.811
2015	1.440	2.238	0.454	6.675	0.626	0.141	1.663	16.465
2016	0.598	2.798	0.482	NA	0.165	0	2.753	27.988
2017	2.929	1.114	NA	10.241	0.749	0	3.385	14.724
2018	0.803	NA	NA	NA	NA	NA	NA	NA

Table 15.6.19 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of exploitable biomass index (kg/hr for individuals >50 cm) for *Raja montagui*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI Q3	BTS BEL Q3	CGFS Q4
1987	0.137	NA	0	NA	NA	NA	NA
1988	0.122	NA	0	NA	NA	NA	0
1989	0.128	NA	0.025	NA	NA	NA	0.360
1990	0.220	NA	0	NA	NA	NA	0.355
1991	0.493	0.148	1.048	NA	NA	NA	0.139
1992	0.276	0.303	0.078	NA	NA	NA	0.029
1993	0.217	0.412	0.260	0.099	NA	NA	0.250
1994	0.271	0.737	0	0.064	NA	NA	0.336
1995	0.505	0.213	0	0.072	NA	NA	0.182
1996	0.216	0.138	0.284	0.096	0.234	NA	0
1997	0.238	0	0.150	0.138	0	NA	0.173
1998	0.395	0.008	0	0.023	0.383	NA	0.151
1999	0.247	1.068	0	0	0.548	NA	0
2000	0.135	0.011	0	0.252	0	NA	0.058
2001	0.146	0.022	0	0.038	0	NA	0.039
2002	0.270	0.033	0	0.121	0.081	NA	0.022
2003	0.266	0.016	0.058	0	0	NA	0.043
2004	0.173	0.179	0	0.011	0.093	NA	0
2005	0.219	0.224	0	0.086	0.060	NA	0.124
2006	0.049	0.133	0	0.087	0.379	NA	0.163
2007	0.466	0.489	0	0.079	0.159	NA	0.561
2008	1.352	0.175	NA	0.039	0.058	NA	0
2009	0.269	0.393	0	0	0.041	NA	0
2010	0.642	0.439	0	0.348	0.107	0.151	0
2011	0.402	0.527	0	0.325	0.196	0.523	0.097
2012	0.824	0.708	0	0.255	0.492	0.218	0.028
2013	0.836	0.577	0.031	0.269	0.399	0.192	0.187
2014	0.851	2.263	0.051	0.739	0.424	0.443	0.035
2015	1.120	0.545	0.039	0.539	0.526	0.217	0.152
2016	0.681	0.818	0.049	NA	0.241	0.372	0
2017	0.878	0.527	NA	0.529	0.310	0.453	0.801
2018	1.092	NA	NA	NA	NA	NA	NA

Table 15.6.20. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of exploitable biomass index (kg/hr for individuals >50 cm) for *Raja brachyura* 4.a. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) survey data in the period 1987–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3
1987	0	NA
1988	0	NA
1989	0.194	NA
1990	0	NA
1991	0	0
1992	0	0
1993	0.044	0
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0.009	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0.141	0
2004	0	0
2005	0	0
2006	0	0
2007	0.557	0.158
2008	0.679	0.084
2009	0.379	0.565
2010	1.150	0
2011	0.416	0.934
2012	0.298	0
2013	1.717	0
2014	1.190	0
2015	0.137	0
2016	0.056	1.148
2017	0	0.318
2018	0	NA

Table 15.6.21 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of exploitable biomass index (kg/hr for individuals >50 cm) for *Raja brachyura* 4.c. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 data in the period 1989–2018. All data are abstracted from DATRAS.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG	BTS TRI Q3	BTS BEL	CGFS Q4
1987	0	NA	0	NA	NA	NA	NA
1988	0	NA	0	NA	NA	NA	0
1989	0	NA	0	NA	NA	NA	0.108
1990	0	NA	0	NA	NA	NA	0
1991	0	0	0	NA	NA	NA	0
1992	0.043	0	0	NA	NA	NA	0
1993	0.374	0	0	0.354	NA	NA	0
1994	0	0	0	0	NA	NA	0.020
1995	0	0	0	0	NA	NA	0.172
1996	0	0	0	0	0	NA	0
1997	0	0	0	0	0	NA	0.127
1998	0	0	0	0	0	NA	0.274
1999	0.066	0	0	0	0	NA	0.138
2000	0	0	0	0	0	NA	0.031
2001	0	0	0	0.028	0	NA	0.13
2002	0	0	0	0.047	0	NA	0.141
2003	0.027	0	0	0.018	0	NA	0.413
2004	0	0	0	0.030	1.316	NA	0.041
2005	0.080	0	0	0.036	0	NA	0
2006	0	0	0	0	0.198	NA	0.126
2007	0.249	0	0	0.100	1.868	NA	0.443
2008	0.582	0	NA	0	0	NA	0
2009	0.053	0	0	0.049	0	NA	0.364
2010	0	0	0	0.570	0	0.030	0.071
2011	0	0	0	0.630	0	0.147	0.386
2012	0.970	0.214	0	0.024	0	0.040	1.080
2013	0.338	0	0	0.428	0	0	0.259
2014	0.905	0	0	1.597	0	0.080	1.473
2015	0.443	0	0	0.296	0	0.059	1.722
2016	0.219	0.122	0	NA	0	0	2.283
2017	0.728	0.413	NA	0.486	0	0	5.309
2018	1.383	NA	NA	NA	NA	NA	NA

Table 15.7.1: Length-weight parameters (a and b) used to convert length to weight (values taken from Silva *et al.*, 2013).

Species	A	B
Leucoraja. naevus	0.0036	3.1399
Raja brachyuran	0.0027	3.2580
Raja clavata	0.0045	3.0961
Raja microocellata	0.0030	3.2250
Raja montagui	0.0041	3.1152
Raja undulata	0.0040	3.1346
Amblyraja radiata	0.0107	2.940
'common skate complex'	0.0038	3.1201
Scyliorhinus canicula	0.0022	3.1194
Mustelus spp	0.003	3.0349

Table 15.13.1. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Technical interactions of otter trawl (OT), beam trawl (BT), gillnet (GN), industrial (Ind). It is also recognized that there are interactions between skates/rays and cod fisheries in 4.c and 7.d.

		Cod 347d	Cod katt.	Had 34	Whg 47d	Sai 346	Ang 346	Ple 4	Ple 7d	Ple 3a	Sol 3a	Sol 4	Sol 7d	San 4	Nop 4	Nep stocks	Pan stocks	DemRays 347	DemSharks 347
Main gears	Cod 347d		L	H	H	M	??	M	M	M	M	M	M	L	L	H	??	L	L
	Cod kattegat	BT, OT		L	0	0	??	0	0	M	M	0	0	0	0	H	??	L	L
	Had 34	OT			H	M	??	L	0	L	L	L	0	L	L	H	??	L	L
	Whg 47d	OT				M	??	M	M	0	0	M	M	L	L	H	??	L	L
	Sai 346	OT					??	L	0	L	L	L	0	L	L	L	??	L	L
	Ang 346																	L	L
	Ple 4	BT		OT	BT	OT	??		0	0	0	H	0	L	L	L	??	H	H
	Ple 7d	BT			BT, OT		??			0	0	0	H	L	L	L	??	H	H
	Ple 3a	BT, OT	BT, OT	OT			??				H	0	0	0	0	L	??	L	L
	Sol 3a	BT,OT,GN	BT,OT,GN	OT	BT, OT					BT		0	0	0	0	L	??	L	L
	Sol 4	BT		OT	BT	OT		BT					0	0	0	L	??	H	H
	Sol 7d	BT			BT				BT					0	0	L	??	H	H
	San 4	Ind		Ind	Ind	Ind									M	0	0	L	L
	Nop 4	Ind		Ind	Ind	Ind								Ind		0	0	L	L
	Nep. stocks																H?	L	L
	Pan stocks																	L	L
	DemRays 347							BT	BT			BT	BT						H
	DemShar 347																		

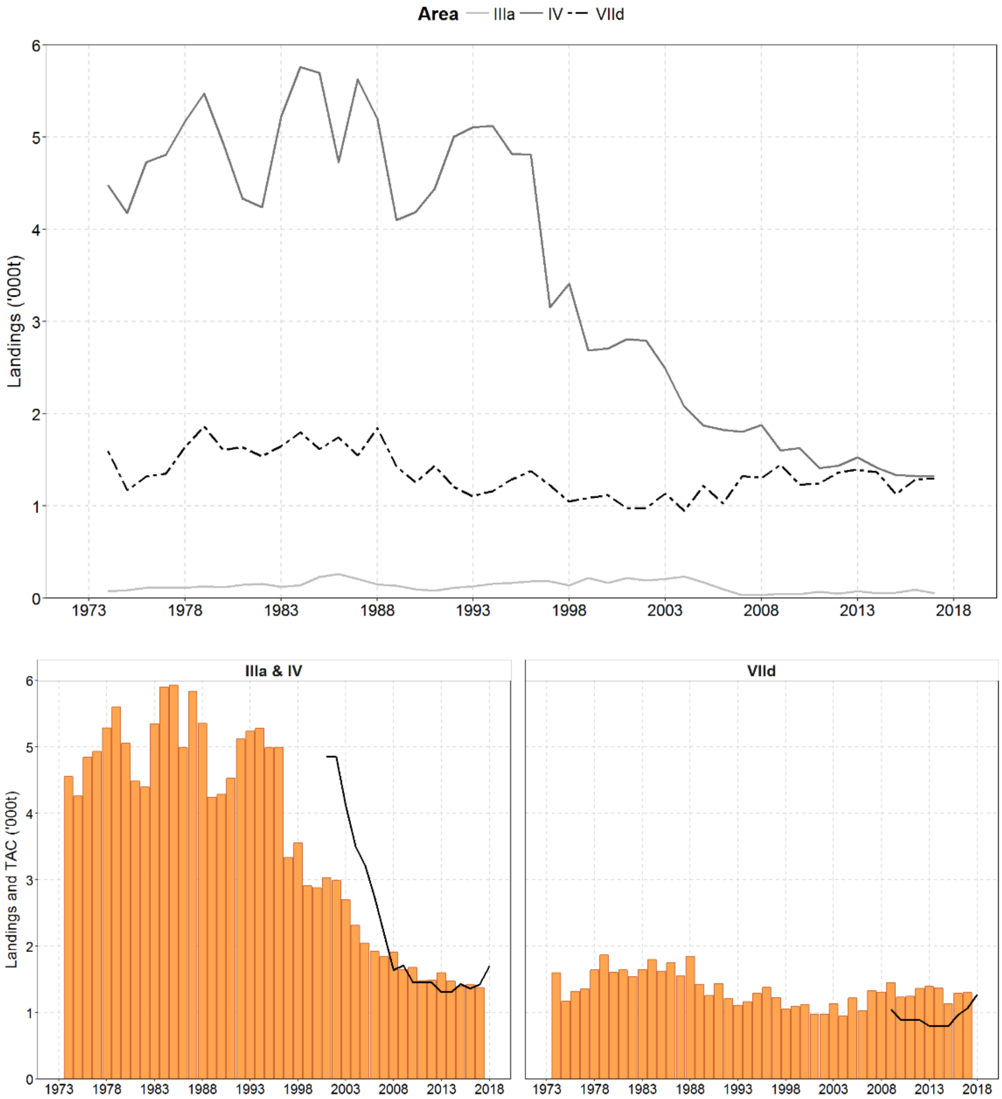

Figure 15.3.1. Top: Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel: total international landings of rays and skates in Division 3.a and Subarea 4 and Division 7.d since 1973, based on WG estimates. Bottom: Landings of area 3.a and 4 (combined) and 7.d, including the TACs for both areas (black lines).

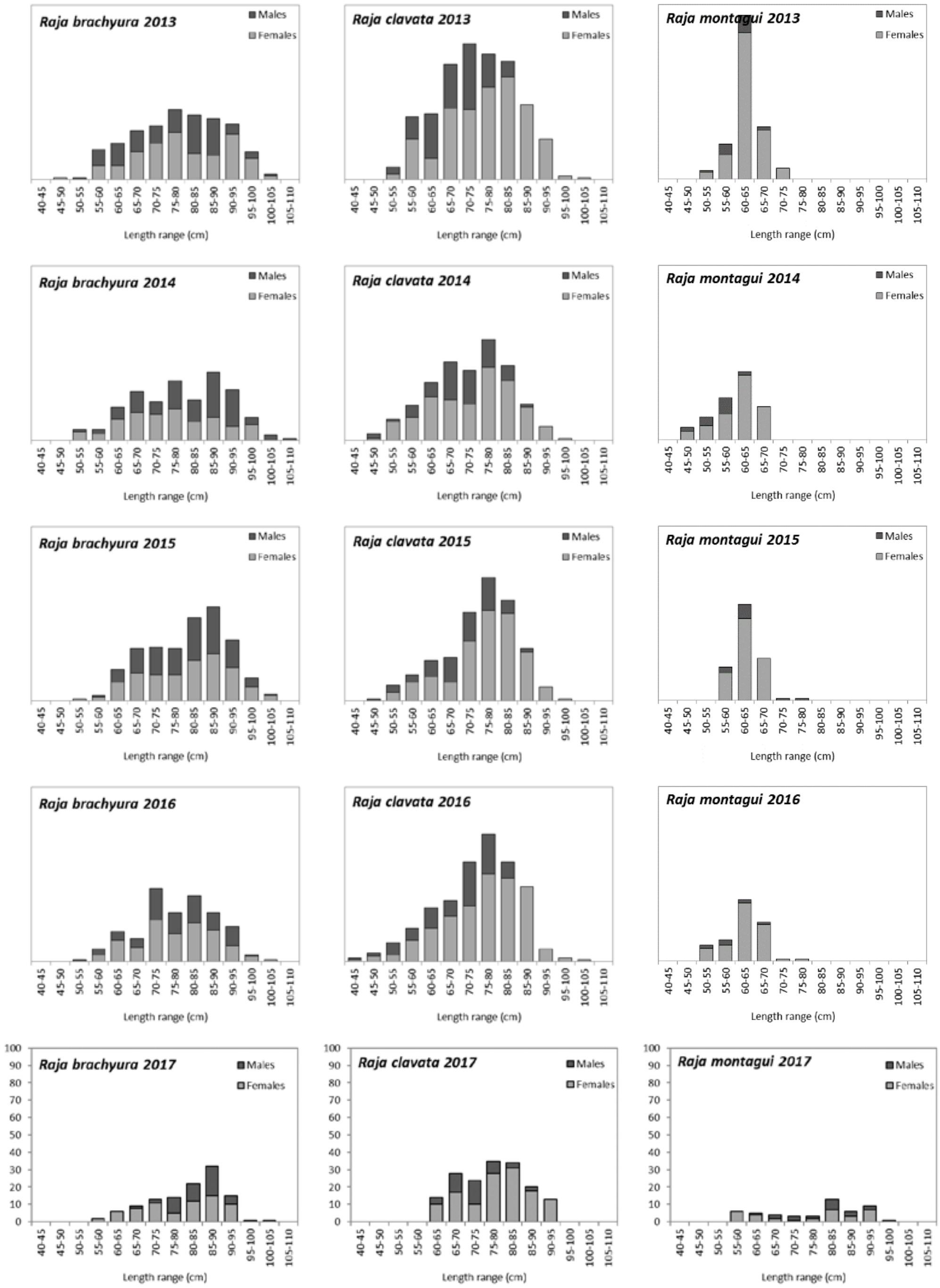

Figure 15.3.2. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Length–frequency distribution of the number of *R. brachyura*, *R. clavata* and *R. montagui* individuals measured during the market sampling programme of the Dutch beam trawl fleet in 2013–2017.

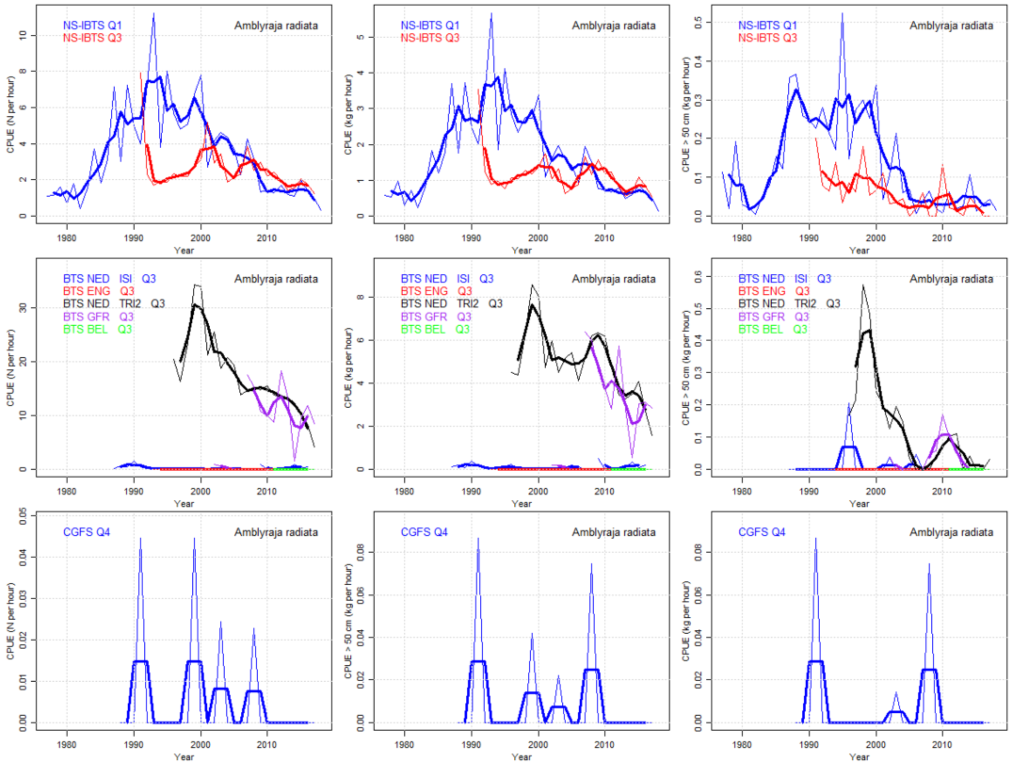

Figure 15.6.1 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Amblyraja radiata* . Abundance index (n.hr-1), biomass index (kg.hr-1) and exploitable biomass (kg.hr-1), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2018. Data extracted from the DATRAS database (selected for CPUE per length per haul) on 15 June 2018.

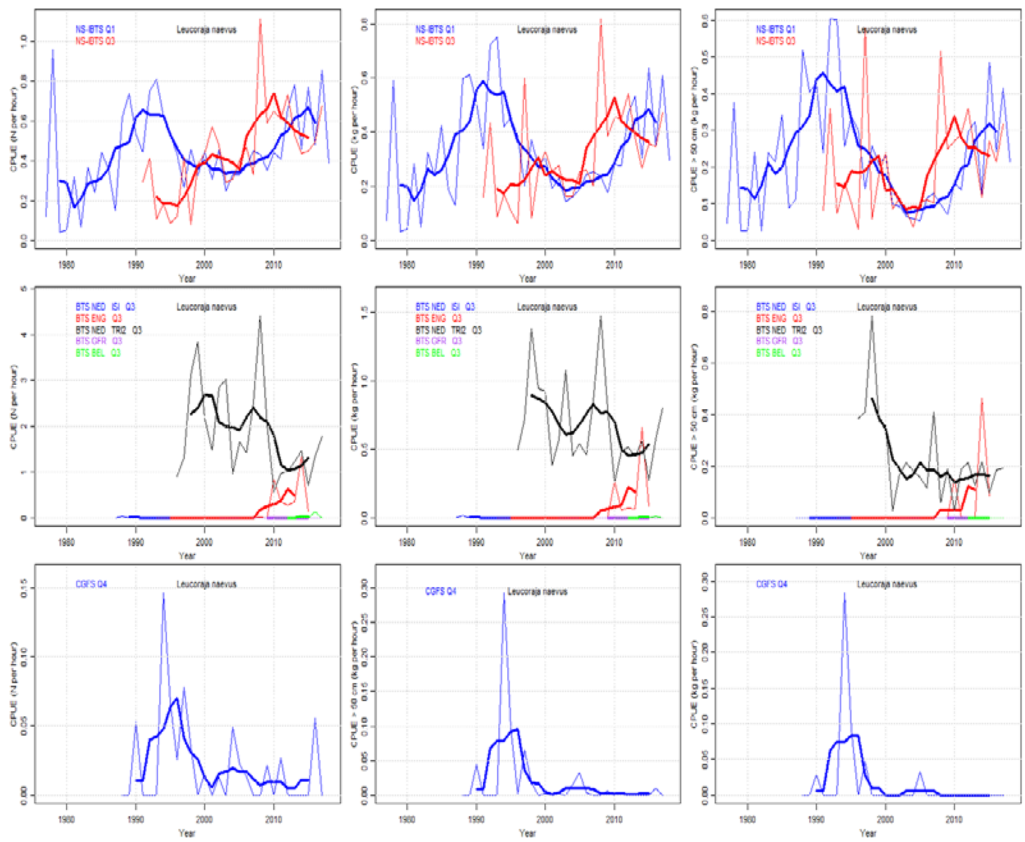

Figure 15.6.2. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Leucoraja naevus*. Abundance index (n.hr-1), biomass index (kg.hr-1) and exploitable biomass (kg.hr-1), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2017 Data extracted from the DATRAS database (selected for CPUE per length per haul) on 31 May 2017.

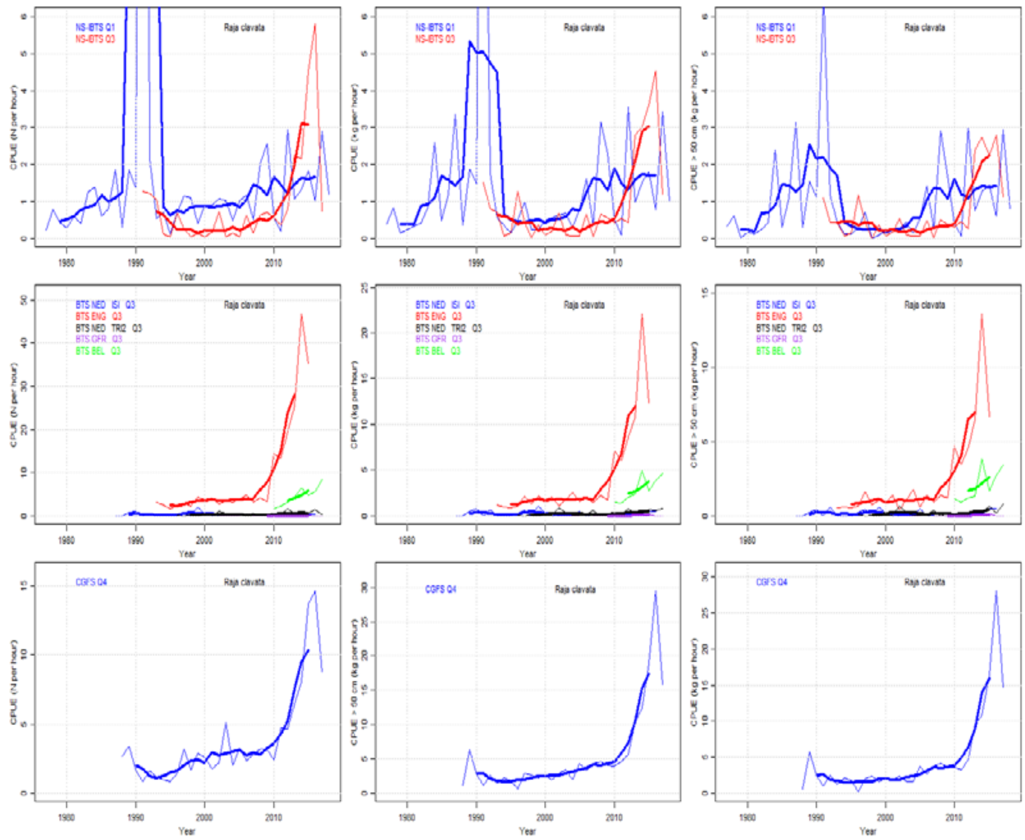

Figure 15.6.3. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Raja clavata*. Abundance index (n.hr-1), biomass index (kg.hr-1) and exploitable biomass (kg.hr-1), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2017 Data extracted from the DATRAS database (selected for CPUE per length per haul) on 15 June 2018.

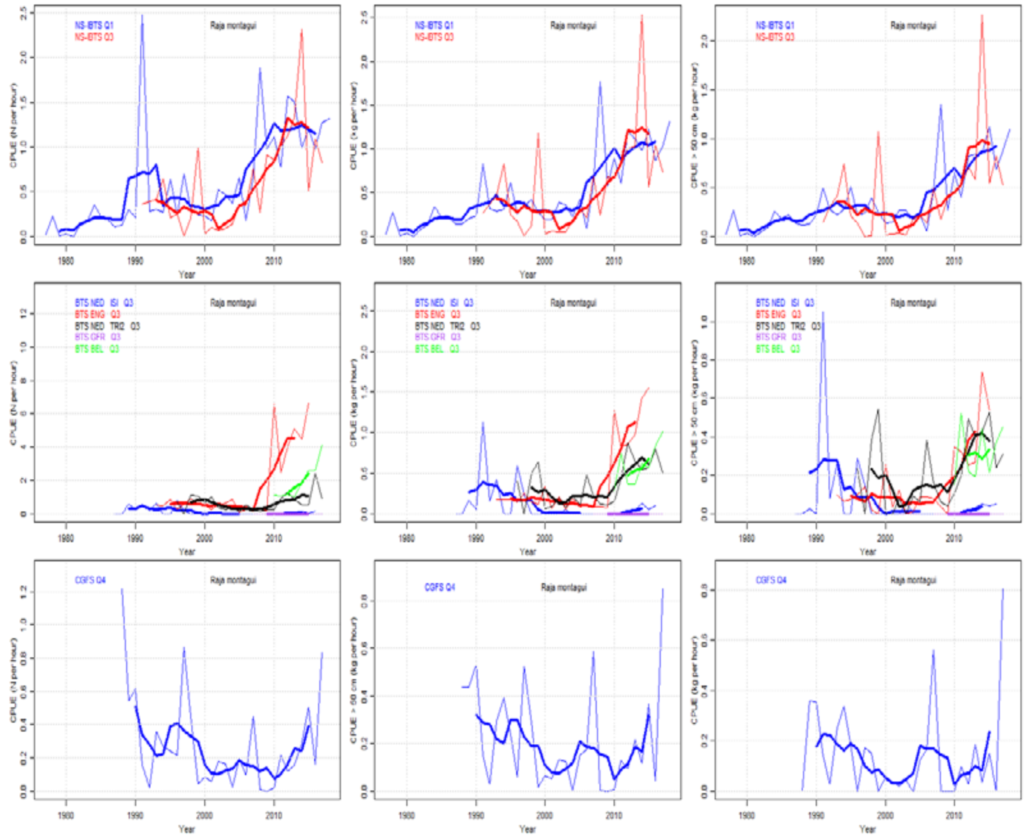

Figure 15.6.4. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Raja montagui*. Abundance index (n.hr-1), biomass index (kg.hr-1) and exploitable biomass (kg.hr-1), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2017 Data extracted from the DATRAS database (selected for CPUE per length per haul) on 15 June 2018.

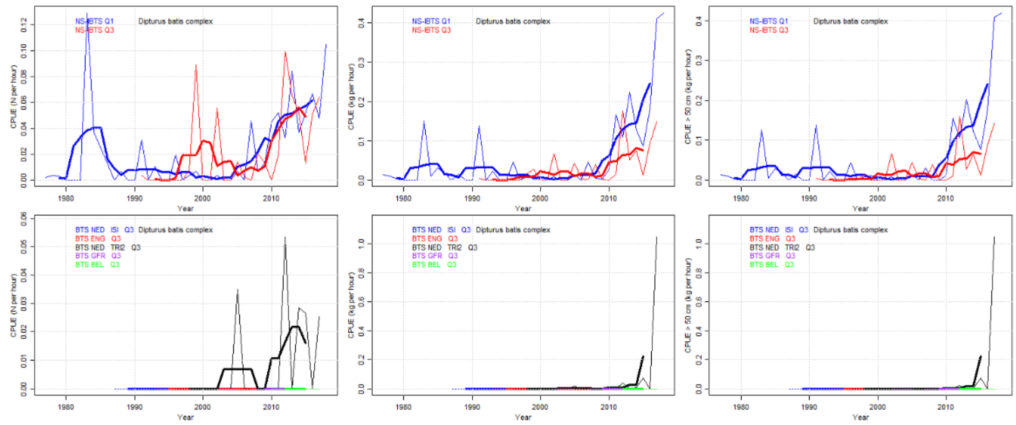

Figure 15.6.5. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. 'common skate complex'. Abundance index (n.hr-1), biomass index (kg.hr-1) and exploitable biomass (kg.hr-1), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2017 Data extracted from the DATRAS database (selected for CPUE per length per haul) on 15 June 2018.

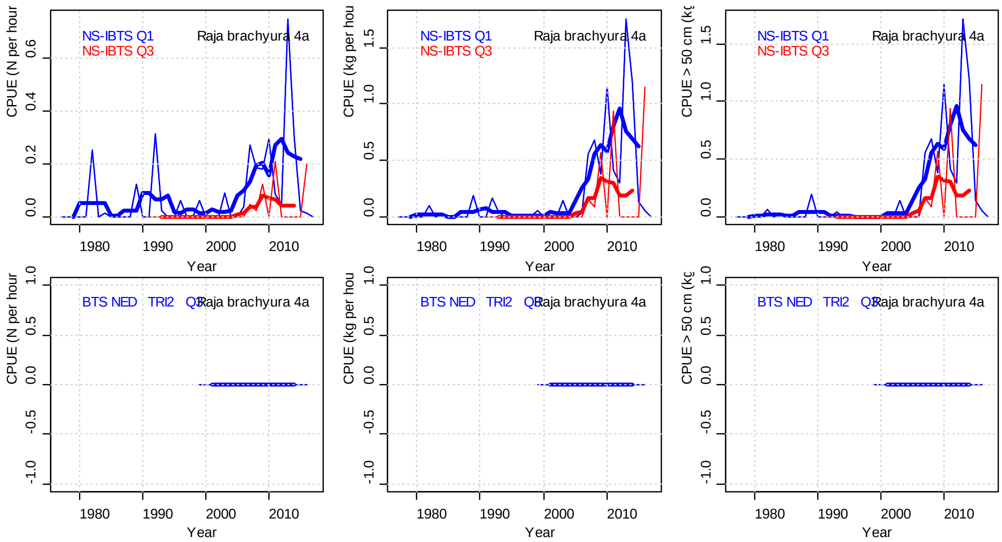

Figure 15.6.6. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Raja brachyura*n 4.a. Abundance index (n.hr-1), biomass index (kg.hr-1) and exploitable biomass (kg.hr-1), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2017 Data extracted from the DATRAS database (selected for CPUE per length per haul) on 15 June 2018.

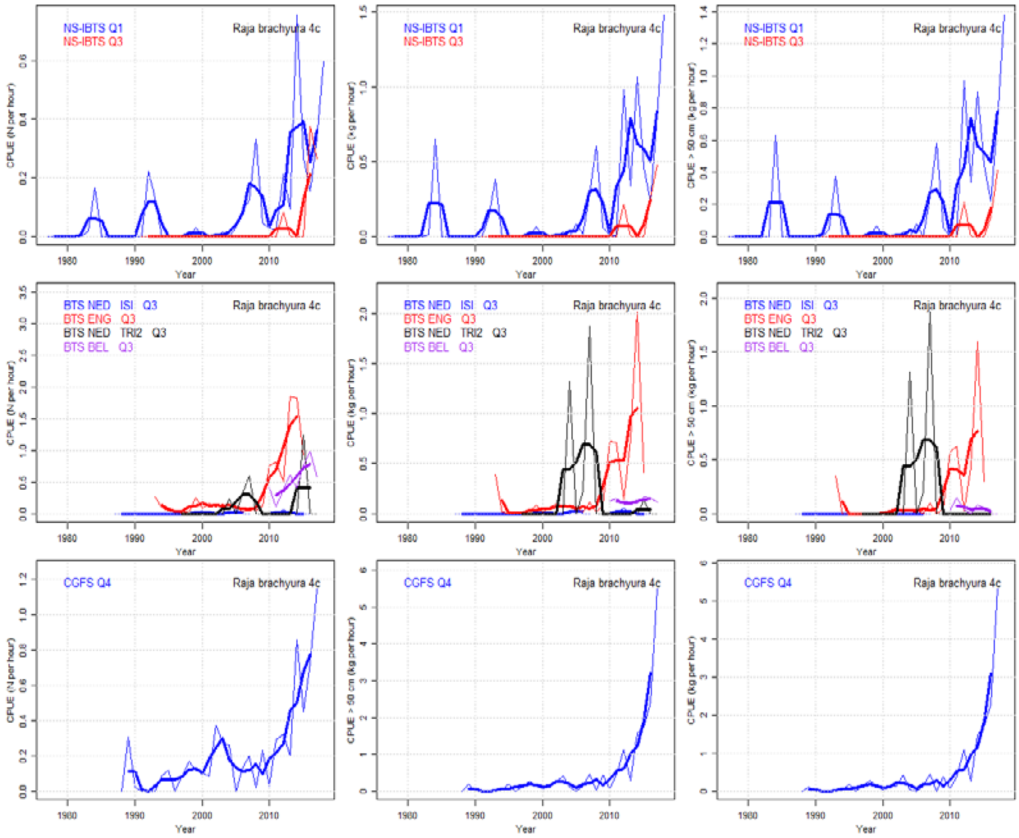

Figure 15.6.7. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Raja brachyura* 4.c. Abundance index (n.hr-1), biomass index (kg.hr-1) and exploitable biomass (kg.hr-1), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2017 Data extracted from the DATRAS database (selected for CPUE per length per haul) on 15 June 2018.

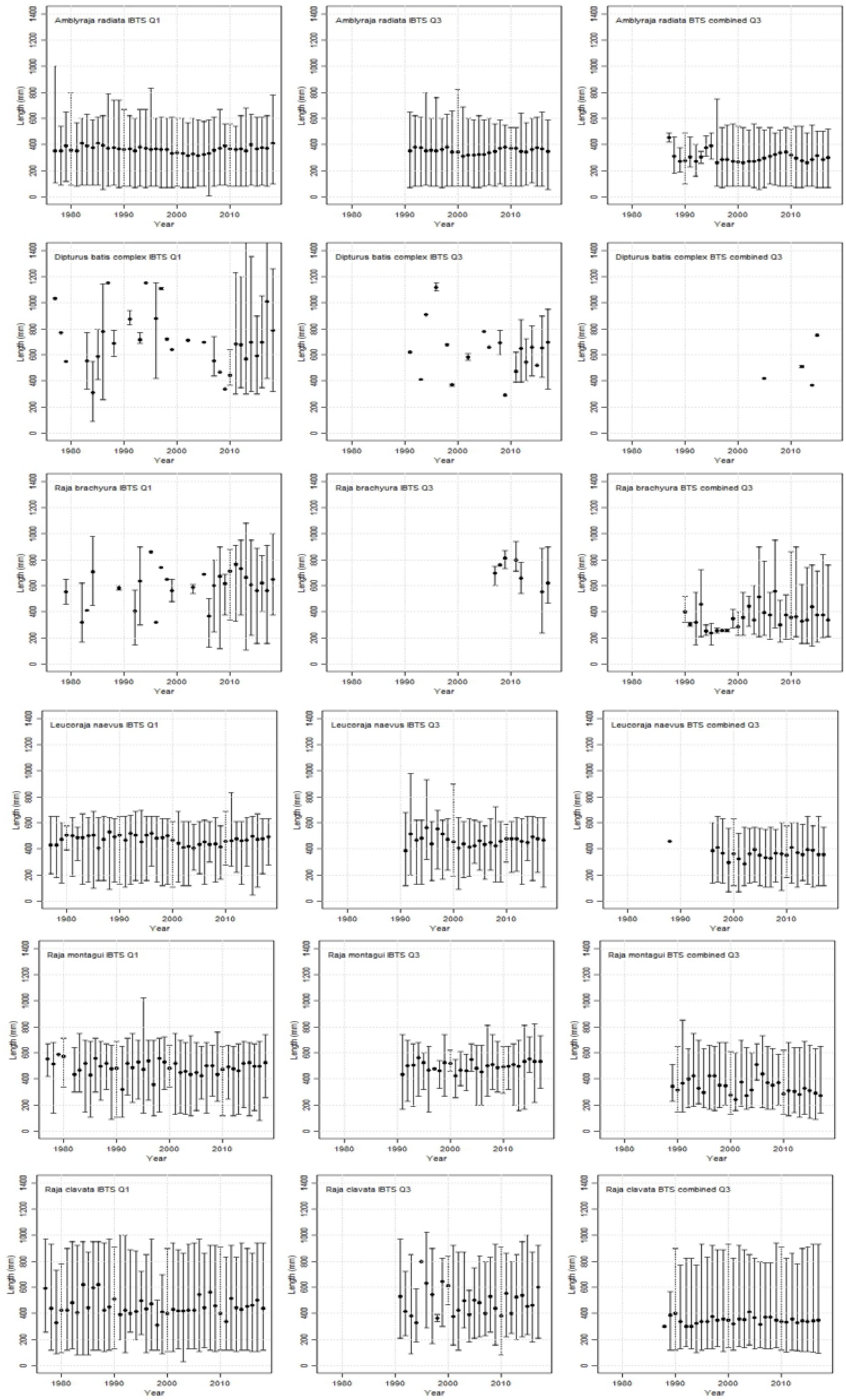

Figure 15.6.8. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Average length (dots) and length range during the North Sea IBTS (roundfish areas 1–7) and BTS surveys. Data extracted from the DATRAS database (selected for CPUE per length per statrec) on 15 June 2018. NOTE: There are still some incorrect data in DATRAS, with some length records of all species (except *R. clavata*) that are >L_{max}.

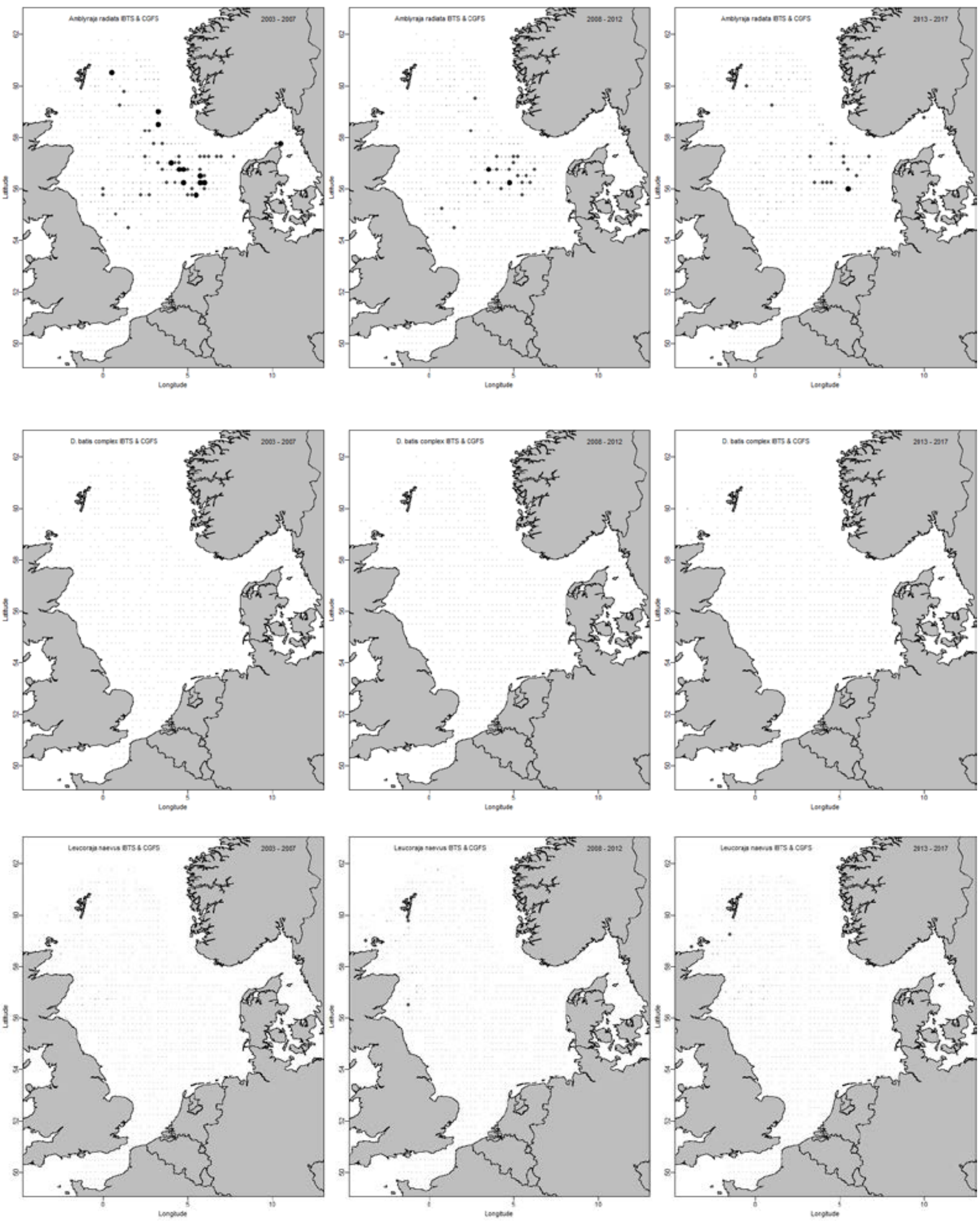

Figure 15.6.9. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and Eastern Channel: distribution plots based on IBTS Q1, IBTS Q3, and eastern Channel CGFS Q4 data in the periods 2003–2007 (left panels), 2008-2012 (centre panels), and 2013–2017 (right panels). All data are abstracted from DATRAS. Data for IBTS are extracted as CPUE per length per statistical rectangle) on 15 June 2018, while data for CGFS are extracted as exchange data. Bubble scale is equal in all panels.

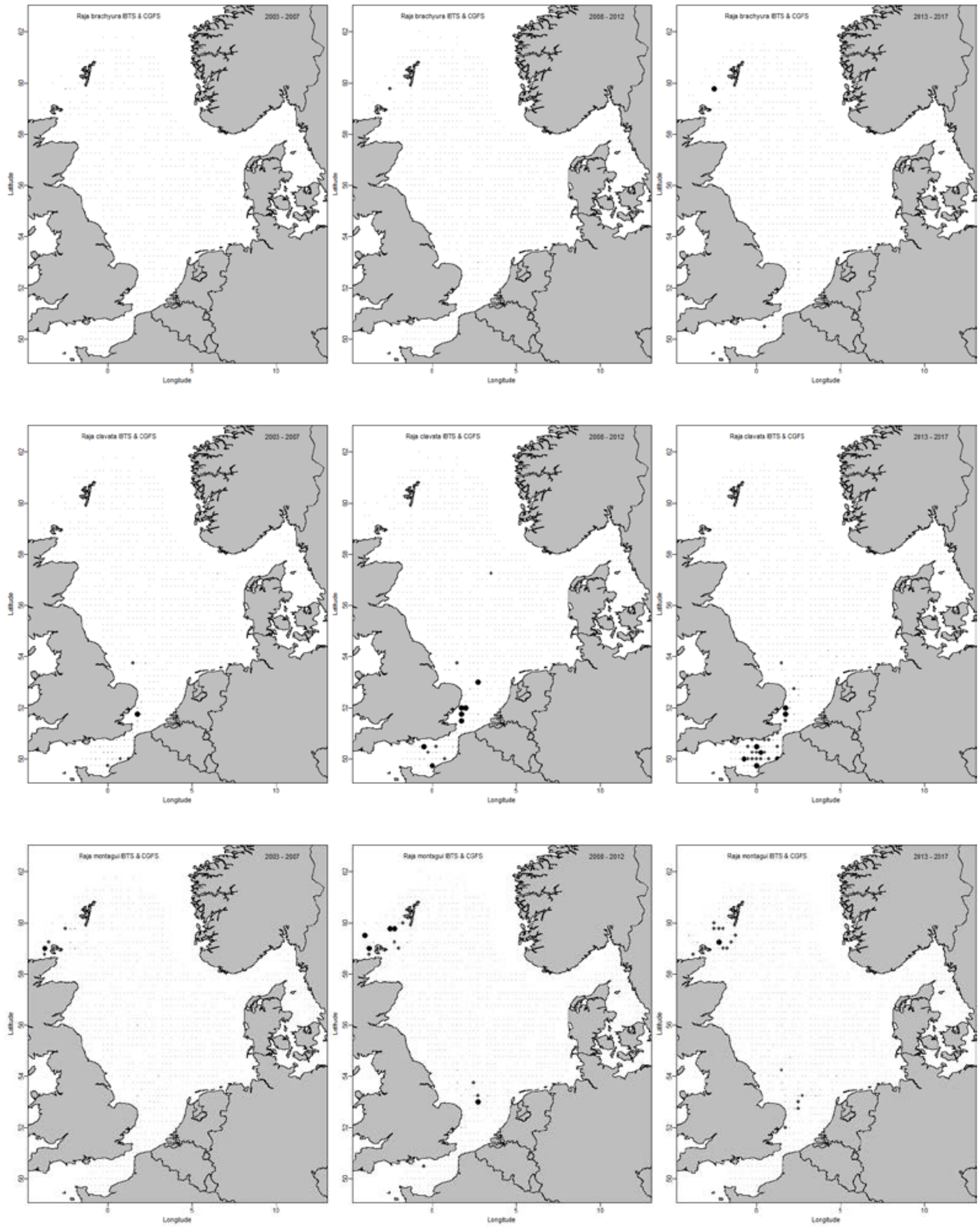

Figure 15.6.9. Continued.

16 Demersal elasmobranchs at Iceland and East Greenland

16.1 Ecoregion and stock boundaries

The elasmobranch fauna off Iceland and Greenland is little-studied and comprises 15 skate and 21 shark species (with six species of chimaeroid also present). The number of species decreases as water temperature decreases, and only a few of these species are common in Icelandic and Greenland waters.

An ecosystem overview for the ecoregion of Icelandic waters has been published and is available at the ICES website:

(http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/Ecosystem_overview-Icelandic_Waters_ecoregion.pdf).

The most abundant elasmobranch species in this ecoregion is starry ray (thorny skate) *Amblyraja radiata*.

In Icelandic waters, other skate species occurring are: Arctic skate *Amblyraja hyperborea,* Jensen's skate *Amblyraja jenseni*, common skate complex, Norwegian skate *Dipturus nidarosienis,* shagreen ray *Leucoraja fullonica*, roughskin skate *Malacoraja spinacidermis,* Krefft's skate, *Malacoraja kreffti*, deep-water ray *Rajella bathyphila*, Bigelow's skate *Rajella bigelowi,* round skate *Rajella fyllae*, sailray *Rajella lintea* (former *D. linteus*) and spinytail skate *Bathyraja spinicauda.*

In Greenland waters, the commonly found skates include *R. fyllae, B. spinicauda* and *A. hyperborea,* with species such as *R. bathyphila*, *M. spinacidermis, R. lintea*, *A. jenseni* and *R. bigelowi* being less frequent (Möller *et al.*, 2010).

Dogfish and sharks in this ecoregion include spurdog *Squalus acanthias* (Section 2); Portuguese dogfish *Centroscymnus coelolepis* and leafscale gulper shark *Centrophorus squamosus* (Section 3); birdbeak dogfish *Deania calcea*, black dogfish *Centroscyllium fabricii*, great lantern shark *Etmopterus princeps*, velvet belly lanternshark *E. spinax,* longnose velvet dogfish *Centroselachus crepidater* and six gill shark *Hexanchus griseus* (Section 5); porbeagle shark *Lamna nasus* (Section 6); basking shark *Cetorhinus maximus* (Section 7); Greenland shark *Somniosus microcephalus* (Section 24); and several scyliorhinid catsharks (Iceland catshark *Apristurus laurussonii,* white ghost catshark *A. aphyodes*, smalleye catshark *A. microps* and mouse catshark *Galeus murinus*).

Chimaeras (rabbitfish *Chimaera monstrosa*, spearnose chimaera *Rhinochimaera atlantica*, large-eyed rabbitfish *Hydrolagus mirabilis*, *H. pallidus*, small-eyed rabbitfish *Hydrolagus affinis*, narrownose chimaera *Harriotta raleighana*) all occur in the area.

Stock boundaries are not known for the species in this area. Neither are the potential movements of species between coastal and offshore areas. Further investigations are necessary to determine potential migrations or interactions of elasmobranch populations within this ecoregion and neighbouring areas.

16.2 The fishery

16.2.1 History of the fishery

Skates and sharks are mainly a bycatch in fisheries, with Iceland being the main fishing nation operating in the ecoregion. Common skate complex is fished with a variety of fishing gears (Figure 16.1a). They used to be regarded as fairly common in Icelandic waters, but landings may now only be about 10% of what was landed 50 years ago. A large part of the landed catch is for local consumption, as the common skate complex is a traditional food in Iceland, particularly at Christmas time. The remaining catch is processed and mainly exported.

A. radiata is a bycatch in a variety of fishing gears around Iceland but was usually discarded. Increased landings since the 1990s may be related to an increased retention compensating for a lower abundance of the common skate complex. Landings are reported mainly from the longline fishery (Figure 16.1b). Reported landings have increased from low levels in 1980 to more than 1000 tonnes annually from 1995–2004. Thereafter, landings declined but have increased again to levels exceeding 1700 tonnes in 2012. From 2012 to 2016, landings have gradually reduced to approximately 1250 tonnes, followed by an abrupt decline to 700 tonnes in 2017. A relatively large proportion of the landings is for local consumption.

16.2.2 The fishery in 2017

No new information.

16.2.3 ICES advice applicable

ICES does not provide advice on these stocks.

16.2.4 Management applicable

There is no TAC for demersal skates in these areas.

16.3 Catch data

16.3.1 Landings

From 1973–2017, 13 countries reported landings of skates, demersal sharks and chimaeras from Divisions 5.a (Iceland) and 14.a and 14.b (East Greenland). Iceland is the main nation fishing in these areas.

Reported landings of skates from Iceland (Division 5.a) and eastern Greenland (Subarea 14) are given in Table 16.1, with these data comprising national landings data provided to WGEF, landings statistics from the Faroese national database (www.hagstova.fo), and data from the ICES database.

Icelandic national data for estimated landings of the common skate complex (1973–2017), *A. radiata* (1977–2017), *R. lintea* (2000–2017) were updated. Database entries for all species were updated with national landings for the years 2001–2017.

Prior to 1992, all skates (except *A. radiata* and common skate complex) were reported as '*Raja* rays nei'. Since 1992, when skates have been reported to the species level, *A. radiata* and *Dipturus batis*-complex have accounted for about 98% of the annual skate landings. Only small quantities of *L. fullonica*, *R. lintea* and *B. spinicauda* have been reported. Fishers do not usually distinguish between *L. fullonica* and *R. lintea* in Icelandic waters, and so landings of *R. lintea* are likely to be underestimated and landings of *L. fullonica* overestimated (as landings of the latter species, which is relatively rare in Icelandic waters, includes some *R. lintea*). Landings reported as *D. batis*-complex could also sometimes be *R. lintea.* Therefore, official landings on *L. fullonica* will be reported as *Raja* rays nei until this issue is locally resolved.

Reported skate landings peaked at 2500 t in 1951. Since then, the landings of the *D. batis*-complex have decreased but landings of *A. radiata* have increased in later years. Landings of starry ray (*A. radiata*) were under 1000 t but after 2005 increased to about

1800 t in 2012 contributing the bulk of landings of elasmobranchs in this ecoregion (Table 16.1; Figures 16.2–16.3). Overall, over 95% of the skate landings came from Division 5.a. The share taken by Iceland from this area increased from <50% in the 1970s to nearly 100% from 1999 to 2016 and 2017.

Information on elasmobranch bycatch in East Greenland waters is unavailable, but several species are probably taken and discarded in fisheries for cod, shrimp and Greenland halibut *Reinhardtius hippoglossoides*.

16.3.2 Discards

No discard data were available.

16.3.3 Quality of catch data

The main skates landing nations in this ecoregion now provides species-specific information, but species identification needs improvement.

16.3.4 Discard survival

No data available to WGEF for the fisheries in this ecoregion.

16.4 Commercial catch composition

No data on the length distribution or sex ratio in commercial landings were available.

16.5 Commercial catch and effort data

No data available.

16.6 Fishery-independent surveys

16.6.1 Surveys in Greenland waters

Since 1998, the Greenland surveys (GR-GHXIVB) have covered the area between 61°45'–67°N at depths of 400–1500 m, although the area between 63–64°N was not covered by the surveys, as the bottom topography was too steep and rough. The surveys are aimed at Greenland halibut, although all fish species are recorded. The surveys use an ALFREDO III trawl (wingspread ≈ 21 m; headline height ≈ 5.8 m; mesh size (cod end) = 30 mm) with rock-hopper ground gear. These data were presented to WGEF in a working paper by Jørgensen (2006) and are summarized in Table 16.2. Another source of survey data in Greenland waters is the German Greenland groundfish survey (GER (GRL)-GFS-Q4), and these data need to be examined.

16.6.2 Surveys in Icelandic waters

The Icelandic autumn groundfish survey (IS-SMH) is the main source of fishery-independent data for demersal elasmobranchs in Icelandic waters. Further, data can be compiled for some species from other surveys e.g. spring groundfish survey (IS-SMB), shrimp and flatfish surveys undertaken by MFRI.

The IS-SMH survey covers the Icelandic shelf and slope at depths of 20–1500 m. It is a stratified systematic survey with standardized fishing methods. Small-meshed bottom trawls (40 mm in the cod-end) with a rock-hopper ground gear are towed at a speed of 3.8 knots for a predetermined distance of 3 nautical miles (See Björnsson *et al.*, 2007 for a detailed description of methodology).

Catch data and frequency of occurrence for skates from IS-SMH is summarised in Table 16.3. Catch data (number of individuals per survey) of all demersal elasmobranchs, for the years 1996–2006, can be found in Björnsson *et al.* (2007).

16.7 Life-history information

Published information on life history of skates and rays in Icelandic waters is scarce.

Amblyraja radiata is by far the most abundant elasmobranch species in Icelandic waters, with a widespread distribution over the Icelandic shelf and upper slope (Figure 16.4). Seasonal differences in distributional patterns have been noted, with *A. radiata* much less abundant on the shelf during autumn surveys (IS-SMH) than in spring survey (IS-SMB), and the bulk of catches in IS-SMH is taken on shelf break/slope north and east of Iceland (Fig. 16.4 a and b see also Björnsson *et al*., 2007) .

Anecdotal information suggests that *A. radiata* undertakes seasonal migrations in relation to egg-laying activity, but this is unconfirmed. Trawl survey data may provide useful information on catches of viable skate egg cases and/or on nursery grounds.

Length–frequency distributions of *A. radiata* in IS-SMH (Figure 16.5) indicate the majority of specimens are <60 cm L_T. Data on maturity derive from autumn survey allowing for calculations of maturity ogives. Length-at-50%-maturity (L_{50}) is 42.9 cm and 41.0 cm LT for males and females respectively (L_{95} for males is 51.1 cm and 50 cm for females). These values are lower in comparison to adjacent waters to the NW Atlantic stock (Templeman, 1987), but larger than observed in the North Sea, where $L_{50\%}$ is 36.2 and 38.4 cm L_T for males and females, respectively (McCully *et al*., 2012).

16.8 Exploratory assessment models

Abundance indices and biomass estimates for *A. radiata* have been calculated based on IS-SMB and IS-SMH, with a decreasing trend in large skates (>50 cm) observed (Björnsson *et al*., 2007). Preliminary survey results indicate stable trends in major size groups in recent years after a period of decline.

16.9 Stock assessment

No assessments have been undertaken for the skates in this ecoregion.

16.10 Quality of assessments

Exploratory analyses of survey trends have been conducted for *A. radiata*. However, the majority of commercial landings data are being taken by gears other than bottom trawl (Figure 16.1) and this should be considered.

16.11 Reference points

No reference points have been proposed for any of these species.

16.12 Conservation considerations

The common skate complex has been found to be vulnerable to exploitation and has been near-extirpated from coastal areas elsewhere in their range (e.g. parts of the Irish and North Seas). Preliminary investigation of the common skate complex in Icelandic waters indicated that the dominant species currently found in Icelandic waters is the smaller *D. cf. flossada*. Further investigation into the common skate complex and other large-bodied skates in Iceland and East Greenland is required.

16.13 Management considerations

The elasmobranch fauna off Iceland and Greenland is little studied and comprises relatively few species (21 sharks, 15 skates and six chimaeras). Most of the landings of skates are now reported to species.

The most abundant demersal elasmobranch in the area is *A. radiata*, which is widespread and abundant in this and adjacent waters. Negative survey trends for large size starry rays have been observed (Björnsson *et al*., 2007). Preliminary results of more recent data indicate that after a period of decline, stock trends have been stable for few years.

16.14 References

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Table 16.1. Demersal elasmobranchs at Iceland and East Greenland. Reported landings of skates from Iceland (Division 5.a) and East Greenland (Subarea 14). Data were updated with landings from ICES historic nominal landings database (ICES, 2016) and national landings data provided to the WG (June 2018). Faroese landings 1990–2015 were extracted from Faroes national statistics database available on www.hagstova.fo *1990–2015: Total catch (live weight). ** Prior to 1992 all skates nei are assumed to belong to common skate complex (see earlier reports).

scientific name	nation	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
common skate complex	Iceland	364	275	188	333	442	424	403	196	229	245	185	178	120	108
Amblyraja radiata	Iceland	0	0	0	0	0	0	0	0	0	9	12	46	15	44
Raja rays nei**	Belgium	59	51	62	36	41	23	27	36	28	11	15	15	19	18
	Faeroe Islands	80	56	43	35	75	27	37	21	25	23	73	24	21	0
	Germany	76	41	49	41	37	10	2	1	2	2	4	3	2	1
	Norway	1	0	63	4	2	3	2	3	6	1	10	3	5	0
	UK - England & Wales	385	187	195	106	5	0	0	0	0	0	0	0	0	0
	UK - Scotland	5	8	14	8	0	0	0	0	0	0	0	0	0	0
Total		970	618	614	563	602	487	471	257	290	291	299	269	182	171

scientific name	nation	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
common skate complex	Iceland	130	152	152	222	304	363	274	299	245	181	118	108	80	94
	Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Amblyraja radiata	Iceland	125	39	100	163	286	317	294	1206	1749	1493	1430	1252	996	1076
Leucoraja fullonica	Iceland	0	0	0	0	0	0	2	12	24	19	16	12	21	27
Raja rays nei**	Belgium	22	20	22	6	9	6	3	0	0	0	0	0	0	0
	Faeroe Islands*	8	2	2	16	5	2	3	3	9	2	2	7	5	0
	Germany	0	0	0	1	3	1	2	0	9	0	0	1	0	7
	Norway	0	0	0	0	0	25	8	8	7	10	2	19	8	3
	Portugal	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	UK - Eng+Wales+N.Irl.	0	0	0	0	0	1	2		4	0	0	1	2	0
Total		285	213	276	408	607	715	588	1529	2047	1705	1569	1400	1112	1210

Table 16.1. (continued). Demersal elasmobranchs at Iceland and East Greenland. Reported landings of skates from Iceland (Division 5.a) and East Greenland (Subarea 14). Data were updated with landings from ICES historic nominal landings database (ICES, 2016a) and national landings data provided to the WG. *Faroese landings 1990–2017 were extracted from Faroes national statistics database available on www.hagstova.fo. Total catch (live weight). ** Official reports on *L. fullonica* are likely misidentification and thus, from 2005, these numbers are reported to WG as rays nei.

scientific name	nation	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
common skate complex	Iceland	82	59	120	145	166	136	123	126	128	117	125	145	153	141	165	143	147
	Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
Amblyraja radiata	Iceland	1211	1781	1491	1013	657	530	496	634	866	1026	1416	1978	1847	1625	1397	1273	652
Rajella lintea	Iceland	0	0	10	8	1	8	7	0	8	12	9	9	7	4	11	3	5
***Leucoraja fullonica*	Iceland	37	32	17	23													0
Raja rays nei	Faeroe Islands*	2	1	0	8	9	16	7	11	6	5	14	5	6	4	7	0	3
	Germany	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	France												0	0	0	0	0	0
	Iceland	0	0	0	0	16	16	17	4	33	19	17	21	37	14	15		10
	Norway	6	5	1	0	0	7	0	1	2	4	4	0	0	0	1	1	0
	Portugal	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Russian Federation	0	0	0	2	6	3	0	0	na	na	0	0	na	na	NA	0	0
	Spain	0	0	15	0	0	0	0	0	0	0		0	0	0	0	0	0
	UK	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0		0
Raja clavata	France								0	0	0	1	0	0	0	0	0	0
Total		1340	1878	1655	1200	855	726	650	786	1043	1183	1520	2039	1917	1788	1595	1433	817

Table 16.2. Demersal elasmobranchs at Iceland and East Greenland. Demersal elasmobranch species captured during groundfish surveys at East Greenland (1998–2005) giving the total number, observed maximum weight (kg), depth range (m) and bottom temperature range °C and most northern position (decimal degrees). Source: Jørgensen (2006).

Species	N	Max wt (kg)	Depth range (m)	Temp range (°C)	Maximum latitude
Bathyraja spinicauda	82	61.5	548–1455	0.5–5.6	65.46°N
Rajella bathyphila	57	45.3	476–1493	0.3–4.1	65.44°N
Rajella fyllae	117	4.8	411–1449	0.8–5.9	65.46°N
Amblyraja hyperborea	12	23.4	520–1481	0.5–5.4	65.47°N
Amblyraja radiata	483	22.1	411–1281	0.8–6.6	66.21°N
Malacoraja spinacidermis	3	3.1	1282–1450	2.3–2.7	62.25°N
Apristurus laurussoni	3	0.7	836–1255	1.7–4.3	65.22°N
Centroscyllium fabricii	812	128	415–1492	0.6–5.1	65.40°N
Somniosus microcephalus	9	500	512–1112	1.4–4.9	65.35°N

Table 16.3. Demersal elasmobranchs at Iceland and East Greenland. Catch data of skates and rays in MRI annual autumn groundfish survey at Iceland (Division 5.a), giving the number of individuals caught (N) and the frequency of occurrence (percentage of stations where species was collected, O%). 2011 survey (noted with asterisk) was discontinued and therefore data are incomplete.

	2000		2001		2002		2003		2004		2005		2006		2007	
	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O
common skate complex	6	<1	1	<1	3	<1	3	<1	1	<1	4	<1	6	1	7	1
Amblyraja radiata	1589	48	1413	45	1442	49	1379	49	1957	51	1678	53	1716	52	1474	52
Rajella lintea	2	<1	0	0	0	0	0	0	0	0	0	0	2	<1	0	0
Amblyraja hyperborea	110	9	160	9	80	8	88	8	97	9	104	8	120	10	59	10
Rajella fyllae	24	4	54	8	53	8	77	6	37	6	53	7	81	8	44	8
Bathyraja spinicauda	7	2	11	2	10	2	25	1	12	2	16	2	21	2	7	2
Rajella bathyphila	1	<1	0	0	0	0	1	<1	0	0	1	<1	0	0	0	0
Rajella bigelowi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	2008		2009		2010		2011*		2012		2013		2014		2015		2016		2017	
	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O
common skate complex	7	1	9	1	4	<1	1	1	0	<1	0	0	5	1	17	2	0	0	4	<1
Amblyraja radiata	1569	48	1590	39	1399	46	295	42	918	34	1142	41	1289	52	1066	49	1268	48	1026	45
Rajella lintea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		0	0
Amblyraja hyperborea	90	9	103	9	86	10	27	8	73	7	63	8	95	9	68	5	79	8	43	5
Rajella fyllae	106	5	48	10	70	7	36	5	24	17	35	4	71	10	30	6	46	6	33	9
Bathyraja spinicauda	18	2	11	2	1	2	2	0	11	1	4	2	11	2	5	1	4	1	5	1
Rajella bathyphila	2	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	<1
Rajella bigelowi	1	<1	0	0	0	0	0	0	0	0	0	0	0	0	1	<1	0	2	1	<1
Malacoraja kreffti															2	<1	3	<1	3	<1

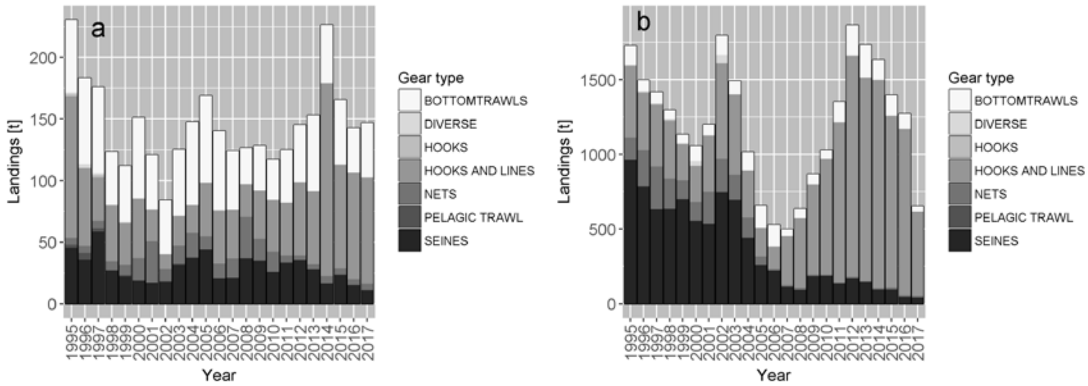

Figure 16.1. Demersal elasmobranchs at Iceland and East Greenland. Icelandic landings of (a) common skate complex and (b) starry ray *A. radiata* by fishing gear). Note different scales at the y-axis.

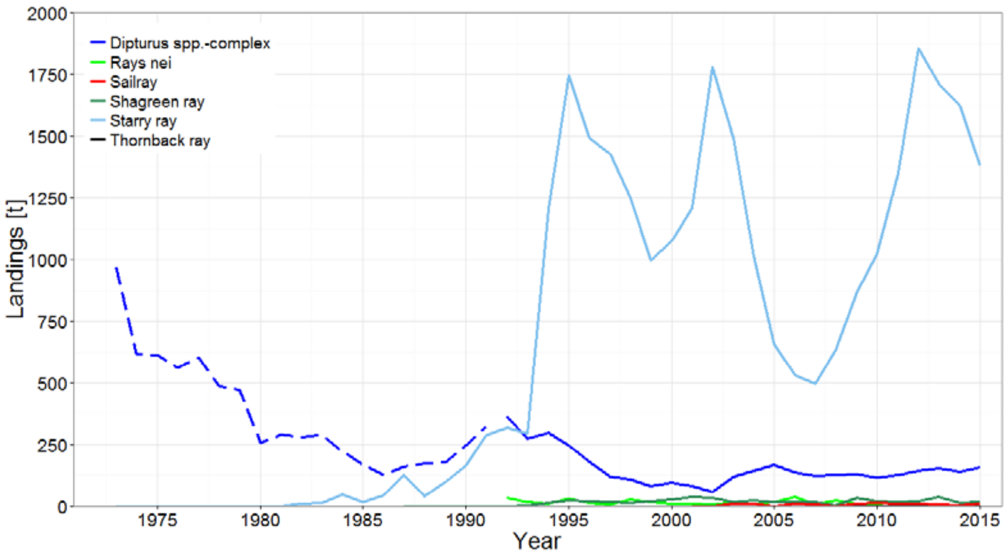

Figure 16.2. Demersal elasmobranchs at Iceland and East Greenland. Landings of skates (Division 5.a and Subarea 14). Prior to 1992 all skates nei are assumed to belong to common skate complex (see earlier reports). WG estimates of the most commonly reported skates, 1973–2015. (ICES, 2016a), national landings data provided to the WG, and Faroese statistical database www.hagstova.fo).

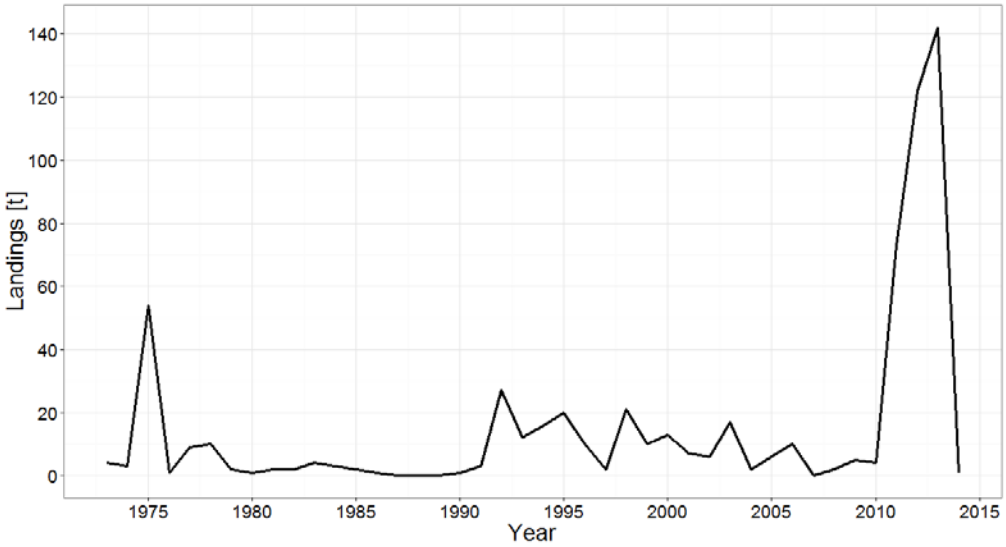

Figure 16.3. Demersal elasmobranchs at Iceland and East Greenland. Combined landings of rays and skates from East Greenland (Subarea 14). The peak landings in 2011–2013 originate from *Amblyraja radiata* (FAO Code RJR). Data from ICES (2016a,b).

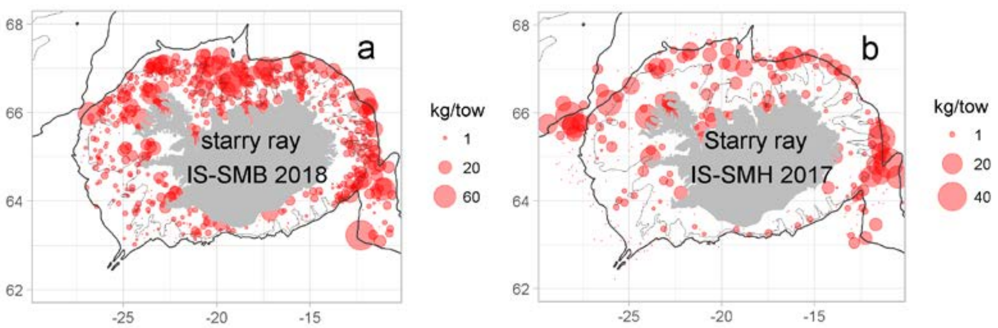

Figure 16.4. Demersal Elasmobranchs at Iceland and East Greenland. Spatial distribution of starry ray *A. radiata* in Icelandic waters (Division 5.a). a: Spring survey (IS-SMB) 2018. b: Autumn survey (IS-SMH) 2017.

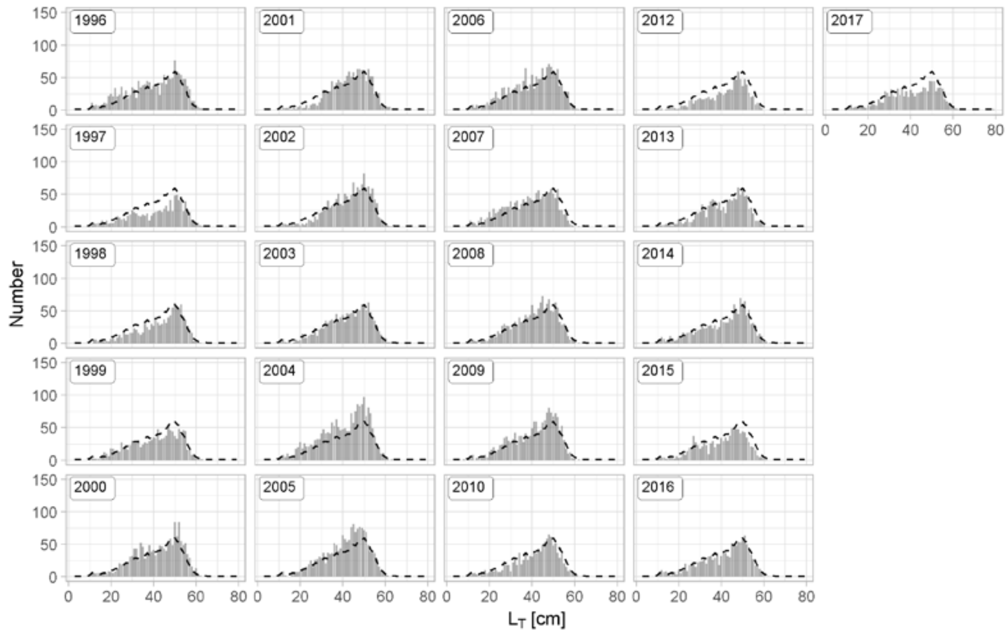

Figure 16.5. Demersal elasmobranchs at Iceland and East Greenland. Length distribution of starry ray *A. radiata* in Icelandic waters (Division 5.a) each year as observed in the annual autumn survey. Broken line denotes average value. Mean length each year is denoted in the upper right corner of each panel.

17 Demersal elasmobranchs at the Faroe Islands

17.1 Ecoregion and stock boundaries

The elasmobranch fauna off the Faroe Islands (ICES divisions 5.b1 and 5.b2) is little studied, though it is likely to be similar to that occurring in the northern North Sea and off NW Scotland and Iceland.

Skates recorded in the area include Arctic skate *Amblyraja hyperborea*, starry ray (thorny skate) *Amblyraja radiata*, common skate complex, long-nosed skate *Dipturus oxyrinchus*, sandy ray *Leucoraja circularis*, shagreen ray *Leucoraja fullonica*, cuckoo ray *Leucoraja naevus*, spotted ray *Raja montagui*, thornback ray *Raja clavata*, round skate *Rajella fyllae* and sailray *Rajella lintea* (formerly *Dipturus linteus*).

Demersal sharks include spurdog *Squalus acanthias* (Section 2), several deep-water species (leafscale gulper shark *Centrophorus squamosus*, black dogfish *Centroscyllium fabricii*, birdbeak dogfish *Deania calcea*, longnose velvet dogfish *Centroselachus crepidater*, smallmouth velvet dogfish *Scymnodon obscurus;* sections 2 and 5), Greenland shark *Somniosus microcephalus* (Section 24) and various scyliorhinids, such as mouse catshark *Galeus murinus* and black-mouth catshark *Galeus melastomus* (Section 25).

Several chimaeras also occur in the area: rabbitfish *Chimaera monstrosa*, large-eyed rabbitfish *Hydrolagus mirabilis*, narrownose chimaera *Harriotta raleighana* and spearnose chimaera *Rhinochimaera atlantica*.

Stock boundaries are not known for the species in this area. Neither are the potential movements of species between the coastal and offshore areas. Further investigations are necessary to determine potential migrations or interactions of elasmobranch populations within this ecoregion and neighbouring areas.

17.2 The fishery

17.2.1 History of the fishery

Since 1973, seven countries have reported landings of demersal elasmobranch from Division 5.b, relating mostly to skates. Scottish vessels reported the largest portion of landings in earlier years, but Faroese vessels have reported the greatest quantities since the 1980s. These include trawlers and, to a lesser extent, longliners and gillnetters. Norwegian longliners fishing in this area target ling, tusk and cod. UK vessels include a small number of larger Scottish trawlers that occasionally obtain quota to fish in Faroese waters, and target gadoids and deeper water species. French vessels fishing in this area are probably from the same fleet that prosecute the mixed deep-water and shelf fishery west of the British Isles. Demersal elasmobranchs likely represent a minor to moderate bycatch in these fisheries.

In 2007, a Russian longliner fished for deep-water sharks in the Faroese Fishing Zone (FFZ) and on the Reykjanes Ridge. The total catch of the elasmobranchs in those and other NEA areas amounted to 483 t (Vinnichenko, 2008; summarised in ICES, 2010).

17.2.2 The fishery in 2017

No new information.

17.2.3 ICES advice applicable

ICES does not provide advice on the skate stocks in this area.

17.2.4 Management applicable

The majority of the area is managed by the Faroes through fishing effort based system which restricts fishing days for demersal gadoids. Some EU vessels have been able to gain access to the Faroes EEZ where they have been managed under individual quotas for the main target species.

17.3 Catch data

17.3.1 Landings

Landings of skates, not usually identified to species level, are summarised in Table 17.1. French reported landings of common skate complex are unlikely to represent the entire catch, as an unknown quantity is included in the category of unidentified skates and rays. Total skate landings are shown in Figure 17.1.

17.3.2 Discards

The amounts of skates and demersal sharks discarded has not been estimated.

17.3.3 Quality of catch data

Species-specific information for commercial catches is incomplete.

17.3.4 Discard survival

No data available for the elasmobranchs taken in commercial fisheries in this area.

17.4 Commercial catch composition

All skates in Division 5.b, with the exception of French landings, were reported as '*Raja* rays nei' before 2008 (see Table 17.1). There were no port sampling data available to estimate species composition. It is likely that catches include common skate complex, *L. fullonica, R. clavata* and *A. radiata*. No data regarding size composition or sex ratio from commercial landings were available.

17.5 Commercial catch and effort data

No information available to WGEF.

17.6 Fishery-independent surveys

No survey data were available. Magnussen (2002) summarized the demersal fish assemblages from the Faroe Bank, based on the analysis of routine survey data collected by the RV *Magnus Heinason* since 1983. Data on elasmobranchs taken in these surveys are summarized in Table 17.2. A more detailed analysis of the demersal elasmobranchs taken in Faroese surveys is still to be undertaken.

17.7 Life-history information

No new information. Trawl survey data may provide useful information on catches of viable skate egg cases and/or on nursery grounds.

17.8 Exploratory assessments

No exploratory assessments have been undertaken.

17.9 Stock assessment

No assessments have been conducted due to insufficient data. Analyses of survey data may allow the general status of the more frequent species to be evaluated.

17.10 Quality of assessments

No assessments have been conducted.

17.11 Reference points

No reference points have been proposed for any of these species.

17.12 Conservation considerations

See sections 15.12 and 18.12.

17.13 Management considerations

Total international reported landings of skates declined from 1973–2003 but increased to above the average of the time-series in 2004–2006. Since then, landings declined below the long-term average again and are continuing to decrease in the most recent years. Without detailed information on the fisheries, (including better separation of species, quantities discarded, sizes caught, etc.), it is not possible to provide information on exploitation patterns or the status of stocks.

The elasmobranch fauna off the Faroe Islands is little studied, though it is likely to be somewhat similar to that occurring in the northern North Sea and off Iceland. Further studies to describe the demersal elasmobranch fauna of this region and to conduct preliminary analyses of fishery-independent survey data are required.

The common skate complex has been demonstrated to be vulnerable to exploitation and has been near-extirpated in the Irish and North Seas, further investigation on the common skate complex and other skates in the Faroe Islands is required, including the data analysis from fishery-independent sources.

17.14 References

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Table 17.1. Demersal elasmobranchs at the Faroe Islands. Reported landings of skates from the Faroes area (Division 5.b). Data were updated with nominal landings from ICES database (ICES, 2017) for years 2006–2015 and also contain national landings data provided to the WG. Faroese landings for 1990–2016 were extracted from Faroese national statistics database available on www.hagstova.fo. *Total catch (live weight).

Species	Country	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Raja rays nei	Faroe Islands*	150	95	107	136	164	201	202	198	135	221	211	281	277
	France	0	0	30	57	159	7	3	0	4	2	0	0	0
	Germany	47	33	36	15	23	55	14	7	1	3	3	3	1
	Netherlands	0	0	1	1	0	0	0	0	0	0	0	0	0
	Norway	29	27	37	42	46	64	37	18	21	13	32	35	14
	UK	384	238	250	276	174	104	108	68	11	32	20	1	1
Common skate complex	France	0	0	0	0	0	5	0	0	0	0	0	0	0
Leucoraja naevus	France	0	0	0	0	0	0	1	0	0	0	0	0	0
Raja clavata	France	0	0	0	0	0	0	10	0	0	1	6	23	38
	Total	610	393	461	527	566	436	375	291	172	272	272	343	331

Table 17.1. Continued. Demersal elasmobranchs at the Faroe Islands. Reported landings of skates from the Faroes area (Division 5b). Data were updated with nominal landings from ICES database (ICES, 2017) for years 2006–2017 and also contain national landings data provided to the WG. Faroese landings for 1990–2017 were extracted from Faroese national statistics database available on www.hagstova.fo. *Total catch (live weight).

Species	Country	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Raja rays nei	Denmark	0	1	0	0	0	0	0	0	0	0	0	0	0
	Faroe Islands*	258	171	92	136	144	207	256	203	167	220	165	185	144
	France	1	6	5	8	5	0	0	0	0	1	1	2	0
	Germany	1	1	0	0	0	1	1	1	3	0	0	0	0
	Norway	22	11	29	84	96	81	37	75	20	14	60	14	45
	UK	0	2	0	1	2	1	5	13	8	7	4	11	7
Common skate complex	France	5	6	7	13	12	5	1	0	0	1	2	3	0
Leucoraja naevus	France	0	2	2	0	0	0	0	0	0	0	0	0	0
Dipturus oxyrinchus	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Raja clavata	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Raja montagui	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Dasyatis pastinaca	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucoraja circularis	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucoraja fullonica	France	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	287	200	135	242	259	295	300	292	198	243	232	215	196

Table 17.1. Continued. Demersal elasmobranchs at the Faroe Islands. Reported landings of skates from the Faroes area (Division 5.b). Data were updated with nominal landings from ICES database (ICES, 2017) for years 2006–2017 and also contain national landings data provided to the WG. Faroese landings for 1990–2017 were extracted from Faroese national statistics database available on www.hagstova.fo. *Total catch (live weight).

Species	Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Raja rays nei	Faroe Islands*	175	0	75	25	98	272	274	238	185	179	150	177	182	198	209
	France	2	0	0	1	5	10	9	20	10	7	6	0	0	0	0
	Germany	1	1	0	0	2	1	0	0	0	0	0	0	0	0	0
	Norway	45	50	21	15	5	0	12	10	16	9	4	11	0	0	0
	UK	6	35	27	12	8	20	8	2	2	2	1	3	0	0	0
Common skate complex	Norway	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
	France	4	2	2	2	3	5	2	3	1	0	0	0	0	0	0
	UK	0	0	0	0	0	0	0	0	0	0	4	5	0	0	0
Leucoraja naevus	France	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	UK	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Dipturus oxyrinchus	France	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Raja clavata	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	UK	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Raja montagui	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Dasyatis pastinaca	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucoraja circularis	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucoraja fullonica	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	UK	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0
Rostroraja alba	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	UK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	233	88	128	55	121	308	305	273	214	201	168	200	182	199	214

Table 17.1. Continued. Demersal elasmobranchs at the Faroe Islands. Reported landings of skates from the Faroes area (Division 5.b). Data were updated with nominal landings from ICES database (ICES, 2017) for years 2006–2017 and also contain national landings data provided to the WG. Faroese landings for 1990–2017 were extracted from Faroese national statistics database available on www.hagstova.fo. *Total catch (live weight). + under 0.5 tonnes.

Species	Country	2014	2015	2016	2017
Raja rays nei	Faroe Islands*	150	114	126	140
	France	0	5	0	2
	Germany	0	0	0	
	Norway	19	13	23	22
	UK	0	0	0	
Common skate complex	Norway	0	0	0	
	France	0	0	0	+
	UK	0	1	1	5
Leucoraja naevus	France	0	0	0	+
	UK	0		3	2
Raja clavata	France	1	0	0	+
	UK	0	1	1	+
Raja montagui	France	3	5	0	1
	UK				+
Dasyatis pastinaca	France	0	0	0	
Leucoraja circularis	France	0	0	0	
Leucoraja fullonica	France	0	0	0	+
	UK	0	0	0	
Rostroraja alba	France	0	0	0	
	Total	173	139	153	173

Table 17.2. Demersal elasmobranchs at the Faroe Islands. Elasmobranchs caught on the Faroe Bank during bottom-trawl surveys (1983–1996) by depth band. Symbols indicate frequency of occurrence in hauls (*: 60–100% of hauls, **: 10–60% of hauls, *: 3–10% of hauls, +: <3% of hauls). Adapted from Magnussen (2002).**

SPECIES	DEPTH						TOTAL
	<100 m	100–200 m	200–300 m	300–400 m	400–500 m	>500 m	
Galeus melastomus	–	+	*	*	**	**	*
Galeorhinus galeus	–	+	–	–	–	*	+
Squalus acanthias	–	*	*	**	*	**	*
Etmopterus spinax	–	+	–	–	*	**	*
Centroscyllium fabricii	–	–	–	–	*	–	+
Amblyraja radiata	–	–	–	–	–	**	+
Common skate complex	–	*	*	–	–	**	*
Leucoraja fullonica	–	+	+	–	–	*	+
Leucoraja circularis	–	–	*	–	–	–	+
Rajella fyllae	–	+	–	–	–	–	+
Rajella lintea	*	+	–	–	–	–	+
Raja clavata	–	+	–	–	–	–	+
Chimaera monstrosa	*	*	**	***	***	***	**

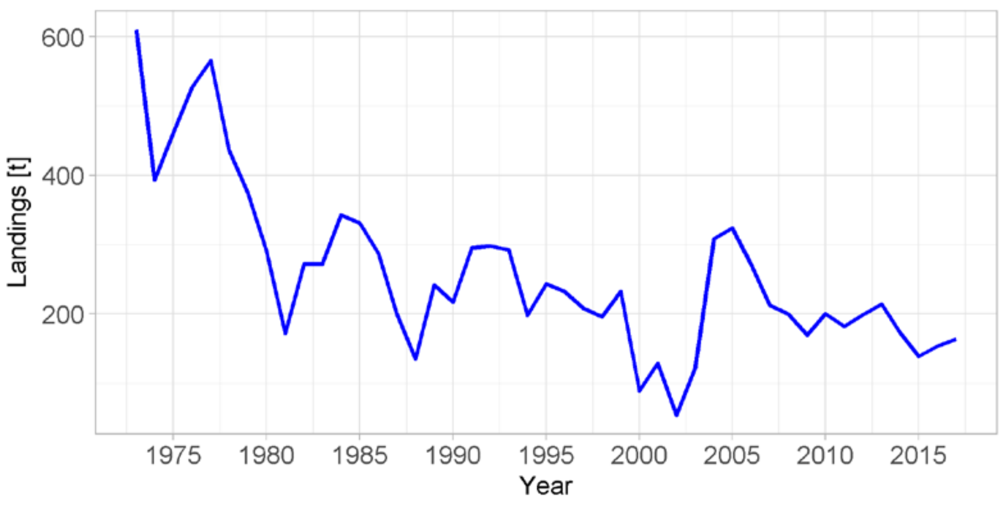

Figure 17.1. Demersal elasmobranchs at the Faroe Islands (Subarea 5.b). Reported landings of skates (1973–2016) based on ICES database (ICES, 2017), national landings data and Faroese national statistics database (www.hagstova.fo).

18 Skates and rays in the Celtic Seas (ICES subareas 6 and 7 (except Division 7.d))

18.1 Ecoregion and stock boundaries

See Stock Annex.

18.2 The fishery

18.2.1 History of the fishery

See Stock Annex.

18.2.2 The fishery in 2017

TAC and quota regulations were restrictive or near-restrictive for most nations and fisheries. The inclusion of common skate (*Dipturus batis*-complex) on the prohibited species list has resulted in increased discarding or misreporting of this species, especially in areas where they are locally common.

18.2.3 ICES advice applicable

ICES provided advice for several species/stocks in this region in 2016 as summarized in Table below.

Stock	Stock code	Assessment category	Advice basis	Advised Landings in 2017 and 2018
Blonde ray *Raja brachyura* Divisions 7.a and 7.f-g	rjh.27.7afg	5.	Precautionary approach	895 t
Blonde ray *Raja brachyura* Division 7.e	rjh.27.7e	5.	Precautionary approach	333 t
Thornback ray *Raja clavata* Subarea 6	rjc.27.6	3	Precautionary approach	145 t
Thornback ray *Raja clavata* Divisions 7.a and 7.f-g	rjc.27.7afg	3	Precautionary approach	1386 t
Thornback ray *Raja clavata* Division 7.e	rjc.27.7e	5	Precautionary approach	212 t
Small-eyed ray *Raja microocellata* Bristol Channel (Divisions 7.f-g)	rje.27.7fg	3	Precautionary approach	154 t
Small-eyed ray *Raja microocellata* English Channel (Divisions 7.d-e)	rje.27.7de	5	Precautionary approach	36 t
Spotted ray *Raja montagui* Subarea 6 and Divisions 7.b and 7.j	rjm.27.67bj	3	Precautionary approach	67 t
Spotted ray *Raja montagui* Divisions 7.a and 7.e-h	rjm.27.7ae-h	3	Precautionary approach	1197 t
Cuckoo ray *Leucoraja naevus* Subareas 6–7 and Divisions 8.a-b and 8.d	Rjn.27.678abd	3	Precautionary approach	2734 t
Sandy ray *Leucoraja circularis* Celtic Seas and adjacent areas	rji.27.67	5	Precautionary approach	42 t
Shagreen ray *Leucoraja fullonica* Celtic Seas and adjacent areas	rjf.27.67	5	Precautionary approach	210 t
Undulate ray *Raja undulata* Divisions 7.b and 7.j	rju.27.7bj	6	Precautionary approach	zero
Undulate ray *Raja undulata* Divisions 7.d-e (English Channel)	rju.27.7de	3	Precautionary approach.	65t
Common skate *Dipturus batis*-complex (flapper skate *Dipturus batis* cf. *flossada* and blue skate *Dipturus cf. intermedia*) Subarea 6 and Divisions 7.a–c and 7.e–j	rjb.27.67a-ce-k	6	Precautionary approach	zero
White skate *Rostroraja alba* in the northeast Atlantic	rja.27.nea	6	Precautionary approach	zero
Other skates Subarea 6 and Divisions 7.a–c and 7.e–j	raj.27.67a-ce-h	6	Insufficient data to provide advice	NA

18.2.4 Management applicable

A TAC for skates in Subarea 6 and divisions 7.a–c and 7.e–k was first established for 2009 and set at 15 748 t. Since then, the TAC has been reduced by approximately 15% (in 2010), 15% (in 2011), 13% (in 2012), 10% (in 2013) and a further 10% (in 2014). In 2017, the TAC was increased by 5%, (including separate TAC for *R. microocellata*), and in 2018, this was increased by a further 15% (including separate TAC for *R. microocellata* and *R. undulata*).

The history of the regulations are as follows:

Year	TAC for EC waters of 6a-b and 7a–c, and 7.e–k	Other measures	Regulation
2009	15 748 t	1,2	Council Regulation (EC) No. 43/2009 of 16 January 2009
2010	13 387 t	1,2,3	Council Regulation (EU) No. 23/2010 of 14 January 2010
2011	11 379 t	1,2,3	Council Regulation (EU) No. 57/2011 of 18 January 2011
2012	9915 t	1,2,3	Council Regulation (EU) No. 43/2012 of 17 January 2012
2013	8924 t	1,2,3	Council Regulation (EU) No. 39/2013 of 21 January 2013
2014	8032 t	1,3,4	Council Regulation (EU) No. 43/2014 of 20 January 2014
2015	8032 t	1,3,5	Council Regulation (EU) No. 2015/104 of 19 January 2015, and amended in Council Regulation (EU) No. 2015/523 of 25 March 2015
2016	8032 t	1,3,6,7	Council Regulation (EU) No 2016/72 of 22 January 2016, and amended in Council Regulation (EU) No. 2016/458 of 30 March 2016
2017	8434 t	1,3,6,7,8	Council Regulation (EU) No 2017/127 of 20 January 2017,
2018	9699 t	1,3,6,7,8,9	Council Regulation (EU) No 2018/120 of 23 January 2018,

[1] Catches of cuckoo ray *L. naevus*, thornback ray *R. clavata*, blonde ray *R. brachyura*, spotted ray *R. montagui*, small-eyed ray *R. microocellata* sandy ray *L. circularis*, shagreen ray *L. fullonica* should be reported separately.

[2] Does not apply to undulate ray *R. undulata*, common skate *D. batis*, Norwegian skate *D. nidarosiensis* and white skate *Rostroraja alba*. Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

[3] Of which up to 5% may be fished in EU waters of Division 7.d.

[4] Shall not apply to undulate ray *R. undulata*, common skate *D. batis* complex, Norwegian skate *D. nidarosiensis* and white skate *Rostroraja alba*. When accidentally caught, these species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

[5] Shall not apply to undulate ray *Raja undulata*. This species shall not be targeted in the areas covered by this TAC. Bycatch of undulate ray in area 7.e exclusively may be landed provided that it does not comprise more than 20 kg live weight per fishing trip and remain under the quotas shown [TAC = 100 t]. This provision shall not apply for catches subject to the landing obligation.

[6] Shall not apply to small-eyed ray *R. microocellata*, except in Union waters of 7.f and 7.g. When accidentally caught, this species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species. Within the limits of the abovementioned quotas, no more than the quantities of small-eyed ray in Union waters of 7.f and 7.g provided below may be taken [TAC = 188 t]

[7] Shall not apply to undulate ray *R. undulata*. This species shall not be targeted in the areas covered by this TAC. In cases where it is not subject to the landing obligation, bycatch of undulate ray in area 7.e may only be landed whole or gutted, and provided that it does not comprise more than 40 kilograms live weight per fishing trip. The catches shall remain under the quotas shown [TAC = 100 t] Bycatch of undulate ray shall be reported separately under the following code: RJU/67AKXD.

[8] Shall not apply to undulate ray *R. undulata*. This species shall not be targeted in the areas covered by this TAC. In cases where it is not subject to the landing obligation, bycatch of undulate ray in area 7.e may only be landed whole or gutted. The catches shall remain under the quotas shown [TAC = 161 t] Bycatch of undulate ray shall be reported separately under the following code: RJU/67AKXD.

[9] Shall not apply to small-eyed ray (*Raja microocellata*), except in Union waters of 7f and 7g. When accidentally caught, this species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species. Within the limits of the abovementioned quotas, no more than the quantities of small-eyed ray in Union waters of 7f and 7g (RJE/7FG.) provided below may be taken [TAC = 154 t].

Raja microocellata in Union waters of Subarea 6 and divisions 7.a–c and 7.e–k were initially subject to strict restrictions at the start of 2016, with Council Regulation (EU) 2016/72 of 22 January 2016 stating that: "*When accidentally caught, this species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species*". However, this was subsequently updated in Council Regulation (EU) 2016/458 of 30 March 2016, whereby the prohibition in landings was revoked for Union waters of 7.f-g, with a precautionary TAC of 188 t being set for this species, within the total skate and ray quota.

A sub TAC of 154 t was similarly applied in 2017 and in 2018.

It is forbidden to retain skates and rays caught on the Porcupine Bank from 1 May – 31 May.

There are also mesh-size regulations for target fisheries, the EC action plan for the conservation and management of sharks (EC, 2009), and some local bylaws and initiatives, which were detailed in ICES (2010).

18.2.5 Other management issues

Alternatives to the current TAC system are being explored by the European Commission. A meeting to set Terms of Reference for an STECF request to propose alternatives was held in May 2017. This follows on from proposals by the NWWAC.

Fishermen off North Devon have a voluntary seasonal closed area over what they consider to be a nursery ground.

There are several French measures designed to regulate fishing for *R. undulata* in the English Channel (7.d and 7.e). These measures include: trip limits, closed seasons, restricted licencing of vessels and in 2017 a minimum size of 78 cm (described in Gadenne, 2017, WD).

18.3 Catch data

A data-call in 2017 again followed the procedures recommended by WKSHARKS2 (ICES, 2016). This meeting had recommended that recent landings of all elasmobranch species be resubmitted by all ICES members. These landings would be re-evaluated, and declared landings from unlikely locations or species be reassessed or reassigned as required. Decision trees on how to treat problematic records were provided in the workshop report. An ICES data call was issued following this meeting requesting all elasmobranch landings from 2005–2015. The 2017 data call requested a resubmission of final 2015 and preliminary 2016 landings data.

These data were examined by WGEF prior to and during WGEF 2016. Tables 18.1 and 18.2 provides the re-assessed landings by stock for this ecoregion. Some data were re-submitted in 2017, therefore there may be slight differences in landings figures between this and previous reports.

The 2018 data call followed the procedures above.

18.3.1 Landings

Landings data for skates (Rajidae) were supplied by all nations fishing in shelf waters within this ecoregion. Data for 2017 are considered provisional.

Landings by nation are given in Table 18.1. Landings for the entire time-series are shown in Figure 18.1a–c. Where species-specific landings have been provided they have also been included in the total for the relevant year. Although historically there have been around 15 nations involved in the skate fisheries in this ecoregion, only five (France, Great Britain, Belgium, Ireland, and Spain) have continually landed large quantities.

Landings are highly variable, with lows of approximately 14 000 t in the mid-1970s and 1990s, and highs of just over 20 000 t in the early and late 1980s and late 1990s. Although landings have fluctuated over most of the time-series, there has been a steady decline in landings since 2000, at least partly due to the introduction of catch limits. Annual reported landings have been less than 10 000 t since 2009 (noting that the TAC was established in 2009).

West of Scotland (Division 6.a)

Average landings in the early 1990s were about 3000 t. Landings have been less than 500 t since 2009, and have remained at a steady low level of between 350–500 t for the last eight years.

Rockall (Division 6.b)

Reported landings from Rockall in the 1990s were about 500 t per year, but have been generally under 200 t since 2009, and less than 100 t in recent years. The increased landings in the mid-1990s were a result of new landings of 300–400 t per year by Spanish vessels. These no longer appear to take place since only limited Spanish landings have been reported in this area in recent years. It is not clear what proportion of these catches may have been taken from Hatton Bank (6.b.1 and 12.b). One to three Russian longliners fished in this area in 2008–2009, mainly catching deep-water species, including sharks, but also catching 7 t of deep-water skate species.

Irish Sea (Division 7.a)

Reported landings in the Irish Sea vary considerably, and ranged from over 1500 t in 1995 to ca. 5000 t in the late 1980s. Since 2006, annual landings have been < 2000 t, and are now at their lowest level, with just 400 t reported in 2016 and 328 t in 2017. This may be as a result of reduced fishing effort and effort changes because of the cod recovery programme in the area, where whitefish boats have switched to *Nephrops* fishing, with the latter thought to have a lower skate bycatch. Most landings are from Ireland, Great Britain and Belgium.

Bristol Channel (Division 7.f)

Following an increase in reported landings in the mid-1970s, skate landings in Division 7.f have been under 1300 t over the last decade. Landings are predominantly from three countries (Great Britain, France and Belgium) and have been under 1000 t for the last four years (2014–2017).

Western English Channel, Celtic Sea and west of Ireland (divisions 7.b–c, 7.e and 7.g–k)

Annual reported landings from divisions 7.b–c, 7.e and 7.g–k were in the general range of 500–1200 t from 1973–1995. Landings then increased during the period 1996–2003, with some annual landings of approximately 4000 t, however the level of misreporting in this period is unknown. Landings declined after 2010 to less than 1000 t per year, with the last five years' landings of between 700 to just over 1000 t (in 2015) which is of a comparable magnitude to earlier landings.

Overall landings are consistently higher in the southern parts of this ecoregion (divisions 7.e and 7.g–h), and these have reduced from ca. 8000 t per year (from 1973–2000) to between 4-5000 t over the last seven years. France, Great Britain, Ireland and Belgium are responsible for most landings in this area.

18.3.2 Skate landing categories

Historically, most skate landings were reported under a generic landing category. There has been a legal requirement to report most skate landings to species level throughout this ecoregion since 2010. On average, 99% of the 2017 landings were reported to species level, with a continuous decline in landings declared in generic categories since 2011. Earlier reports have highlighted various issues regarding the quality of these data (ICES, 2010, 2011, 2012), and this is further discussed in Section 18.4.3.

A study by Silva *et al.* (2012) examined the species-specific data recorded by the UK (England and Wales). Although there were some erroneous or potentially erroneous records, the regional species composition was broadly comparable to that recorded by scientific observers on commercial vessels, and data quality seemed to be improving. Comparable studies to critically evaluate other national data and identify potential errors are still required, so as to better identify where improved training and/or market sampling may improve data quality.

18.3.3 Discards

WKSHARKS3 met in Nantes in February 2017 (ICES, 2017). The objective of the meeting was to examine national discard data and to assess their suitability for use by WGEF.

It was decided that combining national data together to estimate international discards is not suitable. However, if discard data are first raised at national level, it may be possible to combine estimates. However, there are differences in raising methodologies e.g. by fleet, metier, etc., and these must be fully reported and accounted for.

For elasmobranchs, discards are not equivalent to dead catch, as there is some survival, which is probably high for some stocks and fleets. However, survival rate is not accurately known for most species.

Discard data for WGEF were included in the 2018 data. Most countries provided raised discards. Raising methodology was considerably different, both between countries and within countries. Raised discard estimates varied by over 200% in some cases, depending on whether they were raised by vessel, fleet or landings. Therefore discard estimates have not been calculated for skates and rays in this ecoregion.

See Stock Annex for historic discard discussions.

18.3.4 Discard survival

See Stock Annex.

18.3.5 Quality of catch data

See Stock Annex.

18.4 Commercial catch composition

18.4.1 Size composition

Although length data were not examined this year, length frequencies for the more common species have been shown in earlier studies (ICES, 2007, 2011; Johnston and Clarke, 2011 WD; Silva *et al.*, 2012).

The use of length-based indicators to calculate proxy reference point is further discussed in Section 26.

18.4.2 Quality of data

See Stock Annex.

18.5 Commercial catch and effort data

A case study using French on-board observer data is provided in the stock annex. Several stocks are discussed. The trend for *L. fullonica* is used as supporting information in the advice, therefore it is retained here. For all others, refer to the stock annex

Shagreen ray: *Leucoraja fullonica*

rjf.27.67 (Figure 18.2): The species was caught in a relatively high proportion of OTT_DEF. The indicator suggested stability.

18.6 Fishery-independent surveys

Groundfish surveys provide valuable information on the spatial and temporal patterns in the species composition, size composition, sex ratio and relative abundance of various demersal elasmobranchs. Several fishery-independent surveys operate in the Celtic Seas ecoregion. It is noted that these surveys were not designed primarily to inform on the populations of demersal elasmobranchs, and so the gears used, timing of the surveys and distribution of sampling stations may not be optimal for informing on some species and/or life-history stages. However, these surveys provide the longest time-series of species-specific information for skates for many parts of the ecoregion. The distribution of selected skate species caught in surveys coordinated by the IBTS group (see Table 18.4 in the Stock Annex), are shown in the annual IBTS reports.

Descriptions of existing, previous and short-time-series surveys are provided in the Stock Annex.

Updated survey analyses were provided for five surveys in 2018: French EVHOE Groundfish Survey (EVHOE-WIBTS-Q4; Figure 18.3), Irish groundfish survey (IGFS-

WIBTS-Q4; Table 18.3; Figure 18.4), Spanish Porcupine Groundfish Survey (SpPGFS-WIBTS-Q4; Figure 18.5), the UK (England) beam trawl survey (EngW-BTS-Q3; Figure 18.6) and the UK (England) Q1 Southwest ecosystem beam trawl survey (Q1SWBeam; Figure 18.7

Interpretation, data, analyses and expertise from other surveys, in particular the Scottish and Northern Irish Groundfish surveys, which could usefully provide indices for some stocks, were absent, and therefore such data could not be used in the formulation of indices and advice in 2018. Their participation in future years would be valuable.

The list of fishery-independent surveys undertaken in this area include (with additional details and information on the history provided in the Stock Annex):

- French EVHOE Groundfish Survey (EVHOE-WIBTS-Q4): 1995–present in Celtic Sea.
- Irish Groundfish Survey (IGFS-WIBTS-Q4): 2003–present.
- Spanish Porcupine Groundfish Survey (SpPGFS-WIBTS-Q4): 2001–present.
- UK (Northern Ireland) Groundfish Survey – October (NIGFS-WIBTS-Q4): 1992–present.
- UK (Northern Ireland) Groundfish Survey – March (NIGFS-WIBTS-Q1).
- Scottish West Coast Groundfish Survey Q4 (ScoGFS-WIBTS-Q4): 1990–present.
- Rockall survey (Rock-IBTS-Q3): 1991–present.

Three beam trawl surveys currently operate in this ecoregion (see Stock Annex), surveying the Irish Sea, Bristol Channel, western English Channel and the West of Ireland (additional details and information on the history are provided in the Stock Annex):

- UK (England and Wales) Irish Sea and Bristol Channel beam trawl survey (EngW-BTS-Q3): 1993–present.
- UK (England) beam trawl in western English Channel (Q1SWBeam): 2006–present.
- Irish monkfish beam trawl survey – IRL-IAMS surveys: 2016 onwards. This beam trawl survey for monkfish and megrim takes place in Q1 and Q2, to the west and northwest of Ireland. Elasmobranchs are caught during this survey, and in future may provide additional indices once a suitable time series is available.

Historical surveys which have been undertaken in the area and can provide past data on elasmobranchs include (with additional details and information on the history provided in the Stock Annex):

- UK (England and Wales) Western Groundfish Survey (EngW-WIBTS-Q4) 2004–2011.
- UK (England) beam trawl in Start Bay, Division 7.e (Eng-WEC-BTS-Q4): 1989–2010.
- Irish maturity survey for commercially important demersal fish (spring 2004–2009).
- Irish deep-water (500–1800 m) trawl survey to the west of Ireland (2006–2009)
- UK Portuguese high headline trawl 1Q (PHHT-Q1): 1982–2003.

18.6.1 Temporal trends in catch rates

The statuses of skates in this ecoregion are based primarily on the evaluation of fishery-independent trawl surveys. The available survey data have been used to evaluate the status of the stocks in 2018 under the ICES approach to data-limited stocks (Section 18.9).

Analyses of length-based data showing temporal trends from the EVHOE survey were shown for several species in 2015 (ICES, 2015).

18.6.2 Quality of data

18.6.2.1 Species identification in surveys

There are identification problems with certain skate species that may increase uncertainty in the quality of survey data. *Raja montagui* and *R. brachyura* may be confounded occasionally, and the identification of neonatal specimens of *R. clavata*, *R. brachyura* and *R. montagui* can also be problematic. Recent data are considered more reliable.

Many recent surveys in the ecoregion have attempted to ensure that data collected for the common skate complex be differentiated, and whereas national delegates have confirmed which species have been caught, survey data can only be uploaded to DATRAS for the complex, as the two species do not have valid taxonomic codes as yet. Work to clarify the taxonomic problems was discussed intersessionally and will hopefully be resolved by the ICZN soon.

Several skate species, including some coastal species, occur sporadically in the Celtic Seas ecoregion and may have certain sites where they are locally abundant (e.g. *Raja*.). These may be under-represented in existing surveys (see Stock Annex).

18.6.3 New data

A project is currently taking place in the Tralee Bay area in the South-west of Ireland. The project is to provide data on the species composition, relative abundance and distribution of Skates and Rays for an area off the Irish coast (Dingle Bay, Tralee Bay, Brandon Bay, Shannon Estuary) known to harbour a high diversity of species some of which are critically endangered. Synoptic seasonal surveys using catch and release methods combined with individual identification of fish from photographic records will provide information on movement of these species in this area. There are a number of fisheries in the locality which may impact negatively on these populations. Vessels involved in the tangle net fishery for spiny lobster in particular have a significant by-catch of elasmobranchs. The project is also obtaining data and photographic records of elasmobranch by-catch in this fishery. Some by-catch is released alive where net soak times are low. Mitigation measures such as seasonal or spatial closures or operational measures to reduce soak times to reduce the mortality of elasmobranchs in bottom trawl and net fisheries may be developed from the project. Data for these stocks should be available for the next assessments.

18.7 Life-history information

See Stock Annex.

18.7.1 Ecologically important habitats

See Stock Annex.

18.8 Exploratory assessment models

18.8.1 Productivity-Susceptibility Analysis

See Stock Annex

18.8.2 Previous assessments

See Stock Annex

18.9 Stock assessment

ICES provided stock-specific advice in 2016 for 2017 and 2018. The assessments outlined below have been updated using the most recent data. Most stocks belong to Category 3 of the ICES approach to data-limited stocks. Advice is generally therefore based on survey indices. Following decisions made at ADGEF, biomass is now presented instead of numbers of individuals. Therefore results and figures may differ from previous reports.

18.9.1 Blonde ray *Raja brachyura* in Subarea 6 and Division 4.a

Raja brachyura has a patchy distribution in Subarea 6. It is not encountered in sufficient numbers in surveys to derive trends in abundance/biomass. The stock is considered to extend to the northwestern North Sea (Division 4.a). It may also extend along the west coast of Ireland. This Subarea 6 and Division 4.a stock is assessed in North Sea biennial advice years (2015 and 2017), and was last assessed as a Category 5 stock, using landings data only.

18.9.2 Blonde ray *Raja brachyura* in Divisions 7.a and 7.f-g

Raja brachyura has a patchy distribution, and can be locally abundant in some parts of the Irish Sea and Bristol Channel, including off southeast Ireland. Mean catch rates in the Irish Sea and Bristol Channel (e.g. as observed in the UK beam trawl survey) are low and variable. While there was a decrease in abundance in 2015, the stock has been showing an overall increasing trend in the survey. However, it is important to note that this survey does not sample this species effectively, and the survey is not used to provide advice for the stock.

With no reliable survey trend for this stock, it has been assessed since 2016 as a Category 5 stock using landings data. Landings data have been stable at 1000–1200 t since 2011.

18.9.3 Blonde ray *Raja brachyura* in Division 7.e

Raja brachyura has a patchy distribution in the western English Channel, and is locally abundant on certain grounds, such as sandbank habitats in and around the Channel Islands, Normano-Breton Gulf and Lyme Bay. The length–frequency data examined for this stock showed a peak for juvenile fish (< 25 cm L_T), with no fish recorded between 24–31 cm L_T and occasional records of larger specimens > 70 cm L_T.

Mean catch rates in a previous beam trawl survey in Great West Bay (Burt *et al.*, 2013) were low, as *R. brachyura* was caught in a relatively low proportion of tows (See Stock Annex).

With no reliable survey trend for this stock, it has been assessed since 2016 as a Category 5 stock using landings data. These reached a peak in 2015 (708 t) but have since returned to average levels of around 500 t per year.

18.9.4 Thornback ray *Raja clavata* in Subarea 6

Earlier analyses of the Scottish surveys in Division 6.a suggested stable/increasing catch trends (1985–2010) although updated analyses were not available.

The IGFS survey shows a recent increase in abundance, following a decline two years ago. The location of hauls and associated catch rates are shown in Figure 18.4b and Figure 18.4a, respectively. This index is used in a Category 3 assessment.

18.9.5 Thornback ray *Raja clavata* in Divisions 7.a and 7.f-g

The French EVHOE survey indicated fluctuating catch rates at low levels in the Celtic Sea (Figure 18.3d). Nevertheless, it should also be noted that this survey tends to sample offshore grounds, whereas *R. clavata* is a more inshore species.

The UK (England and Wales) beam trawl survey in divisions 7.a and 7.f catches reasonable numbers of *R. clavata* and they are observed regularly, although the gear used (4 m beam trawl with chain mat) may have a lower catchability for larger individuals. The survey shows a continuous increasing trend in biomass (Figure 18.6).

The latter survey (EngW-BTS-Q3) is used for the Category 3 assessment, as this survey covers the main part of the stock range.

18.9.6 Thornback ray *Raja clavata* in Division 7.e

Analyses of data from a discontinued beam trawl survey in the western English Channel (particularly in the Great West Bay area) was provided in 2012, which suggest stable catch rates. A similar pattern of catches is seen in the current UK beam trawl survey of the western English Channel, with most *R. clavata* captured in Lyme Bay with fewer records elsewhere (Figure 18.7). Length–frequency showed a peak in the captures of presumably 0-group fish ≤ 20 cm. This survey provided an abundance index in 2018.This stock is currently assessed as a Category 3 stock, using a biomass index from Q1SWBeam survey. In index showed a decrease in abundance (numbers and biomass) in the last two years following a four-year period of the highest catch rates in the time series. Landings increased steadily since 2009, peaking at 423 t in 2017, decreasing to 371 t in 2018.

18.9.7 Small-eyed ray *Raja microocellata* in the Bristol Channel (Divisions 7.f-g)

Although occasional specimens of *R. microocellata* are caught in Division 7.a, the main concentration of this species is in Division 7.f, with larger individuals occurring slightly further offshore (Division 7.g). The youngest size class is not often taken in surveys, as 0-group fish tend to occur in very shallow water. This species may also occur in some inshore areas of southern and southwestern Ireland, although data are limited for these areas.

The UK (England and Wales) beam trawl survey in the Bristol Channel has previously indicated stable catch rates, but low catch rates (*ca.* 1 individual per hour) were seen in 2013 (Figure 18.6). Survey catches since then have continued to increase. This survey trend is used in the Category 3 assessment for this stock.

18.9.8 Small-eyed ray *Raja microocellata* in the English Channel (Divisions 7.d-e)

There are also localized concentrations of *R. microocellata* in the English Channel, including around the Channel Islands (Ellis *et al.*, 2011) and Baie of Dournanenz, Brittany (Rousset, 1990), with small numbers taken elsewhere.

Preliminary analyses of data from beam trawl surveys in the western English Channel (particularly in the Great West Bay area) were provided in 2012 (See Stock Annex). The low catch rates are probably related to the patchy distribution of the species in this area. Similarly, Silva *et al.* (2014 WD) identified only a few records of this species in the western English Channel beam trawl survey, with smaller size groups likely to occur in waters shallower than can be surveyed by the research vessel.

With no adequate survey trends available, this stock is assessed under Category 5.

18.9.9 Spotted ray *Raja montagui* in Subarea 6 and Divisions 7.b and 7.j

Raja montagui is a widespread and small-bodied skate and is taken in reasonable numbers in a variety of surveys in the ecoregion. Earlier analyses of the Scottish surveys of 6.a suggested stable/increasing catch trends, although updated analyses are not available.

Catches of *Raja montagui* in the Irish Groundfish survey in Subarea 6 and divisions 7.b and 7.j are increasing overall, with a large increase in biomass in 2016, although this declined again in 2017. (Figure 18.4b). This survey trend is used in the Category 3 assessment.

18.9.10 Spotted ray *Raja montagui* in Divisions 7.a and 7.e-g

Both the IGFS (Figure 18.4c) and the UK beam trawl survey (Figure 18.6) in this stock region show increasing catch rates of this species. Both surveys catch *R. montagui* in reasonable numbers, with mature individuals taken offshore on coarse grounds.

The UK beam trawl survery is currently used to provide the index for the Category 3 assessment, with an increasing trend across the time series

Data from a now-discontinued beam trawl survey in the western English Channel (particularly in the Great West Bay area) were provided in 2012 which suggested that recent catches had increased in relation to the preceding five years, although catch rates were greater at the start of the time-series. A concurrent beam trawl survey of the western English Channel found this species to be more common in the English inshore strata, from Lyme Bay to west of the Scilly Isles, with a peak in the length distribution for smaller individuals < 22 cm L_T.

18.9.11 Cuckoo ray *Leucoraja naevus* in Subareas 6 and 7 and Divisions 8.a-b and 8.d

Leucoraja naevus is a widespread and small-bodied skate that is taken in reasonable numbers in a variety of surveys in the ecoregion, especially on offshore grounds. The stock structure of this species is insufficiently known, which makes the interpretation of catch rates in the various surveys more problematic.

The French EVHOE survey showed peaks in relative abundance in 2001–2002 and 2007–2008, with the lowest catches in 2000. The relative abundance in the combined Celtic Sea/Biscay region has been increasing in recent years. However, this survey did not take place in 2017 (Figure 18.3c).

The Spanish survey on the Porcupine Bank indicated a recent slight increase in catches (both in terms of biomass and abundance), although this was from the lowest levels in the time series in 2013 (Figure 18.5b). This survey catches mostly larger fish, with specimens < 30 cm L_T sampled infrequently (Figure 18.5c).

The UK (England and Wales) beam trawl survey in Division 7.a catches small numbers of *L. naevus,* mostly on the offshore stations on coarse grounds. The time series fluctuates, although it is currently showing an increase in recent years (Figure 18.6).

The Irish Groundfish Survey mainly catches *L. naevus* in offshore areas (Figure 18.4a). There are annual variations in abundance. In general, biomass trends are similar to those seen in the EVHOE survey, however in 2015, there was a conflicting signal with the EVHOE survey (Figure 18.3d).

The combined index used in this Category 3 assessment, uses the French EVHOE survey and the Irish Groundfish Survey, and indicates that the stock continues to increase following low stock levels in 2012–2013.

18.9.12 Sandy ray *Leucoraja circularis* in the Celtic Seas and adjacent areas

Leucoraja circularis is a larger-bodied, offshore species that may be distributed outside some of the areas surveyed during internationally coordinated surveys, and the distribution of what is assumed to be a Celtic Sea stock will extend into the northern North Sea (Division 4.a) and parts of the Bay of Biscay (Subarea 8). This species is taken only infrequently in most surveys, such as the EVHOE survey (Figure 18.3a) with some nominal records considered unreliable.

Only the Spanish Porcupine Bank survey covers an important part of the habitat of *L. circularis* and catches this species in any quantity (Figure 18.5a). Peak catches were observed in 2007–2008, with a decline following, but catches steadily increased returning to the higher levels observed in this time series, until 2016–2017 when the biomass decreased. Overall, the time-series shows low and variable catch rates, with an increasing trend until 2015, followed by a decrease in recent years (Figure 18.8b). This survey catches a broad size range, with both smaller (< 20 cm L_T) and some larger (> 100 cm L_T) specimens sampled (Figure 18.8c).

Given that the only survey that samples this species effectively only covers a small proportion of the broader stock range, it is not known whether the survey index would be appropriate for the overall stock. Consequently, this stock is assessed as a Category 5 stock, using landings data. Landings of this species were at their highest level in 2009, at near 80 t, but subsequently dropped to around 50–60 t. Landings dropped to their lowest level (38 t in 2015), then increased to 77 t in 2016, before retuning to ca. 60 t in 2017. ICES were not requested to provide catch advice for this stock in 2018.

The landings estimated by WGEF are lower than national estimates, as WGEF consider nominal landings of 'sandy ray' from outside their main range to refer to *R. microocellata.*

18.9.13 Shagreen ray *L. fullonica* in the Celtic Seas and adjacent areas

Leucoraja fullonica is a larger-bodied, offshore species that may be distributed outside some of the areas surveyed during internationally coordinated surveys, and the distribution of what is assumed to be a Celtic Sea stock will extend into the northern North Sea (Division 4.a) and parts of the Bay of Biscay (Subarea 8).

This species is taken in small numbers in the EVHOE survey (Figure 18.3b), with catch rates declining. There is a lack of survey for most other parts of the stock area, although the increase in beam trawl surveys in the Celtic Sea may provide more data in the future.

The lack of appropriate survey coverage across the stock range and low, variable catch rates of this species, means that a Category 5 assessment using landings data is currently used. Landings in 2016 were at their lowest level (186 t) since 2009, with the peak (301 t) seen in 2010 subsequently declining.

18.9.14 Common skate *Dipturus batis*-complex (flapper skate *Dipturus batis* and blue skate *Dipturus* cf. *intermedia*) in Subarea 6 and divisions 7.a–c and 7.e–j

Although common skate *D. batis* has long been considered depleted, on the basis of its loss from former habitat and historical decline (Brander, 1981; Rogers and Ellis, 2000), this species has recently been confirmed to comprise two species, and longer term data to determine the extents to which the two individual species have declined are lacking. Although the nomenclature is still to be ratified, the smaller species (the form described as *D. flossada* by Iglésias *et al.*, 2010) will probably remain as *Dipturus batis* and the larger species may revert to *D. intermedia.*

Blue skate *Dipturus batis* occurs in parts of Division 6.b (Rockall Bank) and is the predominant member of the complex in the Celtic Sea (Divisions 7.e–k) and it likely extends into Subarea 8. The northern limits to its distribution are unclear.

Flapper skate *D.* cf. *intermedia* occurs primarily in Division 6.a, parts of Division 6.b, and the northern North Sea (Division 4.a). Smaller numbers are taken in the Celtic Sea (divisions 7.e–k), although it's southerly and northerly limits are unknown.

Both species may occur in the intervening areas of divisions 7.a–c, but it is less clear as to which species predominates. The bathymeric ranges of both species are poorly known, as is their western distribution ranges, although unspecified *D. batis* have been reported from the Mid-Atlantic Ridge.

Given that much of the data refer to the species-complex, both species are currently treated together until a suitable time-series of species-specific data are available.

The documented loss of the common skate (*Dipturus batis*) complex from parts of ther former range (e.g. Division 7.a) suggested the complex to be depleted in the Celtic Sea ecoregion.

Analyses of recent data from the Spanish Porcupine Bank Survey indicate low but increasing catch rates for *Dipturus* spp., with the biomass and numbers encountered at their highest level (*ca.* 0.5 individuals and 5 kg per haul) across the time series (Figure 18.8f). The bulk of this catch is comprised of *D. nidarosiensis*, followed by *D. batis* and very few specimens of *D.* cf. *intermedia* encountered (which only entered the survey time series in 2013 for the first time).

A previous examination of Scottish groundfish survey data (see ICES, 2010b; 2011) indicated some increase in the proportion of hauls in which *D. batis*-complex were observed (Figure 18.10), although it should be recognized that catch rates were low and with wide confidence intervals. Updated analyses are required.

Given the lack of robust survey data over the stock range, and lack of landings data (due to their prohibited status), a Category 6 assessment was applied to this stock, and trends in stock size or indicator cannot be evaluated.

Recent prohibitions on landings of *D. batis* complex, and *D. nidarosiensis*, have resulted in increases in declared landings of *D. oxyrinchus*. Landings figures and advice refer to *Dipturus* spp, as landings of these species are believed to be confounded.

18.9.15 Undulate ray *Raja undulata* in divisions 7.b and 7.j

This isolated stock has a very local distribution, mainly in Tralee Bay on the Southwest Irish coast.

There are no trawl surveys that can be used to assess this stock. However, data supplied by Inland Fisheries Ireland (Wögerbauer *et al.*, 2014 WD) shows that tag and recapture rates for *R. undulata* in Tralee Bay (Division 7.j) have significantly declined since the 1970s. Although these data do not allow for potential changes in tagging effort, it suggests that this stock is overexploited (Figure 18.8).

Given the lack of survey data over the coastal habitat for this stocks, and a lack of landings data (due to management measures), a Category 6 assessment was applied to this stock, and trends in stock size or indicator cannot be evaluated.

18.9.16 Undulate ray *Raja undulata* in Divisions 7.d-e (English Channel)

There is thought to be a discrete stock of *R. undulata* in the English Channel (divisions 7.d–e), with the main part of the range extending from the Isle of Wight to the Normano-Breton Gulf. This stock is surveyed, in part, by two different beam trawl surveys: the Channel beam trawl survey (see Chapter 15) and the western English Channel (Eng-WEC-BTS-Q1), as well as the French Channel Groundfish survey (see Chapter 15). The distribution and length ranges of *R. undulata* caught in the western English Channel survey are provided in the Stock Annex. Catch rates are generally variable, partly due to the patchy distribution of this species.

Since ICES (2013) commented "*If ICES are to be able to provide more robust advice on the status of this stock, then either dedicated surveys or more intensive sampling of their main habitat in existing surveys should be considered*" there has been a lot of dedicated surveys by French organisations under the Raimouest and RECOAM projects.

LeBlanc *et al.* (2014 WD) summarized the project so far, and showed that *R. undulata* was the main skate species caught in the Norman-Breton Gulf and dominated in coastal waters. Although it occurs throughout much of the English Channel, its distribution appears to be concentrated in the central region. Tagging studies indicate high site fidelity (Stéphan *et al.*, 2014 WD; see Stock Annex). In the Normano-Breton Gulf, 1 488 *R. undulata* were tagged (656 females (29–103 cm L_T) and 832 males (28–99 cm L_T), with a 5% (n = 77) recapture rate. All the skates tagged in a region were recaptured in the same region, and distance travelled was short (< 80 km). Given that the prohibited listing of the species may have deterred reporting of tags in some fisheries, the degree of exchange between the Normano-Breton Gulf and the south coast of England remains unclear. In Division 7.e, 58.4% of the recaptured skates were taken less than 5 km from their release location, and 75.3% were recaptured less than 20 km from the release location. The survey with the best coverage of this stock area is the French Channel Groundfish Survey, where the biomass indicator used in the Category 3 assessment shows the stock to be at the highest level of the time series, after a period of low and variable trends between 1988–2010, and a steep increase thereafter.

French *Raja undulata* self-sampling program

In 2016, Council Regulation (EU) 2016/458 of 30 March 2016 amended Regulations (EU) 2015/523 as regards individual TACs for *R. undulata* in ICES divisions.

Under this regulation, only vessels possessing a compulsory fishery license were allowed to catch *R. undulata*. Simultaneously, licensed vessels are obliged to record information on species captured by fishing haul and report to national agencies

(Direction des Pêches Maritimes et de lAquaculture (DPMA) of the French Ministry for Agriculture and Fisheries).

First results from this self-sampling programme are described in more detail in the Working Document (Gadenne, 2017 WD) and in Section 27.

Whilst the catch rates in the UK-7d-BTS are too low to provide quantative advice, this time series shows similar trends to the French CGFS, including the recent increase in catch rates.

In 2018, France made a special request to ICES to re-evaluate the advice for this stock. In particular, further industry-provided data were made available. This special request is further discussed in Annex 8 of this report. WGEF recommends that a benchmark process be undertaken to develop a protocol for incorporating discard data, particularly from industry programmes, into the elasmobranch stock assessments.

18.9.17 Other skates in subareas 6 and 7 (excluding Division 7.d)

This section relates to skates not specified elsewhere in the ICES advice. This includes skates not reported to species level and some other, mainly deep-water species throughout the region. It also applies to *R. clavata, R. brachyura,* and *R. microcellata* outside the current defined stock boundaries.

No specific assessment can be applied to this species group, and nominal landings have been shown to have declined dramatically, primarily as a result of improved species-specific reporting of the main commercial skate stocks.

18.10 Quality of assessments

Commercial data are insufficient to proceed using a full stock assessment, although data are improving.

Several updated analyses of temporal changes in relative abundance in fishery-independent surveys were carried out in 2018. These surveys provide the most comprehensive time-series of species-specific information, and cover large parts of the ecoregion. Hence, fishery-independent trawl data are considered the most appropriate data for evaluating the general status of the more common species.

However, it must be stressed that not all skates and rays are well sampled by these surveys, and even some of the most common species (*R. montagui* and *R. clavata*) may only occur in about 30% of hauls. There is also uncertainty regarding the mean catch rates, due to the large confidence intervals.

There are several other issues that influence the evaluation of stock status:

1) The stock identity for many species is not accurately known (although there have been some tagging studies and genetic studies to inform on some species, and the stocks of species with patchy distributions can be inferred from the spatial distributions observed from surveys). For inshore, oviparous species, assessments by ICES division or adjacent divisions may be appropriate, although for species occurring offshore, including *L. naevus*, a better delineation of stock boundaries is required;

2) Age and growth studies have only been undertaken for the more common skate species, although IBTS and beam trawl surveys continue to collect maturity information. Other aspects of their biology, including reproductive output, egg-case hatching success, and natural mortality (including predation on egg-cases) are poorly known;

3) The identification of skate species is considered to be reliable for recent surveys, although there are suspected to be occasional misidentifications;

4) Although fishery-independent surveys are informative for commonly occurring species on the inner continental shelf, these surveys are not well suited for species with localized, coastal distributions (e.g. *R. undulata*, angel shark), patchy distributions (e.g. *R. brachyura*) or outer shelf distributions (e.g. *L. fullonica*).

18.11 Reference points

No reference points have been adopted. Potential methods for establishing precautionary reference points from using the catch-curve method are described in the Stock Annex.

The use of length-based indicators (LBIs) to calculate proxy reference points was discussed, and is further elaborated in Section 26. LBIs for several stocks were estimated by Walker *et al*., 2018WD and Miethe and Dobby, 2018WD.

18.12 Conservation considerations

In 2015, the IUCN published a European Red List of Marine Fisheries (Nieto *et al*., 2015). It should be noted the listings below are on a Europe-wide scale for each species, and these listings are not stock-based.

Species	**IUCN Red List Category**
Amblyraja radiata	Least concern
Dipturus batis	Critically Endangered
Dipturus nidarosiensis	Near Threatened
Dipturus oxyrinchus	Near Threatened
Leucoraja circularis	Endangered
Leucoraja fullonica	Vulnerable
Leucoraja naevus	Least concern
Raja brachyura	Near Threatened
Raja clavata	Near Threatened
Raja microocellata	Near Threatened
Raja montagui	Least concern
Raja undulata	Near Threatened
Rajella fyllae	Least concern
Rostroraja alba	Critically Endangered

In 2016, a redlist for Irish cartilaginous fish (Clarke *et al.* 2016) was published. This assessed and rated the the following species in Irish waters:

Species	**Irish red-list category**
Dipturus flossada (~batis)	Critically endangered
Dipturus intermedia)~batis)	Critically endangered
Dipturus nidarosiensis	Near Threatened
Dipturus oxyrinchus	Vulnerable
Leucoraja circularis	Near Threatened
Leucoraja fullonica	Vulnerable
Leucoraja naevus	Vulnerable
Raja brachyura	Near Threatened
Raja clavata	Least concern
Raja microocellata	Least concern
Raja montagui	Least concern
Raja undulata	Endangered
Rajella fyllae	Least concern
Rostroaja alba	Critically endangered

18.13 Management considerations

A TAC was only introduced in 2009 for the main skate species in this region. Reported landings may be slightly lower than the TAC, but this can be influenced by various issues (e.g. quota allocation and poor weather). There was evidence that quota was restrictive for some nations from at least 2014.

Raja undulata and *R. microocellata* are currently subjected to limited fishing opportunities, which may disproportionally impact upon some coastal fisheries.

Currently, fishery-independent trawl survey data provide the best time-series of species-specific information. Technical interactions for fisheries in this ecoregion are shown in the Stock Annex.

Main commercial species

Thornback ray, *Raja clavata,* is one of the most important commercial species in the inshore fishing grounds of the Celtic Seas (e.g. eastern Irish Sea, Bristol Channel). It is thought to have been more abundant in the past, and more accurate longer term assessments of the status of this species are required.

Blonde ray, *Raja brachyuran,* is a commercially valuable species. The patchy distribution of *R. brachyura* means that existing surveys have low and variable catch rates. More detailed investigations of this commercially valuable species are required.

Cuckoo ray, *Leucoraja naevus,* is an important commercial species on offshore grounds in the Celtic Sea. Further studies to better define the stock structure are required to better interpret these contrasting abundance trends.

The main stock of small-eyed ray, *Raja microocellata,* occurs in the Bristol Channel, and is locally important for coastal fisheries. Similarly, the English Channel stock of undulate ray *Raja undulata* is also important for inshore fleets.

Spotted ray, *Raja montagui,* is also commercially important, although a higher proportion of the catch of this small-bodied species is discarded in some fisheries. Commercial data for *R. brachyura* and *R. montagui* are often confounded.

Other species

Historically, species such as *L. circularis* and *L. fullonica* may have been more widely distributed on the outer continental shelf seas. These species are now encountered only infrequently in some surveys on the continental shelf, though they are still present in deeper waters along the edge of the continental shelf, and on offshore banks. Hence studies to better examine the current status of these species in subareas 6–7 should be undertaken.

The larger-bodied species in this area are from the genus *Dipturus*, and data are limited for all species. *Dipturus batis*-complex were known to be more widespread in inner shelf seas historically, and whilst locally abundant in certain areas, have undergone a decline in geographical extent.

18.14 References

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Table 18.1. Skates and rays in the Celtic Seas. Regional total landings (ICES estimates, t) of Celtic Seas skate stocks by nation. Some of these stocks extend outside the Celtic Seas ecoregion and data for these divisions are reported in relevant report chapters.

Country	ICESStockCode	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
BEL	raj.27.67a-ce-k	1568	1328	1405	413	416	333	227	74	8	1	1	3	3
	rjb.27.67a-ce-k				0	0	0			0	0			
	rjc.27.7afg			0	328	216	197	302	441	391	240	350	241	212
	rjc.27.7e				5	2	8	3	4	4	3	9	14	21
	rje.27.7de						3	5	5	7	7	9	9	11
	rje.27.7fg						37	117	124	99	83	106	123	116
	rjh.27.4a6					0	0							
	rjh.27.7afg				166	170	210	313	404	406	351	359	313	338
	rjh.27.7e				7	6	3	5	5	6	3	6	11	9
	rji.27.67							0	0	0	0	0	0	2
	rjm.27.67bj						0							
	rjm.27.7ae-h				78	63	55	120	70	3	0	1	7	2
	rjn.27.678abd			0	86	81	70	112	93	97	48	51	27	26
	rju.27.7de												5	24
BEL Total		1568	1328	1405	1083	953	917	1204	1219	1022	737	893	753	762
DE	raj.27.67a-ce-k	39	7	26	60	2	4	3	1					
DE Total		39	7	26	60	2	4	3	1					
DK	rjh.27.4a6											0		
DK Total												0		
ES	raj.27.67a-ce-k	2231	2568	2340	1946	210	52	24	20	32	92	45	61	134
	rjb.27.67a-ce-k	24	6	11	26	0	0	0				448	375	300

Country	ICESStockCode	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	rjc.27.6					16	2	10	6	23	21	12	12	50
	rjc.27.7afg											5	6	9
	rjc.27.7e						0	0						
	rjf.27.67					62	42	29	20	33	20	34	15	26
	rjh.27.4a6					0								
	rji.27.67	86	74	40	7	30	16	22	8	10	5	3	5	11
	rjm.27.67bj				7	7	10	5	0	0	0	1		
	rjm.27.7ae-h						0				0	0		
	rjn.27.678abd				1	778	480	387	311	373	300	659	688	433
	rju.27.7bj												1	1
ES Total		2341	2648	2392	1986	1103	603	477	365	471	438	1207	1162	963
FRA	raj.27.67a-ce-k	2048	1740	1757	1669	548	314	174	160	139	128	123	130	183
	rjb.27.67a-ce-k	351	295	308	414	68	30	15	23	21	32	33	17	
	rjc.27.6	64	78	73	82	39	24	19	39	28	10	2	1	1
	rjc.27.7afg	379	264	238	181	147	131	133	106	95	107	70	121	147
	rjc.27.7e	95	86	82	64	122	101	114	108	181	224	225	213	176
	rje.27.7de	21	19	19	22	32	28	28	24	26	24	24	8	8
	rje.27.7fg	27	23	18	21	29	21	16	30	30	65	31	5	57
	rjf.27.67	32	25	33	28	144	150	152	147	127	131	151	130	124
	rjh.27.4a6					1					1	1	1	0
	rjh.27.7afg					36	73	131	87	52	170	218	275	257
	rjh.27.7e					56	148	205	169	191	281	304	223	240
	rji.27.67	199	152	185	178	46	35	25	35	26	33	34	37	34
	rjm.27.67bj	13	7	3	4	2	4	7	5	17	53	43	47	40

Country	ICESStockCode	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	rjm.27.7ae-h	1080	902	833	870	785	934	1062	1135	899	912	745	819	661
	rjn.27.678abd	3164	2565	2575	2507	3217	3069	2909	2571	2195	2515	2621	2233	2142
	rju.27.7bj					0				0		0	1	1
	rju.27.7de					19	9	20	6	3	10	50	58	79
FRA Total		7473	6157	6123	6041	5294	5071	5010	4646	4031	4695	4674	4319	4149
GBR	raj.27.67a-ce-k	2773	2454	2398	1478	508	290	168	153	101	77	46	34	30
	rjb.27.67a-ce-k				96	22	1	19	12	1	63	118	116	106
	rjc.27.6				1	56	61	57	67	120	120	114	147	113
	rjc.27.7afg			0	204	300	371	384	483	416	252	309	274	276
	rjc.27.7e	0	0		3	82	98	98	129	151	151	158	195	172
	rje.27.7de				4	18	40	28	33	32	36	39	19	15
	rje.27.7fg			0	91	157	214	189	208	117	79	78	69	31
	rjf.27.67				13	44	108	97	79	85	55	25	39	21
	rjh.27.4a6				7	5	7	17	4	0	1	3	2	1
	rjh.27.7afg		0	0	97	138	226	273	261	262	229	245	245	270
	rjh.27.7e		0		32	159	215	204	175	222	295	396	352	241
	rji.27.67				0	2	0	0	3	25	22	1	35	17
	rjm.27.67bj				5	16	27	32	30	27	29	43	49	44
	rjm.27.7ae-h	0		0	12	38	102	88	85	90	80	70	80	89
	rjn.27.678abd				225	321	421	402	306	269	262	266	254	259
	rju.27.7de				2	2			0			5	22	36
GBR Total		2773	2454	2399	2270	1868	2179	2056	2031	1919	1752	1917	1933	1721
IRL	raj.27.67a-ce-k	2117	1728	1581	1283	1007	547	394	410	243	219	227	230	284
	rjb.27.67a-ce-k			0		2	4	17	1	0	0	9	7	9

Country	ICESStockCode	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	rjc.27.6					3	33	56	69	71	85	87	99	130
	rjc.27.7afg					8	80	126	134	146	191	169	220	232
	rjc.27.7e									0		2		2
	rje.27.7de													2
	rje.27.7fg						0	0	0	0	0	0	0	
	rjf.27.67						1	6	7	6	4	2	2	49
	rjh.27.4a6					0	4	1	1	24	9	9	11	5
	rjh.27.7afg	3	6			5	402	382	407	377	420	351	171	154
	rjh.27.7e								0			2		2
	rji.27.67						0	4	0					
	rjm.27.67bj					1	20	18	25	24	43	28	20	12
	rjm.27.7ae-h					0	19	63	53	40	49	48	41	10
	rjn.27.678abd					12	55	106	108	93	83	79	69	69
IRL Total		2120	1734	1581	1283	1038	1165	1173	1218	1025	1104	1012	871	961
NLD	raj.27.67a-ce-k	0	1	0	0	0	0	0	0	0				
	rjc.27.7afg												0	
	rjc.27.7e					0	2	1	0	2		0	0	0
	rjh.27.7e								0	0				0
	rjm.27.7ae-h					0		0		0			0	
	rjn.27.678abd						0			0	0			0
NLD Total		0	1	0	0	1	2	1	1	2	0	0	0	0
NOR	raj.27.67a-ce-k	50	101	89	77	96	131	62	107	99	157	272	312	153
NOR Total		50	101	89	77	96	131	62	107	99	157	272	312	153
Grand Total		16364	14429	14016	12800	10355	10071	9986	9587	8568	8883	9975	9350	8710

Table 18.2. Skates and rays in the Celtic Seas. Regional total landings (ICES estimates, t) of Celtic Seas skate stocks by stock. Some of these stocks extend outside the Celtic Seas ecoregion and data for these divisions are reported in relevant report chapters.

ICESStockCode	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
raj.27.67a-ce-k	BEL	1568	1328	1405	413	416	333	227	74	8	1	1	3	3
	DE	39	7	26	60	2	4	3	1					
	ES	2231	2568	2340	1946	210	52	24	20	32	92	45	61	134
	FRA	2048	1740	1757	1669	548	314	174	160	139	128	123	130	183
	GBR	2773	2454	2398	1478	508	290	168	153	101	77	46	34	30
	IRL	2117	1728	1581	1283	1007	547	394	410	243	219	227	230	284
	NLD	0	1	0	0	0	0	0	0	0				
	NOR	50	101	89	77	96	131	62	107	99	157	272	312	153
raj.27.67a-ce-k Total		10826	9926	9597	6928	2787	1671	1053	924	623	674	714	770	787
rjb.27.67a-ce-k	BEL				0	0	0			0	0			
	ES	24	6	11	26	0	0	0				448	375	300
	FRA	351	295	308	414	68	30	15	23	21	32	33	17	
	GBR				96	22	1	19	12	1	63	118	116	106
	IRL			0		2	4	17	1	0	0	9	7	9
rjb.27.67a-ce-k Total		375	301	319	535	93	35	51	37	22	95	609	516	415
rjc.27.6	ES					16	2	10	6	23	21	12	12	50
	FRA	64	78	73	82	39	24	19	39	28	10	2	1	1
	GBR				1	56	61	57	67	120	120	114	147	113
	IRL					3	33	56	69	71	85	87	99	130
rjc.27.6 Total		64	78	73	82	114	120	141	181	241	236	213	260	294
rjc.27.7afg	BEL			0	328	216	197	302	441	391	240	350	241	212

ICESStockCode	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	ES											5	6	9
	FRA	379	264	238	181	147	131	133	106	95	107	70	121	147
	GBR			0	204	300	371	384	483	416	252	309	274	276
	IRL					8	80	126	134	146	191	169	220	232
	NLD												0	
rjc.27.7afg Total		379	264	238	713	671	780	944	1165	1048	790	903	861	876
rjc.27.7e	BEL				5	2	8	3	4	4	3	9	14	21
	ES						0	0						
	FRA	95	86	82	64	122	101	114	108	181	224	225	213	176
	GBR	0	0		3	82	98	98	129	151	151	158	195	172
	IRL									0		2		2
	NLD					0	2	1	0	2		0	0	0
rjc.27.7e Total		95	86	82	71	206	208	216	242	339	379	395	423	371
rje.27.7de	BEL						3	5	5	7	7	9	9	11
	FRA	21	19	19	22	32	28	28	24	26	24	24	8	8
	GBR				4	18	40	28	33	32	36	39	19	15
	IRL													2
rje.27.7de Total		21	19	19	26	50	70	61	62	65	67	72	36	36
rje.27.7fg	BEL						37	117	124	99	83	106	123	116
	FRA	27	23	18	21	29	21	16	30	30	65	31	5	57
	GBR			0	91	157	214	189	208	117	79	78	69	31
	IRL						0	0	0	0	0	0	0	
rje.27.7fg Total		27	23	18	112	187	272	323	362	247	227	216	198	204
rjf.27.67	ES					62	42	29	20	33	20	34	15	26

ICESStockCode	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	FRA	32	25	33	28	144	150	152	147	127	131	151	130	124
	GBR				13	44	108	97	79	85	55	25	39	21
	IRL						1	6	7	6	4	2	2	49
rjf.27.67 Total		32	25	33	41	250	301	283	253	251	211	212	186	219
rjh.27.4a6	BEL					0	0							
	DK											0		
	ES					0								
	FRA					1					1	1	1	0
	GBR				7	5	7	17	4	0	1	3	2	1
	IRL					0	4	1	1	24	9	9	11	5
rjh.27.4a6 Total					7	6	10	17	5	24	10	14	14	7
rjh.27.7afg	BEL				166	170	210	313	404	406	351	359	313	338
	FRA					36	73	131	87	52	170	218	275	257
	GBR		0	0	97	138	226	273	261	262	229	245	245	270
	IRL	3	6			5	402	382	407	377	420	351	171	154
rjh.27.7afg Total		3	6	0	263	350	910	1099	1160	1097	1170	1172	1004	1019
rjh.27.7e	BEL				7	6	3	5	5	6	3	6	11	9
	FRA					56	148	205	169	191	281	304	223	240
	GBR		0		32	159	215	204	175	222	295	396	352	241
	IRL								0			2		2
	NLD								0	0				0
rjh.27.7e Total			0		39	221	365	414	349	419	579	708	587	492
rji.27.67	BEL							0	0	0	0	0	0	2
	ES	86	74	40	7	30	16	22	8	10	5	3	5	11

ICESStockCode	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	FRA	199	152	185	178	46	35	25	35	26	33	34	37	34
	GBR				0	2	0	0	3	25	22	1	35	17
	IRL						0	4	0					
rji.27.67 Total		285	226	226	185	78	51	51	46	61	61	38	77	63
rjm.27.67bj	BEL						0							
	ES				7	7	10	5	0	0	0	1		
	FRA	13	7	3	4	2	4	7	5	17	53	43	47	40
	GBR				5	16	27	32	30	27	29	43	49	44
	IRL					1	20	18	25	24	43	28	20	12
rjm.27.67bj Total		13	7	3	16	27	62	63	61	68	125	114	116	96
rjm.27.7ae-h	BEL				78	63	55	120	70	3	0	1	7	2
	ES						0				0	0		
	FRA	1080	902	833	870	785	934	1062	1135	899	912	745	819	661
	GBR	0		0	12	38	102	88	85	90	80	70	80	89
	IRL					0	19	63	53	40	49	48	41	10
	NLD					0		0		0			0	
rjm.27.7ae-h Total		1080	902	833	960	887	1110	1332	1344	1032	1042	864	947	762
rjn.27.678abd	BEL			0	86	81	70	112	93	97	48	51	27	26
	ES				1	778	480	387	311	373	300	659	688	433
	FRA	3164	2565	2575	2507	3217	3069	2909	2571	2195	2515	2621	2233	2142
	GBR				225	321	421	402	306	269	262	266	254	259
	IRL					12	55	106	108	93	83	79	69	69
	NLD						0			0	0			0
rjn.27.678abd Total		3164	2565	2575	2819	4408	4096	3916	3388	3028	3209	3675	3270	2929

ICESStockCode	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
rju.27.7bj	ES												1	1
	FRA					0				0		0	1	1
rju.27.7bj Total						0				0		0	2	2
rju.27.7de	BEL												5	24
	FRA					19	9	20	6	3	10	50	58	79
	GBR				2	2			0			5	22	36
rju.27.7de Total					2	21	9	20	6	3	10	55	84	139
Grand Total		16364	14429	14016	12800	10355	10071	9986	9587	8568	8883	9975	9350	8710

Table 18.3a. Skates and rays in the Celtic Seas. Biomass estimates (kg per km²) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. *Leucoraja naevus*

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	6.a	3.341261	0.7631530	5.919370
2006	6.a	2.863412	1.5757870	4.151037
2007	6.a	4.253825	2.3167285	6.190920
2008	6.a	1.550122	0.7289567	2.371288
2009	6.a	2.234281	1.1018169	3.366745
2010	6.a	3.717024	2.0798635	5.354184
2011	6.a	1.785025	0.7836924	2.786359
2012	6.a	2.950243	1.4600642	4.440421
2013	6.a	3.500676	1.5592941	5.442058
2014	6.a	3.246034	0.4422661	6.049802
2015	6.a	0.672508	0.1433472	1.201669
2016	6.a	5.603120	2.7747450	8.431495
2017	6.a	2.360295	1.0888993	3.631690

Table 18.3b. Skates and rays in the Celtic Seas. Biomass estimates (kg per km²) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. *Raja montagui*

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	6.&7.bj	3.8203644	0.8772230	6.763506
2006	6.&7.bj	3.5317143	1.7603041	5.303125
2007	6.&7.bj	3.1963185	0.2919647	6.100672
2008	6.&7.bj	2.4079747	1.1541523	3.661797
2009	6.&7.bj	5.0177595	2.1479083	7.887611
2010	6.&7.bj	4.5488637	2.5912639	6.506463
2011	6.&7.bj	6.4196486	3.4717450	9.367552
2012	6.&7.bj	4.0720115	2.3253288	5.818694
2013	6.&7.bj	7.1234651	3.6220724	10.624858
2014	6.&7.bj	9.4745773	3.9045792	15.044575
2015	6.&7.bj	5.9441076	2.9215481	8.966667
2016	6.&7.bj	15.3248874	-3.1670403	33.816815
2017	6.&7.bj	8.9378535	3.9548648	13.920842
2005	7.a,e-h	0.7459104	-0.2892318	1.781053
2006	7.a,e-h	3.6461218	0.9412191	6.351025
2007	7.a,e-h	11.1532172	0.8082230	21.498211
2008	7.a,e-h	6.9323503	0.6528146	13.211886
2009	7.a,e-h	8.0424664	2.1113381	13.973595
2010	7.a,e-h	9.9729479	4.0587944	15.887101
2011	7.a,e-h	6.7392692	2.3894273	11.089111
2012	7.a,e-h	7.8776726	3.1958581	12.559487
2013	7.a,e-h	15.4326483	3.1645578	27.700739
2014	7.a,e-h	16.5616727	4.2940963	28.829249
2015	7.a,e-h	20.3186235	7.1949131	33.442334
2016	7.a,e-h	30.2480582	9.2527723	51.243344
2017	7.a,e-h	12.8967985	4.9479571	20.845640

Table 18.3c. Skates and rays in the Celtic Seas. Biomass estimates (kg per km²) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. ***Raja brachyura***

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	7.a&7.g	0.6014534	-0.3335659	1.5364727
2006	7.a&7.g	0.1426726	-0.1369605	0.4223057
2007	7.a&7.g	1.7877288	-0.2675947	3.8430524
2008	7.a&7.g	3.7541867	-0.5016022	8.0099756
2009	7.a&7.g	0.0000000	0.0000000	0.0000000
2010	7.a&7.g	3.5534812	-0.3123857	7.4193480
2011	7.a&7.g	1.4430961	-1.3853203	4.2715125
2012	7.a&7.g	0.3881487	-0.2841718	1.0604693
2013	7.a&7.g	3.1461458	-1.1897411	7.4820327
2014	7.a&7.g	1.7142022	-0.4667081	3.8951125
2015	7.a&7.g	1.6050991	-0.2292067	3.4394049
2016	7.a&7.g	2.8149362	0.8451547	4.7847177
2017	7.a&7.g	2.2458713	-0.2734638	4.7652064

Table 18.3d. Skates and rays in the Celtic Seas. Biomass estimates (kg per km²) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. ***Raja clavata***

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	6	3.7434568	-0.1480331	7.634947
2006	6	5.9180334	2.4861426	9.349924
2007	6	5.5667234	1.2599530	9.873494
2008	6	7.6147167	2.7638518	12.465582
2009	6	7.2688409	2.7567736	11.780908
2010	6	17.9536507	3.7574574	32.149844
2011	6	13.7808323	4.9685941	22.593070
2012	6	22.8984537	3.2988192	42.498088
2013	6	15.6807027	3.5229155	27.838490
2014	6	12.8470955	1.3826824	24.311508
2015	6	14.3399433	4.0199724	24.659914
2016	6	23.3694853	3.6320664	43.106904
2017	6	15.7783305	7.1192277	24.437433
2005	7.fg	0.4852387	-0.2500962	1.220573
2006	7.fg	1.1089902	0.1300639	2.087916
2007	7.fg	2.9643871	-0.5731053	6.501880
2008	7.fg	4.3403369	0.5933405	8.087333
2009	7.fg	2.3340468	0.0567745	4.611319
2010	7.fg	4.0709832	-0.4147746	8.556741
2011	7.fg	1.3215369	-0.1738435	2.816917
2012	7.fg	1.3579023	0.1158664	2.599938
2013	7.fg	2.6173275	-0.5230054	5.757660
2014	7.fg	2.9940930	-0.8974523	6.885638
2015	7.fg	5.3633727	-1.3119085	12.038654
2016	7.fg	5.7414410	0.8802873	10.602595
2017	7.fg	4.5903049	0.2296374	8.950972

Table 18.3e. Skates and rays in the Celtic Seas. Biomass estimates (kg per km²) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. *Raja microocellata*

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	ICES.27.f-g	0.0000000	0.0000000	0.000000
2006	ICES.27.f-g	2.0380292	-0.5532546	4.629313
2007	ICES.27.f-g	6.9088751	-1.5846139	15.402364
2008	ICES.27.f-g	4.3341235	-0.8869290	9.555176
2009	ICES.27.f-g	0.4155238	-0.3988879	1.229935
2010	ICES.27.f-g	1.5024740	0.0586864	2.946262
2011	ICES.27.f-g	0.7145779	-0.2626957	1.691851
2012	ICES.27.f-g	0.7511249	-0.0690751	1.571325
2013	ICES.27.f-g	1.7806495	-0.5969467	4.158246
2014	ICES.27.f-g	1.8007968	-0.2077030	3.809297
2015	ICES.27.f-g	2.3359211	-0.2738192	4.945661
2016	ICES.27.f-g	4.8460490	-0.8374794	10.529577
2017	ICES.27.f-g	3.3718040	-1.3905964	8.134204

Table 18.3f. Skates and rays in the Celtic Seas. Biomass estimates (kg per km²) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. *Dipturus batis* and *Dipturus interemedius* combined.

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	6&7	0.0647826	0.0190203	0.1105449
2006	6&7	0.3803152	-0.1784847	0.9391151
2007	6&7	0.4278930	-0.0545232	0.9103092
2008	6&7	0.2876187	0.0512355	0.5240019
2009	6&7	0.6405827	0.2032358	1.0779296
2010	6&7	1.8904779	-0.7308948	4.5118505
2011	6&7	1.0733361	-0.4062287	2.5529008
2012	6&7	0.5850637	-0.0695271	1.2396545
2013	6&7	0.6888536	-0.1227879	1.5004950
2014	6&7	0.9398314	0.2384340	1.6412288
2015	6&7	1.2567201	-0.2500285	2.7634687
2016	6&7	3.0762427	-0.7613029	6.9137883
2017	6&7	1.3970494	0.4835118	2.3105869

Figure 18.1a. Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) in the Celtic Seas (ICES subareas 6–7 including 7.d), from 1903–2015 (Source: ICES).

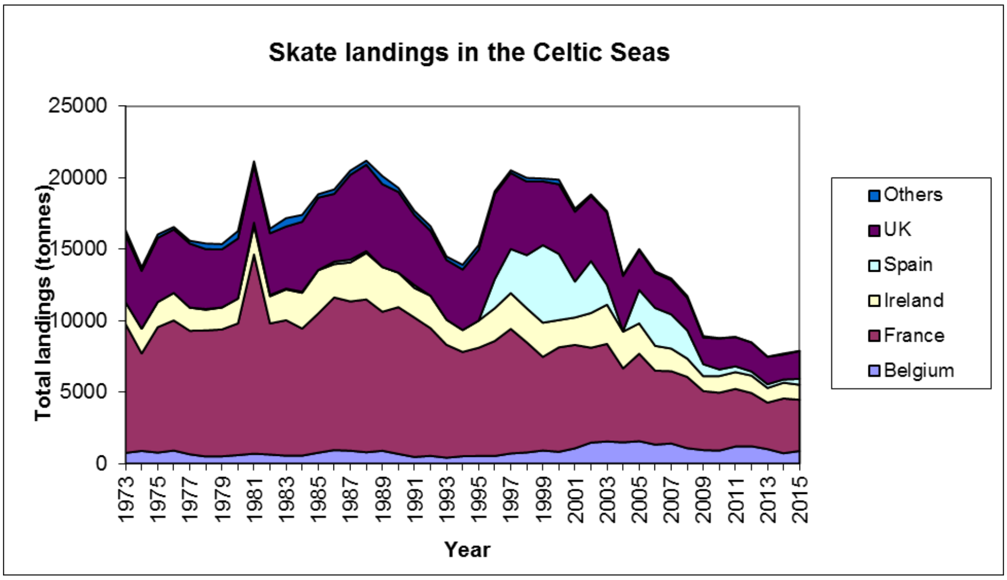


Figure 18.1b. Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) by nation in the Celtic Seas from 1973–2015 (Source: ICES).

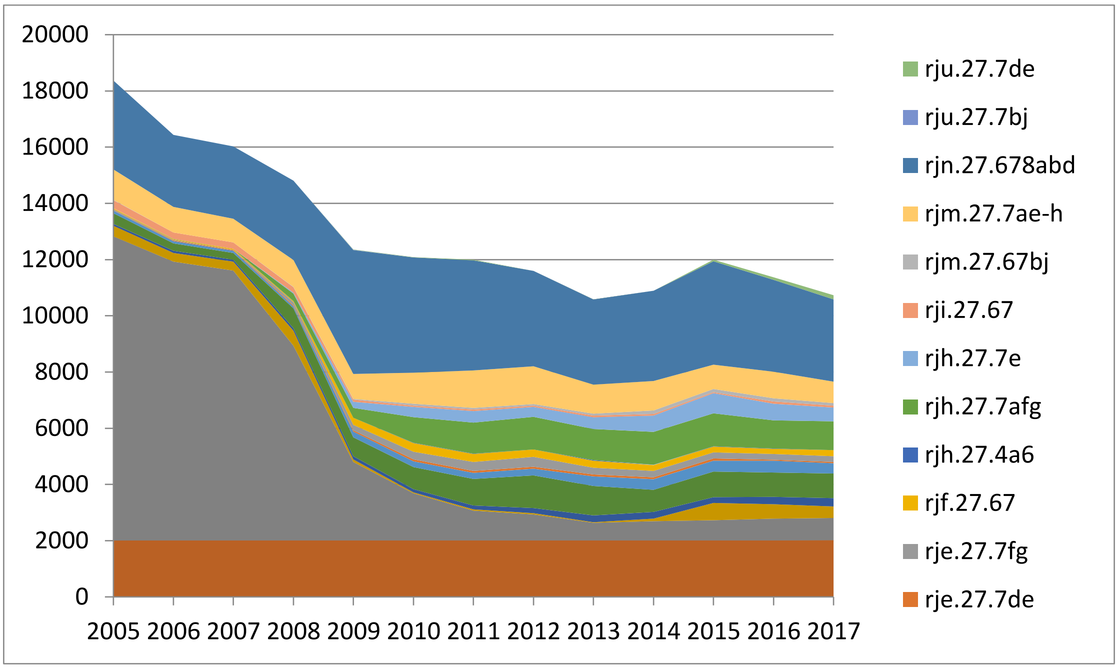


Figure 18.1.c Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) by stock in the Celtic Seas from 2005–2017 (Source: ICES).

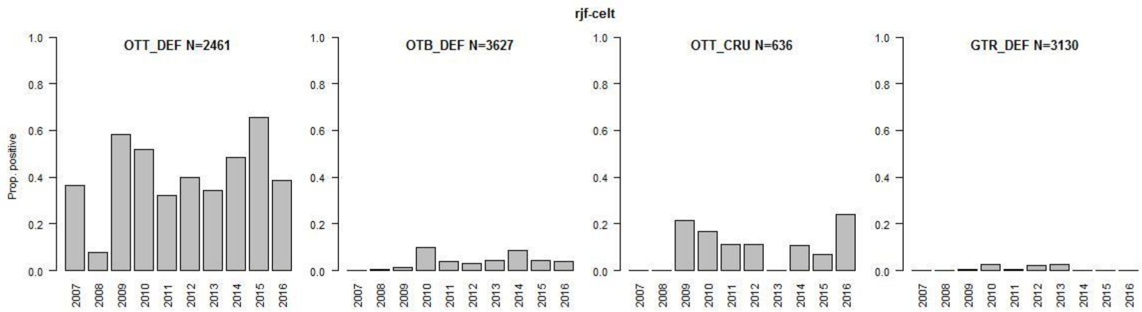


Figure 18.2 Skates and rays in the Celtic Seas. Temporal trends in the proportion of hauls encountering RJF.27.67, based on data collected during French on-board observer trips.

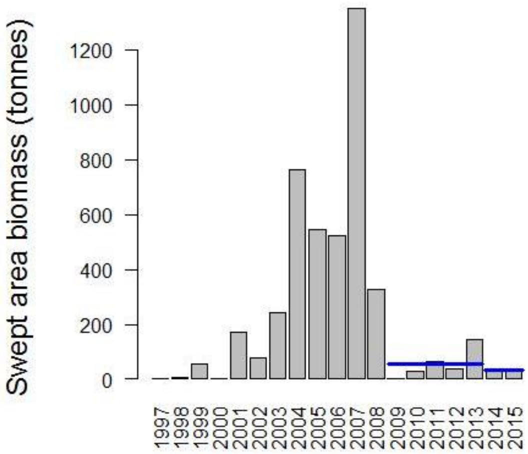


Figure 18.3a. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Leucoraja circularis* (divisions 7.g–j) from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

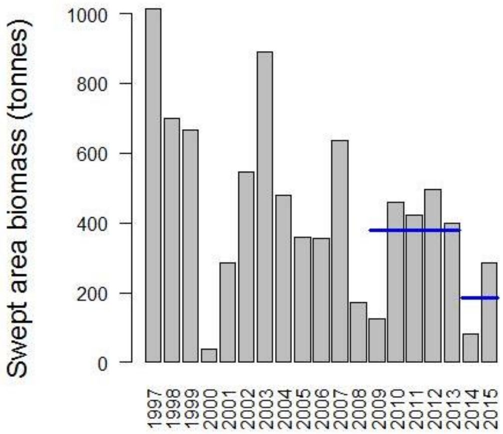


Figure 18.3b. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Leucoraja fullonica* (divisions 7.g-j) from the French EVHOE (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

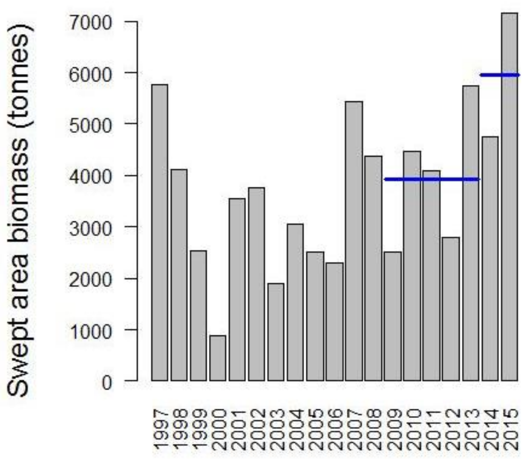


Figure 18.3c. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Leucoraja naevus* from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

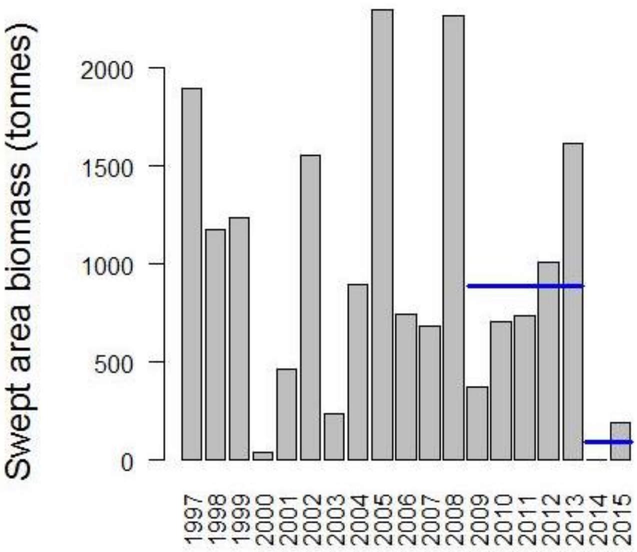


Figure 18.3d. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Raja clavata* (divisions 7.g-j) from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

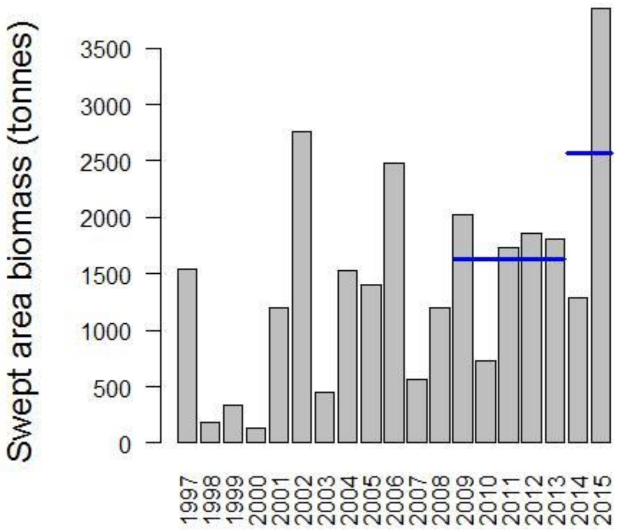


Figure 18.3e. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Raja montagui* (divisions 7.g-j) from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

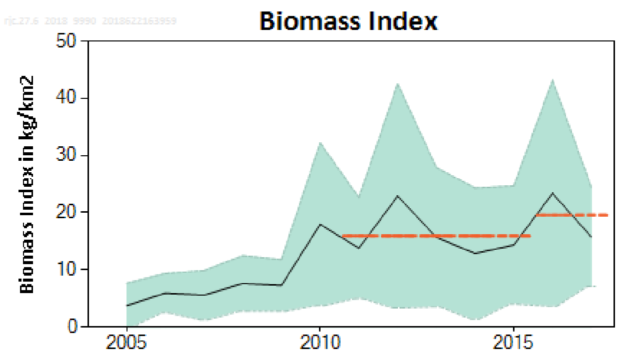


Figure 18.4a. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) biomass index of *Raja clavata* in Division 6.a for 2005–2015. Red lines give average for 2011–2015 and for 2016–2017.

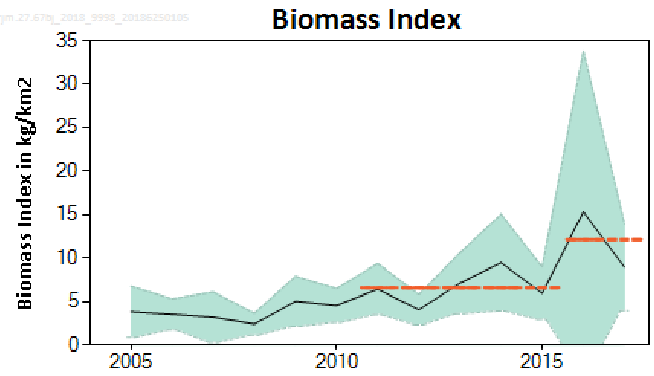


Figure 18.4b. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) mean cpue of Raja montagui in Divisions 6.a and 7.b-c for 2005–2017. Red lines give average for 2011–2015 and for 2016–2017.

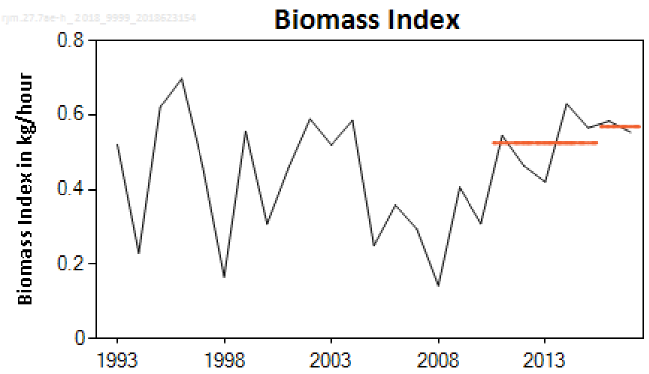


Figure 18.4c. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) mean cpue of *Raja montagui* in Divisions 7.a,e-h for 2005–2017. Red lines give average for 2011–2015 and for 2016–2017.

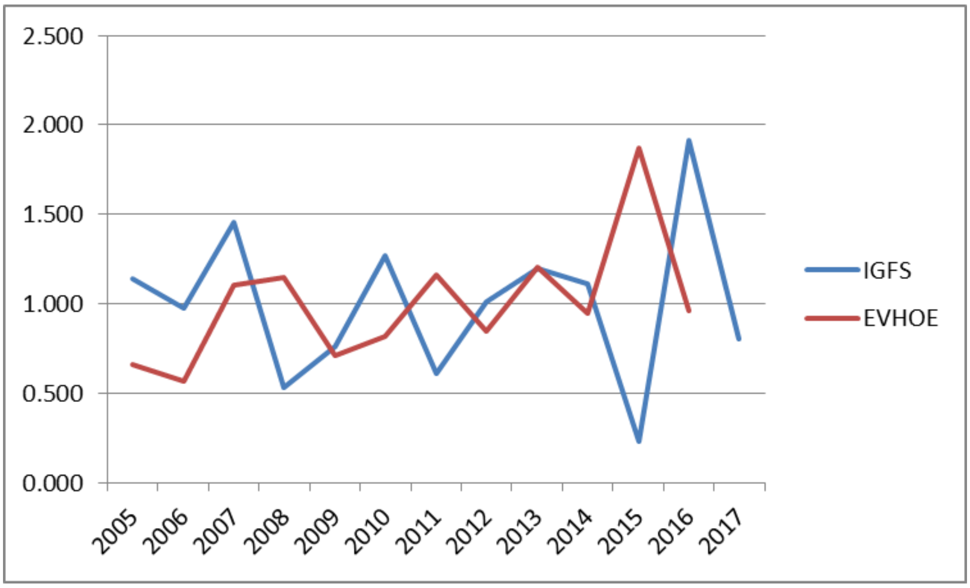
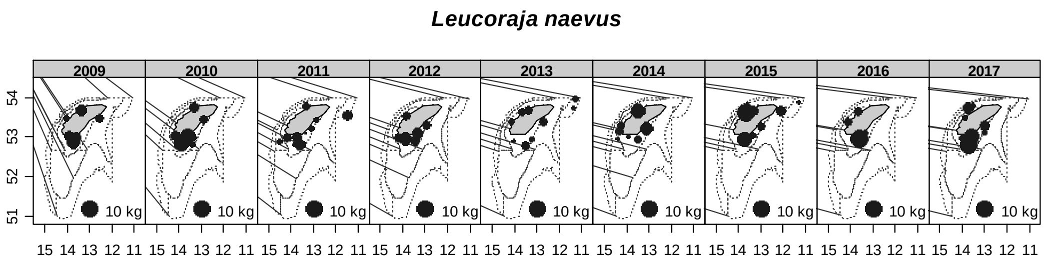


Figure 18.4d. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) (blue) and French EVHOE survey (red) standardized biomasses for of *Leucoraja naevu*s in divisions 6, 7, 8.abd. 2005–2017. The French survey did not take place in 2017.



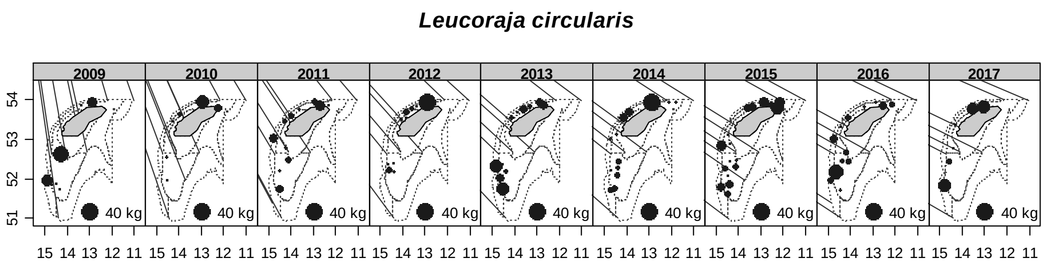


Figure 18.5a. Skates and rays in the Celtic Seas. Geographical distribution of cuckoo ray *Leucoraja naevus* and sandy ray *Leucoraja circularis* catches (kg·haul⁻¹) in Porcupine survey time-series (2009–2017) (Ruiz-Pico *et al.*, 2018 WD).

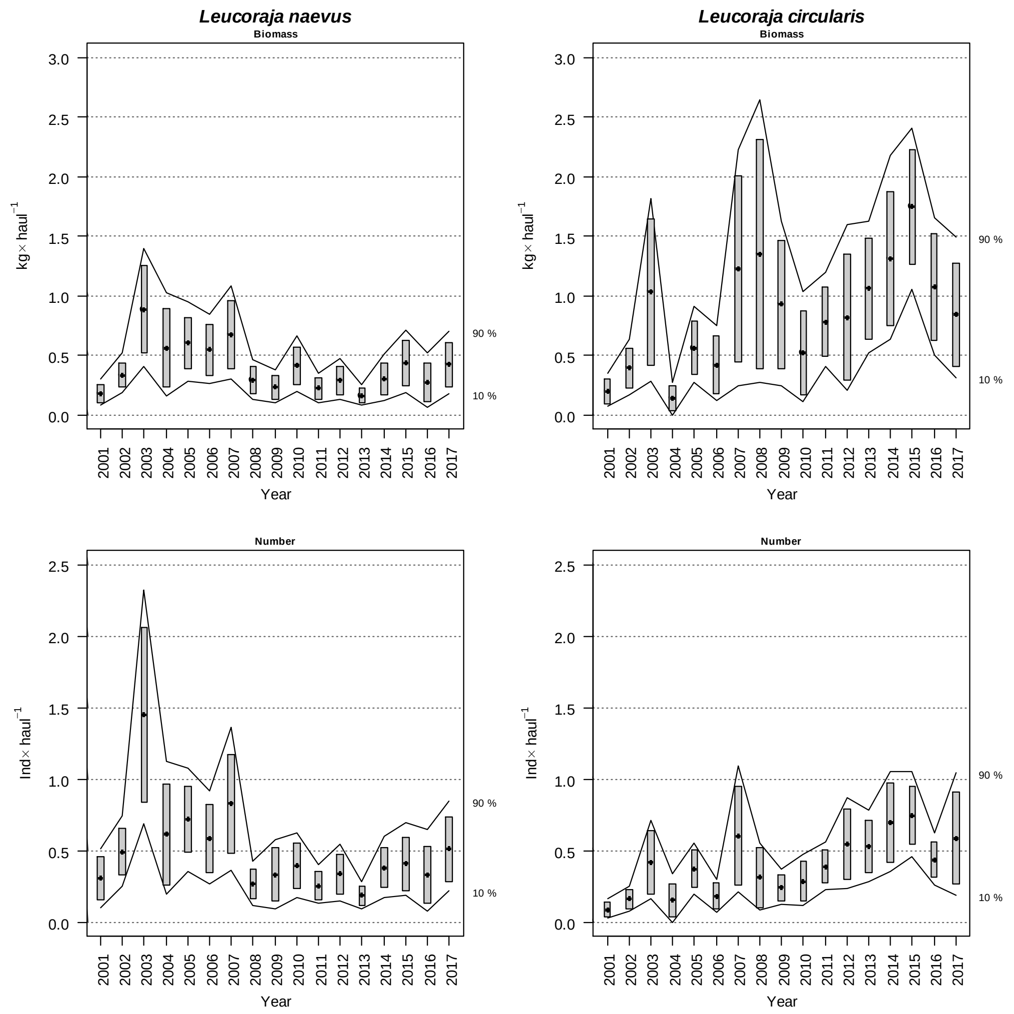


Figure 18.5b. Skates and rays in the Celtic Seas. Temporal changes of cuckoo ray *Leucoraja naevus* and sandy ray *Leucoraja circularis* biomass index (kg·haul^{-1}) during Porcupine survey time-series (2001–2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000) (Ruiz-Pico*et al.*, 2018 WD).

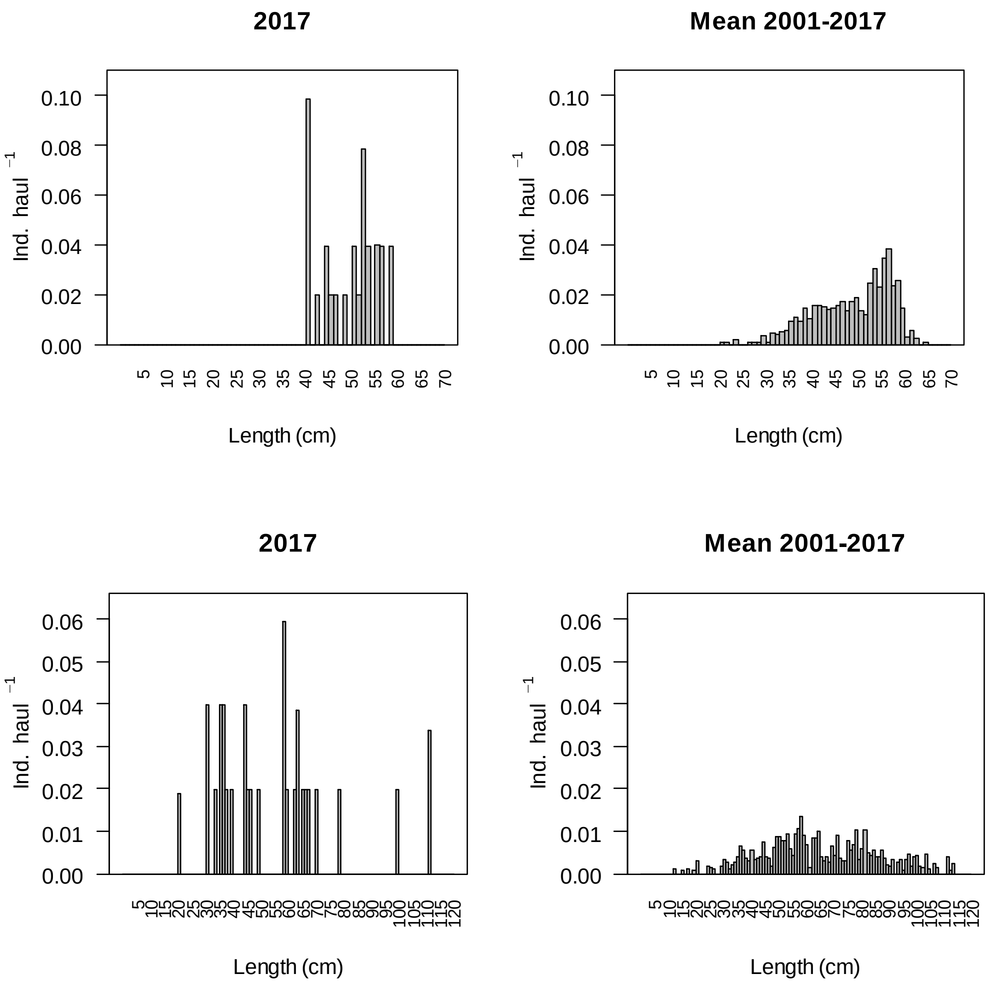


Figure 18.5c. Skates and rays in the Celtic Seas. Stratified length distributions of cuckoo ray *Leucoraja naevus* (top) and sandy ray *Leucoraja circularis* (bottom) in Porcupine survey 2001–2017 (Ruiz-Pico *et al.* 2018 WD).

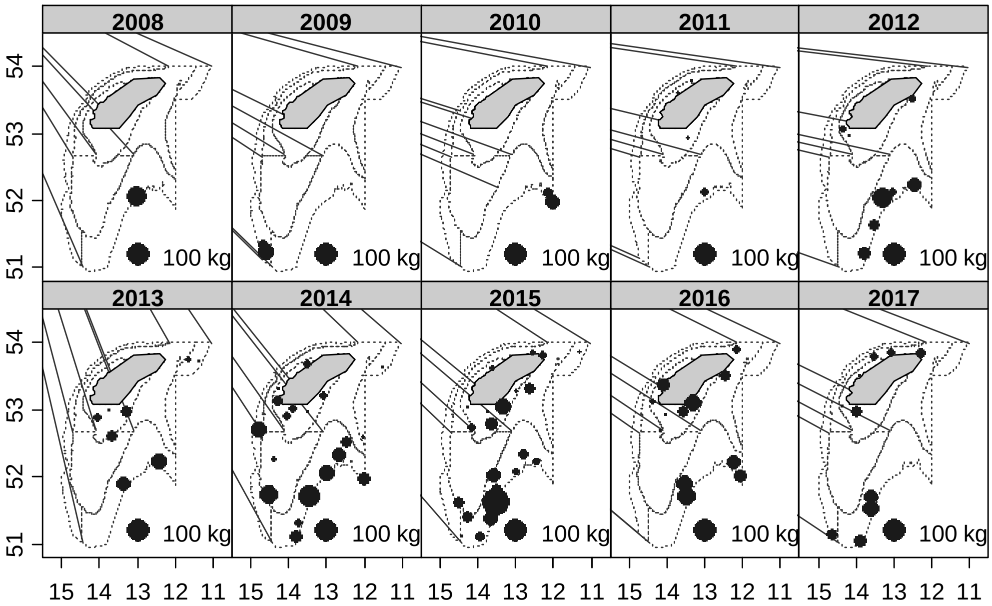


Figure 18.5d. Skates and rays in the Celtic Seas. Geographical distribution of *Dipturus* spp. combined (kg·haul⁻¹) in Porcupine survey time-series (2008–2017) (Ruiz-Pico *et al.* 2018 WD).

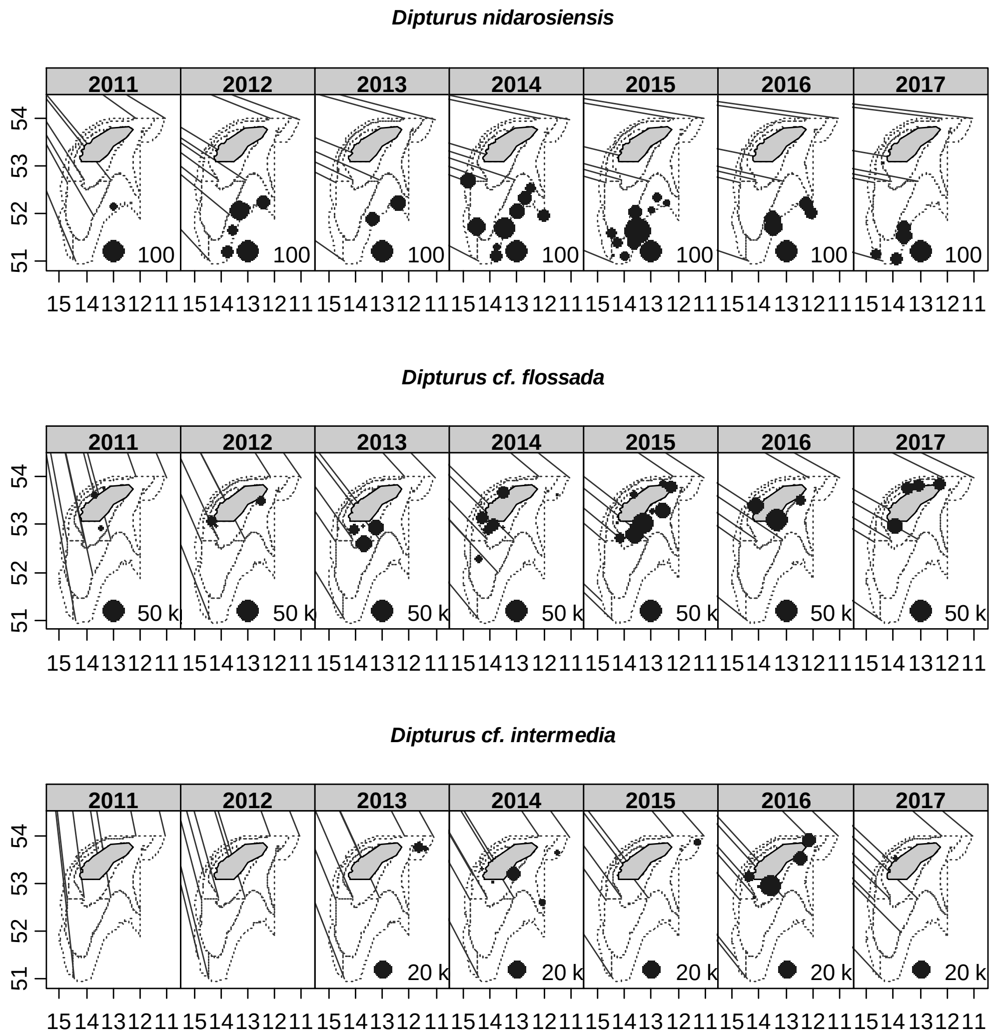


Figure 18.5e. Skates and rays in the Celtic Seas. Geographical distribution of *Dipturus* nidarosiensis, *Dipturus batis* (labelled Dipturus cf. *flossada*) and *Dipturus intermedius* (labelled *Dipturus* cf. *intermedia*) (kg·haul^{-1}) in Porcupine survey time-series (2011–2017) (Ruiz-Pico *et al.* 2018 WD).

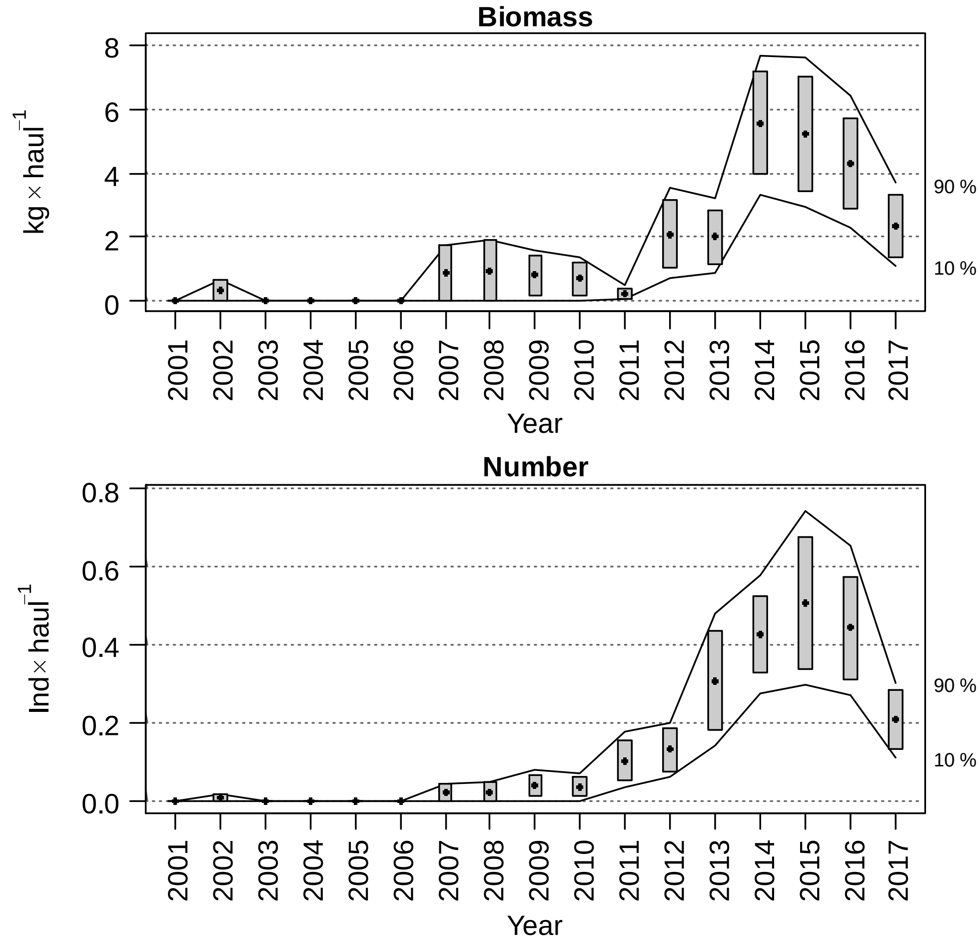


Figure 18.5f. Skates and rays in the Celtic Seas. Changes in *Dipturus* spp. biomass index (kg·haul^{-1}) during Porcupine survey time-series (2001–2017). Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000) (Ruiz-Pico *et al.* 2018 WD).

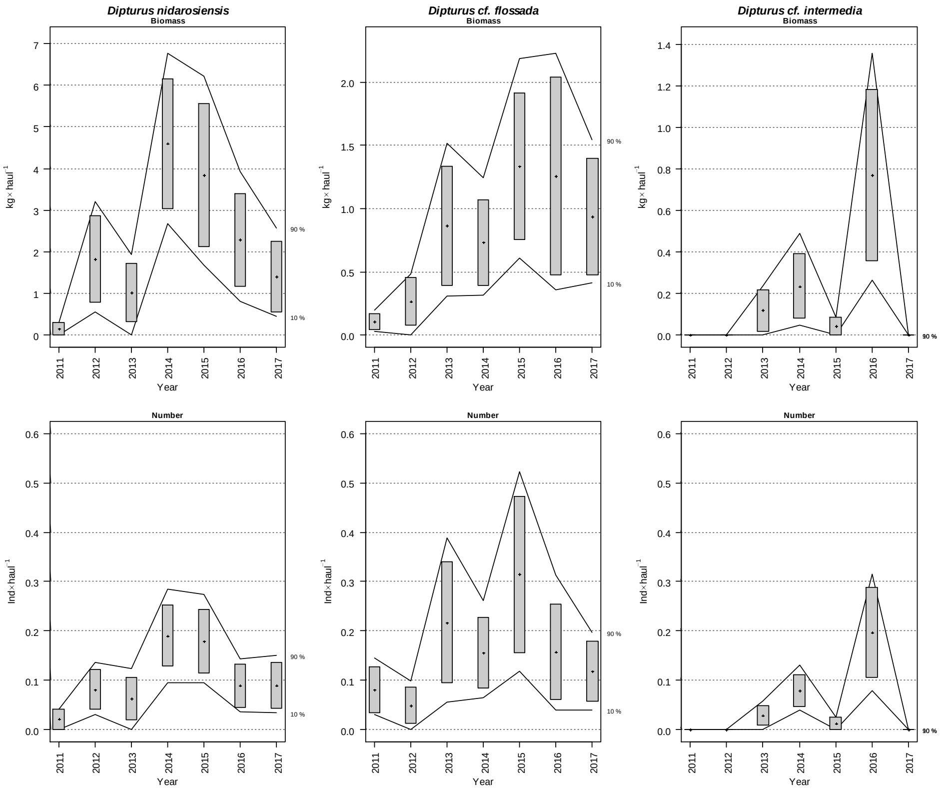


Figure 18.5g. Skates and rays in the Celtic Seas. Changes in *Dipturus* nidarosiensis, *Dipturus batis* (labelled Dipturus cf. *flossada*) and *Dipturus intermedius* (labelled *Dipturus* cf. *intermedia*) biomass index (kg·haul^{-1}) during Porcupine survey time-series (2011–2017). Boxes mark parametric standard error of the stratified index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000) (Ruzi-Pico *et al.* 2018 WD).

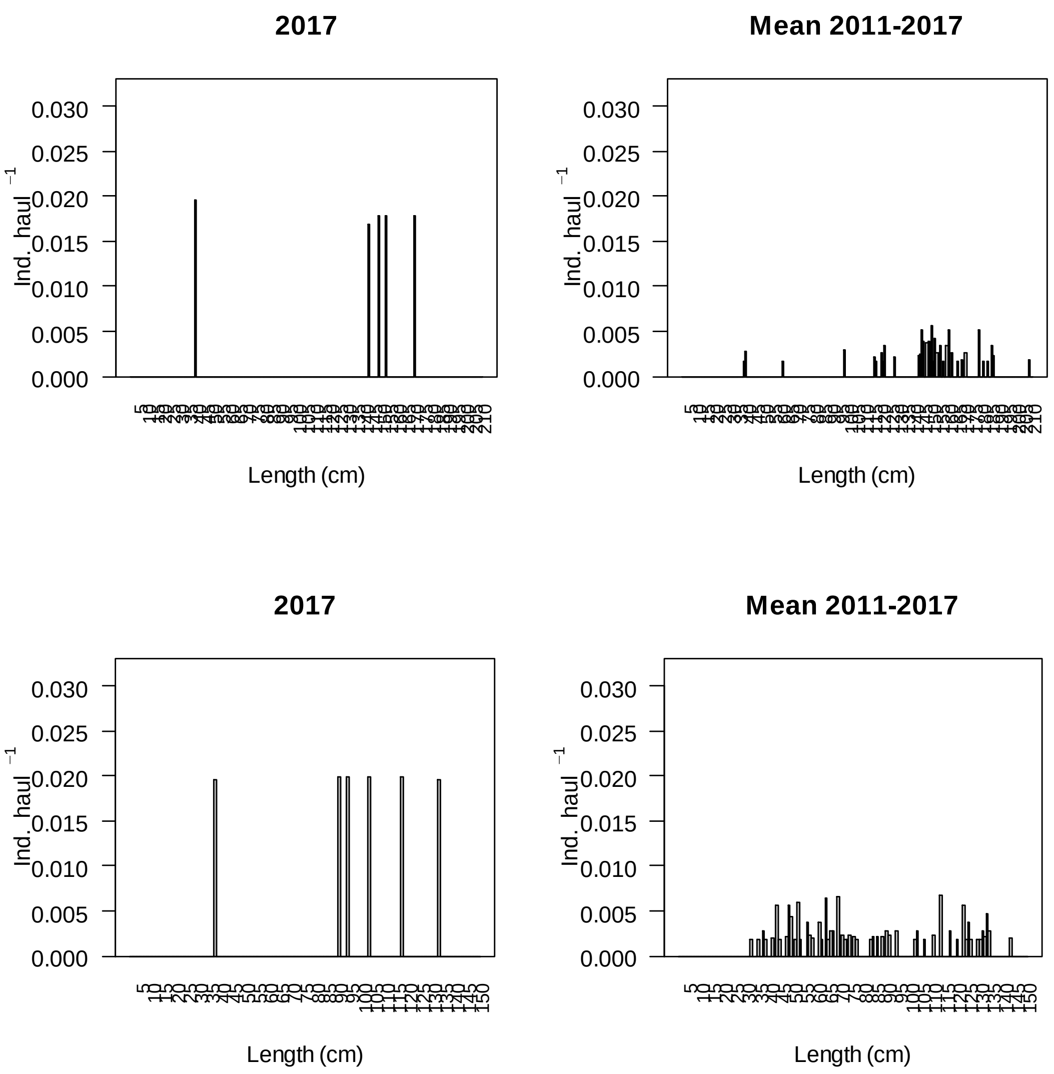


Figure 18.5h. Skates and rays in the Celtic Seas. Mean stratified length distributions of *Dipturus nidarosiensis* (top) and *Dipturus batis* (labelled *Dipturus* cf. *flossada*) from 2017 Porcupine surveys (Ruiz-Pico *et al.* 2018 WD).

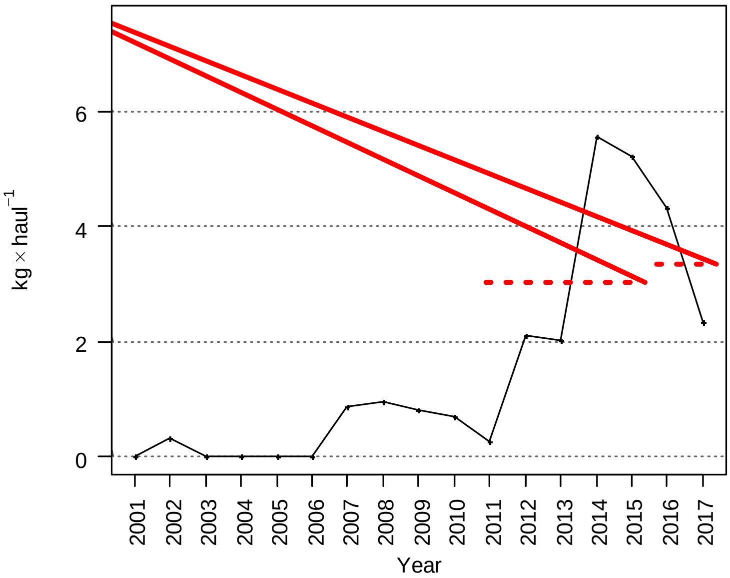


Figure 18.5i. Skates and rays in the Celtic Seas. Changes in Dipturus spp. biomass index during Porcupine survey time series (2001–2017). Dotted lines compare mean stratified biomass in the last two years and in the five previous years. (Ruiz-Pico *et al.* 2018 WD).

Figure 18.6. Skates and rays in the Celtic Seas. Temporal trends (1993–2017) in the CPUE by individuals ($n.h^{-1}$), biomass ($kg.h^{-1}$), and biomass for individuals ≥ 50 cm total length ($kg.h^{-1}$) of skates in the 7.a.f–g beam trawl survey (EngW-BTS-Q3).

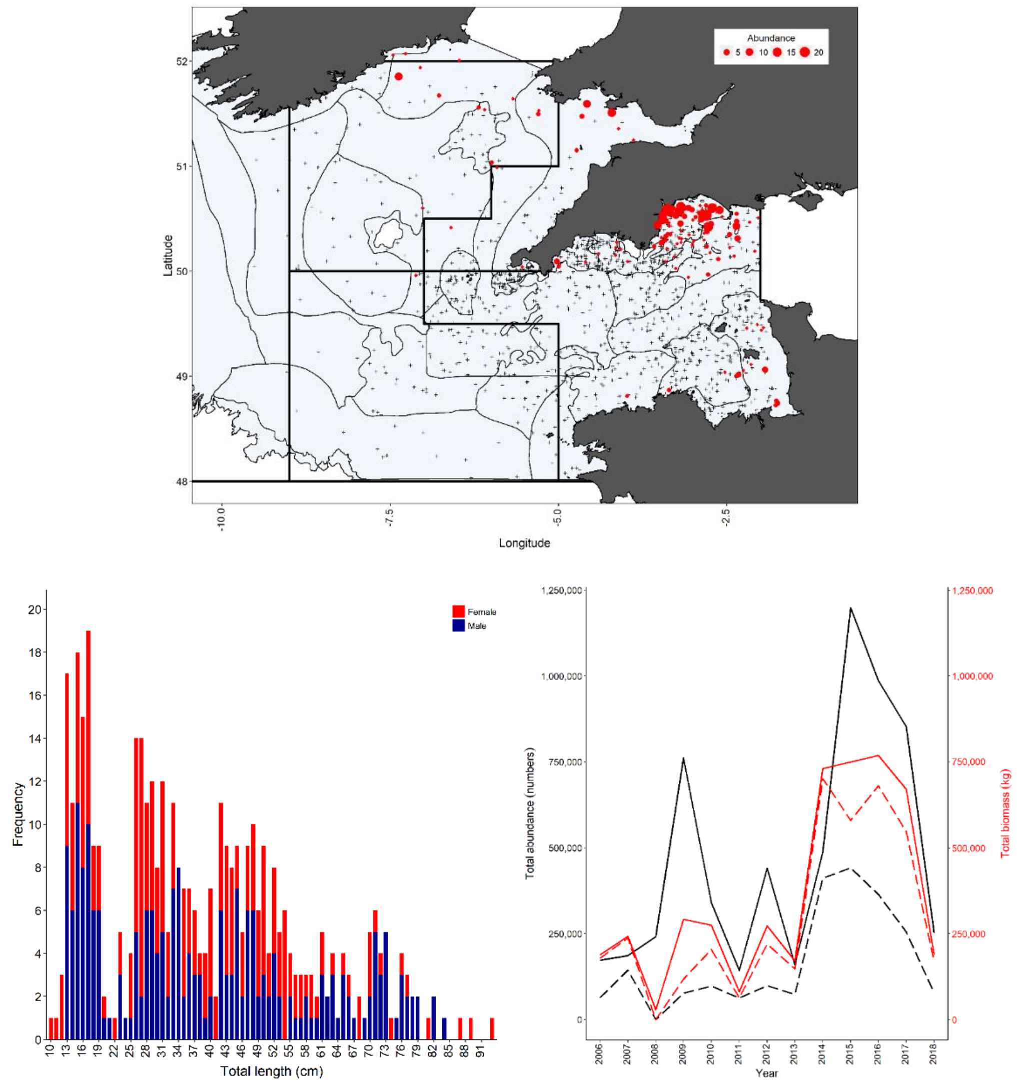


Figure 18.7a. Skates in the Celtic Sea. Distribution and relative abundance (top) and length-frequency by sex (bottom left) and of thornback ray *Raja clavata* in the Q1SWBeam trawl survey. Total biomass (numbers and kg; bottom right) - continuous line relates to all specimens, dashed line relates to individuals ≥ 50 cm total length. (Source: Silva *et al.* 2018WD)

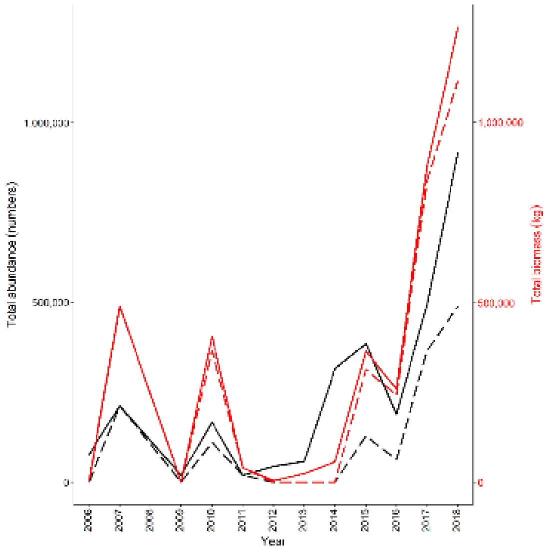


Figure 18.7b. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for common skate *Dipturus batis*-complex. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length. (Source: Silva *et al.* 2018WD).

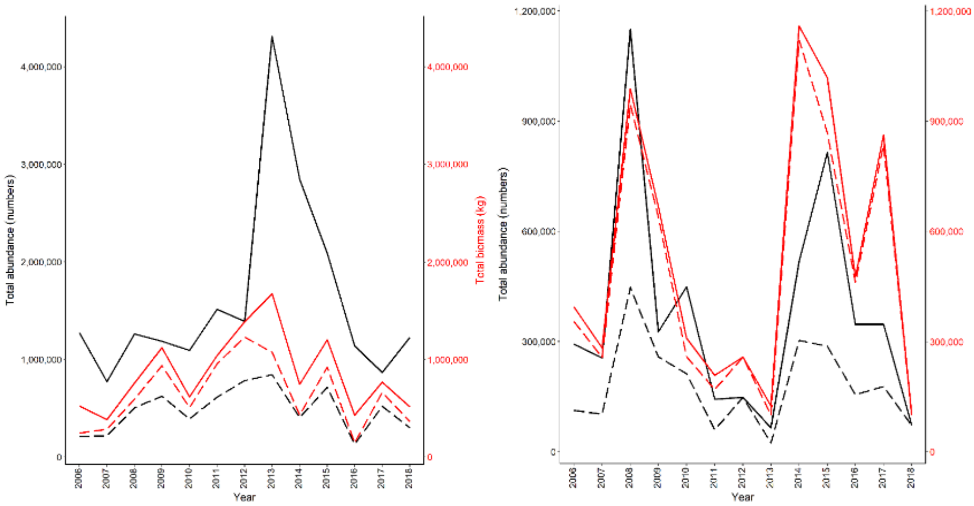


Figure 18.7c. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (left) cuckoo ray *Leucoraja naevus* and (right) blonde ray *Raja brachyura*. Continuous line relates to all specimens, dashed line relates to individuals ≥ 50 cm total length. (Source: Silva *et al.* 2018WD).

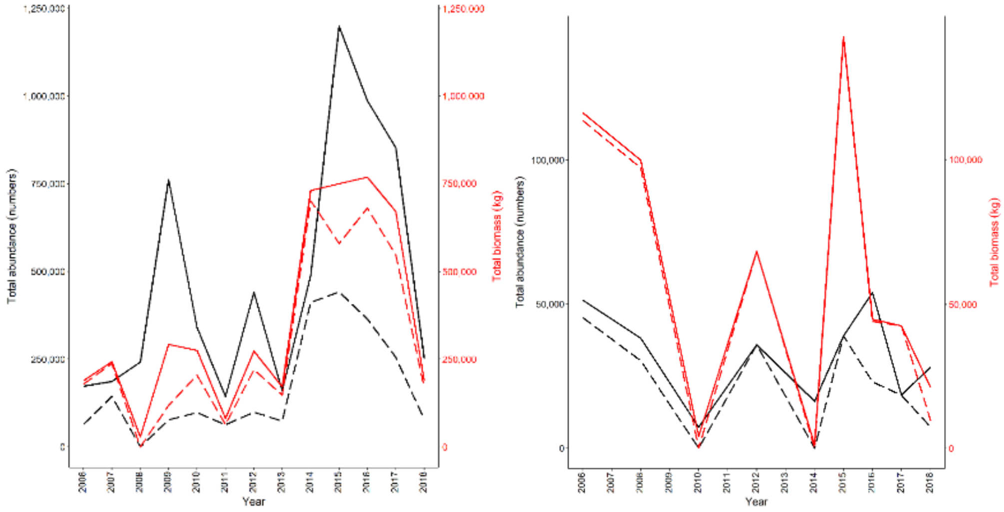


Figure 18.7d. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (left) thornback ray *Raja clavata* and (right) small-eyed ray *Raja microocellata*. Continuous line relates to all specimens, dashed line relates to individuals ≥ 50 cm total length. (Source: Silva *et al.* 2018WD).

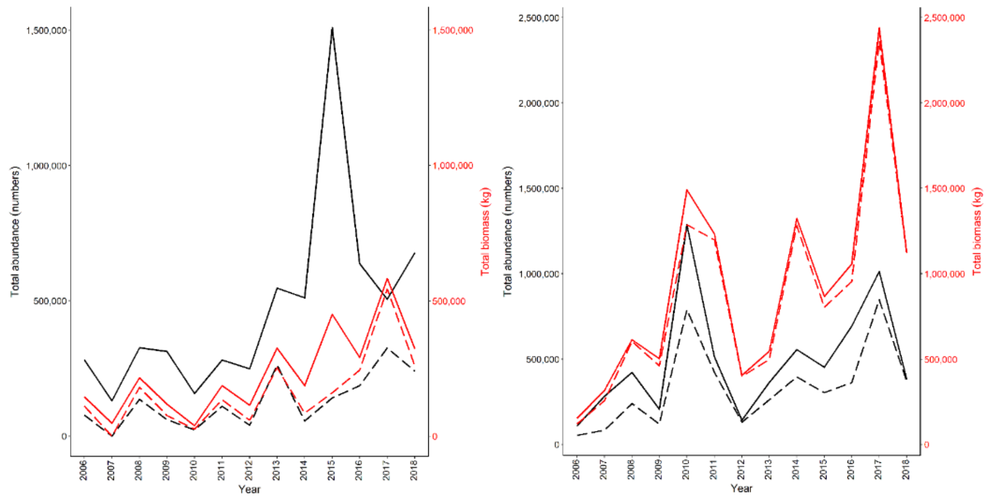


Figure 18.7e. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (left) spotted ray *Raja montagui* and (right) undulate ray *Raja undulata*. Continuous line relates to all specimens, dashed line relates to individuals ≥ 50 cm total length. (Source: Silva *et al.* 2018WD)

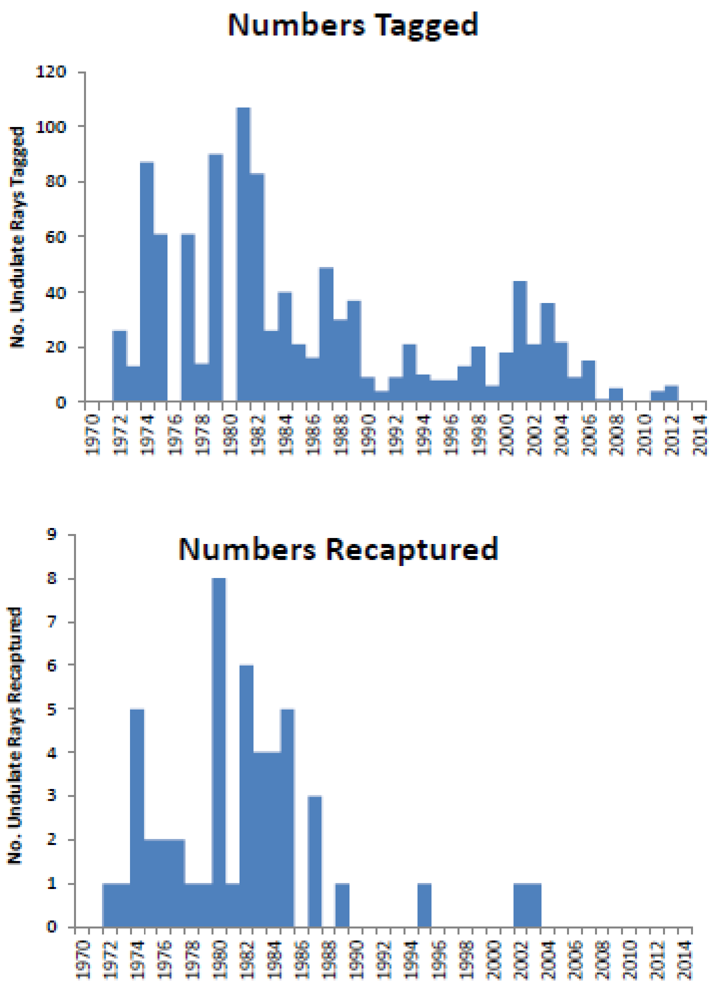


Figure 18.8. Skates in the Celtic Seas. Numbers of *Raja undulata* tagged (top) and recaptured (bottom) in Tralee Bay and surroundings, 1970–2014. Source: Wogerbauer *et al.*, 2014 WD.

19 Skates in the Bay of Biscay and Iberian Waters (ICES Subarea 8 and Division 9.a)

ICES uses the generic term "skate" to refer to all members of the order Rajiformes. The generic term "ray", formerly used by ICES also to refer to Rajiformes, is now only used to refer to other batoid fish, including manta rays and sting rays (Myliobatiformes), and electric rays (Torpediniformes). ICES only provides routine advice for Rajiformes.

19.1 Ecoregion and stock boundaries

The Bay of Biscay and Iberian Waters ecoregion covers the Bay of Biscay (divisions 8.a-b and 8.d), including the Cantabrian Sea (Division 8.c), and the Spanish and Portuguese Atlantic coast (Division 9.a). This ecoregion broadly equates with the area covered by the South Western Waters Advisory Council (SWWAC). Commercially-exploited skates do not occur in the offshore Division 8.e to any major extent.

The northern part of the Bay of Biscay has a wide continental shelf with flat and soft bottom more suitable for trawlers, whilst the Cantabrian Sea has a narrower continental shelf with some remarkable bathymetric features (canyons, marginal shelves, etc.). The Portuguese continental shelf (Division 9.a) is narrow, except for the area located between the Minho River and the Nazaré Canyon, and in the Gulf of Cadíz, where it is about 50 km wide, particularly to the east. The slope is mainly steep with a rough bottom including canyons and cliffs.

Rajidae are widespread throughout this ecoregion but there are regional differences in their distribution as described in earlier reports (ICES, 2010), and this is particularly evident for those species with patchier distributions and limited dispersal (Carrier *et al*., 2004).

Skates in this ecoregion include thornback ray *Raja clavata*, cuckoo ray *Leucoraja naevus*, the less frequent blonde ray *Raja brachyura*, small-eyed ray *R. microocellata*, brown ray *R. miraletus*, spotted ray *R. montagui*, undulate ray *R. undulata*, shagreen ray *Leucoraja fullonica*, common skate *Dipturus batis*-complex, long-nosed skate *D. oxyrinchus*, sandy ray *Leucoraja circularis* and white skate *Rostroraja alba*.

Studies undertaken in the centre of Portugal (Division 9.a; Serra-Pereira *et al*., 2014), and in the Cantabrian Sea (eastern parts of Division 8.c) indicate spatial overlap between *R. clavata* and *L. naevus* (e.g. Sánchez, 1993). In the Bay of Biscay, *L. naevus* is more abundant on the offshore trawling grounds (Sánchez *et al*., 2002). Along the Portuguese coast *R. clavata* and *L. naevus* co-occur in areas deeper than 100 m, on grounds composed of soft bottom, from mud to fine sand (Serra-Pereira *et al*., 2014). *Raja clavata* can also be found from rocky to coarse sandy bottoms. *Raja brachyura* occurs primarily near the coast in shallower depths in areas of rocks surrounded by sand. Juvenile *R. brachyura*, *R. montagui* and *R. clavata* co-occur on grounds shallower than 100 m. In this ecoregion, *R. undulata* and *R. microocellata* occur at depths < 40 m over sandy bottoms. *R. undulata* is locally common in the shallow waters between the Loire and Gironde estuaries (eastern Bay of Biscay; divisions 8.a-b) and occurs along most of the French coastal area.

The geographical distributions of the main skate species in the ecoregion are known, but their stock structure still needs to be more accurately defined. Studies (e.g. tagging and/or genetic studies) to better understand stock structure are required.

A tagging survey of *R. undulata* carried out in the Bay of Biscay (2012–2013) showed that movements of this species were limited to *ca.* 30 km (Delamare *et al*., 2013 WD;

Biais *et al*., 2014 WD). This result supports the hypothesis that several local stocks exist in European waters and corroborates the assumption of three distinct assessment units (divisions 8a–b; 8.c and 9a) in this ecoregion.

For most other skate species, WGEF considers two management units in this ecoregion: Subarea 8 (Bay of Biscay) and Division 9a (Iberian waters). Since 2015, the cuckoo ray from ICES Subareas 6 and 7 in the Celtic seas ecoregion and the Bay of Biscay is considered to form one single stock, cuckoo ray in subareas 6 and 7 and divisions 8.abd. In addition, there are two stocks of cuckoo ray in this ecoregion Division 8.c (Cantabrian Sea) and 9.a (Iberian waters).

19.2 The fishery

19.2.1 History of the fishery

In the Bay of Biscay and Iberian waters, skates are caught mainly as a bycatch in mixed demersal fisheries, which target either flatfish (including sole) or gadiforms (e.g. hake). The main fishing gears used are otter trawl, bottom-set gillnets and trammel nets. The countries involved in these fisheries are France, Spain and Portugal, as detailed below.

France

Skates are traditional food resources in France, where target fisheries were known to occur during the 1800s. In the 1960s, skates were taken primarily as a bycatch of bottom trawl fisheries operating in the northern parts of the Bay of Biscay, the southern Celtic Sea and English Channel. By this time, *R. clavata* was targeted seasonally by some fisheries, and was the dominant skate species landed. After the 1980s, *L. naevus* became the main species landed. However, landings of both *R. clavata* and *L. naevus* declined after 1986.

Other skates are also landed, including *L. circularis*, *L. fullonica*, *R. microocellata*, *D. batis* complex and *D. oxyrinchus*. There have been no major annual landings of *Rostroraja alba* by French fleets in the past three decades.

The historical French catches of skates in coastal fisheries are poorly known. Species such as *R. brachyura* were not reported as species-specific landings until the recent EU obligation. The same applies to *Raja undulata,* which was not reported separately before its inclusion on the EU prohibited species list.

Spain

Spanish demersal fisheries operating in the Cantabrian Sea (Division 8.c) and Bay of Biscay (divisions 8.a-b and 8.d) catch various skate species using different fishing gears. Most landings are a bycatch from trawl fisheries targeting demersal teleosts, (e.g. hake, anglerfish and megrim). Among the skate species landed, *L. naevus* and *R. clavata* are the most frequent. Historically, due to their low commercial value, most skate species, especially those derived from artisanal gillnetters, were landed under the same generic landing name. There are artisanal gillnet fisheries operating in bays, rias and shallow waters along the Cantabrian Sea and Galician coasts (divisions 8.c and 9.a). *R. undulata* is caught mainly in the coastal waters of Galicia (north part of Division 9.a and western part of Division 8.c). Other skate species caught in Galician waters include *R. brachyura*, *R. microocellata*, R. *montagui*, *R. clavata* and *L. naevus*. The characteristics of Spanish artisanal fleets catching skates are not fully known.

Mainland Portugal

Off mainland Portugal (Division 9.a), skates are captured by trawlers, but mainly by the artisanal polyvalent fleet, which accounts for the highest reported landings. The artisanal fleet operates mostly with trammel nets, but other fishing gears (e.g. longlines and gillnets) are also used. The skate species composition of landings varies along the Portuguese coast. *R. clavata* is the main species landed, but *R. brachyura*, *L. naevus* and *R. montagui* are also caught. Before being prohibited, *R. undulata* was frequently landed, particularly at the northern landing ports. Other species, such as *R. microocellata*, *D. oxyrinchus*, *R. miraletus*, *R. alba* and *L. circularis,* are also caught, albeit less frequently (particularly the latter three species). Further details on fisheries in Division 9.a are given in the Stock Annex.

19.2.2 The fishery in 2017

No specific changes noted for 2016, with descriptions of recent investigations provided below.

France

Landings and on-board observation data confirm that skates are primarily a bycatch in numerous fisheries operating in the Bay of Biscay. French landings statistics from more than 100 métiers (defined at DCF level 6) report landings of *R. clavata* and *R. montagui* in the Bay of Biscay. Trammel nets are the main métier for *R. montagui*, while twin-trawl is the main métier for *R. clavata*.

Spain

The results from the DCF pilot study held from 2011–2013 and conducted in the Basque Country waters (Division 8.c) with the objective of describing and characterizing coastal artisanal fisheries (trammel nets targeting mainly hake, anglerfish and mackerel), showed that several skate species (*R. clavata*, *R. montagui*, *L. naevus*, *L. fullonica, L. circularis, R. brachyura* and *R. undulata*) are caught as bycatch. The Basque artisanal fleet consists of 55 small vessels that use gillnets and trammel nets during some periods of the year. Vessels have a mean average length of 12.7 m and 82.4 kW average engine power. The proportions of skates in the total sampled trips were 30% (2011), 35% (2012) and 16% (2013). The estimated landings of skates by this fleet were 19.3 t in 2012 and 26.9 t in 2013 (Diez *et al.*, 2014 WD).

In the Cantabrian Sea (Division 8.c) most skate landings are also from bycatch from otter trawl (47%) and gillnet gears (43%). The remaining landings are derived from longlines and other fishing gears.

Mainland Portugal

Skates are mainly a bycatch in mixed fisheries, particularly from the artisanal polyvalent fleet (representing around 80% of landings). Set nets, or a combination of set nets and traps, account for most skates’ landings (*ca*. 61% in weight and 71% in number of trips in 2017), followed by longline (*ca.* 28% in weight and 20% in number of trips in 2017). Also within the artisanal polyvalent fleet, trawlers may account for 5% of the total skate landings (by weight and number of trips), being only observed in certain landing ports. Methods to estimates landings by skate species were developed during the DCF-funded pilot study focused on skate catches in Portuguese continental fisheries carried out from 2011–2013 (Maia *et al.*, 2013 WD).

The experimental quota of *Raja undulata* assigned to Portugal in 2016 and updated in 2017, involved the assignment of special fishing licenses to vessels, mainly operating close to the coast. This cannot be interpreted as a new fishery as it is a TAC constrained and has as main goal to provide minimum fishery data for future scientific advice.

19.2.3 ICES Advice applicable

Before 2012, ICES provided general advice on skates, but this is inadequate as skate species have different life-history traits. Also a generic skate TAC does not take into account that several stocks straddle the boundary with other management areas. For instance, *L. naevus* is a stock straddling subareas 6 and 7 (excl. Division 7.d) and divisions 8.a-b and 8.d.

From 2012–2014, ICES has moved towards providing advice at the individual stock level, giving quantitative advice where possible.

Advice on skates is given biannually and the last advice provided for Bay of Biscay and Iberian Waters ecoregion was given in 2016. A summary of the 2016 ICES advice is summarized in the table below.

It is important to note that this does not sum up to a generic advice for skates in subareas 8 and 9 and should not be interpreted as advice in relation to the generic skate TAC applicable to this management area.

Scientific name	ICES stock code	Management unit	Advice	Advice 2017 (tonnes)
Raja undulata	rju.27.8ab	8a,b	No target fishery, manage by-catch	-
Raja undulata	rju.27.8c	8c	No target fishery, manage by-catch	-
Raja clavata	rjc.27.8	8	Increase landings 20%	434
Leucoraja naevus	rjn.27.8c	8c	Reduce landings 1%.	27
Raja montagui	rjm.27.8	8	Increase landings 20%	115
Raja montagui	rjm.27.9a	9a	Increase landings 20%	112
Leucoraja naevus	rjn.27.9a	9a	Increase landings 20%	58
Raja clavata	rjc.27.9a	9a	Increase landings 19%	1203
Raja undulata	rju.27.9a	9a	No target fishery, manage by-catch	-
Raja brachyura	rjh.27.9a	9a	Increase landings 4%	177
Dipturus batis complex (*Dipturus cf. flossada*) (*Dipturus cf. intermedia*)	rjb.27.89a	8, 9a	Zero catches	0
Other skates	raj.27.89a	8, 9a	ICES cannot provide catch advice	-

19.2.4 Management applicable

An EU TAC for skates (Rajiformes) in subareas 8 and 9 was first established in 2009, and set at 6423 t. Since then, the TAC has been reduced by approximately 15% in 2010, 15% in 2011, 9% in 2012, 10% in 2013, 10% in 2014 increased 2% in 2015 and 2016 and increased 9% in 2017. The history of the EU regulations adopted for skates in this ecoregion is summarized below:

Year	TAC for EC waters of subareas 8 and 9	ICES landing estimates	Regulation
2009	6423 t	4327 t	Council Regulation (EC) No 43/2009 of 16 January 2009
2010	5459 t	4140 t	Council Regulation (EU) No 23/2010 of 14 January 2010
2011	4640 t	4144 t	Council Regulation (EU) No 57/2011 of 18 January 2011
2012	4222 t	3766 t	Council Regulation (EU) No 43/2012 of 17 January 2012
2013	3800 t	3686 t	Council Regulation (EU) No 39/2013 of 21 January 2013
2014	3420 t	3685 t	Council Regulation (EU) No 43/2014 of 20 January 2014
2015	3420 t	3532 t	Council Regulation (EU) No 104/2015 of 19 January 2015 ammended by the Council Regulation (EU) No 523/2015 of 25 March 2015
2016	3420 t	3296 t	Council Regulation (EU) No 72/2016 of 22 January 2016
2017	3762 t	3430 t	Council Regulation (EU) No 2017/127 of 20 January 2017

(1) *Catches of cuckoo ray (Leucoraja naevus) (RJN/89-C), thornback ray (Raja clavata) (RJC/89-C) shall be reported separately.*

(2) *Does not apply to undulate ray (Raja undulata), common skate (Dipturus batis) and white skate (Rostroraja alba). Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.*

(3) *Catches of cuckoo ray (Leucoraja naevus) (RJN/89-C), blonde ray (Raja brachyura) (RJH/89-C), and thornback ray (Raja clavata) (RJC/89-C) shall be reported separately.*

Regarding *R. undulata* no management measures had been adopted by European Commission (EC) until 2009, when EC regulations stated that *Undulate ray … (in) … EC waters of VI, VII, VIII, IX and X … may not be retained on board. Catches of this species shall be promptly released unharmed to the extent practicable* (CEC, 2009). In 2010 *R. undulata* was listed as a prohibited species on quota regulations (Section 6 of CEC, 2010). In 2017, EC stated that *shall be prohibited for Union fishing vessels to fish for, to retain on board, to transship in Union waters of ICES subareas VI and X* and *It shall be prohibited for third-country vessels to fish for, to retain on board, to tranship or to land the following* undulate ray *whenever they are found in Union waters of ICES subareas VI, IX and X (*Council Regulation (EU) No 2017/127).

In 2017 and under Regulation (EU) No 2017/127) it was stated that *This species shall not be targeted and for cases where it is not subject to the landing obligation, by-catch of undulate ray* were set. It was also stated that the catches shall remain under the quotas shown in the table below.

RAJA UNDULATA	**2017**	**2017**
	Union waters of 8 (RJU/8-C)	Union waters of 9 (RJU/9-C)
Belgium	0	0
France	12	18
Portugal	9	15
Spain	9	15
UK	0	0
UE	30	48

19.2.4.1 Regional management measures

Portugal

The Portuguese Administration adopted, on 29 December 2011, national legislation (Portaria no 315/2011) that *prohibits the catch, the maintenance on board and the landing of any skate species belonging to the Rajidae family, during the month of May along the whole continental Portuguese EEZ*. This applies *to all fishing trips, except bycatch of less than 5% in weight*. The legislation was updated on 21 March 2016 (Portaria no 47/2016) by extending the fishing prohibition period to June.

By 22 August 2014, the Portuguese Administration adopted a national legislation (Portaria no 170/2014) that *establishes a minimum landing size of 52 cm total length (L_T) for all Raja spp. and Leucoraja spp*.

On 19 May 2016, Portugal adopted a legislative framework (Portaria no. 96/2016) regarding the 2016 quota of *Raja undulata* in Division 9.a assigned to Portugal. This framework includes a set of conditions for licensing specific fishing permits to vessels on the owner's request, provided that each vessel fulfills the set of specific conditions which include fishing vessel type, fishing license and historical skate landings. Vessels having the specific fishing permit shall comply with a set of rules, which include obligation to transmit, to both the General Directorate of Natural Resources, Maritime Security and Services (DGRM) and to IPMA, specific fishing data using a form designed by DGRM and IPMA to register haul and catch data on a haul-by-haul basis; the obligation to accept scientific observers duly accredited by IPMA onboard, except in situations where, demonstrably, due to vessel's technical characteristics, it affects the normal activity of the vessel. A fishing permit will be assigned to each vessel that has collaborated with IPMA on the UNDULATA Project.

On each fishing trip, vessels with the special fishing permit are prohibited from targeting undulate ray and are obliged to land the species under specific conditions: a maximum of 30 kg of undulate ray live weight is allowed; only whole or gutted specimens can be landed and a minimum (78 cm L_T) and a maximum (97 cm L_T) landing sizes are adopted. During the months of May, June and July of each year the capture, retention onboard and landing of undulate ray is prohibited, but data on catches should be recorded. On 16 January 2017, Portugal updated the 2016 legislative framework regarding the 2017 quota of *Raja undulata* in Division 9.a assigned to Portugal, from 12 to 14 tonnes with no other major differences on the criteria (Portaria no 27/2017).

France

Based on feedback from scientific programs carried out since 2011 in close partnership with fishermen, it was decided in December 2013 to remove undulate ray from the list of prohibited species, without landings permitted (Total Allowable Catch (TAC) zero). In December 2014, thanks to measures proposed by Member States to ensure the sustainable management of local populations of undulate ray, a small TAC has been allowed for France in ICES subareas 7.e-d and 8.a–c, with limited bycatch but no targeted fishing (ICES, 2016). Since then, the French authorities adopted different decrees to regulate bycatch and landings of undulate ray. For more details on the different modalities of this bycatch by year, see table in Section 18.2.5 above.

19.3 Catch data

19.3.1 Landings

Historical series of landings of the Table 19.1e have been updated, revising the allocation of landings by the WGEF Species Name agreed by the WG. The updated table results in an increase of the landings in the first years of the series compared to the table of the WGEF Report edited in 2017.

Tables 19.1a–e and Figures 19.1(a–b) show ICES combined annual landing estimates for all skates, by country. Table 19.1f gives annual ICES landings by stock and country, and Table 19.2 presents the annual ICES landing estimates, by division, for each ray species including *Myliobatis* spp, Dasyatidae, *Rhinobatos* spp and Torpedinidae species (see Section 19.10).

Skates in Bay of Biscay and Cantabrian Sea (Subarea 8)

Historically, approximately 68% of landings in Subarea 8 were assigned to France and 31% to Spain (Basque Country included). Since 1973, skate landings show no clear trend, although at the earlier years of the time-series (1973–1974) and in the period from 1982–1991 remarkably high values were registered. From 2005–2016, annual landings were around 3100–1900 tonnes y^{-1}.

In 2017, the Divisions with the highest landings were 8.a–b (80%), and these were mostly from France (1322 tonnes). In Division 8.c, landings represented 20% of the total landing of Subarea 8, and were mainly from Spain (377 tonnes in 2017). Landings from Division 8.d were only 32 tonnes.

Skates in Division 9.a

An update was made to the Portuguese landings by skate species reported for 2014 and 2015, due to a revision of the estimation procedure.

In this Division, Portuguese and Spanish landings account for *ca.* 77% and 23%, respectively of reported skate landings. Since 2005, total landings of skates remained relatively stable, at about 1800–1200 tonnes y^{-1}.

Spanish mean annual skate landings were *ca.* 329 tonnes, with a maximum of 481 tonnes in 2013 and a minimum of 134 tonnes in 2008.

From the 1990s until 2010, Portuguese mean annual landings were *ca.* 1200 tonnes y^{-1}, but decreased in later years (1138 tonnes in 2017), in line with reductions in the TAC and the national legislation adopted to reduce fishing effort (see Section 19.2.4.1). In 2017, the main commercial species, in decreasing order, were *R. clavata, R. brachyura, R. montagui, R. microocellata*, *D. oxyrinchus* and *L. naevus* (see Section 19.4.2).

19.3.2 Discards

Discard information is available for divisions 8.a-b, 8.d and 9.a. Although there may be a widespread discarding of skates across fisheries, a proportion of these are likely to survive, particularly in the case of the polyvalent fleets using trammel and gillnets. In these fisheries, discard survivorship varies with soak time.

In WKSHARK3 (February, 2017), current sampling programmes for discards were evaluated to examine the suitability for the estimation of discard rates and quantities for the elasmobranch case study considered.

Basque OTB fleet in Subarea 8

Available information indicates that small specimens are commonly discarded. Discards from the Basque OTB (Bottom Otter Trawler) fleet are given in Table 19.3a. Since 2009, species-specific discard information is available for this fleet. *L. naevus* is the most discarded species (representing depending on the year 4–104% of total landings), maximum estimated discards of 120 tonnes occurred in 2016 (Table 19.3a). For the period 2009–2017, discards of *R. clavata* varied from 0–109% of the landed catch (Table 19.3b) with maximum estimated discards of 34 tonnes occurred in 2016.

Portuguese OTB fleet in Division 9.a

Information on discards of elasmobranchs produced by the Portuguese bottom otter trawl fleets (crustacean and demersal fish bottom otter trawlers) operating in Division 9.a has been collected by the DCF Portuguese on-board sampling program since 2003. Procedures for estimating the probability of a given species being caught in a haul and of a specimen being discarded, as well as the expected number of discarded specimens per haul, are described in the Stock Annex for each species. The overall discard estimates obtained by species for the two fleets were low.

No new information was provided in 2018.

Polyvalent Portuguese fleet in Division 9.a

Discard data for skates were collected during the DCF skate pilot study and the DCF trammel net fishery pilot study targeting anglerfish. The former included fisheries operating in shallow waters (depths < 150 m), whilst the latter examined the fishery operating at depths > 150 m. The frequency of occurrence of rajids was higher in nets operating < 150 m, presumably due to a higher spatial overlap with the species' distributions. For all the skate species, the probability of the species being caught in a haul and a specimen being discarded and the expected number of discarded specimens per haul were low (see Prista *et al.*, 2014 WD and the Stock Annexes for more details).

Under DCF, information on discards from vessels belonging to the polyvalent fleet, particularly those with length overall (LOA) larger than 12 m, using set gillnet and trammel nets to target demersal fish have been collected since 2011, and data were analyzed for the period 2011–2014 (Figueiredo *et al.*, 2017 WD). Within the sampled trips (n = 49), seven species of skate were identified in the discards. The main discarded species was *R. clavata,* which occurred in between 13 to 38% of the sampled hauls. The mean proportion in number of skate species discarded by haul on the sampled trips is presented in Table 19.3d. The mean proportion in number of *R. clavata* discarded by haul on the sampled trips was between 0.16 and 0.33. Only *R. clavata* had sufficient sampled individuals to analyze the length-frequency distribution of the retained and discarded fractions (Figure 19.2a). However, even for that species the observed length pattern varied between years.

No new information was provided in 2018.French fleet in Subarea 8

Gill- and trammel net métiers discard a fraction of large fish, which might be considered as damaged fish (e.g. partly scavenged catch). These discards are dead discards.

In trawl fisheries, due to the low commercial value of small specimens, the mean size of discarded specimens is much smaller than that of landed specimens. It is likely that some discarded specimens may survive.

19.3.3 Discard survival

Table 19.4a shows vitality estimates for *R. clavata*, *L. naevus*, *R. montagui,* and *R. brachyura* based on onboard sampling observations on trammel and gillnet fisheries. Results indicate that the survivorship of all the species addressed after capture is high and that both mesh size and soak time affected survivorship.

In the case of *R. undulata,* onboard observations in the Portuguese polyvalent fleet indicate high vitality after capture (91% were found with "good" health status; 3% were found in "poor" health status; Table 19.4b). The observations also indicated that soak time, mesh size and fish size influenced survival, with larger specimens tending to have higher survival.

WKSHARK3 (February 2017) reviewed available studies to identify where there are existing data on the vessel mortality and post-release mortality of elasmobranch species by gear type and identify important data gaps

19.3.4 Quality of the catch composition data

Species composition of landings in Subarea 8 and Division 9.a, corrected according to the WKSHARKS reporting guidelines (ICES, 2016) are presented (Tables 19.1f and 19.2). In recent years, official landings reported as Rajiformes (indet.) have declined because of the EU mandatory species-specific reporting. In the case of the Portuguese official landings statistics, eight commercial designations were reported in 2017: "raia lenga" (*R. clavata*), "raia pontuada" (*R. brachyura*), "raia manchada" (*R. montagui*), "raia-de-dois-olhos" (*L. naevus*), "raia de S. Pedro" (*L. circularis*), "raia-zimbreira" (*R. microocellata*), "raia-de-quatro-olhos" (*R. miraletus*) and "raia bicuda" (*D. oxyrinchus*).

Landing misidentifications and/or coding errors still occur in Subarea 8 and Division 9.a. To address this, IPMA developed statistical procedures to better estimate species-specific landings during the DCF skate pilot study (2011–2013). Table 19.5 gives updated landing proportions for each skate species (see Stock Annex for more details on the method). As mentioned in Section 19.3.1 the estimates reported for the polyvalent fleet in 2014 and 2015 were revised. After this study, DCF sampling effort for skates decreased, and the precision of the estimates have decreased accordingly. An increment in sampling effort is recommended, ideally included in the Portuguese DCF program.

A similar study was implemented by AZTI in Division 8.c. The main objective of the Basque Country pilot study was to characterize the main fishing parameters of the trammel net fishery (fishing gear, métier, effort and LPUE) and to identify the skate species present in the landings, as well as biometric relationships, such as "wing weight/total weight" and "total length/wing width" to better estimate the live weight of the landed skates.

In France, it is requested that all landings be recorded at species level. The quality of species reporting has improved in the last decade. Some misidentification is still likely to occur, because of e.g. local fish names. However, auction markets now use identification guides and record sales accordingly.

19.4 Commercial catch composition

Subarea 8

Length–frequency distributions of the retained and discarded catches of *R. clavata,* and *L. naevus* from the Basque OTB (Bottom Otter Trawler) are presented for the period 2011–2017 (figures 19.2b). Length–frequencies are extrapolated to the total trips.

Both species are discarded in all the range sizes but only individuals of *L. naevus* and *R. clavata* larger than 30 cm and 37 cm respectively are usually retained.

Division 9.a

Length–frequency distributions of *R. clavata, R. brachyura, R. montagui, R. microocellata* and *L. naevus* from the Portuguese commercial polyvalent and trawl fleets for the period 2008–2017 are presented in Figures 19.2c–h.

Length–frequency distributions were extrapolated to the total estimated landed weight of each species. Within each fleet, length distributions and their ranges were similar between years. However, for some species, there were differences in length distributions between the polyvalent and trawl fleets. In the case of *R. brachyura* and *R. microocellata*, landings from trawlers tended to be comprised of a higher density of smaller length classes.

Length–frequency distributions of *R. undulata* collected onboard polyvalent vessels for the period 2008–2013 (Figure 19.2h) showed that the length-structure of the exploited population shifted to larger individuals by the end of this time-series.

In 2018, there were no new data on the length–frequency distribution of *R. clavata* from the Spanish commercial fleet in this Division.

19.5 Commercial catch–effort data

19.5.1 Spanish data for Subarea 8

Limited new data were available in 2016.

An updated nominal LPUE-series for the Basque Country's OTB DEF>=70 in Subarea 8 from 2001–2017 is given for *L. naevus* and *R. clavata* (Table 19.6; Figure 19.3).

The LPUE of *L. naevus* was generally > 100 kg day^{-1} in the first half of the series, declined from 2009 to 2014 and increased again in 2015 and 2016. The lowest level was observed in 2010 (44 kg day^{-1}) and the greatest in 2007 (169 kg day^{-1}). In 2017, the value dropped strongly to 58 kg day^{-1}. The LPUE of *R. clavata* were smaller and more stable than those recorded for *L. naevus*, ranging from 14–32 kg day^{-1}, but in 2017 the highest value of the series (54 kg day^{-1}) was recorded.

19.5.2 Portuguese data for Division 9.a

Standardized lpue (kg trip^{-1}) time-series (2008–2013) for the most representative skate species (*R. clavata, R. montagui, R. brachyura, L. naevus* and *R. undulata)* were determined based on fishery data collected under the DCF skate pilot study on skates in Division 9.a (figures 19.4a-b). Standardized LPUE indices for *L. naevus* were calculated for both the polyvalent and trawl fleets (the two fleets each contribute *ca.* 50% each of the annual landings). For the remaining species, standardized LPUE indices were only calculated for the polyvalent fleet. Methodological procedures to determined standardized LPUE are described in the Stock Annex.

In 2017, only the LPUE index of *R. brachyura* was updated (Figure 19.4a).

19.5.3 Quality of the catch-effort data

Under the 2011–2013 DCF pilot study on skates developed by IPMA in Division 9.a, the quality of catch and effort data by species has improved greatly. It is recommended that catch-effort data by species continue to be collected, and focused sampling effort be undertaken for more coastal species.

19.6 Fishery-independent surveys

Groundfish surveys provide data on the spatial and temporal patterns in species composition, size composition, relative abundance and biomass for various skates. The fishery-independent surveys operating in the Bay of Biscay and Iberian Waters are discussed briefly below (see Stock Annex for further details).

Due to the patchy (sometimes coastal) distribution and habitat specificity of some skate species (e.g. *R. undulata, R. brachyura* and *R. microocellata*), existing surveys do not provide reliable information on abundance and biomass. In order to gather information on the distribution and spatio-temporal dynamics, and on abundance and biomass for those species, WGEF recommends dedicated surveys using an appropriate fishing gear be developed in this ecoregion.

19.6.1 French EVHOE survey (Subarea 8)

The EVHOE survey has been conducted annually in the Bay of Biscay since 1987 (excluding 1993 and 1996). The survey is usually conducted in October and November (but was undertaken from mid-September to end-October in 1989, 1990, 1992 and 1994, and in May during 1991). In 1988, two surveys were conducted, one in May the other in October. Since 1997, the main objectives have been: i) the construction of time-series of abundance indices for all commercial species in the Bay of Biscay and the Celtic Sea with an emphasis on the yearly assessed species where abundance indices at-age are computed; ii) to describe the spatial distribution of the species and to study their inter-annual variations; and iii) to estimate and/or update biological parameters (e.g. growth, sexual maturity, sex ratio).

Population indices from the French EVHOE survey were calculated for all elasmobranchs caught. Indices of abundance and biomass per year are only considered reliable for *L. naevus* (Figure 19.5a). For other species, the small numbers commonly taken (except in some few occasional hauls with high catches) do not allow reliable estimates. A presence–absence indicator and maps of three years catches by set are considered a useful approach to detect changes in habitats occupied by elasmobranchs (figures 19.5b–d; see also the Stock Annex).

The French EVHOE survey was not carried out in 2017.

19.6.2 Spanish survey data (Divisions 8.c and 9.a)

The Spanish IEO Q4-IBTS annual survey in the Cantabrian Sea and Galician waters (divisions 8.c and 9.a) has covered this area since 1983 (except in 1987), obtaining abundance indices and length distributions for the main commercial teleosts and elasmobranchs. The survey has a stratified random sampling design, with the number of hauls allocated proportionally to the area of each stratum. Results for elasmobranch species sampled in the IEO Q4-IBTS survey on the Northern Iberian shelf (Division 8.c and northern part of 9.a) were presented by Fernández-Zapico *et al*. (2018 WD). Depth stratification ranges from 70–500 m, therefore catch rates of shallower species, such as *R. undulata*, are low and cannot be used to estimate abundance or biomass indices. More information on this survey is given in the Stock Annex.

The Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz (Division 9.a) has been carried out in spring and autumn from 1993–2016 The surveyed area corresponds to the continental shelf and upper-middle slope (depths of 15–800 m) and from longitude 6º20’W to 7º20’W, covering an area of 7224 km^2.

Note: In 2012, the RV *Miguel Oliver* (owned by the Secretary General for Fisheries) replaced the RV *Cornide de Saavedra* and an inter-calibration was performed. In 2013, the first survey on RV *Miguel Oliver* was carried out after the results of the inter-calibration (Velasco, 2013). In 2014, a new inter-calibration experience was performed with the old vessel, R/V Cornide de Saavedra, to study the 2013 results and adjust again the gear in the new vessel R/V Miguel Oliver where the surveys are carried out (Ruiz-Pico *et al*., 2015).

19.6.3 Portuguese survey data (Division 9.a)

The Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) is conducted by IPMA, and aims to monitor the abundance and distribution of hake *Merluccius merluccius* and horse mackerel *Trachurus trachurus* recruitment (Cardador *et al*., 1997). In these surveys, *R. clavata* is the most frequent skate species caught (88% of the total weight of skates). For most of the time series the PtGFS-WIBTS-Q4 was conducted onboard the R/V *Noruega* and used a Norwegian Campelen Trawl gear with rollers in the groundrope, and 20 mm codend mesh size (ICES, 2015). In 1996, 1999, 2003 and 2004 the R/V *Noruega* was unavailable, and the surveys were conducted by the RV *Capricórnio,* using a FGAV019 bottom trawl net, with a 20 mm cod-end mesh size and a ground rope without rollers. In 2012, no vessel was available to conduct the survey. Those years in which the PtGFS-WIBTS-Q4 survey was conducted with a different vessel and gear were excluded from abundance and biomass analyses (Figueiredo and Serra-Pereira, 2013 WD).

The Portuguese crustacean surveys/*Nephrops* TV Surveys (PT-CTS (UWTV (FU 28–29)), also conducted by IPMA, aim to monitor the abundance and distribution of the main commercial crustaceans. The PT-CTS (UWTV (FU 28–29) is conducted on R/V *Noruega*, and uses a FGAV020 bottom trawl with 20 mm cod-end mesh size. No vessel was available to conduct this survey in 2004, 2010 and 2012 (ICES, 2012).

In 2018, updated information on the distribution (presence/absence), biomass and abundance indices and length range for *R. clavata*, *R. montagui* and *L. naevus* was presented (Serra-Pereira and Figueiredo, 2018 WD). In 2016, new information on other species caught in Portuguese research surveys, i.e. *R. miraletus*, *L. circularis* and *D. oxyrinchus* was also presented (Serra-Pereira and Figueiredo, 2016 WD).

19.6.4 Temporal trends

French EVHOE Survey (Subarea 8)

The biomass of *R. clavata* and *L. naevus* show generally the same trend as abundance. In *R. clavata*, peaks were observed in 2007 and 2014 and in *L. naevus* in 2002, 2004 and 2015 (Figure 19.6a-b).

The abundance of *R. clavata* showed no clear temporal trend over the time series, but several peaks were observed in 2001, 2004, 2007, 2008, 2011 and 2014 (Figure 19.6a). For most years, the abundance of *L. naevus* was higher than that of *R. clavata* and fluctuated over time but the overall trend shows an increase since 1997 (Figure 19.6b); high values were recorded in 2002, 2004 and 2014. The survey was also used to describe the spatial distribution by species over time (see Stock Annex).

Mean length of both species show no clear trend although in the case of *L. naevus* the highest mean length occurs in the last years of the series (Figure 19.6c).

L. naevus is distributed mainly in the northern area (Division 8.a) of the Bay of Biscay near the continental slope. Its abundance from 1987–1994 was lower than in the remaining part of the time series.

R. brachyura is always found near the coast but was recorded only in a few hauls in the north of Division 8.a. This species was not caught between 1991 and 2010.

R clavata is commonly caught in certain fishing hauls. It is distributed mainly in the northern and central areas of the Bay of Biscay, occurring near the coast and also in waters in the middle areas of the continental shelf.

R. montagui is found mainly in the northern waters of Division 8.a and, less frequently, in the northern parts of Division 8.b. As with *R. clavata,* this species occurs near the coast, but can also be found in the middle areas of the continental shelf.

R. undulata occurs only in a few shallow hauls close to the coast. Its distribution goes from the northern parts of Division 8.a to the southern parts of Division 8.b. *R. undulata* was not caught in 1987, 2002, 2003 and 2004.

Spanish IEO Q4–IBTS survey (Divisions 8.c and 9.a)

In 2017, of the five main elasmobranch catches per haul three were skates: *R. clavata* (4.89 kg haul^{-1}), *R. montagui* (1.33 kg haul^{-1}) and *L. naevus* (0.56 kg haul^{-1}), (Fernández-Zapico *et al*., 2018 WD). Compared to 2016 in 2017, all these three species decreased the average catches in biomass in the 8.c and 9.a taken together, although there were differences between both Divisions. Information below relates to the 2017 survey:

R. clavata: In 2017, the biomass of this species increased six times the value of the previous year in Division 9.a, 1.62 ± 1.48 Kg haul^{-1} against 0.25 ± 0.20 Kg haul^{-1} in 2016 and it also increased respect to the previous year in 8c Division, thought more softly (5.53 ± 1.84 Kg haul^{-1} against 4.35 ± 1.43 Kg haul^{-1} in 2016) (Figure 19.7a). The ratio of the mean biomass in the last two years (2016–2017) and the previous five years (2011–2015) was 1.08. Thornback ray caught in 2017 showed a wide length distribution as usual, with greater abundance in the eastern part of the Cantabrian Sea (Figure 19.7b). Sizes ranged from 11 cm to 97 cm in the last decade and during the last survey this range increased slightly for larger individual, until 100 cm. The few smallest specimens, between 11 and 19 cm, found in the last decade were also found this last survey for second consecutive year, after the absence in the two previous years (Figure 19.7c).

R. montagui: In 2017, the biomass slightly increased the values of the previous year, 1.62 ± 0.69 Kg haul^{-1} versus 1.41 ± 0.63 Kg haul^{-1} in 2016 ((Figure 19.8a) 4) and the last two years also increased the biomass of the previous five. This species is scarce in Division 9.a and widespread in Division 8.c as usual (Figure 19.8b). Spotted ray showed a narrower length distribution in the last survey than that showed for the last decade, shortening the range in both the smallest and largest sizes (from 20 to 69 cm versus the range for the last decade from 13 to 84 cm). Two modes are located in 43 cm and also in 52 cm, similarly the last one to the mode found for the last decade (Figure 19.8c).

L. naevus: In 2017, the biomass of this species increased slightly 0.69 ± 0.23 Kg haul^{-1} versus 0.45 ± 0.14 Kg haul^{-1} in 2016, maintaining the growing trend since 2015 and reaching the highest biomass in the historical series (Figure 19.9a), The species was absent in Division 9.a and widespread in Division 8.c as usual (Figure 19.9b). Length distribution in 2017 (ranged from 20 to 65 cm) remained similar to 2016 and also similar to that of the last decade (from 19 to 72 cm) (Figure 19.9c).

Portuguese surveys (Division 9.a)

Raja clavata (13–110 cm L_T) is found along the coast, from 23–751 m deep, but more common south off Cabo Carvoeiro and in waters shallower than 200 m deep (Figure 19.10a). Biomass and abundance indices have been relatively stable since 2005 and within the average values for the time-series with an increasing trend since 2015 (Figure 19.10b). The values in 2017 were the highest in the time series. Mean annual biomass index for 2016–2017 (0.52 kg h^{-1}) was 41% greater than observed in the preceding five years (2011–2015; 0.37 kg h^{-1}). The mean annual abundance index for 2016–2017 (1.36 ind. h^{-1}) was 91% greater than observed in the preceding five years (2011–2015; 0.71 ind. h^{-1}). The length-distribution was relatively stable along the time series, with the mean length above average in the last two years (Figure 19.10c).

Leucoraja naevus (14–65 cm L_T) is found along the coast, from 55–728 m deep, but is more common south of Cabo Espichel and in waters shallower than 500 m deep (Figure 19.11a). Biomass and abundance indices have been variable in the last seven years, with 2014–2015 showing a slight increasing trend within the average values for the time-series (Figure 19.11b). No *L. naevus* were caught in the 2016. In 2017, the species was only caught in one station. The observed lower catches of *L. naevus* do not follow the increasing trend observed in the Spanish (IBTS-GC-Q1-Q4 (ARSA) bottom trawl survey in the Gulf of Cadiz. No technical reason was found for the low catchability observed for the species in the last two years, apart from the later timing of the survey conducted in 2017, July/August instead of May/June (C. Chaves *pers. com.*). Mean annual biomass index for 2016–2017 (0.03 kg h^{-1}) was 83% smaller than observed in the preceding five years (2011–2015; 0.15 kg h^{-1}). Mean annual abundance index for 2016–2017 (0.06 ind h^{-1}) was 91% smaller than observed in the preceding five years (2011–2015; 0.64 ind h^{-1}). The length-distribution has been relatively variable during the time series, mainly due to higher catches of juveniles in certain years (Figure 19.11c). Mean length has been above the average since 2015.

Raja montagui (21–71 cm L_T) is found along the coast, from 21–400 m depth, but more common off the southwest coast of Portugal, at depths of 40–150 m (Figure 19.12a). Biomass and abundance indices have been stable over the time series, with an increasing trend since 2014–2015 and stable in 2016–2017 (Figure 19.12b). Mean annual biomass index for 2016–2017 (0.19 kg h^{-1}) was 32% greater than observed in the preceding five years (2011–2015; 0.14 kg h^{-1}). The mean annual abundance index for 2016–2017 (0.51 ind h^{-1}) was 60% greater than observed in the preceding five years (2011–2015; 0.32 ind h^{-1}). The length-distribution was relatively stable along the time-series, with the mean length above the average in 2016 and slightly below the average in 2017 (Figure 19.12c).

Spanish (IBTS-GC-Q1-Q4 (ARSA) bottom trawl survey in the Gulf of Cadiz (Division 9a South)

In the ARSA survey (1993–2015), the most abundant species were *L. naevus* and *R. clavata.* Both species showed an increasing trend in biomass since 1993, with the highest values reached in 2013. Although since 2013 the biomass shows important peaks and valleys the values in 2017 and 2018 remains very stable around 2.5 kg h^{-1} for both species (Figure 19.13a).

The abundance index (nº ind. h^{-1}) of *R. clavata* and *L. naevus*, despite being quite variable both show an increasing trend over the time series since 1993. The highest abundance values of *R. clavata* were recorded in the autumn 2013, 2015, and 2016 surveys, but decreased in 2017. The abundance of *L. naevus* strongly increased since Spring 2016 to the highest values ever recorded in 2017 and 2018 (Figure 19.13b).

19.7 Life history information

Studies on biological aspects, e.g. age and growth, reproduction, diet and morphometry, of the most frequently landed species, such as *R. clavata*, *R. brachyura*, *R. undulata*, *L. naevus* and *R. montagui* caught in Portuguese Iberian waters (Division 9.a) are available. Table 19.7 compiles the main biological information available. New data on the life-history traits of *R. undulata* in the Bay of Biscay were available (Stéphan *et al.*, 2014a). The length of first maturity was estimated to be 81.2 cm for males (n = 832) and 83.8 cm for females (n = 94). Exploratory growth analyses based on increase in size between tagging and recapture of the small number of tagged *R. undulata* for which size-at-recapture was recorded were consistent with growth estimates for the species in Portuguese waters. More information including diet and a trophodynamic model for the northern part of Division 9.a is available in the Stock Annex.

19.7.1 Ecologically important habitats

Recent studies have provided information on ecologically important habitats for *R. clavata*, *R. brachyura*, *R. montagui*, *R. microocellata*, *R. undulata* and *L. naevus* in Portuguese continental waters (Serra-Pereira *et al.*, 2014). Sites with similar geomorphology were associated with the occurrence of juveniles and/or adults of the same group of species. For example, adult *R. clavata* occurred mainly in sites deeper than 100 m with soft sediment. Those were also considered to be habitat for egg-laying of this species. *Raja undulata* and *R. microocellata* occurred preferentially on sand or gravel habitats. Potential nursery areas for *R. brachyura*, *R. montagui* and *R. clavata* were found in coastal areas with rock and sand substrates. Further details are given in the Stock Annex.

Information from trawl surveys on catches of (viable) skate egg-cases is considered valuable to further identify ecologically important habitats. Further information could be collected in trawl surveys.

19.8 Exploratory assessments

Previous analyses of the skates in this ecoregion were based on commercial LPUE data and on survey data. Updated analyses were conducted in 2016 (see below).

19.8.1 *Raja clavata* in the Bay of Biscay

A Bayesian production model was fitted to total catch in divisions 8.a-b and 8.d and EVHOE survey biomass indices (Marandel *et al.* 2016 WD; Marandel *et al.,* in press). The Cantabrian Sea, Division 8.c was not considered in this assessment.

19.8.1.1 Data used

The longest time series of commercial skate landings available for the Northeast Atlantic comes from the North Sea (Heessen 2003, Walker and Hislop, 1998), while historic landings of skates in the Bay of Biscay are unreliable with missing data for several countries in many years and unrealistic temporal patterns until the late 1990s. Therefore, a hypothetical time series of *R. clavata* landings from divisions 8.a-b, d was created for the period 1903–2013 by assuming that the overall trend between 1903 and 1995 followed that of total skate landings in the North Sea, and thereafter the landings collated by ICES were considered reliable (ICES, 2014). The overall level was set so that landings in 1995 were about the mean of ICES landings in 1996–1999, that is 400 tonnes.

A biomass index was calculated using data from the EVHOE bottom trawl survey in the Bay of Biscay (1987–2014) and from surveys carried out in 1973 and 1976. Post-stratification was used by first delineating the area occupied by *R. clavata* in each year and then calculating the swept area based total biomass in the occupied area. The post-stratified biomass index was strongly correlated to the usual design-based EVHOE index (not available for 1973 and 1976).

19.8.1.2 Methodology

Population dynamics were represented by a standard biomass production model with a Schaefer production function. It was based on a discrete-time sequential equation that represents the biomass dynamics of the population. The biomass at time $t+1$ depends on the biomass at time t, the production between times t and $t+1$ and the cumulative catches during the same period. Production was modelled by the Schaefer production function, which integrates biological processes such as recruitment and growth. This production function has two biological parameters: intrinsic growth rate r and carrying capacity K. The annual biomass distribution was truncated at both ends leading to a censored likelihood by assuming that the mean biomass cannot be much larger than the carrying capacity and that biomass is always higher than the hypothetical landings for a given time period.

As the hypothetical landings were uncertain but not necessarily biased, catches were modelled by a lognormal distribution with mean equal to the hypothetical landings and the variance corresponding to a constant coefficient of variation (CV) of 20%.

The observation model linked population biomass to the biomass index via a constant catchability. The observation error of the observed biomass index was modelled with a lognormal distribution and a constant variance τ^2, i.e. constant CV. It incorporates sampling variability and random variation in catchability.

In the case where instead of a biomass index time series only an observation of a depletion level was available, the observation model was replaced by a truncated normal distribution. The distributions of priors of all model parameters are detailed in Table 19.8.

For the Bay of Biscay, four runs were made using different data combinations and time periods to explore the sensitivity of the model to different data types. For the full run (FULL), the full hypothetical landings time series (1903–2013) and biomass index time series (1973, 1976, 1987–2013) were used in the model. To avoid having to make too many assumptions for reconstructing the catch time series, a run (SHORT) restricted to the recent time period (2000–2013) was also carried out. For this run the prior Y2000 used instead of that for *Y1903* (see Table 19.8). The landings only run (LANDINGS) represented the case where no biomass index was available, or where it was deemed unusable due to poor quality. The fourth run (DEPLETION) represented a situation where no biomass index but an estimate of the final depletion level d_{2014} was available. Given *R. clavata* in the Bay of Biscay is thought to be overexploited, a relatively small value was chosen (d_{2014}=0.1) with a small standard deviation (ε=0.05). These values are somewhat arbitrary but the aim was to compare the biomass trajectories obtained with a biomass index and with only information for the depletion level in the final year.

19.8.1.3 Results

The posterior density functions of carrying capacity, intrinsic growth rate, catchability and initial relative biomass are presented in Figure 19.14. The posterior biomass estimate trajectories of *R. clavata* for the four model runs are shown in Figure 19.15.

Although estimates of carrying capacity are uncertain, model outputs appeared to be in agreement with the generally accepted over-exploitation of the stock. It also suggests that the biomass has been rather stable since the 2000s. The EVHOE index for *R. clavata* is also uncertain, because of the low numbers caught each year. Lastly, the results are conditioned by strong assumption in particular the assumed constant intrinsic population growth rate, which may not be true as seen for spurdog (see Section 2), where a density-dependent increase in fecundity has been observed.

19.8.1.1 Exploration of length-based indicators

A sample of thornback ray landed from fisheries in the Bay of Biscay was measured as part of a French project aiming at a close-kin estimation of the abundance of the stock (http://www.asso-apecs.org/-GenoPopTaille-.html). This length distribution was used to fit the BLI and LBSPR (see ToR h chapter in this report).

19.8.2 *Raja undulata* in Divisions 8.a-b

Under the scope of the RAIEBECA and RECOAM tagging projects, data collected from 2011 to mid-2014 in the Bay of Biscay contributed greatly to knowledge of the spatial distribution, movements and biology of *R. undulata*. The results obtained showed that *R. undulata* can be found all along the Atlantic French coast, from the Loire estuary to the Spanish boarder, forming several discrete 'hot spots' of local abundance. The results obtained highly support that perception that this species has high site fidelity, generally only undertaking seasonal movements between deeper (>20 m deep) and shallow waters (Biais *et al.*, 2014; Stephan *et al.* 2014a, b).

For the Bay of Biscay and Western Channel, information on the reproductive biology (reproductive cycle, length at first maturity, length at 50% maturity ($L_{50\%}$ = 81.2 cm L_T in the Atlantic coast and 78.2 cm L_T in the western English Channel) and conversion factors were also obtained (Stephan *et al*., 2014b). Under the RECOAM project, information on the population genetic structure was analyzed (Stephan *et al*. 2014a, b). For more details on the methodologies and results obtained, see Biais *et al.* (2014); Leblanc *et al.* (2014); Stephan *et al.* (2014a, b) and Delamare *et al.* (2013) WD.

In the Bay of Biscay and in the western English Channel, 48.7% and 58.4%, respectively of the skates marked and released were later recaptured in the same location. Furthermore, 89.7% and 75.3% of the skates marked and released in the Bay of Biscay and in the western English Channel, respectively, were recaptured less than 20 km from their original release location.

Exploratory assessments were presented by Biais *et al*. (2014 WD). A mark–recapture survey provided a biomass estimate in the Bay of Biscay, particularly for the Gironde Estuary and for the stock of larger fish (>65 cm L_T). The habitat surface (Figure 19.16) and estimated density indices (Table 19.9) were used to determine the biomass of fish >65 cm, which ranged between 87–120 tonnes in the whole central part of the Bay of Biscay.

The tagging survey also provided catch-at-age ratios, using the length distribution to get number-at-age, using age slicing based on the von Bertalanffy growth curve parameters estimated by Moura *et al*. (2007) for the Portuguese stock. Ages between 9 and 10 were considered unaffected either by the gear selectivity, or by a possible decrease in vulnerability to the longline of the larger fish, at least in November–December (Table 19.10). The ratio obtained provided an estimate of total mortality-at-age 4 in 2008, before the landing ban, and of the fishing mortality (0.17) using the natural mortality estimate as 0.27 from central Portugal (Serra-Pereira *et al*., 2013 WD), assuming that fishing mortality was negligible after the ban implemented in 2009.

Abundance-at-ages 4 and 5 in 2008 were estimated using the mark–recapture abundance estimates at ages 10 and 11 at the beginning of 2014 (ages 9 and 10 at the end of 2013) and considering that fishing mortality-at-age 5 is similar to age 4 in 2008 and that the population was subject to natural mortality only from 2009 onwards.

Based on these estimates, catch and spawning biomass may be estimated in 2008 and in following years, making assumptions about the fishing mortality pattern in 2008. The aim was to investigate the biomass trend since the 2009 landings ban and the consistency of mark–recapture estimates regarding in particular the 2008 catch for which a second estimate was available (Hennache, 2013; cited by Delamare *et al*., 2013 WD). The simulations were carried out for the low and the high abundance estimates which were provided by the mark–recapture survey (Table 19.11).

A flat selectivity-at-age was adopted above age 7, assuming that fish large than 73 cm L_T were subject to the same catchability. Fishing mortality-at-age 6 was fixed to the average of fishing mortalities-at-ages 5 and 7 to smooth the transition between these ages.

Fishing mortalities-at-ages 3 and younger ages were assumed negligible considering that these ages are all discarded and may have high survivorship.

Under these assumptions, fishing mortality-at-age 7 is the only missing parameter to estimate the stock numbers at all ages in 2008 from stock numbers-at-ages 5 and 6. It was estimated assuming that recruitment at age 0 was lower than the estimate of egg number released by the females, calculated using the sex ratio observed in tagging surveys and fecundity estimates from Portuguese waters (Figueiredo *et al*., 2014 WD). This constraint requires that the fishing mortality-at-age 7 is less than 0.76 for the low as well as the high abundances-at-ages 5 and 6 estimated from the mark–recapture survey.

The corresponding catches are 43 tonnes and 60 tonnes in 2008, depending on whether the low or the high abundances-at-ages 5 and 6 are used. Catch in 2008 was estimated between 60 and 100 tonnes by Hennache (2013), using fish auction market data (cited by Delamare *et al*., 2013 WD). This latter catch is consequently estimated too high and/or the abundances are underestimated by the mark–recapture survey.

To estimate stock numbers in 2015, constant recruitment was assumed. The spawning–stock biomass was estimated by adopting a knife edge maturity-at-age derived from available age-at-maturity available (Stephan *et al*., 2014a WD). Note that the constant recruitment assumption has no effect on the spawning biomass trend from 2008 to 2015 as maturity is estimated to occur at age 8. At half of the higher fishing mortality-at-age 7, the spawning biomass was estimated to have been multiplied by 4 for both the high and low assumed fishing mortalities (to about 190 tonnes or 270 tonnes respectively for the low and high abundance estimate). These absolute spawning stock biomass estimates are sensitive to abundances estimated by the mark–recapture survey, but the increasing trend in spawning biomass is not.

However, these results must be considered with caution, as several assumptions were made, including the 100% effectiveness of the ban on landing associated with a high survivorship of discards implied by the zero fishing mortality from 2009 to 2015.

19.9 Stock assessment

ICES provided stock-specific advice in 2016 for 2017 and 2018. Given the limited time range of species-specific landing data, and that commercial and biological data are often limited, the status of most skate stocks in this ecoregion is based primarily on survey data, following the Category 3 of the ICES approach to data-limited stocks. Further analyses of survey data (see Section 19.6) and catch rates were undertaken. Due to the absence of survey data for some of the species in this ecoregion (e.g. rjh.27.9a, rju.27.9a), other approached were adopted for the advice (e.g. LPUE or self-sampling data).

In this section, data and analyses are summarized by stock units for which ICES provides advice. No updated assessments were undertaken in 2017, with the information below relating to work conducted in 2016. The next assessments and advice are scheduled for 2018.

19.9.1 Thornback ray (*Raja clavata*) in Subarea 8 (Bay of Biscay and Cantabrian Sea) (rjc.27.8)

In the Spanish IEO Q4-IBTS survey the biomass of the most abundant ray in the area, *Raja clavata,* showed an increasing trend in 2017.

The indicator of occurrence by haul of net set based upon French on-board observations was updated. It shows that *R. clavata* is caught in a significant proportion of hauls only by the OTT_DEF métier, which operates mainly offshore in the Bay of Biscay. For this métier, the indicator suggested an increasing trend since 2007 (Figure 19.16a). The occurrence in other métier is lower and does not show clear signal.

Supporting studies using data from French on-board observations, showed that *R. clavata* is caught in a significant proportion of hauls only by the OTT_DEF métier, which operates mainly offshore in the Bay of Biscay. The indicator suggested an increasing trend (Figure 19.17a). For this stock, however, on-board observations may not sample effectively some of the coastal sites of local abundance that occur in some bays and estuaries, such as the Gironde.

Marandel *et al*. (2016 WD) developed a Bayesian state-space model with landings and limited survey (EVHOE) data to estimate population biomass in the Bay of Biscay. This exploratory assessment concluded that the estimated biomass of *R. clavata* in 2014 was *ca.* 3% of carrying capacity. However, this conclusion should be made carefully because indices of abundance and biomass per year from the EVHOE survey can be highly variable for *R. clavata*, so may not be robust, and there is also uncertainty in the longer time-series of landings data.

A larger sample of tissue (fin clips) of landed thornback ray was collected in the Ifremer GenoPopTaille project, funded by the National Agency for Research (ANR). The length distribution of this sample was considered representative of landings from Divisions 8.ab and 8.d and used for exploratory length-based indicators (LBI and LBSPR, see ToR h chapter in this report). The length-distribution in this sample was not compared to data from Division 8.c.

19.9.2 Thornback ray (*Raja clavata*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz) (rjc.27.9a)

The status of this stock is evaluated based on survey data derived from the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4; Figure 19.9) and the Spanish ARSA survey in Gulf of Cadiz (SpGFS-GC-WIBTS-Q1 and SpGFS-GC-WIBTS-; Figure 19.12b and 19.13a). The biomass index from the PtGFS-WIBTS-Q4 was stable over the overall series. Both ARSA surveys series indicate a long-term increasing trend (from 1997–2017 and 2018 with a stable biomass status since the Spring 2017).

Combined survey data suggest an increasing trend since 1997 with maximum values observed in the most recent years of the series. Following the ICES DLS approach for Category 3 stocks, the annual trend on the combined surveys (each survey scaled to their average for the overall period) has increased consistently for the overall period.

The ratio between the average biomass index for the last two years (2016–2017) and the average of the biomass index for the reference period (2011–2015) was 1.19.

Auxiliary information provided by the Spanish IEO Q4-IBTS survey in 9.a North, where *Raja clavata* is the most abundant ray caught in the area, also showed an increasing trend in the biomass. Due to the irregular catches of *R. clavata,* this survey is not used in the assessment.

19.9.3 Cuckoo ray (*Leucoraja naevus*) in Subareas 6-7 (Celtic Sea and West of Scotland) and Divisions 8.a-b,d (Bay of Biscay) (rnj.27.678abd)

This stock is addressed in Section 18.

19.9.4 Cuckoo ray (*Leucoraja naevus*) in Division 8.c (Cantabrian sea) (rjn.27.8.c)

In Division 8.c, the catch rates in the Spanish IEO Q4-IBTS survey showed an important increase (0.67 kg haul^{-1}) in 2017; higher than in the two precedent years (Figure 19.9a). Cuckoo ray length-distribution in 2017 remained similar to the last decade, (Figure 19.9c).

The ratio between the mean biomass index for the last two years (2016–2017) and the mean biomass index for the reference period (2011–2015) was 1.37.

19.9.5 Cuckoo ray (*Leucoraja naevus*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz) (rjn.27.9a)

The status of this stock is evaluated based on survey data from the Spanish ARSA surveys in Gulf of Cadiz (Q1 SP-GCGFS and Q4 SP-GCGFS).

Both ARSA surveys series indicate a long-term increasing trend, with the highest records of abundance and biomass in 2017 and 2018

The ratio between the mean biomass index for the last two years (2016–2017) and the mean biomass index for the reference period (2011–2015) was 1.43.

Although not used in the assessment, due to some missing values in recent years, the data series from the PT-CTS (UWTV (FU 28–29) also indicates an overall stable trend (Figure 19.10b).

19.9.6 Spotted ray (*Raja montagui*) in Subarea 8 (Bay of Biscay and Cantabrian Sea) (rjm.27.8)

The biomass index for *R. montagui* in the Spanish IEO Q4-IBTS survey is the highest recorded in Division 8.c since 2014 (Figure 19.7b).

The ratio between the mean biomass index for the last two years (2016–2017) and the mean biomass index for the reference period (2011–2015) was 1.18.

Supporting studies using data from French on-board observations indicate that *R. montagui* is observed in a small proportion of hauls. There have been more records in recent years (Figure 19.16b). The reliability of this potential indicator may, however, be undermined by confusion between *R. brachyura* and *R. montagui*.

Raja montagui is caught sporadically in the EVHOE survey, mostly in the north (Figure 19.18). The occurrence of this species in the survey does not suggest any recent change in abundance (Figures 19.19).

19.9.7 Spotted ray (*Raja montagui*) in Division 9a (west of Galicia, Portugal, and Gulf of Cadiz) (rjm.27.9a)

The status of this stock is evaluated using data from the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4). The biomass and abundance indexes have been stable along the time-series, with an increasing trend in 2014–2015 and stable in 2016–2017 (Figure 19.12b). The length distribution was relatively stable along the time-series, with the mean length above the average in 2016 and slightly below the average in 2017 (Figure 19.12c).The ratio between the average biomass index for the last two years (2016–2017) and the average biomass index for the reference period (2011–2015) is 1.32.

The time-series for *R. montagui* in the ARSA surveys is erratic and with many gaps in recent years with an important peak in the biomass and abundance values in 2016 and 2017. There are no records of this species in the Spanish IEO Q4-IBTS survey in Division 9a over the whole time-series. These surveys are not used in the assessment.

19.9.8 Undulate ray (*Raja undulata*) in Divisions 8a,b (Bay of Biscay) (rju.27.8ab)

The EVHOE survey is uninformative for this stock because the distribution of *R. undulata* is more coastal than the area surveyed. Exploratory assessments were presented by Biais *et al*. (2014 WD) and summarized in Section 19.8.2.

Data collected from the French on-board observation programme indicated that *R. undulata* is caught in a high proportion of hauls in three métiers. The numbers of observations by métiers catching the species are unbalanced. The main métier catching *R. undulata* was GTR_DEF, and data suggested a steady increase in occurrence. This is based upon more than 4000 observations (Figure 19.16c). The three other selected métiers have either a high occurrence of the species with a moderate on-board observations sample size (OTB_SEP, OTB_DEF) or a low occurrence and a high total number of observations (GNS_DEF). No trend was apparent in these métiers.

The trend seen in GRT_DEF is likely the most representative of the stock, because there is a large sample size, the spatial distribution of sampled fishing operations has been fairly stable, and effort covers the main areas of occurrence of the species during the period (Figure 19.20).

19.9.9 Undulate ray (*Raja undulata*) in Division 8.c (Cantabrian Sea) (rju.27.8c)

There are no longer-term survey data to assess temporal trends in this stock.

Scientific studies carried out in the eastern parts of Division 8.c have been conducted to characterize the specific composition of the landed skates, the species-specific CPUE and the geographical distribution of the catches (Diez *et al.*, 2014). During the period 2011–2013, up to 118 trips/hauls of 21 vessels of the trammel net fleet from the nine main ports of the Basque Country were sampled. *Raja undulata* was the fifth most important species caught (5% of the total).

Whilst the total estimated ICES landings from 2005–2014 were 0 t, this period covers several years for which species-specific data were not required and then a period for which *R. undulata* could not be landed legally. Following relaxation of the prohibited status in 2015, and allowance for small quantities of bycatch to be landed, landings of 5 tonnes were reported.

The historical landings data is uninformative and unrepresentative of population levels. According to fishing interviews, this species is locally frequent and widely distributed in the coastal waters of Division 8.c, although not very abundant in catches. This situation may not have changed over the years.

R. undulata is very scarce in the Spanish IEO Q4-IBTS survey in Division 8.c and usually lower than 0.1 kg $haul^{-1}$ in any year of the series. This due to the fact this species is distributed mainly out of the surveyed ground, in shallower areas not covered because they are not accessible to the vessel and the gear used.

19.9.10 Undulate ray (*Raja undulata*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz) (rju.27.9a)

Raja undulata is absent in the Spanish IEO Q4-IBTS survey in Division 9.a and rarely caught in the Portuguese demersal survey (PtGFS-WIBTS-Q4).

By the end of the moratoria period IPMA developed a dedicated project to *R. undulata* – UNDULATA that involved onboard-observations, self-sampling and tagging studies. Under this project a new approach integrating fishermen self-sampling data and onboard observations was tested. The aim of this approach was to estimate abundance of the species along the Portuguese continental coast using georeferenced fishery data. The statistical procedure developed involves the adjustment of an N-mixture model to spatially replicated species count data (Royle, 2004). During the UNDULATA this procedure was applied to the data collected during 2015 in the region of Setúbal and Sesimbra (Southwest of Portugal), an area where the species is known to concentrate. The description of the procedure, as well as, the potential density estimates for the former area were presented in the Figueiredo *et al.* (2015, WD).

Also under the UNDULATA project and using historical data from the IPMA landing sampling program, *R. undulata* landings for the period 2003–2008 were estimated. The data used consisted on the landed weight by skate species, including *R. undulata*, collected from vessel trips sampled between 2003–2009 at the main Portuguese landing ports: Matosinhos, Póvoa do Varzim, Peniche and Portimão (DCF Portuguese program). The relative weights of *R. undulata* landed at each landing port for each of two main fishing segments (trawl and polyvalent) were estimated annually. The posterior relative weight median estimates, as well as the posterior interquartiles, were obtained through the adjustment of a Bayesian hierarchical GLM model using the sampling data available for each year and port. These estimates were then used to determine Portuguese historical annual landings of *R. undulata*. Due to the localized distribution of the species, in particular close association to shallow sandy bottom, landing ports along the Portuguese continental were first grouped based on the topography and bottom type off their adjacent coastal areas. For each cluster, historical annual landings of *R. undulata* were calculated using the posterior estimates of relative landing weight of the species and the total Rajidae landings. Further details on the estimation procedure are described on Maia *et al*. (2015, WD).

In 2015 EU Commission request on *Possible by-catch provisions for undulate ray in ICES areas VIIde, VIIIab and IX* STECF noted that *lack of basic catch and effort data and the limited survey coverage remains a barrier to the development of an analytical assessment based on fishery dependent and independent data…* and … *that it is not in a position to determine whether such landings levels are in accordance with the provisions of the CFP* (STECF-15-03). In 2016 small by-catches of the species in ICES subareas 8 and 9 were introduced (Council Regulation (EU) 2016/72).

In face of EU by-catch allowance, Portuguese authorities adopted, in 2016, the following legislation: i) only vessels possessing a special fishery license were allowed to catch *R. undulata*; ii) the skippers of the licensed vessels authorize the onboard presence of IPMA scientific observers for data collection; iii) licensed vessels are obligated to gather and report information on *R. undulata* capture by fishing haul; iv) only specimens over 780 mm and smaller than 970 mm in total length are allowed to be landed; v) daily landings should not comprise more than 30 Kg live weight per fishing trip and; vi) the landing prohibition during the months of May and June (Portaria no 96/2016, April 2016). In 2017, and as result of the new TAC adopted by EU for the species, Portuguese authorities reviewed the legislation (Portaria no 27/2017 January 2017). The by-catch quotas assigned to Portugal were 12 tonnes and 14 tonnes in 2016 and in 2017, respectively. Based on this by-catch quota, Portugal implemented a closed monitoring plan in line with the scientific advice received from the STECF which stated that "*restricted and closely monitored by-catch may assist with the development of an analytical assessment and could be used as a future indicator of stock development and the basis of an adaptive management strategy*" (STECF-15-03).

In 2016, a total of 53 license fishing permits were attributed to fishermen distributed along the Portuguese continental coast. The fishing license scheme began after the Portuguese Rajidae closed fishing period, which was set in 2016 and encompassed the months from May to June (Portaria nº 47/2016). In 2017, a total of 50 license fishing permits were attributed, from 16 different fishermen associations, geographically distributed along the Portuguese continental coast.

Data collected in 2016 are considered as the experimental phase as some time is required for fishermen to encounter and understand the monitoring program, and to comply with its requests. Given this, only data collected during 2017 were considered for abundance/biomass and potential catch estimates.

For 2017, the potential abundance of *R. undulata* was estimated for different regions off the Portuguese continental waters (Figueiredo *et al.,* 2015). For estimating *R. undulata* potential abundance the two predictors, depth and bottom sediment, considered to be closely related to the species distribution, were included in the model (Figure 19.23). The potential biomass was estimated by multiplying the abundance estimates by an estimate of the mean individual weight:

Region	Year	Potential total abundance (n)	Area (km_2)	Average potential number per km_2	Potential total estimated weight (ton) (n*average weight)
North	2017	236034.2	1525.3	154.7	1426.5
Center	2017	10 772.8	3503.6	3.1	65.1
Southwest	2017	201456.7	2132.9	94.4	1217.5
South	2017	1641420	1330.4	1233.8	9919.9

Using the length data collected under the UNDULATA project, a length-cohort analysis (LCA) with Rodney approach was adjusted. Fishing mortality estimate was 0.07, this value is consistent with the fact that the species was under moratoria but some mortality due to fishing may occur as a consequence of fishing operations taking place where the species occurs. Also using the available knowledge of species biology and dynamics a Beverton-Holt yield per recruit (Y/R) model was adjusted. The fishing mortality for different potential spawning ratio were estimated Table 19.14.

19.9.11 Blonde ray (*Raja brachyura*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz) (rjh.27.9a)

This is a coastal species with a patchy distribution that is caught infrequently by both Spanish and in Portuguese surveys in Division 9.a (usually lower than 0.1 kg $haul^{-1}$ in any year of the series). Consequently, abundance indexes derived from these surveys are not considered indicative of stock status. In this case, the status of the stock is assessed based on fishery-dependent data (landings, effort and length structure).

Annual standardized LPUE estimates determined for Portuguese polyvalent fleet (this fleet represents nearly 90% of the species total landings) for the period 2008–2015 do not show any trend.

The yield per recruit (Y/R) and potential spawning ratio (%SPR) curves at long term for different levels of fishing mortality and age of first capture (TC) were estimated using the polyvalent fishing data as described in the Stock Annex.

The actual F (F_{CURR}=0.17) is at a level correspondent of about 30% of the virgin exploitable spawning biomass ($F_{30\%SPR}$ = 0.15) indicating that the stock has been exploited at a sustainable fishing rate (Figure 19.21).

19.9.12 Common skate *Dipturus batis*-complex (flapper skate *Dipturus batis* and blue skate *Dipturus* cf. *intermedia*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters) (rjb.27.89a)

Recently *D. batis* has been confirmed to comprise two species, and although the nomenclature is still to be ratified, the smaller species (the form described as *D. flossada* by Iglésias *et al.*, 2010) will probably remain as *Dipturus batis* and the larger species may revert to *D. intermedia.*

These species are only caught occasionally in Subarea 8 and might not occur to any degree in Division 9.a.

Despite the *Dipturus batis*-complex being prohibited in EU regulations, some individuals were landed occasionally in French and Spanish fish markets in Subarea 8. In France, sampled specimens in fish markets included an adult female *Dipturus* cf. *intermedia* (200 cm L_T) - a southerly record of the species in recent years; and small individuals of *Dipturus batis* caught at the Glénan archipelago (southern Brittany). As these species are now extirpated from inner shelf areas of their former range, fishermen are not always able to identify them accurately. Available information does not change the perception of the stock status of these species that occur at low levels in this ecoregion.

Differing to other areas, *D. oxyrinchus* was included in 2016 and in 2018 advice for the raj.27.89a and not for rjb.27.89a. It is important to highlight that all landings of the genus *Dipturus* from Portugal in Division 9.a refer to *D. oxyrinchus*, for Spain and France official landings of *D. oxyrinchus* were considered to be correctly identified and all the remaining official landings of the genus *Dipturus* from this ecoregion were allocated to *Dipturus* spp., as species identification problems persist among species of the genus *Dipturus* (Figure 19.22).

19.9.13 Other skates in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters) (raj.27.8. and 9a)

Sandy ray *Leucoraja circularis* occurs on the deeper shelf and along the slope of the Bay of Biscay and in minor abundance in Portuguese landings. Minor occurrences of the shagreen ray *Leucoraja fullonica* are also observed to the North of Division 8.a, but this species is largely absent from Division 9.a. Owing to the higher abundance of these two species in the Celtic Seas, the Bay of Biscay may comprise the southern limits of the Celtic Sea stocks.

In Divisions 8.a-b, occasional catches of *Raja brachyura* and *Raja microocellata* are found at the coast by artisanal fisheries. These two species are scarce in the historical time-series of the Spanish IEO Q4-IBTS survey in divisions 8.c and 9.a.

All four of these species are caught in too small numbers in the EVHOE survey to calculate reliable population indices.

In Division 9.a, *Raja microocellata*, *Raja miraletus* and *D. oxyrinchus* appear occasionally in landings. The two latter species are caught in low numbers in Portuguese surveys.

As mentioned in the previous section, landings allocated to *D. oxyrinchus* were included in this stock.

19.9.14 Summary of the status of skates stocks in the Bay of Biscay and Atlantic Iberian waters

The following table provides a summary of stock status for the main species evaluated in 2016 and using ICES DLS approach.

Species	ICES stock code	ICES DLS Category	Perceived status
Thornback ray	rjc.27.8	3	Survey indices increasing in Subarea 8
Raja clavata	rjc.27.9a	3	The stock size indicator shows an increasing trend since 1999
Cuckoo ray	rjn.27.67	3	The stock size indicator has been relatively stable with an increase in recent years.
Leucoraja naevus	rjn .27.8c	3	The stock size indicator has been fluctuating with no trend
Spotted ray *Raja montagui*	rjm.27.8	3	The stock size indicator is variable. Recent survey estimates are among the highest of the series
	rjm.27.9a	3	The stock size indicator has increased and in the 2015 was the highest in the time-series.
Undulate ray *Raja undulata*	rju.27.8ab	6	Survey data are not informative for this stock
	rju.27.8c	6	Survey data are not informative for this stock
	rju.27.9a	6	Survey data are not informative for this stock
Blonde ray *Raja brachyura*	rjh.27.9a	3	The stock size indicator is stable in relation to five previous years
Common skate *Dipturus batis* complex	rjb.27.89a	6	Data are available do not inform on stock dynamics, species composition, catch, or landings. There are currently no robust stock size indicators.
Other skates	raj.27.89a	6	There are insufficient e data available to assess these species. The decline in landings is due primarily to the improved species-specific reporting.

19.10 Quality of assessments

No full analytic stock assessments have been conducted for skates in Subarea 8 and Division 9.a.

LPUE data for *L. naevus and R. clavata* are available for Divisions 8abd since 2001. Since 2008 LPUE were available for *R. clavata*, *R. microocellata*, *R. montagui*, *R. undulata* and *R. brachyura* in Division 9.a.

In the last five years, a lot of effort has been made by the countries involved in the demersal elasmobranch fisheries on this ecoregion to provide species-specific landings of skates. As a result of this improvement in the data, 19 different species have been identified (plus a general category "Rajidae") from catches in Subareas 8 and 9. A summary of the information available of the species-specific landings of skates by country is shown in Tables 19.1f and 19.2.

The French DCF programme of on-board observations was used as supporting information to appraise temporal trends in stock abundances. Abundance was assessed by the proportion of fishing operations (trawl haul or net set) with catch (discards, landings or both) of the species in the stock area from 2007–2015. Fishing operations were aggregated by DCF level 5 métiers. The four top ranking métiers (limited to those with more than 50 sampled hauls) were used to indicate stock status.

As for surveys in other ecoregions, surveys in Subarea 8 and Division 9.a were not specifically designed for elasmobranchs, producing a high frequency of zero-catch data. The fishing gear used and survey design are not the most appropriate to sample elasmobranchs, especially for species with patchy distributions. The survey effort in coastal areas is very scarce and does not cover a wide range of depths. Nevertheless, for some species, it is possible to estimate some valuable abundance data and by that derive temporal trends on abundance.

Efforts have been made to overcome these data limitations in order to standardize the fishery-independent abundance indexes, using as an example the estimates for *R. clavata* data from the autumn survey (PTGFS-WIBTS-Q4) in Division 9.a (Figueiredo and Serra-Pereira, 2013 WD). To deal with the large amount of zero-catches a generalized linear mixed model (GLMM) was fitted to the data, assuming a Tweedie distribution for the observations. One of the main purposes of applying a GLMM was to incorporate in the model variables that could account for differences between years, namely the difference between stations, depths, survey methodology, etc. Some decisions/assumptions had to be taken in order to proceed with the analysis of the data, including the determination of a subset of the available data which is better represents the geographical distribution of the species.

Tagging studies of *R. undulata* have shown that the distribution of this species is discontinuous, confirming the 2013 tagging results and the need to assess the state of the stocks of this species for areas that fit with the limited movements that this species may make. This behaviour may be a benefit for obtaining mark–recapture stock estimate as the one provided for central part of the Bay of Biscay. Results allow an exploratory analysis including a lot of assumptions. Consequently, it must be regarded as only indicative of the biomass trend.

In Portuguese waters the coastal nature of the *R. undulata* occurrence and the habitat preferences, shallow sandy bottoms (~ down to 50 m) hinders the collection of adequate data from IPMA surveys that allow to inform on stock status. Also the small bycatch quota assigned to Portugal is considered insufficient to obtain the complete spatial coverage of the species distribution area and by that estimate its potential abundance using the self-sampling data provided by licensed fishing vessels.

Using the IPMA results obtained in 2017 and to guarantee the full spatial coverage of fishery dependent data on species in Portuguese continental coast the sampling effort needs to be increased. Figure 19.24 presents the sampling spatial requirements for the full coverage.

19.11 Reference points

No reference points have been proposed for the stocks in this ecoregion.

19.12 Conservation considerations

Initial Red List assessments of North-east Atlantic elasmobranchs were summarized by Gibson *et al.* (2008). In 2015, the European Red List of Marine Fishes was published

(Nieto *et al.*, 2015), and relevant listings given below (noting that these are on a Europe-wide scale for each species, and are not stock-based):

SPECIES	IUCN RED LIST CATEGORY
Dipturus batis	Critically Endangered
Rostroraja alba	Critically Endangered
Leucoraja circularis	Endangered
Leucoraja fullonica	Vulnerable
Dipturus oxyrinchus	Near Threatened
Raja brachyura	Near Threatened
Raja clavata	Near Threatened
Raja microocellata	Near Threatened
Raja undulata	Near Threatened
Leucoraja naevus	Least Concern
Raja miraletus	Least Concern
Raja montagui	Least Concern

19.13 Management considerations

A TAC for skates in this region was only introduced in 2009, along with requirements to provide species-specific data for the main commercial species (initially *L. naevus* and *R. clavata* and, since 2013, *R. brachyura*). Consequently, there is only a relatively short time-series of species-specific landings. In the case of Portugal, estimates of species-specific landings based on DCF sampling data are available since 2008.

Landings of *Raja undulata* were not allowed between 2009 and 2014 (inclusive), with a bycatch allowance only established for Subarea 8 since 2015, which was then extended to Division 9.a. in 2016. Consequently, landings data for *Raja undulata* are not indicative of stock status. However, landings and discards data could be indicative of stock status for this species along with several monitoring's years according to self-sampling program (French and Portuguese) in these areas.

Currently, fishery-independent trawl survey data provide the longest time-series of species-specific information. These surveys do not sample all skate species effectively, with more coastal species (e.g. *R. brachyura, R. microocellata* and *R. undulata*) not sampled representatively.

Biological data and the relative high discard survivorship indicate relatively high resilience of *R. undulata* to exploitation compared to other skate species.

The status of more offshore species, such as *L. circularis* and *L. fullonica*, are poorly understood, but these two species may be more common in the Celtic Seas ecoregion (see Section 18).

Some of the larger-bodied species in this ecoregion are from the genus *Dipturus*, but data are limited for all these species, with some potentially more common further north.

19.13.1 Fishery-science projects to estimate abundance of *Raja undulata* stocks

In 2015, a monitoring plan for *R. undulata* was required by WGEF. This would involve the design of a fishery scientific survey (e.g. sentinel fishery) which would function in cooperation with commercial fishermen in particular small-sized vessels and inshore where the species tend to concentrate. A detailed description of the sentinel fishery regarding main aspects in the sampling plan design and data requirements was presented in ICES WGEF Reports 2015 and 2016.

Data requirements are summarized below:

Vessel	Vessel name and registration number Vessel technical characteristics (e.g. LOA, tonnage, power, etc.) Registration port Skipper identity and experience
Trip	Date and time of departure/arrival Fishing port of departure/arrival Observer's Identification
Environment condition	Tidal state, sea conditions (e.g. wave height, wind strength) Water temperature
Gear characteristics	Gear type, state (new, good state) For gillnet and trammel net: length and height in meters, mesh in millimetres, number of net units, length of a net unit sheet For longline: length in meters, number, size and type of hooks, type of bait For trawl, dredge: gear dimensions, mesh size, trawling speed, presence of tickler chains, description of gear
Fishing haul	Operation ID Date/time of gear deployment and retrieval Geographic location of the fishing haul (including set and hauling) Fishing depth Soaking/trawling time
Biological data	From all the target species, data collected should include: Coordinates of the capture location Biometric measurements such as total length (from nose to tip of tail), width (from one wing to the other) and body weight Health status (lively, sluggish or dead) Sex Maturity stage (whenever possible) Collected tissue samples of specimen (if from live fish, in accordance with appropriate animal welfare protocols) Survivorship of discarded individuals If marked, the number of the mark should be recorded

19.13.2 Monitoring of *Raja undulata* captures

In 2016, Council Regulation (EU) 2016/458 of 30 March 2016 amended Regulations (EU) 2015/523 as regards individual TACs for *R. undulata* in ICES Divisions.

The use of these *R. undulata* individual quotas is guided by scientific protocols *"to ensure the continuity of scientific studies and to assess the state of the resource and ensure, in the future, its sustainable exploitation"* (COUNCIL REGULATION (EU) 2016/72 of 22nd January 2016). Under this regulation, only vessels possessing a compulsory fishery license were allowed to catch *Raja undulata*. Simultaneously, licensed vessels are obliged to record information on species captured by fishing haul and report it to national agencies (Direction des Pêches Maritimes et de l'Aquaculture, DPMA) of the French Ministry for Agriculture and Fisheries and to the General Directorate for Natural Resources, Safety and Maritime Services (DGRM) in France and Portugal respectively).

Portugal:

Historically, in the Portuguese official landings, *R. undulata* was landed under a generic category that encompasses several skate species. This situation limited the use of Portuguese official landings to evaluate historical landings of the species. Under the UNDULATA Project, historical landings of *R. undulata* for the period of 2003–2008 were estimated. The annual median estimates of *R. undulata* landed in Portugal mainland as well as the interquartile estimates are presented in Table 19.12.

Under the *R. undulata* by-catch quota assigned to Portugal and national management measures, fishery information is collected by fishermen and includes: i) date of the fishing haul; ii) fishing haul geographic locations; iii) fishing haul technical characteristics (number and mesh size of the gear and duration); iv) total catch in number and in weight; v) total number of specimens with total length smaller than 780 mm and larger than 970 mm; and vi) number of reproducing females (not mandatory). Using the fishery information from the small experimental quota set for *Raja undulata* in ICES Division 9.a, Portuguese polyvalent potential estimates of species catches in the continental coast were determined for 2017. The data consisted of official national polyvalent daily landings for 2017, provided by the Portuguese Directorate General for Natural Resources (DGRM). Trips from vessels that landed *R. undulata* at least once during 2017 were used to create a classification rule. The classification rule was determined to predict the plausibility of *R. undulata* been caught in a fishing trip of a vessel of the polyvalent fleet operating in the Portuguese coast. For this, landings data at trip level and species composition of landings were used as predictors. Species considered were those occurring in more than 25% of the trips.

The analysis was performed for each region (North, Centre, Southwest and South) where the species is likely to concentrate. Also, given the well-known heterogeneity in the polyvalent fleet and the assumption that the catch weight is proportional to the vessels capacity, vessel size category was considered in the analysis.

Fishery self-sampling data from the Portuguese monitoring plan for *R. undulata* were used to estimate mean caught number and weight for each group of region and vessel size category. Using these estimates, the number of trips with potentially positive catches of *R. undulata* and the total catch in weight per trip were calculated and then summed by region and vessel category (Table 19.13.)

It is important to note that although the available fishery information on *R. undulata* is still short, it is considered a reliable source for the monitoring of species stock status. The role of fishermen in the monitoring process is a key element and they need to be aware of their importance on the process, in particular in providing reliable information. Some of the weaknesses identified on the first fishermen's reports were partially overcome in the second year.

France:

First results are described in more detail in Gadenne (2016 WD).

The data collected during the self-sampling 2016 monitoring program indicate that 64 vessels participated in the protocol out of 125 authorizations issued. A total of 7079 hauls were reported, but only 64% were considered valid for analysis.

In 2016, a total of 41.5 tonnes were landed and 117.7 tonnes were declared discards. They were captured by 7 types of fishing gear (GND, GNS, GTR, LL, LLS, OTB, and OTT).

In the list of 26 authorized gears, seven gears were used by vessels participating in the self-sampling, with bottom trawls (OTB) and trammel nets (GTR) being predominant. Considering the average weight caught by fishing haul, nets (trammel and gillnets) and longlines appear to be the most suitable gears for catching undulate ray. However, longlines showed a higher rate of discards (85%), followed by trawls (~76%).

Data indicate that the species by-catch is mainly coastal in the Bay of Biscay. The monthly evolution of catches raises questions about high catch rates in the first months of the year compared to the rest of the self-sampling period. Following the protocol carefully and consistently over time is an essential condition to validate the trends observed.

In conclusion, the main benefit of this self-sampling program is the possibility of quantifying landings, discards and fishing effort for the species, which are crucial for proper stock evaluation and management.

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Table 19.1a. Skates in the Bay of Biscay and Iberian Waters. Nominal landings (t) of skates by division and country (Source: ICES). Total landings (t) of Rajidae in divisions 8.a-b.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	12	15	9	9	12	4	9	4	6	8	5	4	3
France	2405	1960	1884	1799	1693	1461	1294	1202	1179	1349	1541	1220	1322
Netherlands					0								
Spain	423	334	408	428	295	190	247	235	242	243	212	262	210
UK	10	40	7	4	0	0	1	2	0	0.119	43	0	0
Ireland											35	28	
Norway		15	4										
Total	2850	2364	2312	2239	2000	1656	1551	1443	1427	1601	1836	1514	1534

*** Included in Spanish landings; * * Includes 8d.**

Table 19.1b. Skates in the Bay of Biscay and Iberian Waters. Total landings (t) of Rajidae in Division 8.d.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France	110	63	71	94	72	68	71	76	57	66	61	44	32
Spain	16	10	16	8	0	1	2	2	8	6	6		0
UK				0	0	0	1	0	0	0			
Ireland								0					
Total	127	73	86	103	72	69	74	78	66	72	66	44	32

Table 19.1c. Skates in the Bay of Biscay and Iberian Waters. Total landings (t) of Rajidae in Division 8.c.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France	1	0	1	0	0	0	1	1	0	2	0	0	0
Spain	177	194	420	433	533	551	663	654	608	528	364	407	377
Total	178	194	421	433	533	552	663	655	608	530	364	408	377

*** Included in Spanish landings.**

Table 19.1d. Skates in the Bay of Biscay and Iberian Waters. Total landings (t) of Rajidae in Division 9.a.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France					1						0		
Portugal	1303	1544	1444	1439	1444	1454	1425	1122	1104	1026	1012	1026	1138
Spain	301	283	139	134	276	409	429	468	481	455	253	304	348
Ireland					0								
Total	1604	1827	1583	1573	1721	1863	1853	1590	1585	1481	1265	1330	1487

Table 19.1e. Skates in the Bay of Biscay and Iberian Waters. Combined Landings (t) of Rajidae in Biscay and Iberian Waters.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	12	15	9	9	12	4	9	4	6	8	5	4	3
France	2517	2023	1955	1893	1766	1529	1367	1279	1236	1418	1602	1265	1354
Netherlands					0								
Portugal	1303	1544	1444	1439	1444	1454	1425	1122	1104	1026	1012	1026	1138
Spain	918	823	985	1004	1104	1152	1342	1359	1339	1233	835	973	935
UK	10	43	8	4	1	0	1	2	0	0	43	0	0
Ireland				0	0			0			35	28	
Norway		15	4										
Total	4760	4462	4405	4349	4327	4140	4144	3766	3686	3685	3532	3296	3430

Table 19.1f. Skates in the Bay of Biscay and Iberian Waters. Combined Landings (t) of Rajidae in Biscay and Iberian Waters. Landings by ICES stock and country since 2005. Totals by country are presented in bold.

Country	ICES	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	Stock name	**12**	**15**	**9**	**3**	**4**	**2**	**5**	**2**	**3**	**3**	**2**	**2**	**1**
	raj.27.89a	12	15	9	1	2	1	2	0	1	0	1	0	0
	rjc.27.8				2	2	1	2	2	3	3	1	2	1
	rjh.27.9a													0
	rjm.27.8				0	0	0	0	0					0
France		**1226**	**1096**	**952**	**911**	**654**	**549**	**446**	**419**	**482**	**569**	**574**	**494**	**609**
	raj.27.89a	783	662	610	613	391	244	175	151	179	238	202	181	243
	rjb.27.89a	11	5	3	5	1	0	0	0	0	0	0	0	0
	rjc.27.8	276	300	215	187	195	217	178	179	194	202	212	166	191
	rjm.27.8	155	130	124	106	64	86	91	86	109	121	149	132	153
	rjn.27.8c	0	0		0	0	0	0	0	0	2	0	0	0
	rjn.27.9a											0		
	rju.27.8ab	1	0		0	3	2	2	3	0	7	11	14	22
Netherland						**0**								
	raj.27.89a					0								
Portugal		**1298**	**1538**	**1444**	**1439**	**1444**	**1454**	**1425**	**1122**	**1104**	**1026**	**1012**	**1026**	**1138**
	raj.27.89a	104	123	38	307	308	293	276	240	144	132	113	99	116
	rjc.27.9a	480	569	472	746	740	611	812	571	644	586	581	564	620
	rjh.27.9a	495	586	459	193	163	221	161	165	179	174	236	221	235
	rjm.27.9a	76	90	119	144	184	275	121	108	111	101	67	68	94
	rjn.27.9a	43	51	79	50	50	55	56	39	27	34	20	57	39
	rju.27.9a	100	119	277									23	35
Spain		**918**	**823**	**985**	**1005**	**911**	**1032**	**1283**	**1285**	**1137**	**1029**	**651**	**748**	**766**
	raj.27.89a	918	823	985	1000	707	627	840	762	616	461	299	367	396
	rjb.27.89a			0	1							0	0	
	rjc.27.8		0	0	4	136	214	243	268	286	284	183	198	176
	rjc.27.9a					29	115	139	194	166	215	120	123	124
	rjh.27.9a					1	2	1	0	3	0	0	1	0
	rjm.27.8					11	26	22	19	28	40	28	26	27
	rjm.27.9a			0		7	10	3	2	4	2	1	5	5
	rjn.27.8c					18	34	24	26	33	27	15	13	15
	rjn.27.9a					3	4	12	13	2	0	0	1	2
	rju.27.8c											5	7	8
	rju.27.9a												8	12
UK		**10**	**43**	**8**	**4**	**1**	**0**	**1**	**2**	**0**	**0**	**42**	**0**	**0**
	raj.27.89a	10	43	8	2	0	0		0	0		1		
	rjb.27.89a										0			
	rjc.27.8							1	2			17	0	0
	rjm.27.8				1	1	0	0				1	0	
Ireland					**0**	**0**			**0**			**33**	**27**	
	raj.27.89a				0	0						4	5	

Country	ICES	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	rjb.27.89a											13	15	
	rjc.27.8								0			4	7	
	rjm.27.8											12	1	
Total		3464	3515	3398	3361	3014	3038	3160	2831	2726	2627	2315	2299	2514

Table 19.2. Skates in the Bay of Biscay and Iberian Waters. Species-specific landings (in t) in Divisions 8abde, 8.c and 9.a since 2005. Last table includes landings of Skates (*Myliobatis* spp, Dasyatidae, *Rhinobatos* spp, Torpedinidae) in the same period.

8abd	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Dipturus spp	11	5	3	5	0	0	0	0	0	0	13	15	0
Dipturus oxyrinchus	12	10	2	3	1	6	6	0	0	0	0	0	0
Leucoraja circularis	84	53	58	69	20	28	16	20	20	25	49	22	0
Leucoraja fullonica	14	8	7	7	45	37	36	30	30	38	47	40	27
Leucoraja naevus	1290	927	1002	987	1310	1102	982	935	959	1057	1214	996	916
Raja brachyura				0	11	11	18	7	27	67	65	76	144
Raja clavata	276	300	215	190	239	246	217	227	244	241	266	211	232
Raja microocellata	0	0	0	1	3	2	4	13	20	38	21	30	54
Raja montagui	155	130	124	107	65	86	92	86	109	121	162	133	153
Raja undulata	1	0		0	3	2	2	3	0	7	11	14	22
Rajella fyllae									0				
Rajiformes (indet)	1133	1008	990	974	373	206	252	199	83	79	52	19	18
Rostroraja alba	1		0	0	3	0	1	1	0	1	3	1	0
Total	2977	2441	2401	2343	2072	1725	1626	1520	1493	1673	1902	1558	1566

8c	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Dipturus spp.	0	0	0	1							0	0	
Dipturus oxyrinchus								0	0	0	3	0	
Leucoraja circularis		0		4	1	2	1	1	1	0	0	0	
Leucoraja fullonica		0		0	0					0			0
Leucoraja naevus	0	0		0	18	34	24	27	33	29	16	13	15
Raja brachyura					0	5	1	0	0	0	1	1	0
Raja brachyura	0	0	0	4	94	186	206	224	238	248	150	161	136
Raja clavata													0
Raja montagui					11	25	22	19	28	40	28	26	27
Raja undulata											5	7	8
Rajiformes (indet)	178	194	420	426	409	299	409	385	308	213	162	199	190
Total	178	194	421	433	533	552	663	655	608	530	364	408	377

9a	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Dipturus spp.											0		
Dipturus oxyrinchus				72	75	20	68	24	64	33	74	26	41
Leucoraja circularis	0	0	0	1	2	11	1	0	0	0	0	2	1
Leucoraja fullonica								0			0		
Leucoraja naevus	43	51	79	50	53	59	68	53	29	34	20	59	41
Raja brachyura	495	586	459	193	164	223	162	165	182	174	236	222	236
Raja clavata	480	569	472	746	769	726	951	766	810	801	701	687	744
Raja microocellata	88	105	35	19	45	43	29	36	41	45	32	63	68

Raja miraletus	16	19		4	2	6	5	5	1	2	0	2	0
Raja montagui	76	90	119	144	191	284	124	110	115	103	68	73	99
Raja undulata	100	119	277									31	46
Rajiformes (indet)	301	283	142	344	420	490	445	431	344	288	136	167	210
Rostroraja alba	5	6											
Total	1604	1827	1583	1573	1721	1863	1853	1590	1585	1481	1265	1330	1487

89a	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Dasyatidae	1	2	0	0	0	0	0	0	0	0		0	0
Myliobatis aquila	2	2	1	2	1	1	2	1	1	2	2	2	24
Rhinobatos spp.	0	0	0	0	0		0	0	0	0	0	0	
Torpedo marmorata	27	24	25	28	25	22	20	20	23	14	18	16	14
Torpedo spp.	39	49	45	46	39	50	54	39	43	46	43	49	63
Total	69	76	71	76	66	74	77	60	67	63	63	67	102

Table 19.3a. Skates in the Bay of Biscay and Iberian. *Leucoraja naevus* and *R. clavata* discard estimates (t) of the Basque OTB (Bottom otter trawl) in Subarea 8.

SUBAREA 8	*L. naevus*	*R. clavata*
2003		
2004		
2005		
2006		
2007		
2008		
2009	6	
2010	7	1
2011	18	3
2012	8	0
2013	23	3
2014	15	1
2015	50	4
2016	120	34
2017	87	14

Table 19.3b. Skates in the Bay of Biscay and Iberian Waters. Estimate of the percentage of the elasmobranch discarded/landed by the Basque OTB (Bottom otter trawl) in Divisions 8a,b,d.

Year	*L. naevus*	*R. clavata*
2009	4%	0%
2010	12%	5%
2011	17%	10%
2012	10%	0%
2013	23%	11%
2014	14%	4%
2015	44%	16%
2016	104%	109%
2017	100%	18%

Table 19.4a. Skates in the Bay of Biscay and Iberian Waters. Percentage of individuals by health status (1 = Good; 2 = Moderate; 3 = Poor) in relation to mesh size and soak time in the Portuguese polyvalent fleet for *Raja clavata*, *Raja montagui*, *Raja brachyura* and *Leucoraja naevus*. The total length range is also given.

	Mesh Size (mm)	Soak Time (h)	Health Status			N	TL range (cm)
			1	2	3		
Raja clavata	<180	<24	100%	0%	0%	17	23–72
		>24	72%	12%	16%	25	39–80
	>180	<24	92%	4%	4%	26	48–88
		>24	52%	23%	24%	103	40–96
Raja montagui	<180	<24	100%	0%	0%	18	21–64
		>24	67%	21%	12%	42	10–60
	>180	<24	40%	30%	30%	20	46–62
		>24	37%	33%	30%	43	37–68
Raja brachyura	<180	<24	67%	22%	11%	9	39–66
		>24	92%	4%	4%	24	27–75
	>180	<24	57%	19%	24%	21	49–95
		>24	70%	20%	10%	143	18–106
Leucoraja naevus	<180	<24	100%	0%	0%	1	53–53
	>180	<24	100%	0%	0%	1	61–61
		>24	58%	21%	21%	24	46–62

Table 19.4b. Skates in the Bay of Biscay and Iberian Waters. Percentage of individuals of *R. undulata* by health status by length class (cm), soak time (h) and mesh size (mm) in the Portuguese polyvalent fleet. Total sample size = 100 individuals; size range = 36–88 cm L_T.

		Length class (cm)		Soak Time (h)		Mesh Size (mm)	
Health Status	Total	<50 cm	>50 cm	<24 h	>24 h	<180 mm	>180 mm
1	91%	83%	92%	86%	92%	82%	93%
2	6%	0%	8%	7%	8%	9%	7%
3	3%	17%	0%	7%	0%	9%	0%

Table 19.5. Skates in the Bay of Biscay and Iberian Waters. Relative landed weight (%) for skate species for the Portuguese polyvalent and trawl fleets (2008–2017).

	Polyvalent									
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Raja miraletus	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Raja clavata	48%	48%	40%	54%	44%	56%	53%	53%	52%	55%
Raja microocellata	2%	4%	3%	3%	4%	5%	5%	4%	7%	7%
Raja brachyura	15%	11%	16%	13%	18%	19%	20%	27%	25%	23%
Leucoraja circularis	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Raja montagui	10%	13%	19%	8%	9%	10%	10%	7%	6%	8%
Leucoraja naevus	2%	3%	3%	3%	3%	2%	3%	1%	5%	3%
Dipturus oxyrinchus	6%	5%	1%	4%	3%	5%	3%	8%	3%	4%
Rajidae	17%	16%	16%	15%	19%	4%	6%	0%	0%	0%

	Trawl									
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Raja miraletus	1%	0%	1%	0%	1%	0%	0%	0%	0%	0%
Raja clavata	64%	60%	47%	66%	71%	66%	76%	77%	71%	64%
Raja microocellata	0%	0%	2%	0%	0%	0%	2%	0%	3%	1%
Raja brachyura	8%	12%	13%	5%	6%	8%	8%	7%	10%	14%
Leucoraja circularis	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Raja montagui	10%	11%	17%	8%	11%	12%	4%	4%	8%	12%
Leucoraja naevus	7%	6%	8%	8%	6%	4%	5%	5%	7%	8%
Dipturus oxyrinchus	3%	6%	3%	8%	1%	8%	4%	6%	0%	1%
Rajidae	7%	5%	7%	5%	3%	2%	0%	0%	0%	0%

Table 19.6. Skates in the Bay of Biscay and Iberian Waters. Lpue (kg day^{-1}) of the L. naevus and R. clavata caught by the Basque Country OTB DEF >= 70 (Bottom otter trawl) in Subarea 8.

YEAR	*L. NAEVUS*	*R. CLAVATA*
2001	112	27
2002	91	16
2003	136	19
2004	120	21
2005	134	23
2006	140	24
2007	169	29
2008	137	24
2009	84	18
2010	44	14
2011	115	25
2012	33	21
2013	72	18
2014	79	19
2015	130	28
2016	119	32
2017	58	54

Table 19.7. Skates in the Bay of Biscay and Iberian Waters. Life-history information): Table 2. Biological parameter estimates available for skate species inhabiting Portuguese Iberian waters. Growth models: VBR – von Bertalanffy Growth Model; GG – Gompertz Growth Model.

Species	TL range (cm)	L50 (cm) F	L50 (cm) M	I50 (years) F	I50 (years) M	Fecundity	Reproductive period	Growth model	Growth parameters estimates						Period	Region	Source
									L∞ (cm)	k (y–1)	t0 (years)	Lmax (cm)	Imax (years)	I∞ longevity (years)			
R. undulata	19.4–88.2	76.2	73.6	8.98	7.66	-	-	VBG	110.2	0.11	–1.58	88.2	13	-	1999–2001	Algarve	[1,2]
	23.7–90.5	83.8	78.1	9	8	-	Feb–May	VBG	113.7	0.15	–0.01	90.5	12	23.6	2003–2006	Centre	[3]
	32.0–83.2	-	-	-	-	-	-	VBG	119.3	0.12	–0.41	83.2	9	28.9	1999–2001	Algarve	[3]
	23.5–95.9	86.2 ±2.6	76.8 ±2.4	8.7 ±0.3	7.6 ±0.4	69.8 ± 3.4	Dec–May	-	-	-	-	-	-	-	2003–2013	North /Centre	[4]
R. clavata	14.3–91.3	-	-	-	-		-	VBG	128.0	0.112	–0.62	91.3	10	-	2003–2007	All	[5]
	12.5–105.0	78.4	67.6	7.5	5.8	136	May–Jan		-	-	-	-	-	-	2003–2008	All	[6]
R. brachyura	37.4–106.1	97.9	88.8	-	-	-	Mar–Jul	VBG	110.51	0.12	0.26	106.1	-	-	2003–2004	All	[7]
	37.6–108.8	96.6	88.6	-	-		Mar–Jul		-	-	-	-	-	-	2003–2012	North /Centre	[10]
R. montagui	25.2–76.1	59.4	50.4	-	-	-	Apr–Jun	VBG	75.9	0.23	0.16	76.1	7	-	2003–2004	All	[8]
	36.8–70.2	56.7	48.0	-	-		Apr-Jul	-	-	-	-	-	-	-	2003–2012	All	[10]
L. naevus	12.7–71.8	55.6	56.5	-	-		-	VBG	79.2	0.24	0.12	71.8	-	-	2003–2004	All	[7]
	13.3–71.8	56.5	56.0	-	-	63	Jan-May		-	-	-	-	-	-	2003–2010	All	[9]

[1] Coelho and Erzini, 2002; [2] Coelho and Erzini, 2006; [3] Moura *et al.*, 2008; [4] Serra-Pereira *et al.*, 2015; [5] Serra-Pereira *et al.*, 2008; [6] Serra-Pereira *et al.*, 2011; [7] Farias, 2005; [8] Serra-Pereira, 2005; [9] Maia *et al.*, 2012; [10] Pina Rodrigues, 2012).

Table 19.8. Skates in the Bay of Biscay and Iberian Waters. Model parameters and prior distributions for the application to *R. clavata* in the Bay of Biscay.

Parameter	Description	Prior
r	Intrinsic population growth rate	Beta (34, 300) mean=0.1, CV=0.16
K	Carrying capacity	Uniform (20 000, 100 000)
Y1903	Initial relative biomass in 1903	Beta (17, 4) mean=0.84, CV=0.1
Y2000	Initial relative biomass in 2000	Beta (2,6) mean=0.4, CV=0.6
$1/\sigma^2$	Process error precision (inverse variance)	Gamma (400, 1) mean=399, CV=0.05
q	Survey catchability	Uniform (0.01, 0.6)
$1/\tau^2$	Observation error precision (inverse variance)	Gamma (44,2) mean=22
CV	Uncertainty of landings	0.2 (constant)

Table 19.9. Skates in the Bay of Biscay and Iberian Waters. - Abundance estimate of the stock of *Raja undulata* in the Bay of Biscay potentially exploitable by the longliners in the central part of the Bay of Biscay according to the low (A1) and high (A2) estimates by mark–recapture in the Gironde estuary area.

Abundance in other areas are derived from this estimate by the following formula:

$$A\ (\text{area } x) = \frac{DI\ (\text{area } x)}{DI\ (GE)} . \frac{S\ (\text{area } x)}{S\ (GE)} . \ Ai\ (GE)$$

Where Ai is one of the two interval limits of the abundance estimated by mark–recapture in the Gironde Estuary (GE), Density index (DI) are area coefficients obtained by a variance analysis of standardized CPUE and, Surface (S) is habitat area shown by the catch and tagging data.

Area	Surface (S in nm2)	Density index (DI)	Abundance (A1)	Abundance (A2)
Gironde Estuary (GE)	560	1.45	10214	14 188
West Oléron (WO)	300	1.42	5348	7429
Pertuis d'Antioche (PA)	65	0.62	507	704
Pertuis Breton (PB)	180	0.78	1763	2449
Total	1105	-	17 832	24 770
Biomass (t)	-	-	87	120

Table 19.10. Skates in the Bay of Biscay and Iberian Waters. *Raja undulata* in the Bay of Biscay – Mean length-at-age and estimation of longline catch-at-age in November 2013 (chartered trip) with their log ratios.

Age	Mean length (Nov.)	Catch at age	Log catch ratio
5	66.1	7	–1.95
6	72.6	37	–1.67
7	78.2	95	–0.94
8	83.1	138	–0.37
9	87.3	215	–0.44
10	90.9	139	0.44
11	94.0	24	1.76
12	96.7	13	0.61
13	99.0	4	1.18

Table 19.11. Skates in the Bay of Biscay and Iberian Waters. *Raja undulata* in the Bay of Biscay-Stock number in 2008 derived from the 2014 mark–recapture abundance estimates (lower estimates in the upper table and higher estimates in the lower table), assuming no fishing mortality below age 4 and a flat fishing pattern above age 6 in 2008, no fishing from 2009 to 2015 (example given for half of the highest possible fishing mortality-at-age 7 and above in 2008 according to a recruitment constraint based on the number of eggs released). Biomass in 2009 and 2015 assuming constant recruitments.

YEAR	2008	2008	2008	2009	2014	2015	2015
Age	Stock Number	F	Catch (t)	Biomass (t)	Mark–recapture estimate	Stock Number	Biomass (t)
0	100 621	0.00	0	0		100 621	0
1	76 812	0.00	0	5		76 812	5
2	58 637	0.00	0	17		58 637	17
3	44 762	0.00	0	30		44 762	30
4	34 171	0.17	6	42		34 171	42
5	22 092	0.17	6	41		26 085	49
6	14 228	0.27	8	37		19 913	52
7	8254	0.38	8	28		15 201	52
8	4313	0.38	5	18	Lower	11 604	49
9	2253	0.38	3	11	estimates	8858	44
10	1177	0.38	2	7	5705	6762	39
11	615	0.38	1	4	3688	4355	28
12	321	0.38	1	2		2816	20
13	168	0.38	0	1		1633	13
Total	267 803		39	245		412 232	441
Spawning	8848		12	44		36 029	194
YEAR	2008	2008	2008	2009	2014	2015	2015
Age	Stock Number	F	Catch (t)	Biomass (t)	Mark–recapture estimate	Stock Number	Biomass (t)
0	139 771	0.00	0	0		139 771	0
1	106 698	0.00	0	7		106 698	7
2	81 451	0.00	0	23		81 451	23
3	62 178	0.00	0	42		62 178	42
4	47 465	0.17	8	58		47 465	58
5	30 687	0.17	8	58		36 234	68
6	19 764	0.27	11	52		27 660	73
7	11 465	0.38	11	39		21 115	72
8	5991	0.38	7	25	Higher	16 119	68
9	3130	0.38	4	16	estimates	12 305	62
10	1636	0.38	3	9	7925	9393	54
11	855	0.38	2	6	5124	6050	39
12	447	0.38	1	3		3911	28
13	233	0.38	1	2		2269	18
Total	371 999		55	340		572 620	613
Spawning	12 291		17	61		50 047	269

Table 19.12. Skates in the Bay of Biscay and Iberian Waters. Annual estimates of the posterior median, 25% and 97.5% quartiles of the total landed weight of *Raja undulata* for the period 2003–2008 along the Portuguese mainland (Division 9.a)

Year	median	P2.5	P97.5
2003	164.3	137.1	197.0
2004	197.0	164.2	235.8
2005	171.7	141.2	208.4
2006	271.3	232.6	315.1
2007	156.7	132.3	185.6
2008	208.3	178.4	243.4

Table 19.13. *Raja undulata* potential catches estimates by region and vessel size category for 2017. Official landed weight (in ton) in each region is also presented.

Region	Official landed weigth (ton)	Vessel size Category	Potential total captured number	Potential total captured weight (ton)
North	14.3	>13	2393	9.2
		<13	3624	12.9
Center	2.0698	>12	167	0.4
		<12	8886	23.3
Southwest	9.1224	>10	299	1.6
		<10	10786	27.9
South	7.2303	>10	675	1.0
		<10	14021	41.2
Total	32.716		40851	117.3

Table 19.14. Skates in the Bay of Biscay and Iberian Waters. *Raja undulata* yield per recruit (Y/R for different levels of fishing mortality (F), total mortality (Z), exploitation rate (E) and an age of first capture = 7 years (TC).

	F	Z	E	Y/R (t)
F20%BPR	0.28	0.50	0.57	0.17
F30%BPR	0.20	0.41	0.48	0.15
F35%BPR	0.17	0.38	0.44	0.14
F40%BPR	0.14	0.36	0.40	0.13

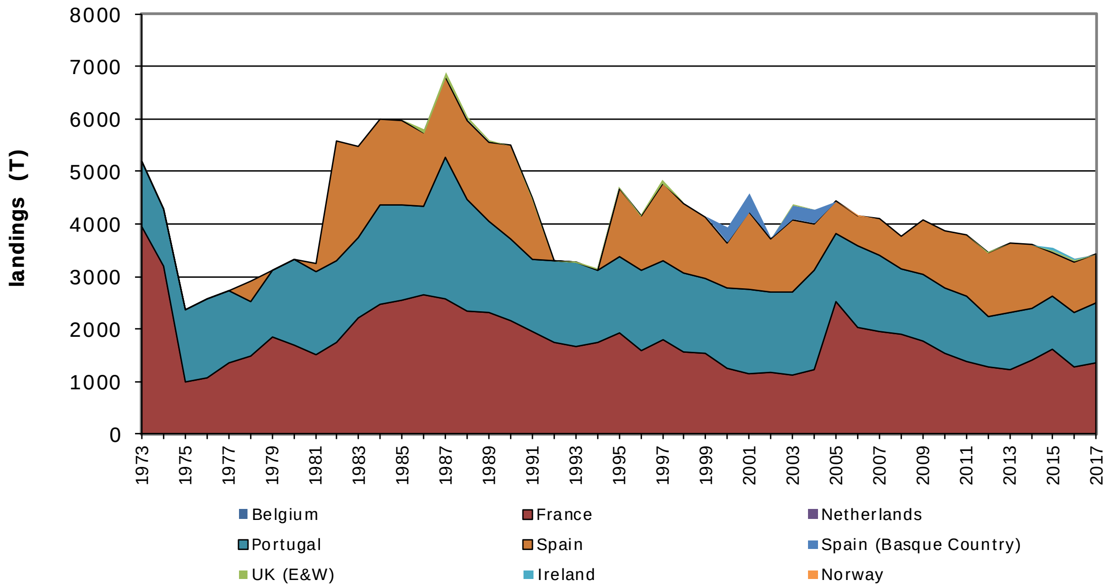


Figure 19.1. Skates in the Bay of Biscay and Iberian Waters. Historical trend in landings of Rajidae in Subarea 8 and Division 9.a.

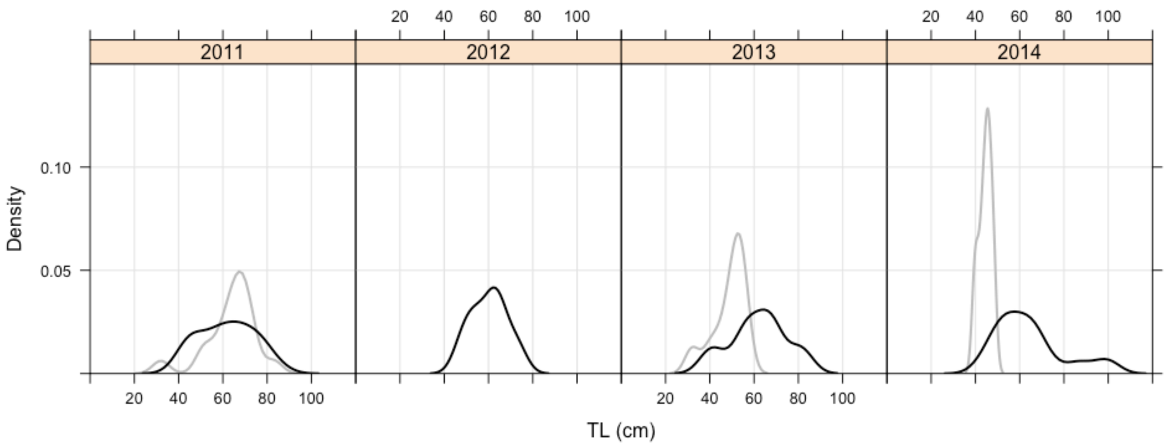
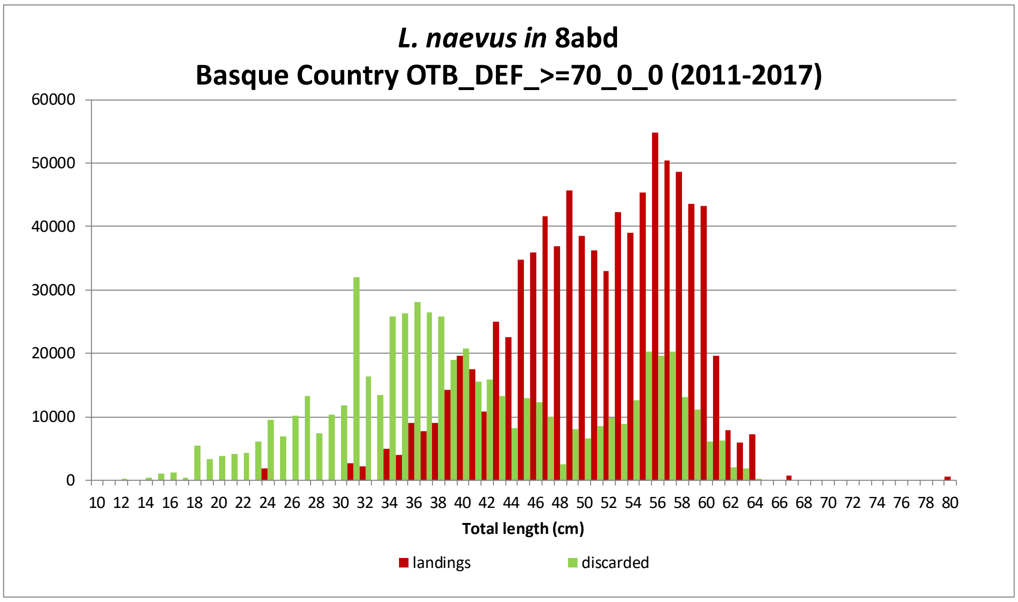


Figure 19.2a. Length frequency distribution of *R. clavata* retained (black) and discarded (grey) fractions observed onboard vessels with LOA >12 m and with fishing permit to operate with gillnets and/or trammel nets, between 2011 and 2014. The length frequencies were not raised to the total landings. n=204 sampled individuals.



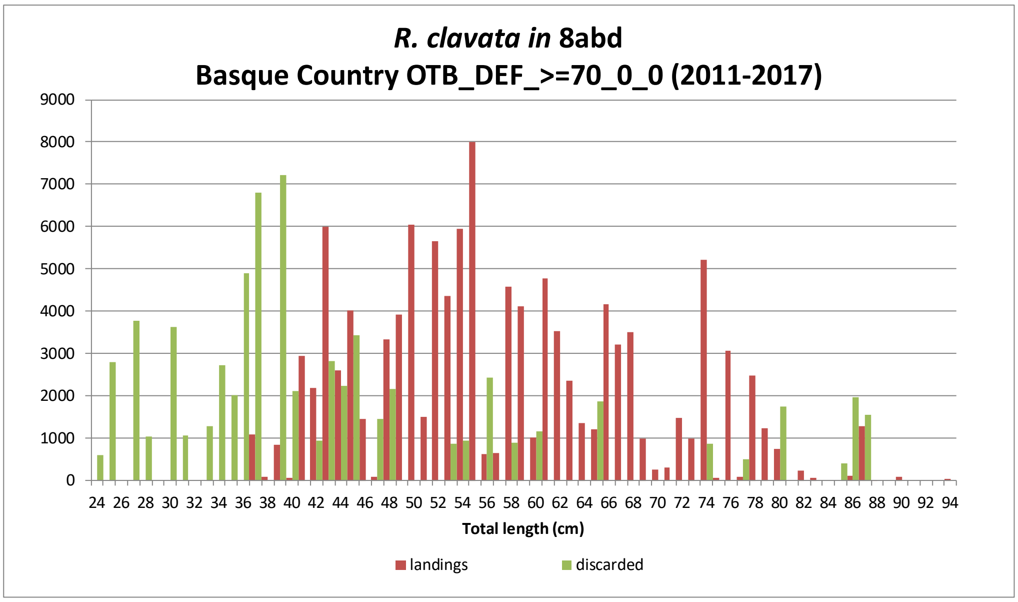


Figure 19.2b. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of the *Leucoraja naevus* and *Raja clavata* for the period from 2011–2017 of the Basque OTB (Bottom Otter Trawler).

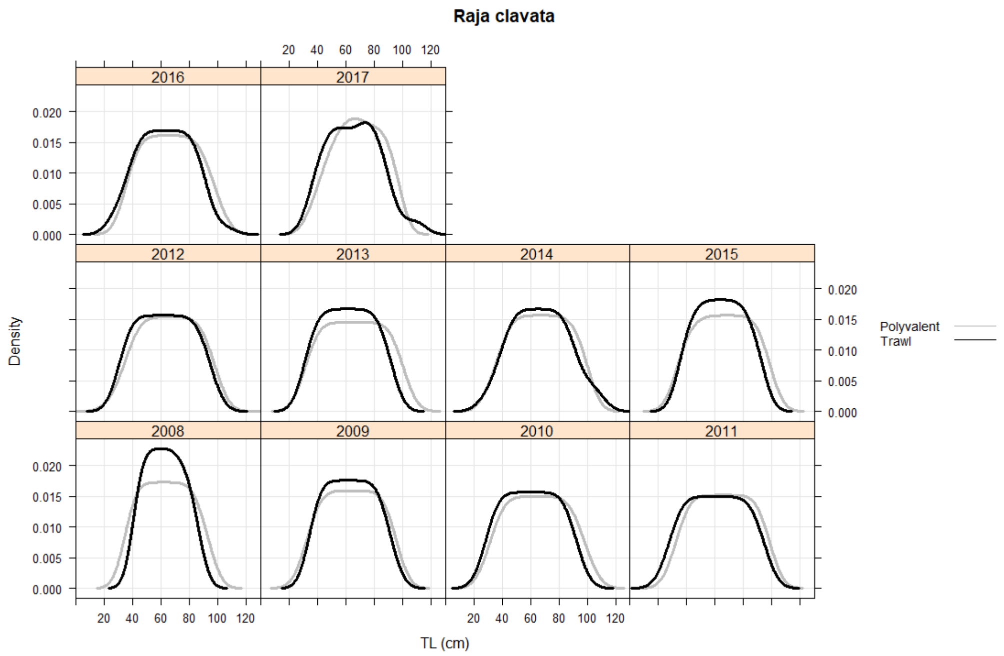


Figure 19.2c. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja clavata* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n = 2410 for the polyvalent segment and n = 642 for the trawl segment.

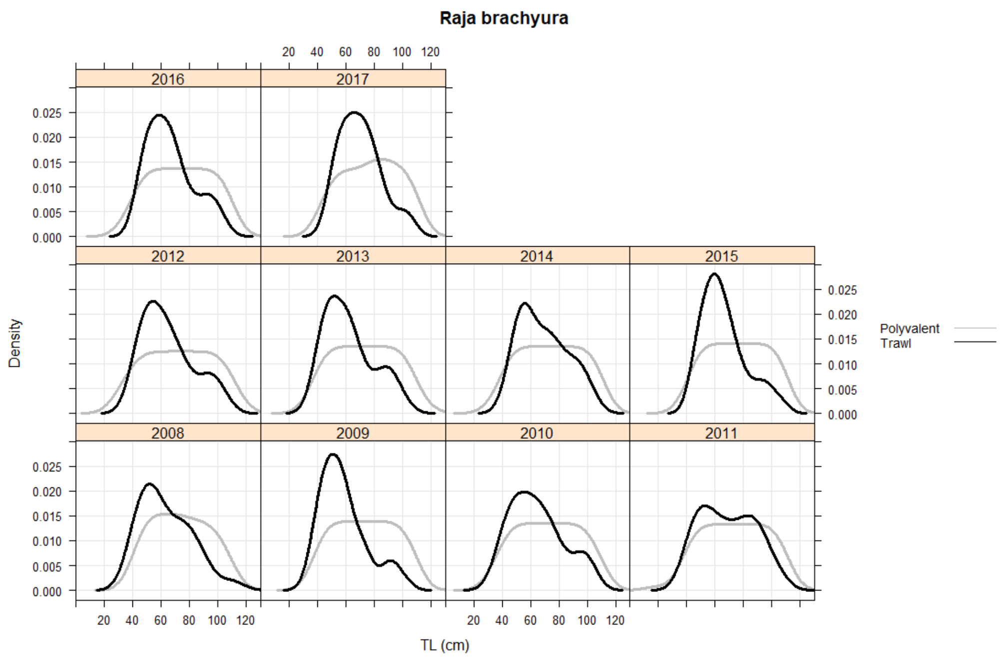


Figure 19.2d. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja brachyura* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n = 1466 for the polyvalent segment and n = 187 for the trawl segment.

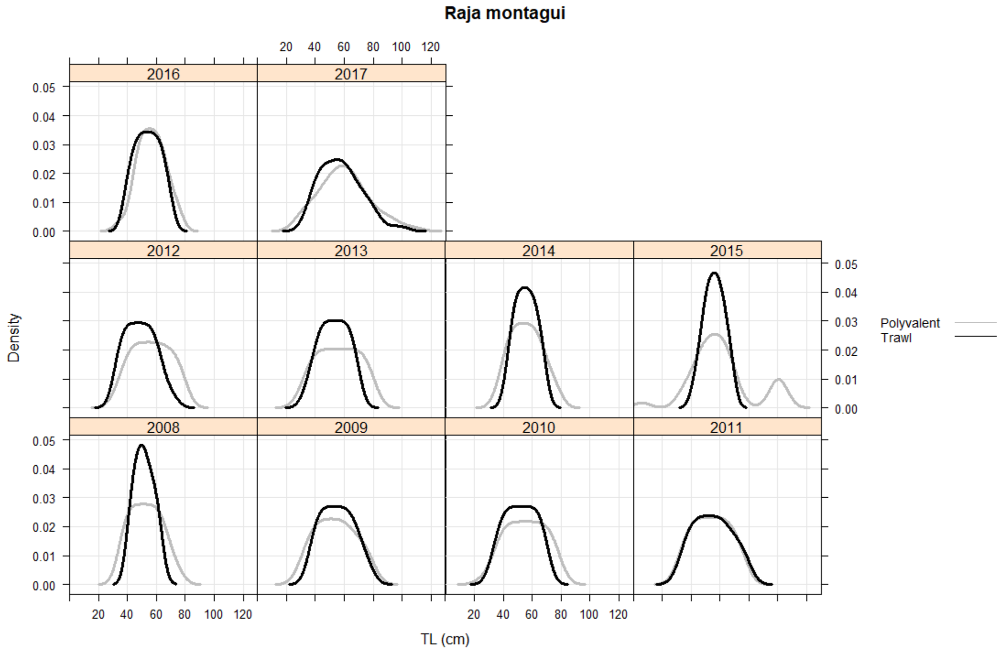


Figure 19.2e. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja montagui* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n=1061 for the polyvalent segment and n=320 for the trawl segment.

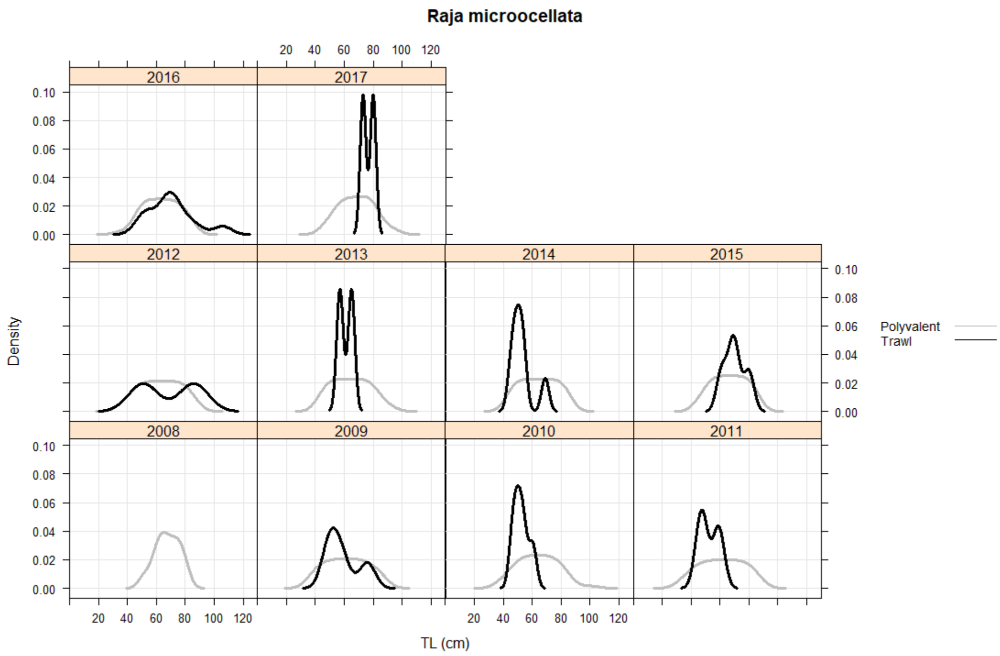


Figure 19.2f. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja microocellata* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n=638 for the polyvalent segment and n=18 for the trawl segment.

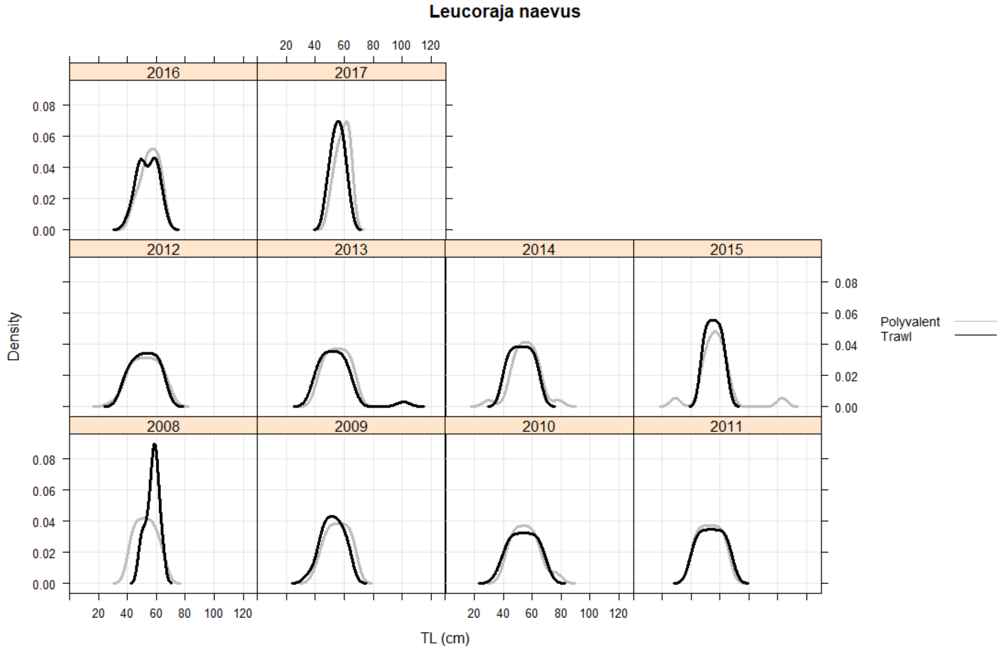


Figure 19.2g. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Leucoraja naevus* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n=299 for the polyvalent segment and n=158 for the trawl segment.

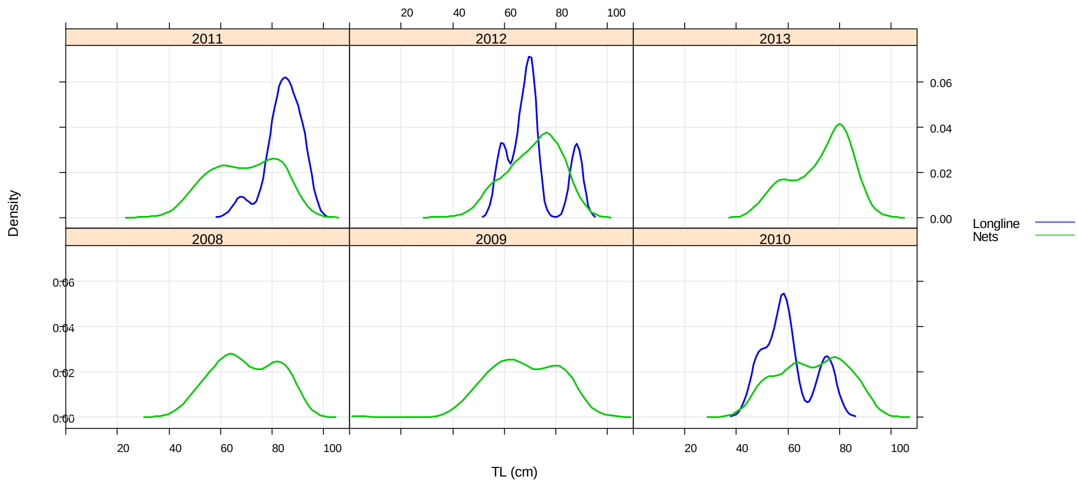


Figure 19.2h. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja undulata* by fishing gear (longline and nets) for the period 2008–2013 in mainland Portugal (Division 9.a).

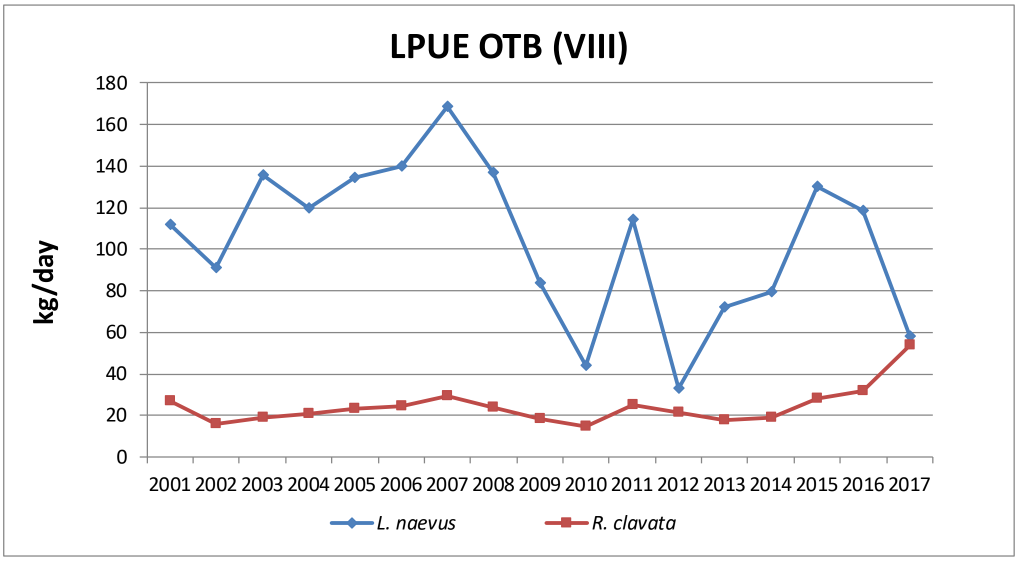


Figure 19.3. Skates in the Bay of Biscay and Iberian Waters. Nominal LPUE (kg.day^{-1}) of *Leucoraja naevus* and *Raja clavata* caught in the OTB DEF >= 70 Basque fleet in Subarea 8 (2001–2017).

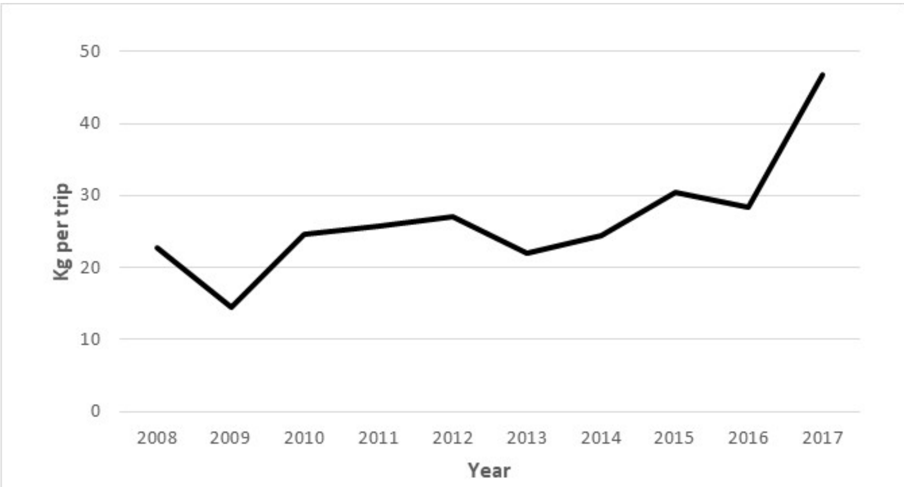


Figure 19.4a. Skates in the Bay of Biscay and Iberian Waters. Standardized LPUE (kg.trip^{-1}) of *R. brachyura* for the period 2008–2017.

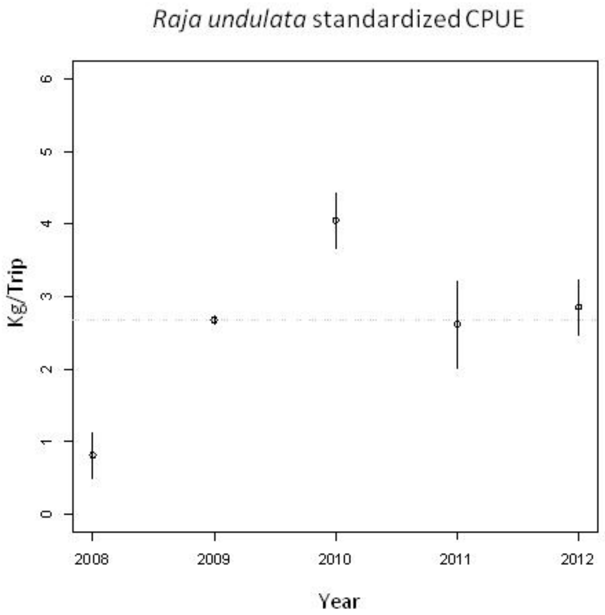


Figure 19.4b. Skates in the Bay of Biscay and Iberian Waters. Standardized CPUE (kg.trip^{-1}) of *Raja undulata* for the period 2008–2013. Dashed line: average of the entire time-series.

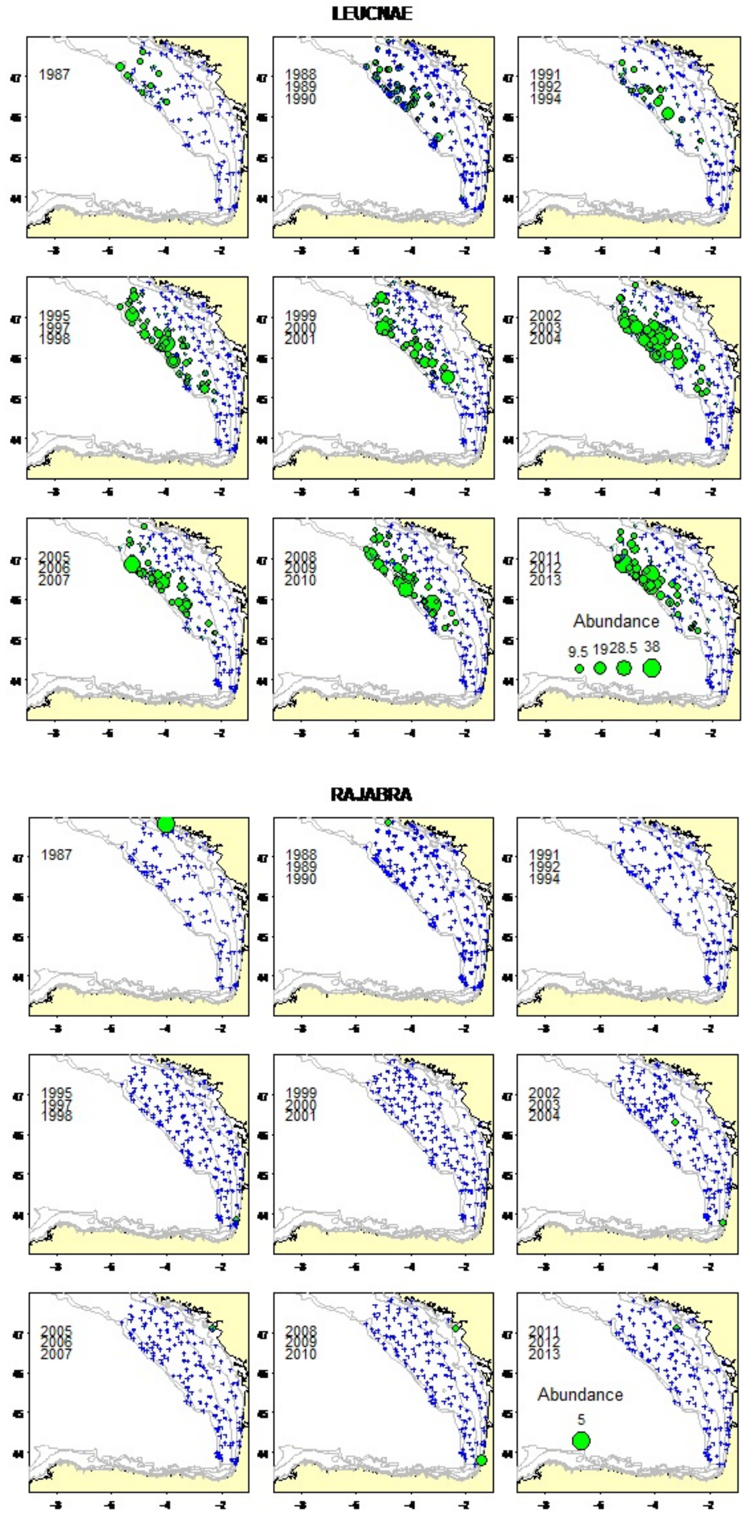


Figure 19.5a. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *L. naevus* (top) and *R. brachyura* (bottom), as observed in the French EVHOE survey.

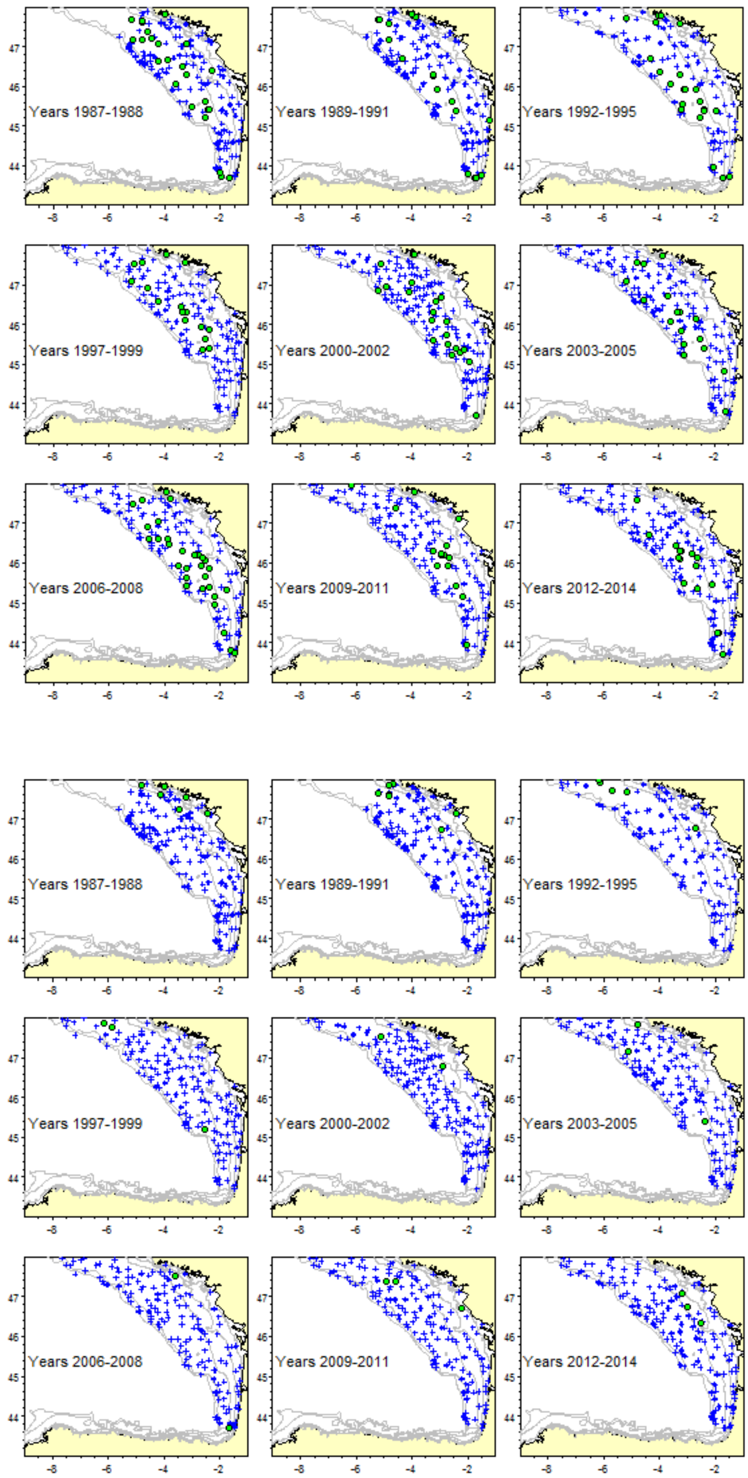


Figure 19.5b. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *R. clavata* (top) and *R. montagui* (bottom), as observed in the French EVHOE survey.

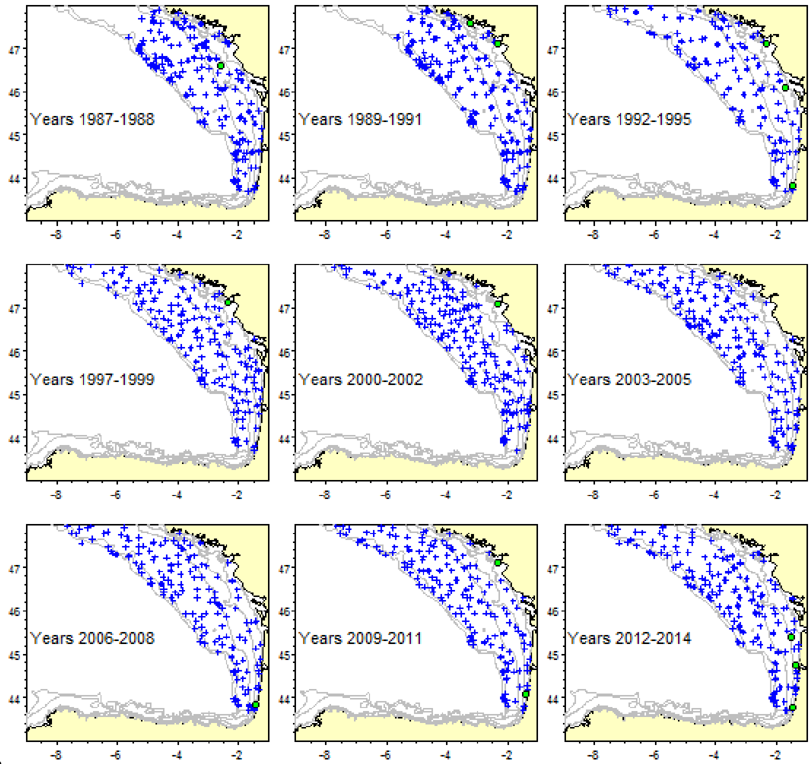


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Figure 19.5c. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *R. undulata*, as observed in the French EVHOE survey.

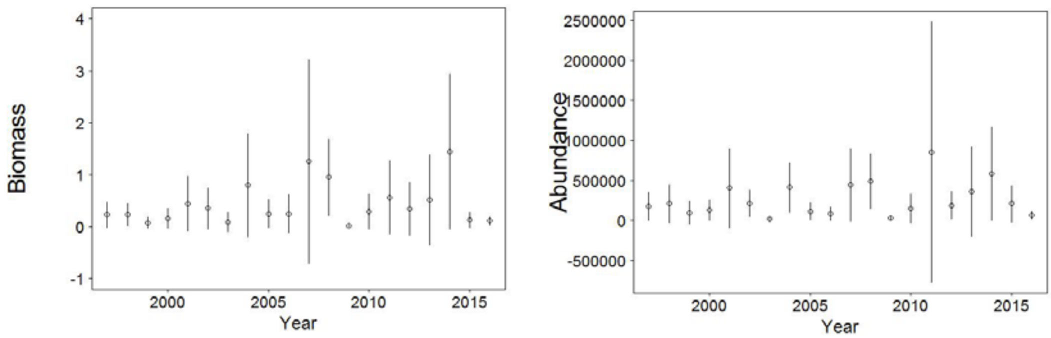


Figure 19.6a. Skates in the Bay of Biscay and Iberian Waters. EVHOE survey indices 1987–2016 of *R. clavata* in the Celtic Sea and Bay of Biscay (Divisions 8.a-c). Abundance and biomass are raised to the total area surveyed (swept area method) but should be considered relative and not absolute estimates.

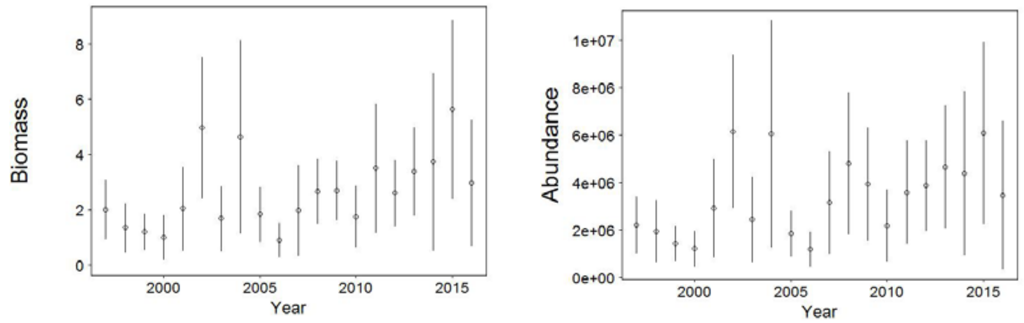


Figure 19.6b. Skates in the Bay of Biscay and Iberian Waters. EVHOE survey indices 1987–2015 of the *L. naevus* in the Bay of Biscay (Divisions 8.a-c). Abundance and biomass are raised to the total area surveyed (swept area method) but should be considered relative and not absolute estimates.

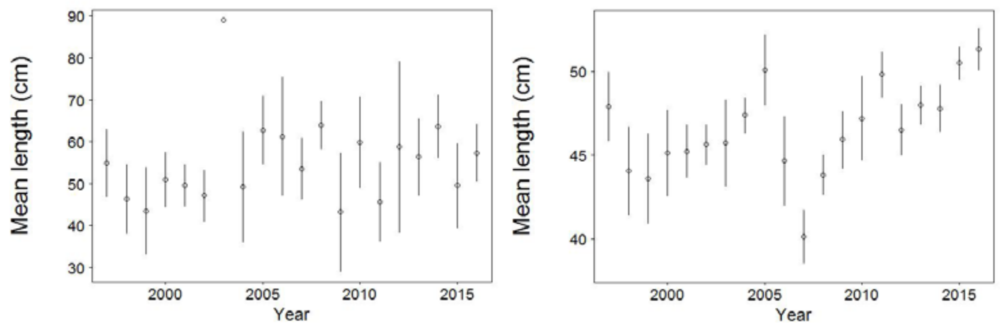


Figure 19.6b. Skates in the Bay of Biscay and Iberian Waters. EVHOE mean length of *R. clavata* and *L. naevus* in the Bay of Biscay Divisions 8abc) in the period 1987-2016.

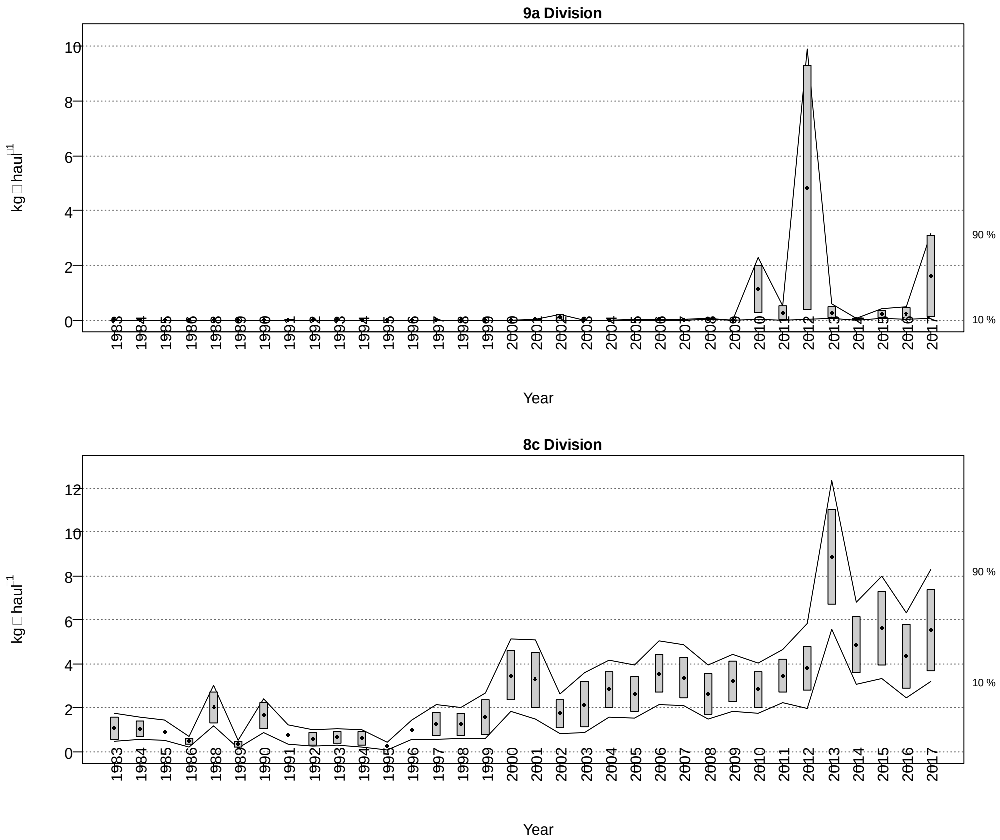


Figure 19.7a. Skates in the Bay of Biscay and Iberian waters. Changes in *Raja clavata* biomass indices, in ICES Divisions 9.a and 8.c, during the North Spanish bottom trawl survey time-series (1983–2017). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

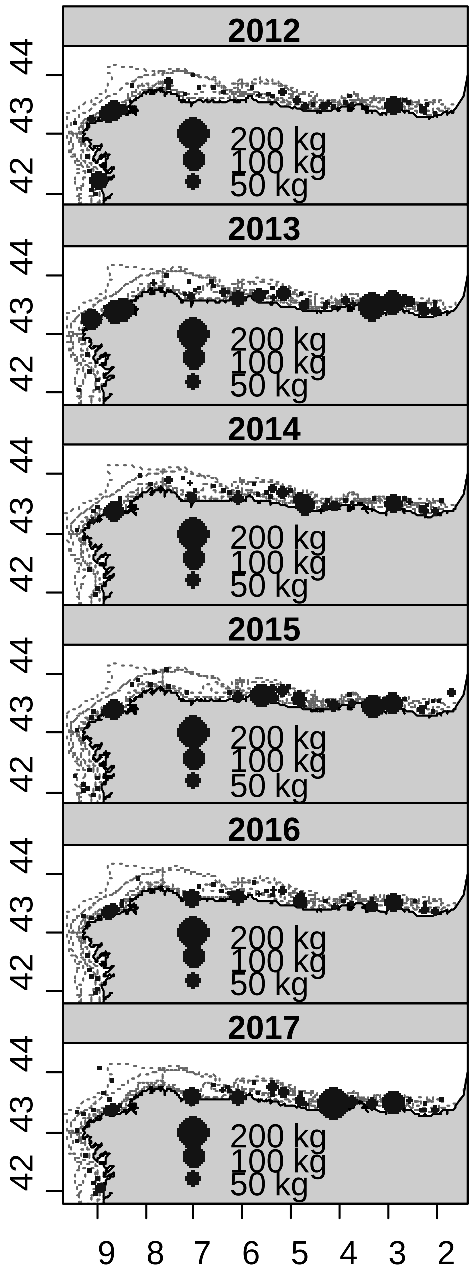


Figure 19.7b. Skates in the Bay of Biscay and Iberian waters. Geographical distribution of *R. clavata* catches (kg/30 min haul) in North Spanish continental shelf from bottom trawl surveys for the period (2013–2017).

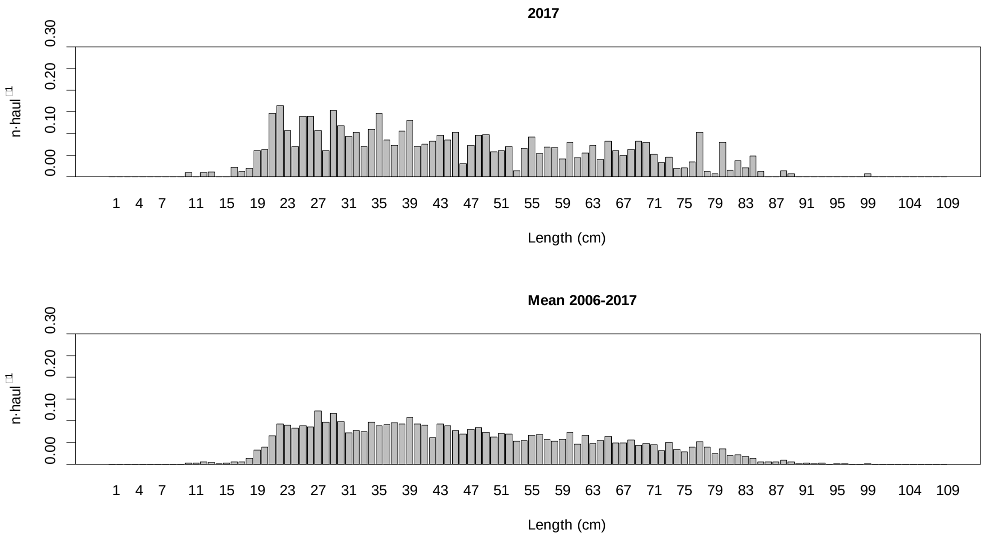


Figure 19.7c. Skates in the Bay of Biscay and Iberian waters. Stratified length distribution of R. clavata obtained from Spanish bottom trawl surveys time-series in the last survey (above) and in the last decade (below) in 8c Division of the North Spanish Shelf.

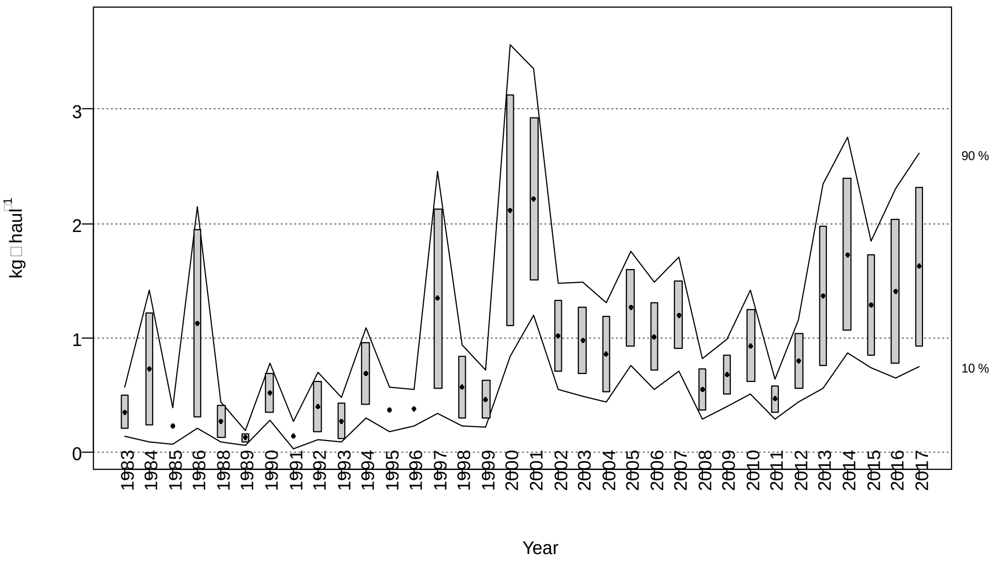


Figure 19.8a. Skates in the Bay of Biscay and Iberian Waters. Changes in *Raja montagui* biomass index during North Spanish shelf bottom trawl survey time-series (1983–2017) in 8c Division covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

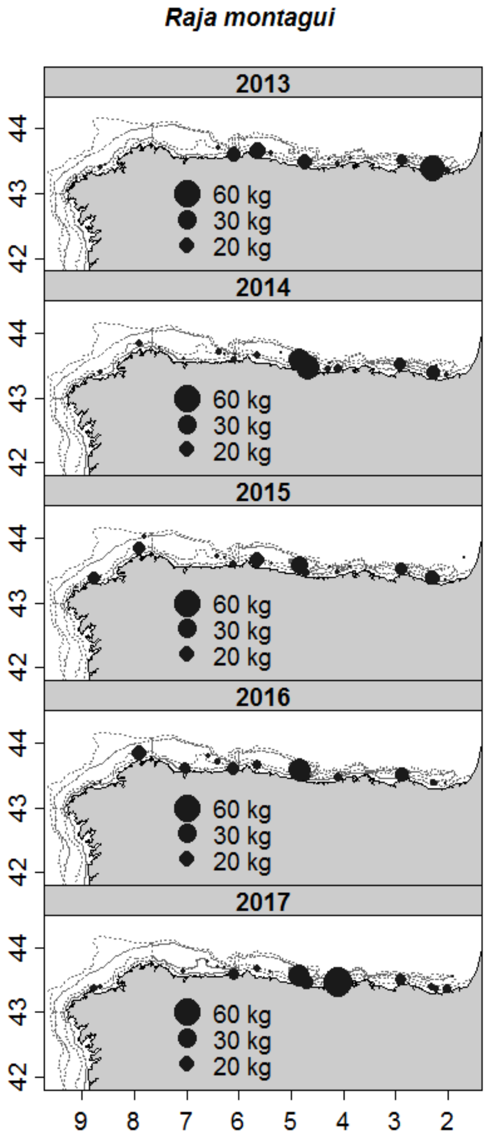


Figure 19.8b. Skates in the Bay of Biscay and Iberian Waters. Geographical distribution of *R. montagui* catches (kg/30 min haul) in North Spanish continental shelf bottom trawl surveys for the period (2013–2017).

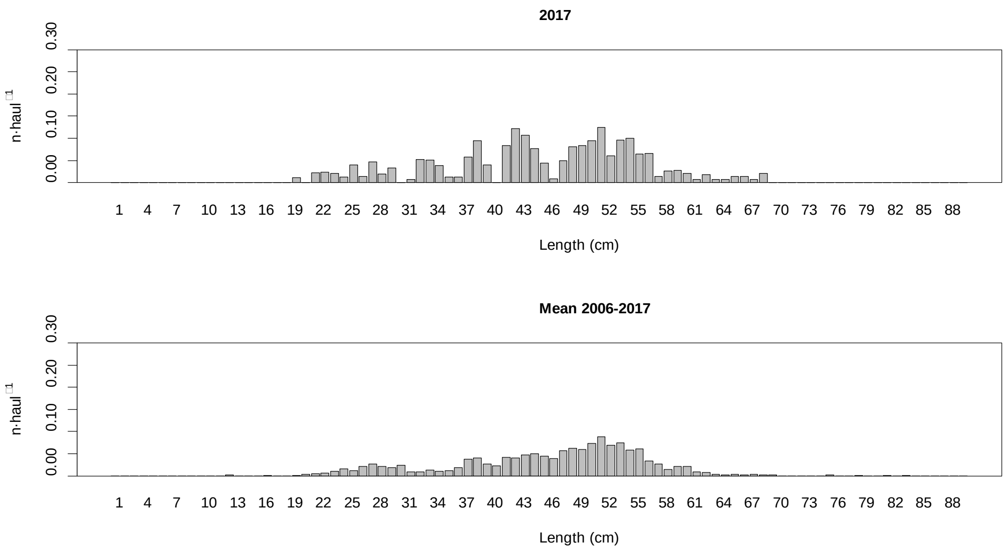


Figure 19.8c. Skates in the Bay of Biscay and Iberian waters. Mean stratified length distribution of Raja montagui in the last survey (above) and in the last decade (below) in 8c Division of the North Spanish Shelf.

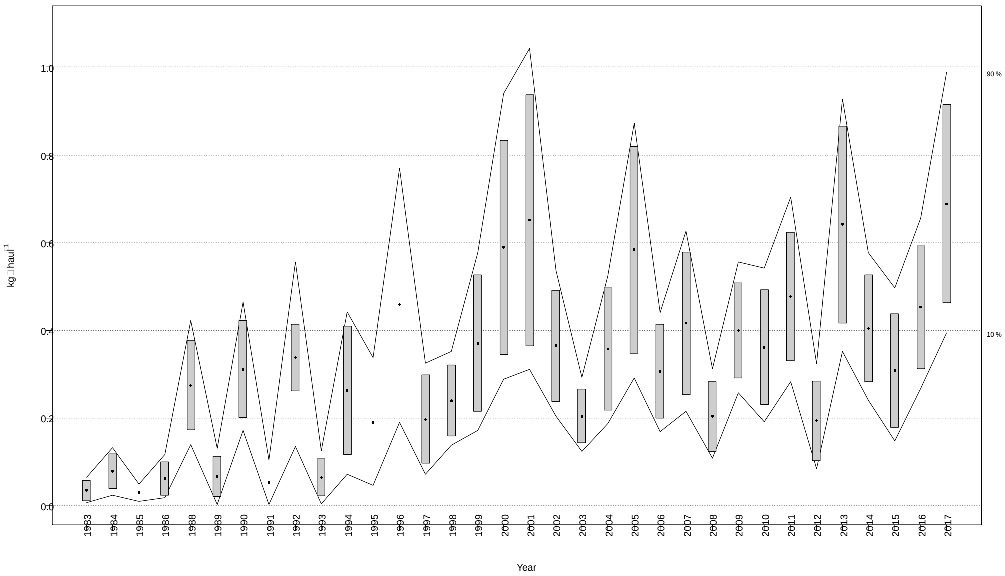


Figure 19.9a. Skates in the Bay of Biscay and Iberian Waters. Changes in *Leucoraja naevus* biomass index during North Spanish shelf bottom trawl survey time-series (1983–2017) in ICES division 8c. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

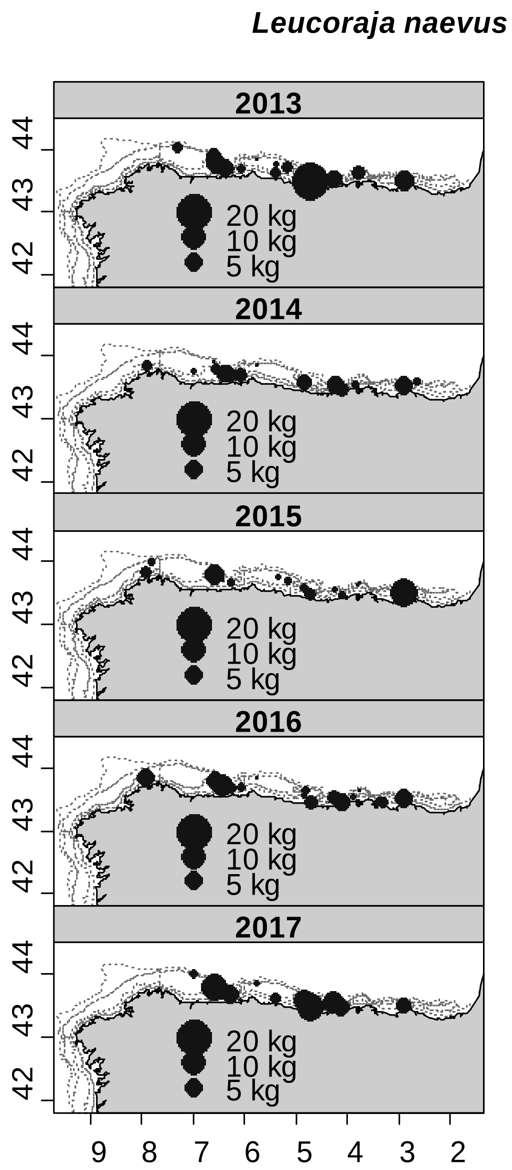


Figure 19.9b. Skates in the Bay of Biscay and Iberian Waters. Geographical distribution of *L. naevus* catches (kg/30 min haul) in North Spanish continental shelf bottom trawl surveys for the period (2013–2017).

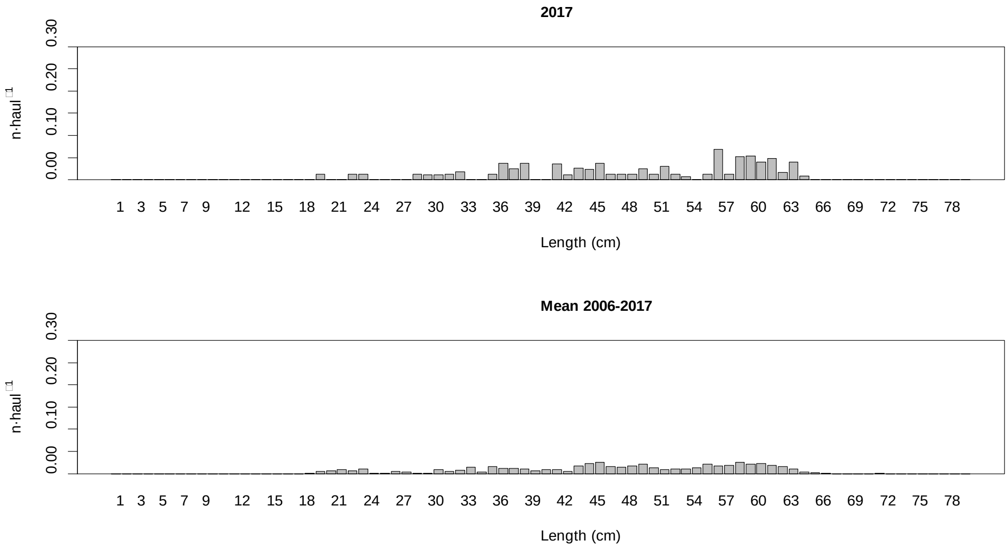


Figure 19.9c Skates in the Bay of Biscay and Iberian waters. Mean stratified length distribution of *Leucoraja naevus* in the last survey (above) and in the last decade (below) in 8c Division of the North Spanish Shelf.

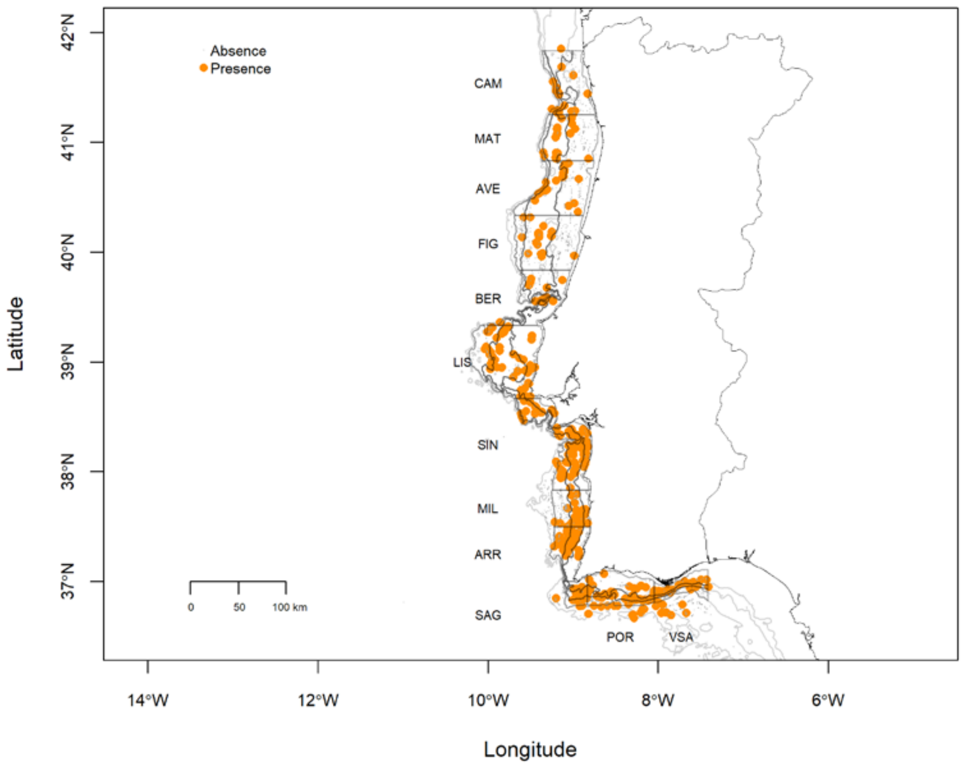


Figure 19.10a. Skates in the Bay of Biscay and Iberian Waters. *Raja clavata* distribution from 1981 to 2017 in the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4), and Portuguese crustacean surveys/*Nephrops* TV surveys (PT-CTS (UWTV), FU 28-29).

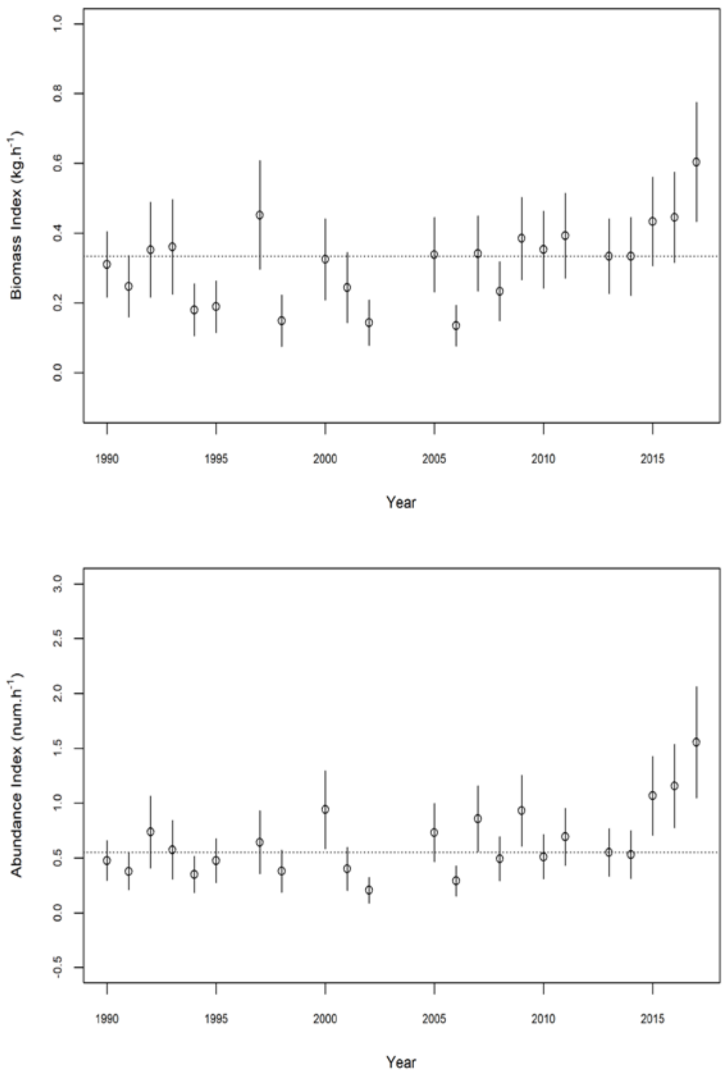


Figure 19.10b. Skates in the Bay of Biscay and Iberian Waters. *Raja clavata* biomass index (kg hour^{-1}) and abundance (ind.hour^{-1}) on PtGFS-WIBTS-Q4from 1990 to 2017. Dashed line represents the mean annual abundance for the considered period.

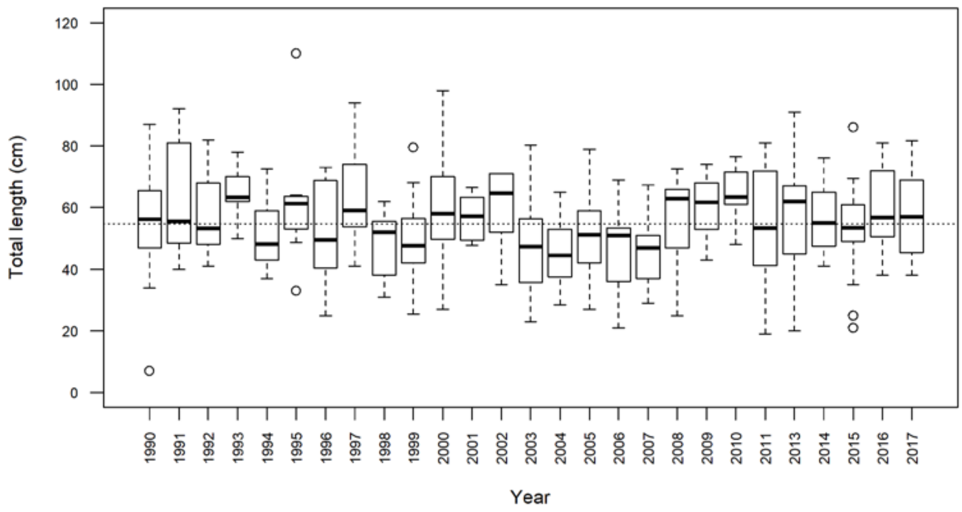


Figure 19.10c. Skates in the Bay of Biscay and Iberian Waters. Total length variation of *Raja clavata*, by year on PtGFS-WIBTS-Q4 (dashed line represents the mean annual length for 1990-2017).

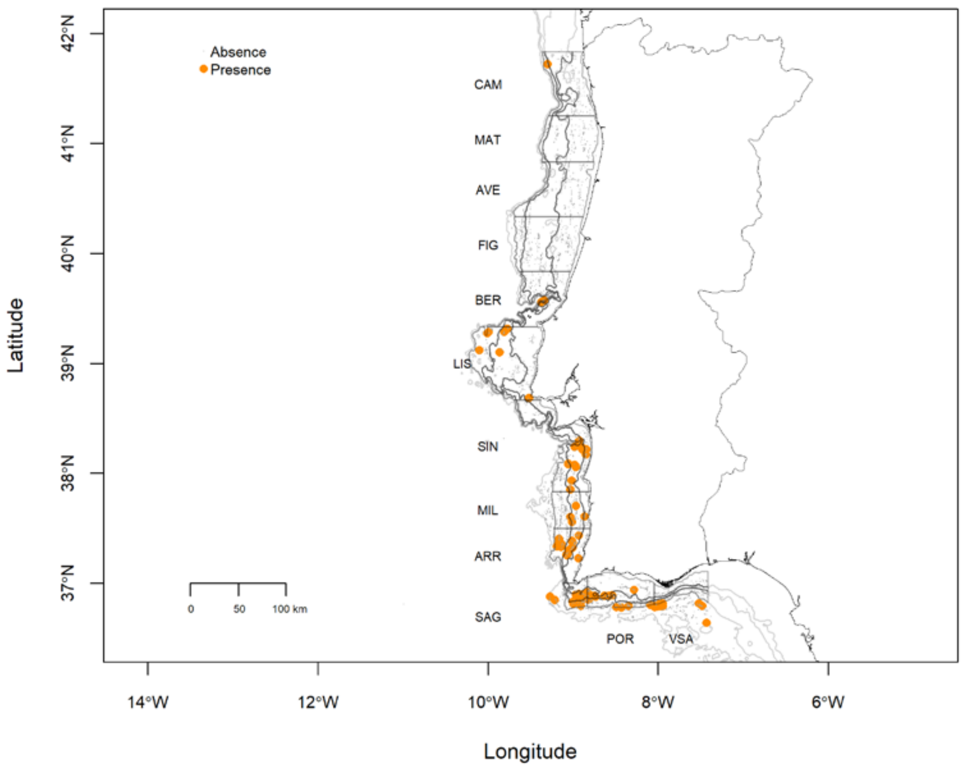
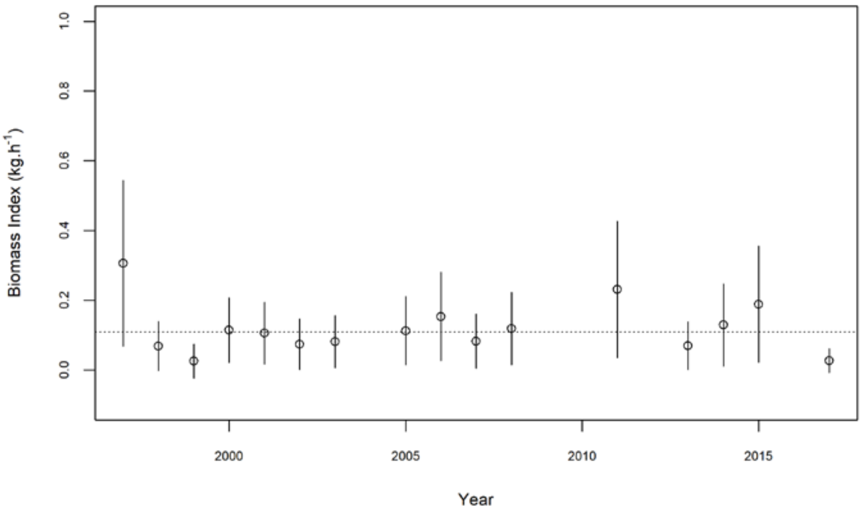


Figure 19.11a. Skates in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* distribution from 1981 to 2017 in the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4), and Portuguese crustacean surveys/Nephrops TV surveys (PT-CTS (UWTV (FU 28-29).



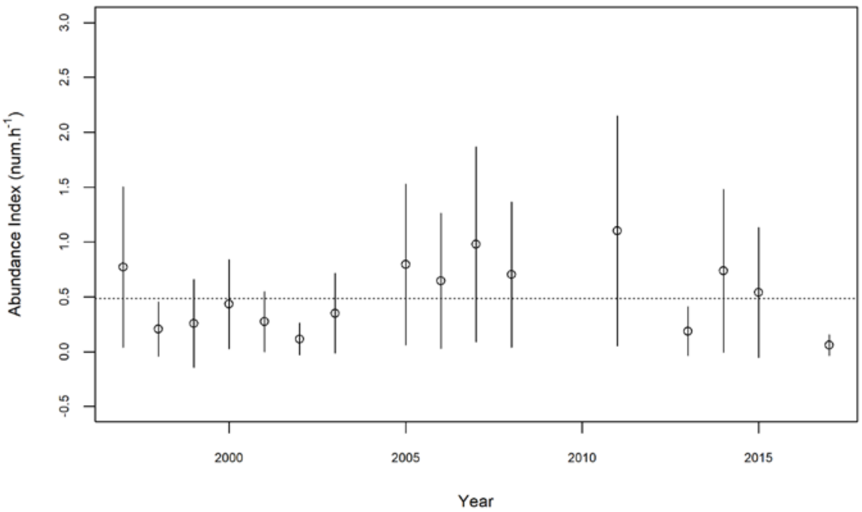


Figure 19.11b. Skates in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* biomass index (kg.hour^{-1}) and abundance (ind.hour^{-1}) on PT-CTS (UWTV (FU 28-29) from 1997 to 2015. Dashed line represents the mean annual abundance for the considered period.

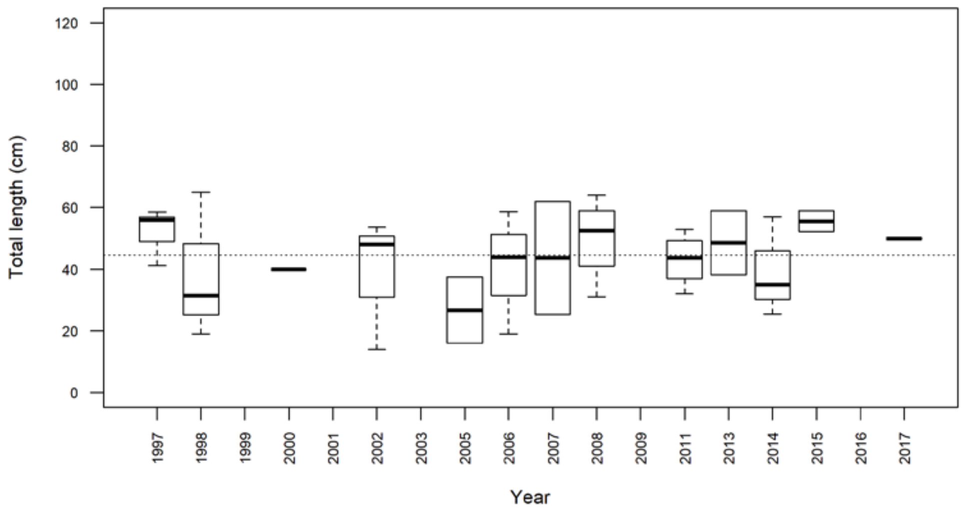


Figure 19.11c. Skates in the Bay of Biscay and Iberian Waters. Total length variation of *Leucoraja naevus*, by year on PT-CTS (UWTV (FU 28-29) (dashed line represents the mean annual length for 1997-2017).

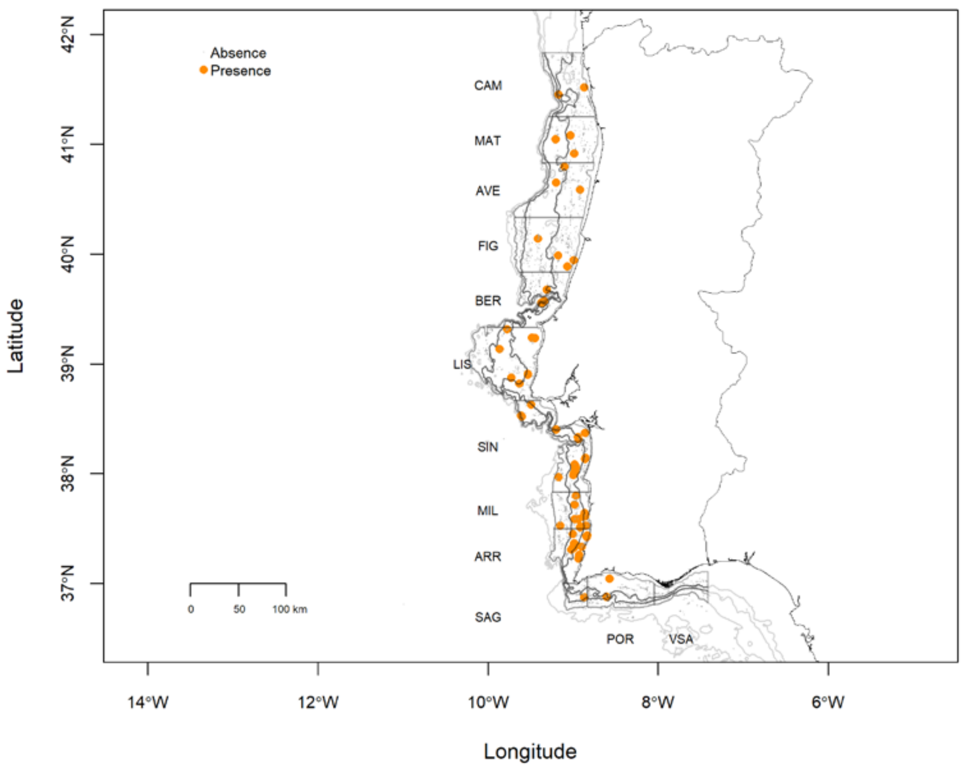


Figure 19.12a. Skates in the Bay of Biscay and Iberian Waters. *Raja montagui* distribution from 1981 to 2017 in the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4).

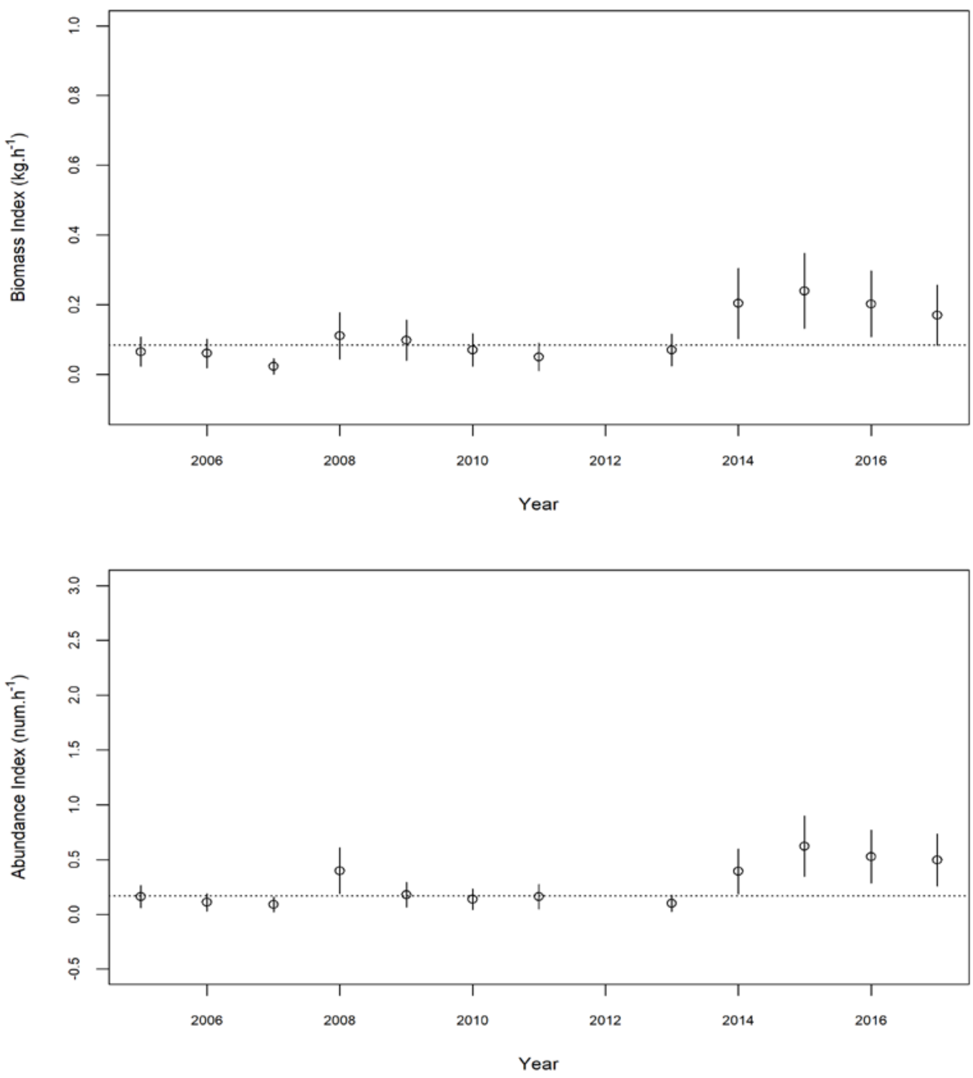


Figure 19.12b. Skates in the Bay of Biscay and Iberian Waters. *Raja montagui* biomass index (kg.hour^{-1}) and abundance (ind.hour^{-1}) on PtGFS-WIBTS-Q4from 1990 to 2017. Dashed line represents the mean annual abundance for the considered period.

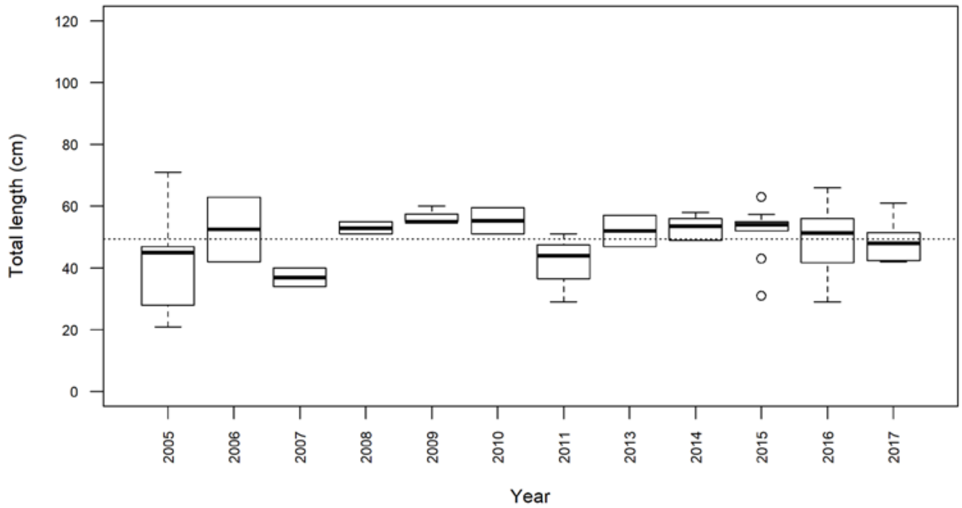


Figure 19.12c. Skates in the Bay of Biscay and Iberian Waters. Total length variation of *Raja montagui*, by year on PtGFS-WIBTS-Q4 (dashed line represents the mean annual length for 1990-2017).

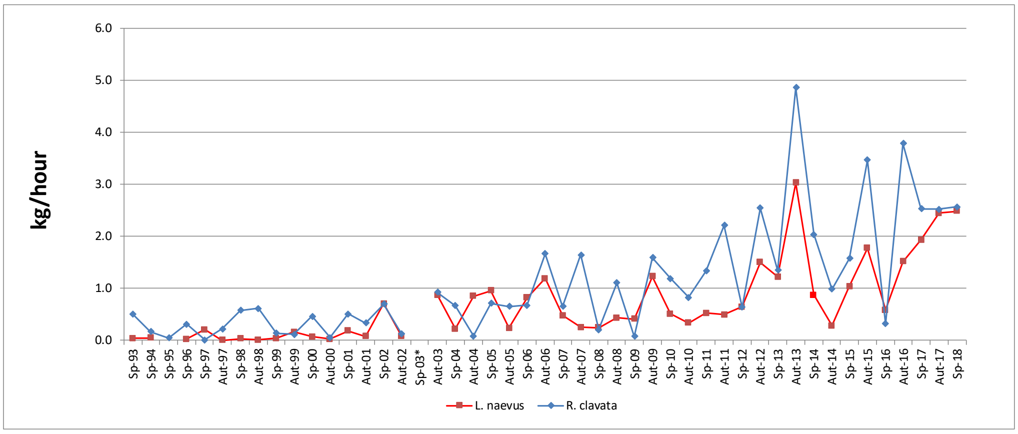


Figure 19.13a. Skates in the Bay of Biscay and Iberian Waters. Trend of the yield of *R. clavata* and *L. naevus* expressed as kg/hour from the Spanish bottom trawl survey ARSA carried out in spring and autumn in the Gulf of Cadiz (9.a South) from 1993 to 2018.

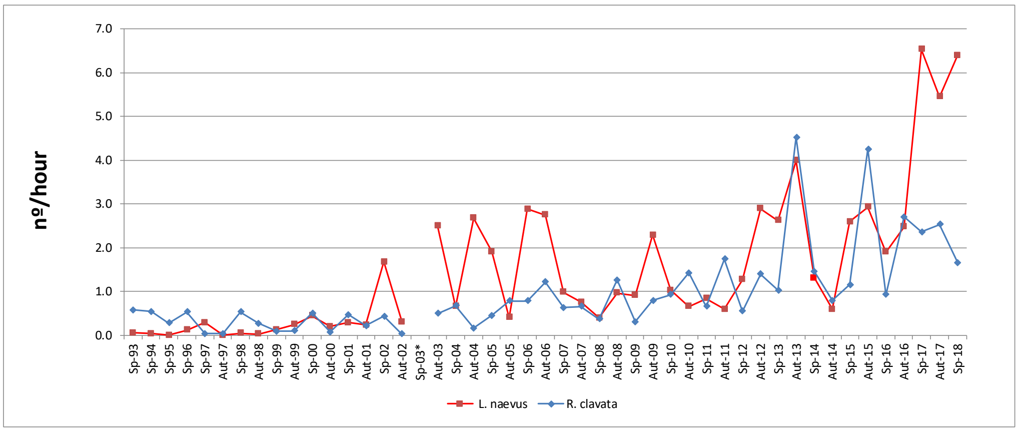


Figure 19.13a-b. Skates in the Bay of Biscay and Iberian Waters. Trend of the yield of *R. clavata* and *L. naevus* expressed as nº/hour from the Spanish bottom trawl survey ARSA carried out in spring and autumn in the Gulf of Cadiz (9.a South) from 1993 to 2018.

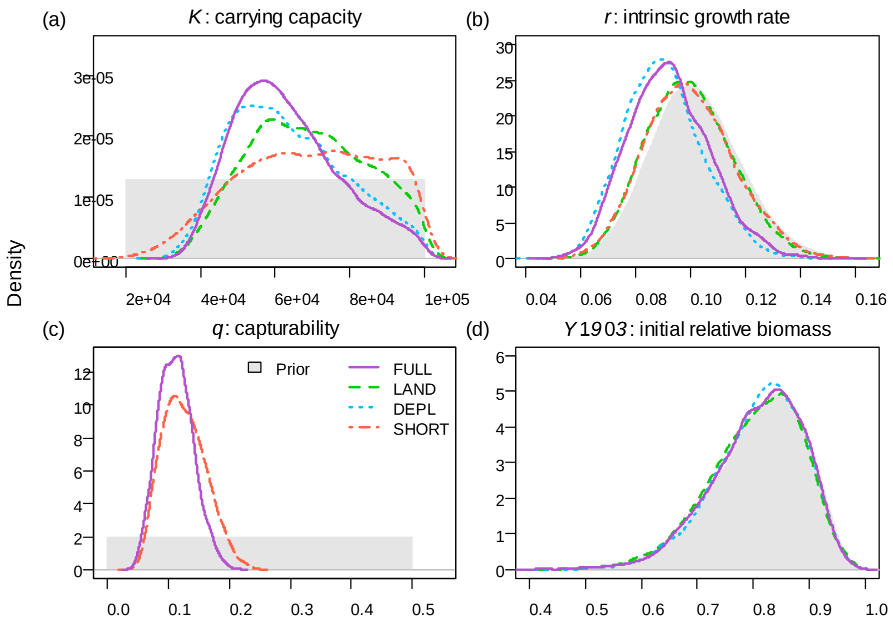


Figure 19.14 Skates in the Bay of Biscay and Iberian Waters. Comparison of prior and marginal posterior parameter distributions for *R. clavata* in the Bay of Biscay for four model runs using different data combinations. FULL: landings and biomass index; LAND: landings only; DEPL: landings and depletion estimated for final year; SHORT: as in FULL but using data for the years 2000-2013 only.

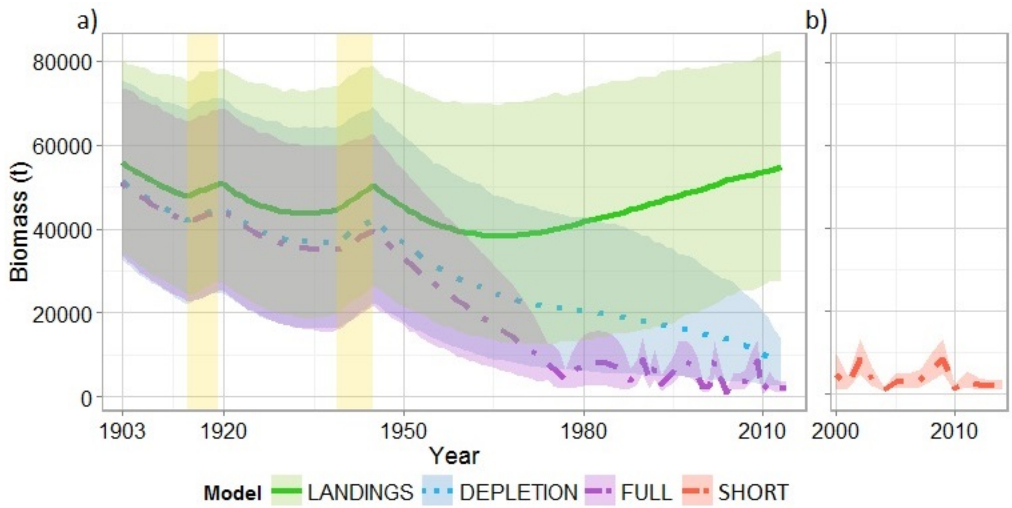


Figure 19.15. Skates in the Bay of Biscay and Iberian Waters. a) Estimated biomasses trajectories for *R. clavata* in the Bay of Biscay for model runs using different data series. LANDINGS: landings only; DEPLETION: landings and final year depletion rate; FULL: landings and biomass index for the years 1973-2013. Coloured areas: credible intervals between 2.5 and 97.5 percentiles. Vertical rectangles: World War I and II periods. b) Estimated biomasses trajectories for *R. clavata* in the Bay of Biscay by using only catches and biomass index time series from 2000 to 2013 (SHORT run).

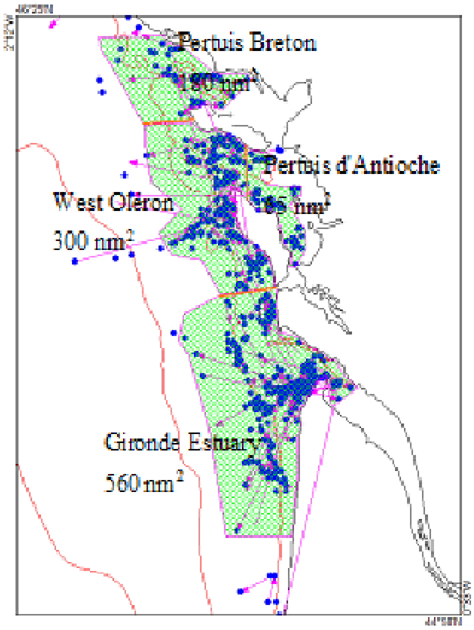


Figure 19.16. Skates in the Bay of Biscay and Iberian Waters. Habitat areas of *R. undulata* in the centre of the Bay of Biscay from 2011–2014 tagging and recapture positions.

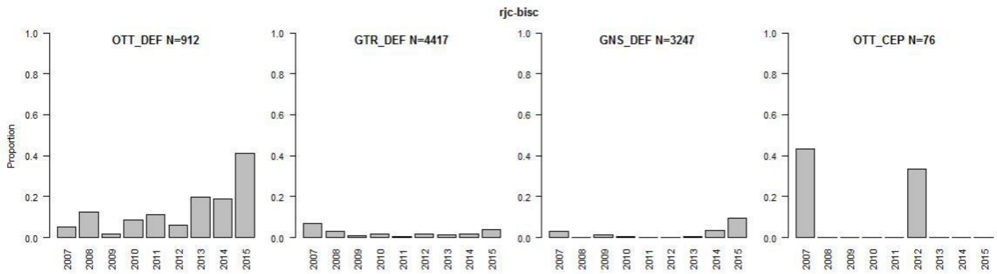


Figure 19.17a. Skates in the Bay of Biscay and Iberian Waters. *Raja clavata* in Subarea 8 (Bay of Biscay), rjc-bisc. Occurrence indicators from the French on-board observations programme in 8abd. N: total number of fishing operations observed for the métier from 2007–2015.

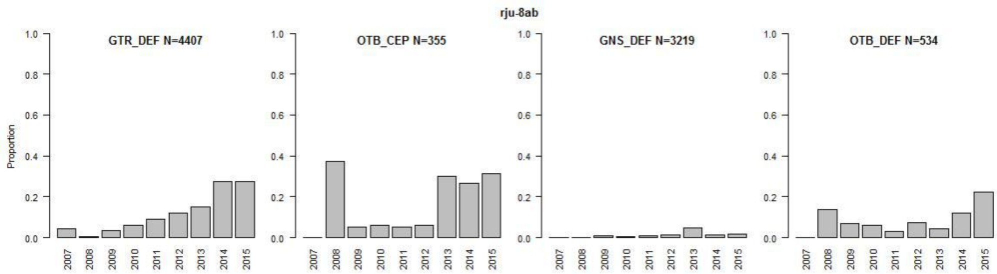


Figure 19.17b. Skates in the Bay of Biscay and Iberian Waters. *Raja undulata* in Divisions 8.a-b (Bay of Biscay North and Central), rju-8ab. Occurrence indicators from the French on-board observations programme in 8abd. N: total number of fishing operations observed for the métier from 2007–2015.

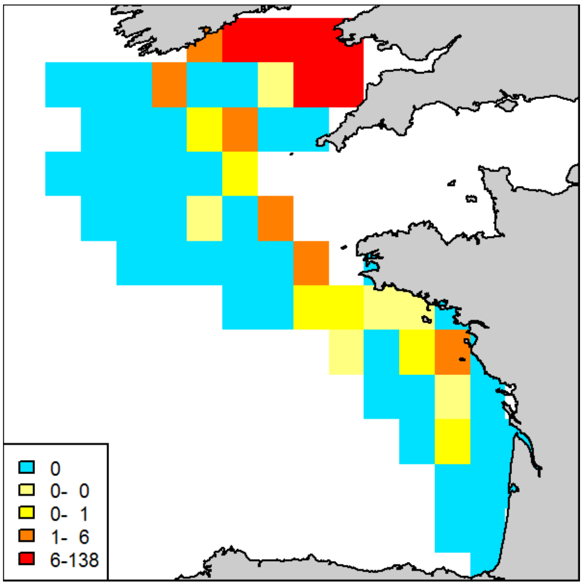


Figure 19.18. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *Raja montagui* in ICES Divisions 7.f-k and 8.a-c, based on catch in the EVHOE survey.

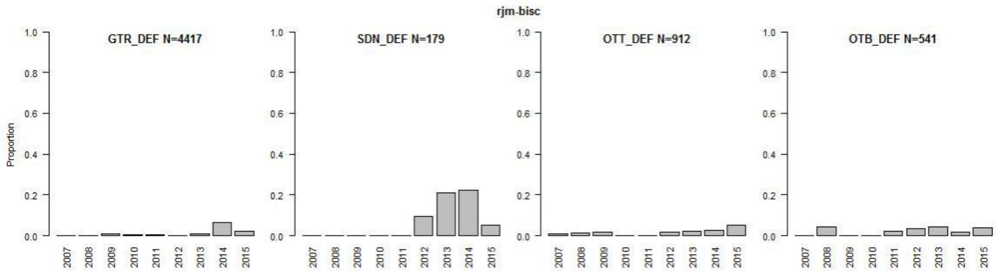


Figure 19.19. Skates in the Bay of Biscay and Iberian Waters. *Raja montagui* in Subarea 8 (Bay of Biscay), rjm-bisc. Occurrence indicators from the French on-board observations programme in 8abd. N: total number of fishing operations observed for the métier from 2007–2015.

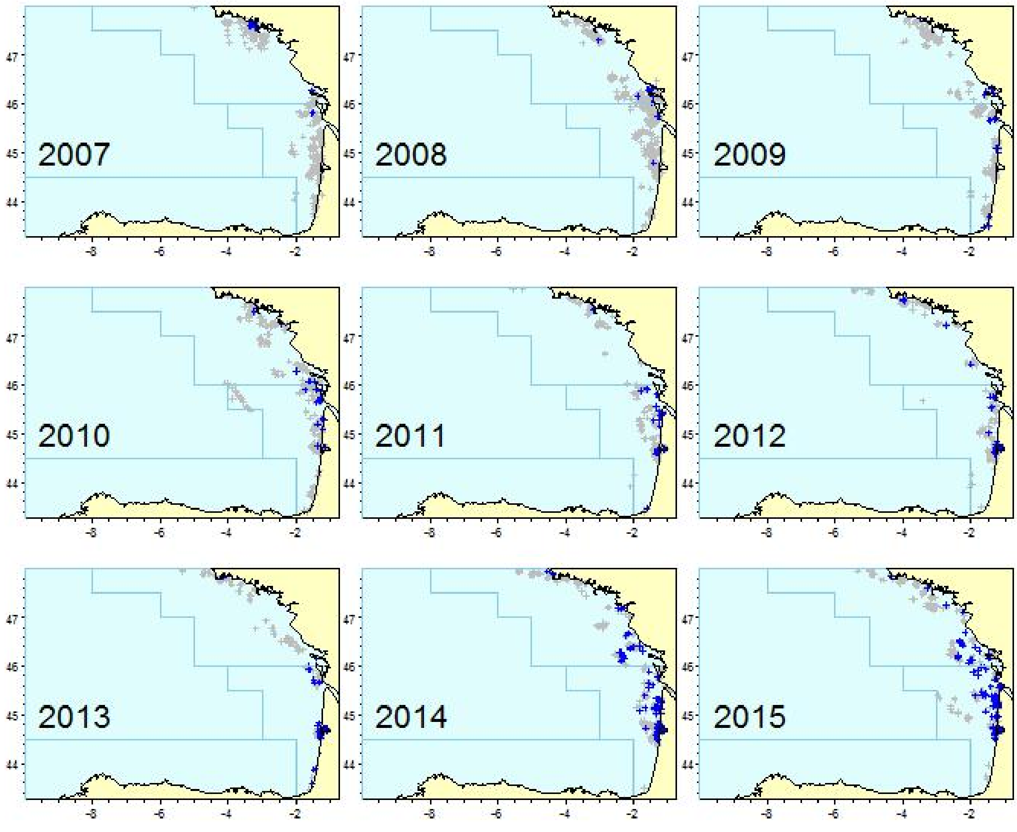


Figure 19.20. Skates in the Bay of Biscay and Iberian Waters. Occurrence of *Raja undulata* in Divisions 8a-b (Bay of Biscay) (rju-8ab) showing the spatial distribution based on occurrence in trammel net catches (DCF level 5 métier GTR_DEF) from 2007–2015, used to estimate the frequency of occurrence (see Figure 19.17b).

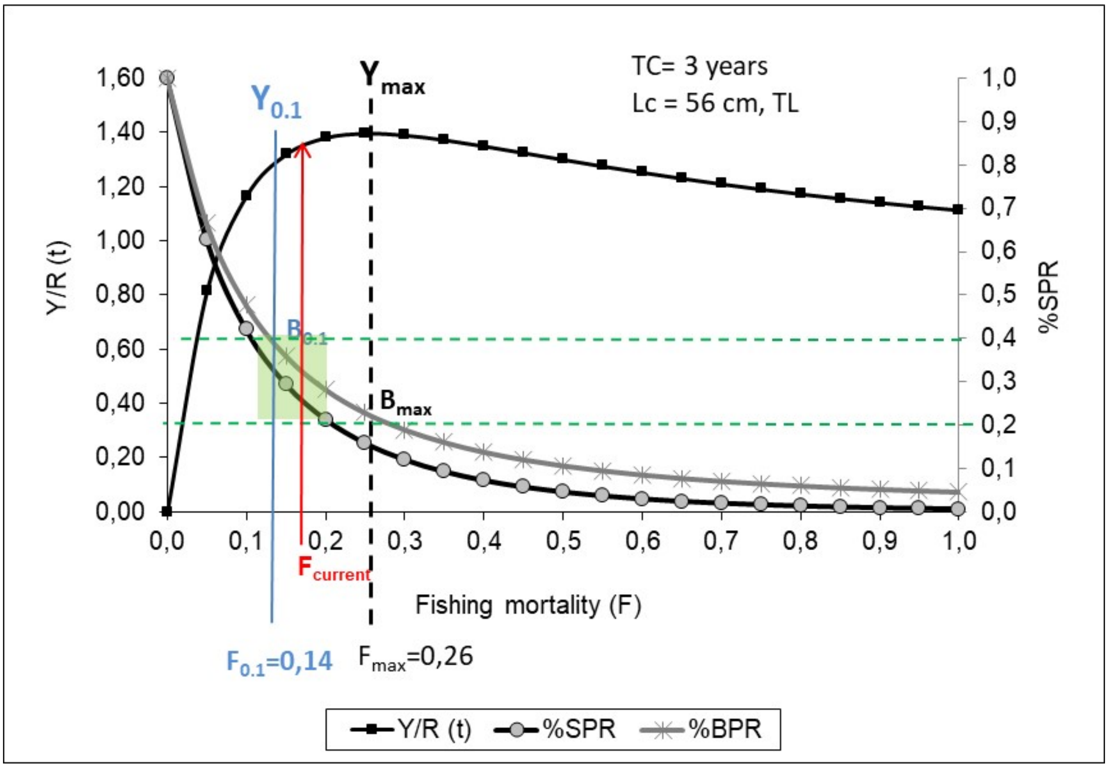
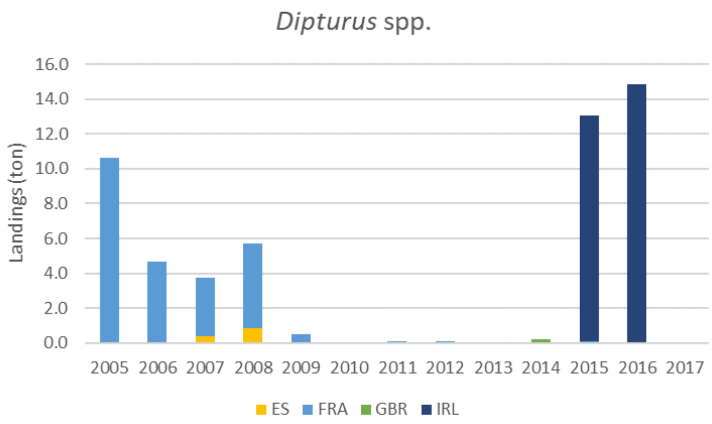


Figure 19.21. Skates in the Bay of Biscay and Iberian Waters. *Raja brachyura* yield per recruit (Y/R and potential spawning ratio (%SPR) curves for different levels of fishing mortality and an age of first capture = 3 years (TC). Red line shows $F_{current}$. *Raja brachyura*.



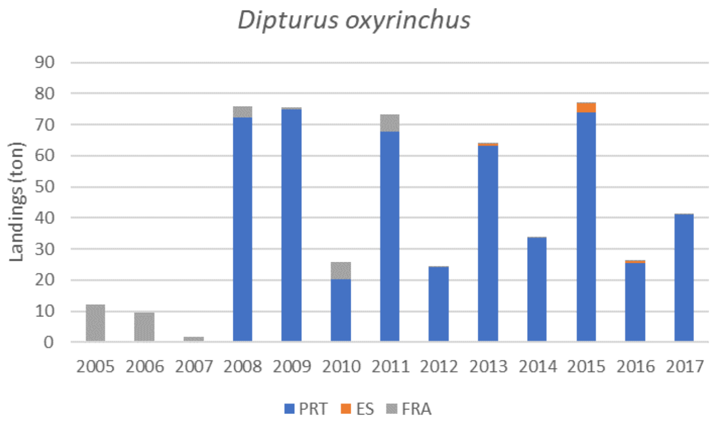


Figure 19.22. Landings (t) of *Dipturus* spp. and *Dipturus oxyrinchus by country* for Divisions 8 and 9a (2004-2016).

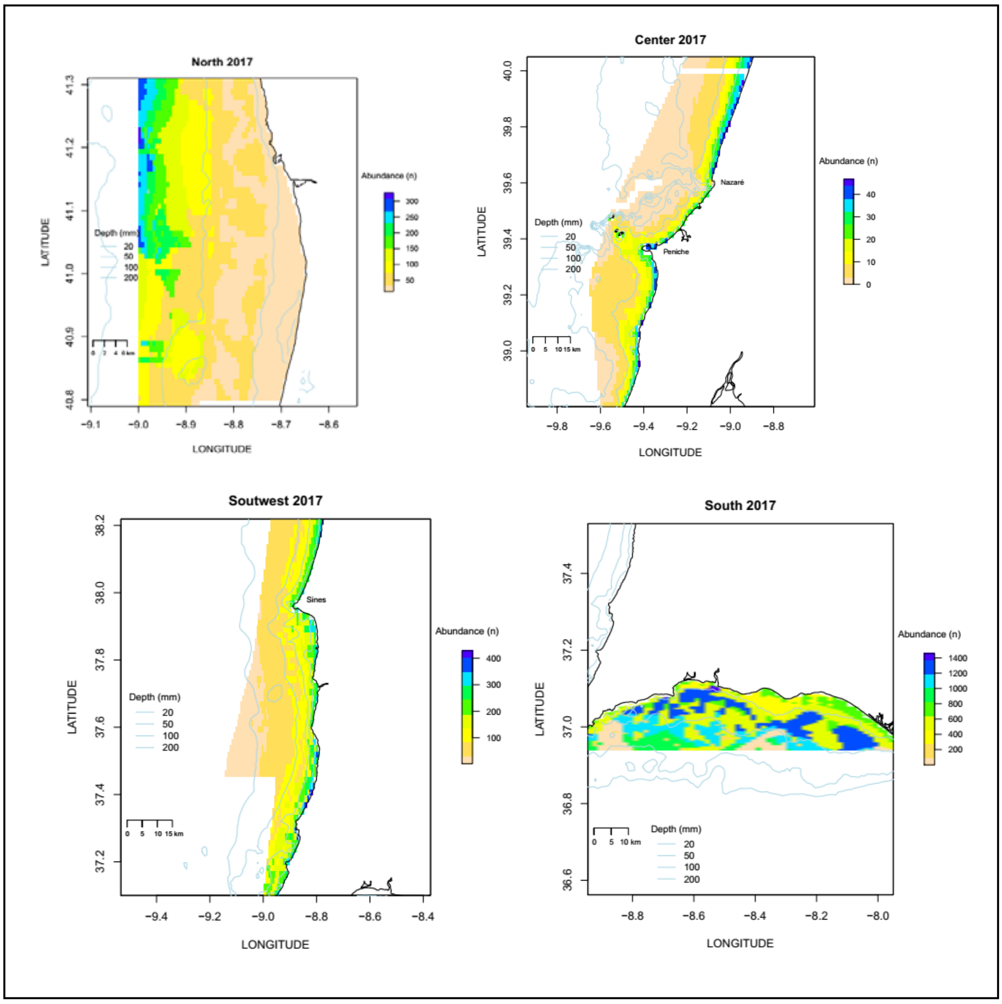


Figure 19.23: ***Raja undulata*** **potential abundance by region for 2017.**

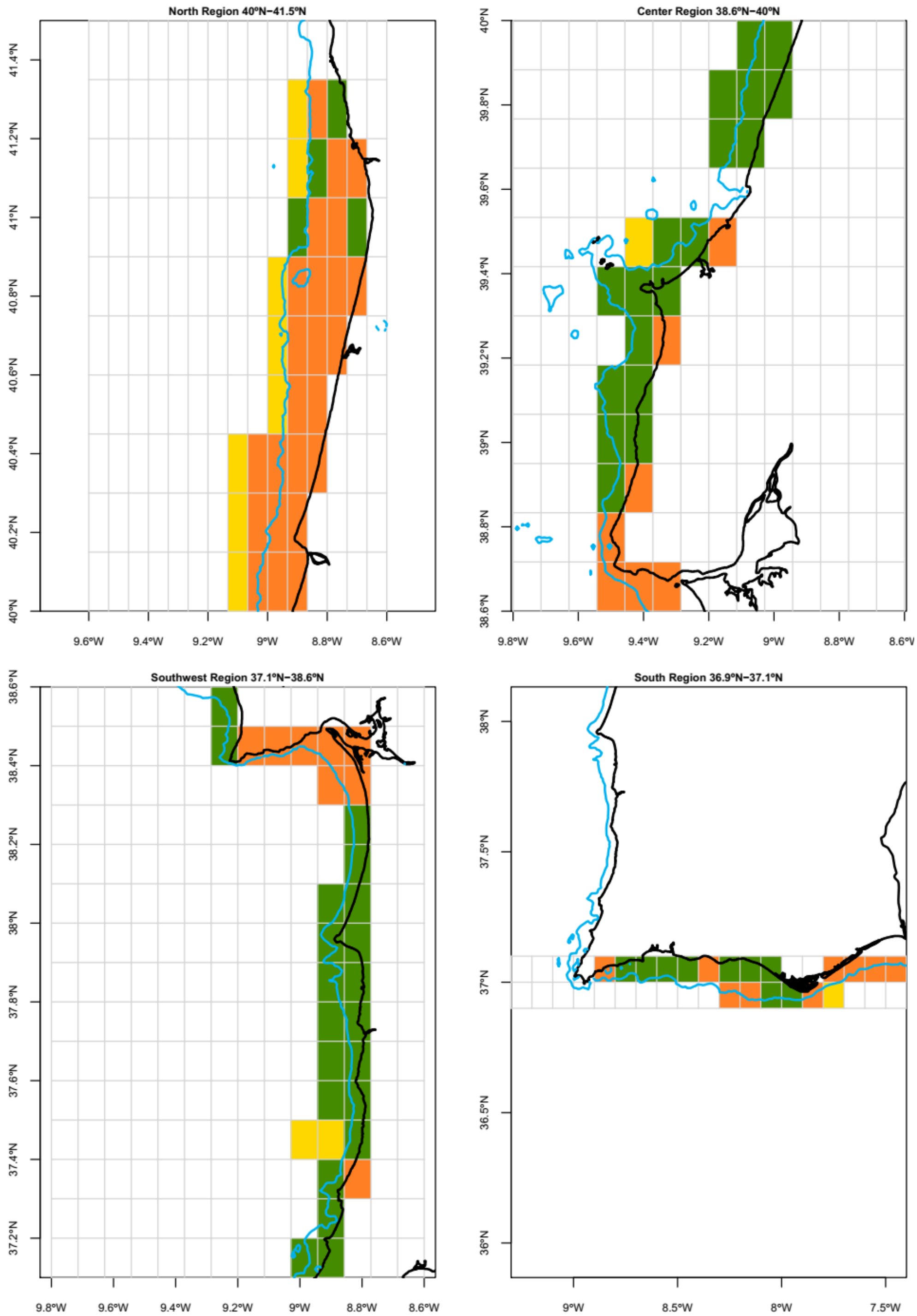


Figure 19.24. Sampling requirements for full spatial coverage of *Raja undulata* spatial distribution. Green - Spatial cells already sampled in 2016 and/or 2017 that need to continue to be monitored; Orange: - Spatial cells not sampled yet that need to be sampled with priority and; Yellow: Spatial cells not sampled yet that need to be sampled with lower priority.

20 Skates and Rays in the Azoresa and Mid-Atlantic Ridge

20.1 Ecoregion and stock boundaries

The Mid-Atlantic Ridge (MAR; ICES subareas 10.a,b, 12.a,c, and 14.b1) is an extensive and diverse area, which includes several types of ecosystem, including abyssal plains, seamounts, active underwater volcanoes, chemosynthetic ecosystems and islands.

The main species of elasmobranch observed in this ecoregion are deep-water species (e.g. *Centrophorus* spp., *Centroscymnus* spp., *Deania* spp., *Etmopterus* spp., *Hexanchus griseus*, *Galeus murinus*, *Somniosus microcephalus*, *Pseudotriakis microdon*, *Scymnodon obscurus*, *Centroscyllium fabricii*; see sections 3 and 5 for more information), particularly whenever the gear fishes deeper than 600 m. As a consequence of their low commercial value or EU restrictive management measures, many of these species are discarded (ICES, 2005; Pinho and Canha, 2011 WD). The kitefin shark *Dalatias licha* and tope *Galeorhinus galeus* are the most important commercial elasmobranchs species in the Azores area (see sections 4 and 10, respectively).

The present section focuses on the skates taken in Azorean waters. Of these, the most abundant in Subarea 10 is thornback ray *Raja clavata*. Other species also observed include the 'common skate complex' (species to be confirmed), *D. oxyrinchus*, *Leucoraja fullonica*, *Rajella bathyphila*, *Raja brachyura* and *Rostroraja alba* (Pinho, 2005 WD, 2014b WD). Other species of batoids, such as Bigelow's ray *Rajella bigelowi* are also observed in this ecoregion (e.g. Santos *et al.*, 1997; Menezes *et al.*, 2006). All these species are generally discarded if caught in the Azorean commercial fisheries (Pinho and Canha, 2011 WD). Some of the scarcer skates observed on MAR include *Bathyraja pallida* and *Bathyraja richardsoni* (ICES, 2005).

Stock boundaries are not known for most of the skate species in this area, neither are the potential movements of species that also occur on the continental shelf of mainland Europe. Genetic studies of *R. clavata* have indicated significant differences between Azorean and the eastern Atlantic sea board populations (Chevolot *et al.*, 2006; Ball *et al.*, 2016), indicating that mixing is limited. Further investigations are necessary to determine potential migrations or interactions of skate populations within this ecoregion and neighbouring areas.

20.2 The fishery

20.2.1 History the fishery

Two broad types of fisheries occur in the area. Oceanic fisheries (large midwater and bottom trawlers and longliners) operate in the central region and northern parts of the MAR. Longline and handline fisheries operate inside the Azorean EEZ, where trawling is prohibited. The latter fishery also targets stocks that may extend south of the ICES area.

The fisheries from these areas were described in earlier WGEF reports (ICES, 2005). Landings from the Azorean fleets have been reported to ICES. Landings from MAR remain very small and variable, or even absent, and few vessels find the MAR fisheries profitable at present.

Skates are caught in the Azores EEZ by a multispecies demersal fishery, using handlines and bottom longlines, and by the black scabbardfish fishery using bottom longlines (ICES, 2005). The most commercially important skate caught and landed from these fisheries is *R. clavata* (ICES, 2005; Pinho, 2005 WD, 2014a WD; Pinho and Pereira, 2017 WD).

20.2.2 The fishery in 2017

There are no target fisheries on the Azores for skates. An expansion of the Azorean bottom longline fishery to the more offshore seamounts has been observed in the last decade as a result of intensive fishing of important commercial demersal and deep-water stocks and also as a result of spatial management measures introduced. A shift from this fishery to the black scabbardfish fishery has been observed during the recent years, although with a very variable annual effort due to market issues.

Skate landings, particularly of *R. clavata,* increased in the Azores since 2009 until 2014, with 2014 and 2015 having the highest records in the time series and averaging 179 t, decreasing slightly thereafter (Tables 20.1–20.2; Figure 20.1). The landing values during 2017 are similar to recent historical values, because the market for these species is very limited, with little domestic consumption and limited demand for export.

There are no fisheries targeting skates on the MAR (ICES subareas 10, 12 and 14) with sporadic landings during the recent years (Table 20.1 and 20.2).

20.2.3 ICES advice applicable

ICES advises that when the precautionary approach is applied, landings should be no more than 78 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches.

20.2.4 Management applicable

20.2.4.1 Mid-Atlantic Ridge

NEAFC has adopted management measures for the MAR areas under its regulatory area (https://www.neafc.org/managing_fisheries/measures/current) These include effort limitations, area and gear restrictions. The recommendations for 2017 that are relevant to skates in this region include:

- Recommendation 6. Each Contracting Party undertakes to limit the effort put into the directed fishing for deep sea species set out in Annex IB of the Scheme in the NEAFC Regulatory Area.
- Recommendation 10. Conservation and Management Measures for Deep Sea Sharks in the NEAFC Regulatory Area for 2017 to 2019.
- Recommendation 11. Conservation and Management Measures for Deep Sea Rays (Rajiformes) in the NEAFC Regulatory Area.
- Recommendation 11. Conservation and Management Measure for Deep Sea Chimaeras in the NEAFC Regulatory Area.
- Recommendation 14. Each Contracting Party shall provide VMS and Catch Data to ICES for Scientific Purposes.

20.2.4.2 Azores EEZ

In 1998, the Azorean government implemented local management actions in order to reduce effort on shallow areas of the islands, including a licence threshold based on the requirement of the minimum value of sales and the creation of a box of three miles around the islands, with fishing restrictions by gear (only handlines are permitted) and vessel type. During 2009, additional measures were implemented, including area restrictions (temporary closure of the Condor Bank) and gear restrictions by vessel type (licence and gear configuration). These technical measures have been updated thereafter (http://www.azores.gov.pt/gra/srmct-pescas/menus/principal/Legislação/).

In 2014, Portugal introduced a new regulation banning the use of bottom trawling and bottom gillnetting on the high seas in the area covered by Portugal's extended continental shelf under the UN Law of the Sea (Portaria n.º 114/2014, 28th May). The new regulation expands the EU regulation adopted in 2005 to ban bottom trawling in the Azores and Madeiran waters and has the key objective of protecting deep-sea ecosystems (such as cold-water corals and seamounts) from the impact of bottom trawling and gillnet fishing.

Under the EU Common Fisheries Policy, a box of 100 miles was created around the Azorean EEZ where only the Azorean fleets are permitted to line fish for deep-sea species (Regulation EC 1954/2003).

20.3 Catch data

20.3.1 Landings

The landings reported by each country and subarea are given in Tables 20.1–20.2. Historical total landings of skates reported for subareas 10, 12 and 14 are presented in Figure 20.1. Landings data from this ecoregion are also collated by NEAFC, and further studies to ensure that these data are consistent with ICES estimates are required.

20.3.2 Discards

No information on the discarding of skates is available for recent years.

Nevertheless, information on discards from observers in the Azorean longline fishery was reported to the WGDEEP, from 2004 to 2010, (Pinho and Canha, 2011 WD). The results showed that *Raja clavata* and 'common skate complex' were among the frequently caught and discarded elasmobranch species.

Discard levels are probably due to the management measures introduced, particularly the TAC/quotas, minimum size and fishing area restrictions (zoning by fleet characteristics) that changed fleet behaviour, expanding the fishing areas to more offshore seamounts and deeper strata. Fisheries occurring outside the ICES area to the south of the Azores EEZ may exploit the same stocks considered here.

20.3.3 Quality of catch data

Species-specific landings data are not currently available for skates landed in this ecoregion (however, it is known that more than 90% of the Azorean landings are estimated to be *R. clavata*).

20.3.4 Discard survival

Information on the discard survival of skates in these fisheries is not currently available.

20.3.5 Species composition

In the Azores, there is no systematic fishery/landing sampling programme for these species because they have low priority on the port sampling programme. Landing statistics on skates and rays from Azorean fisheries are reported under generic categories. Accurate data on the composition of skates landed are not currently available.

20.4 Commercial catch composition

20.4.1 Length composition of landings

Length samples of *R. clavata* have been collected since 1990, however few individuals were sampled until 2004 (Figure 20.2; Pinho and Pereira, 2017 WD). There are no data available for 2017 (Pinho and Silva, 2018 WD).

20.4.2 Length composition of discards

No information available.

20.4.3 Sex ratio of landings

No information available.

20.4.4 Quality of data

Only limited data are available. Improved data collation and quality checks (including for species identification) are required.

20.5 Commercial catch and effort data

Relative indices of abundance for the thornback ray species were estimated for the period 1990–2016 using a Generalized Linear Modeling approach with a hurdle (delta) model (Santos et al, 2018 WD2) (Figure 20.3). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modeling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modeling the positive catch rates on successful trips. Factors considered in the analyses of the thornback ray catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: São Miguel, Terceira and Faial, which represent around 95% of the Azorean landings, and Others, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Menezes et al., 2006), and target. The target was defined as the percentage of thornback ray catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of thornback ray caught per 1000 hooks. Records with missing effort data were excluded from the analysis.

The trends from the nominal and standardized index differed substantially. Indeed, the nominal CPUE showed an oscillation over time, with an increasing trend from 2007–2015, while the standardized index showed a more stable trend overall.

20.6 Fishery-independent surveys

Since 1995, the Department of Oceanography and Fisheries (DOP) has carried out an annual spring demersal bottom longline survey (ARQDACO(P)-Q1) around the Azores. In the years 1998, 2006, 2009, 2014 and 2015, no survey was conducted (Pinho and Silva, 2017 WD). This survey is not specifically designed to catch elasmobranchs, and so does not provide quantitative information for most species.

An overview of the elasmobranch species occurring in the Azores (ICES Subarea 10), their fisheries and available information on species distributions by depth were described by Pinho (2005; 2014a,b WD) and Pinho and Silva (2017 WD).

Raja clavata is one of the most commonly reported elasmobranch species in this survey (ICES, 2006). Relevant biological information available from surveys on this species were updated in 2017, including the annual abundance index (Figure 20.4) and length–frequency distribution (Figure 20.5). The absence of records of the youngest size classes in this survey can be attributed to a gear effect. Catches of other skates are insufficient to be informative of stock trends.

Information on elasmobranchs recorded on MAR is available from the literature (Hareide and Garnes, 2001) and was summarized in ICES (2005).

20.7 Life-history information

No new information is available. There is poor knowledge of the biology of the species for this ecoregion and available information is uncertain. The definitions of the appropriate set of life-history parameters for this group of species (that best describe population dynamics) and for this ecoregion should be addressed in future work in order to provide more accurate data for exploratory assessments.

20.8 Exploratory assessment methods

No exploratory analysis was made this year because no new data from DCF was made available on time.

20.9 Stock assessment

No assessments have been conducted due to insufficient data.

20.10 Quality of assessments

Analyses of survey trends may be informative for *R. clavata* but do not allow the status of other skates to be evaluated.

20.11 Reference points

No reference points have been proposed for any of these species.

20.12 Conservation consideration

No new information.

20.13 Management considerations

WGEF considers that the elasmobranch fauna of Mid-Atlantic Ridge in ICES subareas 10 and 12 is poorly understood. The skate species are probably little exploited compared with continental Europe. The ecoregion is considered to be a sensitive area. Consequently, commercial fisheries taking skates in this area should not be allowed to proceed, unless studies are conducted to demonstrate what sustainable exploitation levels should be permitted.

20.14 References

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Table 20.1. Skates and Rays in the Azores and Mid-Atlantic Ridge. Reported landings (t) from ICES subareas 10 and 12 for the period 1988–2004.

Year	Subarea 10				Subarea 12	Subarea 14
	Portugal (Azores)	France	Spain	Total	UK	UK
1988	48			48		
1989	29			29		
1990	35			35		
1991	52			52		
1992	43			43		
1993	32			32		
1994	55	1		56		
1995	62			62		
1996	71			71		
1997	99			99		
1998	117			117		
1999	103			109		
2000	83		24	107		
2001	68	2	29	99	1	+
2002	70			70	1	+
2003	89			89	6	
2004	72			72	1	

Table 20.2. Skates and Rays in the Azores and Mid-Atlantic Ridge. Reported landings of skates and rays (t) from ICES subareas 10, 12 and 14 for the period 2005–2017 following the 2016 ICES Data Call.

YEAR	SUBAREA 10			SUBAREA 12		SUBAREA 14			Total
	Portugal (Azores)	Spain	France	Spain	France	France	Norway	Germany	
2005	47		0.06	0	0.632			0	48
2006	62		0	0	0.029		6.6	0.2	69
2007	71		0	0	0.0135			0.1	71
2008	72		0.063	0	0.0031		0.7	0	73
2009	60		0.16	1.513	0.757		2.5	0	64
2010	68		0.066	5.106	0.275			0	69
2011	91		0.156	1.764	0.358			0	92
2012	103		0.002	0.671	0.26	0.1		0	103
2013	115		0.081	0.485	0			0	115
2014	187		0.03	2.481	0.189	0		0	187
2015	171		0	0	0.055		0	0	172
2016	127		0	0	0				127
2017	64		0	0	0			0.011	64

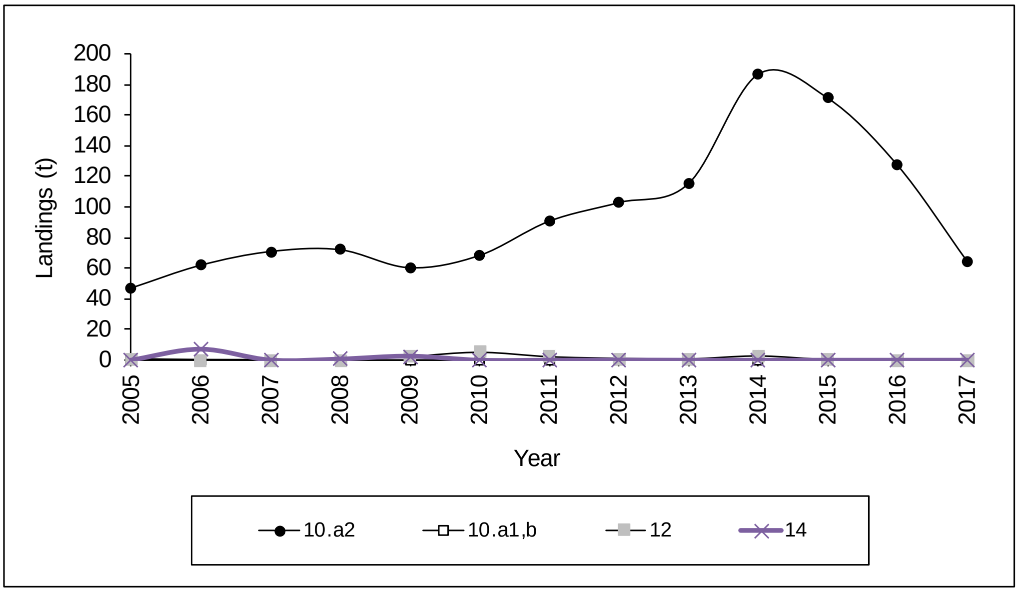

Figure 20.1. Skates and Rays in the Azores and Mid-Atlantic Ridge. Historical landings of skates and rays from Azores (ICES Division 10.a2) and MAR (ICES subareas 10, 12 and 14).

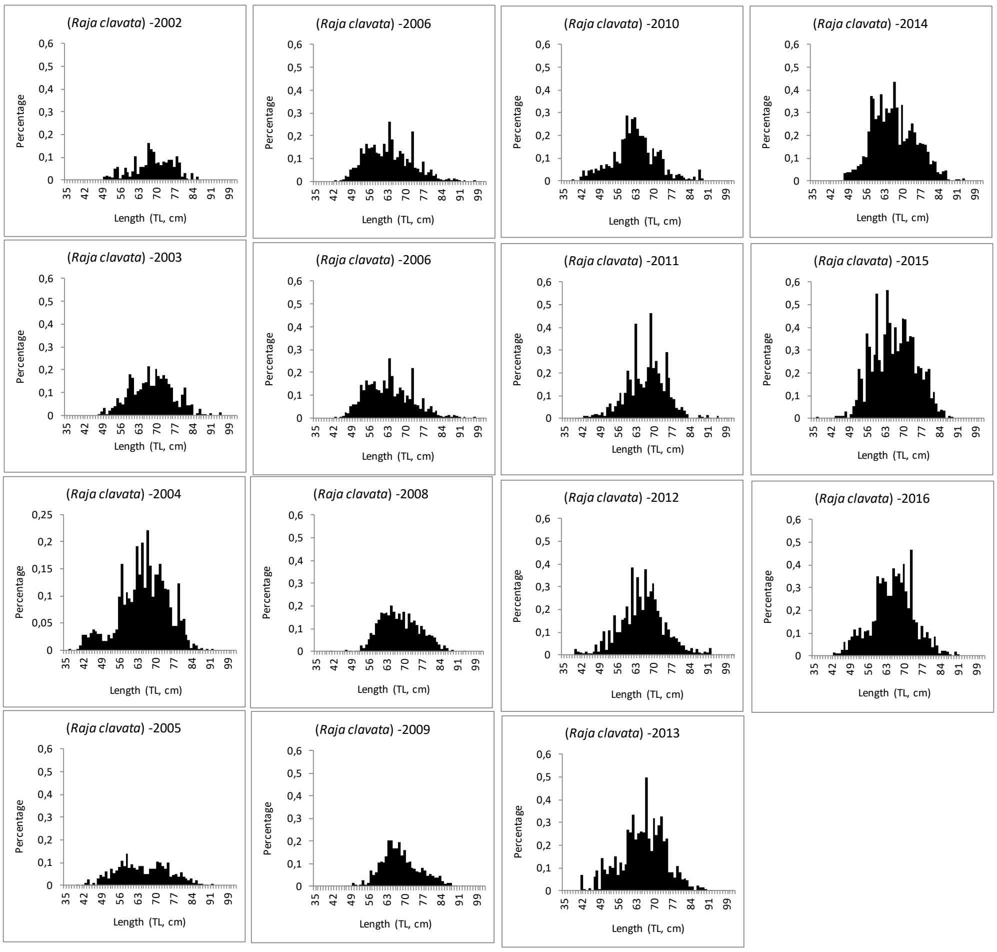

Figure 20.2. Skates and Rays in the Azores and Mid-Atlantic Ridge. Length-frequency of Raja clavata landed in the Azorean for the period 2002–2016.

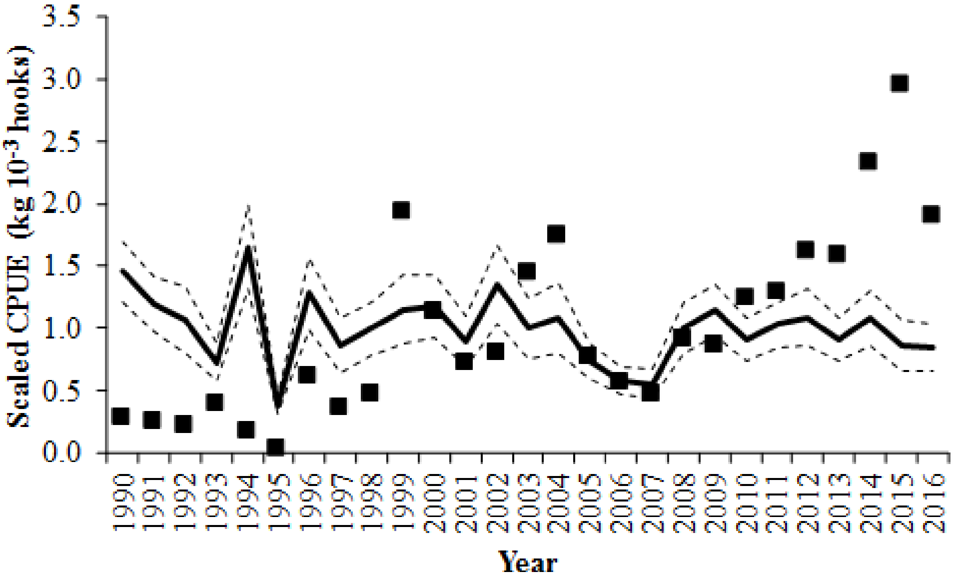

Figure 20.3. Skates and Rays in the Azores and Mid-Atlantic Ridge. Standardized fishery cpue of Raja clavata landed in the Azorean for the period 1990–2016. Square points are observed nominal cpue; Black line: Standardized cpue and dashed lined 95% confidence interval.

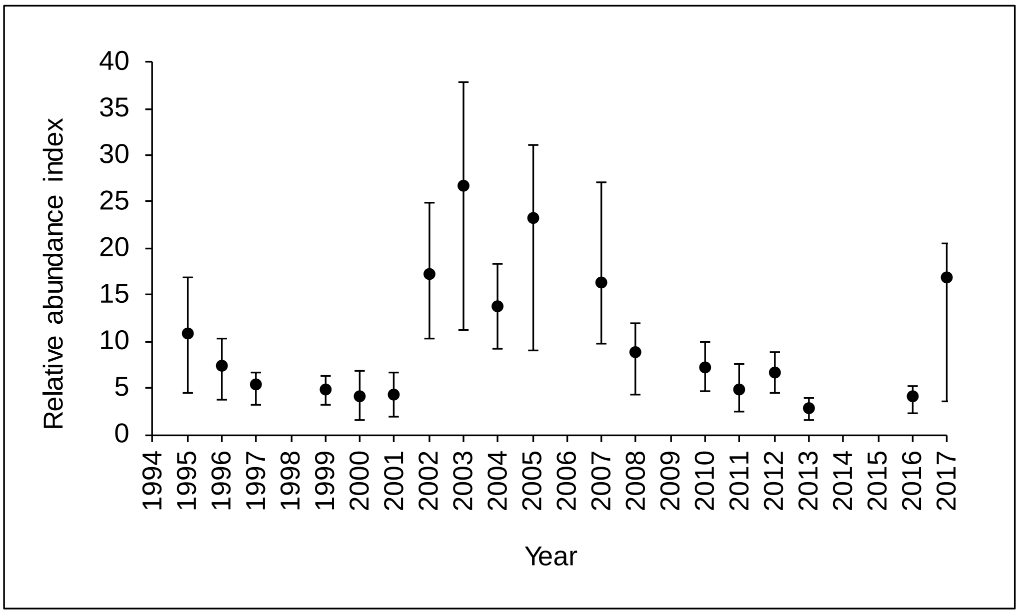

Figure 20.4. Skates and Rays in the Azores and Mid-Atlantic Ridge. Annual abundance, in numbers, of Raja clavata from the Azores (ICES subarea 10) from the Azorean demersal spring bottom long-line survey (1995–2017).

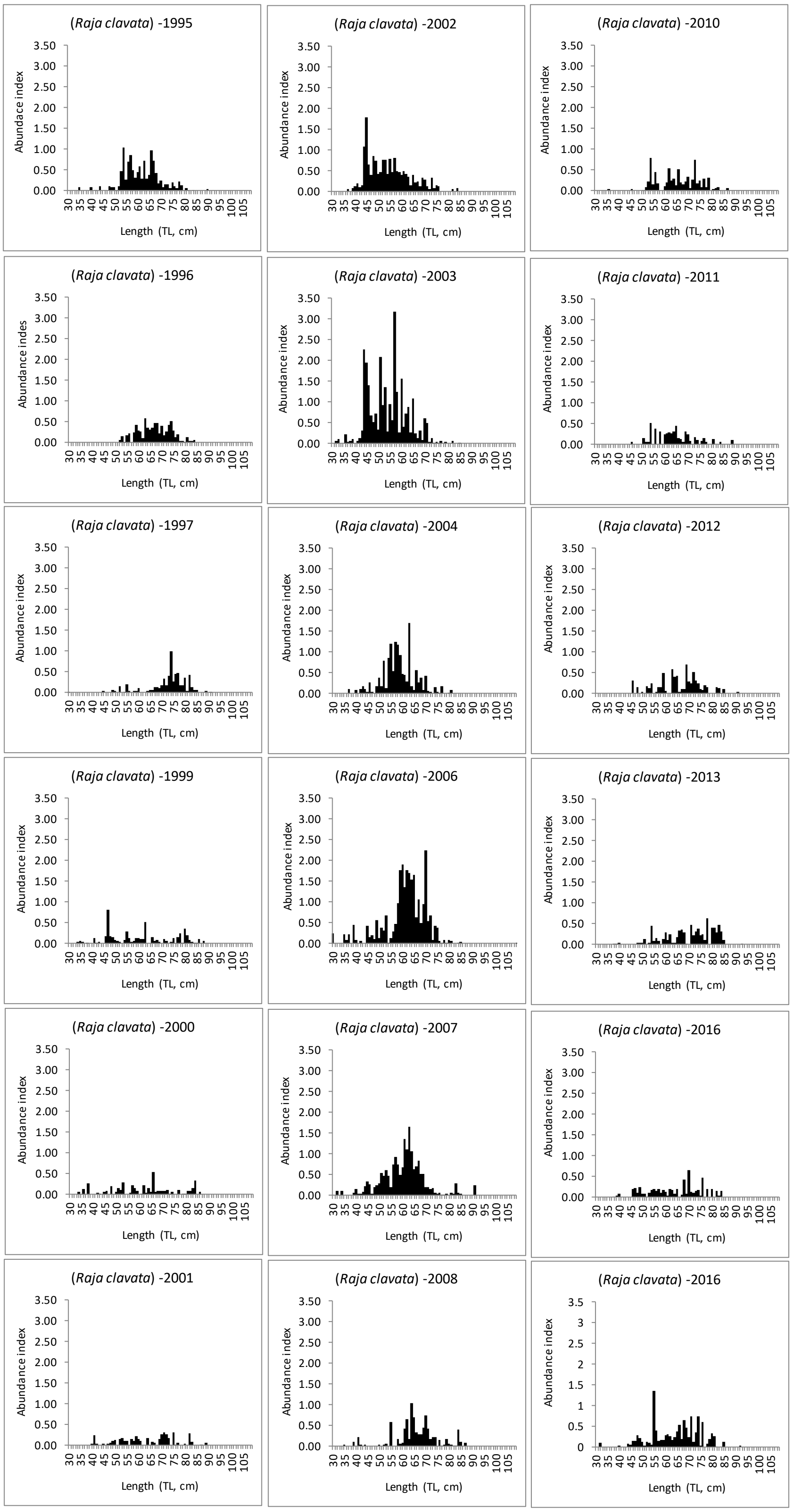

Figure 20.5. Skates and Rays in the Azores and Mid-Atlantic Ridge. Length-frequency of Raja clavata caught in the Azorean demersal spring bottom longline survey for the period 1995–2017.

21 Smooth-hounds in the Northeast Atlantic

Smoothhound advice is provided biennially, and was last updated in 2017. Therefore, this chapter only contains minor edits and updates to landings tables and figures. The advice for 2018 and 2019 is reproduced in Section 21.2.3.

It is recommended that a Stock Annex is produced for this stock in 2019.

21.1 Stock distribution

Three species of smooth-hound (Triakidae) occur in the ICES area.

Starry smooth-hound *Mustelus asterias*: This is the dominant smooth-hound in northern European waters. The development of molecular genetic identification techniques has allowed the reliable identification and discrimination of NE Atlantic *Mustelus* species (Farrell *et al*., 2009). Subsequent studies involving the collection of 231 *Mustelus* from the Irish Sea, Bristol Channel, Celtic Sea and west of Ireland, identified all to be *M. asterias* (Farrell *et al*., 2010a, b). Studies of *Mustelus* samples (n = 504) from the North Sea and English Channel (McCully Phillips and Ellis, 2015) also found all specimens to be *M. asterias*.

There are several on-going tag-and-release programmes for *M. asterias* (e.g. Burt *et al*., 2013 WD). Sportvisserij Nederland, in conjunction with Wageningen Marine Research, have a tagging programme with anglers in the Dutch Delta. This study last reported that 2244 *M. asterias* were tagged, and 80 recaptures reported (Brevé *et al*., 2016). Recapture positions showed a circannual migration, with fish spending the summer in the southern North Sea and overwintering in the English Channel and Bay of Biscay, suggesting a degree of philopatry (Brevé *et al*., 2016). Cooperative large-scale analyses of all available tagging data are required. Tagging studies from the more southern parts of the distribution range could usefully be undertaken.

In the absence of more detailed studies on stock identity, WGEF considers there to be a single biological stock unit of *Mustelus asterias* in the continental shelf waters of ICES Subareas 4, 6–8. The southern limits are uncertain.

Common smooth-hound *Mustelus mustelus*: This species occurs along the west coast of Africa, Mediterranean Sea and western Europe. It is thought to be the more common species in the southern parts of the ICES area, but the northern limits are uncertain. No confirmed specimens have been found in northern parts of the ICES area in recent years and historical records are questionable, especially those records north of the Bay of Biscay. Separating these two species on the presence or absence of spots is unreliable (Compagno *et al*., 2005; Farrell *et al*., 2009), and information and data from northern Europe referring to *M. mustelus* likely refers to *M. asterias*.

Black-spotted smooth-hound *Mustelus punctulatus*: This species occurs in the Mediterranean Sea (Quignard, 1972) and off NW Africa and the southernmost part of ICES Division 9.a is thought to be the northern limit of this species.

Generic issues: The species composition of smooth-hounds in Subareas 8–9 is unclear, and species/stocks in these areas likely extend into the northern part of the CECAF area and Mediterranean Sea. Given species identification issues and that some species and/or stocks may extend beyond the ICES area, the identification of management unit(s) would need appropriate consideration.

Given the problems in separating *M. asterias* and *M. mustelus* and that data for these two species are confounded, data in this chapter are generally combined at genus level.

Whilst assessments conducted by WGEF are based on *Mustelus asterias*, management advice should be applied at the genus level, so as to avoid potential identification problems associated with management and enforcement.

21.2 The fishery

21.2.1 History of the fishery

Smooth-hounds are a seasonal bycatch in trawl, gillnet and longline fisheries. Though they are discarded in some fisheries, other fisheries land this bycatch, depending on market demands. Some may also be landed to supply bait for pot fisheries.

Smooth-hounds are also a relatively important species for recreational sea anglers and charter boat fishing in several areas, with anglers and angling clubs often having catch-and-release protocols, particularly in the Celtic and North Sea ecoregions.

21.2.2 The fishery in 2017

There were no major changes to the fishery noted in 2017. Anecdotal information from the UK fishing industry suggests that increased landings of smooth-hounds are partly to supply market demand for 'dogfish', given the current restrictions on spurdog. *M. asterias* is also of increasing importance to some inshore fisheries, given restricted quotas for traditional quota stocks.

21.2.3 ICES Advice applicable

ICES first provided advice for this stock in 2012 for 2013 and 2014 (which was reiterated for 2015), stating that "*Based on ICES approach to data-limited stocks, ICES advises that catches should be reduced by 4%. Because the data for catches of smooth-hounds are not fully documented and considered highly unreliable (due to the historical use of generic landings categories), ICES is not in a position to quantify the result*".

In 2015, ICES advised that "*when the precautionary approach is applied, landings should be no more than 3272 tonnes in each of the years 2016 and 2017*". This was based on a survey-based (Category 3) assessment, with the stock size indicator based on four survey indices.

In 2017, ICES advised that "*when the precautionary approach is applied, landings should be no more than 3855 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches*".

21.2.4 Management applicable

There are no specific management measures for smooth-hounds.

EC Council Regulations 850/98 for the `conservation of fishery resources through technical measures for the protection of juveniles of marine organisms' details the minimum mesh sizes that can be used to target fish. Although other dogfish (*Squalus acanthias* and *Scyliorhinus* spp.) could be targeted in fixed nets of 120–219 mm and >220 mm mesh size (in regions 1 and 2), *Mustelus* spp. would be classed under 'all other marine organisms', and so can only be targeted in fixed nets of >220 mm. This has been queried by some fishermen.

21.3 Catch data

21.3.1 Landings

No accurate estimates of catch are available for earlier years (Table 21.1; Figure 21.1), as many nations that landed smooth-hounds reported an unknown proportion of landings in aggregated landings categories (e.g. 'dogfish and hounds *nei*').

New ICES estimates, following WKSHARKS2 (ICES, 2016a) indicate that landings have been over 3000 t since 2005 (Table 21.2). The main nations exploiting smooth-hounds are France and UK. The English Channel and southern North Sea are important fishing grounds.

Species-specific landings for the various species of *Mustelus* are not considered accurate, and data have been collated at genus level. These values are likely underestimates, given that some nations still have some landings of 'dogfish and hounds *nei'.*

21.3.2 Discards

Although discards data are available from various nations, data are limited for some nations and fisheries. Four countries reported preliminary estimates of discards, which ranged from 28 to 950 t in 2014. Given the seasonality of catches in some areas, and that *M. asterias* is often taken by inshore vessels where observer data can be more sporadic, further studies to evaluate the most appropriate methods of raising data from observer trips to fleet level are required if catches are to be estimated appropriately.

Earlier studies have indicated that juvenile *M. asterias* are often discarded (Figure 21.2), although the survival of these discards has not been evaluated (Silva *et al*., 2013 WD). *M. asterias* taken by beam trawl and *Nephrops* trawl were composed primarily of juveniles and sub-adults (<70 cm L_T), and nearly all were discarded. Gillnet catches were comprised primarily of fish 60–110 cm L_T, with fish <55 cm L_T usually discarded. Otter trawl catches covered a broad length range, and *M. asterias* <50 cm L_T were usually discarded. The absence of full retention at length in these gears may be due to various factors (e.g. catch quality and local market value) influencing the discarding behaviour of fishers.

Silva *et al.* (2013 WD) also noted that a greater proportion of *M. asterias* were retained since landing opportunities for spurdog had become restrictive. In the years 2002–2005, the retention of *M. asterias* ≥70 cm L_T was 1% and 39% in gillnet and otter trawl fisheries, respectively. In the period 2006–2011, however, retention increased to 73% (gillnets) and 49% (otter trawl).

WKSHARK3 undertook further exploratory analyses of discards data, with the discard-retention patterns described above again noted, and analyses of discards data from Scottish fisheries also presented (ICES, 2017).

21.3.3 Quality of catch data

Landings data have historically been of poor quality, as much of the landings data have been reported under generic landings categories. Most nations have made efforts to improve the recording of species in recent years.

Some northern European nations report more *M. mustelus* than *M. asterias* in official statistics, but WGEF combine these data, as *M. asterias* is the predominant and possibly the only species to occur around the British Isles.

Mustelus spp. are often taken in inshore fisheries, and landings data for vessels <10 m may not be complete.

Mustelus asterias may be landed for bait in pot fisheries around the British Isles targeting whelk, and it is unclear whether such landings are reported consistently.

The availability of landings data from outside the ICES area (e.g. Mediterranean Sea) is limited, and the quality uncertain. In 2010, the European Commission collated landings data as an average across 2008–2010 and three species of *Mustelus* were represented in these data; *M. punctulatus* (269 t from Italy), *M. mustelus* (14 t combined from Italy, Spain, Malta and Slovenia) and *M. asterias* (1 t from Malta) (ICES, 2012). WGEF has not yet considered potential catches/landings for waters off NW Africa.

Better estimates of discarding are required, with information on discard survival also needed as a proportion of discarded *Mustelus* may survive.

21.3.4 Discard survival

Discard survival is variable across this family (Ellis *et al*., 2014 WD). Whilst quantitative data are limited in European waters, Fennessy (1994) reported at-vessel mortality of 29% for Arabian smooth-hound *Mustelus mosis* taken in a prawn trawl fishery. Mortality ranged from 57–93% for three triakid sharks taken in an Australian gillnet fishery, despite the soak times being <24 hours (Braccini *et al*., 2012). High survival of triakids has been reported in longline fisheries (Frick *et al*., 2010a; Coelho *et al*., 2012).

A research programme examining movements, behaviour and discard survival through electronic tagging of *M. asterias* is underway in the UK, and data hope to be available for presentation in 2019.

21.4 Commercial catch composition

Studies to better understand the composition by size and sex (and species where there is spatial overlap) are required. Given the potential for sexual and sex-based segregation of *Mustelus*, appropriate levels of monitoring would be required to fully understand catch composition over appropriate spatial and temporal scales.

21.4.1 Length Composition of landings

In a UK study, 504 *M. asterias* samples (266 females; 238 males, Figure 21.3) were examined (McCully Phillips and Ellis, 2015), of which 286 (with a length range of 52–124 cm L_T) were landed by commercial vessels.

21.4.2 Length composition of discards

Silva *et al*. (2013 WD) analysed the discard and retention patterns of *Mustelus asterias* taken as bycatch in UK fisheries. Beam trawlers caught proportionally more juveniles (most records were of specimens of *ca.* 35–70 cm L_T), and discarding was quite high (95–99%). High rates of discarding (of smaller fish, <65 cm L_T) were also apparent in otter trawls, where about 75–80% of the total catches were discarded in the Celtic Seas and North Sea, respectively. Gillnets were more selective for larger fish (most fish were 60–100 cm L_T), and typically only larger fish (>70 cm L_T) were retained.

21.4.3 Sex ratio of landings

Of 286 commercially landed samples of *M. asterias* from the southern North Sea and eastern English Channel in May–November, 155 were female and 131 were male (McCully Phillips, unpublished). Due to *M. asterias* aggregating by sex and size, the sex ratio (and length–frequency) may vary over the year and between areas.

21.4.4 Quality of data

Mustelus length measurements may be collected as part of the concurrent sampling of the DCF. These data should be made available for future analysis.

21.5 Commercial catch and effort data

There are no data available.

21.6 Fishery-independent information

21.6.1 Availability of survey data

Several fishery-independent surveys operate in the stock area. They are often caught in GOV trawl and other otter trawl surveys in the area (Figure 21.4). For further details of trawl surveys in the stock area, see Section 15 (North Sea ecoregion), Section 18 (Celtic Seas) and Section 19 (Biscay-Iberia).

Larger individuals are not sampled effectively in beam-trawl surveys (because of low gear selectivity). For example, the UK western English Channel beam-trawl survey only occasionally records *M. asterias* >100 cm L_T (Silva *et al.*, 2018 WD; Figure 21.5).

Analyses of survey data need to be undertaken with care, as smooth-hounds are relatively large-bodied (the maximum size of *M. asterias* is at least 124 cm (McCully-Phillips & Ellis, 2015), with other sources suggesting they may attain 133 or 140 cm L_T) and adults may be strong swimmers, and able to avoid capture. As the largest individuals may not be sampled effectively in some surveys gears, survey data may not sample the full length range effectively.

Given their aggregating nature, some surveys may have a large number of zero hauls and a few hauls with relatively large numbers, although this issue does not appear to be as pronounced as seen in spurdog.

Although two species of smooth-hound are often reported in surveys, the discrimination of these species was usually based on the presence or absence of spots, which is not a reliable characteristic. WGEF consider that survey data for these two species should be combined in any analyses, and that starry smooth-hound *Mustelus asterias* is likely to be the only, or main, species in the Celtic Seas and North Sea ecoregions.

More detailed investigations of data in DATRAS undertaken by WGEF in 2017 indicate that data for *Mustelus* spp. and *Galeorhinus galeus* may have been confounded, with this most evident for Danish survey data (see Section 21.6.3), and so further analyses on the quality of IBTS-Q1 and IBTS-Q3 data could usefully be undertaken.

21.6.2 Survey trends

Updated data for six surveys were examined by WGEF, as summarised below (see Section 21.9 for additional quantitative information).

<u>IBTS-Q1 and IBTS-Q3</u>: The IBTS surveys of the North Sea, undertaken in Q1 and Q3 by seven and six countries respectively, catch relatively low numbers of *M. asterias* (which may relate to smooth-hounds being more abundant in the more southern parts of the survey area). The long-term trend in abundance of smooth-hounds has increased over both the Q1 and Q3 time-series (Figure 21.6)

<u>EVHOE-WIBTS-Q4</u>: This survey of ICES Divisions 7.g–k and 8.a.b.d has a 20-year time-series of data (1997–2016), and this was included in the assessment in 2017 (see Section 21.9), as it covers the south-western part of the stock area. Catch rates, though showing

marked inter-annual variability, indicate a broadly increasing trend over the longer-term (Figure 21.7)

BTS-UK(E&W)-Q3 (in 7.af): This survey catches reasonable numbers of *M. asterias*, albeit mostly immature specimens. The mean catch rate was derived from the catch rates from fixed stations (97 stations fished at least 21 years out of the 24-year time-series; Ellis 2017 WD), The temporal trend in CPUE (abundance and biomass) indicate an increasing trend over the longer time series, although CPUE in the last two years has declined slightly compared to the preceding five years. Both abundance and estimated biomass showed similar trends (Figure 21.9).

BTS-Eng-Q3 (in 7.d and 4.c): This survey catches mostly juvenile *M. asterias*. The mean catch rate was derived from the catch rates from fixed stations (76 stations fished at least 20 years out of the 24-year time-series, Ellis 2017 WD). The temporal trend in CPUE (abundance and biomass) indicate an increasing trend over the longer time series, although CPUE is lower and more variable than recorded in the beam trawl survey of the Irish Sea and Bristol Channel (Figure 21.9).

IGFS-WIBTS-Q4: The increasing long-term trend in *M. asterias* is also evident in the Irish Groundfish Survey, but catch rates are generally low (Figure 21.10). This survey was used as supporting information as it covers a shorter time-period in comparison to other surveys.

The UK beam-trawl survey in the western English Channel (7.e) also encounters *M. asterias* (Figure 21.8). Analyses of these data (for the period 2006–2018) noted that 924 specimens had been caught, accounting for 6.2% of the elasmobranch catch by numbers; the observed length range was 28–117 cm L_T (Silva *et al.*, 2018 WD; Figure 21.5). The estimated total abundance and biomass from this survey showed similar trends, including for all specimens and larger fish, with peaks in 2009 and 2013–2014 (Figure 21.8).

Other surveys also capture *M. asterias.* Previous analyses of the UK (Northern Ireland) western IBTS Q4 survey of the Irish Sea indicated increasing catch rates, but recent data have not been analysed.

Although smooth-hounds are not usually subject to additional biological sampling in trawl surveys, UK (England and Wales) and IGFS surveys tag and release *M. asterias*, and the individual weights and sex (all fish) and maturity (male fish only) are recorded prior to release (See Section 21.7.5).

21.6.3 Data quality

Exploratory analyses of DATRAS data (numbers at length data) indicated that there may be some confounding of data for *Mustelus* and *Galeorhinus*, which could be due to taxonomic errors or coding errors.

Exploratory data checks indicated the minimum and maximum recorded sizes of *Mustelus* spp. in IBTS-Q1 were 24–129 cm. While the record of 129 cm is to a certain degree questionable, it is also potentially valid, given the range in the reported L_{max} for the species. All nations recorded a minimum size of free-living pups that was greater than the length of the smallest neonates recorded by McCully Phillips and Ellis (2015), and so are within the accepted range.

Exploratory data checks indicated the minimum and maximum recorded sizes of *Mustelus* spp. in IBTS-Q3 were 22–149 cm. Once again, the minimum lengths observed by each nation (22–70 cm) were all within acceptable limits. In IBTS-Q3 most nations caught *Mustelus* spp. to a maximum length of 97–110 cm, with one vessel (DAN) recording specimens larger than 110 cm, and to 149 cm.

For IBTS-Q3, the length-distributions available for *Mustelus* on DATRAS indicate that only one vessel (DAN) reports *Mustelus* spp. >110 cm (Figure 21.11), and further explorations of DATRAS data indicate that there seems to be inter-annual variation in the species of triakid sharks caught (for specimens >110 cm; Figure 21.12). These preliminary analyses suggest that DATRAS data for *Mustelus* and *Galeorhinus* are confounded for DAN, and further analyses of these data are required, in order to determine whether it is a coding error or misidentification, and also to determine the extent of this issue.

Further analyses of the quality of DATRAS data indicate that there are also some relatively large catches, with most large catch events related to a single vessel. Further analyses of these data are also required.

21.7 Life-history information

Biological data are not collected under EU-MAP, although some *ad hoc* data are collected on fishery-independent surveys and there are some published studies resulting from biological investigations of *Mustelus* spp. in European seas, including from the NE Atlantic and Mediterranean Sea.

21.7.1 Habitat

The distribution of *Mustelus asterias* around the British Isles has been described, with more detailed studies on the habitat utilization undertaken for the eastern English Channel (Martin *et al*., 2010; 2012).

21.7.2 Spawning, parturition and nursery grounds

Mustelus asterias pups are taken in trawl surveys (including beam trawl surveys), and such data might be able to assist in the preliminary identification of pupping and primary nursery grounds. Most of the records for *M. asterias* pups recorded in UK beam-trawl surveys are from the southern North Sea, English Channel (including near the Solent) and Bristol Channel (Ellis *et al*., 2005). Studies on other species of smooth-hound have shown high site fidelity of immature individuals on nursery grounds (Espinoza *et al*., 2011).

Recent biological studies have indicated that full-term pups of *M. asterias* range in size from 205–329 mm L_T and pup size was positively correlated with maternal length (McCully Phillips and Ellis, 2015; Figure 21.13). The smallest free-swimming neonate reported in this study was 24 cm L_T.

Parturition of *M. asterias* occurred in February in the western English Channel and June–July in the eastern English Channel and southern North Sea (Figure 21.14), indicating either protracted spawning or asynchronous parturition for the stock (McCully Phillips and Ellis, 2015).

21.7.3 Age and growth

<u>*Mustelus asterias*</u>: Farrell *et al*. (2010a) studied the age and growth in the Celtic Seas ecoregion. Growth parameters for males (n = 106) were L_∞ = 103.7 cm L_T, L_0 = 38.1 cm, k = 0.195 year^{-1}). Growth parameters for females (n = 114) were (L_∞= 123.5 cm L_T, L_0= 34.9 cm, k = 0.146 year^{-1}). Estimates of longevity were 13 years (males) and 18.3 years (females). The lengths-at-age for *M. asterias* based on these growth parameters are given in Table 21.3.

Mustelus mustelus: Age and growth have been reported for South African waters, with males and females estimated to mature at 6–9 and 12–15 years, respectively (Goosen and Smale, 1997). The maximum age reported in this study was 24 years.

21.7.4 Reproductive biology

Mustelus asterias: Studies on in the Celtic Seas ecoregion indicated that the total length (and age) at 50% maturity for male and females are 78 cm L_T (4–5 years) and 87 cm L_T (six years), respectively (Farrell *et al*., 2010b). Subsequent studies of, collected primarily from the southern North Sea and English Channel, estimated 50% maturity for male and females at ca. 70 cm L_T and 82 cm L_T respectively (McCully Phillips and Ellis, 2015; Figure 21.15).

Estimates of fecundity range from 8–27 (ovarian fecundity) and 6–18 (embryonic fecundity), with a gestation period of about twelve months (Farrell *et al*., 2010b), and there may also be a resting period of a year between pregnancies, giving a two-year reproductive period. Mature female specimens sampled by McCully Phillips and Ellis (2015) included seventeen late gravid females with term pups (uterine fecundity 4–20), which were found to have numerous yolk-filled follicles (n = 6–22; follicle diameters 6–10 mm). Further studies, including more samples of fish from winter and spring, are required to better gauge the reproductive period.

The smallest mature female that Farrell *et al*. (2010b) reported was 83 cm; a lot larger than the smallest female (69 cm L_T; summarised below) recorded by McCully Phillips and Ellis (2015). This is interesting, as the two studies use slightly different maturity keys, with Farrell *et al*. (2010b) assigning a female to be mature when oocytes were present, yellow, and countable at >3 mm in diameter, whereas the Cefas maturity keys (Table II of McCully Phillips and Ellis, 2015), which are comparable to those keys developed within ICES, assigned a female as mature when the oocytes are slightly larger (>5 mm).

McCully Phillips and Ellis (2015) estimate the length at 50% maturity to be 81.9 cm for females (smallest mature = 69 cm; largest immature = 87 cm) and 70.4 cm for males (smallest mature = 65 cm; largest immature = 74 cm).

The number of mature follicles ranged from 0–28 in the mature females. These will not all necessarily develop into embryos, however, and estimates of ovarian fecundity are known to exceed estimates of uterine fecundity. The size-spectra of the mature follicles (within mature females) ranged from 4.1 mm (mid-term gravid female) to 20.7 mm (mature female).

The uterine fecundity ranged from 4–20, which exceeded the maximum uterine fecundity (18) found by Farrell *et al*. (2010b), although they stated that their values may be underestimated due to females aborting pups on capture. The female identified with a fecundity of 20, was found with full-term pups. Uterine fecundity increased with total length (Figure 21.16). Furthermore, there were also positive linear relationships identified between maternal length and average pup length and weight (Figure 21.13; McCully Phillips & Ellis, 2015).

A combined dataset on uterine fecundity, using data from Farrell *et al.* (2010b) and McCully Phillips & Ellis (2015), is given in Table 21.4, with uterine fecundity (F) having a liner relationship with L_T, as described by the equation $F = 0.2813.L_T - 18.409$ (n = 36; $r^2 = 0.4038$).

In the Mediterranean Sea, *Mustelus asterias* reach maturity at about 75 cm (males) and 96 cm (females), with estimates of fecundity ranging from 10–45 (ovarian fecundity) and 10–35 (uterine fecundity), with fecundity increasing with length (Capapé, 1983), although it is possible the higher fecundity in this study may relate to data being confounded with other species of smooth-hound.

Mustelus mustelus: Studies in the Mediterranean Sea have found that females matured at 107.5–123 cm L_T (50% maturity at 117.2 cm) and that males matured at 88–112 cm L_T (50% maturity at 97.1 cm) (Saidi *et al*., 2008). This study also found that embryonic fecundity ranged from 4–18 embryos, with fecundity increasing with length. Further south off Senegal, the lengths at first (and 100%) maturity for *M. mustelus* were found to be 82 cm (95 cm), for males, and 95 cm (104 cm) for females (Capapé *et al*., 2006). This study reported litters of 4–21 pups.

21.7.5 Movements and migrations

Mustelus asterias: Although the movements and migrations of *M. asterias* are not fully known, there have been relatively high numbers tagged and released during various elasmobranch research programmes (e.g. Burt *et al*., 2013 WD; Figure 21.17). A recent (2011–2014) tagging programme undertaken by Sportvisserij Nederland, in conjunction with IMARES, involved anglers tagging *M. asterias* in the Dutch Delta. There were 2244 releases, of which 80 recaptures were reported (Figure 21.18; Brevé *et al*., 2016). Recapture positions indicated annual migrations between summertime grounds in the southern North Sea and overwintering in the English Channel and Bay of Biscay, suggesting a degree of philopatry (Brevé *et al*., 2016).

21.7.6 Diet and role in ecosystem

Mustelus asterias is primarily carcinophagous, predating on various crustaceans, including hermit crabs (Paguridae), stomatopods, brachyuran crabs, squat lobsters and shrimps, with teleosts only eaten occasionally by larger individuals (Ellis *et al*., 1996; McCully and Ellis, 2014). They can be important predators of commercial crustaceans, feeding on velvet swimming crab *Necora puber* and small edible crab *Cancer pagurus.*

Other studies on the feeding habits of *Mustelus* also indicate a high proportion of crustaceans in the diet (Morte *et al*., 1997; Jardas *et al*., 2007; Santic *et al*., 2007; Saidi *et al*., 2009; Lipej *et al*., 2011).

21.7.7 Conversion factors

The length–weight relationship of *Mustelus* spp. caught during the Cefas tagging programme, 2000–2010 is illustrated in Figure 21.19.

The relationship between total length and weight in the smooth-hounds sampled by McCully Phillips and Ellis (2015) are summarised below by sex and maturity stage (see also Figures 21.20 and 21.21).

The relationship for males differed slightly to that of females, largely driven by the larger maximum length of females and the weights of females about to give birth. Of note is the 119 cm outlier, which was a post-partum female with a very low body mass. Samples of the smaller size classes were obtained from scientific trawl surveys, while the larger individuals were commercially-landed specimens.

Relationship Y=ax^b	Sex/Stage	a	b	r^2	n
Total weight to total length	All females	0.0014	3.2	0.992	248
	All males	0.0020	3.1	0.995	237
	Immature female (stage A/B)	0.0020	3.1245	0.994	170
	Immature male (stage A/B)	0.0014	3.2159	0.991	113
	Mature female (incliding early gravid) (stage C/D)	0.0021	3.1396	0.913	54
	Mature male (stage C/D)	0.0077	2.8084	0.938	123
	Mid-/late-term gravid females (stage E/F)	0.0002	3.7072	0.935	21
Gutted weight to total length	Sexes combined	0.0014	3.1580	0.995	484
	Female	0.0016	3.1	0.994	249
	Male	0.0014	3.2	0.996	235

21.8 Exploratory assessment models

21.8.1 Previous studies

No previous assessments of NE Atlantic smooth-hounds have been made. However, there have been assessment methods developed for the Australian species *Mustelus antarcticus* (e.g. Xiao and Walker, 2000; Pribac *et al.*, 2005) which may be applied to European species when relevant data are available.

21.8.2 Data exploration and preliminary assessments

The approach of De Oliveira *et al.* (2013) for spurdog is currently being developed for *M. asterias,* although not all required data are available or collated yet. Four life history stages have been suggested: pups (20–34 cm), juveniles (35–65 cm), sub-adults and adults (66–99 cm) and large mature fish (mostly female; ≥100 cm).

21.9 Stock assessment

No quantitative stock assessment is available yet.

In both 2015 and 2017, the stock of *M. asterias* in northern Europe was evaluated using trends from fishery-independent trawl surveys, as these are the longest time-series of standardised species-specific data available

The biomass trends of the long-term time-series of three different surveys covering a proportion of the species distribution range were used in the 2017 assessment, each showing a consistent increase especially in recent years. These surveys were considered more effective at sampling larger specimens than beam trawl surveys (see below).

IBTS-Q1 and IBTS-Q3: Data from the two North Sea IBTS were used (see Section 15 for further details). These surveys sample the more northerly parts of the stock area. The biomass index for all specimens of *Mustelus* spp. was used, as the GOV samples mostly larger fish. Data from Denmark were excluded in analyses conducted in 2017, due to the suspicion that data for *Mustelus* and *Galeorhinus* were confounded (see Section 21.6.3). The temporal trends in abundance, biomass and biomass of specimens >50 cm all showed similar patterns (Figure 21.6).

EVHOE-WIBTS-Q4: A biomass index from the EVHOE-IBTS-Q4, which was not included in the 2015 assessment, was included in 2017, as this survey covers more south-western parts of the stock area (Divisions 8.a.b.d; Figure 21.7). Data were available for 1997–2016 and indicate an increasing biomass.

Summary: Each of the three survey indices was standardised in relation to its long-term mean for the common time period (1997–2016), and an average taken for the three surveys to derive an annual index of stock size. All three surveys were given equal weighting. The mean index for the years 2015–2016 was 1.738, whilst the mean index for the preceding five years (2010–2014) was 1.296, with the most recent 2-year period being 1.34 times that of the preceding 5-year period (Figure 21.22; Table 21.5).

Supporting information was provided by UK beam trawl surveys and the IGFS-WIBTS-Q4.

BTS-UK (E&W)-Q3 and BTS-Eng-Q3: These surveys sample juvenile *M. asterias* primarily, and so in 2017 were excluded from the assessment and advice. These data indicate that the abundance of pups has increased over the time series in the Irish Sea/Bristol Channel (BTS-UK(E&W)-Q3), but has been more stable in the eastern English Channel and southern North Sea (BTS-Eng-Q3) (Figure 21.23). Further analyses of these data are required, as it may be possible to develop an index of recruitment from such surveys.

IGFS-WIBTS-Q4: This survey is not included in the mean standardised survey index, as it did not begin until 2003, and its inclusion would have reduced the common time frame. However, this survey provides supporting information, and indicates a similar longer-term increase in abundance for the north-western part of the stock area (Figure 21.10).

21.10 Quality of the assessment

Commercial landings data are available for recent years, but may be compromised by poor data quality. Whilst fishery-independent trawl surveys provide the best time-series information, such surveys may under-represent the largest size classes. It is unclear as to how recent increases in CPUE may relate to increased stock abundance and/or a possible northward shift in distribution.

Previous studies examined the positions of survey hauls containing smooth-hounds in the EVHOE-WIBTS-Q4 survey were plotted over the 18-year time-series (Figure 21.24). The number of stations catching smooth-hounds increased over the survey, but the distribution of the catches has remained constant, occurring north of 46°N. There was no evidence from this survey to support the theory of a northward shift in the distribution, which would support the suggestion that increasing catch rates reflect population growth.

21.11 Reference points

Preliminary studies on reference points were undertaken (see Section 26). Important issues to be addressed when considering reference points are

- What is the most appropriate data source for length-based data?

- What are the most appropriate life history parameters? Whilst the length-weight parameters and the lengths at maturity are known, there is uncertainty as to the values of K, M, L_{max} and L_{inf}.
- What are the appropriate indicator reference points?

21.12 Conservation considerations

The most recent IUCN Red List Assessment for European marine fishes (Nieto *et al*., 2015) upgraded all three *Mustelus* spp. to either Near Threatened (*M. asterias*) or Vulnerable (*M. mustelus* and *M. punctulatus*), identifying them as of increasing conservation interest. These species were listed previously as either Data Deficient or Least Concern (Gibson *et al.*, 2008).

21.13 Management considerations

Smooth-hounds appear to be increasing in relative abundance in trawl surveys, and in commercial landings data. Given the potential expansion in fisheries for smooth-hounds (which may reflect an increased abundance and that fishing opportunities for *S. acanthias* are limited), further studies to understand the dynamics of this stock are required.

Smooth-hounds taken by beam trawl are primarily juveniles and subadults (<70 cm L_T), and these are often discarded, as are smooth-hounds <50 cm L_T in otter trawl fisheries. Discard survival is not known, and survival is variable in this family (Ellis *et al*., 2014 WD). Further studies on the at-vessel mortality and post-release mortality, including of juveniles, are needed.

Survey data are available, and the quality of landings data is thought to be improving. Whilst there have been several recent biological investigations (Farrell *et al*., 2010a,b; McCully Phillips & Ellis, 2015), there is still uncertainty in some key biological parameters, including the duration of the reproductive cycle.

Smooth-hounds are also an important target species in some areas for recreational fisheries; though there are insufficient data to examine the relative economic importance of these fisheries, or the degree of mortality associated with recreational fisheries.

Other species of smooth-hound are targeted elsewhere in the world, including Australia/New Zealand and South America. Although smooth-hounds are generally quite productive stocks (relative to some other elasmobranchs), evidence from these fisheries suggests that various management controls can be appropriate.

21.14 References

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Table 21.1. Smooth-hounds in the Northeast Atlantic. Reported species-specific landings (t) for the period 1973–2014. These data are considered underestimates as some smooth-hounds are landed under generic landings categories. Species-specific landings data are not available for the Mediterranean Sea and are limited for the north-west African waters. Data from 2005 are lower than reported to ICES (2016a) and are considered underestimates (see Table 21.2 for recent estimates of landings 2005–2016).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.	
France	0	0	0	0	0	0	32	0	0	222	218	66	143	167
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Portugal	.	.	.	.	.	.	.	.	.	.	.	.		-
UK -E, W & NI	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Scotland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	32	0	0	222	218	66	143	167

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Belgium													
France	119	64	117	126	93	90	102	138	145	228	187	197	0
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	
Portugal													
UK -E, W & NI	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Scotland	0	0	0	0	0	0	0	0	0	0	0	0	0
	119	64	117	126	93	90	102	138	145	228	187	197	0

Table 21.1. (continued). Smooth-hounds in the Northeast Atlantic. Reported species-specific landings (t) for the period 1973–2014. These data are considered underestimates as some smooth-hounds are landed under generic landings categories. Species-specific landings data are not available for the Mediterranean Sea and are limited for the north-west African waters. Data from 2005 are lower than reported to ICES (2016a) and are considered underestimates (see Table 21.2 for recent estimates of landings 2005–2016).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	8	10	1
France	306	377	585	589	682	767	714	908	522	926	969	706	2695	2955	2825
Netherlands	.	.	.	.	.	.	.	.	.	.	8	3	11	20	15
Portugal	.	.	.	.	.	.	.	.	.	.	.	35	42	41	187
Spain	.	.	.	.	.	.	.	.	.	.	34	48	9	83	14
UK -E, W & NI	14	0	0	0	0	0	0	0	115	132	161	919	337	323	647
UK - Scotland	0	0	0	0	0	0	0	0	0	1	0	-	-	-	-
	320	377	585	589	682	767	714	908	637	1059	1172	1712	3101	3433	3690

Table 21.2 Smooth-hounds in the Northeast Atlantic. ICES estimated landings (t; 2005–2017), based on data provided in the ICES Data Call (see ICES, 2016a).

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	-	-	-	-	-	-	-	-	1	1	1	3	2
Denmark	-	-	-	-	-	-	-	-	-	-	-	<0.1	-
Spain	112	134	138	200	297	129	106	120	80	70	42	40	43
France	2685	2722	2958	3403	3082	3204	3241	2821	2942	2836	2963	2855	2725
UK	171	130	155	171	199	275	315	339	325	331	303	468	386
Ireland	-	-	0.4	0.6	0.5	0.5	0.2	-	-	<0.1	0.4	-	-
Netherlands	-	-	-		4	9	3	23	26	24	24	22	22
Portugal	44	57	57	41	45	38	43	42	41	17	15	18	55
Total	**3013**	**3043**	**3308**	**3816**	**3628**	**3655**	**3709**	**3345**	**3415**	**3280**	**3349**	**3406**	**3232**

Table 21.3. Smooth-hounds in the Northeast Atlantic. Age-length key for *Mustelus asterias*, based on data given in Farrell *et al.* (2010a)

Age	Total length (cm)	
	Male	Female
0	38.1	34.9
1	49.7	46.9
2	59.3	57.3
3	67.2	66.3
4	73.6	74.1
5	79.0	80.8
6	83.3	86.6
7	86.9	91.6
8	89.9	95.9
9	92.4	99.7
10	94.4	102.9
11	96.0	105.7
12	97.4	108.1
13	98.5	110.2
14	99.4	112.0
15	100.2	113.6
16	100.8	114.9
17	101.3	116.1
18	101.7	117.1

Table 21.4 Smooth-hounds in the Northeast Atlantic. Fecundity at length data for *Mustelus asterias*, based on data given in Farrell *et al.* (2010b) and McCully Phillips & Ellis (2015).

Source	Total length	Uterine fecundity
Farrell *et al.* (2010)	83	6
	90	8
	91	7
	92	4
	94	7
	97	6
	97	9
	100	9
	103	14
	104	7
	106	7
	106	11
	108	10
	111	18
	112	9
McCully Phillips & Ellis (2015)	86	10
	91	6
	93	4
	96	14
	97	9
	97	5
	98	10
	101	7
	101	11
	101	10
	102	11
	103	12
	104	13
	105	17
	105	8
	106	11
	110	17
	115	12
	116	20
	116	15
	124	13

Table 21.5 Smooth-hounds in the Northeast Atlantic. Biomass indices for *M. asterias* from IBTS-Q1 and IBTS-Q3 (kg/h) and EVHOE-WIBTS-Q4 (kg/km²) and the combined stock size indicator (the annual mean of the three surveys after they had each been standardized by their long-term means over the common time frame, 1997–2016).

Year	IBTS-Q1 (kg/h)	IBTS-Q3 (kg/h)	EVHOE-WIBTS-Q4 (Kg/km²)	Combined stock size indicator
1997	0.062	1.103	0.000	0.268
1998	0.094	0.152	0.003	0.172
1999	0.664	0.781	0.010	0.874
2000	0.092	1.376	0.002	0.391
2001	0.254	0.165	0.004	0.314
2002	0.293	1.436	0.007	0.665
2003	0.223	5.542	0.005	1.375
2004	0.192	1.047	0.017	0.729
2005	0.152	0.409	0.010	0.428
2006	0.295	1.216	0.004	0.541
2007	0.367	4.375	0.020	1.581
2008	0.146	2.570	0.024	1.166
2009	1.178	1.984	0.013	1.543
2010	0.754	1.446	0.034	1.616
2011	0.458	1.409	0.019	1.039
2012	0.642	0.943	0.023	1.195
2013	0.503	2.674	0.005	1.003
2014	1.117	2.021	0.018	1.624
2015	0.330	1.695	0.036	1.397
2016	1.254	1.696	0.036	2.079

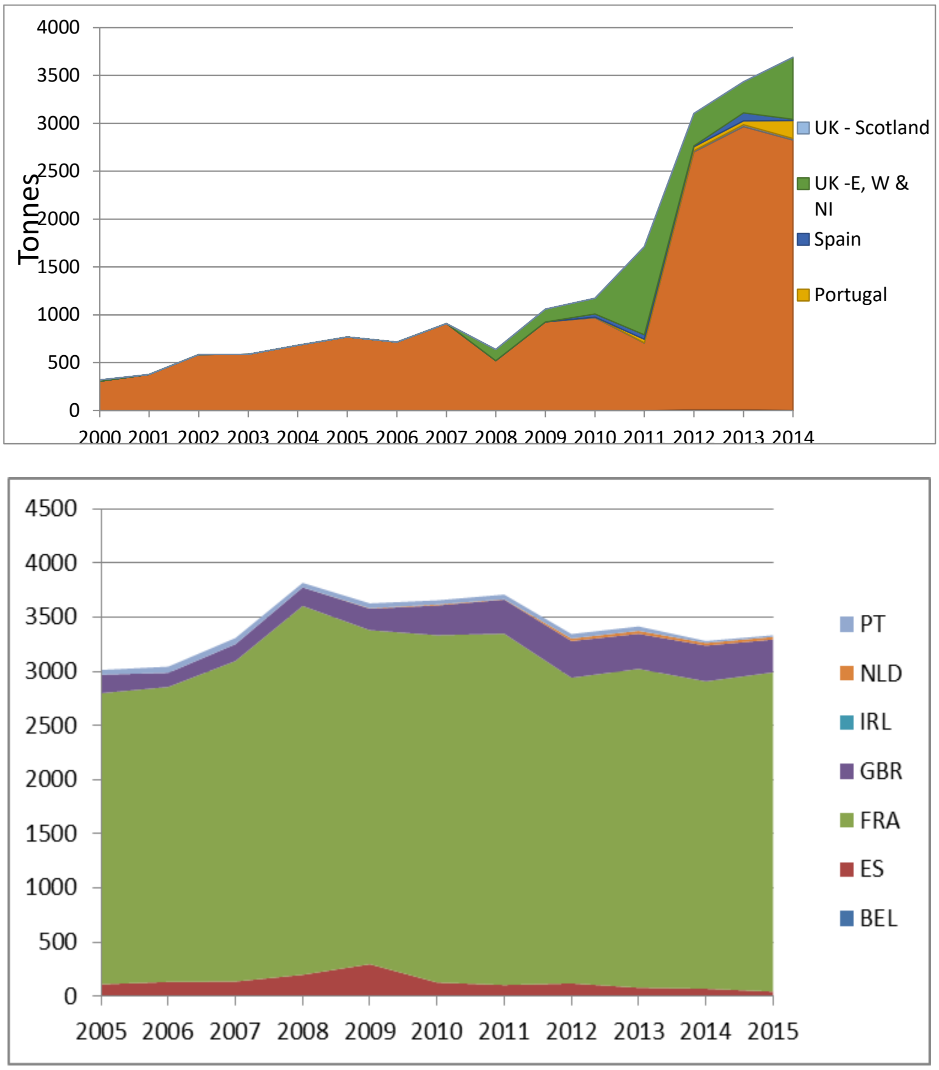
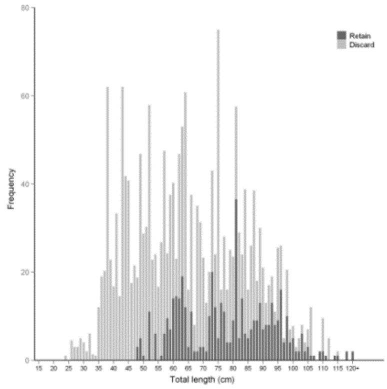


Figure 21.1. Smooth-hounds in the Northeast Atlantic. Earlier ICES estimates of overall *Mustelus* spp. landings by country (2000–2014; top) and revised ICES estimates (2005–2015; bottom). Data are considered underestimates.

A



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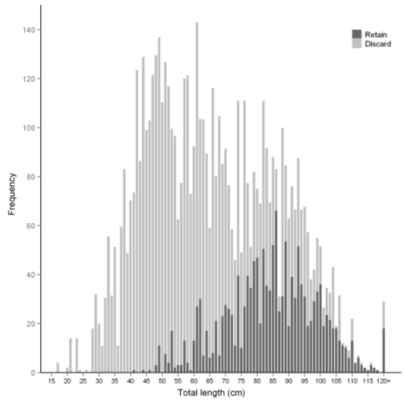

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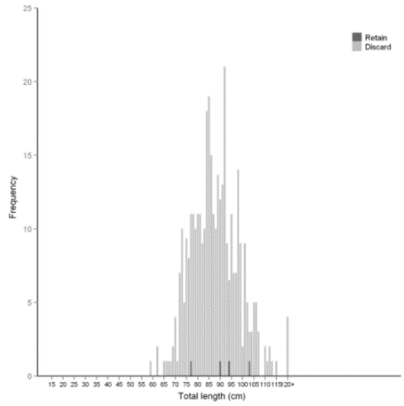

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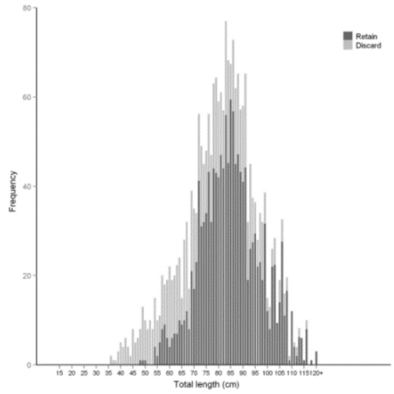

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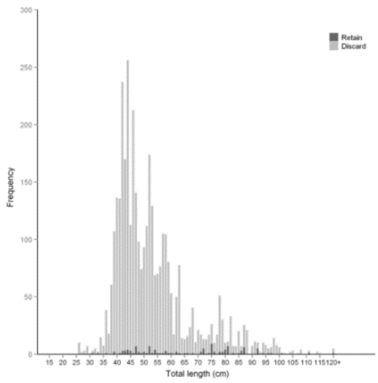

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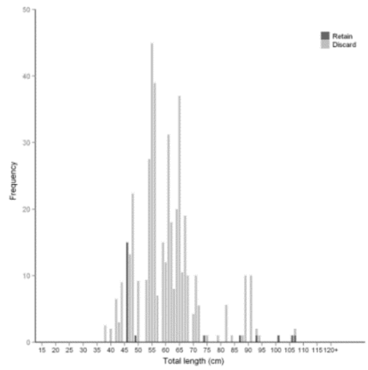


Figure 21.2. Smooth-hounds in the Northeast Atlantic. Length–frequency of discarded (pale grey) and retained (dark grey) smooth-hounds *Mustelus* spp. by (a) otter trawl (2002–2005), (b) otter trawl (2006–2011), (c) gillnet (2002–2005), (d) gillnet (2006–2011), (e) beam trawl (2002–2011) and (f) *Nephrops* trawl (2002–2011), as recorded in the Cefas observer programme. Data aggregated across ecoregions (Source: Silva *et al.*, 2013 WD).

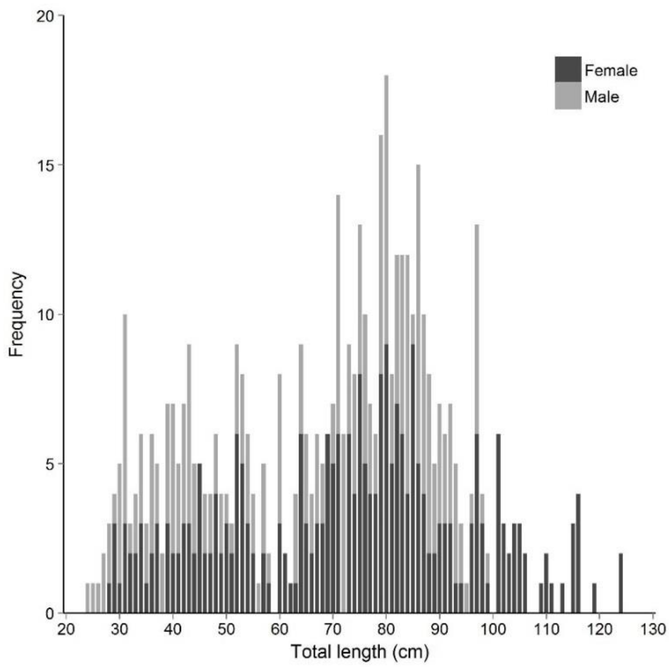


Figure 21.3. Smooth-hounds in the Northeast Atlantic. Number of starry smooth-hounds (n=504) biologically sampled by length and sex. Source: McCully Phillips and Ellis (2015).

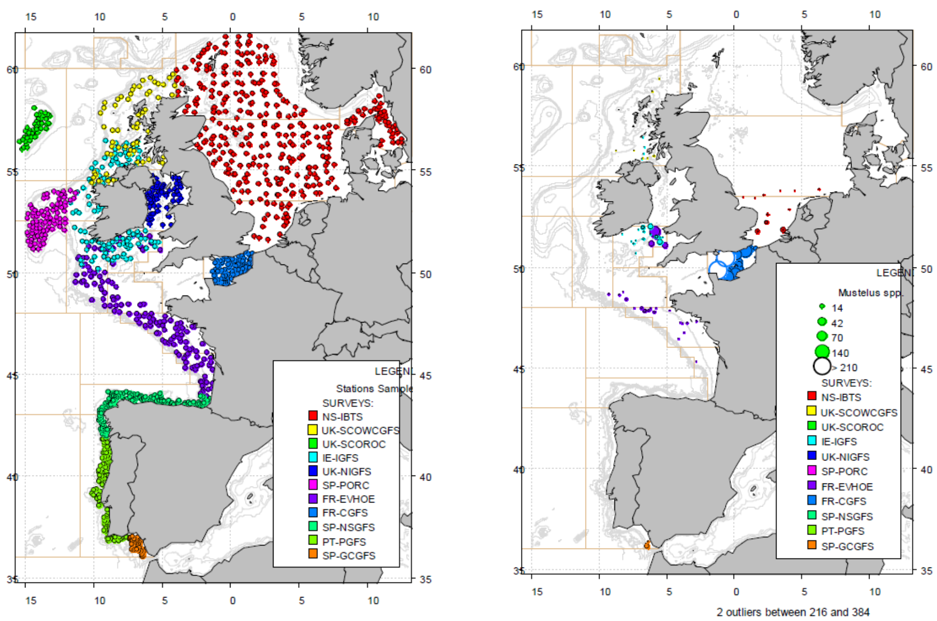


Figure 21.4. Smooth-hounds in the Northeast Atlantic. IBTS hauls undertaken in Q3 and Q4 2015 (left) and corresponding catches of *Mustelus* spp. (right). The catchability of the different gears used in the NE Atlantic surveys is not constant; therefore the map does not reflect proportional abundance in all the areas but within each survey. Source: ICES (2016b).

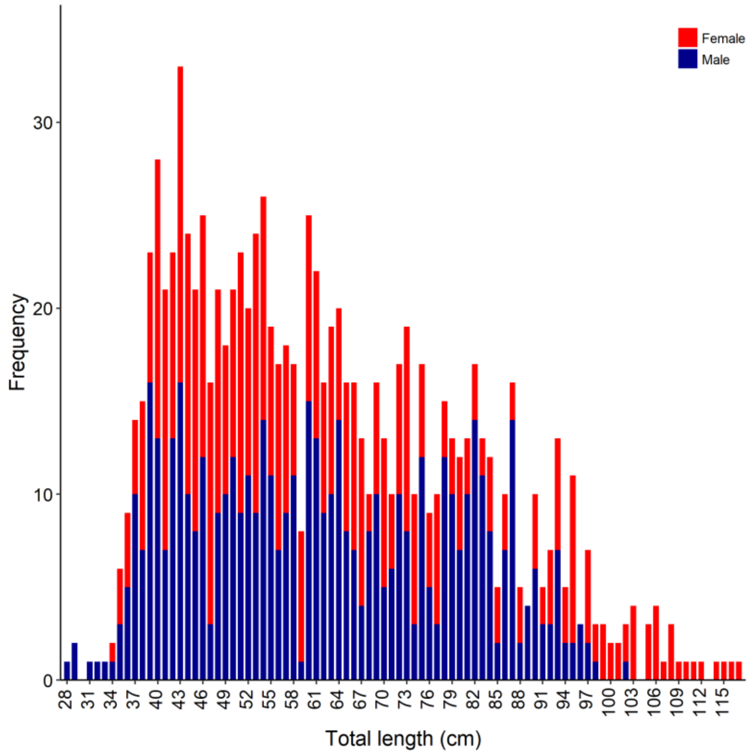


Figure 21.5. Smooth-hounds in the Northeast Atlantic. Length–frequency by sex of smooth-hounds *Mustelus* spp. From the UK Western Channel Q1 Beam-trawl survey. Source: Silva *et al*. (2018 WD).

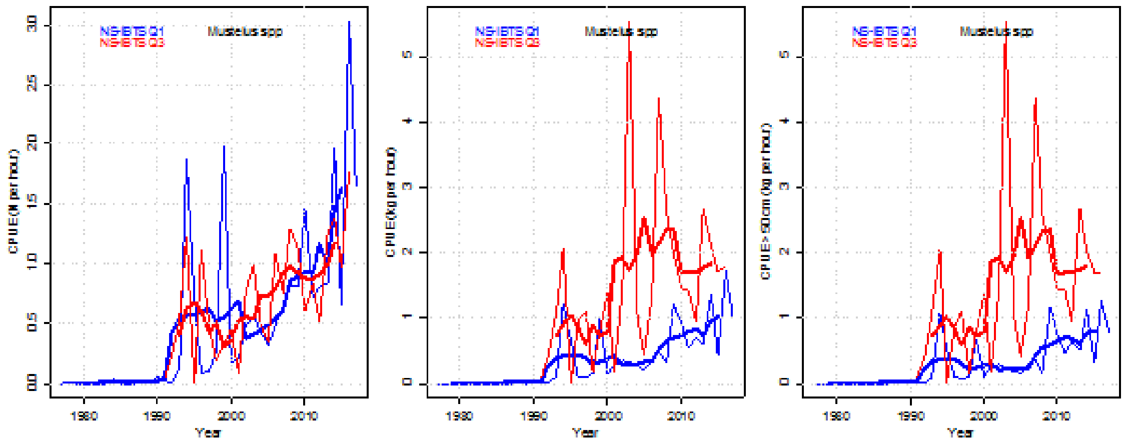


Figure 21.6. Smooth-hounds in the Northeast Atlantic. Survey indices (number per hour; estimated biomass per hour; and estimated exploitable biomass (fish ≥50 cm total length) in Q1-IBTS and Q3-IBTS of the North Sea.

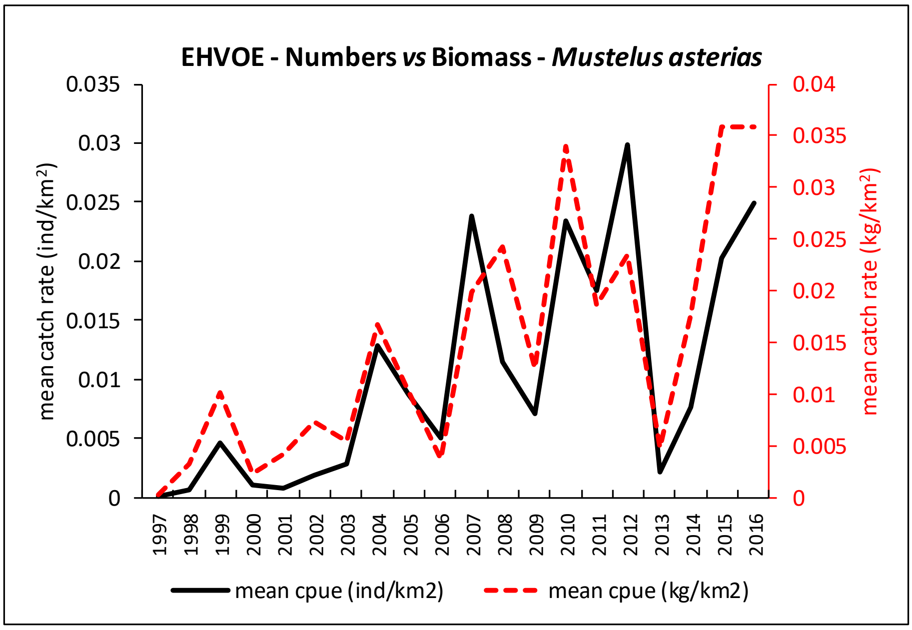
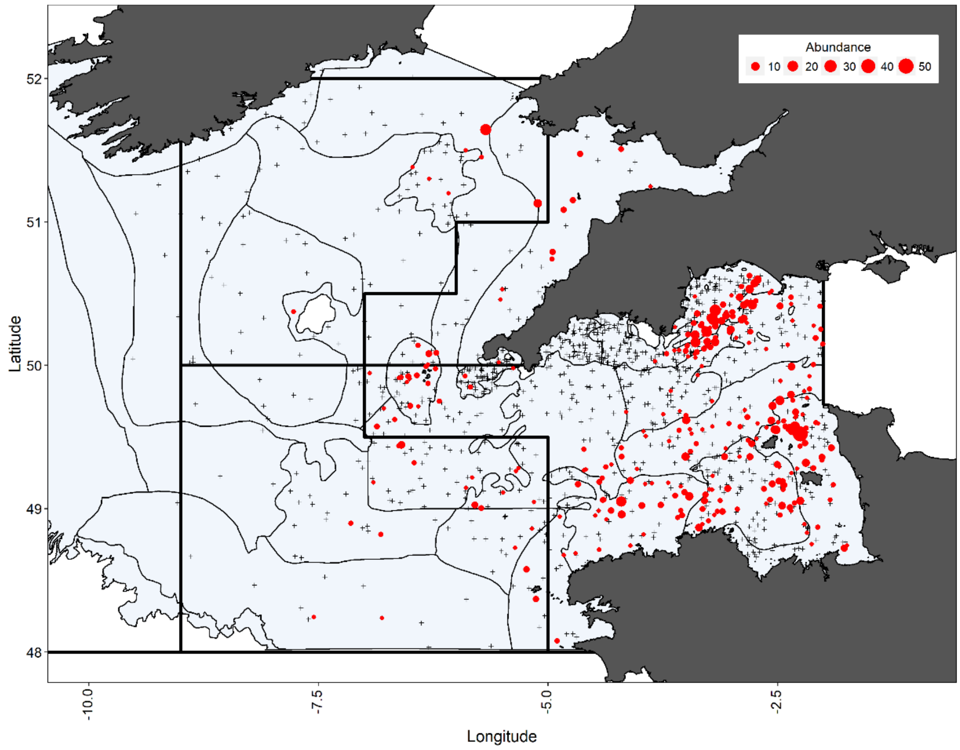


Figure 21.7. Smooth-hounds in the Northeast Atlantic. Biomass index of *Mustelus* spp. from the EVHOE-WIBTS-Q4 survey in Divisions 7.g-j, 8.abd



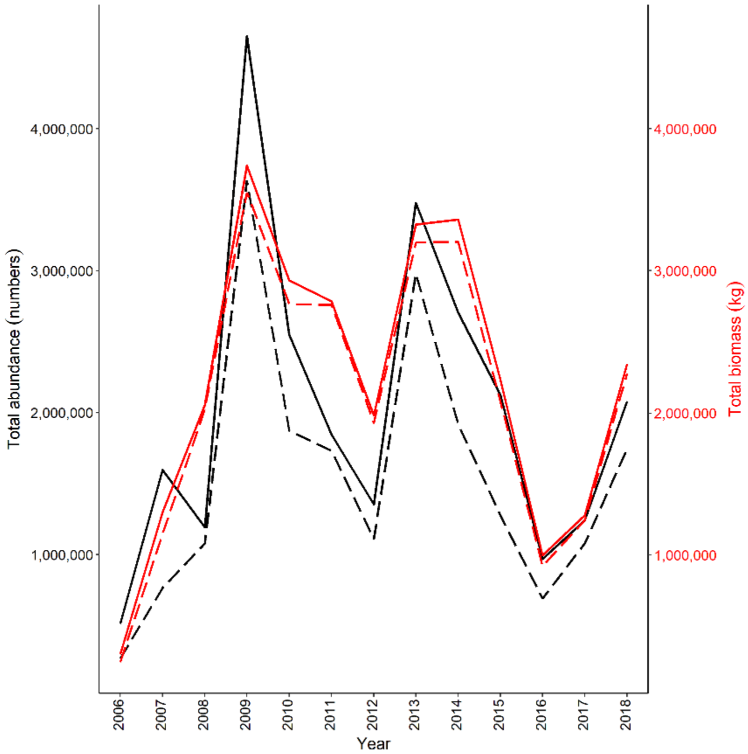
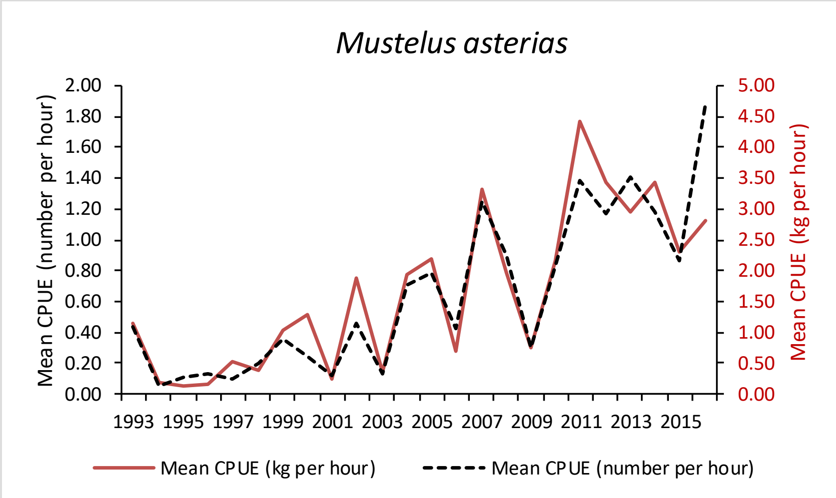


Figure 21.8. Survey grid of the Q1SWECOS survey (2006 – 2018) indicating the distribution and relative abundance of *Mustelus* spp. (top), and the total abundance (numbers) and total biomass (kg) for *Mustelus* spp (bottom)Source: Silva *et al*. (2018 WD).



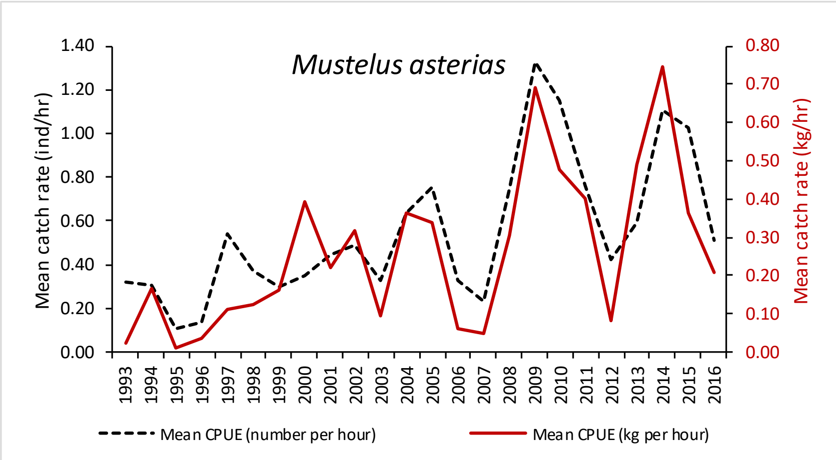


Figure 21.9. Smooth-hounds in the Northeast Atlantic. Survey indices (number per hour and estimated biomass per hour) from BTS-UK (E&W)-Q3 in the Bristol Channel and Irish Sea (top) and BTS-Eng-Q3 in the eastern English Channel and southern North Sea (bottom).

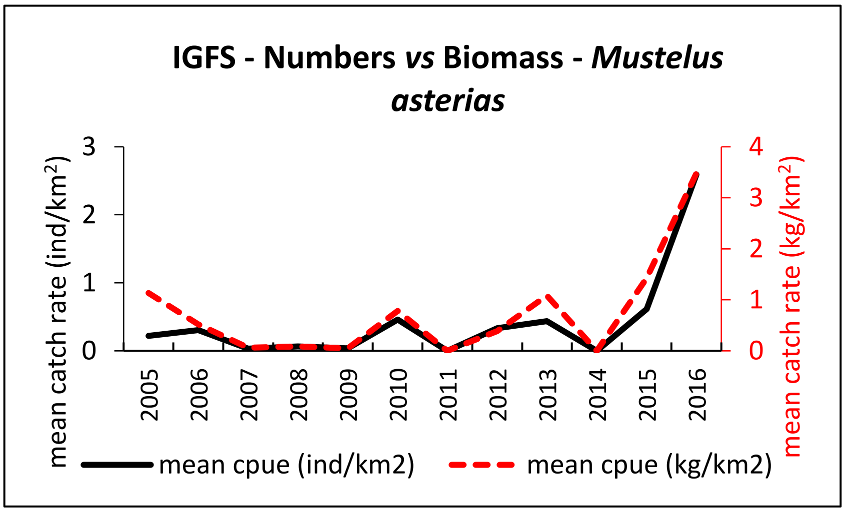


Figure 21.10. Smooth-hounds in the Northeast Atlantic. Survey indices (number per km² and estimated biomass per km²) from the IGFS-WIBTS-Q4.

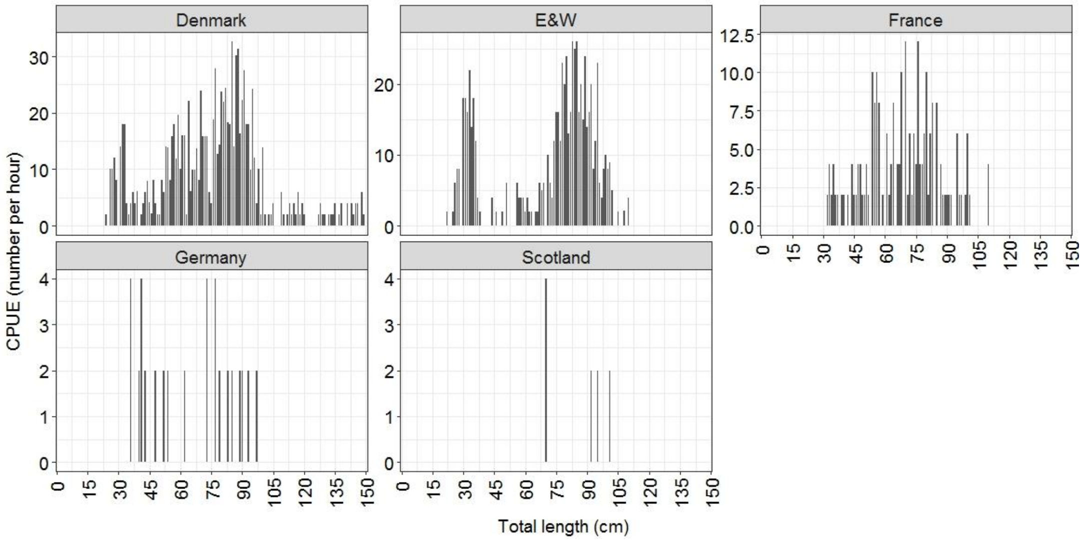


Figure 21.11. Smooth-hounds in the Northeast Atlantic. Length distributions of *Mustelus* spp., in the Q3-IBTS of the North Sea by nation. Most nations record *Mustelus* spp. up to 110 cm, while Danish data (to 149 cm) suggests there may be misidentification with *Galeorhinus galeus* or coding errors.

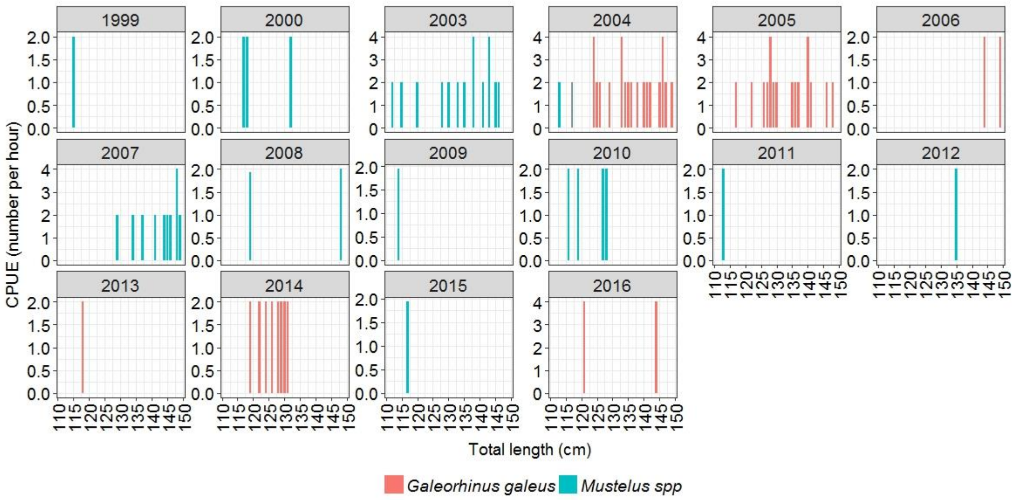


Figure 21.12. Smooth-hounds in the Northeast Atlantic. Length distributions of triakid sharks ≥110 cm as reported on DATRAS for the RV *Dana*. Large specimens of triakid sharks (i.e. *Mustelus* spp. or *Galeorhinus*) are not usually captured in the same year, which suggests potential identification issues or coding errors.

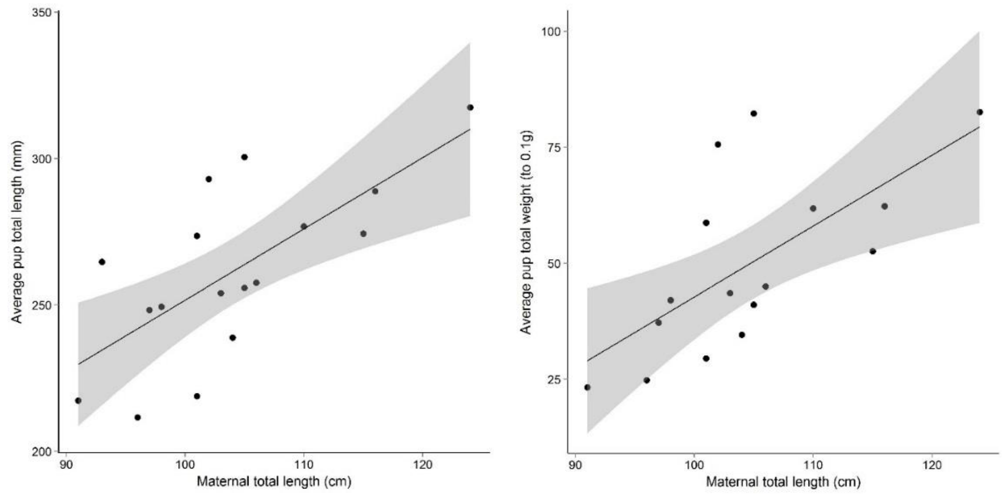


Figure 21.13. Smooth-hounds in the Northeast Atlantic. Relationship between maternal total length and average length and weight of term pups. Source: McCully Phillips and Ellis (2015).

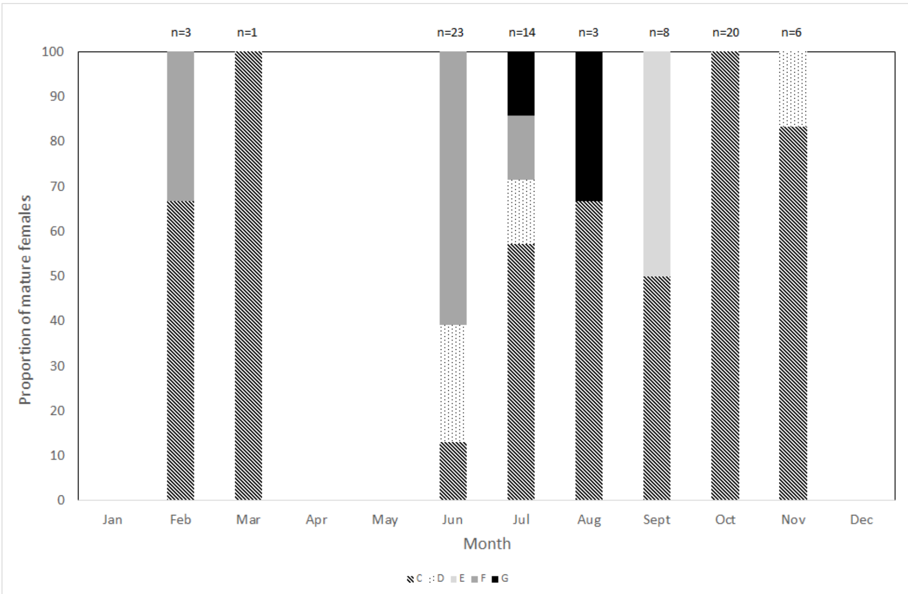


Figure 21.14. Smooth-hounds in the Northeast Atlantic. Percentage of mature females at each developmental stage (D: early gravid; E: mid-gravid; F: late gravid; G: post-partum) by month. Source: McCully Phillips and Ellis (2015).

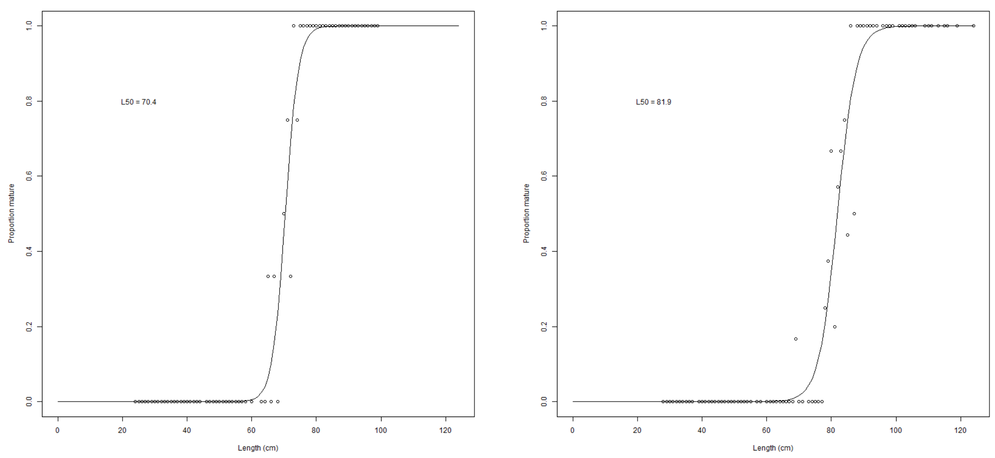


Figure 21.15. Smooth-hounds in the Northeast Atlantic. Maturity ogive for male (n= 237; L_{50} = 70.4 cm L_T) and female (n= 248; L_{50} = 81.9 cm L_T) *M. asterias*. Source: McCully Phillips and Ellis (2015).

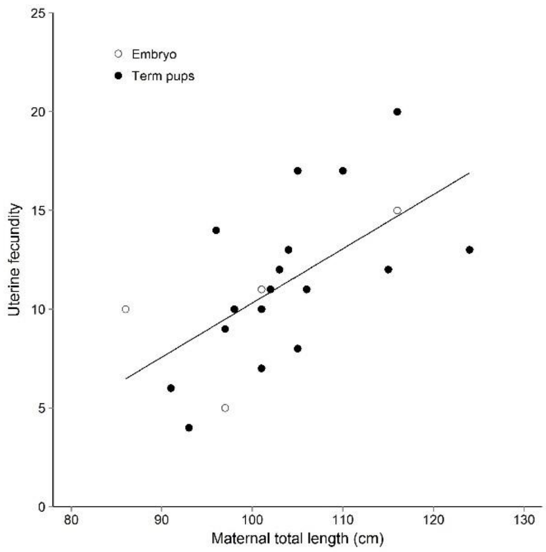


Figure 21.16. Smooth-hounds in the Northeast Atlantic. Relationship between maternal total length and number of term pups produced. Source: McCully Phillips and Ellis (2015).

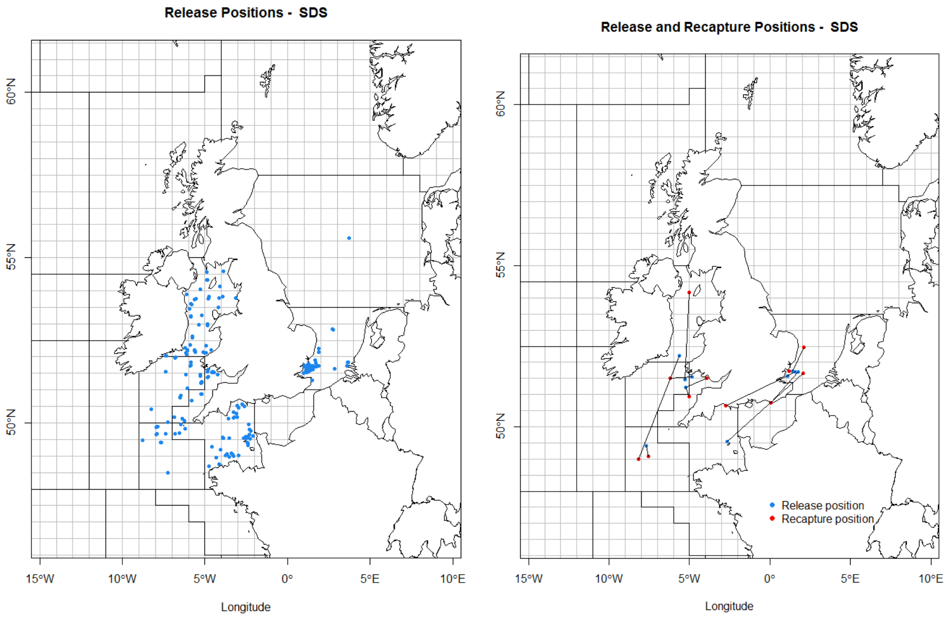


Figure 21.17. Smooth-hounds in the Northeast Atlantic. Locations of smooth-hound, *Mustelus* spp. (i) released and (ii) release and recapture positions for recaptured fish (2000–2013). Source: Burt *et al.* (2013 WD).

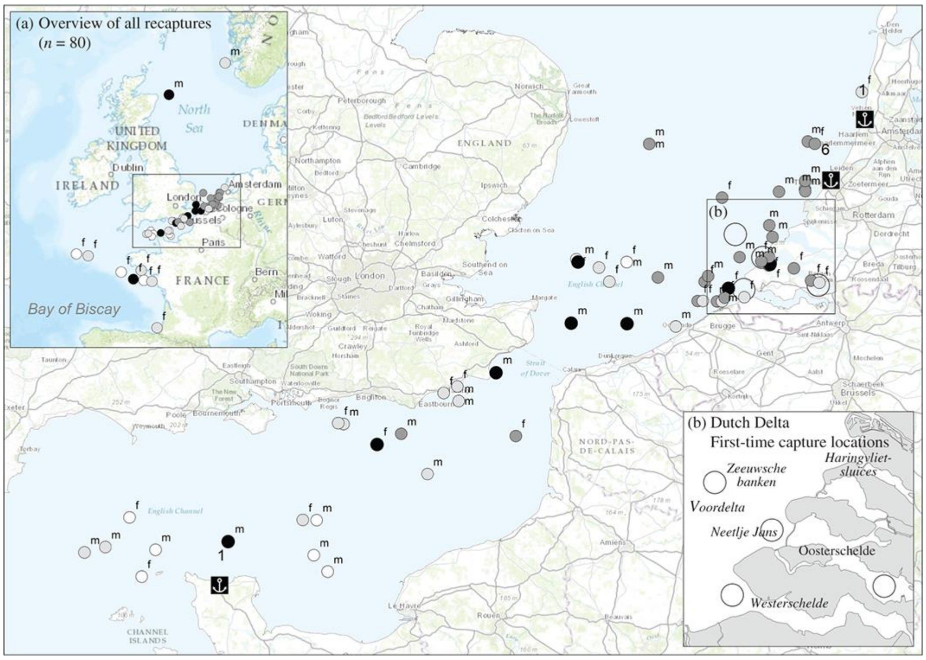


Figure 21.18. Smooth-hounds in the Northeast Atlantic. The main map shows the more detailed distribution of recaptures in the English Channel and southern North Sea. From three fish markets (indicated with anchors), eight tagged *M. asterias* were reported (numbers next to the anchors represent the number of sharks from each fish market) with unknown recapture location. Inset (a) shows the locations of recaptured *Mustelus asterias* ($n = 80$) reported by quarter for the years 2011–2014. Their distribution pattern indicates a circannual migration between the Dutch Delta (summer), the English Channel and Bay of Biscay (winter). Inset (b) shows the tag and release location with the main places fished indicated with open circles. Symbols: f = female; m = male; recaptures per quarter are shown for January to March (○), April to June (○), July to September (●) and October to December (●). Source: Brevé *et al.* (2016).

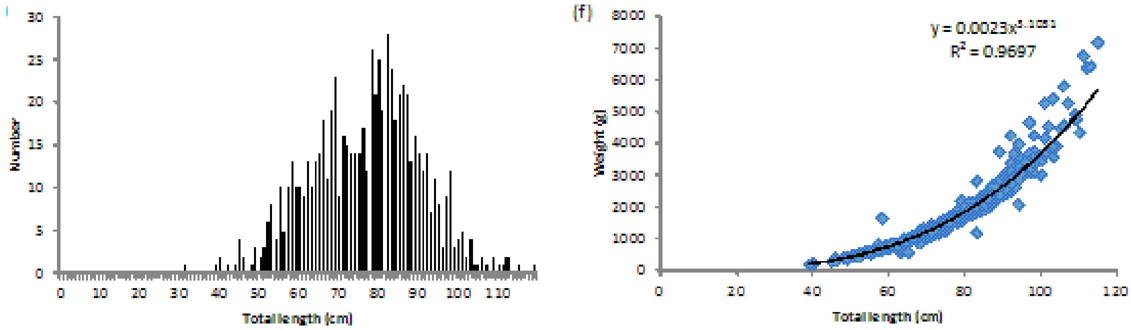


Figure 21.19. Smooth-hounds in the Northeast Atlantic. Length–frequency distributions of *Mustelus* spp. (n = 715), and the length–weight relationships for (*Mustelus* spp. (n = 508) tagged during the Cefas programme. Source: Burt *et al.* (2013 WD).

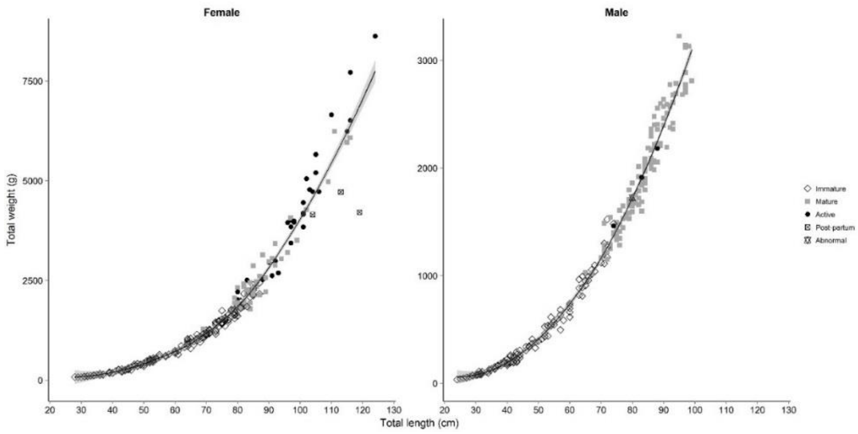


Figure 21.20. Smooth-hounds in the Northeast Atlantic. Length–weight relationship for female (n = 248) and male (n = 237) *M. asterias* by maturity stage (shaded region showing 95% confidence intervals). Source: McCully Phillips and Ellis (2015).

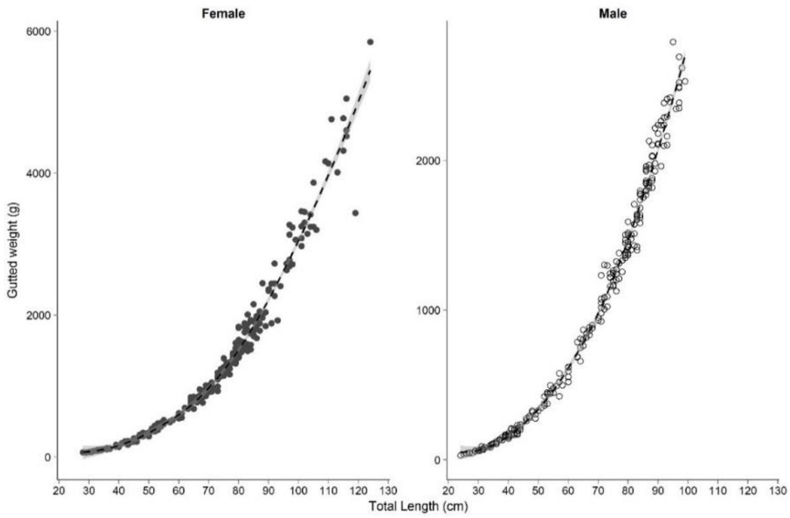


Figure 21.21. Smooth-hounds in the Northeast Atlantic. Total length to gutted weight relationship for female (n = 249) and male (n = 235) *M. asterias* (shaded region showing 95% confidence intervals). Source: McCully Phillips and Ellis (2015).

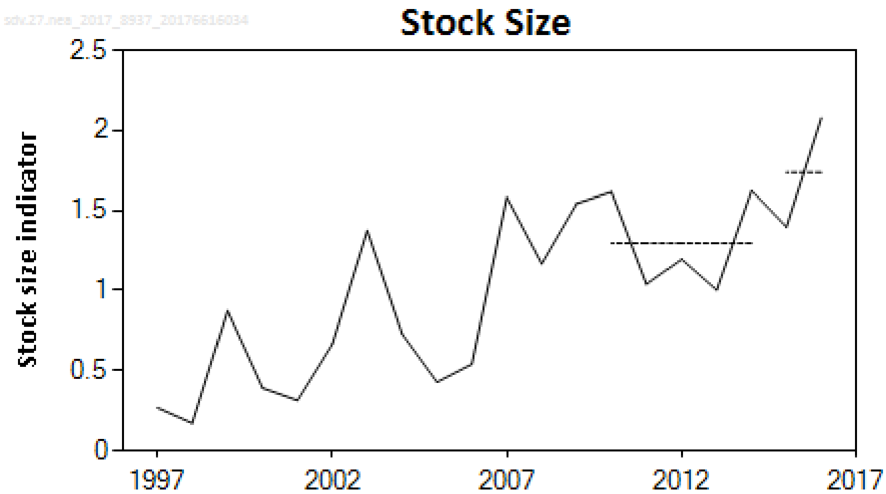


Figure 21.22. Smooth-hounds in the Northeast Atlantic. Stock size indicator based on the average standardised indices from three surveys (Q1-IBTS, Q3-IBTS and EVHOE-WIBTS-Q4). The horizontal lines show the average of the most recent two-years (2015–2016) and the preceding five-years (2000–2014).

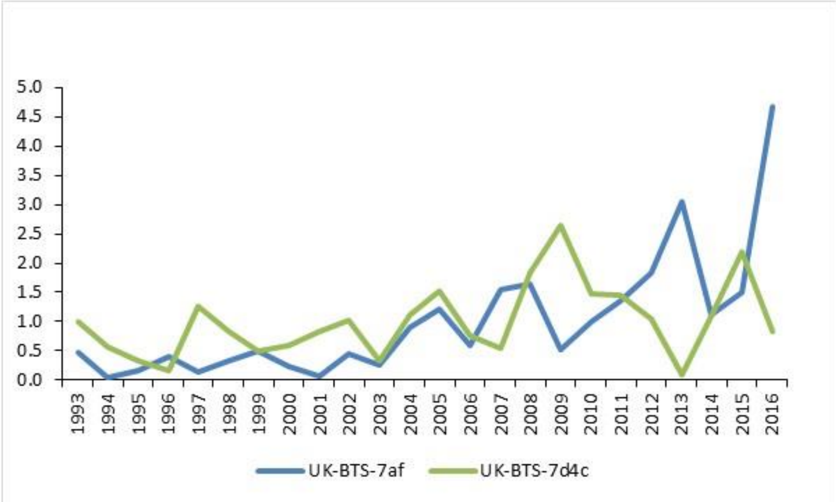


Figure 21.23. Smooth-hounds in the Northeast Atlantic. Annual catch rate of pups (<35 cm) in the BTS-UK(E&W)-Q3 (Bristol Channel and Irish Sea) and BTS-Eng-Q3 (eastern English Channel and southern North Sea), each standardised to the long-term mean for the survey.

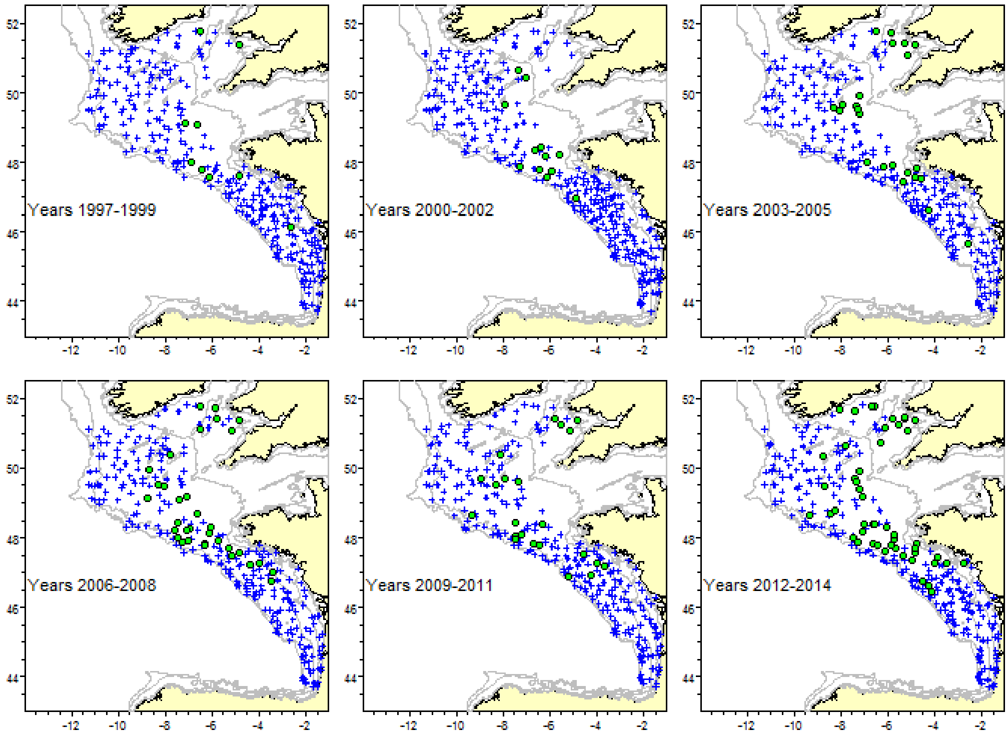


Figure 21.24. Smooth-hounds in the Northeast Atlantic. Distribution of *Mustelus* spp. in catches (green points *vs.* blue points for all sampling stations) in the EVHOE-WIBTS-Q4 (1997–2014).

22 Angel shark *Squatina squatina* in the Northeast Atlantic

22.1 Stock distribution

Angel shark *Squatina squatina* was historically distributed from the British Isles southwards to western Africa, including the Mediterranean Sea (Roux, 1986). As such the species distribution covers parts of ICES Subareas 4 and 6–9.

Stock structure is not known, but available data for this and other species of angel shark indicate high site specificity and possibly localized stocks. Mark–recapture data for *S. squatina* have shown that a high proportion of fish are recaptured from the original release location (Quigley, 2006), although occasional individuals can undertake longer-distance movements. The failure of former populations in the southern North Sea and parts of the English Channel to re-establish is also suggestive of limited mixing. Studies on other species of angel shark elsewhere in the world have also indicated that angel sharks show limited movements and limited mixing (e.g. Gaida, 1997; Garcia *et al.*, 2015). STECF (2003) noted that angel sharks "*should be managed on smallest possible spatial scale*".

Given that this species is considered to be extirpated from parts of its North Atlantic range and highly threatened both in the ICES area and elsewhere in European waters, ICES provide advice at the species level.

22.2 The fishery

22.2.1 History of the fishery

Angel shark is thought to have been the subject of exploitation for much of the 19th century and parts of the 20th century, and was exploited for meat, liver and skin. This species was the original fish termed 'monkfish' until catches declined and anglerfish *Lophius piscatorius* became a marketable species. As catches declined over the course of the 20th century, it was landed occasionally as a 'curio' for fish stalls.

Given the coastal nature of the species, it was also subject to fishing pressure from recreational fishing in parts of its range (e.g. the coasts of Ireland and Wales).

The species has been extirpated from parts of its former range, and most reports of this species in the ICES area are now from occasional bycatch records.

22.2.2 The fishery in 2017

No new information. There are no target fisheries for angel shark and, although they may be a very occasional bycatch in some trawl and gillnet fisheries (Tully, 2011), these captures should be released.

22.2.3 ICES Advice applicable

In 2008, ICES advised that angel shark in the North Sea eco-region was "*extirpated in the North Sea. It may still occur in Division VIId*" (ICES, 2008a). For the Celtic Seas, ICES advised that it "*has a localized and patchy distribution, and is extirpated from parts of its former range. It should receive the highest possible protection. Any incidental bycatch should not be landed, but returned to the sea, as they are likely to have a high survival rate*" (ICES, 2008b).

In both 2010 and 2012, ICES advised that it should remain on the list of Prohibited Species (ICES, 2012).

In 2015, ICES advised that "*when the precautionary approach is applied for angel shark in the Northeast Atlantic, no targeted fisheries should be permitted and bycatch should be minimized. ICES considers that this species should remain on the EU prohibited species list. This advice is valid for 2016 to 2019*".

22.2.4 Management applicable

Council Regulation (EC) 43/2009 stated that "*Angel shark in all EC waters may not be retained on board. Catches of these species shall be promptly released unharmed to the extent practicable*".

It was subsequently included on the list of Prohibited Species, under which it is prohibited for EU vessels to fish for, to retain on board, to tranship and to land angel shark in EU waters (Council Regulations (EC) 2018/120).

Angel shark is listed on the Wildlife and Countryside Act and protected in UK waters.

22.3 Catch data

22.3.1 Landings

Angel shark became increasingly rare in landings data over the available time period, and was reported only rarely prior to it being listed as a Prohibited Species (Table 22.1; Figure 22.1). It is believed that the peak in UK official landings in 1997 from Divisions 7.j-k were either misreported anglerfish (also called monkfish) or hake, given that angel shark is a more coastal species. These figures have been removed from the WGEF estimates of landings. French landings declined from >20 t in 1978 to less than 1 t per year prior to the prohibition on landings.

Whilst some nominal records were available in French national landings data for 2012 and 2013, the reliability of these data is uncertain, due to the areas and quantities reported, and catch gears. Further analyses and clarification of these data are required, and as such they are not included here.

There are no data available for the numbers of angel shark landed during the recreational fisheries that existed in parts of their range.

22.3.2 Discards

Limited data are available. Analyses of the main discard observer programme for the English and Welsh fleets found that no angel sharks had been observed (Silva *et al.*, 2013), whilst observer trips conducted by the Sea Mammal Research Unit (SMRU) recorded three individuals over the period 2011–2014 (Allen Kingston, pers. comm. 2015). These specimens were caught on 29 April 2011 (50.93°N, 6.65°W, 95 m water depth) and 19 September 2014 (53.40°N, 3.60°W and 53.40°N, 3.63°W, 15–16 m water depth). All were caught in tangle or trammel nets (soak times of 64–78 hours), were of estimated individual weights of 15–25 kg, and were all dead.

Examination of data collected under the French discard observer programme (2003–2013) indicated that only two individuals were observed (both in 2012) in the ICES area. According to observations from French fish markets and catches reported by fishermen, four additional individuals (two in 2007 and two in 2010) were also caught (S. Iglésias, pers. comm.). All these six individuals were caught off Pembrokeshire (Wales) at the southern entrance to St George's Channel.

WKSHARKS3 also reviewed available information on angel sharks observed during on-board observer programmes, also concluding this species was only observed very occasionally (ICES, 2017).

22.3.3 Quality of catch data

Catch data are incomplete, as data are unavailable for the periods when angel shark was more abundant. There are some concerns over the quality of some of the landings data (see above). The listing as a 'Prohibited Species' will result in commercial landings data nearing zero. Further studies of possible bycatch and fate of discards in known areas of occurrence would be needed to better estimate commercial catch.

Following the WKSHARKS data call in 2016, landings data-from 2005–2015 were re-assessed by WGEF. There were no major differences between previous landings and the new figures.

22.3.4 Discard survival

Limited data exist for the discard survival of angel shark caught in European fisheries. All three specimens observed by SMRU observers after capture by tangle- or trammel net were dead; soak times were 64–78 hours.

Other species have been studied elsewhere in the world (Ellis *et al.*, 2017). Fennessy (1994) reported at-vessel mortality (AVM) of 60% for African angel shark *Squatina africana* caught by South African prawn trawlers. Braccini *et al.* (2012) reported AVM of 25% for Australian angel shark *S. australis* caught by gillnet (where soak times were <24 h).

22.4 Commercial catch composition

No data available.

22.5 Commercial catch and effort data

No data available for commercial fleets.

22.5.1 Recreational catch and effort data

Information from Inland Fisheries Ireland (IFI) was used by WGEF 2015 to inform on the status of angel shark (ICES, 2010).

The numbers of specimen fish caught by recreational fishers and reported to the specimen fish committee declined over the period 1958–2005 (Table 22.2), with an overall decline in the numbers caught (Figure 22.2).

Other data from the IFI National Marine Sport Fish Tagging Programme confirm the scarcity of angel shark. Tagging of angel sharks has declined markedly in the last 25 years. A total of 1029 individuals have been tagged since 1970, but only a single individual has been tagged since 2006, and no recaptured specimens reported since 2004 (Roche and O'Reilly, 2013 WD; Wögerbauer *et al.*, 2014 WD). Angel shark is now only caught by anglers very occasionally in Tralee Bay, estimated at <3 per year. Effort data for the recreational fisheries are not available.

22.6 Fishery-independent data

Angel shark is encountered very rarely in trawl surveys, which may reflect the low abundance of the species, poor spatial overlap between surveys and refuge populations and their preferred habitats, and low catchability in some survey gears.

Occasional individuals have been captured in the UK beam trawl survey in Cardigan Bay, but the gear used (4 m beam trawl with chain mat) is not thought to be suitable for catching larger angel sharks.

Existing surveys are not considered appropriate for monitoring the status of this species. Dedicated, non-destructive inshore surveys in areas of known or suspected presence could usefully be initiated.

22.7 Life-history information

Limited life-history data are available (Table 22.3). Most recent biological data have come from studies in the Canary Islands (e.g. Meyers *et al.*, 2017), where this species is found regularly.

22.7.1 Habitat

Angel shark is a coastal species that has often been reported from sand bank habitats and similar topographic features. This ambush predator buries into the sand for camouflage. In terms of recent information on their habitats, a potential over-wintering area may occur off Pembrokeshire (51°30' to 52°00'N and 5°03' to 6°03'W; Figure 22.3), small specimens have been reported in Cardigan Bay (summer) and the western coast of Ireland (particularly Tralee Bay) may be important "summer areas" for the species (Wögerbauer *et al.*, 2014 WD). Angel sharks are thought to be nocturnally active (Standora and Nelson, 1977).

22.7.2 Spawning, parturition and nursery grounds

No specific information. Angel sharks giving birth have been reported from parts of the North Sea (e.g. Patterson, 1905) and small specimens have been found in the inshore waters or Cardigan Bay. Information from other angel shark species elsewhere in the world suggests that there may be an inshore migration in early summer, with parturition occurring during the summer.

22.7.3 Age and growth

No information available for *Squatina squatina.* Studies on other species of angel shark have reported problems using vertebrae for validated age determination (Natanson and Cailliet, 1986; Baremore *et al.*, 2009), with tagging studies providing some data (Cailliet *et al.*, 1992).

22.7.4 Reproductive biology

Angel sharks give birth to live young. Patterson (1905) reported on a female (ca. 124 cm long) that gave birth to 22 young. Capapé *et al.* (1990) reported a fecundity of 8–18 (ovarian) and 7–18 (uterine) for specimens from the Mediterranean Sea. Embryonic development takes one year, but the reproductive cycle may be two (or more) years, as indicated by other members of the genus (Bridge *et al.*, 1998; Colonello *et al.*, 2007; Baremore, 2010).

22.7.5 Movements and migrations

Tagging data indicate high site fidelity (Capapé *et al.*, 1990; Quigley, 2006; ICES, 2013). More than half of tagged angel sharks were recaptured less than 10 km from their original location, but individuals are capable of travelling longer distances within a relatively short window (Figure 22.4; Wögerbauer *et al.*, 2014 WD). Occasional longer-distance movements have been reported, with fish tagged off Ireland being recaptured off the south coast of England and in the Bay of Biscay (Quigley, 2006).

Seasonal migrations are suspected, with fish moving to deeper waters in the winter before returning to inshore waters for the summer. Other species of angel shark have also been shown to move into coastal waters in the summer, typically to give birth (Vögler *et al*., 2008).

The uncommon landing of about ten large individuals observed in 2000 from a French trawler fishing off southern Ireland, provide further evidence for localized aggregation of the species (S. Iglésias, *pers. comm*.).

22.7.6 Diet and role in the ecosystem

Angel shark is an ambush predator that predates on a variety of fish (especially flatfish) and various invertebrates (Ellis *et al*., 1996).

22.8 Exploratory assessment models

An exploratory stock assessment of the Tralee Bay (ICES Division 7.j) population, using data from the IFI Marine Sportfish Tagging Programme (Section 22.5.1), was undertaken (Bal *et al*., 2014 WD; ICES, 2014). This was updated after review (Bal *et al*., 2015 WD), with the approach, results and a discussion of the current state of the assessment summarized below.

22.8.1 Data used

The capture–mark–recapture database used is based on 1000 angel shark caught and released year-round by recreational fisheries over the period 1970–2014. There were 164 individual recapture records, although some fish were recaptured several times (180 recaptures in total). Observed recaptures come from both recreational and commercial fisheries.

As the aim of this study was to get first estimates of the size of the population of angel shark in the Tralee bay area, it was necessary to get estimates of capture efficiency and fish survival so as to used catch numbers (new catch plus recaptures) together with parameters to feed a population dynamic model. To reach this goal it was necessary for the data to have a discrete structure. Captures and recaptures that occurred from Mid-June to Mid-August were therefore considered for estimating population size. This period corresponds with the seasonal occurrence and is long enough to ensure having sufficient data for analyses. Fish first captured outside this period were used to help estimating survival and captures probabilities only, and did not enter population estimates. As capture data were from recreational anglers only, recapture data from other fisheries were used only to get information about the state of sharks through time (i.e. dead or alive, 78 recaptures). All fisheries besides recreational angling are assumed to result in dead removals from the stock. Nonetheless if a shark is caught during the reference period by a commercial fishery, it was considered as alive on the reference period and susceptible to being recaptured by anglers. Fish with unknown recapture gears were assumed to have been recaptured by anglers if the recapture date was between May and September and if the recapture location was near the Irish shore. Other unknown recaptures were assumed to correspond to commercial gears. The capture and recapture data used in the study are summarized in Figure 22.5.

22.8.2 Methodology

22.8.2.1 Cormack-Jolly-Seber Model

22.8.2.1.1 Generalities

To disentangle capture probability from survival probability, a Cormack-Jolly-Seber (CJS) model was applied to the capture–recapture data that can be summarized for each fish in capture-recapture histories.

The corresponding state–space model and data structures are summarized in Figure 22.6. State–space models are hierarchical models that decompose an observed time-series of observed response into a process (here, survival rate) and an observation error component (here, capture probability) (After Kery and Schaub, 2012).

In this exploratory assessment, the authors defined the latent variable $A_{i,y}$ which takes the value 1 if an individual *i* is alive and value 0 if an individual is dead year *y*.

Conditionally on being alive at occasion *y*, individual *i* may survive until occasion *y+1* with probability $\Phi_{i,y}(y = 1, ..., Y)$. The following equation defines the state process:

(1) $A_{i,y+1} \mid A_{i,y} \sim Bernouilli(A_{i,y} * \Phi_{i,y})$

The Bernoulli success is composed of the product of the survival and the state variable *z*. The inclusion of *z* insures that an individual dead remain dead and has no further impact on estimates.

If individual *i* is alive at occasion *y*, it may be recapture (*R*) with probability $p_{i,y}(y = 2, ..., Y)$. This can again be modelled as a Bernoulli trial with success probability $p_{i,y}$:

(2) $R_{i,y} \mid A_{i,y} \sim Bernouilli(A_{i,y} * p_{i,y})$

the inclusion of the latent variable *A* insures that an individual dead cannot be modelled again afterwards.

22.8.2.1.2 Specific modelling

To allow for more flexibility, survival is assumed vary per year based on a random walk structure in the logit scale. Equation (2) is changed for the following equation starting on occasion 2:

(3) $A_{i,y+1} \mid A_{i,y} \sim Bernouilli(A_{i,y} * \Phi_y)$
$logit(\Phi_y) \sim Normal(logit(\Phi_{y-1}), \sigma_\Phi)$

with the following uninformative priors

$\Phi_1 \sim Unif(0, 1)$ and $\sigma_\Phi \sim Unif(0, 10)$

The capture probability of individuals as a fixed parameter in equation (1) thus change into the following equation:

(4) $R_{i,y} \mid A_{i,y} \sim Bernouilli(A_{i,y} * p)$

In the case of angel shark, there is not always a well-defined period of tagging and recapture, as recreational anglers can fish year round. On the other hand, the CJS approach needs the data to be discrete and a reference period over which the population is considered closed is necessary. Not to lose information coming from sharks first caught outside the reference period chosen, they were included in the model to get better estimates of survival and recapture probabilities. To do so, the first year survival is corrected by the deviation (Δd_i) between the date the individual *i* was captured at and the following 15th of July (i.e. middle of the reference period chosen):

(5)$\Phi_{i,1} = \Phi_1^{\Delta d_i /365}$

22.8.2.2 Deriving population size: the Jolly Seber approach

The best way of deriving population size estimates would be to add a third population dynamic components to the model described above and to fit the whole model in one go. This is called a Jolly Seber (JS) model (Kery and Schaub, 2012).

Focusing on untagged fish population sizes (for computation cost only), the population size (N) may be derived as follows for occasion 1:

(6) $C_1 \sim Binomial(p, N_1)$ with uninformative prior for $N_1 \sim Unif(0, 300\,000)$

Then a population dynamic can be built using the probability of survival coming from the CJS model described above together on top of the estimate of catch probability. For the occasions following occasion 1, with S referring to survivors from the previous occasion N and E the new entrants to the population, N is estimated as follows:

(7) $S_y \sim Binomial(\Phi_y, N_{y-1})$
$N_y = S_y + E_y$

The series of E is given a Gamma random walk prior structure (gamma distribution in jags are parameterised with shape (α) and rate (β)) to capture rather smooth evolutions. Starting on occasion 3, the following applies:

(8)$E_y \sim Gamma(\alpha_{Ey}, \beta_{Ey})$
$\alpha_{Ey} = E_{y-1} \times \beta_{Ey}$
$\beta_{Ey} = E_{y-1} / \sigma_y^2$

with the following uninformative priors

$E_2 \sim$ Unif(0, 300 000) and $\sigma_y \sim$ Unif(0, 30 000)

Trials made so far to fit the model in one go have been unsuccessful, revealing a mismatch between the CJS and dynamic parts of the model. This may be due to the fact that a fixed *p* for the whole time-series is not realistic.

As a consequence, population estimates are given in two ways:

a) The underlying population dynamics were neglected and *N* was derived in the Bayesian model using parameter *p* and the total number of sharks captured the corresponding year,

b) The CJS model was first fitted. Posteriors were then used as informative priors to sequentially fit the population dynamic model described above, breaking feedbacks between the two parts. The figures are provided for illustrative purposes only.

22.8.3 Computation details

Bayesian fitting, forecasting and the derivations were implemented using Markov Chain Monte Carlo algorithms in JAGS (Just Another Gibbs Sampler, Plummer, 2003; http://mcmc-jags.sourceforge.net) through the R software (R Development Core Team, 2013). Three parallel MCMC chains were run and 20 000 iterations from each were retained after an initial burn-in of 20 000 iterations. Chains thinning used equalled 5. Convergence of chains was assessed using the Brooks-Gelman-Rubin diagnostic (Gelman *et al.*, 2015).

22.8.4 Results

Results are composed of the following figures showing posterior density function of capture rate (Figure 22.7), yearly survival (Figure 22.8) and population size estimates from method a (Figure 22.9) and b (Figure 22.10).

22.8.5 Quality of the assessment

It is clear that the current population of angel shark around Ireland is very low compared to the whole historical time-series, although the actual population size remains uncertain, as shown by the scale difference coming from the two method used to infer population size (Figures 22.9 and 22.10). Nonetheless trends are robust and suggest an important decline starting in the 1980s. This result concurs with anecdotal reports on angel shark abundance (Table 22.4).

Although some size and/or weight data were originally available, they were not considered in this study as they appeared unreliable.

For now, this approach has been unsuccessful in fitting a proper JS model in one go. Expert opinion on tagging and recapture effort may help by alleviating the fitting issues linked to some apparent mismatch between the CJS and population dynamic parts of the model. Additionally, this would result in a more realistic model with annual variations in both survival and capture probabilities. So far models are ready to do so. Information on the variability in fishing effort for commercial fisheries may also be included and should allow us to better differentiate natural survival variability from anthropogenic causes. Planned improvements in the Bayesian capture-recapture model for tope should also have application for angel shark, but catch and tagging rates close to zero will strongly limit on-going assessment.

22.9 Stock assessment

Whilst no quantitative stock assessment has been benchmarked, due to data limitations, the WGEF perception of the stock is based largely on analyses of historical and contemporary trawl surveys.

Historically, coastal trawl surveys around the British Isles often reported angel shark, especially in the western English Channel (Garstang, 1903; Rogers and Ellis, 2000) and Bay of Biscay (Quéro and Cendrero, 1996). In contrast, contemporary surveys encounter this species only very infrequently, if at all. Such patterns have been reported elsewhere in the biogeographic range of angel shark (e.g. Jukic-Peladic *et al.*, 2001).

The apparent scarcity of angel sharks in contemporary trawl surveys is in stark contrast to early texts on British fishes, which generally considered that angel shark were encountered regularly in British seas. Indeed, Yarrell (1836) stated that "*It is most numerous on the southern coast of our island; but it is occasionally taken in the Forth, and some other parts of the east coast, particularly around Cromer and Yarmouth. It is common on the coasts of Kent and Sussex …It is also taken in Cornwall*". Similarly, Day (1880–1884) wrote "*In the Firth of Clyde it is by no means uncommon… In fact it is common in the North Sea and Bristol Channel. Occasionally taken off Yorkshire and is common on the Dogger Bank… taken on the coasts of Kent and Sussex, Hampshire and common at all times along the south coast…Common in Cornwall*". Similar examples are also evident in other accounts (Table 22.4).

WGEF considers that the comparisons of historical data with the near-absence in recent data (landings, surveys, observer programmes, angling data) are sufficient to consider the species to be severely depleted in the Celtic Seas ecoregion and possibly extirpated from the North Sea ecoregion. Whilst its status in the Bay of Biscay and Iberian coastal waters is unknown, it is considered very rare, with only occasional individuals reported.

22.10 Quality of the assessment

No formal stock assessment has been undertaken.

22.11 Reference points

No reference points have been proposed for this stock.

22.12 Conservation considerations

Angel shark is listed as Critically Endangered on the IUCN Red List (Gibson *et al.*, 2008), is listed on the OSPAR List of Threatened and Declining Species (OSPAR Commission, 2010) and is protected on the UK's Wildlife and Countryside Act.

Various organisations (including conservation bodies and academic departments) are developing an Eastern Atlantic and Mediterranean Conservation Strategy for angel sharks (see www.angelsharknetwork.com).

In 2017, angel shark was added to Appendix I and Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). This means it is considered an endangered migratory species, and requires international conservation agreements

22.13 Management considerations

Angel shark is thought to have declined dramatically in the northern parts of the ICES area and Mediterranean Sea, as evidenced from landings data, survey information and the decline in the numbers tagged in Irish waters. The status of angel shark and magnitude of any decline in the southern parts of the ICES area and northwest Africa remain uncertain.

Since ICES advised that this species should receive the highest protection possible, it has been listed as a prohibited species on European fishery regulations.

Dedicated, non-destructive surveys of areas of former local abundance would be needed to inform on current habitat and range, and to assess the possibilities of spatial management.

Given the perceived low productivity of this species and that they have shown high site fidelity, any population recovery would be expected to occur over a decadal time frame.

Improved liaison and training with the fishing industry is required to ensure that any specimens captured are released. National observer programmes encountering this species could usefully collect information on the vitality of discarded individuals.

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Table 22.1a. Angel shark in the Northeast Atlantic. Reported landings (t) for the period 1978–2004. French landings from ICES and Bulletin de Statistiques des Peches Maritimes. UK data from ICES and DEFRA. Belgian data from ICES. UK landings for 1997 considered to be misreported fish.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Belgium	.	.	.	.	.	.	.	.	.	.	.
France	8	3	32	26	29	24	19	18.7	19.5	18	13
UK	.	.	.	.	.	.	.	.	.	.	.
Total	8	3	32	26	29	24	19	18.7	19.5	18	13
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Belgium	.	.	.	.	.	.	.	.	.	.	.
France	9	13	14	12	11	2	2	1	1	1	1
UK	.	.	.	.	.	2	1	1	.	.	.
Total	9	13	14	12	11	4	3	2	1	1	1
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
Belgium	.	.	.	.	.	.	.	.	.	.	
France	2	1	2	+	1	+	+	+	+	+	
UK	.	.	(47)	.	.	.	.	.	.	.	
Total	2	1	2	0	1	0	0	0	0	0	

Table 22.1b. Angel shark in the Northeast Atlantic. Reported landings (t) for the period 2005–2018, following WHSHARK2 (ICES, 2016) and subsequent data calls.

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Belgium	.	.	.	.	.	.	.	.	.	.	.	.
France	1.03	0.40	0.74	0.27	1.60	1.40	0.97	1.22	0.02	0.01	0.53	0.03
UK	0.06	0.04	0.01	.	.	.	.	.	.	.	.	.
Total	**1.09**	**0.44**	**0.75**	**0.27**	**1.60**	**1.40**	**0.97**	**1.22**	**0.02**	**0.01**	**0.53**	**0.03**

	2017
Belgium	.
France	0.02
UK	0.13
Total	**0.15**

Table 22.2. Angel shark in the Northeast Atlantic. Numbers of specimen angel shark (total weight >22.68 kg) reported to the Irish Specimen Fish Committee from 1958–2005.

Year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
No. specimen fish reported	3	1	0	0	4	1	15	13	5	13	0	2

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
No. specimen fish reported	1	3	3	1	4	2	1	5	4	10	5	10

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
No. specimen fish reported	7	3	2	2	0	1	1	2	2	2	1	3

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
No. specimen fish reported	2	1	0	1	1	0	0	0	2	0	0	0

Table 22.3. Angel shark in the Northeast Atlantic. Summary of life-history parameters for *Squatina squatina*.

Common name	Angel shark
Scientific name	*Squatina squatina*
Stock unit	Unknown
The stock structure is unknown, but available data for this and other species of angel sharks indicates high site fidelity, possibly with localized stocks. STECF (2003) noted that angel sharks "*should be managed on smallest possible spatial scale*". However, given that angel shark is perceived as highly threatened throughout the ICES area (and elsewhere in European waters), ICES provide advice at the species level.	

Length–weight relationship	$W = 0.0346.L^{2.7079}$ (n = 8)			Coull *et al.* (1989)
Reproductive mode	Aplacental viviparity			Capapé *et al.* (1990)
Reproductive cycle	Possibly biennial, based on data for congeneric species			Baremore (2010)
Spawning season	Parturition: Summer (possibly June to July)			Quigley (2006)
Fecundity (ovarian)	8–18 (mode = 13)			Capapé *et al.* (1990)
Fecundity (uterine)	8–18 (mode = 13) in the Mediterranean Up to at least 22 in the Atlantic			Capapé *et al.* (1990) Patterson (1905)
Development (months)	Annual			Capapé *et al.* (1990)
Length at birth/hatching	25–28 cm			Capapé *et al.* (1990)
Maximum length	244 cm			Quigley (2006)
	Female	Male	Combined	
Length of smallest mature fish	128 cm	80 cm (?)	–	Capapé *et al.* (1990)
Length at 50% maturity	–	–	–	–
Length of largest immature fish	–	–	–	–
Age at 1^{st} maturity	–	–	–	–
Age at 50% maturity	–	–	–	–
Age at 100% maturity	–	–	–	–
L_{inf}	–	–	–	–
K	–	–	–	–
t_0	–	–	–	–
Maximum age (years)	–			–
Trophic role	Ambush predator that feeds on fish, including flatfish, and larger crustaceans (Ellis *et al.*, 1996)			

Table 22.4. Angel shark in the Northeast Atlantic. Regional chronology of perceived status of angel shark.

Area	Description
Southern North Sea	Laver (1898) "*This frequents the entire Essex coast. It is usually caught in nets. Though occasionally eaten by fishermen, it is according to my taste, far too rank in flavour for a more delicate palate*" Murie (1903) "*The 'fiddlers' are got all round the Kent coast in moderate quantity, but Webb regards it as somewhat of a rarity just at Dover. It is not a common fish in the Thames estuary, in one sense, though there are seasons when it is very frequently got in the trawlers' nets. In 1893 they were unusually plentiful during the summer months in the neighbourhood of the Oaze, Girdler, Gilman, and so called S. Channel generally. From June till August there were few boats but had examples among their catch, and some of the specimens were of large size*" Patterson (1910) "*has been brought into* (Lowestoft) *on several occasions*" Poll (1947) wrote "*Espècie commun, surtout en été*" [A common species, especially in summer]
English Channel	Buckland (1881) "*found in the North Sea, the British Channel, the Mediterranean … It is taken on the 'long lines' which are set for ray, &c … It is common on the bays of Archachon and, I believe, on the sandy banks all along the Bay of Biscay. They are frequently seen in the markets of Dieppe, and are not uncommon at Brighton and Hastings*" Aflalo (1904) "*familiar on most parts of the coast, and is a frequent object of unintentional capture on the long-lines, as well as in both trawl and drift-nets … Small examples of from 12 to 18"are common in many south coast estuaries, notably at Teignmouth, where a few are brought ashore almost every week during May in the sand-eel seines worked just outside the bar*" Le Danois (1915) "*à Roscoff, assez commun vers la fin de l'été*" [At Roscoff, it is quite common in late summer] Cooper (1934) "*Several specimens of this species are caught every year by anglers, usually when Tope fishing, but it appears to have been more common on the south coast of England some twenty or thirty years ago than it is today*" MBA (1957) "*A haul of the trawl in Cawsand Bay will generally yield several specimens. Occasionally trawled on other grounds*"
Irish Sea Ireland	Herdman and Dawson (1902) "*common off our coasts in spring and summer. It occurs not infrequently in the trawl net in the Lancashire district. We have taken it as near Liverpool as the Rock and Horse Channels, and the Deposit Buoy. We have also taken it near Piel in the Barrow Channel, and off Maughold Head. Mr Walker records it from Rhos weir and Colwyn Bay, and Professor White from the Menai Straits. It has been frequently taken off the Isle of Man, one is recorded from Port Erin, and we have taken it also in the Ribble, and have seen it taken on the offshore grounds by the trawlers*" Forrest (1907) "*… frequently met with it off Aberffraw … from Barmouth … not uncommon in the Menai Straits, Colwyn Bay and along the north coast …* (taken in) *St Tudwal's Roads, Red Wharf Bay, and other places*" Williams (1954) "*Taken rather infrequently off Strangford Bar. Said to be common off the north shore of Ireland*" Went & Kennedy (1976) listed it as common noting that it was "*more often caught on rod and line than by any other method*"

Table 22.4. (continued). Angel shark in the Northeast Atlantic. Regional chronology of perceived status of angel shark.

Area	Description
France (Bay of Biscay and Mediterranean)	Moreau (1881) "*L'Ange se trouve sur toutes nos côtes, mais il paraît plus commun dans l'ocean que dans la Méditerranée, il est même assez rare à Cette*" [Angel shark is on all our coasts, but it seems more common in the (Atlantic) ocean than in the Mediterranean, it is quite rare at Séte] Quéro *et al*. (1989) recorded individual fish from trawl surveys, including one from coastal waters near Pornic (just south of the Loire Estuary) in 1973 and one further offshore south-west of the mouth of the Gironde in 1975
Spain	Lozano Rey (1928) reported that angel shark "*vive en todo el litoral ibérico, aunque parece más frecuente en las costas del Atlántico que en las del Mediterráneo, pero en este tampoco es rara … Los individuos jóvenes se pescan en la misma orilla. Nosotros hemos capturadao ejemplares de este especie, de menos de treinta centímetros de longitude, en la bahía de Santander, a un par de metros de profundidad*" [lives all along the Iberian coast, although it seems more common in the Atlantic coasts than in the Mediterranean, but this is not unusual ... Young individuals are caught in the same bank. We have captured specimens of this species, less than 30 cm long, in the Bahía de Santander, in waters a few meters deep] In relation to the Bahía de Santander, García-Castrillo Riesgo (2000) noted "*Hoy en día, esta especie de angelote no está presente en el entorno de la Bahía. La última referencia que tenemos data de 1985, cuando se recogió un ejemplar adulto y moribundo en el Puntal. Por el contrario a principios de siglo, según los datos de la Estación Biólogica de Santander, los jovenes eran frecuentes en los arenales del Puntal, el sable de Afuear, Enmedio y el fondeadero de la Osa, siendo aún más abundantes en al Abra del sardinero y las Quebrantas*". [Today, this kind of angelfish is not present in the environment of the Bahía. The last reference we have dates from 1985, when a dying adult specimen was collected in the Puntal. Rather early in the century, according to data from the Biological Station of Santander, the young were frequent off the beach at Puntal, saber Afuear, Enmedio and the anchorage of the Osa, still more abundant in the Abra del Sardinero and Quebrantas]
Portugal	Nobre (1935) wrote "*Esta espécie aparece freqüentemente no norte do País, sendo apanhada nas rêdes de fundo*" [This species appears frequently in the north of the country, where it is caught in bottom nets]
Italy	Tortonese (1956) stated it was "*Più o meno commune in tutti i nostri mari*" [more or less common in all our seas]

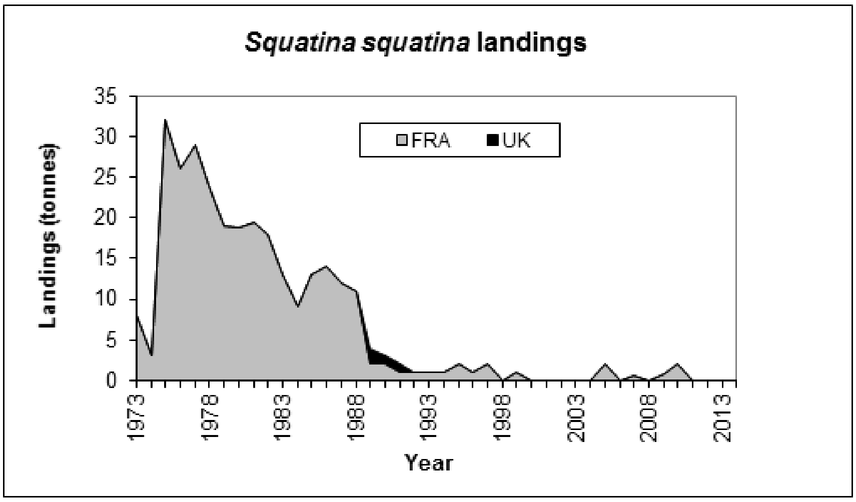

Figure 22.1. Angel shark in the Northeast Atlantic. Total reported landings of *Squatina squatina* (1973–2012). Angel shark has been listed as a non-retained/prohibited species on European fisheries regulations since 2009 and so this species is now reported very rarely in landing statistics.

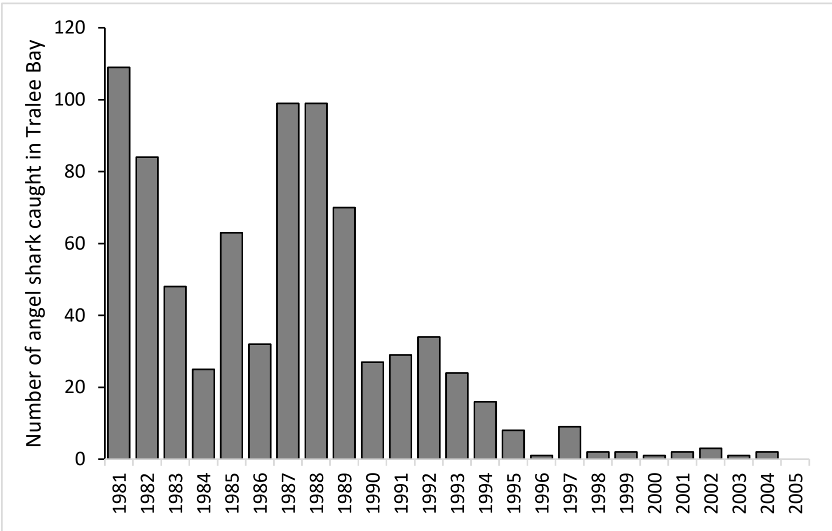

Figure 22.2. Angel shark in the Northeast Atlantic. Numbers of angel shark caught by two charter boats in Tralee Bay 1981–2005. Adapted from Irish Central Fisheries Board data presented in ICES (2008).

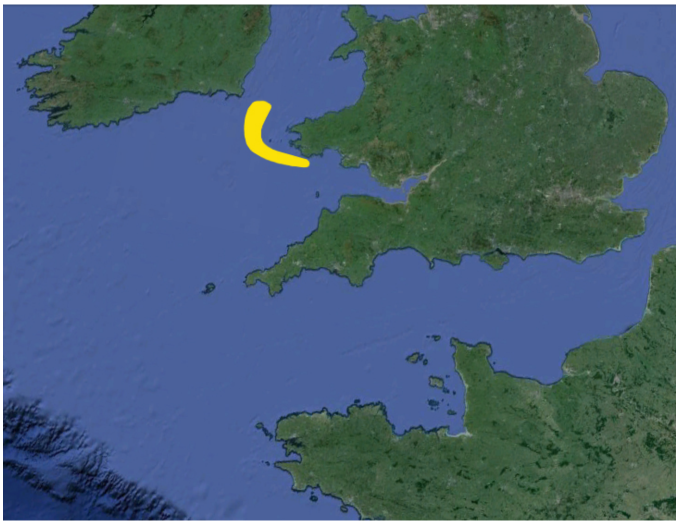

Figure 22.3. Angel shark in the Northeast Atlantic. The suspected over-wintering area off Pembrokeshire, where occasional individuals have been reported by French vessels.

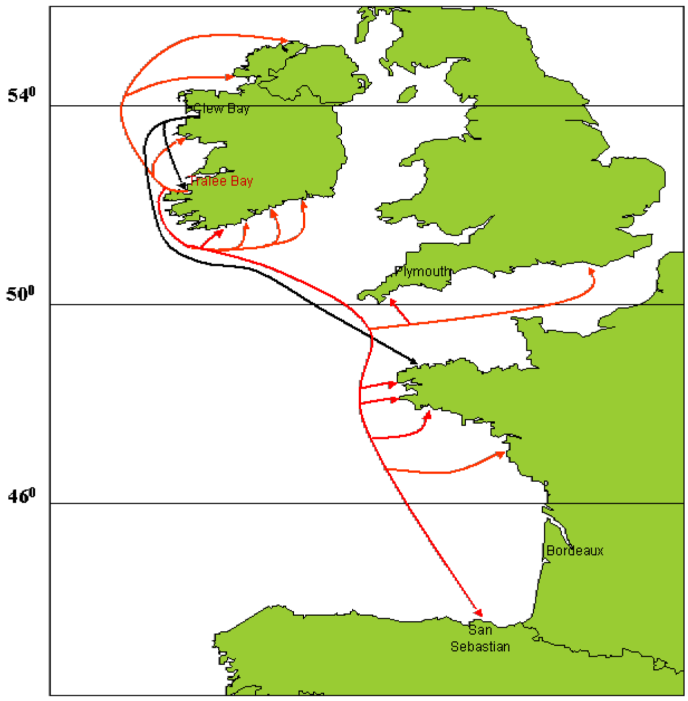

Figure 22.4. Angel shark in the Northeast Atlantic. Longer-distance movements of angel shark tagged off the west coast of Ireland, 1970–2006. Source: Irish Central Fisheries Board.

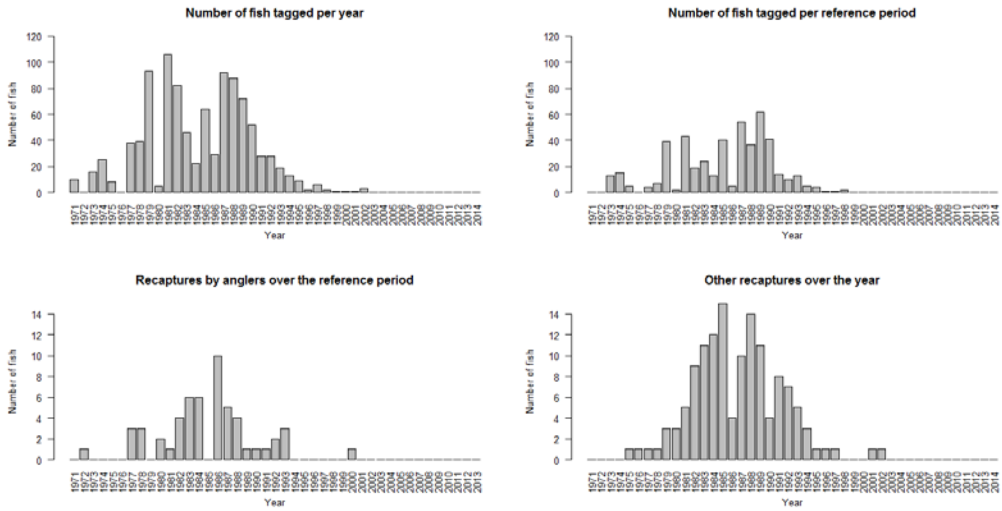

Figure 22.5. Angel shark in the Northeast Atlantic. Number of sharks captured, recaptured and newly captured per year in Tralee Bay, Ireland. Source: Bal *et al.* (2014 WD).

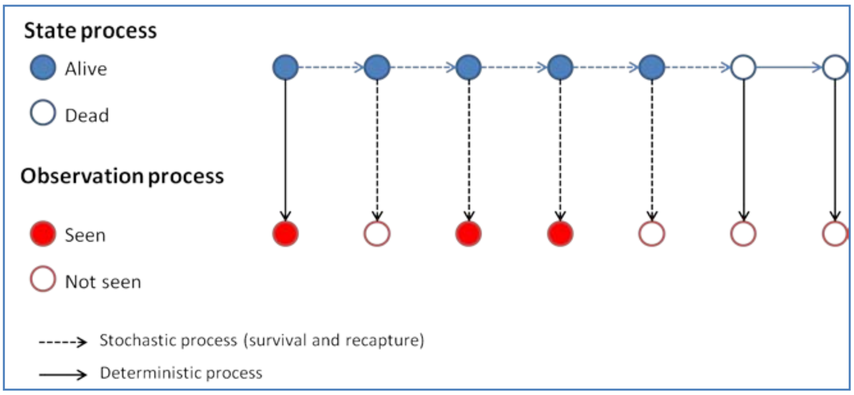

Figure 12.6. Angel shark in the Northeast Atlantic. Example of the state and observation process of a marked individual over time for the CJS model. The sequence of true states in this individual is A = [1, 1, 1, 1, 1, 0, 0] and the observed capture history is H = [1, 0, 1, 1, 0, 0, 0]. Source: Bal *et al.* (2015 WD).

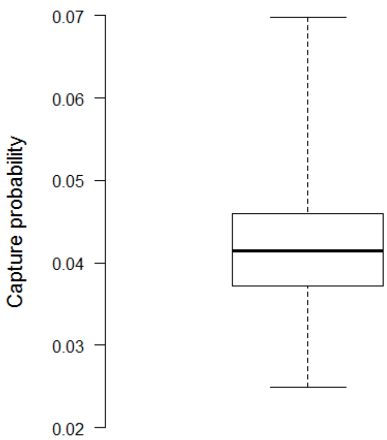

Figure 22.7. Angel shark in the Northeast Atlantic. Boxplot of the individual capture probability posterior. Source: Bal *et al.* (2015 WD).

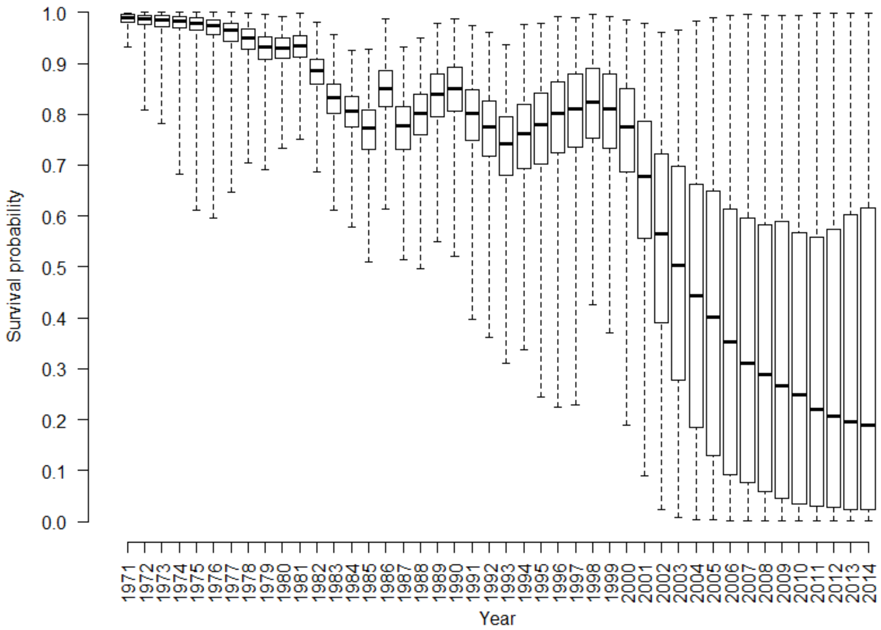

Figure 22.8. Angel shark in the Northeast Atlantic. Boxplot of annual survival probabilities posteriors. Source: Bal *et al.* (2015 WD).

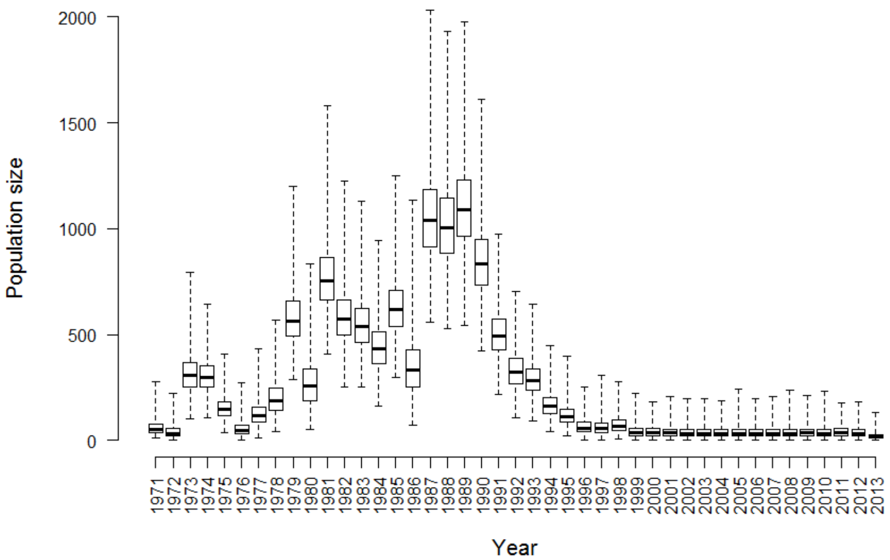

Figure 22.9. Angel shark in the Northeast Atlantic. Boxplot annual population sizes posteriors without population dynamics structure. Source: Bal *et al.* (2015 WD).

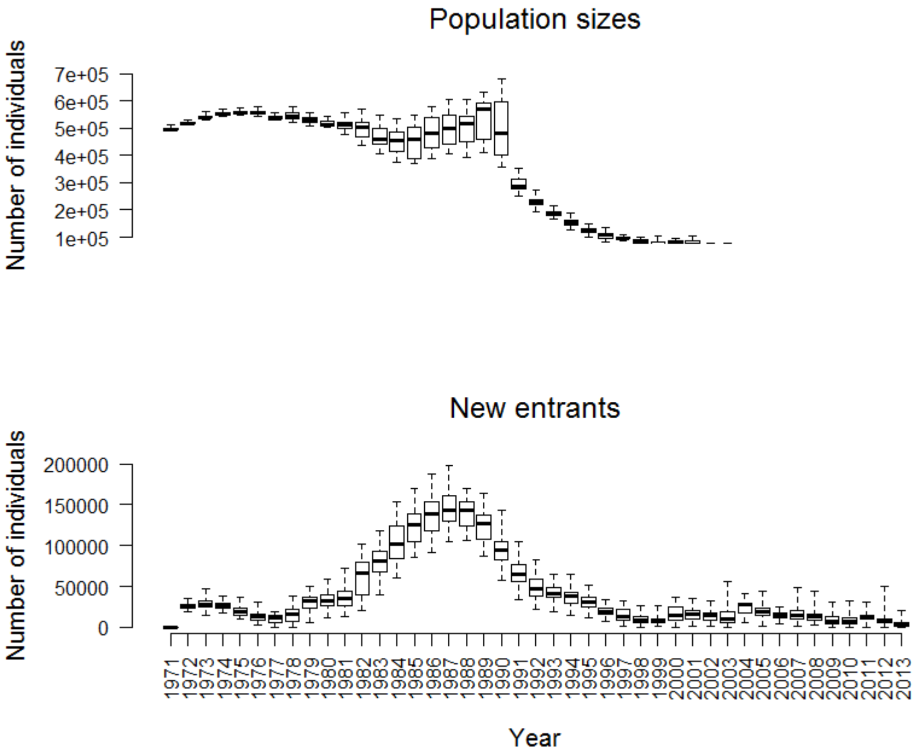

Figure 22.10. Angel shark in the Northeast Atlantic. Boxplot annual population sizes and number of entrants posteriors with population dynamics structure. Source: Bal *et al.* (2015 WD).

23 White skate *Rostroraja alba* in the Northeast Atlantic

23.1 Stock distribution

White skate *Rostroraja alba* is distributed in the eastern Atlantic from the British Isles to southern Africa, including the Mediterranean Sea (Stehmann & Bürkel, 1984). As such, the species distribution covers parts of ICES Subareas 7–9, and may possibly have extended into the southern parts of Subareas 4 and 6.

The stock structure within the overall distribution area is unknown. This data-limited species is perceived as threatened throughout the ICES area (and elsewhere in European waters), and ICES provides advice at the species level.

23.2 The fishery

23.2.1 History of the fishery

R. alba is thought to have been the subject of targeted exploitation for much of the 19th and early 20th centuries, with targeted fisheries in the English Channel, Brittany and possibly the Isle of Man (Irish Sea). It was viewed as a highly marketable skate due to its large size and thickness of the wings (Ellis *et al.*, 2010).

In 1964, 59 t of *R. alba* was landed in the port of Douarnenez (Brittany) from a target longline fishery (Du Buit, *pers. comm.*). After this, the fishery and local stock collapsed. The use of the landing name 'Raie blanche' (white skate) is now discontinued in French fish markets and only known by the oldest fishermen and fish-market workers. Up to 2009, only occasional individuals were landed in France, often under the name '*Dipturus batis*'. It was estimated that 13 ± 10 individuals (117 ± 89 kg) were landed in 2005 in France under the name '*D. batis*'. During a sampling programme of large skates in French ports (2006–2007), only one *R. alba* specimen was positively identified from the 4,110 skates examined (Iglésias *et al.*, 2010). Prior to the inclusion of *R. alba* on the EU prohibited list, individuals were recorded occasionally in Portuguese landing ports (Serra-Pereira *et al.*, 2011).

R. alba may be a very occasional bycatch in some trawl and gillnet fisheries, although as a prohibited species the caught individuals should be released. There was an authenticated record of an individual caught (and released) in the English Channel (in 2013). As the species is largely unknown by fishermen and does not have highly conspicuous morphological characters for its identification, individuals might occasionally be mixed with other skates.

23.2.2 The fishery in 2017

No new information.

23.2.3 ICES Advice applicable

In 2014, ICES advised "on the basis of the precautionary approach … there be no catches of this species. Measures should be taken to minimize bycatch to the lowest level". ICES (2014) also stated that "Rostroraja alba is designated on the EU prohibited species list in the entire ICES area. This is a high-level, long-term conservation strategy aimed at very depleted and vulnerable species. ICES supports this listing, having reviewed it in 2010".

In 2016, ICES advised ICES that when the precautionary approach is applied, there should be zero catches of this species in each of the years 2017, 2018, and 2019.

23.2.4 Management applicable

Council Regulation (EC) 2017/127 continues to prohibit European Union vessels to fish for, to retain on board, to transship or to land *R. alba* in Union waters of ICES Subareas 6–10. Council Regulation (EC) 2018/120 also states that *"when accidentally caught, species…shall not be harmed"* and*"specimens shall be promptly released"*. This prohibited status has been in force since 2010.

R. alba is legally protected in UK waters, being listed on the Wildlife and Countryside Act.

23.3 Catch data

23.3.1 Landings

R. alba became increasingly rare in landings prior to the requirements for species-specific recording (Ellis *et al.*, 2010), and so there is great uncertainty on historical levels of exploitation.

Some of the nominal landings reported for *R. alba* are thought to refer to either other large-bodied skates (*Dipturus* spp.) or shagreen ray *Leucoraja fullonica*, as this species also has a sharply pointed snout. In addition to possible misidentifications, there are likely input errors, especially as the FAO code for Rajidae (RAJ) could easily be input as RJA (*R. alba*).

Landings from around Scotland are assumed to refer to *L. fullonica,* and landings from other areas outside the former distribution have been assigned to Rajiformes (see ICES, 2016). Other nominal landings of *R. alba* (Table 23.1) may still be unreliable.

23.3.2 Discards

Limited data are available. The discard observer programme for the English and Welsh fleets did not record any *R. alba* (Silva *et al.*, 2012). The Portuguese Pilot Study for Skates recorded single specimens of *R. alba* (47 and 62 cm L_T) in two trips using trammel nets, from a total of 20 fishing trips and a total sample of 667 skates. There is uncertainty in the reliability of some nominal records of *R. alba* recorded in other national observer programmes.

23.3.3 Quality of catch data

Both landings and discard data for *R. alba* are very limited and may be confounded with other species. The nominal landings presented are considered unreliable

23.3.4 Discard survival

There are no species-specific data on the discard survival of *R. alba*. Discard survival of skates has been examined for a range of other skate species, with at-vessel mortality low in some inshore fisheries, but more limited data available for post-release mortality (Ellis *et al.*, 2016). The two specimens recorded in the EU/PNAB observer trips were considered in "good" health condition (following Enever *et al.*, 2009).

23.4 Commercial catch composition

No data available.

23.5 Commercial catch and effort data

No data available.

23.6 Fishery-independent information

R. alba is encountered very rarely in trawl surveys, which may reflect the low abundance of the species and/or poor spatial overlap between surveys and refuge populations and/or their favoured habitats. Existing surveys are not considered appropriate for monitoring the status of this species.

Although not taken in English trawl surveys (Ellis *et al.*, 2005), occasional individuals have been captured in the Irish Groundfish survey along the west coast of Ireland. One egg-laying female (185 cm L_T) was caught in the Portuguese Groundfish Survey in 2007.

23.7 Life-history information

Although taken periodically along the west coast of Ireland (Quigley, 1984), the biology of this species in northern European seas is largely unknown. It has been better studied in the Mediterranean Sea (Capapé, 1976; 1977). Kadri *et al.* (2014) examined specimens from the Mediterranean: the smallest mature fish were 110 cm (male) and 120 cm (female). The youngest mature female in this study was estimated to be 17 y, and the oldest fish 35 y.

R. alba egg cases are occasionally found in Galway Bay and Tralee Bay in the West of Ireland (G. Johnston, pers. comm.).

French fishers consider this species to live preferentially on harder substrates, and so it may have been caught more frequently in static set nets and longline fisheries (Iglésias, pers. comm.).

23.8 Exploratory assessment models

No exploratory assessments have been undertaken.

23.9 Stock assessment

No formal stock assessment has been undertaken. The perceived stock status is based on the comparison between recent and historical trawl survey catch data.

Historically, trawl surveys around the British Isles reported *R. alba* (Rogers & Ellis, 2000), whereas it has now disappeared from parts of their former range. Similar longer-term declines have also been reported for the Bay of Biscay (Quéro & Cendrero, 1996).

WGEF considers that the comparison of historical data with the near-absence in recent data sources (historical landings, surveys, observer programmes) is sufficient to consider the species to be severely depleted and near-extirpated from various parts of the Celtic Seas and Biscay-Iberian ecoregions.

23.10 Quality of the assessment

No formal stock assessment has been undertaken.

23.11 Reference points

No reference points have been proposed for this stock.

23.12 Conservation considerations

R. alba is listed as Critically Endangered on the IUCN Red List (Gibson *et al.*, 2008; Nieto *et al.*, 2015). It is listed on the OSPAR List of Threatened and Declining Species (OSPAR Commission 2010). It is protected on the UK's Wildlife and Countryside Act.

23.13 Management considerations

Since ICES advised that this species should receive the highest protection possible, it has been listed as a prohibited species on EC fishery regulations.

Given the low abundance of this species and its high conservation interest, WGEF recommend that (i) any data on *R. alba* collected from national observer programmes be verified whenever possible (e.g. photographed) and (ii) that ongoing national observer programmes collect information on the health state (e.g. lively, sluggish, dead) of any discards of this species.

Dedicated, non-destructive surveys of areas of former abundance would be needed to inform on current habitat and range.

Given the perceived low productivity of this species, any population recovery would take a decadal time frame.

As this species could be overlooked in catches of mixed skates, improved identification material could usefully be developed.

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Table 23.1. White skate in the Northeast Atlantic. Nominal landings of *R. alba* in the ICES area. Some national data reported as white skate have been reassigned to Rajiformes (indet.) or *L. fullonica* (see ICES, 2016). The accuracy of remaining data (below) is unclear, due to possible input errors for the codes RAJ (Rajidae) and RJA (*Rostroraja alba*).

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France	1.00	-	1.52	0.73	59.35	10.65	29.16	12.10	14.92	11.29	7.47	4.25	3.9
Ireland	-	-	-	-	-	-	-	-	-	0.26	0.02	0.12	-
Portugal	4.65	5.51	-	-	-	-	-	-	-	-	-	-	-
UK	-	-	-	0.95	0.09	0.06	-	0.22	0.01	0.10	-	-	0.13
Total	5.65	5.51	1.52	1.68	59.44	10.72	29.16	12.32	14.93	11.65	7.48	4.36	4.0

24 Greenland shark *Somniosus microcephalus* in the Northeast Atlantic

24.1 Stock distribution

The known North Atlantic distribution of Greenland shark Somniosus microcephalus, which has been defined primarily by observations of specimens caught in cold-water commercial fisheries, extends from temperate waters to the Arctic Ocean (MacNeil *et al.*, 2012). It ranges from Georgia (USA) to Greenland, Iceland, Spitzbergen and the Arctic coasts of Russia and Norway to the North Sea and Ireland, with only very occasional individuals recorded further south (Ebert & Stehmann, 2013). Due to their known tolerance for extreme cold water and their ability to inhabit abyssal depths, Greenland sharks may be more widespread. The known distribution is also compromised by taxonomic problems in this genus (MacNeil *et al.*, 2012). The stock unit(s) are unknown.

24.2 The fishery

24.2.1 History of the fishery

Fishing for Greenland shark has been a part of the Scandinavian, Icelandic and Inuit cultures for centuries, extending back to the 13th and 14th century in Norway and Iceland, respectively. Although the meat of Greenland shark may be toxic when fresh (e.g. Anthoni *et al.*, 1991; McAllister, 1968), it is eaten in some countries after curing.

In the early to mid-20th century, Greenland sharks were caught in large quantities as a source of liver oil. At that time, peak annual catches e.g. in Norway are thought to have been in the region of 58 000 individuals (Ebert & Stehmann, 2013; MacNeil *et al.*, 2012). After the invention of synthetic oil in the late 1940s, demand for shark oil diminished, and no intensive fisheries for Greenland sharks have been reported since (Nielsen *et al.*, 2014).

Greenland shark is still targeted in small-scale artisanal fisheries in Iceland and Greenland. Artisanal fisheries target Greenland shark with hook and line, longline or gaffs, but it is also taken in seal nets and cod traps (Ebert & Stehmann, 2013). It is also an occasional bycatch in longline, trawl and gillnet fisheries in the cooler waters of the North Atlantic.

24.2.2 The fishery in 2017

No specific changes in the fishery were apparent in 2017. National landings data are available from Iceland, which have been 25 t on average since 2005.Eighteen tonnes were landed in 2017. No other countries have reported data.

24.2.3 ICES Advice applicable

ICES has not been asked to provide advice on Greenland shark.

24.2.4 Management applicable

Greenland shark is included in the list of deep-sea sharks on EC quota regulations for deep-sea fishes. There is a zero TAC for deep-sea sharks in EU vessels fishing in Union and international waters of ICES Subareas 5–10 (CEC, 2015).

24.3 Catch data

24.3.1 Landings

Limited landings data are available. More comprehensive landings data are available from Iceland (www.hagstofa.is and Marine Freshwater Research Institute databases). Reported annual landings by Iceland (Table 24.1) from ICES Division 5.a and Subarea 14 have varied from about 2 t (2007) to 87 t (1998). Monthly Icelandic landings of Greenland shark (2005–2015) indicate a peak during the summer (Fig. 24.1).

24.3.2 Discards

Limited data are available. Greenland shark is a bycatch in trawl fisheries for Greenland halibut *Reinhardtius hippoglossus* and northern shrimp *Pandalus borealis*, as well as in gillnet and longline fisheries (MacNeil *et al.*, 2012; Nielsen *et al.*, 2014).

In the Barents Sea, bycatch of Greenland shark in bottom trawls were related to sea temperature, with more bycatch at lower water temperatures (Rusyaev & Orlov, 2013). Despite limited data on Greenland shark bycatch in the commercial trawl fishery, Rusyaev & Orlov (2013) estimated an annual catch of 140–150 t in the Barents Sea.

In local fishing communities in Greenland, Greenland shark accounts for 50% of the total waste produced by the fishing industry. Estimated annual amounts of waste products of Greenland shark from fishing and hunting in specific counties may be *ca.* 1000 t (Gunnarsdóttir & Jørgensen, 2008).

24.3.3 Quality of catch data

As observers are not mandatory in the fisheries that may have a bycatch of Greenland shark, bycatch levels are uncertain. In some areas there may be confusion with other members of the genus or even basking sharks (MacNeil *et al.*, 2012).

24.3.4 Discard survival

No estimates on discard survival are available for this species. According to on-board observers, some Greenland sharks caught in offshore trawl and longline fisheries are released alive (MacNeil *et al.*, 2012).

Studies with electronic tags have indicated that another deep-water shark, the leafscale gulper shark *Centrophorus squamosus*, one of the species occurring in European seas, can survive after being caught by longline (2–3 h soak time) from waters of 900–1100m (Rodríguez-Cabello & Sánchez, 2014), but quantified data on the at-vessel mortality (AVM) and post-release mortality (PRM) of deep-water sharks that may be a by-catch in existing deep-water commercial fisheries are currently lacking (Ellis *et al*. 2016).

24.4 Commercial catch composition

No information available.

24.5 Commercial catch and effort data

No information available.

24.5.1 Recreational cpue data

There are recreational catch and release fisheries for Greenland sharks in Norway (year-round) and Greenland (in March) (MacNeil *et al.*, 2012), but CPUE data are not available.

24.6 Fishery-independent information

Greenland sharks are caught regularly during gillnet and bottom-trawl surveys around Greenland, such as the Greenland Institute of National Resources Annual bottom trawl survey (Nielsen *et al.*, 2014). Catches are also reported from the annual German Greenland groundfish survey (61 individuals between 1982 and 2015, Fig. 24.2). Trawl surveys conducted in the Barents Sea also encounter Greenland shark. Occasional catches are also reported in various Icelandic surveys, but with a total of just 68 observations over the period 1936–2012.

Existing scientific surveys are not appropriate for monitoring the abundance of Greenland sharks in their distribution area because catches are rare.

24.7 Life-history information

24.7.1 Habitat and abundance

Greenland sharks show a marked preference for cold water with most observations from waters of -1.8 to 10°C and the majority of records from waters <5°C (Skomal & Benz, 2004; Stokesbury *et al.*, 2005; Fisk *et al.*, 2012; MacNeil *et al.*, 2012). They occur on continental and insular shelves and upper slopes (Ebert & Stehmann, 2013). Confirmed observations cover a broad depth range from abyssal depths of at least 1,560 m (Fisk *et al.*, 2012) to shallow water (Yano *et al.*, 2007; MacNeil *et al.*, 2012). Devine *et al*. (2018) found that off the northern Canadian coast shark densities peaking at intermediate temperatures sampled, and at depths between 450–800 m. Though primarily considered a demersal species, it may be caught both at the surface and in the pelagic zone (e.g. Stokesbury *et al.*, 2005; MacNeil *et al.*, 2012). They often associate with fjordal habitats (MacNeil *et al.*, 2012).

Using baited remote underwater video cameras, Devine *et al*. (2018) calculated Greenland shark abundance and biomass in Arctic Canada. Density estimates varied from 0.4 to 15.5 individuals per km^2 (biomass: 93.3-1210.6 kg per km^2) among regions; being highest in warmer (>0 °C), deeper areas and lowest in shallow, sub-zero temperature regions.

24.7.2 Spawning, parturition and nursery grounds

The only captures of Greenland shark with near-term embryos were near fjords in the Faroe Islands. Based on observations on two presumed neonatal specimens captured by mid-water trawl off Jan Mayen Island, Kondyurin & Myagkov (1983) suggested that parturition may occur in the Norwegian Sea in July–August. Specimens of presumed neonatal size have also been reported from Canadian, Norwegian and Greenland fjords (Bjerkan & Koefoed, 1957).

24.7.3 Age and growth

Greenland shark is the second largest shark in the ICES area and the largest fish inhabiting Arctic seas (Ebert & Stehmann, 2013). Bigelow & Schroeder (1948) reported a maximum size of 640 cm L_T and weight of 1023 kg. Females may attain a larger size than males. The growth rate of Greenland sharks is unknown, but observations from tagging experiments indicate growth rates of 0.5–1 $cm.y^{-1}$ (Hansen, 1963). Conventional vertebral ageing methods are not applicable for Greenland shark (MacNeil *et al.*, 2012). However, a novel study using radiocarbon analysis from eye lenses suggests that Greenland sharks live to be several hundred year-old (Nielsen *et al*. 2016).

24.7.4 Reproductive biology

The Greenland shark is an aplacentally viviparous species (Carrier *et al.*, 2004; Ebert & Stehmann, 2013). The exact size at birth as well as the gestation period remain unknown, but size at birth is thought to be *ca.* 40–100 cm L_T (MacNeil *et al.*, 2012). Size-at-maturity is difficult to determine. The onset of maturity in male Greenland sharks probably occurs at *ca.* 260 cm L_T but is variable, and males may reach maturity at *ca.* 300 cm L_T (Yano *et al.*, 2007). Females from Icelandic waters mature at 355–480 cm L_T (MacNeil *et al.*, 2012). Based on changes in ovary weight, Yano *et al.* (2007) suggested that females matured at >400 cm L_T. Fecundity is uncertain, but may be approximately ten (Bjerkan & Koefoed, 1957; Ebert & Stehmann, 2013).

24.7.5 Movements and migrations

Studies using conventional and electronic (satellite and acoustic) tags have informed on the movements and migrations of Greenland sharks. Recent studies deploying archival pop-off tags (PATs) have shown that sharks displayed a broad vertical distribution, but no obvious diel movements were noted (Campana *et al*. 2015, Fisk *et al*. 2012). Tagged sharks move into deeper water when they mature, and it is possible they migrate offshore to mate and/or give birth (Campana *et al*. 2015). A recent study revealed a previously unknown directed migration from Canadian Arctic to NW-Greenland (Hussey *et al*. 2018). Previous studies have also examined the behaviour of Greenland sharks in the Northwest Atlantic (Skomal & Benz, 2004; Stokesbury *et al*., 2005). All such studies have found examples of localized movements and site fidelity, as well as some larger scale movements.

24.7.6 Diet and role in ecosystem

Greenland sharks feed on a wide variety of invertebrates, fish and marine mammals, indicating they are generalist predators on both benthic and pelagic organisms (MacNeil *et al.*, 2012; Nielsen *et al.*, 2014), and they are important predators in Arctic food webs (Leclerc *et al.*, 2012). They are also important scavengers, including of whales (Leclerc *et al.*, 2011).

24.8 Exploratory assessment models

No exploratory stock assessments have been undertaken.

24.9 Stock assessment

No stock assessment has been undertaken.

24.10 Quality of the assessment

No stock assessment has been undertaken.

24.11 Reference points

No reference points have been proposed for this stock.

24.12 Conservation considerations

On the basis of possible population declines and limiting life-history characteristics, the Greenland shark is listed as Near Threatened in the IUCN Red List (Kyne *et al.*, 2006). It is listed vulnerable in the Swedish Red List of endangered species (Svensson *et al.*, 2010).

24.13 Management considerations

Stock status and many other aspects of the biology of Greenland sharks are unknown. Given the large body size of this species and perceived low population productivity, further studies to better understand population dynamics and sources of mortality are required.

Ruud (1968) reported a longer-term decline in Greenland shark in the Oslofjord, but it is unclear as to how such local depletions towards the south of the distribution range relate to wider population trends.

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Table 24.1. Greenland shark *Somniosus microcephalus* in the Northeast Atlantic. Preliminary estimates of landings (t) for the period 1992–2017). Data were updated with landings from ICES historic nominal landings database (ICES, 2016) and national landings data provided to the WG (June 2017) 2017 data is considered provisional.

Year	Iceland	Greenland	Portugal	Sweden	Total
1992	68				68
1993	41				41
1994	42				42
1995	43				43
1996	61				61
1997	73				73
1998	87				87
1999	51				51
2000	45				45
2001	57				57
2002	56				56
2003	55				55
2004	58				58
2005	50		0.3		50
2006	28		0.5		29
2007	2	17	0.7		20
2008	35		0.6		36
2009	26			0.4	26
2010	43				43
2011	18				18
2012	20				19
2013	6				6
2014	97	8			60
2015	28	17			28
2016	26				26
2017	18				18

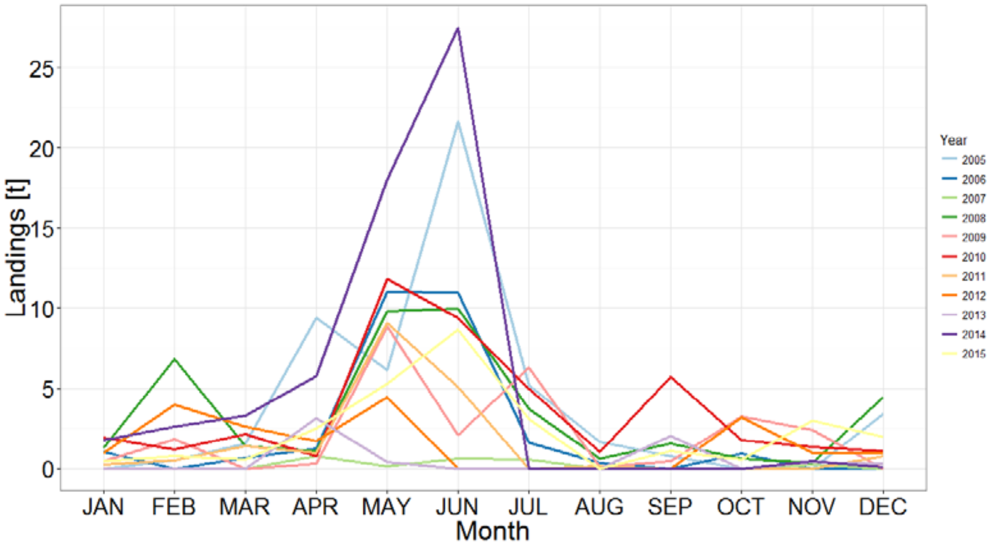

Figure 24.1. Greenland shark (*Somniosus microcephalus*) in the Northeast Atlantic. Monthly Icelandic landings of Greenland shark 2005–2015. Data from www.hagstofa.is

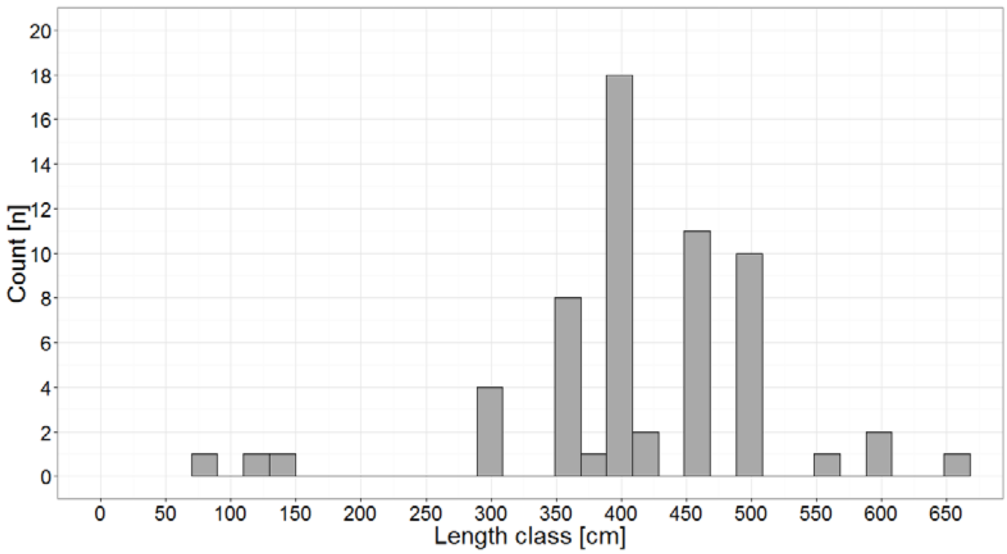

Figure 24.2. Greenland shark (*Somniosus microcephalus*) in the Northeast Atlantic. Length distribution of Greenland shark captured during the annual German Greenland Groundfish Survey (1982–2015; n = 61).

25 Catsharks (*Scyliorhinidae*) in the Northeast Atlantic

Advice for stocks in this ecoregion was last provided in 2017 and will next be provided in 2019. Therefore, this chapter only contains minor edits and updates to landings tables and figures. The advice for 2018 and 2019 is reproduced in Section 25.2.3.

25.1 Stock distribution

This section addresses four species of catshark that occur on the continental shelf and upper slope of the ICES area: Lesser-spotted dogfish (or small-spotted catshark) *Scyliorhinus canicula*, greater-spotted dogfish *Scyliorhinus stellaris*, black-mouth dogfish (or black-mouth catshark) *Galeus melastomus* and Atlantic catshark *Galeus atlanticus.* Other catsharks that occur in deeper waters (*Apristurus* spp. and *Galeus murinus*) are not included here (see Section 5). All catsharks are demersal and oviparous (egg-laying) species.

These species have been referred to as catsharks, dogfishes and other names including hounds. Names recognised by FAO may not be suitable to minimise confusions with *Scyliorhinus canicula* being referred to as small-spotted catshark and *S. stellaris* as nursehound. Therefore, ICES refer to these species as follows:

English name	Scientific name
Lesser-spotted dogfish	Scyliorhinus canicula
Greater-spotted dogfish	Scyliorhinus stellaris
Black-mouth dogfish	Galeus melastomus
Atlantic catshark	Galeus atlanticus

The meta-population structure is not known, but tagging data indicate that movements are generally quite limited (e.g. Burt *et al*., 2013 WD for *S. stellaris;* Rodriguez-Cabello *et al*., 2004, 2007 for *S. canicula*). In relation to lesser-spotted dogfish, STECF (2003) assumed that "*separate stocks reside in separate ICES Divisions and that immigration and emigration from adjacent populations are either insignificant or on a par*" and that such species would best be managed as local populations (i.e. on the level of an ICES Division or adjacent Divisions).

Lesser-spotted dogfish: *S. canicula* is an abundant species occurring on a range of substrates (from mud to rock) on the European continental shelves, from coastal waters to the upper continental slope, but is most abundant on the shelf. Its distribution ranges from Norway and the British Isles to the Mediterranean Sea and Northwest Africa (Ebert and Stehmann, 2013). ICES currently consider 4 stock units for this species: (i) North Sea ecoregion (Subarea 4 and Divisions 3.a and 7.d), (ii) Celtic Seas and west of Scotland (Subarea 6 and Divisions 7.a–c and 7.e–j), (iii) northern Bay of Biscay (Divisions 8.a–b and 8.d), and (iv) Atlantic Iberian waters (Divisions 8.c and 9.a).

Greater-spotted dogfish: *S. stellaris* is a locally frequent inshore shark of the Northeast Atlantic continental shelf and is generally found from shallow water to depths of about 125 m on rough or rocky bottoms, including areas with algal cover (e.g. kelp forests) (Ebert and Stehmann, 2013). It is Europe's largest catshark, growing to at least 130 cm.

This species is currently only assessed for the Subareas 6 and 7, as it is locally common in parts of this area, and data are limited for other parts of the species' biogeographic range, where it occurs at lesser density.

Black-mouth dogfish: *G. melastomus* is a small-sized shark (<90 cm), found on the upper slope in the Mediterranean Sea and the Atlantic from northern Norway and the Faroe Islands to Senegal (Ebert and Stehmann, 2013).

This species is currently assessed over two management units (i) Celtic Seas and west of Scotland (Subarea 6 and Divisions 7.a–c and 7.e–j), and (ii) Bay of Biscay and Atlantic Iberian waters (Subarea 8 and Division 9.a).

Atlantic catshark: *G. atlanticus* is a small catshark found on the continental slopes living in depths of 330–790 m. Its distribution in the Eastern Atlantic ranges from Spain (off Galicia) to Portugal into the Mediterranean and further south to Morocco and possibly to Mauritania. Northern range limits are unknown (Ebert and Stehmann, 2013), as there is confusion between this species and *G. melastomus* (see Rey *et al*., 2006 for distinguishing characters). The stock status of *G. atlanticus* is not assessed.

25.2 The fishery

25.2.1 History of the fishery

Catsharks are a bycatch of demersal trawl, gillnet and longline fisheries over much of the ICES area. They are usually of low commercial value and, with the exception of some seasonal, small-scale fisheries in some coastal areas, are not subject to target fisheries.

The retention patterns of catsharks in the North Sea and Celtic Seas ecoregions are highly variable, with varying proportions retained/discarded (Silva *et al*., 2013 WD). Larger individuals are landed for human consumption (more so in the southern parts of the ICES area). They are also landed in some areas as bait for pot fisheries, especially in fisheries for whelk *Buccinum undatum* or brown crab *Cancer pagurus* around the British Isles.

25.2.2 The fishery in 2017

No changes to the fishery were reported.

25.2.3 ICES Advice applicable

Historically, ICES' advice for catsharks was included in the regional demersal elasmobranch advice. Specific advice sheets have been given since 2012.

The last assessments of catsharks were published in 2017 for 2018 and 2019 and were based on the ICES approach to data-limited stocks. Quantitative advice for some stocks was provided for the first time (see table below).

STOCK	STOCK CODE	ASSESSMENT CATEGORY	ADVICE BASIS	ADVISED LANDINGS IN 2018 AND 2019
Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 4 and Divisions 3.a and 7.d	Syc.27.3a47d	3	Precautionary	Catch of 3380 t
Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 6 and Divisions 7.a-c and 7.e–j	Syc.27.67a-ce-j	3	Precautionary	4296 t
Lesser-spotted dogfish (*Scyliorhinus canicula*) in Divisions 8.a-b and 8.d	Syc.27.8abd	3	Precautionary	Catch of 5592 t, equal to landings of 611 t.
Lesser-spotted dogfish (*Scyliorhinus canicula*) in Divisions 8.c and 9.a	Syc.27.8c9a	3	Precautionary	1178 t
Greater-spotted dogfish (*Scyliorhinus stellaris*) in Subareas 6 and 7	Syt.27.67	3	Precautionary	Decrease by 36%
Black-mouth dogfish (Galeus melastomus) in subareas 6 and 7 (West of Scotland, southern Celtic Seas, and English Channel)	Sho.27.67	3	Precautionary	Increase by no more than 20%
Black-mouth dogfish (*Galeus melastomus*) in Subarea 8 and Division 9.a	Sho.27.89a	3	Precautionary	156t.

The advice for 2016 and 2017 can be found in the 2017 working group report (ICES 2017a).

25.2.4 Management applicable

These species are not subject to fisheries management in EU waters.

Galeus melastomus was originally included in the list of deep-water sharks, but Council Regulation (EC) 1182/2013 removed this species from this list following ICES advice. This review was based on the fact that its main distribution extended to upper slope and outer shelf habitats, which are not considered deep-water habitats, and that it had different life-history traits from other species on the list (with the assumption of lower vulnerability towards fishing pressure). No management has been applied for this species since.

25.3 Catch data

25.3.1 Landings

Landings of catsharks were traditionally reported in category groups (e.g. dogfishes and hounds) in some countries, though in recent years more species-specific landings have become available. The lack of historical landings data and the uncertainty associated with recent species-specific information suggest data herein should be viewed with caution.

Nevertheless, in areas where S*cyliorhinus canicula* is much more abundant than *S. stellaris*, reported landings may be regarded as representative of the former species. The species is of minor interest to small-scale fisheries and local markets and most landings have been sold through fish auction markets.

Landings data for the period 2005-2015 were revised in 2016, following the WKSHARK2 workshop (ICES, 2016) and the dedicated data call where the 10-year time-series was requested. In 2017, the data call for WGEF requested an update of 2015 and report of 2016 landings. The ICES estimates of data presented (Tables 25.1a–f) are based upon an analysis of reported landings data, following the two data calls, and the updated 2018 data call. Some reported data were corrected, allocation to stocks were consolidated based on expert knowledge.

i) Some landings of catsharks have probably been reported in generic ′dogfish′ categories, this fraction of the landings is reducing in recent years to a few percent since 2016;

ii) Some landings reported as either *S. canicula* or *S. stellaris* may comprise a fraction of the other species. For example, Portuguese landings from 9.a assigned to *S. stellaris* are likely to correspond to *S. canicula* only;

iii) It is unclear as to whether catsharks used for pot bait are reported in landings data.

The confusion between *S. canicula* and *S. stellaris* is likely to have a greater impact on the lesser abundant *S. stellaris*.

Nominal landings data for *S. canicula* (including possible mixing with *S. stellaris*) from Subarea 4 and Divisions 3.a and 7.d (Table 25.1a), Subareas 6 and 7 (Table 25.1a), Divisions 8.a–b and 8.d (Table 25.1.c) are reported mainly from France, while those from Divisions 8.c and 9.a are reported by Spain and Portugal.

Nominal landings data for *G. melastomus* from Subareas 6 and 7 (Celtic Seas) were only declared by France and Spain (Table 25.1e). There are no reported landings prior to 2002. It is likely that this species was caught in deep-water fisheries prior to these years, but were potentially discarded or reported under generic landing categories.

Landings data for *G. melastomus* from Subarea 8 are reported mainly by Spain, whereas most landings from Division 9.a are from the Portuguese fleet (Table 25.1f). Since 2010, reported landings declined due to the introduction of the zero-TAC for deep-water sharks (where this species was previously included). Following the removal of this species from the list of deep-water sharks in 2013, international landings returned to similar levels as reported prior to 2009.

Given the widespread discarding of catsharks, reported landings are not considered representative of catch.

25.3.2 Discards

Scyliorhinus canicula and other catsharks are often discarded from continental shelf fisheries (e.g. Silva *et al*., 2013 WD). The potentially high discard survival of species in the Scyliorhinidae family, at least for continental shelf fisheries, means that landing data are likely to be more representative of dead removals.

In 2017, several aspects of the discards were investigated in WKSHARKS3, however overall estimates of discards were not achieved (ICES, 2017b).

Discard data for *G. melastomus* and *S. canicula* from the Iberian and Celtic Sea are available from Spanish on board observations (Santos *et al*., 2010 WD).

Discard information of *S. canicula* and *G. melastomus* is also available from several countries in Subarea 8 and Division 9.a (Table 25.2). For *S. canicula,* discard estimates in the period 2009–2016 ranged from 33–195% of the total landed weight, with trawlers being the main fleet considered. Discards of *G. melastomus* in Subarea 8 and Division 9.a have been higher than reported landings throughout the time-series. However, these preliminary estimates may be an artefact of raising factors applied to the subsampling of commercial catches.

In the Portuguese crustacean bottom otter trawl fishery operating in Division 9.a, the most frequently discarded demersal elasmobranchs were *G. melastomus* and *S. canicula*. Discard estimates for the artisanal fleet are not available, but proportions of discards by métier in sampled trips are presented in Table 25.3. S. *canicula* and *G. melastomus* are among the most discarded species by commercial fishing vessels with a fishing permit to set gillnets or trammel nets (LOA>=12 m) (Figueiredo *et al*., 2017). Frequency of occurrence (%) of both species in the discards from hauls with gillnets and/or trammel nets from those vessels range between 31 and 57% for *S. canicula* and between 0 and 6% for *G. melastomus* (Figueiredo *et al*., 2017). For further details regarding estimated total discarded weight, length distribution and sex ratio for both species please refer to ICES (2014), Prista and Fernandes (2013) and Figueiredo *et al.* (2017).

Discards in French fisheries from 2011 to 2016 have been estimated for stocks syc.27.347d,syc.27.8abd, syc;27.7a-ce-j, syt.27.67, sho.27.67,sho;27.89a (and presented at WKSHARKS3) using two methods: i) standard method for raising discards to the landings of the species and ii) method where observed discards are raised to the total landings of all species combined (ICES, 2017a). *S. canicula* is a bycatch in most French fisheries and a high number of DCF level 6 métiers catch it. For métiers which do not land the species (100% discards) discards were estimated by raising to the total landings (all commercial species of fish, molluscs and crustaceans combined). An overall discarding rate (discards/landings) was calculated to 170%. This rate varied from 10–100% across métiers.

25.3.3 Discard survival

S. canicula have been shown to have a high discard survival in beam and otter trawl fisheries (Revill *et al*., 2005; Rodriguez-Cabello *et al*., 2005), and anecdotal observations suggest that it would also have high survival in coastal longline fisheries. There are no data for discard survival of these species in gillnet fisheries. There are also no data for the survival of *G. melastomus* caught in fisheries operating along the outer continental shelf and upper slope. Recently, a studied carried on survival of deep-water sharks caught by longline indicated some survivorship for this species using this fishing gear (Rodríguez-Cabello & Sanchez, 2017).

25.3.4 Quality of catch data

Accurate species-specific landings data are not currently available. The 2012–2014 French programme "Mislabelling of Chondrichthyans in French landings" aimed to better evaluate the relative proportion of species mixed under a single landing name, as it is for *S. canicula* and *S. stellaris* (see above).

Discarding can be high, but is variable. Furthermore, there is potentially high discard survival, at least for *Scyliorhinus* spp., and so further studies are required to estimate 'dead removals'.

25.4 Commercial catch composition

Data from national observer programmes have provided information on the size distribution of the retained proportions of the catch. Generally, only larger individuals (L_T larger than 45 cm) are landed (Silva *et al.*, 2013 WD).

The length distributions for *S. canicula* from France (Subareas 7–8; 2012–2014) and Spain (OTB Basque fleet in Subarea 8 for 2000–2004 and 2011–2013) were shown in ICES (2014). Length-distributions of *S. canicula* from the Basque country trawl fleet are shown on figure 25.1. Catch length ranges from 10 cm to 73 cm. However, the proportion retained is from 40 cm to 73 cm, while fish of lengths from 10 cm to 66 cm are mostly discarded.

S. canicula caught by the Dutch beam trawl fleet included some smaller fish (35–40 cm L_T) in 2014 than in previous years (Figure 25.2), but most sampled fish were in the 50–65 cm L_T size categories.

Length-distributions of *S. canicula* from the Portuguese trawl and artisanal fleets (2009–2016) were similar for both nets and trawlers, and between years (ICES, 2016; Moura *et al.*, 2017a; Figure 25.3a). Length-frequency distributions of *S. canicula* retained and discarded in fishing trips using set nets, between 2011 and 2014 (n=49) are presented in Figure 25.3b (Figueiredo *et al.*, 2017). A DCF pilot study on trammel nets (GTR_DEF_>=100_0_0; 2012–2014) showed no major differences in the length frequencies of *S. canicula* between sexes or between years (Figure 25.3c).

The length-distribution for *S. stellaris* caught by the French fleet in 2012–2014 was 44–124 cm (ICES, 2014).

25.5 Commercial catch–effort data

Commercial catch and effort data have not been analysed for most scyliorhinid stocks in the ICES area.

<u>*S. canicula* (8.c):</u> Landings per unit of effort data from the Basque Country OTB fleet (Subarea 8; Figure 25.4) showed an increasing trend over the period 2001–2017, with a more stable trend (ca. 200 $kg.day^{-1}$) since 2009 except for a peak in 2015 (280 t).

25.6 Fishery-independent information

Groundfish surveys provide valuable information on the spatial and temporal patterns in the species composition, size composition, sex ratio and relative abundance of catsharks. It is noted that these surveys were not designed primarily to inform on these populations, and so the gears used, timing of the surveys and distribution of sampling stations may not be optimal. However, these surveys provide the longest time-series of species-specific information.

Depending on the area and species, one to several surveys provide reliable time-series of data (see table below).

ICES STOCK CODE	SURVEY USED FOR ASSESSMENT
Syc.27.3a47d	Q1 and Q3 NSIBTS, UK-7d-BTS and CGFS++
Syc.27.7a-ce-j	EVHOE, IGFS, Spanish Porcupine Bank survey and UK-7af-BTS (2001-2016).
Syc.27.8abd	EVHOE
Syc.27.8c9a	Spanish surveys in the South (Gulf of Cadiz) IBTS-GC-Q1-Q4 (ARSA) and in the North of Spain (SpNGFS-WIBTS-Q4) and Portuguese survey (PT-PGFS-Q4)
Syt.27.67	UK-7af-BTS
Sho.27.67	Spanish Porcupine Bank survey
Sho.27.89a	EVHOE survey in Subarea 8, Spanish IBTS-CG-Q1-Q4 (ARSA) and the Portuguese Crustacean Surveys/*Nephrops* TV Surveys (PT-CTS UWTV (FU 28-29)).

For syc.27.67a-ce-j, earlier analyses of the Scottish surveys in Division 6.a suggested increasing catch rates (see ICES, 2010), but updated analyses are required. Despite survey catch trends in the UK-7e-BTS not being used for assessment, *S. canicula* is by far the most abundant elasmobranch caught across the survey grid, with a full length range (8–73 cm) observed. This species is most abundant in the outer parts of Lyme Bay, Eddystone grounds and parts of the Normano-Breton Gulf (Silva *et al.*, 2014 WD).

Previously, the Basque ITSASTEKA survey reported two demersal sharks, *G. melastomus* and *S. canicula*, the latter was the second most abundant species in the survey and often encountered in all trawl stations except areas of shallower waters where they were less abundant (depths <250 m) (ICES, 2014). This survey ceased in 2014 and is therefore no longer used for assessment (for further information, see ICES, 2014).

For Syt.27.67 in is noteworthy that *S. stellaris* has a more restricted distribution than *S. canicula*, preferring rocky and inshore habitats. Hence, most surveys do not sample their main habitats effectively, resulting in low catch rates, especially the smallest size groups. The catchability of larger individuals may also be low in some survey trawls. The UK-7af-BTS is one of the few surveys to encounter this species regularly, especially around Anglesey and Lleyn Peninsula and in Cardigan Bay.

Other surveys: Whilst *S. stellaris* is caught only occasionally in the North Sea ecoregion, it is captured regularly in the eastern Channel (Division 7.d). It is taken in small numbers during the UK-7d-BTS and the French CGFS. Whilst data for the former are too limited to inform on trends in relative abundance, this species is observed in most years (Ellis, 2015 WD).

The Spanish SpGFS-WIBTS-Q4 survey catches *G. melastomus.* However, data are only shown as general trends and not used for assessment since most of the biomass (nearly the 75%) is caught in the additional deeper hauls (depths over 500 m) that are not standardized. In 2016, the biomass of *G. melastomus* in standard hauls remained close to the previous year with the main biomass in 8.c Division (Figure 25.11a). There seems to be no clear pattern to their geographical distribution. The length-distribution of *G. melastomus* caught in 2014 ranged from 14–71 cm over standard stratification (70–500 m) (Ruiz-Pico *et al.*, 2017 WD).

Catsharks occur out of the range of assessment stock units. *S. stellaris* is a coastal species that is caught only occasionally in surveys in the Biscay and Iberian ecoregions. *G. melastomus* is caught in the northern North Sea (Division 4.a) and Norwegian Deep, but most IBTS survey stations are <200 m deep, and so catch rates may not be informative of stock size.

25.7 Life-history information

Catsharks can have protracted spawning periods, with *S. canicula* bearing egg cases observed for much of the year. This protracted egg-laying season may result in no apparent cohorts in length distributions. Age and growth parameters are uncertain for all the species considered here.

The reproductive biology of *S. canicula* has been studied in different regions by different authors. According to Ellis and Shackley (1997), males in the Bristol Channel mature at lengths of 49–54 cm ($L_{50\%}$ at 52 cm) and females at 52–64 cm ($L_{50\%}$ at 55 cm). The egg-laying season lasts at least ten months with a peak in June and July, and fecundity increases with fish length. Egg cases are often laid on erect, sessile invertebrates (e.g. bryozoans, poriferans and hydroids). Although, data for *S. stellaris* in the Atlantic may be lacking, studies in the Mediterranean suggested that for both sexes length-at-maturity ranges from 76–79 cm (Capapé, 1977).

The reproductive biology of *G. melastomus* was studied from specimens collected off the Portuguese southern slope by Costa *et al.* (2005). Sex ratio from specimens caught by commercial crustacean trawlers was 1:1. This species is sexually dimorphic with males approaching maturity at smaller sizes than females ($L_{50\%}$ males= 49.4 cm; $L_{50\%}$ females= 69.7 cm). Mating and egg deposition were found to take place all year round, with peaks of reproductive activity in winter and in summer.

25.8 Exploratory assessment models

ICES (2014) report GAM analyses of survey trends for *S. canicula* in the CGFS, UK-7d-BTS, IBTS-Q1 and IBTS-Q3 surveys.

Biomass indices of *S. canicula* for Portuguese waters (Division 9.a) were standardized using the catch rates by haul from the Portuguese groundfish survey PT-GFS. In the standardization process of CPUE, a generalized linear mixed model (GLMM) with Tweedie distributed errors was applied. CPUE index time-series was estimated based on the relationship between CPUE and available predictive factor variables, selected depending on their significance after model adjustment. In the tested models, the logarithm of catch rate of the species in each haul ($kg.h^{-1}$) was the response variable used. Apart from factor year, the final model included the variables depth stratum (intervals of 100 meters) and fishing sector, the latter as the random variable. More details on the methodology used are presented in Figueiredo and Serra-Pereira (2012 WD) and Moura *et al.* (2015b WD).

Biomass indices of *G. melastomus* for Portuguese waters (Division 9.a) were standardized using catch rates by haul during the Portuguese Crustacean Surveys/*Nephrops* TV Surveys (PT-CTS (UWTV (FU 28-29))). Data were restricted to depths >500 m. In the standardization process of CPUE, a generalized linear model (GLM) was applied. In the tested models, the logarithm of catch rate of the species in each haul ($kg.h^{-1}$) was the response variable. The final model included the variables year and fishing sector, and followed a Gaussian distribution (Moura *et al.*, 2015a WD).

25.9 Stock assessment

25.9.1 Approach

Scyliorhinidae stocks were assessed using survey trends. These stocks are ICES category 3.2 using the ratio of the (possibly combined) survey index in the two last years to the previous five years. Survey data used are described above (see Section 25.6).

25.9.2 Lesser-spotted dogfish (*S. canicula*) in Subarea 4, and Divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, Eastern English Channel)

Survey indices increased by 5–132% for Q1 NSIBTS, Q3 NSIBTS and UK-7d-BTS, with a decrease of 4% on the CFGS survey. The combined index (Figure 25.5a) showed that catch rates for 2013–2014 were 52% higher than the five preceding years (2008–2012).

25.9.3 Lesser-spotted dogfish (*S. canicula*) in Subarea 6 and Divisions 7.a–c and 7.e–j (Celtic Seas and West of Scotland)

The results of 2015 analyses indicated that survey indices decreased by 4–46% in the IGFS and EVHOE surveys, whilst indices for the UK-7af-BTS and Spanish Porcupine Bank survey increased by 12–134% (Figure 25.6a). The combined index (Figure 25.6b) showed that catch rates for 2013–2014 were 17% higher than the five preceding years (2008–2012). The increase may be explained by the highest observed annual CPUE that occurred in 2013 (Fernández-Zapico *et al.*, 2015 WD).

25.9.4 Lesser-spotted dogfish (*S. canicula*) in Divisions 8.a–b and 8.d (Bay of Biscay)

The results of 2015 analyses indicated that survey indices in the EVHOE survey (Figure 25.7) for 2013–2014 were 37% lower than the five preceding years (2008–2012).

25.9.5 Lesser-spotted dogfish (*S. canicula*) in Divisions 8.c and 9.a (Atlantic Iberian waters)

The results of 2017 analyses indicated that there was an overall sustained increase in the biomass indices (Figure 25.8a). The combined survey index (Figure 25.8b) showed that catch rates for 2015–2016 were 32% higher than the five preceding years (2010–2014).

25.9.6 Greater-spotted dogfish (*S. stellaris*) in Subareas 6 and 7 (Celtic Seas and West of Scotland)

The results of 2015 analyses indicated that catch rates for 2013–2014 were 6% lower than the five preceding years (2008–2012), although this should be viewed in the context of a longer-term increase (Figure 25.9). However, this slight "decrease" should be viewed in the context that this species' preferred habitats are limited to certain areas of the survey grid, and there is the indication of a longer-term increase over the entire time-series (Ellis, 2015 WD; Figure 25.9).

25.9.7 Black-mouth dogfish (*Galeus melastomus*) in Subareas 6 and 7 (Celtic Sea and West of Scotland)

Catch rates for 2015–2016 were 39% higher than the five preceding years (2010–2014) (Figure 25.10a).

25.9.8 Black-mouth dogfish (*Galeus melastomus*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)

Survey indices in the four surveys examined (Figure 25.11b) showed that catch rates for 2015–2016 were 20% higher than the five preceding years (2010–2014). This is related to the strong increase observed in EVHOE and slight increases in PT-CTS UWTV. The ARSA survey indicate a longer-term increase in the abundance of *G. melastomus* in the Gulf of Cadiz (Figure 25.11c), with peaks in 2006 and 2013.

25.10 Quality of the assessments

Although the trawl surveys used in this report were not designed to sample catsharks, *S. canicula* and *G. melastomus* are sampled in large numbers in various surveys. Survey indices are considered to properly track stock abundance trends for these species.

In relation to *G. melastomus*, fisheries-independent data in the Portuguese surveys suggest that this species may have been historically aggregated with *G. atlanticus*, and there may be some problems with misidentification of these two species, especially historically (Moura *et al.*, 2015a WD; Moura *et al.*, 2017b WD). Data from the Portuguese crustacean surveys/*Nephrops* TV Surveys (PT-CTS (UWTV (FU 28-29))) conducted in 2014 showed that *G. melastomus* is more abundant and distributed mainly >500 m deep, and so data from depths ≥500 m were considered for assessment purposes.

Survey effort on rocky, inshore grounds is limited, and so catch rates for the larger-bodied *S. stellaris* are low in some surveys, as this species favours rocky, inshore habitats.

Commercial data are more problematic due to the widespread use of generic categories (e.g. “dogfish”), especially in earlier years. Although a greater proportion of the data is reported to species or genus level, the quality of these data has not been evaluated. Other issues may constrain the use of these data, for example possible misidentification in areas such as the Celtic Seas where both *S. canicula* and *S. stellaris* occur. Furthermore, historical data may be underestimated as these species may have not been marketed for human consumption, and might therefore not have all been included on official landings, e.g. in those areas where *S. canicula* may be landed for use as bait in pot fisheries. Therefore, landings data are not considered to be accurate and should be viewed as preliminary results.

Catsharks are mainly caught as bycatch and have a moderate market value (including no human consumption market for the smaller fraction) resulting in a high level of discarding. Previous studies have shown that *S. canicula* may have a high survival rate (see Section 25.3.3), and while there are no current studies for *S. stellaris*, it can be assumed that the survival of this shallow-water species may be equally high. Therefore, discards of Scyliorhinidae should not be considered exclusively as dead removals. However, for *G. melastomus* anecdotal information suggests survival will be lower. Further studies should be considered if more accurate information on the level of discarding is to be inferred for the two latter species.

25.11 Reference points

No reference points have been proposed for these stocks.

25.12 Conservation considerations

Both *S. canicula* and *G. melastomus* are listed as Least Concern, and *S. stellaris* and *G. atlanticus* as Near Threatened on the IUCN Red List (Gibson *et al.*, 2008) and in the recent Red List of European marine fish (Nieto *et al.*, 2015).

S.canicula, S. stellaris and *G. melastomus* are listed as Least Concern on the Irish Red List of Cartilagenous Fish (Clarke *et al.* 2016).

25.13 Management considerations

Catsharks are generally viewed as relatively productive in comparison to other elasmobranchs (e.g. McCully Phillips *et al*., 2015). Given this, and that they are a low value, bycatch species, catsharks are typically of lower management interest in comparison to other elasmobranchs.

Landings data are highly uncertain, and further efforts are required to construct a meaningful time-series.

In recent years, catch rates of *S. canicula* have been increasing in almost all surveys. As one of the more productive demersal elasmobranchs that is often discarded (with a high discard survival) and is known to scavenge on discards, it is unclear as to whether or not the increasing catch rates observed are a sign of a healthy ecosystem.

Discard survival of *Scyliorhinus* spp. is considered to be high, but estimates for discard survival for *Galeus* spp. are currently unavailable.

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Table 25.1a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of landings (t) of lesser-spotted dogfish *Scyliorhinus canicula* in Subarea 4 and Divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, Eastern English Channel). Based on WGEF revised landings 2005-2017. NOTE: These data should be viewed with caution as some countries may have aggregated both *S. canicula* and *S. stellaris* as Scyliorhinidae and the proportion of species-specific may be unknown as both species occur in this area.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	238	267	264	337	309	290	311	249	231	325	416	343	338
France	2265	1857	1843	1822	1758	2055	2150	2061	2021	2189	2090	2173	1747
UK	92	121	104	94	118	146	185	181	184	146	185	330	280
Netherlands	56	48	32	29	37	37	47	35	36	45	85	122	141
Total	2652	2293	2243	2282	2222	2528	2693	2526	2472	2705	2776	2968	2506

Table 25.1b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of landings (t) of lesser-spotted dogfish *Scyliorhinus canicula* in the Subareas 6 and 7 (Celtic Seas). Based on WGEF revised landings 2005-2016. NOTE: These data should be viewed with caution as some countries may have aggregated both *S. canicula* and *S. stellaris* as Scyliorhinidae and the proportion of species-specific may be unknown as both species occur in this area.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	240	225	199	165	168	165	227	236	216	141	252	194	209
Spain	34	33	37	12	17	28	48	109	26	18	20	9	12
France	2936	2873	3101	2728	2479	2368	2359	2060	2284	2292	2024	1969	1748
UK	123	22	115	191	226	111	111	241	380	389	1282	1333	1067
Ireland	92	42	128	248	190	232	317	221	310	336	367	425	524
Netherlands		0			0	6	1	1	4	0	3	1	0
Total	3426	3195	3579	3344	3080	2909	3064	2868	3219	3176	3948	3932	3560

Table 25.1c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary ICES estimates of landings (t) of lesser-spotted dogfish *Scyliorhinus canicula* in Divisions 8.a–b and 8.d (Bay of Biscay).

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	10	13	13	18	24	28	28	32	23	26	27	32	26
Spain	355	338	327	460	445	302	303	472	54	92	130	239	498
France	1229	1247	1352	1382	1117	1085	1000	912	883	720	734	731	698
UK	3						0	2					
Total	1597	1598	1691	1863	1586	1415	1330	1418	960	838	891	1003	1222

Table 25.1d. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of landings (t) of lesser-spotted dogfish *Scyliorhinus canicula* in Divisions 8.c and 9.a (Atlantic Iberian waters).

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France	1	1	1	1	1		0	0	0	0	0	0	0
Spain	297	333	327	272	229	336	354	555	577	464	417	398	448
Portugal	568	591	595	546	535	522	551	544	520	521	554	589	619
Total	866	925	923	819	765	858	905	1099	1097	985	971	987	1067

Table 25.1e. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of landings (t) black-mouth dogfish *Galeus melastomus* in Subareas 6 and 7 (Celtic Seas). Data 2005–2016 revised at WGEF 2016.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France	.	.	.				0.1	0	0.4	0.05	0.02	0		0.26	0.13	0
Spain	9	1	.	0.1	2.9	0.4							0			
Total	9	1	0	0.1	2.9	0.4	0.1	0	0.4	0.05	0.02	0	0	0.26	0.13	0

Table 25.1f. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of landings (t) of black-mouth dogfish *Galeus melastomus* in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters). Data for the period 2005–2016 were revised at WGEF 2016.

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Subarea 8	France										1	1	2	2	3	0	0	1	0	1			0
	UK																1						
	Spain							4	3	6	36	46	67	74	53	21		8	13	49	47	37	34
	Spain (Basque Country)	4	3	6	2	3	1	1	1	1	*	*	*	*	*	*	*	*	*	*	+	*	*
	Total	4	3	6	2	3	1	5	4	7	37	47	69	76	56	22	1	9	13	50	47	37	34
Division 9.a	Portugal	17	17	16	20	37	29	35	29	57	37	28	24	12	16	7	2	2	1	21	25	26	34
	Spain										17	22	37	29	22	3		0	2	5	76	104	90
	Total	17	17	16	20	37	29	35	29	57	53	50	61	41	38	10	2	2	3	25	101	130	124
Subarea 8 and Division 9.a combined	Portugal	17	17	16	20	37	29	35	29	57	37	28	24	12	16	7	2	2	1	21	25	26	34
	Spain	0	0	0	0	0	0	4	3	6	53	68	103	103	75	24		8	15	54	123	141	124
	Spain (Basque Country)	4	3	6	2	3	1	1	1	1	*	*	*	*	*	*	*	*	*	*	+	*	*
	France										1	1	2	2	3	0	0	1	0	1			0
	UK																1						
	Total	21	20	22	22	40	30	40	33	64	91	97	130	116	93	32	3	11	16	75	148	167	158

*** Included in Spanish landings.**

Table 25.2. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Discard estimates (t) of *S. canicula* and *G. melastomus* by country in Subarea 8 and Division 9.a (* denotes estimates from the trawl fleet only)

S. canicula						
	Spain (9.a, 8.b–c)	Spain (Basque country) (8.a–b, 8.d)	Portugal (9.a)	France (8.a–b, 8.d)	Belgium (8.a–b, 8.d)	TOTAL
2003	1933	348				2281
2004	799	654				1453
2005	397	275				672
2006	1723	173				1896
2007	954	417				1371
2008	300	641				941
2009	954	1092				2046
2010	635	688	30*			1353
2011	721	1054	164*	3342		5281
2012	753	905	N.A.	4835	34	6527
2013	1137	64	N.A.	2497	22	3720
2014	2081	499	140*	4432	192	7204
2015		534	N.A.	8616		9150
2016		389	69*	8821		9279

G. melastomus					
	Spain ((9.a, 8.b–c)	Spain (Basque country) (8.a–b, 8.d)	Portugal (9.a)	France ((8.a–b, 8.d)	TOTAL
2003	589	0			589
2004	244	227			470
2005	527	5			533
2006	553	1			554
2007	1063	N.A.			1063
2008	226	23			249
2009	904	0			904
2010	1272	34			1306
2011	731	7			737
2012	1433	0		36*	1469
2013	749	3		17*	769
2014	1123	9		N.A.	1131
2015		13		35*	48
2016		2		167*	169

Table 25.3. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Proportion of *S. canicula* and *G. melastomus* discarded by gear from trips sampled under the Portuguese DCF program in Division 9.a.

	G. melastomus	*G. melastomus*	*S. canicula*
Year	**GNS, GTR**	**LLS (DWS)**	**GNS, GTR**
2011	0.87 (14)	0.22	0.15
2012	1.00 (14)	0.68	0.16
2013	0.00 (14)	0.28	0.17
2014	1.00 (14)	1.00	0.34

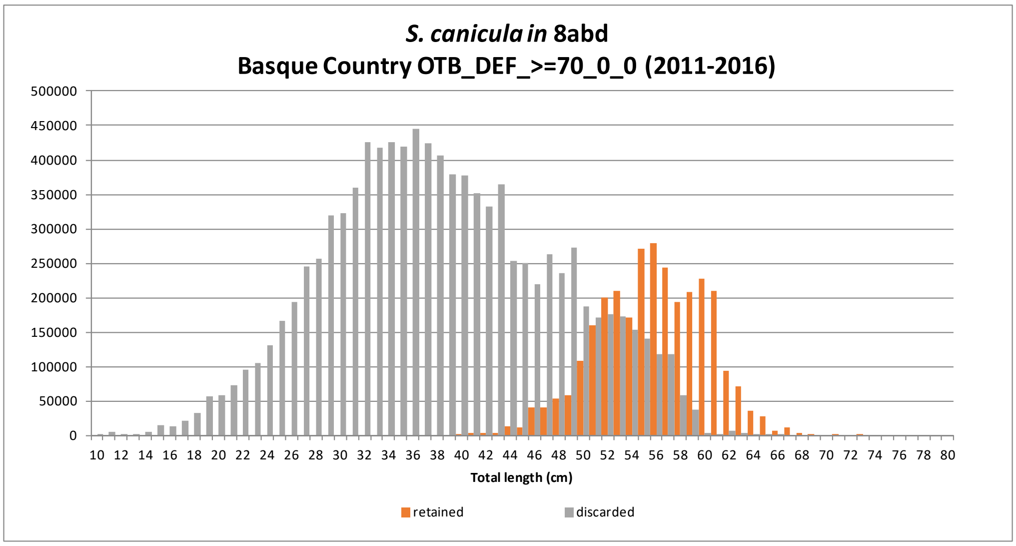


Figure 25.1. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length frequencies of *S. canicula* retained (in red) and discarded (blue) recorded from the trawl fleet of the Basque country from 2011 to 2016 in ICES div. 8abd.

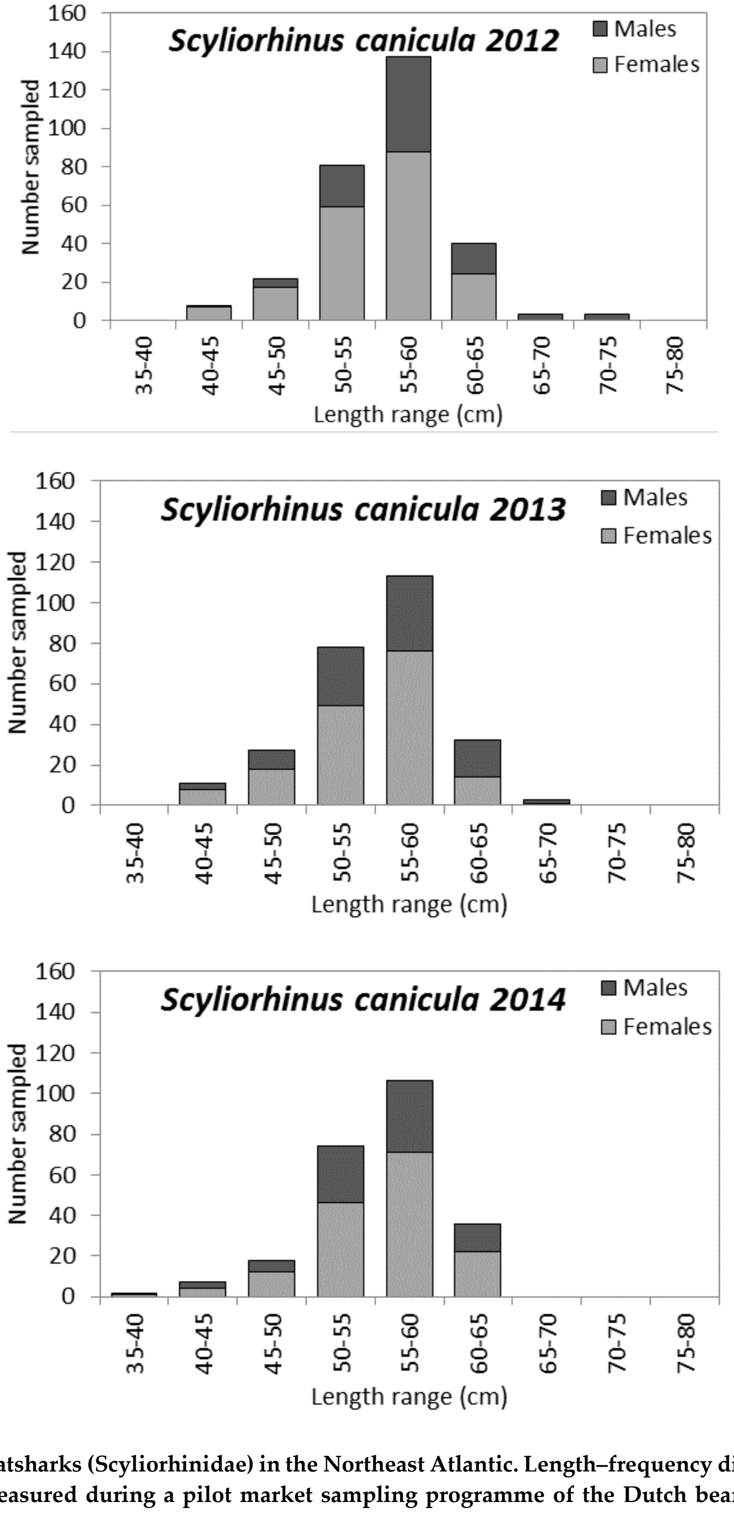


Figure 25.2. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length–frequency distribution of *S. canicula* measured during a pilot market sampling programme of the Dutch beam trawl fleet (2012–2014).

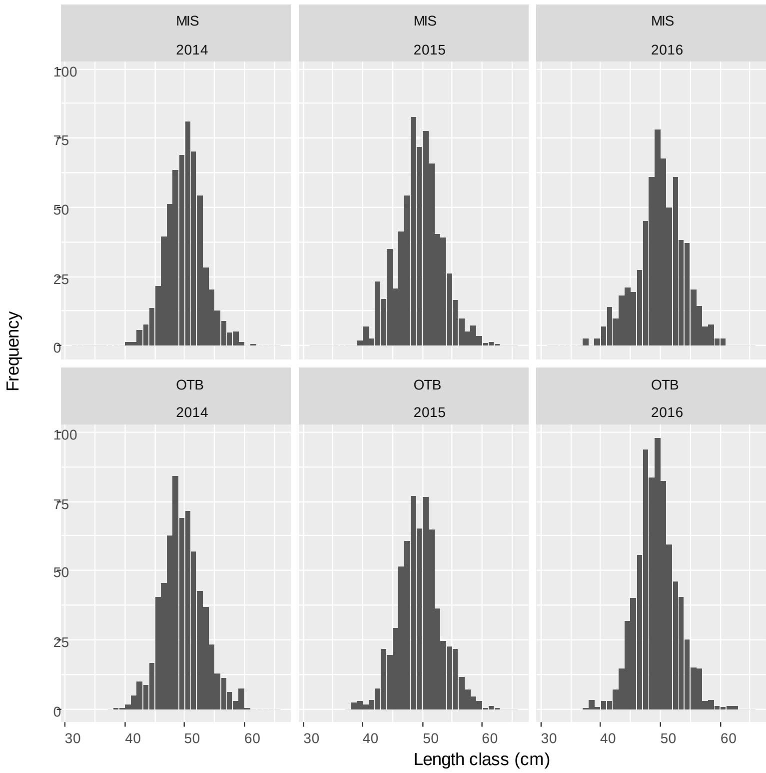


Figure 25.3a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length–frequency distribution of *S. canicula* from specimens sampled at Portuguese landing ports from artisanal (MIS) and trawl (OTB) fleets (2014-2016).

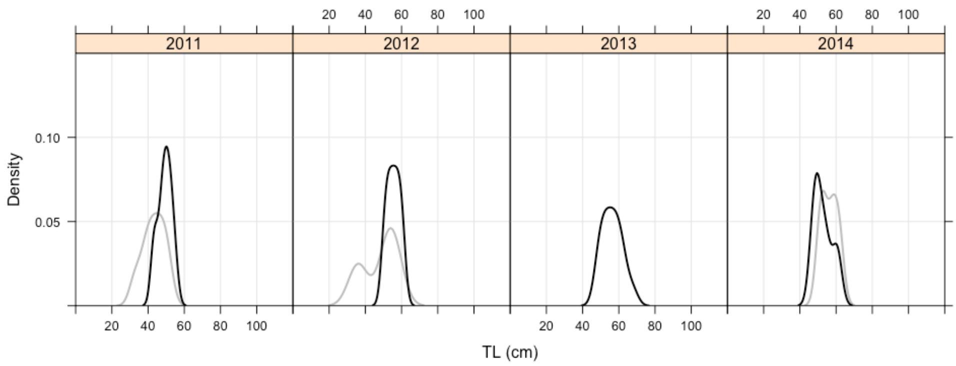


Figure 25.3b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length frequency distribution of S. canicula retained (black) and discarded (grey) fractions observed onboard vessels using set nets, between 2011 and 2014. The length frequencies were not raised to the total landings. n=227 sampled individuals.

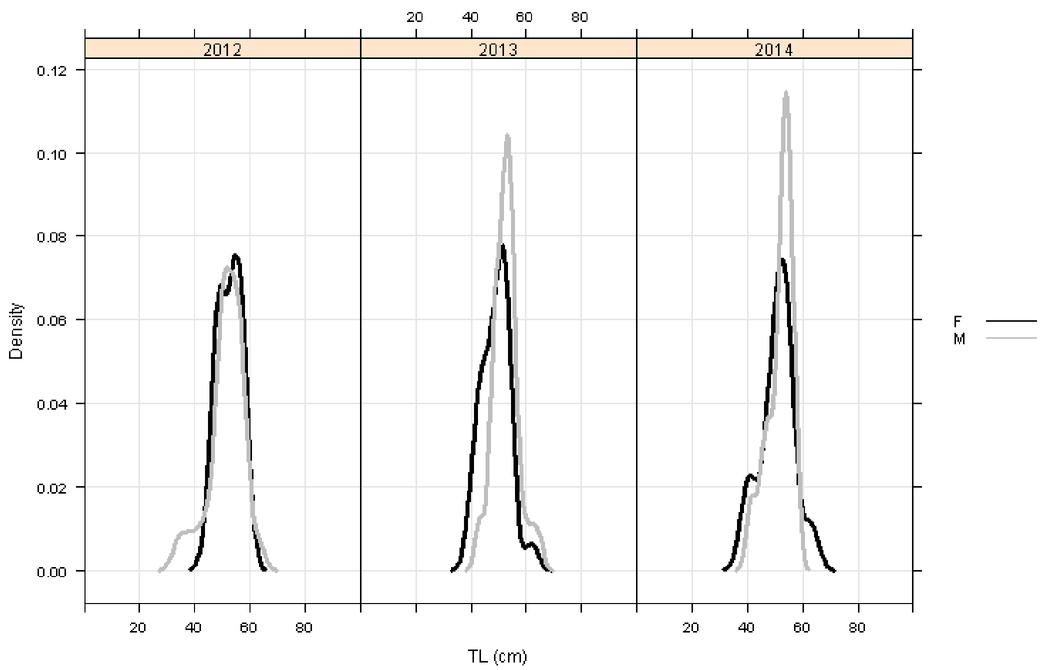


Figure 25.3c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length frequencies of *S. canicula* catches during the DCF pilot study on Portuguese trammel net fisheries (GTR_DEF_>=100_0_0; on-board sampling 2012–2014).

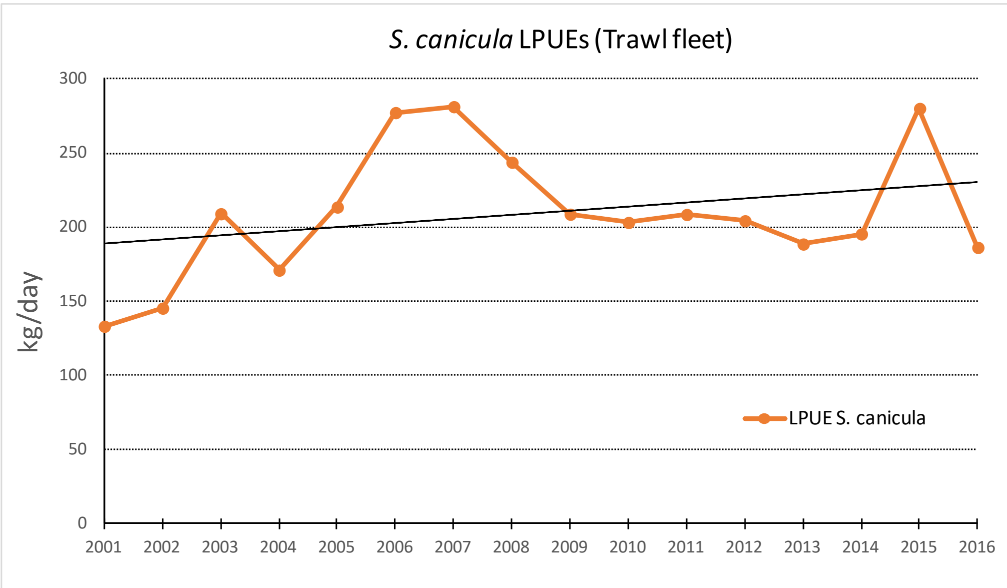
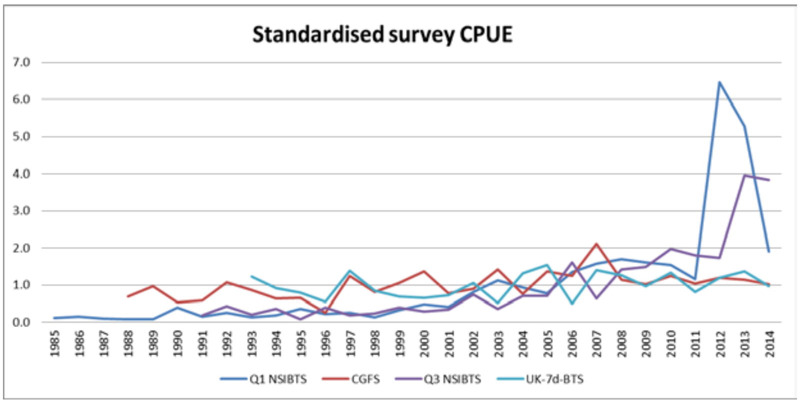


Figure 25.4. Landings per unit of effort data (LPUE) from the Basque Country trawl fleet (OTB_DEF_70) in ICES Div. 8 abd) for *S. canicula*.



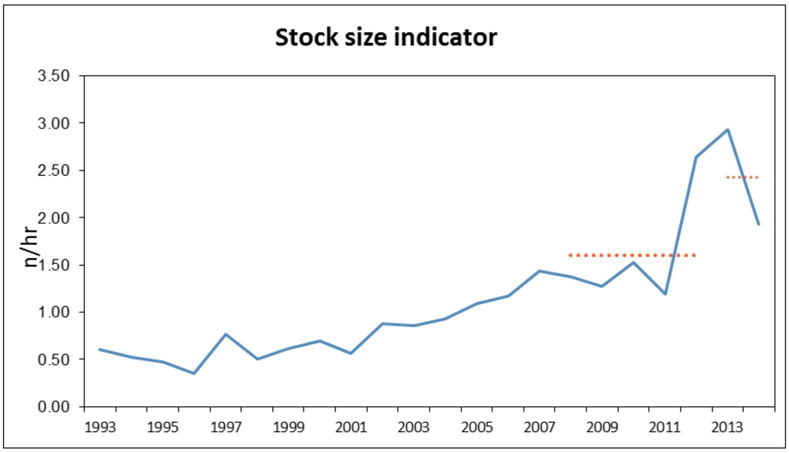
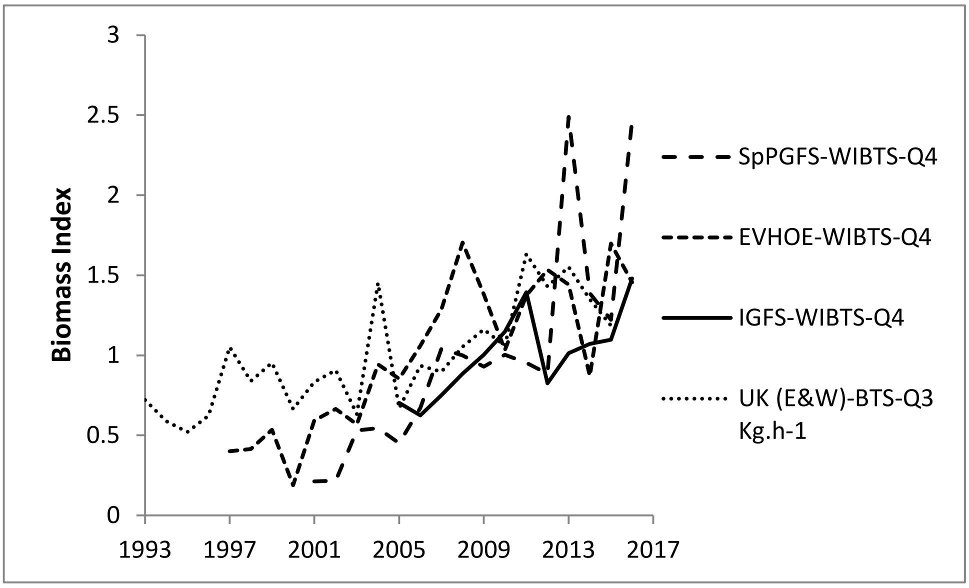


Figure 25.5a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus canicula* in the North Sea, Skagerrak, Kattegat and eastern Channel. Standardised survey indices from four surveys Q1 NSIBTS, Q3 NSIBTS, UK-7d-BTS and CGFS (top) and overall stock size indicator (bottom) for the time period 1993–2014. Dotted lines indicate the average of the last two years and the average catch for the preceding five years.



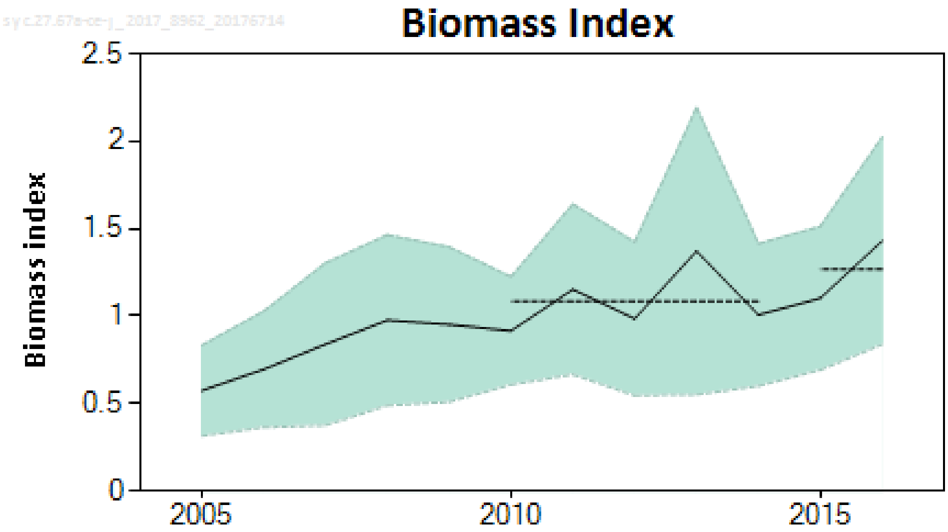


Figure 25.6a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus canicula* in the Celtic Seas Ecoregion. Standardised survey indices from four surveys IGFS, Spanish Porcupine Bank survey, UK-7af-BTSm EVHOE (top) and overall stock size indicator (bottom) for the time period 2005–2016. Dotted lines indicate the average of the last two years and the average catch for the preceding five years.

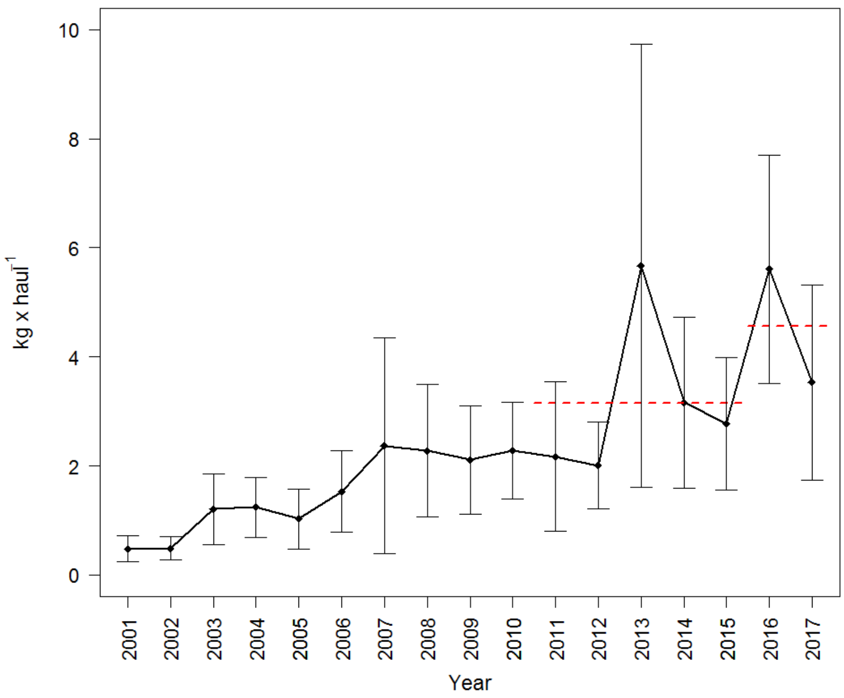


Figure 25.6b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in the *S. canicula* biomass index during the Porcupine Bank survey (2001–2017). Vertical bars correspond to the associated 95% confidence intervals. Dotted lines compare mean stratified biomass in the last two years compared to the preceding five years.

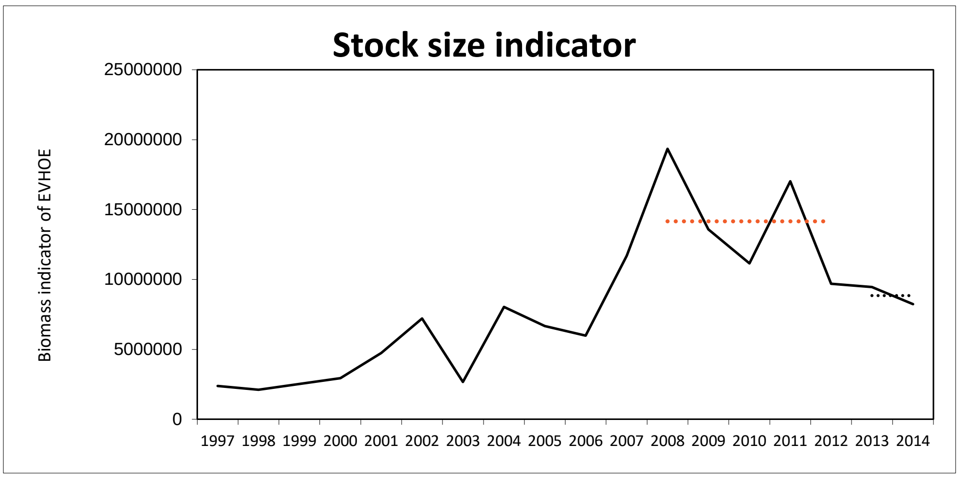


Figure 25.7. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Trends in the stock size of *Scyliorhinus canicula* in the Bay of Biscay (ICES Div. 8.abd), as estimated from the EVHOE survey.

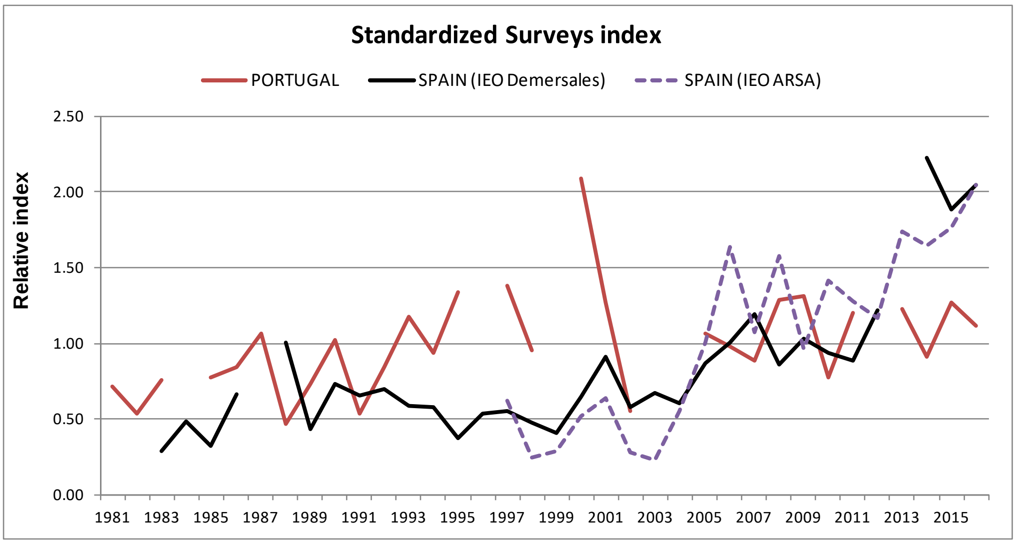


Figure 25.8a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus canicula* in the Atlantic Iberian waters (Divisions 8.c and 9.a). Standardised survey indices from three surveys ARSA (average of spring and summer surveys), Portuguese PT-GFS and North Spanish Shelf bottom survey (top).

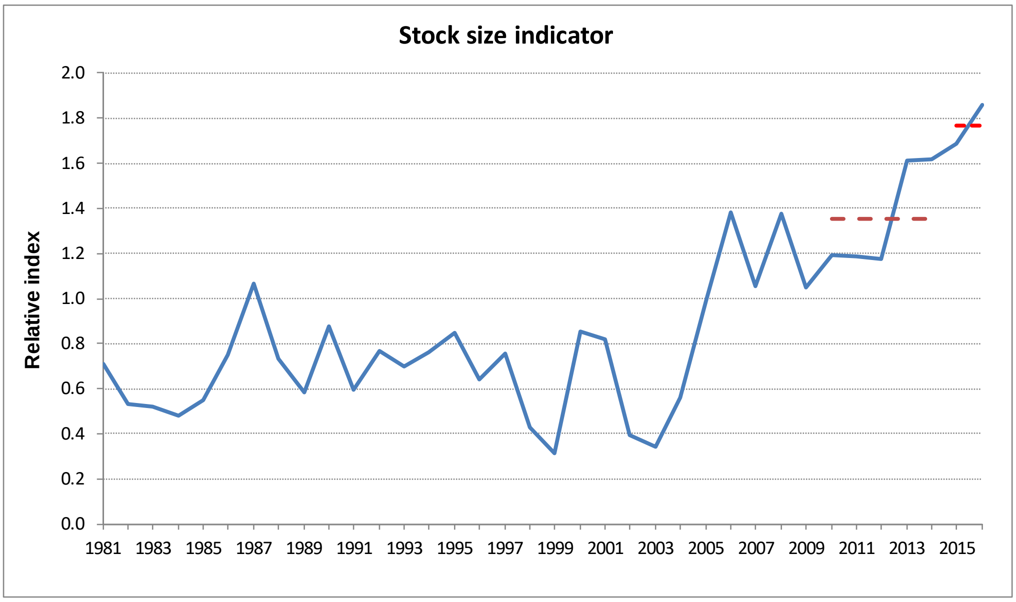


Figure 25.8b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Scyliorhinus canicula in the Atlantic Iberian waters (Divisions 8.c and 9.a). Overall stock size indicator combined for these surveys (bottom). Dotted lines indicate the average of the last two years and the average catch for the preceding five years.

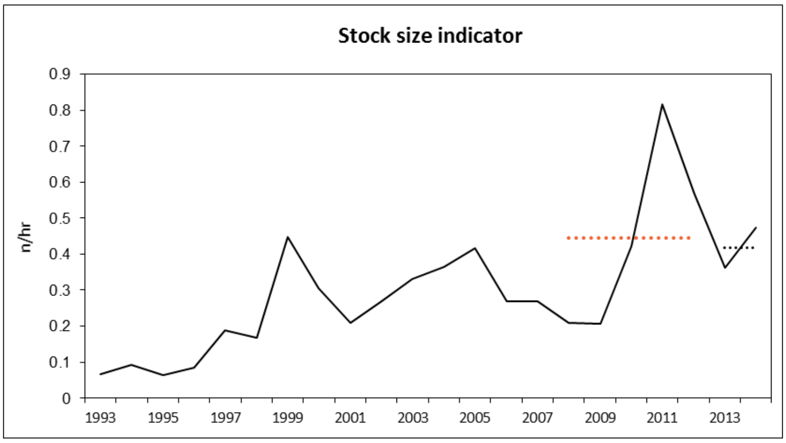


Figure 25.9. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus stellaris* in Subareas 6 and 7 (Celtic Seas and West of Scotland). Overall stock size indicator from UK-7af-BTS. Dotted lines indicate the average of the last two years and the average catch for the preceding five years.

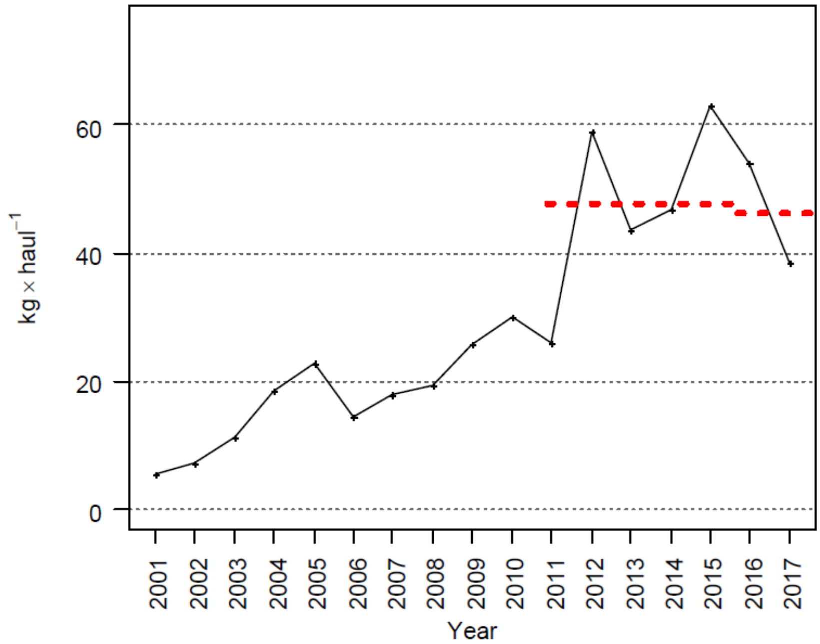


Figure 25.10. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in the biomass index of *Galeus melastomus* during the Porcupine Bank survey (2001–2017). Dotted lines compare mean stratified biomass in the last two years and in the preceding five years.

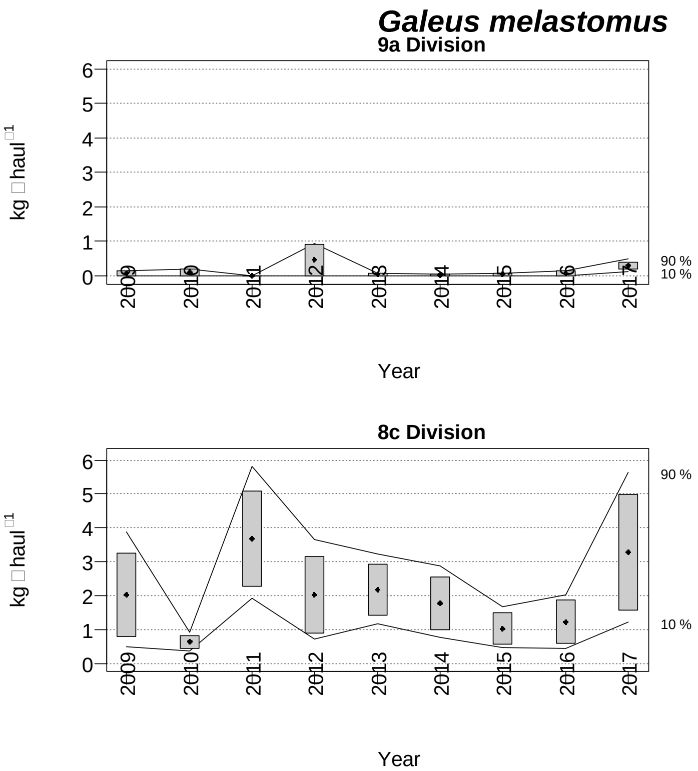


Figure 25.11a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in *Galeus melastomus* stratified biomass index (only with standard hauls between 70 and 500 m) during the North Spanish shelf bottom trawl survey (SpGFS-WIBTS-Q4) between 2009 and 2017 in the two ICES Divisions. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (P= 0.80 bootstrap iterations = 1000).

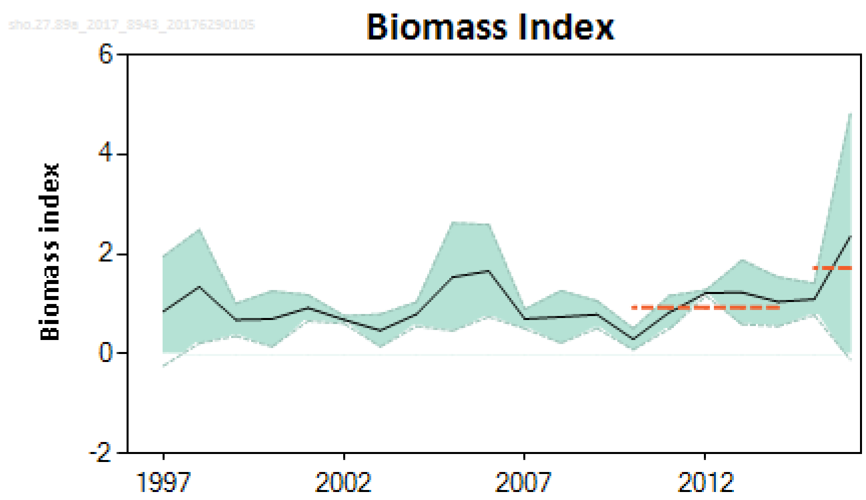
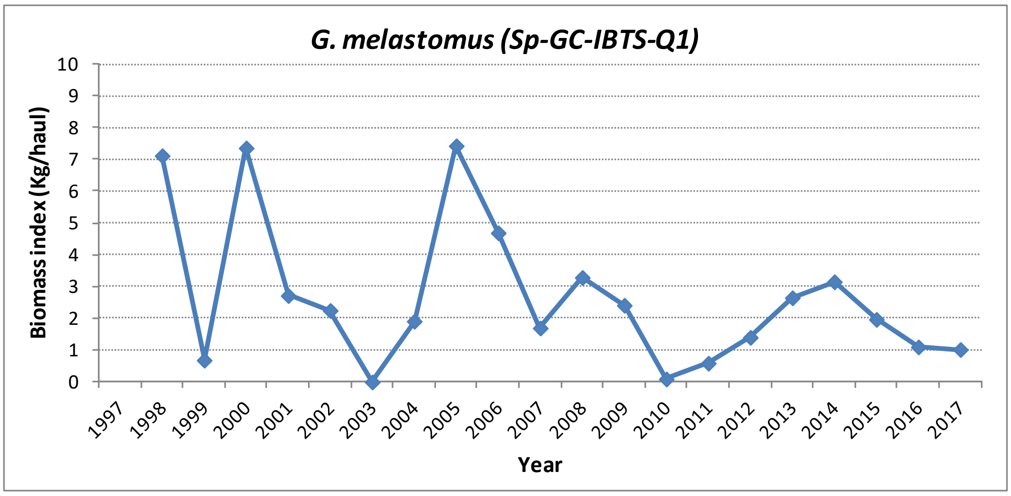


Figure 25.11b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Galeus melastomus* in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian Waters). Standardised survey indices for ARSA, Portuguese 9.a, North Spanish shelf bottom trawl, and EVHOE. Dotted lines indicate the average of the last two years and the average catch for the preceding five years.



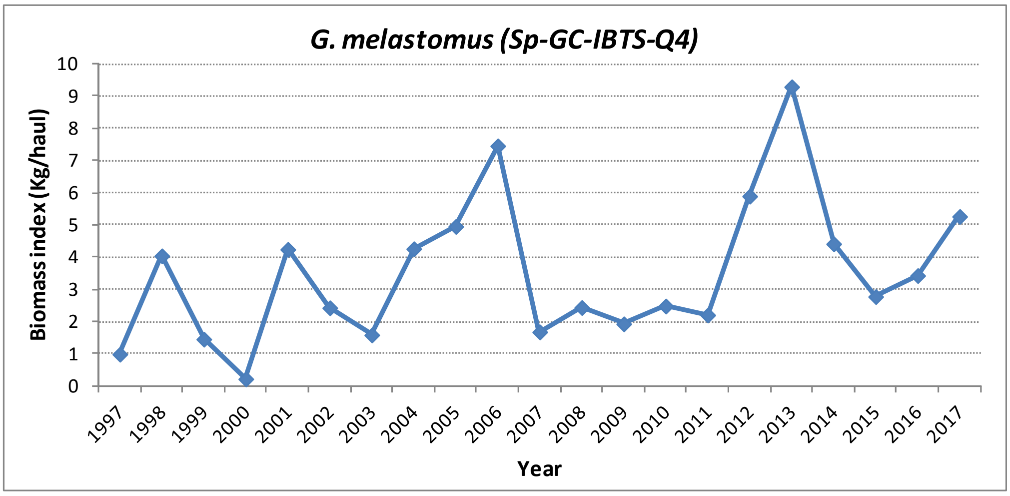


Figure 25.11c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Temporal trends in the biomass index during the South Spanish shelf bottom trawl survey (ARSA) in the Gulf of Cadiz ICES Div. 9a) time-series (1997–2017) in Division 9.a for spring Q1 (top) and autumn Q4 (bottom) surveys respectively.

26 Other issues

26.1 Further development of proposed ToRs for a potential joint ICES-ICCAT meeting in 2019 to (i) assess porbeagle shark and (ii) collate available biological and fishery data on thresher sharks in the Atlantic

26.1.1 Introduction

This chapter addresses ToR i) *Further develop the ToR for the proposed joint ICCAT-ICES meeting in 2019 to (i) assess porbeagle shark and (ii) collate available biological and fishery data on thresher sharks in the Atlantic*

In 2009, ICES and ICCAT held a joint meeting to coordinate their respective work on elasmobranchs. Issues considered at this meeting included fisheries, species-specific landings data and biological parameters being collected on the NEACS. Assessments for the NE Atlantic stocks of spurdog *Squalus acanthias* and porbeagle *Lamna nasus* were undertaken and the results were published in an ICES report (ICES, 2009).

Another joint meeting, focussing on porbeagle and thresher sharks, has been proposed. Following the structure that ICCAT uses for assessment meetings, ICES WGEF suggests that two joint meetings should be held in 2019: a data preparatory meeting, and a subsequent meeting to conduct the assessments.

Detailed information on the porbeagle and both species of the thresher sharks are given in section 6 and 11 of this report.

26.1.2 Planning of the proposed assessment

At the 2017 WGEF meeting preliminary, Terms of Reference were developed for the joint ICCAT-ICES meeting (ICES, 2017). However, ICCAT has had a change in their planning of the stock assessments and will now be concentrating on the shortfin mako (*Isurus oxyrinchus*) in 2019. This means that the joint porbeagle assessment has been postponed, probably until 2020. The Terms of Reference for this meeting will be further developed once a date has been set.

26.1.3 Reporting

Although WGEF does not follow the benchmarking process, it is important that the models proposed to be used in the assessment are reported to, and approved by, ACOM as soon as possible following the data preparatory meeting.

26.2 Further develop MSY proxy reference points relevant for elasmobranchs and explore/apply in MSY Proxies analyses for selected stocks

26.2.1 Introduction

The ICES Workshop on the ‘Development of Quantitative Assessment Methodologies based on Life-history Traits, Exploitation Characteristics and other Relevant Parameters for Data-limited Stocks’ (WKLIFE V) (ICES, 2015) identified and discussed three categories of data-poor approaches: (1) length-based methods, (2) catch-only methods, and (3) catch with CPUE-based methods. These categories address a broad suite of methods applied to the assessment of data-poor fish stocks. WKLIFE integrated and advanced key existing work in these areas to develop operational methods for setting plausible Reference Point (RP) proxies for stocks with different limitations on data availability.

Each of these assessment methods supports evaluation of stock status relative to objective RPs, including MSY. Two length-based approaches (1) were explored by WKLIFE. Firstly, Length-Based Indicators (LBIs) provide a simple model-free framework, which requires only catch size-distribution and reasonable values for von Bertalanffy length infinity and length at maturity. A (fishing-induced) truncation in catch length distributions can be identified using $\bar{L}$, $L_{max5\%}$ or P_{mega} (proportion of megaspawners, Froese, 2004) (ICES, 2015). Secondly, the length-based Spawner Potential Ratio, defined as the ratio between SSB in the fished and SSB in the unexploited state (SSB_0), can be used to estimate mortality and exploitation status directly from catch length distributions (LBSPR, Hordyk *et al*., 2015). (2) The catch only method (CMSY) requires a time series of removals or catch to develop corresponding estimates (with uncertainty) of stock biomass relative to a biomass at MSY RP (Martell and Froese 2013). Finally (3), catch and CPUE are integrated in a surplus production model that provides estimates of biomass (B) and fishing mortality (F), (SPiCT, Pedersen and Berg 2017).

Many elasmobranchs are considered as data-limited stocks, owing to incomplete species-specific catch data, inaccurate species identification and incomplete knowledge of life-history parameters, and because fishery-independent surveys only sample comparatively few species with any degree of effectiveness (ICES, 2017). This status precludes the analytical stock assessment process that is used for many commercial teleost stocks, with only one elasmobranch species (spurdog) within ICES assessed as Category 1 using analytical models. WGEF further explored the application of proxy MSY RPs to elasmobranch fishes. Full information on each analysis is available in associated Working Documents. An overview with general conclusions is presented here.

26.2.2 LBIs to assess the status of skates (Rajidae): Walker *et al*. (2018 WD)

26.2.2.1 Methods

The WKLIFE set of LBIs (ICES, 2015) were applied to the following skate taxa: common skate complex (*Dipturus batis* and *Dipturus intermedius*), shagreen ray *Leucoraja fullonica*, cuckoo ray *Leucoraja naevus*, blonde ray *Raja brachyura*, thornback ray *Raja clavata*, small-eyed ray *Raja microocellata*, spotted ray *Raja montagui* and undulate ray *Raja undulata*.

Length-weight parameters were generally taken from Silva *et al.* (2013) and the lengths at 50% maturity from McCully *et al.* (2012). Published estimates for VBGP were available from a range of published studies, with the most biologically plausible estimates used in the present study (based on whether L_∞ was at a similar size to L_{max}). Where published data for VBGP and the length at 50% maturity were sex-disaggregated, data for females were used for subsequent analyses. VBGP were unavailable for two species (*Dipturus batis* and *Leucoraja fullonica*) and considered biologically implausible for one species (*Raja microocellata*). The parameters L_∞ and K for the remaining stocks were plotted against L_{max} and the linear relationship between these life-history characteristics estimated (L_∞ = 149.92 cm and K = 0.1323 y^{-1} for *D. batis*; L_∞ = 129.82 cm and K = 0.1483 y^{-1} for *L. fullonica,* and L_∞ = 91.65 cm and K = 0.1787 y^{-1} for *R. microocellata*). Length-frequency data for skates came from the English on-shore program (landings) and the UK England and Wales Observer at Sea program (landings and discards). Specific details of data preparation and analysis are given in the Working Document.

26.2.2.2 Results

Common skate complex (*Dipturus batis* and *D. intermedius*) in the Celtic Sea (rjb.27.67)

- Given the model assumption of asymptotic selection, data from netters were considered more appropriate for this large-bodied species.
- Available data indicate that grey skate is by far the dominant species, and parameters for grey skate were considered most appropriate.
- Although available data from netters are too limited for temporal analyses, recent data suggested that LBIs relating to the 'conservation of large individuals' and MSY were of 'good' status, whilst LBIs for the 'conservation of immature individuals' and optimum yield failed to meet expected values.

Shagreen ray *Leucoraja fullonica* in the Celtic Sea (rjf.27.67)

- Data for shagreen ray were limited, and further studies on this stock are required.
- Despite LBIs for the 'conservation of large individuals' and the 'conservation of immature individuals' falling below RPs, the MSY indicator was met, suggesting that the RPs for various LBIs can result in contradictory evaluations.
- Of the two indicators for optimal yield, one showed an increasing trend and the other a decreasing trend, once again indicating the potential for contradictory signals.

Cuckoo ray *Leucoraja naevus* in the Celtic Sea and Bay of Biscay (rjn.27.678abd)

- There were minor differences in stock perception when the different values of L_∞ were used, although the data from the different gears gave very different perceptions.
- Given the smaller L_{max} for this species, data from otter trawlers may provide a more appropriate time series.
- Otter trawl data suggest that indicators for MSY were generally quite stable at, or just below, the expected RPs. Whilst LBIs for the 'conservation of small fish' failed to meet the expected values, LBIs for the 'conservation of large fish' improved over the time series, and were currently perceived to be in a 'good' status.

Cuckoo ray *Leucoraja naevus* in the North Sea (rjn.27.34)

- Otter trawl data suggest that indicators for MSY were close to the expected RPs, but generally falling below in more recent years.
- LBIs for the 'conservation of small fish' and the 'conservation of large fish' generally fell below expected levels, resulting in a perception of 'poor' status.
- These results should be used with caution as the data from English observer programmes may originate from the southern part of the stock area, and may not be indicative of the whole stock area.

Blonde ray *Raja brachyura* in the southern North Sea and eastern English Channel (rjh.27.4c7d)

- Available data for this stock were very limited, and further studies are required. Furthermore, given the morphological similarity between spotted and blonde ray, more dedicated data collection for blonde ray may be required.

Blonde ray *Raja brachyura* in the western English Channel (rjh.27.7e)

- Given the model assumption of asymptotic selection, data from netters may be more appropriate for this large-bodied species.
- Available data from netters were limited, but recent data suggested that LBIs relating to the 'conservation of large individuals' and MSY were of 'good' status, whilst LBIs for the 'conservation of immature individuals' failed to meet expected values.
- LBIs relating to the 'conservation of large individuals' using data from otter trawlers indicated an improving status, and were of 'good' status in more recent years.

Blonde ray *Raja brachyura* in the Bristol Channel and Irish Sea (rjh.27.7afg)

- Given the model assumption of asymptotic selection, data from netters may be more appropriate for this large-bodied species.
- Available data from netters were limited, but recent data suggested that LBIs relating to the 'conservation of large individuals' and MSY were of 'good' status, whilst LBIs for the 'conservation of immature individuals' failed to meet expected values.
- The length-frequency distribution from otter trawlers changed abruptly during the time series, with a more constrained length range in 2009–2013, and broader range in 2016–2017. Further studies are required, to understand whether this is a genuine temporal change in population structure, or an artefact of limited data being raised.

Thornback ray *Raja clavata* in the North Sea and eastern English Channel (rjc.27.47d)

- The length-frequency distribution from otter trawlers changed gradually over the time series, with a broader length range in 2015–2017. Further studies on these data are required, including whether these shifts represent growth of strong cohorts.
- The estimated L_∞ for this stock (118 cm) is biologically plausible, but was much higher than the L_{max} observed in the data, so the LBI relating to the 'conservation of large individuals' failed to meet expected values for otter trawl and gillnet data.
- The LBIs for MSY was close to or above the expected level in recent years for both gears analysed.

Thornback ray Raja clavata in the western English Channel (rjc.27.7e)

- The LBIs relating to the 'conservation of large individuals' appeared to improve over time, whilst the LBIs for the 'conservation of small individuals' decreased over time.
- The LBIs for MSY was close to or above the expected level in recent years for both gears analysed.

Thornback ray *Raja clavata* in the Bristol Channel and Irish Sea (rjc.27.7afg)

- The length-frequency distribution from otter trawlers changed abruptly during the time series, with a more constrained length range in 2009–2013, and broader length range in 2015–2017. Further studies on these data are required, to better understand whether this is a genuine temporal change in population structure, or an artefact of data collection.

- There were minor differences in LBIs when two different estimates of L_∞ were used.
- Whilst LBIs relating to the 'conservation of large individuals' failed to meet expected values, there was an improving status over time for both otter trawl and gillnet data. LBIs for MSY were close to or above the expected values in recent years.

Small-eyed ray *Raja microocellata* in the Bristol Channel (rje.27.7fg)

- The only published estimate for L_∞ is biologically implausible. Consequently, an estimated value is used.
- LBIs relating to the 'conservation of large individuals' have met the expected values in recent years for the two gears analysed, with the LBIs for MSY close to or above the expected values in recent years.

Spotted ray *Raja montagui* in the southern Celtic Sea (rjm.27.7aefg)

- As a smaller-bodied species, otter trawl data may be appropriate for examining temporal trends in LBIs.
- 2% of the gillnetter length distribution exceeded the reported L_{max} and could have been misidentified blonde ray.
- LBIs relating to the 'conservation of large individuals' met the expected values in recent years for the two gears analysed, with the LBIs for MSY also close to or above the expected values in recent years.

Spotted ray *Raja montagui* in the North Sea and eastern English Channel (rjm.27.347d)

- As a smaller-bodied species, otter trawl data may be appropriate for examining temporal trends in LBIs.
- LBIs relating to the 'conservation of large individuals' generally met the expected values in recent years for the two gears analysed, with the LBIs for MSY also close to or above the expected values in recent years.

Undulate ray *Raja undulata* in the English Channel (rju.27.7de)

- As a larger-bodied species, gillnet data may be more appropriate for examining temporal trends in LBIs, providing that sufficient data are available.
- There were major differences in the length-frequency distribution between years, with data for 2014 dominated by smaller fish than in the other years. This may be due to differences in the frequency of mesh sizes being used during observer trips.
- Whilst the annual length-frequency distributions observed in otter trawl data were slightly more consistent, there was bimodality and inter-annual variation in the modal length (which was higher in 2013 and 2017, but much lower in 2015 and 2016). This resulted in large changes in L_c which would then influence subsequent indicators.
- The underlying data for this species may be limited, or there may be differences in fisher behaviour, as to whether they were operating on grounds where adult or juvenile undulate ray occur.

26.2.2.3 Conclusions

As with all models, the quality of the input data will influence the quality of the results. Using the data from the UK England and Wales Observer at Sea program, it is likely that there may have been some issues regarding the raising factors. There appeared to be several cases within the available data where certain length classes may have been over represented. This becomes particularly problematic when calculating LBIs that are reliant on such length-frequency data.

There were also some issues relating to having sufficient data with which to draw robust conclusions. For several species sampled in the UK England and Wales Observer at Sea program, it was necessary to combine the results from gears, or collate data across several years to apply the model. In doing so, using trends in LBIs to draw conclusions on the effect of fishing will be problematic, unless this collation of data is applied consistently over longer time periods (e.g., every two years over a period of 10 years or more).

In addition to issues of raising factors from variable sample sizes, there are potential issues in relation to the spatial, temporal variability and range of vessels that have been sampled over time. This is particularly relevant to elasmobranchs, which often show sex- and size-based aggregations and segregation. Future studies could usefully examine the raw data to determine whether a more consistent subset of the data (e.g. in terms of fleet, fishing ground and seasonal coverage) can give a more reliable temporal source of standardised data with which to examine temporal change (i.e., minimising potential bias from spatial, temporal and gear related differences in the data). In the present study, data for gillnets were aggregated, and future studies should better examine data for 'target' skate and ray netters (which use tangle and trammel nets with larger mesh sizes) and other netters (e.g., smaller mesh sole nets) which generally take smaller skates as a bycatch.

If the application of LBIs requires a more consistent data set (at least for some species), then there may need to be consideration of a "reference fleet" to allow for the collection of more standardised length composition data. The selection of the most appropriate data collection programmes (e.g., scientific trawl surveys, market sampling, at-sea sampling; Table 26.2.2.3) also needs due consideration.

The current ICES assessments for the case study species are generally based on survey trends (Category 3), and so the utility of LBIs to provide additional demographic information when evaluating stock status is a potentially useful tool for managers. It should also be noted, however, that spatial metrics for such stocks may also be informative. Further analyses of spatial information may also inform on the most reliable sources of observer data for the better refinements of input data for LBIs.

The estimation of L_c will impact MSY status, because RP $L_{F=M}$ is calculated from L_c. Low estimations of L_c will lower the value of $L_{F=M}$ which will in turn increase the ratio $L_{mean}/L_{F=M}$, potentially giving over-optimistic MSY status. This appeared to be evident for both shagreen and thornback ray stocks in some years, where MSY status was considered 'good', despite the failure of other LBIs to meet the expectations of a 'healthy' stock.

Another potential reason for the contradiction between the conservation and MSY LBIs for some stocks is the value of the M/K ratio. In the absence of natural mortality estimates, a default value of 1.5 was used. This value is typical of teleost stocks and thought to be different across different taxa and life-histories. As such, the contradiction between the conservation and MSY LBIs could be an indication that the contribution of L_c and L_∞ to the MSY RP (75% and 25% respectively), and therefore the value of the *M/K* ratio, is incorrect.

Application of the LBIs revealed inconsistencies in status between indicators describing the same properties when applied to the same data. There was a tendency for L_{maxy} to be higher than L_{mean}, sometimes giving conflicting status when describing optimal yield in the traffic light assessment and showing diverging trends for shagreen ray. This could be due to the inclusion of weight information when calculating L_{maxy}. Consideration should be given to which indicator is most appropriate for a given species (and fishery).

There were some cases where the traffic light assessment revealed too low a proportion of megaspawners, even when indicators compared to L_∞ revealed a healthy presence of large individuals (e.g., cuckoo and spotted rays in the Celtic Sea). The expectation that $P_{mega} > 0.3$ assumes asymptotic size-selection (e.g., trawl fisheries). If selection is dome-shaped (e.g., gillnet or hook), then lower values of P_{mega} are desirable, following the fishing strategy where no mega-spawners are caught. Hence, due consideration should be given to fishery selection when defining appropriate RPs.

Given the large size of elasmobranchs and the late age at maturity, LBIs based on length at first capture (L_c and $L_{25\%}$) invariably highlight that this occurs before fish mature. It is considered unlikely to have a mixed fishery that captures elasmobranchs to meet these indicators, and a simulation study suggests that targeting a few year classes of immature fish is a more robust strategy for elasmobranchs (Prince, 2005). This is also reflected in our study because the RP L_{opt} was calculated to be below RP L_{mat} for most of the stocks we considered (noting that L_{opt} was calculated assuming *M/K* is 1.5). The RPs adopted by ICES were derived primarily for teleost and shellfish stocks (Froese, 2004; Miethe and Dobby, 2015). It is likely that these RPs and/or their expected values will need to be adjusted for fishes with contrasting life-histories (e.g., Shephard *et al.*, 2018).

The current case studies often provided mixed results from the various LBIs, and so there could be consideration of having more categories than red/green, and consideration of trend-based metrics until appropriate RPs are validated.

Furthermore, it should be recognised that there is a degree of uncertainty in some life-history parameters (e.g., L_∞). Some published age and growth studies have provided values that are biologically implausible, and may be artefacts of low sample size of larger (older) fish and/or uncertainty in age determination. There are also instances when multiple studies have provided very different estimated parameters for the same stock, which could be due to methodological or temporal differences, or artefacts of sample sizes. Results from the present study indicate that the selection of L_∞ can influence the results and on subsequent perceptions of status. Consequently, there needs to be further studies to allow the most appropriate life-history parameters to be selected.

Table 26.2.2.3. Advantages and disadvantages of underlying data relevant to LBIs.

FEATURE	MARKET SAMPLING DATA	AT-SEA OBSERVER PROGRAMMES	FISHERY-INDEPENDENT TRAWL SURVEYS
Data representative of stock area	In theory, data from market sampling should allow for data to be collected from fisheries operating within the stock area.	In theory, data from at-sea observer programmes should collect data from the wider stock area. However, vessel and trip selection was not designed specifically for skates, and the random selection of observer vessels could result in artefacts in LBIs.	Trawl surveys sample the wider stock area for some species, with a similar year-to-year spatial coverage.
Data from the whole length range (selectivity)	Data from market sampling would only provide data from the landed part of the stock, and not all the exploited part of the population. Data may be appropriate for examining those LBIs relating to adults, but data may be less informative for immature fish, as such length groups may be discarded. Some fisheries may land skates as wings only, which may preclude the accurate measurements of total length.	Data from commercial gears should sample the exploitable population effectively, thus enabling LBI to assess the exploitation status. Whilst data for smaller fish (that may be discarded) can also be collected, some commercial gears may not catch the smallest life-history stages effectively, which may affect whether data are suitable for informing on the length structure of the overall population. Different gears will have different selectivity patterns. Beam trawls, for example, may not catch larger skates effectively, therefore not meeting the assumption of asymptotic selection. Data for gillnet fisheries may be influenced by any differences in the dominant mesh sizes used in observed trips, and future studies should consider treating larger-mesh and smaller-mesh gillnets separately.	Data from trawl surveys generally sample smaller length categories more effectively than larger size categories. Hence, the model assumption for asymptotic selectivity may not be met for larger-bodied skate species (e.g., blonde ray, common skate). Data for smaller-bodied skate species (e.g., cuckoo ray and spotted ray) may cover the full length-range, and so may allow analyses of LBI pertaining to the underlying population status (which may not equate fully with the 'exploited population'). Data from trawl surveys may not be representative for LBIs for MSY and optimum catch.

Feature	Market sampling data	At-sea observer programmes	Fishery-independent trawl surveys
Data from consistent source	Routine market sampling at important fishing ports for skates should allow for representative data to be collected in a consistent manner.	The random selection of vessels and trips might result in inconsistent data (in terms of seasonality, gear selectivity, survey coverage etc.). This may not be an issue for commonly occurring species in major fisheries (e.g., cuckoo ray in trawl fisheries), but may be an issue for some localised species/fisheries. Net fisheries may use a range of mesh sizes, which can have very different selection patterns for skates.	Data from trawl surveys should theoretically be better placed to provide consistent data (in terms of spatial coverage, gear selectivity and seasonal coverage) to monitor temporal change.
Sample sizes and raising factors	Commercial landings of skates would be expected to allow for large sample sizes, especially in ports for which skates are either target or important bycatch species. The need to subsample would vary on quantities of fish (all species) to be processed, and the need to minimise disruption to normal market activities. Depending on sampling procedures, sub-sampling may impact on the accuracy of data, depending on whether all species and size categories have been landed appropriately.	Commercial catches of skates would be expected to allow for large sample sizes, especially in fisheries for which skates are either targeted or an important bycatch. Given the nature of catches, more limited staffing, and need to process catches in a timely manner (so as to minimise disruption to the activities of the vessel), there can often be a need to sub-sample catches. Depending on catch sampling procedures, sub-sampling may impact on the accuracy of data.	Trawl catches of skates are generally small, so sample sizes can be limited. In most instances, skate catches would be expected to be fully processed on research vessel surveys, and so not subject to (extreme) raising factors.

FEATURE	MARKET SAMPLING DATA	AT-SEA OBSERVER PROGRAMMES	FISHERY-INDEPENDENT TRAWL SURVEYS
Species identification	Some fisheries may land skates as either wings or skinned wings. The type of processing determines whether accurate species identification can be recorded. There is a requirement to report skates to species-level, but some similar-looking species may be combined and landed by size.	Observer trips generally have individual staff working regionally. Whilst experienced with the more frequent species occurring on their normal fishing grounds, there may be less experience with species from other areas (e.g. vagrants). There may be less time during catch processing to better examine any specimens for which identification was uncertain.	Trawl surveys generally have multiple staff experienced with species identification. There would also be more time available during catch processing to better examine any specimens for which identification was uncertain.
Impacts of management	Some fisheries management measures relating to skates (e.g., prohibited listings for certain species or restrictive fishing opportunities) may influence commercial fishing activities. This would impact on the representativeness of market-sampling data.	Some fisheries management measures relating to skates (e.g. prohibited listings for certain species or restrictive fishing opportunities) may influence commercial fishing activities, thereby potentially influencing the amount and representativeness of observer data.	Trawl surveys not influenced by fisheries management measures relating to skates.

26.2.3 Testing length-based RPs for an elasmobranch stock of Cuckoo ray (*Leucoraja naevus*): Miethe *et al.* (2018 WD)

26.2.3.1 Methods

LBIs have been identified to summarize catch length distributions with regard to exploitation of juveniles, large adults and optimal yield (ICES, 2015; Miethe and Dobby, 2015; Miethe *et al.*, 2016). A truncation in catch length distributions can be identified using $\bar{L}$, $L_{max5\%}$ or P_{mega} (proportion of megaspawners, Froese (2004)). RPs for these indicators need to be adapted to fit to the life history of the respective species (ICES, 2018; Shephard *et al*., 2018). P_{mega} is dependent on L_c and M/K such that a constant RP, such as 0.3 (Froese, 2004) is likely to be misleading if L_c is a lot larger or lower than L_{mat} or M/K is a lot lower than 1.5 (Miethe and Dobby, 2016; ICES, 2018). The mean length in the catch with a RP based on F=M proxy for MSY has been suggested (Jardim *et al.*, 2015). The RP is derived accounting for L_c and M/K. However, it was found that $\bar{L}$ and its respective RP $L_{F=M}$ perform well only if the length at first capture L_c>L_{mat} (Jardim *et al.*, 2015; Miethe and Dobby, 2016). For many elasmobranch stocks, L_c is typically lower than L_{mat} (ICES, 2018). If immature individuals are targeted or maturation occurs late in life, then the RP may not be appropriate.

While the RP $L_{F=M}$ does not take into account the maturation schedule nor the shape of the spawning stock-recruitment relationship of a stock, an approach based on the Spawning Potential Ratio (SPR) may be used to derive RPs (Hordyk *et al.*, 2015). The length-based spawning potential ratio, defined as the ratio between SSB in the fished and SSB in the unexploited state (SSB_0), can be used to estimate mortality and exploitation status directly from catch length distributions. No generic RP has been available for $L_{max5\%}$. Following an SPR approach, RPs representing a particular % of SPR can be derived for the indicator $L_{max5\%}$ dependent on L_c, M/K and L_{mat} (Miethe *et al.*, in prep.). RPs have been suggested to relate to 35% SPR (Clark, 1991) and more recently a target of 40% SPR, when recruitment variability is high (Clark, 1993; Mace, 1994). The spawning stock recruitment relationship was found to have a strong influence on the recommended value of SPR. For stocks with a very steep stock-recruitment relationships a SPR of 60% was suggested to reduce the risk of falling below 20%SPR (Clark, 2002).

RPs for LBIs are sensitive to the value of M/K, the ratio of natural mortality M and the von Bertalanffy growth constant K, which determines the shape of the equilibrium length distribution of an un-fished population (Hordyk *et al.*, 2015; Jardim *et al.*, 2015; ICES, 2016). Rays, Rajidae, exhibit ratios of M/K similar to bony fish (Frisk *et al.*, 2001). Cuckoo ray, *Leucoraja naevus,* is small-bodied often occurring in commercial catches. A relatively high M/K ratio is observed of 1.4 and 1.5 for males and females, respectively. These values of M/K do not seem to limit the application of the LBI $L_{max5\%}$ and a SPR-based RP (Miethe *et al*., in prep). A change in exploitation level and stock status is expected to cause sufficient change in catch length distributions and LBIs.

A length-based population model and management strategy evaluation (MSE) framework was used to test the use of LBI $\bar{L}$ and $L_{max5\%}$ together with respective RPs in harvest control rules (HCRs) to recover an overexploited stock of Cuckoo ray. The main question was whether LBI and RPs based on F=M, SPR of 40% and 60% are appropriate for management of an elasmobranch life history. Different values of L_c and the effect of misspecifying M (i.e., M/K) were tested.

26.2.3.2 Results

The performance of HCR was investigated, using $L_{max5\%}$ and a RP based on 40%SPR assuming correct knowledge of M. With L_c=450 and a constant TAC of 600t (without

HCR) starting in year 10, the simulated stocks were overexploited and collapsed in all 1000 simulations in less than 90 years of exploitation. In this case, the L_c is lower than L_{mat}. A HCR starting in year 40 based on $L_{max5\%}$ with a RP representing 40%SPR, does not recover an overexploited stock. As the indicator $L_{max5\%}$ was slightly above the RP under non-equilibrium conditions, the TAC was even allowed to increase with the start of the HCR, thus promoting overexploitation. Alternatively, the performance of a more precautionary HCR was evaluated based on $L_{max5\%}$ and SPR of 60%. A higher percentage of simulations resulted in recovery of the overexploited stock and reduced the risk of falling to low levels of SSB. The risk of being below 25% and 40% SSB at the end of the simulation period was lower than 10%. A HCR based on $\bar{L}$ and the RP $L_{F=M}$ did not perform well enough in a MSE to recover an overexploited stock. Median values for SSB, recruitment and indicators were compared for these three HCR options. This highlighted that an HCR approach based on the mean length and RP $L_{F=M}$ performs better than $L_{max5\%}$ with 40%SPR, and that at low values of L_c the indicator $L_{max5\%}$ can be useful when applied with a precautionary RP of SPR=60%.

Fishing mortality only on mature individuals (L_c>L_{mat}) facilitated stock recovery. For L_c=600, a proportion of mature individuals were not subject to fishing mortality. In the absence of a HCR, a constant TAC of 725t led to a collapse of SSB to very low levels, but some recruitment could occur. In this case, all three HCR could lead to recovery of overexploited stocks. The risk of collapse decreased in scenarios with higher values of L_c. At high values of L_c, HCR $\mathrm{L}_{\mathrm{max5\%}}^{\mathrm{F60\%SPR}}$ and HCR $\bar{\mathrm{L}}_{\mathrm{F=M}}$were more precautionary with fast recovery, but could lead to reduction in potential yield as the simulated stocks recovered to SPR levels well above 40%. The risk of being below 40% SSB at the end of the simulation period decreased to 6% also for HCR $\mathrm{L}_{\mathrm{max5\%}}^{\mathrm{F40\%SPR}}$.

Results suggested that a RP for $\bar{\mathrm{L}}$ based on SPR can help to protect SSB and prevent stock collapse. Also, due to non-equilibrium dynamics, simulated indicator values of a stock being overexploited with decreasing SSB were further away from their theoretical values when L_c is low (<L_{mat}).

For the $L_{max5\%}$ RP based on SPR 40%, there was a mismatch between SPR and indicator ratio. At lower values of L_c, the indicator ratio may point to sustainable exploitation, while the SPR is actually <40%. A RP of SPR=60% reduced the risk of SPR falling substantially below 20%. In this case, with an indicator ratio >1, one can safely assume the stock is not at risk of collapse (SPR in simulations remained above 20%). The mean length did not necessarily coincide with its RP at SPR 40%. The results were dependent on L_c: at low values of L_c, simulated stocks may have SPR <40% while the RPs indicated sustainable exploitation.

A misspecification of M, will lead to inappropriate RPs. If M is underestimated, RPs are higher and HCRs become more precautionary as indicator and RPs trigger a reduction in TAC at higher levels of SPR. Thereby, underestimation reduces the risk of collapse and but also reduces the expected equilibrium yield. In contrast, if M is overestimated, RPs are lower and less precautionary. Indicators and RPs can fail to identify low levels of SPR. This is a particular problem at low values of L_c, as the risk of being below SSB thresholds increases. In all scenarios, risks were lower for HCR $\mathrm{L}_{\mathrm{max5\%}}^{\mathrm{F60\%}}$, followed by HCR $\bar{\mathrm{L}}_{\mathrm{F=M}}$. The effect of misspecification of M was rather small when L_c was high. Stocks continued to be recovered using all the three HCRs, and the risk of being below SSB thresholds at the end of the simulation period remaind below 5% for L_c=600 for HCR $\mathrm{L}_{\mathrm{max5\%}}^{\mathrm{F60\%}}$ and HCR $\bar{\mathrm{L}}_{\mathrm{F=M}}$.

26.2.3.3 Discussion

Elasmobranch stocks with a M/K ratio >1 are likely to exhibit enough truncation in catch length distributions in response to overexploitation to allow for an application of the indicator $L_{max5\%}$ to monitor stock status. Due to the relatively large maturation size, the longer generation time and reproductive strategy, the management of these stocks (even with high M/K) may be challenging. RPs need to be carefully selected. The RP $L_{F=M}$ is sensitive to the estimation of L_c. A HCR based on the mean length and $L_{F=M}$ does not perform well when length at first capture is well below maturation size (Jardim *et al.*, 2015). This is due to the fact that the analytical RP $L_{F=M}$ is independent of maturation schedule and depends on the assumption of constant recruitment. For elasmobranch stocks, which mature at relatively large size, this assumption can be a problematic when the number of mature females in the stock falls to low levels.

Relatively slow life history will cause some delay in new recruits achieving lengths close to maturation size or close to L_∞. The number of recruits in elasmobranch stocks is closely linked to the number of mature females. Therefore, the potential of very large cohorts when SSB is low, and the recovery of a stock is closely linked to the abundance of mature females. RPs that integrate the maturation schedule of a stock are preferable. It has been suggested for stocks with a very steep stock-recruitment relationship, where a reduction in SSB causes a strong reduction in recruitment, a SPR of 60% can reduce the risk of SSB to fall below 20%SPR (Clark, 2002). Current results suggest that in particular when immature individuals are targeted by the fishery, more precautionary RPs are recommended, i.e. SPR>40% (60%).

At larger L_c, well above L_{mat}, an HCR based on $L_{F=M}$, 40%SPR or 60%SPR RPs tends to be precautionary and can lead to stock recovery. The RPs for $L_{max5\%}$ based on 60%SPR and $L_{F=M}$ are overly precautionary at high values of L_c and may lead to some loss of long term yield.

For elasmobranch stocks for which L_c can be estimated with low uncertainty to be continuously well above L_{mat}, RPs relating to SPR of 40% or $L_{F=M}$ may suffice. For low values of L_c and uncertainty in parameter estimates, a more precautionary approach (SPR=60%) is advised. This precautionary approach can further buffer against parameter misspecification. For example, an overestimation of M leads to lower RPs and can limit the recovery of an overexploited stock for low values of L_c. At high levels of L_c, with protection of immature individuals, a misspecification of M is less problematic. In general, ensuring L_c>L_{mat} where possible best supports any management approach for these stocks. Whenever this is not an option, an SPR approach of 60% is recommended. Larger and later-maturing elasmobranchs stocks are expected to be more vulnerable and have increased risk of collapse, and therefore may require even lower levels of fishing mortality when immature individuals are targeted.

26.2.4 Porbeagle summary into the assessment chapter - comment on CPUE indices: Albert (2018 WD)

26.2.4.1 Conclusions

An exploratory assessment of Porbeagle was run using the SPiCT model with total international landings and a French longline CPUE index as input. To investigate the sensitivity of the model towards varying quality throughout the time series, the model was fitted for a series of different start and stop years for both the CPUE index and the landings data. Also, various choices were made of those parameters to be estimated by the model and that were set by the user. Apart from one run that was considered largely unreliable, all the runs indicated that the stock biomass has increased since the fishery was abandoned in 2010, and is now either above or not far below B_{msy}. The models also suggested that the current fishing mortality F is below F_{msy}, creating potential for a resumed porbeagle fishery in the future. Models to robustly support an open fishery would require re-establishing reliable data series on removals, as well as on stock size and composition. However, more exploratory SPiCT runs need to be undertaken and scrutinized before results can be considered as indicative of the present status of the stock. This exploratory work is fully described in the Porbeagle assessment chapter of this report and in a WGEF 2018 WD.

26.2.5 Dome-shaped gear selection for the LBSPR

26.2.5.1 Conclusions

The spawning potential ratio (Hordyk *et al*., 2015) providing the reproductive potential of a stock relative to its un-fished condition is one of the length-based approaches proposed by ICES to derive stock RP. Given the biological and population dynamics of most demersal elasmobranchs, such as Rajidae, these species may be considered as potential candidates for the application of this approach if reliable length frequency distributions of the exploited population and biological parameters are available. WGEF applied the LBSPR method to a ray stock (rjh_27.9a) but the results obtained were of concern because this stock is mainly exploited by static gears (nets and trammels) and the LBSPR does not yet account for dome-shaped selectivity of nets. The extension of the LBSPR approach to incorporate non-asymptotic selection would support more general application to elasmobranch species. This could be achieved by estimating selectivity parameters separately (e.g., using gear selection experiments) and then inputting these to the model.

26.2.6 WGEF conclusions

26.2.6.1 Specifying LBIs and RPs

The WKLIFE MSY proxies and RPs were initially developed using data for demersal teleost fishes. It is likely that RPs and/or their expected values will need to be adjusted for fishes, such as elasmobranchs and diadromous species, with contrasting life-histories (e.g., Shephard *et al.*, 2018). Current results suggest that in particular when immature individuals are targeted by the fishery, more precautionary RPs are required. Application of the LBIs also revealed inconsistencies in status between indicators describing the same properties when applied to the same data. For instance, there was a tendency for L_{maxy} to be higher than L_{mean}, sometimes giving conflicting status when describing optimal yield in the traffic light assessment and showing diverging trends. This kind of outcome probably reflects the way in which the different LBIs are derived from underlying life history parameters. There may be scope to apply more assessment categories than the current red/green, and for consideration of trend-based metrics until appropriate RPs are validated.

The estimation of L_c will impact MSY status, as the RP $L_{F=M}$ is calculated from L_c. Low estimations of L_c will reduce the value of $L_{F=M}$, which will in turn increase the ratio $L_{mean}/L_{F=M}$, potentially giving over-optimistic MSY status. This outcome appeared to be evident for both shagreen and thornback ray stocks in some years, where MSY status was considered 'good', despite the failure of other LBIs to meet the expectations of a 'healthy' stock. At larger L_c, well above L_{mat}, an HCR based on $L_{F=M}$, 40%SPR or 60%SPR RPs tended to be precautionary and could lead to stock recovery. The RPs for $L_{max5\%}$ based on 60%SPR and $L_{F=M}$ were overly precautionary at high values of L_c and might lead to some loss of long term yield.

26.2.6.2 Are the life history parameters plausible?

Another potential reason for the contradiction between the conservation and MSY LBIs for some stocks is the value of the M/K ratio. In the absence of natural mortality estimates, a default value of 1.5 was used. This value is typical of teleost stocks, but is likely to be different across other taxa and life-histories. As such, the contradiction between the conservation and MSY LBIs could be an indication that the contribution of L_c and L_∞ to the MSY RP (75% and 25% respectively), and therefore the value of the M/K ratio, is not right.

Furthermore, it should be recognised that there is a degree of uncertainty in some life-history parameters (e.g., L_∞). Some published age and growth studies have provided values that are biologically implausible, and may be artefacts of low sample size of larger (older) fish and/or uncertainty in age determination. There are also instances when multiple studies have provided very different estimated parameters for the same stock, which could be due to methodological or temporal differences, or artefacts of sample sizes. Results from the present study indicate that the selection of L_∞ can influence the results and subsequent perceptions of population status. Consequently, there needs to be further studies to inform selection of the most appropriate life-history parameters values.

WGEF recommends that a standard process is defined for how to select these parameters for use in models. Appropriate values should be agreed before WGEF 2019 for the stocks for which advice will be provided in that year

26.2.6.3 Size-selection/sampling design/spatial sampling for size-distribution of samples

Deriving the LBIs from the UK England and Wales Observer at Sea program may have led to some issues regarding raising factors. There appeared to be several cases within the available data where certain length classes were over represented. This effect obviously could bias length-based assessment.

There are also potential issues in relation to the spatial and temporal variability, and the range of vessels that have been sampled over time. This is particularly relevant to elasmobranchs, which often show sex- and size-based aggregations and segregation. Future studies could usefully examine the raw data to determine whether a more consistent subset of the data (e.g., in terms of fleet, fishing ground and seasonal coverage) can give a more reliable temporal source of standardised data with which to examine temporal change (i.e., minimising potential bias from spatial, temporal and gear related differences in the data).

If the application of LBIs requires a more consistent data set (at least for some species), then there may need to be consideration of a "reference fleet" to allow for the collection of more standardised length composition data. The selection of the most appropriate data collection programmes (e.g., scientific trawl surveys, market sampling, at-sea sampling) also needs due consideration.

Data from a stratified reference fleet could potentially be used to support spatial metrics (e.g., percentage occupancy), which could be used to inform the LBIs in a more holistic assessment framework that might capture abundance, size-structure and distribution.

26.2.6.4 Recommendations

The group recommends different approaches for each ICES stock assessment category:

- Category 3: Further development of the LBIs and RPs - see above
- Category 5/6 and bycatch: demographic analyses; occupancy; frequency of occurrence.

Each of these approaches would be served by data collection programmes that account for spatial and temporal distribution of different elasmobranch life history stages.

26.3 Classify the elasmobranch stocks currently assess by ICES as target or bycatch stocks

26.3.1 Introduction

This chapter addresses Term of Reference h) *Classify the elasmobranch stocks currently assessed by ICES as target or bycatch stocks. A target stock is in this context a stock for which the TAC is a main driver for the regulation of fishing activities, and a bycatch stock a stock which is mainly caught as a bycatch and for which the TAC has no or very limited influence on the fishing activities. Explore the possibility of identifying elasmobranch stocks (or species) that can be used as community state indicators within the context of managing mixed fisheries*

This Term of Reference is also relevant for the TACMAN request, which is dealt with in Annex 9 of this report. In that request the relevant TAC areas have been defined as follows.

Bycatch TAC		**TAC area**	**Current TAC (t)**
Skates and rays	6, 7.a-c,e,k	Celtic Seas	9,699
Skates and rays	7.d,e	English Channel	1,276
Skates and rays	8,9	Biscay and Iberian Coast	4,326
Skates and rays	2.a, 4	Norwegian Sea and North Sea	1,425
Picked dogfish (spurdog)	1,5,6,7,8,12 and 14		270
Spurdog	NE Atlantic		Prohibited in North Sea

26.3.2 Overview bycatch and target stocks

The stocks for which the WGEF gives advice have been designated by the group as being 'bycatch' or 'target' according to known information on fishing activities (Table 26.3.2). All the skate and ray stocks are managed through a group TAC, and if targeting occurs it is driven by local conditions of abundance and/or commercial value. The TAC for skates and rays is primarily a group TAC. In specific circumstances, such as to deal with regional differences, there is a TAC for a stock. Undulate ray and small-eyed ray, which were prohibited for a number of years and which have a regional, coastal distribution, are examples. There is a sub-TAC for *Raja undulata* in Areas 7.d and e and 8.a and c ?? as this species was previously on the prohibited species list. *Raja microocellata* in 7.f and g had a non-retention footnote. In both cases a species-specific approach is required. There have been stock TACs for the shark species in the past, but currently only the spurdog has a TAC. Of the 55 stocks for which ICES gives advice, only 10 are actually being targeted as described above in 2018. In the past this was 27 stocks.

Table 26.3.2. Sharks skate and ray stocks designated as 'bycatch' or 'target'. Skate and ray species which have the designation 'target' are targeted within the group TAC by certain fleets. ICES has not a clear definition of bycatch. In making this table the WGEF has considered as bycatch stocks that are not directly targeted.

Stock Key Description	Has TAC ever been applied at stock level	Target or bycatch 2018	Target or bycatch in the past?
Angel shark (*Squatina squatina*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Basking shark (*Cetorhinus maximus*) in Subareas 1-10, 12 and 14 (Northeast Atlantic and adjacent waters)	Yes	Bycatch	Target
Black-mouth dogfish (*Galeus melastomus*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	No	Bycatch	Target
Black-mouth dogfish (*Galeus melastomus*) in subareas 6 and 7 (West of Scotland, southern Celtic Seas, and English Channel)	No	Bycatch	Bycatch
Blonde ray (*Raja brachyura*) in Division 7.e (western English Channel)	No	Target	Target
Blonde ray (*Raja brachyura*) in Division 9.a (Atlantic Iberian waters)	No	Bycatch	Target
Blonde ray (*Raja brachyura*) in divisions 4.c and 7.d (southern North Sea and eastern English Channel)	No	Bycatch	Bycatch
Blonde ray (*Raja brachyura*) in divisions 7.a and 7.f-g (Irish Sea, Bristol Channel, Celtic Sea North)	No	Target	Target
Blonde ray (*Raja brachyura*) in Subarea 6 and Division 4.a (North Sea and West of Scotland)	No	Target	Target
Common skate (*Dipturus batis*-complex flapper skate (*Dipturus cf. Flossada*) and blue skate (*Dipturus cf. intermedia*) in Subarea 6 and divisions 7.a-c and 7.e-k (Celtic Seas and western English Channel)	No	Bycatch	Target
Common skate (*Dipturus batis*-complex) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	No	Bycatch	Bycatch
Common skate (*Dipturus batis*-complex) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	No	Bycatch	Target

Stock Key Description	**Has TAC ever been applied at stock level**	**Target or bycatch 2018**	**Target or bycatch in the past?**
Cuckoo ray (*Leucoraja naevus*) in Division 8.c (Cantabrian Sea)	No	Bycatch	Bycatch
Cuckoo ray (*Leucoraja naevus*) in Division 9.a (Atlantic Iberian waters)	No	Bycatch	Bycatch
Cuckoo ray (*Leucoraja naevus*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	No	Bycatch	Bycatch
Cuckoo ray (*Leucoraja naevus*) in subareas 6–7 and divisions 8.a-b and 8.d (West of Scotland, southern Celtic Seas, and western English Channel, Bay of Biscay)	No	Bycatch	Bycatch
Greater-spotted dogfish (*Scyliorhinus stellaris*) in subareas 6 and 7 (West of Scotland, southern Celtic Sea, and the English Channel)	No	Bycatch	Bycatch
Kitefin shark (*Dalatias licha*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Leafscale gulper shark (*Centrophorus squamosus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.a-b and 8.d (Bay of Biscay)	No	Bycatch	Bycatch
Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	No	Bycatch	Bycatch
Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 4 and Divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)	No	Bycatch	Bycatch
Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 6 and divisions 7.a-c and 7.e-j (West of Scotland, Irish Sea, southern Celtic Seas)	No	Bycatch	Bycatch
Porbeagle (*Lamna nasus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	Yes	Bycatch	Target
Portuguese dogfish (*Centroscymnus coelolepis, Centrophorus squamosus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Rays and skates (Rajidae) (mainly thornback ray (Raja clavata)) in subareas 10 and 12 (Azores grounds and north of Azores)	No	Bycatch	Bycatch
Rays and skates (Rajidae) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)	NA	NA	NA
Rays and skates (Rajidae) in Subarea 6 and divisions 7.a-c and 7.e-h (Rockall and West of Scotland, southern Celtic Seas, western English Channel)	NA	NA	NA
Rays and skates (Rajidae) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	NA	NA	NA
Sandy ray (*Leucoraja circularis*) in subareas 6-7 (West of Scotland, southern Celtic Seas, English Channel)	No	Bycatch	Bycatch
Shagreen ray (*Leucoraja fullonica*) in subareas 6-7 (West of Scotland, southern Celtic Seas, English Channel)	No	Bycatch	Bycatch

Stock Key Description	Has TAC ever been applied at stock level	Target or bycatch 2018	Target or bycatch in the past?
Small-eyed ray (*Raja microocellata*) in divisions 7.d and 7.e (English Channel)	No	Bycatch	Bycatch
Small-eyed ray (*Raja microocellata*) in divisions 7.f and 7.g (Bristol Channel, Celtic Sea North)	Yes	Target	Target
Smooth-hound (*Mustelus* spp.) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Target	Bycatch
Spotted ray (*Raja montagui*) in Subarea 8 (Bay of Biscay)	No	Bycatch	Bycatch
Spotted ray (*Raja montagui*) in Division 9.a (Atlantic Iberian waters)	No	Bycatch	Bycatch
Spotted ray (*Raja montagui*) in divisions 7.a and 7.e-h (southern Celtic Seas and western English Channel)	No	Bycatch	Bycatch
Spotted ray (*Raja montagui*) in Subarea 4 and Divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)	No	Bycatch	Bycatch
Spotted ray (*Raja montagui*) in Subarea 6 and divisions 7.b and 7.j (West of Scotland, west and southwest of Ireland)	No	Bycatch	Bycatch
Spurdog (*Squalus acanthias*) in Subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	Yes	Bycatch	Target
Starry ray (*Amblyraja radiata*) in Subareas 2 and 4, and Division 3.a (Norwegian Sea, North Sea, Skagerrak and Kattegat)	No	Bycatch	Bycatch
Thornback ray (*Raja clavata*) in Division 7.e (western English Channel)	No	Target	Target
Thornback ray (*Raja clavata*) in Division 9.a (Atlantic Iberian waters)	No	Bycatch	Bycatch
Thornback ray (*Raja clavata*) in divisions 7.a and 7.f-g (Irish Sea, Bristol Channel, Celtic Sea North)	No	Target	Target
Thornback ray (*Raja clavata*) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)	No	Target	Target
Thornback ray (*Raja clavata*) in Subarea 6 (West of Scotland)	No	Bycatch	Bycatch
Thornback ray (*Raja clavata*) in Subarea 8 (Bay of Biscay)	No	Target	Target
Thresher sharks (*Alopias* spp.) in Subareas 10, 12, Divisions 7.c-k, 8.d-e, and Subdivisions 5.b.1, 9.b.1, 14.b.1 (Northeast Atlantic)	No	Bycatch	Target
Tope (*Galeorhinus galeus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Undulate ray (*Raja undulata*) in Division 8.c (Cantabrian Sea)	Yes	Bycatch	Target
Undulate ray (*Raja undulata*) in Division 9.a (Atlantic Iberian waters)	Yes	Bycatch	Target
Undulate ray (*Raja undulata*) in divisions 7.b and 7.j (west and southwest of Ireland)	No	Bycatch	Target
Undulate ray (*Raja undulata*) in divisions 7.d and 7.e (English Channel)	Yes	Bycatch	Target

Stock Key Description	Has TAC ever been applied at stock level	Target or bycatch 2018	Target or bycatch in the past?
Undulate ray (*Raja undulata*) in divisions 8.a-b (northern and central Bay of Biscay)	Yes	Bycatch	Target
White skate (*Rostroraja alba*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target

26.3.3 Definition of 'bycatch'

Although the ToR did not specifically require a definition of the term bycatch, a brief overview was made of the current definitions used in the fisheries. There are a number of different definitions of the term bycatch. The OECD (1997) define bycatch as "Total fishing mortality excluding that accounted directly by the retained catch of target species". This definition thus includes fish which die as a result of interaction with the fishing gear, even if they do not leave the water and could include fish which die as a result of "ghost fishing" - capture of fish in the water by lost or abandoned fishing gear. For FAO the term bycatch is be used to refer to that part of the catch which is not the primary target of the fishing effort. It consists of both fish which is retained and marketed (incidental catch) and that which is discarded or released (http://www.fao.org/docrep/w6602e/w6602E03.htm). A comprehensive definition of bycatch, encompassing the above, is given by Gilman (2011) as consisting of: (i) retained catch of non-targeted, but commercially valuable species, referred to as 'incidental catch' or 'byproduct'; (ii) discarded catch, whether the reason for non-retention is economic or regulatory; plus (iii) unobserved mortalities. The latter includes catch that dies and falls from the gear before the gear retrieval, ghost fishing from lost or abandoned gear, and post-release mortality of catch that escapes or is released alive but in poor condition.

ICES does not have a clear definition of bycatch.

26.4 Collate discard data from countries and fleets according to the ICES data call to: (i) address the following issues: data quality and onboard coverage; raising factors; discard retention patterns between fleets and countries; discard survival; and (ii) advise on how to include discard information in the advisory process

This ToRs was not addressed at the meeting due to time constraints. It remains an important issue and work should be continued during future meetings.

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Annex 2: Recommendations

RECOMMENDATION	ADDRESSED TO
1. It is recommended that a **'benchmark process'** is undertaken to determine how industry and on-board observation data can be incorporated into the ICES advisory process. Undulate ray stocks are suggested as a case study. This benchmark should address the issue of raising method when a species is mostly discarded as standard raising procedures are not applicable. It should also address the following issues: data quality and onboard coverage; discard retention patterns between fleets and countries; discard survival; and advise on how to include discard information in the advisory process.	ACOM
2. Another issue that has to be addressed in this process is how to advise on fishing opportunities that ensure that exploitation is sustainable when a species has been under moratorium, as is the case with the undulate ray. This benchmark should be carried out in the near future, ideally before the WGEF meeting in June 2019.	ACOM

Annex 3: Terms of Reference for next meeting

The **Working Group Elasmobranch Fishes** (WGEF), chaired by Paddy Walker (Netherlands) and Sam Shephard (Ireland), will meet at IPMA, Lisbon from 18–27 June 2019 to:

a) Address generic ToRs for Regional and Species Working Groups.

b) Update the description of elasmobranch fisheries for deep-water, pelagic and demersal species in the ICES area and compile landings, effort and discard statistics by ICES Subarea and Division, and catch data by NEAFC Regulatory Area. Describe and prepare a first Advice draft of any emerging elasmobranch fishery with the available data on catch/landings, fishing effort and discard statistics at the finest spatial resolution possible in the NEAFC RA and ICES area(s);

c) Evaluate the stock status for the provision of biennial advice due in 2019 for: (i) skate stocks in the North Sea ecoregion, the Azores and MAR; (ii) catsharks (*Scyliorhinidae*) in the Greater North Sea, Celtic Seas and Bay of Biscay and Iberian Coast ecoregions; (iii) smooth-hounds in the Northeast Atlantic; and (iv) tope in the Northeast Atlantic)

d) Conduct exploratory analyses and collate relevant data in preparation for the evaluation of other stocks (spurdog in the NE Atlantic; and skates in the Celtic Seas and Bay of Biscay and Iberian Coast ecoregions) in preparation for more detailed biennial assessment in 2020;

e) Evaluate the stock status for the provision of quadrennial advice due in 2019 for the following widely-distributed shark stocks: (i) Portuguese dogfish; (ii) Leafscale gulper shark; (iii) Kitefin shark; (iv) Porbeagle, and the following species that are on the prohibited species list: (v) angel shark, (vi) basking shark and (vii) white skate;

f) Collate discard data from countries and fleets according to the ICES data call to: (i) address the following issues: data quality and onboard coverage; raising factors; discard retention patterns between fleets and countries; discard survival; and (ii) advise on how to include discard information in the advisory process;

g) Further develop MSY proxy reference points relevant for elasmobranchs and explore/apply in MSY Proxies analyses for selected stocks;

h) Further develop the ToR for the proposed joint ICCAT-ICES meeting in 2020 to (i) assess porbeagle shark and (ii) collate available biological and fishery data on thresher sharks in the Atlantic;

i) Work intersessionally to draft/update stock annexes to be made available by 31st January 2018, and then develop a procedure and schedule for subsequent reviews.

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group no later than 14 days prior to the starting date.

Annex 4: List of Stock Annexes

STOCK ID	STOCK NAME	LAST UPDATED	LINK
dgs-nea_SA	Spurdog (Squalus acanthia) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	June 2018	dgs.27.nea_SA
rjb-89a_SA	Common skate (Dipturus batis - complex) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	June 2015	rjb-89a_SA
rjc-bisc_SA	Thornback ray (Raja clavata) in the Bay of Biscay VIIIa–c	June 2015	rjc-bisc_SA
rjc-echw_SA	Thornback ray (Raja clavata) in Division 7.e (western English Channel)	June 2015	rjc-echw_SA
rjc-pore_SA	Thornback ray (Raja clavata) in Division 9.a (Atlantic Iberian waters)	June 2015	rjc-pore_SA
rje-ech_SA	Small-eyed ray (Raja microocellata) in divisions 7.d and 7.e (English Channel)	June 2015	rje-ech_SA
rjh-pore_SA	Blonde ray (Raja brachyura) in Division 9.a (Atlantic Iberian waters)	June 2015	rjh-pore_SA
rjm-bisc_SA	Spotted ray (Raja montagui) in Subarea 8 (Bay of Biscay)	June 2015	rjm-bisc_SA
rjm-pore_SA	Spotted ray (Raja montagui) in Division 9.a (Atlantic Iberian waters)	June 2015	rjm-pore_SA
rjn-bisc_SA	Cuckoo ray (Leucoraja naevus) in Division 8.c (Cantabrian Sea)	June 2015	rjn-bisc_SA
rjn-pore_SA	Cuckoo ray (Leucoraja naevus) in Division 9.a (Atlantic Iberian waters)	June 2015	rjn-pore_SA
rju-9a_SA	Undulate ray (Raja undulata) in Division 9.a (Atlantic Iberian waters)	June 2015	rju-9a_SA
rju-ech_SA	Undulate ray (Raja undulata) in divisions 7.d and 7.e (English Channel)	June 2015	rju-ech_SA
sck-nea_SA	Kitefin shark (Dalatias licha) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	June 2015	sck-nea_SA
bsk-nea_SA	Basking shark (Cetorhinus maximus) in Subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	June 2015	bsk-nea_SA
cyo-nea_SA	Portuguese dogfish (Centroscymnus coelolepis, Centrophorus squamosus) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	June 2015	cyo-nea_SA

STOCK ID	STOCK NAME	LAST UPDATED	LINK
guq-nea_SA	Stock Annex: Leafscale gulper shark (Centrophorus squamosus) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	June 2015	guq-nea_SA
por-nea_SA	Porbeagle (Lamna nasus) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	June 2015	por-nea_SA

Annex 5: Audits

All sections of the 2018 report have been cross reviewed by at least two members of the WGEF and coordinated by the chairs. The draft advice was audited in plenary by all members of the working group.

Annex 6: Benchmarks

A workshop, WKSHARK4, was held in February 2018, for which the overall objective was to analyse the appropriateness of length-based indicators (LBIs) for assessment of the status of elasmobranch stocks; See ICES (2018): Report of the Workshop on Length-Based Indicators and Reference Points for Elasmobranchs (WKSHARK4), 6–9 February 2018, Ifremer, Nantes (France). 112 pp.

A benchmark process is proposed with the aim to determine how industry and on-board observation data can be incorporated into the ICES advisory process. Another issue that has to be addressed in this process is how to advise on fishing opportunities that ensure that exploitation is sustainable when a species has been under moratorium, as is the case with the undulate ray. For details, see Annex 2: Recommendations.

Annex 7: Working Documents 2018

List of WGEF 2018 Working Documents:

WD_01: Miethe, T. & Dobby, H. (2018). Testing length-based reference points for an elasmobranch stock of Cuckoo ray (Leucoraja naevus). Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: Elasmobranchs are slow-growing, late maturing and have low fecundity, leading to longer generation time. Sufficient numbers of spawning individuals are important to ensure recruitment and sustainable management of these stocks. Length-based indicators (LBI), such as the mean length in the catch ($\bar{L}$) and the mean length of the largest 5% in the catch (Lmax5%) can be used to describe (for example) the truncation in length distribution in exploited stocks. Reference points for these indicators are calculated using basic life history parameters (growth, natural mortality, maturity). These LBI can support a data-limited stock assessment, particularly for stocks in which the M/k ratio (the ratio of natural mortality and growth coefficient) is known to be high (>1). Using cuckoo ray, *Leucoraja naevus*, as an example, we use management strategy evaluations to compare the performance of harvest control rules based on these LBI and their ability to recover an overexploited stock in different scenarios of fishing selectivity. We illustrate the importance of protecting immature individuals from fishing selectivity of the success of HCR to recover an overexploited stock. At Lc<Lmat reference points, such as LF=M, that do not account for the maturation schedule of a stock are not be suitable. With fishing mortality on immature individuals and due to the sensitivity of reference points to parameter misspecification, more precautionary reference points are recommended for elasmobranchs stocks, such as SPR of 60% rather than 40%.

WD_02: Santos, R.V.S., Novoa-Pabon, A.M., da Silva, H.M., Pereira, J.G. & Pinho, M.R. (2018). Standardized catch rates for thornback ray (ska.27.10a2) from the Azorean bottom longline fleet (1990-2016). Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2016. The CPUE of thornback ray was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were: year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE showed an oscillation over time, with an increasing trend from 2007 to 2015; while the standardized index presented a more stable trend overall.

WD_03: Santos, R.V.S., Novoa-Pabon, A.M., da Silva, H.M., Pereira, J.G. & Pinho, M.R. (2018). Standardized catch rates for tope (lsk.27.10a2) from the Azorean bottom longline fleet (1990-2016). Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2016. The CPUE of tope was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were: year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE showed an oscillation over time, with some peaks in 1999, 2000 and 2014; while the standardized index presented an approximately stable trend since 1994.

WD_04: Fernández-Zapico, O., Velasco, F., Rodríguez-Cabello, C., Preciado, I., Punzón, A., Ruiz-Pico, S. & Blanco, M. (2018). Results on main elasmobranch species captured in the bottom trawl surveys on the Northern Spanish Shelf. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: This working document presents the results on the most abundant elasmobranch species

captured in the Spanish Groundfish Survey on Northern Spanish shelf in 2017. Biomass, spatial distribution and length ranges were analysed for the elasmobranchs caught in the survey. The main species in biomass terms were, as usual for the historical series, *Scyliorhinus canicula* (Lesser spotted dogfish), *Galeus melastomus* (blackmouth catshark), *Etmopterus spinax* (Velvet belly), *Raja clavata* (Thornback ray), *Raja montagui* (Spotted ray) and *Leucoraja naevus* (Cuckoo ray), and other scarce elasmobranchs captured were *G. atlanticus, S. stellaris, R. microcellata, H. griseus* and *R. brachyura*. The *species G. melastomus, G. atlanticus, E. spinax, R. clavata, R. montagu*i and *R. naevus* increased their abundance. However, the biomass of *Dalatias licha* kept similarly to that in the previous year in deeper special hauls and the *species S. canicula, S. stellaris, D. profundorum, H. griseus* and *S. ringens* decreased their biomass.

WD_05: Ruiz-Pico, S., Fernández-Zapico, O., Baldó, F., Velasco, F. and Rodríguez-Cabello, C. (2018). Results on main elasmobranches species from 2001 to 2017, Porcupine Bank (NE Atlantic) bottom trawl surveys. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: This working document presents the results of the most significant elasmobranch species caught on the Porcupine Spanish Groundfish Survey (SP-PORC-Q3) in 2017 and also updates previous documents presented. Biomass, abundance, distribution and length ranges were analysed for *Galeus melastomus* (blackmouth catshark), *Deania* spp., *Scymnodon ringens* (knifetooth dogfish), *Scyliorhinus canicula* (lesser spotted dogfish), *Etmopterus spinax* (velvet belly lantern shark), *Dalatias licha* (kitefin shark), *Hexanchus griseus* (bluntnose sixgill shark), *Dipturus nidarosiensis* (Norwegian skate), *Dipturus* cf. *flossada* (common skate), *Dipturus* cf. *intermedia* (common skate), *Leucoraja circularis* (sandy ray) and *Leucoraja naevus* (cuckoo ray). Biomass indices of these species decreased in 2017, except in the case of *Deania profundorum, D. licha* and *L. naevus*. Some other scarce elasmobranchs were found, especially *Squalus acanthias*. Few small specimens were generally found.

WD_06: Bendall, V. A., Nicholson, R., Hetherington, S., Wright, S., and Burt, G. (2018). Common skate survey of the Celtic Sea. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: Building upon the common skate survey Fisheries Science Partnership (FSP) project in 2011, four subsequent Defra-funded fishery dependent common skate surveys were undertaken annually from 2014–2017 to collect field data on the relative abundance and distribution of the 'common skate complex' in the Celtic Sea (ICES Divisions 7.e–h). Data were collected on 2 400 blue skate *Dipturus batis* (1 103 females, mean total length ($L_{\bar{x}}$) = 115 ± 20 cm; 1 291 males, $L_{\bar{x}}$ = 113 ± 17 cm, with six unsexed) and 28 flapper skate *D. intermedius* (13 females, $L_{\bar{x}}$ = 108 ± 17 cm; 15 males, $L_{\bar{x}}$ = 144 ± 29 cm). Preliminary results are presented across the four survey years showing annual mean catch rates (CPUE) for *D. batis.* Across all exploratory stations fished, annual mean CPUE for abundance ranged from 0.44–0.49 individuals.km^{-1}.h^{-1} and biomass from 3.96–5.66 kg.km^{-1}.h^{-1}. Four prime stations (considered biologically important due to increased abundance of *D. batis*) were fished consistently to within 3 nm each year. These stations showed a higher annual mean CPUE abundance (0.68–0.77 individuals.km^{-1}.h^{-1}) and biomass (6.09–9.27 kg.km^{-}

^{1}.h^{-1}). The lowest mean CPUE biomass, recorded in 2016, was 3.96 kg.km^{-1}.h^{-1} for all stations fished, and 6.09 for kg.km^{-1}.h^{-1} for the four prime stations fished consistently. In addition to catch rates, data on the size and sex composition are presented. Preliminary results from tagging *D. batis* in 2011 and 2014–2017 are presented to show mark recapture locations from 46 mark-ID tags recovered (2% return rate) and 19 archival tags (17% recovery rate). These fish moved 4–170 km from the release position and were at liberty for 1–2098 days prior to recovery.

WD_07: Ellis, J. R. (2018). Skates in the UK beam trawl survey of the Irish Sea (ICES Division 7.a) and Bristol Channel (ICES Division 7.f–g). Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: Annual 4 m beam trawl surveys are conducted in Irish Sea and Bristol Channel (Divisions 7.a and 7.f–g) each September, with the survey grid standardised since 1993. Average catch rates (n.h^{-1} and kg.h^{-1}, and kg.h^{-1} for specimens ≥50 cm total length) are shown for thornback ray *Raja clavata,* spotted ray *Raja montagui*, blonde ray *Raja brachyura*, cuckoo ray *Leucoraja naevus* (7.a.f–g) and small-eyed ray *Raja microocellata* (7.f only).

WD_08: Biseau, A. (2018). French catches estimates of undulate ray in 2016 and 2017 in ICES Divisions 27.7.d, 27.7.e, 27.8.a and 27.8.b. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: This working document provides new data to support the update of the ICES advice regarding undulate ray (*Raja undulata*, RJU) stocks in Divisions 7.de and 8.ab. Catches (landings and discards of undulate ray by ICES divisions in 2016 and 2017 are estimated using the landings of all species as an auxiliary variable. Data include official landings (estimated from a combination of logbooks and other compulsory reporting from fishers, fish auction market sales and other data, e.g. VMS), landings and discards sampling from the French on-board observation program and the undulate ray specific selfsampling program. The self-sampling program involves all the vessels that were allowed to land undulate ray in 2016 and 2017 from Divisions 7de and 8ab. All trips being sampled, the number of samples in this program and the spatio-temporal coverage are much larger than the EU-DCmap onboard sampling program. In 2016, only landings data (59 tonnes for divisions 7de) were used by ICES to provide the fishing opportunities for 2017 and 2018, after the 2010-2015 ban. This analysis provides evidence that recent catches are higher, in the order of 1620-1840 tonnes in Divisions 7de and 510-570 tonnes in Divisions 8ab for 2016-2017 with the raising method using the total landings (all species).

WD_09: Walker, N. D., Bird, C., Ribeiro Santos, A., McCully Phillips, S. R. and Ellis, J. R. (2018). Length-based indicators to assess the status of skates (Rajidae). Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: Length-based indicators are a simple tool for evaluating the status of fish stocks, requiring only length-frequency data and limited life-history information. Here, length-based indicators are applied to data for 14 skate stocks collected during sea-going observer programmes on commercial fishing vessels, and interpreted in relation to the conservation of large and small individuals, optimal yield and maximum sustainable yield. The suitability of these indicators and their expected values for skate stocks is discussed.

WD_10: Ellis, J. R. (2018). Common thresher shark *Alopias vulpinus*: A preliminary bibliography of scientific studies. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: In relation to the term of reference on collating biological and fishery data on thresher sharks in the Atlantic, a preliminary bibliography of scientific papers on the common thresher shark *Alopias vulpinus* was collated. Whilst few scientific studies are available for the North-east Atlantic, the stock in the eastern Pacific Ocean is better studied.

WD_11: McCully Phillips, S. R. and Ellis, J. R. (2018). ***Leucoraja fullonica*** **and** ***Leucoraja circularis*** **in the Northeast Atlantic. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.**

Abstract: Shagreen ray *Leucoraja fullonica* and sandy ray *L. circularis* are large bodied skate species occurring on the edge of the continental shelf and upper slope in the Northeast Atlantic and Mediterranean. They are not well represented in fishery-independent surveys, and consequently are data-limited stocks with no formal assessment (category five), have no defined reference points and are of unknown stock status. These stocks are currently treated as management units covering ICES Subareas 6–7, but these stocks likely extend into the north-western parts of Division 4.a and Subarea 8. DATRAS data (2000–2017) were extracted from all surveys covering the stock area. Catch rates of sandy ray were low, with the 669 records primarily from the Spanish Porcupine Bank survey (64%) and the French EVHOE survey (34%). CPUE in these surveys was greatest at depths of 300–600 m, being on average 1–1.4 individual per hour. The proportion of hauls across surveys with a positive catch was greatest (0.9%) at 301–400 m depth. Catch rates were of a similar low level for shagreen ray, with 362 individuals present in the data, primarily from the EVHOE survey (67%). CPUE of this survey was greatest (0.77 ind.h-1) at depths 301–400m, however, the proportion of hauls across surveys with a positive catch was greatest (1.1%) at the 101–200m depth band. Biological data were collected from 36 specimens of *Leucoraja fullonica* (19–100 cm LT) and 21 specimens of *Leucoraja circularis* (23–110 cm LT) collected from the Northeast Atlantic. Conversion factors are presented along with data on hepato- and gonadosomatic indices, maturity information, nidamental gland width and clasper length data. Preliminary information on diet composition is also given.

WD_12: Silva, J. F., McCully, S. R., Ellis, J. R. and Kupschus, S. (2018). Demersal elasmobranchs in the western Channel (ICES Division 7.e) and Celtic Sea (ICES Divisions 7.f-j). Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: In 2006, CEFAS initiated a new beam trawl survey in the western English Channel (ICES Division 7.e) to provide information on sole *Solea solea* and plaice *Pleuronectes platessa*, as well as providing information on other demersal fish and ecosystem components. The survey extended into the Celtic Sea from 2013. The western Channel is an important area for various demersal elasmobranchs, with species of interest including undulate ray *Raja undulata*, which is locally abundant and, prior to their prohibited status, was an important commercial species in some inshore areas. This study presents updated results on the spatial distribution and size frequency for all dogfish, skates and rays encountered during 2006–2018, now including the wider Celtic Sea area. Results indicated that species including common skate *Dipturus batis*-complex, cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata* and undulate ray showed persistent associations with specific sites, with lesser-spotted dogfish *Scyliorhinus canicula* and starry smooth-hound *Mustelus asterias* distributed over much of the survey grid. Juvenile skates were routinely caught, as beam trawls are more selective for smaller fish. Mature specimens of the smaller-bodied skate species, such as cuckoo ray, were also represented in the catch, while fewer mature specimens of the larger-bodied skate species (e.g. undulate, blonde and thornback ray) were observed. Preliminary results in terms of estimated total abundance and biomass are shown for the western Channel.

WD_13: Albert, O. T. (2018). Porbeagle: Data limited stock assessment, using the SPICT model Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: Exploratory assessments of Porbeagle was run using the SPICT model. To investigate the sensitivity of the model towards varying quality throughout the time series, the model was fitted for a series of different start and stop years for both the CPUE index and the landings data. Also various choices were made of which parameters to be estimated by the model and which that were set by the user. Apart from one run that was considered largely unreliable, all the runs indicate that the stock biomass is now either above or not too far below Bmsy. With the present

F far below Fmsy, a commercial porbeagle fishery may therefore again become advisable in the near or medium-term future. This requires however a reestablishing of reliable data series on removals, as well as on stock size and composition. However, these exploratory runs need to be further scrutinized before the results can be considered as indicative of the present status of the stock.

WD_14: Serra-Pereira, B. and Figueiredo, I. (2018). Biomass and Abundance Indexes for skates in the Portuguese groundfish and crustacean surveys (ICES Division 27.9.a). Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018.

Abstract: Information is annually collected at the Portuguese Autumn Groundfish Surveys (PT-GFS), since 1981, and at the Portuguese crustacean surveys/Nephrops TV surveys (PT-CTS (UWTV (FU 28-29)), since 1997, held along the Portuguese mainland coast (ICES Division 27.9.a). The current working document presents updated information on the Portuguese distribution, survey indexes (biomass and abundance) and length ranges for *R. clavata, R. montagui* and *L. naevus*, in that division, for the period 1990-2017. Increasing trends was observed for *R. clavata*, while *R. montagui* showed a stable trend in the last two years. Captures of *L. naevus* in 2016 and 2017 were limited to take conclusions on biomass and abundance trends.

WD_15: Pinho, M.R., and Marques da Silva, H., (2018). ELASMOBRANCHS LANDINGS OF THE AZORES (ICES AREA 27.10). Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018, 8 pp.

Abstract: About 58 elasmobranch species are listed as occurring in the Azores. The species covers pelagic, benthopelagic and benthic habitats from shallow to deep-water strata in areas around coastal of the islands, banks and seamounts. However, only about 17 shark species were identified by the auctions along the historical landings. Currently elasmobranchs landings from the Azores (ICES area 10a) are mainly by-catches from three main hook and line fisheries: the swordfish fishery, the demersal fishery and the black scabbarfish fishery. Discards are not available for the recent years. Biological sampling data is scarce because these species are not caught due to management restrictions, there are no target fisheries and have low sampling priority under the DCF. There are no biological data available for the year 2017. This paper updates the elasmobranchs landings from the Azores (ICES area 10a) for 2018 WGEF meeting.

WD_16: Campbell, Neil, (2018). Analyses of Scottish deep-water survey data. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, June 19–28 2018, 12 pp.

Abstract: A Generalized Additive Model (GAM) with a negative binomial distribution was used to standardise abundance indices for leafscale gulper shark and Portuguese dogfish caught in the Scottish deep-water survey (2000–2017). The survey covered depths of 300–2040 m and gave representative coverage of the continental slope between approximately 55°N and 59°N (Figures 1 & 2). The survey has occasionally carried out hauls at Rockall and Rosemary Bank, which could potentially bias trends, therefore these stations have been excluded from the present analysis and data are exclusively derived from hauls on the continental slope. The majority of hauls were made at the following strata: 500, 1000, 1500 and 1800 m. In any one year there were usually around 5–6 hauls for each of these depth strata. Data used in the model were restricted to the "core" depth range for each species, established through visual inspection of the data. Core depth ranges for Portuguese dogfish and leafscale gulper shark were considered to be 700–1900 m and 500–1800 m, respectively.

Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon 19-28 June 2018

Testing length-based reference points for an elasmobranch stock of Cuckoo ray (*Leucoraja naevus*)

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Abstract

Elasmobranchs are slow-growing, late maturing and have low fecundity, leading to longer generation time. Sufficient numbers of spawning individuals are important to ensure recruitment and sustainable management of these stocks. Length-based indicators (LBI), such as the mean length in the catch ($\bar{L}$) and the mean length of the largest 5% in the catch ($L_{max5\%}$) can be used to describe (for example) the truncation in length distribution in exploited stocks. Reference points for these indicators are calculated using basic life history parameters (growth, natural mortality, maturity). These LBI can support a data-limited stock assessment, particularly for stocks in which the M/k ratio (the ratio of natural mortality and growth coefficient) is known to be high (>1). Using cuckoo ray, *Leucoraja naevus*, as an example, we use management strategy evaluations to compare the performance of harvest control rules based on these LBI and their ability to recover an overexploited stock in different scenarios of fishing selectivity. We illustrate the importance of protecting immature individuals from fishing selectivity of the success of HCR to recover an overexploited stock. At $L_c<L_{mat}$ reference points, such as $L_{F=M}$, that do not account for the maturation schedule of a stock are not be suitable. With fishing mortality on immature individuals and due to the sensitivity of reference points to parameter misspecification, more precautionary reference points are recommended for elasmobranchs stocks, such as SPR of 60% rather than 40%.

1 Introduction

Elasmobranchs are cartilaginous fish, most of which are k-selected species with relatively slow growth, late maturity, large adult size, and few developed juveniles. The elasmobranch species most vulnerable to overexploitation tend to be larger-sized, slow-growing, late-maturing and long-lived (Smith *et al.*, 1998; Dulvy *et al.*, 2000). In the North Sea, the abundance of the larger common skate and thornback ray declined since the 1960s-70s, and a concomitant increase in smaller-bodied rays, starry and spotted ray was observed (Chevolot *et al.*, 2008; Sguotti *et al.*, 2016). Larger-bodies species tend to be removed first due to size-selective fisheries, increasing the food availability of smaller species with high dietary overlap (Dulvy *et al.*, 2000).

Generally, it was suggested that Rajiformes are less vulnerable to overfishing than both Squaliformes and Lamniformes (Stevens *et al.*, 2000; García *et al.*, 2008). Extinction risk was found to be associated with habitat (deep-sea species higher risk) and reproductive strategy (viviparous higher risk than oviparous) (García *et al.*, 2008). In particular, stocks with maturation occurring at relatively large size and slow growth, are vulnerable to recruitment failure as the size range of mature individuals in limited and decimated size classes are slowly replenished. In contrast, small-bodied species tend to be more productive with a higher rebound potential (Stevens *et al.*, 2000).

Elasmobranchs recruitment is closely linked to the number of mature females, limiting the recovery from overfishing when SSB is low and the potential of replenishment by incoming large cohorts is small (Cailliet *et al.*, 2005). Due to the long generation time, a reduction in exploitation level may take longer to translate into a change in recruitment and recovery of SSB in overexploited stocks. Instead of maximizing yield, the focus of management for elasmobranch stocks should therefore be on the protection of the reproductive potential.

Cuckoo ray, *Leucoraja naevus*, with demersal habitat in the Northeast Atlantic. The species is oviparous, females deposit about 90 egg cases a year and juveniles hatch at around 100mm length (Buit, 1976; Ebert and Stehmann, 2013). Spawning can occur throughout the year, but was observed to be typically highest in the beginning of the year (Maia *et al.*, 2012). Rays are often caught as bycatch in mixed demersal fishery for roundfish and flatfish (ICES, 2017). Estimates of long-term discard mortality are difficult to obtain. From some experiments, it was estimated that 60% of cuckoo rays caught by dredge were still alive after 5 days

(Depestele *et al.*, 2014; Ellis *et al.*, 2017). The discard survival in otter trawl ranged between 50-90% but values did not stabilize within 80h of experiment duration and is therefore likely to be lower (Benoit *et al.*, 2013; Depestele *et al.*, 2014). Estimates of natural mortality are typically scarce. Values of 0.3 for females and 0.4 for males have been suggested (Pauly, 1980; Gallagher *et al.*, 2005a; Then *et al.*, 2015).

Elasmobranchs from the North Sea are not routinely aged, instead of catch age distributions catch length distributions can aid a stock assessment. Catch rates can be used to estimate mortality (Hoenig and Gedamke, 2007). However, so far for the North Sea skates and rays, no commercial effort data is available (ICES, 2017). Alternatively, length distributions of catches can be analysed using length-based indicators, such as the mean length $\bar{L}$ in the catch or the mean length of the largest 5% in the catch, $L_{max5\%}$ (Probst *et al.*, 2013; ICES, 2017). A number of length-based indicators are available and some have been identified as potential suitable to summarize catch length distributions with regard to exploitation of juveniles, large adults and optimal yield (ICES, 2015; Miethe and Dobby, 2015; Miethe *et al.*, 2016). A truncation in catch length distributions can be identified using $\bar{L}$, $L_{max5\%}$ or P_{mega} (proportion of megaspawners, Froese (2004)). Reference points for these indicators need to be adapted to fit to the life history of the respective species (ICES, 2018). P_{mega} is dependent on L_c and M/k such that a constant reference point, such as 0.3 (Froese, 2004) is likely to be misleading if L_c is a lot larger or lower than L_{mat} or M/k is a lot lower than 1.5 (Miethe and Dobby, 2016; ICES, 2018). The mean length in the catch with a reference point based on F=M proxy for MSY has been suggested (Jardim *et al.*, 2015). The reference point is derived accounting for L_c and M/k. However, it was found that $\bar{L}$ and its respective reference point $L_{F=M}$ perform well only if the length at first capture $L_c>L_{mat}$ (Jardim *et al.*, 2015; Miethe and Dobby, 2016). For many elasmobranch stocks L_c is typically lower than L_{mat} (ICES, 2018). If immature individuals are targeted or maturation occurs late in life the reference point may not be appropriate. While the reference point $L_{F=M}$ does not take into account the maturation schedule nor the shape of the spawning stock-recruitment relationship of a stock, an approach based on the Spawning Potential Ratio (SPR) may be used to derive reference points (Hordyk *et al.*, 2015). The length-based spawning potential ratio, defined as the ratio between SSB in the fished and SSB in the unexploited state (SSB_0), can be used to estimate mortality and exploitation status directly from catch length distributions. No generic reference point has been available for $L_{max5\%}$. Following an SPR approach, reference points representing a particular % of SPR can be derived for the indicator $L_{max5\%}$ dependent on L_c, M/k and L_{mat} (Miethe *et al.*, in prep.). Reference points have been suggested to relate to 35% SPR (Clark, 1991) and more recently a target of 40% SPR, when recruitment variability is high (Clark, 1993; Mace, 1994). The spawning stock recruitment relationship was found to have a strong influence on the recommended value of SPR. For stocks with a very steep stock-recruitment relationships a SPR of 60% was suggested to reduce the risk of falling below 20%SPR (Clark, 2002).

Reference points for length-based indicators are sensitive to the value of M/k, the ratio of natural mortality M and the von Bertalanffy growth constant k, which determines the shape of the equilibrium length distribution of an unfished population (Hordyk *et al.*, 2015; Jardim *et al.*, 2015; ICES, 2016). Rays, Rajidae, exhibit ratios of M/k similar to bony fish (Frisk *et al.*, 2001). Cuckoo ray, *Leucoraja naevus*, is small-bodied often occurring in commercial catches. Life history parameters for Cuckoo ray in the Irish Sea are listed in Table 1. A relatively high M/k ratio is observed of 1.4 and 1.5 for males and females, respectively. Following the analysis by Miethe et al. (in prep), these relatively high values of M/K do not limit the application of the length-based indicator $L_{max5\%}$ and a SPR-based reference point. A change in exploitation level and stock status is expected to cause a sufficient change in the catch length distributions and in the length-based indicators.

With help of length-based population models and management strategy evaluation (MSE), we test the use of length-based indicators $\bar{L}$ and $L_{max5\%}$ together with respective reference points in harvest control rules to recover an overexploited stock of Cuckoo ray. We test whether length based indicators and reference points based on F=M, SPR of 40% and 60% are appropriate for management of an elasmobranch life history. We investigate different values of L_c and misspecification of M (i.e. M/k).

2 Methods

2.1 Population model

Discrete length-structured models often make use of size classes with constant bin width (Drouineau *et al.*, 2008). However, in our model we construct length classes with varying bin width such that individuals grow into the next length class within a single time step as described by Andrews *et al.* (2006), Gurney *et al.* (2007) and Speirs *et al.* (2010). This results in a parsimonious number of length classes for each sex. The use of very small time steps or many narrow length classes can thereby be avoided, improving computational efficiency.

In the model, growth occurs instantaneously at the end of each time step and is irreversible. To incorporate variability in growth into the model, it is assumed that only a fraction, p, of individuals in a length class grows to the next size class within any time step and the remaining fraction, (1-p), of individuals stay at their current size for another time step (Gurney *et al.*, 2007; Speirs *et al.*, 2010). A value of p=0.9 is selected, which limits the variability allowing only 10 % of individuals to remain in their current length class after one time step while keeping the general growth pattern close to the respective von Bertalanffy growth equation.

In order to create the length bins, a development index (q) is defined for each sex as a function of length L (Gurney *et al.*, 2007; Speirs *et al.*, 2010):

$$q \equiv -\ln\left(\frac{L_\infty - L}{L_\infty - L_{min}}\right), \qquad (1)$$

where L_∞ is the respective asymptotic length. At the minimum length at which recruits are assumed to enter the population, L_{min}, q is zero. Following von Bertalanffy growth, q increases linearly with length and tends to infinity as the individual length approaches L_∞. A finite q_{max} can be calculated for an arbitrary maximum length L_{max}, which is slightly less than L_∞. All length classes are of fixed q width (Δq) but varying length bin width: classes are wider (in length) early in life when the individual growth rate is high and decrease as growth slows later in life, when individuals approach asymptotic size.

To ensure growth follows the von Bertalanffy growth equation, it can be shown that in the unexploited population, the increment Δq is set with respect to the growth rate k, growth variability coefficient p and the time step Δt of the model (Speirs *et al.*, 2010):

$$\Delta q = \frac{k\Delta t}{p}. \tag{2}$$

The number of length classes for each sex (n_m, n_f) can then be calculated using the respective sex-specific growth parameters:

$$n_{sex} = \frac{q_{max}}{\Delta q} \tag{3}$$

The total number of length classes in the model, n, is the sum of male, n_m, and female length classes, n_f. The left-hand (lower) boundary of each length class i in terms of the development index is:

$$L_i = L_\infty - (L_\infty - L_{min})\, e^{(-(i-1)\Delta q)}. \tag{4}$$

using L_∞ and Δq for the respective sex. The midpoint of each length class, l_i, is calculated as the mean length of the lower boundary (Equation 4) and the lower boundary of the next larger length class. For the maximum length class of each sex, the respective L_∞ is used as the upper boundary to calculate the midpoint.

The length classes are constructed under the assumption of size-independent mortality. The approach is robust to size-dependent mortality, which directly affects the size distribution while the size distribution of a cohort at any age changes relatively little (Gurney *et al.*, 2007).

Using $N_{i,t}$ to denote the number of individual in length class i at time t, the population dynamics are expressed in difference equations for two sexes and n length classes:

$$N_{i,t+1} = \begin{cases} e^{-(M+F_{i,t})}(1-p)N_{i,t} + \frac{1}{2}R_{t+1} & \text{for } i = 1 \text{ and } i = (n_m + 1) \\ e^{-(M+F_{i-1,t})}pN_{i-1,t} + e^{-(M+F_{i,t})}(1-p)N_{i,t} & \text{for } 1 < i < n_m \text{ and } (n_m + 1) < i < n_f \\ e^{-(M+F_{i-1,t})}pN_{i-1,t} & \text{for } i = n_m \text{ and } i = n_f \end{cases} \quad (5)$$

where R_{t+1} is total recruitment at time t+1 and assumed to be split equally between males and females (entering only the smallest length class).

2.1.1 Mortality

The population is subject to both fishing and natural mortality, which occur simultaneously and continuously through time. Natural mortality is assumed to be constant over time, length and for both sexes. Natural mortality is estimated using the length-based updated Pauly estimator recommended by Then *et al.* (2015) using L_∞ of the larger sex (female):

$$M = 4.118k^{0.73}(L_\infty/10)^{-0.33} \qquad (L_\infty \text{ in mm}) \qquad (6)$$

Fishing mortality at time t and length class i, $F_{i,t}$, is assumed to be separable and can be written as the product of a length-dependent selectivity ogive (logistic curve) and a time-dependent component, f_t, related to the level of fishing effort in the fisheries:

$$F_{i,t} = f_t \frac{1}{1+e^{-v(l_i - L_{50\%})}} e^{\varepsilon_{i,t}} \qquad (7)$$

where $L_{50\%}$ is the length at 50% retention, and v is a constant describing the steepness of the selectivity ogive. A lognormal error is included to allow for variability in fishing mortality, with $\varepsilon_{i,t}$ being normally distributed with $N(0, \sigma_F^2)$ (Figure 1).

Catch in numbers by length class i at time t is calculated according to the Baranov catch equation:

$$C_{i,t} = \frac{F_{i,t}}{M+F_{i,t}}\left(1 - e^{-(M+F_{i,t})}\right)N_{i,t} \tag{8}$$

and total yield (assuming zero discards) are given by:

$$Y_t = \sum_{i=1}^{n} w_i\, C_{i,t} \tag{9}$$

2.1.2 Reproduction

In this model, the smallest length class includes individuals from 100 mm length for either sex. Mature individuals produce offspring at the beginning of the time step and only in the following time step do recruits enter the smallest length class of the population. The maturity ogive is defined as a logistic function with an inflection point around the sex-specific length at 50% maturity, L_{mat} and calculated for the midpoint of each length class l_i (Figure 2):

$$Mat_i = \frac{1}{1+e^{-u(l_i - L_{mat})}} \tag{10}$$

Spawning stock biomass is calculated as the sum of individual weights of all mature individuals in the stock:

$$SSB_t = \sum_{i=1}^{n} Mat_i N_{i,t} a l_i^b \tag{11}$$

The individual weights at length are calculated using sex-specific exponential length-weight relationships with parameters a and b, which are constant over time.

Recruitment is related to the number of mature females in the previous year and is assumed to follow a Beverton-Holt relationship with multiplicative lognormal error (Figure 3a):

$$R_{t+1} = \frac{cNMat_t}{1+dNMat_t} e^{\left(\varepsilon_{t+1} - \frac{\sigma_R^2}{2}\right)} \tag{12}$$

The error ε_{t+1} is normally distributed with N(0, σ_R^2) and is combined with a bias correction term (Thorson and Kristensen, 2016). The specific life history parameters used in the model are listed in Table 1.

2.2 Reference points

The derivation of the reference point for $\overline{L}$, $L_{F=M}$, requires the assumptions that the population is at equilibrium with individuals following deterministic von Bertalanffy growth, natural mortality is independent of size, fishing mortality occurs with knife-edged selectivity. An analytical expression for the calculation of the reference point $L_{F=M}$ was presented by Jardim *et al.* (2015), with $\theta = \frac{k}{M}$ and $\gamma = \frac{F}{M} = 1$:

$$L_{F=\gamma M, k=\theta M} = \frac{\theta L_\infty + (\gamma+1)L_c}{\theta+\gamma+1} \qquad (13)$$

The reference point depends on L_c and stock-specific biological parameters of L_∞, M, and k (females, Table 1). The respective values of L_c are calculated from the 'sampled' catch-at-length data generated with the simulation model. Alternative expected values for the mean length in the catch can be calculated for any given F/M.

We follow the approach by Miethe *et al.* (in prep.) to calculate reference points for $L_{max5\%}$ based on the spawning potential ratio (SPR) using simple per recruit models. For that purpose, $F_{40\%}$ or $F_{60\%}$ and the respective mean length of the largest 5% in the catch are derived. The standardized von Bertalanffy growth equation are used to calculate the expected non-dimensional length distribution in the stock and in the catch, under the assumptions that the population is at equilibrium with individuals following deterministic von Bertalanffy growth, natural mortality independent of size and fishing mortality with knife-edged fishery selectivity. An analytical expression for the mean length of the largest 5% in the catch, $L^F_{max5\%}$, at fishing mortality F can be derived (Miethe *et al.*, in prep.):

$$L^F_{max5\%} = \left(1 - \frac{1}{1+k/(F+M)} 0.05^{\frac{k}{F+M}} \left(1 - \frac{L_c}{L_\infty}\right)\right) L_\infty. \qquad (14)$$

The theoretical mean length of the largest 5% in the catch of an unexploited stock, $L^{0}_{max5\%}$, is calculated from equation equation 14 by setting F=0.

We calculate $L^{F_{x\%}}_{max5\%}$ by solving equation 14 numerically for $F_{40\%}$ and $F_{60\%}$which satisfies SPR=0.4 and SPR=0.6, respectively:

$$\mathrm{SPR} = \begin{cases} \dfrac{\int_{t_{mat}}^{\infty} e^{Ft_c} e^{-(F+M)t} \tilde{L}^b dt}{\int_{t_{mat}}^{\infty} e^{-Mt} \tilde{L}^b dt} & t_{mat} < t_c \\ \dfrac{\int_{t_{mat}}^{t_c} e^{-Mt} \tilde{L}^b dt + \int_{t_c}^{\infty} e^{Ft_c} e^{-(F+M)t} \tilde{L}^b dt}{\int_{t_{mat}}^{\infty} e^{-Mt} \tilde{L}^b dt} & t_{mat} \geq t_c \end{cases} \quad (15)$$

where $\tilde{L} = \frac{L}{L_{\infty}}$ is the standardized length and t_c and t_{mat} are calculated from the respective standardized lengths $\tilde{L}_c$ and $\tilde{L}_{mat}$:

$$t = \frac{-\ln(1-\tilde{L})}{k}. \quad (16)$$

In the harvest control rules, we test a constant reference point for $L_{max5\%}$, using the maximum of defined $L^{F_{40\%}}_{max5\%}$ or $L^{F_{60\%}}_{max5\%}$for the larger sex (females). Reference points are calculated for L_c ranging from 350 to 700 mm illustrated in Figure 4 and Figure 5.

2.3 Simulation scenarios and harvest control rules

To evaluate the performance of indicator-based HCRs, we make use of a MSE framework and consider a number of different scenarios with respect to selectivity of the fishery, natural mortality and reference points. Robustness of HCRs to selectivity is investigated through alternative scenarios with regard to $L_{50\%}$ of the selectivity ogive. For the baseline model runs, $L_{50\%}$ is 600 mm which is just above the maturation size of females. For comparison, we run scenarios with an $L_{50\%}$ of 450mm (i.e. smaller than L_{mat}) and with $L_{50\%}$ of 600 mm (greater than L_{mat}).

Each scenario is simulated 1000 times. The simulations are run for a total of 150 years to allow observation of the full recovery cycle with TAC (total allowable catch) management using the HCR. All simulations are carried out in R (R Core Team, 2017). Each simulation is initiated with a stock at the unexploited equilibrium and with stochastic recruitment. After 10 years without exploitation, the fishery is assumed to begin, initially with a constant catch (TAC) at a level which causes the stock to be overexploited. Then from year 40 onwards when a TAC management is implemented, catch is defined by an indicator-based HCR.

Two HCRs, which update the TAC on a quadrennial basis, are tested within the MSE framework. The HCRs are referred to as HCR $L_{max5\%}$ and HCR $\bar{L}$, and are based on the respective length-based indicators and reference points. In each HCR, the future TAC is assumed to be proportional to the current TAC (year t) and a time-dependent multiplier, calculated as the ratio of the average of the length-based indicator (LBI) in the previous four years to the respective reference point (Ref):

$$\mathrm{TAC}_{t+1} = \frac{1}{4}\sum_{k=t-4}^{t-1}\frac{\mathrm{LBI}_k}{\mathrm{Ref}} \times \mathrm{TAC}_t \qquad \text{where } t = 40, 44, 48, \ldots \tag{17}$$

The initial TAC for time 10 to 40 is constant. For the simulation of an overexploited stock and given selectivity ogive, the initial TAC is set to a value to allow for median SSB to fall below 40%SPR in the first 40 years of the simulation.

The annual TAC change after t=40 is limited to ±15 %. Truncation of the length distribution will first be visible in the larger sex (in this case females) if both sexes are exploited equally. Therefore the HCRs are based only on the female indicators and reference points. The reference points are derived using analytical models as detailed in the following section 2.1.

To test misspecification in M or M/k, reference points are calculated with ±10% error and HCRs evaluated.

For a given TAC, the annual fishing mortality multiplier, f_t (equation 7), is derived by numerically solving equation 7-9. The value of f_t is limited to a maximum of 6.0, to avoid infinite values of fishing mortality as the population declines to zero. The numerically derived f_t is then used to calculate catch-at-length data and project the population for the next time step. To account for observation error introduced through the sampling process, ‘sampled’ catch-at-length data are generated by randomly selecting 0.1 % of the total number of individuals in the catch from the model-simulated empirical catch-length distribution.

Length-based indicators, $L_{max5\%}$ and $\bar{L}$, are calculated from the ‘sampled’ catch-at-length data for use in the HCR. $\bar{L}$ is calculated as the mean length of individuals larger than L_c (the length at first capture), the length at which the frequency reaches 50 % of the mode on the left hand side of the distribution (Jennings *et al.*, 2001; ICES WKLIFE, 2012). L_c of the ‘sampled’ catches is then equivalent to the $L_{50\%}$ of the selectivity ogive, and it corresponds to L_c in the analytical model with knife-edge selectivity to determine the reference points.

For each scenario and HCR, we calculate the annual probability of being below 0.25 SSB_0 (25% of unexploited spawning stock biomass) and 0.4 SSB_0. The risk of falling below 0.25 SSB_0 and 0.4 SSB_0 after implementation of the HCR (year 40) is determined for each 10-year period as the maximum annual probability of being below the respective SSB threshold. The duration of recovery from overexploitation, defined as the number of years to recover median SSB to 0.4SSB_0 with implementation of HCR, is compared between HCRs. The variability in yield at the end of the simulated time period is calculated as the standard deviation across 1000 simulations of the final five years.

3 Results

In a first step, we investigate the performance of HCR using $L_{max5\%}$ and a reference point based on 40%SPR assuming the correct knowledge of M. At L_c=450 and constant TAC of 600t (without HCR) starting in year 10, the simulated stocks are overexploited and collapse in all 1000 simulation in less than 90 years of exploitation (Figure 6). In this case, the L_c is lower than L_{mat}. A HCR starting in year 40 based on $L_{max5\%}$ with a reference point representing 40%SPR, does not recover an overexploited stock (Figure 7, Table 3). As the indicator $L_{max5\%}$ is slightly above the reference point under non-equilibrium conditions, the TAC is even allowed to increase with start of the HCR promoting overexploitation. Alternatively, we evaluate the performance of a more precautionary HCR based on $L_{max5\%}$

and SPR of 60%. A higher percentage of simulations result in recovery of the overexploited stock and reduce the risk of falling to low levels of SSB (Figure 8). The risk of being below 25% and 40% SSB at the end of the simulation period is lower than 10% (Table 3). A harvest control rule based on $\bar{L}$ and the reference point $L_{F=M}$ does not perform well enough in a MSE to recover an overexploited stock (Figure 9). Median values for SSB, recruitment and indicators are compared for these three HCR options in Figure 10. This highlights that an HCR approach based on the mean length and reference point $L_{F=M}$ performs better than $L_{max5\%}$ with 40%SPR. And at low values of L_c the indicator $L_{max5\%}$ can be useful when applied with a more precautionary reference point of SPR=60%.

Fishing mortality only on mature individuals (L_c>L_{mat}) facilitates stock recovery. For L_c=600, a proportion of mature individuals are not subject to fishing mortality. In the absence of a HCR, a constant TAC of 725t leads to a collapse of SSB to very low levels, but some recruitment can occur. In this case, all three HCR can lead to recovery of overexploited stocks (Figure 12-Figure 14, Table 4). The risk of collapse decreases in scenarios with higher values of L_c. At high values of L_c, HCR $L_{max5\%}^{F60\%SPR}$ and HCR $\bar{L}_{F=M}$were more precautionary with fast recovery, but can lead to reduction in potential yield as the simulated stocks recover to SPR levels well above 40% (Table 5, Figure 15). The risk of being below 40% SSB at the end of the simulation period decreased to 6% also for HCR $L_{max5\%}^{F40\%SPR}$.

Figure 4 and Figure 5 suggest that a reference point for $\bar{L}$ based on SPR can help to protect SSB and prevent stock collapse. Also, due to non-equilibrium dynamics, simulated indicator values of a stock being overexploited with decreasing SSB are further away from their theoretical values when L_c is low (<L_{mat}).

The comparison of stock status to indicator values from all simulations are illustrated in Figure 16. For the $L_{max5\%}$ reference point based on SPR 40%, there is a mismatch between SPR and indicator ratio. At lower values of L_c, the indicator ratio may point to sustainable exploitation while the SPR in actually below 40% (lower right quadrant of plot). A reference point of SPR=60% reduces the risk of SPR to fall below 20% substantially. In this case, with an indicator ratio above 1, one can safely assume the stock is not at risk to collapse (SPR in simulations remains above 20%). The mean length not necessarily coincides with its reference point at SPR 40%. The results are dependent on L_c (Figure 16c). At low values of L_c, simulated stocks may have SPR lower than 40% while the reference points indicate sustainable exploitation.

A misspecification of M, will lead to inappropriate reference points. If M is underestimated, reference points are higher (Table 2) and HCRs become more precautionary as indicator and reference points trigger a reduction in TAC at higher levels of SPR (Figure 17). Thereby, and underestimation reduces the risk of collapse and but also reduces the expected equilibrium yield. In contrast, if M is overestimated, reference points are lower and less precautionary. Indicators and reference points can fail to identify low levels of SPR. This is a problem in particular at low values of L_c (Figure 20). The risk of being below SSB thresholds increases (Table 6). In all scenarios risks were lower for HCR $L_{max5\%}^{F60\%}$, followed by HCR $\bar{L}_{F=M}$. The effect of misspecification of M is rather small when L_c is high (Figure 20). Stocks continue to be recovered using all the three HCRs, and risk of being below SSB thresholds are low at the end of the simulation period remains below 5% for L_c=600 for HCR $L_{max5\%}^{F60\%}$ and HCR $\bar{L}_{F=M}$ (Table 7).

4 Discussion

Elasmobranchs differ in their life histories from other fish species. Elasmobranch stock with a M/k ratio larger than 1 are likely to exhibit enough truncation in catch length distributions in response to overexploitation to allow for an application of the indicator $L_{max5\%}$ to monitor stock status. Due to the relatively large maturation size, the longer generation time and the particular reproductive strategy, the management of these stocks (even with high M/k) may be more challenging. The reference points need to be carefully selected.

The reference point $L_{F=M}$ is sensitive to the estimation of L_c. A HCR based on the mean length and $L_{F=M}$ does not perform well when length at first capture is well below maturation size (Jardim *et al.*, 2015). This is due to the fact that the analytical reference point $L_{F=M}$ is independent of maturation schedule and depends on the assumption of constant recruitment. For elasmobranch stocks, which mature at relatively large size, this assumption can be a problematic when the number of mature females in the stock falls to low levels.

The relatively slow life history will cause some delay of new recruits to achieve lengths close to maturation size or close to L_∞. The number of recruits in elasmobranch stocks is closely linked to the number of mature females. Therefore, the potential of very large cohorts when SSB is low, and the recovery of a stock is closely linked to the abundance of mature females. Reference points that take into consideration the maturation schedule of a stock are preferable. It has been suggested for stocks with a very steep stock-recruitment relationships, where a reduction in SSB causes a strong reduction recruitment, a SPR of 60% can reduce the risk of SSB to fall below 20%SPR (Clark, 2002). We find that in particular when immature individuals are targeted by the fishery, more precautionary reference points are recommended, i.e. SPR>40% (60%).

At larger size at first capture, well above L_{mat}, HCR based on $L_{F=M}$, 40%SPR or 60%SPR reference points tends to be precautionary and can lead to stock recovery. The reference points for $L_{max5\%}$ based on 60%SPR and $L_{F=M}$ are overly precautionary at high values of L_c and may lead to some loss of long term yield.

For elasmobranch stocks for which L_c can be estimated with low uncertainty to be continuously well above L_{mat}, reference points relating to SPR of 40% or $L_{F=M}$ may suffice. For low values of L_c and uncertainty in parameter estimates a more precautionary approach

(SPR=60%) is advised. This precautionary approach can further buffer against parameter misspecification. For example, an overestimation of M leads to lower reference points and can limit the recovery of an overexploited stock for low values of L_c. At high levels of L_c, with protection of immatures, a misspecification of M is less problematic. In general, if possible ensuring $L_c > L_{mat}$ best supports any management approach for these stocks. Whenever this is not an option, it is recommended to use a SPR approach of 60%. The larger and later maturing elasmobranchs stocks are expected to be more vulnerable and have increased risk of collapse and may require even lower levels of fishing mortality when immatures are targeted.

5 Table and Figures

Table 1. Parameters *L.naevus*, using life history characteristics for Irish Sea stock.

Description	parameter	value	unit	reference
Von Bertalanffy growth	K (male)	0.294		Gallagher *et al.* (2005b)
	K (female)	0.197		
	L_{∞} (male)	746	mm	
	L_{∞} (female)	839	mm	
Natural mortality	M (male)	0.406		Then *et al.* (2015)
	M (female)	0.292		
Life history ratio M/K	M/K (male)	1.38		
	M/K (female)	1.48		
Maximum length to determine number of classes	L_{max} (male)	745.5	mm	0.5 below L_{∞}
	L_{max} (female)	838.5	mm	
Minimum modelled length	L_{min}	100	mm	ICES 2004
Growth variability constant	p	0.9		
Times step	Δt	1		
Length at 50% retention	$L_{50\%}$	400	mm	
Selectivity ogive constant	v	0.07		
Standard deviation of $\varepsilon_{t,i}$ (fishing mortality)	σ_F	0.1		
Length-weight relationship	a' (male)	0.0041	g cm^{-b}	McCully *et al.* (2012) to mm a=a'10^{-b}
	a' (female)	0.0035		
	b (male)	3.105	g cm^{-b}	
	b (female)	3.147		
Size at 50% maturity	L_{mat} (males)	568.7	mm	Gallagher *et al.* (2005b)
	L_{mat} (females)	561.6	mm	
Maturity ogive constant	u	0.06		
Recruitment relationship	c	6		
	d	6*10^{-7}		
Standard deviation of ε_{t+1} (fecundity)	σ_{Rec}	0.08		

Table 2. Reference points $L_{max5\%}^{Fx\%SPR}$ for females, using different assumptions on M (±10%) and SPR.

M for reference point calculation	M/k	SPR=40%	SPR=60%
0.9M=0.262	1.33	775	799
M=0.292	1.48	765	791
1.1M=0.321	1.63	756	783

Table 3. Risks to fall below SSB thresholds, in 1000 simulations, L_c=450, initial TAC of 600t.

	Year 91-100	101-110	111-120	121-130	131-140	141-150	HCR
0.25 SSB	100	100	100	100	100	100	No rule
0.40 SSB	100	100	100	100	100	100	
0.25 SSB	100	100	100	100	100	100	$L_{max5\%}^{F40\%}$
0.40 SSB	100	100	100	100	100	100	
0.25 SSB	36	22.2	13.9	8.8	6.9	6.4	$L_{max5\%}^{F60\%}$
0.40 SSB	98.6	89.1	57.8	22.4	9.7	6.9	
0.25 SSB	96	95.8	94.1	91.7	87.5	85	$\bar{L}_{F=M}$
0.40 SSB	100	100	100	99.6	98.7	93.5	

Table 4. Risks to fall below SSB thresholds, in 1000 simulations, L_c=600, initial TAC of 725t.

	Year 91-100	101-110	111-120	121-130	131-140	141-150	HCR
0.25 SSB	100	100	100	100	100	100	No rule
0.40 SSB	100	100	100	100	100	100	
0.25 SSB	52.8	14.7	0.8	0	0	0	$L_{max5\%}^{F40\%}$
0.40 SSB	100	98.7	78.5	33.5	10	6	
0.25 SSB	0	0	0	0	0	0	$L_{max5\%}^{F60\%}$
0.40 SSB	2.1	0	0	0	0	0	
0.25 SSB	0	0	0	0	0	0	$\bar{L}_{F=M}$
0.40 SSB	49.9	5.7	0.1	0	0	0	

Table 5. Comparison of recovery duration (years), median yield (tonnes) and standard deviation, L_c=600, initial catch of 725t, 1000 simulations.

HCR	Duration recovery (SSB>0.4SSB$_0$)	Median yield (year 145-150)	SD in yield
No rule	-	268	22.9
$L_{max5\%}^{F40\%}$	77	558	39.7
$L_{max5\%}^{F60\%}$	39	482	14.9
$\bar{L}_{F=M}$	51	470	15.1

Table 6. Risks to fall below SSB thresholds, in 1000 simulations, L_c=450, initial TAC of 725t, with overestimated M.

	Year 91-100	101-110	111-120	121-130	131-140	141-150	HCR
0.25 SSB	100	100	100	100	100	100	No rule
0.40 SSB	100	100	100	100	100	100	
0.25 SSB	100	100	100	100	100	100	$L_{max5\%}^{F40\%}$
0.40 SSB	100	100	100	100	100	100	
0.25 SSB	96.2	95.4	92.9	89.3	84.7	80.1	$L_{max5\%}^{F60\%}$
0.40 SSB	100	100	100	99.3	95.6	89.2	
0.25 SSB	100	100	100	100	100	100	$\bar{L}_{F=M}$
0.40 SSB	100	100	100	100	100	100	

Table 7. Risks to fall below SSB thresholds, in 1000 simulations, L_c=600, initial TAC of 725t, with overestimated M.

	Year 91-100	101-110	111-120	121-130	131-140	141-150	HCR
0.25 SSB	100	100	100	100	100	100	No rule
0.40 SSB	100	100	100	100	100	100	
0.25 SSB	98	82.4	26.7	2	0	0	$L_{max5\%}^{F40\%}$
0.40 SSB	100	100	97.2	62.3	12.2	3.4	
0.25 SSB	0	0	0	0	0	0	$L_{max5\%}^{F60\%}$
0.40 SSB	48.4	7.6	0.8	0.1	0	0	
0.25 SSB	0.5	0.1	0	0	0	0	$\bar{L}_{F=M}$
0.40 SSB	91.7	52.7	8.2	0.7	0	0	

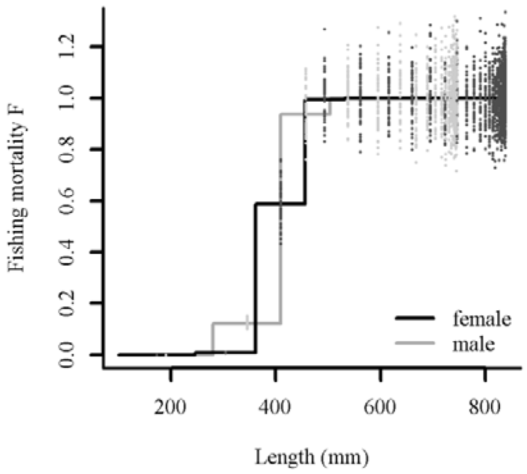

Figure 1. Fishing selectivity (f=1, L_c=400).

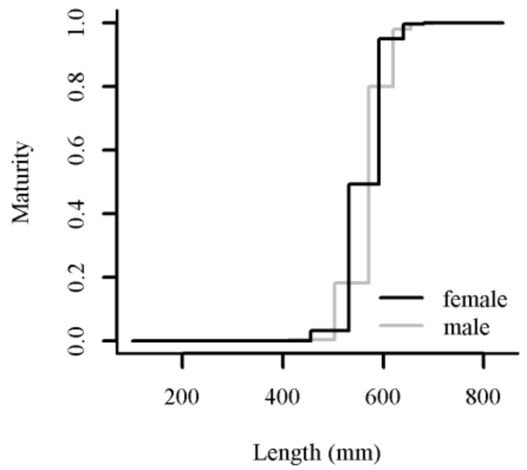

Figure 2. Maturity ogive for males and females

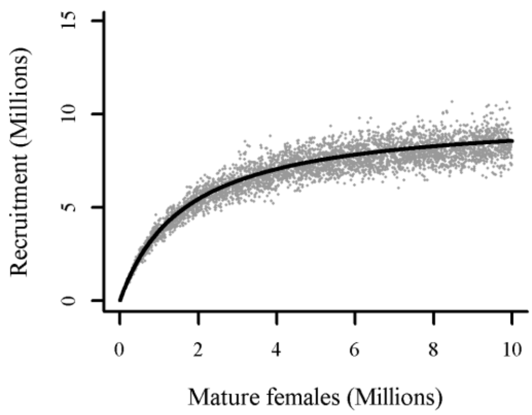

Figure 3. Spawner-recruitment relationship

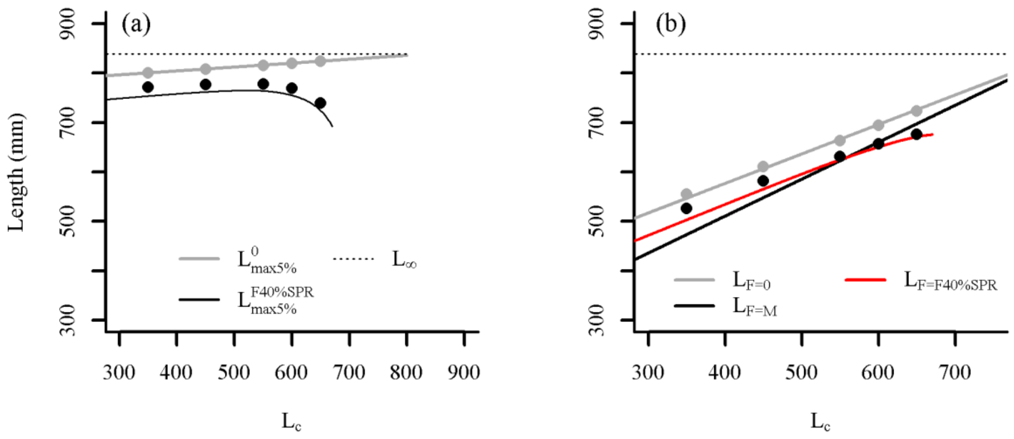

Figure 4. Reference points $L^{F40\%}_{max5\%}$ and $L_{F=M}$ for different values of L_c. Simulated values of overexploited stock at SPR=40% (dots). Theoretical mean length at SPR=40% in red.

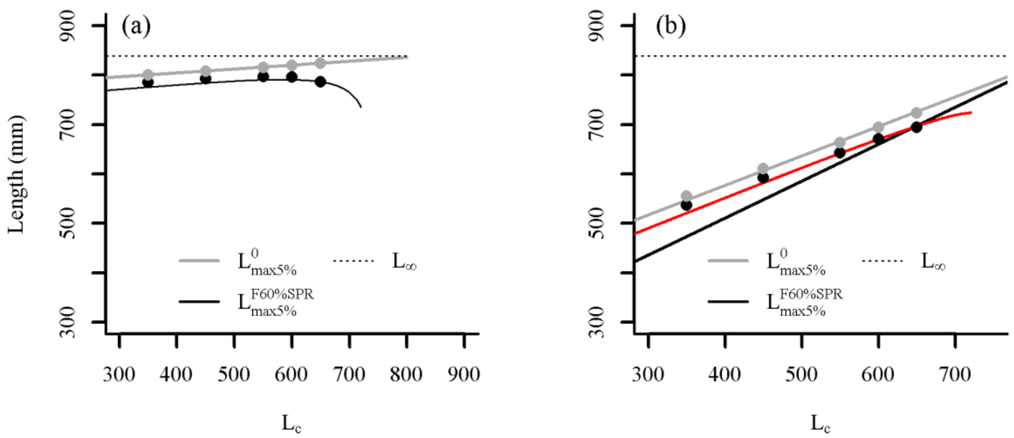

Figure 5. Reference points $L^{F60\%}_{max5\%}$ and $L_{F=M}$ for different values of L_c (in mm). Simulated values of overexploited stock at SPR=60% (dots). Theoretical mean length at SPR=60% in red.

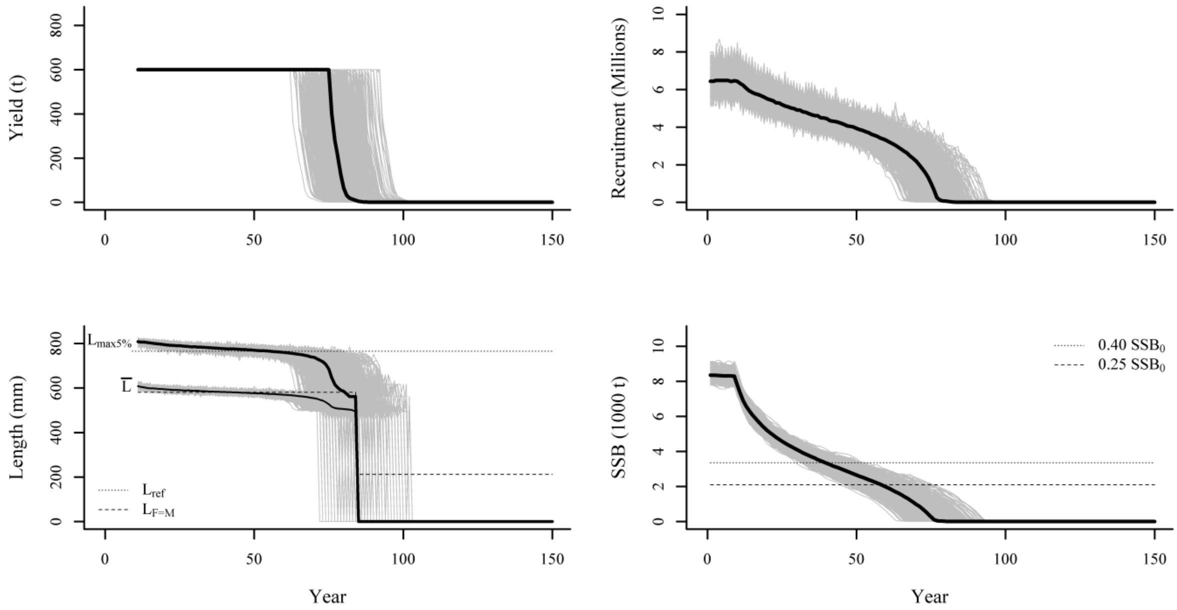

Figure 6. No HCR, L_c=450, initial TAC of 600t, 1000 simulations, simulated stocks collapse.

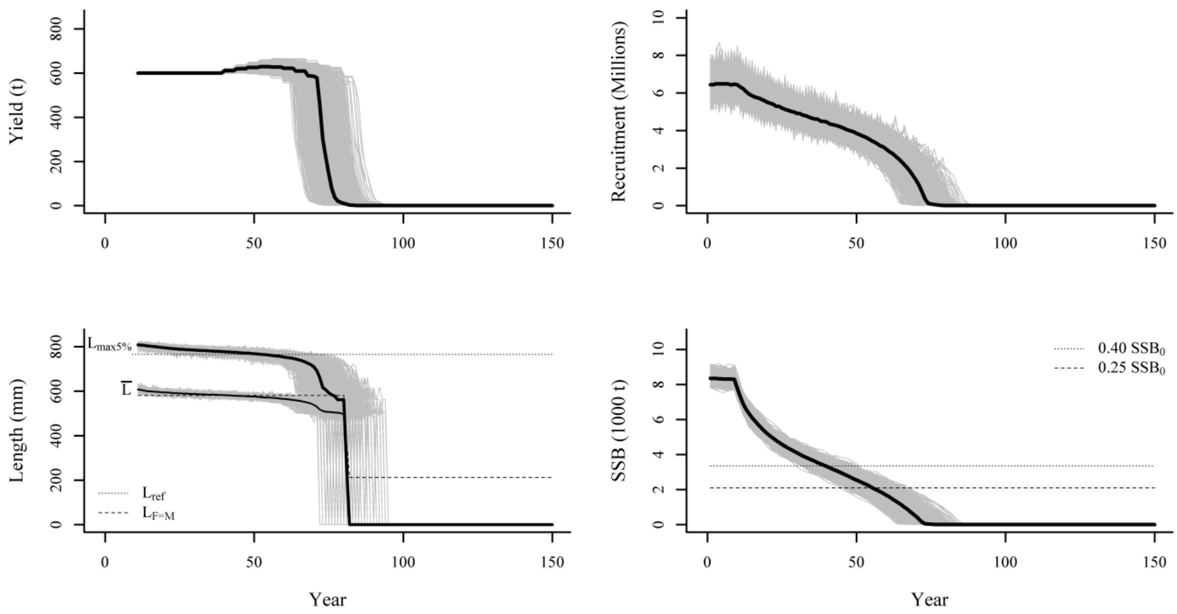

Figure 7. HCR $L_{max5\%}^{F40\%SPR}$, L_c=450 initial TAC of 600t, 1000 simulations.

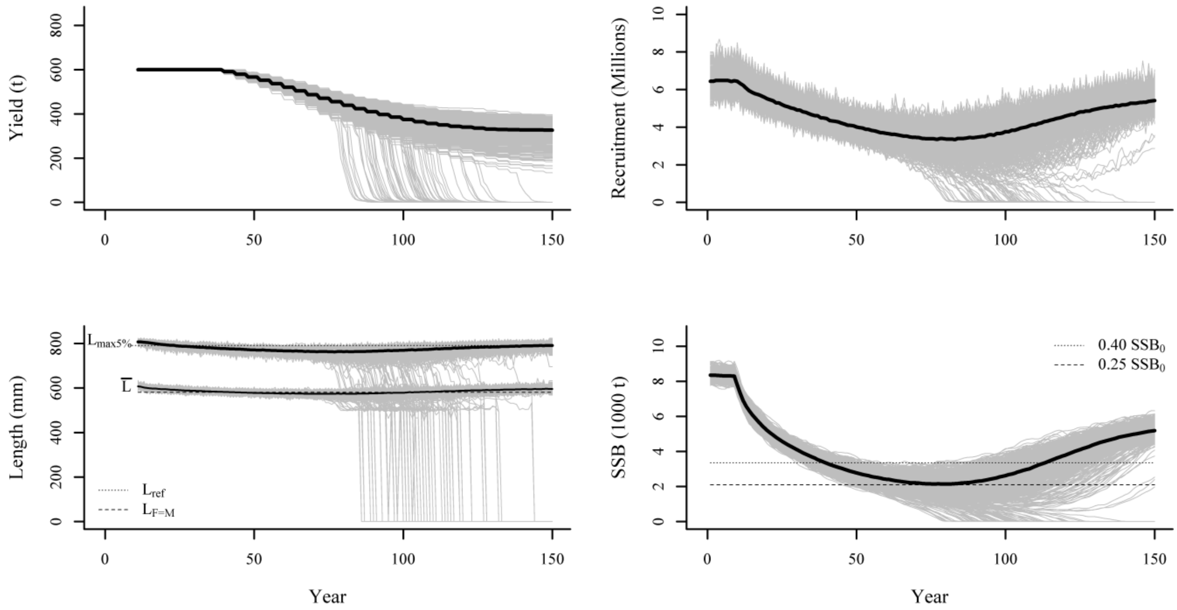

Figure 8. HCR $L_{max5\%}^{F60\%SPR}$, L_c=450, initial TAC of 600t, 1000 simulations.

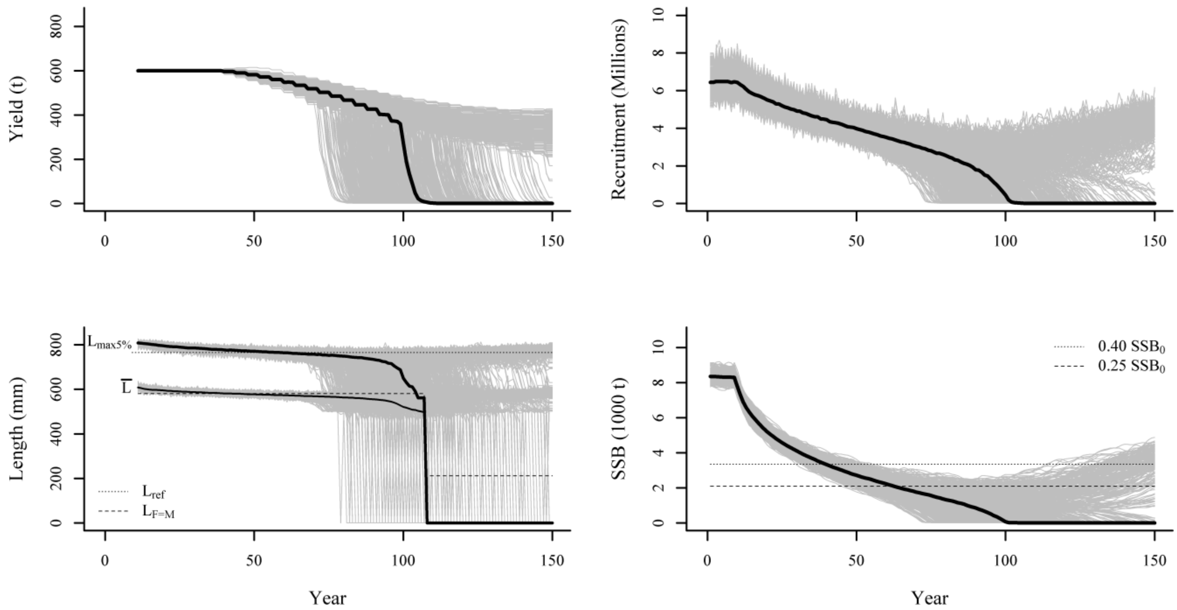

Figure 9. HCR $\overline{L}$, L_c=450, initial TAC of 600t, 1000 simulations.

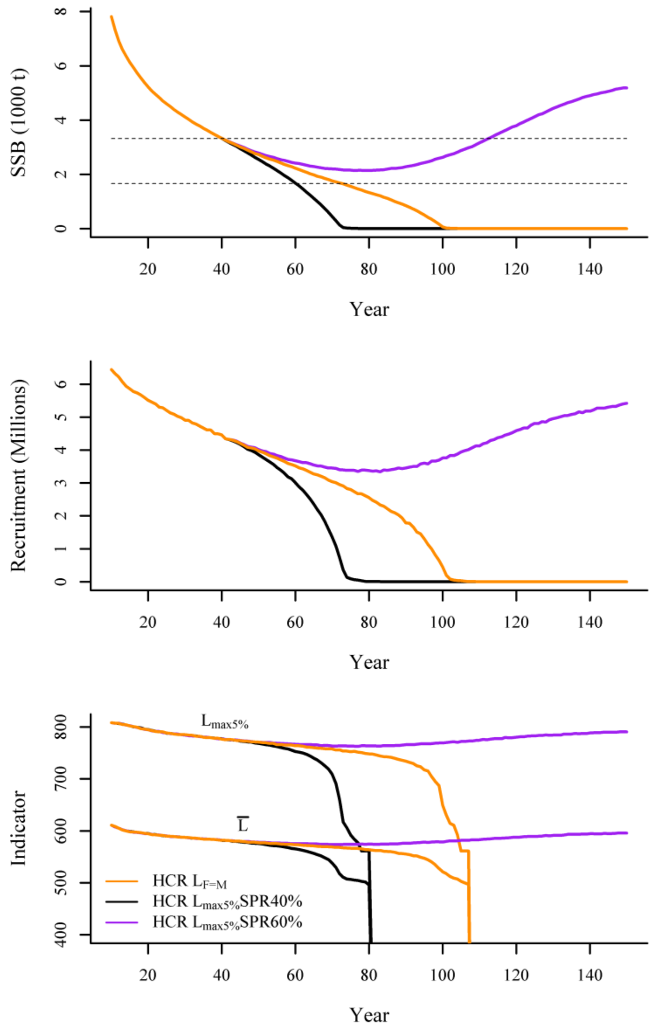

Figure 10. Comparison of simulation results for HCRs at L_c=450, plotted are median values for SSB, recruitment and two length-based indicators from catches (in mm).

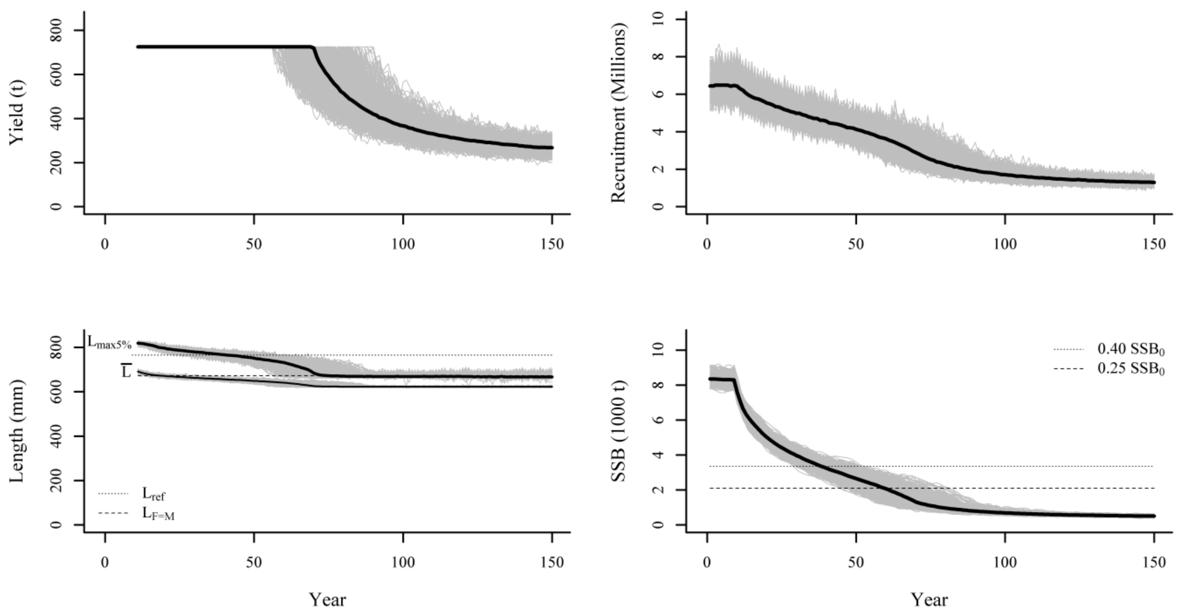

Figure 11. No HCR, L_c=600, initial TAC of 725t, 1000 simulations, simulated stocks collapse.

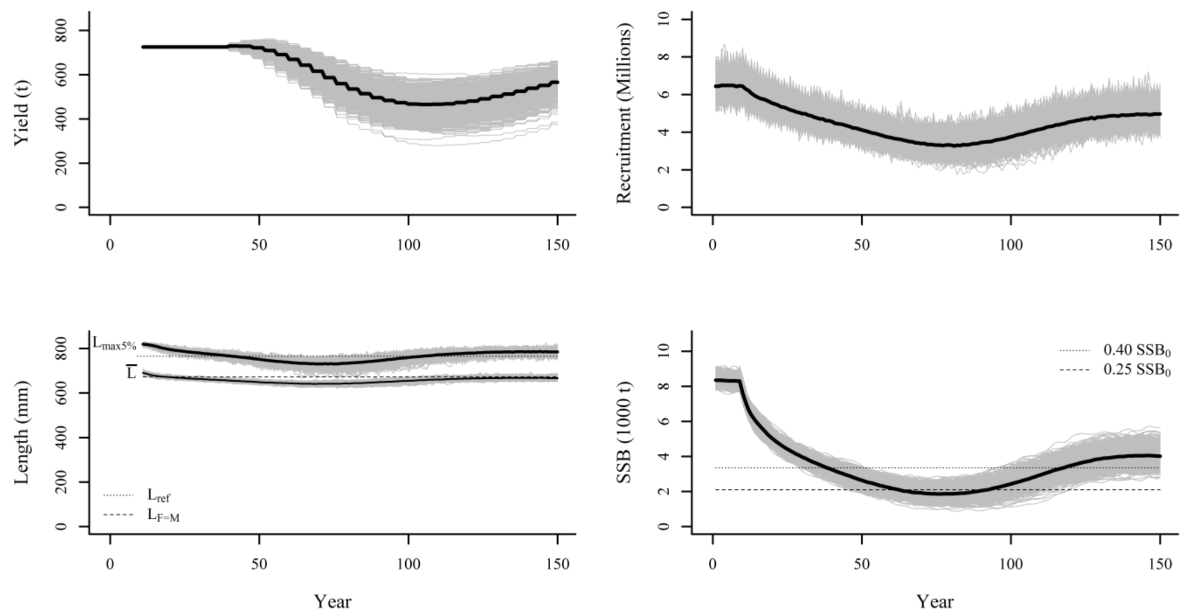

Figure 12. HCR $L_{max5\%}^{F40\%SPR}$ L_c=600, initial TAC of 725t, 1000 simulations.

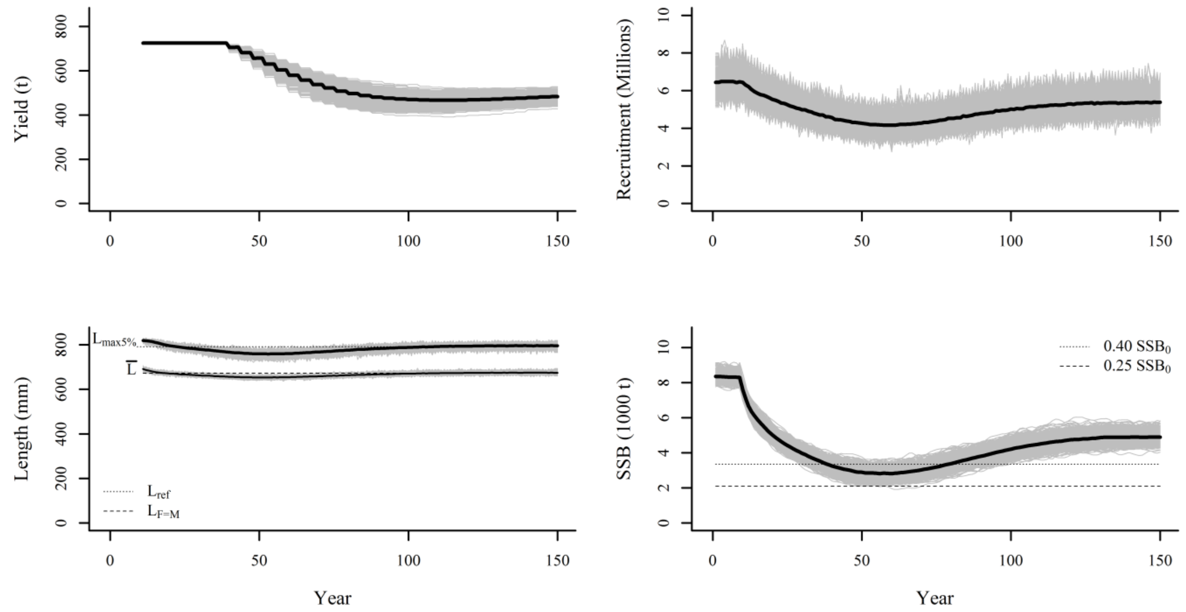

Figure 13. HCR $L_{max5\%}^{F60\%SPR}$, L_c=600, initial TAC of 725t, 1000 simulations.

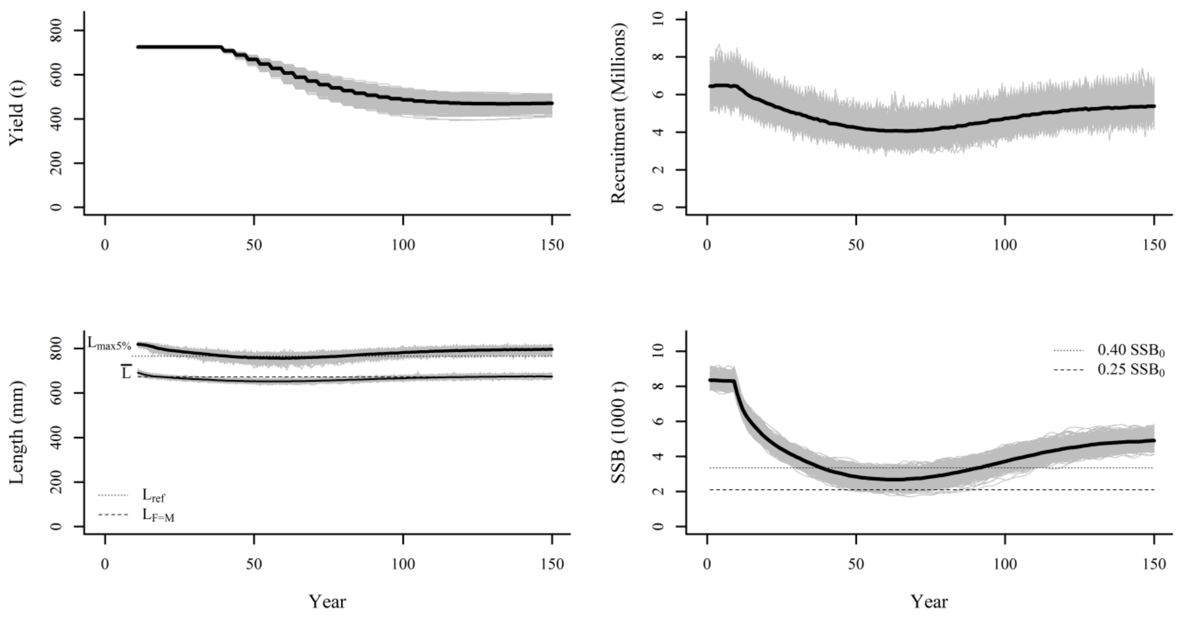

Figure 14. HCR L̄, L_c=600, initial TAC of 725t, 1000 simulations.

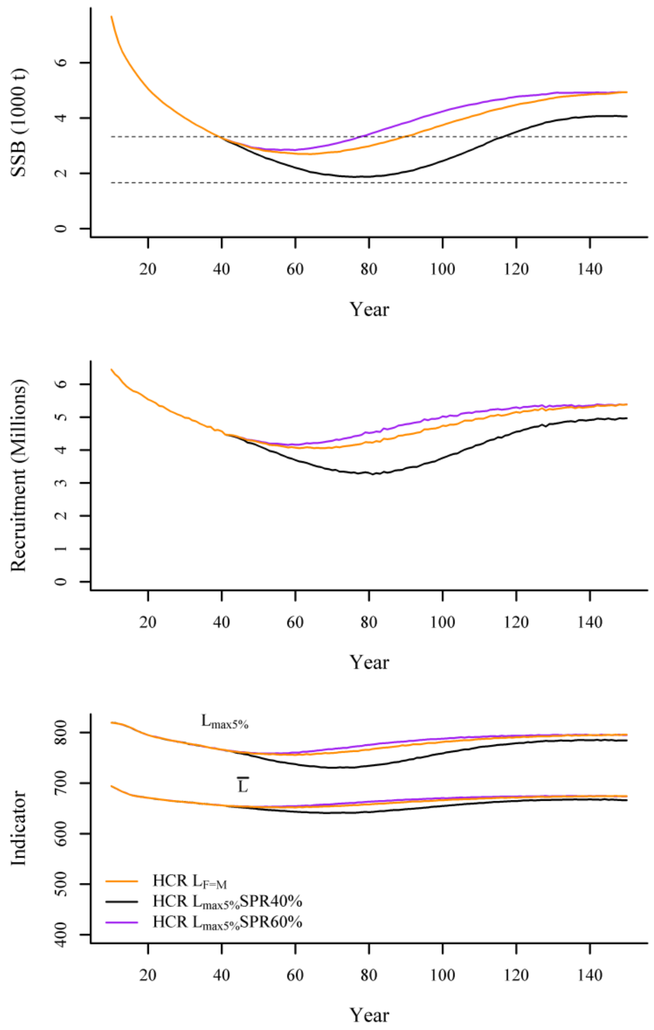

Figure 15. Comparison of simulation results for HCRs at L_c=600, plotted are median values for SSB, recruitment and two length-based indicators from catches (in mm).

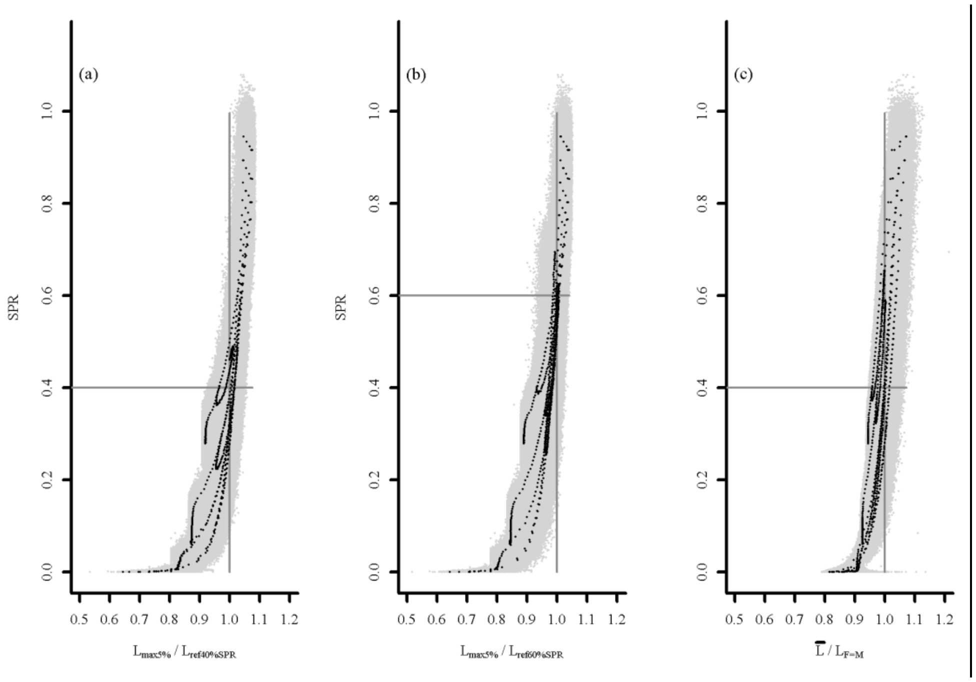

Figure 16. Stock status compared to indicator ratios for scenarios L_c is 350, 450, 550, 600, 650. Relationship between SPR and ratio indicator and reference point (a) 40%SPR, (b) 60%SPR and (c) $L_{F=M}$.

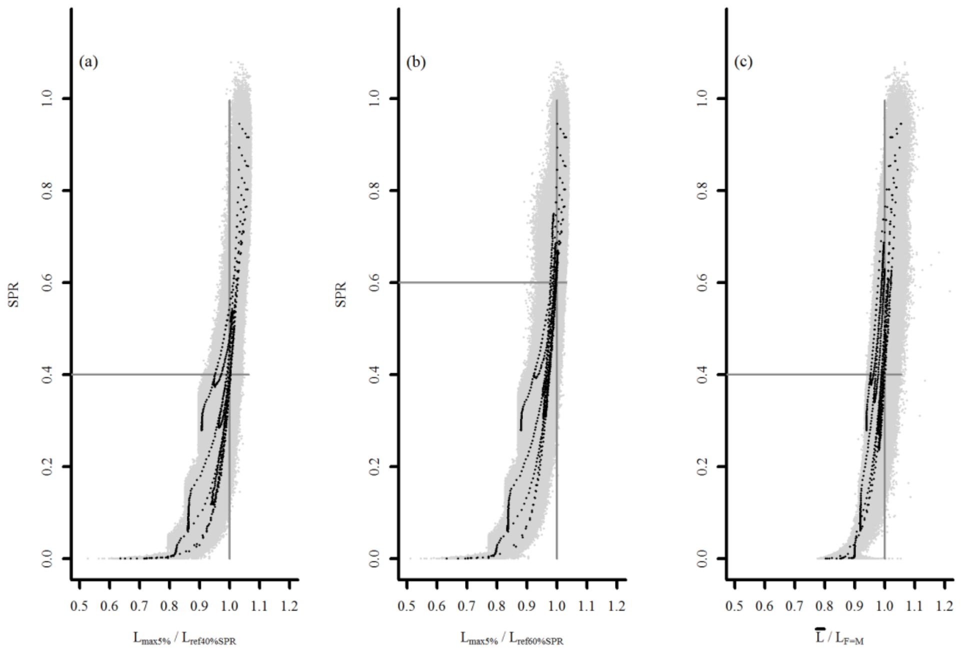

Figure 17. Misspecification of M (-10%). Stock status compared to indicator ratios for scenarios L_c is 350, 450, 550, 600, 650. Relationship between SPR and ratio indicator and reference point (a) 40SPR%, (b) 60%SPR and (c) $L_{F=M}$.

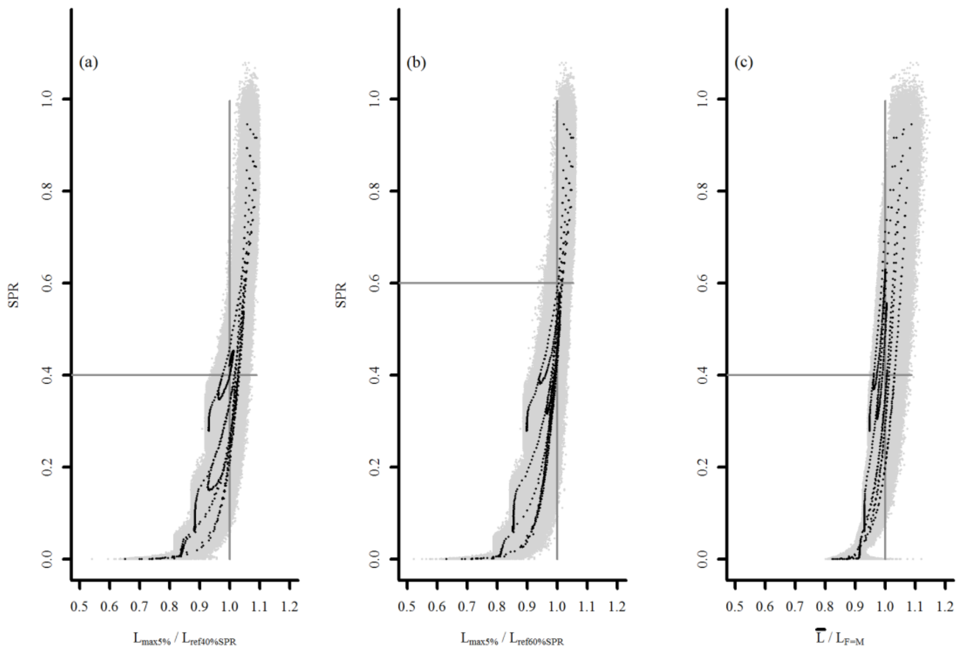

Figure 18. Misspecification of M (+10%). Stock status compared to indicator ratios for scenarios L_c is 350, 450, 550, 600, 650. Relationship between SPR and ratio indicator and reference point (a) 40%SPR, (b) 60%SPR and (c) $L_{F=M}$.

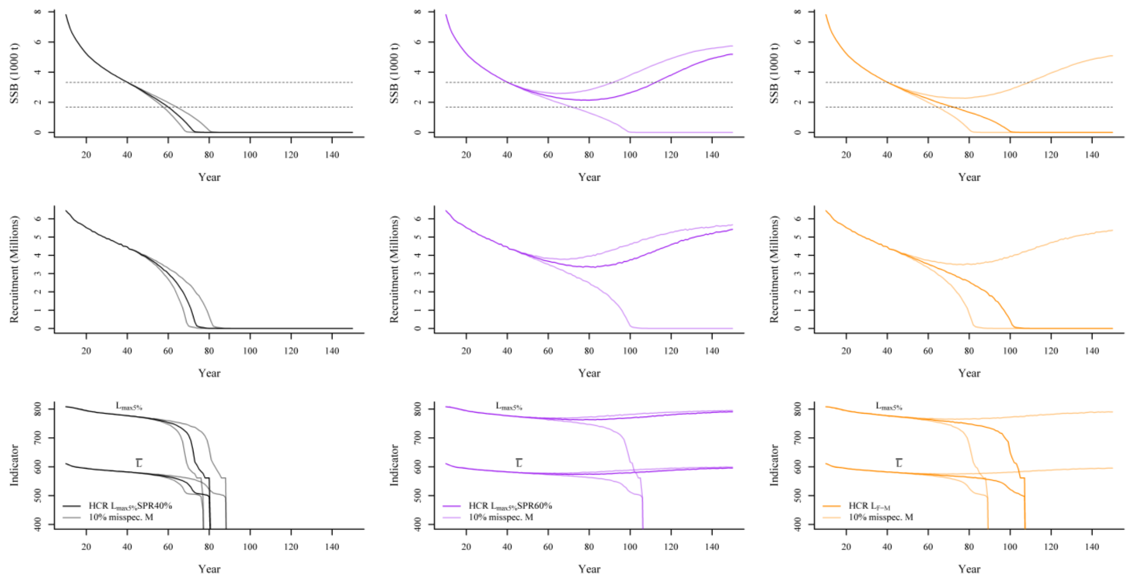

Figure 19. Misspecification of M (±10%). Stock status compared to indicators for L_c=450. HCR used reference points relating to 40%SPR (black), 60%SPR (purple) and $L_{F=M}$ (orange).

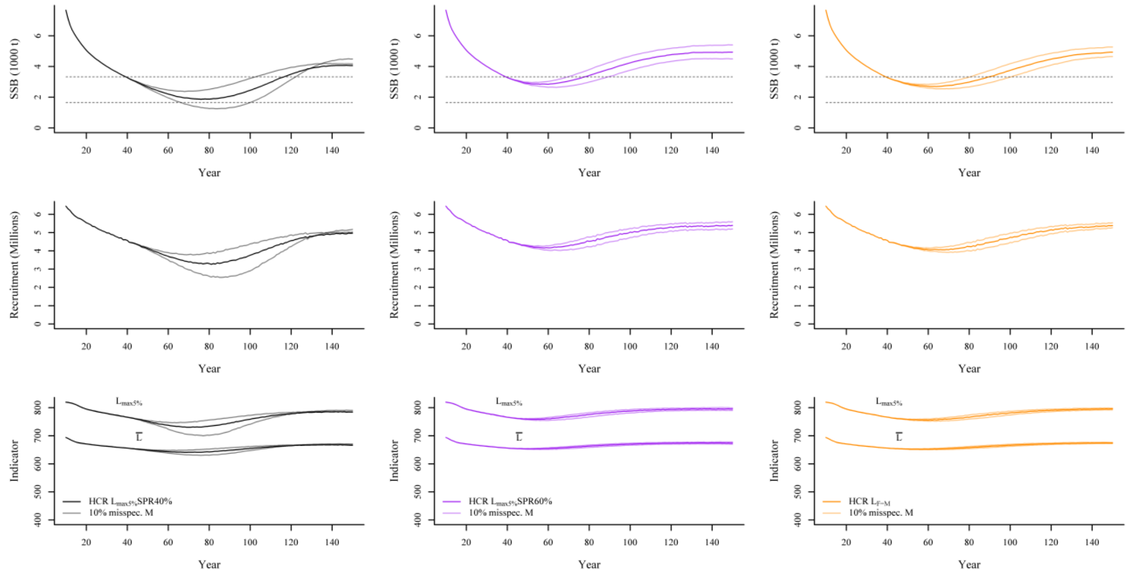

Figure 20. Misspecification of M (±10%). Stock status (SSB and recruitment) compared to indicators for L_C=600. HCR used reference points relating to 40%SPR (black), 60%SPR (purple) and $L_{F=M}$ (orange).

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STANDARDIZED CATCH RATES FOR THORNBACK RAY (ska.27.10a2) FROM THE AZOREAN BOTTOM LONGLINE FLEET (1990-2016)

Régis V. S. Santos[1*], Ana M. Novoa-Pabon[1], Helder M. da Silva[1], João G. Pereira[1], Mario R. Pinho[1]

ABSTRACT

Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2016. The CPUE of thornback ray was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were: year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE showed an oscillation over time, with an increasing trend from 2007 to 2015; while the standardized index presented a more stable trend overall.

KEYWORDS

Raja clavata; demersal fisheries; CPUE; abundance; Azores; GLMM

Introduction

The Azorean fishery for demersal species has traditionally been a multispecific fishery, where several types of hooks and gears are used by the local fleet. The demersal fishing fleet consists mainly of small scale boats (length < 12 m), mostly equipped with handlines and bottom longlines. The thornback ray (*Raja clavata*) is the main elasmobranch species caught by the Azorean bottom longline fleet, which directs its effort to the other demersal fish species such as red seabream (*Pagellus bogaraveo*), bluemouth rockfish (*Helicolenus dactylopterus*), wreckfish (*Polyprion americanus*), forkbeard (*Phycis phycis*), conger eel (*Conger conger*) and alfonsinos (*Beryx splendens* and *Beryx decadactylus*) (Pinho and Menezes, 2005; Menezes *et al*., 2009; Diogo *et al*., 2015; Pinho *et al*., 2015).

The most important commercial elasmobranchs species caught in the Azores area are the blue shark (*Prionace glauca*) from the Portuguese mainland and Spanish pelagic fisheries, and kitefin shark (*Dalatias licha),* tope (*Galeorhinus galeus)* and thornback ray *(Raja clavata)* from local

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demersal/deep-water fisheries (Santos *et al*., 2018). Other species are caught but discarded, due to low commercial value or because of management measures introduced.

Indices of abundance from commercial fisheries have been used to tune stock assessment models (Quinn and Deriso, 1999, Maunder and Punt, 2004), and their use have been strictly recommended by the International Council for the Exploration of the Sea (ICES) for the stocks advice. The utility of indices of abundance based on nominal catch rates can be improved by standardizing them to remove the impact of factors other than changes over time in stock biomass, usually by using statistical regression methods (Ortiz and Arocha, 2004).

This study aimed to standardize the catch rates for thornback ray captured by the Azorean bottom longline fleet through 2016, using a Generalized Linear Mixed Model with random factor interactions particularly for the *Year* effect.

Material and methods

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAç), and was collected during the period of 1990–2016 as part of the mandate of the Data Collection Framework (DCF). Sampling was designed to cover the main ports of the Azores and was performed by clerks who carried out standardized fishing inquiries (n = 9275) to the captains of the bottom longline vessels during the landings. Each record report included: the vessel identification, the dates of departure and return to the port and detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, fishing area and catch in weight for each species landed.

Thornback ray is the main elasmobranch species caught by the Azorean bottom longline fleet and was reported in 33% of the trips (**Fig. 1**), representing up to 5% of the total catch landed along the studied period (**Fig. 2**). Factors considered in the analyses of the thornback ray catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: *São Miguel*, *Terceira* and *Faial*, which represent around 95% of the Azorean landings, and *Others*, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Pinho and Menezes, 2005; Menezes *et al*., 2006), and target (**Table 1**). The target was defined as the percentage of thornback ray catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of thornback ray caught per 1000 hooks. Records with missing effort data were excluded from the analysis.

Relative indices of abundance for the thornback ray species were estimated by Generalized Linear Modeling approach using a hurdle (delta) model (Lo *et al*., 1992; Ortiz and Arocha, 2004; Zuur and Ieno, 2016). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modeling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modeling the positive catch rates on successful trips.

Deviance tables were used to select the explanatory factors and interactions that explained most of the variability in the data (Ortiz and Arocha, 2004). The effect of each explanatory factor/interaction was evaluated according to: 1) the percent of deviance explained by the addition of a specific factor/interaction to the model, and 2) the result of the Chi-squared (χ^2) test between two nested models. Only those factors and interactions that accounted for 5% or more of the variability were selected as explanatory variables.

After selecting the set of explanatory factors/interactions for each error distribution, all interactions that included the factor *Year* were treated as random interactions (Cooke, 1997). This process converted the basic models from generalized linear models into generalized linear mixed models (GLMMs). The significance of the random interactions was evaluated using the likelihood ratio test (Pinheiro and Bates, 2000), the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), where lower values indicated better model fitting. Once a final model was identified, model diagnostics were revised to identify potential departure from the GLMM assumptions or observations with large influence in the model results.

The indices of abundance were estimated as the product of the least squares means (LSmeans) of the factor *Year* from each of the two analyses that constitute a hurdle model, after back-transforming to the response scale. The variance estimation of the standardized index was calculated following Walter and Ortiz (2012) for two-stage CPUE estimators.

All the analyses were conducted using the software R-3.4.3 (R Core Team, 2017) with additional packages *lmtest* (Zeileis and Hothorn, 2002), *lattice* (Sarkar, 2008), *influence.ME* (Nieuwenhuis *et al*., 2012), *lme4* (Bates *et al*., 2015) and *lsmeans* (Lenth, 2016).

Results and Discussion

Deviance tables for thornback ray from the DCF dataset analyses are presented in **Table 2**. For the proportion of positive catches; *Year*, *Vessel*, *Port* and *Target* and the interactions *Year:Quarter*, *Year:Vessel* and *Year:Port*, were the major factors that explained whether or not a set caught at least one fish. For the positive catches; the main factors *Year*, *Vessel* and *Target* and the interaction *Year:Vessel* were more significant. The *Year* interactions were considered as random effects in the hurdle model subcomponents, and their statistical effect were evaluated using the AIC, BIC, and likelihood ratio test (**Table 3**).

Model diagnostics for the positive catches included plots for a check of the link function, the variance function, and the check for the error distribution of the model (**Fig. 3a-c**). All diagnostic plots showed no indication of departure from the expected or null pattern, and there was no observation with large influence in the model results (**Fig. 3d**). Thus, we can conclude that the model selected is not grossly wrong.

Standardized CPUE series for thornback ray are shown in **Table 4** and **Fig. 4**. The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE showed an oscillation over time, with an increasing trend from 2007 to 2015; while the standardized index presented a more stable trend overall. According to Ortiz (2017), it is not necessary that the nominal and standardized trends follow the same trend. The standardized index for the *year* factor show in theory the trend of the population, while the nominal catch rates should represent the combined trends of all other factors and its interactions.

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TABLES

Table 1. Explanatory variables (main factors) used in the model formulations for standardized thornback ray catch rates.

Variable	Type	Observations
Year	Categorical (27)	Period: 1990-2016
Quarter	Categorical (4)	1: January-March
		2: April-June
		3: July-September
		4: October-December
Vessel	Categorical (5)	1: ≤ 10 m
		2: > 10 and ≤ 12 m
		3: > 12 and ≤ 18 m
		4: > 18 and ≤ 24 m
		5: > 24 and ≤ 40 m
Port	Categorical (4)	1: São Miguel
		2: Terceira
		3: Faial
		4: Others
Depth	Categorical (3)	1: shallow (< 200 m)
		2: intermediate (200-600 m)
		3: deep (> 600 m)
Target	Categorical (4)	1: 1st quartile (≤ 25%)
		2: 2nd quartile (> 25% and ≤ 50%)
		3: 3rd quartile (> 50% and ≤ 75%)
		4: 4th quartile (> 75%)

Table 2. Deviance analysis table of explanatory variables for the zero-altered lognormal model formulations for thornback ray catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Factors and interactions that accounted for 5% or more of the variability were highlighted and correspond to the selected explanatory variables.

Model structure	**d.f.**	**Res Dev**	**Δ Dev.**	**% of Dev. exp.**	***p*-value**
Binomial (proportion of positive catches)					
Null		11655.0			
Year	26	10904.0	750.8	**22.4**	< 0.001
Year Quarter	3	10867.0	36.7	1.1	< 0.001
Year Quarter Vessel	4	10701.0	166.1	**4.9**	< 0.001
Year Quarter Vessel Port	3	10201.0	500.5	**14.9**	< 0.001
Year Quarter Vessel Port Depth	2	10065.0	135.4	4.0	< 0.001
Year Quarter Vessel Port Depth Target	3	9343.0	722.4	**21.5**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	77	9156.0	186.8	**5.6**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	83	8705.0	451.5	**13.4**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	65	8354.0	350.8	**10.4**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	49	8298.0	56.3	1.7	0.220
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	38	190238.0	0.0	0.0	1.000
Lognormal (positive catches)					
Null		6322.8			
Year	26	5663.6	659.1	**20.8**	< 0.001
Year Quarter	3	5648.5	15.1	0.5	< 0.010
Year Quarter Vessel	4	4516.2	1132.4	**35.7**	< 0.001
Year Quarter Vessel Port	3	4483.7	32.5	1.0	< 0.001
Year Quarter Vessel Port Depth	2	4427.4	56.3	1.8	< 0.001
Year Quarter Vessel Port Depth Target	3	3709.9	717.5	**22.6**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	73	3582.6	127.3	4.0	< 0.010
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	76	3330.9	251.6	**7.9**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	43	3249.3	81.7	2.6	< 0.010
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	37	3196.4	52.8	1.7	0.162
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	38	3153.4	43.1	1.4	0.514

d.f.: degrees of freedom; Res. Dev.: residual deviance; Δ Dev.: change in deviance; % of Dev. exp.: percent of deviance explained; *p*-value: based on chi-squared (χ^2) distribution and used to determine the explanatory variables that contributed significantly ($p < 0.05$) to the deviance explained.

Table 3. Analyses of alternative zero-altered lognormal mixed model formulations for thornback ray catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Model structure	− 2 REM log likelihood	Akaike's information criterion	Bayesian information criterion	Likelihood ratio test	
Binomial (proportion of positive catches)					
Year Vessel Port Target Quarter	9508.4	9588.4	9873.8		
Year Vessel Port Target Quarter *Year:Quarter*	9492.6	9574.6	9867.2	15.7	< 0.001
Year Vessel Port Target Quarter *Year:Quarter Year:Vessel*	9285.4	9369.4	9669.1	207.2	< 0.001
Year Vessel Port Target Quarter *Year:Quarter Year:Vessel Year:Port* *	9105.9	9191.9	9498.7	179.5	< 0.001
Lognormal (positive catches)					
Year Vessel Target	9322.1	9392.1	9602.7		
Year Vessel Target *Year:Vessel* *	9304.2	9376.2	9592.9	17.89	< 0.001

The factors in normal typeface are treated as fixed effects and those in italics are random interactions.

* The final zero-altered lognormal mixed model.

Table 4. Nominal and standardized CPUE series (kg 10^{-3} hooks) for thornback ray (*Raja clavata*) catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds.

Year	Nominal CPUE	Standardized CPUE	LCI	UCI
1990	0.28	1.45	1.21	1.70
1991	0.24	1.20	0.98	1.41
1992	0.22	1.07	0.81	1.34
1993	0.38	0.73	0.58	0.87
1994	0.17	1.65	1.31	1.99
1995	0.03	0.38	0.31	0.45
1996	0.61	1.28	0.99	1.57
1997	0.36	0.86	0.65	1.08
1998	0.48	1.00	0.79	1.21
1999	1.93	1.15	0.87	1.43
2000	1.13	1.18	0.93	1.43
2001	0.72	0.90	0.69	1.10
2002	0.80	1.35	1.03	1.66
2003	1.44	1.00	0.75	1.25
2004	1.75	1.08	0.80	1.37
2005	0.76	0.74	0.59	0.88
2006	0.56	0.57	0.46	0.68
2007	0.47	0.56	0.44	0.67
2008	0.91	1.01	0.81	1.21
2009	0.86	1.14	0.94	1.34
2010	1.24	0.91	0.74	1.08
2011	1.29	1.03	0.84	1.21
2012	1.61	1.08	0.86	1.31
2013	1.59	0.91	0.74	1.08
2014	2.32	1.08	0.87	1.30
2015	2.96	0.86	0.65	1.06
2016	1.91	0.84	0.66	1.03

FIGURES

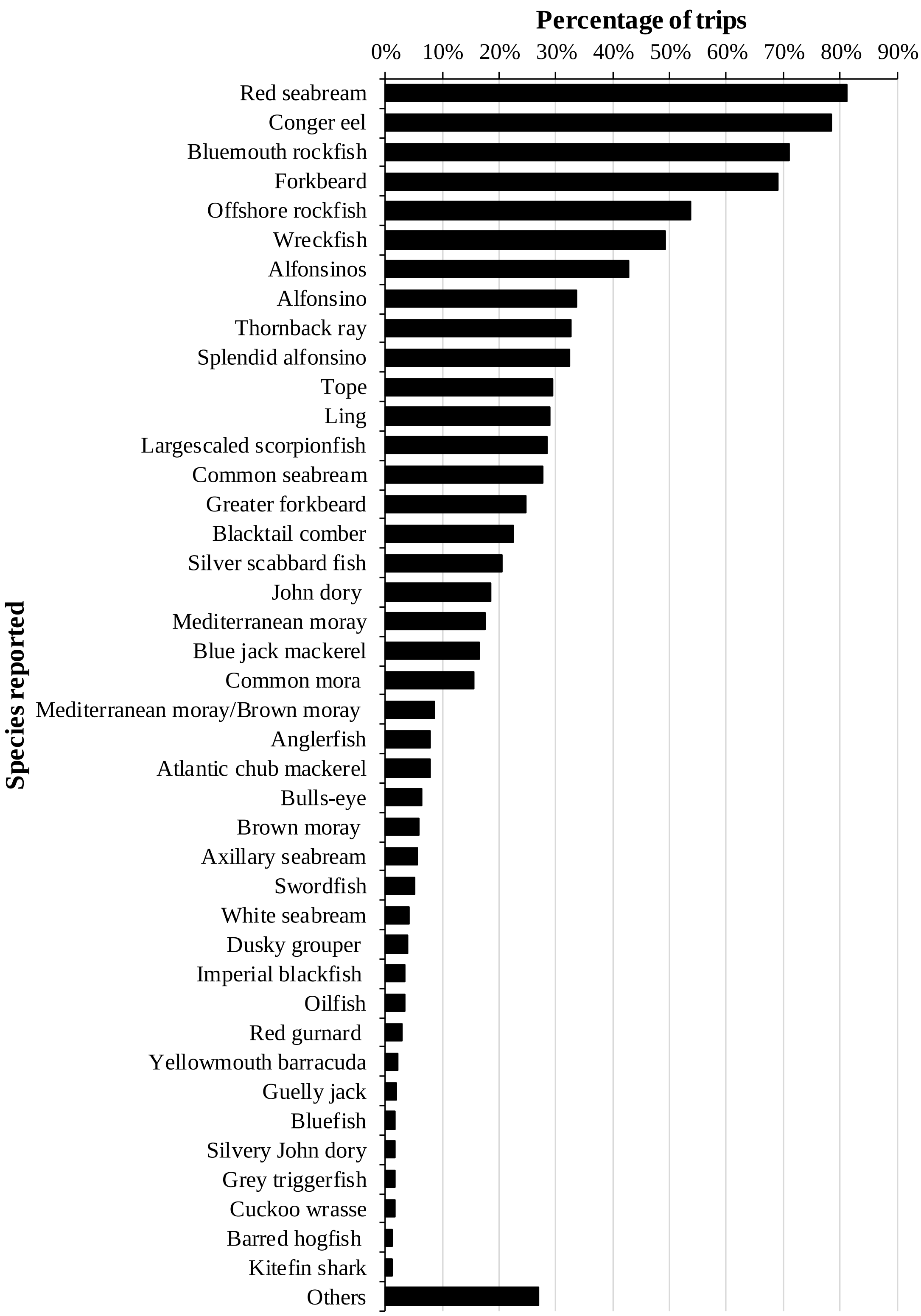

Fig. 1. Species reported by trip by the Azorean bottom longline fleet, according to the DCF inquiries.

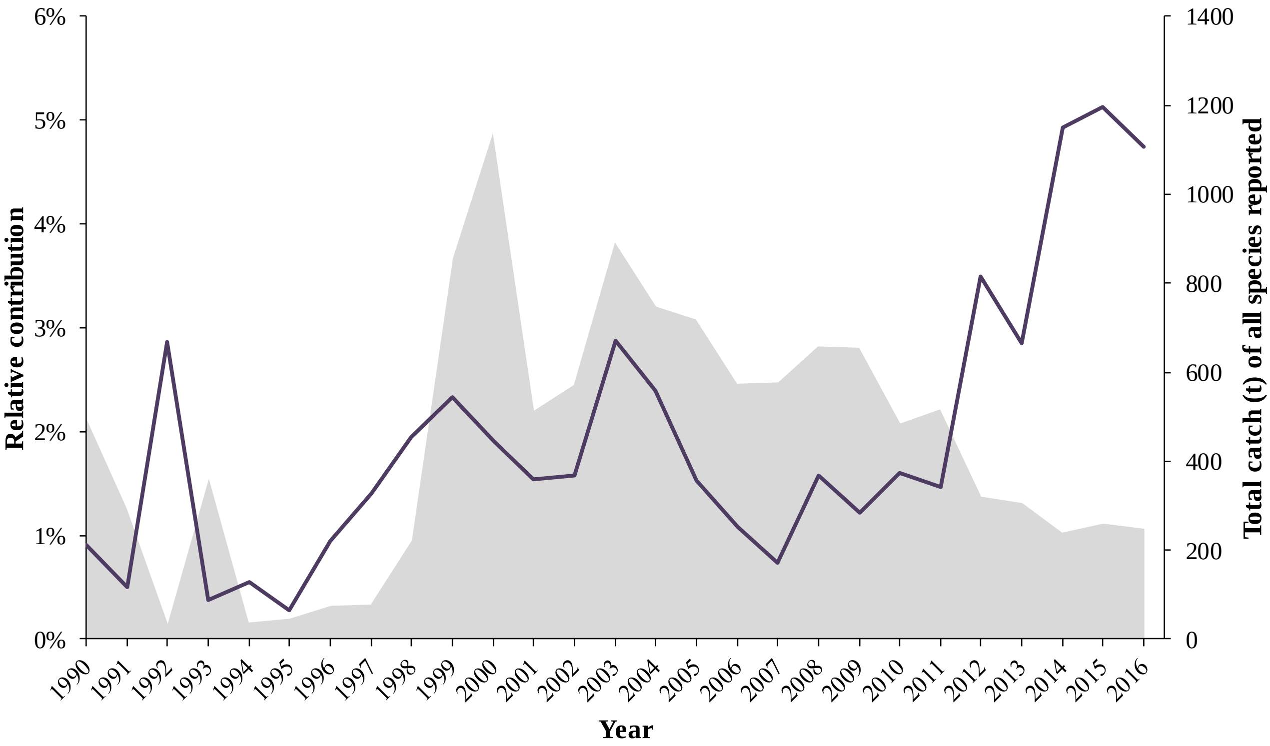

Fig. 2. Total catch of all species (■) and relative contribution of thornback ray (*Raja clavata*) to all species (▬) landed by the Azorean bottom longline fleet and sampled by the DCF inquiries.

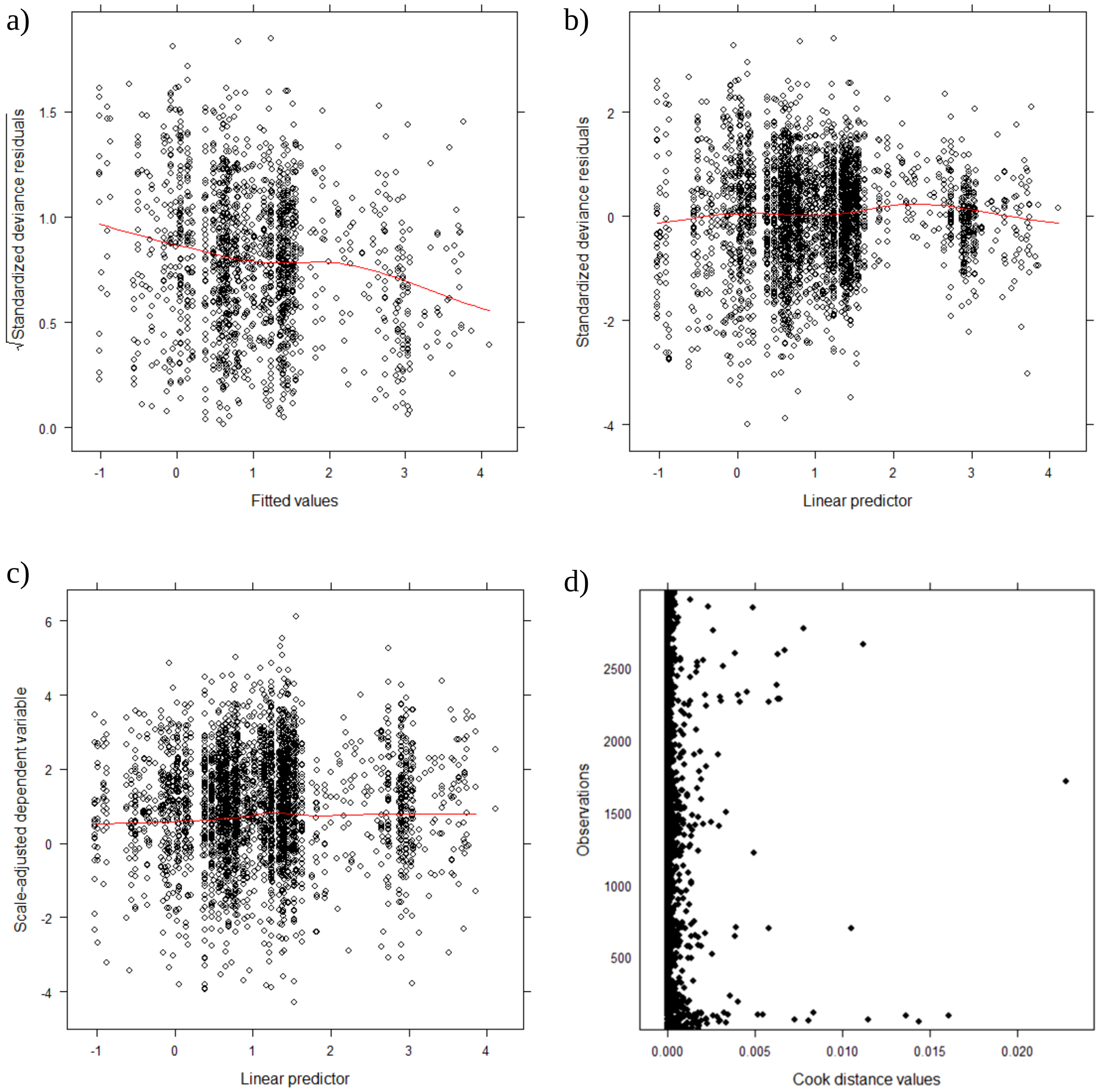

Fig. 3. Diagnostic plots for positive thornback ray (*Raja clavata*) catch rates to check (a) the adequacy of the assumed variance function, (b) the assumed error distribution, (c) the link function selection, and (d) the influential observations. The null pattern is a no trend in the residuals (a), a distribution of residuals with mean zero and constant variance (b), a straight line (c), and no observation with Cook distance value greater than 1 (d). The red line is the loess smoother through the plotted values.

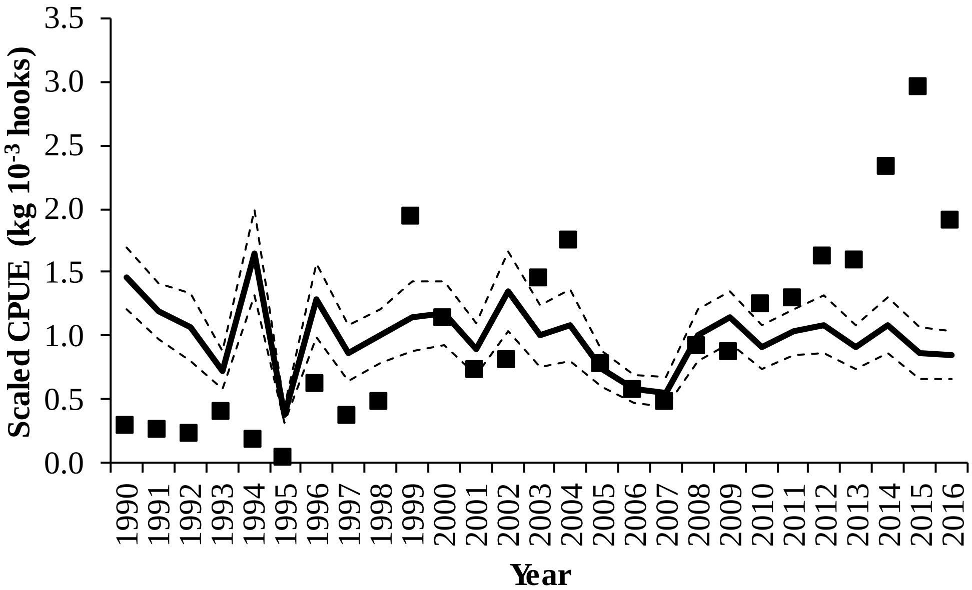

Fig. 4. Nominal (■) and standardized (▬) CPUE (kg 10^{-3} hooks) for thornback ray (*Raja clavata*) from the Azorean bottom longline fishery, 1990–2016. Dotted lines represent 95% confidence intervals for the standardized CPUE.

STANDARDIZED CATCH RATES FOR TOPE (lsk.27.10a2) FROM THE AZOREAN BOTTOM LONGLINE FLEET (1990-2016)

Régis V. S. Santos[1*], Ana M. Novoa-Pabon[1], Helder M. da Silva[1], João G. Pereira[1], Mario R. Pinho[1]

ABSTRACT

Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2016. The CPUE of tope was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were: year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE showed an oscillation over time, with some peaks in 1999, 2000 and 2014; while the standardized index presented an approximately stable trend since 1994.

KEYWORDS

Galeorhinus galeus; demersal fisheries; CPUE; abundance; Azores; GLMM

Introduction

The Azorean fishery for demersal species has traditionally been a multispecific fishery, where several types of hooks and gears are used by the local fleet. The demersal fishing fleet consists mainly of small scale boats (length < 12 m), mostly equipped with handlines and bottom longlines. The tope (*Galeorhinus galeus*) is one of the main elasmobranch species caught by the Azorean bottom longline fleet, which directs its effort to the other demersal fish species such as red seabream (*Pagellus bogaraveo*), bluemouth rockfish (*Helicolenus dactylopterus*), wreckfish (*Polyprion americanus*), forkbeard (*Phycis phycis*), conger eel (*Conger conger*) and alfonsinos (*Beryx splendens* and *Beryx decadactylus*) (Pinho and Menezes, 2005; Menezes *et al*., 2009; Diogo *et al*., 2015; Pinho *et al*., 2015).

The most important commercial elasmobranchs species caught in the Azores area are the blue shark (*Prionace glauca*) from the Portuguese mainland and Spanish pelagic fisheries, and kitefin shark (*Dalatias licha),* tope (*Galeorhinus galeus)* and thornback ray *(Raja clavata)* from local

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demersal/deep-water fisheries (Santos *et al*., 2018). Other species are caught but discarded, due to low commercial value or because of management measures introduced.

Indices of abundance from commercial fisheries have been used to tune stock assessment models (Quinn and Deriso, 1999, Maunder and Punt, 2004), and their use have been strictly recommended by the International Council for the Exploration of the Sea (ICES) for the stocks advice. The utility of indices of abundance based on nominal catch rates can be improved by standardizing them to remove the impact of factors other than changes over time in stock biomass, usually by using statistical regression methods (Ortiz and Arocha, 2004).

This study aimed to standardize the catch rates for tope captured by the Azorean bottom longline fleet through 2016, using a Generalized Linear Mixed Model with random factor interactions particularly for the *Year* effect.

Material and methods

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAç), and was collected during the period of 1990–2016 as part of the mandate of the Data Collection Framework (DCF). Sampling was designed to cover the main ports of the Azores and was performed by clerks who carried out standardized fishing inquiries (n = 9275) to the captains of the bottom longline vessels during the landings. Each record report included: the vessel identification, the dates of departure and return to the port and detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, fishing area and catch in weight for each species landed.

Tope is one of the main elasmobranch species caught by the Azorean bottom longline fleet and was reported in 29% of the trips (**Fig. 1**), representing up to 2% of the total catch landed along the studied period (**Fig. 2**). Factors considered in the analyses of the tope catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: *São Miguel*, *Terceira* and *Faial*, which represent around 95% of the Azorean landings, and *Others*, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Pinho and Menezes, 2005; Menezes *et al*., 2006), and target (**Table 1**). The target was defined as the percentage of tope catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of tope caught per 1000 hooks. Records with missing effort data were excluded from the analysis.

Relative indices of abundance for the tope species were estimated by Generalized Linear Modeling approach using a hurdle (delta) model (Lo *et al*., 1992; Ortiz and Arocha, 2004; Zuur and Ieno, 2016). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modeling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modeling the positive catch rates on successful trips.

Deviance tables were used to select the explanatory factors and interactions that explained most of the variability in the data (Ortiz and Arocha, 2004). The effect of each explanatory factor/interaction was evaluated according to: 1) the percent of deviance explained by the addition of a specific factor/interaction to the model, and 2) the result of the Chi-squared (χ^2) test between two nested models. Only those factors and interactions that accounted for 5% or more of the variability were selected as explanatory variables.

After selecting the set of explanatory factors/interactions for each error distribution, all interactions that included the factor *Year* were treated as random interactions (Cooke, 1997). This process converted the basic models from generalized linear models into generalized linear mixed models (GLMMs). The significance of the random interactions was evaluated using the likelihood ratio test (Pinheiro and Bates, 2000), the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), where lower values indicated better model fitting. Once a final model was identified, model diagnostics were revised to identify potential departure from the GLMM assumptions or observations with large influence in the model results.

The indices of abundance were estimated as the product of the least squares means (LSmeans) of the factor *Year* from each of the two analyses that constitute a hurdle model, after back-transforming to the response scale. The variance estimation of the standardized index was calculated following Walter and Ortiz (2012) for two-stage CPUE estimators.

All the analyses were conducted using the software R-3.4.3 (R Core Team, 2017) with additional packages *lmtest* (Zeileis and Hothorn, 2002), *lattice* (Sarkar, 2008), *lme4* (Bates *et al*., 2015) and *lsmeans* (Lenth, 2016).

Results and Discussion

Deviance tables for tope from the DCF dataset analyses are presented in **Table 2**. For the proportion of positive catches; *Year* and the interactions *Year:Depth* and *Year:Target*, were the major factors that explained whether or not a set caught at least one fish. For the positive catches; the main factors *Year*, *Vessel* and *Target* were more significant. The *Year* interactions were considered as random effects in the hurdle model subcomponents, and their statistical effect were evaluated using the AIC, BIC, and likelihood ratio test (**Table 3**).

Model diagnostics for the positive catches included plots for a check of the link function, the variance function, and the check for the error distribution of the model (**Fig. 3a-c**). All diagnostic plots showed no indication of departure from the expected or null pattern, and there was no observation with large influence in the model results (**Fig. 3d**). Thus, we can conclude that the model selected is not grossly wrong.

Standardized CPUE series for tope are shown in **Table 4** and **Fig. 4**. The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE showed an oscillation over time, with some peaks in 1999, 2000 and 2014; while the standardized index presented an approximately stable trend since 1994. According to Ortiz (2017), it is not necessary that the nominal and standardized trends follow the same trend. The standardized index for the *year* factor show in theory the trend of the population, while the nominal catch rates should represent the combined trends of all other factors and its interactions.

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TABLES

Table 1. Explanatory variables (main factors) used in the model formulations for standardized tope catch rates.

Variable	Type	Observations
Year	Categorical (27)	Period: 1990-2016
Quarter	Categorical (4)	1: January-March
		2: April-June
		3: July-September
		4: October-December
Vessel	Categorical (5)	1: ≤ 10 m
		2: > 10 and ≤ 12 m
		3: > 12 and ≤ 18 m
		4: > 18 and ≤ 24 m
		5: > 24 and ≤ 40 m
Port	Categorical (4)	1: São Miguel
		2: Terceira
		3: Faial
		4: Others
Depth	Categorical (3)	1: shallow (< 200 m)
		2: intermediate (200-600 m)
		3: deep (> 600 m)
Target	Categorical (4)	1: 1st quartile (≤ 25%)
		2: 2nd quartile (> 25% and ≤ 50%)
		3: 3rd quartile (> 50% and ≤ 75%)
		4: 4th quartile (> 75%)

Table 2. Deviance analysis table of explanatory variables for the zero-altered lognormal model formulations for tope catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Factors and interactions that accounted for 5% or more of the variability were highlighted and correspond to the selected explanatory variables.

Model structure	d.f.	Res Dev	Δ Dev.	% of Dev. exp.	*p*-value
Binomial (proportion of positive catches)					
Null		11159.0			
Year	26	10023.0	1136.3	**4.0**	< 0.001
Year Quarter	3	9999.0	24.6	0.1	< 0.001
Year Quarter Vessel	4	9929.0	69.1	0.2	< 0.001
Year Quarter Vessel Port	3	9617.0	312.4	1.1	< 0.001
Year Quarter Vessel Port Depth	2	9544.0	72.6	0.3	< 0.001
Year Quarter Vessel Port Depth Target	3	9153.0	391.4	1.4	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	77	9034.0	118.6	0.4	< 0.010
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	83	8681.0	352.8	1.2	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	63	212946.0	0.0	0.0	1.000
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	50	205809.0	7136.6	**24.9**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	38	186778.0	19031.0	**66.4**	< 0.001
Lognormal (positive catches)					
Null		5722.8			
Year	26	5121.2	601.6	**18.3**	< 0.001
Year Quarter	3	5120.2	1.0	0.0	0.809
Year Quarter Vessel	4	3645.5	1474.7	**44.9**	< 0.001
Year Quarter Vessel Port	2	3597.4	48.2	1.5	< 0.001
Year Quarter Vessel Port Depth	2	3506.8	90.5	2.8	< 0.001
Year Quarter Vessel Port Depth Target	3	2841.8	665.0	**20.3**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	72	2740.8	101.1	3.1	< 0.050
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	75	2597.3	143.5	4.4	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	39	2535.5	61.8	1.9	< 0.050
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	38	2478.3	57.2	1.7	< 0.050
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	36	2439.4	38.9	1.2	0.361

d.f.: degrees of freedom; Res. Dev.: residual deviance; Δ Dev.: change in deviance; % of Dev. exp.: percent of deviance explained; *p*-value: based on chi-squared (χ^2) distribution and used to determine the explanatory variables that contributed significantly ($p < 0.05$) to the deviance explained.

Table 3. Analyses of alternative zero-altered lognormal mixed model formulations for tope catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Model structure	**– 2 REM log likelihood**	**Akaike's information criterion**	**Bayesian information criterion**	**Likelihood ratio test**	
Binomial (proportion of positive catches)					
Year Depth Target	9552.1	9616.1	9844.2		
Year Depth Target *Year:Depth* *	9513.6	9579.6	9814.9	38.5	< 0.001
Year Depth Target *Year:Depth Year:Target*	9513.6	9581.6	9824.0	0.0	0.999
Lognormal (positive catches)					
Year Vessel Target *	7929.2	7999.2	8206.0		

The factors in normal typeface are treated as fixed effects and those in italics are random interactions.

* The final zero-altered lognormal mixed model.

Table 4. Nominal and standardized CPUE series (kg 10^{-3} hooks) for tope (*Galeorhinus galeus*) catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds.

Year	**Nominal CPUE**	**Standardized CPUE**	**LCI**	**UCI**
1990	0.37	2.01	1.74	2.29
1991	1.51	1.94	1.62	2.27
1992	0.08	2.86	2.25	3.47
1993	0.62	1.26	1.02	1.49
1994	0.22	0.71	0.57	0.85
1995	0.14	0.81	0.67	0.95
1996	0.20	0.57	0.45	0.69
1997	0.76	0.94	0.72	1.16
1998	1.63	0.95	0.73	1.17
1999	2.43	1.28	0.95	1.62
2000	2.40	1.24	0.93	1.55
2001	1.53	1.06	0.80	1.31
2002	1.08	1.09	0.84	1.35
2003	1.39	0.74	0.59	0.88
2004	0.67	0.64	0.50	0.78
2005	0.39	0.57	0.47	0.67
2006	0.41	0.56	0.47	0.65
2007	0.30	0.49	0.41	0.57
2008	0.62	0.56	0.46	0.65
2009	0.78	0.82	0.69	0.95
2010	1.00	0.74	0.62	0.86
2011	1.09	0.84	0.71	0.97
2012	1.38	0.74	0.62	0.87
2013	1.53	1.01	0.86	1.16
2014	1.59	0.79	0.65	0.94
2015	1.51	0.89	0.72	1.07
2016	1.39	0.88	0.70	1.06

FIGURES

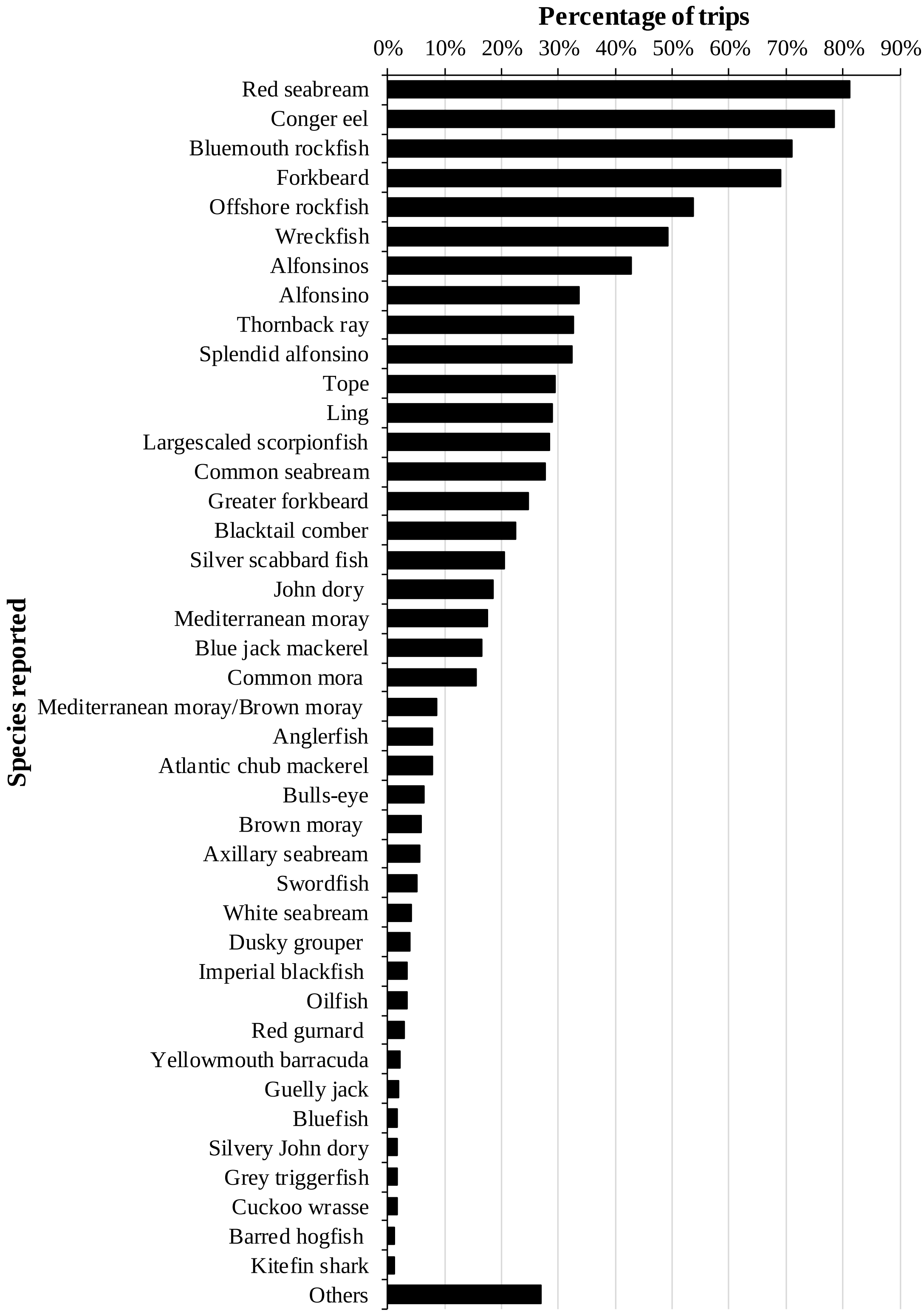

Fig. 1. Species reported by trip by the Azorean bottom longline fleet, according to the DCF inquiries.

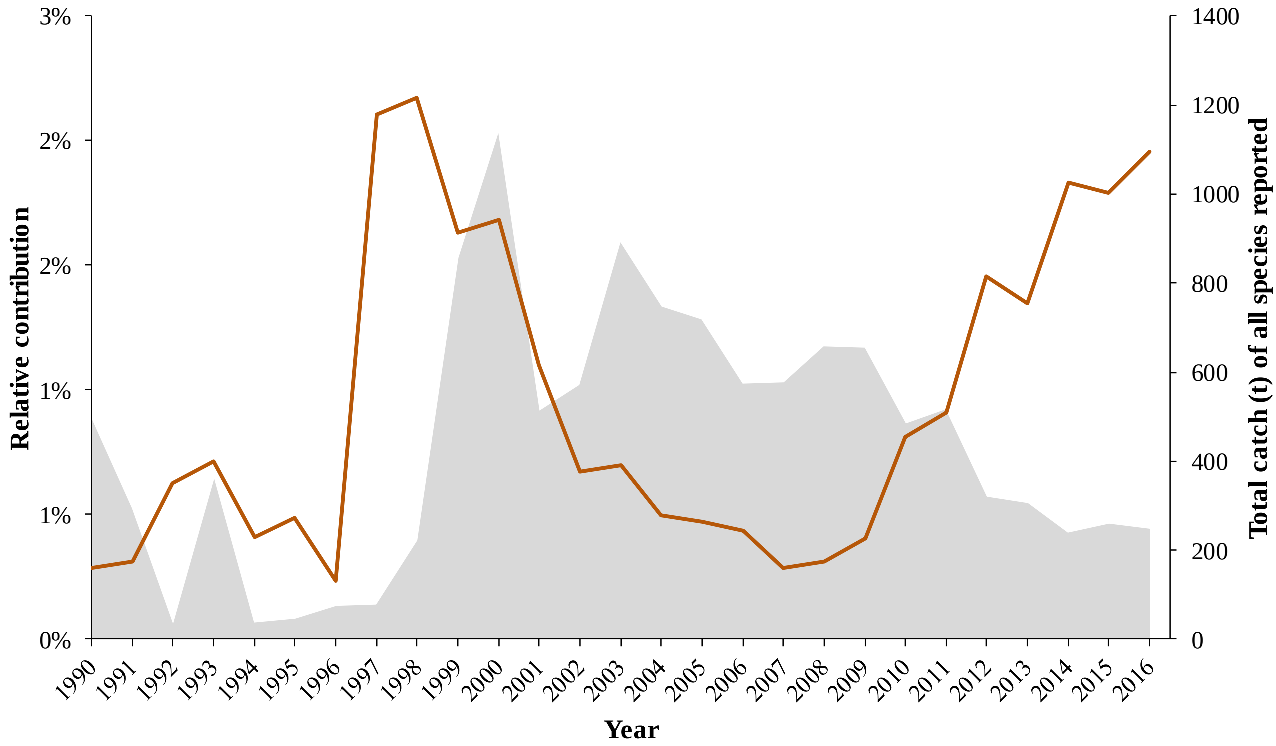

Fig. 2. Total catch of all species (■) and relative contribution of tope (*Galeorhinus galeus*) to all species (▬) landed by the Azorean bottom longline fleet and sampled by the DCF inquiries.

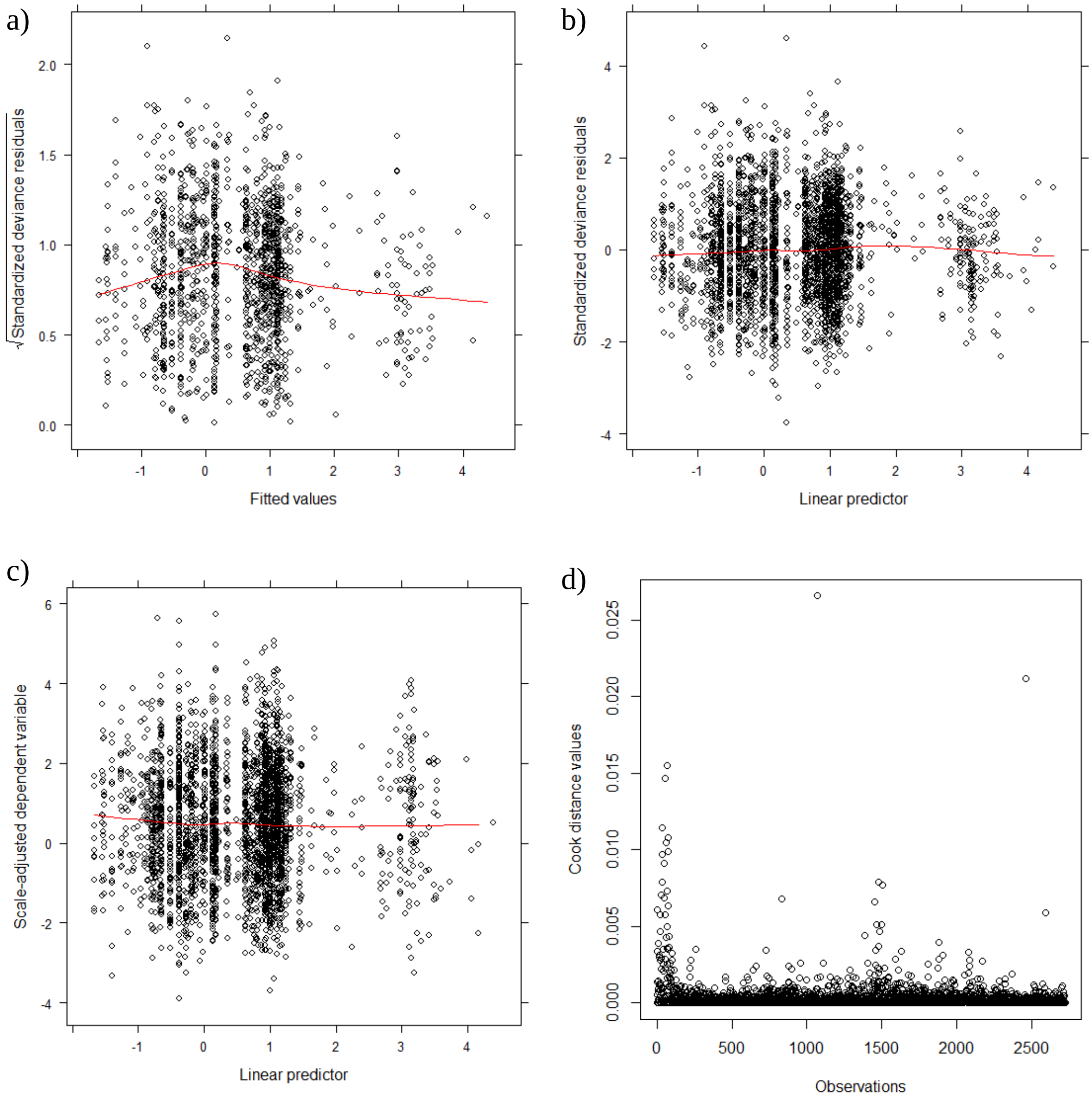

Fig. 3. Diagnostic plots for positive tope (*Galeorhinus galeus*) catch rates to check (a) the adequacy of the assumed variance function, (b) the assumed error distribution, (c) the link function selection, and (d) the influential observations. The null pattern is a no trend in the residuals (a), a distribution of residuals with mean zero and constant variance (b), a straight line (c), and no observation with Cook distance value greater than 1 (d). The red line is the loess smoother through the plotted values.

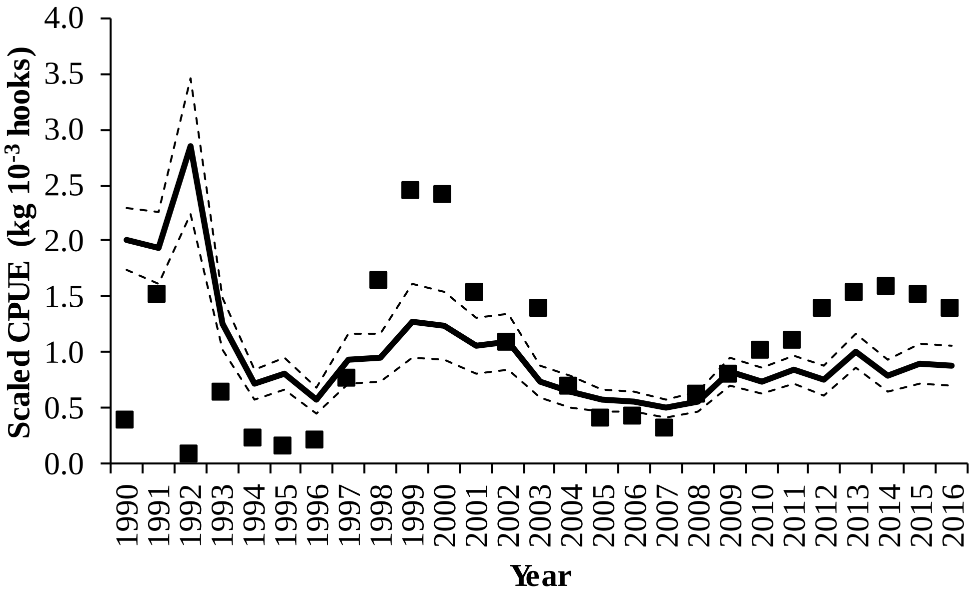

Fig. 4. Nominal (■) and standardized (—) CPUE (kg 10^{-3} hooks) for tope (*Galeorhinus galeus*) from the Azorean bottom longline fishery, 1990–2016. Dotted lines represent 95% confidence intervals for the standardized CPUE.

Results on main elasmobranch species captured in the bottom trawl surveys on the Northern Spanish Shelf

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Abstract

This working document presents the results on the most abundant elasmobranch species captured in the Spanish Groundfish Survey on Northern Spanish shelf in 2017. Biomass, spatial distribution and length ranges were analysed for the elasmobranchs caught in the survey. The main species in biomass terms were, as usual for the historical series, *Scyliorhinus canicula* (Lesser spotted dogfish), *Galeus melastomus* (blackmouth catshark), *Etmopterus spinax* (Velvet belly), *Raja clavata* (Thornback ray), *Raja montagui* (Spotted ray) and *Leucoraja naevus* (Cuckoo ray), and other scarce elasmobranch captured were *G. atlanticus*, *S. stellaris*, *R. microcellata*, *H. griseus* and *R. brachyura*. *The species G. melastomus*, *G. atlanticus*, *E. spinax*, *R. clavata*, *R. montagui* and *R. naevus* increased their abundance. However the biomass of *Dalatias licha* kept similarly to that in the previous year in deeper special hauls and the species *S. canicula*, *S. stellaris*, *D. profundorum*, *H. griseus* and *S. ringens* decreased their biomass.

Introduction

The bottom trawl survey on the Northern Spanish Shelf has been carried out every autumn since 1983, except in 1987, to provide data and information for the assessment of the commercial fish species and the ecosystems on the Galician and Cantabrian shelf (ICES Divisions 8c and 9a North) (ICES, 2017).

The aim of this working document is to update the results (abundance indices, length frequency and geographic distributions) of the most common elasmobranch fish species in 2017 survey, following the results presented in previous documents (Ruiz-Pico et al., 2017; Fernández-Zapico et al., 2016; Ruiz-Pico et al., 2015). The species analyzed in this working document were *Scyliorhinus canicula* (Lesser spotted dogfish), *Scyliorhinus stellaris* (Greater spotted dogfish), *Galeus melastomus* (Blackmouth catshark), *Galeus atlanticus* (Atlantic sawtail catshark), *Etmopterus spinax* (Velvet belly), *Hexanchus griseus* (Bluntnose sixgill shark), *Scymnodon ringens* (Knifetooth dogfish), *Dalatias licha* (Kitefin shark), *Deania calcea (*Birdbeak dogfish*)*, *Deania profundorum* (Arrowhead dogfish), *Raja clavata* (Thornback ray), *Raja montagui* (Spotted ray) and *Leucoraja naevus* (Cuckoo ray). Also the less common rays that were present in the last survey were analyzed. These species were *Raja microcellata* (Small-eyed ray), *Raja brachyura* (Blonde ray), *Raja undulata* (Undulate ray), *Leucoraja circularis* (Sandy ray) and *Diptutus nidarosiensis* (Norwegian skate).

Material and methods

The area covered in the Northern Spanish Shelf Groundfish Survey in the Cantabrian Sea and Off Galicia (Divisions 8c and Northern part of 9a; SPNGFS) extends from longitude 1° W to 10° W and from latitude 42° N to 44.5° N, following the standard IBTS methodology for the western and southern areas (ICES, 2017). The sampling design is random stratified with five geographical sectors (MF: Miño-Finisterre, FE: Finisterre-Estaca de Bares, EP: Estaca de Bares - Peñas, PA: Peñas - Ajo, AB: Ajo - Bidasoa) and three depth strata (70-120 m, 121-200 m and 201-500) (Figure 1). The shallower depth stratum was changed in 1997 from 30-100 m to 70-120 m.

Nevertheless, some extra hauls are carried out every year, if possible, to cover shallower (<70 m) and deeper (>500 m) grounds. These additional hauls are plotted in the distribution maps, although they are not included in the calculation of the stratified abundance indices since the coverage of these grounds (deep and shallow) is not considered representative of the area. The information from these depth ranges is relevant due to the changes in the depth distribution of fishing activities in the area (Punzón et al. 2011) and these hauls are also used to define the depth range of the species.

In the last survey, some extra hauls (called “zero minute hauls”) were carried out in order to know the capture during the tacking maneuver out of the sampling time.

Results

In 2017, 135 valid hauls were carried out, 112 of them in the standard sampling. In addition, 23 extra hauls were carried out of the standard sampling, 3 shallower than 70 m, 12 between 500 m and 800 m and 8 more extra hauls (“zero minute hauls”) (Figure 1).

In the last survey, fishes represented about 69% of the total stratified catch and elasmobranchs 11% of the total stratified fish catch, although the percentage would be higher (around 14%) if the additional hauls were considered. In 2017, the mean catch per haul of elasmobranchs which mainly occur in standard hauls (70-500 m) were: *Scyliorhinus canicula* (12.47 ± 1.85 kg $\cdot$haul^{-1}), *Raja clavata* (4.89 ± 1.57 kg$\cdot$haul^{-1}), *Galeus melastomus* (2.77 ± 1.42 kg $\cdot$haul^{-1}), *R.montagui* (1.33 ± 0.58 kg $\cdot$haul^{-1}), *Leucoraja naevus* (0.56 ± 0.18 kg $\cdot$haul^{-1}), *Etmopterus spinax* (0.36 ± 0.19 kg $\cdot$haul^{-1}), *Galeus atlanticus* (0.18 ± 0.08 kg $\cdot$haul^{-1}), *Scyliorhinus stellaris* (0.04 ± 0.02 kg $\cdot$haul^{-1}), *Raja microocellata* (0.04 ± 0.04 kg $\cdot$haul^{-1}), *Hexanchus griseus* (0.03 ± 0.02 kg $\cdot$haul^{-1}) and *Raja brachyura* (0.03 ± 0.02 kg $\cdot$haul^{-1}).

On the other hand, the elasmobranchs *G.melastomus, E.spinax, Deania profundorum, Scymnodon ringens, Dalatias licha, Leucoraja circularis and Dipturus nidarosiensis* were mainly found in deeper waters. Their biomass in the additional hauls (>500) was nearly 50% or more than the total biomass. For that reason data corresponding to both standard and deeper hauls were plotted independently.

In 2017, the species *G.melastomus*, *G.atlanticus*, *E.spinax*, *R.clavata*, *R.montagui* and *R.naevus* increased their abundance. The greatest increase was for the species *Galeus melastomus*, in both standardized and additional hauls. A sharp increase was also observed for *E.spinax* in additional hauls, and it occurred too for the three species of rays (*R.clavata*, *R.montagui* and *R.naevus*) in the standard hauls, especially in 8c Division. However the biomass of *Dalatias licha* kept similarly to that in 2016 in deeper special hauls and the species *S. canicula*, *S.stellaris*, *D.profundorum*, *H.griseus* and *S.ringens* decreased their biomass.

Scyliorhinus canicula (Lesser spotted dogfish) and *Scyliorhinus stellaris* (Nursehound)

In 2017, the biomass of *Scyliorhinus canicula* followed the decreasing trend of the four previous years in all the area surveyed, Divisions 9a and 8c.

The biomass in the 9a Division, 3.40 ± 0.80 Kg·haul^{-1}, kept up a similar value, even slightly lower than last year (3.47 ± 1.20 Kg·haul^{-1}) and it has decreased a third part during the last two years, with respect to the previous five, although still above the average of the time series before 2012, when the biomass shot up. However, in the 8c Division, where the biomass of this species quadrupled that of division 9a, a more pronounced decrease is appreciated 14.36 ± 2.23 Kg·haul^{-1} vs. 17.75± 2.07 Kg·haul^{-1} in 2016 (

Figure 2 and Figure 3).

Scyliorhinus stellaris was only caught in 8c Division and its biomass fell down in this last survey, from 0.22 ± 0.16 Kg·haul^{-1} in 2016 to 0.050 ± 0.02 Kg·haul^{-1} in 2017, returning to the average values of the historical series after the peak of the last year (

Figure 2).

Both species of the genus *Scyliorhinus* followed the usual distribution in the study area: *S. canicula* is widespread, whereas *S. stellaris* is sparse and scarce (Figure 4).

In 2017 Lesser spotted dogfish length distribution remained similar to previous years, although with a slight reduction in the size range, losing the smallest sizes, especially in the 9a division (size range from 16 to 59 cm vs. 10 to 62 cm in 2016). For the species *S.stellaris* the reduction in the size range is even more accused, from 23 to 47cm vs. 11 to 61 cm for the series from 2008 (Figure 5).

Galeus melastomus (Blackmouth catshark) and *Galeus atlanticus* (Atlantic sawtail catshark)

These two species were comparatively analysed in this working document like in previous reports, since *Galeus atlanticus* was detected for the first time in the study area in 2009 after its redescription and validation in 2007 (Castilho et al., 2007). In addition, the biomass in standard and additional hauls were also reported like previous years, because the catches in additional deep hauls (>500 m) are significant.

In 2017, 32% of the hauls with presence of *G. melastomus* were found deeper than 500 m and they contained the 66% of the biomass. In standard hauls, the biomass of *Galeus melastomus* increased slightly the low values of previous years in the 9a Division (0.3 ± 0.11 Kg·haul^{-1} vs. 0.08 ± 0.08 Kg·haul^{-1} in 2016) and doubled that of the previous year in the 8c Division (3.28 ± 1.71 Kg·haul^{-1} vs. 1.23 ± 0.64 Kg·haul^{-1} in 2016). In additional hauls the biomass of this species has increased strongly, though even more markedly in 9a Division (Figure 8, Figure 9, Figure 9 and Figure 9).

On the other hand, *G. atlanticus* remained scarce in the study area. In 8c Division it is almost absent; though in the last survey the biomass in this area has increased slightly, both in standard and additional hauls. In 9a Division, the biomass decreased particularly in the additional hauls but also slightly in standard hauls (Figure 6, Figure 8, Figure 9 and Figure 9).

In 2017, the size ranges of *G. melastomus* did not vary too much depending on the depth of capture (9a division: from 14 to 66 cm in standard stratification; from 15 to 58 cm in additional hauls; 8c division: from 15 to 70 cm in standard stratification; from 15 to 68 cm in additional hauls) and they quite fit the ranks of the historical series, although they are slightly reduced. However, modes are located in larger sizes in the additional hauls: in 9a division the mode is dispersed around 39 cm and 62 cm in the stratified hauls, with a very low abundance, whereas in additional hauls, in the same ICES area, mode is clearly in 43 cm. In 8c division, there is a main mode in 40cm and two more secondary modes in 28 cm and 58-60 cm in the standard hauls, whereas in additional hauls it can be distinguished a mode in 54 cm, with a higher abundance. There is a scarce group of small individuals between 15 and 25 cm in both areas, in the entire bathymetry. Additionally, it seems that in deep hauls, there are a higher proportion of males versus females in 9a Division, and this is reversed in 8c Division (Figure 10, Figure 11).

For *G.atlanticus*, the size range is wider in the additional hauls, with larger individuals: in 8a Division ranged from 31 to 63 cm, versus the range in standard hauls from 21 to 51 cm. However the mode is for larger individuals in the standard stratification in 8c Division, with 47 cm compared to the mode in 36 cm in the additional hauls in the same area. In 9a Division, in the last survey, there has only been capture in deep hauls and the sizes ranged from 43 to 65 cm.

***Etmopterus spinax* (Velvet belly)**

The biomass of *Etmopterus spinax* in standard and additional hauls was reported because a significant catch was found in additional deep hauls (>500 m), 70% of the hauls with *E. spinax* were found deeper than 500 m and containing more than a half of the biomass in 2017. The biomass of this species has remained constant since last year in standardized hauls (0.36 ± 0.19) Kg·haul^{-1}. However, it has increased considerably in the additional deep hauls (3.87 Kg·haul^{-1} compared to 0.73 Kg·haul^{-1} in 2016) (Figure 12). During the last two years, the biomass of this species has doubled compared to the previous five years (Figure 13).

Like previous years, *E. spinax* is mainly caught in Galician waters out the standard stratification, in hauls deeper than 500 m, particularly close to 9º W longitude. Also a spot of biomass is usually caught in the central area of the Cantabrian Sea (5º W) (Figure 14).

A narrower length distribution (10-33 cm) was found in standard hauls than in additional deep hauls (12-50 cm). It seems that there was a majority of females in both areas (Figure 15).

Other shark species

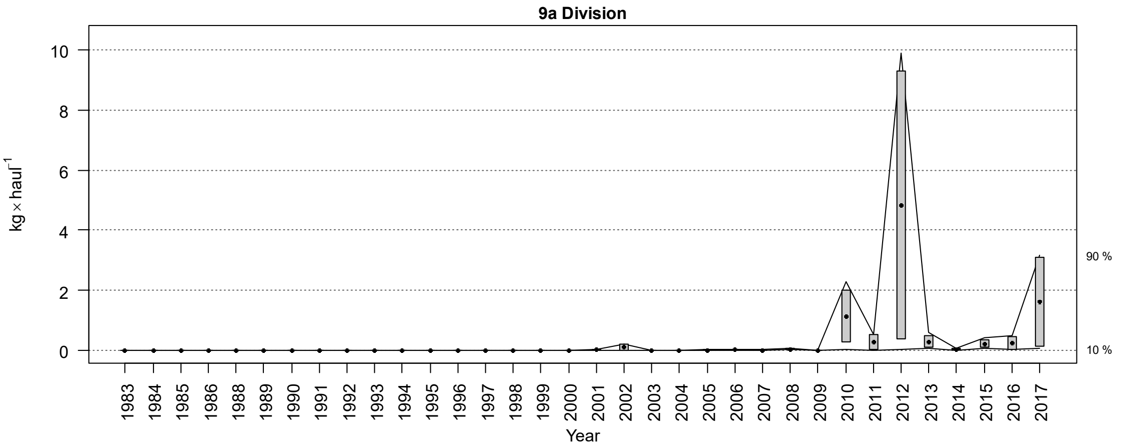
Other shark species scarcely caught in the survey were *Deania profundorum*, *Hexanchus griseus, Scymnodom ringens* and *Dalatias licha*. The species *Deania calcea*, that used to be a usual capture in additional hauls, was absent in 2017 survey for first time since 2009. All of these species of sharks were common in additional deeper hauls (> 500 m) and scarce or absent on the standard hauls (70-500 m), except *H. griseus* which showed a shallower distribution.

During 2017 survey *D. profundorum* was not caught in standard hauls, whereas in the additional hauls its biomass was reduced almost to the half of 2016 (Figure 16). *H. griseus* biomass decreased in standard hauls 4 times from the previous year (0.03 ± 0.02 Kg·haul^{-1} vs. 0.12 ± 0.54 Kg·haul^{-1} in 2016, being absent since 2015 in additional deeper ones (Figure 17). *S. ringens* biomass decreased to nearly the half from 2016 in additional hauls and was not captured in standard hauls during the last four years (Figure 18). Finally, the species *Dalatias licha* was absent in standard hauls during the last twenty years, however its biomass kept similarly to that in 2016 in deeper special hauls (Figure 19).

These scarce species, as usually, showed their higher biomasses in the north of Galicia. However *D.licha* was only captured western the Peñas Cape (Figure).

***Raja clavata* (Thornback ray)**

In 2017 the biomass of the most abundant ray in the area, *Raja clavata,* increased six times the value of the previous year in 9a Division, 1.62 ± 1.48 Kg·haul^{-1} against 0.25 ± 0.20 Kg·haul^{-1} in 2016 and it also increased respect to the previous year in 8c Division, thought more softly (5.53 ± 1.84 Kg·haul^{-1} against 4.35± 1.43 Kg·haul^{-1} in 2016) (



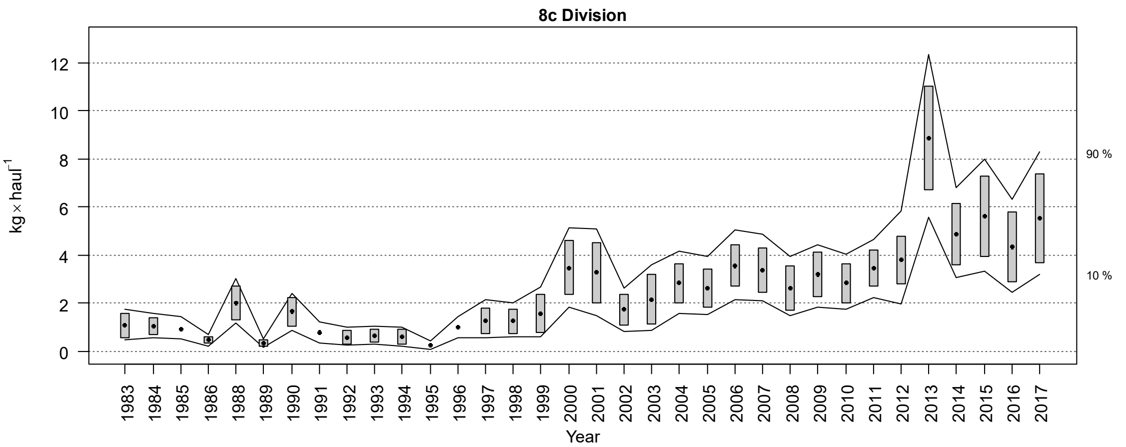


Figure 20 and Figure 21). However, the biomass of this species in both areas decreased slightly during the last two years respect to the previous five (Figure 22).

Thornback ray caught in 2017 showed a wide length distribution as usual, with greater abundance in the eastern part of the Cantabrian Sea (Figure 23). Sizes ranged from 11 cm to 97 cm in the last decade and during the last survey this range increased slightly for larger individual, until 100 cm. The few smallest specimens, between 11 and 19 cm, found in the last decade were also found this last survey for second consecutive year, after the absence in the two previous years (Figure 23).

Raja montagui (Spotted ray)

In 2017 the biomass of *Raja montagui* slightly increased the values of the previous year, 1.62 ± 0.69Kg·haul^{-1} versus 1.41 ± 0.63Kg·haul^{-1} in 2016 (Figure 24) and the last two years also increased the biomass of the previous five (Figure 25).

It was really scarce in the 9a Division (absent in MF sector) and widespread in the 8c Division, as usual (Figure 26).

Spotted ray showed a narrower length distribution in the last survey than that showed for the last decade, shortening the range in both the smallest and largest sizes (from 20 to 69 cm versus the range for the last decade from 13 to 84 cm). Two modes are located in 43 cm and also in 52 cm, similarly the last one to the mode found for the last decade (Figure 27).

Leucoraja naevus (Cuckoo ray)

In 2017 the biomass of *Leucoraja naevus* increased slightly 0.69 ± 0.23Kg·haul^{-1} versus 0.45 ± 0.14 Kg·haul^{-1} in 2016, maintaining the growing trend since 2015 and reaching the highest biomass in the historical series (Figure 28). Additionally, the last two years together showed a higher mean value than the previous five years (Figure).

It was absent in the 9a Division and widespread in the 8c Division as usual (Figure 29).

Cuckoo ray length distribution in 2017 (ranged from 20 to 65 cm) remained similar to 2016 and also similar to that of the last decade (from 19 to 72 cm) (Figure 30).

Other skates species

Other skates usually scarce in the surveys were caught in 2017, namely, *Leucoraja circularis*, *R.microcellata*, *Raja undulata*, *Raja brachyura,* and *Dipturus nidarosiensis.* Among these scarce species, *L. circularis* and *R. undulata* are a little more frequent than the others. This last survey, *L. circularis* was found in the Galician area whereas *R. undulata* was in the Cantabrian Sea, as usual (Figure 31).

Acknowledgements

We would like to thank R/V *Miguel Oliver* crew and the scientific teams from IEO that made possible SPNSGFS Surveys.
This survey is included in the ERDEM4 project, co-funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program for the collection, management and use of data from the fisheries sector and support for scientific advice in relation to the EU Common Fisheries Policy.

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Figures

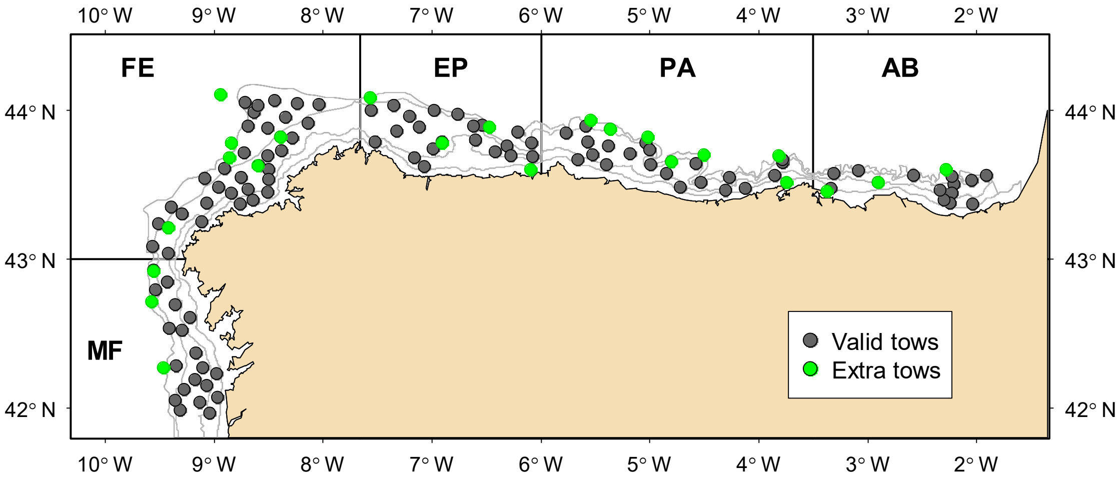

Figure 1 Stratification design and hauls on the Northern Spanish shelf groundfish survey in 2017; Depth strata are: A) 70-120 m, B) 121 – 200 m and C) 200 – 500 m. Geographic sectors are MF: Miño-Finisterre, FE: Finisterre-Estaca, EP: Estaca-cabo Peñas, PA: Peñas-cabo Ajo, and AB: Ajo-Bidasoa.

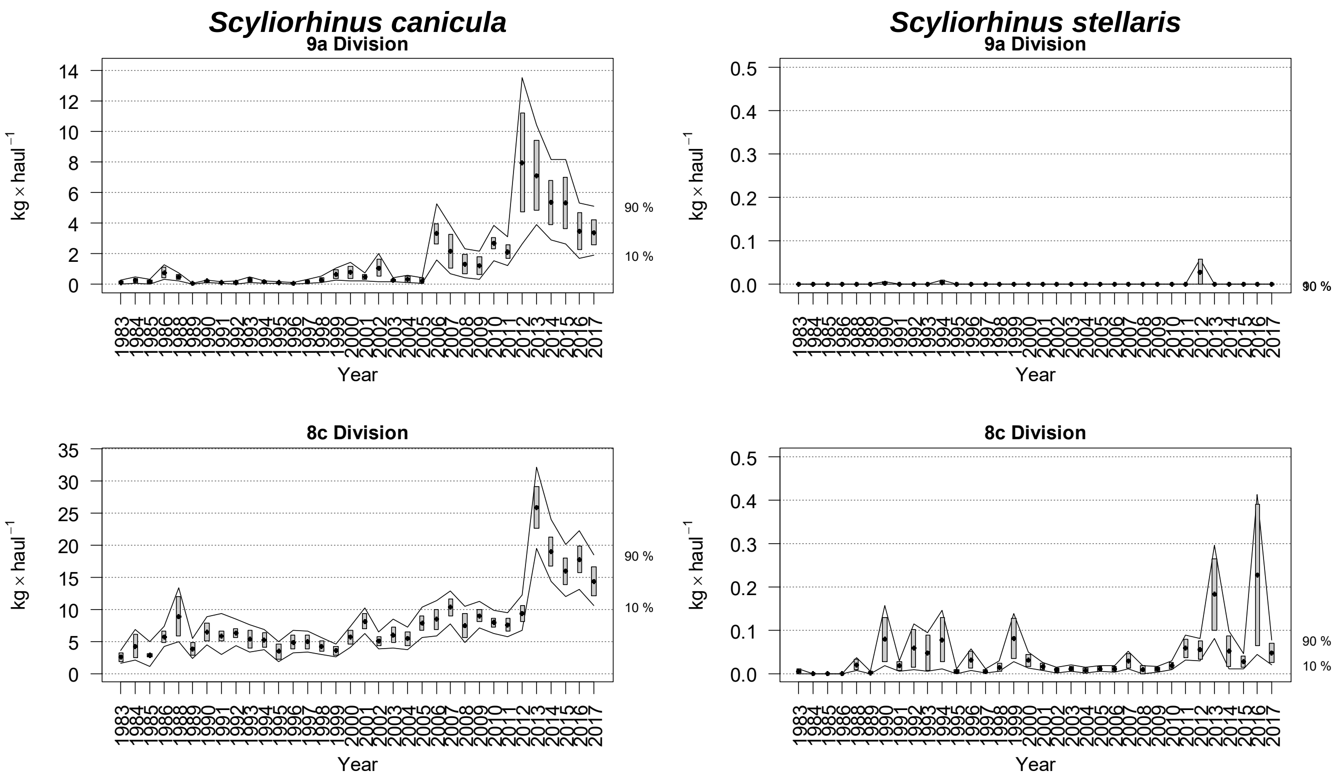

Figure 2 Evolution of *Scyliorhinus canicula* and *Scyliorhinus stellaris* biomass index during the North Spanish shelf bottom trawl survey time series in the two ICES Divisions covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

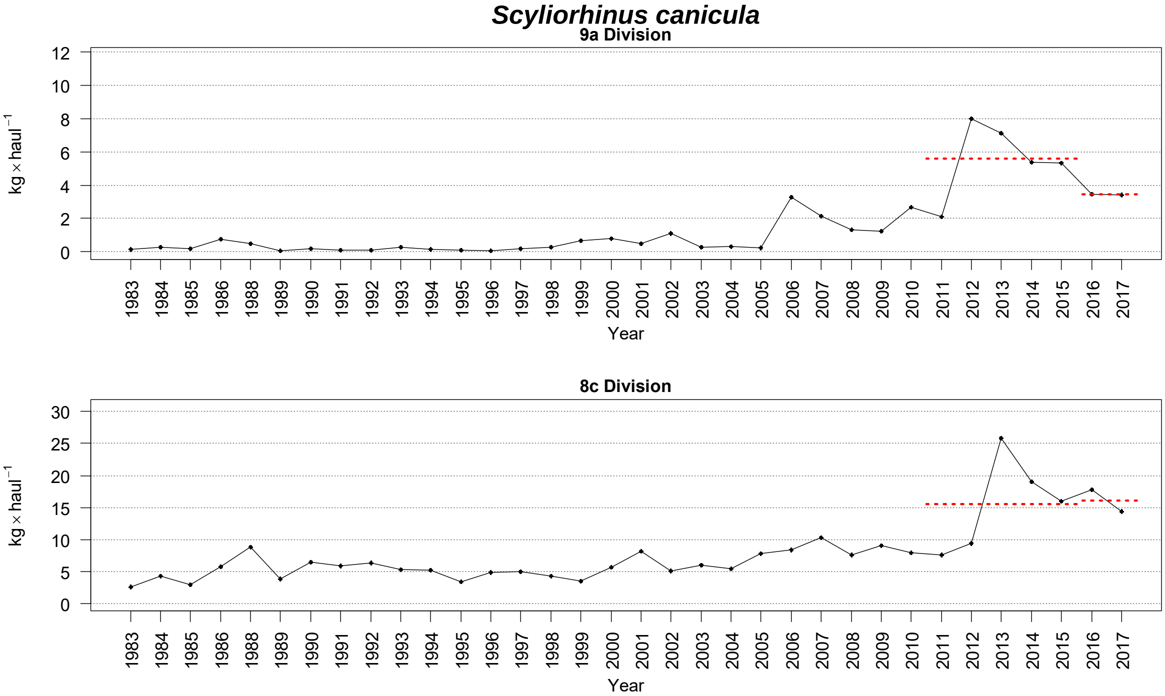

Figure 3 Evolution of *Scyliorhinus canicula* biomass index during the North Spanish shelf bottom trawl survey time series in the two ICES Divisions covered by the survey. Red lines mark a comparative between last two years and the five previous

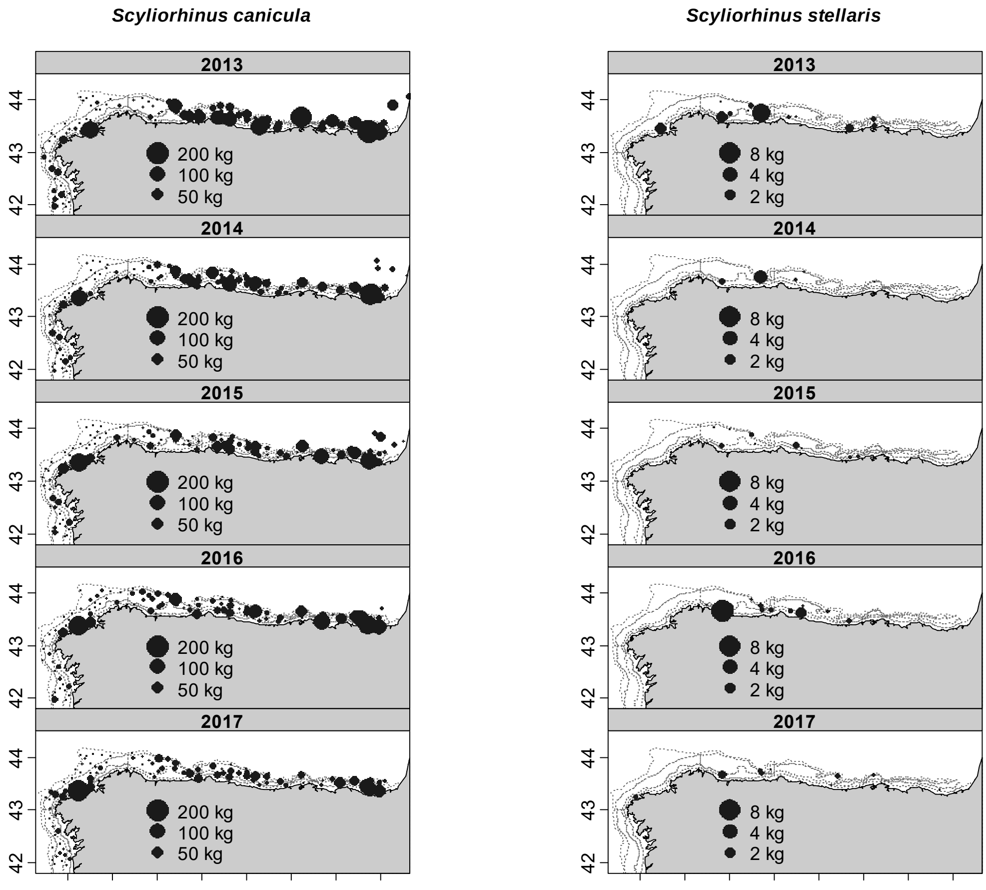

Figure 4 Geographic distribution of *Scyliorhinus canicula* and *Scyliorhinus stellaris* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2013 and 2017

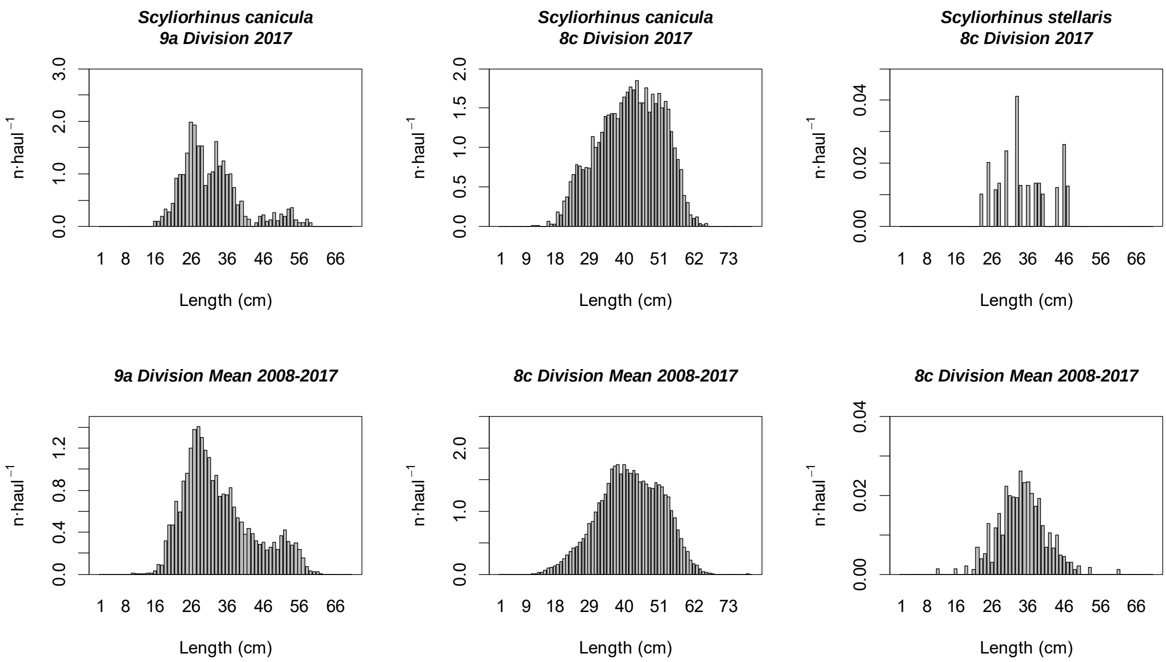

Figure 5 Stratified length distributions of *Scyliorhinus canicula* and *Scyliorhinus stellaris* in 2017 in the two ICES Divisions covered by the North Spanish Shelf bottom trawl survey, and the mean values for the last decade in both areas.

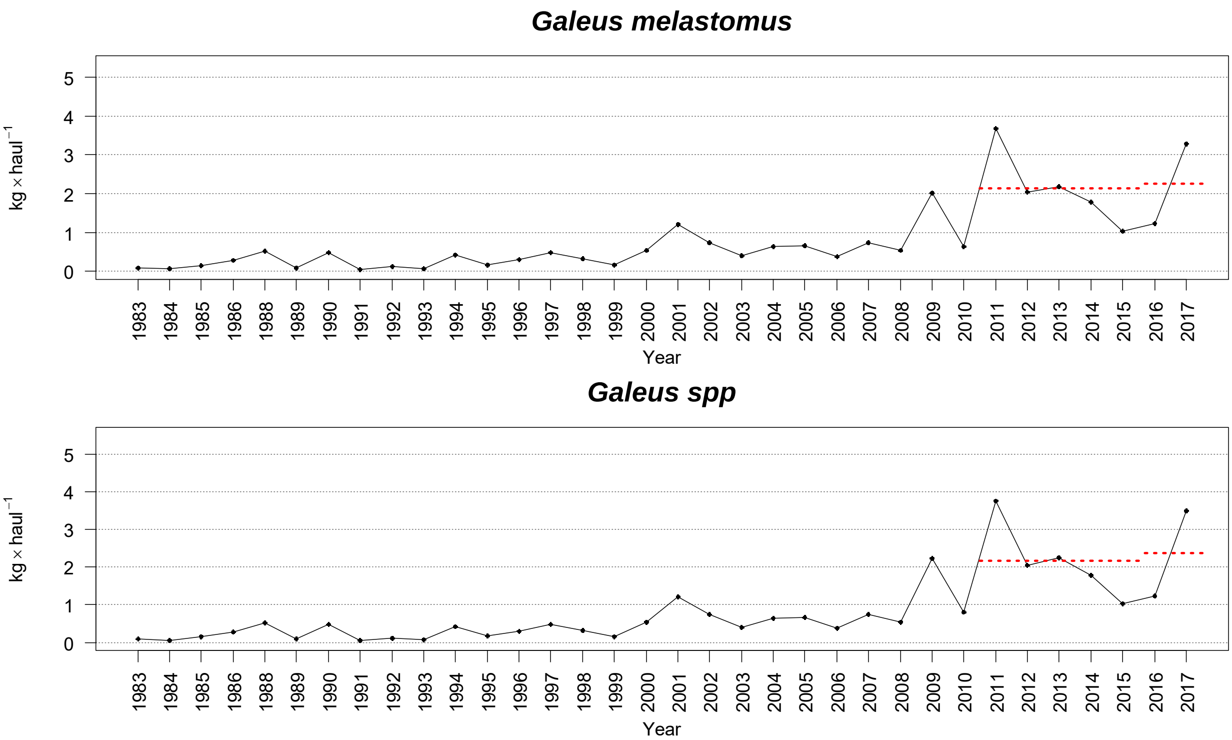

Figure 6 Evolution of *Galeus melastomus* and *Galeus* spp. biomass index during the North Spanish shelf bottom trawl survey time series in the two ICES Divisions. Red lines mark a comparative between last two years and the five previous

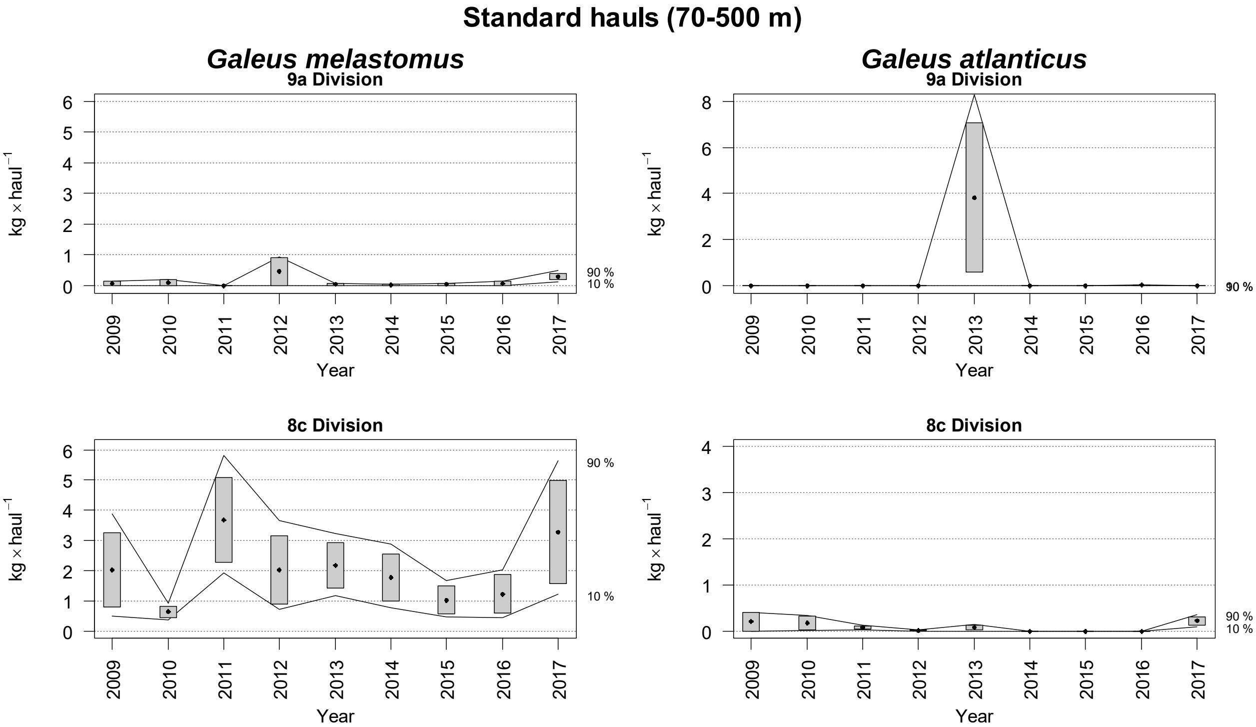

Figure 7 Evolution of *Galeus melastomus* and *Galeus atlanticus* stratified biomass index (only with standard hauls between 70 and 500 m) during the North Spanish shelf bottom trawl survey between 2009 and 2017 in the two ICES Divisions. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80 bootstrap iterations = 1000)

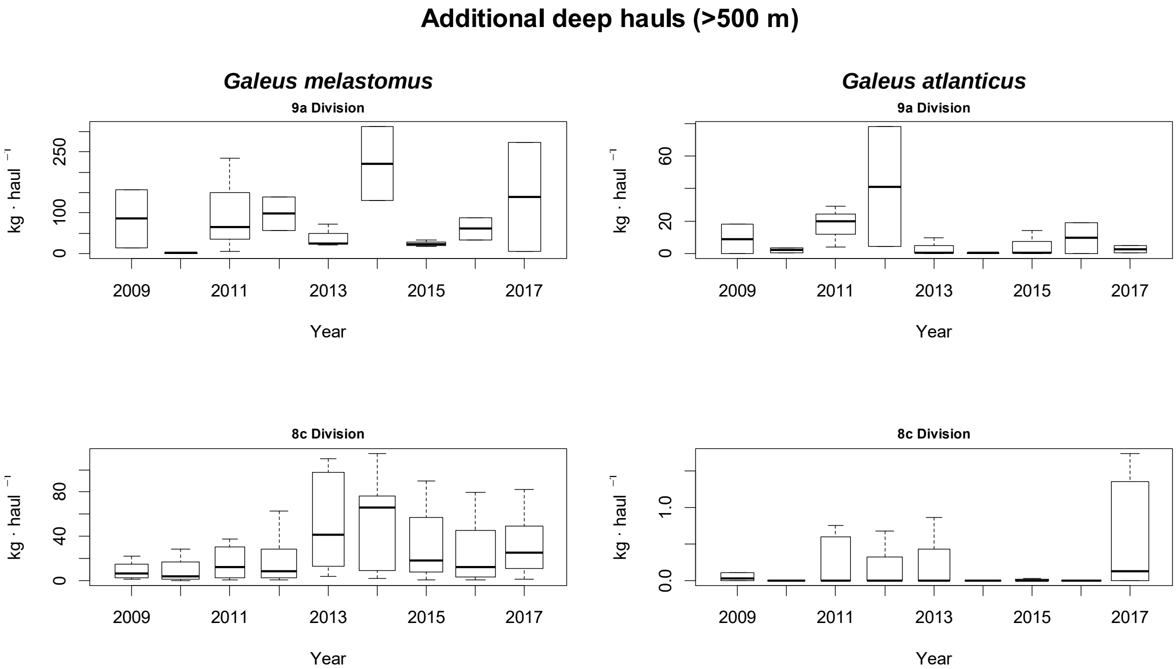

Figure 8 Evolution of *Galeus melastomus* and *Galeus atlanticus* catches in additional hauls out of the standard stratification (>500 m) between 2009 and 2017 in the two ICES divisions. Boxes mark parametric standard error of the biomass in additional hauls. Lines mark the median and whiskers the interquartile range

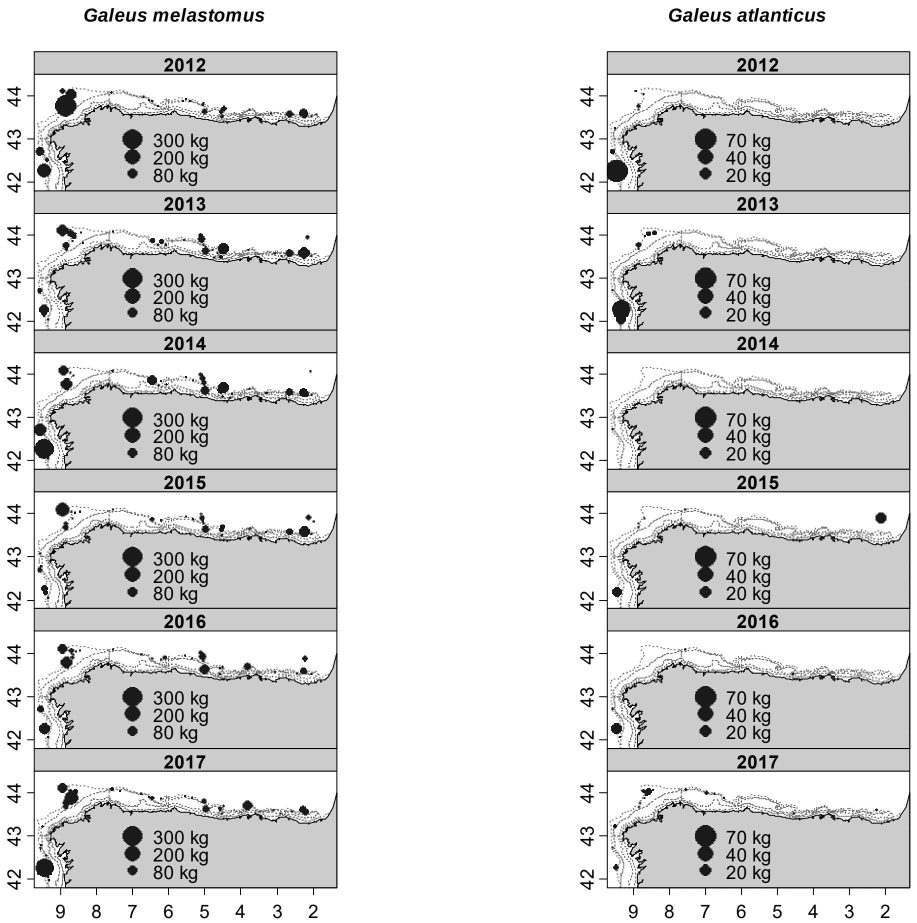

Figure 9 Geographic distribution of *Galeus melastomus* and *Galeus atlanticus* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2012 and 2017.

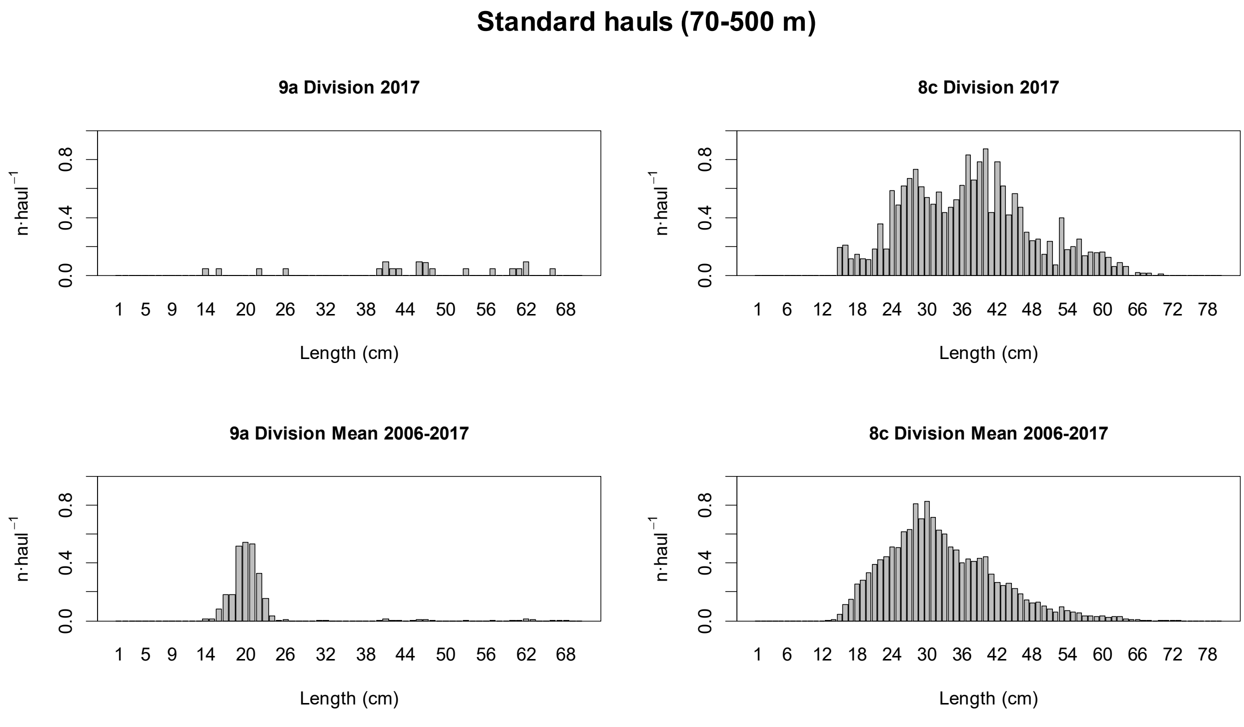

Figure 10 Mean length distributions of *Galeus melastomus* in standard hauls (70-500 m) in the North Spanish Shelf survey 2017 by ICES areas.

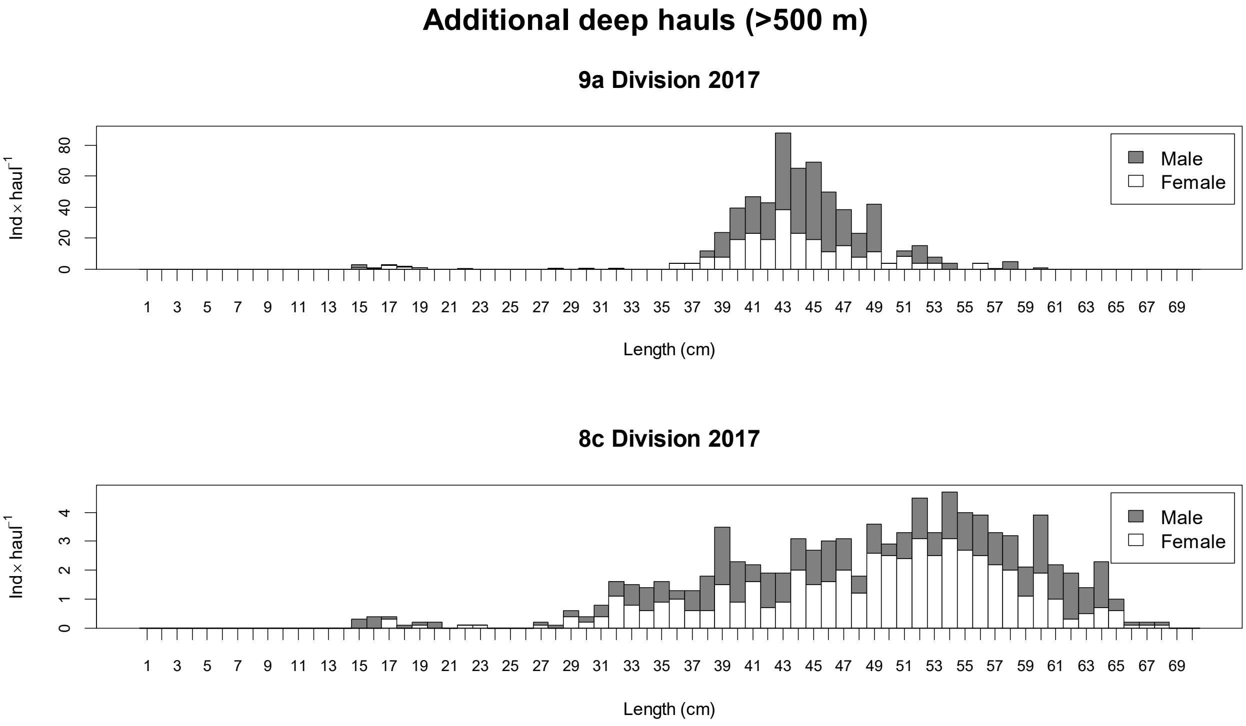

Figure 11 Mean length distributions of *Galeus melastomus* in additional hauls (>500 m) in the North Spanish Shelf survey 2017 by ICES areas.

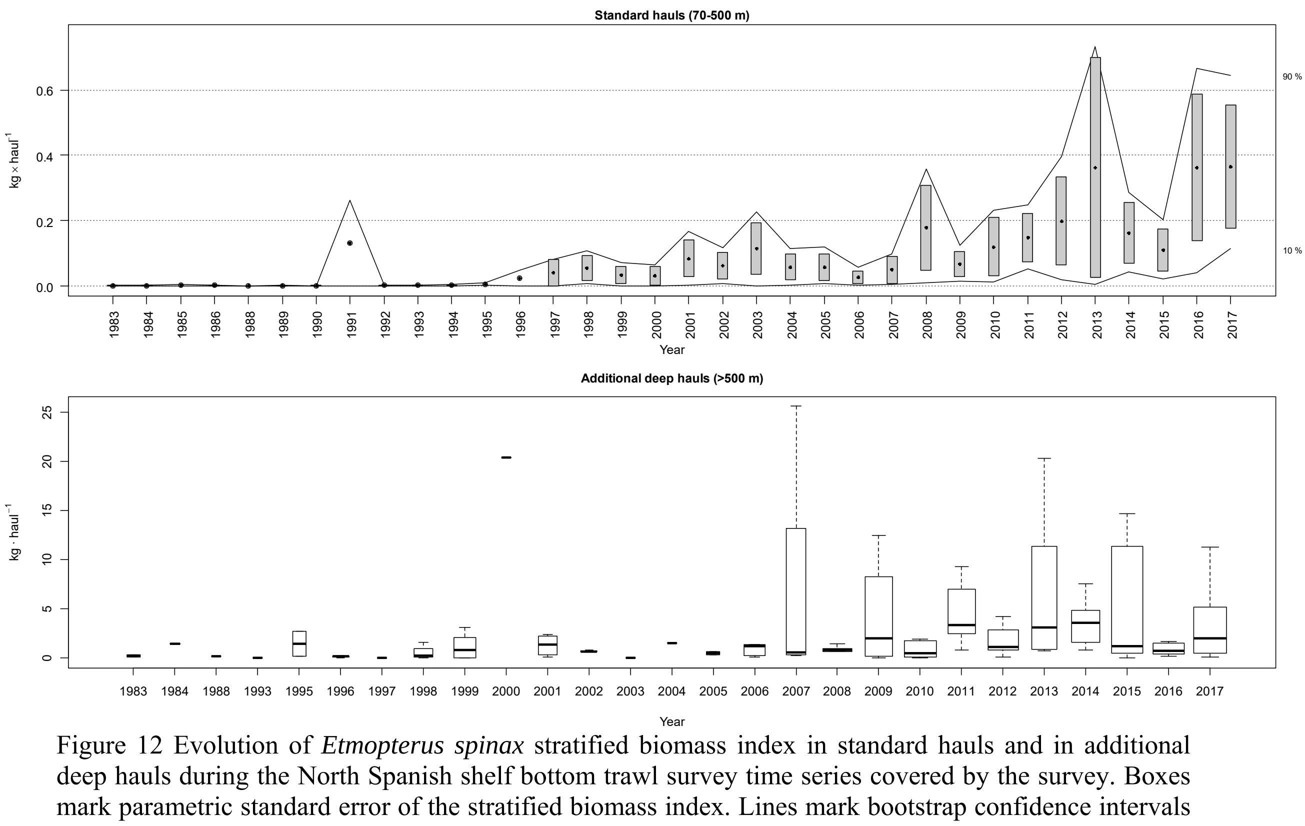

Figure 12 Evolution of *Etmopterus spinax* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

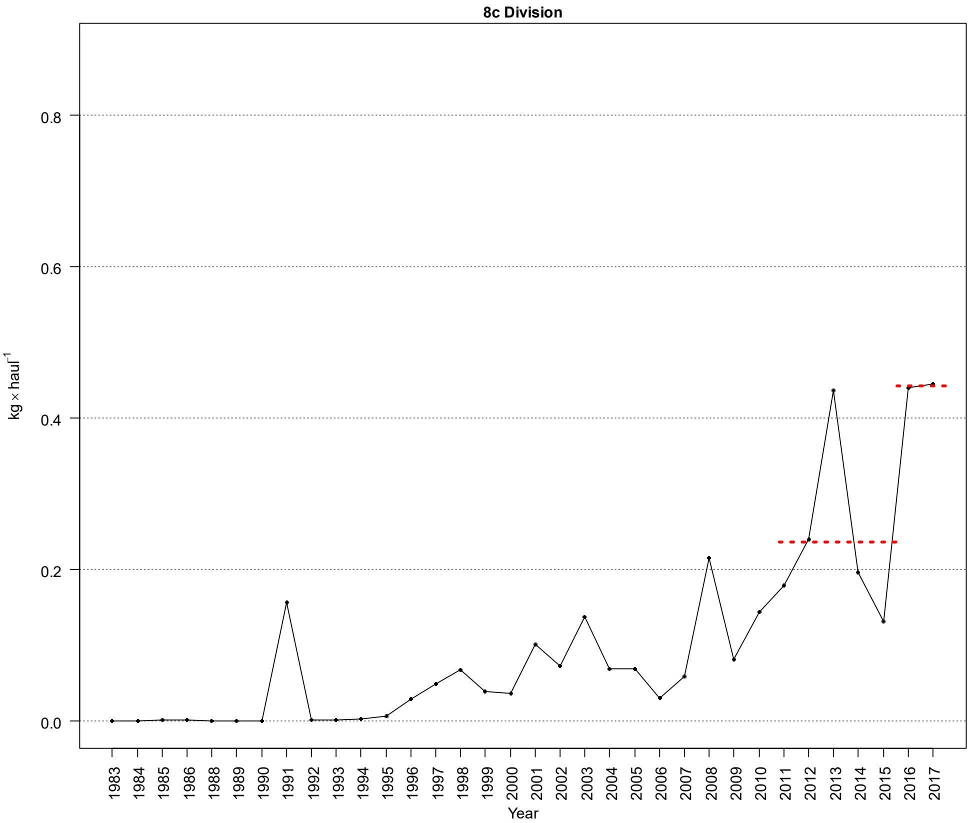

Figure 13 Evolution of *Etmopterus spinax* biomass index during the North Spanish shelf bottom trawl survey time series in 8c Division covered by the survey. Red lines mark a comparative between last two years and the five previous.

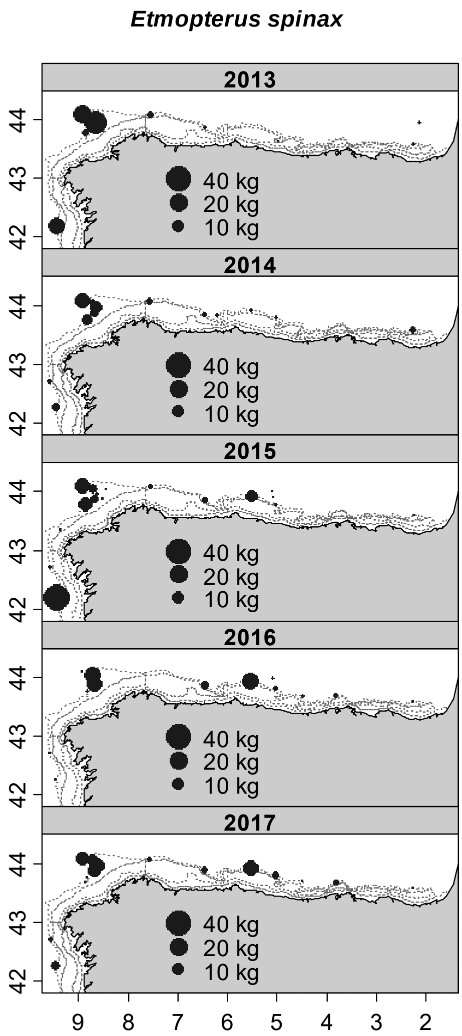

Figure 14 Geographic distribution of *Etmopterus spinax* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2013 and 2017.

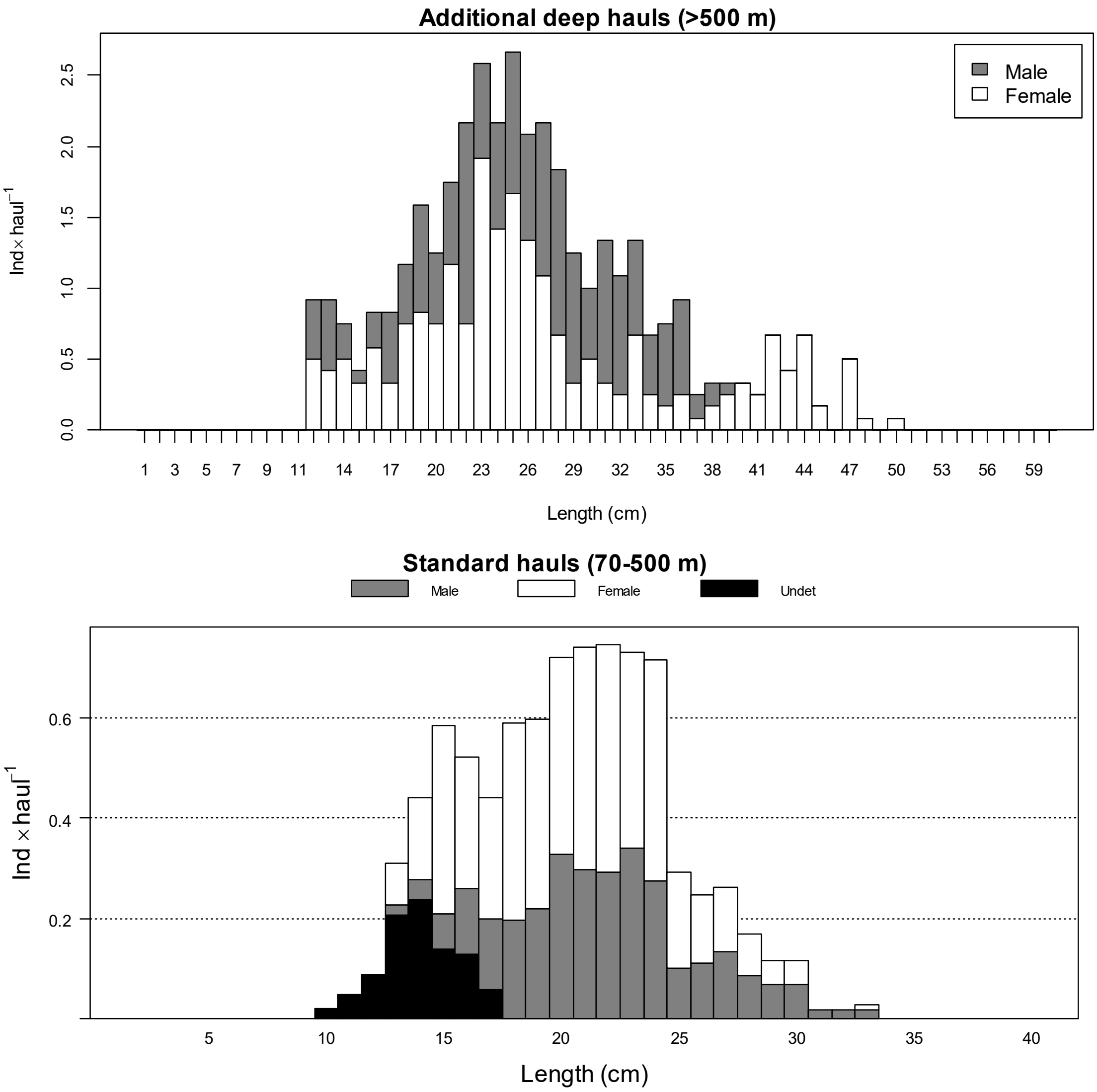

Figure 15 Mean length distributions of *Etmoperus spinax* in additional hauls (>500 m) and in standard hauls (70-500 m) in the North Spanish Shelf survey 2017.

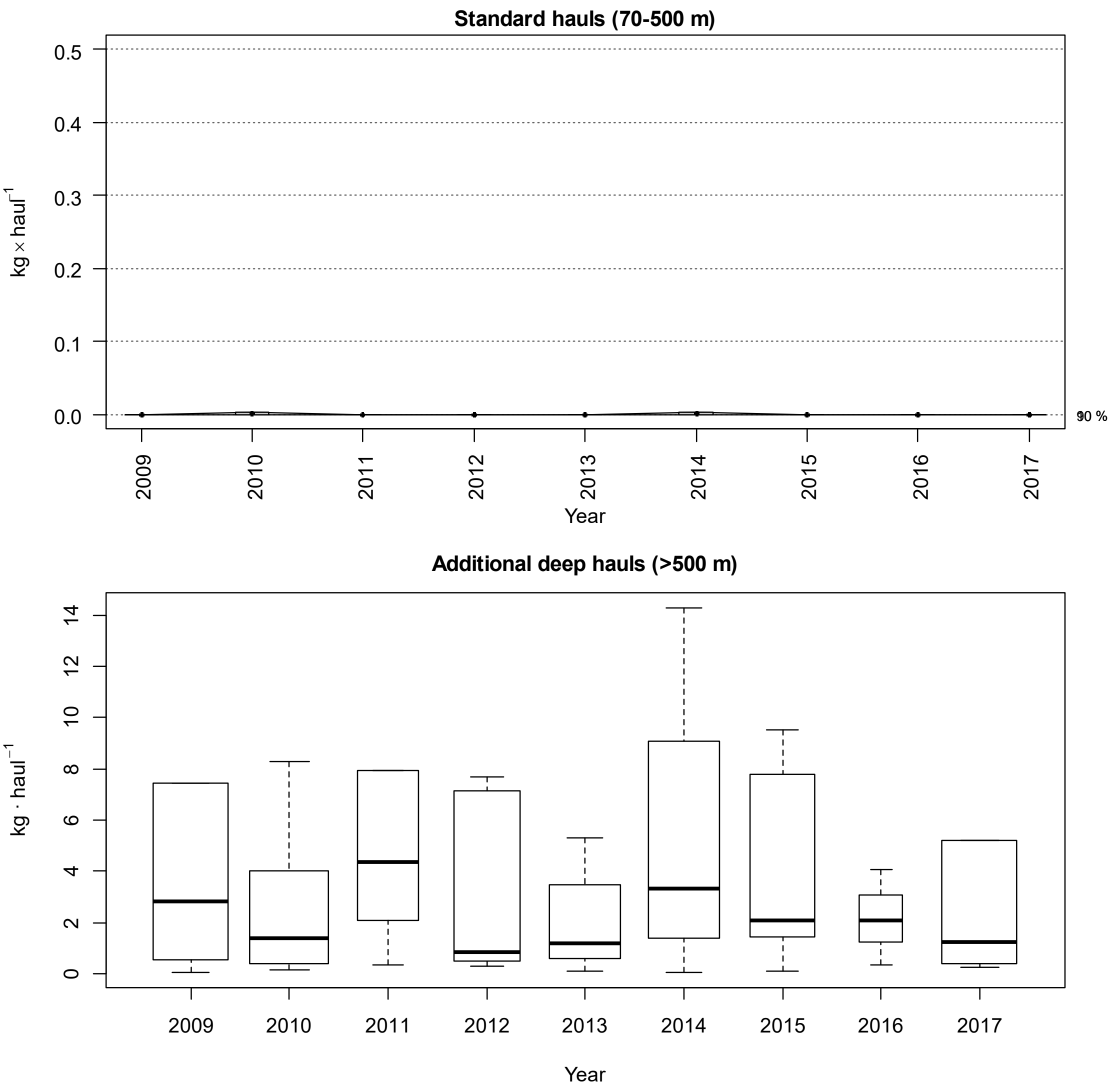

Figure 16 Evolution of *Deania calcea* and *Deania profundorum* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

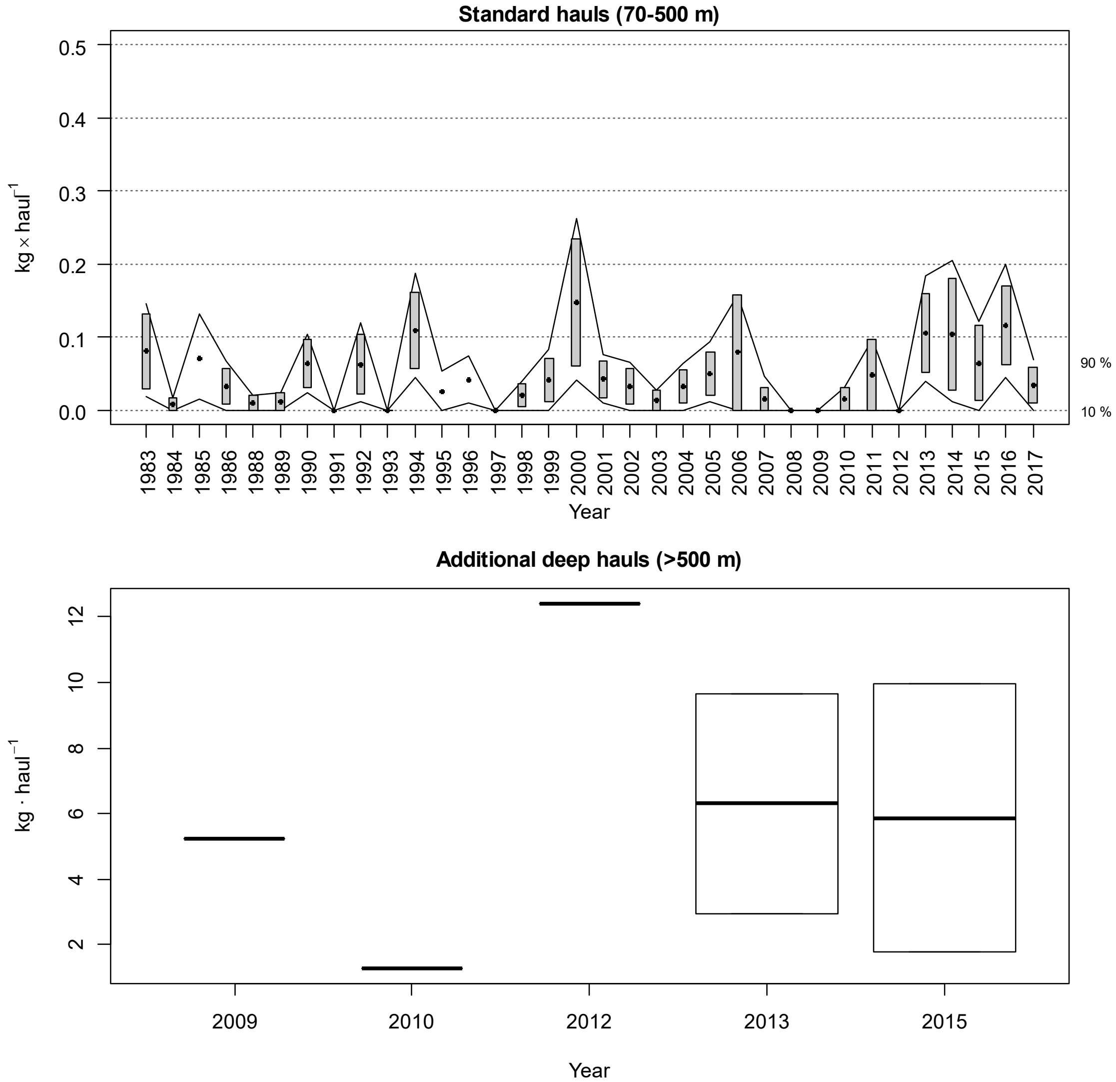

Figure 17 Evolution of *Hexanchus griseus* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

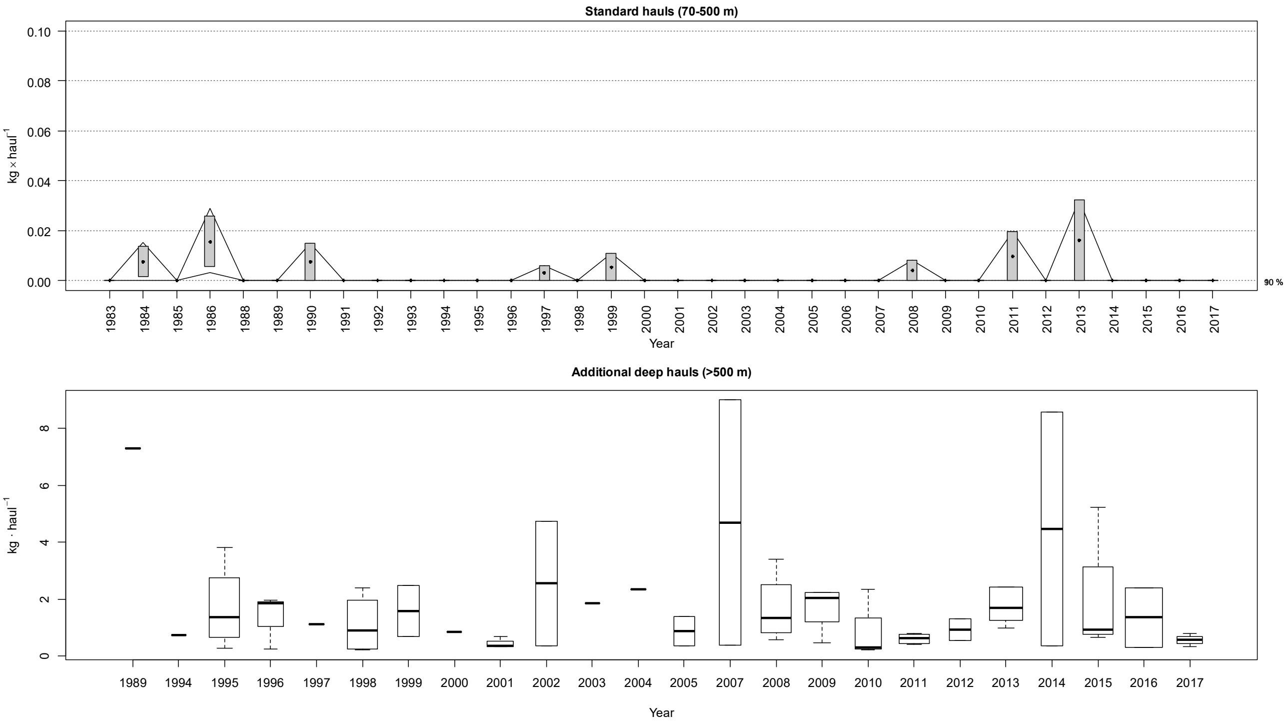

Figure 18 Evolution of *Scymnodom ringens* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

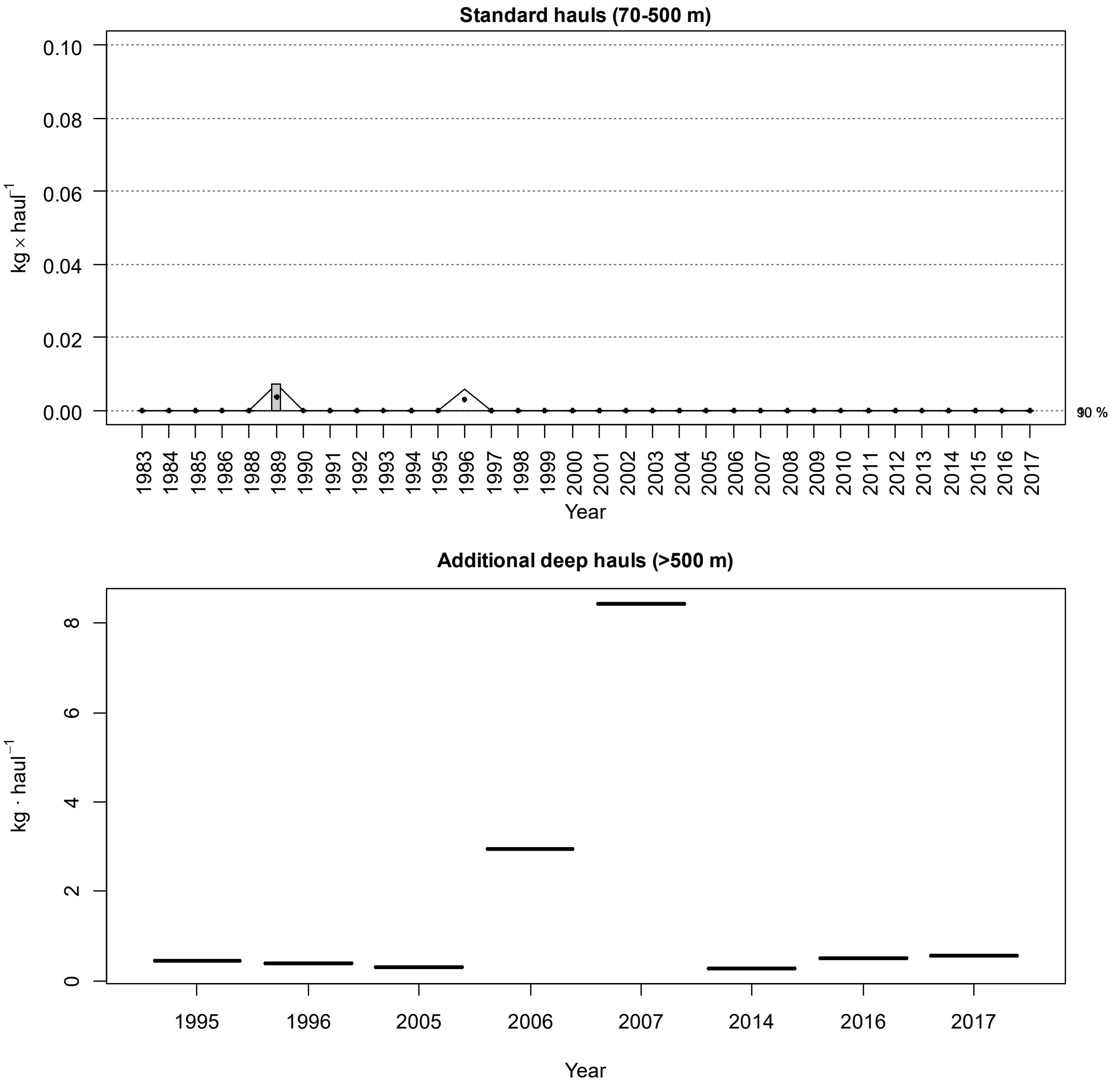

Figure 19 Evolution of *Dalatias licha* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

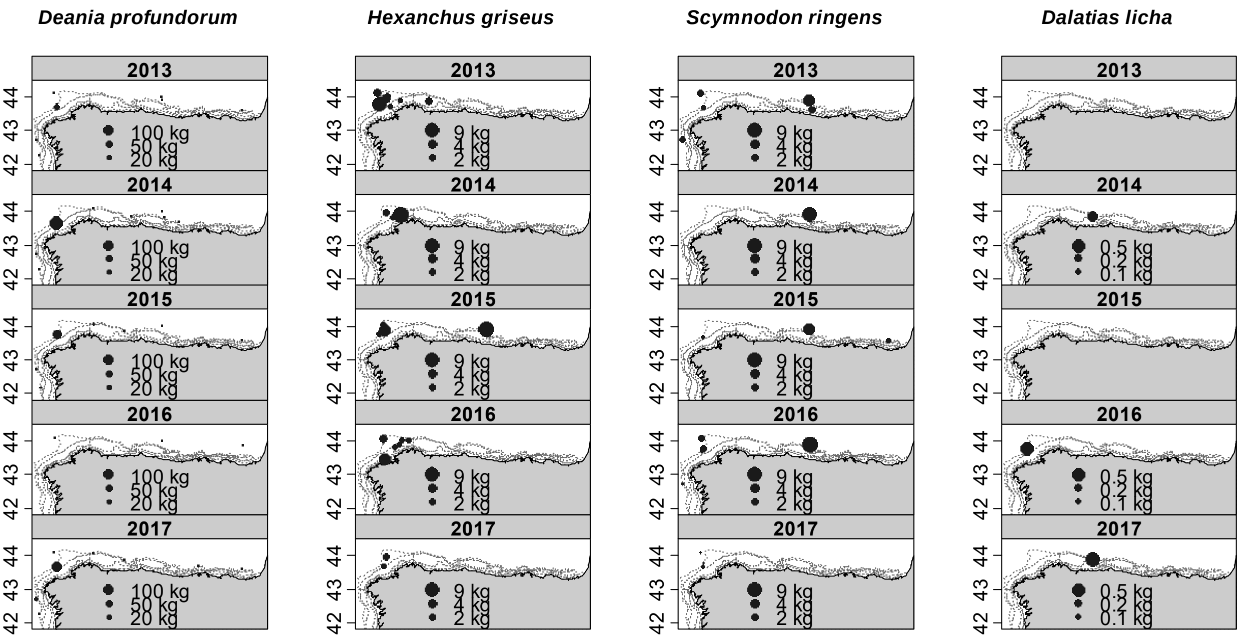

Figure 20 Geographic distribution of *Deania calcea*, *Deania profundorum*, *Hexanchus griseus* and *Scymnodon ringens* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2013 and 2017

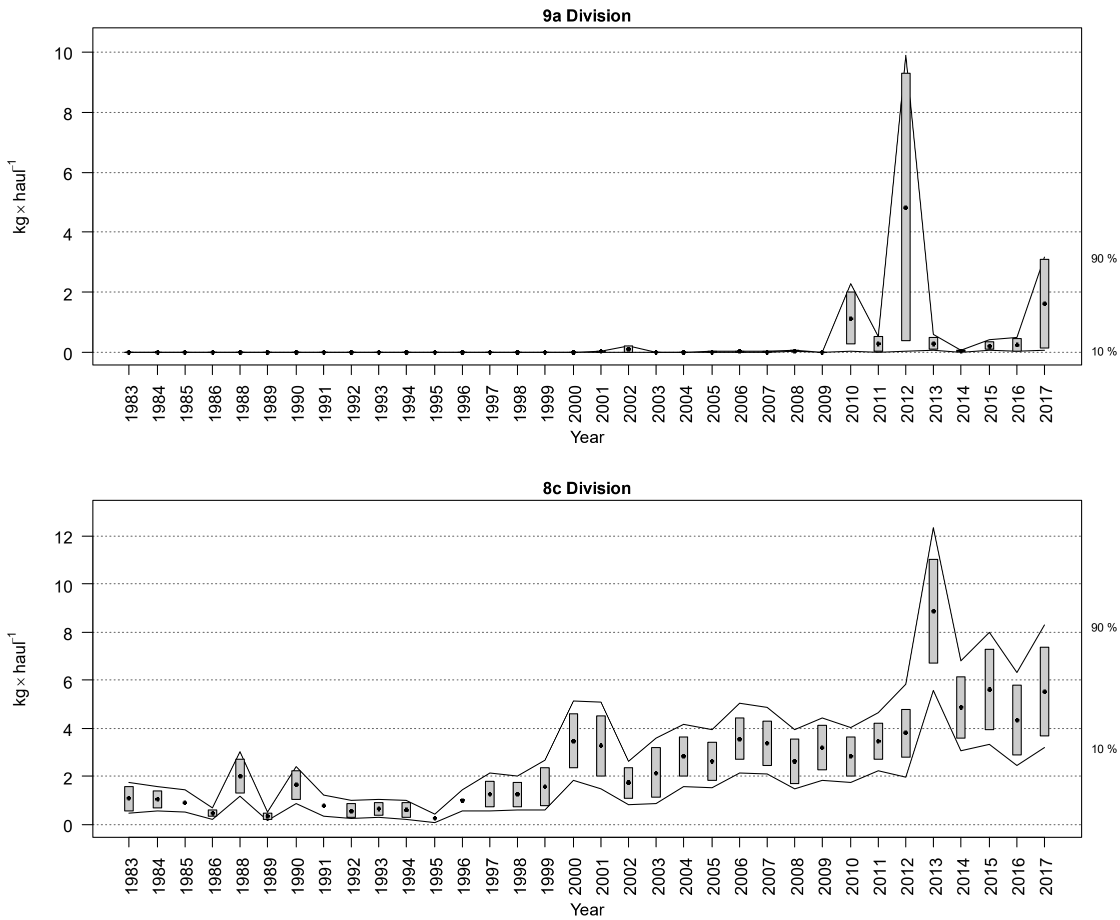

Figure 20 Evolution of *Raja clavata* biomass index during the North Spanish shelf bottom trawl survey time series in the two ICES Divisions covered by the surveys. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

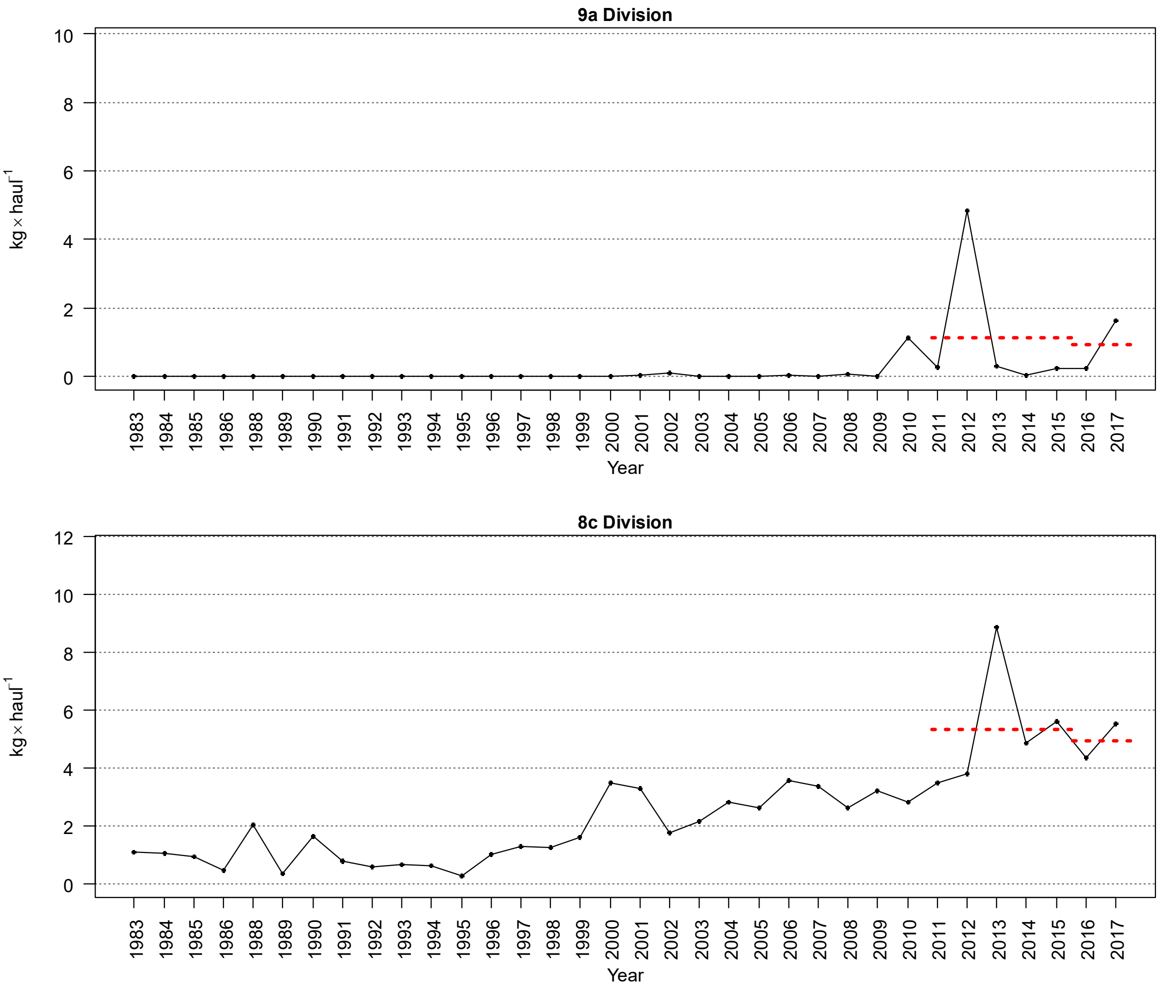

Figure 21 Evolution of *Raja clavata* biomass index during the North Spanish shelf bottom trawl survey time series. Red lines mark a comparative between last two years and the five previous

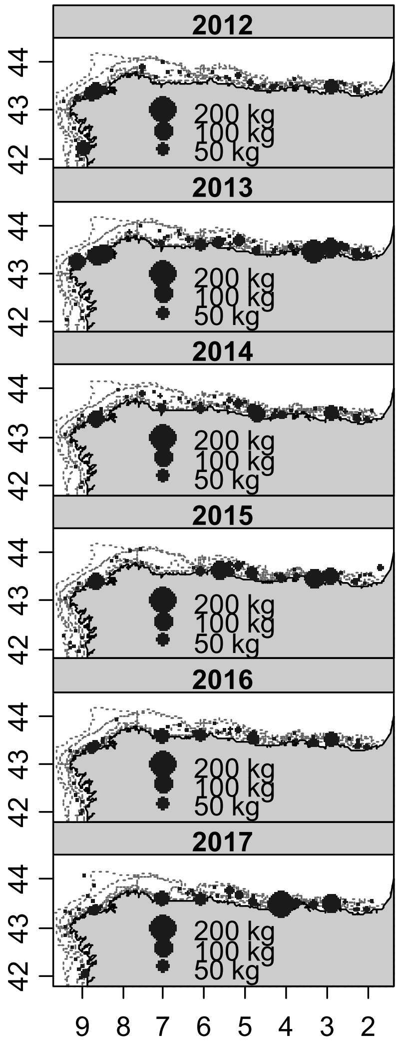

Figure 22 Geographic distribution of *Raja clavata* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2012 and 2017

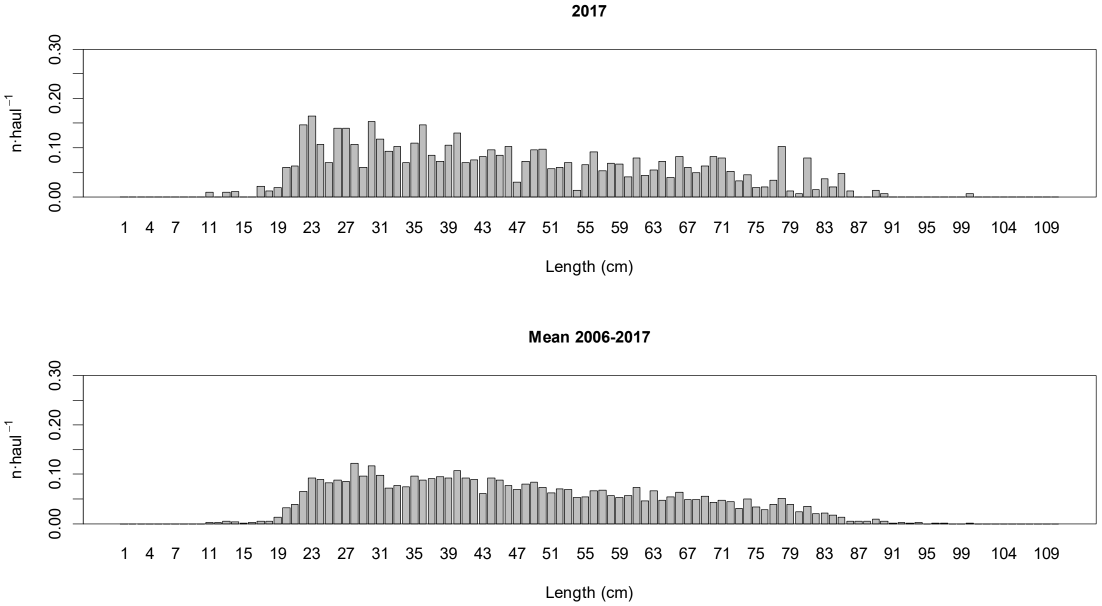

Figure 23 Mean stratified length distribution of *Raja clavata* in the last decade (above) and in the last survey (below) in 8c Division of the North Spanish Shelf

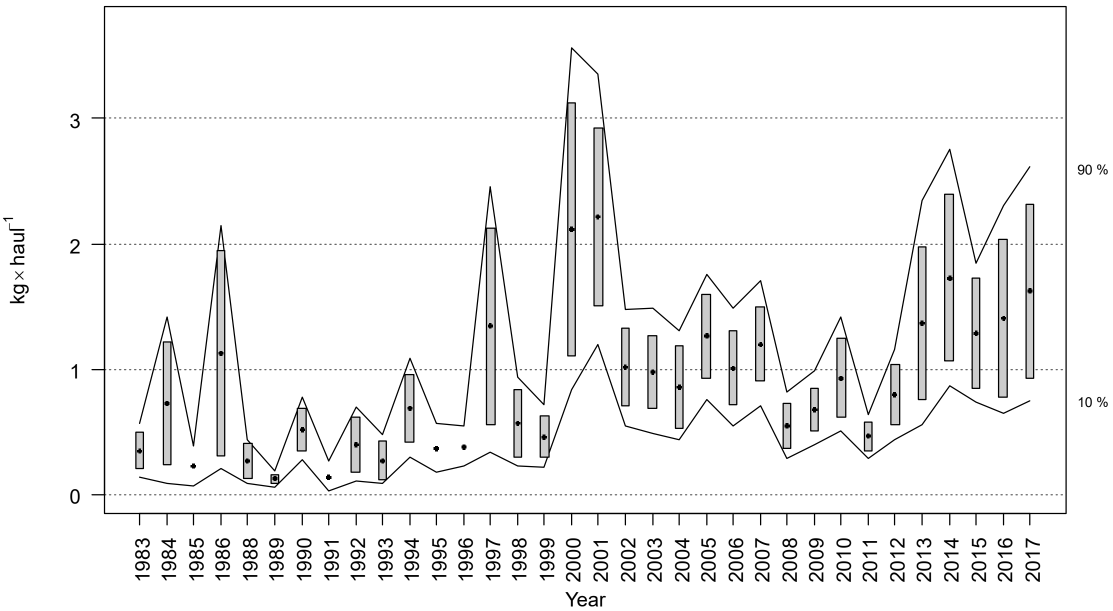

Figure 24 Evolution of *Raja montagui* biomass index during the North Spanish shelf bottom trawl survey time series in 8c Division covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

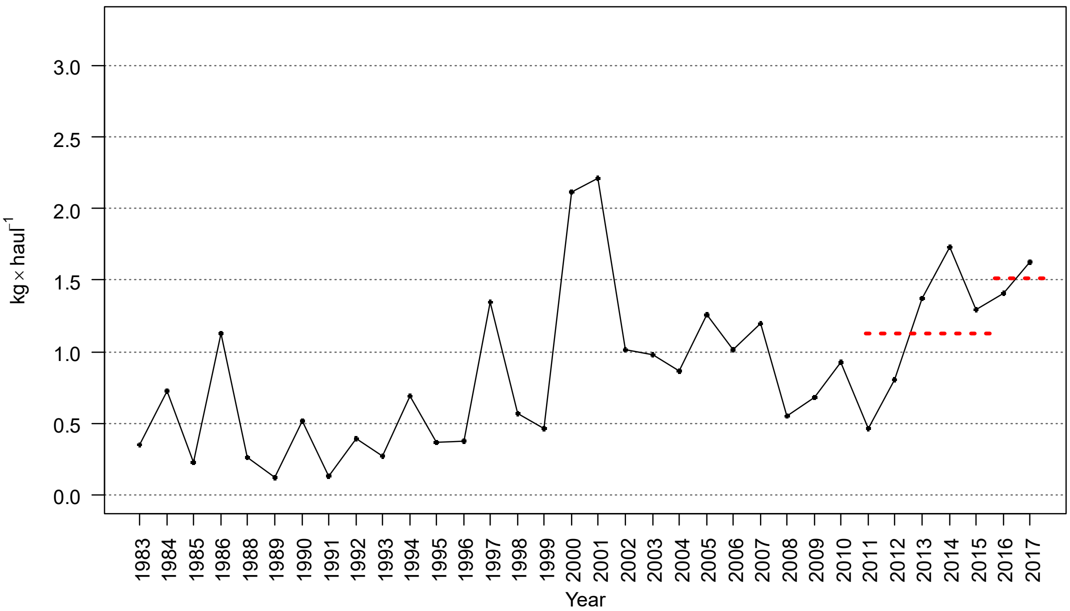

Figure 25 Evolution of *Raja montagui* biomass index during the North Spanish shelf bottom trawl survey time series in 8c Division covered by the survey. Red lines mark a comparative between last two years and the five previous

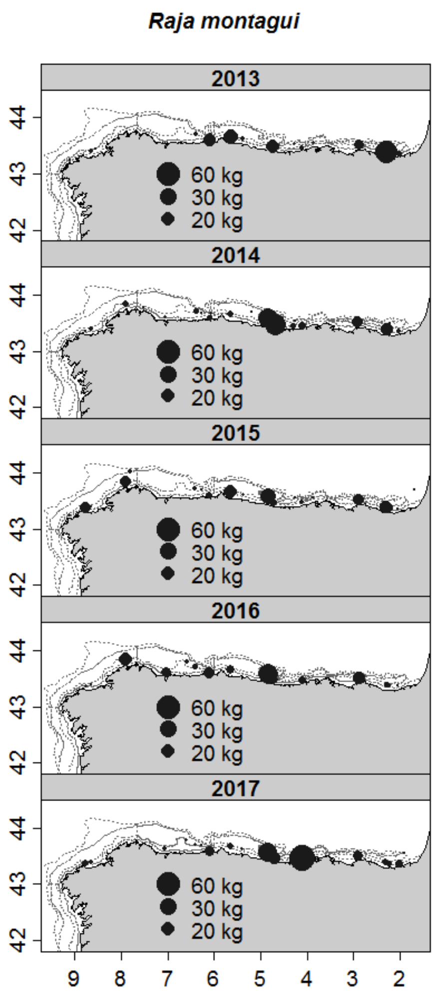

Figure 26 Geographic distribution of *Raja montagui* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2013 and 2017

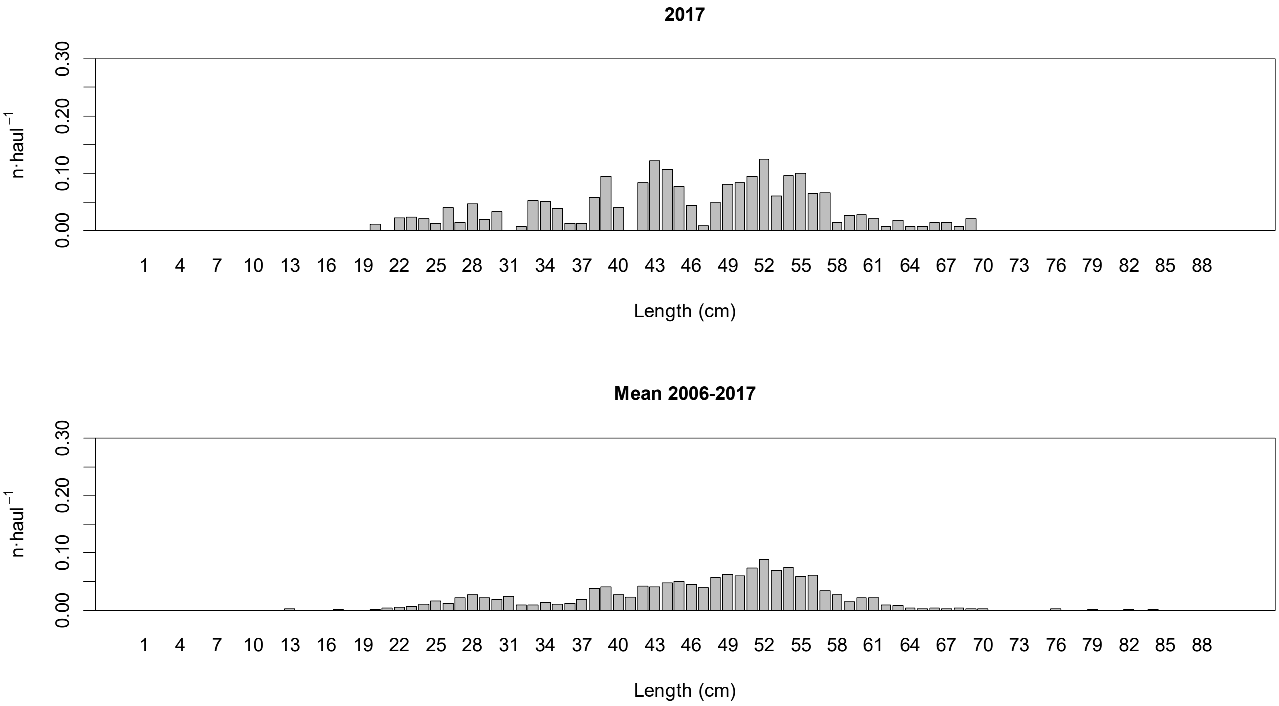

Figure 27 Mean stratified length distribution of *Raja montagui* in the last decade (above) and in the last survey (below) in 8c Division of the North Spanish Shelf

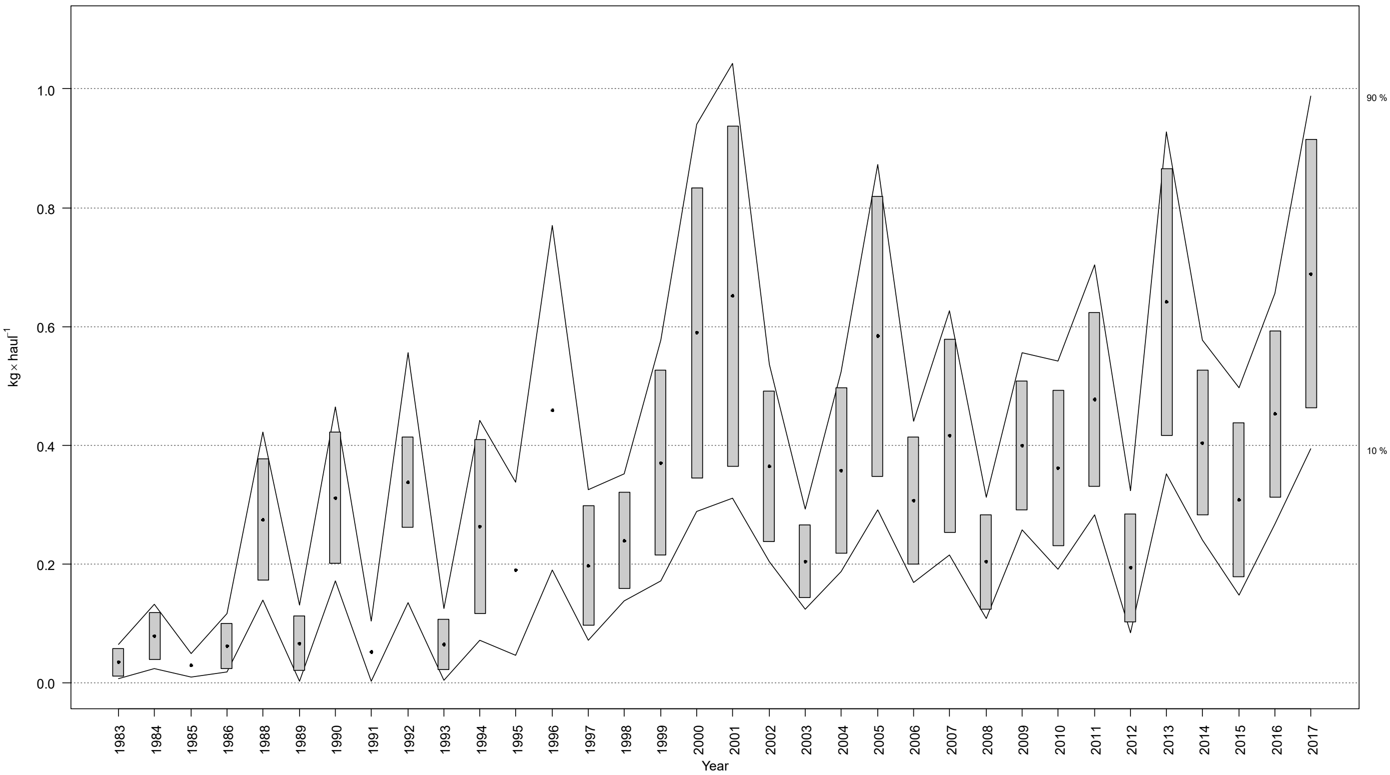

Figure 28 Evolution of *Leucoraja naevus* biomass index during the time series of the North Spanish shelf bottom trawl surveys in 8c Division covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

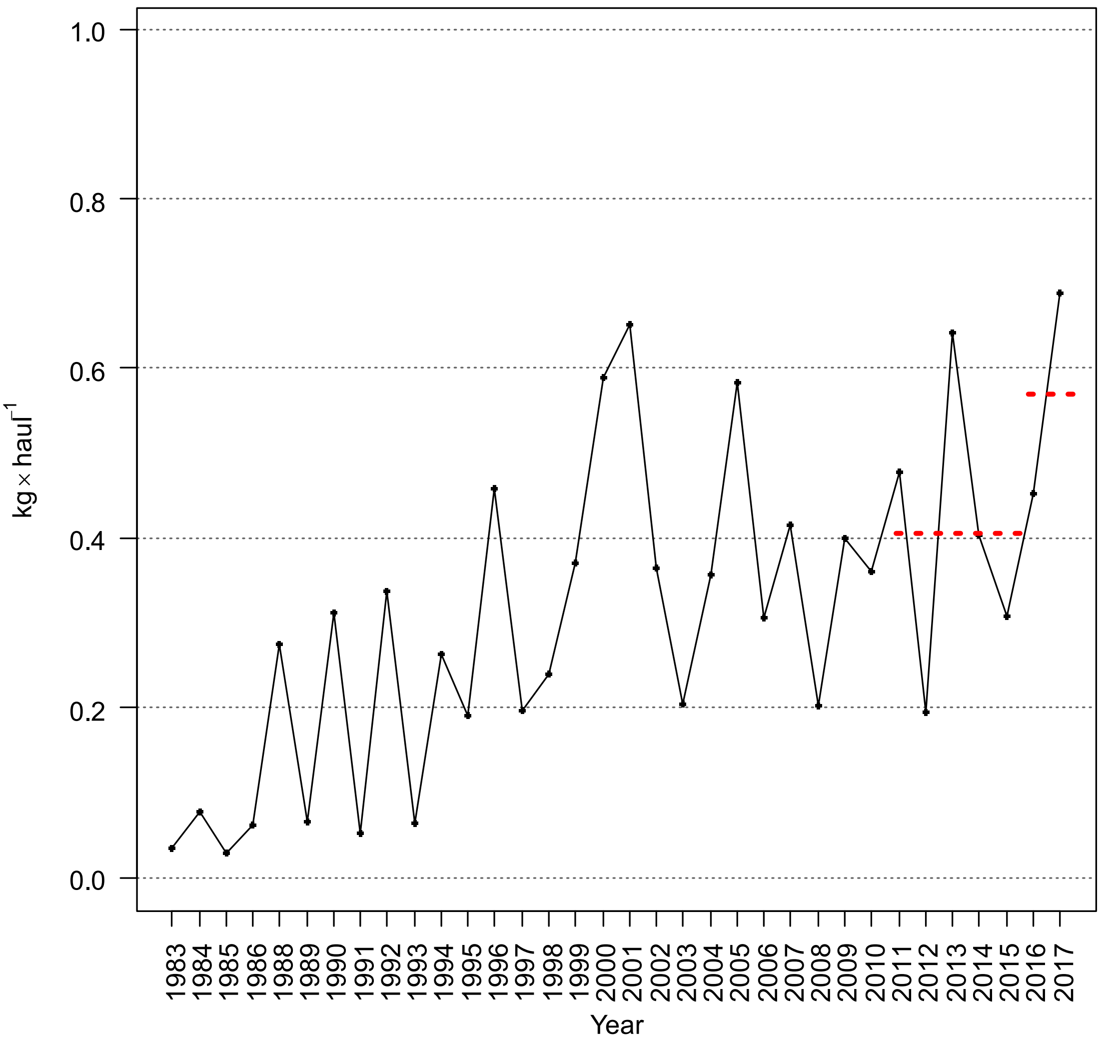

Figure 30 Evolution of *Leucoraja naevus* biomass index during the North Spanish shelf bottom trawl survey time series in 8c Division covered by the survey. Red lines mark a comparative between last two years and the five previous

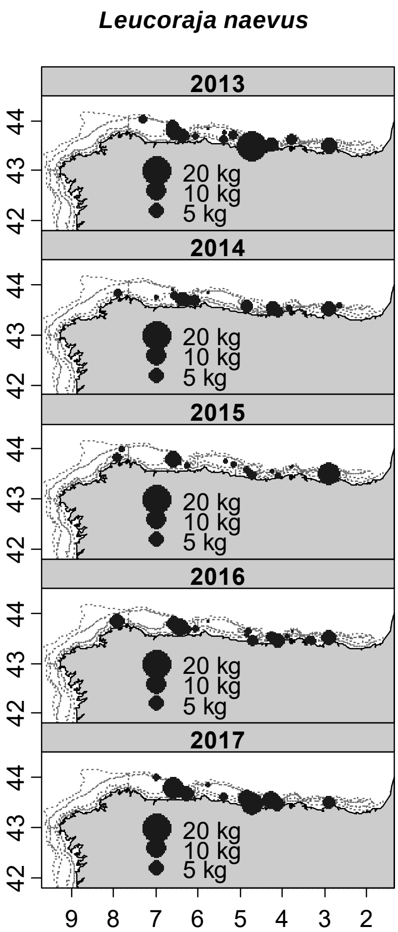

Figure 29 Geographic distribution of *Leucoraja naevus* catches (kg/30 min haul) in North Spanish shelf bottom trawl surveys between 2013 and 2017

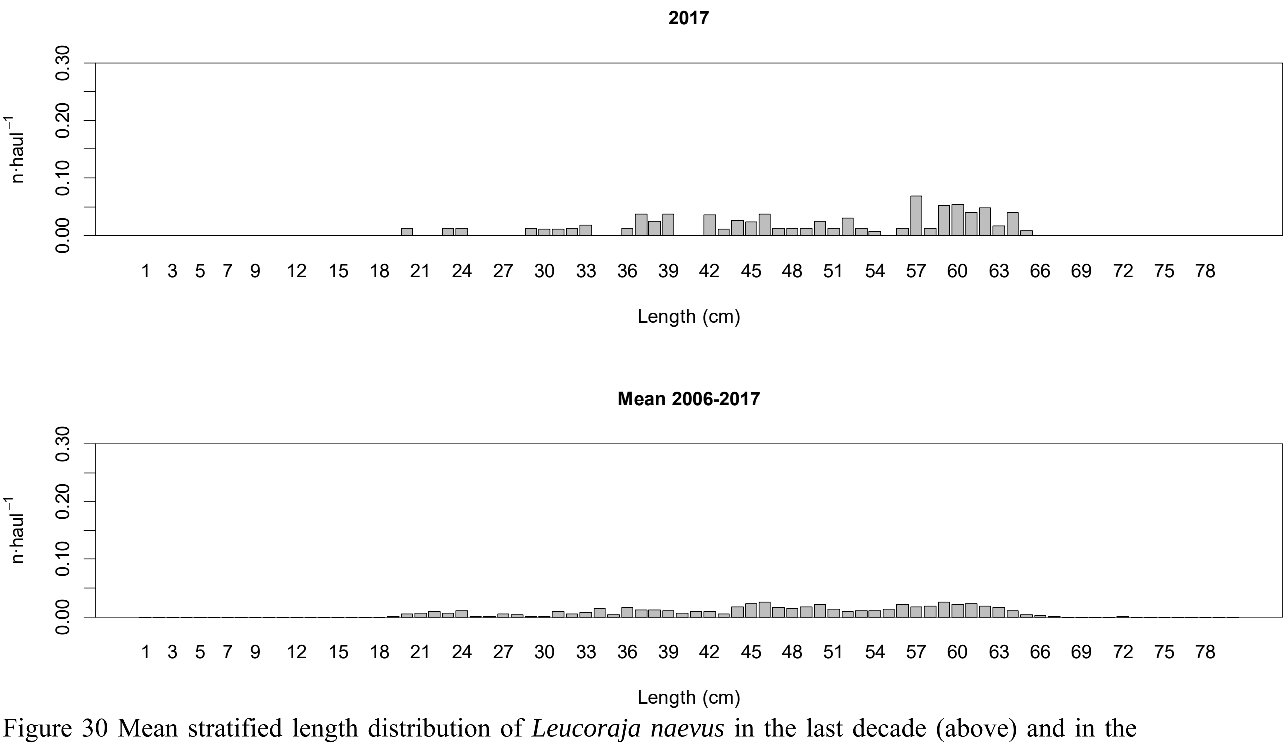

Figure 30 Mean stratified length distribution of *Leucoraja naevus* in the last decade (above) and in the last survey (below) in 8c Division of the North Spanish Shelf

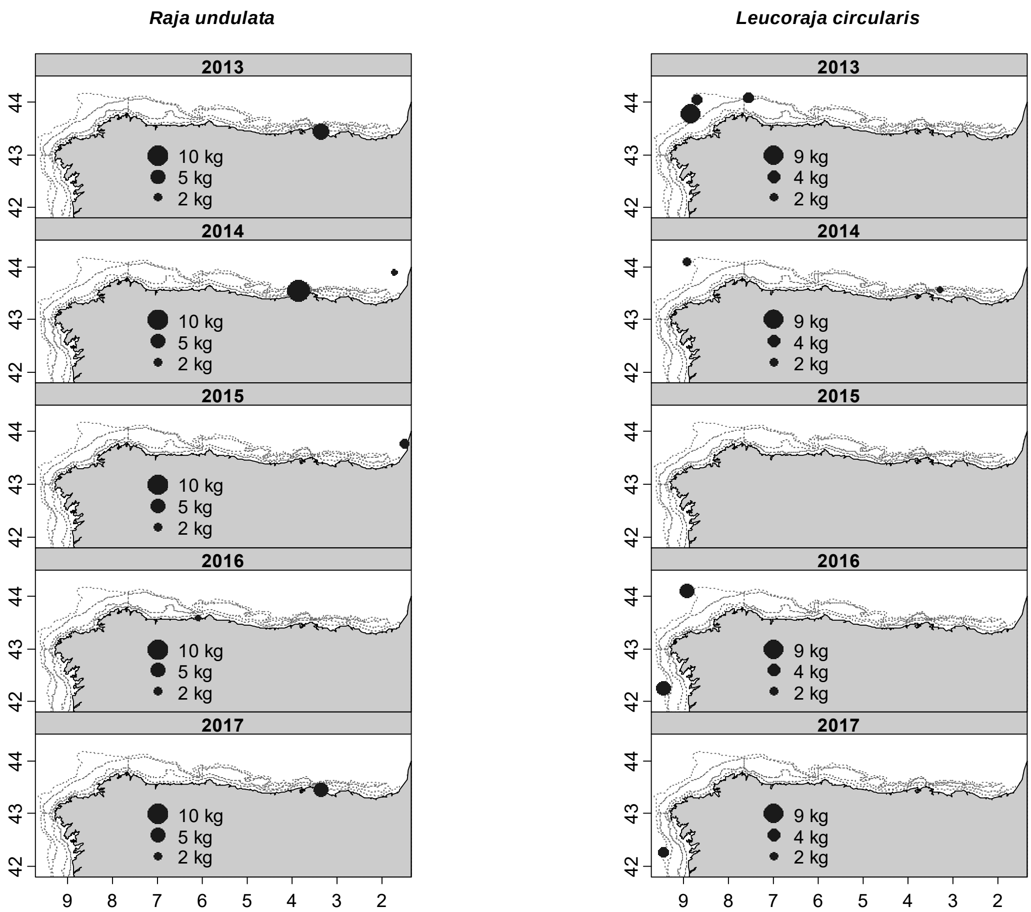

Figure 31 Geographic distribution of *Raja undulata* and *Leucoraja circularis* and other unidentified rays catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2013 and 2017

Working Document presented to the Working Group on Elasmobranch Fishes
ICES WGEF, 16-28th June 2018, Lisbon, Portugal

Results on main elasmobranches species from 2001 to 2017 Porcupine Bank (NE Atlantic) bottom trawl surveys

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Abstract

This working document presents the results of the most significant elasmobranch species caught on the Porcupine Spanish Groundfish Survey (SP-PORC-Q3) in 2017 and also updates previous documents presented. Biomass, abundance, distribution and length ranges were analysed for *Galeus melastomus* (blackmouth catshark), *Deania spp.*, *Scymnodon ringens* (knifetooth dogfish), *Scyliorhinus canicula* (lesser spotted dogfish), *Etmopterus spinax* (velvet belly lantern shark), *Dalatias licha* (kitefin shark), *Hexanchus griseus* (bluntnose sixgill shark), *Dipturus nidarosiensis* (Norwegian skate), *Dipturus cf. flossada* (common skate), *Dipturus cf. intermedia* (common skate), *Leucoraja circularis* (sandy ray) and *Leucoraja naevus* (cuckoo ray). Biomass indices of these species decreased in 2017, except in the case of *Deania profundorum*, *D. licha* and *L. naevus.* Some other scarce elasmobranchs were found, especially *Squalus acanthias*. Few small specimens were generally found.

Introduction

The Spanish bottom trawl survey on the Porcupine Bank (ICES Divisions 7c and 7k) has been carried out annually in the third-quarter (September) since 2001 to provide data and information for the assessment of the commercial fish species in the area (ICES Divisions 7c and 7k) (ICES 2017).

The aim of this working document is to update the results (abundance indices, length frequency distributions and geographic distributions) of the most common elasmobranch species in Porcupine bottom trawl surveys, after the previously presented results (Ruiz-Pico *et al.* 2014; Fernández-Zapico *et al.* 2015; Ruiz-Pico *et al.* 2016; Fernández-Zapico *et al.* 2017). The species analysed were: *Galeus melastomus* (blackmouth catshark), *Deania calcea* (birdbeak dogfish), *Deania profundorum* (arrowhead dogfish), *Scymnodon ringens* (knifetooth dogfish), *Etmopterus spinax* (velvet belly lantern shark), *Scyliorhinus canicula* (lesser spotted dogfish), *Dalatias licha* (kitefin shark), *Hexanchus griseus* (bluntnose sixgill shark), *Leucoraja circularis* (sandy ray), *Leucoraja naevus* (cuckoo ray), *Dipturus nidarosiensis* (Norwegian skate), *Dipturus cf. flossada* and *Dipturus cf. intermedia* (common skate).

Material and methods

The area covered in the Spanish Ground Fish Survey on the Porcupine bank (SP-PORC-Q3) (Figure 1) extends from longitude 12° W to 15° W and from latitude 51° N to 54° N following the standard IBTS methodology for the western and southern areas (ICES 2017). The R/V "Vizconde de Eza" a stern trawler of 53 m and 1800 Kw has been used throughout the historical series to carry out the SP-PORC-Q3. The sampling design was random stratified to the area (Velasco and Serrano 2003) with two geographical sectors (Northern and Southern) and three depth strata (> 300 m, 300-450 m and 450-800 m). Hauls allocation is proportional to the strata area following a buffered random sampling procedure (as proposed by Kingsley *et al*. 2004) to avoid the selection of adjacent 5×5 nm rectangles (Figure 2). More details on the survey design and methodology in ICES (2017).

Biomass, geographical distribution and length compositions were analysed, and the mean stratified biomass of the most abundant species of the last two years was compared with the mean of the previous five years.

The reduction in the time of trawling (20 instead of 30 minutes) applied in the last two surveys worked successfully. Now the catches are reduced and more manageable for people who sort it, but keep on being abundant enough to be representative samples. The biomass indices of the whole time series are not affected by this reduction because the results of these last surveys were extrapolated to 30 minutes of trawling time to keep the time series.

Trying to know the catches when the net contacts ground and before it starts to trawl, some "zero minute hauls" were carried out this 2017 survey within the frame of an IBTSWG experiment.

Results and discussion

In 2017, 80 standard hauls, 4 additional hauls and 10 zero-minute hauls were carried out (Figure 2).

The total mean catch per haul increased slightly this last year (Figure 3). Fishes represented about 96% of the total stratified catch and the elasmobranchs considered constituted the 5% of that total fish catch, with the following percentages per species: *Galeus melastomus* (64.3%), *Deania calcea* (13.3%), *Deania profundorum* (0.5%), *Scymnodon ringens* (4%), *Scyliorhinus canicula* (5.9%), *Etmopterus spinax* (2.2%), *Hexanchus griseus* (1.6%), *Dalatias licha* (1%), *Centroscymnus crepidater* (0.08%) and *Squalus acanthias* (0.8%). The skate and rays species were: *Leucoraja naevus* (0.7%), *Leucoraja circularis* (1.4%), *Dipturus nidarosiensis* (2.4%) and *Dipturus cf. flossada* (1.6%).

In 2017, the biomass of all of these elasmobranchs decreased, except *D. profundorum*, *D. licha* and *L. naevus* which showed a slight increase. However, the mean stratified biomass of these species remained similar or higher than the five previous years except *S. ringens* and *L. circularis*. Sixteen specimens of the scarce shark, *S. acanthias*, (maximum in the time series) were caught this last survey. Regarding recruitment, a reduction of small specimens was generally found, except for *L. circularis*.

Galeus melastomus (blackmouth catshark)

The biomass and abundance of *G. melastomus* dropped this last year, following the decreasing trend of the previous year (Figure 4). However the values remained similar to the five previous years and high from 2012 when a remarkable rise was found (Figure 5).

The species distributed similarly in the southern area this last survey than in previous years and with no presence in the north western part of the bank reported in 2016 (Figure 6).

Blackmouth catshark length distribution ranged from 12 cm to 79 cm. As in previous years, three modes were found, around 22 cm, 35-49 cm and 60 cm. However, a lower abundance of small specimens (< 20 cm) was found this last survey (Figure 7).

Deania calcea (birdbeak dogfish*)* and *Deania profundorum* (arrowhead dogfish)

These two species were comparatively analysed in this working document, as in previous reports, since *D. profundorum* was identified and frequently found in the study area. Initially in the time series, the arrowhead dogfish had been misidentified as birdbeak dogfish.

D. profundorum was scarcer than *D. calcea* in the area. The biomass and abundance of *Deania spp.* (mainly *D. calcea*) have followed an up and down trend since the last decade. In 2017, the values decreased, but they remained between the average values of the time series and high to the previous five years (Figure 8 and Figure 9). Particularly, *D. calcea* decreased, whereas *D. profundorum* increased reaching the highest values of the time series (Figure 10).

Both species showed a similar distribution in this last survey, in the deepest strata and in the south, west and north of the study area, although the biggest spot of biomass, in both, was in the western area at 650 m (Figure 11 and Figure 12).

Larger specimens of *D. calcea* than *D. profundorum* were found as usual in the last survey. The length distribution of *D. calcea* ranged from 67 cm to 110 cm, whereas the few specimens of *D. profundorum* ranged from 19 cm to 93 cm. A main mode of specimens of *D. calcea* around 86 cm and about 71 cm in *D. profundorum* were found as in previous years (Figure 13, Figure 14), but no specimens smaller than 65 cm were found this last survey for *D. calcea,* only for *D. profundorum* (Figure 15).

Scymnodon ringens (knifetooth dogfish)

This last survey, the biomass and abundance of *S. ringens* decreased but remained among the average values of the time series (Figure 16). Even so, the mean biomass of the last two years remained lower than the previous five years (Figure 17).

As usual *S. ringens* was mainly found in the deepest strata in the southeast of the study area (Figure 18).

The length distribution of *S. ringens* remained similar to the previous years, with specimens from 31 cm to 78 cm and seven large specimens from 92 cm to 111 cm. Specimens around 75 cm, the usual mode throughout the time series, were less abundant in this last survey (Figure 19)

***Scyliorhinus canicula* (lesser spotted dogfish)**

Biomass and abundance of *S. canicula* decreased this last survey, but the values remained among the highest average values of the time series and followed the increasing trend of this species since the beginning of the time series (Figure 20). The mean biomass of the last two years remained higher than the previous five years (Figure 21).

The geographical distribution of *S. canicula* remained similar to the previous year, in the north of the study area, particularly around the bank and on the Irish shelf (Figure 22).

The *S. canicula* caught in 2017 showed a narrower length distribution than the previous years, from 43 to 78 cm, but with the usual mode around 64 cm. The signs of recruitment of the previous year (17-23 cm) were not showed in this last survey (Figure 23).

***Etmopterus spinax* (velvet belly)**

The biomass and abundance of *E. spinax* decreased sharply in 2017, after the remarkable increase of the previous year. The values have followed an ascending and descending trend throughout the time series (Figure 24). However, the mean biomass of the last two years remained slightly higher than the previous five years (Figure 25).

The specimens of *E. spinax* were mainly found southeast of the bank, as usual, and some to the west of the bank, but hardly found north of the bank (Figure 26).

The length distribution of *E. spinax* remained similar to the previous year from 12 cm to 52 cm, with two little modes around 21 cm and 38 cm but lower abundances per size (Figure 27).

***Hexanchus griseus* (bluntnose sixgill shark)**

The biomass and abundance of this scarce shark decreased this last survey. The biomass remained among the average values of the time series whereas the abundance among the lowest values (Figure 28).

The geographical distribution remained without au unclear pattern, some specimens north of the bank, some southeast of the bank and some in the deepest south of the study area (Figure 29).

Six of the nine specimens found were from 69 cm to 91 cm and three larger than 100 cm (102 cm, 120 cm and 158 cm) (Figure 30).

***Dalatias licha* (kitefin shark)**

In 2017, the biomass of *D. licha* followed the increasing trend from 2016, whereas the abundance decreased (Figure 28). This is explained because a large specimen was caught north of the bank, the largest specimen in the time series (129 cm), which contributed more to the biomass than to the abundance. Other spots of biomass were found in the western area and some specimens in the south and east of the study area (Figure 29). All of them in the deepest strata, particularly from 463 m to 754 m in this last survey. Eight of the twelve specimens were 42 cm to 70 cm and three around 100 cm (Figure 31).

Leucoraja circularis (sandy ray) *and Leucoraja naevus* (cuckoo ray)

The biomass and abundance of *L. naevus* increased this last survey although they remained among the average values of the time series. The biomass of *L. circularis* decreased and remained also among the average values of the time series. However, the abundance of this species, which has followed an increasing trend since the beginning of the time series, increased this last year due to the major contribution of small specimens, one of 21 cm and nine from 30 to 40 cm of the thirty specimens found (Figure 32).

In 2017, as in previous years, the specimens of *L. naevus* were found in the shallower strata around the bank, whereas *L. circularis* was found in the southwest and northwest of the study area (Figure 33). As usual, *L. circularis* was found deeper than *L. naevus* (Figure 34).

Regarding the length distributions, apart from small specimens of *L. circularis*, other were found around 50 cm, 60-70 cm, one of 100 cm and two of 112 cm (among the highest sizes of the time series). However, *L. naevus* showed a narrower length distribution, as usual, from 41 cm to 59 cm in this last survey (Figure 35 and Figure 36).

Dipturus spp. (common skate)

Dipturus nidarosiensis, *Dipturus cf. flossada* and *Dipturus cf. intermedia* were comparatively analysed since 2011 as in previous reports, since *D. batis* was split into *D. cf. flossada* and *D. cf. intermedia.* Both three rays together as *Dipturus* spp. were also analysed.

The biomass and abundance of *Dipturus* spp. decreased this last survey but the values remained high with respect to the time series and almost similar with respect to the previous five years (Figure 37 and Figure 38). *D. nidarosiensis* and *D. cf. flossada* decreased slightly and the only one specimen of *D. cf. intermedia* was found in an additional haul. *D. nidarosiensis* has followed a downward trend since the last three years and *D. cf. flossada* since the last two (Figure 39).

The biomass decrease of the three species showed smaller spots of biomass in the study area map than the previous year, but they were found in the usual areas (Figure 40), shallower around the bank the specimens of *D. cf. flossada* and *D. cf. intermedia* and deeper in the south the specimens of *D. nidarosiensis* (Figure 41 and Figure 42).

One of the six specimens caught from each of the two species *D. nidarosiensis* (39 cm) and *D. cf. flossada* (37 cm) was close to the smallest specimens of the time series . The other five specimens ranged from 143 cm to 170 cm in *D. nidarosiensis* and from 90 cm to 133 cm in *D. cf. flossada* (Figure 43 and Figure 44). The only one specimen of *D. cf. intermedia* found in one additional haul was 57 cm.

Other elasmobranch species

This last year, the biomass and abundance of the scarcer elasmobranchs *Squalus acanthias* increased remarkably (Figure 45). Sixteen specimens (maximum in the time series), from 63 cm to 85 cm, were found mainly north of the Irish shelf (Figure 46).

As ususal in the last four years, *Centroscymnus crepidater* was found in the south of the study area, two specimens of 31 cm and 82 cm.

In addition, two scarcer rays were found in this last survey, *Leucoraja fullonica* and *Raja clavata*. They have not been found in the previous two years, but in 2017 two specimens of *L. fullonica* and one of *R. clavata* were caught north of the bank.

Acknowledgements

We would like to thank the R/V *Vizconde de Eza* crew and the IEO scientific teams that made SP-PORC-Q3 Surveys possible. They are included in the ERDEM project, which has been co-funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

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Figures

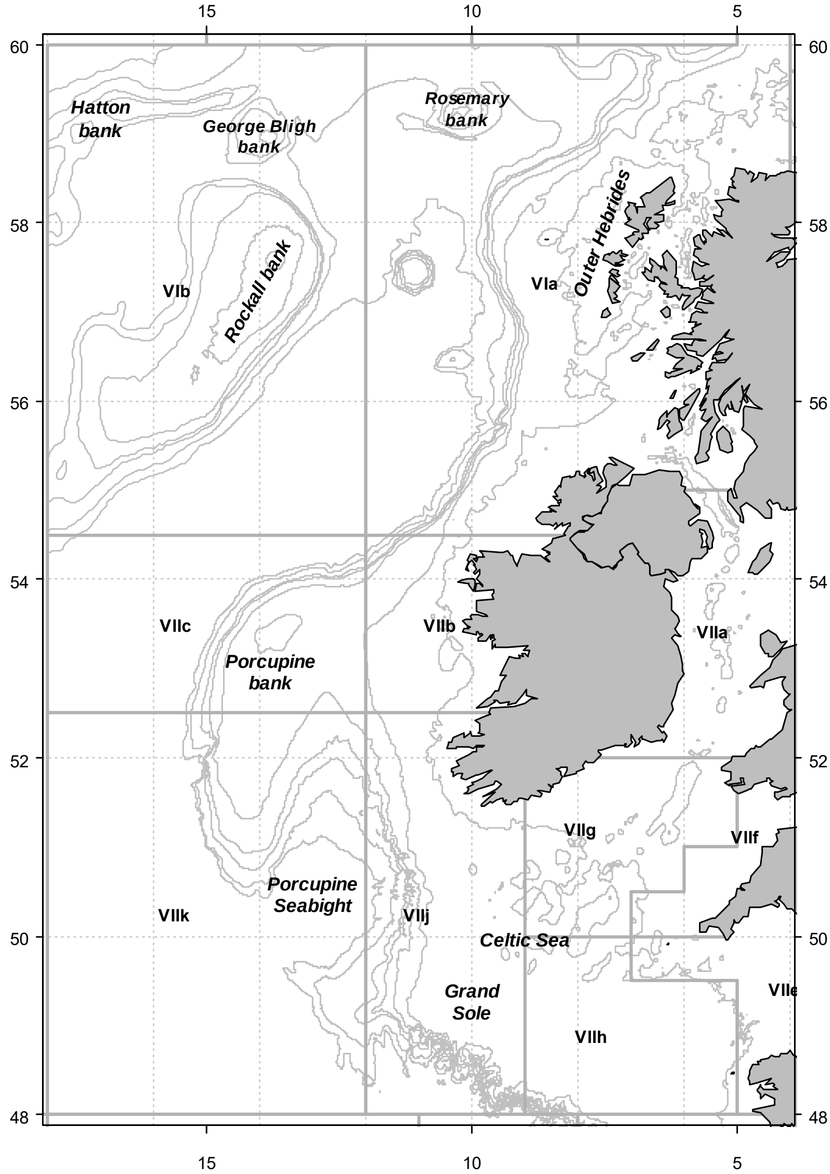


Figure 1 North eastern Atlantic showing the Porcupine bank, Porcupine Seabight, and ICES divisions

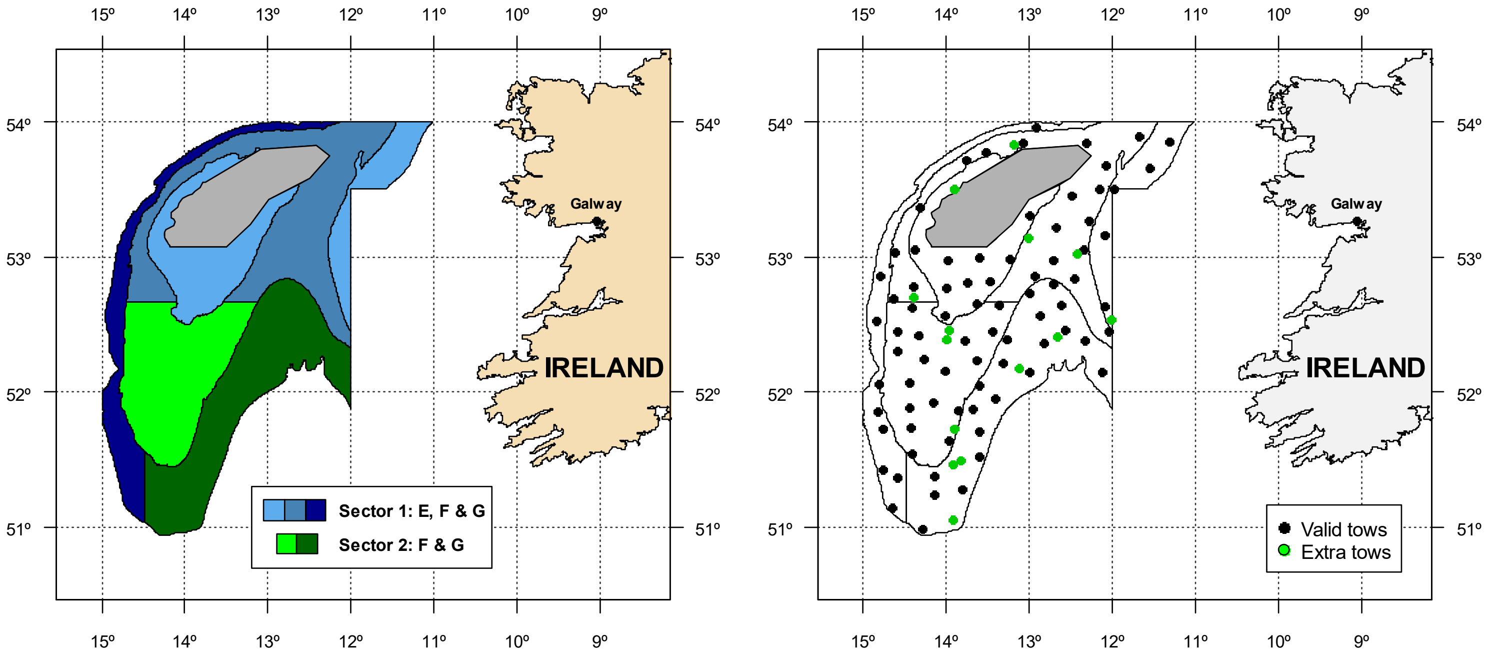


Figure 2 a) Stratification design and hauls in 2017 Porcupine surveys; Straight lines show geographical sectors (North in blue and South in green) and the isobaths delimit the three depth strata (> 300 m light blue (E), 300 – 450 m medium blue and light green (F) and 450 - 800 m dark blue and green (G)).
b) Hauls performed during 2017Porcupine Survey.

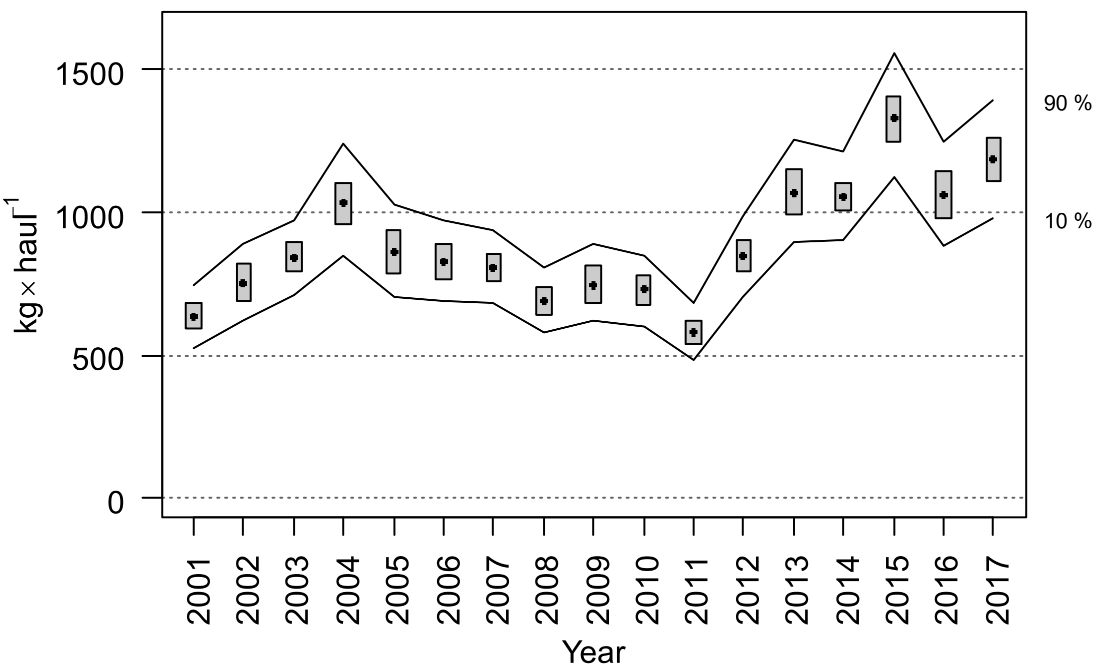


Figure 3 Evolution of the total stratified catch in Porcupine survey time series (2001-2017)

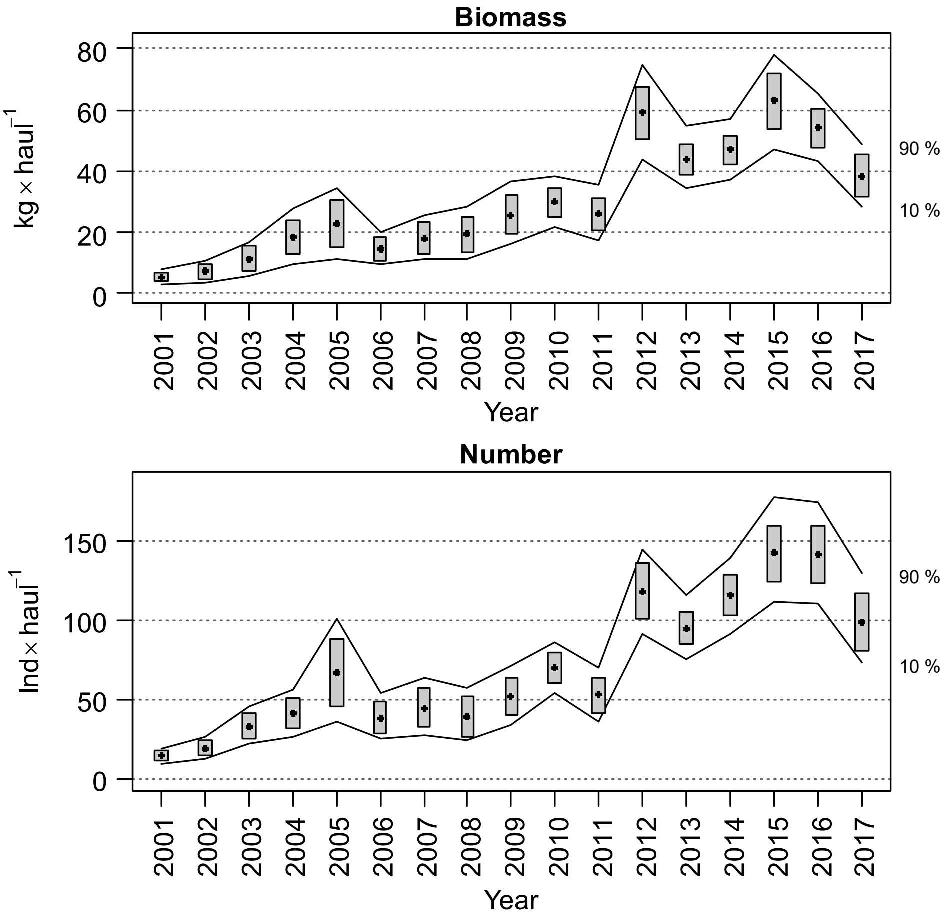


Figure 4 Changes in *Galeus melastomus* biomass index and abundance in Porcupine surveys (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

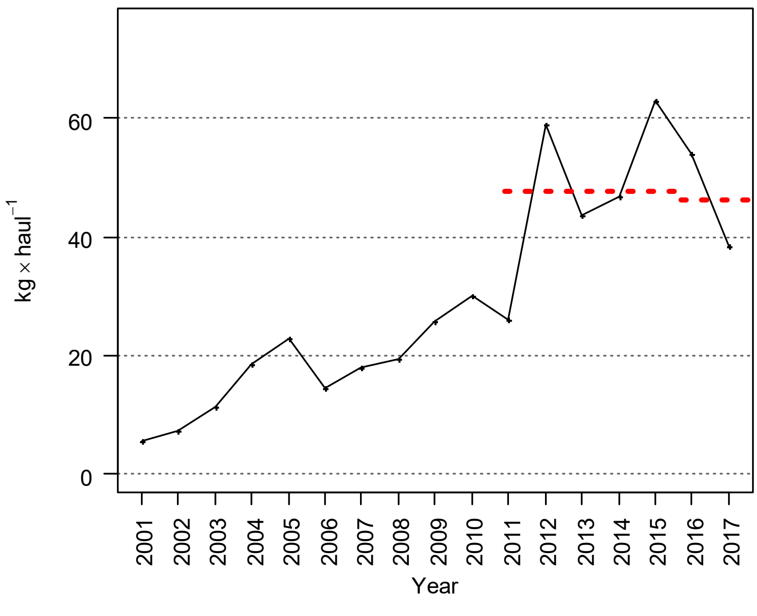


Figure 5 Changes in *Galeus melastomus* biomass index in Porcupine surveys (2001-2017). Dotted lines compare mean stratified biomass in the last two years and in the five previous years

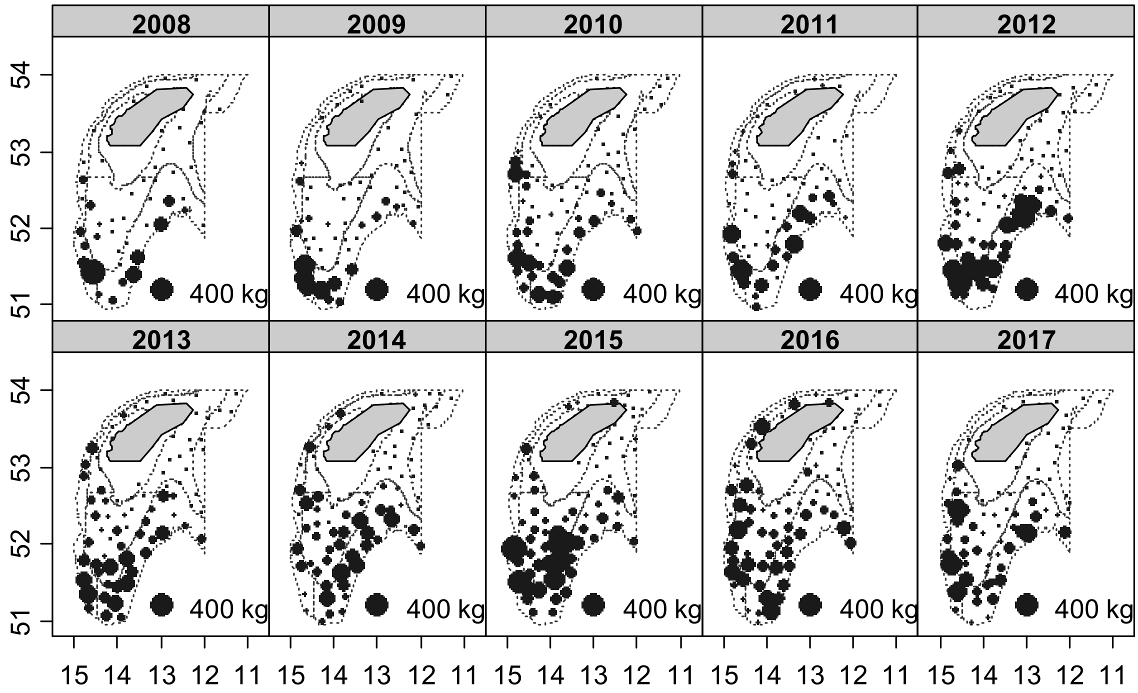


Figure 6 Geographic distribution of *Galeus melastomus* catches (kg·haul^{-1}) in Porcupine surveys (2008-2017)

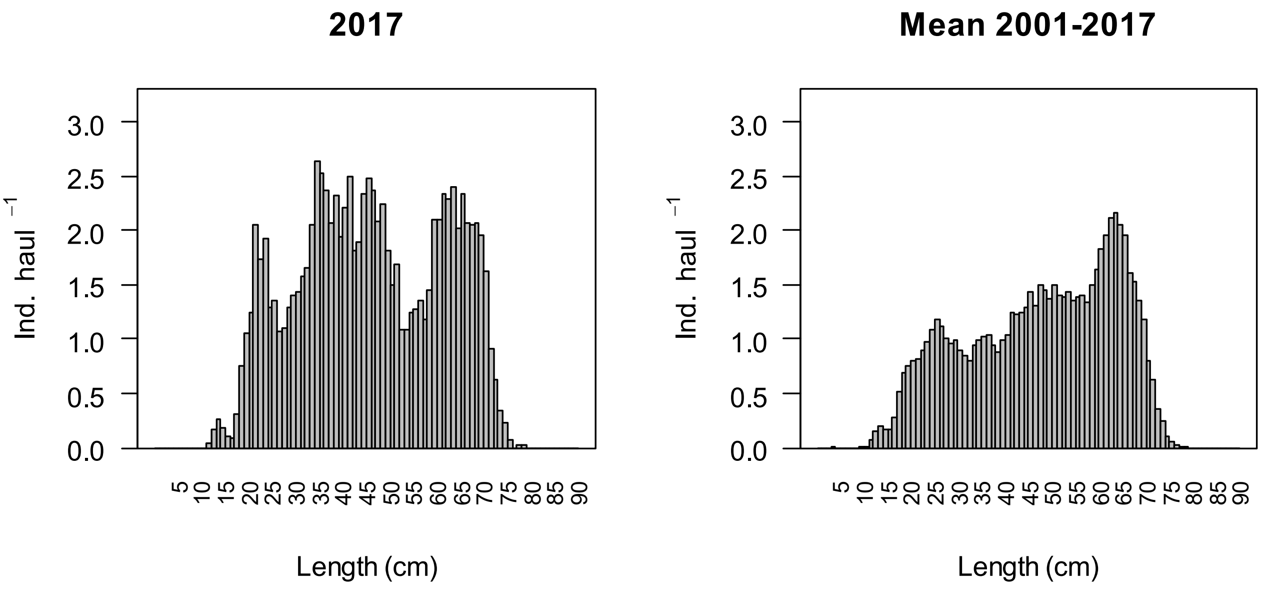


Figure 7 Stratified length distributions of *Galeus melastomus* in 2017 Porcupine survey, and mean values in Porcupine surveys (2001-2017)

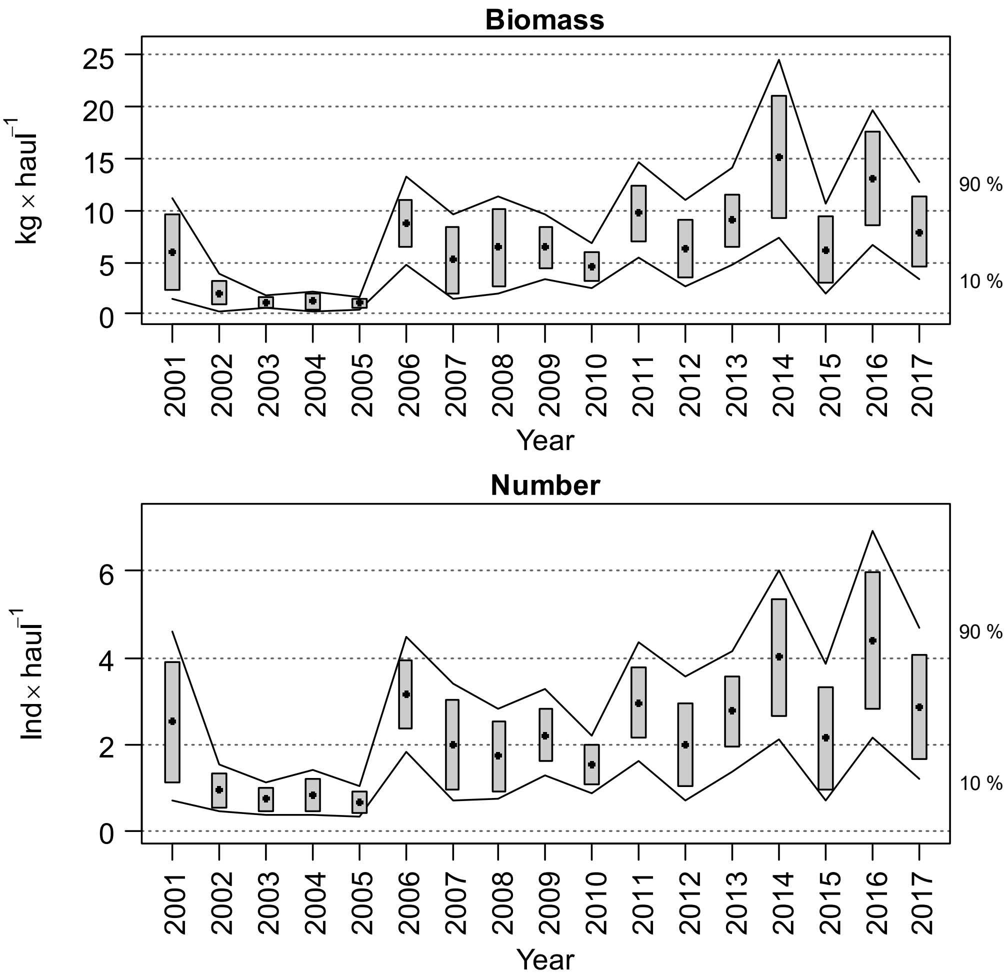


Figure 8 Evolution of *Deania* spp. (mainly *D. calcea)* biomass index (kg·haul^{-1}) in Porcupine surveys (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000)

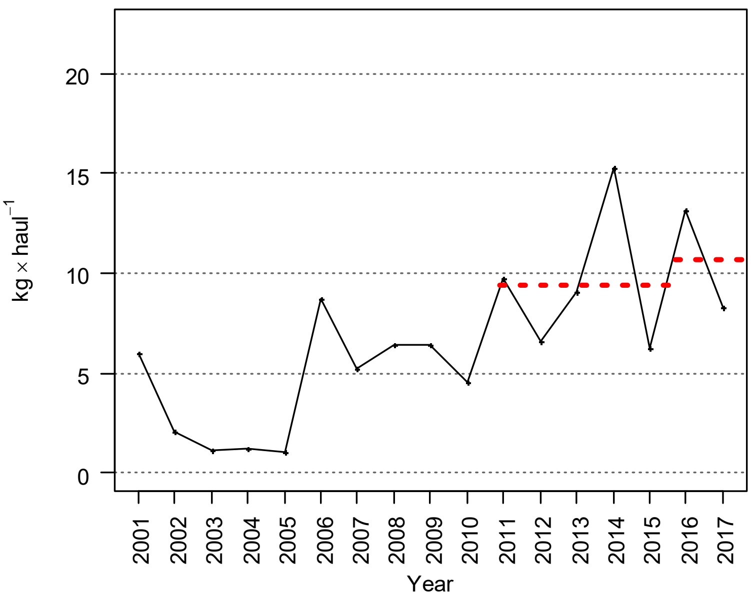


Figure 9 Changes in *Deania* spp. (mainly *D. calcea)* biomass index in Porcupine surveys (2001-2017). Dotted lines compare mean stratified biomass in the last two years and in the five previous years

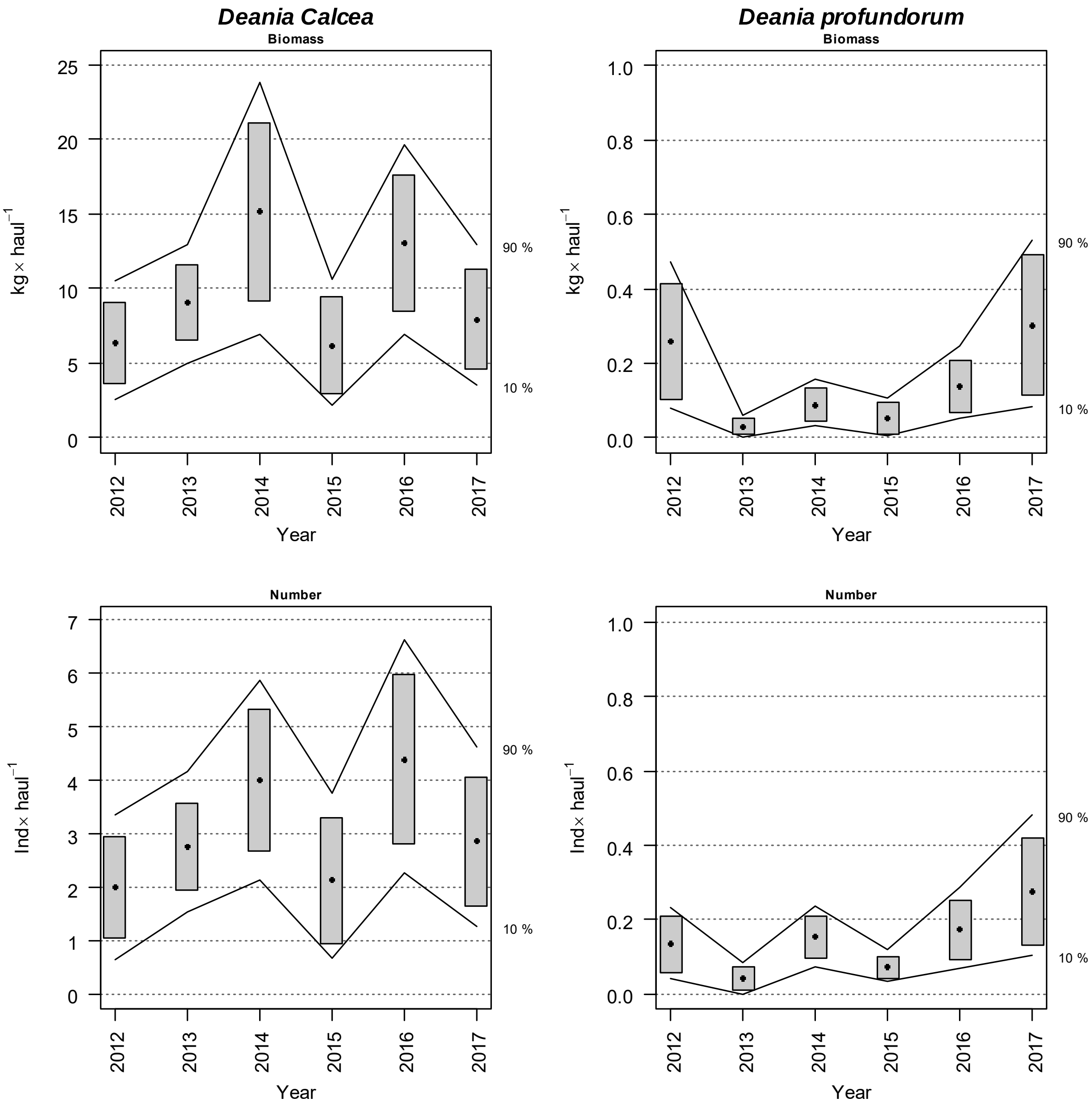


Figure 10 Evolution of *Deania calcea* and *Deania profundorum* biomass index (kg·haul^{-1}) from 2012 and 2017 Porcupine surveys. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000)

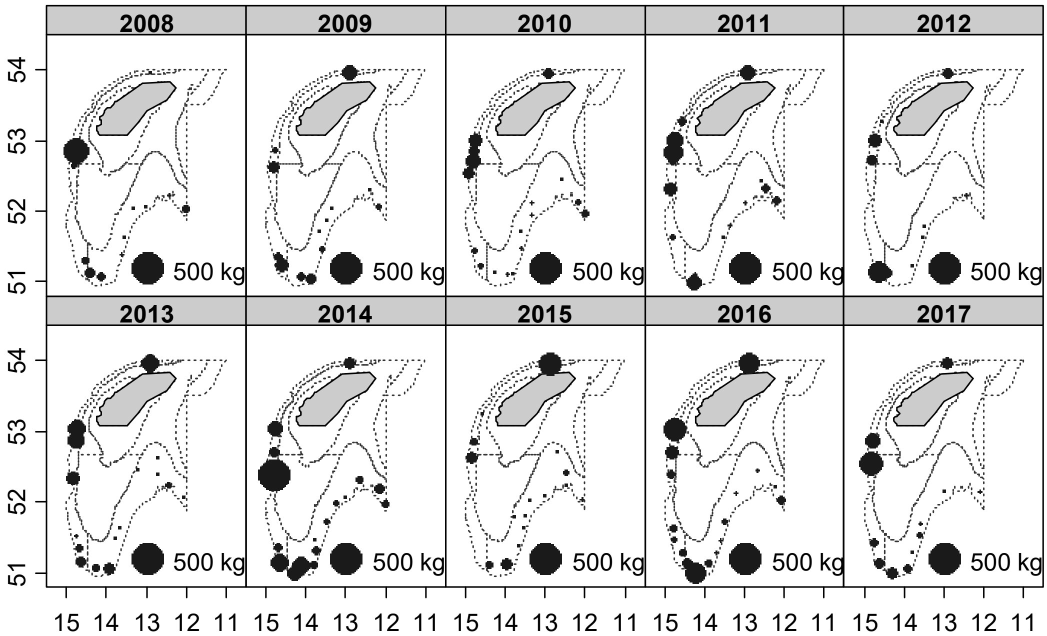


Figure 11 Geographic distribution of *Deania* spp. (mainly *D. calcea*) catches (kg·haul^{-1}) in Porcupine surveys (2008-2017)

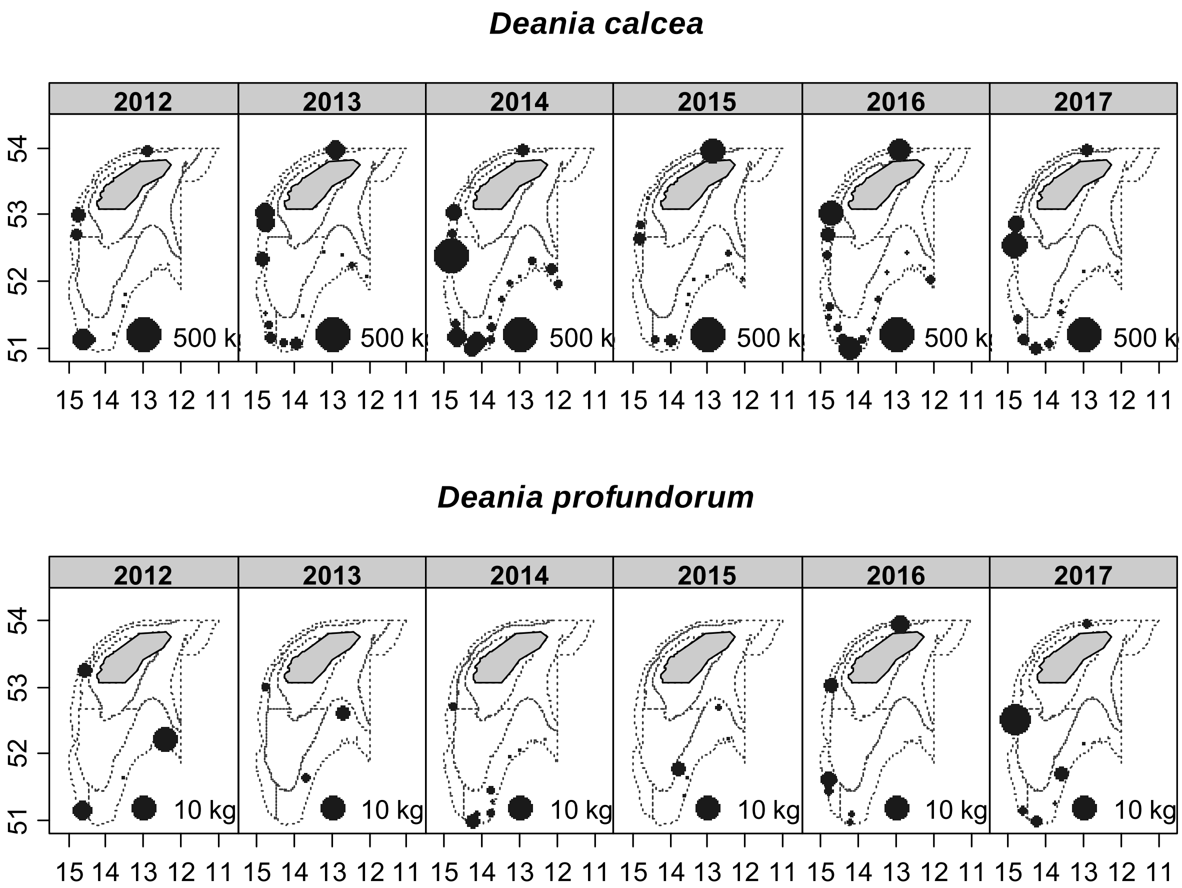


Figure 12 Geographic distribution of *Deania calcea* and *Deania profundorum* catches (kg·haul^{-1}) from 2012 to 2017 Porcupine surveys

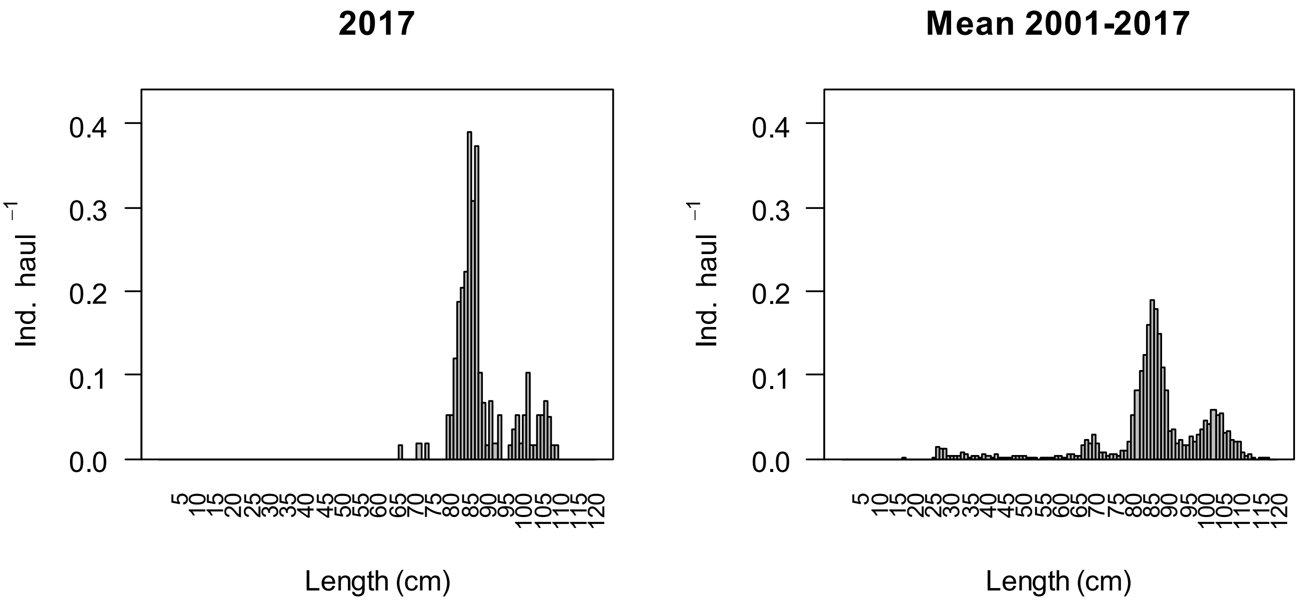


Figure 13 Stratified length distribution of *Deania calcea* in 2017 compared with mean values in Porcupine surveys (2001-2017)

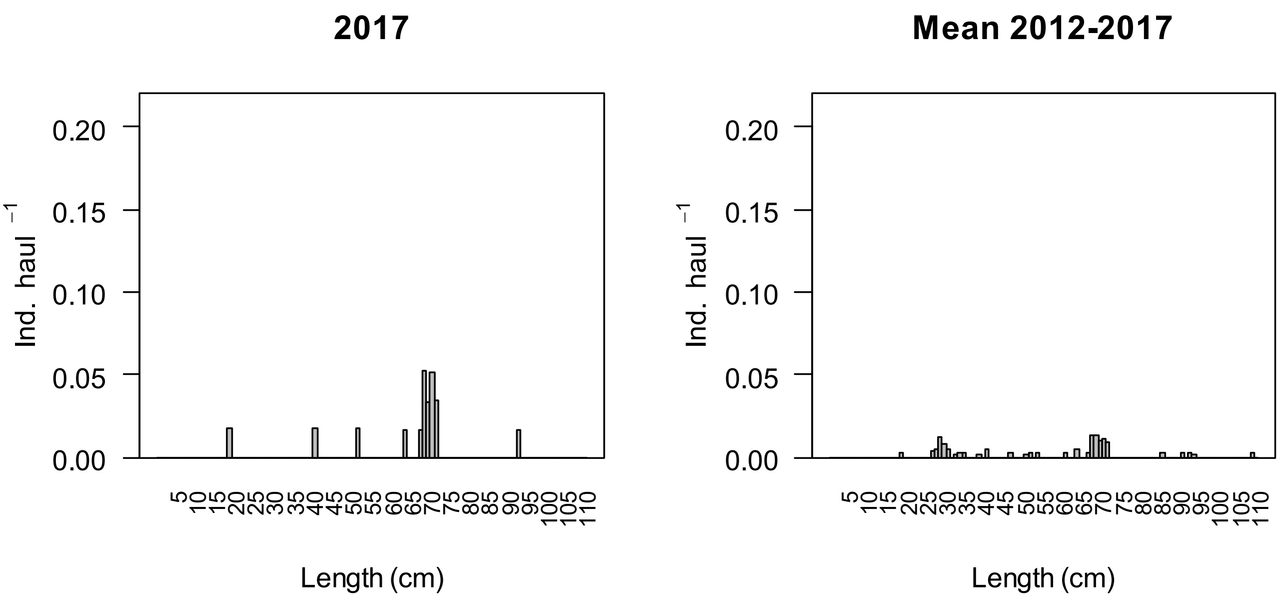


Figure 14 Stratified length distribution of *Deania profundorum* in 2017 compared with mean values in Porcupine surveys (2012-2017)

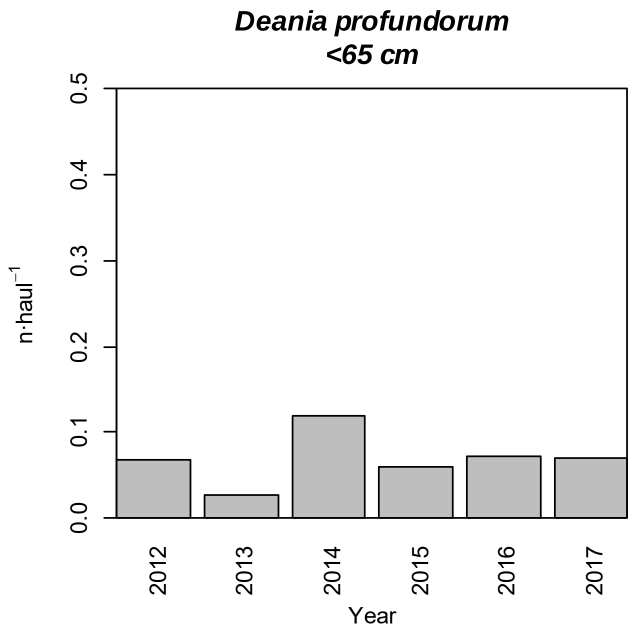


Figure 15 Abundance of *Deania profundorum* smaller than 65 cm in Porcupine surveys (2012-2017)

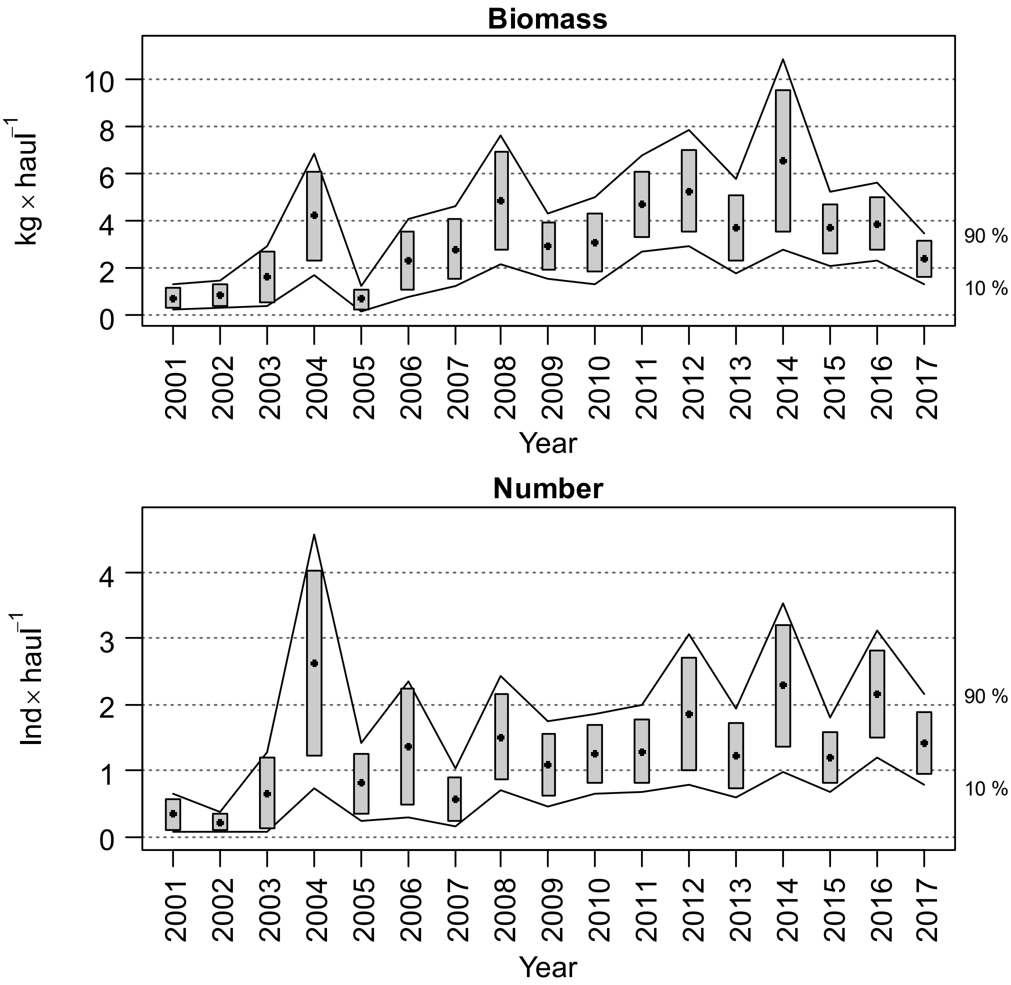


Figure 16 Evolution of *Scymnodom ringens* biomass index (kg·haul^{-1}) in Porcupine surveys (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

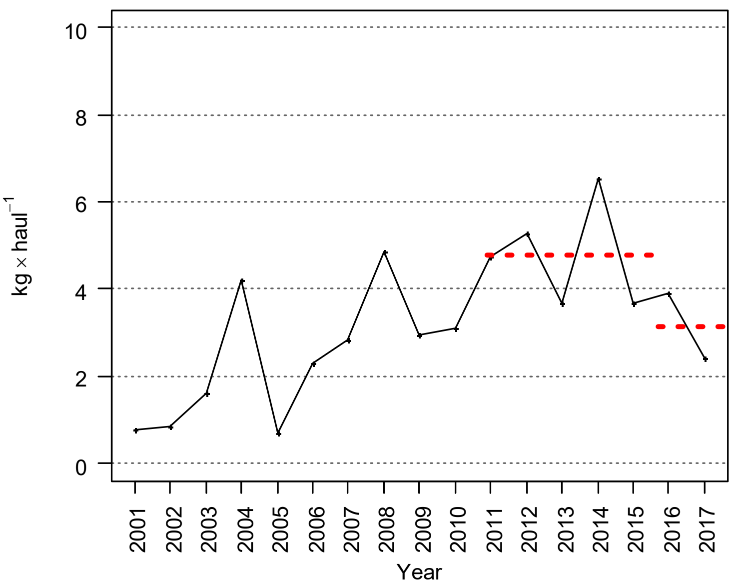


Figure 17 Changes in *Scymnodom ringens* biomass index in Porcupine surveys (2001-2017). Dotted lines compare mean stratified biomass in the last two years and in the five previous years

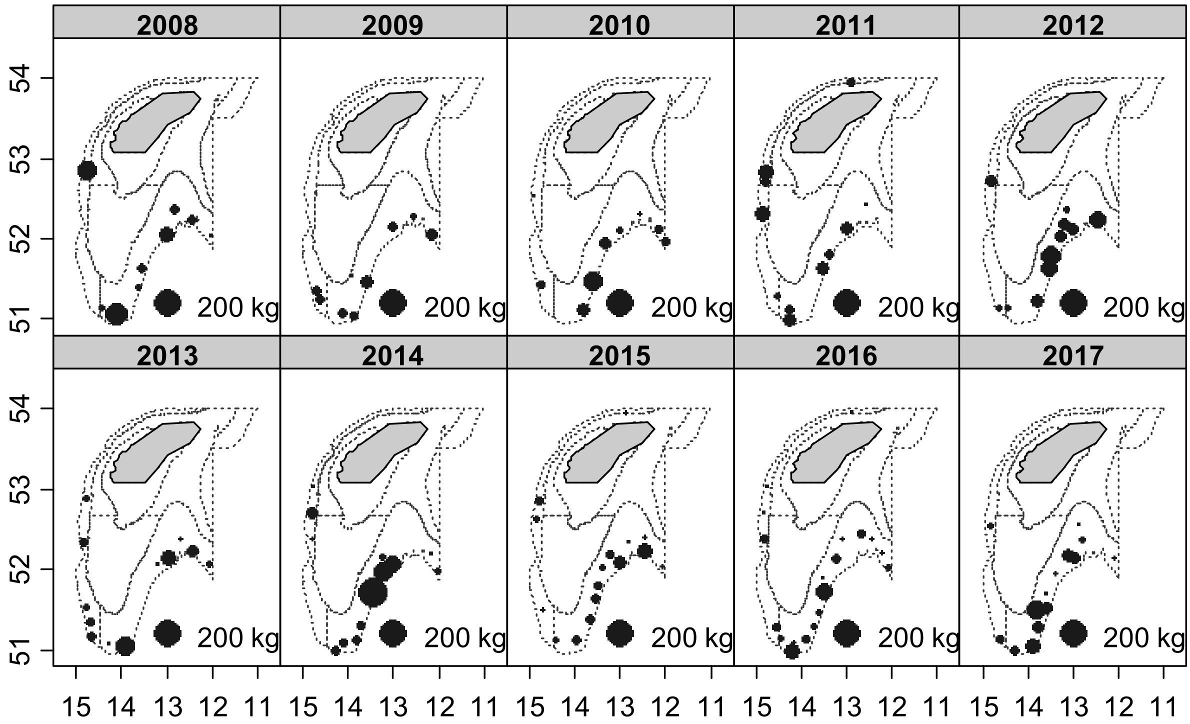


Figure 18 Geographic distribution of *Scymnodon ringens* catches (kg·haul^{-1}) in Porcupine surveys (2008-2017)

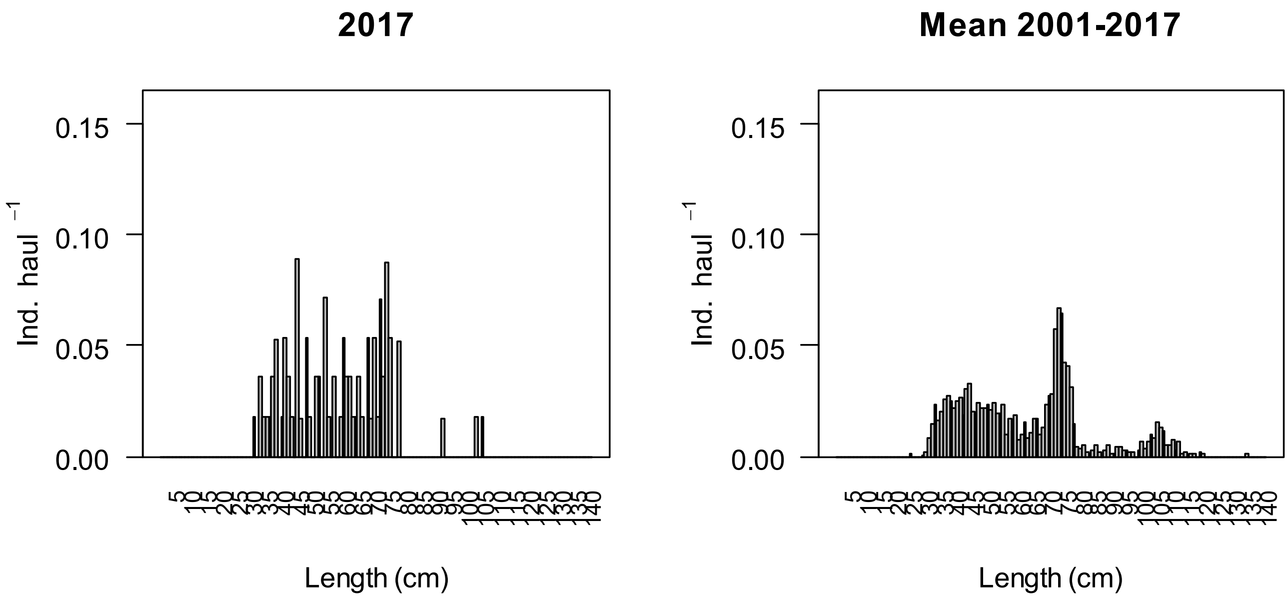


Figure 19 Stratified length distributions of *Scymnodon ringens* in 2017 in Porcupine survey, and mean values in Porcupine surveys (2001-2017)

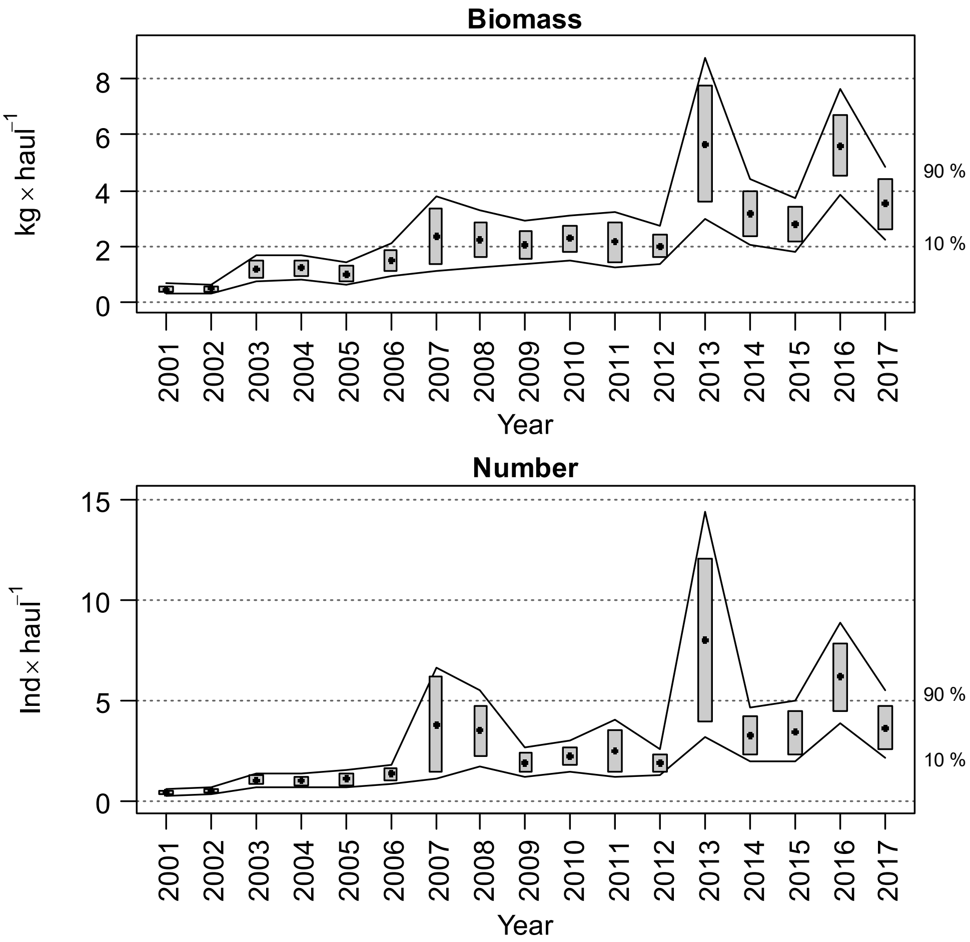


Figure 20 Evolution of *Scyliorhinus canicula* biomass index (kg·haul^{-1}) in Porcupine surveys (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

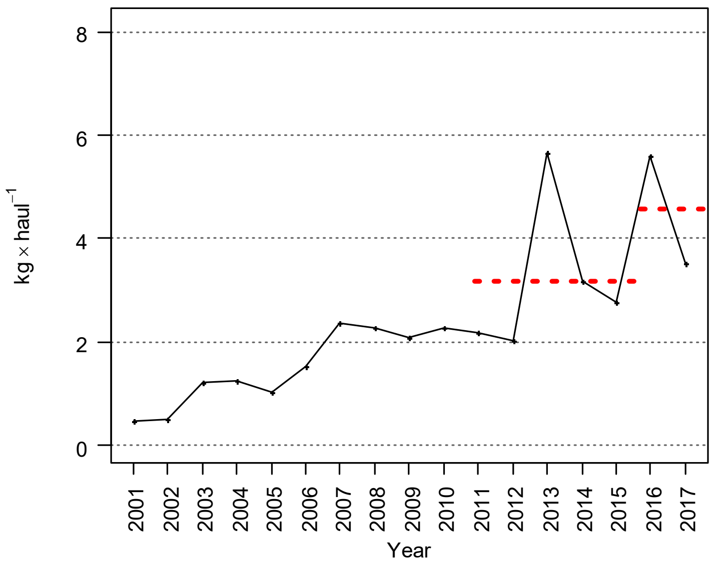


Figure 21 Changes in *Scyliorhinus canicula* biomass index in Porcupine surveys (2001-2017). Dotted lines compare mean stratified biomass in the last two years compared to the five previous years

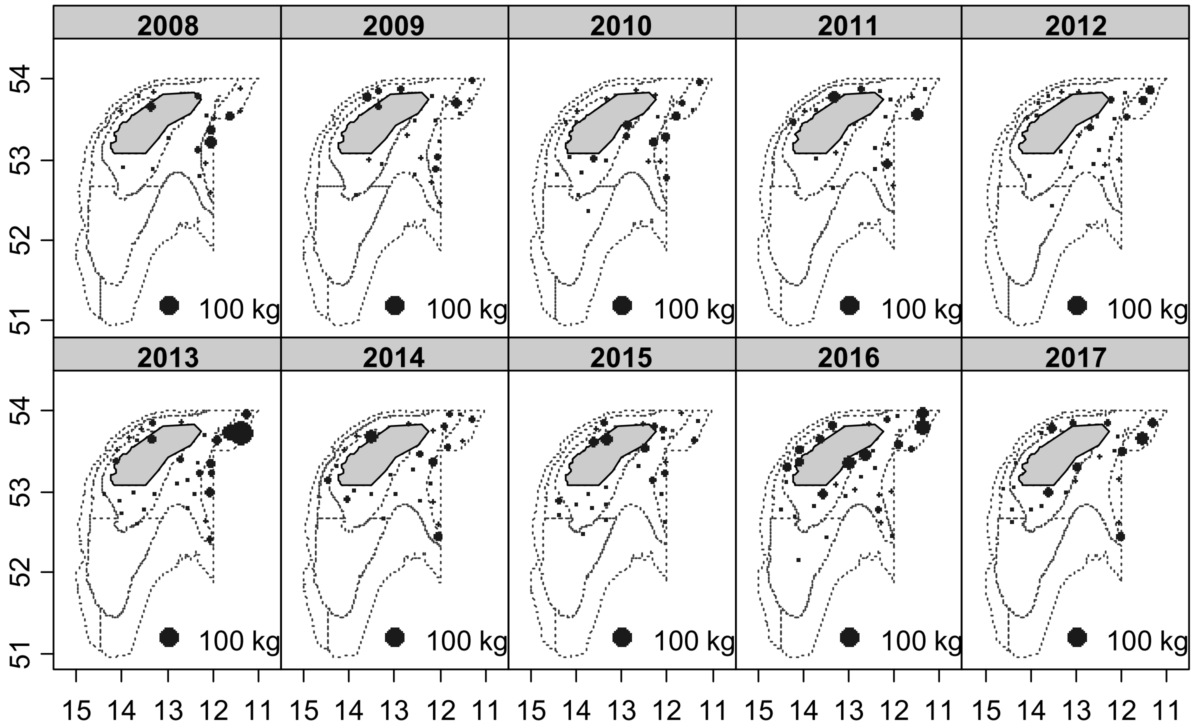


Figure 22 Geographic distribution of *Scyliorhinus canicula* catches (kg·haul^{-1}) in Porcupine surveys (2008-2017)

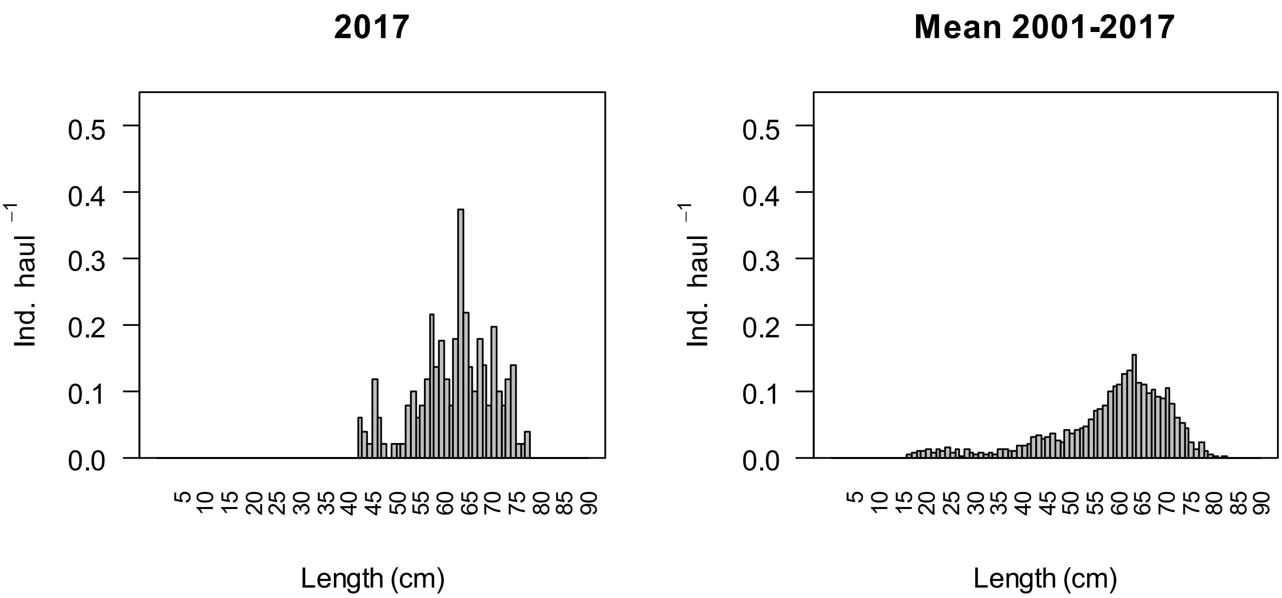


Figure 23 Stratified length distribution of *Scyliorhinus canicula* in 2017 in Porcupine survey, and mean values in Porcupine surveys (2001-2017)

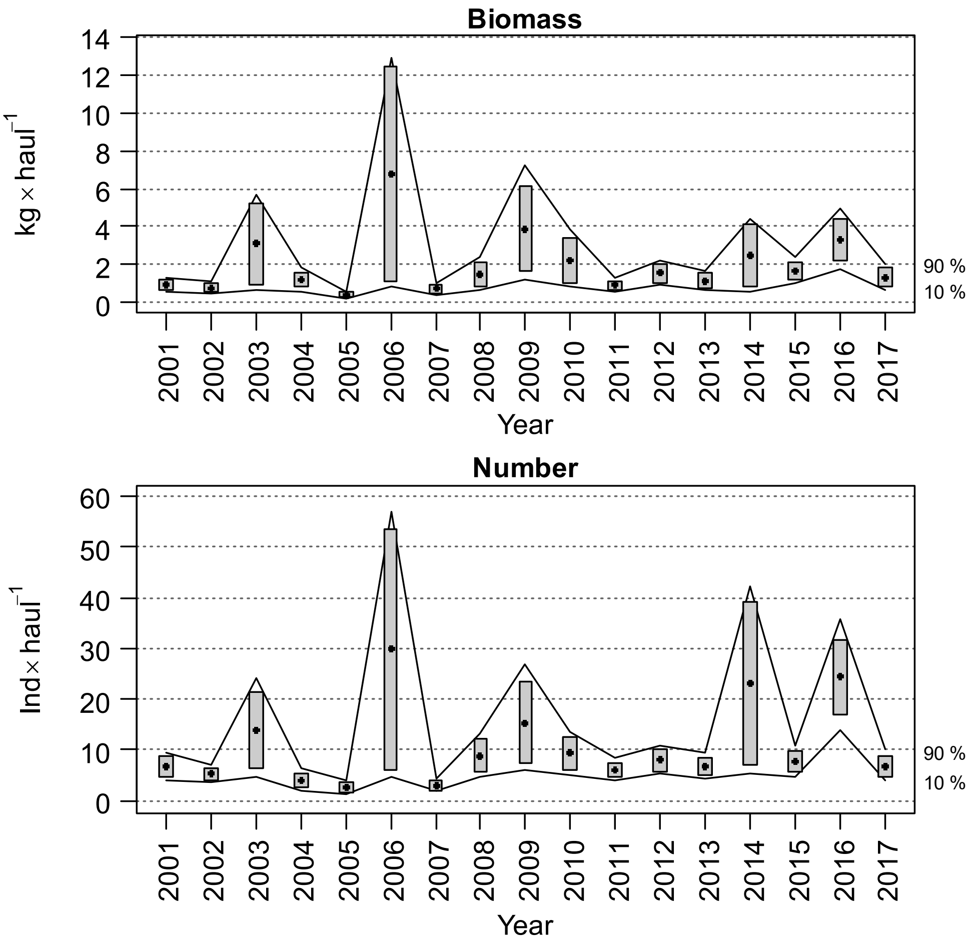


Figure 24 Evolution of *Etmopterus spinax* biomass index (kg·haul^{-1}) in Porcupine surveys (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

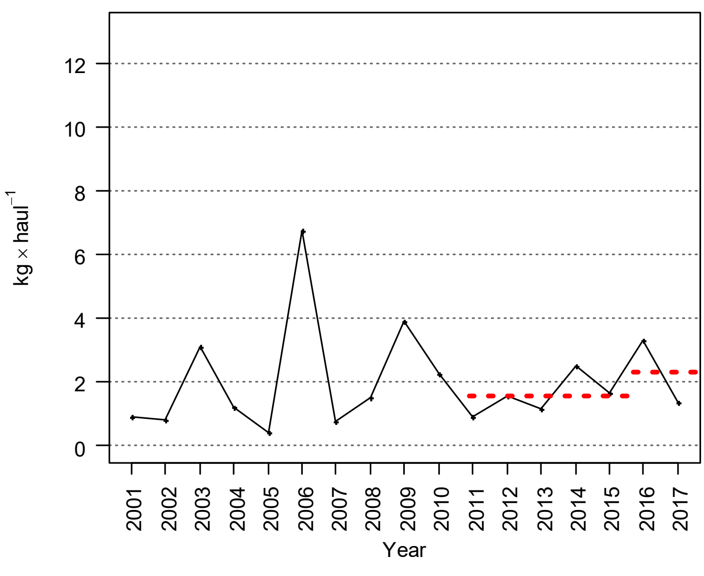


Figure 25 Changes in *Etmopterus spinax* biomass index in Porcupine surveys (2001-2017). Dotted lines compare mean stratified biomass in the last two years compared to the five previous years

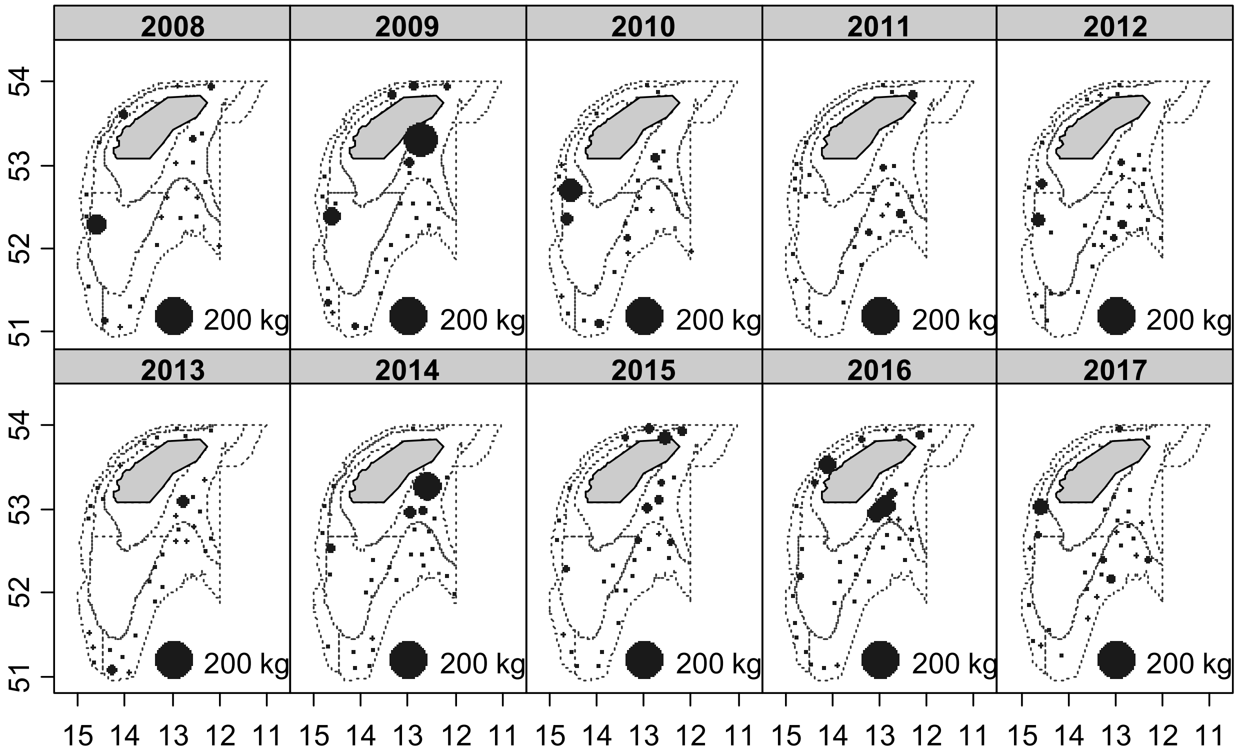


Figure 26 Geographic distribution of *Etmopterus spinax* catches (kg·haul^{-1}) in Porcupine surveys (2008-2017)

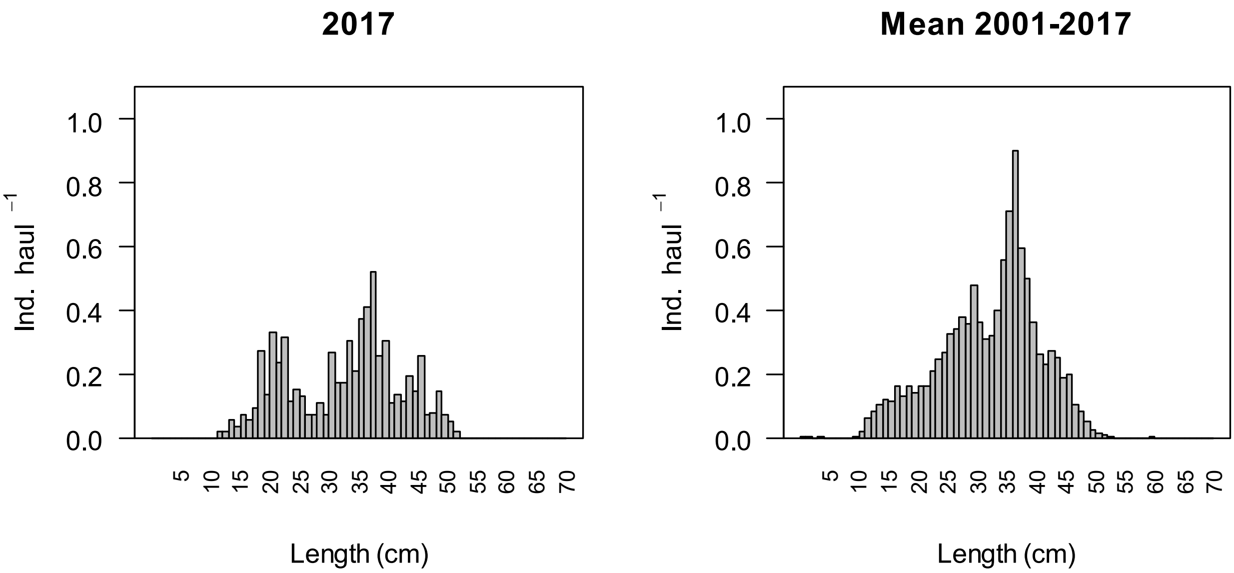


Figure 27 Stratified length distribution of *Etmopterus spinax* in 2017 in Porcupine survey, and mean values in Porcupine surveys (2001-2017)

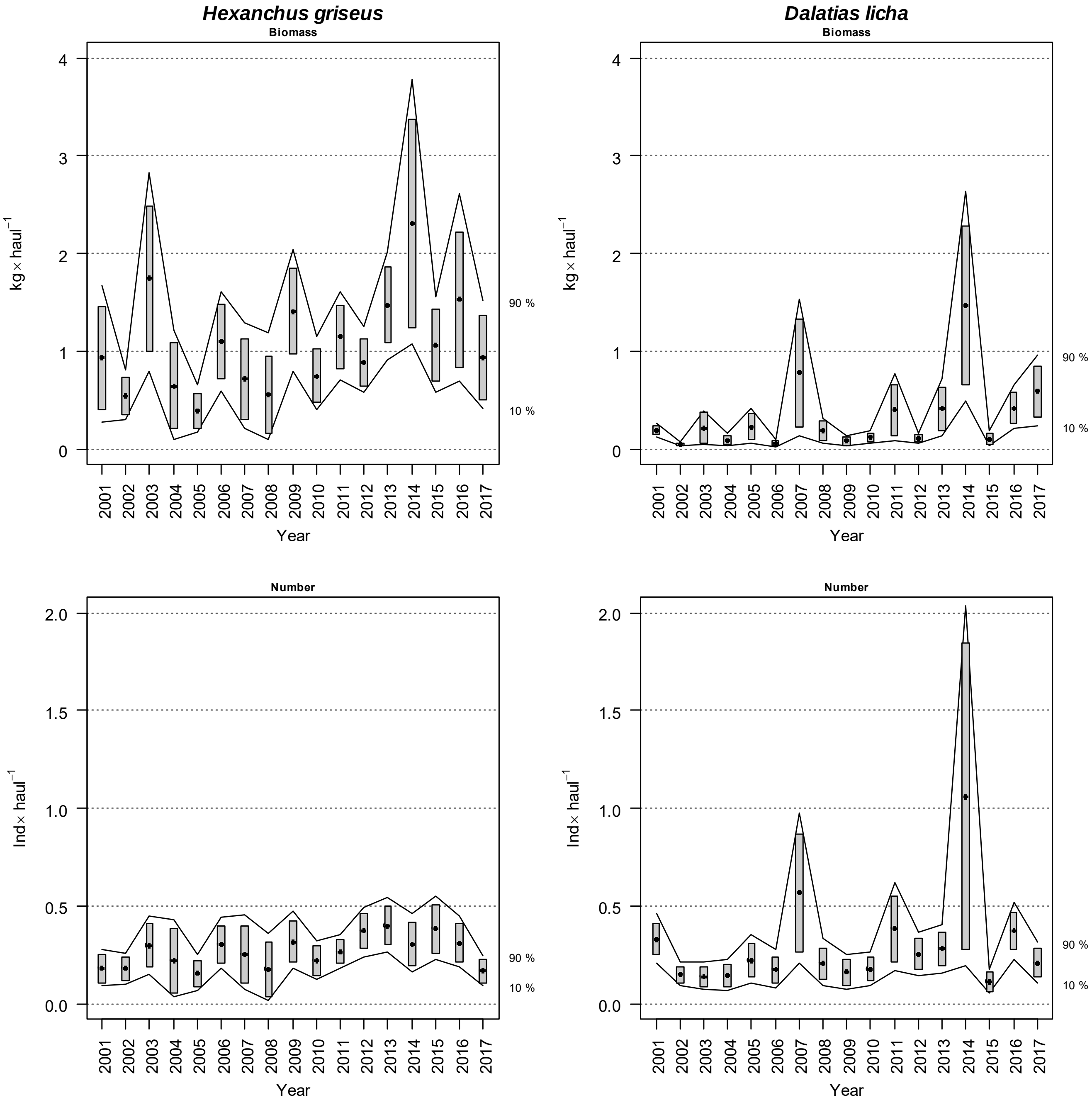
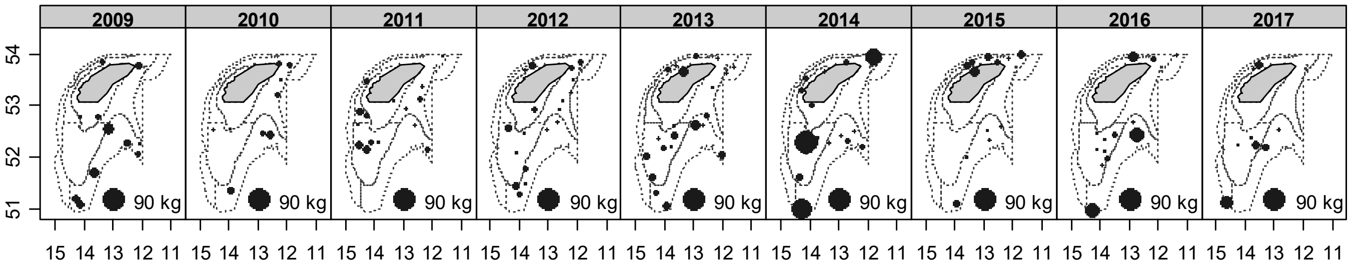


Figure 28 Evolution of *Hexanchus griseus* and *Dalatias licha* biomass index (kg·haul^{-1}) in Porcupine surveys (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

Hexanchus griseus



Dalatias licha

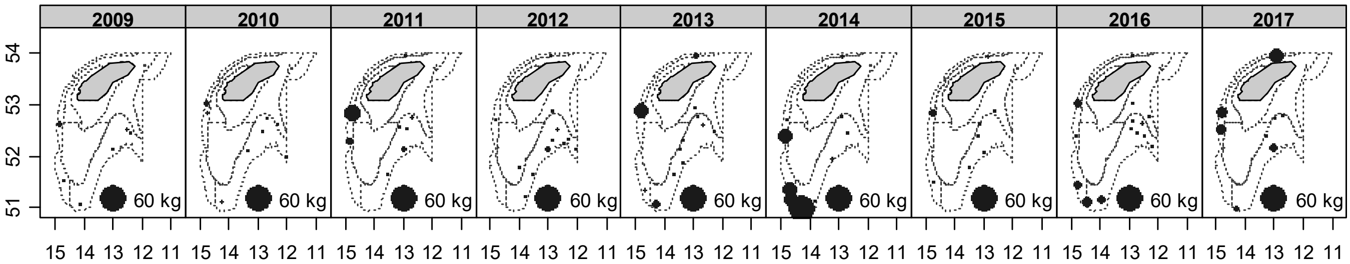


Figure 29 Geographic distribution of *Hexanchus griseus* and *Dalatias licha* catches (kg×30 min haul^{-1}) in Porcupine surveys (2009-2017)

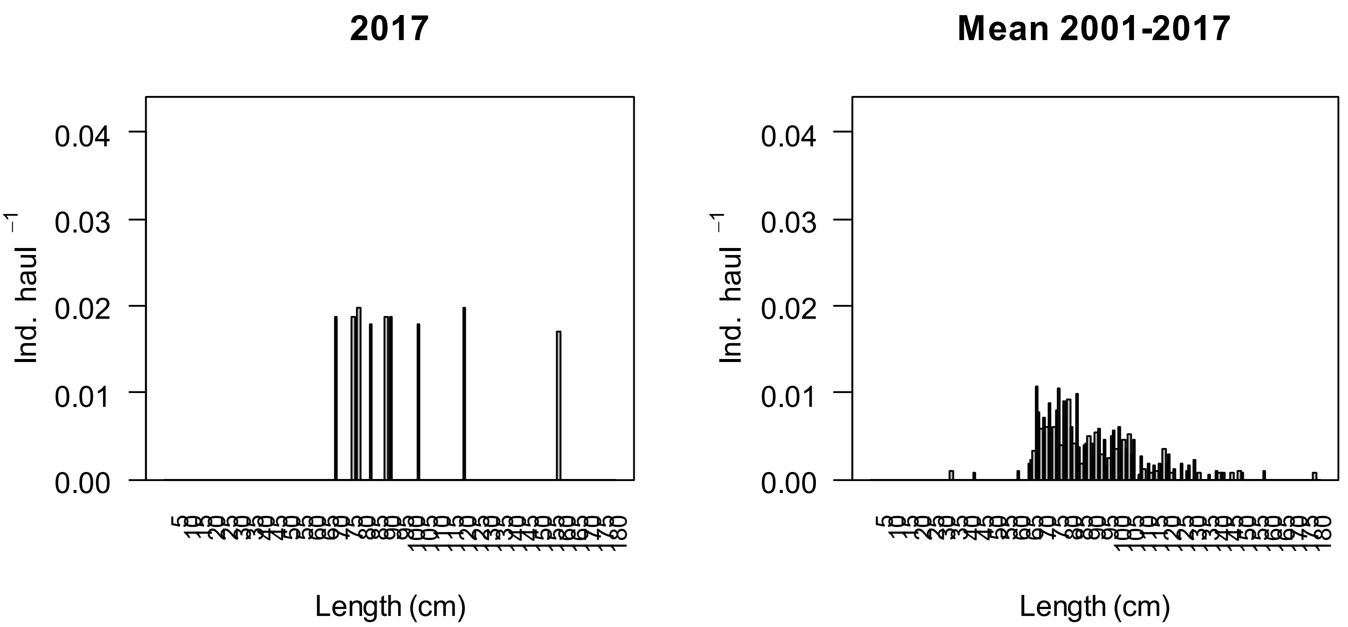


Figure 30 Stratified length distribution of *Hexanchus griseus* in 2017 Porcupine survey, and mean values in Porcupine surveys (2001-2017)

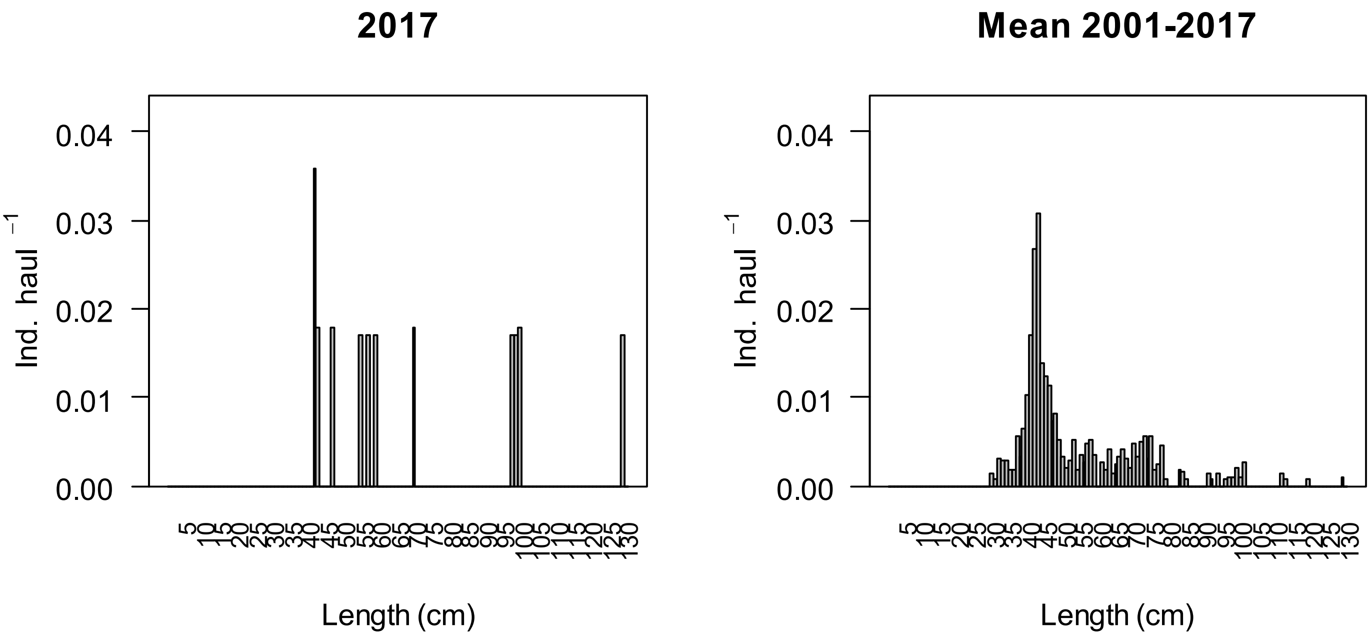


Figure 31 Stratified length distribution of *Dalatias licha* in 2017 Porcupine survey, and mean values in Porcupine surveys (2001-2017)

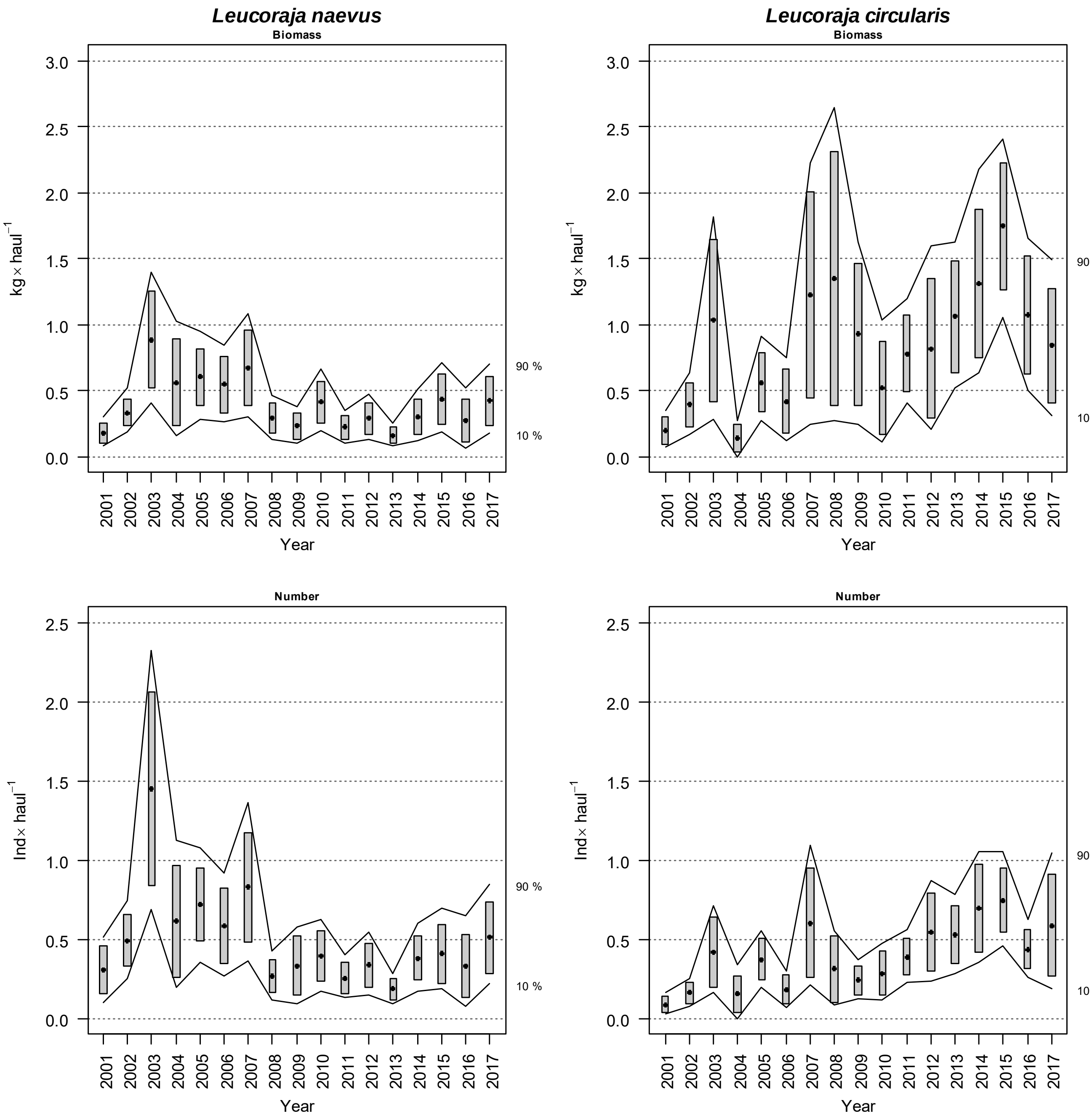


Figure 32 Changes in *Leucoraja naevus* and *Leucoraja circularis* biomass index (kg·haul^{-1}) in Porcupine surveys (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000)

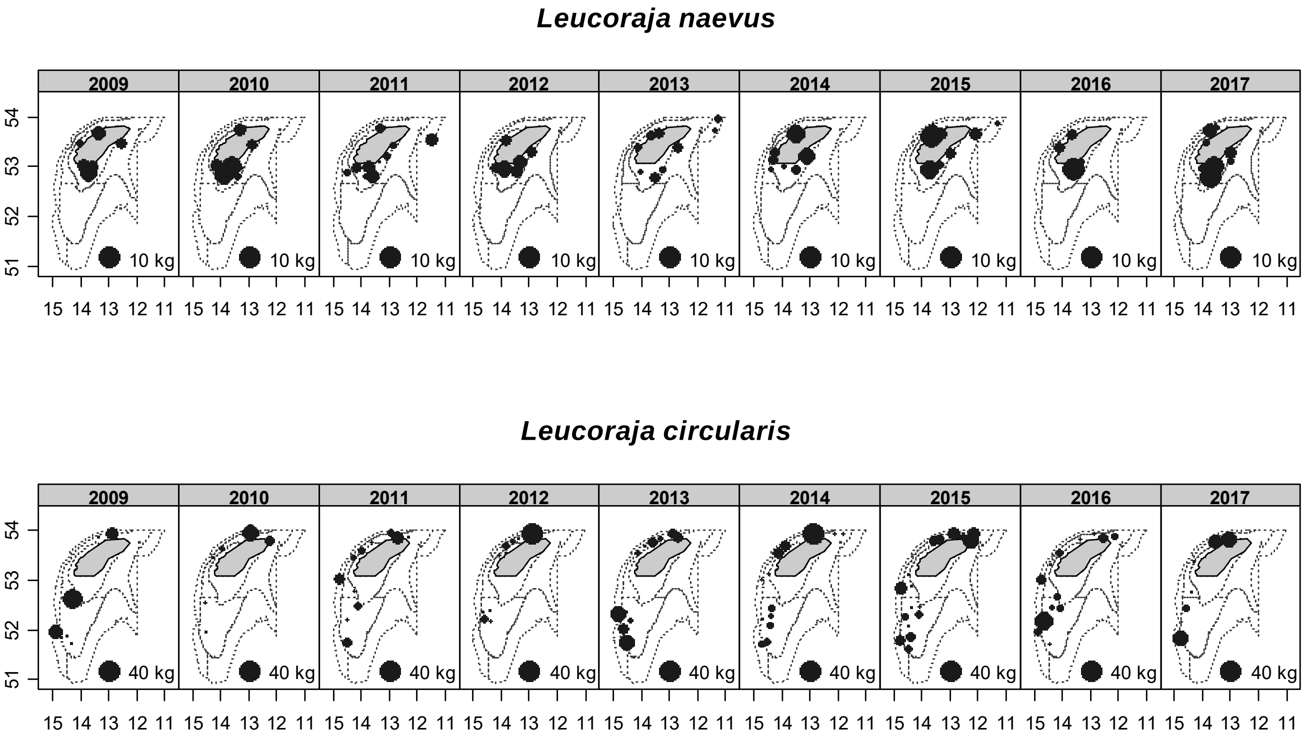


Figure 33 Geographic distribution of *Leucoraja naevus* and *Leucoraja circularis* catches (kg·haul^{-1}) in Porcupine surveys (2009-2017)

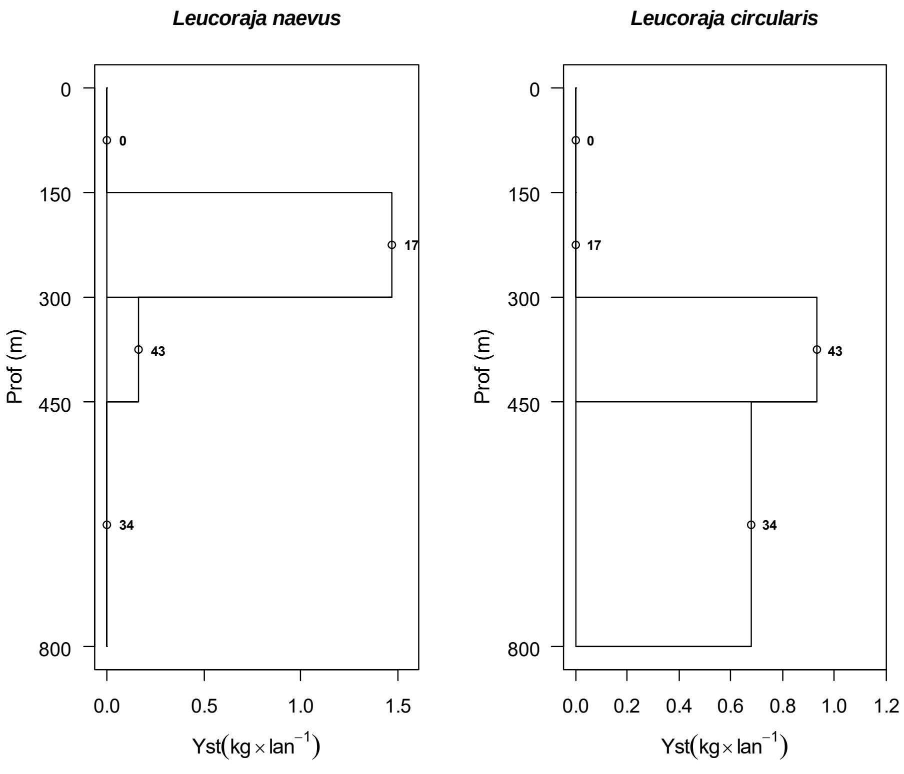


Figure 34 Depth distribution of *Leucoraja naevus* and *Leucoraja circularis* in Porcupine survey 2017. Numbers mark total hauls

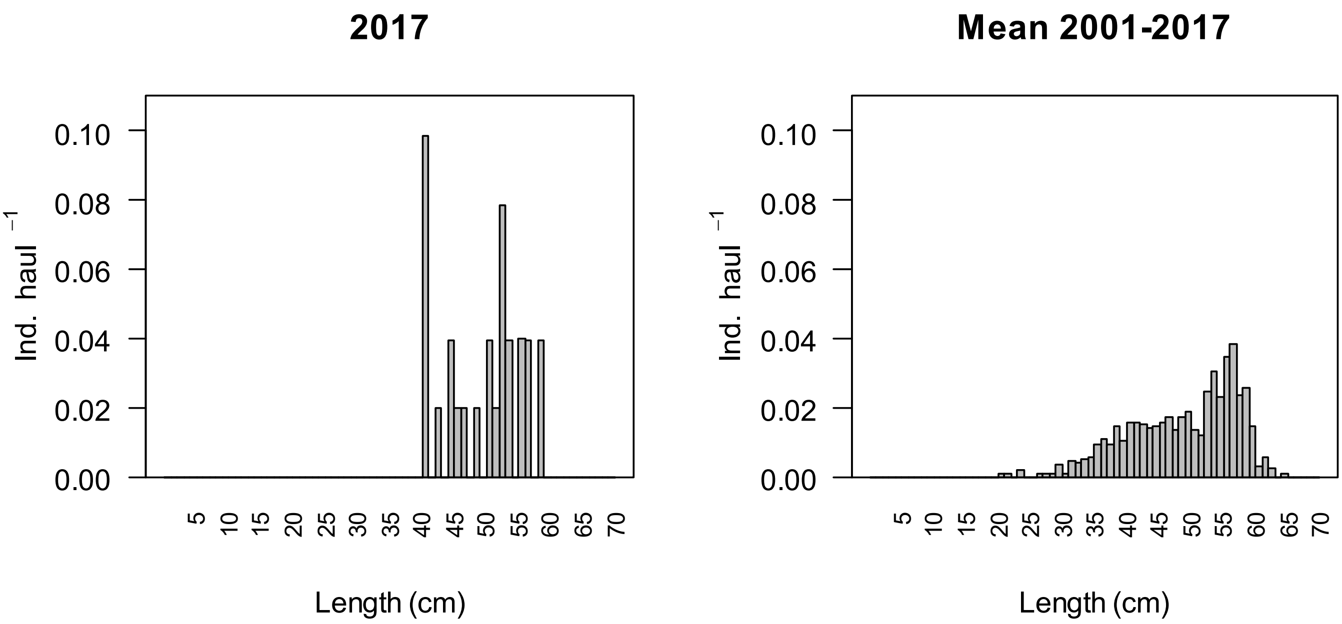


Figure 35 Stratified length distribution of *Leucoraja naevus* in 2017 Porcupine survey, and mean values in Porcupine surveys (2001-2017)

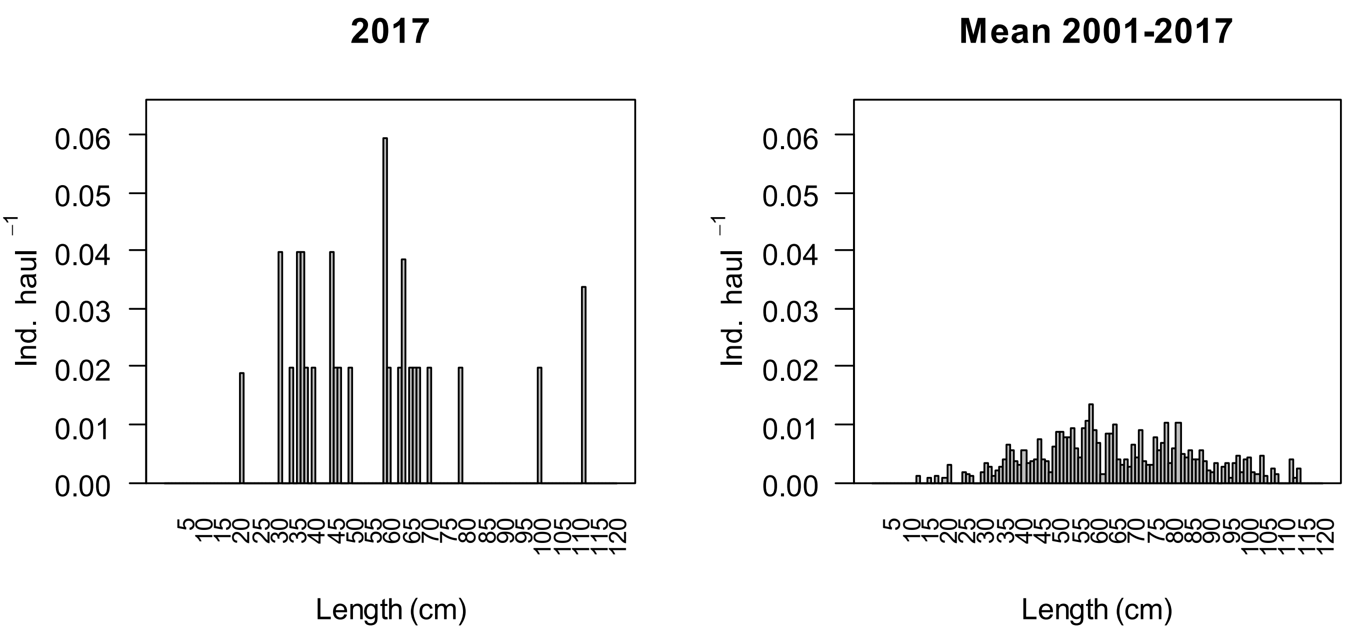


Figure 36 Stratified length distribution of *Leucoraja circularis* in 2017 Porcupine survey, and mean values in Porcupine surveys (2001-2017)

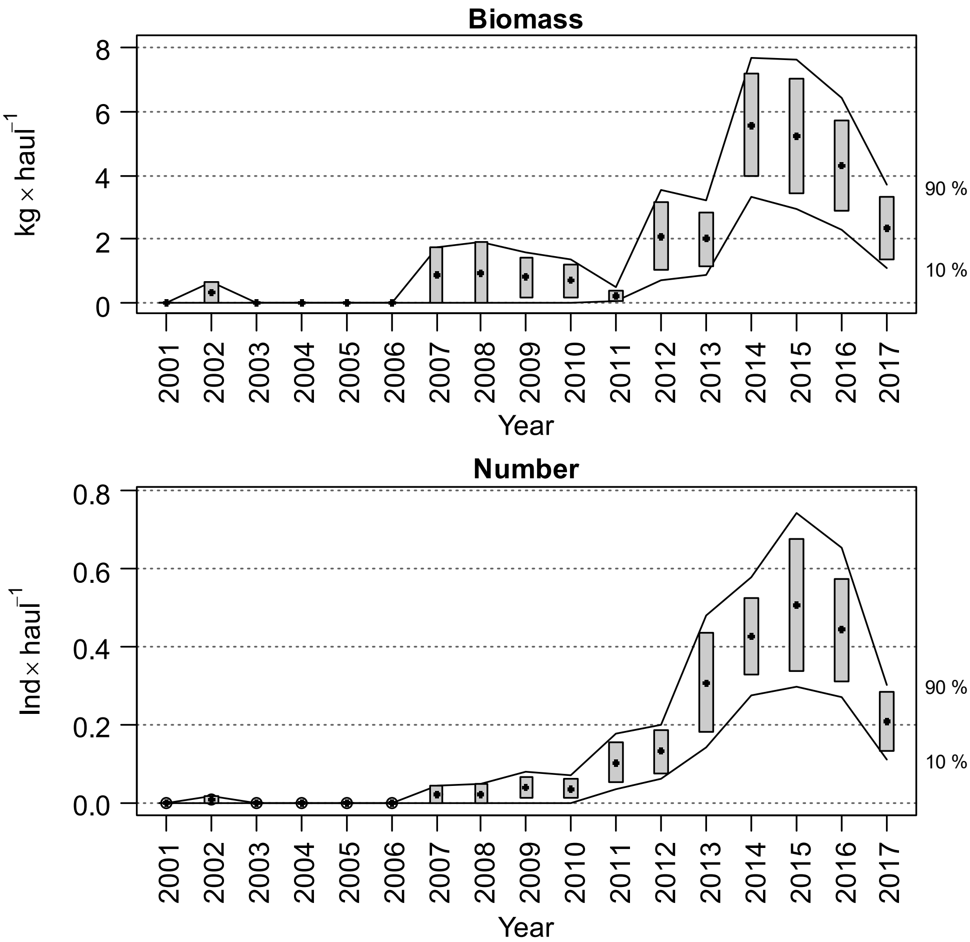


Figure 37 Evolution of *Dipturus* spp. biomass index (kg·haul^{-1}) in Porcupine surveys (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

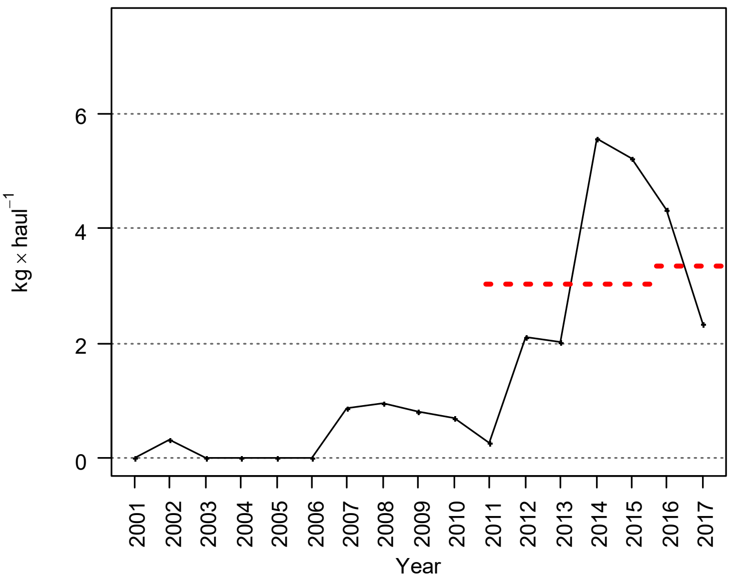


Figure 38 Changes in *Dipturus* spp. biomass index in Porcupine surveys (2001-2017). Dotted lines compare mean stratified biomass in the last two years and in the five previous years

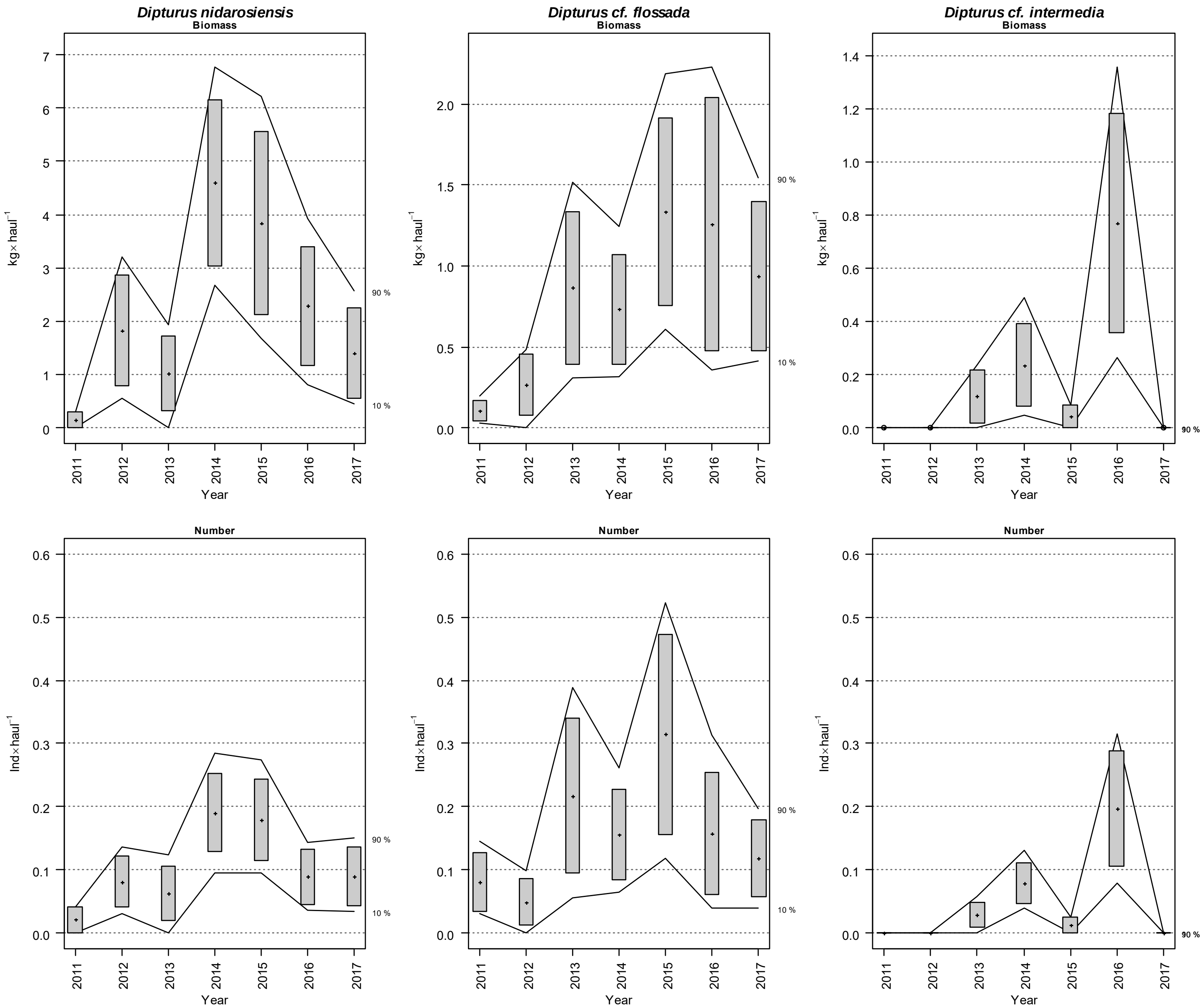


Figure 39 Evolution of *Dipturus nidarosiensis*, *Dipturus cf. flossada* and *Dipturus cf. intermedia* biomass index (kg·haul^{-1}) in Porcupine surveys (2011-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

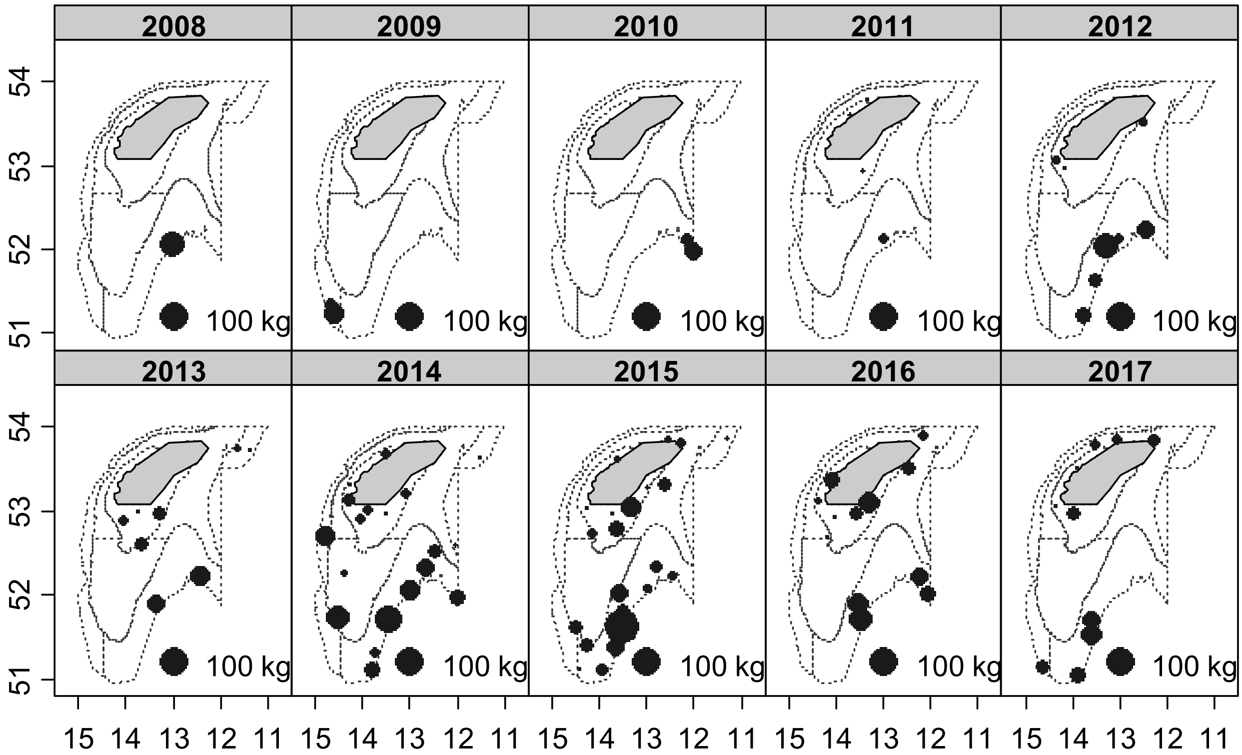


Figure 40 Geographic distribution of *Dipturus* spp. catches (Kg· haul^{-1}) in Porcupine surveys (2008-2017)

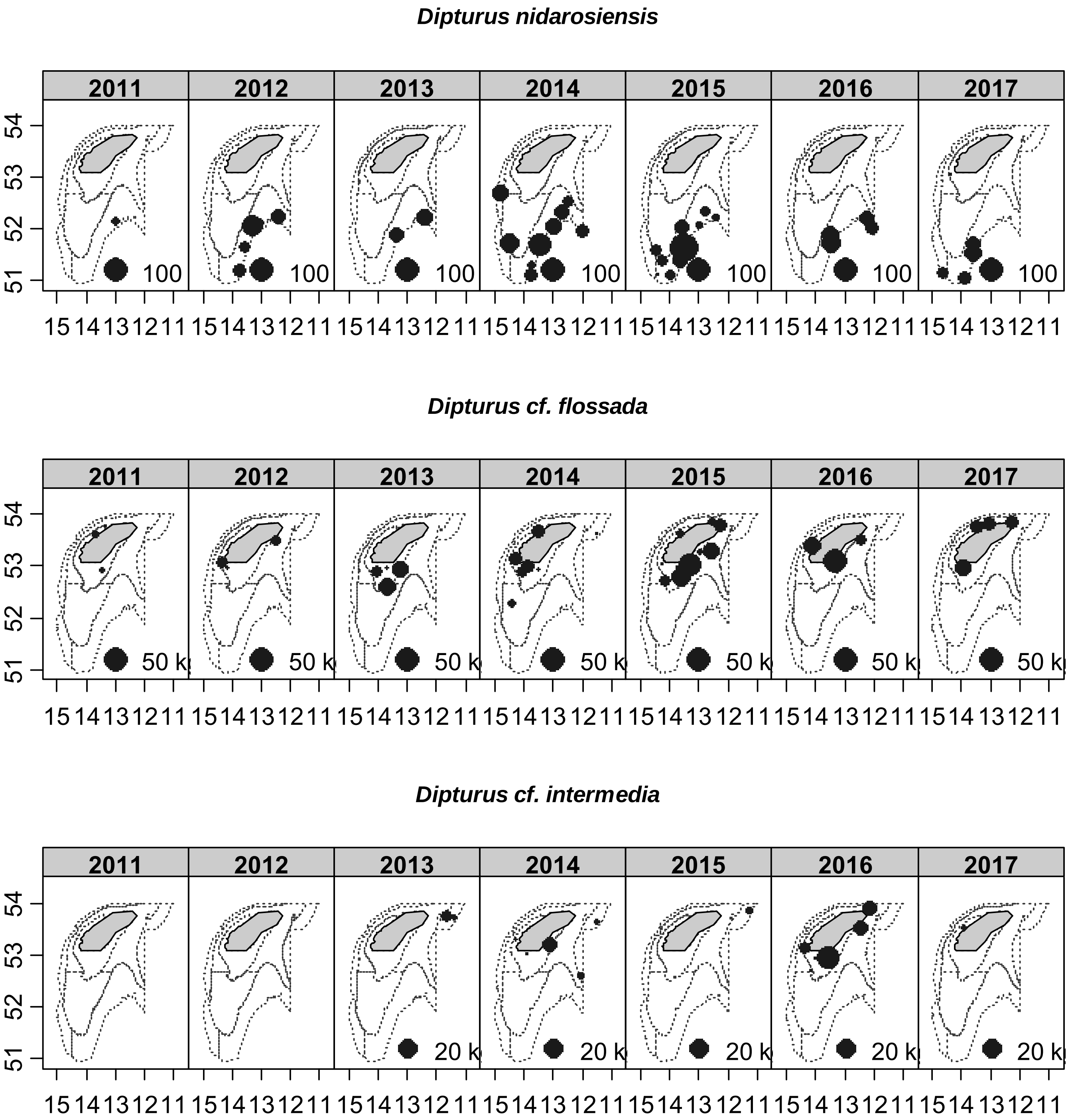


Figure 41 Geographic distribution of *Dipturus nidarosiensis*, *Dipturus cf. flossada* and *Dipturus cf. intermedia* catches (Kg· haul^{-1}) in Porcupine surveys (2011-2017)

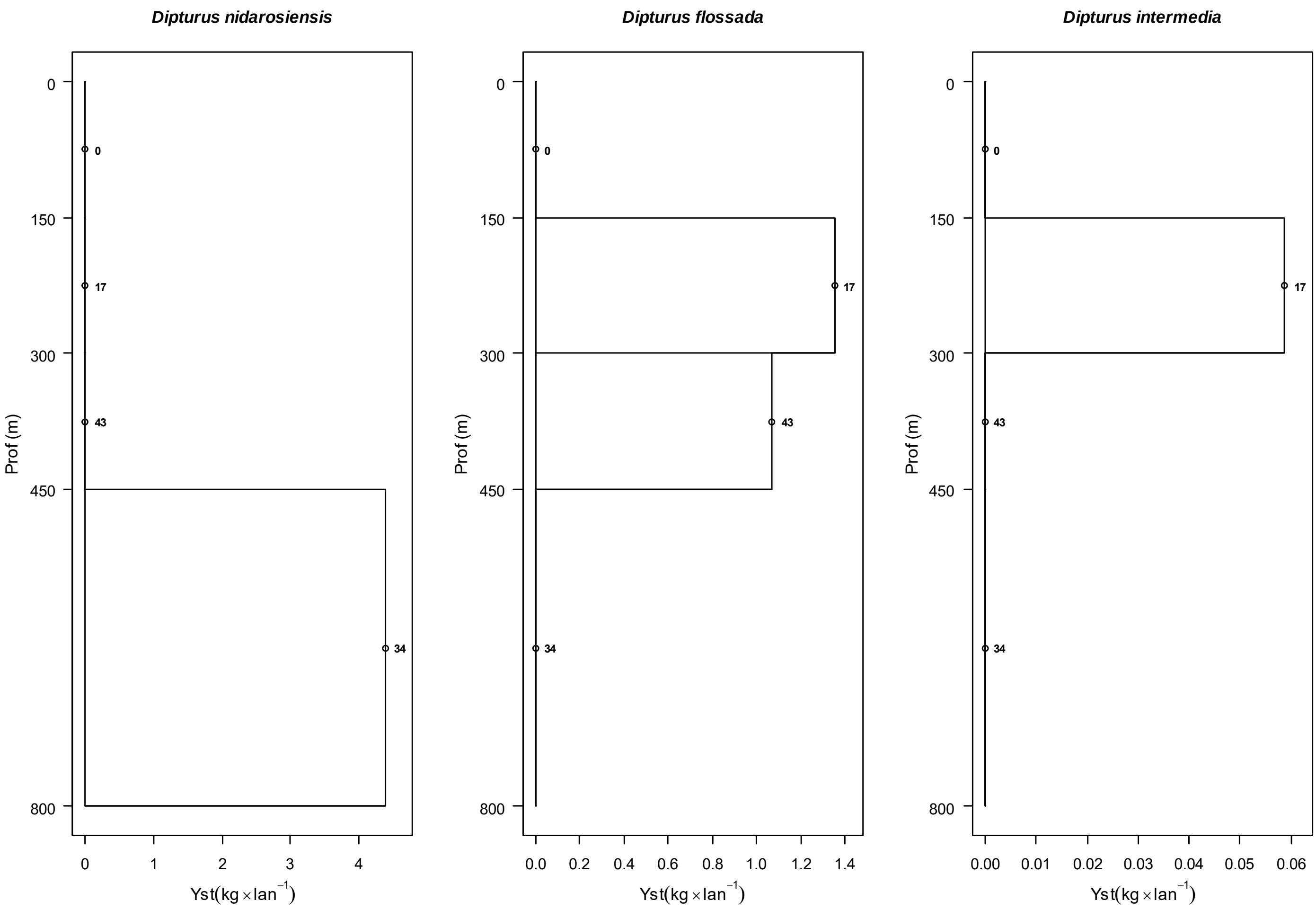


Figure 42 Depth distribution of *Dipturus nidarosiensis*, *Dipturus cf. flossada* and *Dipturus cf. intermedia* catches (kg/30 min haul) in Porcupine surveys 2017. Numbers mark total hauls

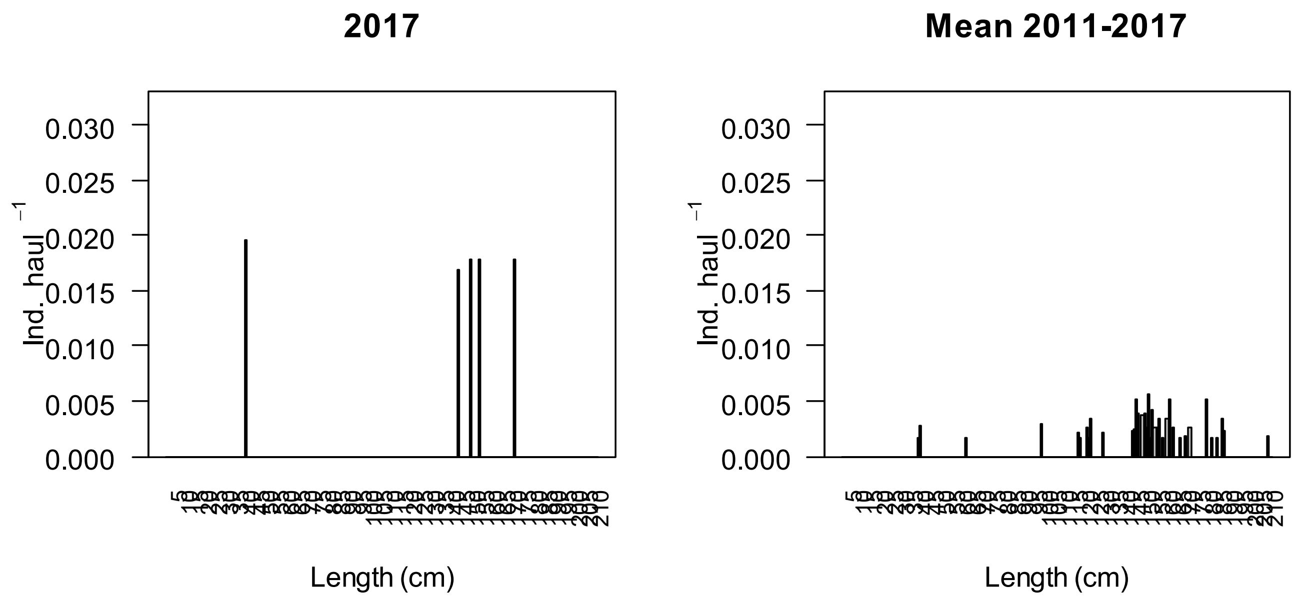


Figure 43 Stratified length distribution of *Dipturus nidarosiensis* in 2017 Porcupine survey, and mean values in Porcupine surveys (2011-2017)

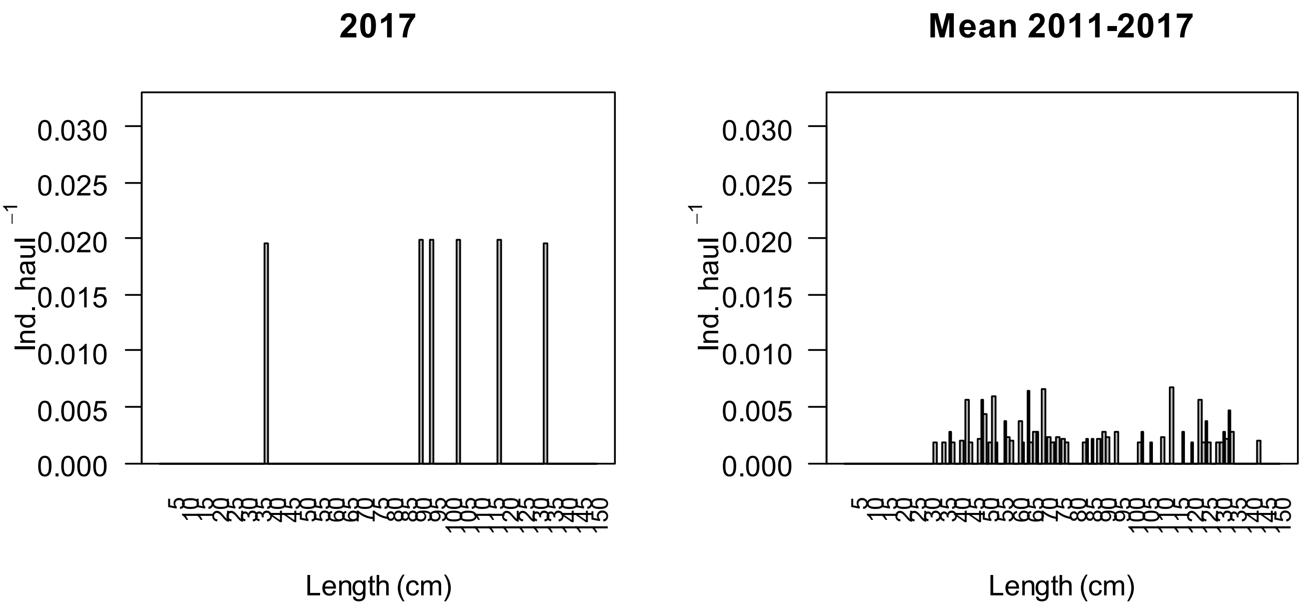


Figure 44 Stratified length distribution of *Dipturus cf. flossada* in 2017 Porcupine survey, and mean values in Porcupine surveys (2011-2017)

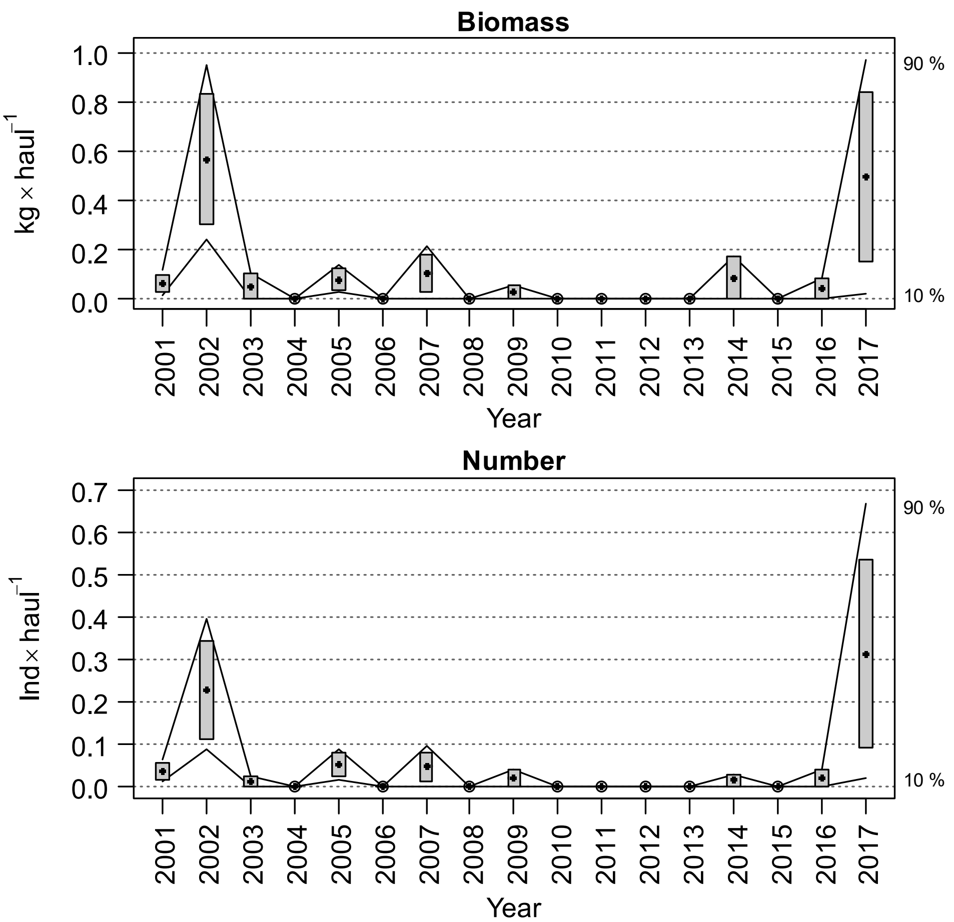


Figure 45 Evolution of *Squalus acanthias* biomass index (kg·haul^{-1}) in Porcupine surveys (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

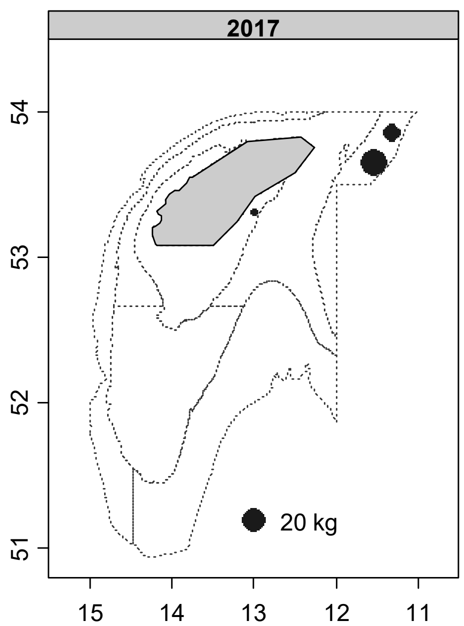


Figure 46 Geographic distribution of *Squalus acanthias*. catches (Kg· haul^{-1}) in Porcupine surveys 2017

Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 19–28 2018

Not to be cited without prior reference to the author

Common skate survey of the Celtic Sea

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Abstract: Building upon the common skate survey Fisheries Science Partnership (FSP) project in 2011, four subsequent Defra-funded fishery dependent common skate surveys were undertaken annually from 2014–2017 to collect field data on the relative abundance and distribution of the 'common skate complex' in the Celtic Sea (ICES Divisions 7.e–h). Data were collected on 2 400 blue skate *Dipturus batis* (1 103 females, mean total length ($L_{\bar{x}}$) = 115 ± 20 cm; 1 291 males, $L_{\bar{x}}$ = 113 ± 17 cm, with six unsexed) and 28 flapper skate *D. intermedius* (13 females, $L_{\bar{x}}$ = 108 ± 17 cm; 15 males, $L_{\bar{x}}$ = 144 ± 29 cm). Preliminary results are presented across the four survey years showing annual mean catch rates (CPUE) for *D. batis.* Across all exploratory stations fished, annual mean CPUE for abundance ranged from 0.44–0.49 individuals.km^{-1}.h^{-1} and biomass from 3.96–5.66 kg.km^{-1}.h^{-1}. Four prime stations (considered biologically important due to increased abundance of *D. batis*) were fished consistently to within 3 nm each year. These stations showed a higher annual mean CPUE abundance (0.68–0.77 individuals.km^{-1}.h^{-1}) and biomass (6.09–9.27 kg.km^{-1}.h^{-1}). The lowest mean CPUE biomass, recorded in 2016, was 3.96 kg.km^{-1}.h^{-1} for all stations fished, and 6.09 for kg.km^{-1}.h^{-1} for the four prime stations fished consistently. In addition to catch rates, data on the size and sex composition are presented. Preliminary results from tagging *D. batis* in 2011 and 2014–2017 are presented to show mark recapture locations from 46 mark-ID tags recovered (2% return rate) and 19 archival tags (17% recovery rate). These fish moved 4–170 km from the release position and were at liberty for 1–2098 days prior to recovery.

Introduction

Once thought to be a single species, common skate complex is now known to comprise two distinct species: the larger-bodied flapper skate *Dipturus intermedius* and the smaller-bodied blue (or grey) skate *Dipturus batis* (previously referred to as *Dipturus* cf. *flossada*, Iglésias *et al*., 2010). It is generally thought that *D. intermedius* has a more northerly range, occurring predominantly in the waters off the west coast of Scotland and in the northern North Sea, whilst *D. batis* is more common in the Celtic Sea. The two species overlap to varying extents.

Under EU fisheries legislation, the common skate complex are prohibited species, meaning that they cannot be targeted, retained, trans-shipped or landed. However, previous surveys have shown that they are susceptible to by-catch, particularly in Celtic Sea trammel net fisheries (Bendall *et al.*, 2012, 2016, 2017; Ellis *et al.*, 2015; Hetherington *et al*., 2016), and the prohibition on landings can result in high discard levels.

Fishermen operating in the Celtic Sea (ICES Divisions 7.e–h) consider the prohibition on landing common skate complex to be an ineffective management measure, as they believe high levels of *D. batis* by-catch indicate high local abundance. The Cornish Fish Producers Organisation (CFPO) suggest that *D. batis* should not be listed as a prohibited species, due to its abundance in parts of the Celtic Sea, and that it should possibly be included under the current Total Allowable Catch (TAC) for 'skates and rays'.

The common skate survey began in 2011 under a Fisheries Science Partnership (FSP) project (Bendall *et al.*, 2012) providing information on common skate by-catch in the UK trammel net fishery in the Celtic Sea. Building upon this initial survey, and following an industry request to UK policy makers, four subsequent fishery-dependent common skate surveys were undertaken from 2014 through to 2017 and reported upon here with the aim of developing a stock size indicator for *D. batis.* Such information is required to allow scientists and policy makers to develop practical and pragmatic management measures for Celtic Sea trammel net fisheries, where *D. batis* are particularly susceptible to by-catch and discarding.

Comments are welcomed from the ICES working group upon the contribution of such fishery dependent data to our understanding of *D. batis* and *D. intermedius* stocks in the Celtic Sea, together with any recommendations to our current UK data collection programmes that would benefit future policy and ICES advice for the stocks.

Methods

<u>*Vessel and sampling area:*</u> The four annual surveys between 2014–2017 were undertaken by FV *Govenek of Ladram*, a 22.7 m gillnetter operating out of Newlyn, Cornwall. The skipper, who also undertook the initial FSP common skate survey in 2011, has fished in the Celtic Sea and south-west approaches for ca. 20 years and has considerable experience of common skate catches in this area. The main survey area ran along a transect of stations running 12 to 80 nm to the south and west of Newlyn, Cornwall, UK. Using fixed trammel nets, the survey area was designed to collect data on the spatial extent of catch rates; species, size and sex compositions; reproductive biology and to provide a platform for tagging common skate (Bendall *et al.,* 2012, 2016, 2017; Hetherington *et al.,* 2016). On-deck vitality was also recorded but is not reported here. The four surveys returned to the survey area studied during the 2011 FSP survey, with exploratory stations to help inform the spatial extent of common skate catches in the survey area, with biologically important survey stations (where increased catches of mature males and egg-bearing females had been observed previously) repeated annually along the transect to develop a time-series index of catch rates and relative abundance (Figure 1).

<u>*Survey stations:*</u> For both 2014 and 2015, a systematic survey design was trialled, where the ICES rectangles in the survey area were subdivided into two sub-rectangles. Each sub-rectangle was overlaid with a nine-box grid, to which the centre box was surveyed by at least one trammel net, set at random within the centre box. In 2016, the survey design was modified to continue the time-series of 2011, 2014 and 2015, while exploring catches on different substrates, banks and off-banks, and extending the survey further to the south west. For 2017, the survey design was modified, based on previous survey locations, and 12 fixed (prime) stations which had been sampled in multiple years identified. These sites (a 3 nm bullring in which the nets could be set at random by the skipper) were fished, with a further two stations extended to the north. Wherever possible, two sets of nets were deployed at each prime station.

<u>*Gear description:*</u> Fixed trammel nets were used throughout the four field surveys with gradual standardisation of the lengths, depth and mesh size deployed. In 2014 trammel nets fished at all stations consisted of 262–300 mm mesh panels, each 100 m long and between 3.2–3.4 m deep, with 25–53 panels used per net (net length = 2 500–5 300 m). For 2015, a greater standardisation was achieved, with most of the trammel nets consisting of 262 mm mesh size panels (12 of a total of 17 nets; 71%), each 100 m long and 3.6 m deep, with 14 of the 17 survey stations (82%) fished with 24 panel nets (net length = 2 400 m). For 2016 and 2017, standardisation was further improved with all

trammel nets of 262–300 mm mesh size, each consisting of 24 panels (each 100 m long and 3.6 m deep, net length = 2 400 m). The soak times ranged from 9–30 h, which is less than standard commercial practices (usually 48–72 h or more), to reduce mortality, and maximise coverage of the survey area.

Catch sampling: All catch information was recorded by species for each survey station fished. All common skate were identified to species, and data collected for on-deck vitality (health state; excellent, good, poor or dead, together with vitality reflex and injury assessment see Hetherington *et al*., 2016), total length, disc width, sex and maturity (males). The presence of egg-laying females was also recorded. It should be noted that while species composition was predominantly made up of *D. batis*, biological data for a variety of other elasmobranch species captured were also collected, but are not reported upon here (Bendall *et al.,* 2012, 2016, 2017; Hetherington *et al.,* 2016).

Tagging: Where possible, common skate were tagged with an external mark ID tag (ST1 button sure-tag) placed directly onto the wing. In addition, Cefas Technology Ltd. G5 electronic archival tags or Data Storage Tags (DSTs) were attached to a ST1 button sure-tag and attached externally through the wing to record fine-scale behaviours and movements (swimming movements, depth and temperature measurements), programmed to record depth and temperature at 10-minute intervals. Physical recovery of tags was necessary to retrieve catch and archived tag information. Tag recovery was achieved either through the commercial fishery upon the capture of tagged skate or through beach recovery by members of the public following tag shedding, either naturally or via the pop-off mechanism. Data for all retrieved archival tags were downloaded, with depth and temperature data split and analysed by month and combined seasonal quarters of the year: winter and autumn (Q1 and Q4), spring and summer (Q2 and Q3). A hidden Markov model was applied to returned archival tag data to geographically reconstruct daily spatial movements of tagged skate from the point of release to the point of recapture. A full description of the model is provided in Pedersen *et al.* (2008).

Data analysis of catch per unit effort (CPUE): All *D. batis* caught during the survey were counted and measured. Individual weights W_T (g) were estimated from the parameters given by Silva *et al.* (2013):

$$W_T = 0.0038 \times {L_T}^{3.1201}$$

Fishing effort was defined as kilometre-hours (km.h) of net soaked:

$$Unit\ Effort = Length\ of\ net\ (km) \times Soak\ time\ (hours)$$

CPUE was calculated for each station, as abundance (individuals.km^{-1}.h^{-1}) and biomass (kg.km^{-1}.h^{-1}), based on the number of individuals N_T and summed weights converted to kg respectively:

$$Abundance = \frac{N_T}{Length\ of\ net\ (km) \times Soak\ time\ (hours)}$$

$$Biomass = \frac{\sum W_T\ (kg)}{Length\ of\ net\ (km) \times Soak\ time\ (hours)}$$

For each year surveyed, mean abundance and biomass were calculated for (a) all stations fished, and (b) for prime stations that were fished each year (2014–2017). Where prime stations were fished multiple times, the average was calculated for the prime station prior to averaging across prime stations.

As female immature and mature stages could not be recorded without internal examination of reproductive organs (which was not feasible during surveys), *D. batis* catch data by maturity stage were calculated using published estimates of the length at 50% maturity (L_{50}) (Iglésias *et al,* 2010).

Results

Survey coverage: Four annual common skate surveys (6–9 days duration) were undertaken in September 2014–2016 and October 2017 (delayed due to poor weather). For each survey a total of 15–23 trammel nets were fished in the survey area (Table 1). Given changes to survey design over time, the number of prime stations sampled ranged from 6–14 along the survey transect line, with four prime stations sampled in each of the four survey years (Table 2 and Figure 1).

Size and sex composition of D. batis and D. intermedius: For all stations fished during the four surveys between 2014–2017, total catch sampling data were collected for 2 400 *D. batis* (1 103 females, mean total length (L_x) = 115 ± 20 cm; 1 291 males, L_x= 113 ± 17 cm, with six unsexed) and 28 specimens of *D. intermedius* (13 females, L_x = 108 ± 17 cm; 15 males, L_x = 144 ± 29 cm). The size range of *D. batis* ranged from 61–149 cm L_T for females, and from 57– 146 cm L_T for males. *D. intermedius* ranged from 90–142 cm L_T (females) and 114–195 cm L_T (males) (Table 3; Figure 2).

The overall sex ratio (all years combined; females to males) was 1:1.17, with the sex ratios observed in 2014 and 2016 showing significantly more males (chi-squared test, P < 0.05), whilst more equal sex ratios were observed in 2015 and 2017.

Broadly similar size and sex patterns were also consistently observed for catch sampling data collected at prime survey stations (along the survey transect line), across survey years, where 1 952 *D. batis*

(916 females, $L_{\bar{x}}$ = 114 ± 21 cm; 1 030 males, $L_{\bar{x}}$ = 112 ± 17 cm) and 26 *D. intermedius* (12 females, $L_{\bar{x}}$ = 106 ± 15 cm; 14 males, $L_{\bar{x}}$ = 145 ± 29 cm) were sampled (Table 4).

Preliminary examination of the cumulative length frequency distributions (%) of *D. batis* catches (all survey years; all stations combined) by mesh size (262 mm and 300 mm) suggested that trammel nets with 262 mm mesh size caught proportionally more *D. batis* <124 cm L_T (Figure 3).

Catch rates of D. batis (CPUE): Dipturus batis was distributed widely in the survey area. Across the 2014–2017 survey period, the mean CPUE by abundance (individuals.km^{-1} h^{-1}) and biomass (kg.km^{-1}.h^{-1}) for *D. batis* remained relatively stable. Lower catch rates were observed at the south west edge, mid-point and to the north of the transect line (within the vicinity of prime stations C1, C5 and C10–C12, respectively; Figure 4). Mean CPUE ranged from 0.44–0.49 individuals.km^{-1} and, in terms of biomass, from 3.96–5.66 kg.km^{-1}.h^{-1}, with notable standard deviations of the mean (Table 5; Figure 5; Appendix 1).

Only four prime stations were fished in all four survey years (C03, C04, C07 and C09), and the mean CPUE at these sites ranged from 0.68–0.77 individuals.km^{-1}.h^{-1} and 6.09–9.27 kg.km^{-1}.h^{-1} (Table 6; Figure 5). The lowest recorded mean CPUE (biomass) was recorded in 2016, at 3.96 kg.km^{-1}.h^{-1} for all stations fished, and 6.09 for kg.km^{-1}.h^{-1} for prime stations that were fished each year.

Spatial distribution of D. batis: Based upon published length at 50% maturity data (L_{50} = Males >115 cm; females >123 cm; Iglésias *et al.,* 2010), both mature and immature male and female *D. batis* were found to be distributed throughout the survey area and over the years (Figure 6). Mature male and female *D. batis* were recorded in larger numbers near the mid-point and to the north of the transect line (within the vicinity of prime stations C06–C07 and C03–C04 respectively), where females were also observed to be spawning (egg-cases protruding from the cloaca; n = 40 across survey years). Immature *D. batis* (males and females combined) were recorded in larger numbers from the mid-point to the south and west of the transect line (within vicinity of prime station C06–C12) and to the north of the transect line (within the vicinity of prime stations C02–C03).

Tagging of D. batis and D. intermedius: A total of 2 909 *D. batis* (1 467 females, 1 442 males) were mark-ID tagged in 2011 and 2014–2017. Of these, 46 (1.58%) have been recovered to date (Figure 7; Appendix 2). These recaptures were reported from between 4–170 km from the release position and had been at liberty for between 24–2098 days prior to recapture.

In addition, specimens of both *D. batis* (n = 115; 61 females and 54 males), and *D. intermedius* (n = 21; 14 males and seven females) were tagged externally with a floated Cefas G5 archival tag. Of these, 19 *D. batis* (16.5%) and one *D. intermedius* (4.8%) have been returned to date, yielding >5,000 days of data (Figures 7 and 8; Appendix 3). Of the 19 *D. batis* returns, nine were males at liberty between 104–494 days, with nine females at liberty between 1–905 days, the sex of one fish was not recorded.

Individual daily geolocated positions were calculated from depth and temperature recorded by returned the archival tags to examine the spatial movements and habitat range of male and females by combined seasonal quarters (autumn and winterQ1 and Q4; spring and summer Q2 and Q3; Figure 8). For autumn and winter quarters (Q1 and Q4), both males and females appeared to be distributed widely from the point of release towards the outer edge of deep waters (50–200 m) of the continental shelf of the Celtic Sea, with some northward movements observed for females off the north coast of Cornwall and Devon. Available data for spring and summer combined seasonal quarters (Q2 and Q3) were more limited, with preliminary evidence that spatial movements remain central to the habitat range observed in Q1 and Q4.

Discussion

Building upon initial work in 2011 under a Fisheries Science Partnership (FSP), the four fishery-dependent common skate surveys undertaken in 2014–2017 provide insights into the temporal spatial abundance of *D. batis* and *D. intermedius* in an area of the Celtic Sea (7.e –h).

Survey coverage: Survey design and coverage has been developed across the survey years 2014 – 2017, working towards standardisation, based upon the biologically important locations identified during the 2011 survey. Exploratory stations were fished with trammel nets to the east, south west and north of the 2011 survey area to help define the spatial extent and habitat of common skate catches between 2014–2016, with the development of 14 standardised prime survey stations in 2017, running through previous survey areas along a transect 12 to 80 nm from Newlyn, Cornwall, UK. The survey is therefore in its infancy with regards a robust and standardised time-series data at this stage, however data from the four prime stations which have been repeated across all survey years provides a preliminary time-series of *D. batis* catches within an area of biological importance, which can be extended and built upon further.

Size and sex composition: Size ranges and sex composition of *D. batis* caught were broadly consistent throughout survey years, albeit with an indication of more males in some years. Most of the skates caught were >100 cm L_T, which is likely to be related to the selectivity of the trammel net gear. In comparison, another Defra-funded study using a commercial twin-rig otter trawler operating in ICES Divisions 7.e–h has recently collected field data on juveniles of the *D. batis* complex (typically <60 cm L_T), a life-history stage and size not typically caught in trammel nets, presumably due to a different gear selectivity (Hetherington *et al.,* 2017). This study is evaluating how Remote Electronic Monitoring (REM) can help validate fishers' self-sampling records of the common skate complex, thus providing further information (relative abundance, spatial distribution and maturity) on a segment of the population underrepresented in the trammel net surveys.

Catch rates: Catches sampled within the Celtic Sea study area support fisher's anecdotal information that *D. batis* is locally abundant, with all stations fished during the four surveys showing relatively consistent mean CPUE in terms of abundance and biomass, albeit over a short time period. The same consistent trend was also observed for just those prime stations fished across all four survey years. These four prime stations are thought to be biologically important areas where increased catches of immature and mature males and females (based upon total length at maturity data by Iglésias *et al*, 2010), and occurrence of active males and egg-bearing females have been observed.

The observed mean CPUE (biomass) was lowest in 2016, which could in part be an artefact of survey design, as some sets looked at small-scale differences between habitats (on and off banks) where *D. batis* were captured. Therefore, combined catch rates and biomass estimates that have not been consistently collected across the four survey years need to be treated with considerable caution.

Further data collection and exploration are required to establish whether more mature fish are now naturally coming through to benefit the stock following the prohibition upon commercial catches in 2009. Furthermore, it is unclear as to whether the surveyed area would be representative of the wider stock area. Therefore, a monitoring strategy for common skate in the Celtic Sea might rely on a certain number of survey stations in such biologically important locations, assuming that analyses take into account the higher CPUE values at these stations compared to the wider stock area, where catches can be very low.

Spatial distribution of D. batis: Catches of *D. batis* classed as immature or mature (based upon length at maturity data; Iglésias *et al.,* 2010), were distributed across the survey area and over survey years.

Mature male and female *D. batis* were recorded in larger numbers near the mid-point and to the north of the transect, where females across survey years had been observed to be spawning (egg-cases protruding from the cloaca). Immature male and female *D. batis* were recorded in larger numbers from the mid-point to the south and west of the transect line and to the north. These preliminary results may help inform mapping of potential spawning and nursery grounds in the Celtic Sea region for future conservation and sustainable management measures.

Tagging: Data recovered to date from both mark ID and archival tags provide additional insights and increased understanding of the seasonal spatial range of *D. batis* in the Celtic Sea, which requires further study. Recaptured skates were taken in commercial gears up to 170 km from the point of release, giving an indication of the spatial range of skate within the region. Such evidence was further supported by the reconstructed daily locations from archival tags, where *D. batis* were observed to undertake extensive movements within a relatively restricted spatial range, inhabiting the 50–200 m shelf contour of the Celtic Sea region. While more data have been gathered from archival tags for autumn and winter spatial movements, data on spring and summer movements are currently more limited, and so deployment of archival tags during the spring and summer seasons would prove valuable to better map the seasonal habitat range and spatial extent of *D. batis* to help inform potential conservation or fisheries management measures in the future.

Acknowledgements

With thanks to Defra for funding the programme of work, skipper Philip Mitchell and his crew of the FV *Govenek of Ladram*, Cefas colleagues Samantha Smith and Patrick Jones together with Thomas Barreau of the Muséum National d'Histoire Naturelle (MNHN) France for their expertise and involvement in the fieldwork surveys, Paul Trebilcock and colleagues from the CFPO for their continued support, and Jim Ellis and Sophy Phillips for commenting on the paper.

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Table 1: Summary of the number of trammel net deployments by mesh size (262 mm or 300 mm) and station (all or prime) by survey year

Year	Dates	All stations			Prime stations		
		262 mm	300 mm	Total	262 mm	300 mm	Total
2014	15th – 22nd September	4	17	21	2	7	9
2015	20th – 25th September	12	5	17	7	2	9
2016	23rd – 28th September	11	4	15	9	4	13
2017	26th – 31st October	15	8	23	15	8	23

Table 2: Summary of prime station trammel net deployments by survey year (dark grey; highlights those sampled in continuous years 2014–2017)

Prime stations	2014	2015	2016	2017	Total
C01		2		2	4
C02				2	2
C03	1	1	1	2	5
C04	1	1	1	2	5
C05	1	2		2	5
C06	1	1		2	4
C07	3	1	1	2	7
C08			1	2	3
C09	2	1	2	1	6
C10			3	1	4
C11			2	1	3
C12			2	1	3
C13				2	2
C14				1	1
Total number of sets fished at prime stations	**9**	**9**	**13**	**23**	**54**
Number of prime stations fished	**6**	**7**	**8**	**14**	**35**

Table 3: Numbers of *D. batis* and *D. intermedius* caught at all stations by survey with length ranges.

Year	*Dipturus batis**		*Dipturus intermedius*	
	No. Females (length range)	**No. Males (length range)**	**No. Females (length range)**	**No. Males (length range)**
2014	285 (61–147 cm)	409 (62–139 cm)	8 (90–142 cm)	11 (114–195 cm)
2015	301 (61–146 cm)	340 (61–139 cm)	1 (137 cm)	1 (130 cm)
2016	178 (61–138 cm)	245 (67–146 cm)		
2017	339 (63–149 cm)	297 (57–136 cm)	4 (100–108 cm)	3 (117–193 cm)
Total	**1 103 (61–149 cm)**	**1 291 (57–146 cm)**	**13 (90–142 cm)**	**15 (114–195 cm)**

* Excludes *D. batis* (n = 6; 75–107 cm L_T) where sex was not recorded.

Table 4: Numbers of *D. batis* and *D. intermedius* caught at all prime stations by survey with length ranges.

Year	*Dipturus batis**		*Dipturus intermedius*	
	No. Females (length range)	**No. Males (length range)**	**No. Females (length range)**	**No. Males (length range)**
2014	198 (73–147 cm)	266 (62–136 cm)	8 (90–142 cm)	11 (114–195 cm)
2015	203 (61–141 cm)	235 (61–138 cm)		
2016	176 (61–138 cm)	232 (67–146 cm)		
2017	339 (63–149 cm)	297 (57–136 cm)	4 (100–108 cm)	3 (117–193 cm)
Total	**916 (61–149 cm)**	**1 030 (57–146 cm)**	**12 (90–142 cm)**	**15 (114–195 cm)**

* Excludes *D. batis* (n = 6; 75–107 cm L_T) where sex was not recorded.

Table 5: Annual catch rates of *D. batis* for all stations fished (see Appendix 1 for detailed information)

Year	Number of stations fished with trammel nets	Mean (± SD) CPUE (abundance)	Mean (± SD) CPUE (biomass)
2014	19 [1]	0.49 (± 0.40)	5.66 (± 4.71)
2015	16 [2]	0.44 (± 0.31)	4.93 (± 3.43)
2016	15	0.47 (± 0.40)	3.96 ± (3.63)
2017	23	0.46 (± 0.34)	4.81 (± 4.30)

[1] Excluding two stations located East of the Isles of Scilly

[2] Excluding one station where the length of net was not recorded

Table 6: Annual catch rates of *D. batis* at four prime stations sampled in all years (see Appendix 1 for detailed information)

Year	Total number of trammel net deployments	Mean (± SD) CPUE (abundance)	Mean (± SD) CPUE (biomass)
2014	7	0.68 (± 0.34)	9.27 (± 4.62)
2015	4	0.77 (± 0.17)	8.90 (± 0.41)
2016	5	0.72 (± 0.59)	6.09 (± 3.48)
2017	7	0.74 ± (0.20)	7.72 (± 2.70)

Figure 1: Common skate survey stations fished with trammel nets (2014–2017).

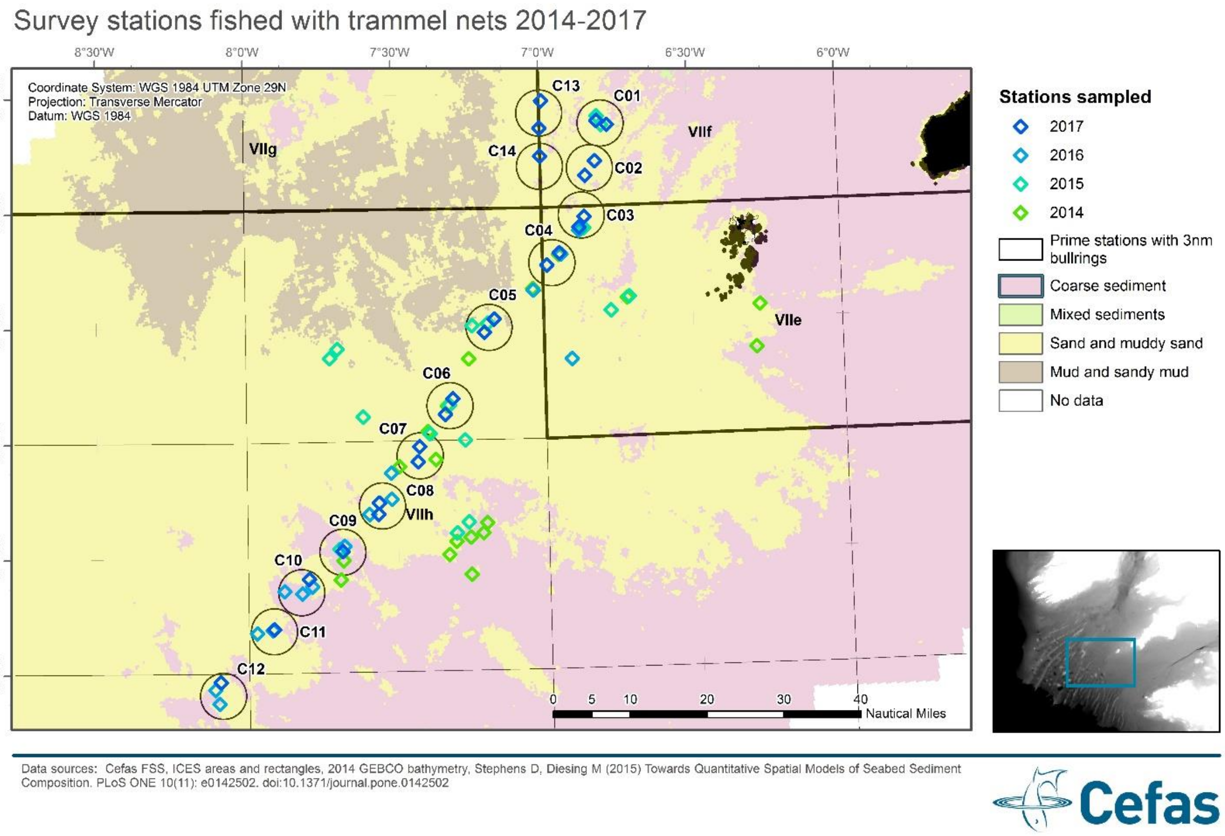


Figure 2: Length composition by sex of *D. batis* (by survey year; all stations combined)

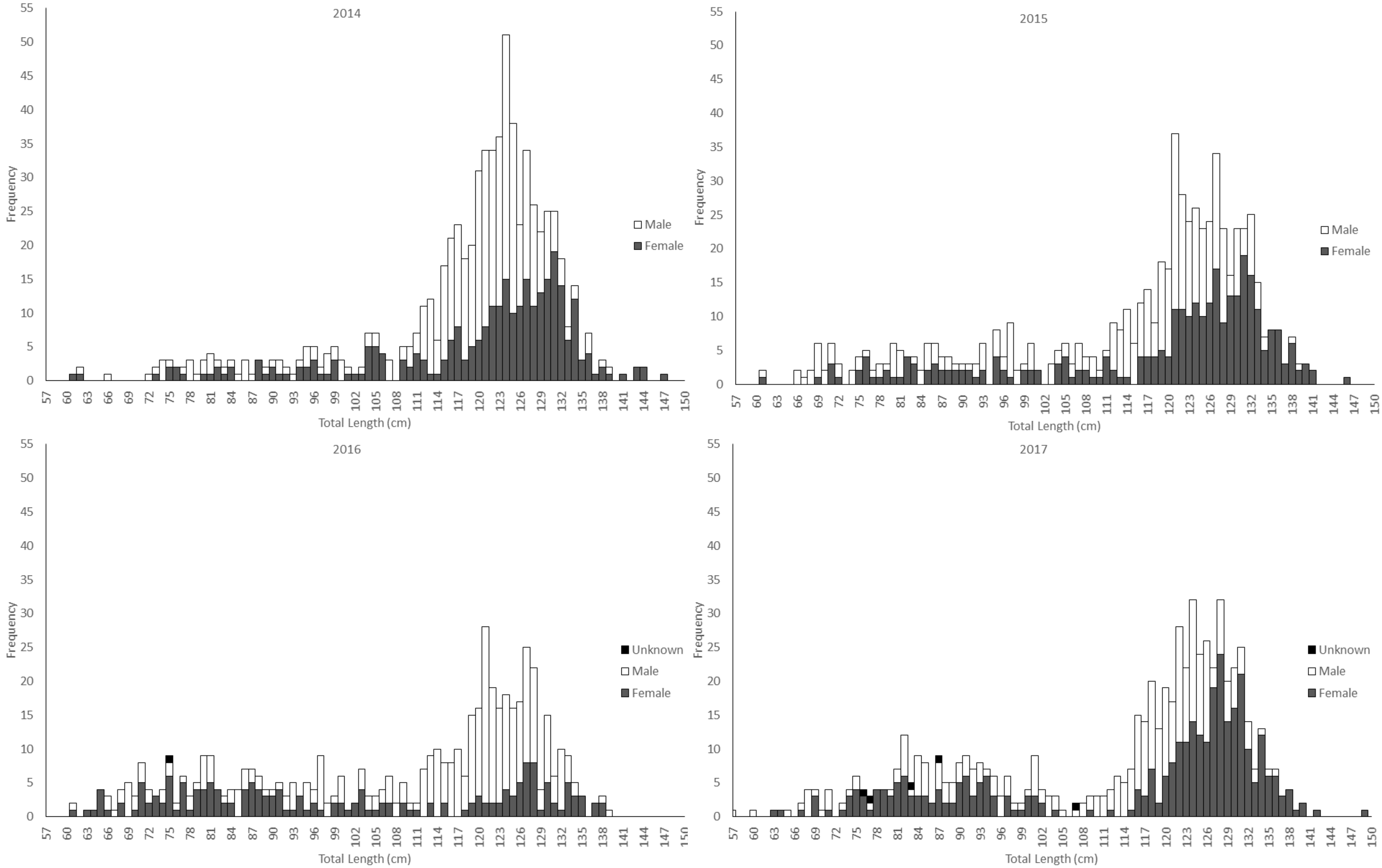


Figure 3: Cumulative length frequency distribution (%) of *D. batis* caught by trammel net (all survey years; all stations combined) by mesh size.

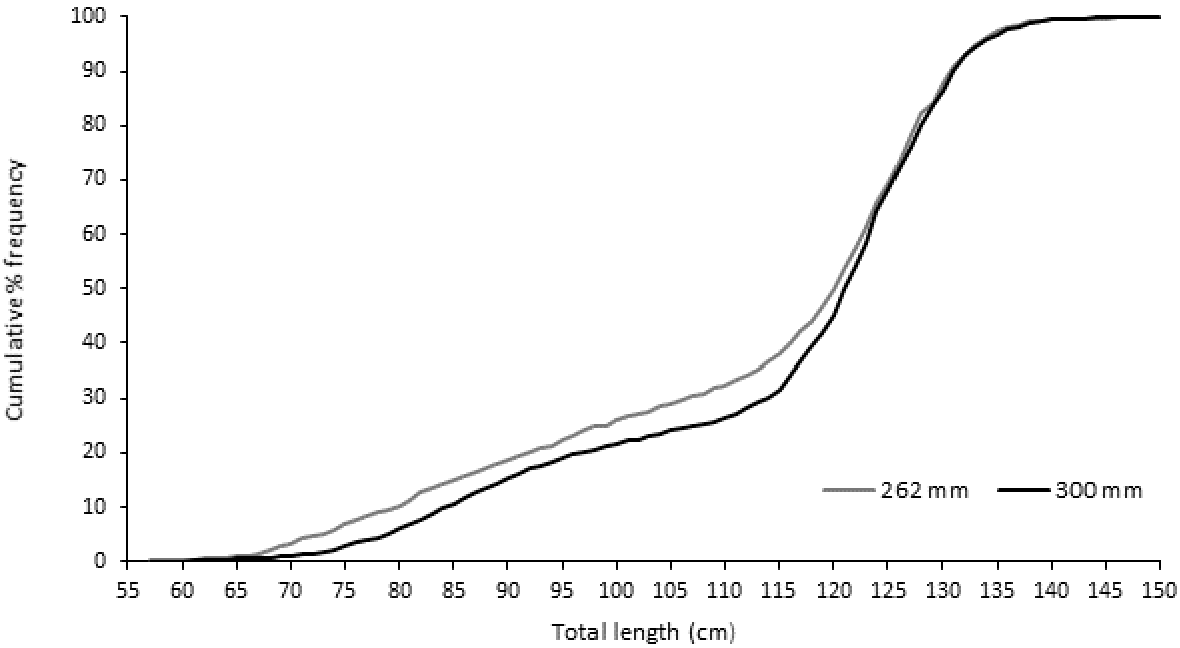
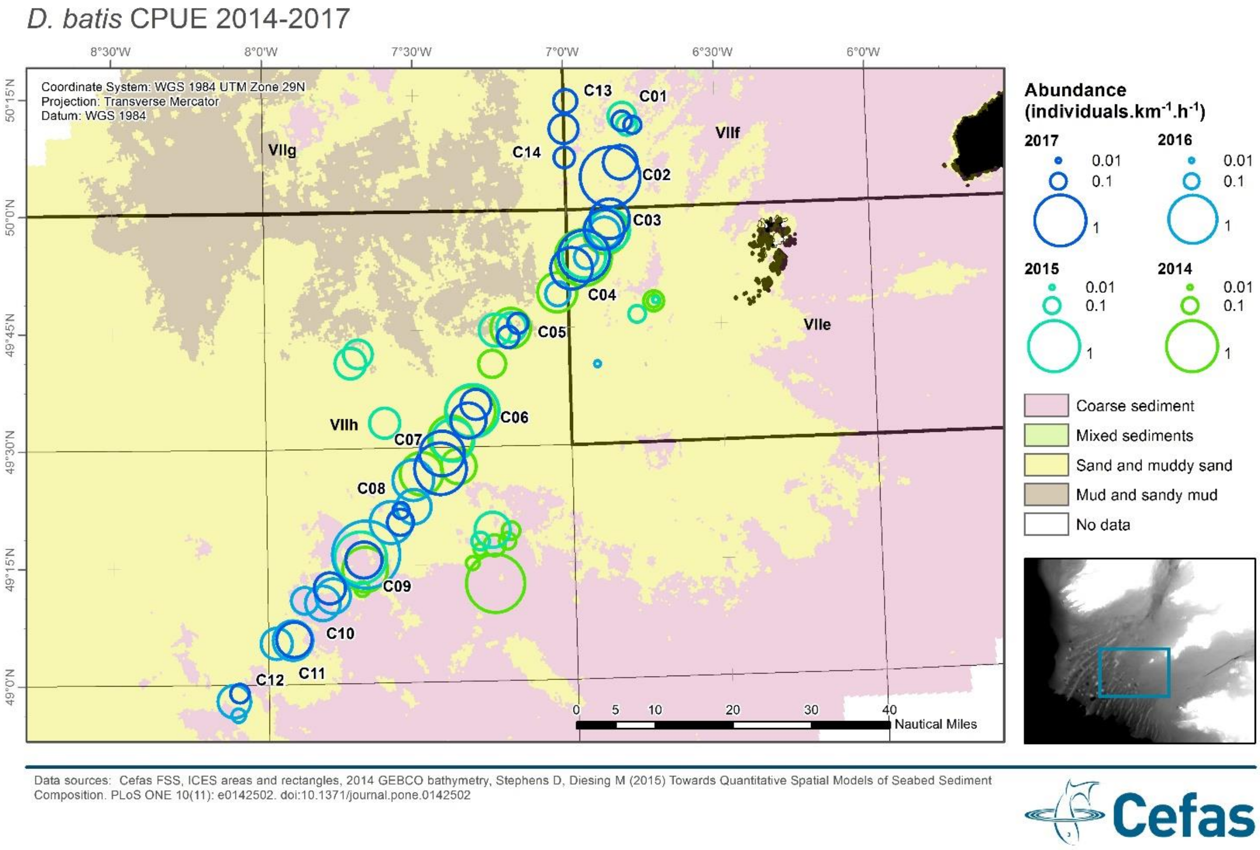


Figure 4: Distribution and CPUE of *D. batis* at all stations fished, showing (a) abundance (indidivudals.km^{-1}.h^{-1}) and (b) biomass (kg.km^{-1}.h^{-1}).

a)



b)

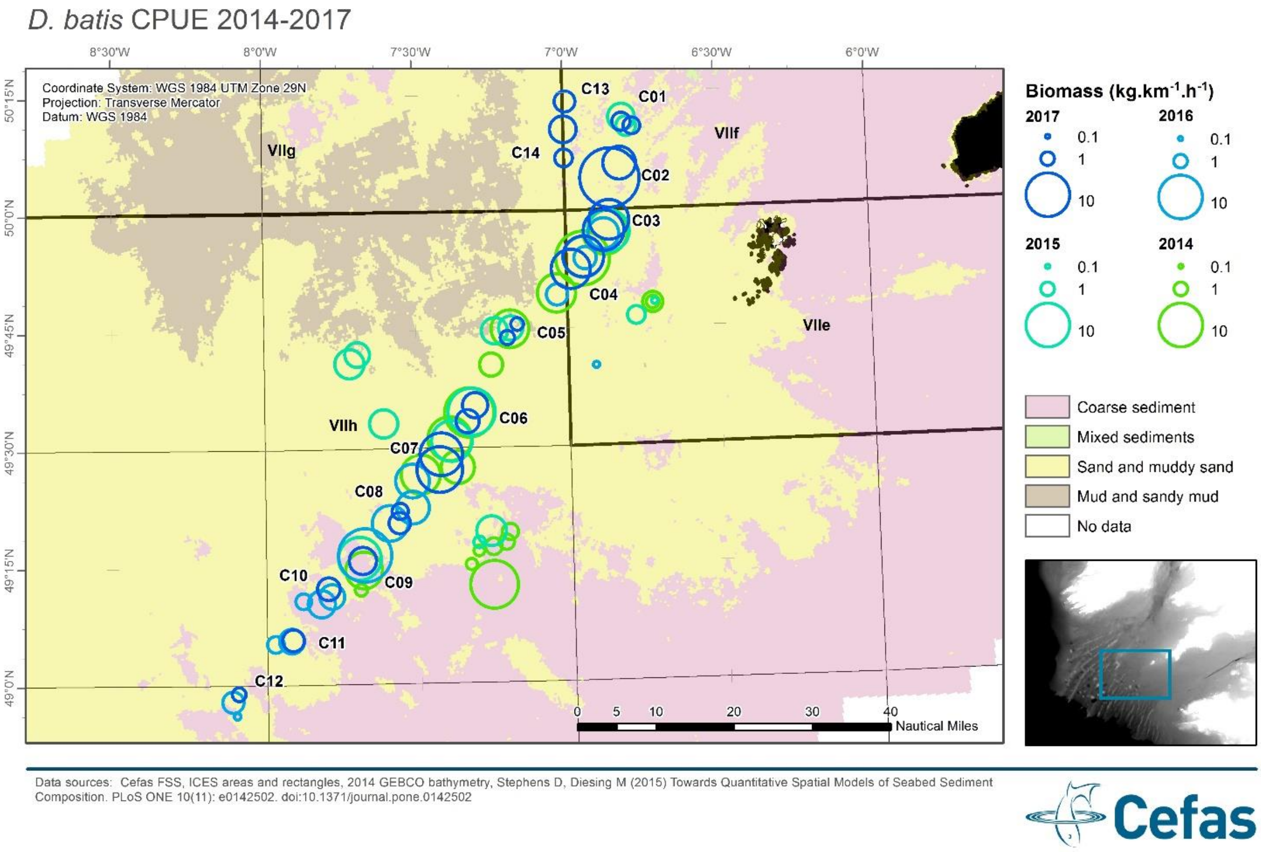


Figure 5: Temporal changes in catch rates of *D. batis* (left panel: abundance; right panel: biomass) for all stations fished (top) and for prime stations sampled each year (bottom).

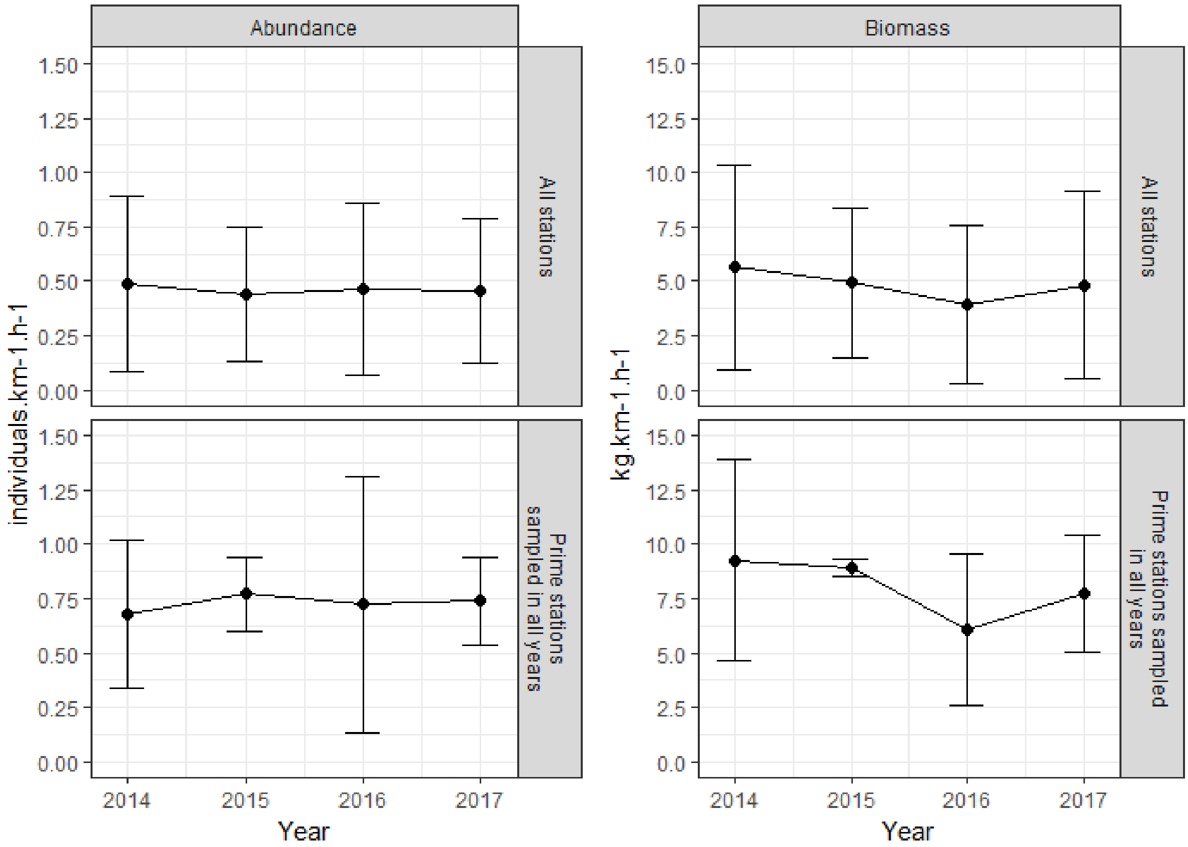


Figure 6: Spatial distribution and relative abundance of *D. batis* by year for (a) 'mature' females, (b) 'mature' males and (c) 'immature' fish (males and females combined). Maturity split based upon published length at maturity data (Iglésias *et al.*, 2010).

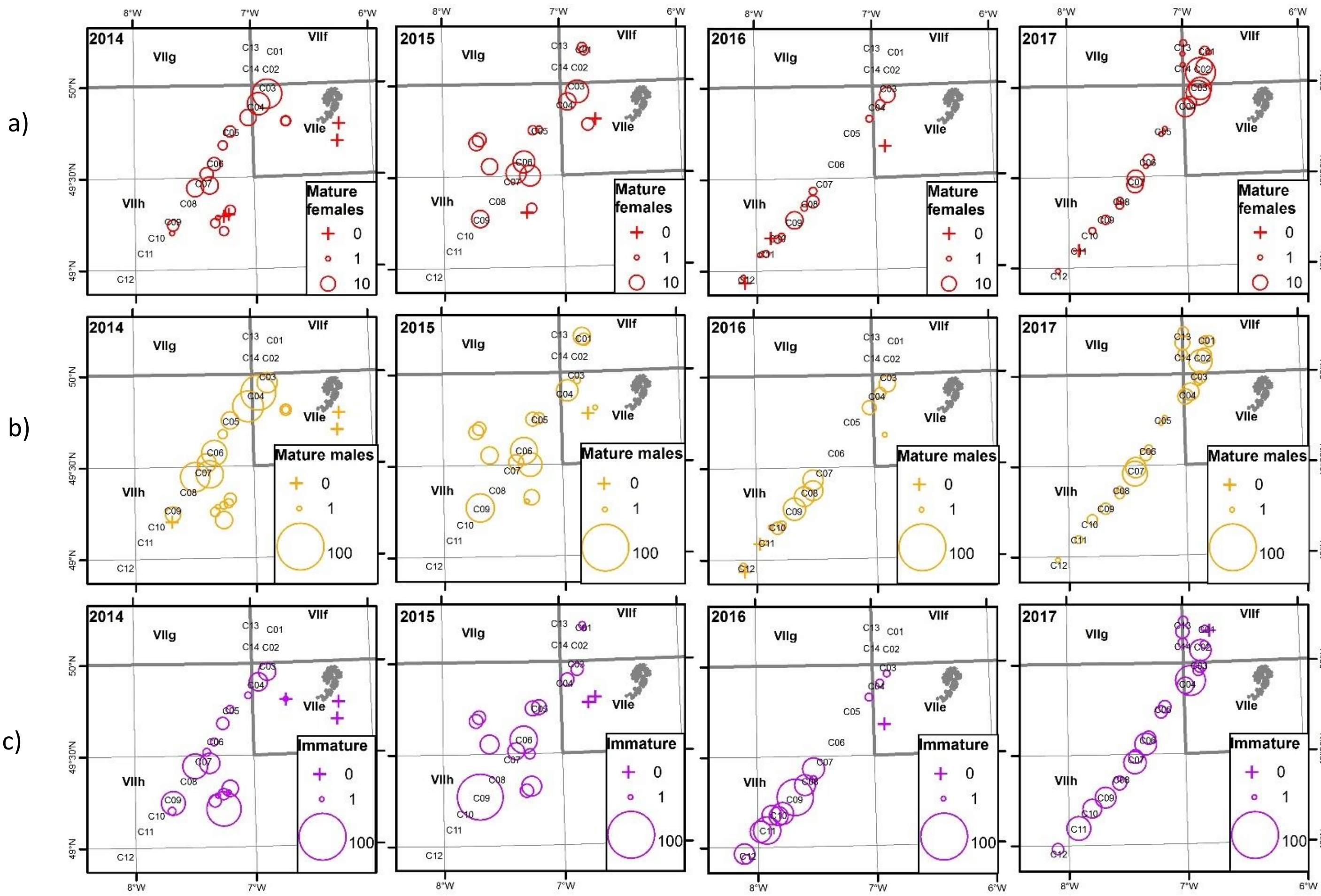


Figure 7: Release and recovery locations *Dipturus batis* (n = 19) and *Dipturus intermedius* (n = 1) tagged with data storage tags (DST; left) and mark ID tags (*Dipturus batis* only; right)

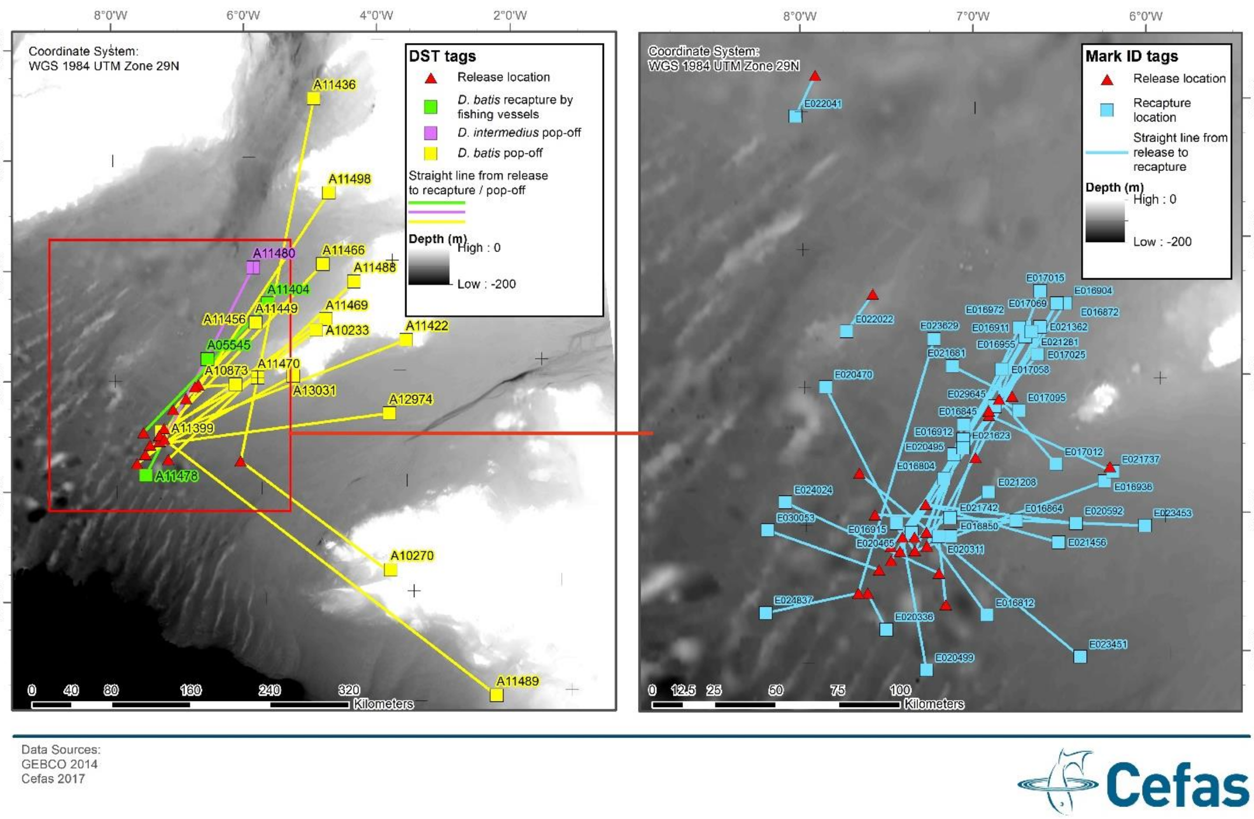
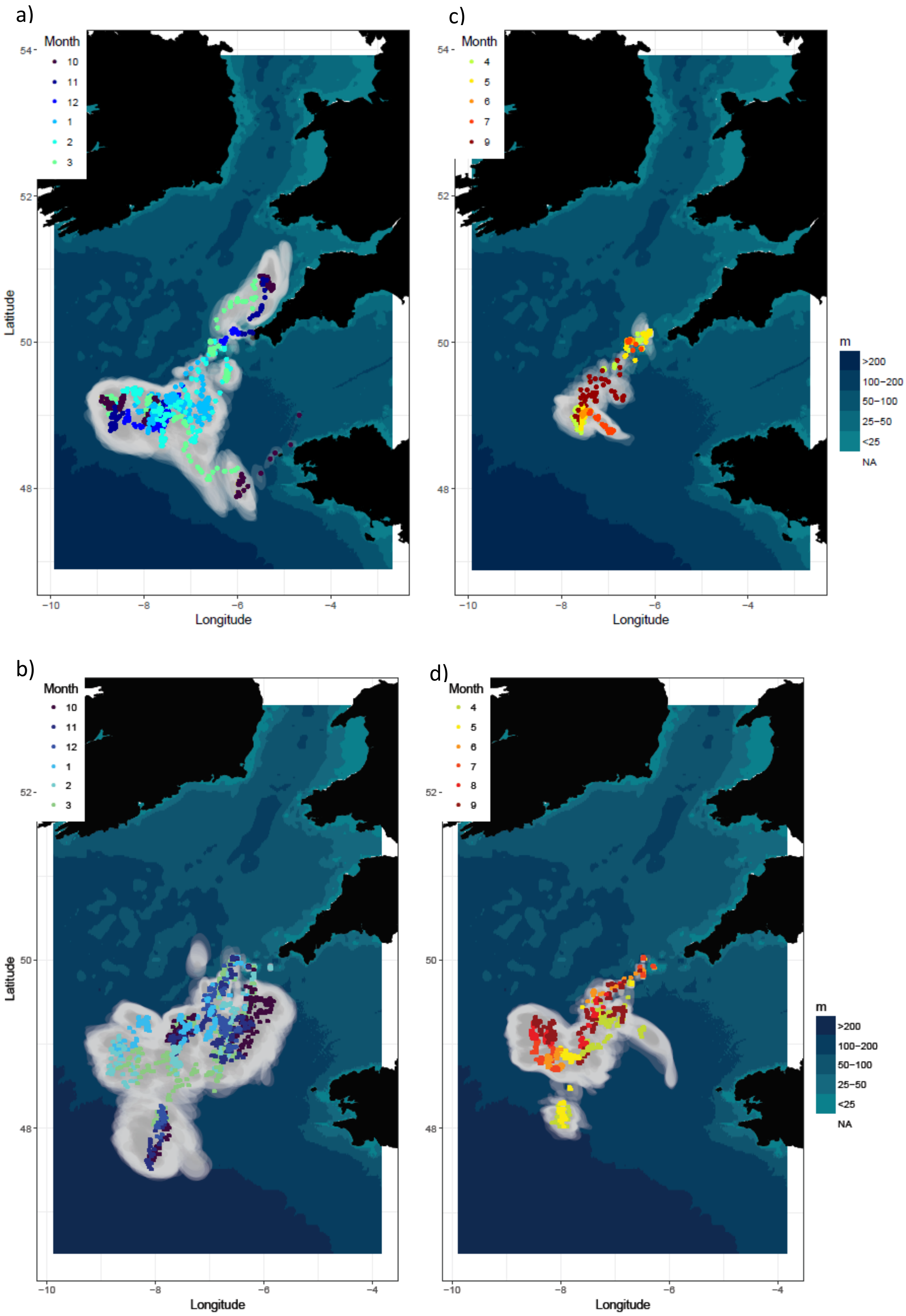


Figure 8: Reconstructed daily spatial movements of *D. batis* tagged with DSTs, by combined seasonal quarters, for winter and autumn (Q1 and Q4); (a) females (n= 6; 1 546 days of data) and (b) males (n= 8; 2 320 days of data); and for spring and summer quarters (Q2 and Q3), (c) females (n= 6; 275 days of data) and (d) males (n= 6; 369 days of data). Each filled circle symbol is an estimate of daily position of an individual, coloured by month, at liberty.



Appendix 1: Numbers and estimated biomass of *D. batis* caught in trammel nets by all survey stations for each year.

Year	Station No. (prime station No.)	Length of net (m)	Soak time (hh:mm)	Effort (km-hours of net soaked)	Catches of *D. batis*		CPUE	
					Number of individuals	Estimated biomass (kg)	Abundance (individuals .km^{-1}.h^{-1})	Biomass (kg.km^{-1}.h^{-1})
2014	1	5000	15:53	79.417				
2014	2	5000	19:30	97.500				
2014	3	5000	18:45	93.750	15	2.139	0.160	200.577
2014	4	4800	26:00	124.800	8	0.872	0.064	108.839
2014	5 (C04)	4500	18:15	82.125	99	14.995	1.205	1231.469
2014	6 (C03)	4500	21:30	96.750	75	10.285	0.775	995.121
2014	9	2500	41:30	103.750	61	7.701	0.588	799.005
2014	10 (C05)	2500	16:00	40.000	24	7.501	0.600	300.021
2014	11	2500	21:15	53.125	15	2.821	0.282	149.860
2014	13 (C07)	2500	14:30	36.250	27	9.877	0.745	358.048
2014	14 (C06)	2500	17:00	42.500	40	12.538	0.941	532.870
2014	20 (C07)	5300	26:30	140.450	67	5.699	0.477	800.440
2014	21 (C07)	4200	28:00	117.600	83	7.949	0.706	934.768
2014	26	2500	18:45	46.875	5	1.209	0.107	56.672
2014	27	2500	21:00	50.042	3	0.585	0.060	29.281
2014	28	2500	20:15	50.625	9	1.497	0.178	75.808
2014	31 (C09)	2500	23:00	57.500	44	7.113	0.765	408.977
2014	32 (C09)	2500	23:45	59.375	5	0.786	0.084	46.687
2014	33	2500	22:30	56.250	73	11.748	1.298	660.827
2014	34	5300	43:00	227.900	15	0.660	0.066	150.387
2014	36	4200	50:00	210.000	26	1.422	0.124	298.596
2015	1	2400	27:30	66.000	7	1.615	0.106	106.615
2015	2	2400	28:0	67.200	1	0.202	0.015	13.588
2015	3 (C01)	2400	28:30	68.400	20	3.746	0.292	256.254

Year	Station No. (prime station No.)	Length of net (m)	Soak time (hh:mm)	Effort (km-hours of net soaked)	Catches of *D. batis*		CPUE	
					Number of individuals	Estimated biomass (kg)	Abundance (individuals .km^{-1}.h^{-1})	Biomass (kg.km^{-1}.h^{-1})
2015	5 (C01)	2400	31:30	75.600	12	2.094	0.159	158.299
2015	7 (C03)	2400	23:00	55.200	36	8.980	0.652	495.699
2015	8 (C04)	2400	25:00	60.000	43	8.606	0.717	516.344
2015	9 (C05)	2400	22:30	54.000	18	3.112	0.333	168.028
2015	11 (C05)	2400	24:0	57.600	23	3.625	0.399	208.798
2015	12 (C06)	2400	35:45	85.800	91	11.543	1.061	990.416
2015	14	Not recorded	28:15	Unknown	53	Not calculated	Not calculated	743.579
2015	15 (C07)	2200	29:15	64.350	44	8.552	0.684	550.329
2015	16	2400	30:00	72.000	34	4.658	0.472	335.368
2015	18	2400	31:15	75.000	9	0.744	0.120	55.784
2015	19 (C09)	4400	33:30	147.400	151	9.447	1.024	1392.501
2015	20	4200	30:15	127.050	44	4.156	0.346	527.972
2015	21	2400	32:45	78.600	25	3.250	0.318	255.488
2015	22	2400	34:15	82.200	30	4.482	0.365	368.421
2016	1 (C12)	2400	22:30	54.000	4	0.237	0.074	12.808
2016	2 (C12)	2400	22:15	53.400	22	2.401	0.412	128.193
2016	3 (C11)	2400	24:15	58.200	22	1.454	0.378	84.616
2016	4 (C11)	2400	26:00	62.400	38	3.228	0.609	201.405
2016	5 (C10)	2400	27:00	64.800	18	1.355	0.278	87.830
2016	6 (C10)	2400	24:30	58.800	27	3.889	0.459	228.686
2016	7 (C10)	2400	25:30	61.200	28	3.295	0.458	201.631
2016	8 (C09)	2400	24:00	57.600	99	14.921	1.719	859.424
2016	9 (C09)	2400	25:00	60.000	41	6.817	0.683	409.048
2016	10 (C08)	2400	25:30	61.200	28	5.708	0.458	349.338
2016	11 (C07)	2400	29:00	69.600	44	5.927	0.632	412.551
2016	15	2400	25:00	60.000	1	0.205	0.017	12.287
2016	16	2400	26:00	62.400	14	2.438	0.224	152.110

Year	Station No. (prime station No.)	Length of net (m)	Soak time (hh:mm)	Effort (km-hours of net soaked)	Catches of *D. batis*		CPUE	
					Number of individuals	Estimated biomass (kg)	Abundance (individuals .km^{-1}.h^{-1})	Biomass (kg.km^{-1}.h^{-1})
2016	17 (C04)	2400	26:30	63.600	13	2.598	0.204	165.212
2016	18 (C03)	2400	27:30	66.000	25	4.952	0.379	326.843
2017	1 (C12)	2400	24:15	58.200	8	0.996	0.137	57.964
2017	2 (C11)	2400	25:00	60.000	29	2.429	0.483	145.764
2017	3 (C09)	2400	24:30	58.800	30	3.898	0.510	229.209
2017	4 (C10)	2400	25:30	61.200	23	2.751	0.376	168.339
2017	5 (C08)	2400	24:00	57.600	6	1.363	0.104	78.511
2017	6 (C08)	2400	24:45	59.400	16	2.406	0.269	142.920
2017	7 (C07)	2400	26:00	60.040	46	9.539	0.766	572.697
2017	8 (C07)	2400	26:15	63.000	64	10.972	1.016	691.266
2017	9 (C06)	2400	23:50	57.200	20	3.340	0.350	191.045
2017	10 (C06)	2400	25:00	60.000	29	2.866	0.483	171.954
2017	11 (C05)	2400	25:00	60.000	11	1.089	0.183	65.357
2017	12 (C05)	2400	25:45	61.800	10	0.835	0.162	51.582
2017	13 (C04)	2400	25:45	61.800	41	7.964	0.663	492.201
2017	14 (C04)	2400	26:30	63.600	64	8.624	1.006	548.518
2017	15 (C02)	2400	25:45	61.800	27	5.519	0.437	341.062
2017	16 (C02)	2400	27:00	64.800	89	18.187	1.373	1178.544
2017	17 (C03)	2400	24:00	57.600	35	8.654	0.608	498.462
2017	18 (C03)	2400	25:45	61.800	37	8.213	0.599	507.587
2017	19 (C13)	2400	23:00	55.200	9	1.692	0.163	93.424
2017	20 (C13)	2400	23:45	57.000	19	3.707	0.333	211.283
2017	21 (C14)	2400	24:30	58.800	12	2.251	0.204	132.364
2017	22 (C01)	2400	25:15	60.600	9	1.792	0.149	108.625
2017	23 (C01)	2400	25:15	60.600	7	1.461	0.116	88.559

Appendix 2: Summary details for all external mark-ID returned D. *batis*, released during common skate surveys 2011–2017. Distance travelled is the straight-line distance between release and recapture locations.

Tag ID	Release date	Recapture date	Sex	L_T (cm)	Disc width (cm)	Health state	Soak time (h)	Distance travelled (km)	Days at liberty	Recovery (method)
E020495	20/09/2014	24/06/2015	M	81	63	Poor	28	39	24	FRA (Trawl)
E017095	24/08/2011	06/10/2011	M	128	88	Excellent	18	9	44	UK (Net)
E022041	21/04/2014	24/11/2014	F	53	NR	Excellent	NR	18	66	FRA (Trawl)
E021737	17/09/2014	24/11/2014	F	130	90	Good	18	55	69	FRA (Trawl)
E016804	21/08/2011	01/11/2011	F	113	90	Excellent	26	23	73	FRA (Trawl)
E020470	20/09/2014	04/12/2014	F	83	60	Good	28	68	76	FRA (Trawl)
E017012	24/08/2011	10/11/2011	F	129	93	Excellent	18	35	79	FRA (Trawl)
E021623	17/09/2014	20/12/2014	M	124	90	Poor	22	29	95	FRA (Trawl)
E021344	19/09/2014	20/01/2015	M	126	91	Excellent	14	170	124	IRE (Trawl)
E020336	21/09/2014	08/04/2015	M	110	80	Excellent	18	17	199	FRA (Trawl)
E023451	24/09/2015	15/04/2016	F	136	98	Excellent	10	116	204	FRA (Trawl)
E017058	24/08/2011	19/03/2012	F	128	97	Excellent	18	12	209	FRA (Trawl)
E016850	21/08/2011	21/03/2012	M	102	75	Excellent	26	10	214	FRA (Trawl)
E030053	26/09/2016	04/05/2017	M	89	65	Good	25	48	220	UK (Trawl)
E012690	17/09/2014	25/04/2015	F	125	90	Excellent	22	37	221	IRE (Trawl)
E020499	20/09/2014	02/05/2015	M	81	58	Poor	28	54	224	FRA (Trawl)
E021208	20/09/2014	10/05/2015	M	66	46	Excellent	27	30	232	FRA (Trawl)
E017015	24/08/2011	16/04/2012	F	129	90	Excellent	18	47	237	UK (Net)
E016912	22/08/2011	07/05/2012	M	116	86	Excellent	49	45	259	FRA (Trawl)
E021742	17/09/2014	16/06/2015	M	121	84	Good	17	46	272	FRA (Trawl)
E020311	22/09/2014	29/06/2015	M	124	84	Excellent	22	28	280	FRA (Trawl)
E021681	17/09/2014	13/08/2015	F	122	91	Good	6	27	330	UK (Trawl)
E016812	21/08/2011	28/08/2012	M	111	80	Excellent	26	41	373	FRA (Trawl)
E029645	26/09/2016	30/10/2017	F	113	80	Poor	22	70	399	UK (Net)
E016915	22/08/2011	27/09/2012	M	106	78	Excellent	46	13	403	FRA (Trawl)
E021456	23/09/2015	07/12/2016	F	99	71	Excellent	11	56	441	RUS (Trawl)
E016848	21/08/2011	07/11/2012	F	100	69	Excellent	26	NR	445	FRA (Trawl)
E024024	24/09/2015	06/05/2017	M	121	87	Good	6	68	590	UK (Trawl)
E023629	24/09/2015	21/05/2017	M	105	75	Excellent	10	107	605	FRA (Trawl)
E021362	18/09/2014	20/05/2016	M	117	82	Excellent	41	59	610	UK (Net)
E021281	19/09/2014	14/06/2016	M	125	90	Excellent	17	82	634	UK (Net)
E020592	23/09/2015	26/06/2017	F	121	86	Excellent	12	61	642	FRA (Trawl)
E022022	19/01/2014	27/10/2015	F	121	92	NR	NR	18	646	UK (Net)
E017025	24/08/2011	04/06/2013	F	121	87	Excellent	18	23	650	UK (Net)
E024837	24/09/2015	10/08/2017	M	97	72	Excellent	10	38	686	FRA (Trawl)
E016845	21/08/2011	27/08/2013	M	125	89	Excellent	15	46	737	UK (Trawl)
E023453	24/09/2015	29/10/2017	M	112	77	Excellent	7	109	766	UK (Net)
E016864	21/08/2011	28/04/2014	M	131	89	Excellent	15	41	1004	FRA (Trawl)
E020465	20/09/2014	29/10/2017	M	118	85	Excellent	28	4	1135	UK (Net)
E016936	22/08/2011	14/10/2014	M	102	74	Excellent	46	81	1150	FRA (Trawl)
E017069	24/08/2011	19/05/2016	F	133	94	Excellent	18	45	1730	UK (Net)
E016872	22/08/2011	19/05/2016	M	118	88	Excellent	49	111	1732	UK (Net)
E016904	22/08/2011	19/05/2016	F	87	62	Excellent	43	125	1732	UK (Net)
E016972	22/08/2011	20/05/2016	M	100	70	Excellent	43	103	1733	UK (Net)
E016955	22/08/2011	19/06/2016	F	89	62	Excellent	43	105	1763	UK (Net)
E016911	22/08/2011	20/05/2017	M	120	82	Excellent	46	99	2098	UK (Net)

Appendix 3: Summary details for 19 returned DSTs from *D. batis,* and one *D. intermedius*, released during common skate surveys 2011–2017.

Species	Tag ID	Release date	Recapture date	Sex	L_T (cm)	Disc width (cm)	Health state	Soak time (h)	Recovery distance (km)	Days at liberty	Recovery (method)
D. batis	A05545	21/08/2011	04/03/2012	M	124	85	Excellent	26	96	197	UK (Net)
	A10233	24/09/2015	27/12/2016	M	120	87	Good	9	225	460	UK (Beach)
	A10270	24/09/2015	15/11/2015	F	118	81	Good	10	218	52	UK (Beach)
	A10873	28/09/2016	31/10/2016	F	125	87	Excellent	27	41	33	UK (Beach)
	A11399	23/09/2015	06/05/2016	M	126	91	Excellent	5	5	226	UK (Beach)
	A11404	24/09/2015	08/04/2016	F	131	91	Good	10	180	197	UK (Trawl)
	A11422	23/09/2015	30/07/2016	F	123	91	Excellent	5	266	311	UK (Beach)
	A11436	24/09/2015	06/12/2015	NR	NR	NR	NR	10	372	73	UK (Beach)
	A11449	18/09/2014	07/04/2015	M	124	86	Excellent	26	104	202	UK (Beach)
	A11456	18/09/2014	10/07/2015	F	128	91	Excellent	16	121	295	UK (Beach)
	A11466	19/09/2014	31/12/2014	M	125	87	Excellent	14	239	104	UK (Beach)
	A11469	19/09/2014	19/09/2014	F	147	106	Excellent	15	204	1	UK (Beach)
	A11470	19/09/2014	21/12/2014	F	126	90	Excellent	17	107	94	UK (Beach)
	A11478	20/09/2014	23/04/2015	M	121	80	Excellent	27	41	215	FRA (Trawl)
	A11488	21/09/2014	25/10/2015	M	123	89	Excellent	20	259	399	UK (Beach)
	A11489	20/09/2014	13/03/2017	F	120	91	Excellent		422	905	FRA (Beach)
	A11498	20/09/2014	27/01/2016	M	118	84	Excellent	26	299	494	UK (Beach)
	A12974	26/09/2016	25/02/2017	F	130	84	Excellent	29	242	152	UK (Beach)
	A13031	26/09/2016	15/07/2017	M	117	83	Excellent	25	168	292	UK (Beach)
D. intermedius	A11480	20/09/2014	25/04/2015	M	150	111	Excellent	26	195	217	UK (Beach)

Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 19–28 2018

Not to be cited without prior reference to the author

Skates in the UK beam trawl survey of the Irish Sea (ICES Division 7.a) and Bristol Channel (ICES Division 7.f–g)

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Abstract: Annual 4 m beam trawl surveys are conducted in Irish Sea and Bristol Channel (Divisions 7.a and 7.f–g) each September, with the survey grid standardised since 1993. Average catch rates (n.h^{-1} and kg.h^{-1}, and kg.h^{-1} for specimens ≥50 cm total length) are shown for thornback ray *Raja clavata,* spotted ray *Raja montagui,* blonde ray *Raja brachyura*, cuckoo ray *Leucoraja naevus* (7.a.f–g) and small-eyed ray *Raja microocellata* (7.f only).

Introduction

Several species of skate occur in the coastal waters of the Irish Sea and Bristol Channel (Stehmann & Bürkel, 1984; Fahy & O'Reilly, 1990), the main species being thornback ray *Raja clavata,* spotted ray *Raja montagui,* blonde ray *Raja brachyura*, small-eyed ray *Raja microocellata* and cuckoo ray *Leucoraja naevus*. Common skate *Dipturus batis*-complex and white skate *Rostroraja alba* are now observed less frequently in these areas (Brander, 1981; Dulvy *et al.*, 2000; Rogers & Ellis, 2000), although the former still occurs in parts of the Irish Sea (e.g. Belfast Lough) and is more frequent on the offshore grounds of the Celtic and Hebridean Seas. Shagreen ray *Leucoraja fullonica* and undulate ray *Raja undulata* may occur very occasionally in the Irish Sea and Bristol Channel (e.g. Quéro and Gueguen, 1981; Ellis *et al.,* 2002), but both these species are more frequent elsewhere. Whilst it has been suggested that long-nosed skate *Dipturus oxyrinchus* has been lost form the Irish Sea (Dulvy *et al.*, 2000), this was purported on the basis of this species being listed as occurring in the Irish Sea (Bruce *et al.*, 1963), whilst the original source of information (Herman & Dawson, 1902) casts doubt on the identification of the nominal record and there is no basis for considering *D. oxyrinchus* as extirpated from the Irish Sea (Ellis *et al.*, 2002, 2010).

Skates are an important fishery resource in the area and elsewhere in the Celtic Seas ecoregion, and there have been various studies providing information on skate fisheries, landings and species composition (Holden, 1963; Du Buit, 1968b, 1970, 1972a, 1973; Fahy, 1988, 1989b, c; Gallagher *et al.*, 2005a; Ellis *et al.,* 2010; Silva *et al.*, 2012). Various aspects of skate biology have also been addressed for this ecoregion, including feeding habits (Du Buit, 1968a, 1972b, 1978; Fitzmaurice, 1974; Ajayi, 1982; Ellis *et al.*, 1996), age and growth (Holden, 1972; Du Buit, 1976a; Ryland & Ajayi, 1984; Brander & Palmer, 1985; Du Buit & Maheux, 1986; Fahy, 1989a, 1991; Gallagher *et al.*, 2005b), reproductive biology (Du Buit, 1976b; Nottage & Perkins, 1983; Gallagher *et al.*, 2005b; Whittamore & McCarthy, 2005; McCully *et al.*, 2012), condition (Du Buit, 1975), habitats (Kaiser *et al.*, 2004) and movements (Pawson & Nichols, 1994).

Annual beam trawl surveys conducted in the Irish Sea and Bristol Channel (Divisions 7.a.f–g) sample a variety of demersal elasmobranchs (Ellis *et al*., 2005a, 2005b), including five species of skate: cuckoo ray *Leucoraja naevus*, blonde ray *Raja brachyura*, thornback ray *Raja clavata*, small-eyed ray *Raja microocellata* and spotted ray *Raja montagui*. Updated survey indices for these species are shown.

Methods

Beam trawl surveys in the Irish Sea and Bristol Channel are conducted each September (although surveys in any one year may extend into late August or early October). These surveys have been conducted since 1989, although the survey grids have been better standardised since 1993 (Parker-Humphreys, 2004 a, b). The gear used is a 4 m beam trawl with chain mat, as described by Burt *et al*. (2013).

The survey and 97 fixed stations were fished consistently over time (during at least 22 years within the 25-year study period; Figure 1). The fixed stations used in the present analysis were prime stations 2–7, 9–10, 12, 14–19, 22–23, 27–28, 30–32, 36–38, 40–43, 47, 49, 53–55, 101–105, 109–117, 119–122, 124, 126, 128–139, 203, 206, 213–214, 220, 229, 233, 302, 309, 313, 316, 321, 401, 405, 408–409, 416, 419, 421, 423–425, 430, 438, 440–444, 447 and 501. Data from other stations were excluded from the present analysis of temporal trends, so that data were as standardised as possible.

The catch per unit effort (CPUE) was calculated for both abundance (mean number per hour across the standard stations) and biomass (numbers at length were transformed to biomass using the length-weight conversion factors of Silva *et al.* (2013; see Table 1). The mean annual CPUE (biomass) was calculated for all fish and also for just those specimens ≥50 cm total length (L_T), the latter equating with that part of the stock that would generally be landed (Silva *et al.*, 2012).

Results and discussion

Cuckoo ray *Leucoraja naevus:* All three indices of CPUE declined from 1993 to 2012, since when there has been a general increase in numbers and total biomass (Figure 2). The biomass of specimens ≥50 cm L_T has been broadly stable since the early 2000s. The mean CPUE for cuckoo ray ≥50 cm L_T decreased slightly from 0.211 kg.h^{-1} in 2011–2015 to 0.182 kg.h^{-1} in 2016–2017 (Table 2).

Blonde ray *Raja brachyura:* This species is not sampled effectively in many trawl surveys, which may be due to low catchability of larger individuals, and lower overlap between survey areas and their preferred habitats. Whilst CPUE was low, both the biomass and abundance have shown increasing trends (Figure 2).

Thornback ray *Raja clavata:* This species is the most abundant skate in survey area. Catch rates, in terms of biomass and abundance, have increased steadily over the entire survey time-series (Figure

2). The mean CPUE for thornback ray ≥50 cm L_T increased from 2.515 kg.h^{-1} in 2011–2015 to 5.053 kg.h^{-1} in 2016–2017 (Table 2).

Small-eyed ray *Raja microocellata:* This species is locally common in the Bristol Channel, and only those data from stations in 7.f–g were used. The catch rates observed over the survey time-series increased in the first few years, before declining steadily to about 2013. Since then, catch rates have increased slowly (Figure 2). The mean CPUE for small-eyed ray ≥50 cm L_T increased from 0.531 kg.h^{-1} in 2011–2015 to 1.089 kg.h^{-1} in 2016–2017 (Table 2).

Spotted ray *Raja montagui*: This species is also a frequent skate across the survey area. Catch rates increased steadily over the survey time-series (Figure 2), although the biomass of specimens ≥50 cm L_T has been more stable. The mean CPUE for spotted ray ≥50 cm L_T increased slightly from 0.524 kg.h^{-1} in 2011–2015 to 0.568 kg.h^{-1} in 2016–2017 (Table 2).

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Table 1: Length-weight parameters used. Source: Silva *et al.* (2013)

Species	a	b
L. naevus	0.0036	3.1399
R. brachyura	0.0027	3.258
R. clavata	0.0045	3.0961
R. microocellata	0.003	3.225
R. montagui	0.0041	3.1152

Table 2: Average catch rates by numbers (n.h^{-1}) and biomass (kg.h^{-1}), and biomass for individuals ≥50 cm total length (*kg.h^{-1}) for skates sampled during beam trawl surveys of the Irish Sea and Bristol Channel (ICES Divisions 7.a.f–g) from 1993–2017.

	Leucoraja naevus			*Raja brachyura*			*Raja clavata*			*Raja microocellata* (7.f–g)			*Raja montagui*		
Year	n.h^{-1}	kg.h^{-1}	*kg.h^{-1}	n.h^{-1}	kg.h^{-1}	*kg.h^{-1}	n.h^{-1}	kg.h^{-1}	*kg.h^{-1}	n.h^{-1}	kg.h^{-1}	*kg.h^{-1}	n.h^{-1}	kg.h^{-1}	*kg.h^{-1}
1993	1.565	0.530	0.281	0.217	0.203	0.127	3.394	2.147	1.259	0.848	1.209	1.055	2.179	0.900	0.520
1994	1.773	1.040	0.733	0.351	0.362	0.296	2.515	1.919	1.379	1.273	2.184	1.882	1.753	0.504	0.230
1995	1.474	0.750	0.468	0.547	0.397	0.278	3.651	3.084	2.171	2.679	2.941	2.270	2.295	1.078	0.621
1996	1.347	0.528	0.224	0.441	0.409	0.355	3.962	2.660	1.737	1.576	0.865	0.529	2.525	1.151	0.698
1997	1.011	0.629	0.474	0.316	0.499	0.462	4.967	2.782	1.733	2.394	2.918	2.294	2.653	1.042	0.461
1998	1.116	0.488	0.337	0.505	0.129	0.019	3.768	2.909	2.230	5.097	3.778	2.558	2.463	0.634	0.166
1999	1.753	0.620	0.334	0.763	0.395	0.285	3.400	2.513	1.873	3.182	3.322	2.542	3.601	1.105	0.556
2000	0.783	0.350	0.216	1.087	0.589	0.397	3.065	1.815	1.180	2.375	1.615	0.823	3.283	0.902	0.308
2001	0.854	0.419	0.267	0.500	0.417	0.347	5.330	3.123	1.905	2.848	2.733	1.902	3.729	1.258	0.458
2002	0.907	0.299	0.176	0.495	0.299	0.224	3.572	2.695	1.822	2.667	2.887	2.316	2.907	1.151	0.589
2003	0.928	0.392	0.168	0.722	0.381	0.244	3.773	2.781	2.050	2.061	1.905	1.316	4.000	1.164	0.519
2004	1.625	0.542	0.294	1.555	0.406	0.116	6.107	5.440	4.367	3.458	2.407	1.601	6.021	1.540	0.585
2005	1.188	0.330	0.106	0.729	0.549	0.451	4.068	2.642	1.688	2.182	2.330	1.751	3.542	0.827	0.250
2006	1.031	0.396	0.175	0.680	0.439	0.341	4.763	2.796	1.812	2.909	1.496	0.514	3.753	0.925	0.358
2007	0.938	0.259	0.110	0.299	0.342	0.299	5.340	2.627	1.468	2.788	1.452	0.536	3.845	0.934	0.294
2008	0.834	0.411	0.236	0.824	0.543	0.429	5.500	3.113	2.056	2.485	1.145	0.512	3.533	0.627	0.143
2009	1.124	0.441	0.234	1.006	0.621	0.404	6.195	3.806	2.616	3.087	1.850	0.774	6.721	1.359	0.406
2010	0.640	0.220	0.132	0.884	0.679	0.527	7.475	3.924	2.562	2.121	1.599	1.062	4.904	0.976	0.309
2011	0.917	0.553	0.343	0.963	0.750	0.586	7.494	3.355	1.795	2.909	1.619	0.785	6.673	1.421	0.544
2012	0.351	0.114	0.036	0.996	0.372	0.168	8.280	3.669	1.929	2.848	1.499	0.583	6.856	1.435	0.464
2013	0.934	0.389	0.188	1.308	0.561	0.334	12.080	5.273	3.256	1.052	0.626	0.285	6.643	1.328	0.420
2014	1.052	0.511	0.321	1.438	0.976	0.696	9.032	5.382	3.421	1.394	1.129	0.657	5.795	1.610	0.629
2015	1.031	0.395	0.166	0.546	0.371	0.312	9.262	4.118	2.175	2.030	0.886	0.348	7.131	1.654	0.565
2016	0.760	0.272	0.158	1.798	0.814	0.458	13.864	7.261	4.635	1.818	1.019	0.577	9.476	1.946	0.583
2017	1.959	0.614	0.205	1.686	0.803	0.501	13.082	8.163	5.470	2.909	2.097	1.601	11.767	2.162	0.553
Index A (2016–2017)	1.360	0.443	**0.182**	1.742	0.808	**0.479**	13.473	7.712	**5.053**	2.364	1.558	**1.089**	10.621	2.054	**0.568**
Index B (2011–2015)	0.857	0.392	**0.211**	1.050	0.606	**0.419**	9.230	4.359	**2.515**	2.047	1.152	**0.531**	6.620	1.490	**0.524**
Index A/Index B	1.587	1.129	**0.862**	1.658	1.334	**1.144**	1.460	1.769	**2.009**	1.155	1.353	**2.050**	1.605	1.379	**1.083**

Figure 1: Survey grid of the Bristol Channel and Irish Sea showing locations of fixed stations sampled most consistently (1993–2017).

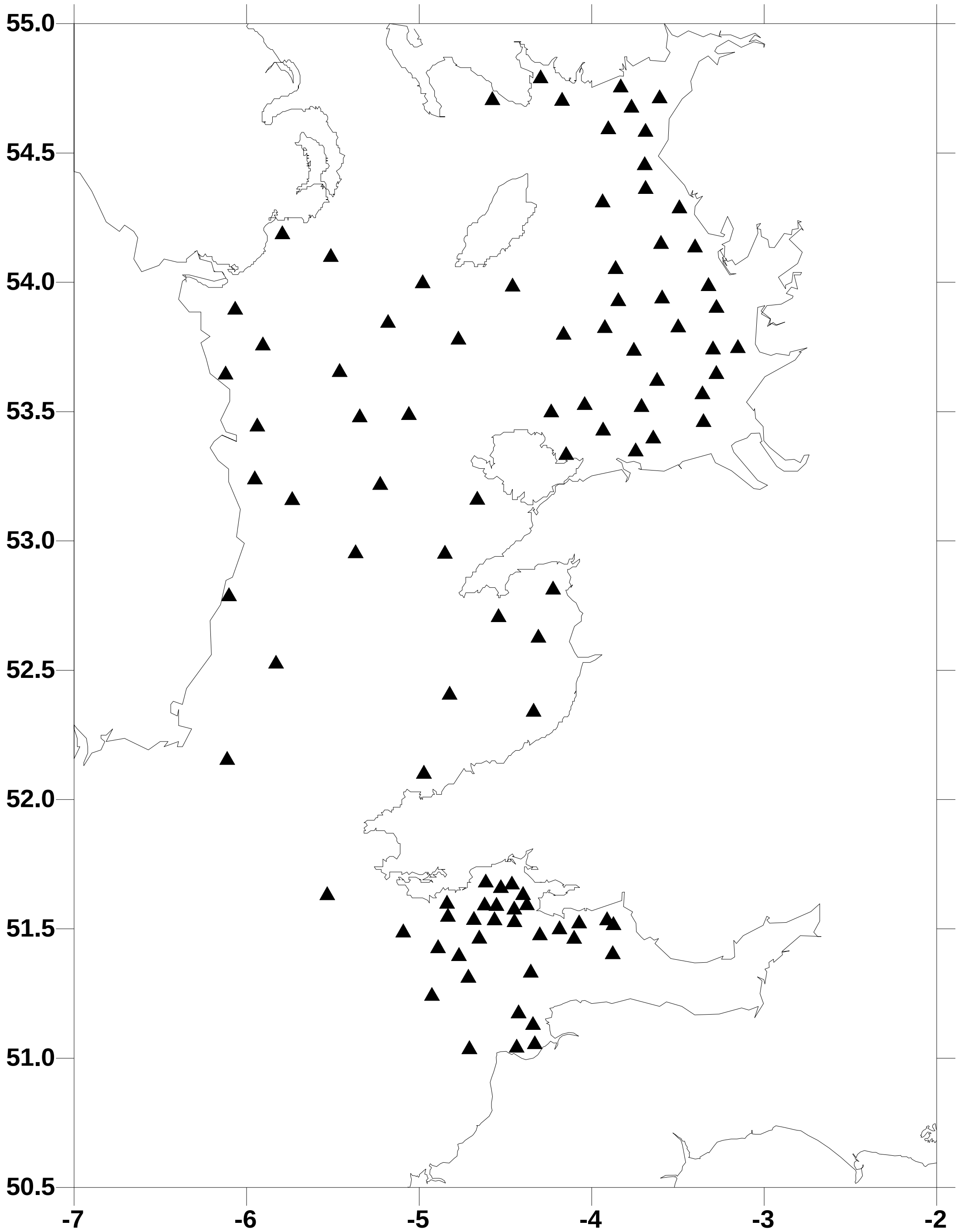
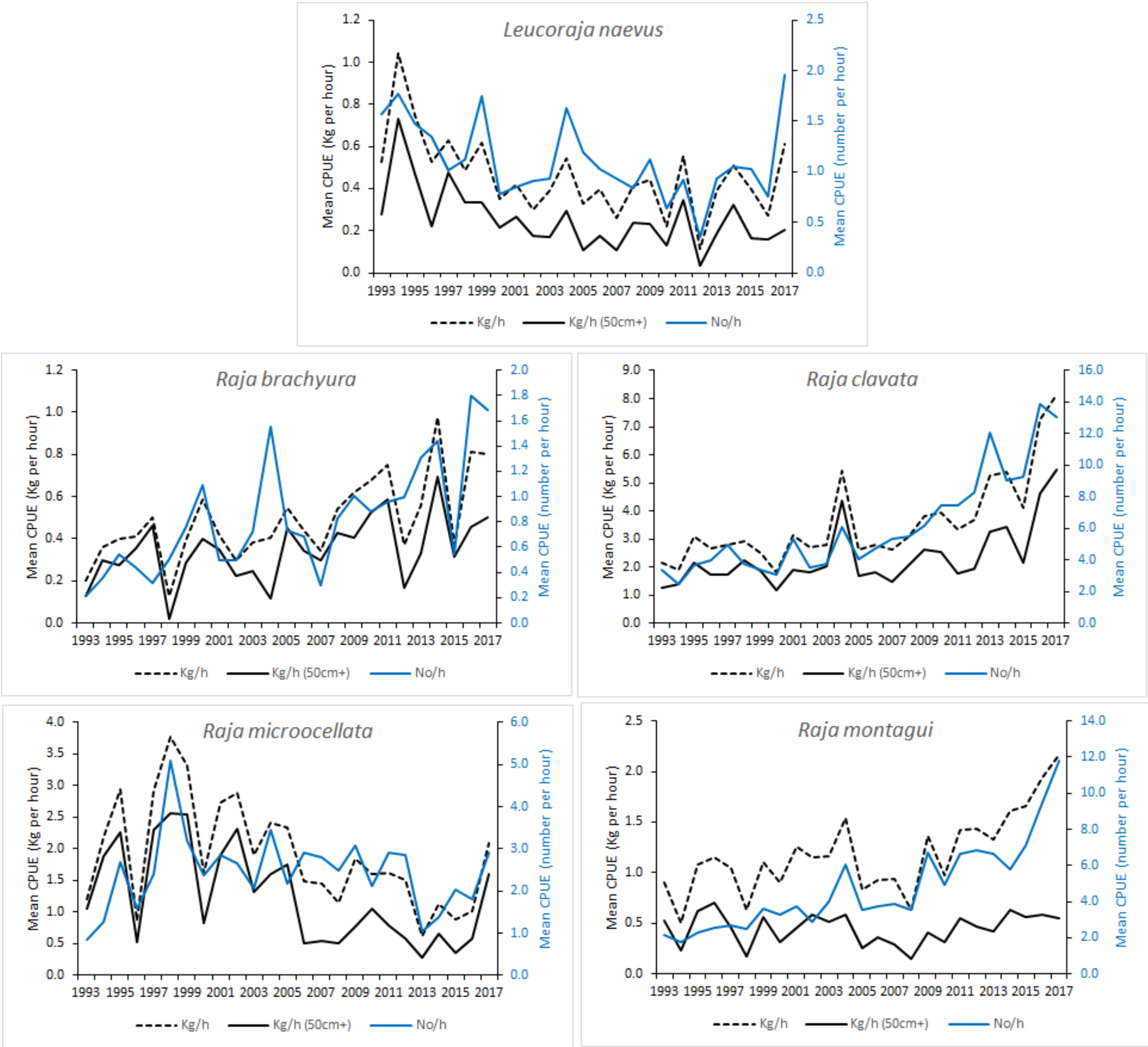


Figure 2: Temporal trends (1993–2017) in the CPUE by individuals (n.h^{-1}), biomass (kg.h^{-1}), and biomass for individuals ≥50 cm total length (kg.h^{-1}) of skates in the 7.a.f–g beam trawl survey.



French catches estimates of undulate ray in 2016 and 2017 in ICES Divisions 27.7.d, 27.7.e, 27.8.a and 27.8.b

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Framework

This document aims to provide new data to support the update of the ICES advice regarding the undulate ray (*Raja undulata*, RJU). Two stocks of the species occur in French coastal areas where they are caught by French fleets:

- rju.27.8ab: undulate ray (*Raja undulata*) in divisions 8.a–b (northern and central Bay of Biscay),
- rju.27.7de: undulate ray (*Raja undulata*) in divisions 7.d and 7.e (English Channel)

This study covers the years 2016 and 2017. It is based on French official landings (estimated from a combination of logbooks and other compulsory reporting from fishers, fish auction market sales and VMS), French on-board observations carried in application of the EU-DCmap program extracted on 01/01/2018 from the French fishery information data facility (SIH – Système d'Informations Halieutiques), and a specific self-sampling program aiming at collecting data on the level of bycatch on undulate ray; these data were made available for this analysis on 25/04/2018.

Abstract

This working document provides new data to support the update of the ICES advice regarding undulate ray (*Raja undulata*, RJU) stocks in Divisions 7.de and 8.ab. Catches (landings and discards) of undulate ray by ICES divisions in 2016 and 2017 are estimated using the landings of all species as an auxiliary variable. Data include official landings (estimated from a combination of logbooks and other compulsory reporting from fishers, fish auction market sales and other data, e.g. VMS), landings and discards sampling from the French on-board observation program and the undulate ray specific self-sampling program. The self-sampling program involves all the vessels that were allowed to land undulate ray in 2016 and 2017 from Divisions 7de and 8ab. All trips being sampled, the number of samples in this program and the spatio-temporal coverage are much larger than the EU-DCmap onboard sampling program. In 2016, only landings data (59 tonnes for divisions 7de) were used by ICES to provide the fishing opportunities for 2017 and 2018, after the 2010-2015 ban. This analysis provides evidence that recent catches are higher, in the order of 1620-1840 tonnes in Divisions 7de and 510-570 tonnes in Divisions 8ab for 2016-2017 with the raising method using the total landings (all species).

1. Introduction

The undulate ray has a wide but patchy distribution, with sightings from North Sea, across the north-east Atlantic coast to north coast of Africa, including the west Mediterranean (Ellis *et al*. 2012). It is one of the lesser known species of skate which has caused difficulty in providing management measures (Ellis *et al*. 2012, ICES 2016c). The species was added to the list of prohibited species in December 2009 (EC 43/2009). This decision was disputed since high abundances have been continuously observed by fishermen (Ellis *et al*. 2011, 2012, Leblanc *et al*. 2014, Stephan *et al*. 2015) but hardly reported for this species. Most landings were reported as 'Skates and rays' or using a confusing common name. Based on scientific projects carried out since 2011 in close partnership with fishermen, the Council of Ministers decided, in December 2013, to remove the undulate ray from the list of prohibited species, but to keep a zero TAC. In 2015, a small TAC was set in ICES divisions 7.de and 8.ab, respectively, allowing some bycatch (EC 2015/960). Since then, the French authorities have implemented several management measures to regulate the bycatch and the landings of undulate ray (Gadenne, 2017).

Since 2015, under the French regulation, only a small number of vessels have been allowed (and licensed for) to land undulate ray. These vessels are committed to providing detailed information on their fishing effort and their catch of undulate ray, on a trip by trip basis.

New data were requested by French authorities to support the update of the ICES advice regarding the undulate ray stocks in ICES Divisions 7.de, and 8.ab. The aim of this study is to present French catch estimates of the species for 2016 and 2017 using all available data. Landings and on-board observation data were downloaded from the Ifremer fishery information data facility (http://sih.ifremer.fr/?page=accueil.htm). This study also uses the data collected in the undulate ray specific self-sampling project deployed in 2015 in application of the French regulation (decree NOR DEVM1512434A). This protocol was refined from 2016 (decree NOR DEVM1607305A). In 2017, the list of authorized vessels was expanded together with few changes in the protocol (decree NOR DEVM1702388A). Firstly, a description of quantitative and spatial coverage of each used dataset is done. Secondly, a method to validate self-sampling data is presented to consolidate the use of the self-sampling dataset. Finally, different methods were used to raise data and to estimate total catches (discards and landings) of undulate ray.

2. Description of quantitative and spatial coverage of each dataset

2.1 Official landings

a. Data sources

French official landings are derived from a combination of logbooks for vessels larger than 10 m Length overall (LOA) and monthly fishing sheets (for smaller vessels not obliged to report EU-logbooks), fish auction market sales and VMS. All official landings records are associated to gear (type, length or number), fishing time, and fishing area (statistical rectangle) information.

Overall, 2469 vessels are susceptible to have bycatch of undulate ray, corresponding to 485 516 fishing trips. These values were obtained by counting vessels and fishing trips with similar gear types and in the same areas than vessels which reported landings of undulate ray. That is, 185 vessels in 2016 and 126 vessels in 2017 and, 2540 trips between 2016 and 2017 (Annexe 1).

b. Quality Process of official landings

Official undulate ray landings are considered reliable because the sales of this species by the licensed vessels are only allowed in fish auction markets and declarative data (logbook or fishing sheet) are checked against the auction sales data.

However, the occurrence of illegal, unreported and unregulated (IUU) fishing completely bypassing the official system should not be ruled out. Further, as undulate ray is a coastal species, recreational catch have existed. Although, the current ban of catch should apply to recreational fishers, compliance with this ban is unknown.

c. Undulate ray official landings

Official French landings of the undulate ray are presented by year and ICES Division in **Table 1**. Official landings details by fishing gear are presented in **Appendix 1**.

Table 1: Official French landings of undulate ray in tonnes (*source: Ifremer-DPMA SACROIS*)

Division	2016	2017
7.d	12.5	14.4
7.e	45.5	64.7
8.a	8.0	15.5
8.b	6.3	6.2
Total	72.4	100.7

Landings of undulate ray by ICES statistical rectangles are presented in **Figure 1**.

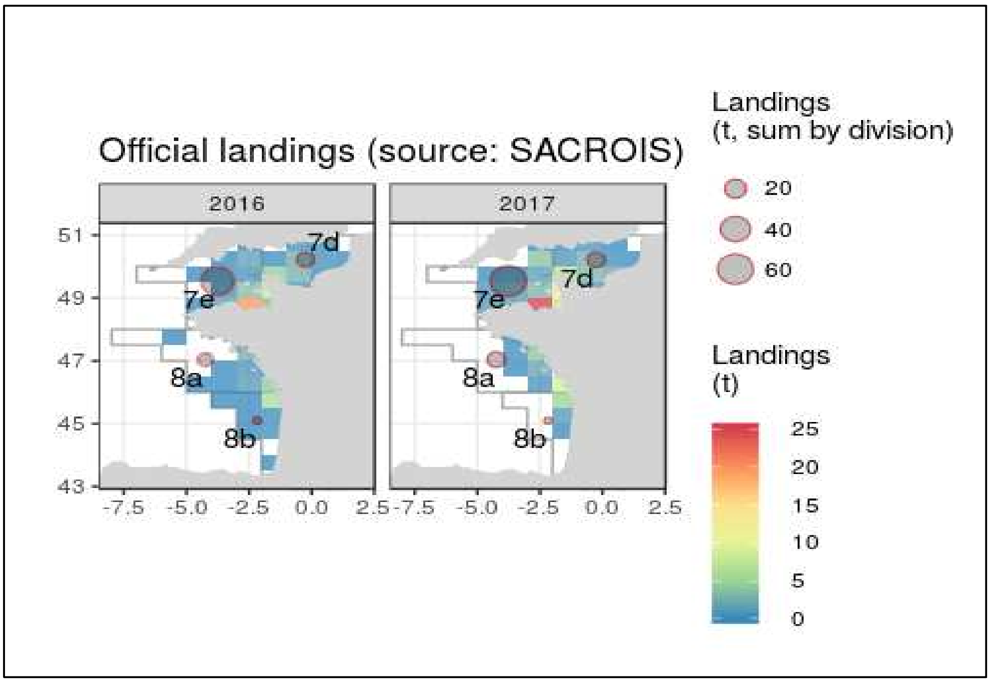

Figure 1: Fishing area and official landings (in tonnes) of undulate rays by statistical rectangle (*source: Ifremer-DPMA SACROIS*)

Undulate ray official landings are unequally distributed according to either stock 7.d-e or 8.a-b.

Official landings of undulate ray by gear and rectangle are presented in Figure 2 for the vessels involved in the self-sampling program and for the other vessels (called regular fleet).

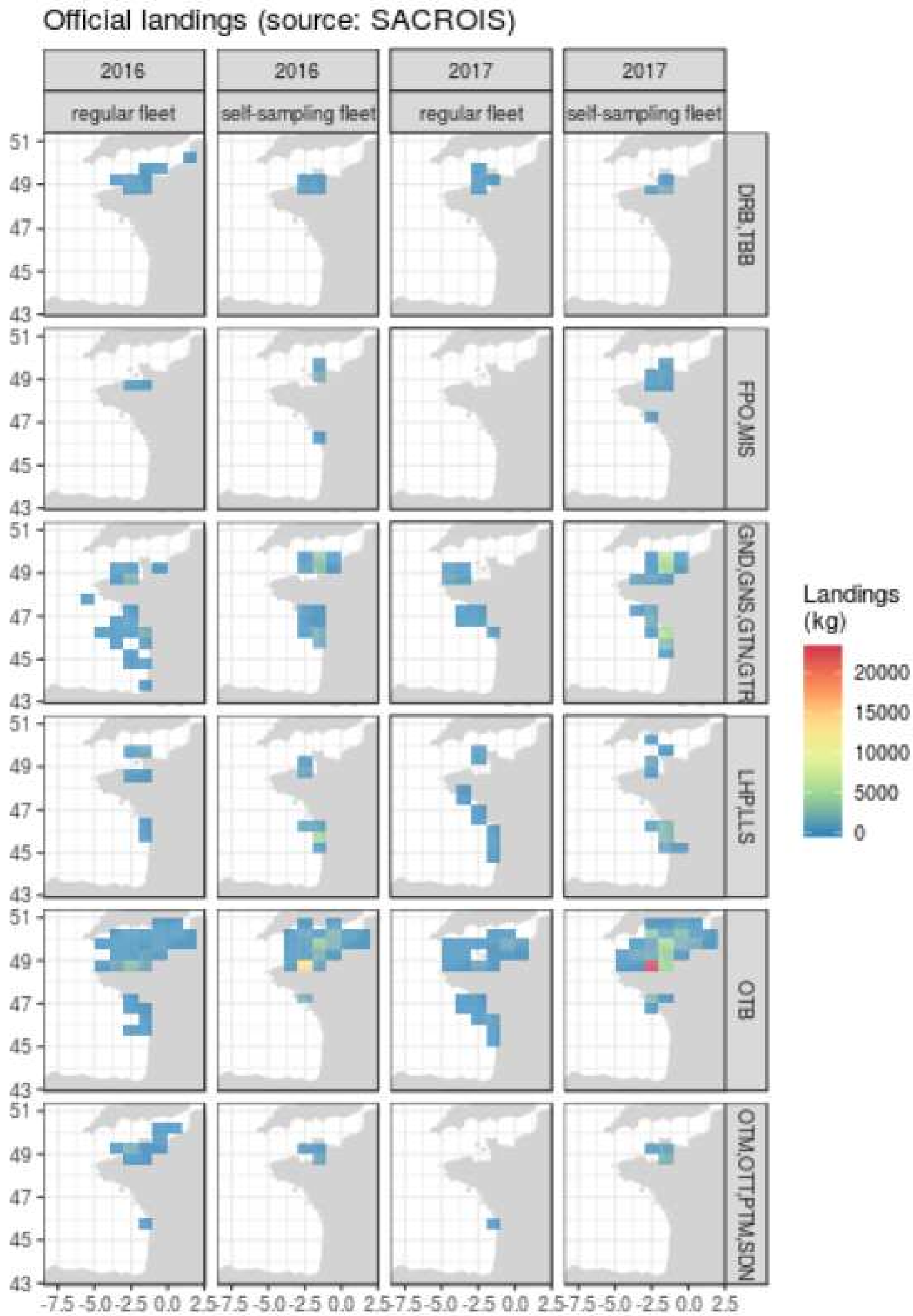

Figure 2: Fishing area and official landings (in tonnes) of undulate rays by fleet, gear and statistical rectangle for 2016 and 2017, for the vessels involved in the self-sampling program and for the other vessels (called regular fleet). *(source: Ifremer-DPMA SACROIS)*

2.2 Sampling data

2.2.1 On-board sampling program

a. Data sources

Since 2003, France has been collecting information on catches (landings and discards), through an on-board sampling program. In 2009, this sampling gained momentum with the implementation of the DCF Regulation (Data Collection Framework), as well as the setting of a government's plan for a sustainable and responsible fishing practice.

On-board observation data include the characteristics of fishing operations (gear type and size, mesh sizes, fishing position, fishing effort..) and catch sampling (landing and discard components), in weight number of individuals, for all species; length composition and sex ratio are also sampled for the most important species and sex data is collected for all elasmobranch species.

b. **Quality Process of data from** on-board sampling **program**

The quality of these data is controlled at different levels: stratified sampling plan by métiers validated by the EU (Anonymous. 2011) posted into a WAO web service. On-board observation guide and various documents, including identification guide for all species susceptible to be caught by French fleets are provided to observers and available on a dedicated access restricted webpage of the Ifremer Fisheries Information System (http://sih.ifremer.fr/?page=accueil.htm). Training is provided to observer to standardize data collection. Quality process further include data entry software on a national database, quality control procedure with validation tools, standardized data export formats and analysis tools (Cornou *et al*. 2015).

c. **Undulate ray landings and discards from** on-board sampling **program**

The number of trips and hauls sampled by the on-board observation program in which undulate ray was observed. In 2016 and 2017 respectively, 213 and 171 observed fishing trips resulted in discards of undulate ray and 33 and 28 resulted in landings (**Table 2**).More observations were made in the English Channel (divisions 7de) than in the Bay of Biscay. Detailed information by fishing gear is provided in **Appendix 2**.

As a consequence of the very small TACs for undulate ray, the number of trips and hauls are obviously greater for discards sampling than landings (**Table 2**, **Figure 3**). Areas where undulate ray is discarded and landed are presented in **Figure 3** by ICES statistical rectangles. Undulate ray is more frequently caught in coastal fisheries in ICES divisions 8.a and 8.b, and is caught in larger quantity in the English Channel (ICES Division 7.d and 7.e).

Table 2: Number of trips with undulate ray caught during on-board observations in 2016 and 2017. The total number of fishing operations (trawl hauls, fixed gear sets) during hauls where the species was caught in reported between brackets. (*source: Ifremer - Système d'Informations Halieutiques*)

Division	Year	Discards	Landings
27.7.d	2016	74 (139)	16 (39)
27.7.d	2017	73 (126)	14 (41)
27.7.e	2016	75 (183)	8 (16)
27.7.e	2017	45 (88)	6 (16)
27.8.a	2016	26 (42)	8 (10)
27.8.a	2017	17 (32)	5 (6)
27.8.b	2016	39 (66)	1 (1)
27.8.b	2017	37 (72)	3 (6)
Total	2016	213 (430)	33 (66)
Total	2017	171 (318)	28 (69)

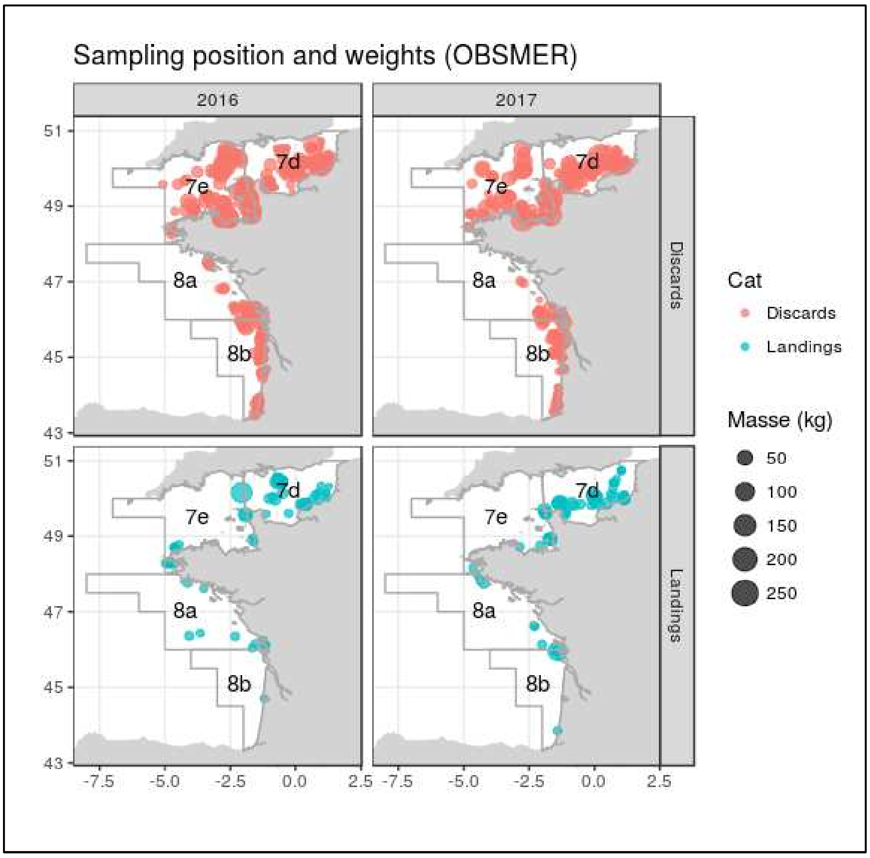

Figure 3: Spatial distribution and weight caught of undulate ray discards and landings (in kilogram) in French on-board observations in 2016 and 2017. (*source: Ifremer - Système d'Informations Halieutiques*)

2.2.2 Self-sampling program

A self-sampling program has been implemented in France since 2015 and was mandatory for all vessels detaining a license for undulate ray fishing. Data collected in 2015 covered only part of the year and fleet and were not used in this analysis.

a. Data sources

This dataset is presented here for 2016 and 2017 according to scientific protocols describe by year in by Gadenne (2017).

In 2016, a total of 125 vessels received bycatch fishing permits, but only 56 contributed to the data collection. In 2017, 59 vessels out of 77 with fishing permits contributed to the self-sampling program. In addition, vessels involved in the self-sampling program reported catch of undulate ray (discards and landings) and total catch for all species from, in principle, all their fishing hauls and trips in 2016 and 2017 (Gadenne 2017).

b. Quality Process of data from self-sampling program

According to the specific French regulation, all fishing operations carried out for each trip of vessels authorized to land undulate ray should be recorded by the self-sampling program (even when no undulate ray is landed) and therefore, landings data reported in the self-sampling program should be similar to French official landings. However, this is not always true and 43 % on average in 2016 and 34 % in 2017 of underestimations of declared landings weights of undulate ray in the self-sampling program have been detected, which can be attributed to a lack of compliance/cooperation from some fishers.

To ensure the quality of these declared data, different processes of quality control, corrections and validation of the data have been implemented: a data entry software including European repositories was distributed to each stakeholders, leaving them only access to their registered authorized vessels. A data entry guide has been distributed, training has been provided and the entry is followed and controlled throughout the years. Finally, quality control procedures with validation tools, standardized data export formats and calculation tools were performed.

c. Undulate ray landings and discards from self-sampling program

In 2016 and 2017 respectively, 1236 and 1971 fishing trips were recorded in the self-sampling program (**Table 3**). About half of these were in ICES Division 7e. Detailed information by fishing gear is provided in **Appendix 3**.

Areas where undulate ray is discarded and landed are presented in **Figure 4** by ICES statistical rectangles. Undulate ray is more frequently caught in coastal fisheries in ICES divisions 8.a and 8.b, and is caught in larger quantity in the English Channel (ICES Division 7.d and 7.e).

Given the very limited quota, a large proportion of trips within the self-sampling program only reported discards: 2790 hauls in 2016 and 3057 in 2017 (54% and 45%, respectively, **Table 3**).

The self-sampling program provides information on discards and landings of undulate ray, for a much higher number of samples (hauls) than observed by the onboard observers sampling program.

Table 3: Number of trips and total number of hauls (in brackets), sampled in the self-sampling program. The last column shows the number of trips and hauls (in brackets) for which discards were reported without landings. *(source:DPMA - self-sampling program)*

Division	Year	Sampling	Discard > 0 & Landings = 0
27.7.d	2016	190 (832)	102 (359)
27.7.d	2017	205 (1248)	86 (537)
27.7.e	2016	663 (3747)	511 (2316)
27.7.e	2017	789 (3960)	515 (2101)
27.8.a	2016	154 (317)	44 (51)
27.8.a	2017	432 (1104)	121 (208)
27.8.b	2016	229 (294)	47 (64)
27.8.b	2017	545 (548)	209 (211)
Total	2016	1236 (5190)	704 (2790)
Total	2017	1971 (6860)	931 (3057)

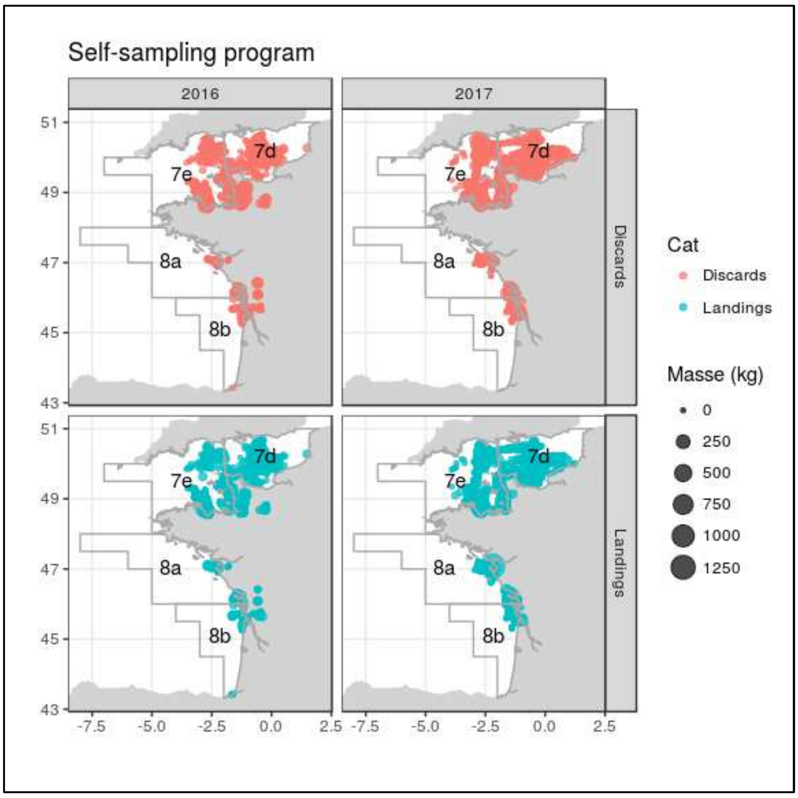

Figure 4: Spatial distribution and weight caught of undulate ray discards and landings (in kilogram) in self-sampling observations in 2016 and 2017. *(source: DPMA - self-sampling program)*

It is important to note that the undulate ray data collected under the present regulation are, in principle, only from by-catches.

d. Reliability and validation of the self-sampling data

Data quality in self-sampling program can be questionable (Kraan *et al.* 2013). Thanks to some overlap between DCF on-board observations and the self-sampling program, analyses were performed in order to assess the reliability of the self-sampling information. The number of trips observed in the DCF on-board observations program (**Table 2**) is more than 5 times lower than the total number of trips recorded within the self-sampling program (**Table 3**). Unlike the on-board observation program, the self-sampling program is not conducted within a statistically designed sampling program, but attempt to be exhaustive. Only 40 trips sampled in the two programs were analyzed. The number of hauls sampled by trip was different due to the difference between the two protocols, and this makes difficult any direct comparison. Thus, the comparison was made on an average weight (landing and discard) of undulated ray by trip for each program. **Figure 5** presents the results. Despite the very low number of observations (n=5), landings reported by self-sampling vessels and landings estimated by on-board observers for the same trips are compared. A simple regression between the two variables indicates a slope close to 1. Landings weights of undulate ray appear to be in accordance between the two programs. For discards weights, there was more dispersion. The ratio of discards reported by self-sampling vessels to discards observed by on-board observers, for the same trips varied. A simple regression between the two indicates a mean ratio of about 0.6, where the expected value should be 1. This can be considered resulting from the small number of data points (n=40 trips compared) and both estimates from fishers and on-board observers are most often visual estimates as weighing on a scale on-board of a small vessels in not feasible. Despite the small number of trips available for these comparisons, like it was often the case in this type of comparisons (Roman *et al*. 2011; Mion *et al*. 2015; Bell *et al*. 2017), no significant disagreement between the two datasets was observed. This result indicates that for the subset of trips tested, fishers reported accurately self-report information. Therefore the full self-sampled dataset was used to estimate the catches at the fleet level.

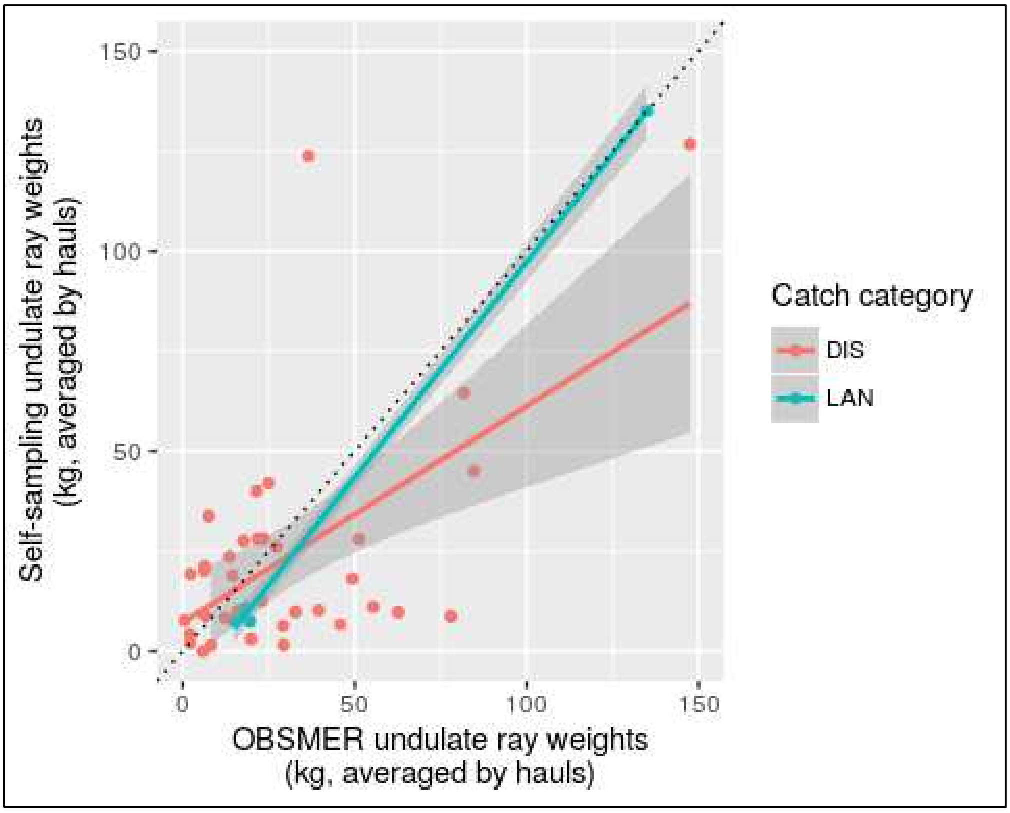

Figure 5: Undulate ray weights reported in trips sampled by the French on-board observations program called OBSMER (x-axis) and the self-sampling program (y-axis). Weights were averaged by hauls. Weights are presented by catch category (DIS: discards, LAN: landings). The colored lines are the regression lines associated with each catch category (grey areas display the confidence interval (95%) around the regression lines). The dotted black line is the regression line for a 0 intercept and a slope of 1.

2.2.3 Summary of the available samples

Samples of undulate ray by gear and statistical rectangle are presented in **Figure 6** for two fleets. The first fleet is composed of all the vessels involved in the self-sampling program, while the second fleet includes all the other vessels operating in the same area; estimates for the latter being derived from the on-board observations for the vessels not participating in the self-sampling program (corresponding to regular fleet).

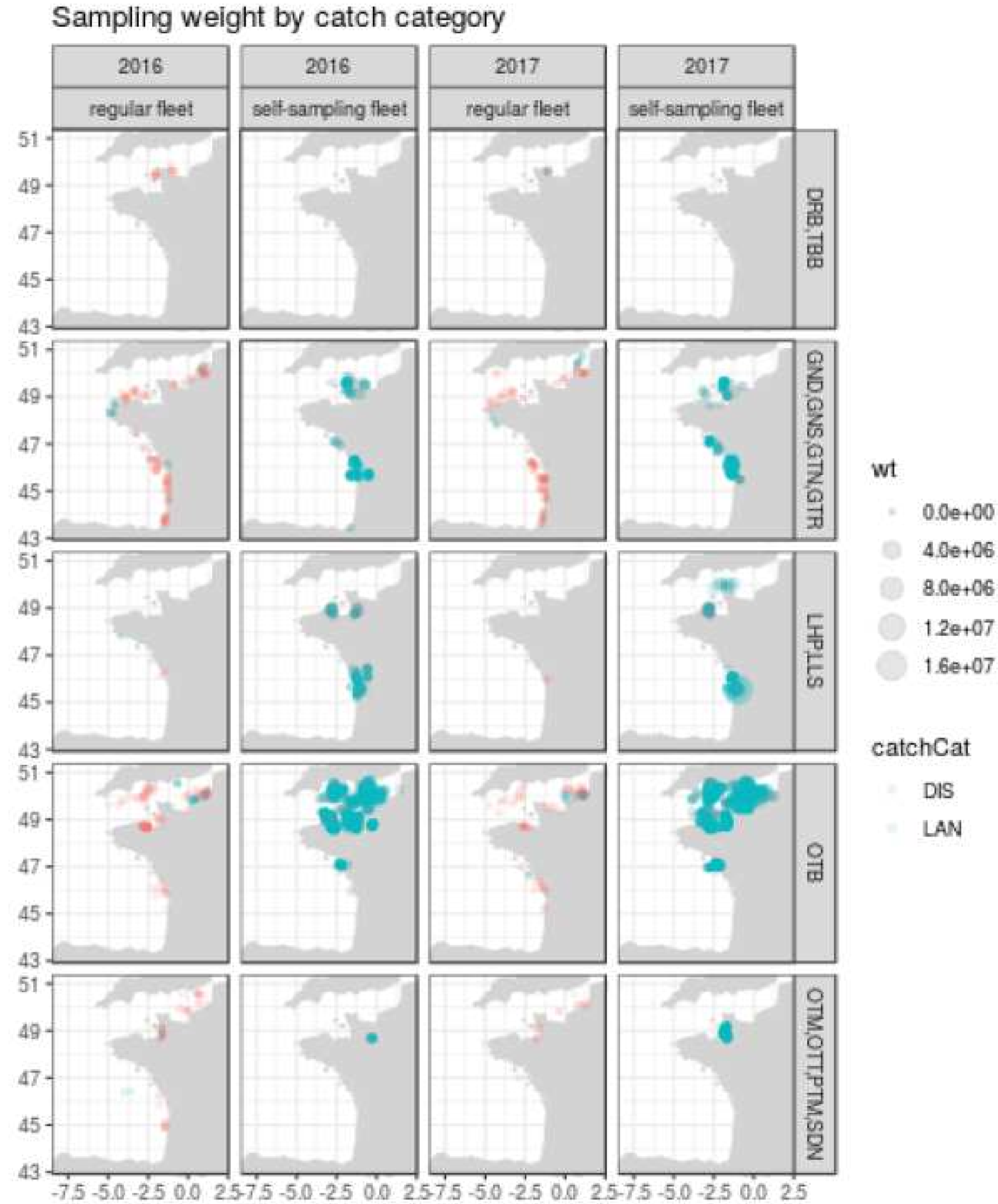

Figure 6: Spatial distribution and weight caught of undulate ray discards (DIS) and landings (LAN) (wt in kilogram) by gear and fleet (regular and self-sampling) in 2016 and 2017. *(source: Ifremer - Système d'Informations Halieutiques, DPMA - self-sampling program*)

The number of fishing operations realized by the different gear types shows a big disproportion between the trawls and the remaining gear types (**Appendix 3)**. In the self-sampling program, 83% of the fishing operations were performed using trawls. This imbalance can be explained by the number of fishing operations performed by trip, i.e. one haul every 3 hours for the trawlers, whereas the gillnetters and longliners only realize one fishing operation by fishing trip. The trawlers (OTB) represent also the highest number of vessels (n=30 in 2016 and n=29 in 2017, corresponding to 45 % of number of all the vessels involved in self-sampling program by year).

3. Catches estimates

Some trips from vessels participating in the self-sampling program were also sampled by the DCF on-board observations program, which allows for comparison at trip level (section 2.2.2d). However, because participating in the self-sampling program allows the vessel to land undulate rays with a limit of 150 kg per day/trip, it was considered that trips where landing of undulate ray was allowed should be excluded from the on-board observations data set when raising discards of undulate ray as the fishing strategy might be impacted by having a fishing license. Therefore, the raising procedure was performed separately for the vessels involved in the self-sampling program and for the vessels observed by the on-board observations program (but not participating in the self-sampling program) to account for possibly two different fishing strategies.

3.1 Methods

Catch (landings and discards) were estimated using the landings weights of all species as auxiliary variable in order to increase the precision of the estimate by taking advantage of the correlation between the landings or discards of undulate ray and the landings weights of all species (Cochran 1977). This approach follows the recommendation of the WKSHARK3 report (ICES 2017), where raising methodology for undulate ray fisheries are presented pages 28-30.

The analyses and the raising procedures are applied to the two fleets (self-sampling and regular fleets). The landings data are calculated separately for the two fleets. Estimates are calculated on strata defined by the year, the ICES division and the fishing gear. Estimates are provided only if at least 3 samples of trips are available in the strata.

3.2 Results

a) Test of landing estimates

In order to test the raising procedure, the estimated landing values for the two fleets are presented in **Table 4** together with the official landings.

Table 4: Landings estimates and official values of undulate ray (in tonnes) by fleet, ICES Division in 2016 and 2017.

		Fleet 1 (self-sampled vessels)		Fleet 2 (Other vessels)		Total	
Area	Year	Estimated Landings	Official Landings	Estimated Landings	Official Landings	Estimated Landings	Official Landings
27.7.d	2016	75.1	10	18.9	2.54	94.0	12.54
	2017	32.3	12.67	39.2	1.68	71.5	14.35
27.7.e	2016	162.9	32.2	9.6	13.33	172.5	45.54
	2017	194.0	61.06	0.0	3.66	194.0	64.72
Total 7de	**2016**	**238.0**	**42.20**	**28.5**	**15.87**	**266.5**	**58.08**
	2017	**226.3**	**73.73**	**39.2**	**5.34**	**265.6**	**79.07**
27.8.a	2016	55.6	5.73	18.5	2.32	74.1	8.04
	2017	65.9	14.5	10.0	1.01	75.9	15.51
27.8.b	2016	5.0	5.9	0.1	0.43	5.1	6.33
	2017	6.1	5.97	0.4	0.19	6.5	6.16
Total 8ab	**2016**	**60.6**	**11.63**	**18.6**	**2.75**	**79.2**	**14.37**
	2017	**72.0**	**20.47**	**10.4**	**1.20**	**82.4**	**21.67**

b) Discard estimates

Like for landings, discards were estimated, separately for the two fleets, using the landings weights of all species as auxiliary variable. The discards estimates by ICES division and year are presented in **Table 5**.

Table 5: Discards estimates of undulate ray (in tonnes) by fleet, ICES Division in 2016 and 2017

Year	Area	Fleet 1 (self-sampled vessels)	Fleet 2 (Other vessels)	Total Discards
27.7.d	2016	73.1	197.7	270.8
	2017	78.9	407.7	486.6
27.7.e	2016	448.3	854.2	1302.5
	2017	283.4	588.0	871.4
Total 7de	**2016**	**521.4**	**1 051.9**	**1573.3**
	2017	**362.3**	**995.7**	**1358.0**
27.8.a	2016	74.3	167.9	242.3
	2017	36.1	243.4	279.5
27.8.b	2016	7.8	176.9	184.7
	2017	14.3	191.2	205.4
Total 8ab	**2016**	**82.1**	**344.8**	**426.9**
	2017	**50.4**	**434.5**	**484.9**

c) Catch estimates

A detailed view of the discards estimates with the landings values by gear is presented in **Figure 7**. Estimates of landings and discards of undulate ray, for the French fleets, are given in **Table 6**.

As expected, given the very limited quota, a large part of the catches of undulate ray is discarded.

Table 6: Estimated by raising observed landings and discards of undulate ray (in tonnes), by ICES Division in 2016 and 2017, for the two fleets (self-sampling and other vessels) to official landings of all species, and discard rates.

Area	Year	Landings	Discards	**Catches**	% discards
27.7.d	2016	94.0	270.8	364.8	74%
	2017	71.5	486.6	558.1	87%
27.7.e	2016	172.5	1302.5	1475.0	88%
	2017	194.0	871.4	1065.4	82%
Total 7de	**2016**	**266.5**	**1573.3**	**1839.8**	**86%**
	2017	**265.6**	**1358.0**	**1623.5**	**84%**
27.8.a	2016	74.1	242.3	316.3	77%
	2017	75.9	279.5	355.4	79%
27.8.b	2016	5.1	184.7	189.8	97%
	2017	6.5	205.4	211.9	97%
Total 8ab	**2016**	**79.2**	**426.9**	**506.2**	**84%**
	2017	**82.4**	**484.9**	**567.3**	**85%**

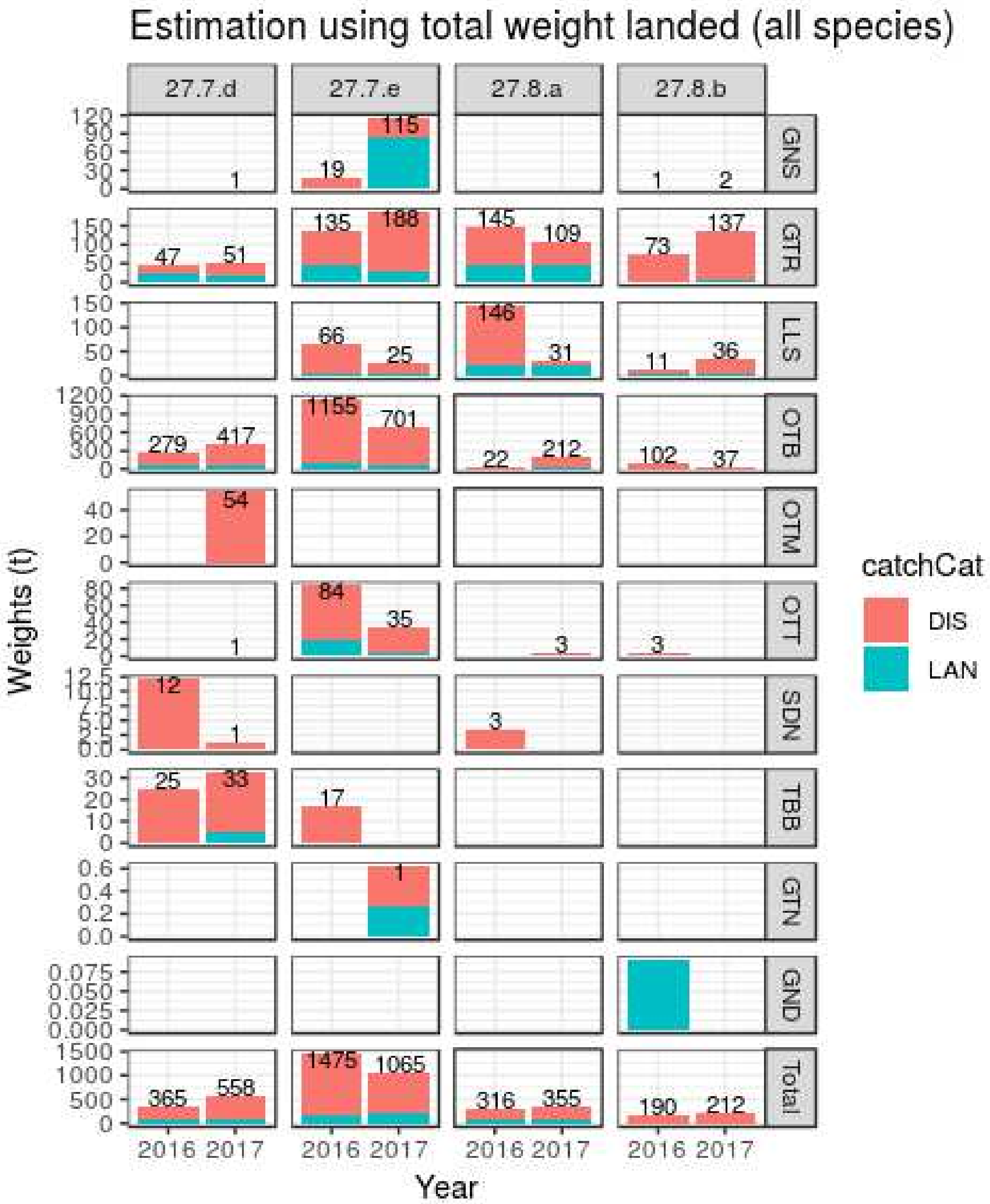

Figure 7: Estimated landings (LAN) and discards (DIS) of undulate ray by year, ICES division and main gear (in tonnes, catches values written in black), using total weight landed of all species.

The contribution of the different gear types to both landings and discards varies between ICES divisions (**Figure 6**, **Table 6**). The main area of catches is 7.e. In the English Channel (ICES Divisions 7.de) bottom otter trawl (OTB) contributes the most for both landings and discards, while in the Bay of Biscay (ICES Divisions 8.ab) trammel nets (GTR) and bottom-set longlines (LLS) are the most representative gear types, with OTB in 2017.

4. Discussion

In most cases, using the landings of all species as an auxiliary variable to raise the samples, leads to estimated values of undulate ray landings somewhat higher than the official ones (Table 4). This is not surprising and, in addition to some under-reporting, this may be due to the fact that not all trips from the vessels involved in the self-sampling program have been subject to self-sampling, especially the ones with no landings of undulate ray. As a consequence, the actual total landings (all species) of these vessels (all trips) are somewhat higher than total landings recorded in the self-sampling data base. Furthermore, the trips not self-sampled are considered similar to the ones self-sampled, assuming landings that might not occur. All this contributes to the higher estimates of landings.

There are different methods to raise the discards samples per haul, or per trip, to the population level. To highlight the contrast between different methods, three raising methods were used following the guidelines described in the WKSHARK3 2017 report (ICES 2017):

- Method 1: raising discards of the stock to landings of the same stock,
- Method 2: raising discards of the stock to landings of all species,
- Method 3: raising discards of the stock to fishing days by gear type

A detailed view of the landings and discards estimates of undulate ray considering different auxiliary variables (Methods dependent) is presented for the French fleets in **Table 7** for Landings and in **Table 8** for discards.

Table 7: Landings estimates of undulate ray (in tonnes), by ICES Division in 2016 and 2017, according to the raising methodology applied

a) for Fleet 1 (self-sampled vessels)

Year	Area	Auxiliary variable Landings all species	 Landings of undulate ray	 Fishing time	Official landings
		Method 2	Method 1	Method 3	
27.7.d	2016	75.1	9.96	50.4	10
	2017	32.3	12.67	36.1	12.67
27.7.e	2016	162.9	29.23	99.3	32.2
	2017	194.0	57.34	111.0	61.06
Total 7de	**2016**	**238.0**	**39.19**	**149.8**	**42.20**
	2017	**226.3**	**70.01**	**147.1**	**73.73**
27.8.a	2016	55.6	5.7	23.7	5.73
	2017	65.9	14.33	53.2	14.5
27.8.b	2016	5.0	5.81	4.0	5.9
	2017	6.1	5.85	6.1	5.97
Total 8ab	**2016**	**60.6**	**11.51**	**27.8**	**11.63**
	2017	**72.0**	**20.18**	**59.3**	**20.47**

b) for Fleet 2 (other vessels)

Year	Area	Auxiliary variable Landings all species	 Landings of undulate ray	 Fishing time	Official landings
		Method 2	Method 1	Method 3	
27.7.d	2016	18.9	1.34	37.9	2.54
	2017	39.2	1.68	56.7	1.68

27.7.e	2016	9.6	3.02	11.4	13.33
	2017	0.0	3.18	0.0	3.66
Total 7de	**2016**	**28.5**	**4.36**	**49.3**	**15.87**
	2017	**39.2**	**4.86**	**56.7**	**5.34**
27.8.a	2016	18.5	1.06	11.2	2.32
	2017	10.0	0.97	13.8	1.01
27.8.b	2016	0.1	0	0.1	0.43
	2017	0.4	0	0.4	0.19
Total 8ab	**2016**	**18.6**	**1.06**	**11.3**	**2.75**
	2017	**10.4**	**0.97**	**14.2**	**1.20**

Table 8: Discards estimates of undulate ray (in tonnes), by ICES Division in 2016 and 2017, according to the raising methodology applied

a) for Fleet 1 (self-sampled vessels)

			Auxiliary variable	
Year	**Area**	**Landings all species**	**Landings of undulate ray**	**Fishing time**
		Method 2	Method 1	Method 3
27.7.d	2016	73.1	10.82	49.8
	2017	78.9	47.83	112.0
27.7.e	2016	448.3	80.46	220.8
	2017	283.4	150.50	211.7
Total 7de	**2016**	**521.4**	**91.28**	**270.6**
	2017	**362.3**	**198.33**	**323.7**
27.8.a	2016	74.3	8.06	31.8
	2017	36.1	8.49	31.1
27.8.b	2016	7.8	10.71	5.2
	2017	14.3	14.58	13.4
Total 8ab	**2016**	**82.1**	**18.77**	**37.0**
	2017	**50.4**	**23.07**	**44.5**

b) for Fleet 2 (other vessels)

			Auxiliary variable	
Year	**Area**	**Landings all species**	**Landings of undulate ray**	**Fishing time**
		Method 2	Method 1	Method 3
27.7.d	2016	197.7	9.18	387.6
	2017	407.7	20.61	666.9
27.7.e	2016	854.2	19.57	1 573.4
	2017	588.0	50.27	1 303.4
Total 7de	**2016**	**1 051.9**	**28.75**	**1 961.0**
	2017	**995.7**	**70.88**	**1 970.3**
27.8.a	2016	167.9	8.93	144.2
	2017	243.4	15.25	384.5
27.8.b	2016	176.9	0.00	274.3
	2017	191.2	0.00	218.6
Total 8ab	**2016**	**344.8**	**8.93**	**418.5**
	2017	**434.5**	**15.25**	**603.1**

It should be noted that, obviously, the raising procedure using landings of the species as auxiliary variable cannot be applied when a landing ban for this species occurred. Given the very low TACs for undulate ray in 2016-2017, using the landings of undulate ray as an auxiliary variable to raise the discards samples is probably not fully relevant for the second fleet (vessels not involved in the self-sampling program). Therefore, even though the landings estimates are obviously very close to the official ones, the discards estimates for this second fleet are likely to be underestimated (**Table 8**).

Using the fishing effort, as an auxiliary variable (as commonly used to answer the ICES data call for most stocks), is fine as soon as the effort data are reliable enough. However, this is not always the case for passive gears or small vessels (without VMS). Therefore since, for undulate ray, the fishery is prosecuted by different types of gears, with a non-negligible part of passive gears, this method might lead to unrealistic results, with estimated landings much higher than the official ones (**Table 7** and **8**).

Given the use of the fishing effort as an auxiliary variable is considered irrelevant for landings it is likely to be irrelevant for discards as well, and this raising variable should not be used in such a case.

As expected, the raised discards from the on-board observations using the total landings (all species) as the auxiliary variable are much higher than when using the undulate ray landings only (**Table 7** and **8**).

As mentioned in the WKSHARKS guidance (ICES 2017), using the total landings (all species) as the auxiliary variable (Method 2) probably leads to the most reliable estimates.

In this particular case of a bycatch fishery, monitored by a specific self-sampling protocol, with vessels detaining a specific license, and constrained by different limits (quantities by day/week, sizes, and opening *vs.* closing of landings periods), this raising method may induces bias not considered by WKSHARKS3. Furthermore, assuming the same fishing strategy all the year round for the vessels involved in the self-sampling program may also introduce a bias since the fishing strategy of these vessels might have been different during the period for which the landings of undulate ray is allowed and when the quota is fully taken and the landing of undulate ray is no more allowed..

5. Conclusion

When the 2016 ICES advice was released, only reported landings for 2015 were considered to apply the category 3 rule. However, these 2015 landings were very much constrained by a very limiting TAC (in both areas) and should not have been used, alone, as the basis for the advice. Discards should have been included. Given the current amount of discards (more than 75%) the actual catch values on which the advice should have been based are much greater than the 54 t used for the 7.de advice.

In a working document for WGEF in 2014, Leblanc *et al* provided an estimate of landings of undulate ray prior to the ban, based on the difference in the landings of the total rays (undefined species as reported in the French statistics in the past) before and after the ban. This difference was about 300 tonnes in Division 7e and at least 35 tonnes from Division 7d (the latter estimate being based only on data from auctions located in Basse-Normandie).

It should also be noted that STECF, in its report (EW 15-03), wrote: "*The authors of the ad hoc report estimated, based on interviews and historic observer data, that the annual landings of undulate ray from Division VIIde before the ban, was around 300 t and those from VIIIab were in the order of 82 –*

120 t. ", and farther: " *STECF considers that a pragmatic upper limit for a TAC for undulate ray in Division VIIde would be the estimated annual landings of 300 t identified in the ad hoc report, as the stock appears to have been able to sustain landings of that order and at the same time there are indications that the stock has increased.*"

Estimates of discards made by Leblanc *et al* (2014), from DCF on-board observations data (raised using fishing days), are about 750 tonnes in 2011-2013 in 7e for bottom trawlers (OTB_DEF) only.

All these estimates suggest that the values used as the basis for the 2016 advice were largely underestimated. The present analysis shows that the estimated catches in Divisions 7de were 1840 t in 2016 and 1624 t in 2017. In Divisions 8ab, catches are estimated respectively to be 506 t and 567 t in 2016 and 2017.

Acknowledgements: All the participants of the two sampling programs (DCF on-board observations and self-sampling) should be thanked, and especially the fishermen and the observers. Special thanks to the Ifremer team SIH-CREDO who performed the statistical analysis used in this document. Thanks also to Pascal Lorance (Ifremer Nantes) for his useful comments on this working document.

Appendix

Appendix 1: Official French landings of undulate ray by gear in tons and Euros *(source: Ifremer-DPMA SACROIS)*

Gear	Division	Year	Vessels	Trips	Landings (t)	Prices (euros)
DRB	27.7.d	2016	1	1	0.025	62.06
DRB	27.7.e	2016	10	27	1.357	3 377.00
DRB	27.7.e	2017	4	35	2.297	5 761.00
FPO*	27.7.d	2016	1	2	0.035	90.05
FPO*	27.7.e	2016	10	28	2.564	6 214.00
FPO*	27.7.e	2017	7	22	1.487	3 845.00
FPO*	27.8.a	2016	1	1	0.030	135.90
FPO*	27.8.a	2017	1	7	0.171	451.90
GND	27.8.b	2016	1	10	0.078	218.30
GND	27.8.b	2017	1	3	0.124	411.50
GNS	27.7.d	2016	2	2	0.030	79.04
GNS	27.7.e	2016	6	39	2.861	5 903.00
GNS	27.7.e	2017	4	17	1.188	3 143.00
GNS	27.8.a	2016	4	15	1.084	4 000.00
GNS	27.8.a	2017	2	3	0.037	157.50
GNS	27.8.b	2016	1	1	0.002	8.75
GTN	27.7.e	2017	1	3	0.234	634.40
GTR	27.7.d	2016	4	41	1.595	4 624.00
GTR	27.7.d	2017	1	4	0.343	733.20
GTR	27.7.e	2016	10	73	7.425	18 340.00
GTR	27.7.e	2017	12	153	14.280	38 294.00
GTR	27.8.a	2016	11	68	3.285	10 731.00
GTR	27.8.a	2017	10	166	8.990	28 801.00
GTR	27.8.b	2016	10	71	1.527	4 682.00
GTR	27.8.b	2017	2	96	2.651	8 776.00
LHP	27.7.e	2016	1	1	0.023	46.20
LLS	27.7.d	2016	2	14	1.024	2 609.00
LLS	27.7.d	2017	1	1	0.005	13.86
LLS	27.7.e	2016	4	15	1.506	3 635.00
LLS	27.7.e	2017	3	27	1.389	3 459.00
LLS	27.8.a	2016	5	43	1.682	6 644.00
LLS	27.8.a	2017	5	54	2.908	10 083.00
LLS	27.8.b	2016	6	54	4.686	12 455.00
LLS	27.8.b	2017	6	82	3.301	9 228.00
MIS	27.7.e	2016	1	1	0.018	36.06
OTB	27.7.d	2016	18	117	9.704	22 448.00
OTB	27.7.d	2017	15	113	14.000	36 477.00
OTB	27.7.e	2016	49	324	26.360	62 457.00
OTB	27.7.e	2017	36	534	40.690	108 033.00
OTB	27.8.a	2016	13	77	1.959	5 856.00
OTB	27.8.a	2017	8	114	3.405	9 528.00
OTB	27.8.b	2016	3	3	0.020	64.40
OTB	27.8.b	2017	3	7	0.086	282.10
OTM	27.7.d	2016	1	1	0.004	8.03
OTM	27.8.b	2017	1	1	0.001	5.67

OTT	27.7.e	2016	4	18	1.438	3 269.00
OTT	27.7.e	2017	2	31	2.924	7 385.00
PTM	27.7.e	2016	2	10	1.834	4 945.00
PTM	27.8.b	2016	1	1	0.012	28.04
SDN	27.7.d	2016	1	1	0.008	19.04
TBB	27.7.d	2016	1	2	0.115	352.50
TBB	27.7.e	2016	1	2	0.147	322.30
TBB	27.7.e	2017	1	4	0.229	687.40
Total		2016			72.438	183 659.67
Total		2017			100.739	276 190.53

* Landings of undulate ray are attributed to the good gear for the trawlers. Concerning gillnetters, some gears are sometimes badly assigned. For example, gear with the code FPO is operated by small multipurpose vessels, which also use skate net. These vessels are sometimes pot vessels which declare, with this gear code, their catches of skate. But these species caught occasionally using nets in addition to the trap fishery. Landings of undulate ray from these vessels are therefore often by mistake attributed to the FPO gear code in SACROIS.

Appendix 2: Trips and hauls numbers (in brackets) with undulate ray observation in discards and landings through DCF on-board sampling data (*source: Ifremer - Système d'Informations Halieutiques*)

Gear	Division	Year	Discards	Landings
GNS	27.7.d	2017	0	1 (1)
GNS	27.7.e	2016	8 (8)	1 (1)
GNS	27.7.e	2017	9 (9)	1 (1)
GNS	27.8.b	2016	3 (3)	1 (1)
GNS	27.8.b	2017	3 (3)	0
GTN	27.7.e	2016	1 (1)	0
GTR	27.7.d	2016	26 (42)	7 (7)
GTR	27.7.d	2017	20 (27)	5 (8)
GTR	27.7.e	2016	18 (37)	6 (12)
GTR	27.7.e	2017	14 (23)	3 (7)
GTR	27.8.a	2016	16 (28)	6 (7)
GTR	27.8.a	2017	8 (20)	4 (4)
GTR	27.8.b	2016	29 (50)	0
GTR	27.8.b	2017	30 (60)	3 (6)
LLS	27.8.a	2016	3 (4)	1 (1)
LLS	27.8.b	2017	1 (3)	0
OTB	27.7.d	2016	34 (70)	9 (32)
OTB	27.7.d	2017	42 (82)	7 (29)
OTB	27.7.e	2016	40 (108)	0
OTB	27.7.e	2017	20 (48)	2 (8)
OTB	27.8.a	2016	5 (8)	0
OTB	27.8.a	2017	8 (11)	1 (2)
OTB	27.8.b	2016	4 (4)	0
OTB	27.8.b	2017	4 (6)	0
OTM	27.7.d	2017	3 (4)	0
OTT	27.7.d	2016	2 (2)	0
OTT	27.7.d	2017	1 (1)	0
OTT	27.7.e	2016	5 (19)	1 (3)
OTT	27.7.e	2017	3 (8)	0
OTT	27.8.a	2016	0	1 (2)
OTT	27.8.a	2017	1 (1)	0
OTT	27.8.b	2016	2 (8)	0
SDN	27.7.d	2016	8 (17)	0
SDN	27.7.d	2017	3 (5)	0
SDN	27.8.a	2016	2 (2)	0
SDN	27.8.b	2016	1 (1)	0
TBB	27.7.d	2016	4 (8)	0
TBB	27.7.d	2017	6 (7)	1 (3)
TBB	27.7.e	2016	3 (10)	0

Appendix 3: Self-sampling trips and hauls numbers (in brackets) with undulate ray observation in discards and landings *(source: DPMA - self-sampling program*)

Gear	Division	Year	Discards	Landings
GND	27.8.b	2016	11 (11)	11 (11)
GND	27.8.b	2017	9 (9)	9 (9)
GNS	27.7.d	2016	1 (1)	1 (1)
GNS	27.7.d	2017	8 (13)	8 (13)
GNS	27.7.e	2017	8 (8)	8 (8)
GNS	27.8.a	2016	29 (33)	29 (33)
GNS	27.8.a	2017	21 (21)	21 (21)
GNS	27.8.b	2016	2 (2)	2 (2)
GTN	27.7.e	2017	7 (7)	7 (7)
GTR	27.7.d	2016	70 (139)	70 (139)
GTR	27.7.d	2017	102 (203)	102 (203)
GTR	27.7.e	2016	26 (36)	26 (36)
GTR	27.7.e	2017	50 (53)	50 (53)
GTR	27.8.a	2016	36 (47)	36 (47)
GTR	27.8.a	2017	180 (219)	180 (219)
GTR	27.8.b	2016	95 (98)	95 (98)
GTR	27.8.b	2017	111 (111)	111 (111)
LLS	27.7.d	2017	8 (8)	8 (8)
LLS	27.7.e	2016	71 (74)	71 (74)
LLS	27.7.e	2017	55 (56)	55 (56)
LLS	27.8.a	2016	54 (56)	54 (56)
LLS	27.8.a	2017	72 (72)	72 (72)
LLS	27.8.b	2016	120 (182)	120 (182)
LLS	27.8.b	2017	425 (428)	425 (428)
OTB	27.7.d	2016	119 (692)	119 (692)
OTB	27.7.d	2017	93 (1024)	93 (1024)
OTB	27.7.e	2016	562 (3623)	562 (3623)
OTB	27.7.e	2017	625 (3555)	625 (3555)
OTB	27.8.a	2016	35 (181)	35 (181)
OTB	27.8.a	2017	159 (792)	159 (792)
OTB	27.8.b	2016	1 (1)	1 (1)
OTT	27.7.e	2016	4 (14)	4 (14)
OTT	27.7.e	2017	45 (281)	45 (281)

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Length-based indicators to assess the status of skates (Rajidae)

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ABSTRACT

Length-based indicators are a simple tool for evaluating the status of fish stocks, requiring only length-frequency data and limited life-history information. Here, length-based indicators are applied to data for 14 skate stocks collected during sea-going observer programmes on commercial fishing vessels, and interpreted in relation to the conservation of large and small individuals, optimal yield and maximum sustainable yield. The suitability of these indicators and their expected values for skate stocks is discussed.

INTRODUCTION

Many elasmobranchs are considered as data-limited stocks, owing to incomplete species-specific catch data, inaccurate species identification, incomplete knowledge of life-history parameters and that fishery-independent surveys only sample comparatively few species with any degree of effectiveness (ICES, 2017). This precludes the formal stock assessment process that is used for many commercial teleost stocks, with only one elasmobranch species (spurdog) within ICES assessed using analytical models.

Recently, the need to provide management advice, especially in relation to maximum sustainable yield (MSY), for an increasing number of fish species taken in commercial fisheries has led to a proliferation of data-limited assessment methodologies, reflecting differing data availabilities and intended use of assessment. These include methods based on time-series of catch (Martell and Froese, 2013; Zhou *et al.*, 2017), catch-based methods that use additional information on life-histories (MacCall, 2009; Dick and MacCall, 2011) or size structure (Gedamke and Hoenig, 2006; Hordyk *et al.*, 2015a, 2015b) and process-based models that require additional indices of biomass or abundance (Pedersen and Berg, 2017).

Many biological and fishery processes are related to size (e.g. fecundity, fishery selection and natural mortality). Length data can therefore contain substantial information on stocks and the fisheries impacting them (ICES, 2014). Given that length data are relatively cheap and straightforward to obtain, and that length-frequency data are the primary data collected under the data collection framework (DCF), length-based assessments may be suitable for various data-limited stocks.

Length-based indicators (LBI) are assumed to reflect size-selective fishing pressure. Indicators of status are calculated from length-frequency distributions and compared to reference points (RP) derived from life-history parameters and ecological theory or empirical observation, providing a snapshot assessment of status under steady state assumptions. The ICES workshop on the ‘Development of Quantitative Assessment Methodologies based on Life-history Traits, Exploitation Characteristics and other Relevant Parameters for Data-limited Stocks’ (WKLIFE V) selected a set of LBIs characterising conservation of large and small individuals, yield optimisation and maximum sustainable yield (ICES, 2015). A traffic light approach is used to compare ratios of indicators and reference points to expected values where conservation, yield or MSY properties are considered achieved. This suite of LBI outputs is considered to provide an overall perception of stock status.

Here, length-based indicators were applied to the following skate taxa: common skate complex (*Dipturus batis* and *Dipturus intermedius*), shagreen ray *Leucoraja fullonica,* cuckoo ray *Leucoraja naevus,* blonde ray *Raja brachyura,* thornback ray *Raja clavata,* small-eyed ray *Raja microocellata,* spotted ray *Raja montagui* and undulate ray *Raja undulata*.

METHODS

Life-history data

The LBIs require estimates of length at 50% maturity (L_{mat}), weights-at-length, obtained here using the allometric relationship $w = aL^b$ and the von Bertalanffy growth parameter (VBGP) for asymptotic length (L_∞). Information on maximum length (L_{max}) was also collated, to indicate whether published values of L_∞ were biologically plausible. Life-history parameters for the species and stocks examined are given in Table 1.

Length-weight parameters were generally taken from Silva *et al.* (2013) and the lengths at 50% maturity from McCully *et al.* (2012). Published estimates for VBGP were available from a range of published studies, with the most biologically plausible estimates used in the present study (based on whether L_∞ was at a similar size to L_{max}). Where published data for VBGP and the length at 50% maturity were sex-disaggregated, data for females were used for subsequent analyses.

VBGP were unavailable for two species (*Dipturus batis* and *Leucoraja fullonica*) and considered biologically implausible for one species (*Raja microocellata*). The parameters L_∞ and K for the remaining stocks were plotted against L_{max} and the linear relationship between these life-history characteristics estimated (L_∞ = 149.92 cm and K = 0.1323 y^{-1} for *D. batis*; L_∞ = 129.82 cm and K = 0.1483 y^{-1} for *L. fullonica,* and L_∞ = 91.65 cm and K = 0.1787 y^{-1} for *R. microocellata*).

Length-frequency data

Length-frequency data (see Appendix) for skates came from the English on-shore program (landings) and the UK England and Wales Observer at Sea program (landings and discards). For each trip, numbers-at-length were raised to the haul based on an estimated proportion of the total catch sampled, then to the trip based on the proportion of sampled hauls. Trip-raised estimates were summed for sampled vessels in each stratum (ICES area x gear class (otter trawls, beam trawls, netters, seines, hooks and lines and other gears) x year). They were then raised to the fleet using a ratio between the total number of trips and the number of trips sampled in the same stratum. Effort, as the number of trips per stratum, was used to raise discard data when landings were not available. The threshold for reporting discard estimates was 25 fish in each stratum.

Length-frequency data for species attaining <90 cm L_T (e.g. cuckoo ray) were analysed in 1 cm length intervals, whilst species reaching a maximum size of ca. 90–120 cm (e.g. thornback ray) were analysed in 2 cm length intervals, and fish attaining ≥120 cm (e.g. common skate complex) were analysed in 5 cm length intervals.

Table 1: Input parameters for LBI. Length-weight conversion parameters (a and b) from Silva et al. (2013) and length at 50% maturity from McCully et al. *(2012), unless otherwise specified. Where available data for VBGP and length at 50% maturity were sex-disaggregated, data for females were used. VBGP in square parentheses were estimated from the linear relationships between L∞ (and K) with Lmax using the data below.*

Scientific name	**Common name**	**CEFAS code**	**FAO code**	**ICES Stock code**	**Run**	L_∞	K	L_{max}	$L_{max\ obs}$	L_{mat_F}	a	b
Dipturus batis	Common (Grey) skate	SKT (SKG)	RJB (RJB)	rjb.27.67	1	[149.92]	[0.1323]	149 [2]	191	122.9 [9]	0.0038	3.1201
Dipturus intermedius	Common (Flapper) skate	SKT (SKF)	RJB (DRJ)		2	253.73 [8]	0.0570 [8]	250 [3]		197.5 [9]	0.0038	3.1201
Leucoraja fullonica	Shagreen ray	SHR	RJF	rjf.27.67		[129.82]	[0.1483]	129 [4]	106	*ca.* 90 [1]	0.0009 [1]	3.3995 [1]
Leucoraja naevus	Cuckoo ray	CUR	RJN	rjn.27.678abd	1	73.1 [10]	0.23 [10]	72 [5]	89*	59.8	0.0036	3.1399
				rjn.27.678abd	2	83.92 [11]	0.197 [11]	72 [5]	89*	59.8	0.0036	3.1399
				rjn.27.34		75.2 [12]	0.16 [12]	72 [5]	64	53.6	0.0036	3.1399
Raja brachyura	Blonde ray	BLR	RJH	rjh.27.7afg		118.4 [14]	0.19 [14]	120 [3]	104	83.4	0.0027	3.2580
				rjh.27.7e		118.4 [14]	0.19 [14]	120 [3]	120	83.4	0.0027	3.2580
				rjh.27.4c7d		118.4 [14]	0.19 [14]	120 [3]	109	83.4	0.0027	3.2580
Raja clavata	Thornback ray	THR	RJC	rjc.27.47d		118.0 [12]	0.14 [12]	115 [4] (130)	101	73.7	0.0045	3.0961
				rjc.27.7e		107.0 [14]	0.13 [14]	115 [4]	114	78.2	0.0045	3.0961
				rjc.27.7afg	1	107.0 [14]	0.13 [14]	115 [4]	106	78.2	0.0045	3.0961
				rjc.27.7afg	2	115.25 [10]	0.185 [10]	115 [4]	106	78.2	0.0045	3.0961
Raja microocellata	Small-eyed ray	PTR	RJE	rje.27.7fg	1	*? 137.0 [6]*	*? 0.086 [6]*	91 [6]	89	77.9	0.0030	3.2250
					2	[91.65]	[0.1787]	91 [6]	89	77.9	0.0030	3.2250
Raja montagui	Spotted ray	SDR	RJM	rjm.27.7ae-h		72.8 [14]	0.18 [14]	80 [3]	92*	62.5	0.0041	3.1152
				rjm.27.347d		79.2 [12]	0.21 [12]	80 [3]	88*	62.5	0.0041	3.1152
Raja undulata	Undulate ray	UNR	RJU	rju.27.7de		116.5 [13]	0.135 [13]	114–120 [7]	108	86.2 [13]	0.0040	3.1346

Data sources: [1] McCully (unpublished); [2] Cefas (unpublished); [3] Stehmann & Bürkel (1984); [4] Heessen *at al.* (2015); [5] Ellis *et al.* (2005); [6] Ryland & Ajayi (1984); [7] Ellis *et al.* (2012); [8] Du Buit (1976); [9] Iglésias et al. (2010); [10] Fahy (1991); [11] Gallagher *et al.* (2005); [12] Walker (1999); [13] Serra-Pereira *et al.* (2015; values for L∞ and K mean values from Moura *et al.* (2007) study); [14] Holden (1972).
Note 1: Published VBGP for *Raja microocellata* are not considered biologically plausible.
Note 2: The maximum lengths observed in observer data for cuckoo ray and spotted ray (*) were greater than the maximum lengths reported elsewhere, and may be due to misidentifications.

Length-based indicators

Conservation of large individuals: Comparing indicators characterising the upper portion of the length-frequency distribution to the RP L_∞ provides an indication of the degree of truncation of the population size structure that may be caused by fishing. Indicators chosen to characterise the upper portion are the mean length of the largest 5% ($L_{max5\%}$) and the 95th percentile ($L_{95\%}$) of the length-frequency distribution, both of which are considered more stable than the maximum length in the catch (Probst *et al.*, 2013; ICES, 2014). The ratio of indicator to RP L_∞ is expected to be above 0.8, based on a simulation study (Miethe and Dobby, 2015).

The proportion of mega-spawners (fish larger than the optimum length plus 10%) in the stock (P_{mega}) follows the principle of '*Let the mega-spawners live*' (Froese, 2004). Old, large fish play several important roles in the long-term survival of a population, as they may produce more eggs (increased fecundity), larger eggs or young (which may have better survival) and may have a greater spawning success. Consequently, P_{mega} can be viewed as a simple proxy for the resilience of a stock. The principle is to implement a fishing strategy where no mega-spawners are caught. However, if the catch reflects the size structure of the population, values above 0.3 are considered healthy (Froese, 2004; ICES, 2015).

Conservation of immatures: LBI relating to small individuals follow the principle '*Let them spawn*' (Froese, 2004). Overfishing is theoretically impossible if every spawner produces at least one replacement spawner (Myers and Mertz, 1998); therefore, if the indicator length at first capture (L_c; estimated as the length at 50% of the overall mode) is above the RP L_{mat} biomass is likely to be above that which produces MSY (ICES, 2014). A simulation study found the 25th percentile ($L_{25\%}$) of the length-frequency distribution to be a suitable proxy when L_c is difficult to estimate (Miethe and Dobby, 2015). Based on theory, the ratio of indicator to RP L_{mat} is expected to be greater than 1.

Optimal yield: LBI relating to optimal yield follow the principle '*Let them grow*' (Froese, 2004) which states that all fish caught should be within 10% of the RP optimum harvest length (L_{opt}). L_{opt} represents the length where cohort biomass and egg production are maximal in an unexploited state and where catch is maximal for a given fishing mortality (F), or F minimal for a given catch (Cope and Punt, 2009). L_{opt} is calculated:

$$L_{opt} = \frac{3}{3 + {M}/{k}} L_\infty$$

Where M is natural mortality and k is the von Bertalanffy rate coefficient. The ratio M/k is a life-history invariant thought to be more stable than either of the parameters separately and is estimated at 1.5 for teleost fishes. The ICES approximation of L_{opt} therefore simplifies to $2/3L_\infty$. If the central indicators mean length of individuals larger than L_c (L_{mean}) or length class with maximal biomass (L_{maxy}) are close to the RP L_{opt} then either the stock is lightly exploited or the fishery is operating with a target length that is sustainable and close to MSY (ICES, 2014). Given the requirement that fish caught are within 10% of L_{opt}, the ratio of indicator to RP should be 0.9–1.1.

MSY: F=M is a proxy for MSY. The length at which F=M ($L_{F=M}$) is rearranged from Beverton and Holts equation for mean length in the catch as a function of the von Bertalanffy growth parameters, length at first capture and natural and fishing mortality:

$$L_{F=M} = (1 - a)L_c + aL_\infty$$

$$a = \frac{1}{2\left({}^{M}/_{k}\right) + 1}$$

Assuming M/k = 1.5, this simplifies to $0.75L_c + 0.25L_\infty$. This RP gives the mean length in the catch expected from fishing at F=M in the long term; hence a suitable indicator is L_{mean}. If L_{mean} is less than $L_{F=M}$ then fishing mortality is likely to be larger than M and hence F_{MSY} (ICES, 2014). The ratio of indicator to RP should therefore be greater than or equal to 1.

The corresponding reference points and indicator ratios for length-based indicators are summarised in Table 2. The case study stocks and métiers examined are listed in Table 3.

Table 2: Summary of length-based indicators (LBI) with corresponding reference points and indicator ratios (* = simplified equations resulting from substituting M/k = 1.5; an assumption based on the life-history of teleost fish).

Indicator	Calculation	Reference point	Indicator ratio	Expected value
$L_{max5\%}$	Mean length of largest 5%	L_∞	$L_{max5\%}/L_\infty$	> 0.8
$L_{95\%}$	95th percentile	L_∞	$L_{95\%}/L_\infty$	> 0.8
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3-0.4	P_{mega}	> 0.3
$L_{25\%}$	25th percentile	L_{mat}	$L_{25\%}/L_{mat}$	> 1
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	> 1
L_{mean}	Mean length of individuals > L_c	$L_{opt}=2/3L_\infty$ *	L_{mean}/L_{opt}	≈ 1
L_{maxy}	Length class with maximum biomass in catch	$L_{opt}=2/3L_\infty$ *	L_{maxy}/L_{opt}	≈ 1
L_{mean}	Mean length of individuals > L_c	$L_{F=M}=(0.75L_c+0.25L_\infty)$ *	$L_{mean}/L_{F=M}$	≥ 1

Table 3: Summary of stocks and métiers for which LBIs were investigated

Species	ICES stock code	Otter trawl	Gillnets	All gears
Common skate complex	rjb.27.67	All years combined	All years combined	–
Thornback ray	rjc.27.7afg	By year	All years combined	–
	rjc.27.7e	By year	All years combined	–
	rjc.27.347d	By year	By year	–
Small-eyed ray	rje.27.7fg	By year	By year (2015–2017)	–
Shagreen ray	rjf.27.67	–	–	By year
Blonde ray	rjh.27.4c7d	–	–	All years combined
	rjh.27.7afg	By year	By year (2015–2017)	–
	rjh.27.7e	By year	By year (2015–2017)	–
Spotted ray	rjm.27.7ae-h	By year	All years combined	–
	rjm 347d	By year	All years combined	–
Cuckoo ray	rjn 34	By year	–	–
	rjn 678	By year	By year	–
Undulate ray	rju 7de	By year and all years combined	By year and all years combined	–

RESULTS

Whilst data were available for 14 skate stocks, the amount of data varied between stocks, gears and over time. Whilst temporal trends in LBI could be examined for some stocks, temporal data were aggregated for some stocks.

Common skate complex (*Dipturus batis* and *D. intermedius*) in the Celtic Sea (rjb.27.67)

Length-frequency data for the common skate complex were aggregated across all years with available data for larger fish from gillnet and otter trawl métiers. Beam trawl data (not analysed) would likely comprise mostly smaller common skate.

Given uncertainty in the actual species in the data (which would be expected to be comprised mostly of the smaller-bodied grey skate), two runs were undertaken. One run used the life-history parameters L_∞ and L_{mat} for grey skate, and a second run used the parameters for flapper skate.

Netters caught larger fish than otter trawls (Figure 1), and therefore produced more optimistic LBIs. Indictors relating to optimal yield showed otter trawls to be catching common skate below the optimum length, and netters above the optimum length (

Table 4). These result in the indicators for large and small individuals being closer to their associated reference points when considering data from gillnet fisheries, resulting in a positive status assessment in terms of large individuals and MSY (grey skate parameters). The common skate complex failed to meet expected values in terms of small individuals and immature fish, but were relatively close when considering the gillnet data.

The larger L_∞ and L_{mat} of flapper skate resulted in a more pessimistic assessment (

Table 5), with all LBI failing to meet their expected values. However, it should be noted that available species-specific data indicate that grey skate is the predominant species in the Celtic Sea, and flapper skate much less frequent.

Key points:

- Given the model assumption of asymptotic selection, data from netters were considered more appropriate for this large-bodied species.

- Available data indicate that grey skate is by far the dominant species, and parameters for grey skate were considered most appropriate.

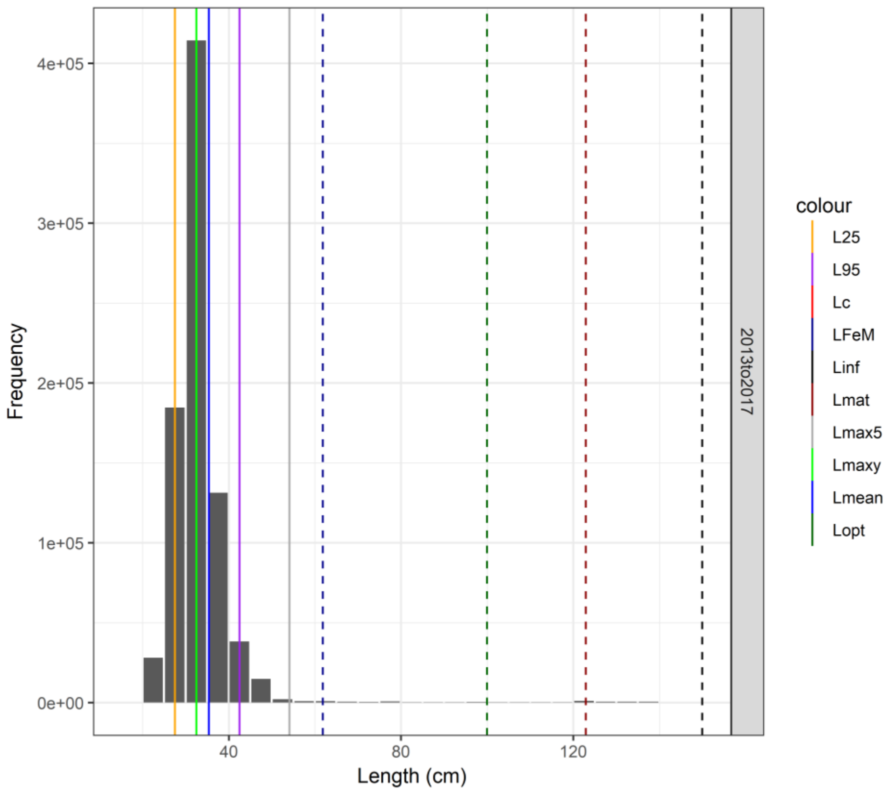
- Although available data from netters are too limited for temporal analyses, recent data suggested that LBIs relating to the ‘conservation of large individuals’ and MSY were of ‘good’ status, whilst LBIs for the ‘conservation of immature individuals’ and optimum yield failed to meet expected values.

Table 4: LBI for common skate complex in Celtic Sea otter trawl and gillnet métiers, assuming life-history parameters for grey skate Dipturus batis.

Otter trawls (Grey skate parameters)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2013–2017	0.36	0.28	0	0.22	0.26	0.35	0.33	0.57
Netters (Grey skate parameters)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2010–2014	0.91	0.88	0.54	0.75	0.79	1.17	1.28	1.06

Table 5: LBI for common skate complex in Celtic Sea otter trawl and gillnet métiers, assuming life-history parameters for flapper skate Dipturus intermedius.

Otter trawls (Flapper skate parameters)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2013–2017	0.21	0.17	0	0.14	0.16	0.21	0.19	0.4
Netters (Flapper skate parameters)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2010–2014	0.54	0.52	0	0.47	0.49	0.69	0.75	0.86



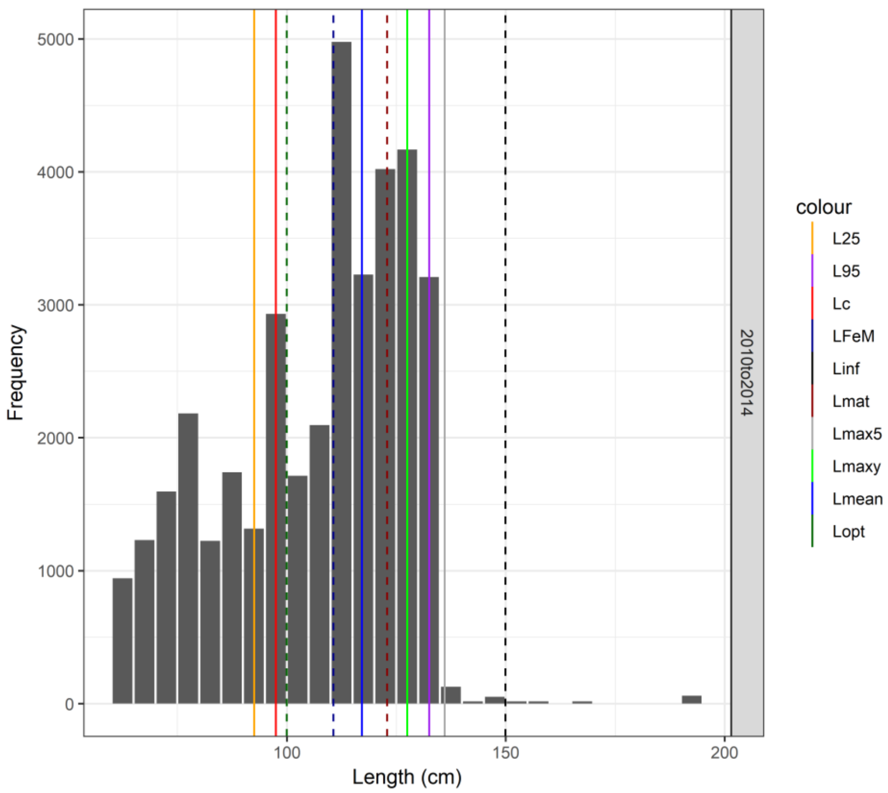


Figure 1: Length-frequency distributions of the common skate complex in the Celtic Sea with indicators (solid vertical lines) and reference points (based on grey skate parameters; dashed vertical lines) for otter trawls (top) and gillnets (bottom).

Shagreen ray *Leucoraja fullonica* in the Celtic Sea (rjf.27.67)

Length-frequency data for shagreen ray came from the beam trawl fleet only and were available from 2015 onwards.

The right tails of the length-frequency distributions were similar in each of the three years, leading to the same classification of being below expected indicator ratio values when considering large individuals, although this should be viewed in relation to gear selectivity. In the absence of a published estimate, L_∞ was estimated from L_{max}, which might also contribute to this poor status classification if estimated too high.

The indicators relating to small and immature fish consistently fell below reference points (Table 6), with the indicator ratios decreasing in the final two years due to an increased proportion of smaller fish in the catch (Figure 2). Consequently, this decrease in L_c led to a decrease in the MSY proxy reference point $L_{F=M}$ that switches the MSY status from 'bad' to 'good'. There appear to be diverging trends between the indicator ratios relating to optimal yield.

<u>Key points</u>:

- Data for shagreen ray were very limited, and further studies on this stock are required.
- Despite LBIs for the 'conservation of large individuals' and the 'conservation of immature individuals' falling below reference points, the MSY indicator was met, suggesting that the reference points for various LBIs can result in contradictory evaluations.
- Of the two indicators for optimal yield, one showed an increasing trend and the other a decreasing trend, once again indicating the potential for contradictory signals.

Table 6: LBI for shagreen ray in the Celtic Sea beam trawl métier.

Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2015	0.74	0.71	0.02	0.75	0.69	0.89	1.01	0.97
2016	0.75	0.71	0.04	0.58	0.47	0.8	1.01	1.07
2017	0.75	0.71	0.04	0.53	0.42	0.73	1.13	1.05

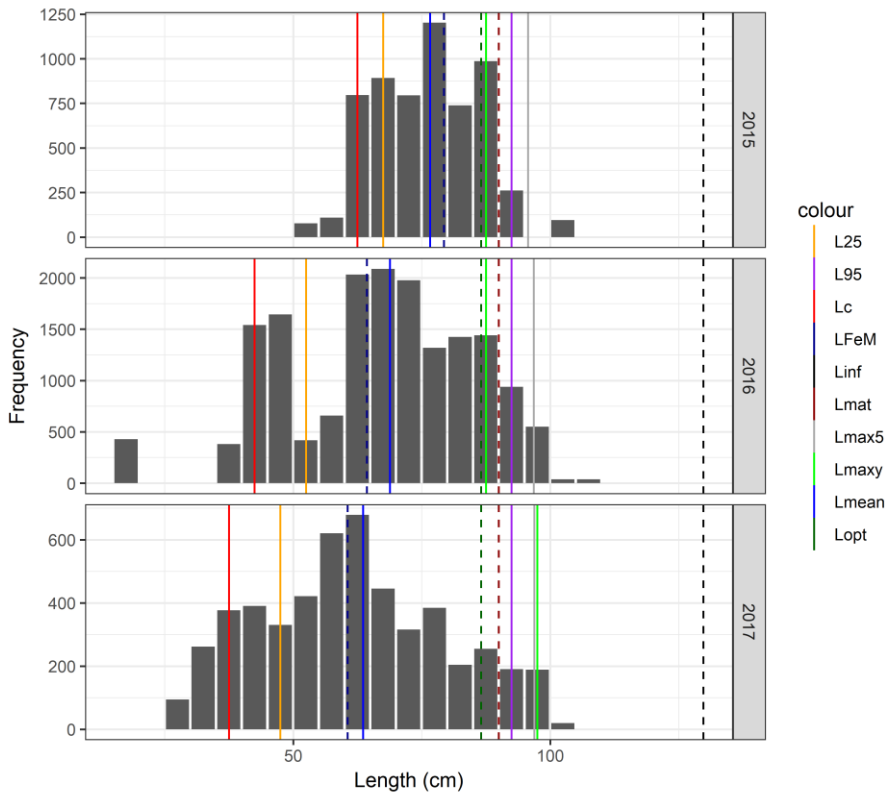


Figure 2: Length-frequency distributions of shagreen ray in the Celtic Sea with indicators (solid vertical lines) and reference points (dashed vertical lines).

Cuckoo ray *Leucoraja naevus* in the Celtic Sea and Bay of Biscay (rjn.27.678abd)

Length-frequency data for cuckoo ray were analysed for gillnet and otter trawl métiers. Otter trawls appeared to be one of the main métiers catching cuckoo ray, while the numbers caught by netters appears to have increased from 2015. Beam trawl data were not considered here, with this gear expected to catch mostly smaller fish.

Two runs were carried out, one using the L_∞ reported by Fahy (1991;

Table 7), and a second using the L_∞ reported by Gallagher *et al.* (2005; Table 8).

The optimal yield LBI showed netters to catch larger fish than otter trawls. This was also reflected in the LBI for large and small individuals, with otter trawls mostly failing to meet expectations and netters mostly satisfying conditions. Selection in the otter trawl fishery appears to have shifted towards larger fish, as indicated by the increase in indicator ratio values for small individuals and a shift from 'poor' to 'good' status for LBI characterising large individuals. Both métiers gave similar MSY indictor ratio values, with those of otter trawls falling just below the expected value of 1 and netters just above.

Using an alternative value of L_∞ will affect all indicator ratio values aside from those relating to small or immature fish. The larger value of L_∞, as reported by Gallagher *et al.*, (2005), resulted in a more pessimistic assessment, as it shifted the reference point further away from the right tail of the length-frequency distributions and the indicators characterising them. More of the LBI characterising large fish in the otter trawl fishery failed to meet expected values, while MSY status in the gillnet fishery mostly switched from 'good' to 'poor'. The lower value of L_∞ (Fahy, 1991) is closer to the reported value of L_{max}, while the higher value of L_∞ (Gallagher *et al.*, 2005) is closer to the L_{max} of our data.

Key points:

- There were minor differences in stock perception when the different values of L_∞ were used, although the data from the different gears gave very different perceptions.

- Given the smaller L_{max} for this species, data from otter trawlers may provide a more appropriate time series.

- Otter trawl data suggest that indicators for MSY were generally quite stable at, or just below, the expected reference point. Whilst LBI for the 'conservation of small fish' failed to meet the expected values, LBI for the 'conservation of large fish' improved over the time series, and were currently perceived to be in a 'good' status.

Table 7: LBI for cuckoo ray in the Celtic Sea otter trawl and gillnet métiers, based on the L∞ reported by Fahy (1991).

Otter trawls (Fahy asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2010	0.72	0.7	0	0.73	0.73	0.98	1.04	0.94
2011	0.68	0.68	0	0.49	0.38	0.8	0.89	1.1
2012	0.67	0.65	0	0.49	0.41	0.73	0.87	0.97
2013	0.67	0.65	0	0.54	0.49	0.79	0.89	0.96
2014	0.84	0.73	0.05	0.51	0.48	0.8	0.85	0.99
2015	0.94	0.92	0.32	0.73	0.61	1.04	1.34	1.12
2016	0.9	0.84	0.09	0.69	0.69	0.94	0.87	0.93
2017	0.97	0.94	0.54	0.79	0.69	1.15	1.39	1.14
Netters (Fahy asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2010	1	0.96	0.97	1.1	1.13	1.41	1.41	1
2011	0.96	0.94	0.94	1.06	1.08	1.37	1.39	1
2012	1	0.98	0.91	1.05	1.05	1.36	1.32	1.02
2013	0.97	0.96	0.83	0.96	1.06	1.37	1.41	1.02
2015	0.97	0.95	0.97	1.05	1.05	1.35	1.32	1.01
2016	0.97	0.95	1	1.05	1.08	1.38	1.41	1.01
2017	0.97	0.95	0.96	1.01	0.94	1.3	1.36	1.05

Table 8: LBI for cuckoo ray in the Celtic Sea otter trawl and gillnet métiers, based on the L∞ reported by Gallagher et al. *(2005).*

Otter trawls (Gallagher asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2010	0.62	0.61	0	0.73	0.73	0.85	0.9	0.89
2011	0.6	0.59	0	0.49	0.38	0.69	0.78	1.02
2012	0.58	0.57	0	0.49	0.41	0.64	0.76	0.91
2013	0.59	0.57	0	0.54	0.49	0.69	0.78	0.9
2014	0.73	0.64	0.01	0.51	0.48	0.7	0.74	0.93
2015	0.82	0.8	0.14	0.73	0.61	0.91	1.17	1.05
2016	0.78	0.73	0.05	0.69	0.69	0.82	0.76	0.88
2017	0.84	0.82	0.26	0.79	0.69	1	1.21	1.08
Netters (Gallagher asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2010	0.87	0.84	0.87	1.1	1.13	1.23	1.22	0.96
2011	0.84	0.82	0.85	1.06	1.08	1.2	1.21	0.97
2012	0.87	0.85	0.77	1.05	1.05	1.19	1.15	0.98
2013	0.85	0.84	0.63	0.96	1.06	1.2	1.22	0.98
2015	0.84	0.83	0.75	1.05	1.05	1.18	1.15	0.97
2016	0.85	0.83	0.77	1.05	1.08	1.2	1.22	0.97
2017	0.84	0.83	0.63	1.01	0.94	1.14	1.19	1

Cuckoo ray *Leucoraja naevus* in the North Sea (rjn.27.34)

Length-frequency data for cuckoo ray in the North Sea were analysed for the otter trawl métier only.

The indicators characterising large individuals fluctuated around or below the expected value of 0.8L_{∞} (0.3 for P_{mega}), while the indicators relating to small or immature individuals consistently fell below the reference point L_{mat} (

Table 9). Indicator ratios relating to optimal yield generally indicated targeting at the optimum length. Both MSY indicator and reference point changed with the length-frequency distributions but followed the same trend, with indicators above reference points in some years, and below in others.

Key points:

- Otter trawl data suggest that indicators for MSY were close to the expected reference point, but generally falling below in more recent years.
- LBI for the 'conservation of small fish' and the 'conservation of large fish' generally fell below expected levels, resulting in a perception of 'poor' status.
- These results should be used with caution, however, as the data from English observer programmes may originate from the southern part of the stock area, and may not be indicative of the whole stock area.

Table 9: LBI for cuckoo ray in the North Sea otter trawl métier

Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.76	0.7	0.04	0.7	0.59	0.84	0.97	1
2010	0.82	0.8	0.25	0.87	0.87	1.05	0.99	0.98
2011	0.79	0.78	0.22	0.76	0.62	0.92	0.89	1.05
2012	0.79	0.78	0.29	0.77	0.76	1.02	1.11	1.04
2013	0.68	0.68	0	0.83	0.96	1.03	1.03	0.9
2014	0.76	0.7	0.04	0.74	0.77	0.92	0.83	0.92
2015	0.82	0.79	0.21	0.76	0.7	0.99	0.95	1.05
2016	0.75	0.68	0.05	0.68	0.72	0.9	0.97	0.95
2017	0.71	0.71	0	0.64	0.64	0.81	1.07	0.91

Blonde ray *Raja brachyura* in the southern North Sea and eastern English Channel (rjh.27.4c7d)

Due to limited data availability, data for all gears reporting catches of blonde ray in the southern North Sea and eastern English Channel were analysed together, including beam trawl, otter trawl and gillnets, and combined over all the years with data available.

The length-frequency distribution was highly skewed to the left (Figure 3) resulting in all LBI characterising the conservation of large and small individuals falling below expected values (Table 10). This also agreed with the indicator ratio L_{mean}/L_{opt} which suggested fishing on individuals below the optimum length. L_{maxy} was calculated based on biomass (as a function of length) rather than length alone and fell within its range of target values, contrary to the other LBI. The MSY criteria for 'good' status was not met.

<u>Key points</u>:

- Available data for this stock of blonde ray were very limited, and further studies on this stock are required. Furthermore, given the morphological similarity between spotted and blonde ray, more dedicated data collection for blonde ray may be required.

Table 10: LBI for blonde ray in the southern North Sea and eastern English Channel (all métiers and years combined).

Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2010–2017	0.75	0.65	0.04	0.27	0.27	0.51	0.92	0.87

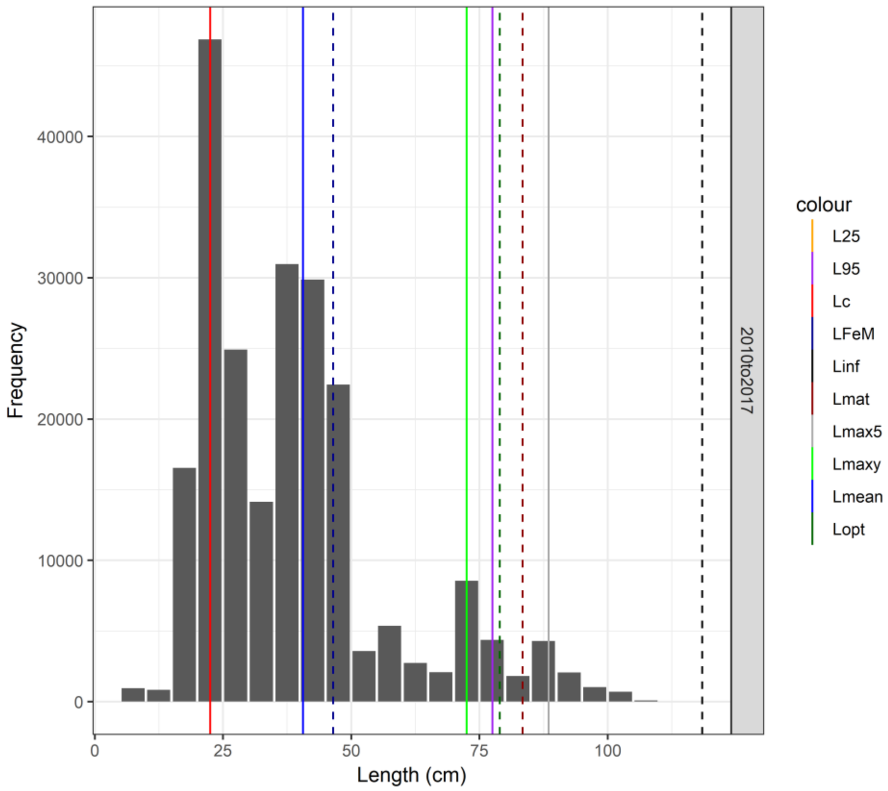


Figure 3: Length-frequency distribution of blonde ray in the southern North Sea and eastern English Channel with indicators (solid vertical lines) and reference points (dashed vertical lines).

Blonde ray *Raja brachyura* in the western English Channel (rjh.27.7e)

Length-frequency data for blonde ray in the western English Channel were analysed for both gillnet and otter trawl métiers. Otter trawls appear to be the dominant métier catching blonde ray, while data for netters were only available from 2015 onwards. Beam trawl data were not analysed.

The optimal yield LBI showed netters to catch larger fish than otter trawls, with LBI for otter trawls mostly falling below the expected range, and LBI for netters falling at or above (Table 11). There appeared to be a change in selection, moving towards larger individuals, in the otter trawl fishery, reflected by an increase in all indicators and indicator ratios (Figure 4) and status shifts from 'bad' to 'good' when considering large individuals and MSY. Indicators relating to small or immature individuals consistently fell below L_{mat} for both métiers.

Key points:

- Given the model assumption of asymptotic selection, data from netters may be more appropriate for this large-bodied species.
- Although available data from netters were limited, recent data suggested that LBI relating to the 'conservation of large individuals' and MSY were of 'good' status, whilst LBIs for the 'conservation of immature individuals' failed to meet expected values.
- LBI relating to the 'conservation of large individuals' using data from otter trawlers indicated an improving status, and were of 'good' status in more recent years.

Table 11: LBI for blonde ray in the western English Channel for otter trawl and gillnet métiers

Otter trawls								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2012	0.44	0.4	0	0.39	0.39	0.49	0.6	0.72
2013	0.45	0.44	0	0.33	0.33	0.49	0.6	0.77
2014	0.58	0.4	0.01	0.33	0.33	0.47	1.3	0.74
2015	0.89	0.82	0.1	0.57	0.51	0.77	1.24	0.99
2016	0.9	0.87	0.16	0.57	0.51	0.83	1.3	1.07
2017	0.9	0.82	0.23	0.69	0.63	0.89	1.11	1.02
Netters								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2015	0.97	0.87	0.43	0.87	0.87	1.11	1.24	1.04
2016	0.89	0.87	0.34	0.93	0.93	1.1	1.05	0.99
2017	0.92	0.87	0.43	0.93	0.93	1.12	1.24	1.01

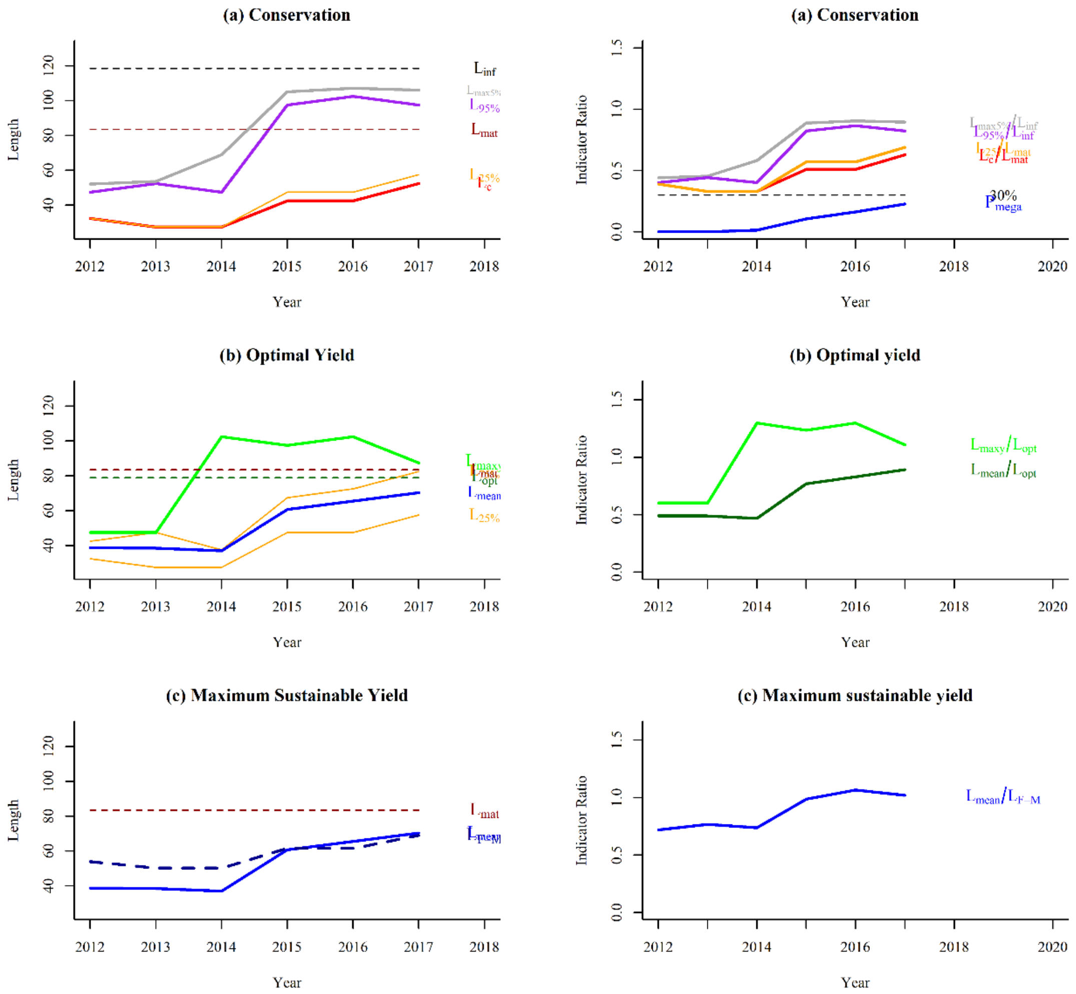


Figure 4: Indicators, reference points and indicator ratios for blonde ray caught by otter trawl in the western English Channel.

Blonde ray *Raja brachyura* in the Bristol Channel and Irish Sea (rjh.27.7afg)

Length-frequency data for blonde ray in the Bristol Channel and Irish Sea were analysed for gillnet and otter trawl métiers. Otter trawls appeared to be the dominant métier catching blonde ray, while data for netters were only available from 2015 onwards. Beam trawl data were not considered.

The three fixed reference points (L_{∞}, L_{mat} and L_{opt}) fell beyond the right tails of the length-frequency distributions in most years, resulting in 'poor' status assessment for all LBI (aside from L_{maxy}/L_{opt} in 2017) when considering data from the otter trawl fishery (Table 12; Figure 5). The optimal yield LBI showed netters to catch larger fish, selecting fish at or slightly above the optimum length range. This was also reflected in the 'good' classification when considering LBI relating to large individuals and MSY (Table 12). Indicators relating to small or immature individuals consistently failed to exceed L_{mat} for both métiers.

<u>Key points</u>:

- Given the model assumption of asymptotic selection, data from netters may be more appropriate for this large-bodied species.

- Although available data from netters were limited, recent data suggested that LBI relating to the 'conservation of large individuals' and MSY were of 'good' status, whilst LBIs for the 'conservation of immature individuals' failed to meet expected values.

- The length-frequency distribution from otter trawlers changed abruptly during the time series, with a more constrained length range in 2009–2013, and broader length range in 2016–2017. Further studies on these data are required, to better understand whether this is a genuine temporal change in population structure, or an artefact of limited data being raised.

Table 12: LBI for blonde ray in the Bristol Channel and Irish Sea for otter trawl and gillnet métiers.

Otter trawls								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.46	0.44	0	0.39	0.39	0.49	0.67	0.72
2010	0.44	0.4	0	0.39	0.33	0.47	0.54	0.73
2011	0.43	0.4	0	0.39	0.33	0.47	0.54	0.73
2012	0.45	0.44	0	0.45	0.45	0.54	0.54	0.74
2013	0.44	0.44	0	0.27	0.51	0.56	0.54	0.72
2016	0.73	0.65	0.03	0.57	0.63	0.78	0.73	0.9
2017	0.74	0.7	0.03	0.51	0.51	0.77	1.05	0.99
Netters								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2015	0.84	0.82	0.48	0.87	0.87	1.09	1.17	1.03
2016	0.82	0.78	0.35	0.93	0.93	1.07	1.05	0.97
2017	0.83	0.82	0.34	0.87	0.81	1.03	1.11	1.01

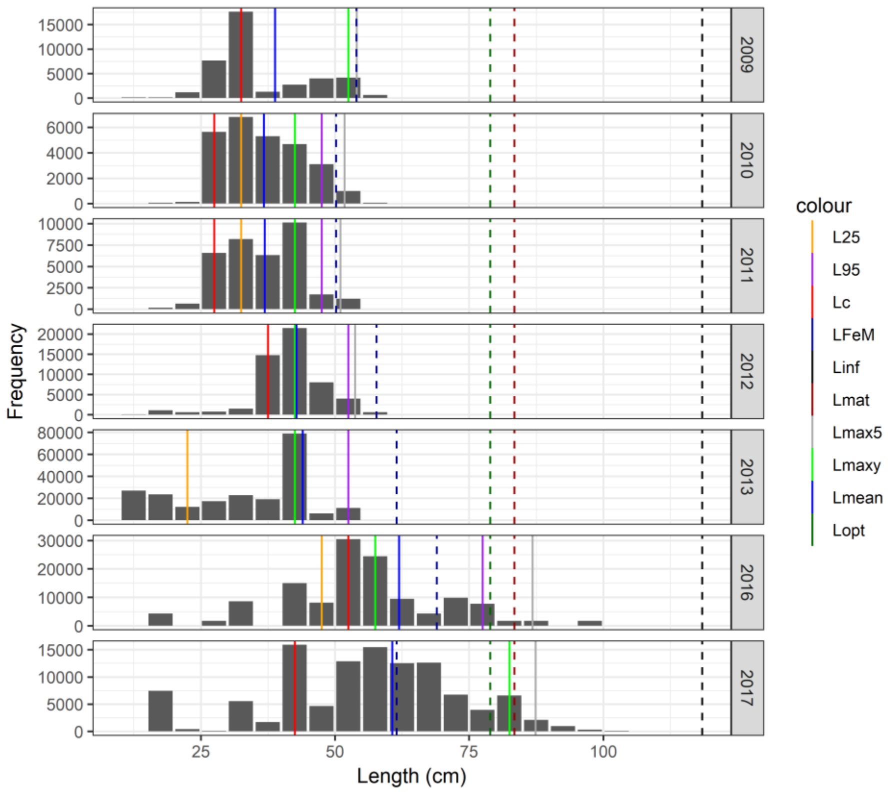


Figure 5: Length-frequency distributions of blonde ray in the Bristol Channel and Irish Sea with indicators (solid vertical lines) and reference points (dashed vertical lines).

Thornback ray *Raja clavata* in the North Sea and eastern English Channel (rjc.27.47d)

Length-frequency data for thornback ray in the North Sea and eastern English Channel from both gillnet and otter trawl métiers were analysed. Data from other métiers, including beam trawls and hooks and lines, were not considered.

The three fixed reference points (L_{∞}, L_{mat} and L_{opt}) fell on or beyond the right tails of the length-frequency distributions for both the otter trawl (Figure 6) and gillnet métiers (Figure 7), resulting in 'poor' status assessment for most LBIs (

Table 13). The reported value of L_∞ used as, or to calculate, reference points far exceeded the right tail of the length-frequency distributions and the maximum observed length in the data, driving the ‘poor’ classification in terms of large individuals, optimal yield and, to some extent, MSY.

The reference point L_{mat} should be at or below the 25th percentile of the length-frequency distributions, but consistently fell on the right tails for both métiers, driving the ‘poor’ classification in terms of small or immature individuals and further contributing to the perception of poor MSY status.

Key points:

- The length-frequency distribution from otter trawlers changed gradually over the time series, with a broader length range in 2015–2017. Further studies on these data are required, including whether these shifts represent growth of strong cohorts.

- The estimated L_∞ for this stock (118 cm) is biologically plausible, but was much higher than the maximum length observed in the data set, and so the LBI relating to the ‘conservation of large individuals’ failed to meet expected values for both otter trawl and gillnet data.

- The LBI for MSY was close to or above the expected level in recent years for both gears analysed.

Table 13: LBI for thornback ray in the southern North Sea and eastern English Channel for otter trawl and gillnet métiers.

Otter trawls								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.43	0.38	0	0.26	0.23	0.33	0.47	0.62
2010	0.36	0.31	0	0.23	0.2	0.33	0.37	0.64
2011	0.37	0.33	0	0.31	0.28	0.36	0.47	0.62
2012	0.42	0.4	0	0.31	0.28	0.45	0.52	0.78
2013	0.5	0.45	0	0.39	0.5	0.58	0.62	0.8
2014	0.46	0.43	0	0.31	0.23	0.42	0.55	0.78
2015	0.7	0.65	0.01	0.5	0.42	0.69	0.93	1.03
2016	0.7	0.67	0.01	0.56	0.5	0.72	0.9	0.99
2017	0.73	0.72	0.02	0.45	0.23	0.7	0.95	1.3
Netters								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.48	0.47	0	0.42	0.37	0.53	0.67	0.83
2010	0.58	0.53	0	0.39	0.34	0.51	0.8	0.83
2011	0.69	0.65	0.01	0.53	0.34	0.72	0.9	1.17
2012	0.74	0.7	0.04	0.39	0.34	0.58	1.06	0.95
2013	0.55	0.5	0	0.37	0.28	0.5	0.67	0.87
2014	0.54	0.47	0	0.34	0.28	0.43	0.95	0.75
2015	0.73	0.69	0.02	0.72	0.83	0.92	1.03	0.97
2016	0.73	0.7	0.02	0.5	0.28	0.73	0.95	1.27
2017	0.75	0.72	0.04	0.8	0.8	0.91	0.95	0.97

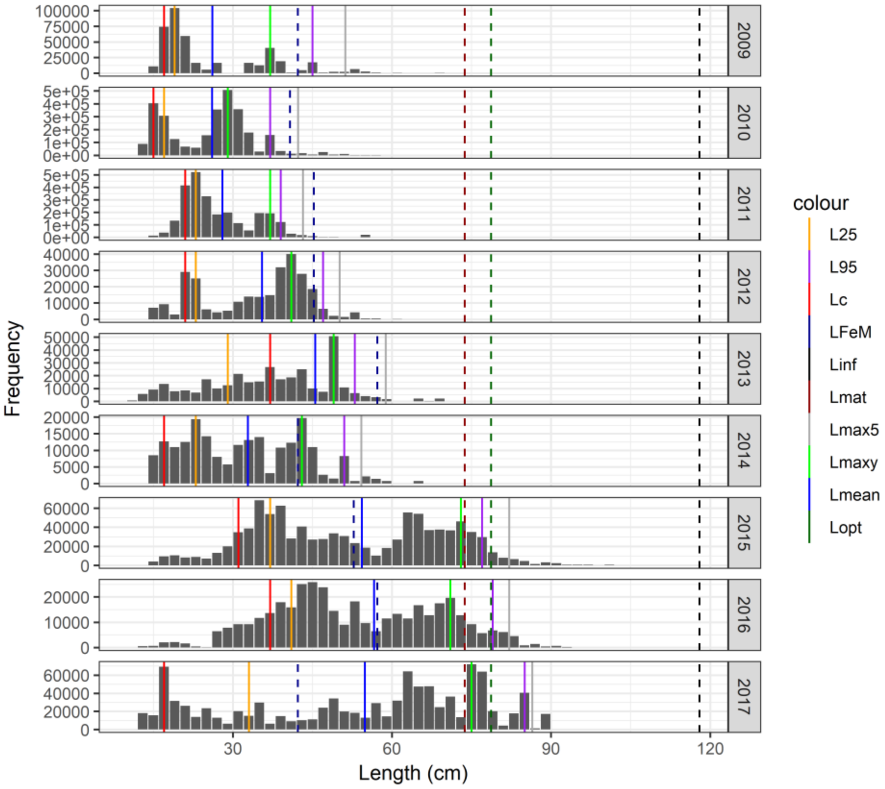


Figure 6: Length-frequency distributions of thornback ray caught by otter trawls in the North Sea and eastern English Channel with indicators (solid vertical lines) and reference points (dashed vertical lines).

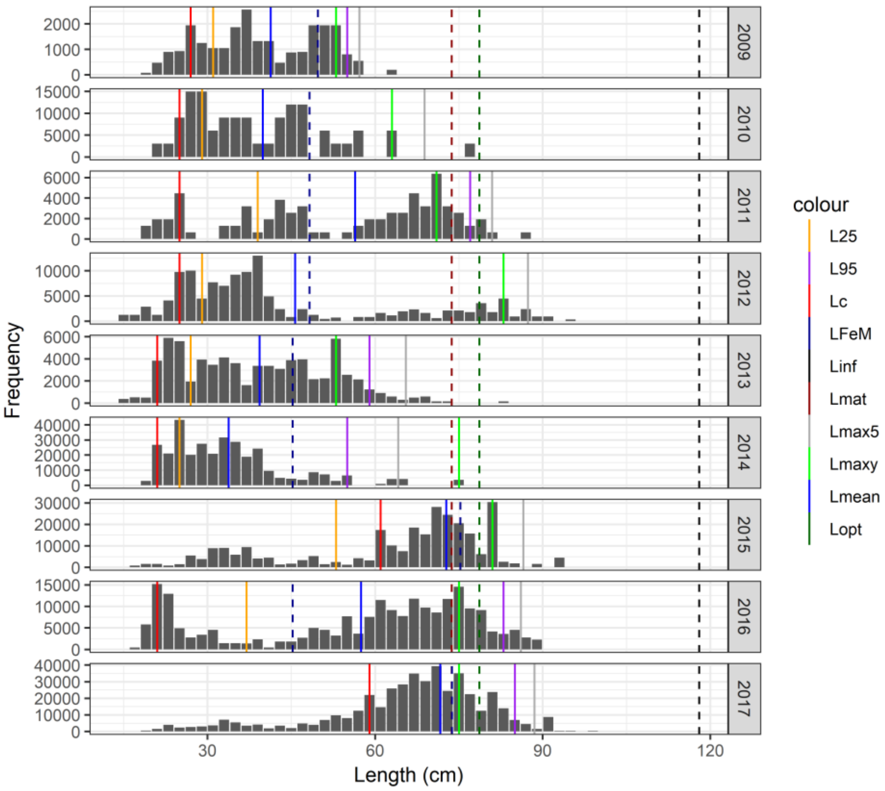


Figure 7: Length-frequency distributions of thornback ray caught by gillnets in the North Sea and eastern English Channel with indicators (solid vertical lines) and reference points (dashed vertical lines).

Thornback ray *Raja clavata* in the western English Channel (rjc.27.7e)

Length-frequency data for thornback ray in the western English Channel were analysed for both gillnet and otter trawl métiers. Otter trawls appeared to be the dominant métier catching thornback ray, and data for netters were only available 2015–2016, and therefore combined over this two-year period. Data from other gears, including beam trawls, were not considered.

The optimal yield indicators showed otter trawls to catch fish generally below the optimum length range (Table 14), although this length range appeared to have widened over the time series, as shown by the increasing LBI for large individuals and decreasing LBI for small or immature individuals (Figure 8). This resulted in a relatively stable, albeit slight increase, in L_{mean}. The decreasing length at first catch, L_c, lowered the value of the MSY reference point $L_{F=M}$ so that the slight increase in indicator L_{mean} resulted in a switch from 'poor' to 'good' MSY status.

The optimal yield LBI indicated that netters caught larger fish, typically above the optimum length range. This is also indicated by 'good' status when considering LBI relating to the conservation of large individuals. Netters, however, failed to meet the expectations regarding small or immature individuals.

Key points:

- The LBI relating to the 'conservation of large individuals' appeared to improve over time, whilst the LBI for the 'conservation of small individuals' decreased over time.
- The LBI for MSY was close to or above the expected level in recent years for both gears analysed.

Table 14: LBI for thornback ray in the western English Channel for otter trawl and gillnet métiers.

Otter trawls								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2010	0.48	0.42	0	0.5	0.5	0.6	0.63	0.76
2013	0.45	0.44	0	0.37	0.35	0.52	0.63	0.8
2014	0.7	0.66	0.01	0.37	0.32	0.58	1.02	0.91
2015	0.81	0.78	0.07	0.42	0.37	0.7	1.16	1.03
2016	0.84	0.79	0.09	0.47	0.29	0.71	1	1.15
2017	0.79	0.72	0.05	0.35	0.19	0.63	1.14	1.19
Netters								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2015–2016	0.94	0.87	0.62	0.96	0.86	1.14	1.22	1.06

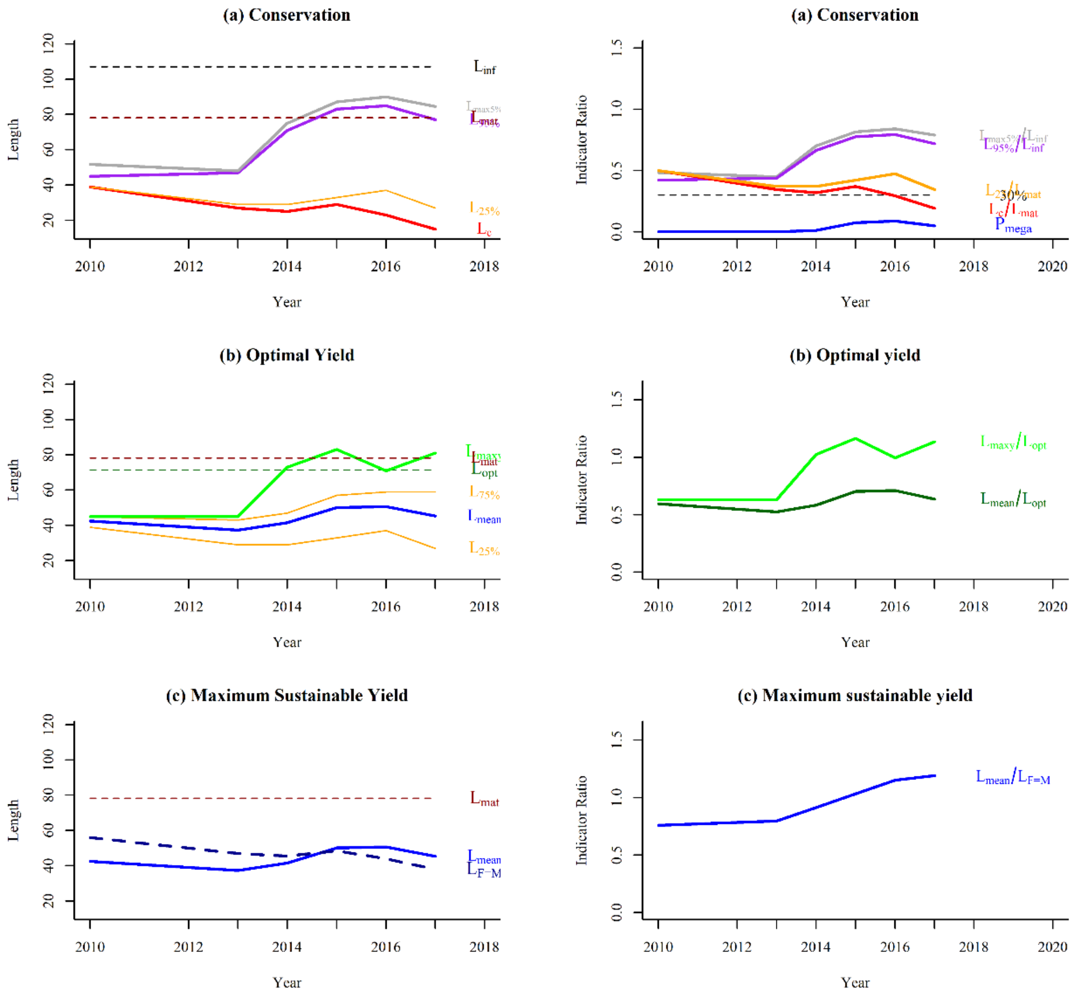


Figure 8: Indicators, reference points and indicator ratios for thornback ray caught by otter trawls in the western English Channel.

Thornback ray *Raja clavata* in the Bristol Channel and Irish Sea (rjc.27.7afg)

Length-frequency data for thornback ray in the Bristol Channel and Irish Sea were analysed for both gillnet and otter trawl métiers. Otter trawls appeared to be the dominant métier catching thornback ray, while data for netters were only available 2016–2017, and therefore combined over this two-year period. Data from beam trawls were not considered. Two runs, using the parameter L_∞ as reported by Holden (1972) and Fahy (1991) respectively, were carried out.

The three fixed reference points (L_∞, L_{mat} and L_{opt}) fell beyond the right tails of the length-frequency distributions in most years (2009–2013; Figure 9), resulting in a perception of 'poor' status for almost all LBI when considering data from the otter trawl fishery (

Table 15). Given that the LBI failed to meet expected values using the lower L_∞ (Holden,1972), increasing L_∞ to a less favourable value had little impact on the status classification.

There were one (Holden L_∞) or two (Fahy L_∞) years where the MSY condition was satisfied even though none of the conservation LBI were. This is because the unfavourable decrease in L_c lowers the MSY reference point $L_{F=M}$ allowing indicator L_{mean} to exceed.

The optimal yield LBI showed gillnets to catch larger fish (Table 16). This was also apparent from LBI relating to large individuals meeting expected values. The larger L_∞ of Fahy (1991) increased the reference points L_{opt} and $L_{F=M}$ which, for the optimal yield LBI, reduced the distance between indicator and reference point and resulted in a switch from 'poor' to 'good' status and, for the MSY LBI, allowed the reference point to exceed the indicator and resulted in a switch from 'good' to 'poor' status.

Key points:

- The length-frequency distribution from otter trawlers changed abruptly during the time series, with a more constrained length range in 2009–2013, and broader length range in 2015–2017. Further studies on these data are required, to better understand whether this is a genuine temporal change in population structure, or an artefact of data collection.

- There were only minor differences in LBI when two different estimates of L_∞ were used.

- Whilst LBI relating to the 'conservation of large individuals' failed to meet expected values, there was an improving status over time for both otter trawl (Figure 10) and gillnet data. LBI for MSY were close to or above the expected values in recent years.

Table 15: LBI for thornback ray in the Bristol Channel and Irish Sea for the otter trawl métier, using the L∞ parameter as reported by Holden (1972, top) and Fahy (1991, bottom)

Otter trawls (Holden asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.5	0.48	0	0.4	0.42	0.54	0.52	0.74
2010	0.53	0.5	0	0.45	0.42	0.59	0.63	0.82
2011	0.49	0.48	0	0.45	0.45	0.59	0.66	0.8
2012	0.49	0.48	0	0.4	0.4	0.54	0.55	0.77
2013	0.51	0.51	0	0.47	0.47	0.61	0.77	0.79
2015	0.72	0.68	0.01	0.29	0.27	0.54	1.02	0.91
2016	0.75	0.7	0.03	0.5	0.35	0.75	0.97	1.14
2017	0.75	0.7	0.03	0.45	0.37	0.7	0.91	1.03
Otter trawls (Fahy asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.47	0.44	0	0.4	0.42	0.5	0.48	0.72
2010	0.49	0.46	0	0.45	0.42	0.55	0.59	0.79
2011	0.45	0.44	0	0.45	0.45	0.55	0.61	0.77
2012	0.45	0.44	0	0.4	0.4	0.5	0.51	0.74
2013	0.48	0.48	0	0.47	0.47	0.56	0.72	0.76
2015	0.67	0.63	0	0.29	0.27	0.5	0.95	0.87
2016	0.7	0.65	0.01	0.5	0.35	0.7	0.9	1.1
2017	0.7	0.65	0.01	0.45	0.37	0.65	0.85	0.98

Table 16: LBI for thornback ray in the Bristol Channel and Irish Sea for the gillnet métier, using the L∞ parameter as reported by Holden (1972, top) and Fahy (1991, bottom)

Netters (Holden asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2016–2017	0.9	0.87	0.63	0.96	0.98	1.18	1.14	1
Netters (Fahy asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2016–2017	0.83	0.81	0.35	0.96	0.98	1.1	1.05	0.97

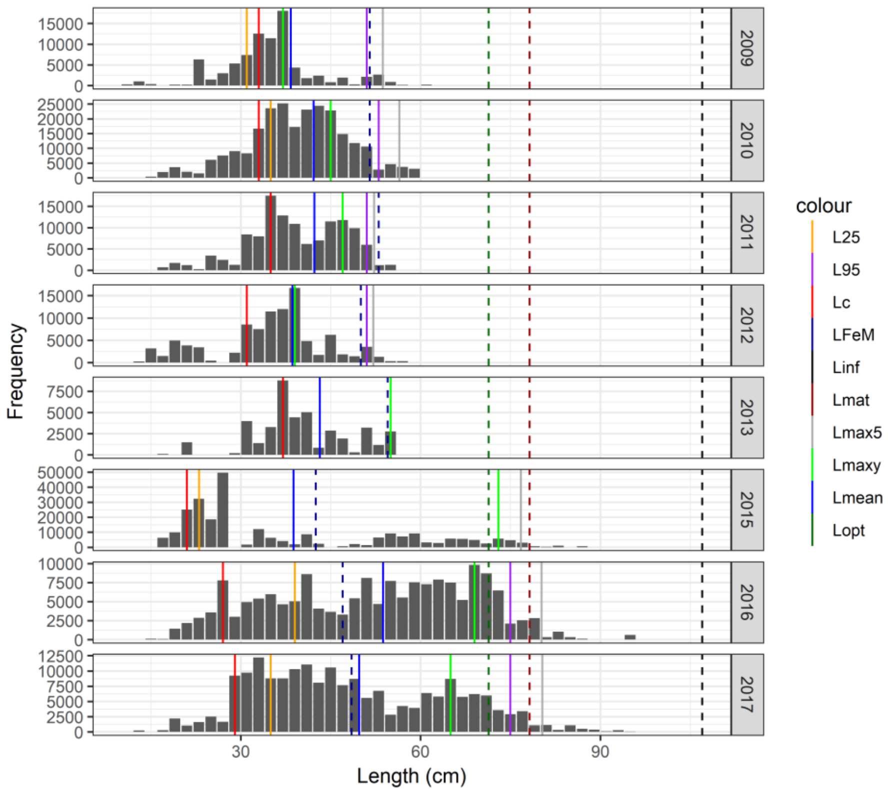


Figure 9: Length-frequency distributions of thornback ray caught by otter trawl in the Bristol Channel and Irish Sea with indicators (solid vertical lines) and reference points (based on Holden *L*∞; dashed vertical lines).

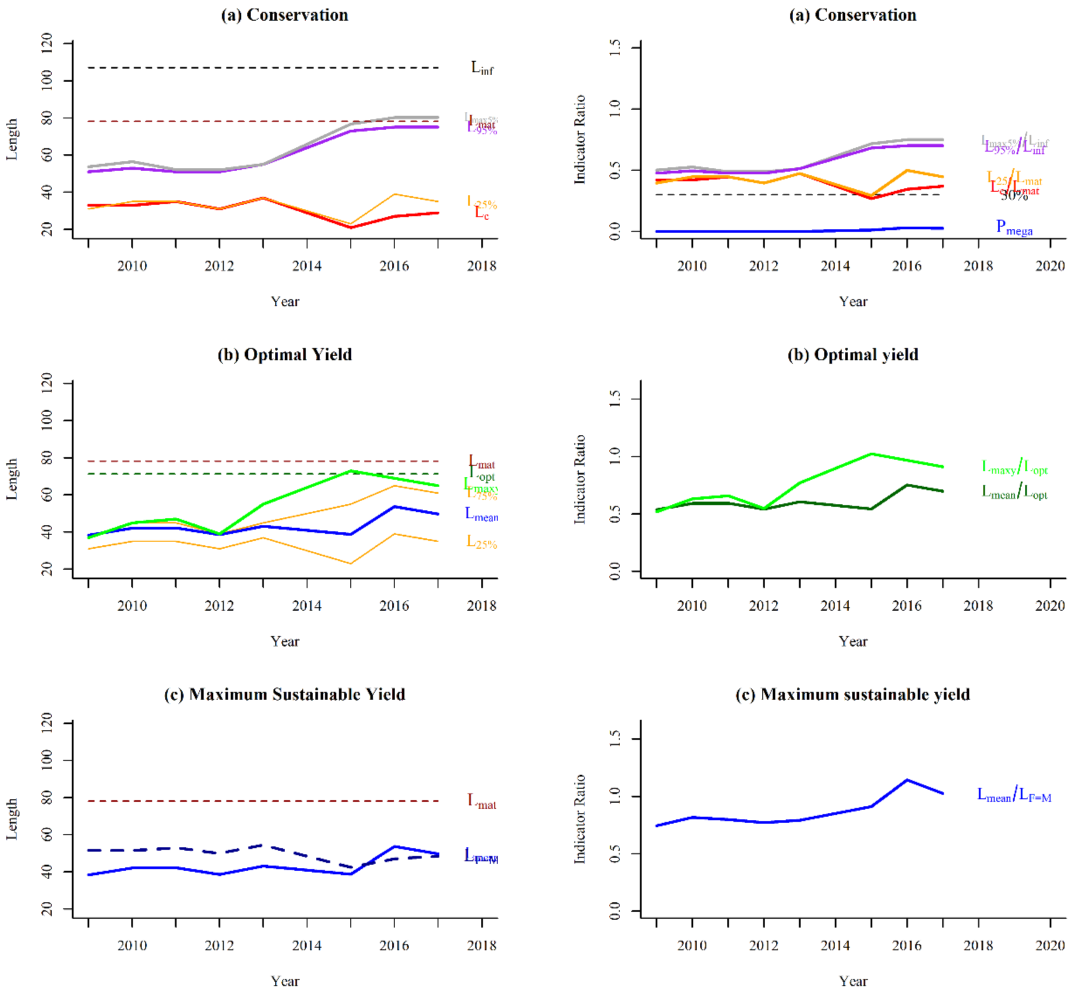


Figure 10: Indicators, reference points (based on Holden $L\infty$) and indicator ratios for thornback ray caught by otter trawls in the Bristol Channel and Irish Sea.

Small-eyed ray *Raja microocellata* in the Bristol Channel (rje.27.7fg)

Length-frequency data for small-eyed ray in the Bristol Channel were analysed for gillnet and otter trawl métiers. Data for netters were available from 2015 onwards. Data from beam trawls were not considered. Two runs, using life-history parameter L_∞ as reported by Ryland and Ajayi (1984) and as estimated from the relationship between L_{max} and L_∞ for other stocks, were carried out, as the L_∞ reported by Ryland and Ajayi (1984) seems biologically implausible.

When using the Ryland and Ajayi (1984) value of L_∞, L_∞ , the two reference points derived from it (L_{opt} and $L_{F=M}$) and L_{mat} fell beyond the right tail of the length-frequency distributions most years (2009–2013; Figure 11) when considering data from the otter trawl fishery, resulting in all LBI failing to meet expected values (Table 17). The optimal yield LBI showed gillnets to catch lager fish that otter trawls, but still below the optimal length range.

The value of L_∞ estimated by Ryland and Ajayi (1984) is considered biologically implausible, hence L_∞ was estimated from the relationship between L_{max} and L_∞ for the other stocks. This lower value of L_∞ resulted in all LBI relating to the conservation of large individuals meeting expectations from 2016 for otter trawls and in all years for gillnets (Table 18). The alternative value of L_∞ also affected the optimal yield and MSY LBI whose reference points L_{opt} and $L_{F=M}$ are calculated from L_∞. The optimal yield LBI showed netters to be targeting above the optimal length and otter trawls mostly below but increasing. L_{mean} for otter trawls increased faster than $L_{F=M}$, so that indicator exceeded reference point in the final two years. MSY conditions were also met for netters in the final two years. Changing L_∞ had no effect on the LBI relating to small or immature individuals.

Key points:

- The only published estimate for L_∞ is biologically implausible. Consequently, an estimated value is used.

- LBIs relating to the 'conservation of large individuals' have met the expected values in recent years for the two gears analysed, with the LBI for MSY close to or above the expected values in recent years.

Table 17: LBI for small-eyed ray in the Bristol Channel for the otter trawl and gillnet métiers using the L∞ *parameter as reported by Ryland and Ajayi (1984).*

Otter trawls (Ryland and Ajayi asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.43	0.4	0	0.58	0.55	0.54	0.58	0.75
2010	0.37	0.36	0	0.47	0.5	0.48	0.49	0.68
2011	0.36	0.34	0	0.47	0.47	0.46	0.45	0.67
2012	0.36	0.36	0	0.42	0.42	0.44	0.45	0.69
2013	0.35	0.33	0	0.5	0.55	0.48	0.47	0.66
2016	0.61	0.61	0	0.81	0.81	0.78	0.8	0.88
2017	0.59	0.58	0	0.63	0.68	0.73	0.78	0.9
Netters (Ryland and Ajayi asypmtotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM

2015	0.59	0.59	0	0.94	0.94	0.83	0.8	0.85
2016	0.63	0.62	0	0.94	0.91	0.86	0.93	0.9
2017	0.62	0.62	0	0.89	0.86	0.82	0.84	0.88

Table 18: LBI for small-eyed ray in the Bristol Channel for the otter trawl and gillnet métiers using an estimated L_∞ parameter.

Otter trawls (estimated asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.64	0.6	0	0.58	0.55	0.81	0.87	0.9
2010	0.55	0.53	0	0.47	0.5	0.71	0.74	0.83
2011	0.54	0.51	0	0.47	0.47	0.68	0.67	0.82
2012	0.54	0.53	0	0.42	0.42	0.66	0.67	0.85
2013	0.52	0.49	0	0.5	0.55	0.72	0.7	0.8
2016	0.91	0.91	0.58	0.81	0.81	1.17	1.19	1.02
2017	0.89	0.86	0.38	0.63	0.68	1.09	1.16	1.07
Netters (estimated asymptotic length)								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2015	0.88	0.88	0.95	0.94	0.94	1.24	1.19	0.98
2016	0.94	0.93	0.96	0.94	0.91	1.29	1.39	1.04
2017	0.93	0.93	0.77	0.89	0.86	1.22	1.26	1.02

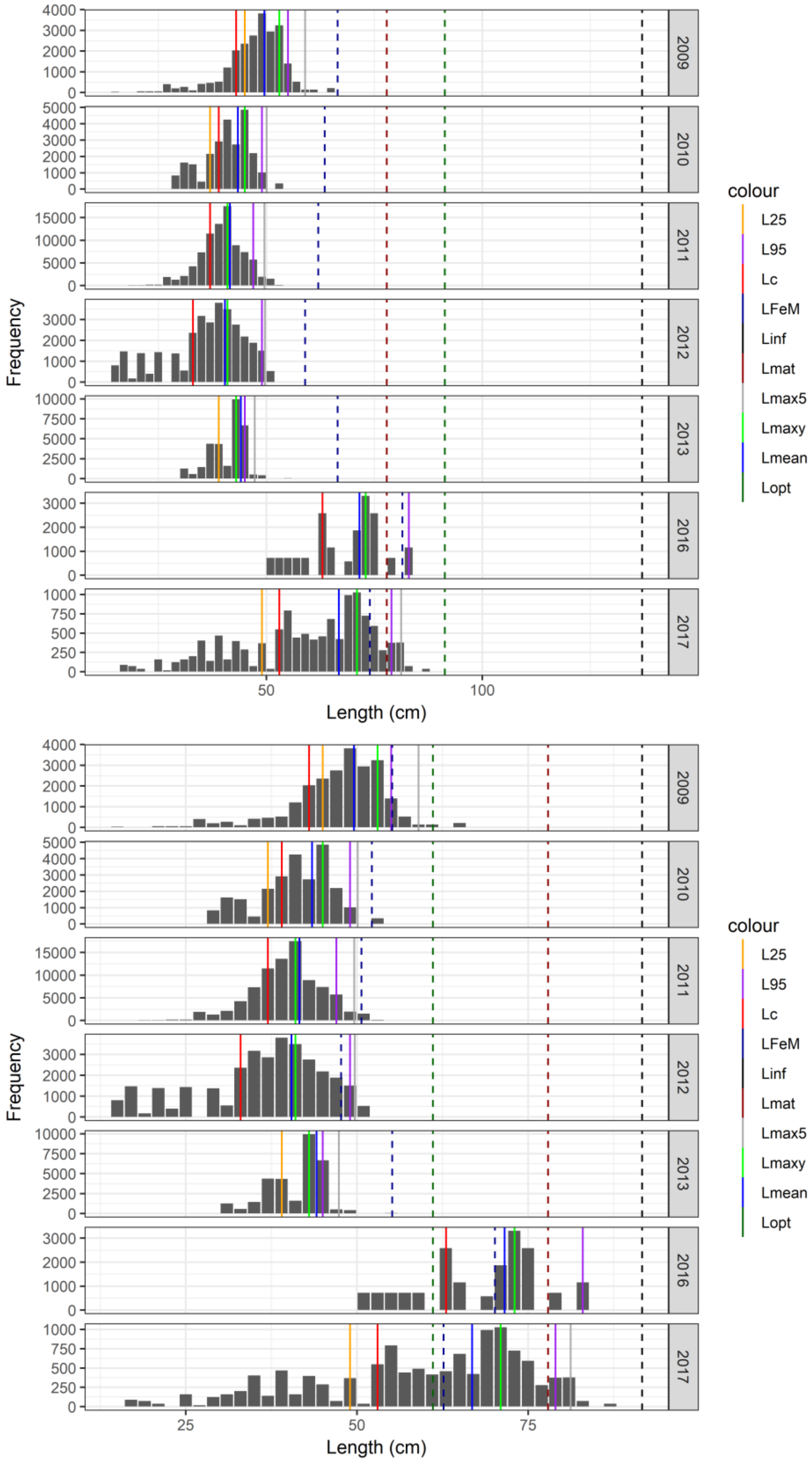


Figure 11: Length-frequency distributions of small-eyed ray caught by otter trawl in the Bristol Channel with indicators (solid vertical lines) and reference points (top based on Ryland and Ajayi $L\infty$ and bottom estimated $L\infty$; dashed vertical lines).

Spotted ray *Raja montagui* in the southern Celtic Sea (rjm.27.7aefg)

Length-frequency data for spotted ray in the southern Celtic Sea were analysed for both gillnet and otter trawl métiers. Otter trawls appeared to be the dominant métier catching spotted ray, while data for netters were only available from 2015 onwards, and were combined over this three-year period. Data from beam trawls were not considered.

When considering data from the otter trawl fishery, the first two LBI relating to the conservation of large individuals increased over the time-series, exceeding the target of 0.8 L_∞ from 2014 and 2015 respectively (Table 19). The indicators relating to small or immature individuals remained relatively stable and below L_{mat} over the time series, but with a sharp drop in L_c in 2016. Optimal yield LBI showed the otter trawl fishery to be mostly targeting the optimal length range, while L_{mean} was relatively stable, exceeding the MSY reference point in some years and not others (Figure 12).

The optimal yield reference point L_{opt} fell on the left tail of the gillnet length-frequency distribution (not shown), resulting in the indication that gillnetters were targeting above the optimal length range. This was also reflected in the indicators for the conservation of large individuals, which exceeded L_∞ (the target is 0.8 L_∞) or 0.3 in the case of P_{mega}. Despite catching larger fish, the gillnet fishery still failed to meet LBI relating to the conservation of small or immature individuals. The MSY condition was met.

Key points:

- As a smaller-bodied species, otter trawl data may be appropriate for examining temporal trends in LBI.
- 2% of the gillnetter length distribution exceeded the reported L_{max} and could have been misidentified blonde ray.
- LBI relating to the 'conservation of large individuals' met the expected values in recent years for the two gears analysed, with the LBI for MSY also close to or above the expected values in recent years.

Table 19: LBI for spotted ray in the southern Celtic Sea for otter trawl and gillnet métiers.

Otter trawls								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.79	0.76	0.09	0.55	0.6	0.92	1.06	0.97
2010	0.71	0.68	0.01	0.58	0.62	0.91	0.94	0.94
2012	0.79	0.76	0.1	0.58	0.55	0.92	0.94	1.02
2013	0.68	0.65	0	0.55	0.55	0.81	0.77	0.9
2014	0.86	0.76	0.06	0.62	0.65	0.95	0.88	0.95
2015	0.96	0.93	0.26	0.6	0.66	1.07	1.31	1.05
2016	0.94	0.91	0.25	0.58	0.47	0.96	0.98	1.16
2017	0.88	0.82	0.09	0.65	0.65	0.95	0.94	0.95
Netters								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2015–2017	1.08	1.01	0.95	0.94	0.9	1.32	1.37	1.06

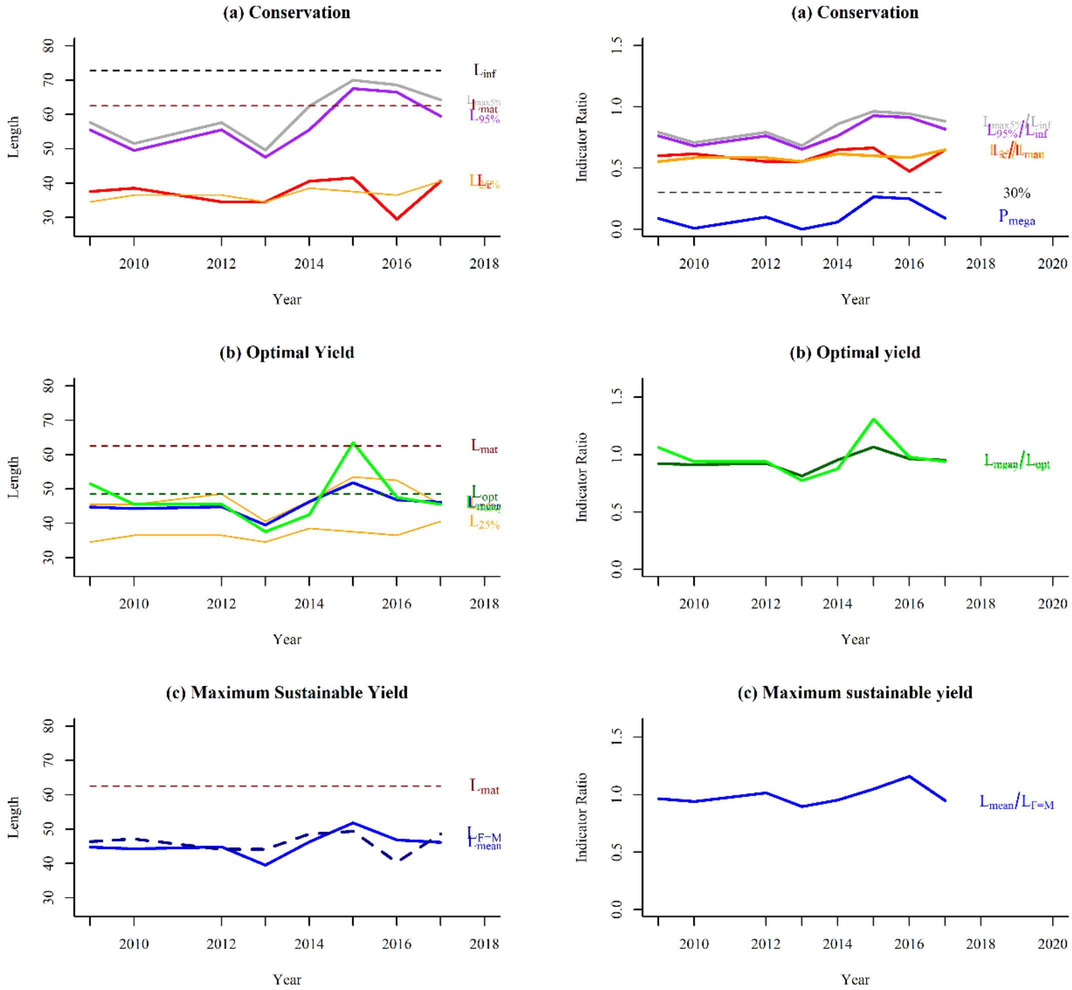


Figure 12: Indicators, reference points and indicator ratios for spotted ray caught by otter trawls in the southern Celtic Sea.

Spotted ray *Raja montagui* in the North Sea and eastern English Channel (rjm.27.347d)

Length-frequency data for spotted ray in the North Sea and eastern English Channel from both gillnet and otter trawl métiers were analysed. Otter trawls appeared to be the dominant métier catching spotted ray, while data for netters are only available for 2014–2016 and were aggregated over this three-year period. Data from other gears, including beam trawls, seines and hook and line, were not considered.

The length-frequency distributions for otter trawls were patchy most years (Figure 13), resulting in fluctuating indictors (Table 20). Aside from the years 2015–2016, where the distributions seem more complete and LBI relating to optimal yield and MSY were met, nearly all LBI failed to meet expected values. Optimal yield LBI showed fishing to be at or below the optimum length range, which was reflected by conservation LBI mostly falling below expected values. The MSY reference point $L_{F=M}$ fluctuated with L_c, with L_{mean} exceeding in few years.

Optimal yield LBI showed netters to be targeting within the optimum length range. Despite this, all conservation LBI apart from $L_{max5\%}/L_{\infty}$ failed to meet expected values. The MSY LBI falls on the threshold for 'good' status classification.

Key points:

- As a smaller-bodied species, otter trawl data may be appropriate for examining temporal trends in LBI.
- LBI relating to the 'conservation of large individuals' generally met the expected values in recent years for the two gears analysed, with the LBI for MSY also close to or above the expected values in recent years.

Table 20: LBI for spotted ray in the North Sea and eastern English Channel for otter trawl and gillnet métiers.

Otter trawls								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2009	0.71	0.7	0.01	0.63	0.54	0.86	0.9	1.01
2010	0.67	0.66	0	0.46	0.46	0.72	0.77	0.92
2011	0.68	0.65	0	0.63	0.66	0.84	0.8	0.87
2012	0.7	0.68	0.01	0.66	0.63	0.85	0.92	0.91
2013	0.47	0.47	0	0.3	0.28	0.38	0.71	0.61
2014	0.75	0.75	0.09	0.58	0.55	0.82	0.96	0.95
2015	0.81	0.78	0.23	0.78	0.74	1.04	1.09	1
2016	0.81	0.8	0.16	0.66	0.46	0.92	1.01	1.19
2017	0.75	0.71	0.03	0.58	0.65	0.85	0.77	0.89
Netters								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2014–2016	0.81	0.8	0.16	0.74	0.71	1.01	1.07	1

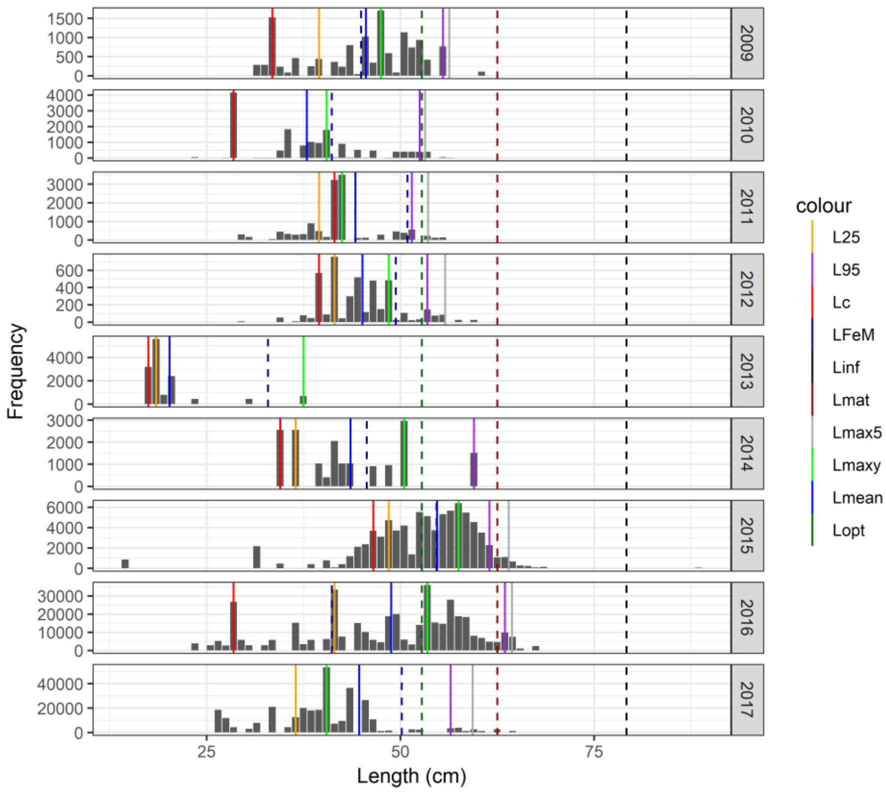


Figure 13: Length-frequency distributions of spotted ray caught by otter trawls in the North Sea eastern English Channel with indicators (solid vertical lines) and reference points (dashed vertical lines).

Undulate ray *Raja undulata* in the English Channel (rju.27.7de)

Length-frequency data for undulate ray in the English Channel were analysed for otter trawl and gillnet métiers. Data from beam trawls were not considered.

When considering length-frequency data from otter trawls, LBI relating to the conservation of large individuals were relatively stable and met expected values. L_c showed a large drop 2014–2016 due to the stronger bi-modality of the length-frequency distributions in those years (Figure 14). $L_{25\%}$ was less affected but showed a similar pattern. This large change in L_c was also reflected in the MSY reference point $L_{F=M}$, calculated as 0.75 L_c + 0.25 L_∞ when M/K is assumed 1.5. The strong contribution of L_c to the MSY reference point means it reacts to changes in the left-hand side of the distribution faster than the mean, resulting in a switch from 'good' to 'poor' MSY status during these years.

Combining otter trawl data over all years still resulted in a bimodal length frequency distribution with L_c falling on the first mode (Figure 15). This low value of L_c results in a low value of the MSY reference point $L_{F=M}$ and hence an optimistic MSY status.

Changes in the LBI calculated for the gillnet fishery (

Table 21) were likely due to data collection and raising. Prior to 2016 each length-frequency distribution appeared to capture different portions of the length spectrum, while the 2016–2017 data showed higher catch numbers and a fuller range of lengths skewed to the right (Figure 16). The single mode and L_c remained relatively stable while the mean reacted to the low number of individuals being introduced in the left tail, resulting in L_{mean} being more reactive than $L_{F=M}$ in this case.

Combining gill net data over all years resulted in the overall mode also containing L_c (Figure 17). This higher L_c resulted in one 'good' status in relation to the conservation of small or immature individuals, but also raised the value of the MSY reference point $L_{F=M}$ and resulted in a 'poor' MSY status.

Key points:

- As a larger-bodied species, gillnet data may be more appropriate for examining temporal trends in LBI, providing that sufficient data are available.

- There were major differences in the length-frequency distribution between years, with data for 2014 dominated by smaller fish than in the other years. This may be due to differences in the dominant mesh sizes being used during observer trips.

- Whilst the annual length-frequency distributions observed in otter trawl data were slightly more consistent, there was bimodality and inter-annual variation in the modal length (which was higher in 2013 and 2017, and much lower in 2015 and 2016). This resulted in large changes in L_c which would then influence subsequent indicators.

- The underlying data for this species may be limited, or there may be differences in fisher behaviour, as to whether they were operating on grounds where adult or juvenile undulate ray occur.

Table 21: LBI for undulate ray in the English Channel for otter trawl and gillnet métiers.

Otter trawls								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2013	0.85	0.84	0.46	0.67	1.02	1.19	1.19	0.97
2014	0.84	0.84	0.39	0.67	0.61	0.99	1.19	1.13
2015	0.85	0.84	0.35	0.61	0.55	0.93	1.19	1.11
2016	0.86	0.84	0.32	0.61	0.61	0.94	1.26	1.07
2017	0.85	0.84	0.58	0.9	1.02	1.19	1.19	0.97
2013–2017	**0.85**	**0.84**	**0.42**	**0.67**	**0.61**	**1**	**1.19**	**1.14**
Netters								
Year	Lmax5_Linf	L95_Linf	Pmega	L25_Lmat	Lc_Lmat	Lmean_Lopt	Lmaxy_Lopt	Lmean_LFeM
2012	0.82	0.79	0.79	1.02	1.02	1.16	1.19	0.95
2014	0.61	0.45	0.02	0.38	0.38	0.49	1.19	0.71
2015	0.86	0.84	0.85	1.02	1.02	1.18	1.13	0.97
2016	0.85	0.84	0.58	0.84	0.96	1.17	1.19	1
2017	0.84	0.84	0.68	0.96	0.96	1.16	1.13	0.99
2013–2017	**0.84**	**0.84**	**0.59**	**0.9**	**1.02**	**1.18**	**1.19**	**0.97**

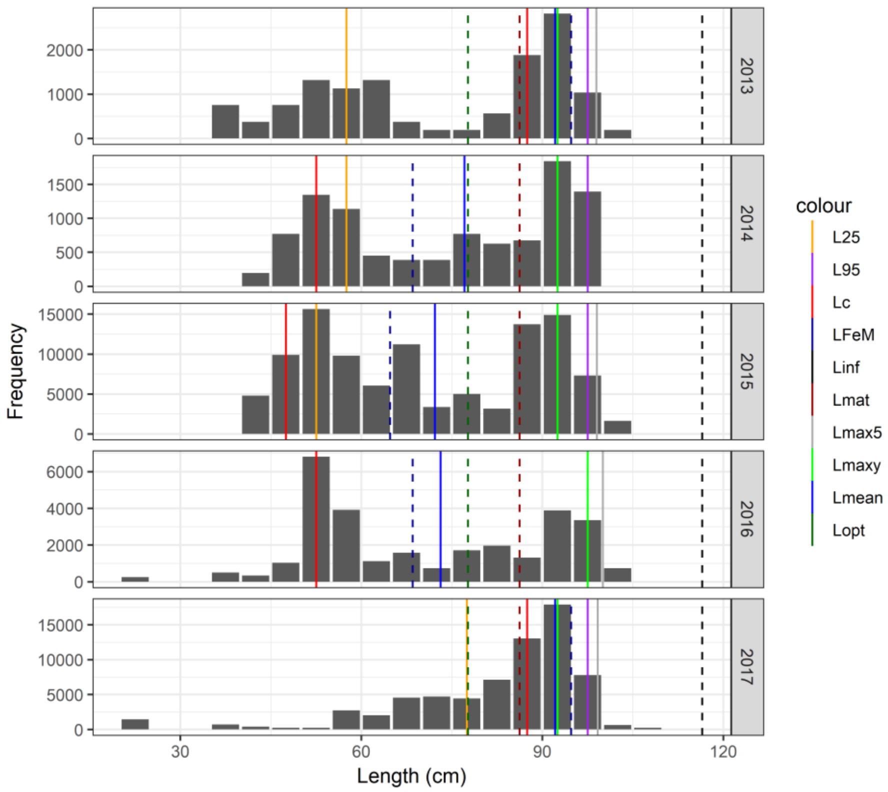


Figure 14: Length-frequency distributions of undulate ray caught by otter trawls in the English Channel with indicators (solid vertical lines) and reference points (dashed vertical lines).

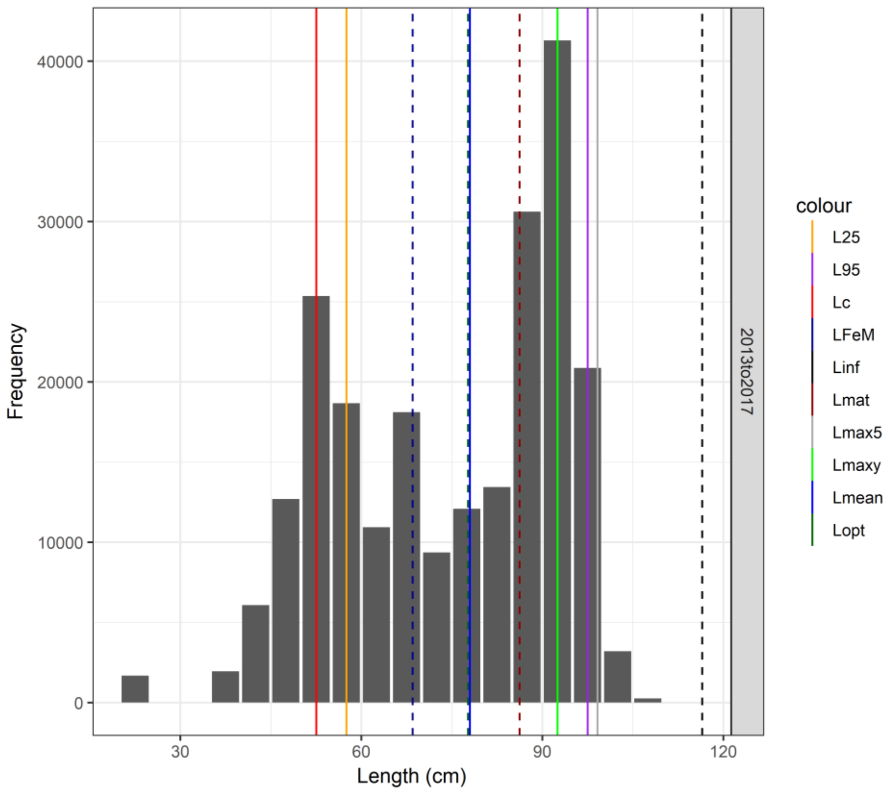


Figure 15: Length-frequency distributions of undulate ray caught by otter trawls (all years combined) in the English Channel with indicators (solid vertical lines) and reference points (dashed vertical lines).

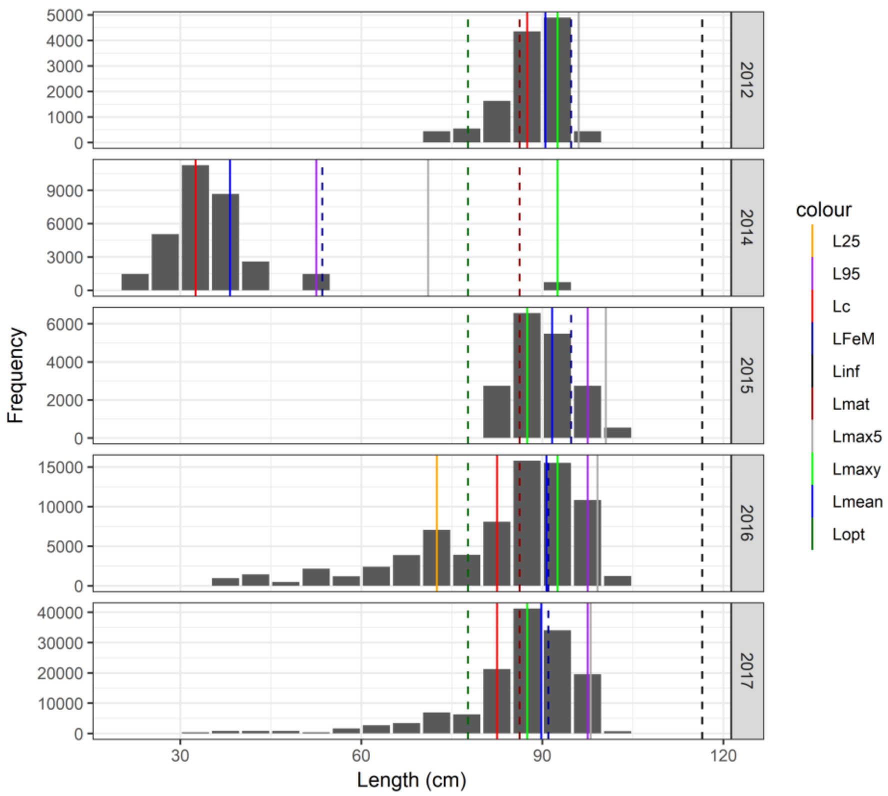


Figure 16: Length-frequency distributions of undulate ray caught by gillnets in the English Channel with indicators (solid vertical lines) and reference points (dashed vertical lines).

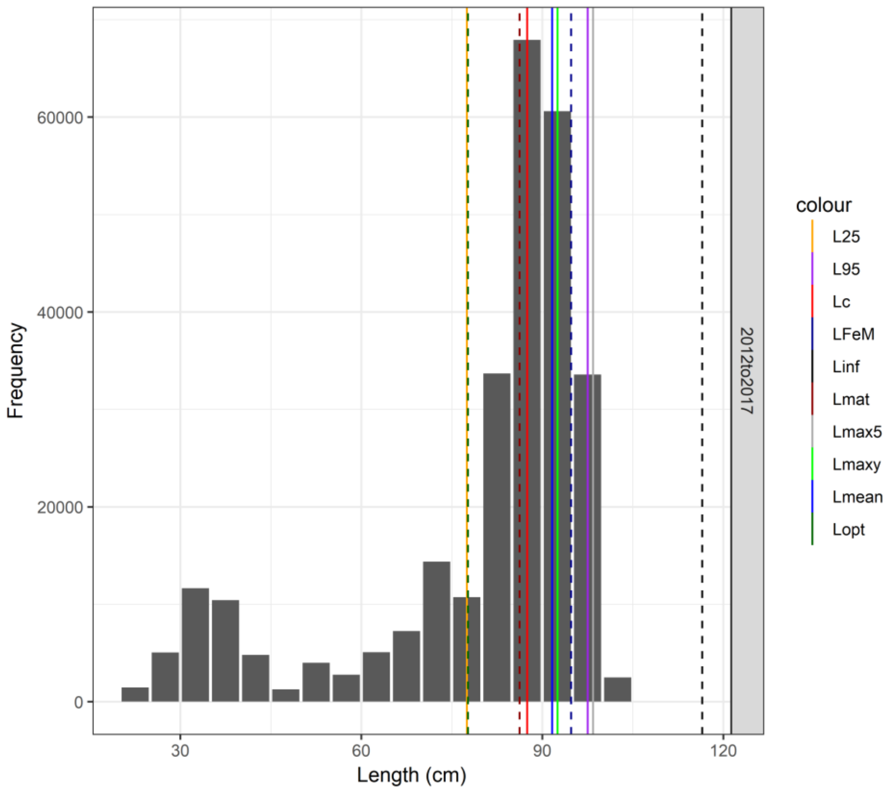


Figure 17: Length-frequency distributions of undulate ray caught by gillnets (all years combined) in the English Channel with indicators (solid vertical lines) and reference points (dashed vertical lines).

DISCUSSION

As with all models, the quality of the input data will influence the quality of the results. Using the data from the UK England and Wales Observer at Sea program, it is likely that there may have been some issues regarding the raising factors. There appeared to be several cases within the available data where certain length classes may have been over represented. This becomes particularly problematic when calculating LBI's that are reliant on such length-frequency data.

There were also some issues relating to having sufficient data with which to draw robust conclusions. For several species sampled in the UK England and Wales Observer at Sea program, it was necessary to combine the results from gears, or collate data across several years to apply the model. In doing so, using trends in LBIs to draw conclusions on the effect of fishing will be problematic, unless this collation of data is applied consistently over longer time periods (e.g. every two years over a period of 10 years or more).

In addition to issues of raising factors from variable sample sizes, there are potential issues in relation to the spatial, temporal variability and range of vessels that have been sampled over time. This is particularly relevant to elasmobranchs, which often show sex- and size-based aggregations and segregation. Future studies could usefully examine the raw data to determine whether a more consistent subset of the data (e.g. in terms of fleet, fishing ground and seasonal coverage) can give a more reliable temporal source of standardised data with which to examine temporal change (i.e. minimising potential bias from spatial, temporal and gear related differences in the data). In the present study, data for gillnets were aggregated, and future studies should better examine data for 'target' skate and ray netters (which use tangle and trammel nets with larger mesh sizes) and other netters (e.g. smaller mesh sole nets) which generally take smaller skates as a bycatch.

If the application of LBIs requires a more consistent data set (at least for some species), then there may need to be consideration of a "reference fleet" to allow for the collection of more standardised length composition data. The selection of the most appropriate data collection programmes (e.g. scientific trawl surveys, market sampling, at-sea sampling; Table 22) also needs due consideration.

The current ICES assessments for the case study species are generally based on survey trends (Category 3), and so the utility of LBIs to provide additional demographic information when evaluating stock status is a potentially useful tool for managers. It should also be noted, however, that spatial metrics for such stocks may also be informative. Further analyses of spatial information may also inform on the most reliable sources of observer data for the better refinements of input data for LBIs.

The estimation of L_c will impact MSY status, as RP $L_{F=M}$ is calculated from L_c (Table 2). This can be seen in the time series plots presented. Low estimations of L_c will lower the value of $L_{F=M}$ which will in turn increase the ratio $L_{mean}/L_{F=M}$, potentially giving over-optimistic MSY status. This appeared to be evident for both shagreen and thornback ray stocks in some years, where MSY status was considered 'good', despite the failure of other LBIs to meet the expectations of a 'healthy' stock.

Another potential reason for the contradiction between the conservation and MSY LBIs for some stocks is the value of the M/K ratio. In the absence of natural mortality estimates, a default value of 1.5 was used. This value is typical of teleost stocks and thought to be different across different taxa and life-histories. As such, the contradiction between the conservation and MSY LBIs could be an indication that the contribution of L_c and L_∞ to the MSY reference point (75% and 25% respectively; Table 2), and therefore the value of the M/K ratio, is not right.

Application of the LBIs revealed inconsistencies in status between indicators describing the same properties when applied to the same data. There was a tendency for L_{maxy} to be higher than L_{mean}, sometimes giving conflicting status when describing optimal yield in the traffic light assessment and showing diverging trends for shagreen ray. This could be due to the inclusion of weight information when calculating L_{maxy}. Consideration should be given to which indicator is most appropriate for the species (and fishery).

There were some cases where the traffic light assessment revealed too low a proportion of mega spawners, even when indicators compared to L_∞ revealed a healthy presence of large individuals (e.g. cuckoo and spotted rays in the Celtic Sea). The expectation that $P_{mega} > 0.3$ assumes asymptotic selection. If selection is dome-shaped then lower values of P_{mega} are desirable, following the fishing strategy where no mega-spawners are caught. Hence, due consideration should be given to fishery selection when defining appropriate reference points.

Given the large size of elasmobranchs and the late age at maturity, LBI based on length at first capture (L_c and $L_{25\%}$) invariably highlight that this occurs before fish mature. It is considered unlikely to have a mixed fishery that captures elasmobranchs to meet these indicators, and a simulation study suggests targeting a few year classes of immatures to be a more robust strategy for elasmobranchs (Prince, 2005). This is also reflected in our study because the RP L_{opt} was calculated to be below RP L_{mat} for most of the stocks we considered (noting that L_{opt} was calculated assuming M/K is 1.5). The RPs adopted by ICES were derived primarily for teleost and shellfish stocks (Froese, 2004; Miethe and Dobby, 2015). It is likely that these RPs and/or their expected values will need to be adjusted for fishes with contrasting life-histories (e.g., Shephard *et al.*, 2018).

The current case studies often provided mixed results from the various LBIs, and so there could be consideration of having more categories than red/green, and consideration of trend-based metrics until appropriate reference points are validated.

Furthermore, it should be recognised that there is a degree of uncertainty in some life-history parameters (e.g. L_∞). Some published age and growth studies have provided values that are biologically implausible, and may be artefacts of low sample size of larger (older) fish and/or uncertainty in age determination. There are also instances when multiple studies have provided very different estimated parameters for the same stock, which could be due to methodological or temporal differences, or artefacts of sample sizes. Results from the present study indicate that the selection of L_∞ can influence the results and on subsequent perceptions of status. Consequently, there needs to be further studies to allow the most appropriate life-history parameters to be selected.

Table 22: Advantages and disadvantages of underlying data relevant to LBIs

Feature	Market sampling data	At-sea observer programmes	Fishery-independent trawl surveys
Data representative of stock area	In theory, data from market sampling should allow for data to be collected from fisheries operating within the stock area.	In theory, data from at-sea observer programmes should collect data from the wider stock area. However, vessel and trip selection was not designed specifically for skates, and the random selection of observer vessels could result in artefacts in LBIs.	Trawl surveys sample the wider stock area for some species, with a similar year-to-year spatial coverage.
Data from the whole length range (selectivity)	Data from market sampling would only provide data from the landed part of the stock, and not all the exploited part of the population. Data may be appropriate for examining those LBIs relating to adults, but data may be less informative for immature fish, as such length groups may be discarded. Some fisheries may land skates as wings only, which may preclude the accurate measurements of total length.	Data from commercial gears should sample the exploitable population effectively, thus enabling LBI to assess the exploitation status. Whilst data for smaller fish (that may be discarded) can also be collected, some commercial gears may not catch the smallest life-history stages effectively, which may affect whether data are suitable for informing on the length structure of the overall population. Different gears will have different selectivity patterns. Beam trawls, for example, may not catch larger skates effectively, therefore not meeting the assumption of asymptotic selection. Data for gillnet fisheries may be influenced by any differences in the dominant mesh sizes used in observed trips, and future studies should consider treating larger-mesh and smaller-mesh gillnets separately.	Data from trawl surveys generally sample smaller length categories more effectively than larger size categories. Hence, the model assumption for asymptotic selectivity may not be met for larger-bodied skate species (e.g. blonde ray, common skate). Data for smaller-bodied skate species (e.g. cuckoo ray and spotted ray) may cover the full length-range, and so may allow analyses of LBI pertaining to the underlying population status (which may not equate fully with the 'exploited population'). Data from trawl surveys may not be representative for LBIs for MSY and optimum catch.
Data from consistent source	Routine market sampling at important fishing ports for skates	The random selection of vessels and trips might result in inconsistent data (in terms of seasonality, gear selectivity,	Data from trawl surveys should theoretically be better placed to provide

Feature	Market sampling data	At-sea observer programmes	Fishery-independent trawl surveys
	should allow for representative data to be collected in a consistent manner.	survey coverage etc.). This may not be an issue for commonly occurring species in major fisheries (e.g. cuckoo ray in trawl fisheries), but may be an issue for some localised species/fisheries. Net fisheries may use a range of mesh sizes, which can have very different selection patterns for skates.	consistent data (in terms of spatial coverage, gear selectivity and seasonal coverage) to monitor temporal change.
Sample sizes and raising factors	Commercial landings of skates would be expected to allow for large sample sizes, especially in ports for which skates are either target or important bycatch species. The need to subsample would vary on quantities of fish (all species) to be processed, and the need to minimise disruption to normal market activities. Depending on sampling procedures, sub-sampling may impact on the accuracy of data, depending on whether all species and size categories have been landed appropriately.	Commercial catches of skates would be expected to allow for large sample sizes, especially in fisheries for which skates are either targeted or an important bycatch. Given the nature of catches, more limited staffing, and need to process catches in a timely manner (so as to minimise disruption to the activities of the vessel), there can often be a need to sub-sample catches. Depending on catch sampling procedures, sub-sampling may impact on the accuracy of data.	Trawl catches of skates are generally small, so sample sizes can be limited. In most instances, skate catches would be expected to be fully processed on research vessel surveys, and so not subject to (extreme) raising factors.
Species identification	Some fisheries may land skates as either wings or skinned wings. The type of processing determines whether accurate species	Observer trips generally have individual staff working regionally. Whilst experienced with the more frequent species occurring on their normal fishing grounds, there may be less experience with species from other areas (e.g. vagrants).	Trawl surveys generally have multiple staff experienced with species identification. There would also be more time available

Feature	Market sampling data	At-sea observer programmes	Fishery-independent trawl surveys
	identification can be recorded. There is a requirement to report skates to species-level, but some similar-looking species may be combined and landed by size.	There may be less time during catch processing to better examine any specimens for which identification was uncertain.	during catch processing to better examine any specimens for which identification was uncertain.
Impacts of management	Some fisheries management measures relating to skates (e.g. prohibited listings for certain species or restrictive fishing opportunities) may influence commercial fishing activities. This would impact on the representativeness of market-sampling data.	Some fisheries management measures relating to skates (e.g. prohibited listings for certain species or restrictive fishing opportunities) may influence commercial fishing activities, thereby potentially influencing the amount and representativeness of observer data.	Trawl surveys not influenced by fisheries management measures relating to skates.

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Appendix: Length frequency plots for case study stocks

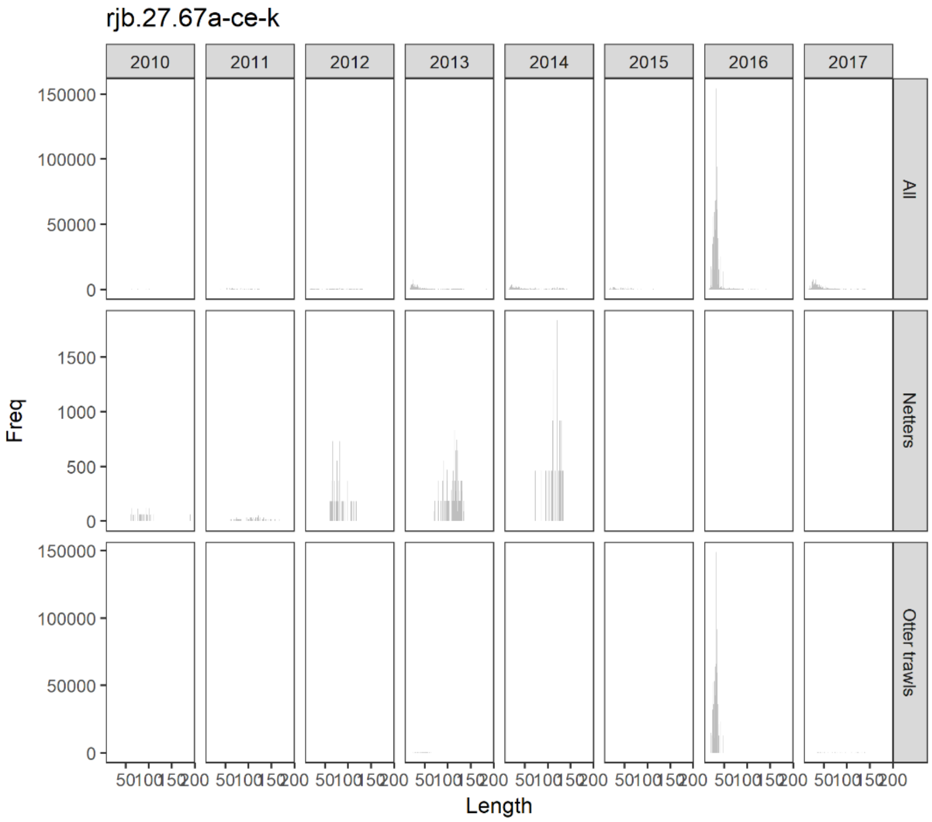

Figure A1: Length-frequency plots for common skate complex in the Celtic Sea showing landings (grey) and discards (black).

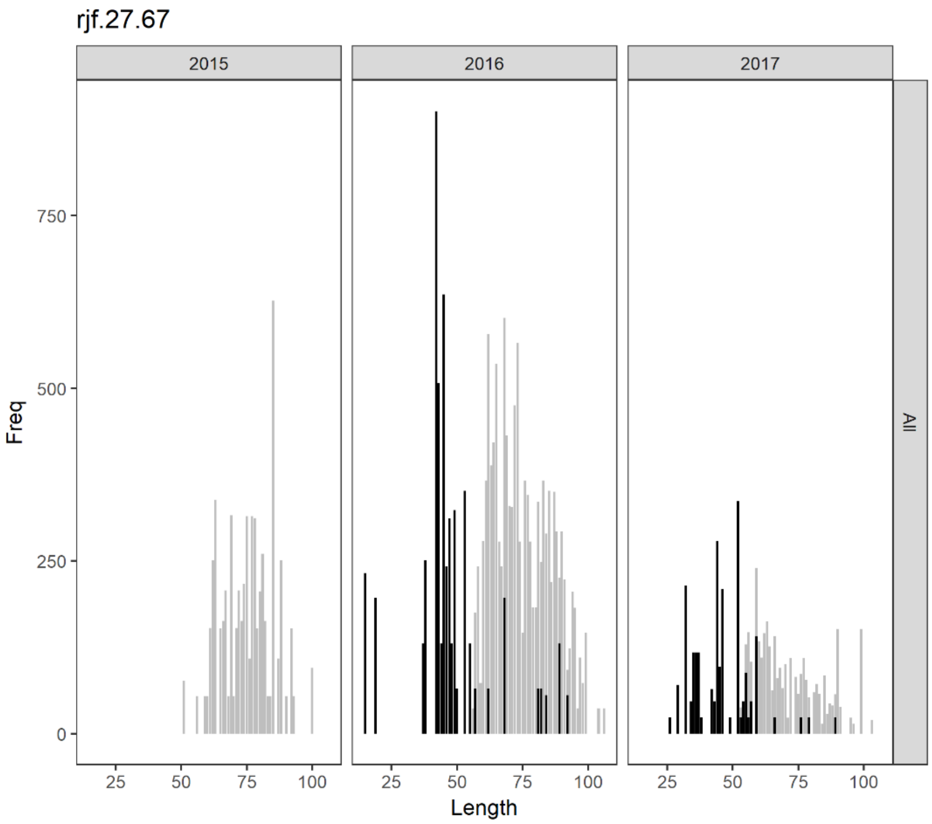

Figure A2: Length-frequency plots shagreen ray in the Celtic Sea showing landings (grey) and discards (black).

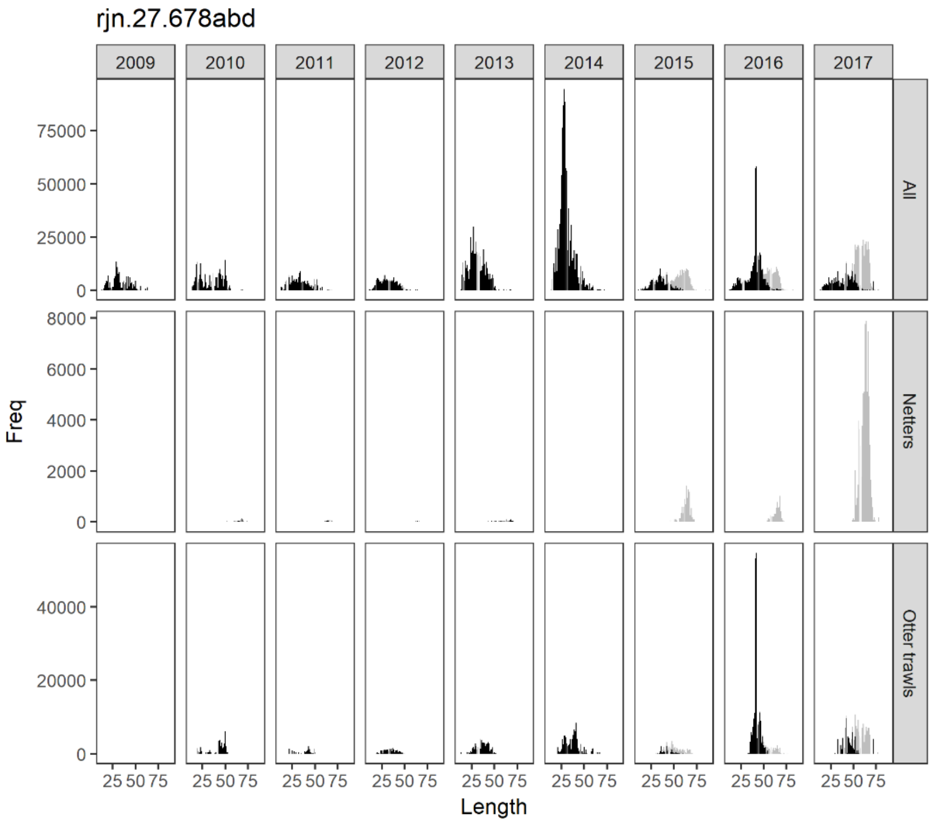

Figure A3: Length-frequency plots for cuckoo ray in the Celtic Sea and Bay of Biscay showing landings (grey) and discards (black).

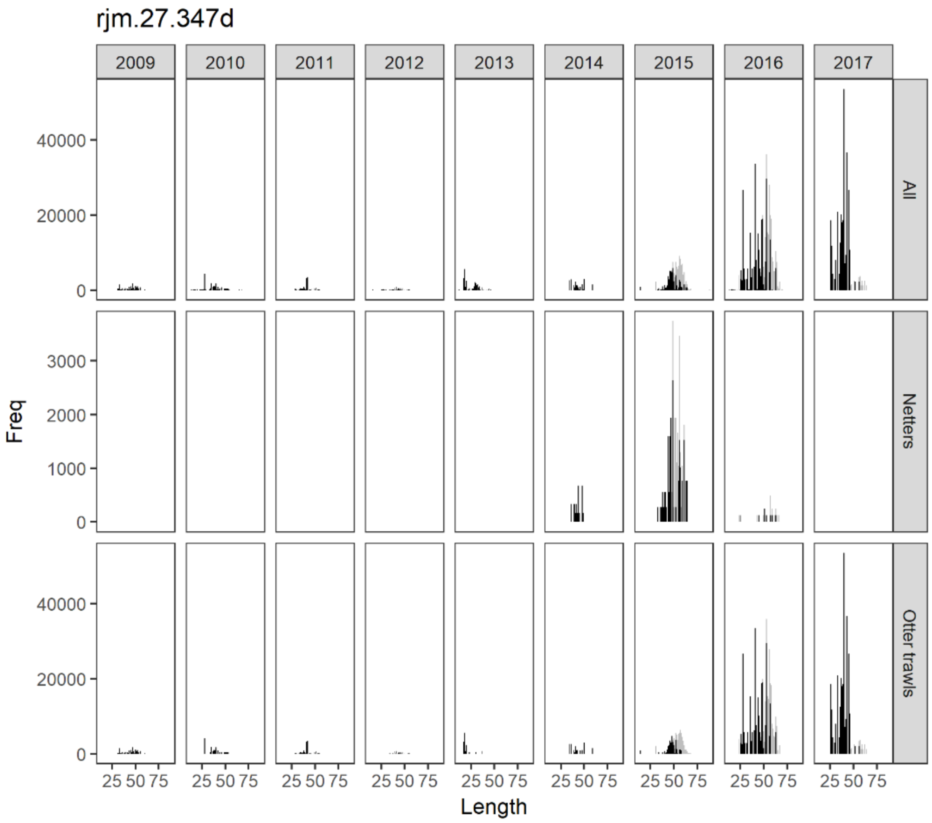

Figure A4: Length-frequency plots for cuckoo ray in the North Sea showing landings (grey) and discards (black).

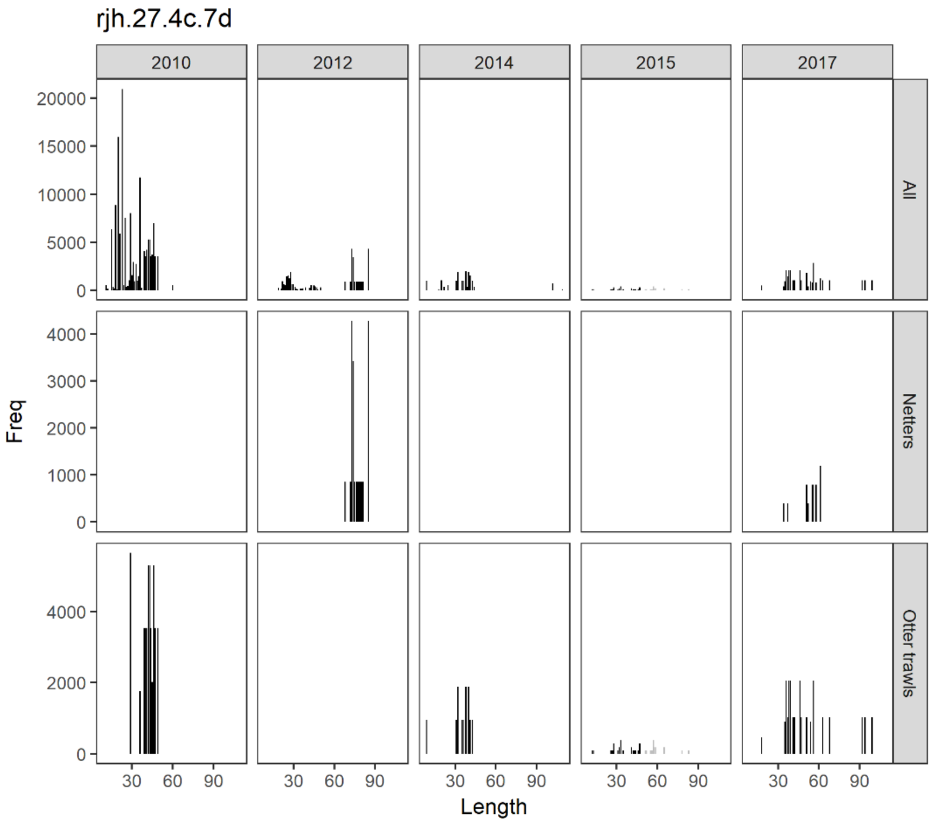

Figure A5: Length-frequency plots for blonde ray in the southern North Sea and English Channel showing landings (grey) and discards (black).

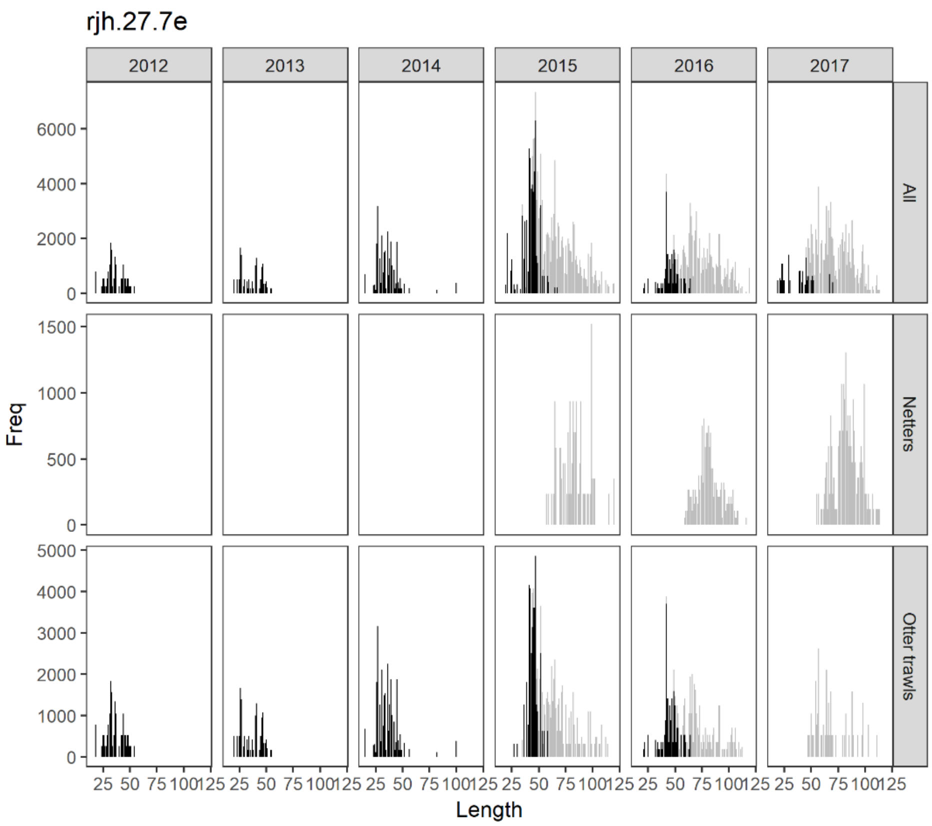

Figure A6: Length-frequency plots for blonde ray in the western English Channel showing landings (grey) and discards (black).

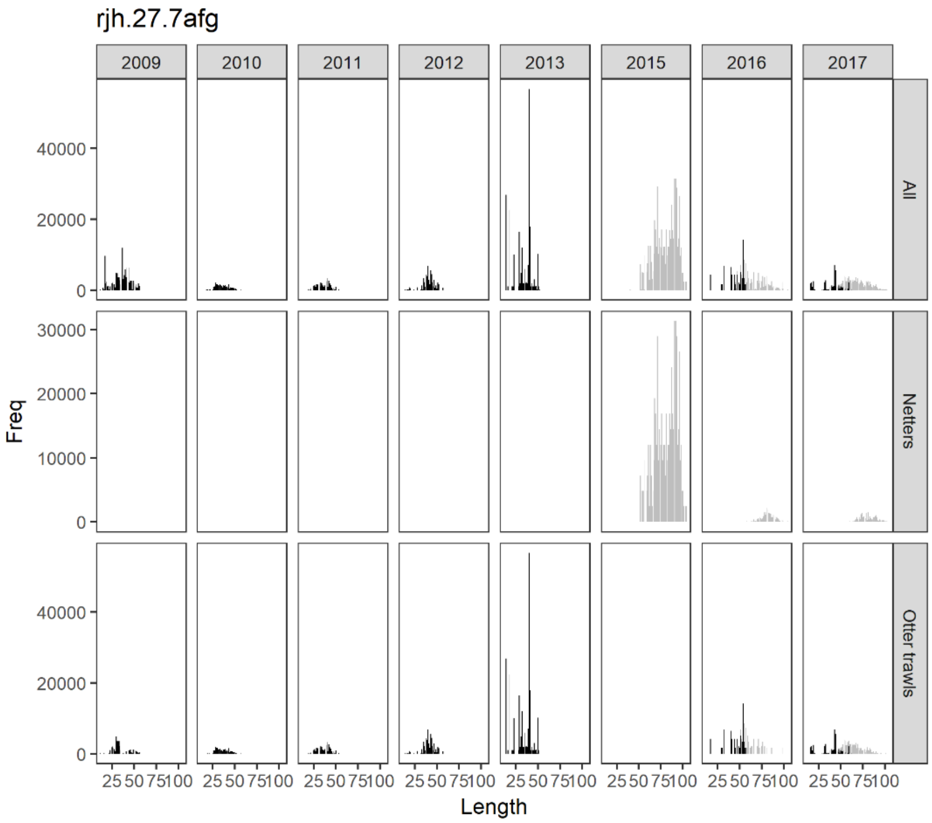

Figure A7: Length-frequency plots for blonde ray in the Bristol Channel and Irish Sea showing landings (grey) and discards (black).

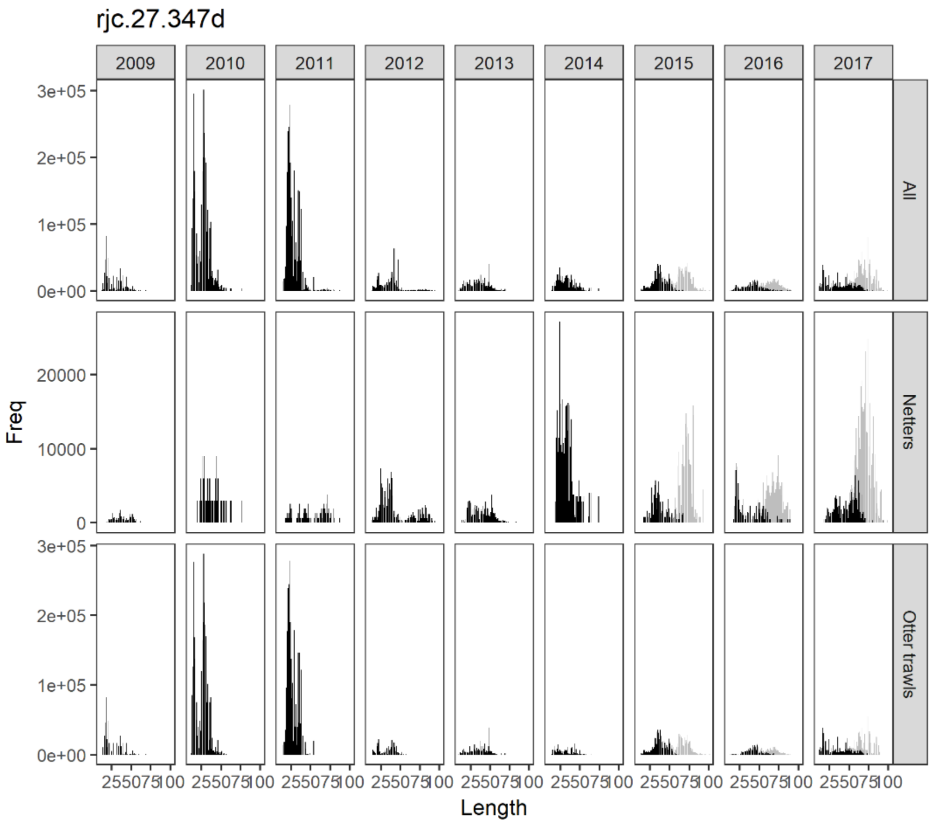

Figure A8: Length-frequency plots for thornback ray in the North Sea and eastern English Channel showing landings (grey) and discards (black).

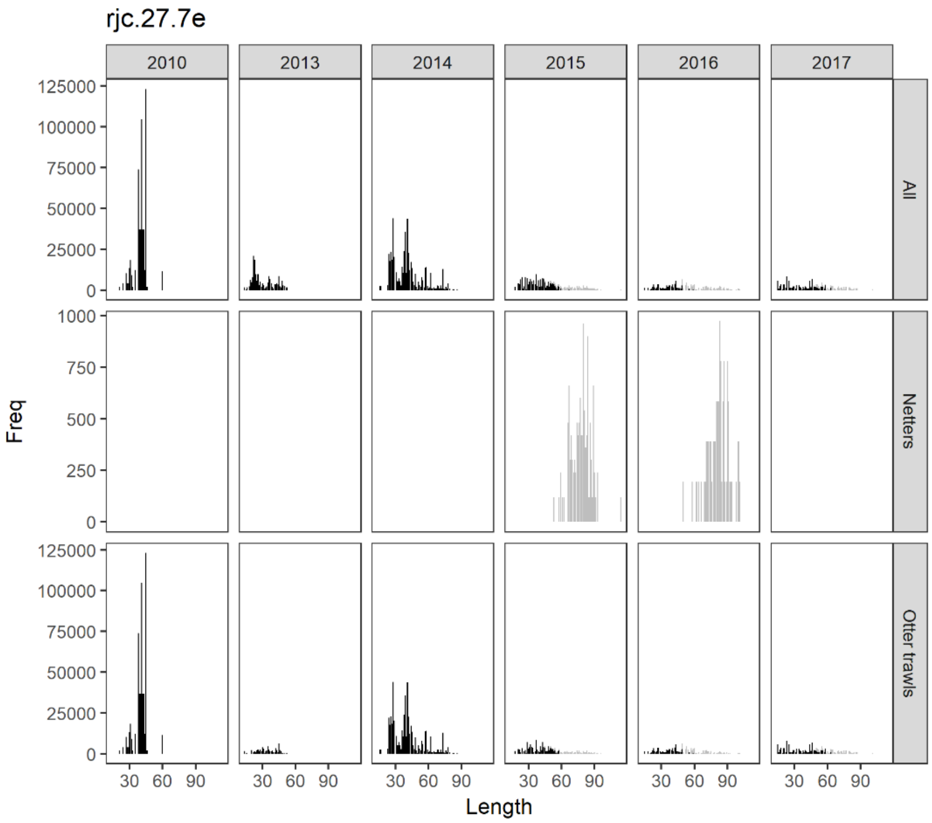

Figure A9: Length-frequency plots for thornback ray in the western English Channel showing landings (grey) and discards (black).

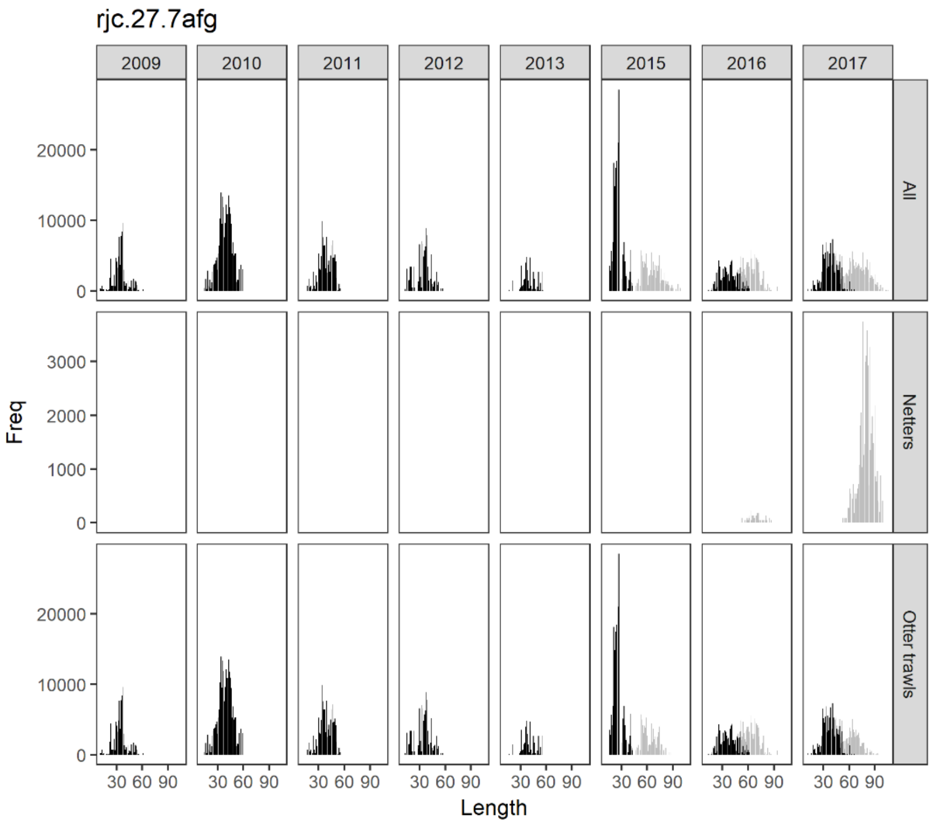

Figure A10: Length-frequency plots for thornback ray in the Bristol Channel and Irish Sea showing landings (grey) and discards (black).

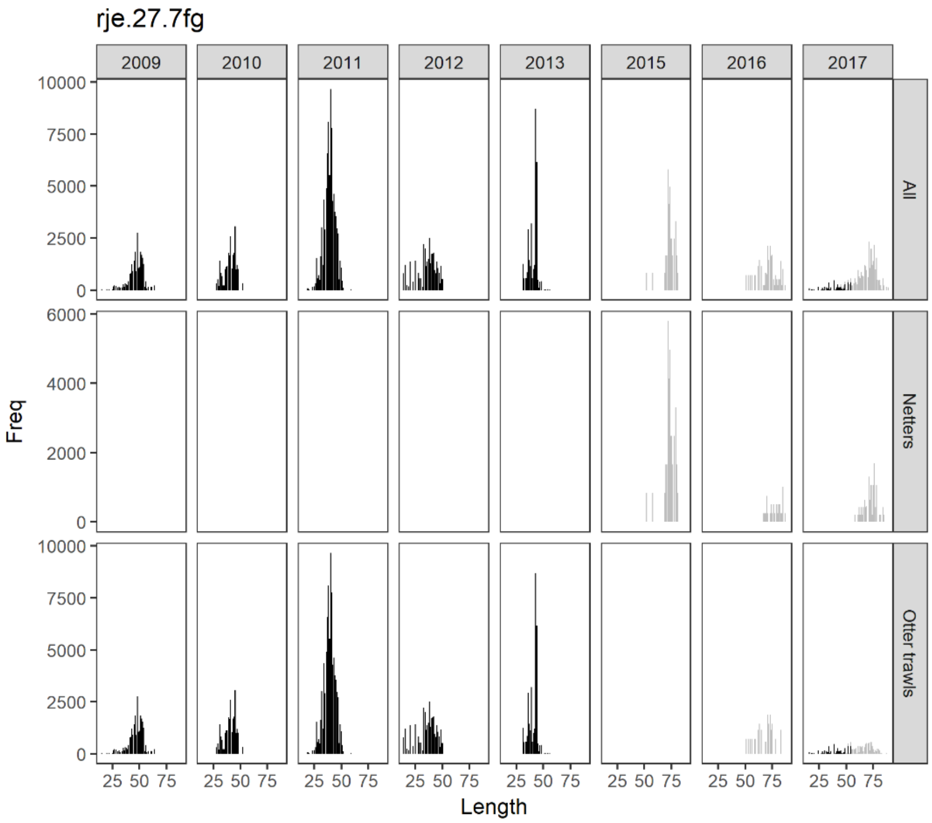

Figure A11: Length-frequency plots for small-eyed ray in the Bristol Channel showing landings (grey) and discards (black).

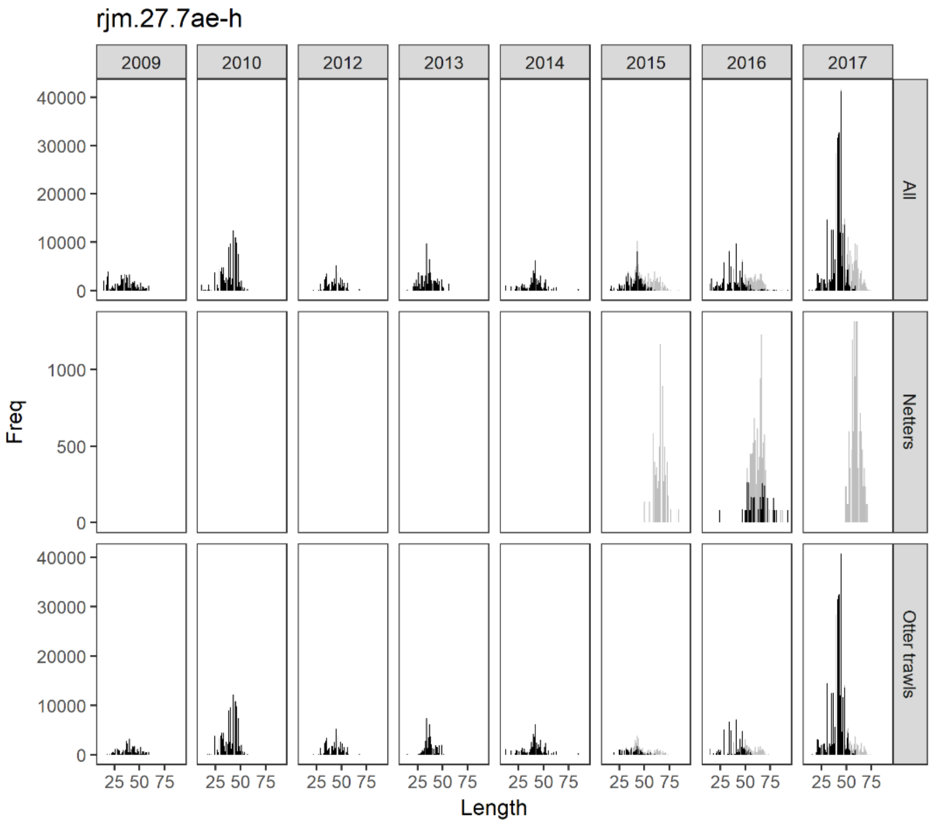

Figure A12: Length-frequency plots for spotted ray in the southern Celtic Sea showing landings (grey) and discards (black).

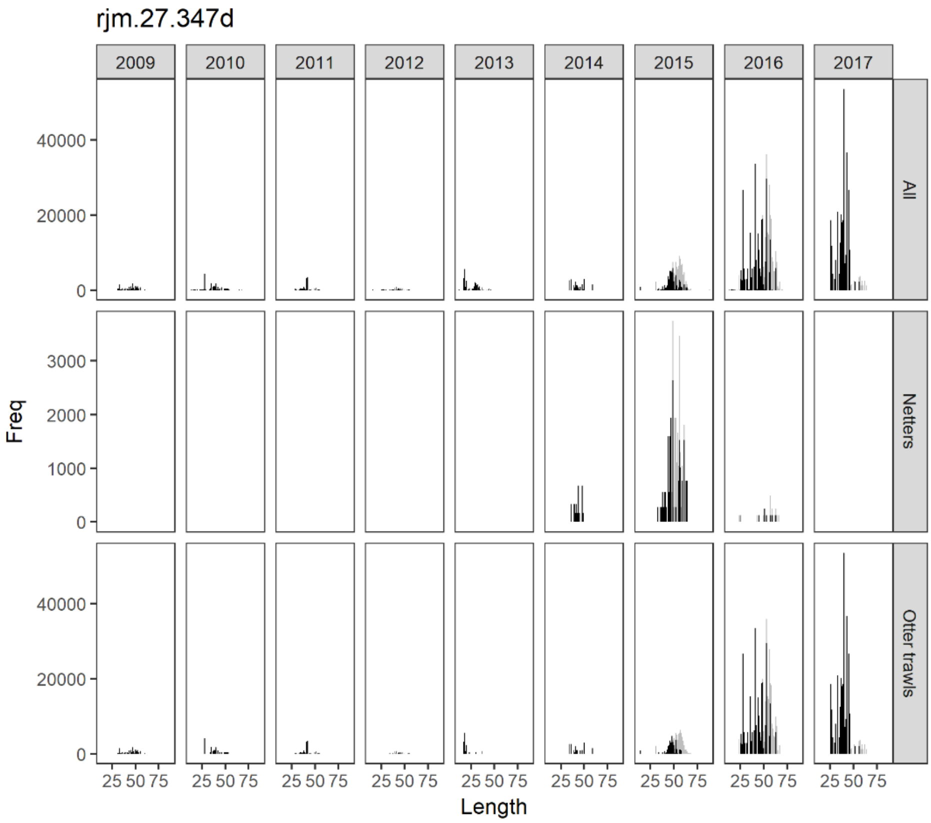

Figure A13: Length-frequency plots for spotted ray in the North Sea and eastern English Channel showing landings (grey) and discards (black).

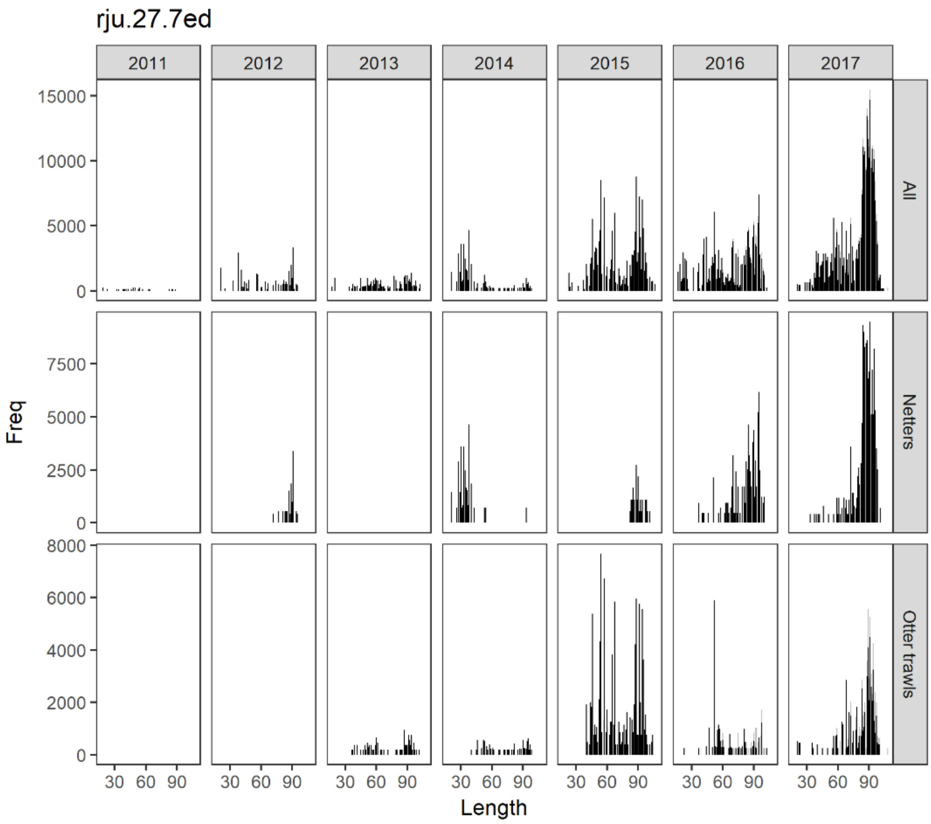

***Figure A14**: Length-frequency plots for undulate ray in the English Channel showing landings (grey) and discards (black).*

Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 19–28 2018

Common thresher shark *Alopias vulpinus*: A preliminary bibliography of scientific studies

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Abstract: In relation to the term of reference on collating biological and fishery data on thresher sharks in the Atlantic, a preliminary bibliography of scientific papers on the common thresher shark *Alopias vulpinus* was collated. Whilst few scientific studies are available for the North-east Atlantic, the stock in the eastern Pacific Ocean is better studied.

A preliminary bibliography of scientific studies on the common thresher shark Alopias vulpinus

Aalbers, S. A., Bernal, D. and Sepulveda, C. A. (2010). The functional role of the caudal fin in the feeding ecology of the common thresher shark (*Alopias vulpinus*). *Journal of Fish Biology*, 76: 1863–1868.

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Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, 19–29 June 2018

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Leucoraja fullonica and *Leucoraja circularis* in the Northeast Atlantic

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Summary

Shagreen ray *Leucoraja fullonica* and sandy ray *L. circularis* are large bodied skate species occurring on the edge of the continental shelf and upper slope in the Northeast Atlantic and Mediterranean. They are not well represented in fishery-independent surveys, and consequently are data-limited stocks with no formal assessment (category five), have no defined reference points and are of unknown stock status. These stocks are currently treated as management units covering ICES Subareas 6–7, but these stocks likely extend into the north-western parts of Division 4.a and Subarea 8.

DATRAS data (2000–2017) were extracted from all surveys covering the stock area. Catch rates of sandy ray were low, with the 669 records primarily from the Spanish Porcupine Bank survey (64%) and the French EVHOE survey (34%). CPUE in these surveys was greatest at depths of 300–600 m, being on average 1–1.4 individual per hour. The proportion of hauls across surveys with a positive catch was greatest (0.9%) at 301–400 m depth. Catch rates were of a similar low level for shagreen ray, with 362 individuals present in the data, primarily from the EVHOE survey (67%). CPUE of this survey was greatest (0.77 ind.h^{-1}) at depths 301–400m, however, the proportion of hauls across surveys with a positive catch was greatest (1.1%) at the 101–200m depth band.

Biological data were collected from 36 specimens of *Leucoraja fullonica* (19–100 cm L_T) and 21 specimens of *Leucoraja circularis* (23–110 cm L_T) collected from the Northeast Atlantic. Conversion factors are presented along with data on hepato- and gonadosomatic indices, maturity information, nidamental gland width and clasper length data. Preliminary information on diet composition is also given.

Introduction

Shagreen ray *Leucoraja fullonica* and sandy ray *L. circularis* (Figure 1) are large-bodied skate species occurring on the edge of the continental shelf and upper slope in the Northeast Atlantic and Mediterranean Sea.

Very little data are available for these lesser-known skate species. Yarrell's (1841) *A history of British fishes* gave no accurate descriptions of either species, with information for shagreen ray *Raia chagrinea* confounded with long-nosed skate. Day (1880–1884) reported that *L. fullonica* occurred in deeper water, with occasional records from the Moray Firth, Firth of Forth, off Yorkshire (Scarborough and Whitby) and Portrush (Ireland). The description of *Raia circularis* given by Day (1880–1884) clearly refer to cuckoo ray *L. naevus*. In contrast, Couch (1862) did provide an accurate description of *L. circularis* (as *Raja circularis*), and noted that it was "a common species, at least in the west of England". The more offshore nature of these two species, combined with taxonomic and nomenclatural confusion, means that historic ichthyological information is also limited and uncertain.

Figure 1: Shagreen ray *Leucoraja fullonica* (left) and sandy ray *Leucoraja circularis* (right).

Occurrence, assessment and advice

Given the fragmented distribution of these scarce species, they are currently treated as management units covering Subareas 6-7, but these stocks likely extend into the north-western parts of Division 4.a and Subarea 8. ICES advice has been very limited given their under-representation in fishery-independent surveys. Consequently, both stocks are Category five stock, using available landings data, although there is a degree of uncertainty in the landings data.

The latest advice indicated that, "*when the precautionary approach is applied, landings should be no more than 42 tonnes in each of the years 2017 and 2018*" for sandy ray, and "*no more than 210 tonnes in each of the years 2017 and 2018*" for shagreen ray. These skates are managed as part of the generic skate and ray TAC. WGEF estimates of landings (2009–2015) have ranged from 46–77 t for sandy ray, and 196–301 t for shagreen ray, however there have been known issues with misidentification of both of these species, so these values may be under-estimates.

In the Northeast Atlantic, shagreen ray is suspected to have experienced continued population declines of 30–50% over three generations, and is classified as '*Vulnerable*' by the IUCN (McCully and Walls, 2015). Sandy ray is classified as '*Endangered*' by the IUCN (McCully *et al*., 2015), given that it is suspected to have declined in the Northeast Atlantic and Mediterranean Sea by more than 50% in the last three generations.

Biology

To date, there are very limited published investigations on the life history of either of these large-bodied skates. Shagreen ray *Leucoraja fullonica* reaches a maximum size of between 100–120 cm total length (Bauchot, 1987; Muus and Nielsen, 1999). To date, information in the literature has been largely restricted to notes on occurrence in trawl surveys, and distributional range (Ellis *et al*., 2015). Very little is known regarding its biology and reproductive cycle, other than that it is oviparous, and produces egg-cases that measure about 80 mm by 50 mm (Stehmann and Bürkel 1984). McCully *et al*. (2012) reported on a limited number of specimens from trawl surveys of the Celtic Sea (1992–2011), with total length (L_T) ranging from 21 to 96 cm and 24 to 70 cm in males and females, respectively. All female specimens were immature, while only two males at 75 and 96 cm L_T were mature; the largest immature male caught was 82 cm L_T.

Sandy ray *Leucoraja circularis* is even more data-limited than its congener. The maximum recorded size is *ca.* 120 cm L_T (Stehmann, 1990), but most individuals caught are between 70 and 80 cm L_T (Serena, 2005, Ebert and Stehmann, 2013). Very little is known regarding its biology and reproductive cycle, other than that it is oviparous, and produces egg-cases that measure 88–90 by 50–60 mm (Stehmann and Bürkel 1984; Mnsari *et al*. 2009). Age at maturity, longevity, size at birth, reproductive age, gestation time, reproductive periodicity, fecundity, rate of population increase and natural mortality are all unknown (McCully *et al*., 2015). It is also an offshore species, occurring in deeper shelf and slope waters, down to depths of up to 800 m.

Materials and Methods

Occurrence and bathymetric distribution

DATRAS exchange data (2000–2017; https://datras.ices.dk) were extracted for seven fisheries-independent surveys covering the north-east Atlantic range (Table 1).

A total of 15,842 unique hauls were considered, including those with zero catch. Data from all stations were mapped in R software version 3.3.1 (R Core Team, 2016) to show species occurrence in relation to THE survey areas (Figures 1 and 2). Catches were plotted as actual numbers caught, rather than CPUE, given the low catch rates.

Table 1: Summary of DATRAS data used in analyses

Survey	Year From	Year To	Excluding/Notes
IBTS-Q1	2000	2017	
IBTS-Q3	2000	2017	
IGFS	2003	2017	
Porcupine Bank	2001	2017	
Rockall Bank	2001	2016	Excl. 2004, 2010, 2017
Scottish West Coast	2000	2017	
EVHOE	2000	2016	Excl. 2017 (ship breakdown)

Biology

Specimens of both species were caught during the EVHOE surveys of the Celtic Sea in 2014–2016. Some additional specimens were included from Cefas' observer programme and fisheries-independent surveys. Specimens were initially frozen prior to detailed examination in the laboratory (see Table 2 for measurements collected). Some specimens that were subjected to prolonged freezing were dehydrated and therefore excluded from length-weight analyses. Maturity for males was assigned based on gross external examination of the claspers and internal inspection of the testes, while for females, it was assigned following internal examination of the ovaries, oocytes and development of the nidamental gland. Specimens were classified as immature (A), developing (B), mature (C), or active (D), according to the maturity key given in Appendix I. Tissue samples were analysed to determine the concentrations of trace metals, with results given in Nicolaus *et al.* (2017).

Table 2: Parameters collected from the *Leucoraja* cadavers (Note: not all parameters (e.g. stomach contents) could be collected for some specimens, due to freezer damage).

All specimens:	Males only:
• Sex • Total length (cm) • Disc width (mm) • Total weight (g) • Liver weight (0.1 g) • Gonad weight (0.1 g, including epigonal organ) • Weight of stomach contents (0.1 g) • Gutted weight (g) • Maturity stage • Stomach 'fullness' score • Identification of stomach contents	• Outer clasper length (mm) • Inner clasper length (mm) Females only: • Nidamental gland width (mm) • Number of mature follicles • Maximum follicle diameter (mm)

Results

Geographical and bathymetric distributions

Records of *L. fullonica* were primarily located along the continental shelf of the Celtic Sea to the south coast of Ireland and also around the Rockall Bank (Figure 2), with some catches seen in the northern North Sea around the Shetland Isles, and occasional records from the Scottish west coast.

Records of *L. circularis* were primarily found very closely associated to the continental shelf and slope waters along the Celtic Sea, and in good numbers around the Porcupine Bank (Figure 3). Occasional records were made from the Rockall Bank and northern North Sea. The records made from the shallow waters of the central North Sea are likely misidentifications.

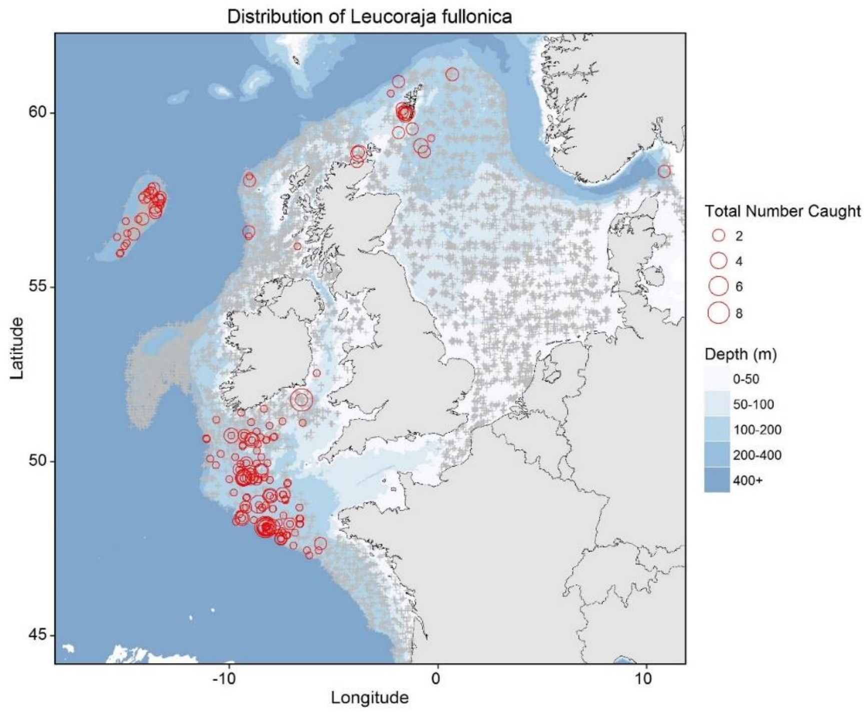

Figure 2: Occurrence of shagreen ray in the Northeast Atlantic from fisheries-independent surveys (grey cross indicates a station with zero catch).

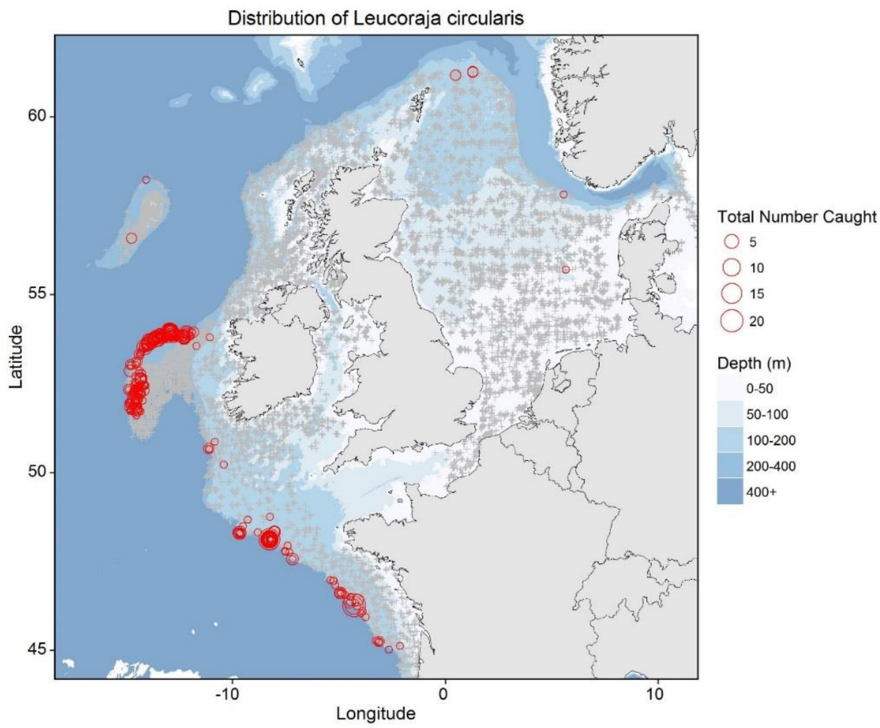

Figure 3: Occurrence of sandy ray in the Northeast Atlantic from fisheries-independent surveys (grey cross indicates a station with zero catch).

Sandy ray: Catch rates were low, with a total of 669 records, primarily from the Spanish Porcupine Bank survey (64%) and the French EVHOE survey (34%; Table 3). CPUE in the EVHOE survey was greatest at depths of 301–400 m at 1.4 individuals per hour (ind.h^{-1}), but remained relatively high at 401–500m at 1.3 ind.h^{-1} (Appendix 2a).

In the Porcupine Bank survey, the CPUE was highest at greater depths of 501–600 m at 1.04 ind.h^{-1}, however, an additional peak was also seen at 301–400 m of 1.01 ind.h^{-1} (Appendix 2b). The proportion of hauls across all surveys with a positive catch was greatest (0.9%) in the 301–400 m depth band. Positive catches from all surveys indicated that 31% of specimens which were from the 351–400 m depth band (dominated by EVHOE records), with another peak (15%) found at the 551–600m depth band (dominated by Porcupine Bank records; Figure 4).

Shagreen ray: Catch rates were of a similar low level for shagreen ray, with records of 362 individuals present in the data, primarily from the EVHOE (67%), Rockall (12%) and North Sea IBTS (12%) surveys (Table 3). CPUE of the EVHOE survey was greatest (0.77 ind.h^{-1}) at depths 301–400 m (Appendix 3), however, the proportion of hauls across surveys with a positive catch was greatest (1.1%) at the 101–200 m depth band. Positive catches from all surveys, indicated that 47% of individuals were made between 101–150m (dominated by EVHOE records; Figure 4).

Table 3: Numbers of sandy and shagreen ray present in survey data

Survey	Sandy ray		Shagreen ray	
	Total number	%	Total number	%
EVHOE	226	33.78	243	67.11
IGFS	3	0.45	22	6.08
North Sea IBTS	8	1.20	46	12.72
Rockall Bank	3	0.45	46	12.70
Porcupine Bank	429	64.13	0	0
Scottish West Coast	0	0	5	1.38
Total	**669**		**362**	

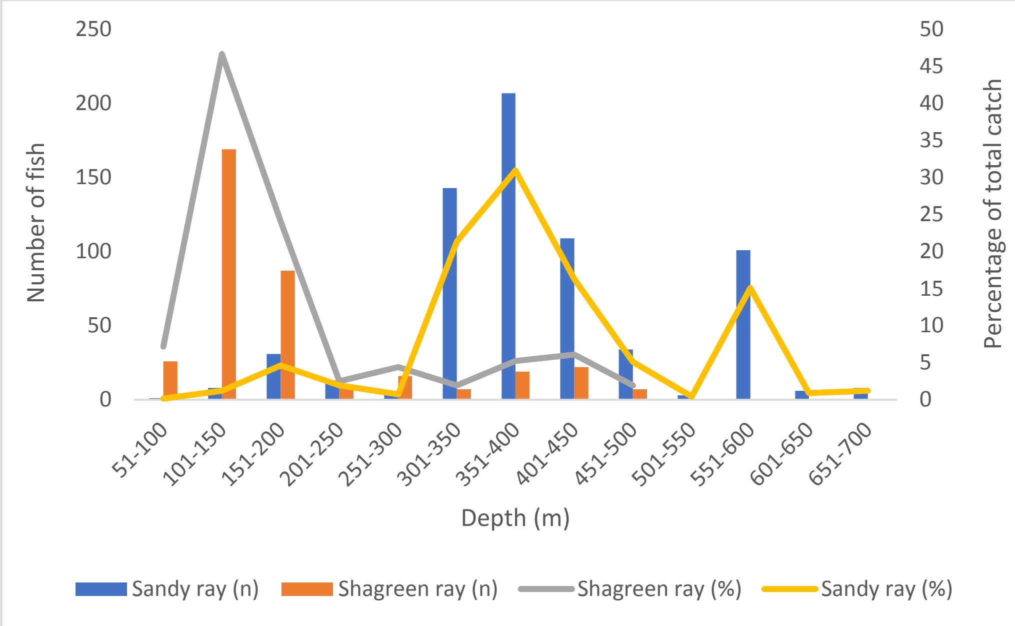

Figure 4: Numbers and percentage of fish caught at each depth band.

The sex ratio of both species found within catches was slightly skewed towards females at 1.44:1 and 1.36:1 for sandy and shagreen ray respectively. This was clearer at the larger length classes (Figure 5), which is not unexpected as females tend to reach a larger L_{max}. The fisheries-independent surveys caught fish across the whole length range (sandy ray: 13 – 115cm L_T; shagreen ray 16 – 105cm L_T) indicating that they are representative of the stock and population.

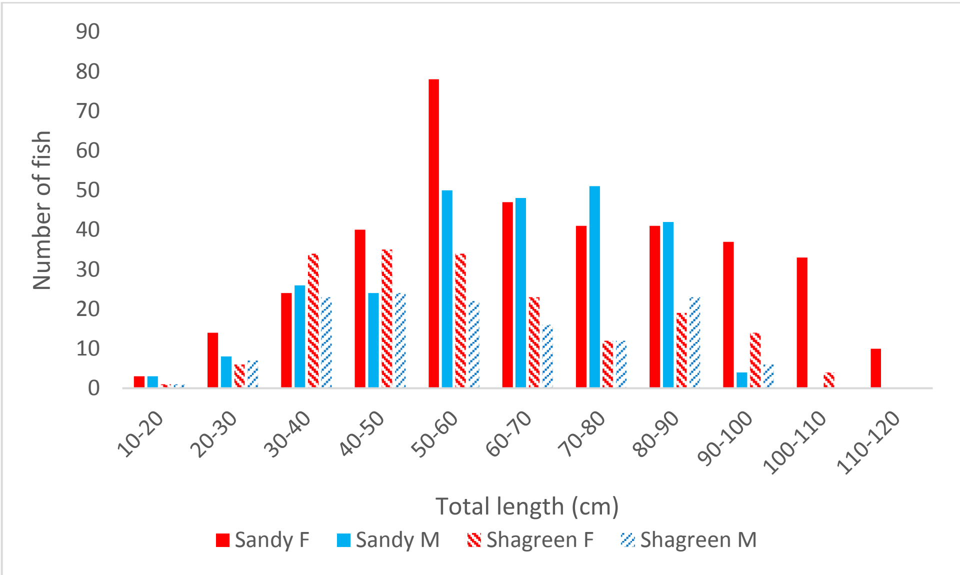

Figure 5: Length range by sex for sandy and shagreen ray caught in trawl surveys.

Biological investigations

To date, 21 *Leucoraja circularis* (13 females, 8 males) and 36 *Leucoraja fullonica* (19 females, 17 males) samples have been obtained and fully dissected for scientific study.

Length-weight conversion factors: Figure 6 shows the relationship between total length and weight in the specimens sampled by sex. The trend was very similar between the species, especially in the smaller specimens. *L. circularis,* the larger of the two species, were marginally heavier for a given L_T than *L. fullonica*, although data for larger *L. circularis* were limited, and the low sample size of larger specimens may skew the estimated length-weight relationship.

Skates are traditionally landed for the market gutted, and therefore, a conversion factor of eviscerated weight to length is also a useful parameter to determine (Figure 7) to augment data collected during market sampling programmes. Again, the relationship was very similar between the species, with large overlap within the 95% confidence limits throughout most of the size range. These relationships were not examined by sex, given the small sample size.

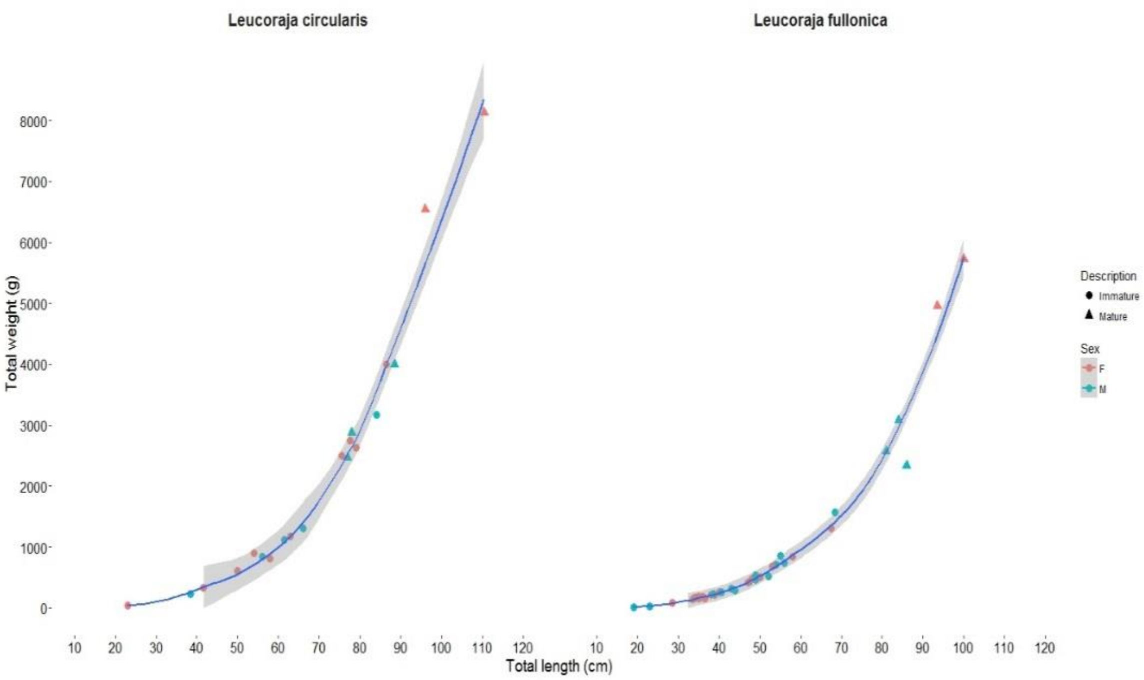

Figure 6: Relationship between total weight and total length (95% confidence interval shaded): *L. circularis* y=0.001156$x^{3.3614}$ (r^2 = 0.994) and *L. fullonica* y=0.000861$x^{3.40334}$ (r^2 = 0.991).

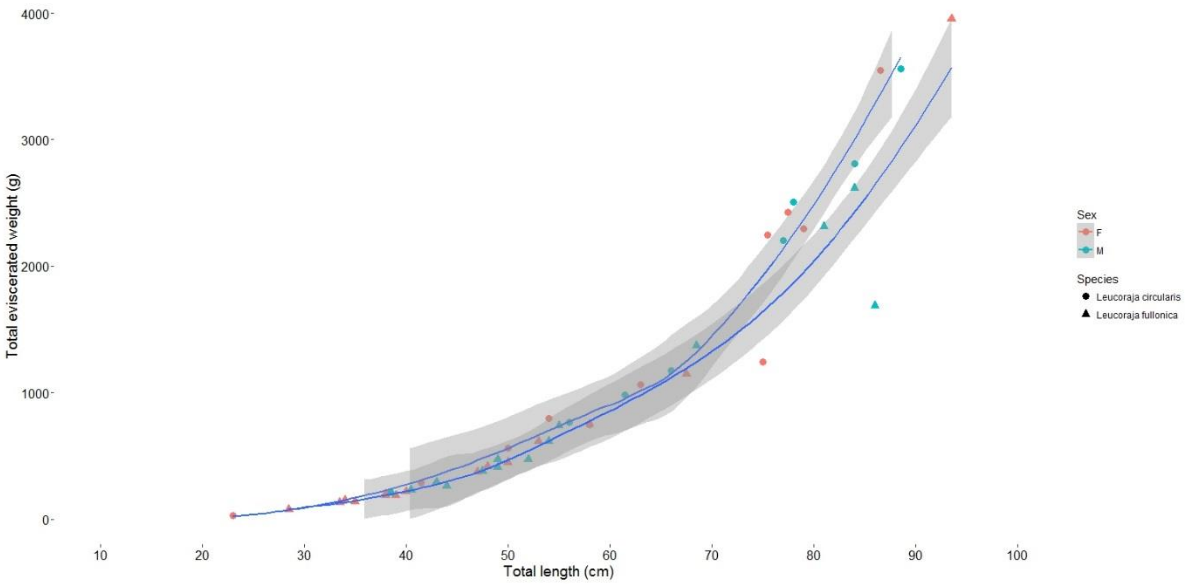

Figure 7: Total length to gutted weight relationship (95% confidence interval shaded), represented by the equations: $y= 0.000734x^{3.43}$ (*L. circularis* $r^2 = 0.986$) and $y= 0.001564x^{3.22}$ (*L. fullonica* $r^2 = 0.988$).

Hepatosomatic index

Livers were removed and weighed for each specimen, as relating the relative weight of this organ to fish condition and maturity stage is important for understanding the reproductive cycle of elasmobranch fish. The relationship between liver weight and total length was examined (Figure 8) and, although positively correlated, it is likely to depend on several factors, including sex, maturity stage and season. The liver weight can also be expressed as a proportion of body weight (the hepatosomatic index, HSI; Table 4), which is a frequently used indicator of the energy reserve in an animal, thus the lowest values are usually seen in females nearing the end of the reproductive cycle (McCully Phillips & Ellis, 2015), however, this was not evident here due to the lack of mature and active females. Changes in this index can indicate spawning seasons and environmental quality. The average HSI across all samples was 5.02, with the smallest (2.78) exhibited by the smallest sandy ray in the samples (L_T = 23cm), however, two smaller shagreen ray specimens had a larger HIS. The largest index (10.28) from a mature shagreen male (L_T = 86cm), with the largest shagreen female (L_T = 100) having a lower HSI (6.62), possible linked to the presence of large mature follicles, which would have reduced the available energy reserve.

Table 4: Hepatosomatic index (HSI) of *Leucoraja* sampled by sex and maturity stage

Maturity Stage	**Mean HSI (females)**		**Mean HSI (males)**	
	L. circularis (n)	*L. fullonica* (n)	*L. circularis* (n)	*L. fullonica* (n)
A	4.77 (10)	4.54 (17)	3.91 (3)	4.74 (16)
B	-	-	4.76 (2)	-
C	6.37 (2)	7.78 (2)	5.33 (3)	7.64 (3)

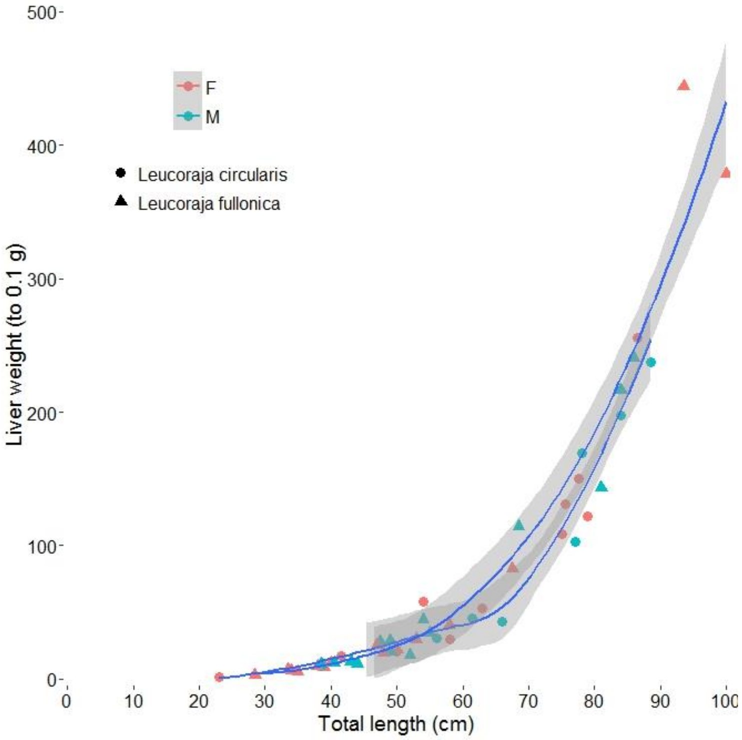

Figure 8: Relationship between total length and liver weight (95% confidence interval shaded) represented by the equations: y= 8.51229E^{-06}$x^{3.8052}$ (*L. circularis* r^2 = 0.954) and y= 5.40925E^{-06} $x^{3.936}$ (*L. fullonica* r^2 = 0.976).

Gonadosomatic index

The basic relationship between total length and gonad weight was explored (Figure 9). The pattern seen across this length range showed a clear increase with size. The association between gonad weight and total body length was expressed as the gonadosomatic index (GSI), and the average GSI by sex and maturity stage is given in Table 5. As expected, this increases throughout life to the 'mature' stage.

Table 5: Mean gonad weight and gonadosomatic index (GSI) by sex and maturity

Sex	**Female**				**Male**			
Maturity Stage	**Mean gonad weight (g)**		**Mean GSI (%)**		**Mean gonad weight (g)**		**Mean GSI (%)**	
	L. circularis (n)	*L. fullonica (n)*	*L. circularis*	*L. fullonica*	*L. circularis (n)*	*L. fullonica (n)*	*L. circularis*	*L. fullonica*
A	7.0 (11)	1.38 (17)	0.40	0.30	2.37 (3)	1.46 (15)	0.31	0.26
B	-		-	-	10.9 (2)	-	0.48	-
C	110.6 (2)	68.0 (2)	1.52	1.24	23.07 (3)	21.5 (3)	0.73	0.81

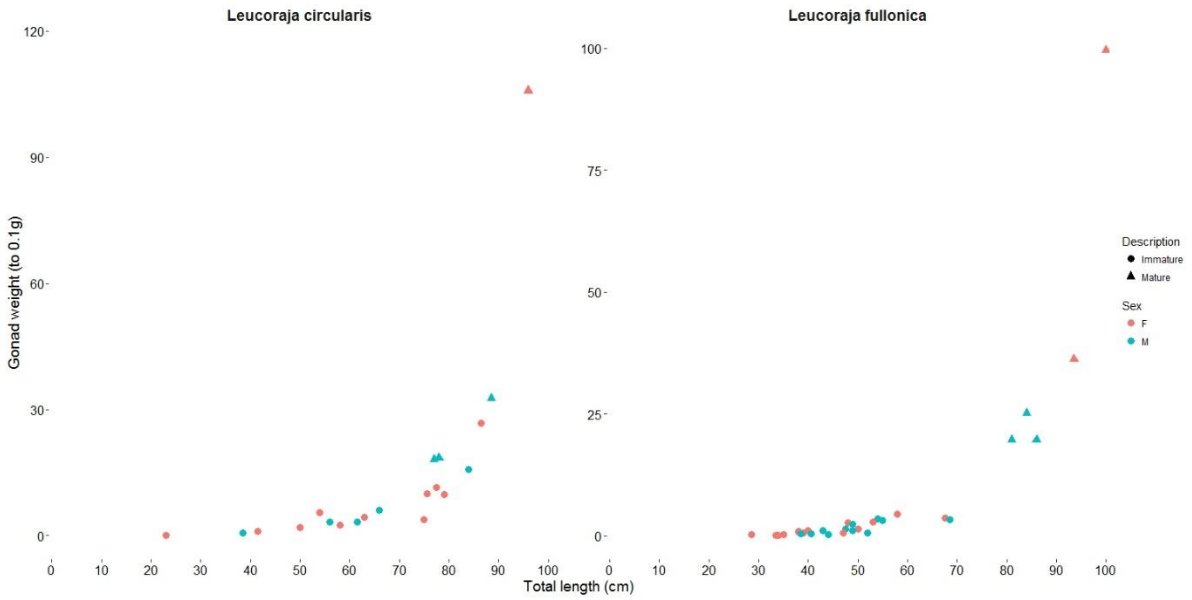

Figure 9: Relationship between total length and gonad weight.

Maturity

The size at which fish mature is an important factor to determine in fisheries management. Length at 50% maturity ogives and estimates cannot be given, due to the lack of samples, especially of mature females. However, Table 6 indicates the sizes of the smallest mature and largest immature fish, which is a large size in comparison to most other European rajids, and is conceivably similar to or larger than that of *Raja brachyura* (L_{50} of 78.0 and 83.4 for males and females respectively; McCully *et al*., 2012).

Table 6: Maturity estimates for the samples to date (number of samples available in brackets)

	L. circularis		***L. fullonica***	
	Female	***Male***	***Female***	***Male***
Smallest mature	96 (2)	77 (3)	93.5 (2)	81 (3)
Largest immature	86.5 (11)	84 (5)	67.5 (17)	68.5 (14)

The nidamental gland is where the follicles are fertilised and encapsulated before passing down into the uterus. The width of this gland is closely associated with maturity, and so is an important parameter to measure – especially where different biological studies employ different maturity scales. Figure 10 shows this relationship for both immature and mature females, which separate between approximately 10–35 mm width mark, although unfortunately a more accurate estimate is hampered by the lack of mature females.

Similar to nidamental gland width in females, clasper length of males can also provide a quantitative measure of maturity to augment the qualitative assignment of maturity scales. The outer clasper length to total length relationship for the males sampled to date, by maturity stage is shown in Figure 11, with the maturation of males occurring approximately between 90–100 mm outer clasper length.

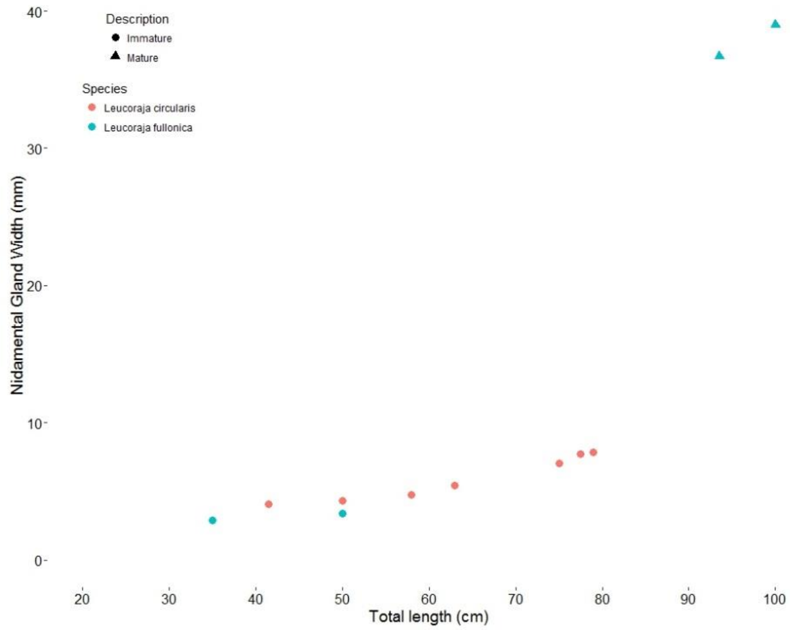

Figure 10: Relationship between nidamental gland width and total length in females.

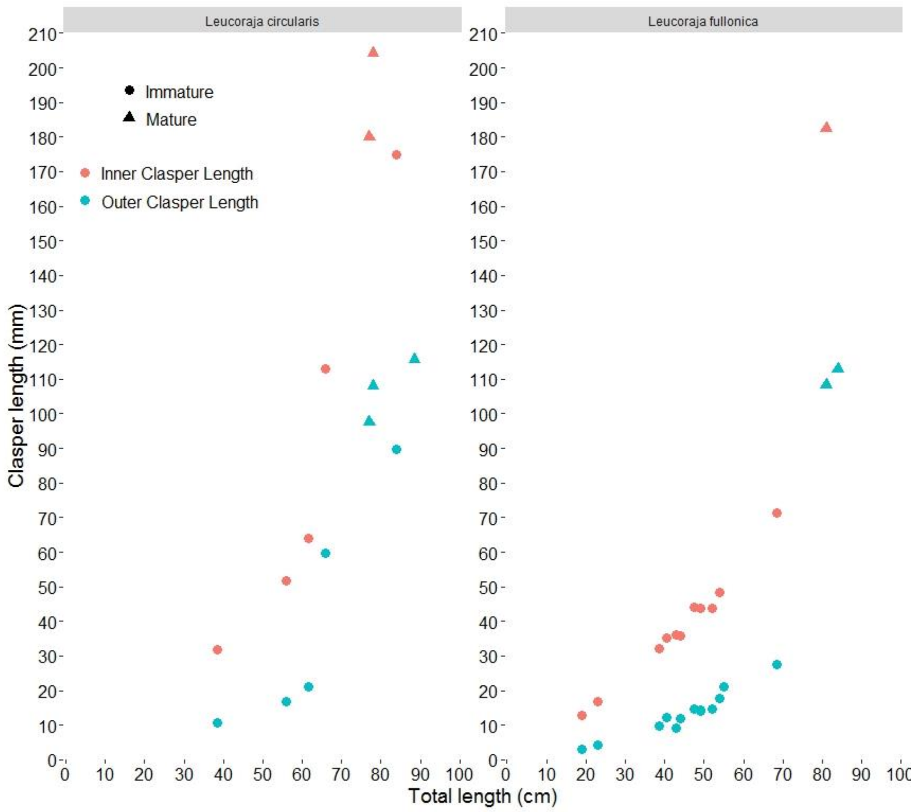

Figure 11: Relationship between outer clasper length and total length in males.

Diet composition and stomach fullness

The stomachs of each specimen were extracted, qualitatively given a 'fullness' score (0–10, where 0 = completely empty and 10 = completely full), before being emptied and the contents weighed and identified. The weights of the stomach contents (to nearest 0.1 g) ranged from 0–261.5g, averaging 17 g (n = 41). The species identified are given in Table 7. Primarily, the most common contents were digested remains, crustacean remains and fish remains, but of those remains which could be identified, shrimps and *Capros aper* (Figure 12) dominated the diet of *L. circularis*. The diet of *L. fullonica* also included crustaceans, such as euphausiids and *Processa* spp., but this species was generally more piscivorous, including predation on other elasmobranchs (*Scyliorhinus canicula* and *Leucoraja naevus*). One 86 cm L_T specimen had a 37cm L_T *L. naevus* in its stomach (possibly consumed in the net, Figure 12), while two specimens contained *S. canicula*, one of which had consumed 13 individuals up to 22 cm L_T.

Figure 11: Stomach contents of *L. circularis* showing *Capros aper* (left) and an unidentified Polychelidae (right)

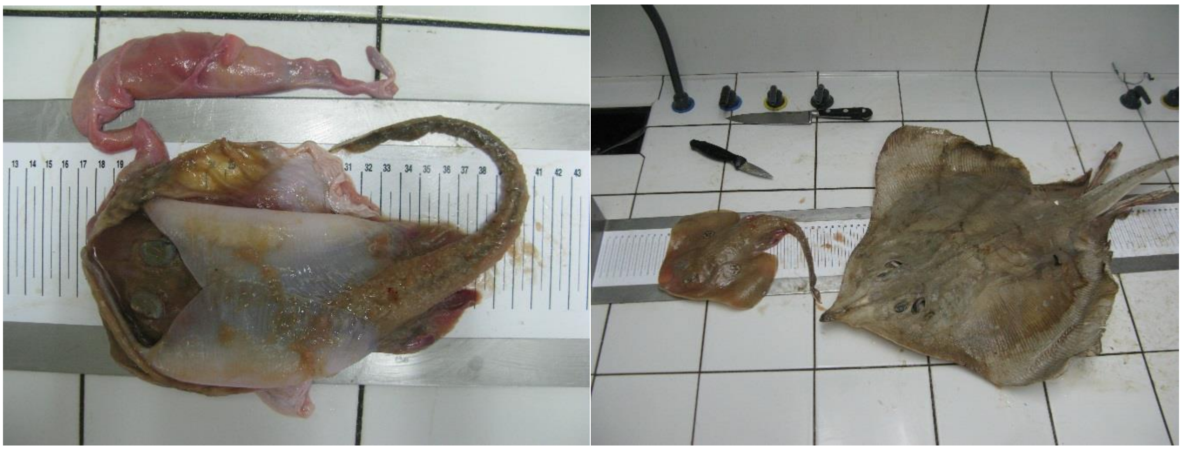

Figure 12: Stomach contents of *L. fullonica* showing a freshly consumed 37cm L_T *L. naevus*

Table 5: Species present in the stomach contents of *Leucoraja*.

Group	Prey remains
Polychaeta	Polychaete indet.
Crustacea	Amphipoda
	Euphausidacea
	Processa spp.
	Solenocera membranacea
	Shrimps indet.
	Polychelidae
	Brachyura indet.
	Crustacea indet.
Pisces	*Scyliorhinus canicula*
	Leucoraja naevus
	Capros aper
	Fish remains
Other	Digested remains

Acknowledgements

Many thanks to Pascal Lorance and Florianne Marandel (IFREMER, Nantes) for helping with the provision of samples and biological sampling.

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Appendix I: Maturity scale used in the present study

Maturity stage	Males	Females
A (Immature)	Claspers undeveloped, shorter than extreme tips of posterior margin of pelvic fin Testes small and thread-shaped	Ovaries small, gelatinous, or granulated, but with no differentiated oocytes visible Oviducts small and thread-shaped, width of shell gland not much greater than the width of oviduct
B (Developing)	Claspers longer than posterior margin of pelvic fin, their tips more structured, but claspers soft and flexible and cartilaginous elements not hardened Testes enlarged, sperm ducts beginning to meander	Ovaries enlarged and with more transparent walls. Oocytes differentiated in various small sizes (<5 mm). Oviducts small and thread-shaped, width of shell gland greater than width of the oviduct, but not hardened
C (Mature)	Claspers longer than posterior margin of pelvic fin, cartilaginous elements hardened, and claspers stiff Testes enlarged, sperm ducts meandering and tightly filled with sperm	Ovaries large with enlarged oocytes (>5 mm), with some very large, yolk-filled oocytes (ca. 10 mm) also present Uteri enlarged and wide, shell gland fully formed and hard
D (Active)	Clasper reddish and swollen, sperm present in clasper groove, or flowing if pressure exerted on cloaca	Egg capsules beginning to form in shell gland, partially visible in uteri, or egg capsules fully formed and hardened and in oviducts/uteri, or egg case being exuded from cloaca

Appendix 2a: CPUE of sandy ray in the EVHOE survey by year and depth band

Year	Depth band (m)					
	101-200	201-300	301-400	401-500	501-600	Grand Total
2000	0.02	0.00	0.00	0.00		0.02
2001	0.02	0.00	1.83	0.00	0.00	0.16
2002	0.08	0.00	2.34	1.38	0.00	0.50
2003	0.04	0.34	1.18	1.13	1.00	0.17
2004	0.12	0.00	0.00	1.48	0.00	0.30
2005	0.00	0.67	1.68	1.00	0.00	0.28
2006	0.08	0.80	0.00	1.62	0.00	0.34
2007	0.00	0.00	0.00	2.00	0.00	0.43
2008	0.00	0.00	0.00	1.67	0.00	0.14
2009	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.33	0.00	0.02
2011	0.02	0.00	0.00	0.40	0.00	0.03
2012	0.03	0.00	1.24	0.50	0.00	0.08
2013	0.07	0.97	0.00	1.28	0.67	0.18
2014	0.02	0.28	0.00	1.08	0.00	0.09
2015	0.08	0.56	0.00	0.29	0.00	0.10
2016	0.04	0.29	0.00	1.33	0.00	0.09
2017	0.00			0.00		0.00
Grand Total	0.04	0.26	1.39	1.28	0.11	0.18

Appendix 2b: CPUE of sandy ray in the Porcupine Bank survey by year and depth band

Year	Depth band (m)					
	201-300	301-400	401-500	501-600	601-700	Grand Total
2001	0.00	0.36	0.13	0.00	0.00	0.15
2002	0.11	0.50	0.00	0.57	0.00	0.25
2003	0.00	0.82	0.14	1.28	0.00	0.61
2004	0.00	0.54	0.00	0.00	0.00	0.21
2005	0.00	1.14	0.56	0.00	0.00	0.58
2006	0.16	0.33	0.20	0.84	0.00	0.31
2007	0.00	1.16	0.00	1.86	0.00	0.78
2008	0.00	0.40	0.22	2.40	0.00	0.58
2009	0.00	0.73	0.21	1.04	0.00	0.44
2010	0.00	0.90	0.00	1.50	0.00	0.50
2011	0.00	1.23	0.00	0.55	0.39	0.63
2012	0.17	1.32	0.21	1.25	0.00	0.83
2013	0.00	1.25	0.00	1.07	0.86	0.78
2014	0.00	1.19	0.43	1.90	0.28	0.95
2015	0.00	1.27	0.91	0.93	1.44	0.96
2016	0.00	1.41	0.80	0.25	0.75	0.77
2017	0.00	1.70	0.60	0.00	0.00	0.87
Grand Total	0.03	1.01	0.29	1.04	0.22	0.62

Appendix 3: CPUE of shagreen ray in the EVHOE survey by year and depth band

Year	Depth band (m)					
	1-100	101-200	201-300	301-400	401-500	Grand Total
2000	0.00	0.09	0.00	0.00	0.00	0.07
2001	0.08	0.26	0.29	1.85	0.32	0.36
2002	0.00	0.27	0.00	0.69	1.26	0.24
2003	0.00	0.27	0.76	1.48	0.77	0.32
2004	0.00	0.22	0.00	0.00	1.33	0.24
2005	0.00	0.15	0.40	0.50	0.00	0.13
2006	0.00	0.22	0.00	0.00	1.33	0.23
2007	0.00	0.38	0.00	0.00	0.40	0.29
2008	0.00	0.17	0.00	0.00	0.67	0.14
2009	0.00	0.19	0.00	0.00	0.00	0.13
2010	0.00	0.29	0.00	0.80	0.00	0.22
2011	0.58	0.08	0.57	0.00	0.33	0.23
2012	0.00	0.13	0.00	0.00	0.50	0.09
2013	0.00	0.18	0.89	0.00	0.52	0.19
2014	0.00	0.04	0.00	0.00	0.65	0.05
2015	0.00	0.24	0.32	0.00	0.29	0.19
2016	0.00	0.10	0.67	1.33	0.00	0.13
2017	0.00	0.00			0.00	0.00
Grand Total	0.05	0.19	0.26	0.77	0.61	0.19

Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 19-28, 2018

Not to be cited without prior reference to the authors

Demersal elasmobranchs in the western Channel (ICES Division 7.e) and Celtic Sea (ICES Divisions 7.f-j)

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Abstract

In 2006, CEFAS initiated a new beam trawl survey in the western English Channel (ICES Division 7.e) to provide information on sole *Solea solea* and plaice *Pleuronectes platessa*, as well as providing information on other demersal fish and ecosystem components. The survey extended into the Celtic Sea from 2013. The western Channel is an important area for various demersal elasmobranchs, with species of interest including undulate ray *Raja undulata*, which is locally abundant and, prior to their prohibited status, was an important commercial species in some inshore areas. This study presents updated results on the spatial distribution and size frequency for all dogfish, skates and rays encountered during 2006–2018, now including the wider Celtic Sea area. Results indicated that species including common skate *Dipturus batis*-complex, cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata* and undulate ray showed persistent associations with specific sites, with lesser-spotted dogfish *Scyliorhinus canicula* and starry smooth-hound *Mustelus asterias* distributed over much of the survey area. Juvenile skates were routinely caught, as beam trawls are more selective for smaller fish. Mature specimens of the smaller-bodied skate species, such as cuckoo ray, were also represented in the catch, while fewer mature specimens of the larger-bodied skate species (e.g. undulate, blonde and thornback ray) were observed. Preliminary results in terms of estimated total abundance and biomass are shown for the western Channel.

Introduction

The western English Channel is a diverse area for demersal elasmobranchs (Ellis *et al*., 2005). Although the occurrence of elasmobranchs is well documented for the fishing grounds off Plymouth (Marine Biological Association, 1957) and for other parts of the English Channel (Le Danois, 1913; Le Gall and Cantacuzene, 1956; Le Mao, 2009; Pawson, 1995), the distribution of the various species over the wider Channel area is little known.

CEFAS has conducted other fishing surveys operating in parts of the English Channel (Parker-Humphreys, 2005; Warnes and Jones, 1995; Tidd and Warnes, 2006), but none of these surveys allowed comprehensive coverage of the western part of the Channel area. A new survey was designed and initiated in 2006 to cover this little surveyed area more extensively, and was called the Q1 Southwest Beam Trawl Survey (Q1SWBeam) and has been renamed Q1 Southwest Ecosystem Survey (Q1SWECOS). The aim of this working document is to give preliminary results on the spatial and size distribution of dogfish, rays and skates that were encountered during this annual survey conducted between late February and early April 2006–2018. The present analysis shows an overview of the whole survey area, including not only the area most consistently fished (broadly equating to ICES Division 7.e, previously shown in Silva *et al.,* 2014) but also initial studies of the data collected in the Bristol Channel and Celtic Sea (ICES Divisions 7.f-j).

The main aim of the survey was to provide age-based indices for sole *Solea solea* and plaice *Pleuronectes platessa*, which support valuable commercial fisheries in the area. However, it was designed with a wider ecosystem remit in mind, and collects data on a wide range of demersal species, such as megrim *Lepidorhombus whiffiagonis*, lemon sole *Microstomus kitt*, anglerfish *Lophius piscatorius* and cuttlefish *Sepia officinalis*.

The innovative nature of the survey design, based on a random stratified sampling design, allows a better understanding of the fish assemblages within the area, thus adopting an ecosystem monitoring approach, where additional environmental data are also collected. The later include ecosystem components such as hydrography, epifauna, zooplankton, phytoplankton, sediment, infauna and geochemistry. The survey will also provide data to inform Marine Strategy Framework Directive (MSFD) descriptors. Further details on the survey are described in van der Kooij *et al*. (2011) and ICES (2013).

Methods

Gears

Stations are fished using two 4-metre beam trawls, based on a commercial design and towed simultaneously. Both gears are identical in terms of chain mats, flip up ropes and woven heavy-duty polypropylene netting. The only difference between them is that one has an 80 mm mesh cod-end with 40 mm cod-end liner (usually fished on the starboard side), which improves the catchability of smaller fish and invertebrates, whereas the other beam trawl uses an 80 mm mesh cod-end (without a liner) and is more comparable to commercial beam trawl designs (Figure 1).

Strata and survey area

The western Channel beam trawl survey follows a stratified design with stations chosen randomly within 13 different strata (Figure 2). Five of these strata are located along the English coast with three slightly larger strata covering the French coastal zone and Channel Islands. The remaining four strata are considered offshore, based on the oceanographic features, with the Hurd Deep (stratum 9) containing the deepest part of the survey area (depths of *ca.* 200 m, although such depths are limited to a very small part of the stratum).

Since 2013, the survey area has been extended to the wider Celtic Sea (stratum A–K and P), however data for this first year are not shown, as only one beam trawl was deployed. From 2014 onwards, two 4-m beam trawls were deployed within those strata, similarly to the western Channel area. In 2016, the first Irish Beam Trawl Ecosystem survey (IBES) coordinated with the Q1SWECOS, using the same gear and methods, with some of the strata in the wider Celtic Sea being sampled by Ireland and not the UK. Over the time series, the area and target number of stations within the strata in the western English Channel have changed slightly, due to the redesign to include the wider Celtic Sea (Table 1 and Figure 2).

Catch processing and biological sampling

Catch processing is standardized across CEFAS fisheries surveys and follows the internationally agreed protocol of the ICES Working Group for Beam Trawl Surveys (WGBEAM). In contrast to most traditional one-gear surveys the catch for each beam trawl is processed separately and stored on CEFAS' database as separated identities. Given the complex database structure this survey produces, the data for both gears are not currently available on DATRAS. The presence of epibenthic species is recorded routinely from both gears, with a more detailed quantification of epibenthic catches recorded for the beam trawl with the 40 mm cod-end liner.

All elasmobranch specimens are recorded (biomass and individuals) and measured (total length, L_T) to the centimetre below. Further biological information collected includes the individual weights and maturity, and the disc width for some skates and rays. Some of these data were analysed in McCully *et al*. (2012) and are not shown in the present document. In addition to maturity staging, various elasmobranch species are tagged and released if specimens are healthy. Information on smooth-hounds *Mustelus* spp. and greater-spotted dogfish *Scyliorhinus stellaris* tagged and released (2006–2013) was shown previously by Burt *et al.* (2013).

Data analysis

The present study analysed data for all dogfish, rays and skates that were caught in the western English Channel (7.e), Bristol Channel (7.f) and wider Celtic Sea (7.g–j) over the period (2006–2018). Only stations where both gears were deployed successfully were considered in this analysis, excluding any invalid or additional stations, in order to provide preliminary estimates of total abundance and biomass for selected species in Division 7.e. Although no index is shown for the wider Celtic Sea part of the survey area (due to the limited time series), the spatial distributions and length frequency distributions shown include all strata in order to better delineate geographical distributions and to further extend the knowledge on whether species distribution may fall into different management units.

Total numbers of fish measured per station were raised to 2 nautical miles in order to provide standardized species abundance across fishing stations and to further inform on the species-specific spatial distribution. Fish that were recorded as unsexed (3 occasions), were disregarded for the length frequency plots but used for the spatial distribution maps and calculations of indices.

This study shows a first estimate of the total abundance (by numbers) and total biomass (kg) for the western Channel (ICES Division 7.e). These were both calculated for all fish but also for the assumed 'exploitable' biomass (specimens ≥50 cm L_T; Silva *et al*., 2012).

For each given year and stratum, the total number of stations fished and area per stratum fished (m^2) were calculated, with the latter being converted from nautical miles to swept area fished by multiplying the distance fished (nm) per station by 8 (beam width = 8 m) and 1852 (to convert nm into m). For the total number per swept area, the total number of fish per year and stratum (across both gears) were calculated, then multiplied for the overall stratum area per year (Table 1) and divided by the swept area fished previously calculated to provide an estimate of the total abundance for the whole 7.e survey area (m^2). The total biomass per year and stratum (across both gears) was also calculated and then converted to total biomass per swept area, using the same approach as described above. However, prior to estimating the biomass, numbers at length were converted to biomass using length-weight conversion factors from Silva *et al.* (2013; see Table 7). For the exploitable biomass the same calculations were performed, using only records of fish ≥50 cm L_T. The data were analysed using R software version 3.4.3 (R Core Team, 2017).

Prior to further analysis, data were checked for potential misidentification issues by comparing records with known species spatial and size distribution around the British Isles.

Data for smooth-hounds were analysed at a genus level due to possible confusion between starry smooth-hound *Mustelus asterias* and smooth-hound *Mustelus mustelus* (Farrell *et al.*, 2009), although these likely all refer to *M. asterias*. Recent studies (Griffiths *et al.* 2010; Iglésias *et al.*, 2010) have highlighted that what was historically referred to as common skate *Dipturus batis* are two different species: blue/grey skate *D. batis* and flapper skate *D. intermedius*, so data were aggregated and referred to as *D. batis*-complex. One record of starry ray *Amblyraja radiata* was recorded early in the survey series and considered an erroneous record as it was outside the known spatial distribution. It is possible a misidentified thornback ray *Raja clavata*, though without the ability to confirm this it was treated at the family level (Rajidae). One record (a 2 cm L_T lesser-spotted dogfish *Scyliorhinus canicula*) was considered an input error and excluded.

Data for electric ray *Torpedo nobiliana* should be viewed with caution as there may have been some confusion in the early years of the survey between electric ray and marbled electric ray *Torpedo marmorata*. Two out of the six records of electric ray may be potential misidentifications due to their lengths (30 and 43 cm L_T) and sites of capture (close to the French inshore sector) being more consistent with what is known for marbled electric ray. The larger specimen (55 cm L_T) was caught further offshore and this record was more consistent with the known biogeographical and bathymetric range of electric ray. However, due to the inability to confirm these records, this study assumes data to be as they were initially recorded. It should be noted that some specimens of marbled electric ray had a much darker colouration and indistinct marble pattern, which emphasises the need to check the margin of the spiracles when identifying these species (Figure 3).

Results and discussion

Over the period 2006–2018, sixteen elasmobranch species were encountered (Table 2), of which the main species, in terms of numbers caught, were lesser-spotted dogfish *Scyliorhinus canicula* (ca. 79%), *Mustelus* spp. (5.3%) and cuckoo ray *Leucoraja naevus* (5.0%), spotted ray *R. montagui* (3.3%) and thornback ray *Raja clavata* (2.2%). Other commercially important skate species such as blonde ray *R. brachyura* and small-eyed ray *R. microocellata* were also encountered during this survey. The total number of elasmobranchs caught and measured by year are shown in Table 3, and also by stratum for the western Channel survey area (Table 4) and for the wider Celtic Sea survey area (Table 5).

The total number of stations where both gears were successfully fished per stratum and year are shown in Table 6, with only the western Channel survey strata used for the index calculations. Table 8 provides the preliminary indices for species of interest.

Lesser-spotted dogfish *Scyliorhinus canicula*: Over the time series, this species was by far the most abundant elasmobranch across the entire survey area and was captured over a wide length range (Figure 4). Although most specimens were above 20 cm L_T, there were some records of newly hatched fish (8–10cm L_T). They were most abundant in the outer parts of Lyme Bay, the Eddystone grounds, in parts of the Normano-Breton Gulf and at the southern entrance to St George's Channel. The most southern and western strata of the survey area showed lower numbers of this species. In the western Channel (Division 7.e), the estimated total abundance showed an overall increase over the time series, with a consistent biomass trend across years (Figure 16, Table 8).

Greater-spotted dogfish *Scyliorhinus stellaris*: This species was recorded consistently in the Normano-Breton Gulf, Lyme Bay and southern entrance to St George's Channel, with fewer records elsewhere (Figure 5). Records showed fish were caught over a wide length range (16–118 cm L_T), but very few neonates <20 cm L_T were caught. In the western Channel (Division 7.e), the estimated total biomass was highly variable, which may be due to the sporadic nature of catches of this species (Figure 16, Table 8).

Smooth-hounds *Mustelus* spp.: Improved identification in recent years suggests all smooth-hounds encountered, at least in recent years, were starry smooth-hound. They were widely distributed in the western English Channel, from the English inshore coast (Lyme Bay) to the Scilly Isles with a considerable number of specimens caught around the Channel Islands (Figure 6). Specimens were caught over a wide length range, albeit with only occasional fish >100 cm L_T observed (mainly females). In the western Channel (Division 7.e), the estimated total abundance and biomass showed similar trends, including for all specimens and larger fish, with peaks in 2009 and 2013–2014 (Figure 17, Table 8).

Marbled electric ray *Torpedo marmorata*: This species was commonly found in French coastal waters, with a few fish encountered in the middle of the Channel. Fish that were presumably recently born (<20 cm L_T) were observed over the time series (Figure 7).

Common skate-complex *Dipturus batis*-complex: Presently a prohibited species, common skate was encountered rarely, with the few records coming from the western parts of the survey area, including around the Scilly Isles. Since the survey extended into the Celtic Sea, there have been more records of this species (Figure 8). In the western Channel (Division 7.e), the total abundance and biomass have increased since 2013 (Figure 17; Table 8), although this could reflect increases in the area coverage of stratum 1.

Cuckoo ray *Leucoraja naevus*: This species was caught mainly on the grounds to the west of Falmouth, occasionally on the Eddystone grounds and was infrequent in the more easterly parts of the survey area. However, this species is also abundant on the grounds fished in the Celtic Seas strata, extending into southern, deeper waters. Although still within the stratified survey area for the western Channel beam trawl survey, some of the records were from Division 7.h (Strata 8 and 13) (Figure 9). Cuckoo ray is a small-bodied species which could explain the presence of both immature and mature fish (> 45 cm L_T) over the time series. In the western Channel (Division 7.e), the total abundance and biomass showed similar trends, including for all specimens and just specimens ≥50 cm L_T, excluding in terms of numbers for all specimens. This suggests that there was a higher proportion of un-exploitable biomass (< 50 cm L_T) fished on those given years 2013 and 2014. There is the indication of a decreasing trend since 2012–2013 (Figure 18; Table 8), although estimated indices in recent years are at similar levels to those observed at the start of the time series.

Blonde ray *Raja brachyura*: Currently a species of interest, as little is known in terms of stock units in UK waters. Observations showed, as expected, a patchy distribution across the survey area, with the Channel Islands, Normano-Breton Gulf, Lyme Bay and Bristol Channel important sites. The length-frequency for blonde ray showed a peak for juvenile fish (<25 cm L_T), with no fish recorded between 24–31 cm L_T and only occasional records of larger specimens >70 cm L_T (Figure 10). To help better understand the stock structure of this species, larger and healthier fish were often tagged and released. In the western Channel (Division 7.e), the total abundance and biomass did not show any consistent trends, likely reflecting the patchy distribution of this species (Figure 18; Table 8).

Thornback ray *Raja clavata*: Thornback ray was caught mostly in Lyme Bay (stratum 5), with fewer records elsewhere, in line with the findings of Burt *et al.* (2013). Length-frequency showed a peak in the captures of presumably 0-group fish ≤20 cm L_T (Figure 11). Although records were mostly from one stratum in Division 7.e, the total abundance and biomass were calculated. There was an increasing trend over the longer time-series, with a recent decrease following a peak in abundance during 2014–2017 (Figure 19; Table 8). This trend should be viewed with some caution, as survey data were mostly from one part of the western Channel (Lyme Bay).

Spotted ray *Raja montagui*: Contrary to the sympatric blonde ray, spotted ray was more commonly found in the English inshore coast strata from Lyme Bay to west of the Scilly Isles. It was also found in the Bristol Channel and across the entrance to St George's Channel and in the northern parts of the survey area, along the Irish coast. Nevertheless, the length distributions of fish caught for both these species showed a similar peak for smaller individuals <22 cm L_T (Figure 12). In the western Channel (Division 7.e), total abundance by numbers and biomass showed an increasing trend, though total abundance for all specimens peaked in 2015, suggesting a higher proportion of smaller-sized fish were caught (Figure 20; Table 8).

Undulate ray *Raja undulata*: This was previously listed as a prohibited species, though it is known to be locally abundant in some areas of the English Channel (Ellis *et al.*, 2011, 2012). They were commonly found around the Channel Islands and elsewhere in the Normano-Breton Gulf with fewer records from the middle of the Channel and the inshore English coast (generally east of Start Point). There were no encounters in any of the Celtic Sea strata, confirming the perception of there being a discrete stock in the English Channel. Beam trawls caught mainly immature fish (<70 cm L_T), with only occasional records of larger mature specimens > 80 cm L_T (Figure 13). Larger and healthier fish were often tagged and released. In the western Channel (Division 7.e), the total abundance and biomass have shown an increasing trend over the longer time-series, with the peak observed in 2017, though a slight decrease in 2018. It also suggests that there is a high proportion of 'exploitable' biomass in the survey, since there were only marginal differences in the indices for all specimens and just specimens ≥50 cm L_T (Figure 20; Table 8).

A further six species of elasmobranch were also recorded (Figure 14 and 15), but these species were only taken occasionally in the surveys. The paucity of records may be a combination of factors, such as the study area representing only the fringe of their habitat, a low gear efficiency for these species, or that they have patchy distributions.

Spurdog *Squalus acanthias*: Spurdog was rarely caught on this survey, with most of the records from shallower waters around Lyme Bay and Scilly Isles (Figure 15). Although spurdog and smooth-hounds have similar morphological features (in terms of size and body shape), the lower numbers of juvenile spurdog caught suggest that either they are not locally abundant at this time of the year and/or there is a lower selectivity for this life-history stage. Spurdog may be higher in the water column when feeding, whilst smooth-hound forage on the seafloor and may be more susceptible to capture in beam trawls.

Black-mouth dogfish *Galeus melastomus*: In 2017, one specimen of black-mouth dogfish *Galeus melastomus* was observed in waters 98 m deep off the Scilly Isles (Figure 15; Table 2).

Electric ray *Torpedo nobiliana*: As previously noted, records for electric ray should be viewed with care and, from the spatial distribution presented in Figure 15, the most westerly records are considered reliable, with the two easterly records possibly misidentified *Torpedo marmorata* (Figure 6).

Shagreen ray *Leucoraja fullonica*: Limited data were available for shagreen ray (n = 28), but fish were mostly immature, with only three records of larger specimens (85, 94 and 105 cm L_T) from the deeper waters further west of the Channel and in the southern Celtic Sea (Figure 14; Table 2).

Small–eyed ray *Raja microocellata*: There were few records of this species, and whilst these were generally from coastal waters, more data are required to inform accurately on its spatial distribution (Figure 14). Whereas the 0-groups of many skates were observed, few records of *R. microocellata* <23 cm L_T were observed, with smaller size groups likely to occur in waters shallower than can be surveyed by the research vessel. However, it should be noted that these juvenile records were mainly from stratum C in the Bristol Channel, an important area in terms of their spatial distribution. In the western Channel (Division 7.e), the total abundance and biomass do not show a consistent trend reflecting the nature of this species in terms of its narrow distribution within this part of the survey area (Figure 19; Table 8).

Common stingray *Dasyatis pastinaca*: Only three records of common stingray *Dasyatis pastinaca* were observed, two were caught in 2014 in waters 57 m deep off Guernsey, and one in 2016 within stratum 6 in waters 61 m deep (Figure 15; Table 2).

Summary

Beam trawls are designed to catch flatfish and smaller demersal fish, and so juvenile skates are generally sampled more effectively than larger individuals (Ellis *et al.*, 2005; Silva *et al.*, 2012). Consequently, juvenile catch rates may for some species provide reliable estimates of recruitment trends, and catch rates for smaller-bodied skates may be indicative of the adult parts of the stock. Records of larger individuals for large-bodied skates can provide information on species presence and geographic range, but due to their more sporadic nature in catches, it is uncertain whether they would provide a reliable reflection of the trends in abundance of adult fish over time.

Length-frequency distributions showed some species with higher peaks for smaller and even newly hatched/early born fish (e.g. blonde ray) that may be explained by the gear selectivity. However, further studies should be carried out to explore if certain locations are species-specific preferred sites for their early life stages (e.g. nursery grounds).

Further analyses are also needed to better understand if the two beam trawls catches are significantly different in terms of species-specific length-frequency (e.g. if newly hatched/born fish are mainly caught by the finer mesh gear). However, preliminary visual analysis through plotting length frequency by the two types of gear suggests there may not be an appreciable difference. Analyses of sex ratio were not conducted, as there was limited information to draw any accurate conclusion for most species. However, with the extended survey area, future work could investigate whether sexual segregation occurs in some of the more frequently encountered species (e.g. cuckoo ray and spotted ray).

Further investigations are needed on how to approach a more accurate index of abundance and biomass for species with patchy and limited distributions within this survey (e.g. blonde ray and thornback ray).

Several demersal elasmobranchs that were recorded in earlier studies of the English Channel ichthyofauna were not found during this survey time-series, including angel shark *Squatina squatina*, sandy ray *Leucoraja circularis* and white skate *Rostroraja alba*. Whilst there were historical records of long-nosed skate *Dipturus oxyrinchus*, it is unclear as to whether these would relate to long-nosed skate or flapper skate. There were no records of tope *Galeorhinus galeus*, which is known to occur in the area, but this species occurs higher up in the water column and is rarely captured by beam trawls.

Acknowledgements

We thank the scientists and crew of RV CEFAS Endeavour for collecting field data. This work was supported by contracts MD003, MA011 and MB5201.

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Table 1 – Area and target number of trawl stations per stratum for the time periods 2006–2013, 2014–2015 and 2016 onwards.

	Stratum	2006–2013		2014–2015		2016–present	
		Area (km^2)	No. of stations	Area (km^2)	No. of stations	Area (km^2)	No. of stations
Western Channel	1	2890.4	5	2094.5	5	2105.0	5
	2	909.1	5	896.3	5	909.1	5
	3	1163.6	5	1163.5	5	1164.6	5
	4	2185.2	10	2185.1	10	2189.7	10
	5	2696.9	8	2696.8	8	2705.1	8
	6	4677.1	5	4676.7	5	4694.0	5
	7	3721.4	5	3721.1	6	3716.9	6
	8	8393.4	5	9149.5	5	9149.5	5
	9	6100.1	5	6099.7	5	6097.3	5
	10	5505.1	9	5504.8	9	5504.1	9
	11	7244.6	9	7244.1	7	7238.5	7
	12	6006.8	5	5995.7	5	5970.1	5
	13	9674.6	5	9655.0	6	9685.1	6
Celtic Sea*	A*	-	-	4922.5	*	6725.1	*
	B	-	-	12833.8	5	15610.9	5
	C	-	-	14287.5	5	14290.4	5
	D	-	-	2526.0	5	2540.2	5
	E	-	-	13845.2	5	13840.8	5
	F	-	-	19574.6	5	18161.6	5
	G	-	-	21967.3	5	17324.0	5
	H	-	-	8762.1	5	8131.2	5
	I	-	-	16564.9	5	22398.9	5
	J	-	-	6100.8	5	5141.6	5
	K	-	-	3816.7	5	3797.4	5
	P*	-	-	-	-	17983.2	*

* Stratum A currently fished by the Irish, and Stratum P opportunistically fished one year, for operational reasons, to accommodate long distances between stations.

Table 2 – Total numbers (by sex) of elasmobranchs caught during this survey (2006–2018), with associated length (L_T, cm) and depth range (D, m - recorded at the time of deployment).

Family	**Scientific Name**	**Common name (code)**	**Females**			**Males**		
			N_T	**L_T range (cm)**	**D range (m)**	**N_T**	**L_T range (cm)**	**D range (m)**
Squalidae	*Squalus acanthias*	Spurdog (DGS)	11	26 - 91	60 - 114	9	23 - 78	55 - 107
Scyliorhinidae	*Galeus melastomus*	Black-mouth dogfish (DBM)	1	72	98	-	-	-
	Scyliorhinus canicula	Lesser-spotted dogfish (LSD)*	7039	8 - 72	13 - 173	8104	8 - 75	13 - 183
	Scyliorhinus stellaris	Greater-spotted dogfish (DGN)	40	17 - 107	17 - 150	52	16 - 118	17 - 120
Triakidae	*Mustelus* spp.	Smooth-hounds (SDS)	484	34 - 117	23 - 170	524	28 - 102	18 - 142
Torpedinidae	*Torpedo nobiliana*	Electric ray (ECR)	4	43 - 73	78.5 - 142	2	30 - 32	98.3 - 151
	Torpedo marmorata	Marbled electric ray (MER)*	46	11 - 64	69 - 115	78	14 - 43	69 - 116.9
Rajidae	*Dipturus batis*–complex	Common skate (SKT)	79	18 - 89	58 - 145	78	18 - 114	75 - 145
	Leucoraja fullonica	Shagreen ray (SHR)	12	18 - 105	90 - 170	16	20 - 85	96 - 170
	Leucoraja naevus	Cuckoo ray (CUR)	453	13 - 71	23 - 183	498	12 - 72	23 - 183
	Raja brachyura	Blonde ray (BLR)	127	16 - 94	23 - 103	108	13 - 103	26 - 120
	Raja clavata	Thornback ray (THR)	208	10 - 93	15 - 120	221	13 - 84	15 - 106
	Raja microocellata	Small–eyed ray (PTR)	24	15 - 83	33 - 76	24	13 - 76	33 - 93
	Raja montagui	Spotted ray (SDR)	292	11 - 69	27 - 120	332	11 - 70	23 - 120
	Raja undulata	Undulate ray (UNR)	90	17 - 100	18 - 94	110	13 - 94	20.1 - 150
	Rajidae indet.	Skate indet. (SKA)	1	31	53	-	-	-
Dasyatidae	*Dasyatis pastinaca*	Common stingray (SGR)	-	-	-	3	47 - 57	57 - 61

* unsexed specimens of LSD (n = 2) and MER (n = 1) not shown in the present table.

** fish at 55 cm (total length) assumed to be correct, the other two specimens may be misidentified *T. marmorata* so these data should be viewed with care.

Table 3 – Total number of specimens measured by year for the entire survey area. Data from 2014 (inclusive) also incorporates the Celtic Sea extended survey area. See Table 2 for list of species code.

Species	Western Channel								Western Channel and Celtic Sea					Σ
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
DGS	-	2	-	1	-	-	2	1	2	2	2	7	1	20
DBM	-	-	-	-	-	-	-	-	-	-	-	1	-	1
LSD	693	1011	1061	889	724	760	658	925	1149	1935	1814	1696	1830	15145
DGN	8	3	4	2	5	8	7	2	6	10	16	11	10	92
SDS	27	61	45	138	82	60	51	128	114	109	46	68	79	1008
ECR	-	2	1	-	-	-	-	-	-	-	2	1	-	6
MER	7	1	8	4	5	5	7	2	15	29	15	18	9	125
SKT	4	3	-	1	3	1	2	3	9	23	18	55	35	157
SHR	2	-	-	-	-	-	2	1	-	7	1	7	8	28
CUR	33	32	76	35	30	54	40	86	121	161	118	76	89	951
BLR	17	10	35	9	17	5	6	2	24	40	26	18	26	235
THR	11	11	19	50	25	13	39	11	29	56	80	61	24	429
PTR	4	-	2	-	1	-	1	-	5	6	15	7	7	48
SDR	22	7	16	18	14	21	16	35	82	113	92	99	89	624
UNR	4	9	14	7	42	15	6	14	10	14	24	27	14	200
SKA	-	1	-	-	-	-	-	-	-	-	-	-	-	1
SGR	-	-	-	-	-	-	-	2	-	-	1	-	-	3

Table 4 – Total number of specimens measured by stratum in the Western Channel survey area (Division 7.e) between 2006 and 2018. See Table 2 for list of species code.

Species	Coastal inshore waters (England)					Middle of English Channel					Coastal inshore waters (France and Channel Islands)			∑
	1	2	3	4	5	8	13	7	9	6	12	10	11	
DGS	4	-	-	5	2	-	1	-	-	1	-	-	-	13
DBM	1	-	-	-	-	-	-	-	-	-	-	-	-	1
LSD	418	764	941	819	1732	508	791	1267	590	1379	150	736	1773	11868
DGN	1	1	-	6	13	-	-	-	4	3	1	16	23	68
SDS	35	6	-	53	224	22	19	34	76	63	85	105	202	924
ECR	-	-	-	-	-	1	-	-	1	-	1	-	-	3
MER	-	-	-	-	-	1	15	5	23	-	53	7	-	104
SKT	16	2	-	-	-	41	-	-	-	-	-	-	-	59
SHR	2	-	-	-	-	9	-	-	-	-	-	-	-	11
CUR	207	287	12	3	-	165	64	2	6	-	5	-	-	751
BLR	8	5	-	10	12	-	2	2	8	6	9	15	87	164
THR	1	1	6	15	257	-	-	2	-	70	1	4	18	375
PTR	-	4	1	4	4	-	-	1	-	3	-	-	2	19
SDR	106	51	4	22	84	7	5	6	2	49	2	4	8	350
UNR	-	1	-	5	7	-	2	6	13	31	3	31	101	200
SKA	-	1	-	-	-	-	-	-	-	-	-	-	-	1
SGR	-	-	-	-	-	-	-	-	-	1	-	-	2	3

Table 5 – Total number of specimens measured by stratum in the Celtic Sea survey area (Divisions 7.f–j) for 2014–2018. See Table 2 for list of species code.

Species	B	C	D	E	F	G	H	I	J	K	A*	P*	∑
DGS	-	1	-	1	5	-	-	-	-	-	-	-	7
LSD	1076	393	1004	41	269	52	26	17	23	270	105	1	3277
DGN	5	1	17	-	-	-	-	-	-	-	1	-	24
SDS	24	36	4	-	2	-	4	2	7	5	-	-	84
ECR	-	-	-	-	-	1	1	-	-	-	-	1	3
MER	-	-	-	-	1	-	-	-	14	6	-	-	21
SKT	5	2	20	27	13	25	4	-	-	2	-	-	98
SHR	-	-	-	1	-	8	5	2	-	1	-	-	17
CUR	35	3	6	4	16	11	67	40	2	15	1	-	200
BLR	15	49	1	-	-	-	-	-	6	-	-	-	71
THR	18	29	3	-	2	-	-	-	-	-	2	-	54
PTR	1	27	1	-	-	-	-	-	-	-	-	-	29
SDR	80	107	46	-	18	-	-	1	6	-	16	-	274

* Stratum A and P not currently fished – not part of the main survey area.

Table 6 – Number of stations per year and stratum within the western Channel used for the index calculation.

Year	Coastal inshore waters (England)					Middle of English Channel					Coastal inshore waters (France and Channel Islands)			Σ
	1	2	3	4	5	8	13	7	9	6	12	10	11	
2006	5	5	4	10	8	4	5	5	4	4	3	10	9	76
2007	5	5	5	10	9	4	5	5	5	5	4	9	8	79
2008	5	5	5	10	8	5	4	5	5	5	5	7	9	78
2009	5	5	5	10	8	5	5	5	5	4	4	9	7	77
2010	5	10	5	10	8	5	5	5	5	5	5	9	8	85
2011	5	5	5	10	12	5	5	5	5	5	5	9	9	85
2012	5	5	5	10	8	5	5	5	5	5	5	9	9	81
2013	5	5	5	10	10	4	5	5	5	5	4	9	8	80
2014	5	4	4	7	6	4	4	5	4	4	4	6	5	62
2015	5	5	5	10	8	5	6	6	5	5	5	8	7	80
2016	5	8	5	10	8	5	6	6	5	5	5	9	7	84
2017	5	5	5	10	8	5	6	6	5	5	5	9	6	80
2018	5	5	5	10	8	5	6	6	5	5	5	9	7	81

Table 7 – Length-weight conversion factors used to convert numbers at length to biomass. Source: Silva *et al.* (2013).

Species	*A*	*b*
Scyliorhinus canicula	0.0022	3.1194
Scyliorhinus stellaris	0.0045	3.0155
Mustelus spp.	0.003	3.0349
Dipturus batis - complex	0.0038	3.1201
Leucoraja naevus	0.0036	3.1399
Raja brachyura	0.0027	3.258
Raja clavata	0.0045	3.0961
Raja microocellata	0.003	3.225
Raja montagui	0.0041	3.1152

Table 8 – Estimated total abundance for all specimens (numbers in m^2) and for individuals ≥50 cm total length (*numbers in m^2), total biomass for all specimens (kg in m^2), and individuals ≥50 cm total length (*kg in m^2) in the western Channel (ICES Division 7.e) from 2006–2018.

Year	*Scyliorhinus canicula* (LSD)				*Scyliorhinus stellaris* (DGN)				*Mustelus spp.* (SDS)				*Dipturus batis* - complex (SKT)				*Leucoraja naevus* (CUR)			
	numbers	***numbers**	**kg**	***kg**	**numbers**	***numbers**	**kg**	***kg**	**numbers**	***numbers**	**kg**	***kg**	**numbers**	***numbers**	**kg**	***kg**	**numbers**	***numbers**	**kg**	***kg**
2006	18809198	9814614	3223057	2520409	263104	263104	711169	711169	512635	267308	296377	242652	76504	-	2722	-	1274515	211550	525025	244933
2007	22858092	12950250	3286698	2472617	52443	21354	59211	54669	1597050	765806	1298241	1146003	212441	212441	489434	489434	773411	217181	384097	284179
2008	22827578	9495702	3592530	2672694	121484	121484	414982	414982	1191900	1078874	2055167	2027786	-	-	-	-	1262181	506427	759175	594153
2009	21023094	11692181	3600702	2707331	75647	-	26530	-	4652342	3635820	3739144	3552907	18940	-	703	-	1186936	623163	1120633	935685
2010	19583257	11829630	3679193	2856621	151855	30371	100663	64160	2548742	1872936	2931765	2767010	166620	111080	406187	366562	1094270	391954	616888	507331
2011	17797594	11435999	3924994	3264142	222170	186566	494370	482398	1845738	1732098	2782980	2758500	19126	19126	39701	39701	1514431	614583	1040334	955868
2012	17157462	10046052	3233235	2562158	139893	107389	227674	226875	1354517	1110463	1980942	1928656	43352	-	4446	-	1390980	783735	1387782	1229447
2013	24621931	13633953	4537187	3839348	41002	41002	88766	88766	3477150	2980368	3325020	3198720	56821	-	23326	-	4310001	844618	1674742	1073787
2014	26616287	14423618	3758401	3012795	128766	128766	280240	280240	2705820	1919279	3360102	3203275	315237	-	55821	-	2846476	404015	746242	431773
2015	32225343	19285073	3736236	2949771	145274	110714	455395	453029	2123655	1275203	2229790	2076966	385211	128654	363963	314345	2087937	716168	1201986	921356
2016	23943512	11312962	3359000	2469328	102528	56596	131334	121814	969411	690647	994733	919368	189043	63014	259210	241639	1139986	132209	428992	145947
2017	32957510	12303440	4658927	3550735	146567	108569	215598	214710	1240511	1078917	1276569	1242847	495277	366856	880767	840485	866936	520076	767282	663231
2018	34891874	11521270	4273611	3038772	109882	57212	136948	133049	2081012	1745557	2344149	2276865	917141	489142	1264707	1116868	1225626	299589	514993	363418
Index A (2016–2017)	28450511	11808201	4008963	3010031	124547	82582	173466	168262	1104961	884782	1135651	1081107	342160	214935	569988	541062	1003461	326142	598137	404589
Index B (2011–2015)	23683723	13764939	3838010	3125643	135421	114887	309289	306261	2301376	1803482	2735767	2633223	163949	73890	97451	177023	2429965	672624	1210217	922446
Index A / Index B	1.20	0.86	1.04	0.96	0.92	0.72	0.56	0.55	0.48	0.49	0.42	0.41	2.09	2.91	5.85	3.06	0.41	0.48	0.49	0.44

Table 8 (cont.) – Estimated total abundance for all specimens (numbers in m²) and for individuals ≥50 cm total length (*numbers in m²), total biomass for all specimens (kg in m²), and individuals ≥50 cm total length (*kg in m²) in the western Channel (ICES Division 7.e) from 2006–2018.

Year	***Raja brachyura* (BLR)**				***Raja clavata* (THR)**				***Raja microocellata* (PTR)**				***Raja montagui* (SDR)**				***Raja undulata* (UNR)**			
	numbers	***numbers**	**kg**	***kg**	**numbers**	***numbers**	**kg**	***kg**	**numbers**	***numbers**	**kg**	***kg**	**numbers**	***numbers**	**kg**	***kg**	**numbers**	***numbers**	**kg**	***kg**
2006	292993	112573	394518	354611	172814	63596	188279	178484	51416	45341	116395	113720	281789	77224	144916	110816	107467	53733	153214	120034
2007	255619	102618	282603	257143	186172	143839	242650	237359	-	-	-	-	130141	-	46917	-	281657	83252	316303	256476
2008	1149860	447421	987741	945441	241673	-	28308	-	38147	30371	99904	97242	326556	135734	215814	180228	421941	239715	612894	603499
2009	326567	258628	667445	639197	761883	76759	291834	117928	-	-	-	-	312660	60631	118032	76004	205778	119586	501929	460730
2010	448925	212597	309300	258970	340452	97746	274637	203895	7266	-	4039	-	157563	22959	38618	25245	1286449	789081	1491702	1287141
2011	143110	59519	207872	169332	143249	62510	80975	63160	-	-	-	-	280982	109812	186118	134023	512821	422046	1232869	1198204
2012	148156	148156	257816	257816	440443	98656	272595	219818	35872	35872	68352	68352	248327	40076	114258	58648	141828	130802	405330	397642
2013	65050	24285	124701	99811	159190	73435	170885	147432	-	-	-	-	546585	262829	324855	252575	363633	262193	546092	497935
2014	518447	302989	1159054	1120886	487704	411090	730643	701616	16252	-	1201	-	511265	55988	186566	85035	555531	395836	1323397	1282179
2015	814911	287278	1018079	867845	1198794	441916	749989	579854	38939	38939	142765	142765	1510041	141167	450098	160294	451813	303201	866233	803511
2016	346937	155184	476278	460546	986728	364616	768499	680513	54026	22966	44755	44042	637384	186520	290825	244257	692681	361655	1056412	954249
2017	346755	177767	863251	835052	852371	254963	670482	546982	18407	18407	42460	42460	505815	326033	582882	544443	1012824	847687	2439532	2363145
2018	71298	71298	98765	98765	251398	76962	187480	167647	28086	7353	21110	9583	677411	239799	322134	260004	381449	369820	1120653	1120179
Index A (2016–2017)	346846	166475	669765	647799	919550	309790	719491	613748	36217	20686	43607	43251	571600	256276	436853	394350	852752	604671	1747972	1658697
Index B (2011–2015)	337935	164445	553504	503138	485876	217521	401018	342376	30354	37406	70773	105559	619440	121974	252379	138115	405125	302816	874784	835894
Index A / Index B	1.03	1.01	1.21	1.29	1.89	1.42	1.79	1.79	1.19	0.55	0.62	0.41	0.92	2.10	1.73	2.86	2.10	2.00	2.00	1.98

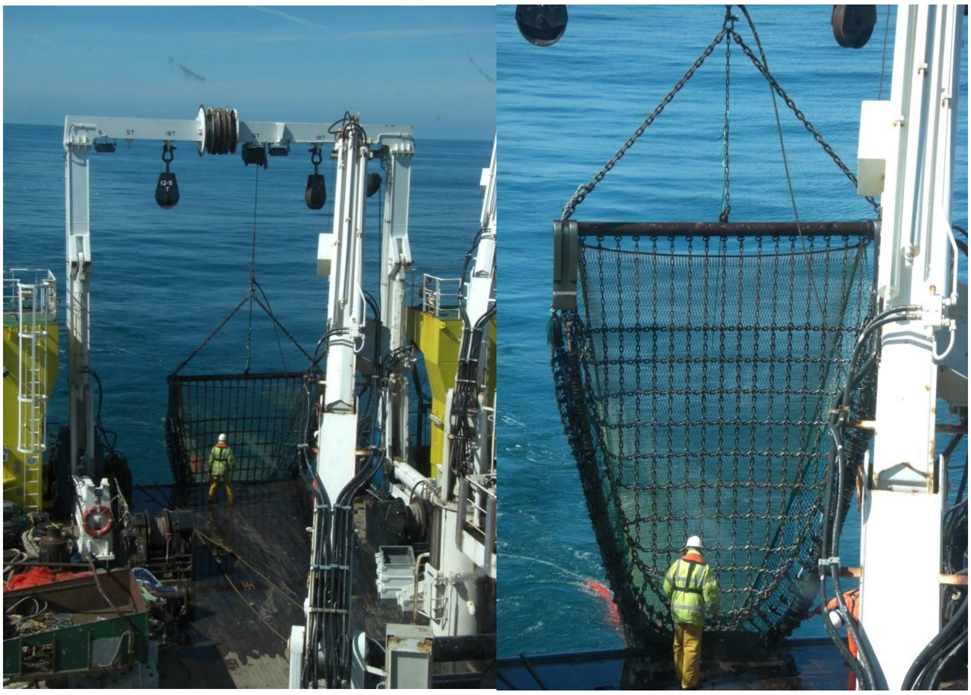


Figure 1: One of the beam trawls used during the survey.

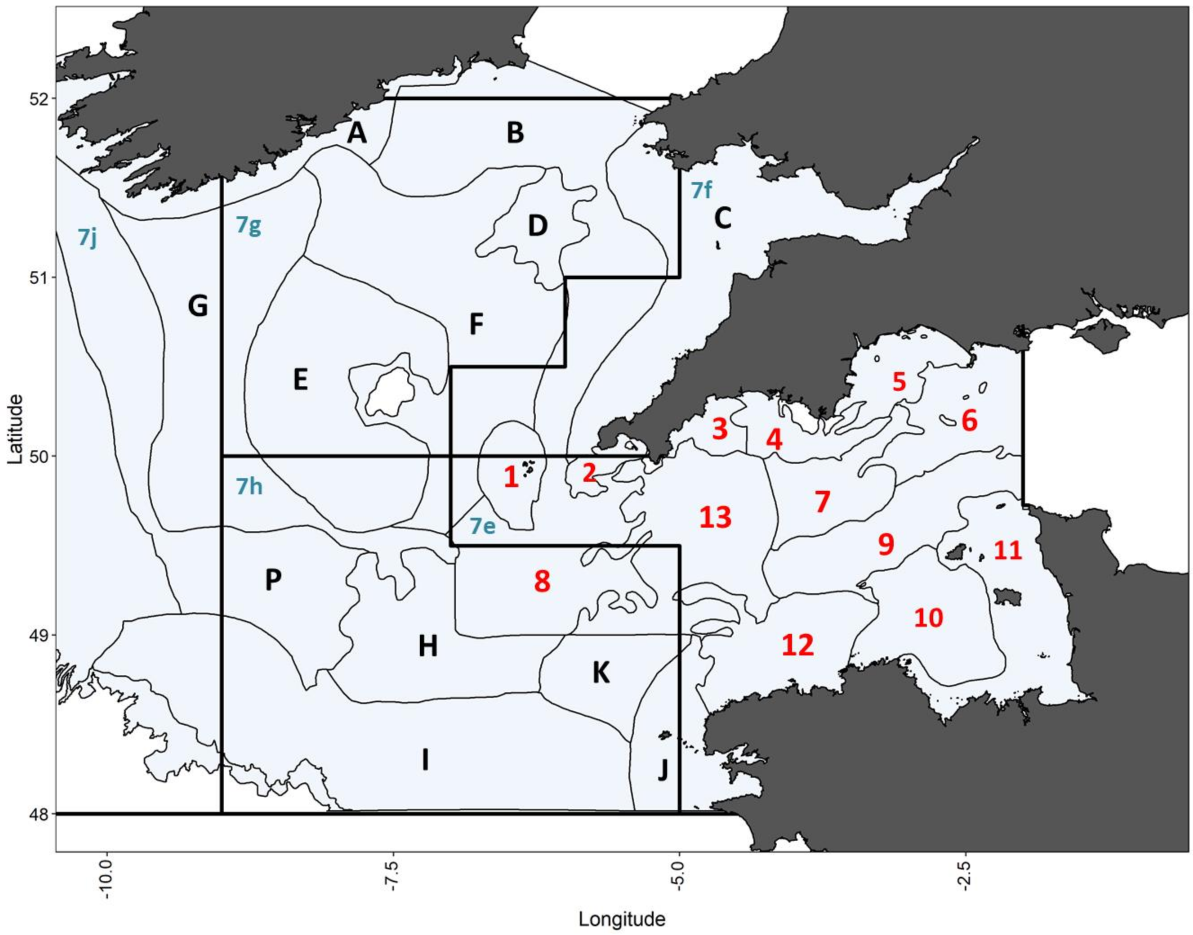


Figure 2: CEFAS beam trawl survey area and stratification within the western English Channel (7.e), Bristol Channel (7.f) and Celtic Sea (7.g–j).

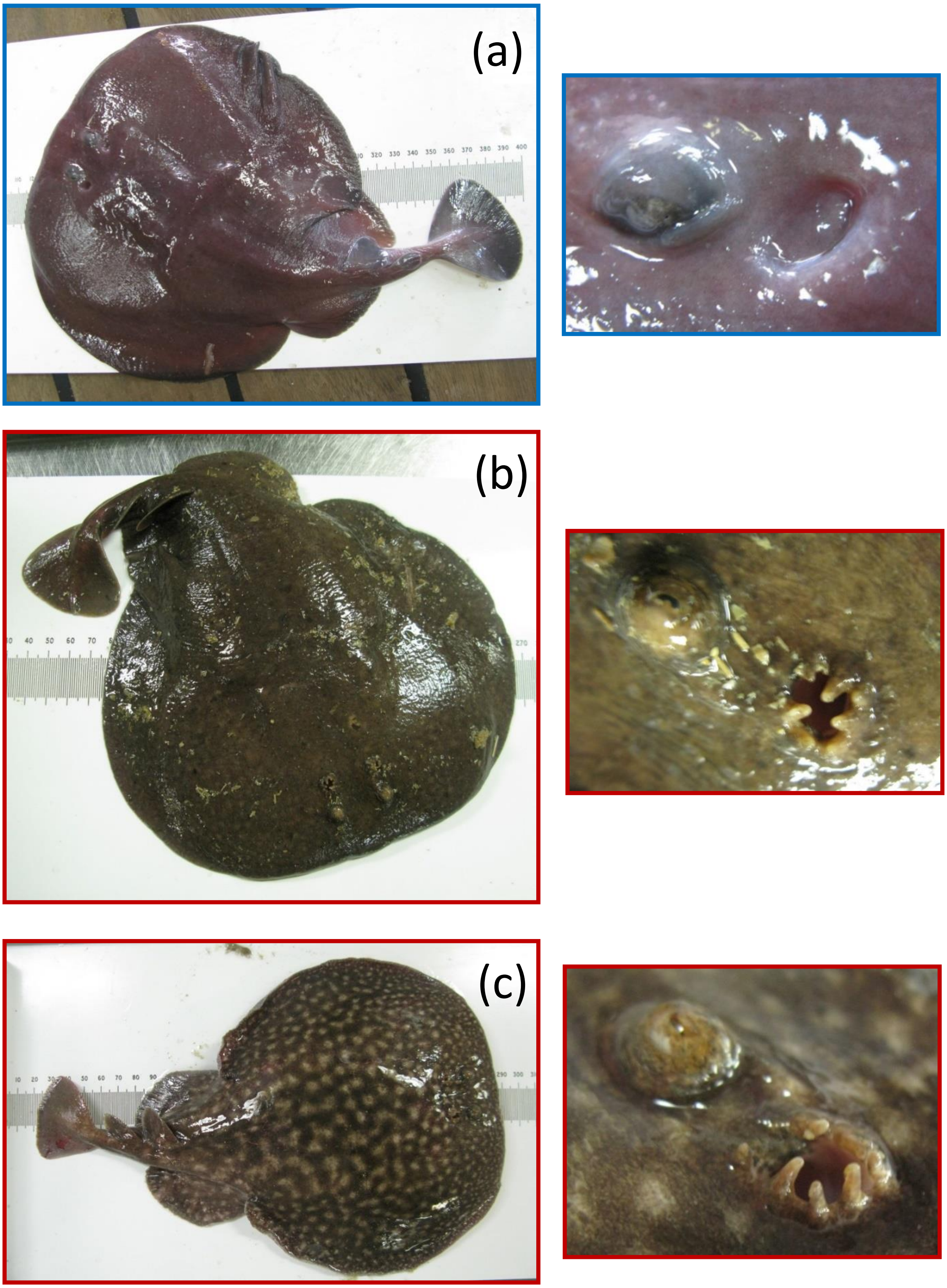
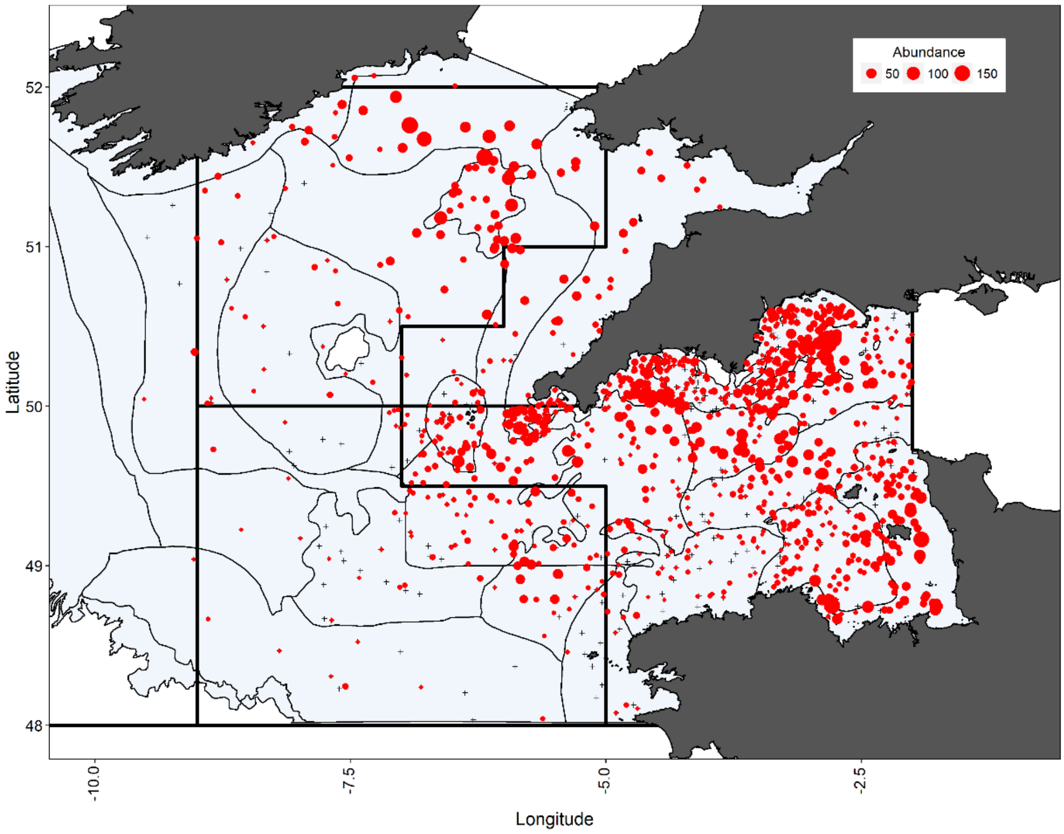


Figure 3: Electric rays (*Torpedo* spp.) showing whole specimens and detail of spiracles of (a) *T. nobiliana,* (b) *T. marmorata* with more uniform dark colouration and (c) *T. marmorata* with normal marbled colouration. Both specimens of *T. marmorata* caught in the western English Channel, specimen of *T. nobiliana* from the Celtic Sea.



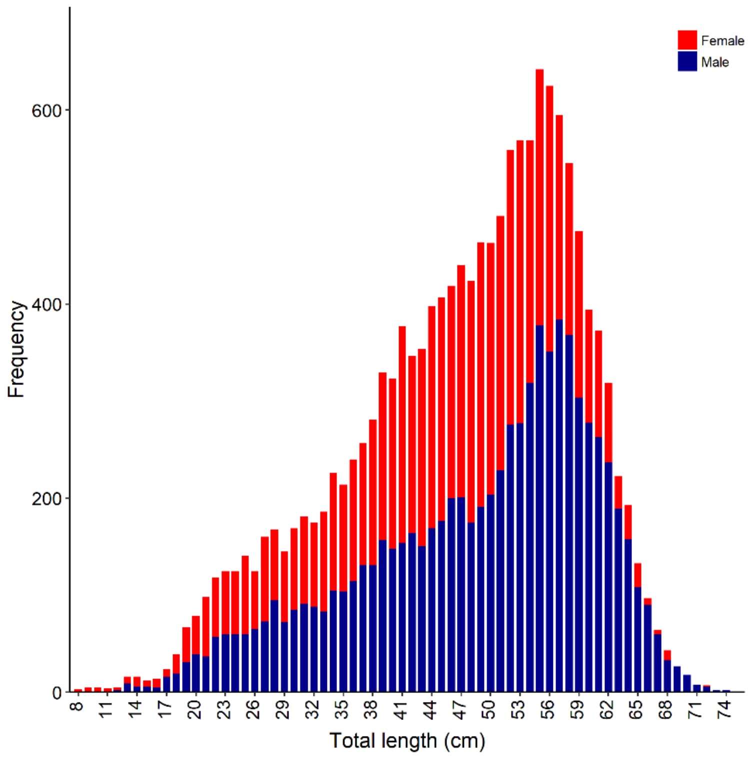


Figure 4: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of lesser-spotted dogfish *Scyliorhinus canicula*.

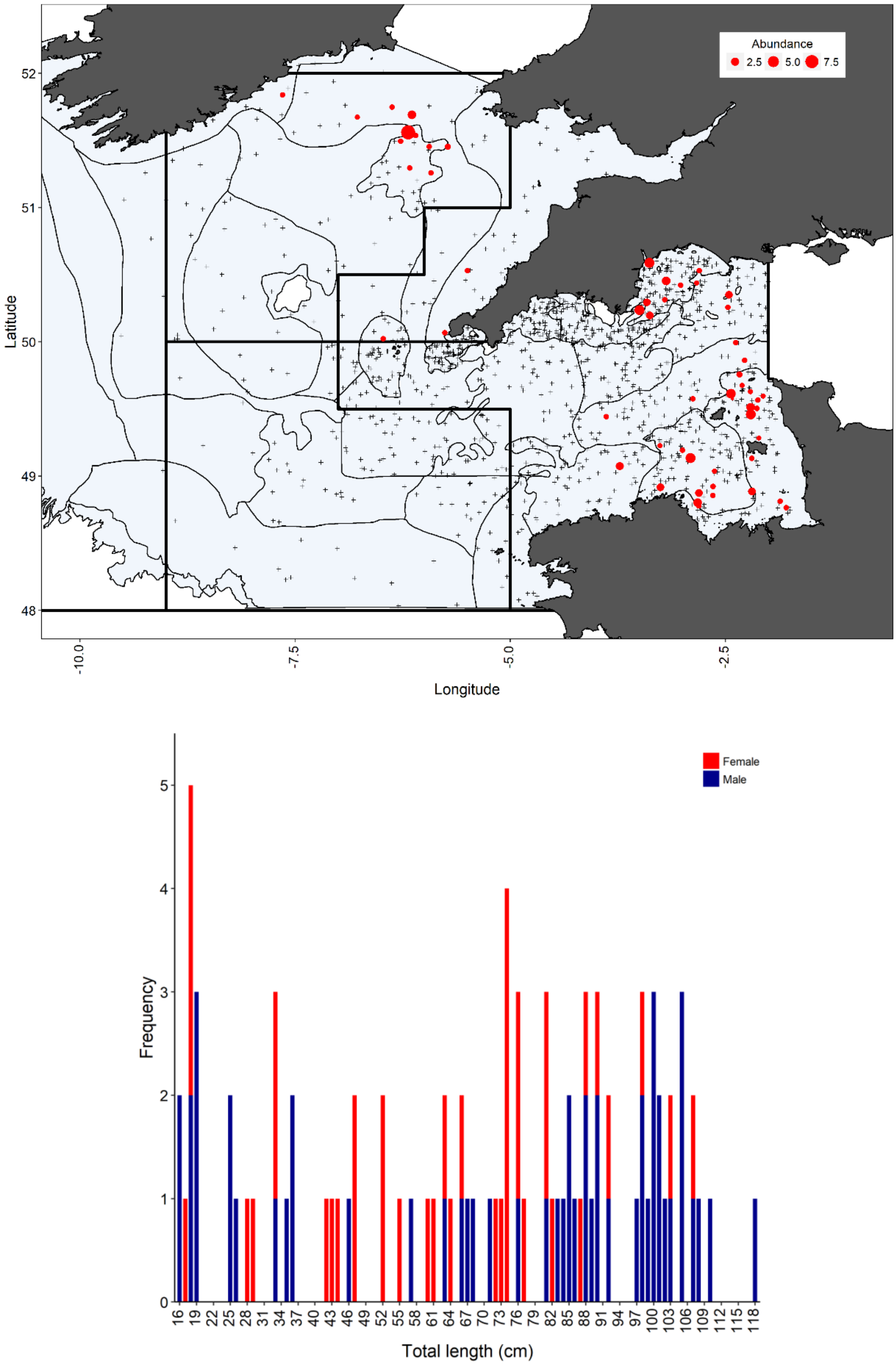


Figure 5: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of greater-spotted dogfish *Scyliorhinus stellaris*.

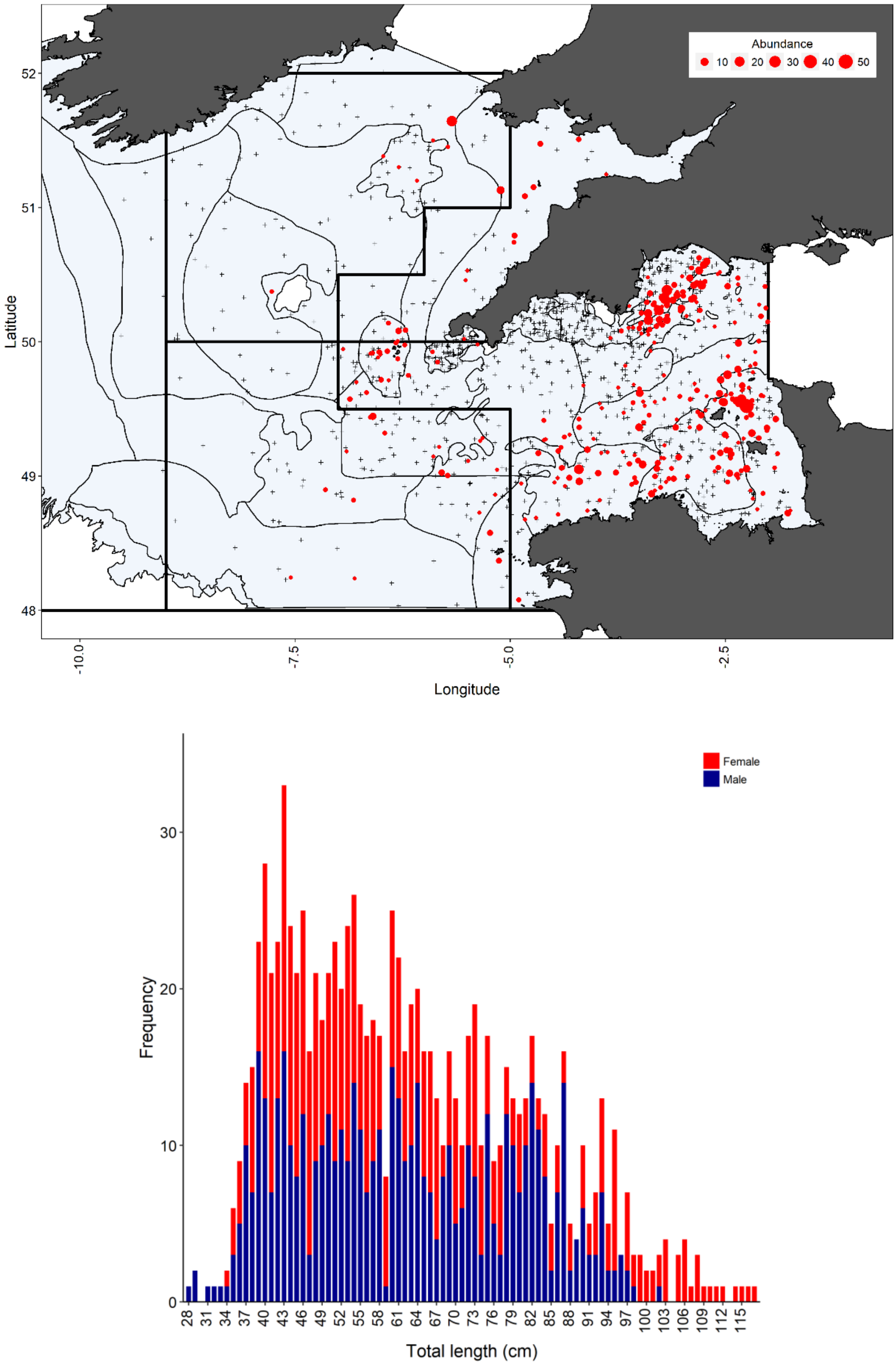
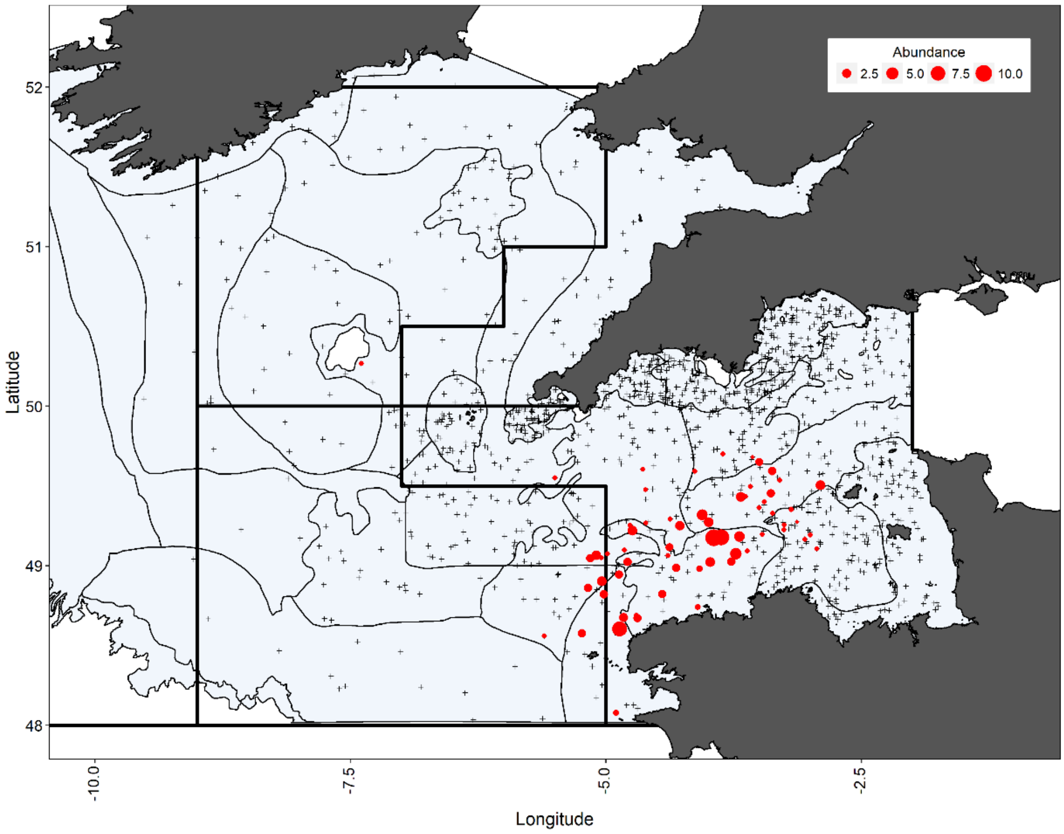


Figure 6: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of smooth-hounds *Mustelus* spp.



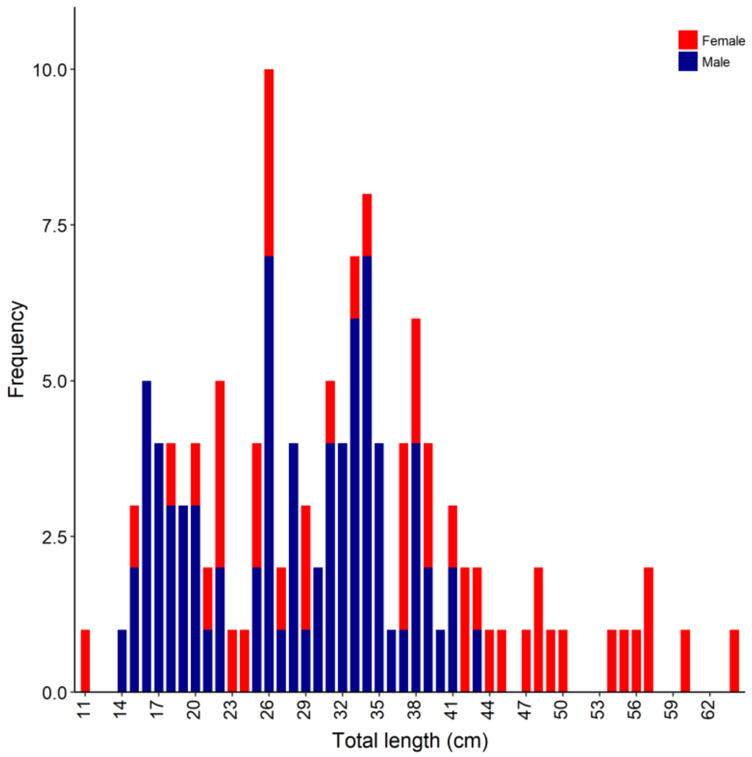


Figure 7: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of marbled electric ray *Torpedo marmorata*.

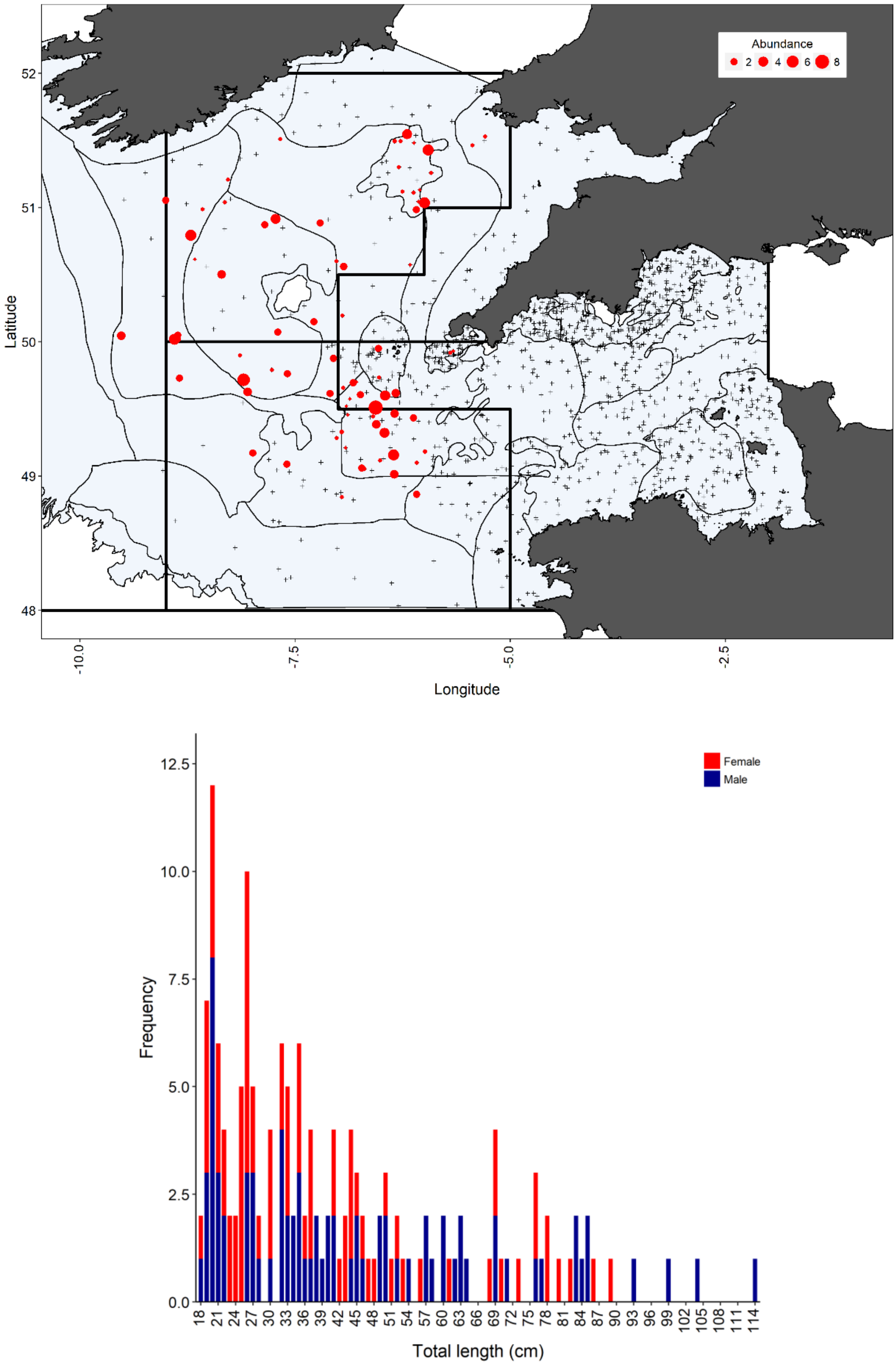
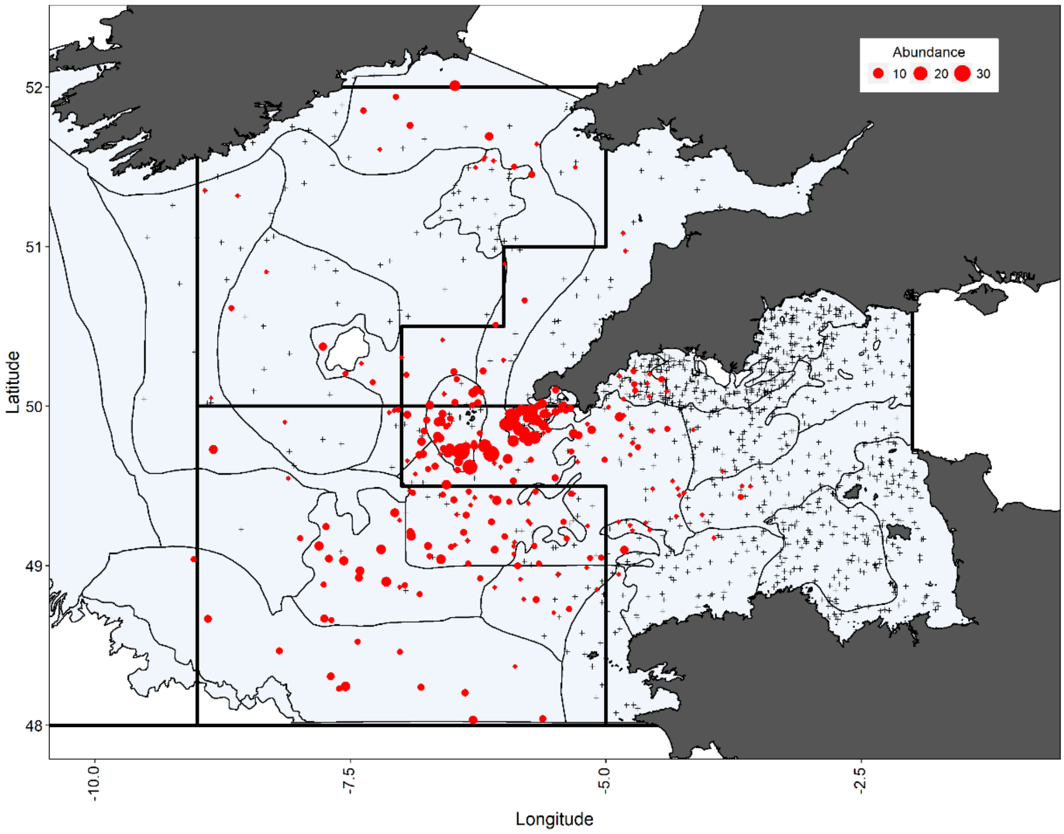


Figure 8: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of common skate *Dipturus batis*-complex.



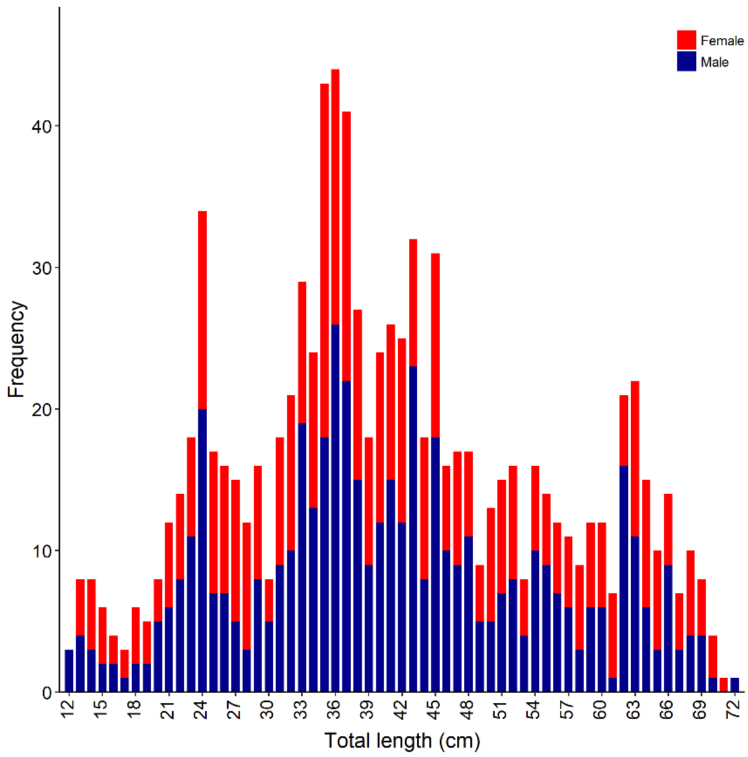


Figure 9: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of cuckoo ray *Leucoraja naevus*.

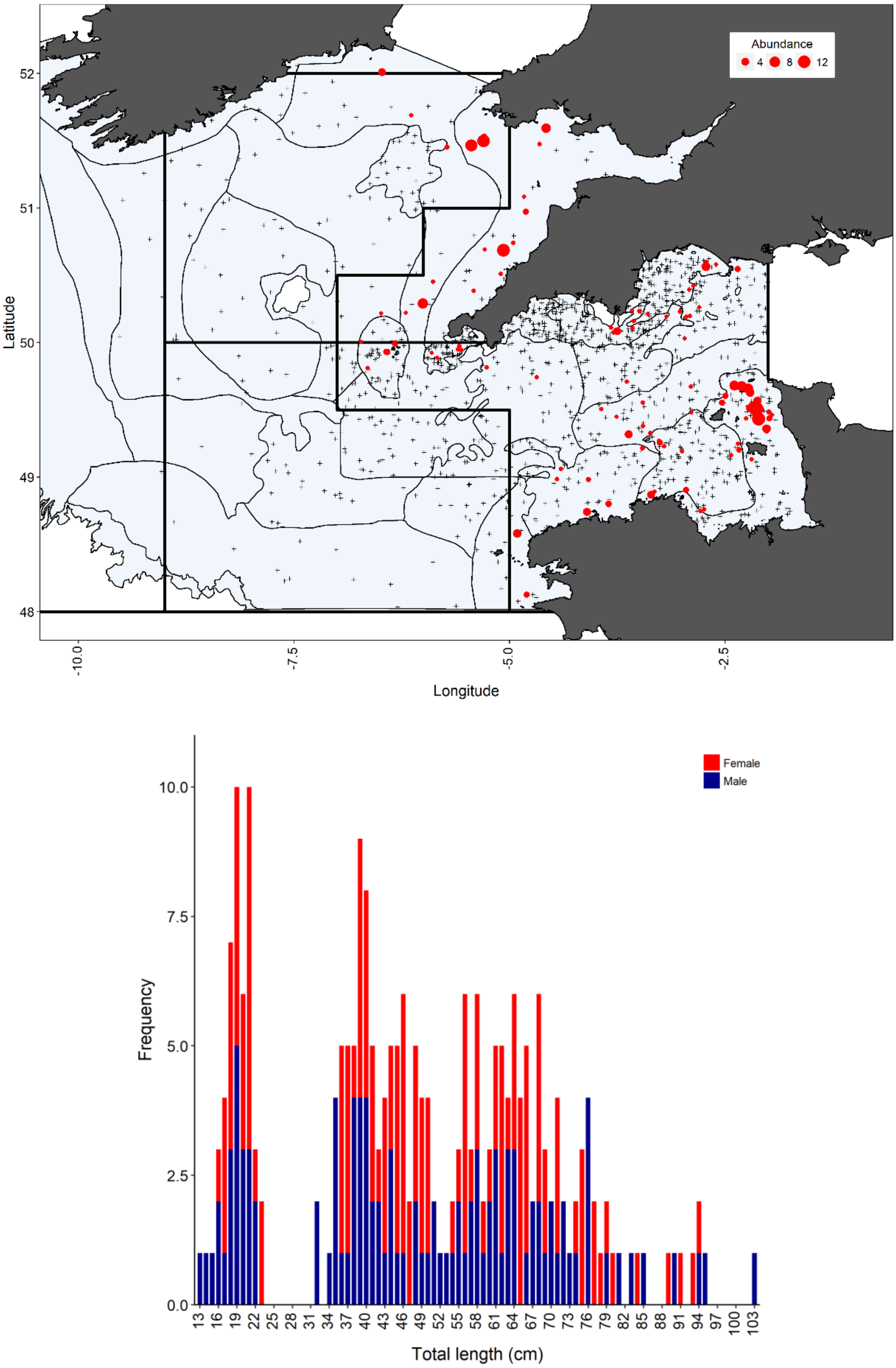
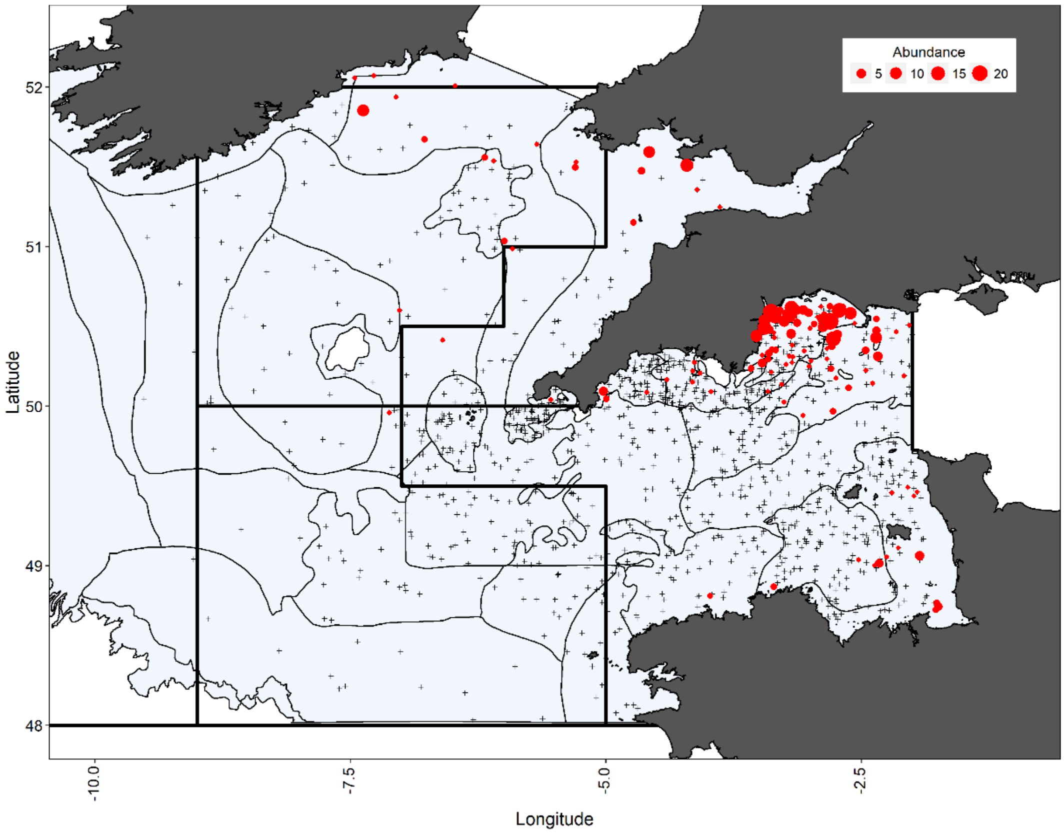


Figure 10: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of blonde ray *Raja brachyura*.



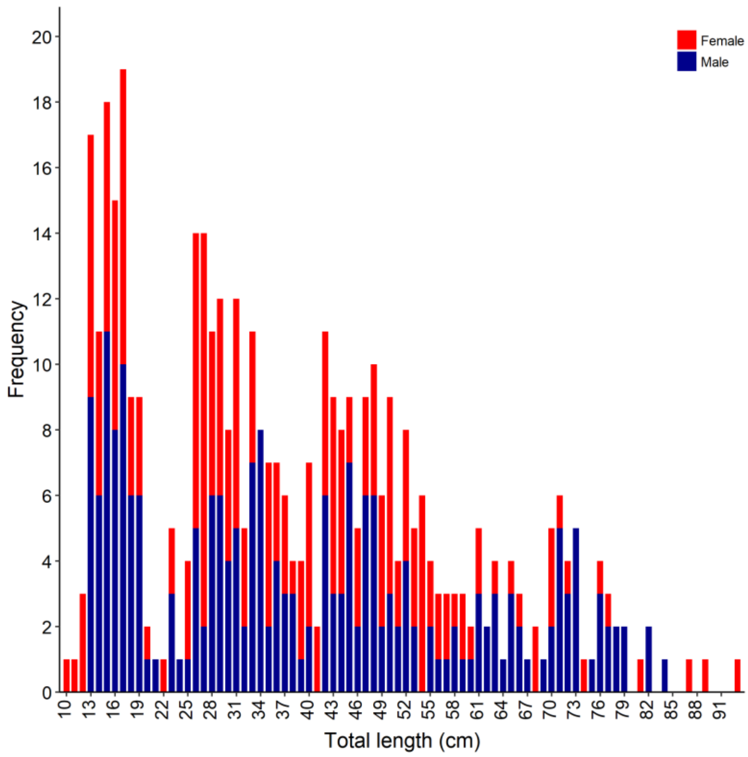


Figure 11: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of thornback ray *Raja clavata*.

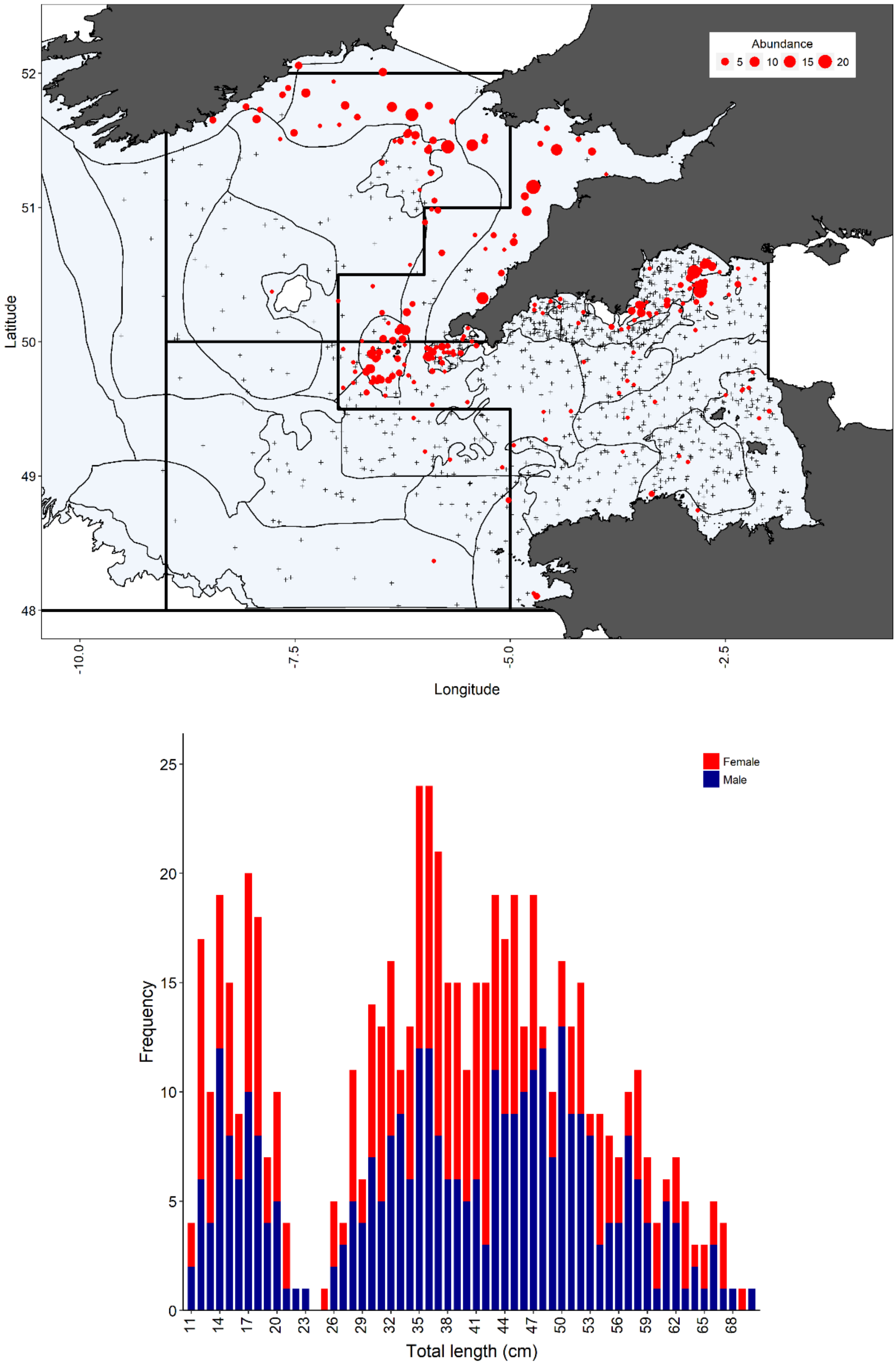


Figure 12: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of spotted ray *Raja montagui*.

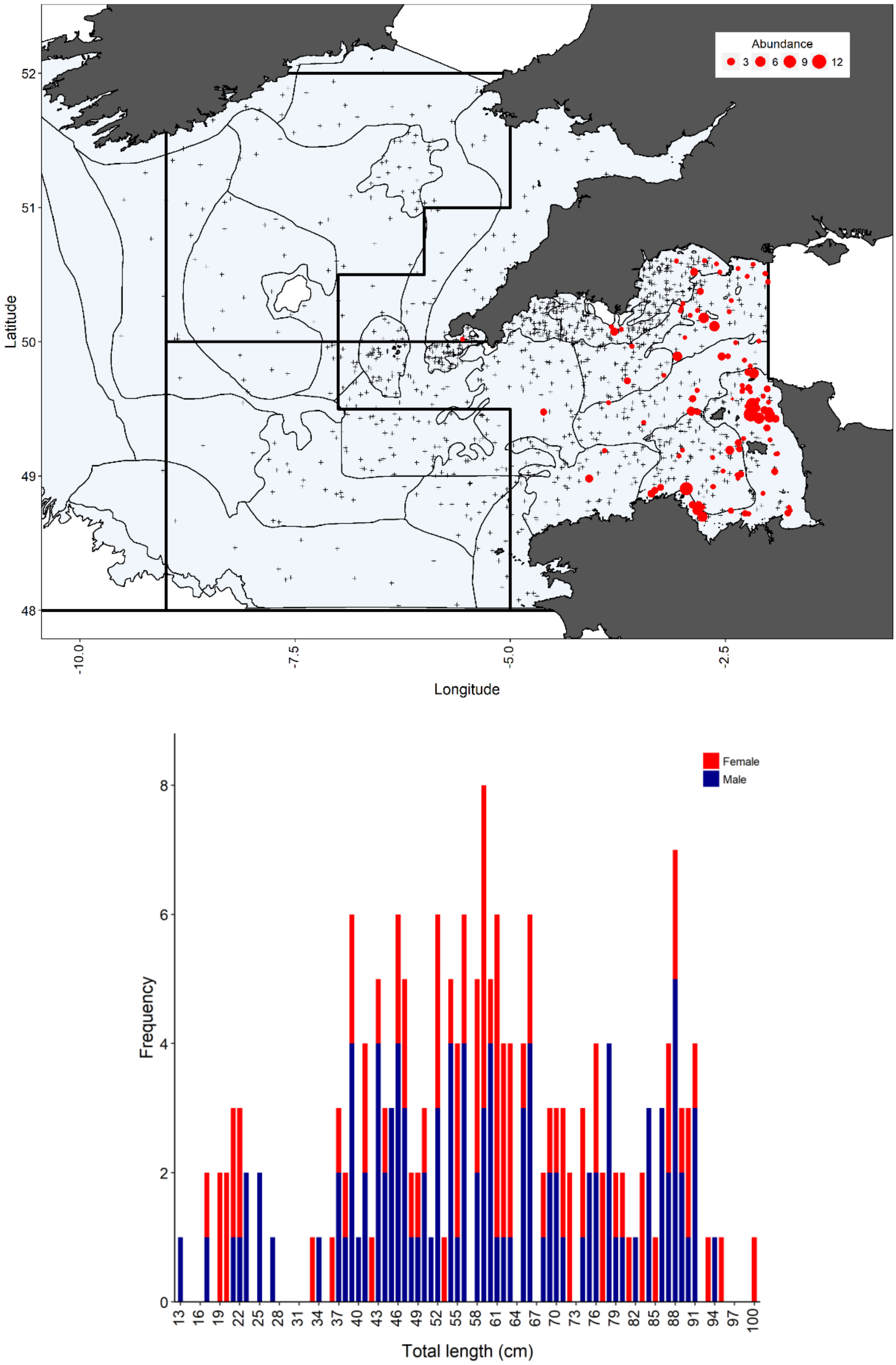


Figure 13: Demersal elasmobranchs in the Q1SWECOS indicating (top) the distribution and relative abundance, and (bottom) length-frequency by sex of undulate ray *Raja undulata*.

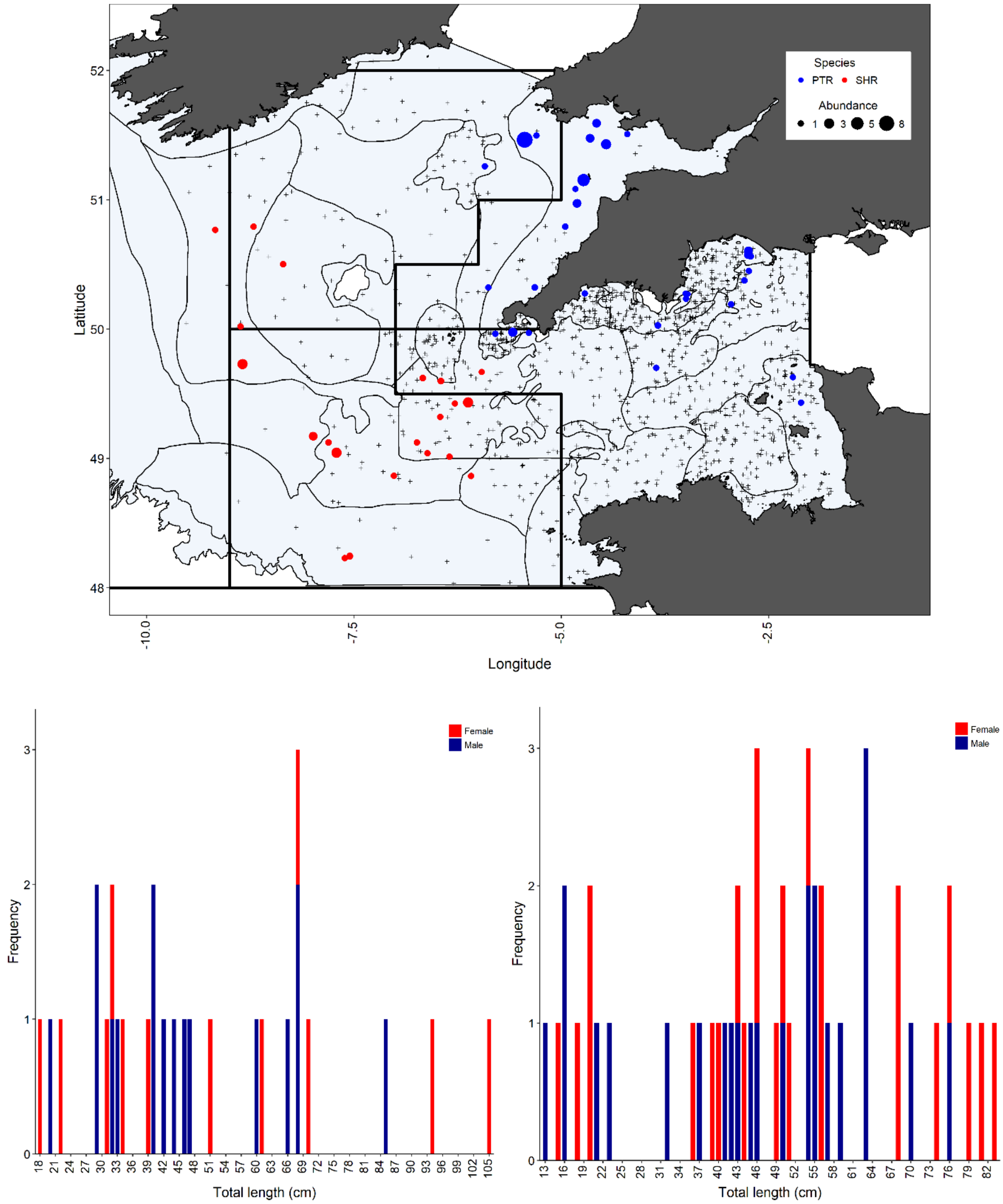


Figure 14: Demersal elasmobranchs in the Q1SWECOS indicating the relative abundance of (top) shagreen ray *Leucoraja fullonica* (red) and small-eyed ray *Raja microocellata* (blue), and (bottom) length-frequency by sex of (left) shagreen ray *Leucoraja fullonica* and (right) small-eyed ray *Raja microocellata*

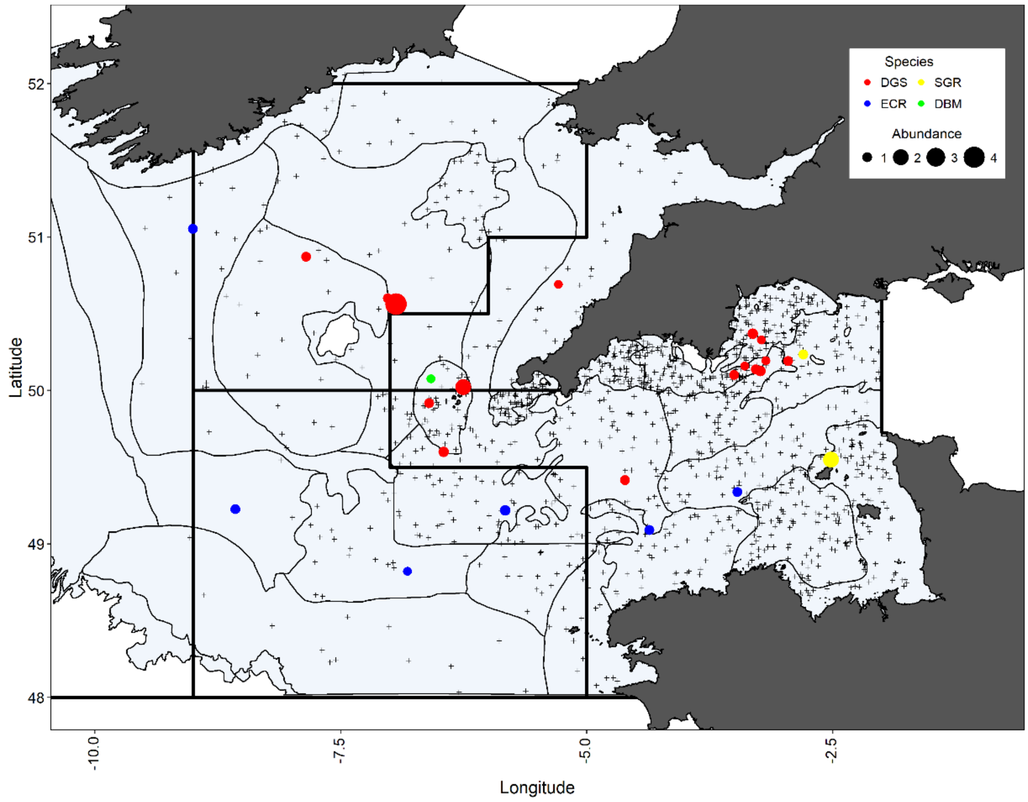


Figure 15: Demersal elasmobranchs in the Q1SWECOS indicating the relative abundance of spurdog *Squalus acanthias* (red), electric ray *Torpedo nobiliana* (blue), common stingray *Dasyatis pastinaca* (yellow) and Black-mouth dogfish *Galeus melastomus* (green).

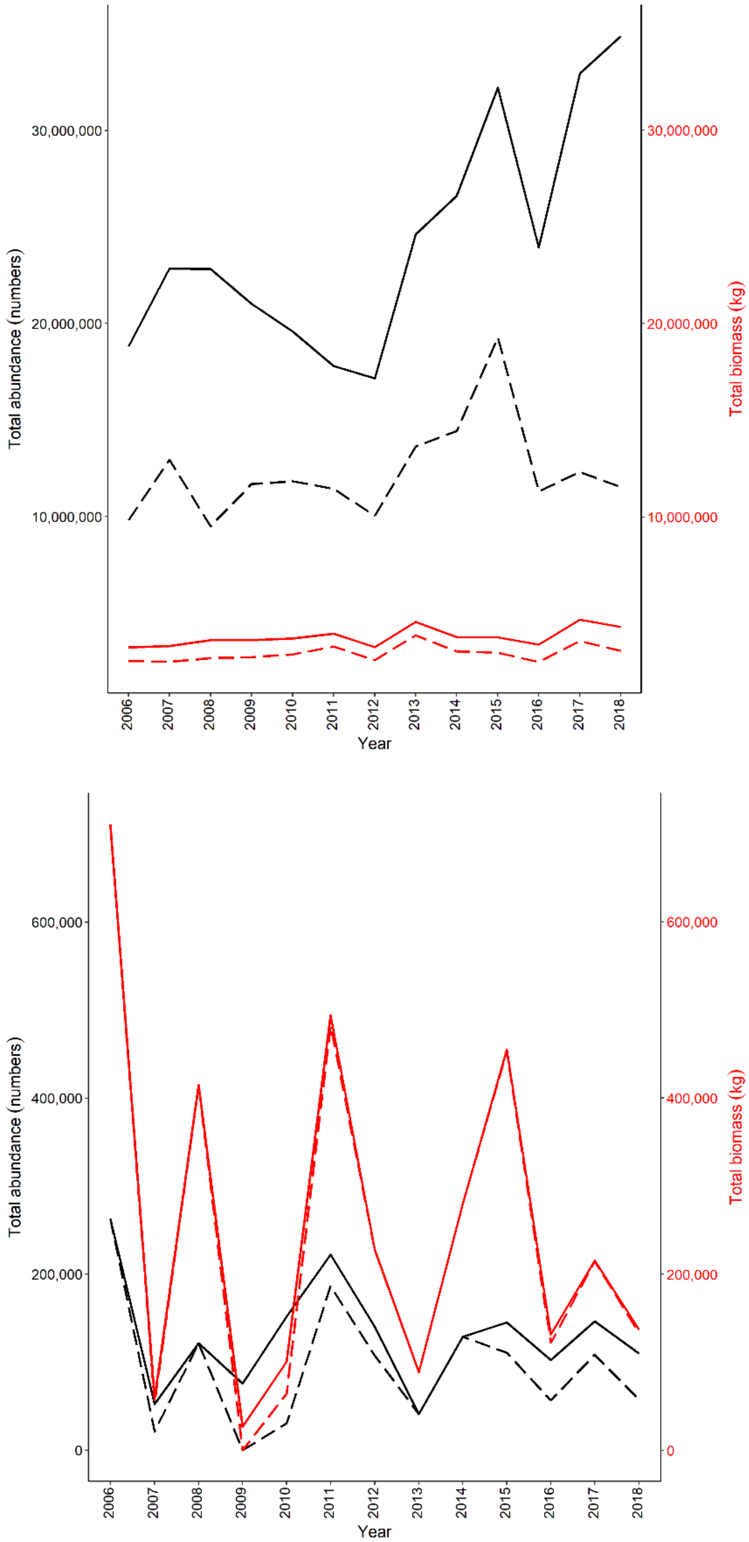


Figure 16: Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (top) lesser-spotted dogfish *Scyliorhinus canicula* and (bottom) greater-spotted dogfish *Scyliorhinus stellaris*. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length.

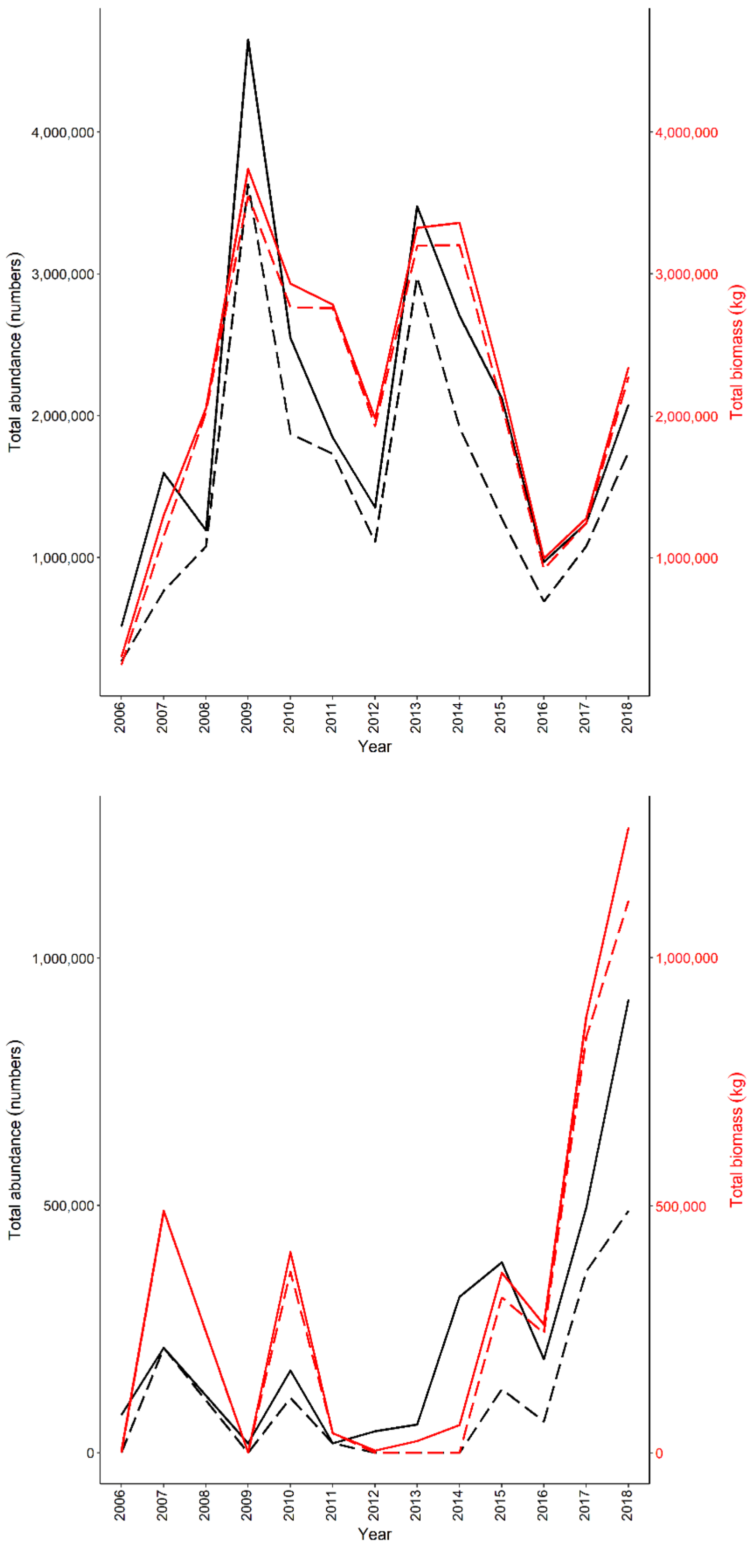


Figure 17: Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (top) smooth-hounds *Mustelus* spp and (bottom) common skate *Dipturus batis*-complex. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length.

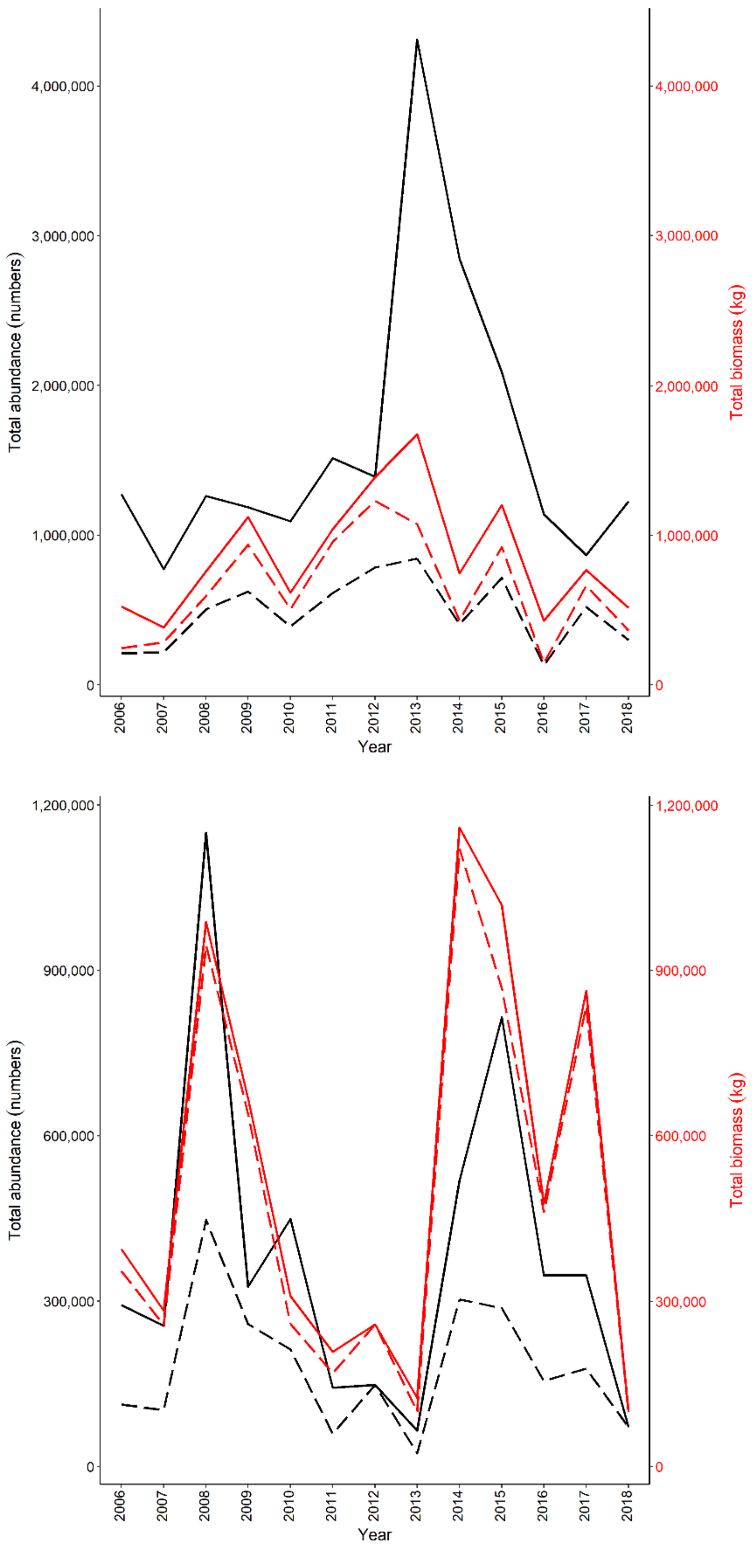


Figure 18: Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (top) cuckoo ray *Leucoraja naevus* and (bottom) blonde ray *Raja brachyura*. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length.

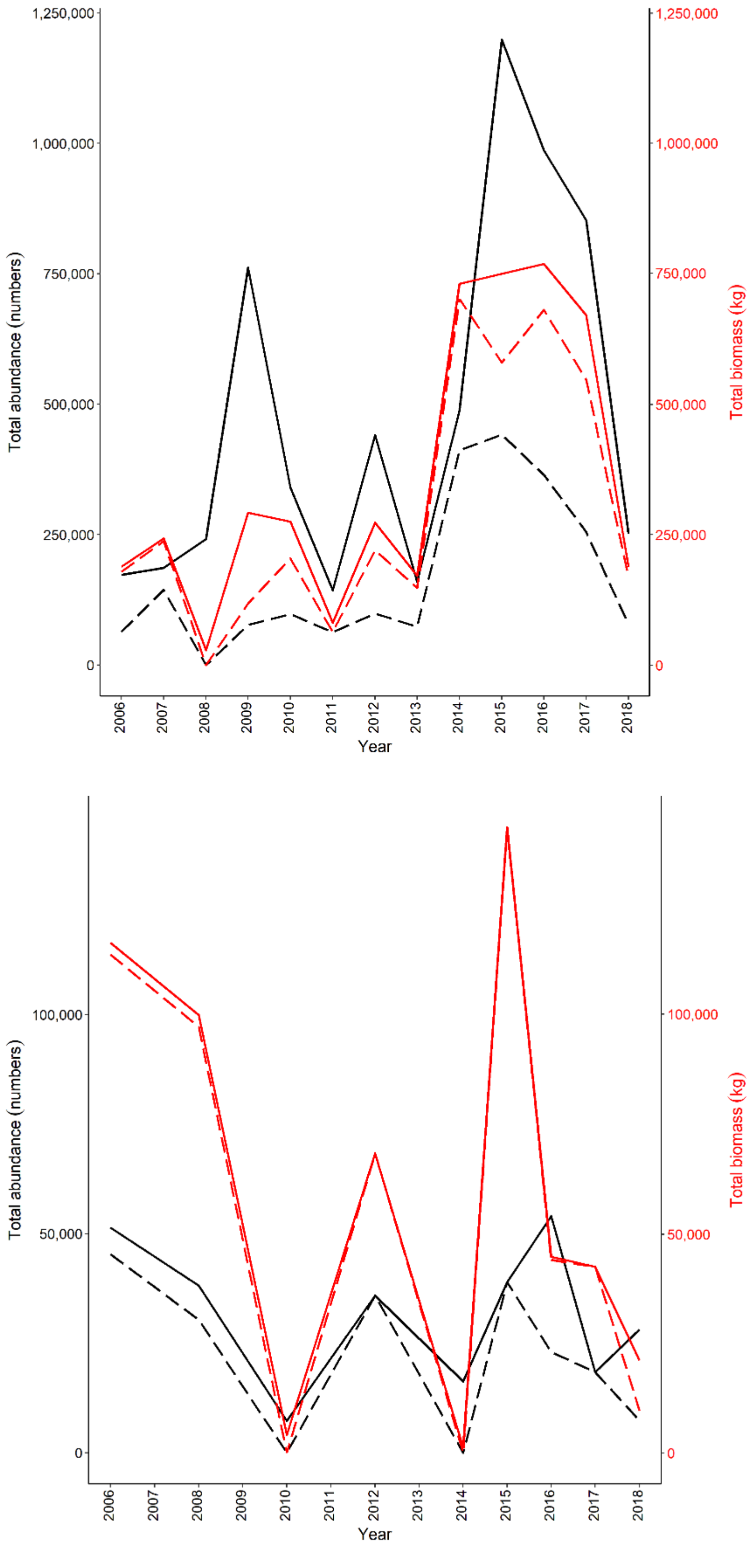


Figure 19: Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (top) thornback ray *Raja clavata* and (bottom) small-eyed ray *Raja microocellata*. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length.

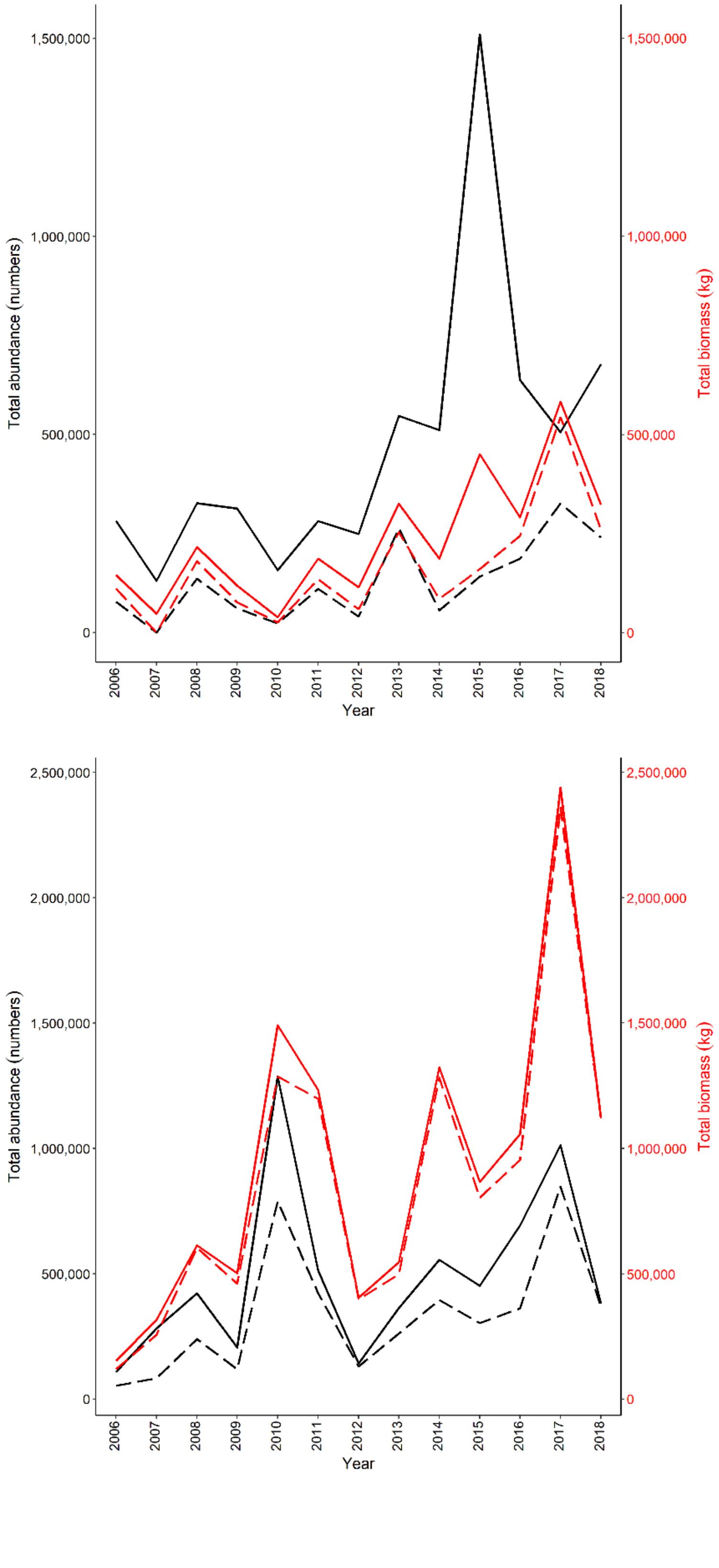


Figure 20: Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (top) spotted ray *Raja montagui* and (bottom) undulate ray *Raja undulata*. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length.

WG

Porbeagle: Data limited stock assessment, using the SPICT model

Working document to WGEF 2018, Lisbon 19-28 June 2018

Ole Thomas Albert
Institute of Marine Research, Norway

Introduction

SPICT analyzes were conducted based on a French CPUE long-line index from Biscaya, as well as on total international landings, both available in the latest working group report (ICES 2017). The CPUE index was available for the years 1972-2007 and landing data from 1950-2016.

For EU countries, there has been zero quota since 2010 and dead discards have not been reported. Direct fishing has been prohibited in Norway since 2007, and from 2011 only dead bycatch (i.e. dead when hauled onboard) could be landed. However, contrary to the general rule in Norway, landing of dead porbeagle is not mandatory. The values of such landings are confiscated since the species is exempted from the general landing obligation. Landing data after 2010 must therefore be regarded as very little representative of the actual withdrawal.

To investigate the sensitivity of the SPICT model towards varying quality throughout the time series, the model was fitted for a series of different start and stop years for both the CPUE index and the landings data. As recommended (Pedersen & Berg, 2016), various choices were also made of which parameters to be estimated by the model and which that were set by the user. According to Pedersen & Berg (2016) standard assumptions are to set the parameters n=2, which implies that the symmetric Schaefer model is used, and to set alpha = 1, which means that the process and observation noise are equal (Ono et al. 2012; Thorson et al. 2013). They also suggest trying to fix alpha = 4 which is similar to estimates found by Meyer and Millar (1999).

Results and discussion

Tables P1a and P1b summarize settings, diagnostics and results from ten different runs. Figure P1 shows the two input-series and figures P2-P11 show the results plots for each of the ten runs while the retrospective pattern is shown in figures P12-P14.

In assessing the individual model runs, emphasis was placed on the extent to which the historical development, as it appears in the KOBE plots, seems in line with what is known with regard to fishing history. The large but strongly declining landings in the 50s and 60s are likely to have reduced the stock heavily. The relatively stable landings from the late 60s up to the 2010 fishing ban coincided with a CPUE index from the French longline fishery which showed a further sharp decline in the 70's and with a subsequent stabilization from the 80’s onwards. The very low landings from 2010 must be regarded as lower than the actual removals, because the extent of dead discards is unknown. However, it is still assumed that the real catches during this period were at a low level. One would therefore expect the KOBE plots to show a development from a period of F> Fmsy and a decreasing B> Bmsy, over a period of F> Fmsy and B <Bmsy, and further to a terminal period with F <Fmsy and B on the way upwards.

In addition to the KOBE-plots, the model output also includes precision estimates of the different parameters, like K, MSY, Fmsy, B og F.

The KOBE-plots from all the runs except the first one, showed more or less realistic trajectories. However, the runs with landings data only starting in 1971 (Run 1-3) gave extremely unprecise estimates, with confidence intervals covering large parts of the plots. This is probably due to the fact that they covered a period of relatively small contrast in the landings data, and only the left side of the production curve was supported by data points.

The best results are therefore from runs where the catch data dates back to 1950. In run 4, 5 and 10 we have truncated the catch series when the fishing ban was implemented. These all show that the stock was in the red zone at that time. The runs that continue until 2016 (Run 6, 7, 8 and 9) show that fishing mortality fell below Fmsy in 2010 and that the stock is on its way up again. Pedersen & Berg (2016) points out that the shape of the production curve is important for unbiased reference points and recommends to try a run without fixing the shape parameter n. In Run 6 the n-parameter was allowed to be estimated, while in Run 7 it was fixed at n=2 (Schaefer), while all other input data were the same. The results from the two runs were largely similar, but Bmsy was smaller and Fmsy higher when n was estimated. This resulted in estimated present biomass of 60% above Bmsy, compared to slightly below Bmsy (86%) when n was fixed.

It may seem that the stock biomass is now either above or not too far below Bmsy. With F far below Fmsy, a commercial porbeagle fishery may therefore again become advisable in the near or medium-term future. This requires however a reestablishing of reliable data series on removals, as well as on stock size and composition.

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Thorson, J.T., Minto, C., Minte-Vera, C.V., Kleisner, K.M., Longo, C. and Jacobson, L. (2013) A new role for effort dynamics in the theory of harvested populations and data-poor stock assessment. Canadian Journal of Fisheries and Aquatic Sciences 70, 1829–1844.

Table P1 a. Input and output from the different model runs.

	Run_1	Run_2	Run_3	Run_4	Run_5	Run_6	Run_7	Run_8	Run_9	Run_10
Catch_start	1971	1971	1971	1950	1950	1950	1950	1950	1950	1950
Catch_stop	2016	2009	1995	1995	2007	2016	2016	2016	2016	2009
Ind_start	1972	1972	1972	1972	1972	1972	1972	1972	1972	1972
Ind_stop	2007	2007	1995	1995	2007	2007	2007	2007	2007	2007
Restriction							n=2	n=2, alf=1	n=2, alf=4	n=2, alf=4
Convergens	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
C_shapiro	***	ns	ns	ns	ns	***	***	***	***	ns
C_bias	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C_acf	ns	ns	ns	ns	*	*	ns	*	*	*
C_Lbox	ns	ns	ns	ns	*	*	ns	*	ns	**
I_shapiro	ns	ns	**	**	ns	*	ns	ns	ns	ns
I_bias	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
I_acf	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
I_Lbox	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
K	17561	10154	12290	9789	9903	9700	12848	13454	12256	10429
K_low	313	816	752	7576	5686	4855	7224	5630	7766	6969
K_high	984770	126225	208194	12648	17247	19382	22852	32151	19341	15610
q	0,00095	0,00046	0,00044	0,00046	0,00047	0,00038	0,00028	0,00026	0,00029	0,00041

Table P1 b. More output from the different model runs. Estimates of Bfinal/Bmsy and of Ffinal/Fmsy are color coded according to if the estimates indicate that the stock was severely overfished and if overfishing was occurring at the final year (the greener the better, the redder the worse). The next-to-last line indicates the authors subjective evaluation of how well the trajectory describes the history of the fishery. The last line gives the rate of the upper and lower estimate of K, an indicator of carrying capacity.

	Run_1	Run_2	Run_3	Run_4	Run_5	Run_6	Run_7	Run_8	Run_9	Run_10
Bmsys	4946	3797	3801	3610	3203	3232	6319	6266	6080	5185
Bmsys_low	111	817	690	2348	1122	862	3634	2794	3875	3477
Bmsys_high	220592	17641	20930	5550	9145	12123	10989	14054	9541	7730
Fmsys	0,2	0,18	0,17	0,19	0,21	0,19	0,12	0,12	0,12	0,17
Fmsys_low	0,02	0,06	0,04	0,13	0,07	0,05	0,05	0,04	0,06	0,08
Fmsy_high	2,1	0,6	0,7	0,27	0,63	0,72	0,28	0,33	0,27	0,38
MSYs	1001	694	652	676	664	622	741	730	757	892
MSYs_low	216	367	390	507	463	460	506	468	536	572
MSYs_high	4645	1308	1091	900	951	842	1084	1138	1069	1394
Bfinal/Bmsy	0,0004	0,4	0,4	0,4	0,5	1,6	0,86	0,82	0,91	0,32
Ffinal/Fmsy	43,5	1,8	3,2	3,4	1,3	0,016	0,025	0,026	0,023	2,1
Final year	**2016**	2009	1995	1995	2007	**2016**	**2016**	**2016**	**2016**	2009
Reasonable trajectory?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
K_high/K_low	3146	155	277	2	3	4	3	6	2	2

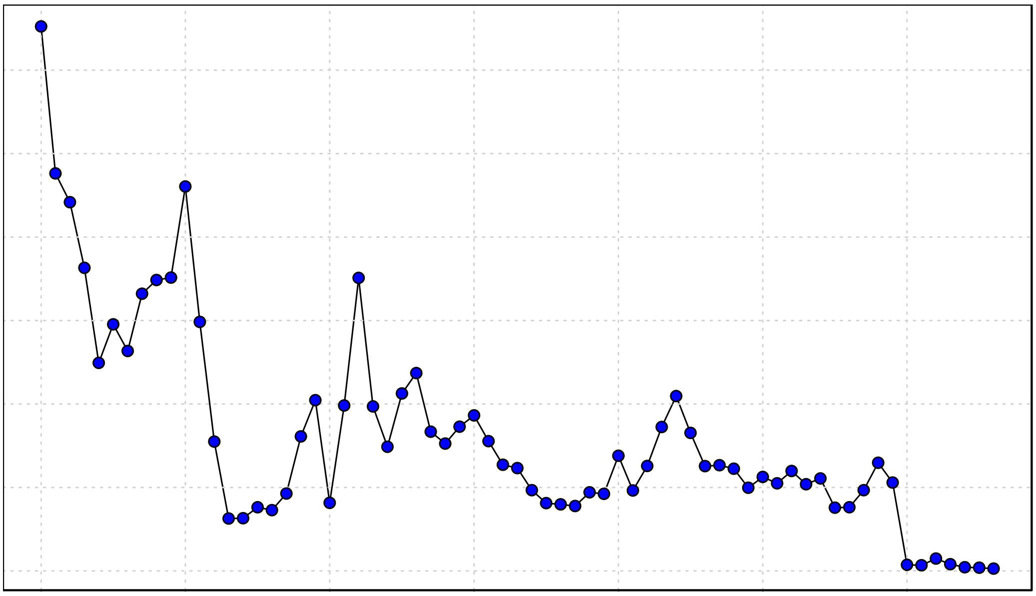

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Figure P1. Input data series on total international landings (top) and CPUE from the French longline fishery on porbeagle in Bay of Biscay. The different runs (Run1-Run10) used different truncations of these data series.

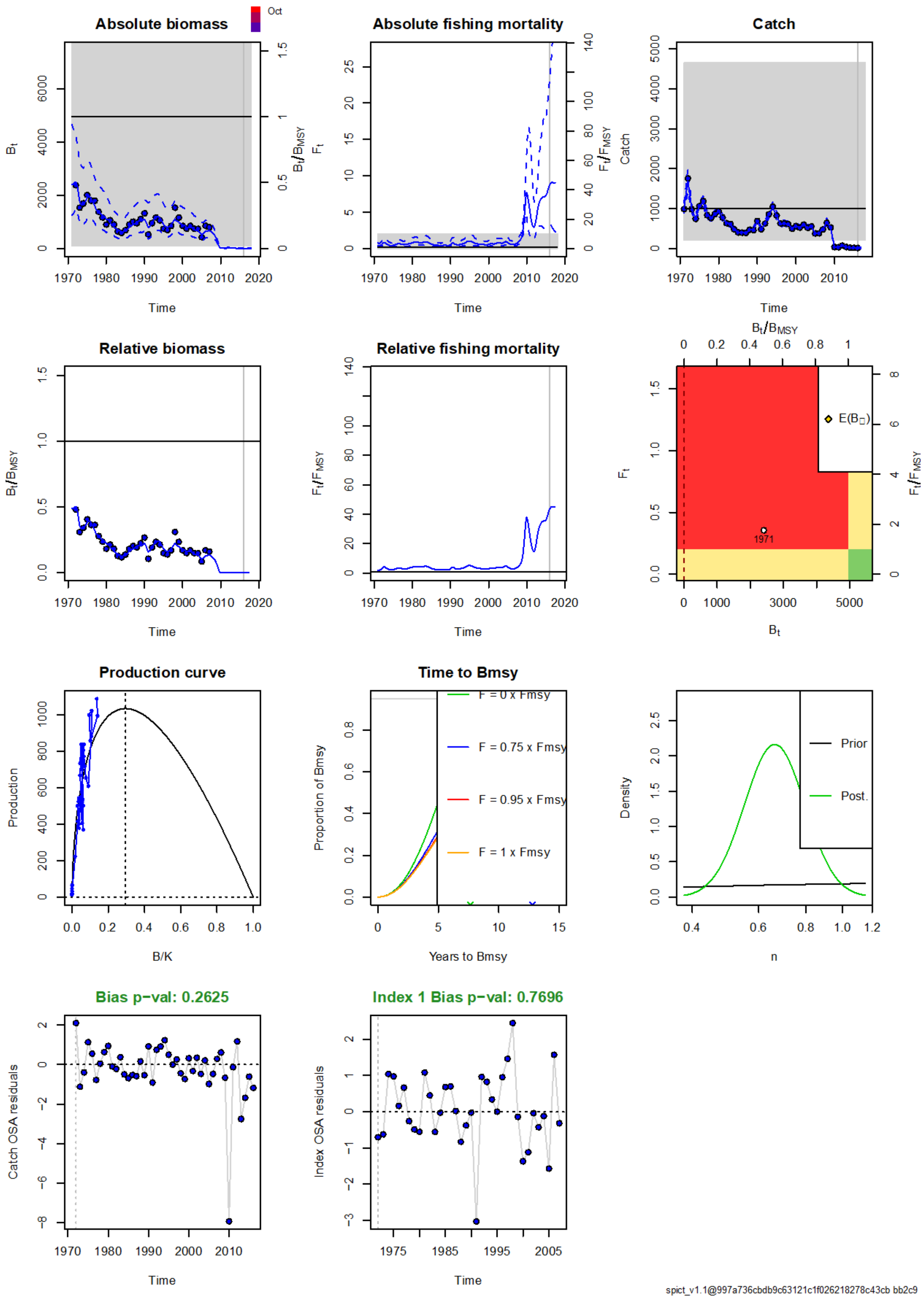

Figure P2. Results from Run_1.

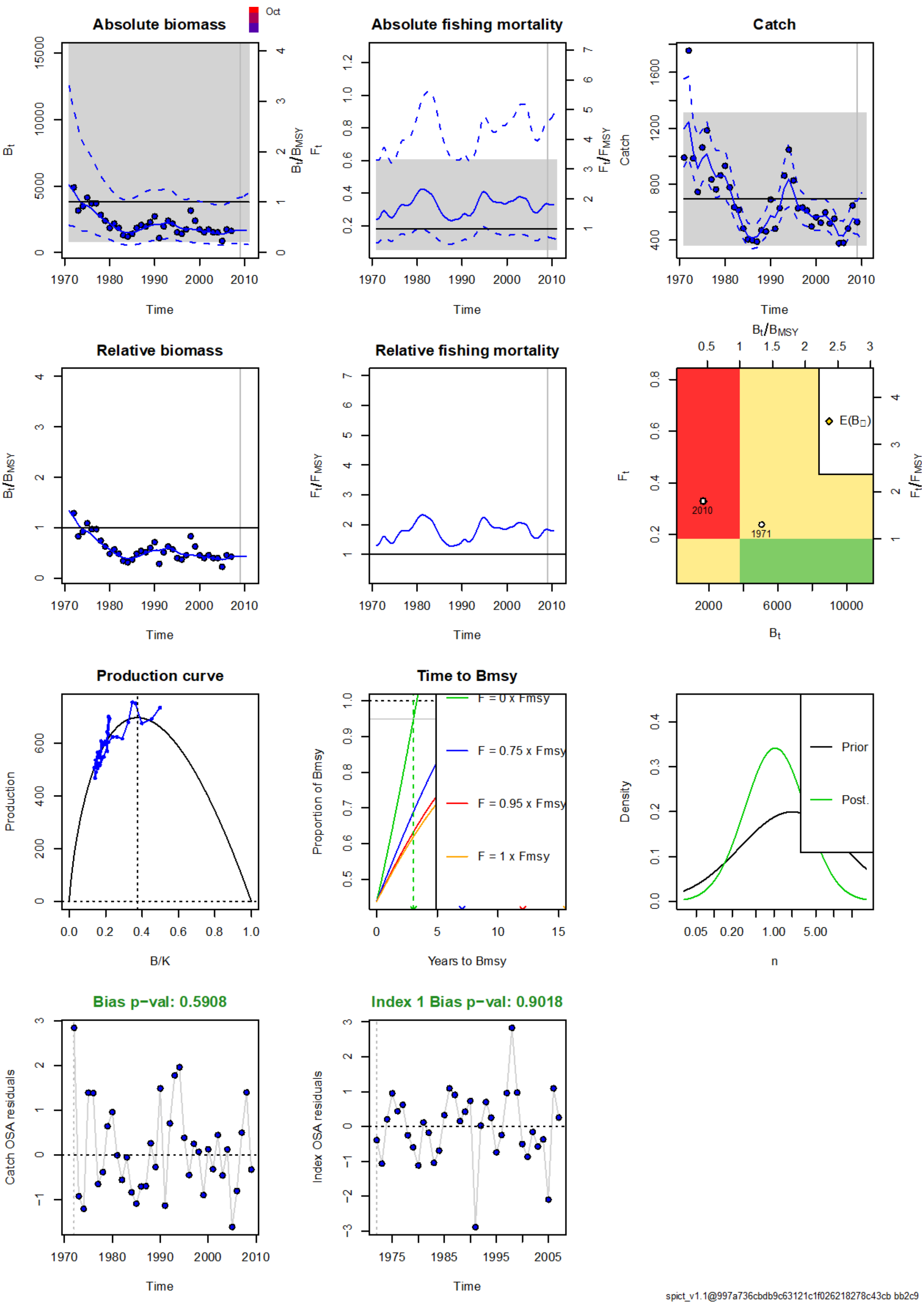

Figure P3. Results from Run_2

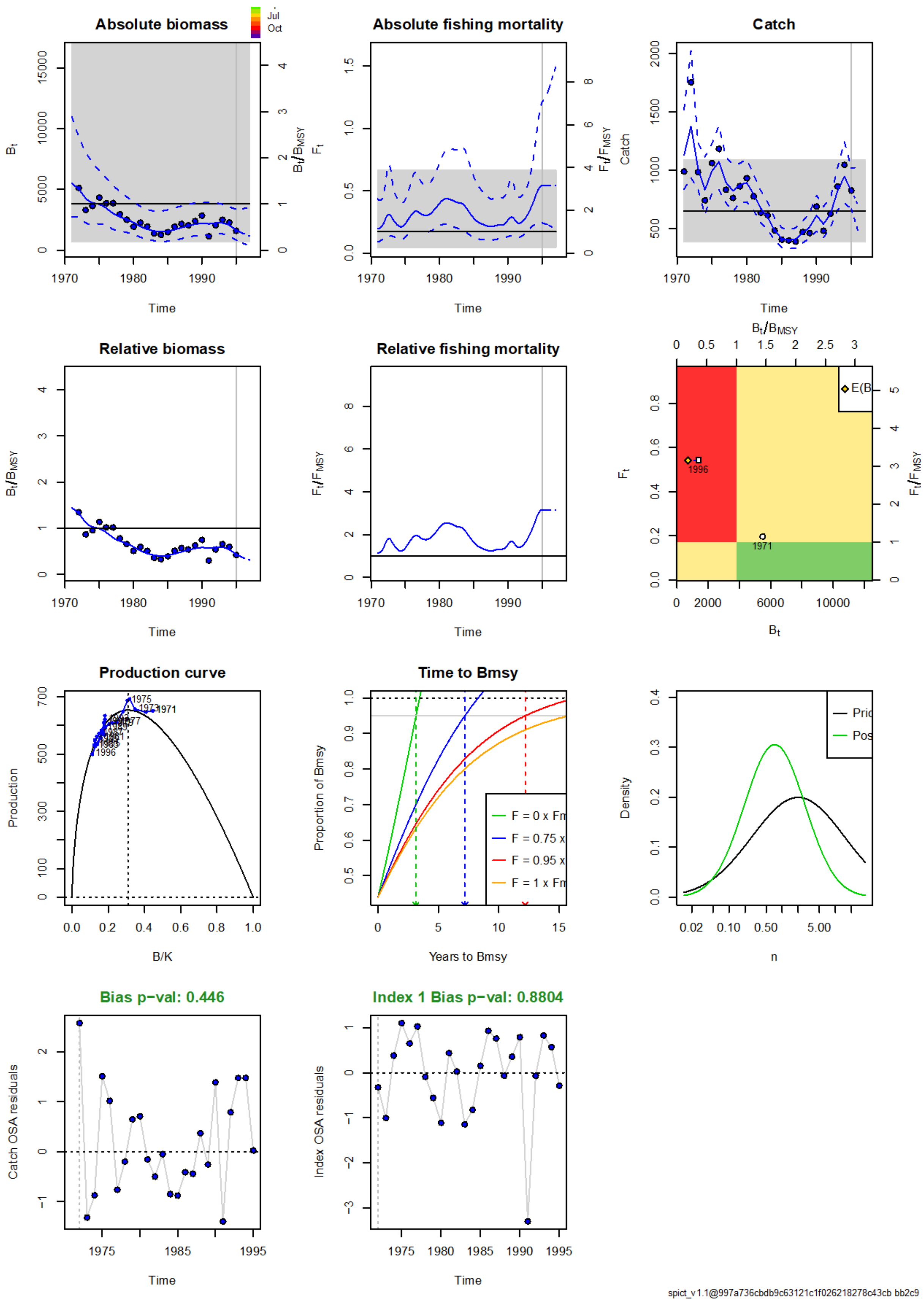

Figure P4. Results from Run_3.

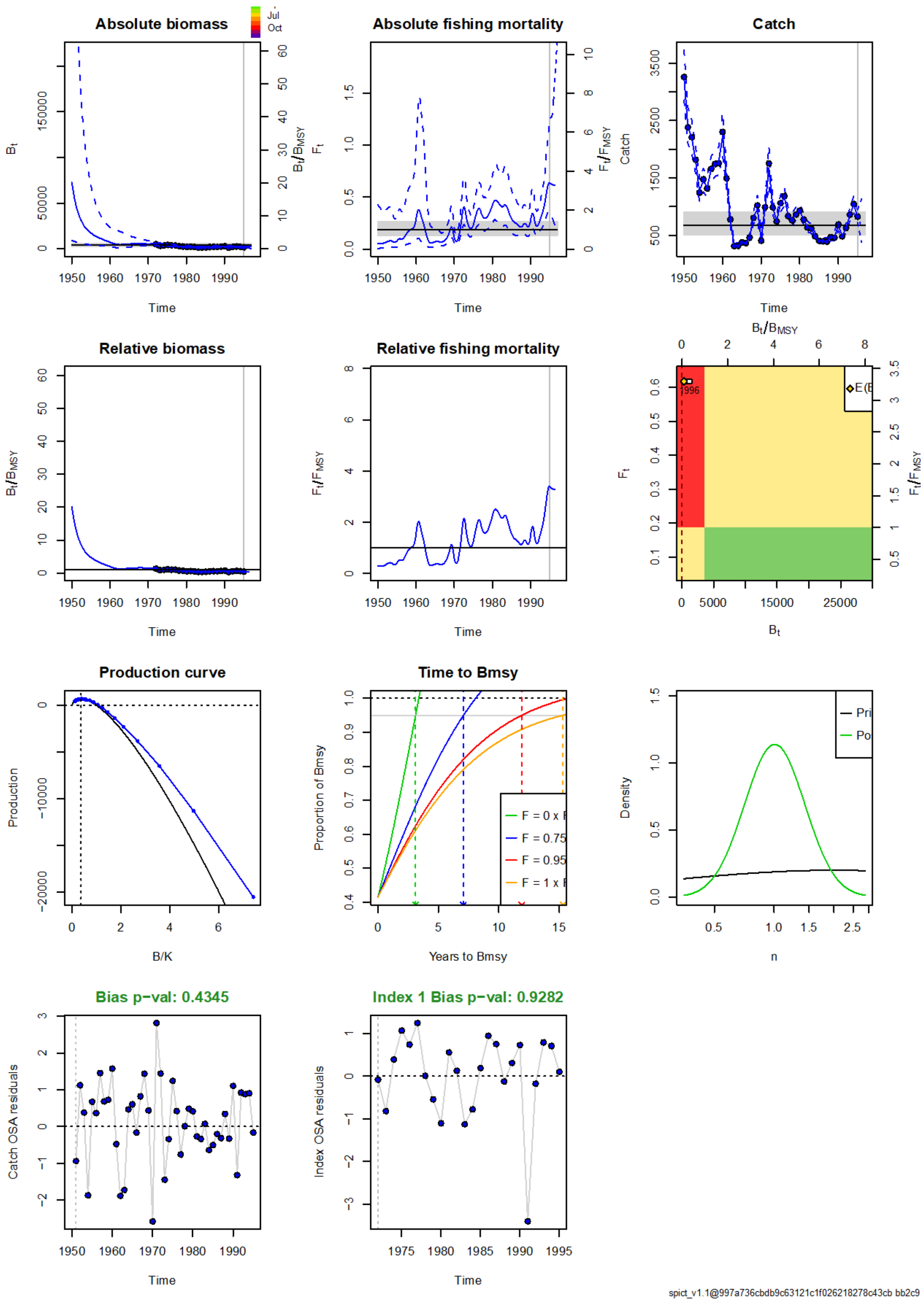

Figure P5. Results from Run_4.

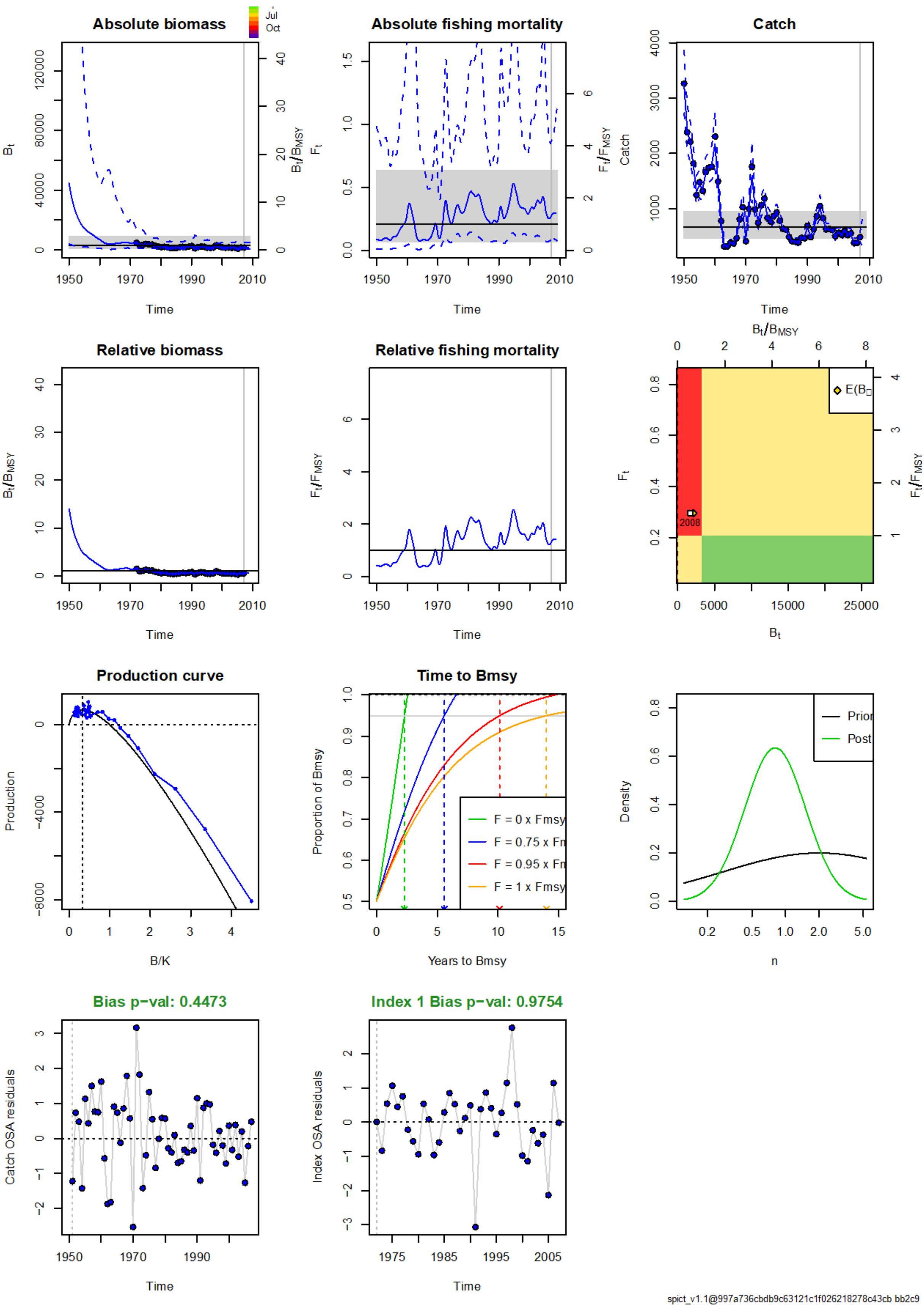

Figure P6. Results from Run_5.

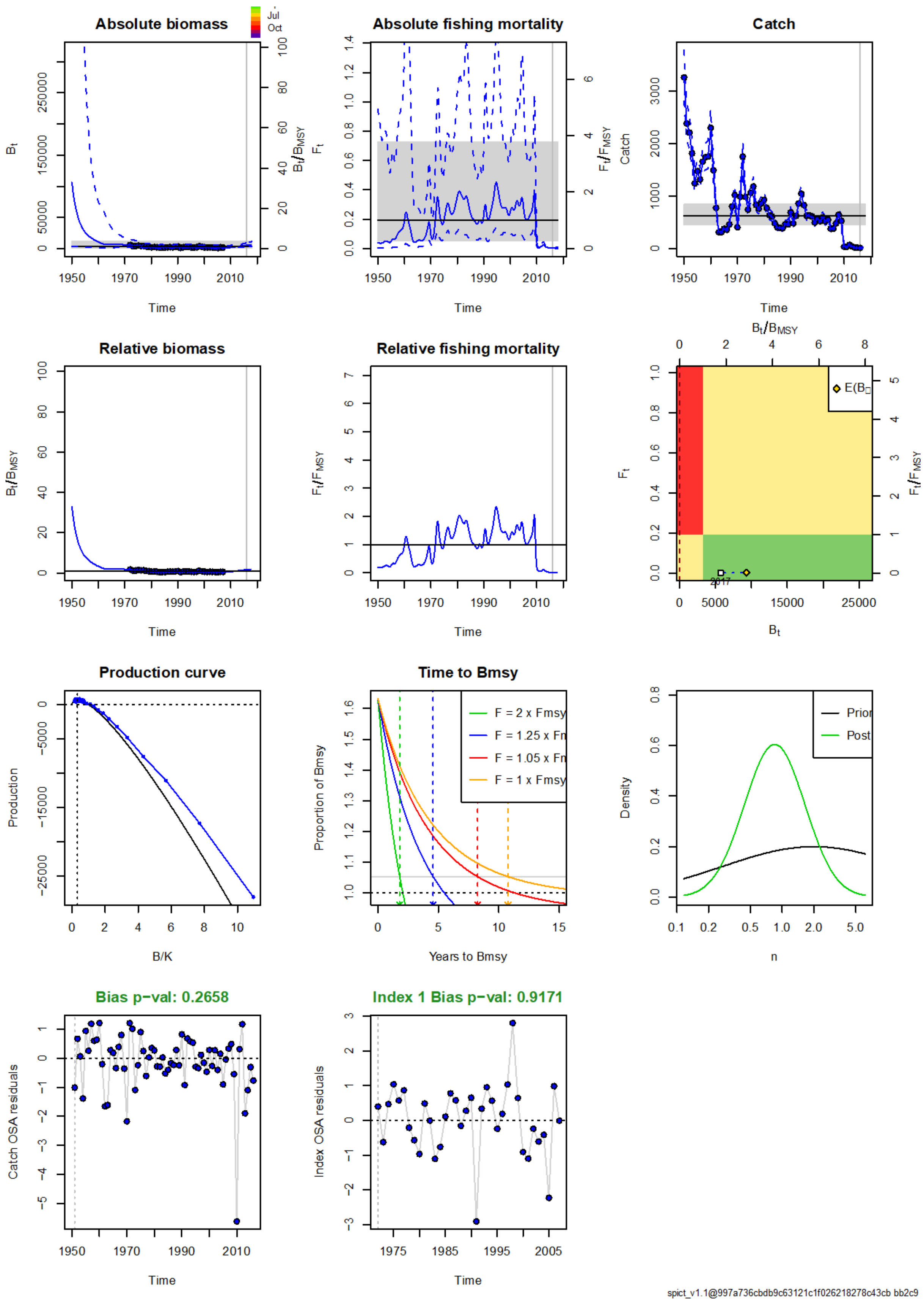

Figure P7. Results from Run_6.

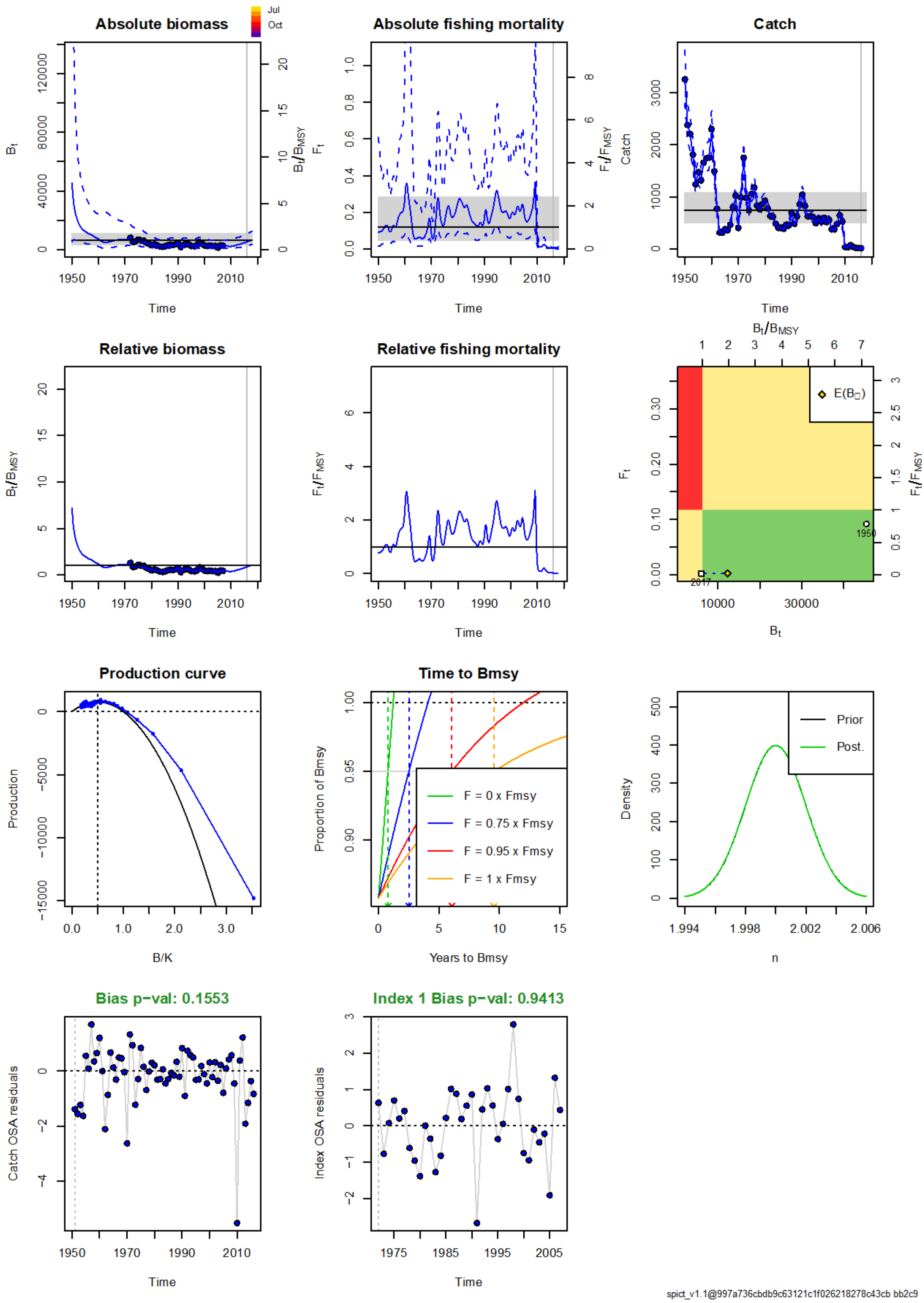

Figure P8. Results from Run_7.

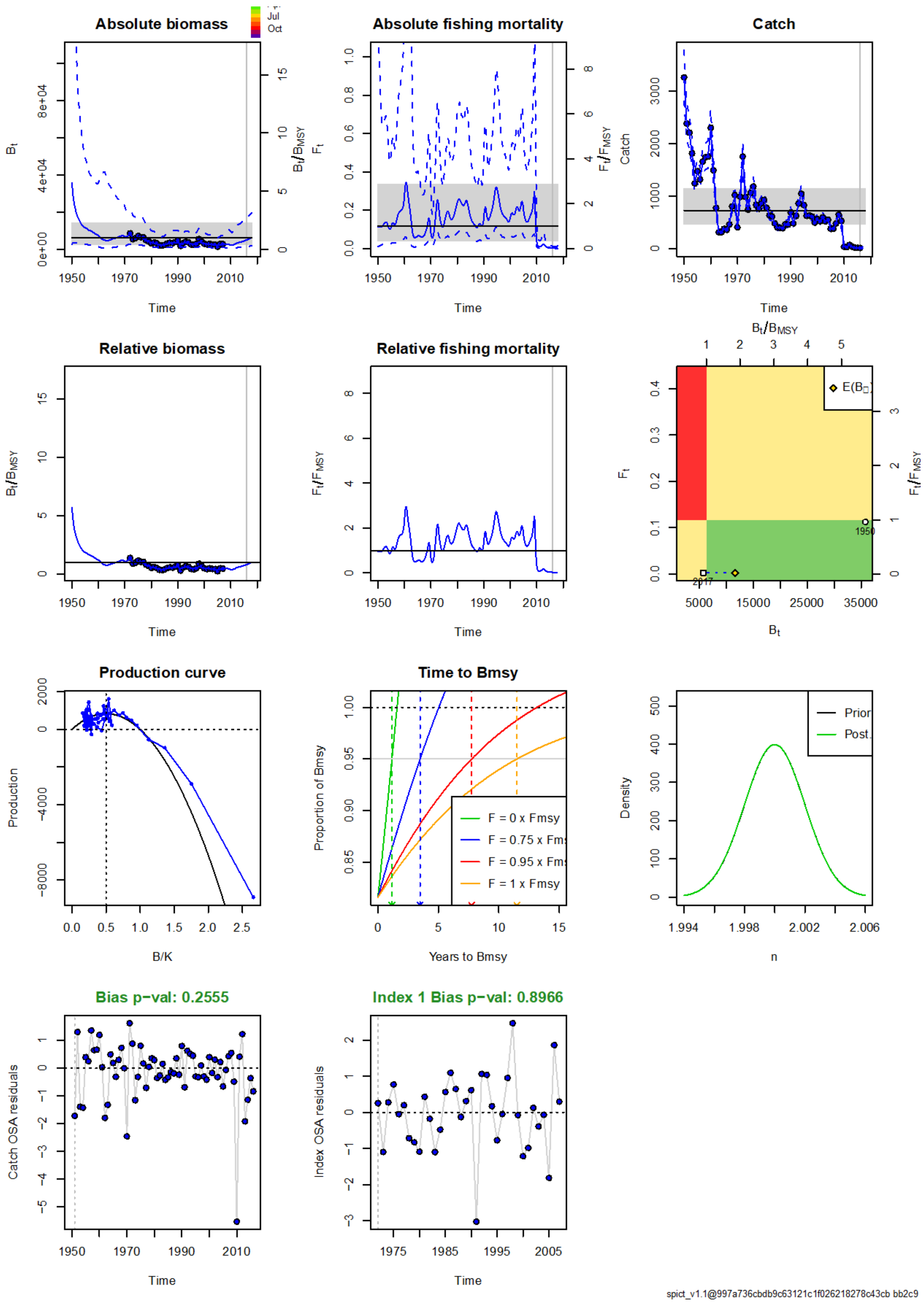

Figure P9. Results from Run_8.

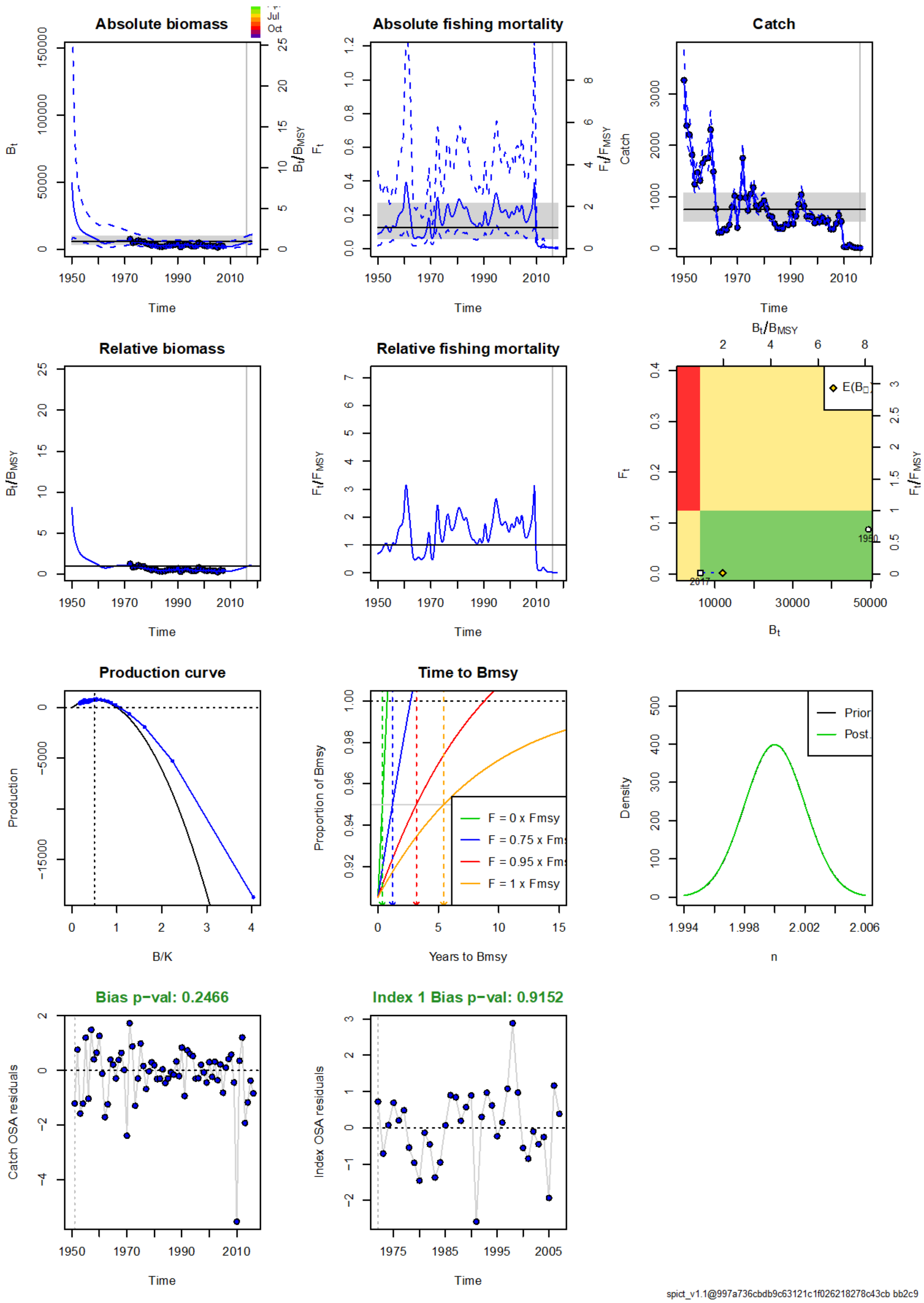

Figure P10. Results from Run_9.

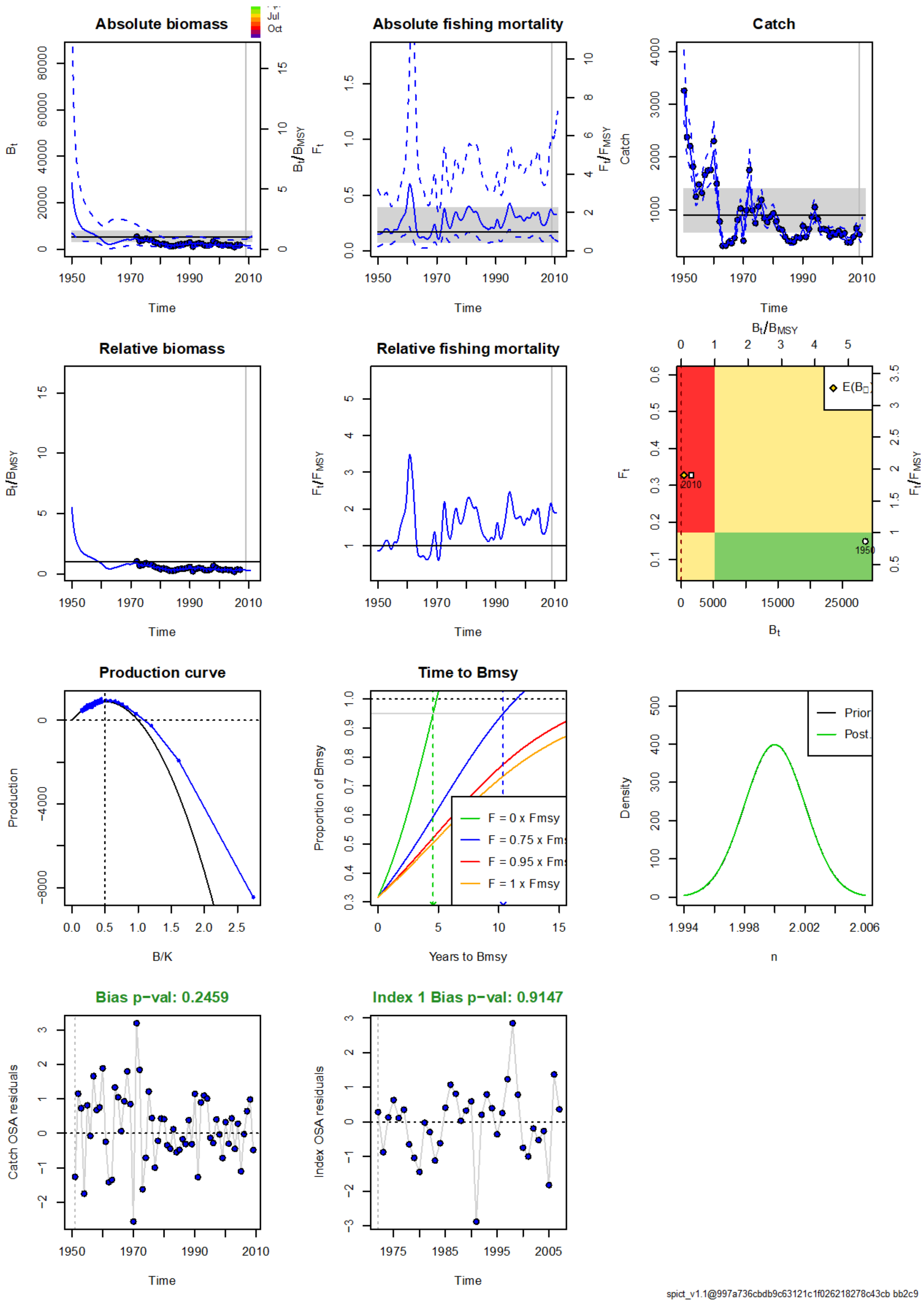

Figure P11. Results from Run_10.

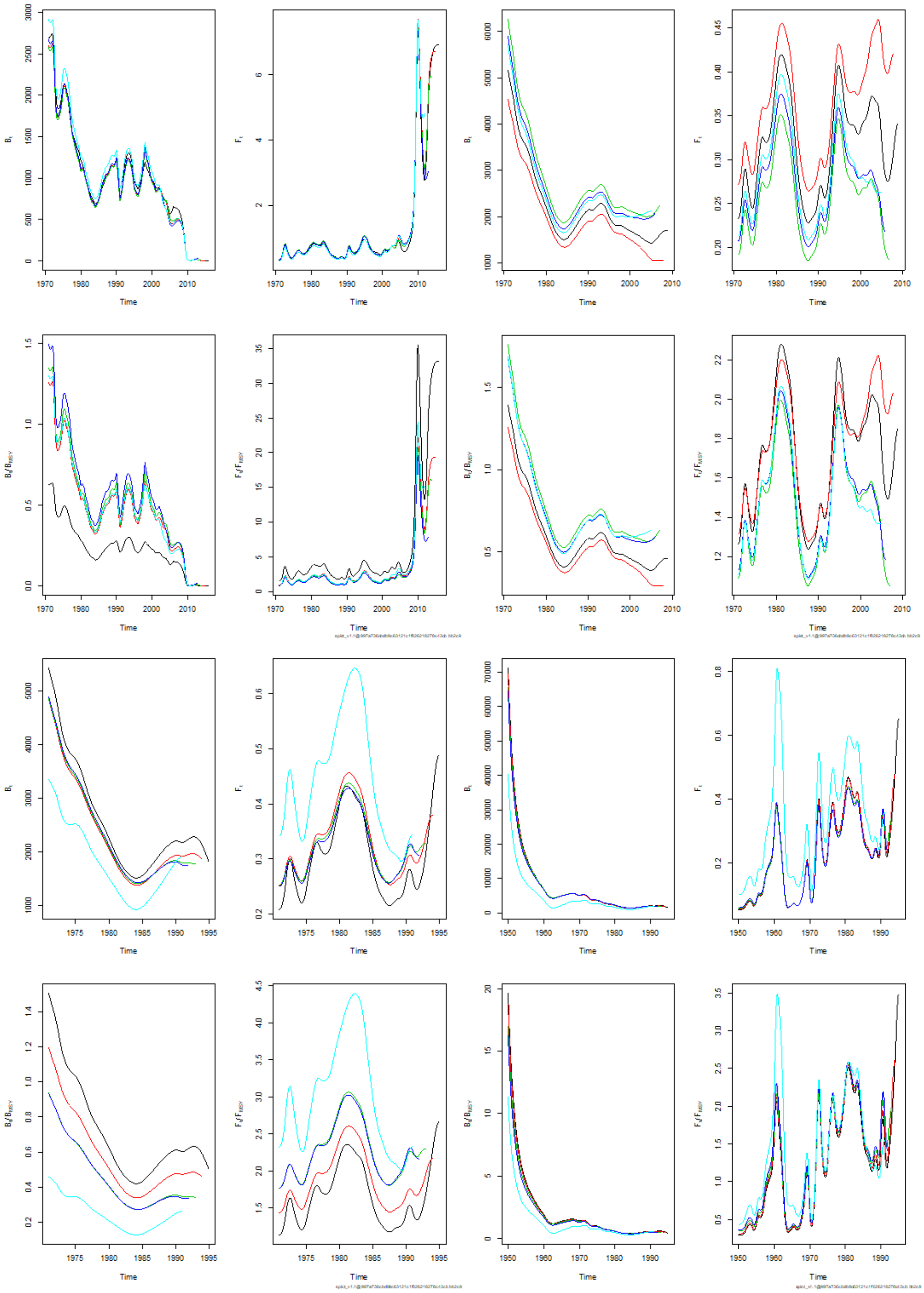

Figure P12. Retrospective analysis for Run_1 – Run_4 (from upper left to bottom right)

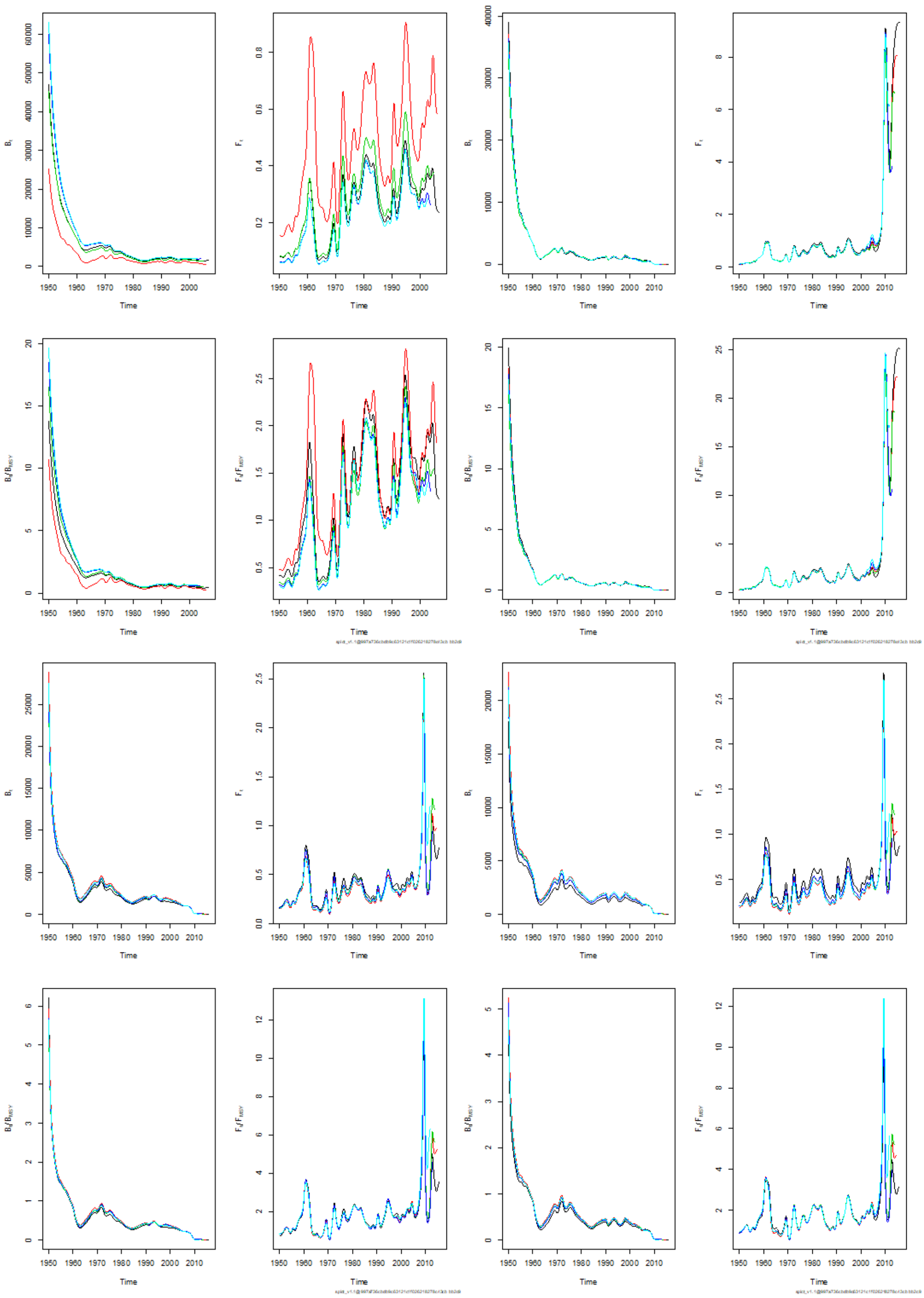

Figure P13. Retrospective analysis for Run_5 – Run_8 (from upper left to bottom right)

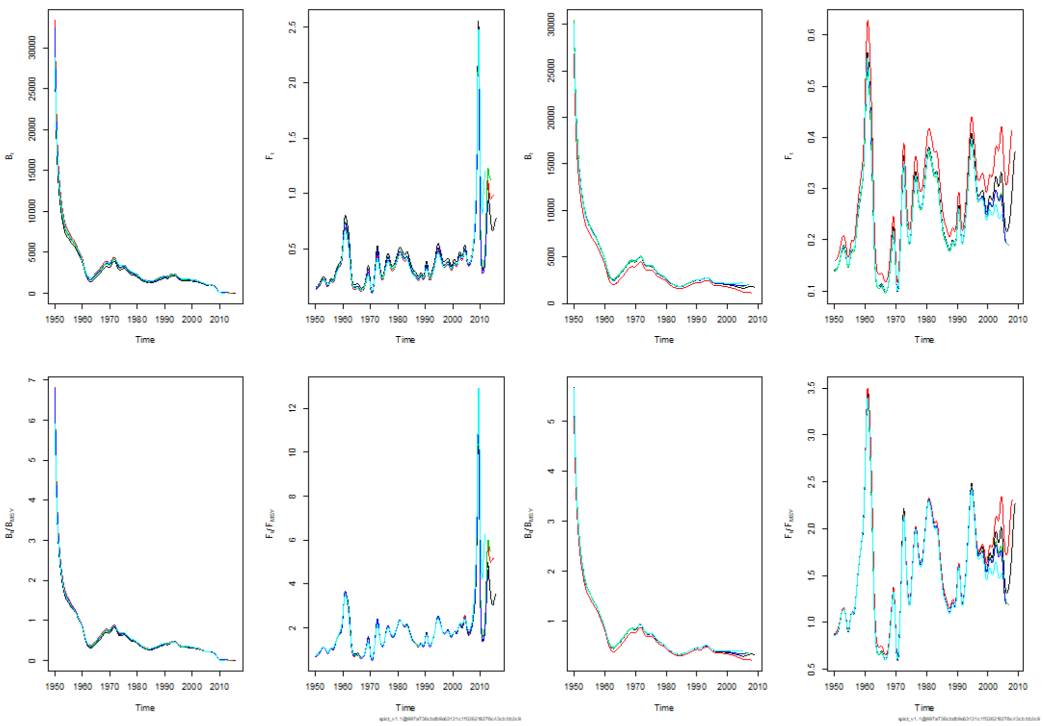

Figure P14. Retrospective analysis for Run_9 (left) og Run_10 (right)

Biomass and Abundance Indexes for skates in the Portuguese groundfish and crustacean surveys (ICES Division 27.9.a)

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Abstract*: Information is annually collected at the Portuguese Autumn Groundfish Surveys (PT-GFS), since 1981, and at the Portuguese crustacean surveys/Nephrops TV surveys (PT-CTS (UWTV (FU 28-29)), since 1997, held along the Portuguese mainland coast (ICES Division 27.9.a). The current working document presents updated information on the Portuguese distribution, survey indexes (biomass and abundance) and length ranges for R. clavata, R. montagui and L. naevus, in that division, for the period 1990-2017. Increasing trends was observed for R. clavata, while R. montagui showed a stable trend in the last two years. Captures of L. naevus in 2016 and 2017 were limited to take conclusions on biomass and abundance trends.*

1. Introduction

At the Portuguese continental coast, the information available for skate and ray species (Rajidae) is derived from two sources: fishery dependent and survey data. Among skates and rays caught in groundfish and crustacean surveys conducted in Portuguese mainland waters, the thornback ray *Raja clavata* is the most frequent species, representing 88% of the total weight caught of this group. It is also the most important species landed at the Portuguese landing ports, representing ~ 45% in weight of the total landed weight of Rajidae (Serra-Pereira et al., 2011). Other species caught in Portuguese surveys include spotted ray *Raja montagui*, cuckoo ray *Leucoraja naevus*, brown ray *Raja miraletus*, sandy ray *Leucoraja circularis*, long-nosed skate *Dipturus oxyrinchus* and Iberian pigmy skate *Neoraja iberica*.

Skate and ray species are characterized for their patchy distribution and strong habitat affinities (Simpfendorfer and Heupel, 2012), which, along with the fact that Portuguese surveys are not design to estimate biomass and abundance indexes for this group of species, contribute to a high frequency of zeroes in fishery-independent surveys data. Therefore, the adoption of a statistical methodology to deal with the high frequency of zeroes in survey data is of high importance for the stock assessment of skates and rays, since such data source can provide relevant species-specific information on trends in relative abundance and spatial distribution available for this group of species. In 2013, Figueiredo and Serra-Pereira (2013) presented a Working Document proposing a statistical routine to deal with this type of data. Following that methodology this working document presents updated information on the Portuguese survey indexes (biomass and abundance) for *R. clavata*, *R. montagui* and *L. naevus*, in ICES Division 27.9.a.

2. Methods

The study was based on the data collected at the Portuguese Autumn Groundfish Surveys (PT-GFS), since 1981, and at the Portuguese crustacean surveys/Nephrops TV surveys (PT-CTS (UWTV (FU 28-29)), since 1997, held along the Portuguese coast. Distribution maps (presence/absence) were produced for each species, based on all data available. No information was available from PT-CTS for *R. montagui*.

Data used for modelling the biomass and abundance of *R. clavata* (RJC) and *R. montagui* (RJM) was obtained from the PT-GFS surveys from 1990 to 2015 (except for RJM that was from 2005 to 2015), while that for *L. naevus* (RJN) was obtained from PT-CTS surveys from 1997 to 2015, conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR).

Biomass (kg.hour^{-1}) and abundance (num.hour^{-1}) indexes were standardized by the adjustment of Generalized Linear Mixed Models (GLMM; Bolker et al., 2009) assuming a Tweedie distribution for the observations, following the routine presented by Figueiredo and Serra-Pereira (2013).

All the statistical analyses were performed in R 3.0 (www.r-project.org) and the level of significance was α < 0.05.

3. Results/Discussion

3.1. Raja clavata (thornback ray, RJC)

Raja clavata (13-110 cm LT) is found along the coast, from 23 to 751 m deep, but more common south off Cabo Carvoeiro and shallower than 200 m deep (Fig. 1). The biomass and abundance Indexes have been relatively stable since 2005 and within the average values for the time-series, with an increasing trend since 2015 (Table 1 and Fig. 2). Mean annual biomass index for 2016-2017 (0.52 kg.h^{-1}) was 41% greater than observed in the preceding five years (2011-2015; 0.37 kg.h^{-1}). While, mean annual abundance index for 2016-2017 (1.36 num.h^{-1}) was 91% greater than observed in the preceding five years (2011-2015; 0.71 num.h^{-1}). The length distribution was relatively stable along the time-series, with the mean length above the average in the last two years (Fig. 3).

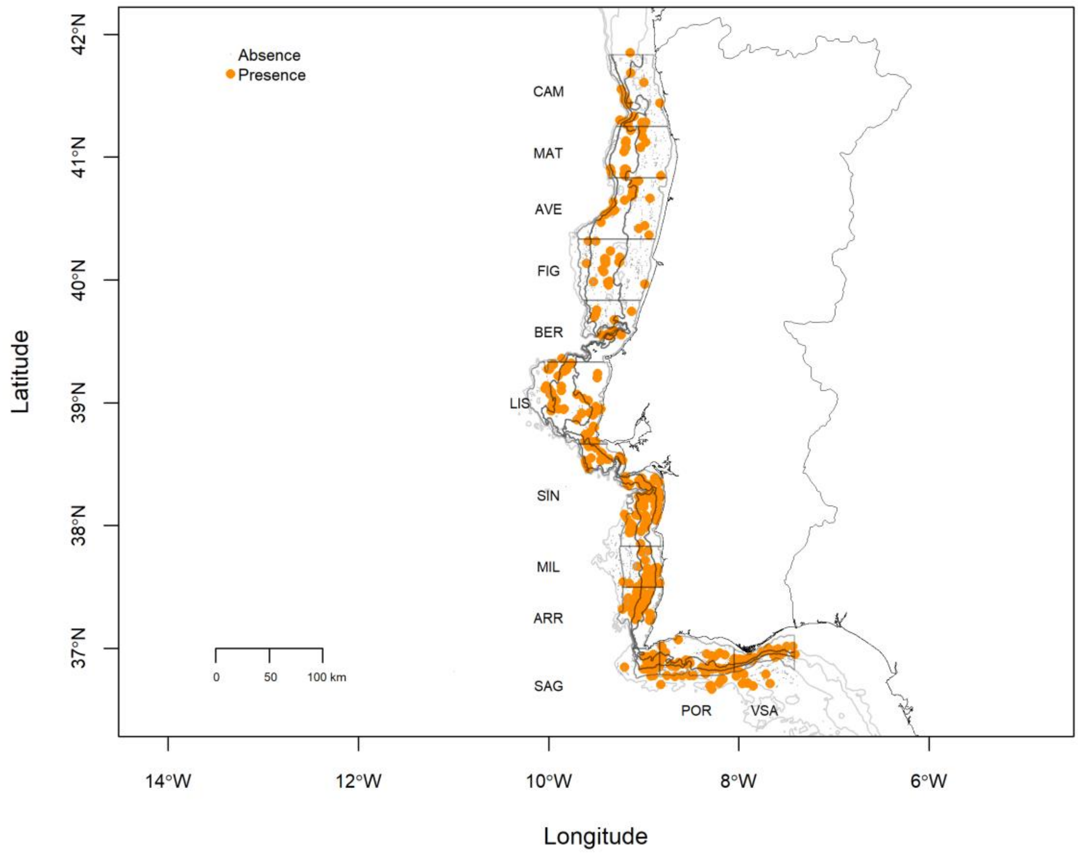

Figure 1. *Raja clavata* distribution from 1981 to 2017 (PT-GFS surveys).

Table 1.*Raja clavata* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PT-GFS from 1990 to 2017. Standard error (s.e.) is also presented for each index.

YEAR	Biomass	s.e.	Abundance	s.e.
1990	0.3106	0.09445	0.4758	0.1822
1991	0.2475	0.08832	0.3777	0.1665
1992	0.3525	0.13675	0.7369	0.3286
1993	0.3610	0.13598	0.5736	0.2697
1994	0.1801	0.07470	0.3492	0.1655
1995	0.1891	0.07457	0.4763	0.2008
1997	0.4521	0.15595	0.6428	0.2878
1998	0.1488	0.07409	0.3784	0.1934
2000	0.3251	0.11606	0.9403	0.3558
2001	0.2440	0.10010	0.4007	0.1975
2002	0.1433	0.06542	0.2052	0.1165
2005	0.3379	0.10714	0.7317	0.2657
2006	0.1351	0.05874	0.2907	0.1377
2007	0.3419	0.10752	0.8572	0.2997
2008	0.2334	0.08479	0.4927	0.2017
2009	0.3848	0.11866	0.9322	0.3238
2010	0.3529	0.11072	0.5104	0.2025

2011	0.3926	0.12182	0.6915	0.2592
2013	0.3335	0.10696	0.5506	0.2178
2014	0.3334	0.11153	0.5292	0.2190
2015	0.4336	0.12716	1.0673	0.3594
2016	0.4451	0.12961	1.1570	0.3815
2017	0.6039	0.17053	1.5543	0.5085

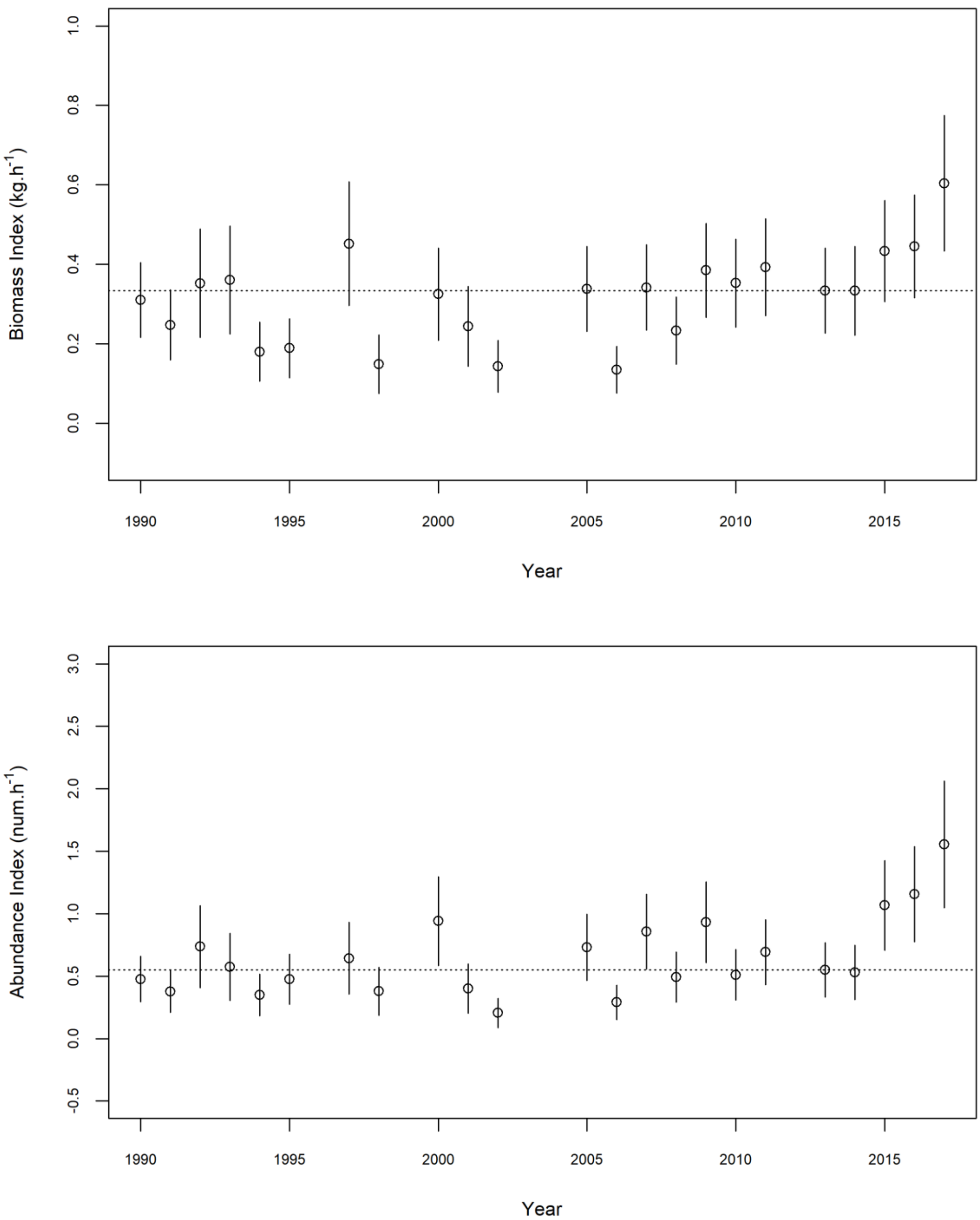

Figure 2. *Raja clavata* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PT-GFS from 1990 to 2017. Dashed line represents the mean annual abundance for the considered period.

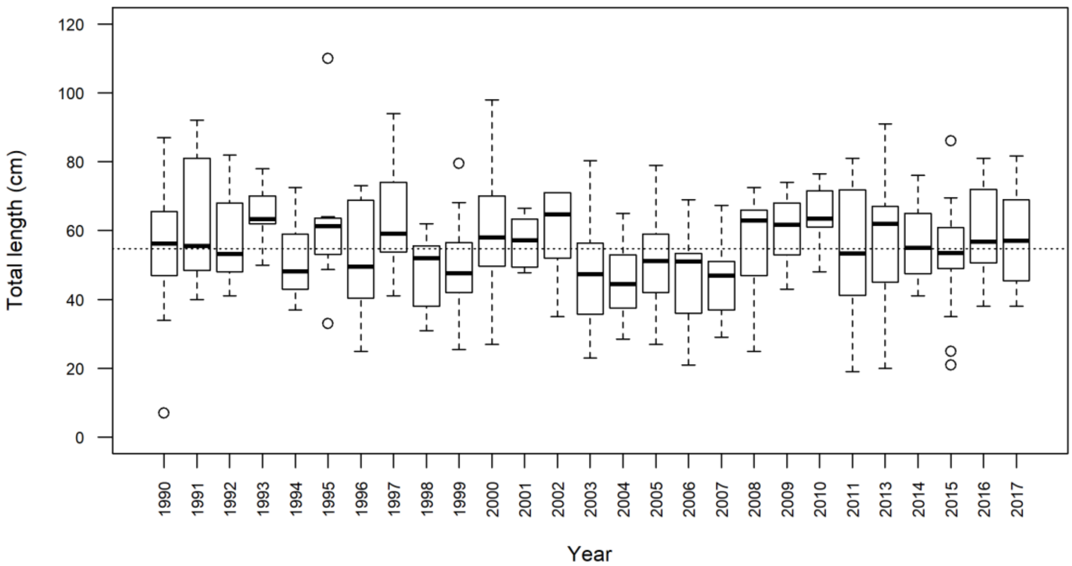

Figure 3. Total length variation of *Raja clavata*, by year on PT-GFS (dashed line represents the mean annual length for 1990-2017).

3.2. Raja montagui (spotted ray, RJM)

Raja montagui (21-71 cm LT) is found along the coast, from 21 to 400 m deep, but more common in the southwest coast of Portugal, between 40 and 150 m deep (Fig. 4). The biomass and abundance indexes have been stable along the time-series, with an increasing trend in 2014-2015 and stable in 2016-2017 (Table 2 and Fig. 5). Mean annual biomass index for 2016-2017 (0.19 $kg.h^{-1}$) was 32% greater than observed in the preceding five years (2011-2015; 0.14 $kg.h^{-1}$). While, mean annual abundance index for 2016-2017 (0.51 $num.h^{-1}$) was 60% greater than observed in the preceding five years (2011-2015; 0.32 $num.h^{-1}$). The length distribution was relatively stable along the time-series, with the mean length above the average in 2016 and slighlty below the average in 2017 (Fig. 6).

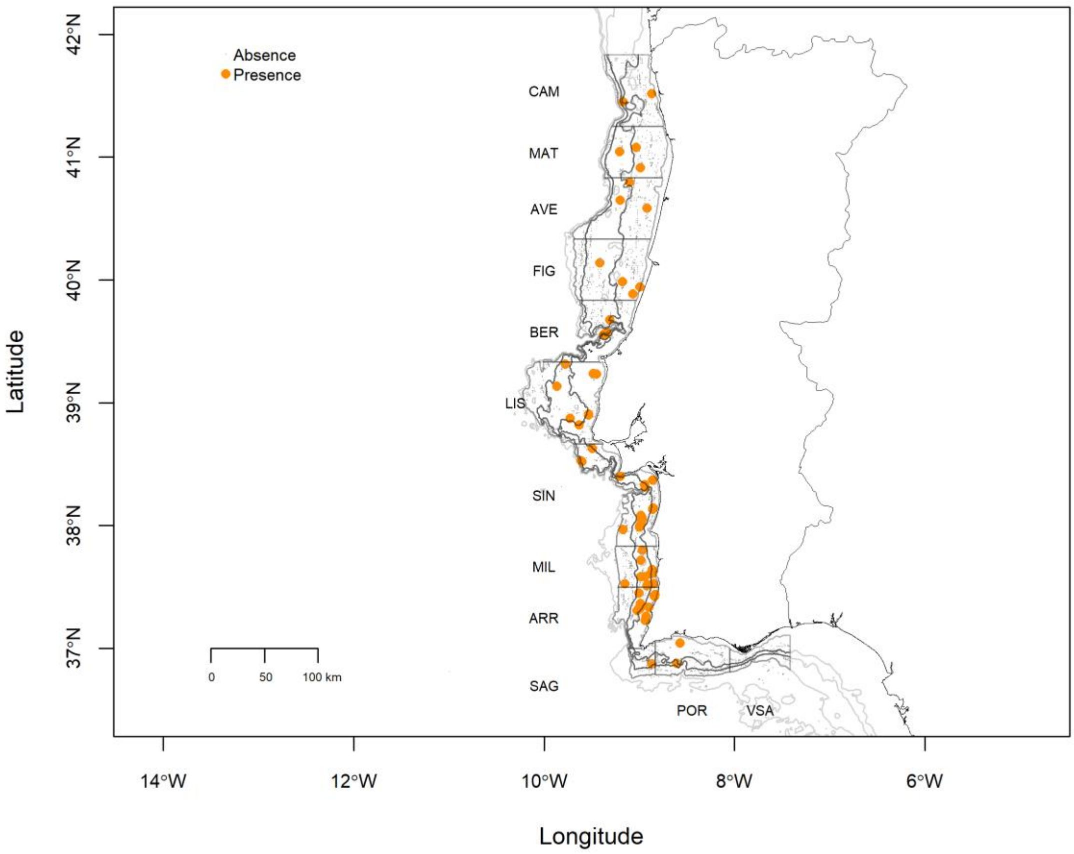

Figure 4. *Raja montagui* distribution from 1981 to 2017 (PT-GFS surveys).

Table 2.*Raja montagui* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PT-GFS from 2005 to 2017. Standard error (s.e.) is also presented for each index.

YEAR	Biomass	s.e.	Abundance	s.e.
2005	0.06555	0.04254	0.16170	0.10144
2006	0.06058	0.04147	0.10968	0.07962
2007	0.02380	0.02236	0.09039	0.06943
2008	0.11082	0.06663	0.39828	0.20869
2009	0.09844	0.05736	0.17843	0.11167
2010	0.07066	0.04754	0.13868	0.09612
2011	0.05052	0.03987	0.16153	0.11127
2013	0.07038	0.04615	0.10078	0.07622
2014	0.20412	0.10139	0.39329	0.20603
2015	0.23991	0.10775	0.62167	0.27740
2016	0.20256	0.09492	0.52655	0.24255
2017	0.17005	0.08631	0.49498	0.23826

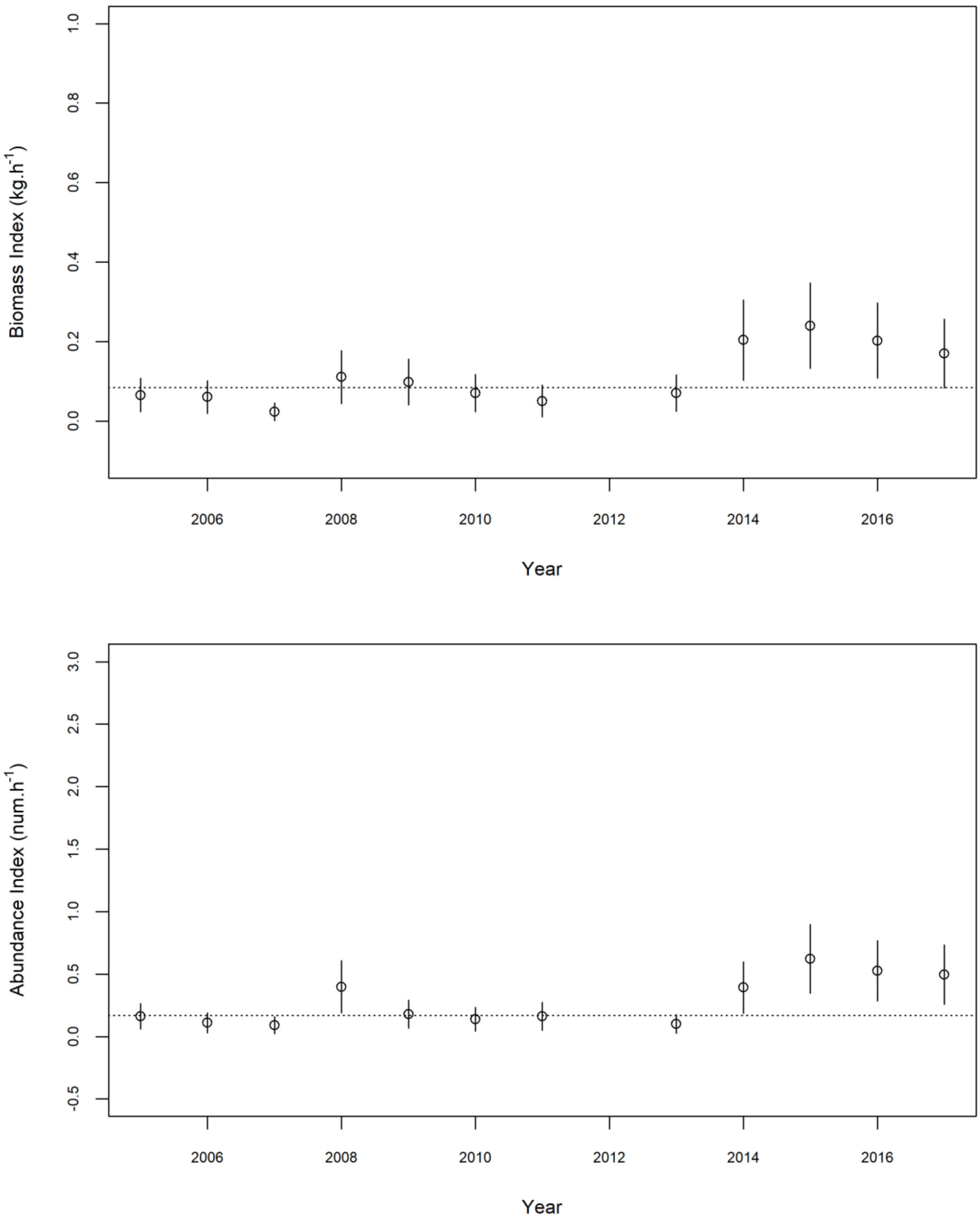

Figure 5. *Raja montagui* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PT-GFS from 2005 to 2017. Dashed line represents the mean annual abundance for the considered period.

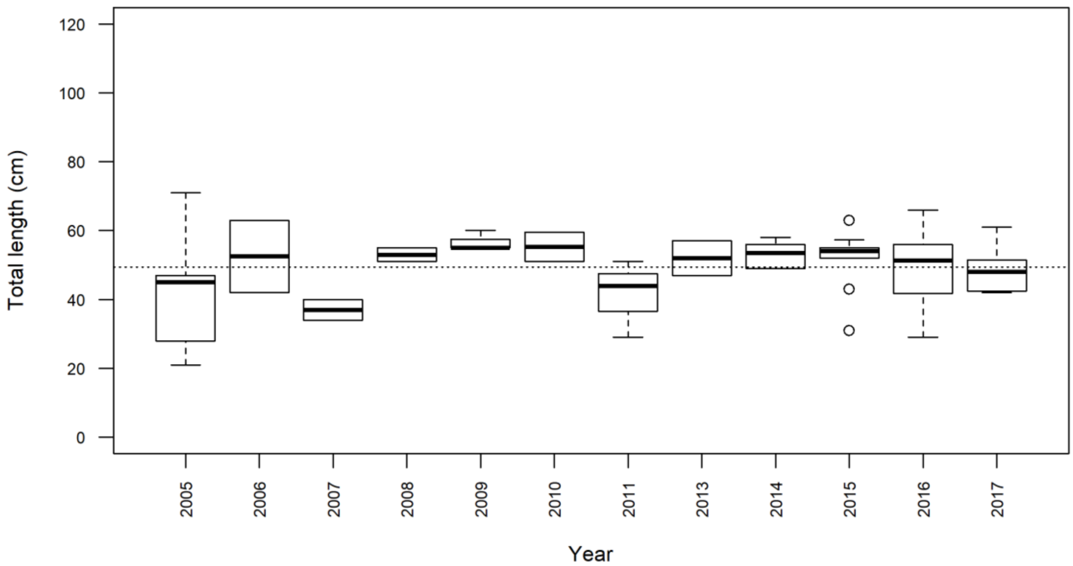

Figure 6. Total length variation of *Raja montagui*, by year on PT-GFS (dashed line represents the mean annual length for 2005-2017).

3.3. Leucoraja naeuvus (cuckoo ray, RJN)

Leucoraja naevus (14-65 cm LT) is found along the coast, from 55 to 728 m deep, but more common south off Cabo Espichel and shallower than 500 m deep (Fig. 7). The biomass and abundance Indexes have been variable in the last seven years, but in 2014-2015 showing a slight increasing trend and within the average values for the time-series (Table 3 and Fig. 8). No *L. naevus* were caught in the 2016. In 2017 the species was only caught in one station. The observed lower catches of *L. naevus* does not follow the increasing trend observed in the Spanish (IBTS-GC-Q1-Q4 (ARSA) bottom trawl survey in the Gulf of Cadiz. No technical reason was found for the low catchability observed for the species in the last two years, apart from the later timing of the survey conducted in 2017, July/August instead of May/June (C. Chaves *pers. com.*). Mean annual biomass index for 2016-2017 (0.03 kg.h-1) was 83% smaller than observed in the preceding five years (2011-2015; 0.15 kg.h-1). While, mean annual abundance index for 2016-2017 (0.06 num.h^{-1}) was 91% smaller than observed in the preceding five years (2011-2015; 0.64 num.h^{-1}). The length distribution has been relatively variable along the time-series, mainly due to higher catches of juveniles in certain years (Fig. 9). The mean length was above the average since 2015.

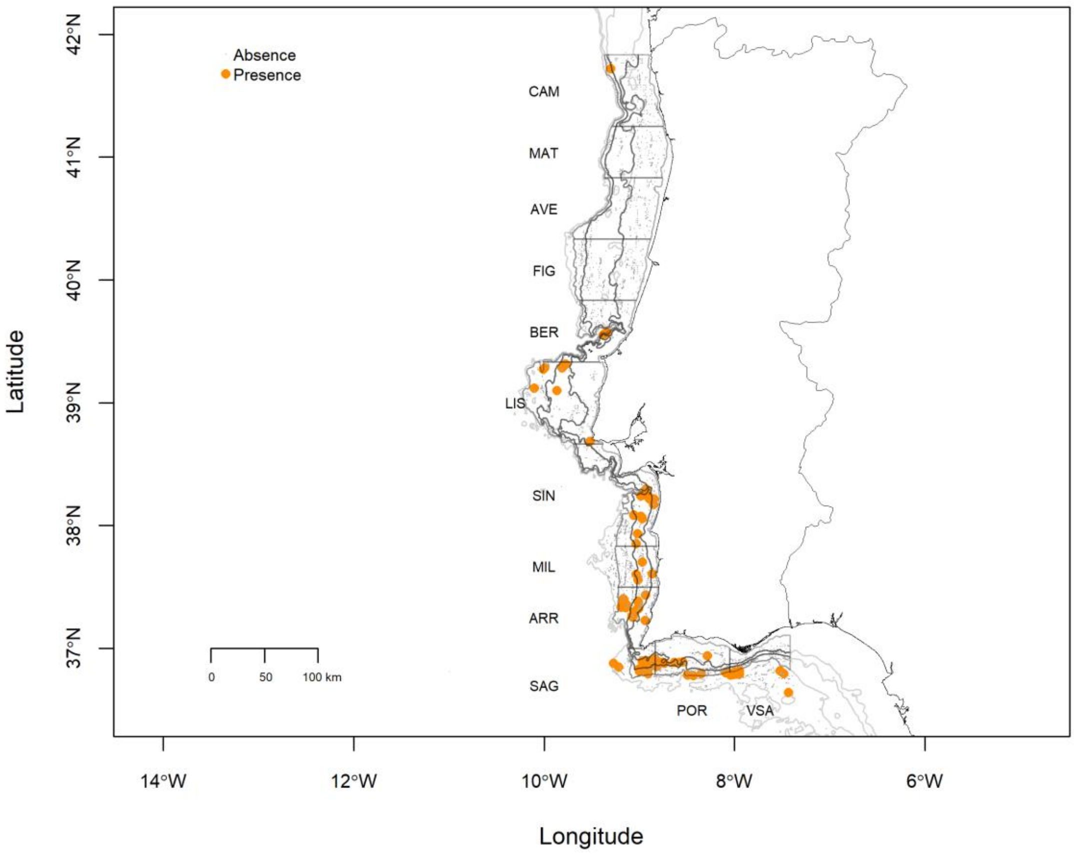

Figure 7. *Leucoraja naevus* distribution from 1981 to 2017 (all surveys combined).

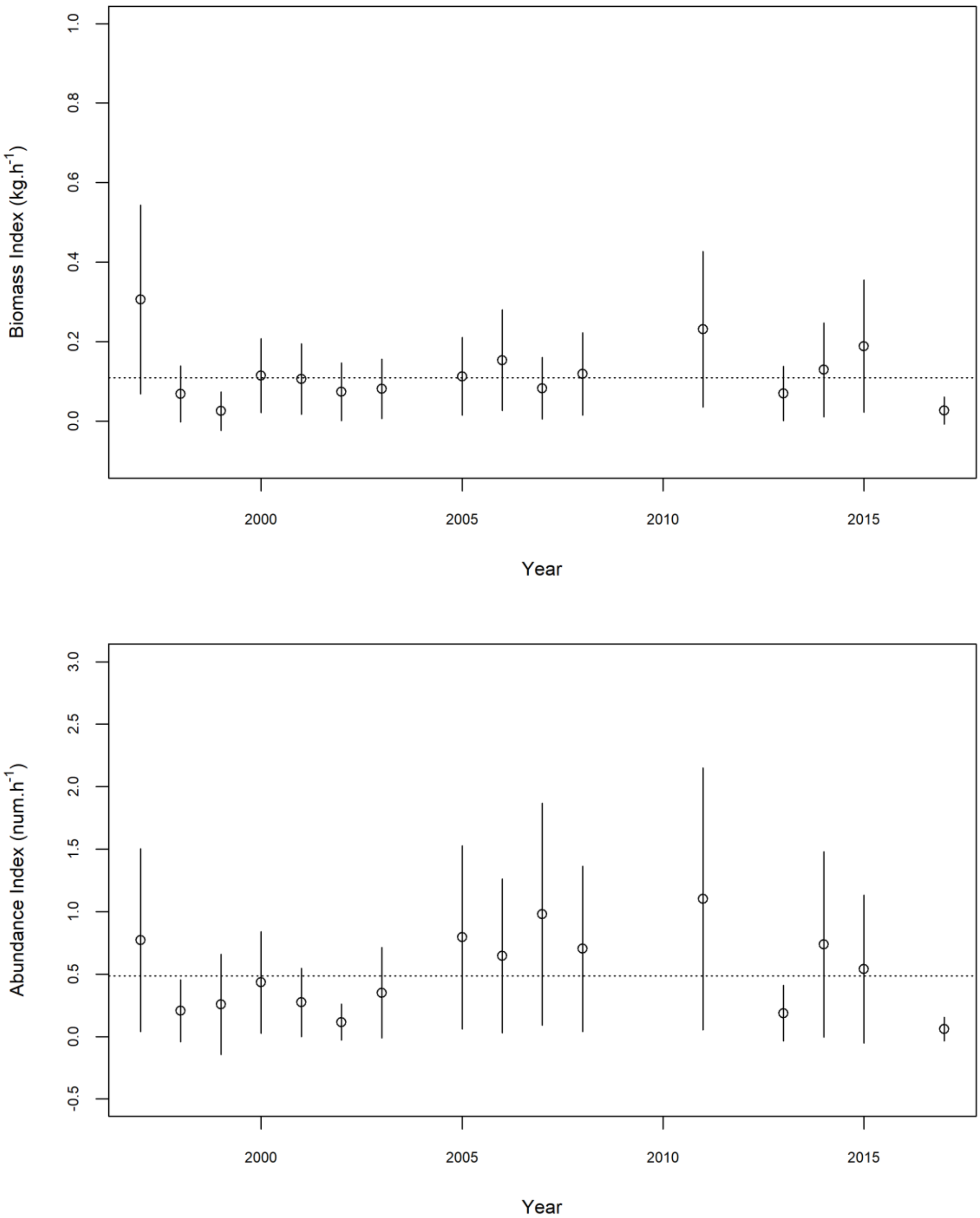

Figure 8. *Leucoraja naevus* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PT-CTS from 1997 to 2017. Dashed line represents the mean annual abundance for the considered period.

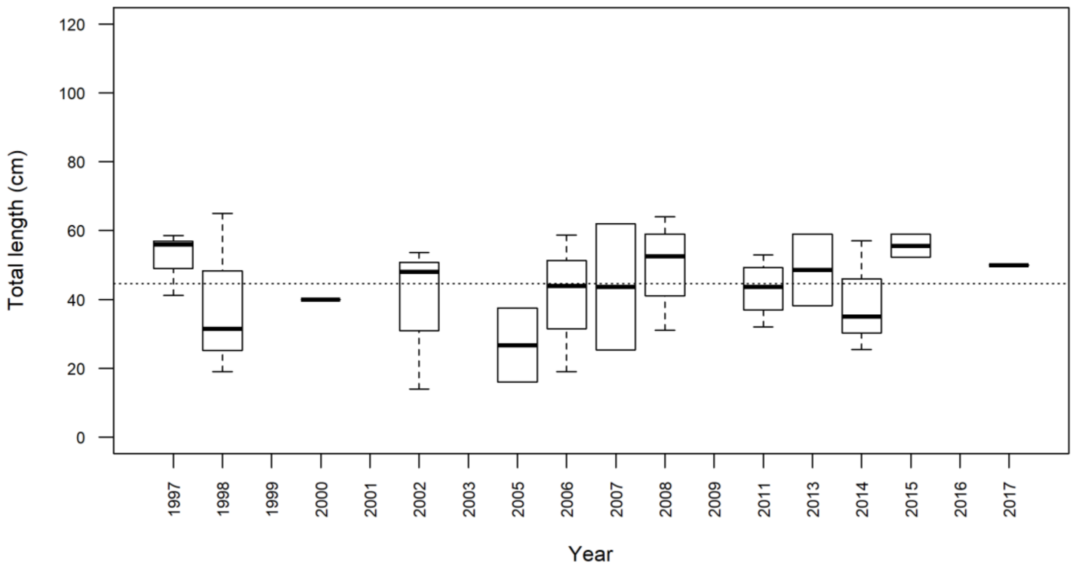

Figure 9. Total length variation of *Leucoraja naevus*, by year on PT-CTS (dashed line represents the mean annual length for 1997-2017).

4. Acknowledgements

We would like to thank the crew and scientific teams onboard the RV "Noruega" crew from IPMA (IPIMAR) that made possible the PT-GFS and PT-CTS surveys.

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ELASMOBRANCHS LANDINGS OF THE AZORES (ICES AREA 27.10)

By

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Abstract

About 58 elasmobranch species are listed as occurring in the Azores. The species covers pelagic, benthopelagic and benthic habitats from shallow to deep-water strata in areas around coastal of the islands, banks and seamounts. However, only about 17 shark species were identified by the auctions along the historical landings. Currently elasmobranchs landings from the Azores (ICES area 10a) are mainly by-catches from three main hook and line fisheries: the swordfish fishery, the demersal fishery and the black scabbarfish fishery. Discards are not available for the recent years. Biological sampling data is scarce because these species are not caught due to management restrictions, there are no target fisheries and have low sampling priority under the DCF. There are no biological data available for the year 2017. This paper updates the elasmobranchs landings from the Azores (ICES area 10a) for 2018 WGEF meeting.

Keywords: Elasmobranchs, Azores, landings, species, fisheries.

Introduction

Elasmobranchs information have been reported to WGEF at least since 2005 (ICES, 2005). From the 58 elasmobranch species listed as occurring in the Azores (Santos et al, 1997; Barreiros and Gadig, 2011) very few are nowadays landed. Currently, there are no target fisheries for elasmobranchs in the Azores. Most of the important species have zero TAC or landings come from by-catch of mixed hook and line fisheries covering the different components of the ecosystem (pelagic, benthopelagic and demersal). Information from the pelagic species is reported to the ICCAT. Fisheries targeting the benthopelagic strata for Black scabbard fish do not developed in the Azores region or operate occasionally along time (see WGDEEP report). The few landings reported come from the demersal deep-water mixed hook and line fisheries. Some species are completely discarded (case of *Etmopterus* spp.) and some others demersal and deep-water elasmobranchs may be discarded on this fishery. However, discard information is not available for the recent years.

For this paper available historical information of landings on weight and value of fresh fish on the auctions from the Azorean fisheries are updated.

Material and methods

Landing data in weight and value were collected from the fresh landings at the Azorean auctions. Information was resumed by year and species. Data for the genera “Raja”, “Deania” and “Etmopterus” was aggregated to avoid misinterpretations. The landings of “Rajas” correspond, for the very most part, to the landings of the species *Raja clavata*. Only data from the landings registered at the Azorean auctions are reported here. Data from the last the last four years was resumed from the Regional Statistical Service (SREA). At this level, less detailed is available by species.

Length compositions from the national sampling program (DCF) to the landings was not updated for the year 2017 because this information was not available.

Results

Species and fisheries

Pinho (2005) listed 38 species of elasmobranchs observed from the Azores fisheries and surveys. However, only about a dozen of this species have been landed (Table 1). About 17 shark species are identified by the auctions on the landings. Species misidentification on the landings is suspected, although some efforts have been done by the auctions and DCF to update it.

Elasmobranchs catches from the Azores (ICES area 10a) are mainly by-catches from three main fisheries: (1) the swordfish fishery, (2) the demersal fishery and (3) the black scabbarfish fishery. For a description of these fisheries see Pinho (2005). Detailed data (observers and logbooks) from the pelagic fisheries are reported on the framework of ICCAT. Data reported here refers only to official landings declared to the Azorean auctions, and so may not represent the total catch from the ICES area Xa. The swordfish fishery may cover subdivisions (10a2, 10a1 and 10b) and CECAF area 2.0. The demersal/deep water fishery may cover mainly the subdivisions 10a2 and 10a1. The black scabbardfish fishery covers mainly the 10a2.

A target fishery for black scabbardfish fishery has been developed during the last two decades (2010-2017) but with a very variable annual shifting of longliners from the traditional demersal/deep-water mixed hook and line fishery. No target fishery occurred during 2017. There are almost no landings of sharks reported from this fishery due to the by-catch restrictions.

Demersal and deep water elasmobranchs are mainly a by-catch of local demersal mixed hook and lines fisheries and most of the species are discarded or retained onboard for bait or consumption (Pinho and Canha, 2011).

Landings

Elasmobranches landings data from the Azores for the last six years are resumed in Table 1. Updates of the historical data for the total elasmobranchs landings and for the most representative species landed by the Azorean fisheries are resumed on Figures 1-6.

Elasmobranchs landings on the Azores have been decreasing since the start of the nineties (Fig.1), following the decreasing pattern of the kitefin shark (Fig. 2), and with a small peak in the period 2011-2016 due mainly to the punctual increase observed on the landings of blue shark an also of rajas and tope shark (Fig. 3). The increase of pelagic species, blue shark (*P. glauca*) and short fin mako (*I. oxyrhincus*) in 2011, 2012 and 2013 was due to the shift of small vessels from mix demersal hook and line fishery to the pelagic fishing targeting big pelagic species. This was more concentrated on the Este group of islands as a result of intensive exploitation or overexploitation of traditional demersal resources. However, an important decrease is observed since 2013.

Historically the landings were dominated by the demersal/deep-water species due to the target fishery for kitefin, however, nowadays the landings of the pelagic species (tope and blue shark) are at the same or larger level of the demersal/deep-water species with the exception of the rajas that dominate the landings in the recent years. Total landings have been declining slowly, settling in the last year (2017) around the 149 tonnes (Fig.1).

Pelagic species *G. galeus*, *P. glauca* and *I. oxyrhinchus* and Rajas sp. on the benthic component are the most important species. However, landings are modest and for most of the species a decrease trend is observed in the last years (Fig. 2-6). The mean price for these species are usually modest being the highest values observed for tope shark (*G.*

Galeus) and short fin mako (*I. oxyrhincus*).The Mean price of *Dalatias licha* (Kitefin) during the years 2007 and 2008 was the biggest of the Azorean historic series.

Official landings of deep-water species are very low due to the zero TAC but discards may be relatively high.

Length compositions and mean length

Size composition is only available for four species (Figures 9-12). However, they should be used with caution because the sampling coverage is low, particularly for blue shark and short fin mako (Pinho, 2015). Tope shark presents a bimodal size composition (Fig. 9) and Raja clavata unimodal (Fig. 12) slight skew to the right.

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Table 1. Elasmobranchs landings (weight and value) from the Azores for the period 2010-2017.

	Azorean common name	Scientific name	Tonnes								Price/Kg (€)							
			2010	2011	2012	2013	2014	2015	2016	2017	2010	2011	2012	2013	2014	2015	2016	2017
Demersal	RAIA	*Raja sp.*	68.3	90.7	102.9	115.3	186.9	171.2	127.3	64.3	1.0	1.0	0.8	0.7	1.0	1.2	1.5	1.6
	GATA LIXA	*Dalatias licha*	1.9	1.1	0	0	0	0	0	0	0.3	0.4	0	0	0	0	0	0
	SAPATAS 1)	*Deania sp.*	2.55	0	0	0	0	0	0	0	0.09	0	0	0	0	0	0	0
	BARROSO-LUSITANICO	*Centrophorus lusitanicus*	0.0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0
	SAPATA-PRETA	*Centroscymnus crepidater*	0.2	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0
	LIXINHA DA FUNDURA	*Etmopterus sp.*	0.0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0
Benthopelagi	BICO DOCE (Tubarão rosa)	*Heptranchias perlo*	0.2	0.4	0.3	0.4	0.1	0.2	0.0	0.0	0.6	0.9	0.4	0.3	0.1	0.6	0.0	0.0
	BARROSO	*Cetrophorus granlosus*	0.9	0.5	0	0	0	0	0	0	0.8	0.7	0	0	0	0	0	0
	ALBAFAR	*Hexanchus griseus*	0.6	1.2	0	0	0.1	0	0	0	0.4	0.0	0	0	1	0	0	0
	CAÇÃO	*Galeorhinus galeus*	41.3	43.5	47.4	45.7	65.4	71.0	84.9	69.8	2.1	1.7	1.6	1.9	1.4	1.7	2.1	2.2
Pelagic	CORNUDA (Tubarão martelo)	*Sphyrna zygaena*	2.3	1.1	0.7	0.7	0.2	0.1	0.0	0.0	0.5	0.4	0.4	0.4	0.4	2.1	0.0	1.5
	TINTUREIRA	*Prionaca glauca*	16.2	129.8	292.6	109.9	25.8	37.7	42.3	13.2	0.3	0.4	0.4	0.6	0.3	0.4	0.4	2.2
	RINQUIM	*Isurus oxyrhinchus*	9.7	15.6	24.0	8.8	4.6	3.1	4.1	1.8	2.7	2.5	2.4	2.6	2.3	2.8	3.1	3.6
	TUBARÃO-RAP-OLHUDO	*Alopias superciliosus*	0.0	0.0	0.0	0	0	0.0	0	0	0.7	0.0	1.2	0	0	0.0	0	0
	Others	*Not identified or mixed*	1.9	4.6	31.0	69.7	0	0	0	0	0.2	1.5	1.5	1.0	0	0	0	0
	TOTAL		146	288	499	351	283	283	259	149	1.27	0.91	0.77	0.93	1.03	1.50	1.48	1.80

1) Include all species from the genera "Deania" identified as "sapatas" on the landings (*D. profundorum* , *D. calceus* and *Deania sp* .)

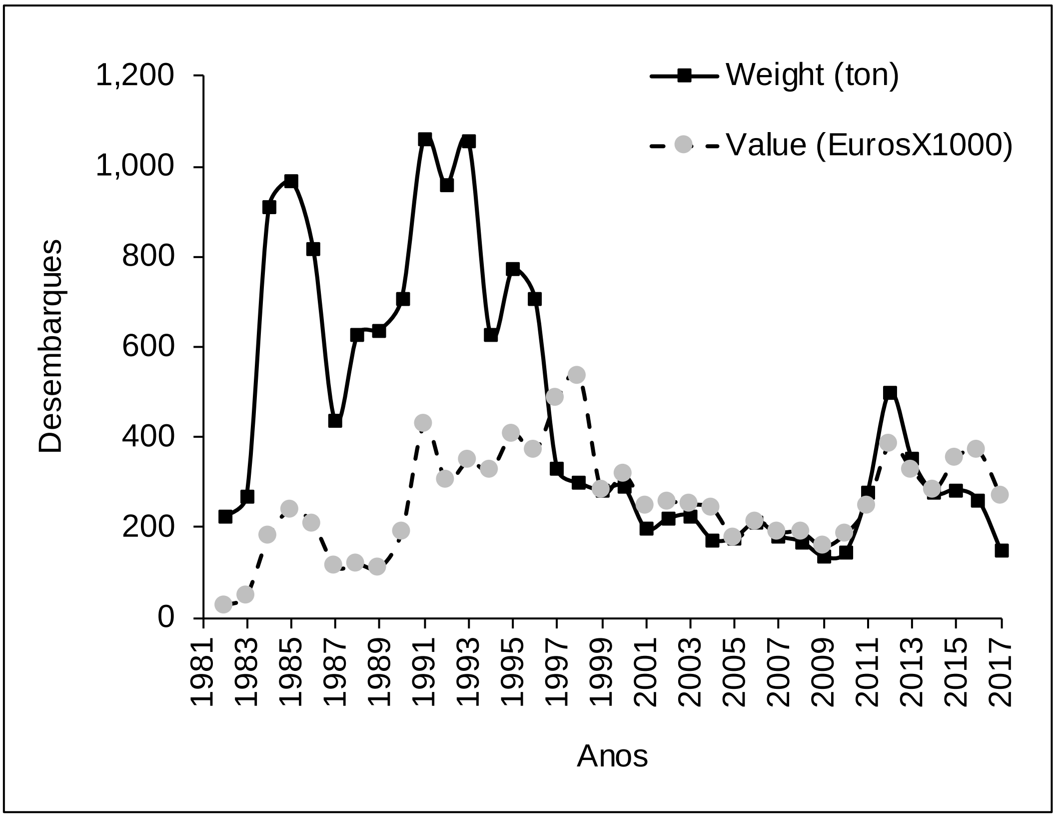

Figure 1. Total landings of elasmobranchs on the Azorean auctions for the period 1982-2017.

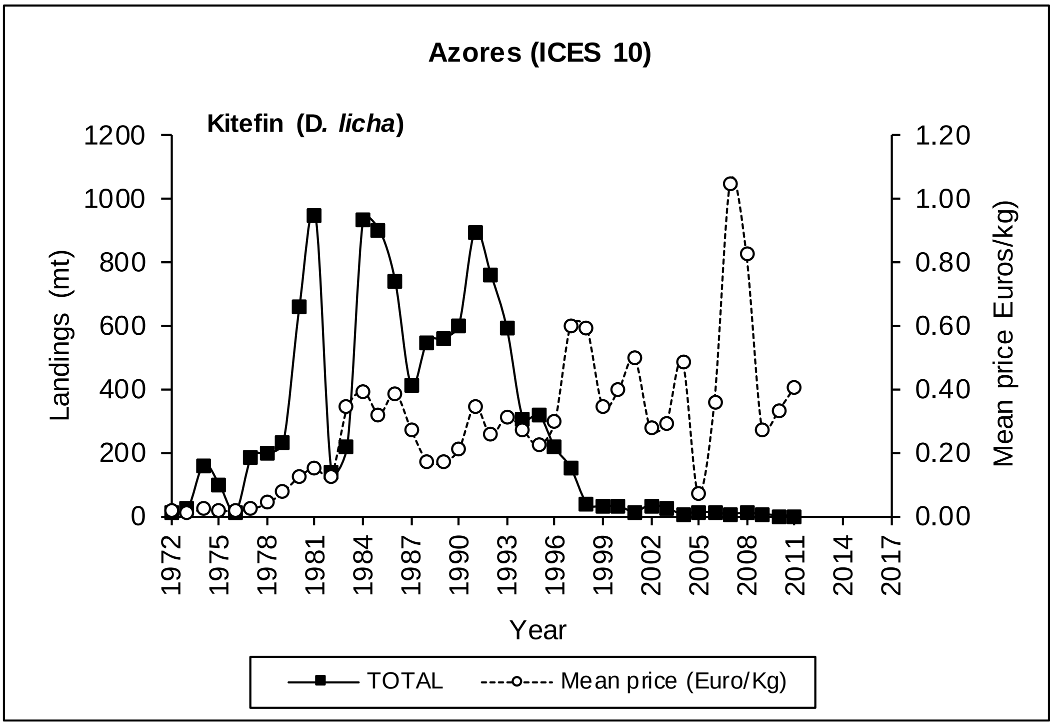

Figure 2. Historical annual landings in weight and value of *kitefin shark* (*Dalatias licha*) in the Azores (ICES 10.a).

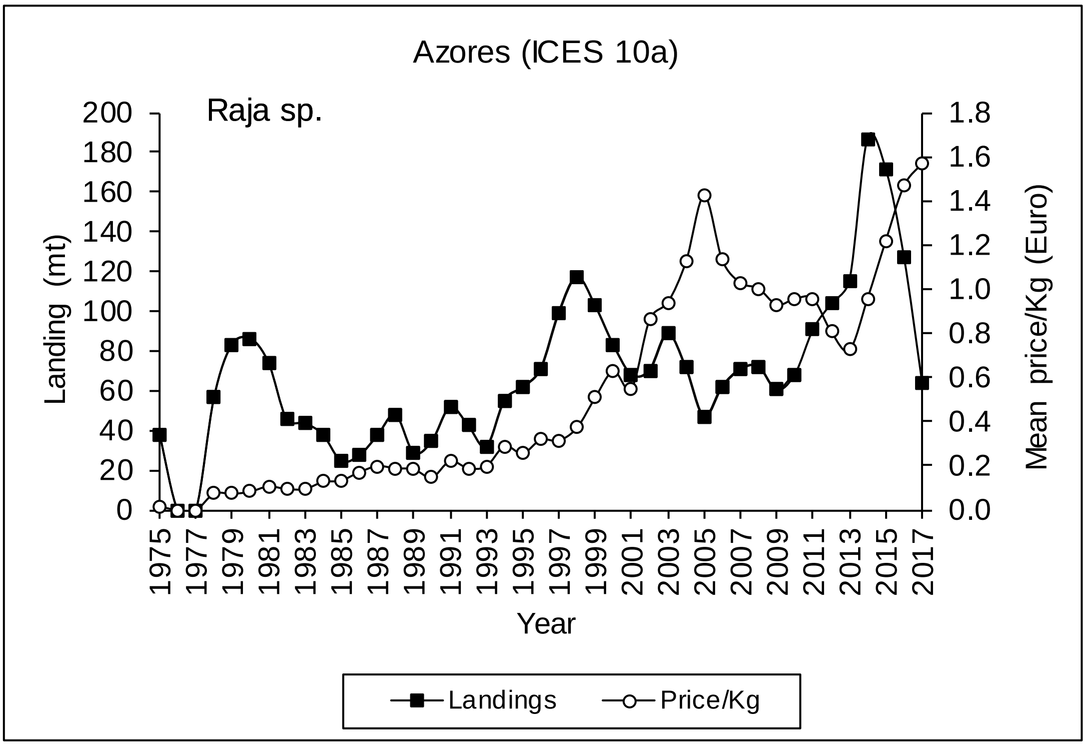

Figure 3. Annual landings in weight and value of *Rajas sp*. in the Azores.

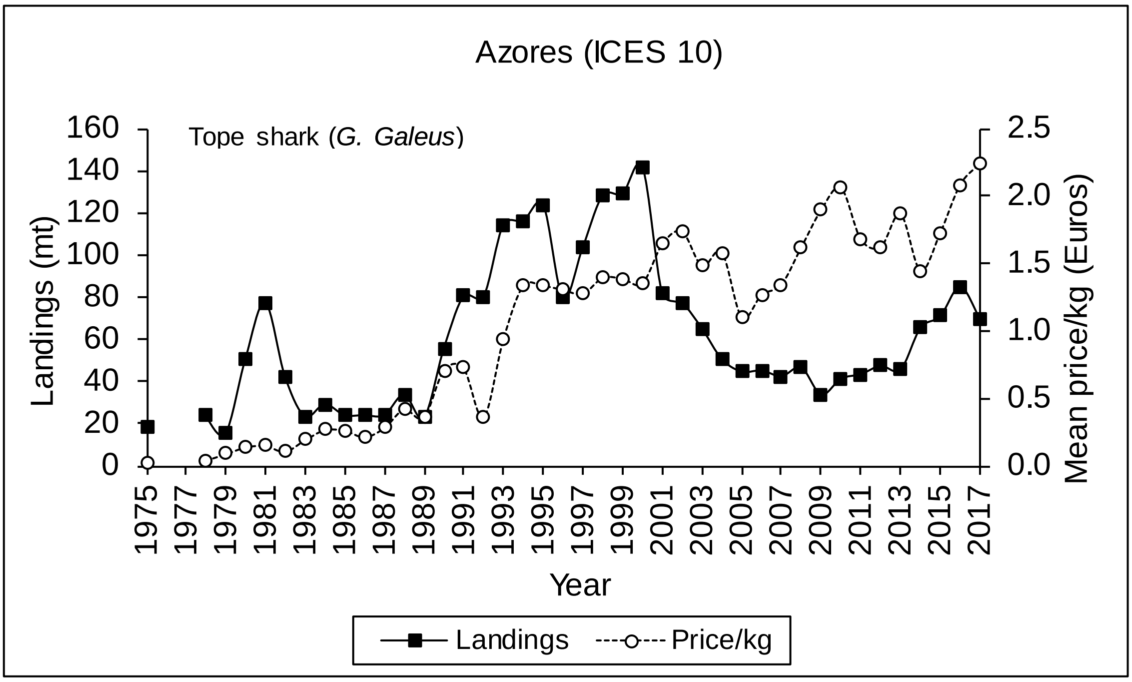

Figure 4. Annual landings in weight and value of Tope shark (*G. galeus*) from the Azores.

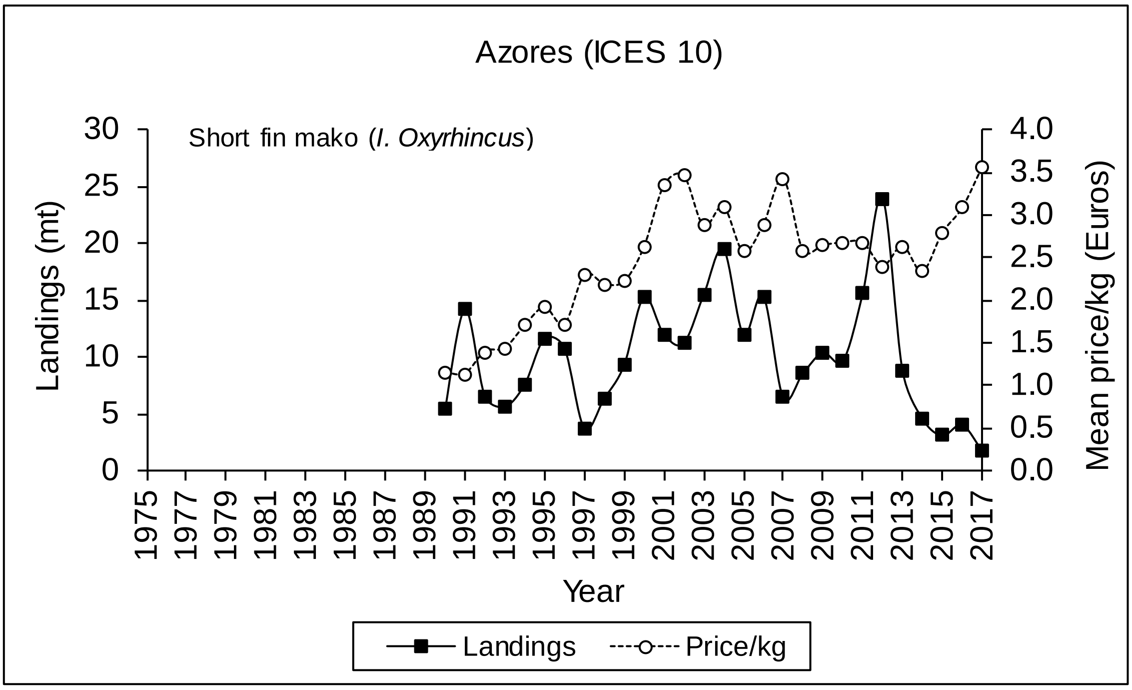

Figure 5 Annual landings in weight and value of Short fin mako (*I. oxyrhincus*) from the Azores.

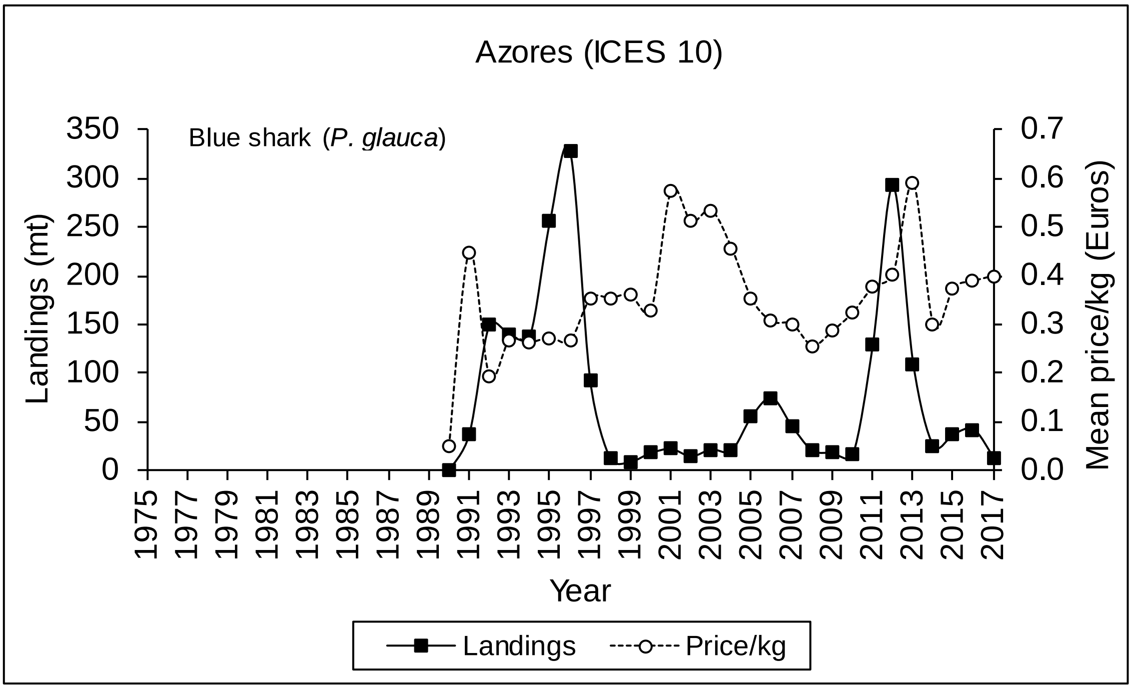

Figure 6. Annual landings in weight and value of blue shark (*P. glauca*) from the Azores.

Analyses of Scottish deep-water survey data

A Generalized Additive Model (GAM) with a negative binomial distribution was used to standardise abundance indices for leafscale gulper shark and Portuguese dogfish caught in the Scottish deep-water survey (2000–2017). The survey covered depths of 300–2040 m and gave representative coverage of the continental slope between approximately 55°N and 59°N (Figures 1 & 2). The survey has occasionally carried out hauls at Rockall and Rosemary Bank, which could potentially bias trends, therefore these stations have been excluded from the present analysis and data are exclusively derived from hauls on the continental slope. The majority of hauls were made at the following strata: 500, 1000, 1500 and 1800 m. In any one year there were usually around 5–6 hauls for each of these depth strata. Data used in the model were restricted to the "core" depth range for each species, established through visual inspection of the data. Core depth ranges for Portuguese dogfish and leafscale gulper shark were considered to be 700–1900 m and 500–1800 m, respectively. The percentages of hauls within the expected depth range in which both deep-water sharks were caught are presented in Figures 3 & 4. Summary information is given in Table 1.

The model took the form:

$$No \sim duration + depth + latitude + year$$

Depth, latitude and duration were considered as smoothed variables, and year as a factor. Summaries of the model fits for both species are presented in Table 2 and Figures 5 & 6.

The abundance index was standardised to a fixed duration of 60 minutes for both species, and to a depth of 1000 m and latitude 57°N for leafscale gulper shark, and 1600 m and 56°N for Portuguese dogfish. These reference depths and latitudes were selected to reflect highest catch rates and low standard deviation in the fitted GAMs. Standardised abundance indices are plotted in Figures 7 & 8.

Table 1. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Data included in the GAM analysis of Scottish deep-water survey data: numbers of hauls within the specified depth range, numbers of individuals caught and numbers caught per hour.

	Portuguese Dogfish			Leafscale gulper shark		
Year	No. Hauls	No. Fish	Mean NpH	No. Hauls	No. Fish	Mean NpH
2000	22	103	4.68	29	70	2.41
2002	20	63	3.15	26	65	2.50
2004	14	26	1.86	23	18	0.78
2005	14	39	2.79	19	46	2.42
2006	20	35	1.75	28	34	1.21
2007	13	35	2.69	19	16	0.84
2008	20	40	2.00	28	11	0.39
2009	28	31	1.11	35	19	0.54
2011	20	30	1.50	25	0	0.00
2012	21	31	1.48	26	4	0.15
2013	21	49	2.33	21	16	0.76
2015	23	90	3.91	28	15	0.54
2017	29	25	0.86	30	28	0.93

Table 2. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Summary of model fit GAM analysis of Portuguese dogfish in Scottish deep-water surveys (2000–2017).

	Estimate	Standard Error	T value	Pr(>|t|)	Significance
(Intercept)	0.1119	0.22665	0.494	0.62149	
as.factor(year)2002	-0.06629	0.17584	-0.377	0.706167	
as.factor(year)2004	-0.69668	0.22947	-3.036	0.002397	**
as.factor(year)2005	-0.33847	0.20229	-1.673	0.094284	.
as.factor(year)2006	-0.75307	0.20518	-3.67	0.000242	***
as.factor(year)2007	-0.32088	0.23816	-1.347	0.177871	
as.factor(year)2008	-0.45577	0.21325	-2.137	0.032579	*
as.factor(year)2009	-0.36289	0.40541	-0.895	0.370725	
as.factor(year)2011	-0.76982	0.45908	-1.677	0.093564	.
as.factor(year)2012	-0.08749	0.37911	-0.231	0.817492	
as.factor(year)2013	-0.25891	0.39541	-0.655	0.5126	
as.factor(year)2015	0.57163	0.35286	1.62	0.105236	
as.factor(year)2017	-1.14578	0.39895	-2.872	0.004079	**

	Estimated degrees of freedom	Reference degrees of freedom	Chi squared	p-value	Significance
s(duration)	7.963	8.705	33.73	8.58E-05	***
s(depth)	8.430	8.893	405.63	2.00E-16	***
s(latitude)	8.734	8.973	126.52	2.00E-16	***

Signif. codes: 0 - '***', 0.001 - '**', 0.01 - '*', 0.05 - '.', >0.1 ' '

R-sq.(adj) = 0.531 Deviance explained = 65.0%

UBRE = 1.1296 Scale est. = 1 n = 265

Table 2 (cont.). Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Summary of model fit GAM analysis of Leafscale gulper shark in Scottish deep-water surveys (2000–2017).

	Estimate	Standard Error	T value	Pr(>|t|)	Significance
(Intercept)	-0.0135	0.2125	-0.063	0.949452	
as.factor(year)2002	0.0557	0.1810	0.308	0.7582	
as.factor(year)2004	-1.0090	0.2695	-3.742	0.000182	***
as.factor(year)2005	-0.1612	0.2087	-0.772	0.439892	
as.factor(year)2006	-0.5580	0.2168	-2.574	0.01005	*
as.factor(year)2007	-0.7916	0.2871	-2.757	0.005834	**
as.factor(year)2008	-1.4150	0.3379	-4.188	2.81E-05	***
as.factor(year)2009	-1.1090	0.4138	-2.679	0.00738	**
as.factor(year)2011	-43.8600	13420000	0	0.999997	
as.factor(year)2012	-2.2270	0.5898	-3.777	0.000159	***
as.factor(year)2013	-0.7001	0.3925	-1.784	0.074485	.
as.factor(year)2015	-0.8465	0.3958	-2.139	0.032454	*
as.factor(year)2017	-0.5225	0.3536	-1.478	0.13947	

	Estimated degrees of freedom	Reference degrees of freedom	Chi squared	p-value	Significance
s(duration)	3.524	4.273	5.458	0.242	
s(depth)	7.288	8.112	187.766	2.00E-16	***
s(latitude)	5.47	6.53	32.831	2.05E-05	***

R-sq.(adj) = 0.472 Deviance explained = 53.9%

UBRE = 0.58044 Scale est. = 1 n = 337

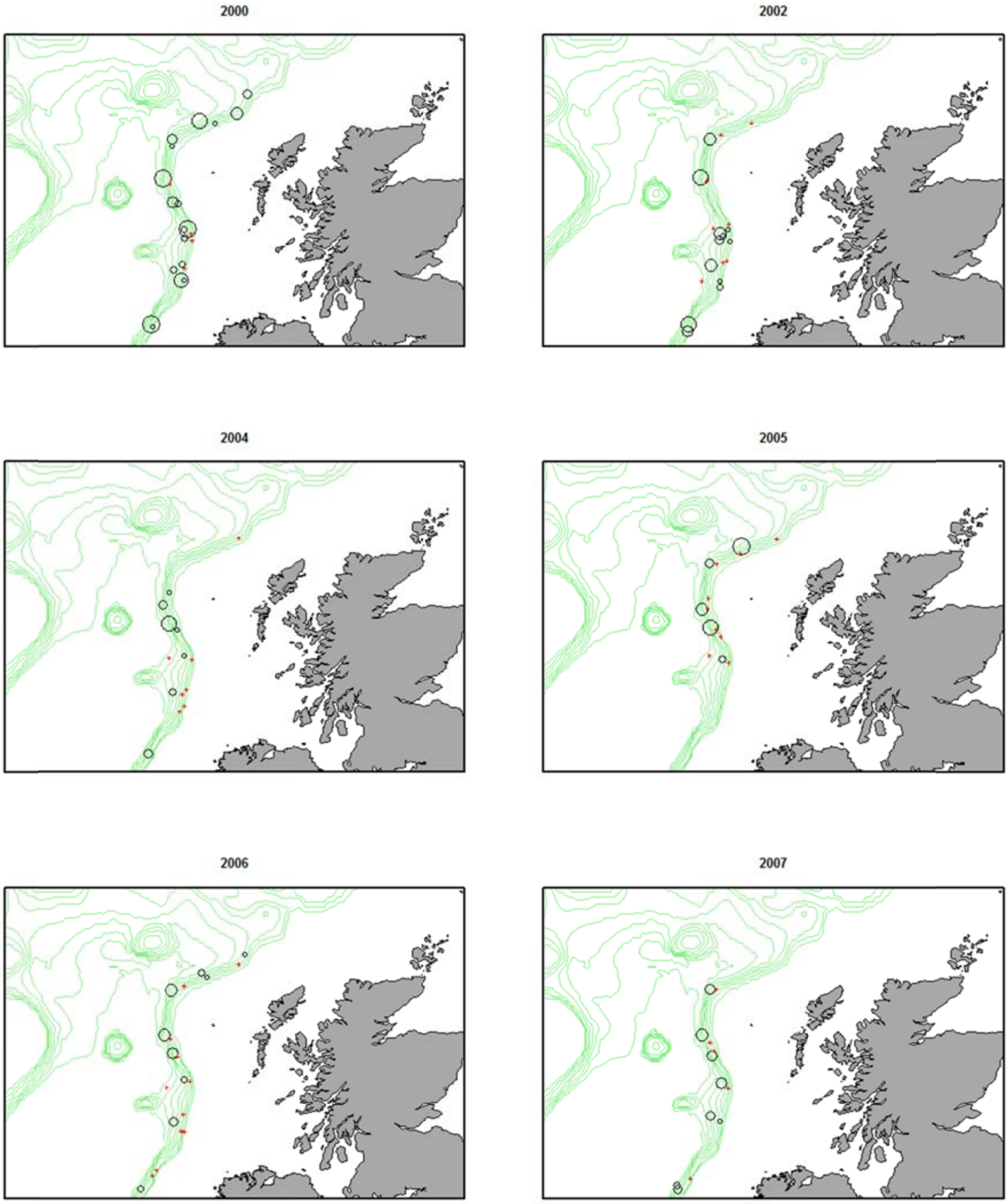

Figure 1. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Distribution of catches of Portuguese dogfish within the expected depth range (700 to 1900 m) in Scottish deep-water surveys 2000 to 2007. Black circles indicate catches of one or more individuals, red crosses indicate hauls with no catch of this species.

Figure 1. (cont.) Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Distribution of catches of Portuguese dogfish within the expected depth range (700 to 1900 m) in Scottish deep-water surveys 2008 to 2017. Black circles indicate catches of one or more individuals, red crosses indicate hauls with no catch of this species.

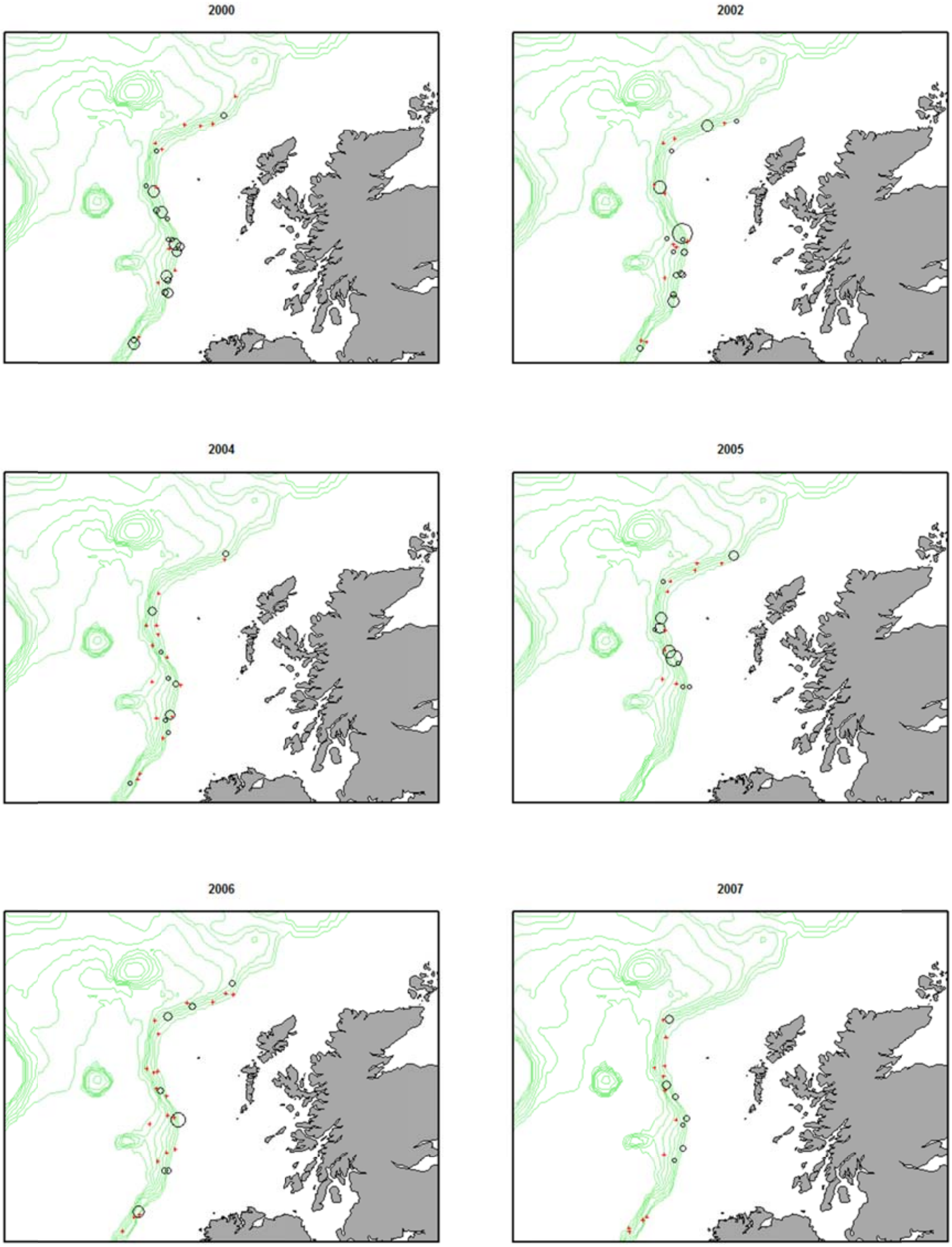

Figure 2. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Distribution of catches of leafscale gulper shark within the expected depth range (500 to 1800 m) in Scottish deep-water surveys 2000 to 2007. Black circles indicate catches of one or more individuals, red crosses indicate hauls with no catch of this species.

Figure 2. (cont) Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Distribution of catches of leafscale gulper shark within the expected depth range (500 to 1800 m) in Scottish deep-water surveys 2008 to 2017. Black circles indicate catches of one or more individuals, red crosses indicate hauls with no catch of this species.

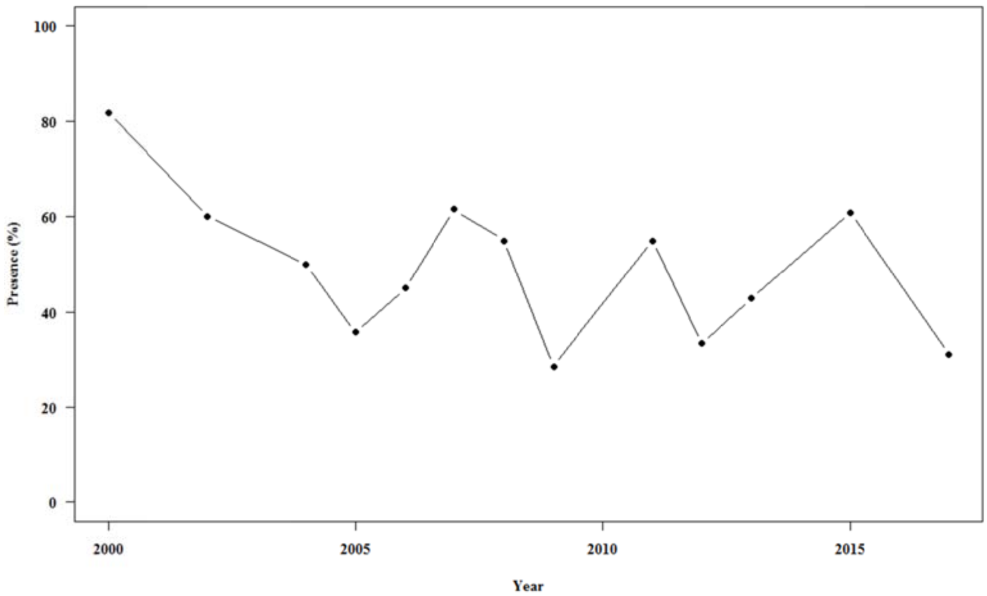

Figure 3. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Percentage of hauls within the expected depth range (700 to 1900 m) in which Portuguese dogfish were caught. Scottish deep-water surveys 2000 to 2017 slope stations only.

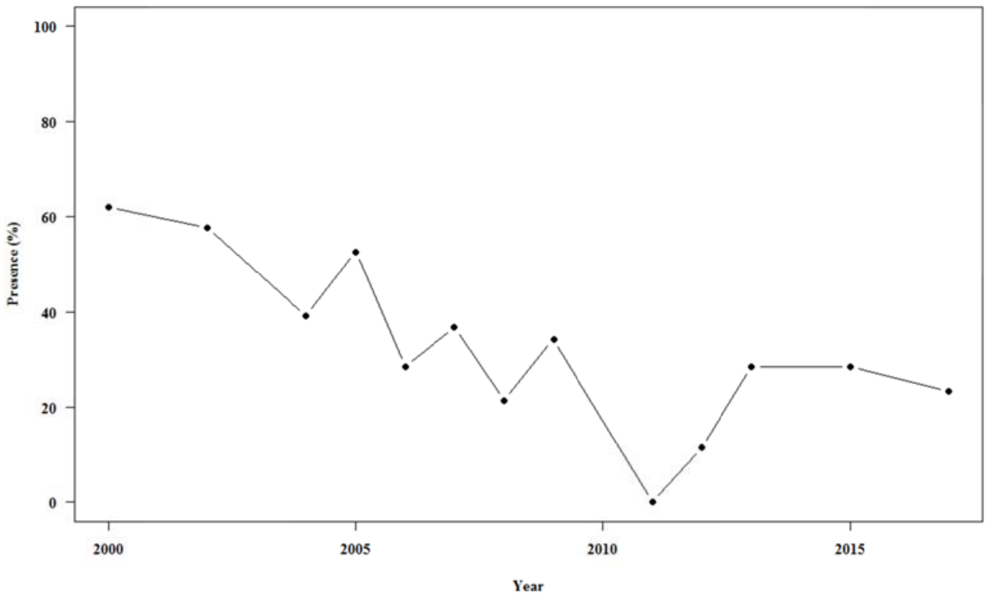

Figure 4. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Percentage of hauls within the expected depth range (500–1800 m) in which Leafscale gulper shark were caught. Scottish deep-water surveys 2000 to 2017 slope stations only.

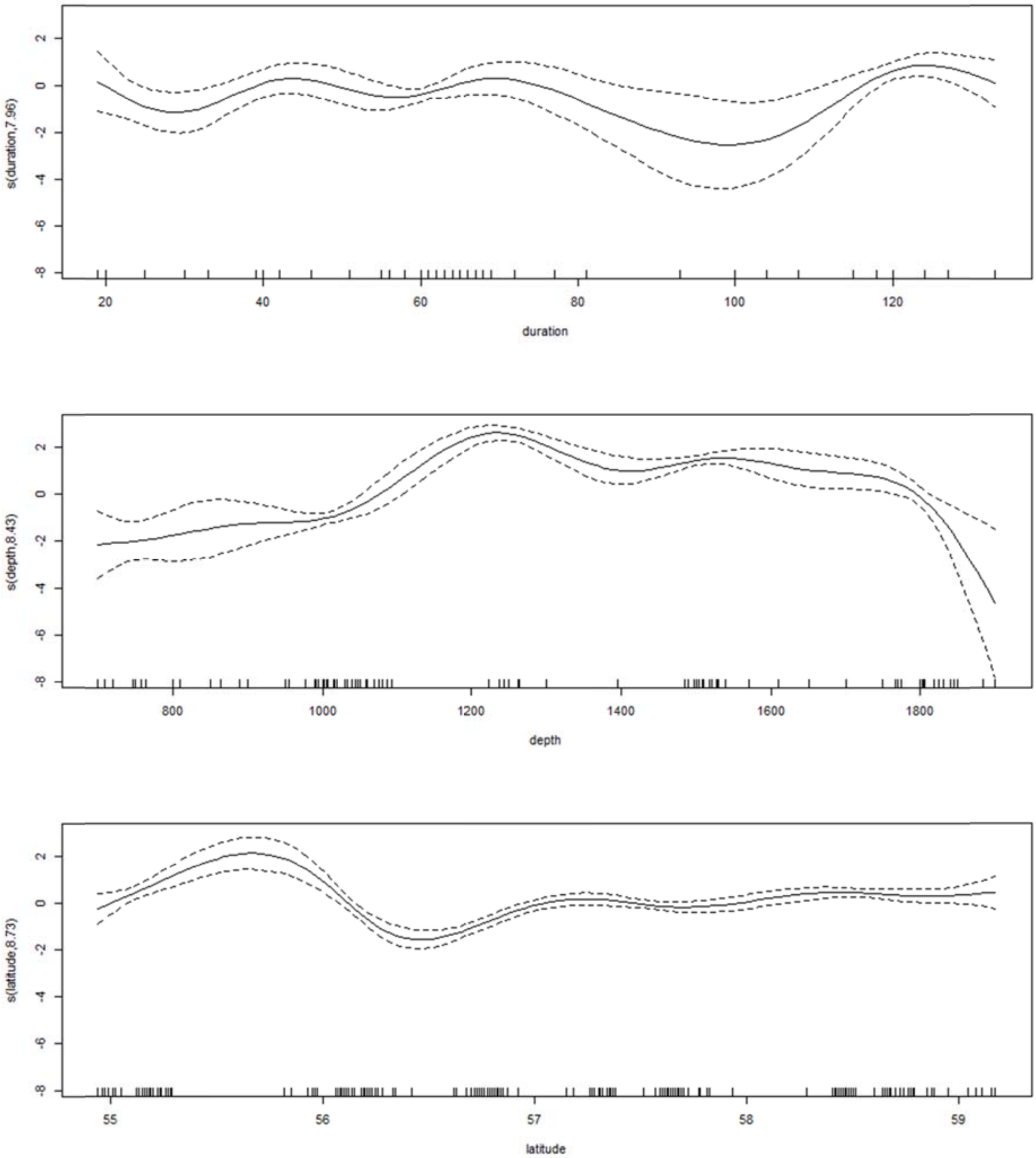

Figure 5. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Model fits for smoothed terms in GAM analysis of Portuguese dogfish in Scottish deep-water surveys 2000 to 2013.

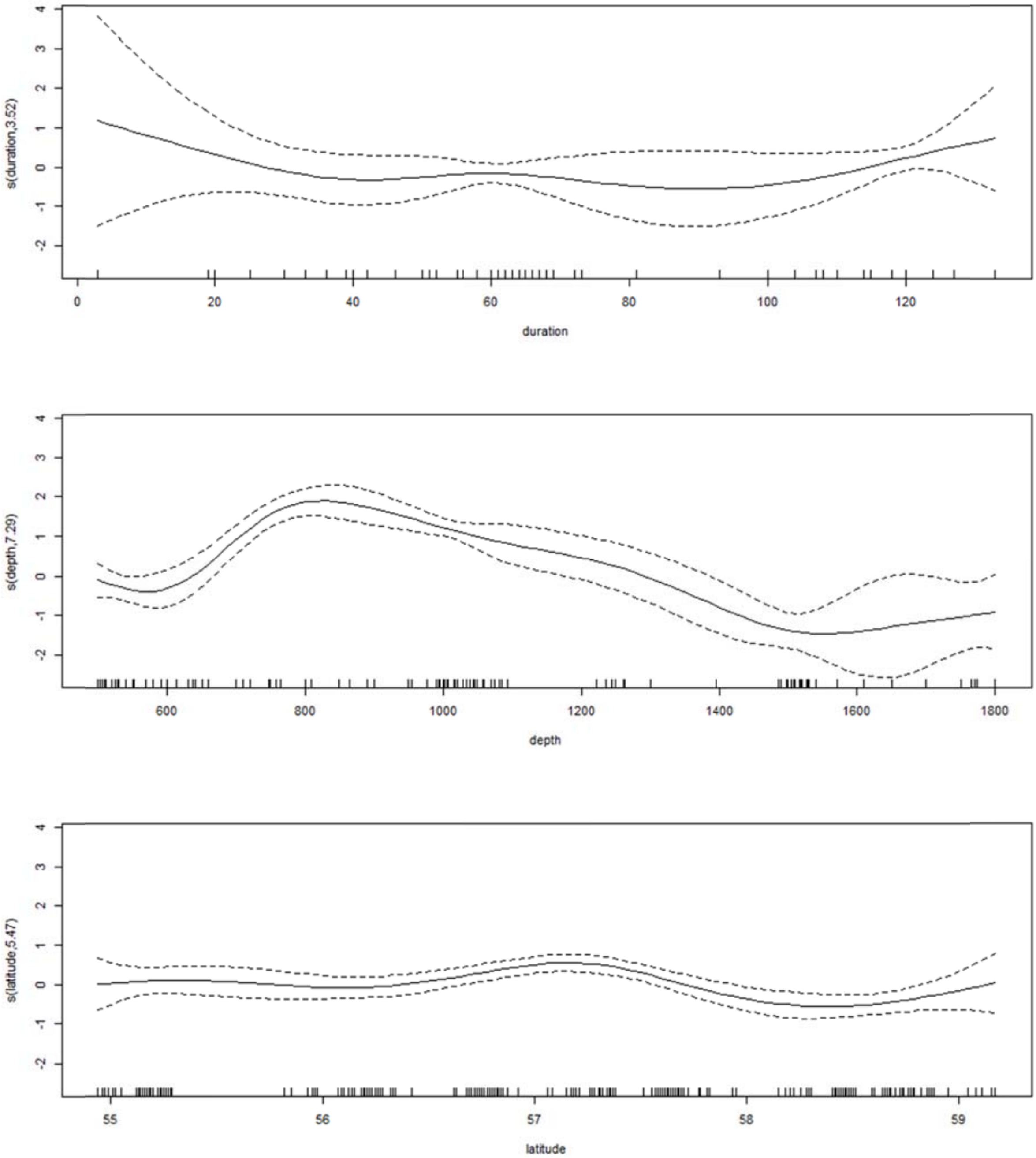

Figure 6. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Model fits for smoothed terms in GAM analysis of leafscale gulper shark in Scottish deep-water surveys 2000 to 2013.

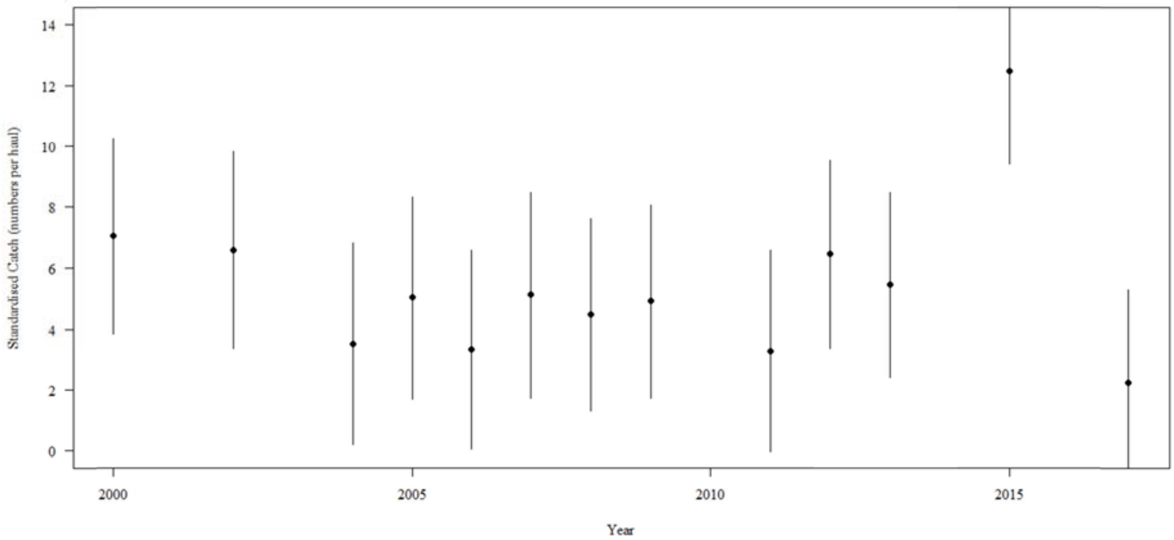

Figure 7. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Standardized abundance index for Portuguese dogfish in Scottish deepwater surveys 2000 to 2017 (error bars = ± 2 standard error).

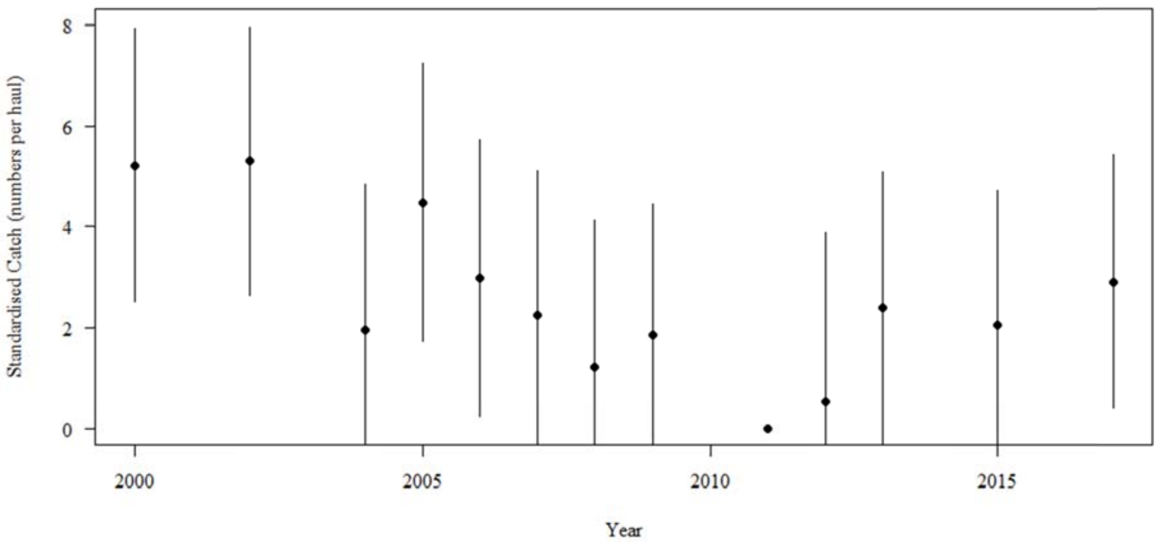

Figure 8. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (Subareas 4–14). Standardized abundance index for leafscale gulper shark in Scottish deep-water surveys 2000 to 2017 (error bars = ± 2 standard error).

Annex 8: Report in response to the French request for updated advice on Undulate ray (*Raja undulata*) in Divisions 7.d–e and 8.a–b for 2018

Contents

- Report on the French request for updated advice on Undulate ray (Raja undulata) in Divisions 7.d-e and 8.a-b for 2018
- Skates and rays in the Celtic Seas (ICES subareas 6 and 7 (except Division 7.d))
- Skates in the Bay of Biscay and Iberian Waters (ICES Subarea 8 and Division 9.a)
- Reviewers' comments

NB: Section 18: Skates and rays in the Celtic Seas (ICES subareas 6 and 7 (except Division 7.d)) and Section 19: Skates in the Bay of Biscay and Iberian Waters (ICES Subarea 8 and Division 9.a) of this report were released again in connection with the release of the single-stock advice on fishing opportunities for elasmobranch stocks in October 2018. Please see these sections (pp. 452-585) for the most up to date information.

1 ToR k)Special request from France to revise the advice provided in 2016 on fishing opportunities for 2018 for the stocks of undulate ray (*Raja undulata*) in 7.de and in 8.ab.

1.1 Introduction

WGEF had the following ToR:

Address the special request from France to revise the advice provided in 2016 on fishing opportunities for 2018 for the stocks of undulate ray (*Raja undulata*) in 7.de and in 8.ab by:

i) validating new data provided by France from:

- industry self-sampling programme
- observer programme

ii) update the catch advice for 2018 based on the results of the data validation, the STECF report on survivability and updated assessment. Prepare a draft advice document for these two stocks.

1.1.1 Background on undulate ray

Regulation during the past decade

Landings of undulate ray from these two stocks were banned for six years from 2009 to 2014 as undulate ray was included in the EU list of prohibited species following alarming signal from the UK-BTS Q3 surveys where the species was not caught during three consecutive years. Except in Division 7.d, where the French CGFS survey provides a reliable indicator, surveys do not provide reliable biomass trends of the two stocks of undulate ray. In the Bay of Biscay, the distribution of the species is mostly inshore of the area sampled by the EVHOE survey, which does not cover water shallower than 25-30 m. In Division 7.e, only small numbers are caught in the UK-BTS survey. Since 2015, small bycatch TAC have been allowed in Division 7.e, 7.b and 8.ab.

Background studies

Data and analyses on undulate ray were presented in previous years to WGEF. The working document from Leblanc et al. (2014 WD) showed that *R. undulata* was the main skate species caught in the Norman-Breton Gulf. The species was shown to be dominant in coastal waters; although it occurs in almost all the English Channel its distribution appears to be concentrated in the central region of the English Channel. This working document also shown that the decrease in catch of skates and rays in the French fisheries of the Gulf Normand-Breton, may have been 300 tonnes.

In the Bay of Biscay a tagging survey was carried out from the end of 2011 to mid-2014 in the Bay of Biscay with the partnership of the fishing industry (Biais et al., 2014, WD). It showed that the undulate ray can be found all along the French coast from the Loire estuary to the Spanish boarder, forming several isolated units, the more important being likely in the central part of the Bay of Biscay (Pertuis Charentais – Gironde area). Even within this limited area, the population is structured in sub-units with a low exchange rate between them. The biomass of undulate rays longer than 65 cm in the inner Gironde estuary was estimated to be in the range from 51 to 70 t during the 2013-2014 winter (95% confidence interval is 30-124 t). The Gironde estuary being only a small proportion of the area where the species occurs in the Bay of Biscay.

Further, tagging studies in Division 7.de indicated high site fidelity (Stéphan et al., 2014 WD; Figure 18.40). In the Normano-Breton Gulf, 1488 *R. undulata* were tagged with a 5% (n=77) recapture rate. All the skates tagged in a region were recaptured in the same region, and distance travelled was short (<80 km).

In 2015, WGEF carried out preliminary estimates of discards of undulate ray in the English Channel for the year 2013, when the species was on the prohibited list. The estimated discards in 2013 amounted to 875 tonnes and 66 tonnes respectively in 7.e and 7.d for trawl metiers. The total estimated discards in 7.de by all métiers (towed and passive) was estimated to 1778 t in 2013.

1.1.2 Treatment of the special request by WGEF

A working document based on analyses of the French self-sampling progamme applied to vessels allowed to land undulate ray and on-board observers data collected under the EU-DCmap in 2015-2017 was presented (Gadenne and Biseau, 2018, WD; Section 1.2).

In addition an analysis of landings and discards from 2009 to 2017 of undulate ray and five other ray species (blonde ray, cuckoo ray spotted ray, small-eyed ray and thornback ray) caught in French fisheries of Divisions 7.de and 8.ab was carried out. Survey data in Division 7.d were also used to compare abundance of the undulate ray to thornback and blonde rays.

1.2 Estimating French discards of undulate ray from the self-sampling programme

This analysis aims to provide new data to support the update of the ICES advice regarding the undulate ray (*Raja undulata*), for two stocks occurring in French coastal areas where they are caught by French fleets:

- rju.27.8.ab: undulate ray in divisions 8.a–b (northern and central Bay of Biscay),

- rju.27.7.de: undulate ray in divisions 7.d and 7.e (English Channel).

An advice was issued in 2016 based on recent landing, which were very strongly constrained by the total allowable catch (TAC), arbitrarily set in 2015.

Table 1. History of TAC for undulate ray stocks in three areas.

Year	TAC for EC waters of 7.e	TAC for EC waters of 7.d	TAC for EC waters of 8.abc
2009	landing ban	landing ban	landing ban
2014	0 t	0 t	0 t
2015	41 t	8 t	9 t
2016	41 t	9 t	16 t
2017	65 t	14 t	19 t
2018	65 t	14 t	19 t

This study (Gadenne and Biseau, 2018, WD) provides new data to support the update of the ICES advice regarding undulate ray stocks in Divisions 7.de and 8.ab. Catches (landings and discards) of undulate ray by ICES divisions in 2016 and 2017 are estimated using the landings of all species as an auxiliary variable.

Data include (Gadenne and Biseau, 2018, WD) official landings (estimated from a combination of logbooks and other compulsory reporting from fishers, fish auction market sales and other data, e.g. VMS), landings and discards sampling from the French onboard observations program, carried in application of the EU-DCmap program from the French fishery information data facility (SIH – Système d'Informations Halieutiques), and the undulate ray specific self-sampling program aiming at the collection of data by fishers on the level of bycatch on undulate ray. The self-sampling program involves all the vessels that were allowed to land undulate ray in 2016 and 2017 from Divisions 7.de and 8.ab according to EC 2015/960 and several management measures to regulate the bycatch and the landings of undulate ray (Gadenne, 2017).

Table 2. Overview of data used

	Official landings data		On-board observations data		Specific self-sampling data	
Year	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Landing/Discard	LAN	LAN	LAN (DIS)	LAN (DIS)	LAN & DIS	LAN & DIS
Vessels number	185	126			56	59
Trips number		2540	213 (33)	171 (28)	1236	1971
Fishing trips			430 (66)	318 (69)	5190	6860

All trips being sampled, the number of samples in this program and the spatio-temporal coverage are much larger than the EU-DCmap onboard sampling program (Table 2). In 2016, only landings data (59 tonnes for divisions 7.de) were used by ICES to provide the fishing opportunities for 2017 and 2018, after the 2010-2015 ban.

In the working document (Gadenne and Biseau, 2018, WD) the description of quantitative and spatial coverage of each used dataset is first detailed. Secondly, a method to validate self-sampling data is presented to consolidate the use of the self-sampling dataset. Finally, different methods were used to raise data and to estimate total catches (discards and landings) of undulate ray.

1.2.1 Methods

Because participating in the self-sampling program allows the vessel to land undulate ray with a limit of 150 kg per day/trip, it was considered that trips for which landing of undulate ray was allowed should be excluded from the on-board observations data set when raising discards of undulate ray as the fishing strategy might be impacted by having a fishing license (Gadenne and Biseau, 2018, WD).

Therefore, the raising procedure was performed separately for the vessels involved in the self-sampling program and for the vessels observed by the on-board sampling program (but not participating in the self-sampling program) to account for possibly two different fishing strategies.

Three raising methods were used following the guidelines described in the WKSHARK3 (ICES, 2017) report (based on landings for the stock considered, landings of all species by the selected fleets, fishing effort of the select fleets, respectively). Here, for the sake of simplicity, are only presented estimations of catches (landings and discards) estimated using the landings of all species as auxiliary variable, which was judged more reliable (ICES, 2017). The results obtained using the other two methods are detailed in Gadenne and Biseau (2018). The use of an auxiliary variable increases the accuracy of the estimate by taking advantage of the correlation between the landings or discards of undulate ray and the landings weights of all species (Cochran, 1977). This approach follows the recommendation of the WKSHARK3 report (ICES, 2017).

The analyses and the raising procedures are applied to the two fleets (self-sampling and regular fleets). Estimates are calculated on strata defined by the year, the ICES division and the fishing gear. Estimates are provided only if at least 3 samples of trips are available in the strata.

1.2.2 Results

<u>Landing estimates</u>

In order to test the raising procedure, the estimated landing values for the two fleets are presented together with the official landings in 2016 and 2017.

Table 3. Landings estimates and official values of undulate ray (in tonnes) by fleet, ICES Division in 2016 and 2017 (Gadenne and Biseau, 2018, WD).

		Fleet 1 (self-sampled vessels)		Fleet 2 (Other vessels)		Total	
Area	**Year**	**Estimated Landings**	**Official Landings**	**Estimated Landings**	**Official Landings**	**Estimated Landings**	**Official Landings**
27.7.d	2016	75.1	10	18.9	2.54	94.0	12.54
	2017	32.3	12.67	39.2	1.68	71.5	14.35
27.7.e	2016	162.9	32.2	9.6	13.33	172.5	45.54
	2017	194.0	61.06	0.0	3.66	194.0	64.72
Total 7de	**2016**	**238.0**	**42.20**	**28.5**	**15.87**	**266.5**	**58.08**
	2017	**226.3**	**73.73**	**39.2**	**5.34**	**265.6**	**79.07**
27.8.a	2016	55.6	5.73	18.5	2.32	74.1	8.04
	2017	65.9	14.5	10.0	1.01	75.9	15.51
27.8.b	2016	5.0	5.9	0.1	0.43	5.1	6.33
	2017	6.1	5.97	0.4	0.19	6.5	6.16
Total 8ab	**2016**	**60.6**	**11.63**	**18.6**	**2.75**	**79.2**	**14.37**
	2017	**72.0**	**20.47**	**10.4**	**1.20**	**82.4**	**21.67**

The contribution of the different gear types varies between ICES divisions (Gadenne and Biseau, 2018, WD).

Discard estimates

Like for landings, discards were estimated separately for the 2 fleets, using the landings weights of all species as auxiliary variable. The discards estimates by ICES division and year are presented.

Table 4. Discards estimates of undulate ray (in tonnes) by fleet, ICES Division in 2016 and 2017 (Gadenne and Biseau, 2018, WD).

Year	Area	Fleet 1 (self-sampled vessels)	Fleet 2 (Other vessels)	Total Discards
27.7.d	2016	73.1	197.7	270.8
	2017	78.9	407.7	486.6
27.7.e	2016	448.3	854.2	1302.5
	2017	283.4	588.0	871.4
Total 7de	**2016**	**521.4**	**1 051.9**	**1573.3**
	2017	**362.3**	**995.7**	**1358.0**
27.8.a	2016	74.3	167.9	242.3
	2017	36.1	243.4	279.5
27.8.b	2016	7.8	176.9	184.7
	2017	14.3	191.2	205.4
Total 8ab	**2016**	**82.1**	**344.8**	**426.9**
	2017	**50.4**	**434.5**	**484.9**

The contribution of the different gear types varies between ICES divisions (Gadenne and Biseau, 2018, WD).

Catch estimates

Estimates of landings and discards of undulate ray, for the French fleets, are given.

Table 5. Estimated landings and discards of undulate ray (in tonnes), by ICES Division in 2016 and 2017, for the two fleets (self-sampling and other vessels.

Area	Year	Landings	Discards	Catches	% discards
27.7.d	2016	94.0	270.8	364.8	74%
	2017	71.5	486.6	558.1	87%
27.7.e	2016	172.5	1302.5	1475.0	88%
	2017	194.0	871.4	1065.4	82%
Total 7de	**2016**	**266.5**	**1573.3**	**1839.8**	**86%**
	2017	**265.6**	**1358.0**	**1623.5**	**84%**
27.8.a	2016	74.1	242.3	316.3	77%
	2017	75.9	279.5	355.4	79%
27.8.b	2016	5.1	184.7	189.8	97%
	2017	6.5	205.4	211.9	97%
Total 8ab	**2016**	**79.2**	**426.9**	**506.2**	**84%**
	2017	**82.4**	**484.9**	**567.3**	**85%**

As expected, given the very limited quota, a large part of the catches of RJU is discarded. The contribution of the different gear types to both LAN and DIS varies between ICES divisions (Gadenne and Biseau, 2018, WD).

1.2.3 Discussion

In most cases, using the landings of all species as an auxiliary variable to raise the samples leads to estimated values of undulate ray landings somewhat higher than the official ones. As a consequence, the actual total landings (all species) of these vessels (all trips) are somewhat higher than total landings recorded in the self-sampling data base. Furthermore, the trips not self-sampled are considered similar to the ones self-sampled, assuming landings that might not occur. All this contributes to the higher values of estimated landings.

In this particular case of a bycatch fishery, monitored by a specific self-sampling protocol, with vessels detaining a specific license, and constrained by different limits (quantities by day/week, sizes, and opening vs. closing of landings periods), the raising method used here may induces bias not considered by WKSHARK3.

Furthermore, assuming the same fishing strategy all the year round for the vessels involved in the self-sampling program may also introduce a bias since:

- the fishing strategy of these vessels might have been different during the period for which the landings of RJU is allowed and
- when the quota is fully taken and the landing of undulate ray is no more allowed

1.2.4 Conclusion

When the 2016 ICES advice was released, only reported landings for 2015 were considered to apply the category 3 rule.

However, these 2015 landings were very much constrained by a very limiting TAC (in both areas) and should not have been used, alone, as the basis for the advice.

Discards should have been included. Given the current amount of discards (more than 75%) the actual catch values on which the advice should have been based are much greater than the 54 t used for the 7.de advice.

In a working document for WGEF in 2014, Leblanc *et al*. provided an estimate of landings of undulate ray prior to the ban, based on the difference in the landings of the total rays (undefined species as reported in the French statistics in the past) before and after the ban.

This difference was about 300 tonnes in Division 7e and at least 35 tonnes from Division 7d (the latter estimate being based only on data from auctions located in Basse-Normandie).

It should also be noted that STECF, in its report (EW 15-03), wrote: "*The authors of the ad hoc report estimated, based on interviews and historic observer data, that the annual landings of undulate ray from Division VIIde before the ban, was around 300 t and those from VIIIab were in the order of 82 – 120 t.* ", and farther: " *STECF considers that a pragmatic upper limit for a TAC for undulate ray in Division VIIde would be the estimated annual landings of 300 t identified in the ad hoc report, as the stock appears to have been able to sustain landings of that order and at the same time there are indications that the stock has increased*."

Estimates of discards made by Leblanc *et al.* (2014), from DCF on-board observations data (raised using fishing days), are about 750 tonnes in 2011-2013 in 7e for bottom trawlers (OTB_DEF) only.

All these estimates suggest that the values used as the basis for the 2016 advice were largely underestimated. The present analysis shows that the estimated catches in Divisions 7de were 1840 t in 2016 and 1624 t in 2017. In Divisions 8ab, catches are estimated respectively to be 506 t and 567 t in 2016 and 2017.

1.3 Landings and discards of ray in French Fisheries

1.3.1 Introduction

This analysis was carried out to develop an approach to estimate a level of TAC compatible with the objectives of the CFP for the stocks of undulate ray in the English Channel (rju.27.7de) and the Bay of Biscay (rju.27.8ab).

From 2015, three small TACs were set in in divisions 7d, 7e and 8ab. In the English Channel these TACs areas do not match ICES stock units as ICES considers one single undulate ray in divisions 7de (rju.27.7de). The separation in two TACs is considered by WGEF to be based upon management considerations about the attribution of national quotas under a TAC. Nevertheless, the species abundance relative to other ray species is different in 7d and 7e, therefore the present analyses was carried out separately for 7d and 7e. Based upon survey data, in Division 7d, the main ray species in the past three decades has been the thornback ray. Amongst other species, blonde and undulate ray have been observed at about 10 times lesser abundance and spotted as well as small-eyed as further lesser abundance. In Division 7e, the relative abundance of species is less clear but thornback ray is not clearly dominant and landings of thornback and blonde ray have been of similar magnitude in the last 10 years. In the Bay of Biscay, the ICES stock assessment unit (rju.27.8ab) matches the EU-TAC area.

Levels at which the small TACs open in 2015 were set were mostly arbitrary, but designed to be sustainable and to allow for further stock rebuilding. In other words chosen levels were set below any MSY or precautionary reference point at expert judgement. The 2016 ICES advice used the ICES approach for DLS stocks based on Cat.3 for rju.27.7de and Cat.6 for rju.27.8ab.

Before 2009, there was no separated French landings statistics of undulate ray. It was therefore impossible to appraise the contribution of undulate ray to French skates and rays landings. Reporting landings species-by-species became mandatory in 2009 in the Biscay Iberian and Celtic seas ecoregions. However, these data are little informative for undulate ray because this species was included in the prohibited list about at the same time as species-by-species reporting became mandatory. Following the WKSHARK2 workshop (ICES, 2016) WGEF has estimated species-specific landings of elamosbranchs since 2005. Data for years 2005-2008 are considered less reliable than data from later years. Part of species-specific estimated landings in 2005_08 are estimations based on total skates and rays landings and sampling of the species-composition for national programmes and no sampling of the species composition of skates and rays landings in French fishing ports in 2005-2008 was available to ICES.

Landings from most recent years are limited to the small TACs and corresponding licensed fleet and do not include bycatch of all other fleets, which are discarded.

There is no standard ICES procedure to evaluate the level of a catch that would be in accordance with MSY and precautionary reference points for a stock assessed from DLS categories 3 to 6. MSY proxies, e.g. length based indicators (LBIs) allow evaluating whether recent catch are in accordance or not of proxy MSY reference points but do not allow setting a catch when there is no recent catch and when these were strongly limited by regulation.

In these ICES stock categories, advised catch or landings are updated according to the variations of a biomass for Cat.3 and are kept at same levels or reduced by 20% depending on ancillary information on the sustainability of recent catch. For undulate ray as for most elasmobranch stocks landings rather than catch advice are delivered. For rju.27.7 (Cat.3) the biomass index comes from the FR-CGFS survey in Division 7.d and from UK-BTS-Q3 (?) in division 7.e. The former shows a clear increasing trend since 2011 while the latter does not show a clear trend. In the Bay of Biscay there is no index of biomass of undulate ray because the species distribution is mostly inshore of the area sampled by the FR-EVHOE survey.

The approach taken here to estimate a level of landings compatible with the ICES MSY approach and therefore allow to setting regulations in accordance with the CFP objectives is based on on-board observations of French fleets were all landings and discards are quantified by fishing operation (towed gear haul or fixed gear set). Landings and discards of the six species are compared.

TACs per stock should scale to the product of their biomass multiplied by their productivity (productivity being used here in the sense of intrinsic population growth rate). Therefore if the biomass of undulate ray in an area is intermediate between those of two other ray species, the sustainable catch of undulate ray in that area should be intermediate to sustainable catches of the two other species. As said above, the conversion from the biomass to the TAC should be ideally weighted by species productivity, which may have to be substituted by a coefficient of vulnerability, e.g. the inverse of the species maximum length.

1.3.2 Method.

Estimating landings and discards from on-board observations

Observed landings and discards by aggregated gears (bottom trawls, nets, hooks and lines, pelagic trawls, seines and other gears) were raised to total landings of all species from the same gears. Raised landings were compared to reported landings in order to appraise the uncertainty of raised estimates. It is assumed that estimated discards present a similar level of uncertainty than estimated landings. Only French data were use. The approach taken assumes that biomass per species per area are proportional to catches per area. This is a strong assumption. The validity of this assumption should be considered closely in relation to the following points:

- at the scale of the fishing gear the six species of demersal skates considered might have similar probabilities of being caught when they encounter a fishing gear.
- species are subject to different levels of targeting depending on their price, spatial distribution and the fishing regulations. The undulate ray has a higher price together with the blonde ray; the thornback ray might have a slightly lesser price and the spotted and cuckoo ray have lower prices. In terms of spatial distribution the undulate, blonde and small-eyed rays are considered to have a similar coastal distribution as each other in this approach.
- as a consequence of the restrictive TAC, fisheries avoid catches of undulate ray, this means that the biomass derived from on-board observation is expected to be an underestimation relative to other species.
- because quotas of skates and rays have become restrictive in recent years, targeting is likely limited in that period. There is however some targeting using nets and hooks. Targeting is assumed to be low in trawl fleets in recent years because catch of rays are restricted. At the same time the quotas for some demersal species increased, in particular for hake in the Bay of Biscay and flatfishes in the Channel.

Because of the difference in the relative abundance of ray species between divisions 7d and 7e, the analysis was carried out for these two areas separately. Estimates of possible sustainable landings by Divisions are then summed up into estimates for the stock area

Total Discards were estimated using a ratio estimator, the auxiliary variable being the catch of all species. This approach was taken instead of the more usual of raising the discards to total landings of the same species, because most vessels discards 100% of their catch of undulate ray. The same method was applied to the six ray species so that estimates are comparable for all species.

Estimating sustainable landings of undulate ray

Estimates of the potential sustainable landings of undulate ray in each of divisions 7.d, 7.e and 8.ab were calculated from the ratio of total catch of undulate ray to another species This other species is further reference species "reference species" multiplied by landings of the other species and weighted by the biological productivity, in the sense of the intrinsic growth rate of population in a production model (Eq. 1). Additional aspect

$$PotLan(rju) = \left[\frac{O(rju)}{O(other)}\right] * \frac{r_{rju}}{r_{other}} * Lan(other) \qquad \text{(Eq. 1)}$$

Where PotLan (rju) is the potential sustainable landings of undulate ray. O(rju) and O(other) are raised estimates of the total catch from on-board observations of undulate ray and another species and Lan(other) are reported landings of the other species.

As WGEF considered than undulate and blonde ray have similar biological productivities, when the other species in blonde ray this formula simplifies to:

$$PotLan(rju) = \left[\frac{O(rju)}{O(rjh)}\right] * lan(rjh) \qquad \text{(Eq. 2)}$$

These formulas implicitly assume that possible bias in estimated of total catch are similar for undulate ray and the other species. Further coefficients could be added for example the ratio of catchabilities of the two species could be integrated but there is no data to estimate those.

Vulnerability of species has been related to life history parameters, e.g. maximum length (Lmax, Le Quesne and Jennings, 2012). Here the length at 50% maturity (Lmat) of females was taken instead because length-at- maturity is better known than maximum length. Lmat value were taken from McCully et al (2012) for thornback and blonde ray and from Stephan et al. (2014 WD) for undulate ray. Values were Lmat=73 and Lmat=78 cm for thornback ray respectively for the greater North Sea and Celtic Seas ecoregions. For blonde ray the same value Lmat=83.4 cm (McCully et al 2012) was used for all areas. For undulate ray Lmat estimate were available for the English Channel (Lmat=82 cm) and the Bay of Biscay (Lmat=84 cm). These imply quite similar biological productivities for undulate and blonde ray.

1.3.3 Results

1.3.3.1 Division 7.d

Comparison of reported and estimated landings

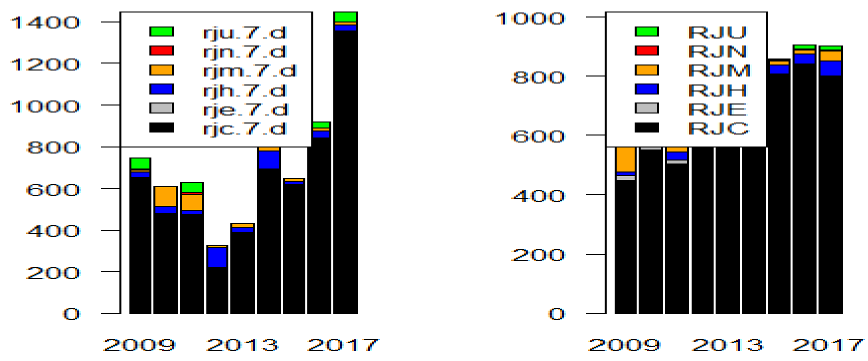

Figure 1: raised landings (left) and reported landings (right) in tonnes by species in Division 7.d

Reported French landings of the six species have been between 800 t and 1000 tonnes since 2009 (Figure 1). Slightly higher levels have been reported in recent years as a result of increasing quotas of skates and rays in Divisions 7d. The average over year 2009-2017 of estimated landings is in the same 800-1000 tonnes range, with strong year-to-year variations. These variations results from the variance of observed landings per fishing trip and hauls. The species composition of estimated landings is similar to that of reported landings. Therefore potential sustainable landings were calculated from Eq.1 and Eq.2 using these species respectively.

Estimates of discards

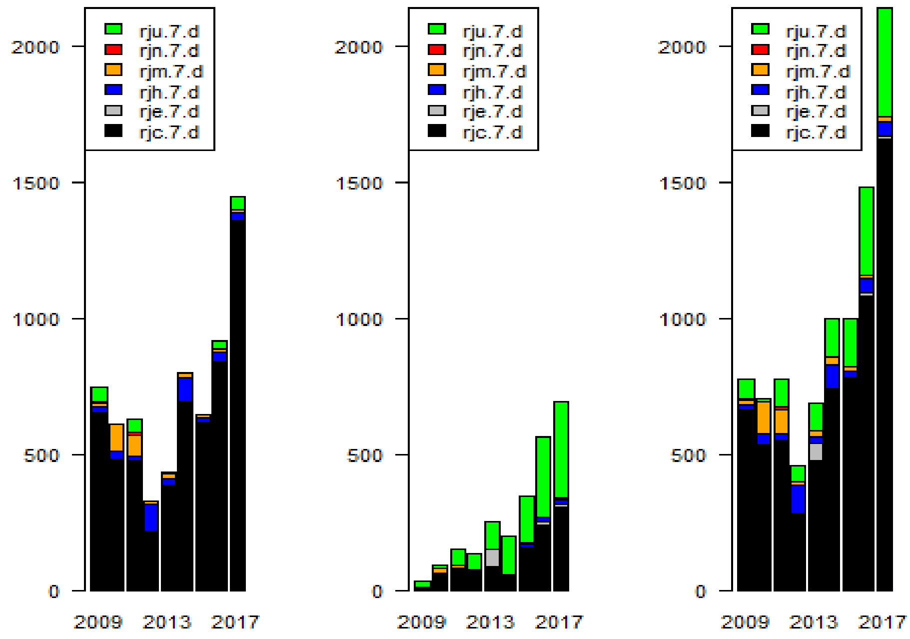

Figure 2. Estimates of landings (the same as in figure 1), discards and catch by species in Division 7.d.

The main discarded species are thornback ray and undulate ray with a lesser proportion of blonde ray. Thornback is discarded as a consequence of the quota constraints. Discards have increased in recent years as a consequence of the increasing biomass, which is reflected by the FR-CGFS survey). Undulate ray might have been fully discarded when it was on the prohibited list some landings, there where however reported in on-board observations, leadings to some raised landings in 2009-10. Discards that were minor in 2009-10 have steadily increased and this is in-line with the increasing biomass indicators from the FR-CGFS survey (Figure xx). In recent years discards of undulate ray and thornback ray been at similar levels of 250 to 350 tonnes per year.

The proportion of undulate in the total catch has increased (Figure 2) as well as the ratio of undulate ray to thornback in the catch (Appendix 1.1).

Estimating sustainable landings of undulate ray in Division 7.d

In division 7.d catches of undulate ray are intermediate between catches of thornback ray and catches of blonde ray (Table 1 and appendix 1.1).

Table 1. Estimated French total catch (landings and discards) of rju, rjc and rjh and reported international landings of rjc and rjh.

Year	Estimated total catch			Reported landings	
	rju	rjc	rjh	rjc	rjh
2009	72	662	22	589	65
2010	9	536	40	652	69
2011	100	550	26	658	90
2012	57	280	107	935	84
2013	98	477	25	1132	93
2014	137	738	93	1186	90
2015	174	780	25	988	87
2016	323	1080	48	1115	85
2017	400	1659	49	1076	116
Average 2014-17	259	1064	54	1091	95

The calculated potential landings using blonde and thornback as reference species were 460 and 238 tonnes respectively.

1.3.3.2 Division 7.e

Comparison of reported and estimated landings

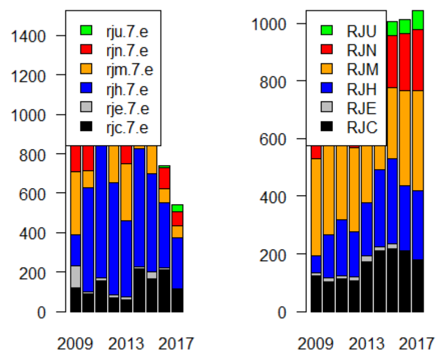

Figure 3: Raised landings (left) and reported landings (right) in tonnes by species in Division 7.e.

The overall levels of estimated landings varies from year-to year between 500 and 1500 t with the lowest estimate in 2017. The species composition derived from on-board observations differs from that of reported landings with a larger proportion of blonde ray and a lesser proportion of spotted ray in estimated. This may come from confusions between these two species, where is addition to similar pattern the French names are also similar (raie lisse and raie douce, which translate into soft ray and smooth ray). The estimated landings are dominated by blonde ray while the reported are dominate by spotted ray. Estimated landings of thornback ray are smaller than those of blonde ray while reported landings of these two species are similar.

Estimates of discards

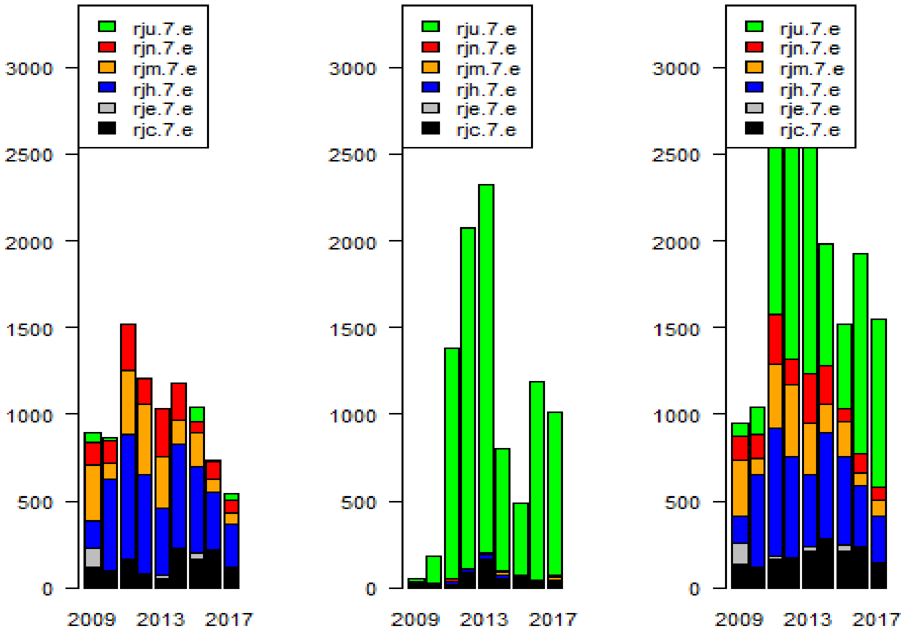

Figure 4. Estimates of landings (the same as in figure 3), discards and catch by species in Division 7.e.

The main discarded species is undulate ray, with strong year-to-year variations of the estimate discards (Figure 4 and appendix 1.2). Estimated discards were small in 2009-2010 then increased in 2011 and varied in the range 500-200 t. The only other species discarded in substantial quantities is the thornback ray. The total catch is estimated to decrease since 2012. However the species composition of the total catch is fairly stable, with about half of it being undulate ray since 2012. The reduction in the estimated total catch requires investigation of the realized sampling per year and the stratification. Nevertheless, on-board observations suggest that undulate ray is the main species in French catches from Divisions 7.e.

Estimating sustainable landings of undulate ray in Division 7.e

In division 7.e catches of undulate ray are higher than catches of any other species, the first of which is blonde ray.

Table 2. Estimated French total catch (landings and discards) of rju, rjc and rjh and reported international landings of rjc and rjh.

Year	Estimated total French catch			International reported landings	
	rju	rjc	rjh	rjc	rjh
2009	74	135	164	206	221
2010	166	109	532	208	365
2011	1332	168	739	216	414
2012	1963	162	586	242	349
2013	2120	213	420	339	419
2014	707	273	614	379	579
2015	487	212	508	395	708
2016	1157	233	342	423	587
2017	974	142	271	371	492
Average 2014-17	831	215	434	392	591

The calculated potential landings of undulate ray using blonde and thornback as reference species were 1147 and 1444 tonnes respectively. However, in 7e, the undulate ray is mostly abundant along the French coast and catch from other countries may come from area were the species composition is different. Therefore, using international landings implies raising the ratio of undulate and the reference species to area were undulate ray if less abundant or does not occur. To account for this, the estimation was done using French estimated catch and reported landings only (Table 3).

Table 3. Estimated French total catch (landings and discards) of rju, rjc and rjh and reported French landings of rjc and rjh.

Year	Estimated total French catch			French reported landings	
	rju	rjc	rjh	rjc	rjh
2009	74	135	164	56	122
2010	166	109	532	148	101
2011	1332	168	739	205	114
2012	1963	162	586	169	108
2013	2120	213	420	191	181
2014	707	273	614	281	224
2015	487	212	508	304	225
2016	1157	233	342	223	213
2017	974	142	271	240	176
Average 2014-17	831	215	434	262	210

Doing the calculation with French landings only, the calculated potential landings using blonde and thornback as reference species were 407 and 966 tonnes respectively.

1.3.3.3 Divisions 8.ab

Comparison of reported and estimated landings

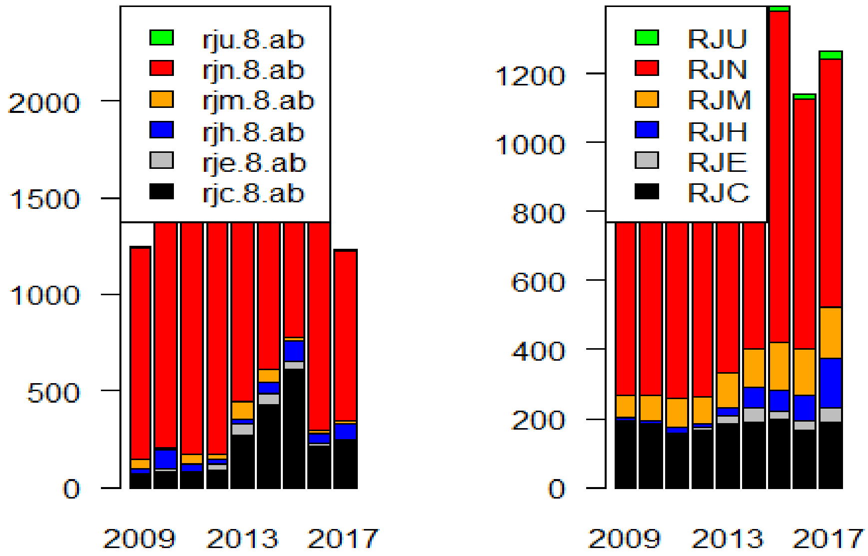

Figure 5: raised landings (left) and reported landings (right) in tonnes by species in divisions 8.ab.

In this area landings of cuckoo ray are strongly overestimated in some years and similar to reported landings in other years. The second species in the thornback ray which average estimated landings per year is similar to reported levels but year-to-year variations of the estimate are large. Expected the overestimates of the cuckoo ray in most years, the relative abundance of species in estimated landings is similar to that is reported landings.

Estimates of discards

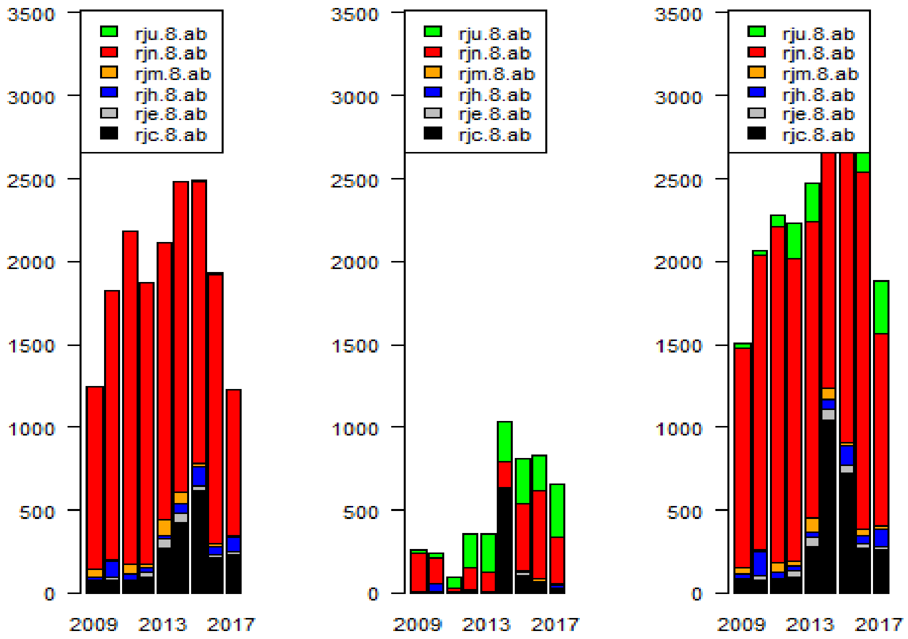

Figure 6. Estimates of landings (the same as in figure 5), discards and catch by species in divisions 8.ab.

The main discarded species is estimated to be cuckoo ray in most years. The large discard of thornback ray in 2014 might be a sampling artifact as there is also an unrealistic estimate of landings.

Estimating sustainable landings of undulate ray in Division 7.e

In Division 8.ab, it was considered that undulate ray occurs in coastal habitats where only French vessels are fishing, so the potential landings were estimated using French reported landings only for thornback and blonde ray.

Table 4. Estimated French total catch (landings and discards) of rju, rjc and rjh and reported French landings of rjc and rjh from 8.ab.

Year	Estimated total French catch			French reported landings	
	rju	rjc	rjh	rjc	rjh
2009	21	79	25	193	7
2010	34	77	147	215	10
2011	65	74	40	172	10
2012	206	96	29	173	9
2013	230	280	21	193	7
2014	241	1039	60	201	10
2015	272	722	112	210	37
2016	221	271	51	166	42
2017	322	260	103	190	12
Average 2014-17	264	573	82	192	25

The calculated potential landings were 81 to 82 tonnes depending on the species used a reference species (Table 4).

1.3.4 Discussion

It was considered that undulate ray and blonde ray have a similar coastal distribution, and are therefore accessible to the same fleets.

1.4 Estimating sustainable landings of undulate ray in Division 7.d from biomass indices inn the FR-CGFS survey

1.4.1 Method

Estimates of the potential sustainable landings of undulate ray in Division 7.d was calculated in a similar manner as the method used for on-board observations. Estimates of the swept area biomass of undulate ray, thornback ray and blonde ray were available from the FR-CGFS survey. Cat.3 assessments of the two latter based on the ICES Cat.3 rule suggest that both have been exploited sustainably in recent years. Therefore these two species were used as reference species to calculate the level of TAC which would correspond to the survey swept area biomass of undulate ray.

$$PotLan(rju) = \left[\frac{B\ (rju)}{B\ (reference)}\right] * \frac{r_{rju}}{r_{reference}} * Lan(reference)$$

(Eq. 3)

Where PotLan (rju) is the potential sustainable landings of undulate ray. B(rju) and B(reference) are swept area estimates of the biomass of undulate ray and the reference species from FR-CGFS. Lan(reference) is the international landings of the reference species from 7d.

Biological productivity was taken as the inverse of Lmax. Lmax value used were 102, 107 and 119 cm for undulate ray, thornback ray and blonde ray respectively (Le Quesne and Jennings, 2012). However, WGEF considered than undulate and blonde ray have similar biological productivities, therefore when using blonde ray as the and as coastal as each other, when the other species was blonde ray thee ratio of productivities was assumed one and equation 2 was used.

The ues of Lmat instead of Lmax should still be considered.

1.4.2 Results

Biomass indices from FR-CGFS have shown an increasing trend for all ray species since about 2010. The estimated biomass of undulate ray and blonde ray are similar to a level of about 10% of the estimated biomass of thornback ray (Figure 7 and Appendix 2).

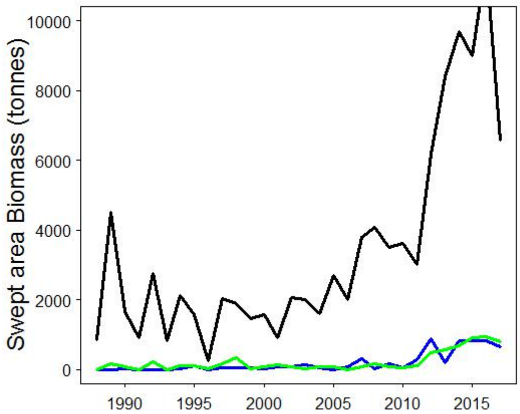

Figure 7. Swept area estimate of biomass of thornback ray (black), blonde ray (blue) and undulate ray (green).

Applying Eq. 3 to the average biomass estimates over the five last years, potential landings of undulate ray for Division 7d were calculated to 111 tonnes and 130 tonnes taking blonde and thornback ray as the reference species respectively (Table 5). Applying Eq. 3 to the last year only resulted in slightly larger landings of 141 and 131 tonnes for the two reference species respectively.

1.5 Overall discussion

The group considered the request from France and discussed the questions posed on the validation of the industry self-sampling programme and the observer programme, as well as the possibility to update the 2018 advice.

Suitability of on-board observation data

In Division 7d the calculated potential landings was 110 to 140 tonnes based upon survey data and 260 to 450 tonnes based on on-board observations. The survey is considered to provide reliable biomass indices of the three species, as undulate ray is the most coastal species and the survey does not cover shallow waters, it should tend to underestimate the biomass of undulate relative to the two other. Therefore the estimates based upon the survey and on-board observations should not be considered conflicting.

In Division 7e, only on-board observations are available for estimations. . The calculated potential landings were 1515 t and 2542 t using blonde and thornback ray as reference species, respectively. As the latter occur at lesser abundance both on-board observations and landings data may be less reliable. The high potential landings calculated for undulate ray relates to the high proportion of the species in on-board observations. The status of the stock of the two other species is unknown, these being ICES Cat.6 stocks. Therefore the approach taken here could be used to consider that sustainable landings of undulate ray in 7e are larger than those of blonde ray but the suitable levels are unknown for both. As current landings do not seem detrimental to the blonde ray stock in 7e, having a comparable level for the undulate ray for a few years and monitoring the biomass could be a suitable approach.

In the Bay of Biscay (divisions 8ab), the potential landings were calculated to be 80 tonnes, as compared to the current 30 TAC.

The working group considers that self-sampling programmes and on board observations can inform on the relative abundance of ray species for the areas considered, and can be used to augment survey data, which are limited for some important habitats. Absolute estimates of total discards are uncertain due to issues of raising.

As far as updating the catch advice for 2018 based on the results of the data validation, the STECF report on survivability and updated assessment the following was agreed.

Data from national on-board observer programmes were used to inform the 2018 catch advice. WGEF consider that industry self-sampling data cannot yet be used in the assessment and advisory process.

It is recommended to carry out a benchmark process to determine how industry and on-board observation data can be incorporated in the advisory process with undulate ray as an example. The benchmark should address the issue of raising method when a species is mostly discarded as standard raising procedures are not applicable.

Another issue that has to be addressed is how to advise on fishing opportunities that ensure that exploitation is sustainable when a species has been under moratorium, as is the case with the undulate ray.

This benchmark should be carried out in the near future, ideally in time to carry out the undulate ray assessment for 7.e, d and 8.a, b again in 2019.

The following are data requirements for the benchmark

- Data required for areas 7.e,d and 8.a,b - from 2005 onwards where possible
- Quantities of discards from all countries active in the areas (as detailed as possible)
- Spatial distribution of discards from on-board observations and self-sampling
- Spatial distribution of species by size category from on-board observer and survey data
- CPUEs derived from on-board observations
- Exploratory work on use of LBIs

The updated advice on fishing opportunities should be based on considerations of the survival of discarded rays. Survival of discarded rays is considered to be potentially high (50 to 80%: STECF 2015) for many species of skates and rays but there are no specific survival estimates for undulate ray that would be applicable to the entire fishery for each of these stocks.

The **STECF recommendation** for the stock status assessment and management scientific advice, according to which a "***restricted and closely monitored by-catch may assist with the development of an analytical assessment and could be used as a future indicator of stock development and the basis of an adaptive management strategy***", should be taken into account.

1.6 References

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Appendix 1: Underlying data to figures included in this chapter

Appendix 1.1. Estimated Landings, discards and catch in Division 7.d

Table 1: estimated landings by species in Division 7.d

	rjc	rje	rjh	rjm	rjn	rju
2009	654	NA	22	12	6	50
2010	480	NA	32	98	1	0
2011	471	2	21	77	12	46
2012	217	2	99	8	NA	NA
2013	390	0	21	20	NA	1
2014	694	NA	86	18	NA	NA
2015	618	NA	17	11	NA	3
2016	838	3	36	11	NA	28
2017	1356	0	31	14	NA	46

Table 2: estimated discards by species in Division 7.d

	rjc	rje	rjh	rjm	rjn	rju
2009	8	0	0	4	NA	21
2010	56	NA	8	20	NA	9
2011	79	NA	5	11	NA	55
2012	63	NA	9	4	NA	57
2013	87	63	3	1	NA	97
2014	44	NA	7	10	NA	137
2015	161	NA	8	7	0	171
2016	242	13	12	2	NA	295
2017	303	12	18	5	0	354

Table 3: estimated catch (Landings+discards) by species in Division 7.d

	rjc	rje	rjh	rjm	rjn	rju	ratio_rju_rjc
2009	662	0	22	16	6	72	0.1088
2010	536	NA	40	118	1	9	0.01679
2011	550	2	26	88	12	100	0.1818
2012	280	2	107	12	NA	57	0.2036
2013	477	64	25	21	NA	98	0.2055
2014	738	NA	93	29	NA	137	0.1856
2015	780	NA	25	18	0	174	0.2231
2016	1080	16	48	13	NA	323	0.2991
2017	1659	13	49	19	0	400	0.2411

Appendix 1.2. Estimated Landings, discards and catch in Division 7.e

Table 4: estimated landings by species in Division 7.e

	rjc.7.e	rje.7.e	rjh.7.e	rjm.7.e	rjn.7.e	rju.7.e
2009	122	108	158	319	135	54
2010	90	10	525	89	136	18
2011	154	15	717	370	268	1
2012	71	12	570	405	152	2
2013	58	17	386	290	282	NA
2014	218	8	599	144	215	NA
2015	167	35	497	192	70	76
2016	212	8	329	74	106	9
2017	112	3	257	63	73	32

Table 5: estimated discards by species in Division 7.e

	rjc.7.e	rje.7.e	rjh.7.e	rjm.7.e	rjn.7.e	rju.7.e
2009	13	11	6	3	3	20
2010	20	0	8	3	0	148
2011	13	NA	22	2	16	1331
2012	91	NA	16	1	2	1961
2013	155	7	34	3	2	2120
2014	55	1	15	17	8	707
2015	45	0	11	12	5	411
2016	22	2	14	5	2	1148
2017	31	1	14	22	3	943

Table 6: estimated catch (landings+discards) by species in Division 7.e

	rjc.7.e	rje.7.e	rjh.7.e	rjm.7.e	rjn.7.e	rju.7.e
2009	135	119	164	323	138	74
2010	109	10	532	92	137	166
2011	168	15	739	372	283	1332
2012	162	12	586	406	154	1963
2013	213	24	420	292	284	2120
2014	273	9	614	161	223	707
2015	212	35	508	205	75	487
2016	233	10	342	79	108	1157
2017	142	4	271	85	76	974

Appendix 1.3. Estimated Landings, discards and catch in divisions 8.ab

Table 7: estimated landings by species in Division 8.ab

	rjc.8.ab	rje.8.ab	rjh.8.ab	rjm.8.ab	rjn.8.ab	rju.8.ab
2009	74	1	24	43	1100	5
2010	76	16	102	12	1616	6
2011	69	10	40	52	2011	2
2012	91	34	24	22	1698	3
2013	269	61	21	93	1667	NA
2014	426	58	60	63	1874	NA
2015	613	35	110	20	1705	8
2016	214	16	46	23	1626	10
2017	233	15	84	12	878	8

Table 8: estimated discards by species in Division 8.ab

	rjc.8.ab	rje.8.ab	rjh.8.ab	rjm.8.ab	rjn.8.ab	rju.8.ab
2009	5	4	1	NA	228	17
2010	1	11	44	0	151	29
2011	5	2	NA	NA	23	63
2012	5	1	5	5	135	203
2013	11	0	1	0	117	230
2014	613	10	0	9	155	241
2015	109	15	2	6	410	264
2016	57	8	5	16	533	211
2017	27	3	18	10	283	314

Table 8: estimated catch (Landings+discards) by species in Division 8.ab

	rjc.8.ab	rje.8.ab	rjh.8.ab	rjm.8.ab	rjn.8.ab	rju.8.ab
2009	79	6	25	43	1328	21
2010	77	27	147	13	1768	34
2011	74	12	40	52	2034	65
2012	96	35	29	28	1833	206
2013	280	61	21	94	1785	230
2014	1039	68	60	72	2029	241
2015	722	50	112	27	2116	272
2016	271	23	51	38	2159	221
2017	260	18	103	22	1160	322

Appendix 2. Swept area estimates of biomass of the main three ray species in the Eastern Channel

Year	Thornback ray	Blonde ray	Undulate ray
1988	853	0	1
1989	4515	0	154
1990	1661	7	73
1991	914	0	0
1992	2739	0	217
1993	835	0	0
1994	2106	22	112
1995	1564	109	103
1996	263	0	30
1997	2040	38	168
1998	1903	45	327
1999	1448	57	24
2000	1586	30	65
2001	925	88	131
2002	2063	73	66
2003	2009	139	24
2004	1600	47	77
2005	2695	0	68
2006	1998	70	0
2007	3797	301	71
2008	4079	11	177
2009	3490	151	67
2010	3628	34	40
2011	3023	266	112
2012	6175	891	482
2013	8380	184	563
2014	9693	817	683
2015	8984	829	910
2016	11636	818	940
2017	6567	657	801
Five year average	9052	661	779.4

18 Skates and rays in the Celtic Seas (ICES subareas 6 and 7 (except Division 7.d))

18.1 Ecoregion and stock boundaries

See Stock Annex.

18.2 The fishery

18.2.1 History of the fishery

See Stock Annex.

18.2.2 The fishery in 2017

TAC and quota regulations were restrictive or near-restrictive for most nations and fisheries. The inclusion of common skate (*Dipturus batis*-complex) on the prohibited species list has resulted in increased discarding or misreporting of this species, especially in areas where they are locally common.

18.2.3 ICES advice applicable

ICES provided advice for several species/stocks in this region in 2016 as summarized in Table below.

Stock	Stock Code	Assessment Category	Advice Basis	Advised Landings in 2017 and 2018
Blonde ray *Raja brachyura* Divisions 7.a and 7.f-g	rjh.27.7afg	5.	Precautionary approach	895 t
Blonde ray *Raja brachyura* Division 7.e	rjh.27.7e	5.	Precautionary approach	333 t
Thornback ray *Raja clavata* Subarea 6	rjc.27.6	3	Precautionary approach	145 t
Thornback ray *Raja clavata* Divisions 7.a and 7.f-g	rjc.27.7afg	3	Precautionary approach	1386 t
Thornback ray *Raja clavata* Division 7.e	rjc.27.7e	5	Precautionary approach	212 t
Small-eyed ray *Raja microocellata* Bristol Channel (Divisions 7.f-g)	rje.27.7fg	3	Precautionary approach	154 t
Small-eyed ray *Raja microocellata* English Channel (Divisions 7.d-e)	rje.27.7de	5	Precautionary approach	36 t
Spotted ray *Raja montagui* Subarea 6 and Divisions 7.b and 7.j	rjm.27.67bj	3	Precautionary approach	67 t
Spotted ray *Raja montagui* Divisions 7.a and 7.e-h	rjm.27.7ae-h	3	Precautionary approach	1197 t
Cuckoo ray *Leucoraja naevus* Subareas 6–7 and Divisions 8.a-b and 8.d	Rjn.27.678abd	3	Precautionary approach	2734 t
Sandy ray *Leucoraja circularis* Celtic Seas and adjacent areas	rji.27.67	5	Precautionary approach	42 t
Shagreen ray *Leucoraja fullonica* Celtic Seas and adjacent areas	rjf.27.67	5	Precautionary approach	210 t
Undulate ray *Raja undulata* Divisions 7.b and 7.j	rju.27.7bj	6	Precautionary approach	zero
Undulate ray *Raja undulata* Divisions 7.d-e (English Channel)	rju.27.7de	3	Precautionary approach.	65t
Common skate *Dipturus batis*-complex (flapper skate *Dipturus batis* cf. *flossada* and blue skate *Dipturus cf. intermedia*) Subarea 6 and Divisions 7.a–c and 7.e–j	rjb.27.67a-ce-k	6	Precautionary approach	zero
White skate *Rostroraja alba* in the northeast Atlantic	rja.27.nea	6	Precautionary approach	zero
Other skates Subarea 6 and Divisions 7.a–c and 7.e–j	raj.27.67a-ce-h	6	Insufficient data to provide advice	NA

18.2.4 Management applicable

A TAC for skates in Subarea 6 and divisions 7.a–c and 7.e–k was first established for 2009 and set at 15 748 t. Since then, the TAC has been reduced by approximately 15% (in 2010), 15% (in 2011), 13% (in 2012), 10% (in 2013) and a further 10% (in 2014). In 2017, the TAC was increased by 5%, (including separate TAC for *R. microocellata*), and in 2018 this was increased by a further 15% (including separate TAC for *R. microocellata* and *R. undulata*).

The history of the regulations are as follows:

Year	TAC for EC waters of 6.a–b, 7.a–c and 7.e–k	Other measures	Regulation
2009	15 748 t	1,2	Council Regulation (EC) No. 43/2009 of 16 January 2009
2010	13 387 t	1,2,3	Council Regulation (EU) No. 23/2010 of 14 January 2010
2011	11 379 t	1,2,3	Council Regulation (EU) No. 57/2011 of 18 January 2011
2012	9915 t	1,2,3	Council Regulation (EU) No. 43/2012 of 17 January 2012
2013	8924 t	1,2,3	Council Regulation (EU) No. 39/2013 of 21 January 2013
2014	8032 t	1,3,4	Council Regulation (EU) No. 43/2014 of 20 January 2014
2015	8032 t	1,3,5	Council Regulation (EU) No. 2015/104 of 19 January 2015, and amended in Council Regulation (EU) No. 2015/523 of 25 March 2015
2016	8032 t	1,3,6,7	Council Regulation (EU) No 2016/72 of 22 January 2016, and amended in Council Regulation (EU) No. 2016/458 of 30 March 2016
2017	8434 t	1,3,6,7,8	Council Regulation (EU) No 2017/127 of 20 January 2017,
2018	9699 t	1,3,6,7,8,9	Council Regulation (EU) No 2018/120 of 23 January 2018,

[1] Catches of cuckoo ray *L. naevus*, thornback ray *R. clavata*, blonde ray *R. brachyura*, spotted ray *R. montagui*, small-eyed ray *R. microocellata* sandy ray *L. circularis*, shagreen ray *L. fullonica* should be reported separately.

[2] Does not apply to undulate ray *R. undulata*, common skate *D. batis*, Norwegian skate *D. nidarosiensis* and white skate *Rostroraja alba*. Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

[3] Of which up to 5% may be fished in EU waters of Division 7.d.

[4] Shall not apply to undulate ray *R. undulata*, common skate *D. batis* complex, Norwegian skate *D. nidarosiensis* and white skate *Rostroraja alba*. When accidentally caught, these species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

[5] Shall not apply to undulate ray *Raja undulata*. This species shall not be targeted in the areas covered by this TAC. Bycatch of undulate ray in area 7.e exclusively may be landed provided that it does not comprise more than 20 kg live weight per fishing trip and remain under the quotas shown … [TAC = 100 t]. This provision shall not apply for catches subject to the landing obligation.

[6] Shall not apply to small-eyed ray *R. microocellata*, except in Union waters of 7.f and 7.g. When accidentally caught, this species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species. Within the limits of the abovementioned quotas, no more than the quantities of small-eyed ray in Union waters of 7.f and 7.g provided below may be taken [TAC = 188 t]

[7] Shall not apply to undulate ray *R. undulata*. This species shall not be targeted in the areas covered by this TAC. In cases where it is not subject to the landing obligation, bycatch of undulate ray in area 7.e may only be landed whole or gutted, and provided that it does not comprise more than 40 kilograms live weight per fishing trip. The catches shall remain under the quotas shown [TAC = 100 t] …. Bycatch of undulate ray shall be reported separately under the following code: RJU/67AKXD.

[8] Shall not apply to undulate ray *R. undulata*. This species shall not be targeted in the areas covered by this TAC. In cases where it is not subject to the landing obligation, bycatch of undulate ray in area 7.e may only be landed whole or gutted. The catches shall remain under the quotas shown [TAC = 161 t]. Bycatch of undulate ray shall be reported separately under the following code: RJU/67AKXD.

[9] Shall not apply to small-eyed ray (Raja microocellata), except in Union waters of 7f and 7g. When accidentally caught, this species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species. Within the limits of the abovementioned quotas, no more than the quantities of small-eyed ray in Union waters of 7f and 7g (RJE/7FG.) provided below may be taken [TAC = 154 t].

Raja microocellata in Union waters of Subarea 6 and Divisions 7.a–c and 7.e–k were initially subject to strict restrictions at the start of 2016, with Council Regulation (EU) 2016/72 of 22 January 2016 stating that: "*When accidentally caught, this species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species*". However, this was subsequently updated in Council Regulation (EU) 2016/458 of 30 March 2016, whereby the prohibition in landings was revoked for Union waters of 7.f–g, with a precautionary TAC of 188 t being set for this species, within the total skate and ray quota.

A sub TAC of 154 t was similarly applied in 2017 and in 2018.

It is forbidden to retain skates and rays caught on the Porcupine Bank from 1–31 May.

There are also mesh-size regulations for target fisheries, the EC action plan for the conservation and management of sharks (EC, 2009), and some local bylaws and initiatives, which were detailed in ICES (2010).

18.2.5 Other management issues

Alternatives to the current TAC system are being explored by the European Commission. A meeting to set Terms of Reference for an STECF request to propose alternatice was held in May 2017. This follows on from proposals by the NWWAC.

Fishermen off North Devon have a voluntary seasonal closed area over what they consider to be a nursery ground.

There are several French measures designed to regulate fishing for *R. undulata* in the English Channel (7.d and 7.e). These measures include: trip limits, closed seasons, restricted licencing of vessels and in 2017 a minimum size of 78 cm (described in Gadenne 2017 WD).

18.3 Catch data

A data-call in 2017 again followed the procedures recommended by WKSHARKS2 (ICES, 2016). This meeting had recommended that recent landings of all elasmobranch species be resubmitted by all ICES members. These landings would be re-evaluated, and declared landings from unlikely locations or species be reassessed or reassigned as required. Decision trees on how to treat problematic records were provided in the workshop report. An ICES data call was issued following this meeting requesting all elasmobranch landings from 2005–2015. The 2017 data call requested a resubmission of final 2015 and preliminary 2016 landings data.

These data were examined by WGEF prior to and during WGEF 2016. Tables 18.1 and 18.2 provides the re-assessed landings by stock for this eco-region. Some data were resubmitted in 2017; therefore, there may be slight differences in landings figures between this and previous reports.

The 2018 data call followed the procedures above.

18.3.1 Landings

Landings data for skates (Rajidae) were supplied by all nations fishing in shelf waters within this ecoregion. Data for 2017 are considered provisional.

Landings by nation are given in Table 18.1. Landings for the entire time-series are shown in Figure 18.1a–c. Where species-specific landings have been provided they have also been included in the total for the relevant year. Although historically there have been around 15 nations involved in the skate fisheries in this ecoregion, only five (France, Great Britain, Belgium, Ireland, and Spain) have continually landed large quantities.

Landings are highly variable, with lows of approximately 14 000 t in the mid-1970s and 1990s, and highs of just over 20 000 t in the early and late 1980s and late 1990s. Although landings have fluctuated over most of the time-series, there has been a steady decline in landings since 2000, at least partly due to the introduction of catch limits. Annual reported landings have been less than 10 000 t since 2009 (noting that the TAC was established in 2009).

West of Scotland (Division 6.a)

Average landings in the early 1990s were about 3000 t. Landings have been less than 500 t since 2009, and have remained at a steady low level of between 350–500 t for the last eight years.

Rockall (Division 6.b)

Reported landings from Rockall in the 1990s were about 500 t per year, but have been generally under 200 t since 2009, and less than 100 t in recent years. The increased landings in the mid-1990s were a result of new landings of 300–400 t per year by Spanish vessels. These no longer appear to take place since only limited Spanish landings have been reported in this area in recent years. It is not clear what proportion of these catches may have been taken from Hatton Bank (6.b.1 and 12.b). One to three Russian longliners fished in this area in 2008–2009, mainly catching deep-water species, including sharks, but also catching 7 t of deep-water skate species.

Irish Sea (Division 7.a)

Reported landings in the Irish Sea vary considerably, and ranged from over 1500 t in 1995 to ca. 5000 t in the late 1980s. Since 2006, annual landings have been < 2000 t, and are now at their lowest level, with just 400 t reported in 2016 and 328 t in 2017. This may be as a result of reduced fishing effort and effort changes because of the cod recovery programme in the area, where whitefish boats have switched to *Nephrops* fishing, with the latter thought to have a lower skate bycatch. Most landings are from Ireland, Great Britain and Belgium.

Bristol Channel (Division 7.f)

Following an increase in reported landings in the mid-1970s, skate landings in Division 7.f have been under 1,300 t over the last decade. Landings are predominantly from three countries (Great Britain, France and Belgium) and have been under 1000 t for the last four years (2014–2017).

Western English Channel, Celtic Sea and west of Ireland (Divisions 7.b–c, 7.e and 7.g–k)

Annual reported landings from divisions 7.b–c, 7.e and 7.g–k were in the general range of 500–1200 t from 1973–1995. Landings then increased during the period 1996–2003, with some annual landings of approximately 4000 t, however the level of misreporting in this period is unknown. Landings declined after 2010 to less than 1000 t per year, with the last five years' landings of between 700 to just over 1000 t (in 2015) which is of a comparable magnitude to earlier landings.

Overall landings are consistently higher in the southern parts of this ecoregion (divisions 7.e and 7.g–h), and these have reduced from ca. 8000 t per year (from 1973–2000) to between 4–5000 t over the last seven years. France, Great Britain, Ireland and Belgium are responsible for most landings in this area.

18.3.2 Skate landing categories

Historically, most skate landings were reported under a generic landing category. There has been a legal requirement to report most skate landings to species level throughout this ecoregion since 2010. On average, 99% of the 2017 landings were reported to species level, with a continuous decline in landings declared in generic categories since 2011. Earlier reports have highlighted various issues regarding the quality of these data (ICES, 2010, 2011, 2012), and this is further discussed in Section 18.4.3.

A study by Silva *et al.* (2012) examined the species-specific data recorded by the UK (England and Wales). Although there were some erroneous or potentially erroneous records, the regional species composition was broadly comparable to that recorded by scientific observers on commercial vessels, and data quality seemed to be improving. Comparable studies to critically evaluate other national data and identify potential errors are still required, so as to better identify where improved training and/or market sampling may improve data quality.

18.3.3 Discards

WKSHARKS3 met in Nantes in February 2017 (ICES, 2017). The objective of the meeting was to examine national discard data and to assess their suitability for use by WGEF.

It was decided that combining national data together to estimate international discards is not suitable. However if discard data are first raised at national level, it may be possible to combine estimates. However there are differences in raising methodologies e.g. by fleet, metier, etc., and these must be fully reported and accounted for.

For elasmobranchs, discards are not equivalent to dead catch, as there is some survival, which is probably high for some stocks and fleets. However, survival rate is not accurately known for most species.

Discard data for WGEF were included in the 2018 data. Most countries provided raised discards. Raising methodology was considerably different, both between countries and within countries. Raised discard estimates varied by over 200% in some cases, depending on whether they were raised by vessel, fleet or landings. Therefore discard estimates have not been calculated for skates and rays in this ecoregion.

See Stock Annex for historic discard discussions.

18.3.4 Discard survival

See Stock Annex.

18.3.5 Quality of catch data

See Stock Annex.

18.4 Commercial catch composition

18.4.1 Size composition

Although length data were not examined this year, length frequencies for the more common species have been shown in earlier studies (ICES, 2007, 2011; Johnston and Clarke, 2011 WD; Silva *et al*., 2012).

The use of length-based indicators to calculate proxy reference point is further discussed in Section 28.

18.4.2 Quality of data

See Stock Annex.

18.5 Commercial catch and effort data

A case study using French on-board observer data is provided in the stock annex. Several stocks are discussed. The trend for *L. fullonica* is used as supporting information in the advice, therefore it is retained here. For all others, refer to the stock annex

Shagreen ray: *Leucoraja fullonica*

rjf.27.67 (Figure 18.2): The species was caught in a relatively high proportion of OTT_DEF. The indicator suggested stability.

18.6 Fishery-independent surveys

Groundfish surveys provide valuable information on the spatial and temporal patterns in the species composition, size composition, sex ratio and relative abundance of various demersal elasmobranchs. Several fishery-independent surveys operate in the Celtic Seas ecoregion. It is noted that these surveys were not designed primarily to inform on the populations of demersal elasmobranchs, and so the gears used, timing of the surveys and distribution of sampling stations may not be optimal for informing on some species and/or life-history stages. However, these surveys provide the longest time-series of species-specific information for skates for many parts of the ecoregion. The distribution of selected skate species caught in surveys coordinated by the IBTS group (see Table 18.4 in the Stock Annex), are shown in the annual IBTS reports.

Descriptions of existing, previous and short-time-series surveys are provided in the Stock Annex.

Updated survey analyses were provided for five surveys in 2018: French EVHOE Groundfish Survey (EVHOE-WIBTS-Q4; Figure 18.3), Irish groundfish survey (IGFS-WIBTS-Q4; Table 18.3; Figure 18.4), Spanish Porcupine Groundfish Survey (SpPGFS-WIBTS-Q4; Figure 18.5), the UK (England) beam trawl survey (EngW-BTS-Q3; Figure 18.6) and the UK (England) Q1 Southwest ecosystem beam trawl survey (Q1SWBeam; Figure 18.7

Interpretation, data, analyses and expertise from other surveys, in particular the Scottish and Northern Irish Groundfish surveys, which could usefully provide indices for some stocks, were absent, and therefore such data could not be used in the forumation of indices and advice in 2018. Their participation in future years would be valuable.

The list of fishery-independent surveys undertaken in this area include (with additional details and information on the history provided in the Stock Annex):

- French EVHOE Groundfish Survey (EVHOE-WIBTS-Q4): 1995–present in Celtic Sea.
- Irish Groundfish Survey (IGFS-WIBTS-Q4): 2003–present.
- Spanish Porcupine Groundfish Survey (SpPGFS-WIBTS-Q4): 2001–present.
- UK (Northern Ireland) Groundfish Survey – October (NIGFS-WIBTS-Q4): 1992–present.
- UK (Northern Ireland) Groundfish Survey – March (NIGFS-WIBTS-Q1).
- Scottish West Coast Groundfish Survey Q4 (ScoGFS-WIBTS-Q4): 1990 – present.
- Rockall survey (Rock-IBTS-Q3): 1991 – present.

Three beam trawl surveys currently operate in this ecoregion (see Stock Annex), surveying the Irish Sea, Bristol Channel, western English Channel and the West of Ireland (additional details and information on the history are provided in the Stock Annex):

- UK (England and Wales) Irish Sea and Bristol Channel beam trawl survey (EngW-BTS-Q3): 1993 – present.
- UK (England) beam trawl in western English Channel (Q1SWBeam): 2006 – present.
- Irish monkfish beam trawl survey – IRL-IAMS surveys: 2016 onwards. This beam trawl survey for monkfish and megrim takes place in Q1 and Q2, to the west and northwest of Ireland. Elasmobranchs are caught during this survey, and in future may provide additional indices once a suitable time series is available.

Historical surveys which have been undertaken in the area and can provide past data on elasmobranchs include (with additional details and information on the history provided in the Stock Annex):

- UK (England and Wales) Western Groundfish Survey (EngW-WIBTS-Q4) 2004–2011.
- UK (England) beam trawl in Start Bay, Division 7.e (Eng-WEC-BTS-Q4): 1989–2010.
- Irish maturity survey for commercially important demersal fish (spring 2004–2009).
- Irish deep-water (500–1800 m) trawl survey to the west of Ireland (2006–2009)
- UK Portuguese high headline trawl 1Q (PHHT-Q1): 1982–2003.

18.6.1 Temporal trends in catch rates

The statuses of skates in this ecoregion are based primarily on the evaluation of fishery-independent trawl surveys. The available survey data have been used to evaluate the status of the stocks in 2018 under the ICES approach to data-limited stocks (Section 18.9).

Analyses of length-based data showing temporal trends from the EVHOE survey were shown for several species in 2015 (ICES, 2015).

18.6.2 Quality of data

18.6.2.1 Species identification in surveys

There are identification problems with certain skate species that may increase uncertainty in the quality of survey data. *Raja montagui* and *R. brachyura* may be confounded occasionally, and the identification of neonatal specimens of *R. clavata*, *R. brachyura* and *R. montagui* can also be problematic. Recent data are considered more reliable.

Many recent surveys in the ecoregion have attempted to ensure that data collected for the common skate complex be differentiated, and whereas national delegates have confirmed which species have been caught, survey data can only be uploaded to DATRAS for the complex, as the two species do not have valid taxonomic codes as yet. Work to clarify the taxonomic problems was discussed intersessionally and will hopefully be resolved by the ICZN soon.

Several skate species, including some coastal species, occur sporadically in the Celtic Seas ecoregion and may have certain sites where they are locally abundant (e.g. *Raja*. These may be under-represented in existing surveys (see Stock Annex).

18.6.3 New data

A project is currently taking place in the Tralee Bay area in the South-west of Ireland. The project is to provide data on the species composition, relative abundance and distribution of Skates and Rays for an area off the Irish coast (Dingle Bay, Tralee Bay, Brandon Bay, Shannon Estuary) known to harbour a high diversity of species some of which are critically endangered. Synoptic seasonal surveys using catch and release methods combined with individual identification of fish from photographic records will provide information on movement of these species in this area. There are a number of fisheries in the locality which may impact negatively on these populations. Vessels involved in the tangle net fishery for spiny lobster in particular have a significant by-catch of elasmobranchs. The project is also obtaining data and photographic records of elasmobranch by-catch in this fishery. Some by-catch is released alive where net soak times are low. Mitigation measures such as seasonal or spatial closures or operational measures to reduce soak times to reduce the mortality of elasmobranchs in bottom trawl and net fisheries may be developed from the project. Data for these stocks should be available for the next assessments.

18.7 Life-history information

See Stock Annex.

18.7.1 Ecologically important habitats

See Stock Annex.

18.8 Exploratory assessment models

18.8.1 Productivity-Susceptibility Analysis

See Stock Annex

18.8.2 Previous assessments

See Stock Annex

18.9 Stock assessment

ICES provided stock-specific advice in 2016 for 2017 and 2018. The assessments outlined below have been updated using the most recent data. (Most stocks belong to Category 3 of the ICES approach to data-limited stocks. Advice is generally therefore based on survey indices. Following decisions made at ADGEF, biomass is now presented instead of numbers of individuals. Therefore, results and figures may differ from previous reports.

18.9.16 Undulate ray *Raja undulata* in Divisions 7.d-e (English Channel)

There is thought to be a discrete stock of *R. undulata* in the English Channel (divisions 7.d-e), with the main part of the range extending from the Isle of Wight to the Normano-Breton Gulf. This stock is surveyed, in part, by two different beam trawl surveys: the Channel beam trawl survey (see Chapter 15) and the western English Channel (Eng-WEC-BTS-Q1), as well as the French Channel Groundfish survey (see Chapter 15). The distribution and length ranges of *R. undulata* caught in the western English Channel survey are provided in the Stock Annex. Catch rates are generally variable, partly due to the patchy distribution of this species.

Since ICES (2013) commented "*If ICES are to be able to provide more robust advice on the status of this stock, then either dedicated surveys or more intensive sampling of their main habitat in existing surveys should be considered*" there has been a lot of dedicated surveys by French organisations under the Raimouest and RECOAM projects.

LeBlanc *et al.* (2014 WD) summarized the project so far, and showed that *R. undulata* was the main skate species caught in the Norman-Breton Gulf and dominated in coastal waters. Although it occurs throughout much of the English Channel, its distribution appears to be concentrated in the central region. Tagging studies indicate high site fidelity (Stéphan *et al.*, 2014 WD; see Stock Annex). In the Normano-Breton Gulf, 1 488 *R. undulata* were tagged (656 females (29–103 cm L_T) and 832 males (28–99 cm L_T), with a 5% (n = 77) recapture rate. All the skates tagged in a region were recaptured in the same region, and distance travelled was short (<80 km). Given that the prohibited listing of the species may have deterred reporting of tags in some fisheries, the degree of exchange between the Normano-Breton Gulf and the south coast of England remains unclear. In Division 7.e, 58.4% of the recaptured skates were taken less than 5 km from their release location, and 75.3% were recaptured less than 20 km from the release location. The survey with the best coverage of this stock area is the French Channel Groundfish Survey, where the biomass indicator used in the Category 3 assessment shows the stock to be at the highest level of the time series, after a period of low and variable trends between 1988–2010, and a steep increase thereafter.

French *Raja undulata* self-sampling program

In 2016, Council Regulation (EU) 2016/458 of 30 March 2016 amended Regulations (EU) 2015/523 as regards individual TACs for *R. undulata* in ICES Divisions.

Under this regulation, only vessels possessing a compulsory fishery license were allowed to catch *R. undulata*. Simultaneously, licensed vessels are obliged to record information on species captured by fishing haul and report to national agencies (Direction des Pêches Maritimes et de lAquaculture (DPMA) of the French Ministry for Agriculture and Fisheries).

First results are more detailed described in the working document (Gadenne, 2017 WD) and in Section 27.

Whilst the catch rates in the UK-7d-BTS are too low to provide quantative advice, this time series shows similar trends to the French CGFS, including the recent increase in catch rates.

In 2018, France made a special request to ICES to re-evaluate the advice for this stock. In particular, further industry-provided data were made available. This special request is further discussed in Annex 8.

18.9.17 Other skates in Subareas 6 and 7 (excluding Division 7.d)

This section relates to skates not specified elsewhere in the ICES advice. This includes skates not reported to species level and some other, mainly deep-water species throughout the region. It also applies to *R. clavata, R. brachyura,* and *R. microcellata* outside the current defined stock boundaries.

No specific assessment can be applied to this species group, and nominal landings have been shown to have declined dramatically, primarily as a result of improved species-specific reporting of the main commercial skate stocks.

18.10 Quality of assessments

Commercial data are insufficient to proceed using a full stock assessment, although data are improving.

Several updated analyses of temporal changes in relative abundance in fishery-independent surveys were carried out in 2018. These surveys provide the most comprehensive time-series of species-specific information, and cover large parts of the ecoregion. Hence, fishery-independent trawl data are considered the most appropriate data for evaluating the general status of the more common species.

However, it must be stressed that not all skates and rays are well sampled by these surveys, and even some of the most common species (*R. montagui* and *R. clavata*) may only occur in about 30% of hauls. There is also uncertainty regarding the mean catch rates, due to the large confidence intervals.

There are several other issues that influence the evaluation of stock status:

1) The stock identity for many species is not accurately known (although there have been some tagging studies and genetic studies to inform on some species, and the stocks of species with patchy distributions can be inferred from the spatial distributions observed from surveys). For inshore, oviparous species, assessments by ICES division or adjacent divisions may be appropriate, although for species occurring offshore, including *L. naevus*, a better delineation of stock boundaries is required;

2) Age and growth studies have only been undertaken for the more common skate species, although IBTS and beam trawl surveys continue to collect maturity information. Other aspects of their biology, including reproductive output, egg-case hatching success, and natural mortality (including predation on egg-cases) are poorly known;

3) The identification of skate species is considered to be reliable for recent surveys, although there are suspected to be occasional misidentifications;

4) Although fishery-independent surveys are informative for commonly occurring species on the inner continental shelf, these surveys are not well suited for species with localized, coastal distributions (e.g. *R. undulata*, angel shark), patchy distributions (e.g. *R. brachyura*) or outer shelf distributions (e.g. *L. fullonica*).

18.11 Reference points

No reference points have been adopted. Potential methods for establishing precautionary reference points from using the catch-curve method are described in the Stock Annex.

The use of length-based indicators (LBIs) to calculate proxy reference points was discussed, and is further elaborated on in Section XXX. LBIs for several stocks were provided by Walker *et al*. 2018WD and Miethe and Dobby 2018WD.

Discussion on WKSHARKS4 needs to go here. (ICES, 2018)

18.12 Conservation considerations

In 2015 the IUCN published a European Red List of Marine Fisheries (Nieto *et al.*, 2015). It should be noted the listings below are on a Europe-wide scale for each species, and these listings are not stock-based.

Species	IUCN Red List Category
Amblyraja radiata	Least concern
Dipturus batis	Critically Endangered
Dipturus nidarosiensis	Near Threatened
Dipturus oxyrinchus	Near Threatened
Leucoraja circularis	Endangered
Leucoraja fullonica	Vulnerable
Leucoraja naevus	Least concern
Raja brachyura	Near Threatened
Raja clavata	Near Threatened
Raja microocellata	Near Threatened
Raja montagui	Least concern
Raja undulata	Near Threatened
Rajella fyllae	Least concern
Rostroraja alba	Critically Endangered

In 2016 a redlist for Irish cartilaginous fish (Clarke *et al.* 2016) was published. This assessed and rated the following species in Irish waters:

Species	Irish red-list category
Dipturus flossada (~batis)	Critically endangered
Dipturus intermedia)~batis)	Critically endangered
Dipturus nidarosiensis	Near Threatened
Dipturus oxyrinchus	Vulnerable
Leucoraja circularis	Near Threatened
Leucoraja fullonica	Vulnerable
Leucoraja naevus	Vulnerable
Raja brachyura	Near Threatened
Raja clavata	Least concern
Raja microocellata	Least concern
Raja montagui	Least concern
Raja undulata	Endangered
Rajella fyllae	Least concern
Rostroaja alba	Critically endangered

18.13 Management considerations

A TAC was only introduced in 2009 for the main skate species in this region. Reported landings may be slightly lower than the TAC, but this can be influenced by various issues (e.g. quota allocation and poor weather). There was evidence that quota was restrictive for some nations from at least 2014.

Raja undulata and *R. microocellata* are currently subjected to limited fishing opportunities, which may disproportionally impact upon some coastal fisheries.

Currently, fishery-independent trawl survey data provide the best time-series of species-specific information. Technical interactions for fisheries in this ecoregion are shown in the Stock Annex.

Main commercial species

Thornback ray *Raja clavata* is one of the most important commercial species in the inshore fishing grounds of the Celtic Seas (e.g. eastern Irish Sea, Bristol Channel). It is thought to have been more abundant in the past, and more accurate longer term assessments of the status of this species are required.

Blonde ray *Raja brachyura* is a commercially valuable species. The patchy distribution of *R. brachyura* means that existing surveys have low and variable catch rates. More detailed investigations of this commercially valuable species are required.

Cuckoo ray *Leucoraja naevus* is an important commercial species on offshore grounds in the Celtic Sea. Further studies to better define the stock structure are required to better interpret these contrasting abundance trends.

The main stock of small-eyed ray *Raja microocellata* occurs in the Bristol Channel, and is locally important for coastal fisheries. Similarly, the English Channel stock of undulate ray *Raja undulata* is also important for inshore fleets.

Spotted ray *Raja montagui* is also commercially important, although a higher proportion of the catch of this small-bodied species is discarded in some fisheries. Commercial data for *R. brachyura* and *R. montagui* are often confounded.

Other species

Historically, species such as *L. circularis* and *L. fullonica* may have been more widely distributed on the outer continental shelf seas. These species are now encountered only infrequently in some surveys on the continental shelf, though they are still present in deeper waters along the edge of the continental shelf, and on offshore banks. Hence studies to better examine the current status of these species in subareas 6–7 should be undertaken.

The larger-bodied species in this area are from the genus *Dipturus*, and data are limited for all species. *Dipturus batis*-complex were known to be more widespread in inner shelf seas historically, and whilst locally abundant in certain areas, have undergone a decline in geographical extent.

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Table 18.1. Skates and rays in the Celtic Seas. Regional total landings (ICES estimates, t) of Celtic Seas skate stocks by nation. Some of these stocks extend outside the Celtic Seas ecoregion and data for these divisions are reported in relevant report chapters.

Country	ICES Stock Code	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
BEL	raj.27.67a-ce-k	1568	1328	1405	413	416	333	227	74	8	1	1	3	3
	rjb.27.67a-ce-k				0	0	0			0	0			
	rjc.27.7afg			0	328	216	197	302	441	391	240	350	241	212
	rjc.27.7e				5	2	8	3	4	4	3	9	14	21
	rje.27.7de						3	5	5	7	7	9	9	11
	rje.27.7fg						37	117	124	99	83	106	123	116
	rjh.27.4a6					0	0							
	rjh.27.7afg				166	170	210	313	404	406	351	359	313	338
	rjh.27.7e				7	6	3	5	5	6	3	6	11	9
	rji.27.67							0	0	0	0	0	0	2
	rjm.27.67bj						0							
	rjm.27.7ae-h				78	63	55	120	70	3	0	1	7	2
	rjn.27.678abd			0	86	81	70	112	93	97	48	51	27	26
	rju.27.7de												5	24
BEL Total		**1568**	**1328**	**1405**	**1083**	**953**	**917**	**1204**	**1219**	**1022**	**737**	**893**	**753**	**762**
DE	raj.27.67a-ce-k	39	7	26	60	2	4	3	1					
DE Total		**39**	**7**	**26**	**60**	**2**	**4**	**3**	**1**					
DK	rjh.27.4a6											0		
DK Total												**0**		

Country	ICES Stock Code	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ES	raj.27.67a-ce-k	2231	2568	2340	1946	210	52	24	20	32	92	45	61	134
	rjb.27.67a-ce-k	24	6	11	26	0	0	0				448	375	300
	rjc.27.6					16	2	10	6	23	21	12	12	50
	rjc.27.7afg											5	6	9
	rjc.27.7e						0	0						
	rjf.27.67					62	42	29	20	33	20	34	15	26
	rjh.27.4a6					0								
	rji.27.67	86	74	40	7	30	16	22	8	10	5	3	5	11
	rjm.27.67bj				7	7	10	5	0	0	0	1		
	rjm.27.7ae-h						0				0	0		
	rjn.27.678abd				1	778	480	387	311	373	300	659	688	433
	rju.27.7bj												1	1
ES Total		**2341**	**2648**	**2392**	**1986**	**1103**	**603**	**477**	**365**	**471**	**438**	**1207**	**1162**	**963**
FRA	raj.27.67a-ce-k	2048	1740	1757	1669	548	314	174	160	139	128	123	130	183
	rjb.27.67a-ce-k	351	295	308	414	68	30	15	23	21	32	33	17	
	rjc.27.6	64	78	73	82	39	24	19	39	28	10	2	1	1
	rjc.27.7afg	379	264	238	181	147	131	133	106	95	107	70	121	147
	rjc.27.7e	95	86	82	64	122	101	114	108	181	224	225	213	176
	rje.27.7de	21	19	19	22	32	28	28	24	26	24	24	8	8
	rje.27.7fg	27	23	18	21	29	21	16	30	30	65	31	5	57
	rjf.27.67	32	25	33	28	144	150	152	147	127	131	151	130	124
	rjh.27.4a6					1					1	1	1	0

Country	ICES Stock Code	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	rjh.27.7afg					36	73	131	87	52	170	218	275	257
	rjh.27.7e					56	148	205	169	191	281	304	223	240
	rji.27.67	199	152	185	178	46	35	25	35	26	33	34	37	34
	rjm.27.67bj	13	7	3	4	2	4	7	5	17	53	43	47	40
	rjm.27.7ae-h	1080	902	833	870	785	934	1062	1135	899	912	745	819	661
	rjn.27.678abd	3164	2565	2575	2507	3217	3069	2909	2571	2195	2515	2621	2233	2142
	rju.27.7bj					0				0		0	1	1
	rju.27.7de					19	9	20	6	3	10	50	58	79
FRA Total		**7473**	**6157**	**6123**	**6041**	**5294**	**5071**	**5010**	**4646**	**4031**	**4695**	**4674**	**4319**	**4149**
GBR	raj.27.67a-ce-k	2773	2454	2398	1478	508	290	168	153	101	77	46	34	30
	rjb.27.67a-ce-k				96	22	1	19	12	1	63	118	116	106
	rjc.27.6				1	56	61	57	67	120	120	114	147	113
	rjc.27.7afg			0	204	300	371	384	483	416	252	309	274	276
	rjc.27.7e	0	0		3	82	98	98	129	151	151	158	195	172
	rje.27.7de				4	18	40	28	33	32	36	39	19	15
	rje.27.7fg			0	91	157	214	189	208	117	79	78	69	31
	rjf.27.67				13	44	108	97	79	85	55	25	39	21
	rjh.27.4a6				7	5	7	17	4	0	1	3	2	1
	rjh.27.7afg		0	0	97	138	226	273	261	262	229	245	245	270
	rjh.27.7e		0		32	159	215	204	175	222	295	396	352	241
	rji.27.67				0	2	0	0	3	25	22	1	35	17
	rjm.27.67bj				5	16	27	32	30	27	29	43	49	44

Country	ICES Stock Code	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	rjm.27.7ae-h	0		0	12	38	102	88	85	90	80	70	80	89
	rjn.27.678abd				225	321	421	402	306	269	262	266	254	259
	rju.27.7de				2	2			0			5	22	36
GBR Total		**2773**	**2454**	**2399**	**2270**	**1868**	**2179**	**2056**	**2031**	**1919**	**1752**	**1917**	**1933**	**1721**
IRL	raj.27.67a-ce-k	2117	1728	1581	1283	1007	547	394	410	243	219	227	230	284
	rjb.27.67a-ce-k			0		2	4	17	1	0	0	9	7	9
	rjc.27.6					3	33	56	69	71	85	87	99	130
	rjc.27.7afg					8	80	126	134	146	191	169	220	232
	rjc.27.7e									0		2		2
	rje.27.7de													2
	rje.27.7fg						0	0	0	0	0	0	0	
	rjf.27.67						1	6	7	6	4	2	2	49
	rjh.27.4a6					0	4	1	1	24	9	9	11	5
	rjh.27.7afg	3	6			5	402	382	407	377	420	351	171	154
	rjh.27.7e								0			2		2
	rji.27.67						0	4	0					
	rjm.27.67bj					1	20	18	25	24	43	28	20	12
	rjm.27.7ae-h					0	19	63	53	40	49	48	41	10
	rjn.27.678abd					12	55	106	108	93	83	79	69	69
IRL Total		**2120**	**1734**	**1581**	**1283**	**1038**	**1165**	**1173**	**1218**	**1025**	**1104**	**1012**	**871**	**961**
NLD	raj.27.67a-ce-k	0	1	0	0	0	0	0	0	0				
	rjc.27.7afg												0	

Country	ICES Stock Code	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	rjc.27.7e					0	2	1	0	2		0	0	0
	rjh.27.7e								0	0				0
	rjm.27.7ae-h					0		0		0			0	
	rjn.27.678abd						0			0	0			0
NLD Total		**0**	**1**	**0**	**0**	**1**	**2**	**1**	**1**	**2**	**0**	**0**	**0**	**0**
NOR	raj.27.67a-ce-k	50	101	89	77	96	131	62	107	99	157	272	312	153
NOR Total		**50**	**101**	**89**	**77**	**96**	**131**	**62**	**107**	**99**	**157**	**272**	**312**	**153**
Grand Total		**16364**	**14429**	**14016**	**12800**	**10355**	**10071**	**9986**	**9587**	**8568**	**8883**	**9975**	**9350**	**8710**

Table 18.2. Skates and rays in the Celtic Seas. Regional total landings (ICES estimates, t) of Celtic Seas skate stocks by stock. Some of these stocks extend outside the Celtic Seas ecoregion and data for these divisions are reported in relevant report chapters.

ICES Stock Code	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
raj.27.67a-ce-k	BEL	1568	1328	1405	413	416	333	227	74	8	1	1	3	3
	DE	39	7	26	60	2	4	3	1					
	ES	2231	2568	2340	1946	210	52	24	20	32	92	45	61	134
	FRA	2048	1740	1757	1669	548	314	174	160	139	128	123	130	183
	GBR	2773	2454	2398	1478	508	290	168	153	101	77	46	34	30
	IRL	2117	1728	1581	1283	1007	547	394	410	243	219	227	230	284
	NLD	0	1	0	0	0	0	0	0	0				
	NOR	50	101	89	77	96	131	62	107	99	157	272	312	153
raj.27.67a-ce-k Total		**10826**	**9926**	**9597**	**6928**	**2787**	**1671**	**1053**	**924**	**623**	**674**	**714**	**770**	**787**
rjb.27.67a-ce-k	BEL				0	0	0			0	0			
	ES	24	6	11	26	0	0	0				448	375	300
	FRA	351	295	308	414	68	30	15	23	21	32	33	17	
	GBR				96	22	1	19	12	1	63	118	116	106
	IRL			0		2	4	17	1	0	0	9	7	9
rjb.27.67a-ce-k Total		**375**	**301**	**319**	**535**	**93**	**35**	**51**	**37**	**22**	**95**	**609**	**516**	**415**
rjc.27.6	ES					16	2	10	6	23	21	12	12	50
	FRA	64	78	73	82	39	24	19	39	28	10	2	1	1
	GBR				1	56	61	57	67	120	120	114	147	113
	IRL					3	33	56	69	71	85	87	99	130
rjc.27.6 Total		**64**	**78**	**73**	**82**	**114**	**120**	**141**	**181**	**241**	**236**	**213**	**260**	**294**

ICES Stock Code	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
rjc.27.7afg	BEL			0	328	216	197	302	441	391	240	350	241	212
	ES											5	6	9
	FRA	379	264	238	181	147	131	133	106	95	107	70	121	147
	GBR			0	204	300	371	384	483	416	252	309	274	276
	IRL					8	80	126	134	146	191	169	220	232
	NLD												0	
rjc.27.7afg Total		**379**	**264**	**238**	**713**	**671**	**780**	**944**	**1165**	**1048**	**790**	**903**	**861**	**876**
rjc.27.7e	BEL				5	2	8	3	4	4	3	9	14	21
	ES						0	0						
	FRA	95	86	82	64	122	101	114	108	181	224	225	213	176
	GBR	0	0		3	82	98	98	129	151	151	158	195	172
	IRL									0		2		2
	NLD					0	2	1	0	2		0	0	0
rjc.27.7e Total		**95**	**86**	**82**	**71**	**206**	**208**	**216**	**242**	**339**	**379**	**395**	**423**	**371**
rje.27.7de	BEL						3	5	5	7	7	9	9	11
	FRA	21	19	19	22	32	28	28	24	26	24	24	8	8
	GBR				4	18	40	28	33	32	36	39	19	15
	IRL													2
rje.27.7de Total		**21**	**19**	**19**	**26**	**50**	**70**	**61**	**62**	**65**	**67**	**72**	**36**	**36**
rje.27.7fg	BEL						37	117	124	99	83	106	123	116
	FRA	27	23	18	21	29	21	16	30	30	65	31	5	57
	GBR			0	91	157	214	189	208	117	79	78	69	31

ICES Stock Code	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	IRL						0	0	0	0	0	0	0	
rje.27.7fg Total		**27**	**23**	**18**	**112**	**187**	**272**	**323**	**362**	**247**	**227**	**216**	**198**	**204**
rjf.27.67	ES					62	42	29	20	33	20	34	15	26
	FRA	32	25	33	28	144	150	152	147	127	131	151	130	124
	GBR				13	44	108	97	79	85	55	25	39	21
	IRL						1	6	7	6	4	2	2	49
rjf.27.67 Total		**32**	**25**	**33**	**41**	**250**	**301**	**283**	**253**	**251**	**211**	**212**	**186**	**219**
rjh.27.4a6	BEL					0	0							
	DK											0		
	ES					0								
	FRA					1					1	1	1	0
	GBR				7	5	7	17	4	0	1	3	2	1
	IRL					0	4	1	1	24	9	9	11	5
rjh.27.4a6 Total					**7**	**6**	**10**	**17**	**5**	**24**	**10**	**14**	**14**	**7**
rjh.27.7afg	BEL				166	170	210	313	404	406	351	359	313	338
	FRA					36	73	131	87	52	170	218	275	257
	GBR		0	0	97	138	226	273	261	262	229	245	245	270
	IRL	3	6			5	402	382	407	377	420	351	171	154
rjh.27.7afg Total		**3**	**6**	**0**	**263**	**350**	**910**	**1099**	**1160**	**1097**	**1170**	**1172**	**1004**	**1019**
rjh.27.7e	BEL				7	6	3	5	5	6	3	6	11	9
	FRA					56	148	205	169	191	281	304	223	240
	GBR		0		32	159	215	204	175	222	295	396	352	241

ICES Stock Code	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	IRL								0			2		2
	NLD								0	0				0
rjh.27.7e Total			**0**		**39**	**221**	**365**	**414**	**349**	**419**	**579**	**708**	**587**	**492**
rji.27.67	BEL							0	0	0	0	0	0	2
	ES	86	74	40	7	30	16	22	8	10	5	3	5	11
	FRA	199	152	185	178	46	35	25	35	26	33	34	37	34
	GBR				0	2	0	0	3	25	22	1	35	17
	IRL						0	4	0					
rji.27.67 Total		**285**	**226**	**226**	**185**	**78**	**51**	**51**	**46**	**61**	**61**	**38**	**77**	**63**
rjm.27.67bj	BEL						0							
	ES				7	7	10	5	0	0	0	1		
	FRA	13	7	3	4	2	4	7	5	17	53	43	47	40
	GBR				5	16	27	32	30	27	29	43	49	44
	IRL					1	20	18	25	24	43	28	20	12
rjm.27.67bj Total		**13**	**7**	**3**	**16**	**27**	**62**	**63**	**61**	**68**	**125**	**114**	**116**	**96**
rjm.27.7ae-h	BEL				78	63	55	120	70	3	0	1	7	2
	ES						0				0	0		
	FRA	1080	902	833	870	785	934	1062	1135	899	912	745	819	661
	GBR	0		0	12	38	102	88	85	90	80	70	80	89
	IRL					0	19	63	53	40	49	48	41	10
	NLD					0		0		0			0	
rjm.27.7ae-h Total		**1080**	**902**	**833**	**960**	**887**	**1110**	**1332**	**1344**	**1032**	**1042**	**864**	**947**	**762**

ICES Stock Code	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
rjn.27.678abd	BEL			0	86	81	70	112	93	97	48	51	27	26
	ES				1	778	480	387	311	373	300	659	688	433
	FRA	3164	2565	2575	2507	3217	3069	2909	2571	2195	2515	2621	2233	2142
	GBR				225	321	421	402	306	269	262	266	254	259
	IRL					12	55	106	108	93	83	79	69	69
	NLD						0			0	0			0
rjn.27.678abd Total		**3164**	**2565**	**2575**	**2819**	**4408**	**4096**	**3916**	**3388**	**3028**	**3209**	**3675**	**3270**	**2929**
rju.27.7bj	ES												1	1
	FRA					0				0		0	1	1
rju.27.7bj Total						**0**				**0**		**0**	**2**	**2**
rju.27.7de	BEL												5	24
	FRA					19	9	20	6	3	10	50	58	79
	GBR				2	2			0			5	22	36
rju.27.7de Total					**2**	**21**	**9**	**20**	**6**	**3**	**10**	**55**	**84**	**139**
Grand Total		**16364**	**14429**	**14016**	**12800**	**10355**	**10071**	**9986**	**9587**	**8568**	**8883**	**9975**	**9350**	**8710**

Table 18.3a. Skates and rays in the Celtic Seas. Biomass estimates (kg per km^2) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. ***Leucoraja naevus***

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	6.a	3.341261	0.7631530	5.919370
2006	6.a	2.863412	1.5757870	4.151037
2007	6.a	4.253825	2.3167285	6.190920
2008	6.a	1.550122	0.7289567	2.371288
2009	6.a	2.234281	1.1018169	3.366745
2010	6.a	3.717024	2.0798635	5.354184
2011	6.a	1.785025	0.7836924	2.786359
2012	6.a	2.950243	1.4600642	4.440421
2013	6.a	3.500676	1.5592941	5.442058
2014	6.a	3.246034	0.4422661	6.049802
2015	6.a	0.672508	0.1433472	1.201669
2016	6.a	5.603120	2.7747450	8.431495
2017	6.a	2.360295	1.0888993	3.631690

Table 18.3b. Skates and rays in the Celtic Seas. Biomass estimates (kg per km²) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. ***Raja montagui***

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	6 & 7.bj	3.8203644	0.8772230	6.763506
2006	6 & 7.bj	3.5317143	1.7603041	5.303125
2007	6 & 7.bj	3.1963185	0.2919647	6.100672
2008	6 & 7.bj	2.4079747	1.1541523	3.661797
2009	6 & 7.bj	5.0177595	2.1479083	7.887611
2010	6 & 7.bj	4.5488637	2.5912639	6.506463
2011	6 & 7.bj	6.4196486	3.4717450	9.367552
2012	6 & 7.bj	4.0720115	2.3253288	5.818694
2013	6 & 7.bj	7.1234651	3.6220724	10.624858
2014	6 & 7.bj	9.4745773	3.9045792	15.044575
2015	6 & 7.bj	5.9441076	2.9215481	8.966667
2016	6 & 7.bj	15.3248874	-3.1670403	33.816815
2017	6 & 7.bj	8.9378535	3.9548648	13.920842
2005	7.a, 7.e-h	0.7459104	-0.2892318	1.781053
2006	7.a, 7.e-h	3.6461218	0.9412191	6.351025
2007	7.a, 7.e-h	11.1532172	0.8082230	21.498211
2008	7.a, 7.e-h	6.9323503	0.6528146	13.211886
2009	7.a, 7.e-h	8.0424664	2.1113381	13.973595
2010	7.a, 7.e-h	9.9729479	4.0587944	15.887101
2011	7.a, 7.e-h	6.7392692	2.3894273	11.089111
2012	7.a, 7.e-h	7.8776726	3.1958581	12.559487
2013	7.a, 7.e-h	15.4326483	3.1645578	27.700739
2014	7.a, 7.e-h	16.5616727	4.2940963	28.829249
2015	7.a, 7.e-h	20.3186235	7.1949131	33.442334
2016	7.a, 7.e-h	30.2480582	9.2527723	51.243344
2017	7.a, 7.e-h	12.8967985	4.9479571	20.845640

Table 18.3c. Skates and rays in the Celtic Seas. Biomass estimates (kg per km²) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. *Raja brachyura*

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	7.a & 7.g	0.6014534	-0.3335659	1.5364727
2006	7.a & 7.g	0.1426726	-0.1369605	0.4223057
2007	7.a & 7.g	1.7877288	-0.2675947	3.8430524
2008	7.a & 7.g	3.7541867	-0.5016022	8.0099756
2009	7.a & 7.g	0.0000000	0.0000000	0.0000000
2010	7.a & 7.g	3.5534812	-0.3123857	7.4193480
2011	7.a & 7.g	1.4430961	-1.3853203	4.2715125
2012	7.a & 7.g	0.3881487	-0.2841718	1.0604693
2013	7.a & 7.g	3.1461458	-1.1897411	7.4820327
2014	7.a & 7.g	1.7142022	-0.4667081	3.8951125
2015	7.a & 7.g	1.6050991	-0.2292067	3.4394049
2016	7.a & 7.g	2.8149362	0.8451547	4.7847177
2017	7.a & 7.g	2.2458713	-0.2734638	4.7652064

Table 18.3d. Skates and rays in the Celtic Seas. Biomass estimates (kg per km^2) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. ***Raja clavata***

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	6	3.7434568	-0.1480331	7.634947
2006	6	5.9180334	2.4861426	9.349924
2007	6	5.5667234	1.2599530	9.873494
2008	6	7.6147167	2.7638518	12.465582
2009	6	7.2688409	2.7567736	11.780908
2010	6	17.9536507	3.7574574	32.149844
2011	6	13.7808323	4.9685941	22.593070
2012	6	22.8984537	3.2988192	42.498088
2013	6	15.6807027	3.5229155	27.838490
2014	6	12.8470955	1.3826824	24.311508
2015	6	14.3399433	4.0199724	24.659914
2016	6	23.3694853	3.6320664	43.106904
2017	6	15.7783305	7.1192277	24.437433
2005	7.fg	0.4852387	-0.2500962	1.220573
2006	7.fg	1.1089902	0.1300639	2.087916
2007	7.fg	2.9643871	-0.5731053	6.501880
2008	7.fg	4.3403369	0.5933405	8.087333
2009	7.fg	2.3340468	0.0567745	4.611319
2010	7.fg	4.0709832	-0.4147746	8.556741
2011	7.fg	1.3215369	-0.1738435	2.816917
2012	7.fg	1.3579023	0.1158664	2.599938
2013	7.fg	2.6173275	-0.5230054	5.757660
2014	7.fg	2.9940930	-0.8974523	6.885638
2015	7.fg	5.3633727	-1.3119085	12.038654
2016	7.fg	5.7414410	0.8802873	10.602595
2017	7.fg	4.5903049	0.2296374	8.950972

Table 18.3e. Skates and rays in the Celtic Seas. Biomass estimates (kg per km^2) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. *Raja microocellata*

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	ICES.27.f-g	0.0000000	0.0000000	0.000000
2006	ICES.27.f-g	2.0380292	-0.5532546	4.629313
2007	ICES.27.f-g	6.9088751	-1.5846139	15.402364
2008	ICES.27.f-g	4.3341235	-0.8869290	9.555176
2009	ICES.27.f-g	0.4155238	-0.3988879	1.229935
2010	ICES.27.f-g	1.5024740	0.0586864	2.946262
2011	ICES.27.f-g	0.7145779	-0.2626957	1.691851
2012	ICES.27.f-g	0.7511249	-0.0690751	1.571325
2013	ICES.27.f-g	1.7806495	-0.5969467	4.158246
2014	ICES.27.f-g	1.8007968	-0.2077030	3.809297
2015	ICES.27.f-g	2.3359211	-0.2738192	4.945661
2016	ICES.27.f-g	4.8460490	-0.8374794	10.529577
2017	ICES.27.f-g	3.3718040	-1.3905964	8.134204

Table 18.3f. Skates and rays in the Celtic Seas. Biomass estimates (kg per km^2) of assessed stocks from the IGFS-IBTS-Q4 survey, 2005–2017. *Dipturus batis* and *Dipturus interemedius* combined.

Year	MgtArea	CatchWgtKg	ci_l	ci_u
2005	6 & 7	0.0647826	0.0190203	0.1105449
2006	6 & 7	0.3803152	-0.1784847	0.9391151
2007	6 & 7	0.4278930	-0.0545232	0.9103092
2008	6 & 7	0.2876187	0.0512355	0.5240019
2009	6 & 7	0.6405827	0.2032358	1.0779296
2010	6 & 7	1.8904779	-0.7308948	4.5118505
2011	6 & 7	1.0733361	-0.4062287	2.5529008
2012	6 & 7	0.5850637	-0.0695271	1.2396545
2013	6 & 7	0.6888536	-0.1227879	1.5004950
2014	6 & 7	0.9398314	0.2384340	1.6412288
2015	6 & 7	1.2567201	-0.2500285	2.7634687
2016	6 & 7	3.0762427	-0.7613029	6.9137883
2017	6 & 7	1.3970494	0.4835118	2.3105869

Figure 18.1a. Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) in the Celtic Seas (ICES Subareas 6–7 including 7.d), from 1903–2015 (Source: ICES).

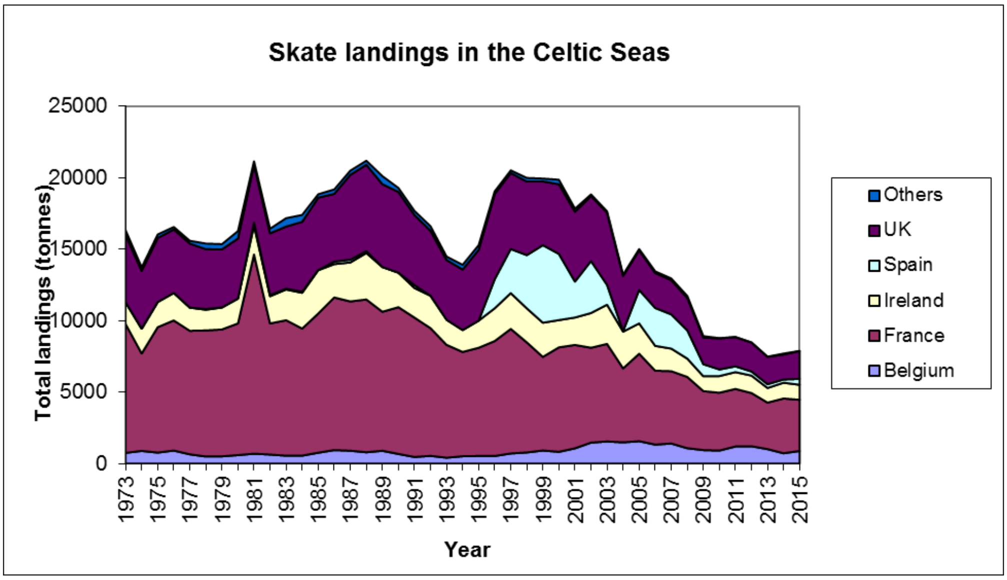

Figure 18.1b. Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) by nation in the Celtic Seas from 1973–2015 (Source: ICES).

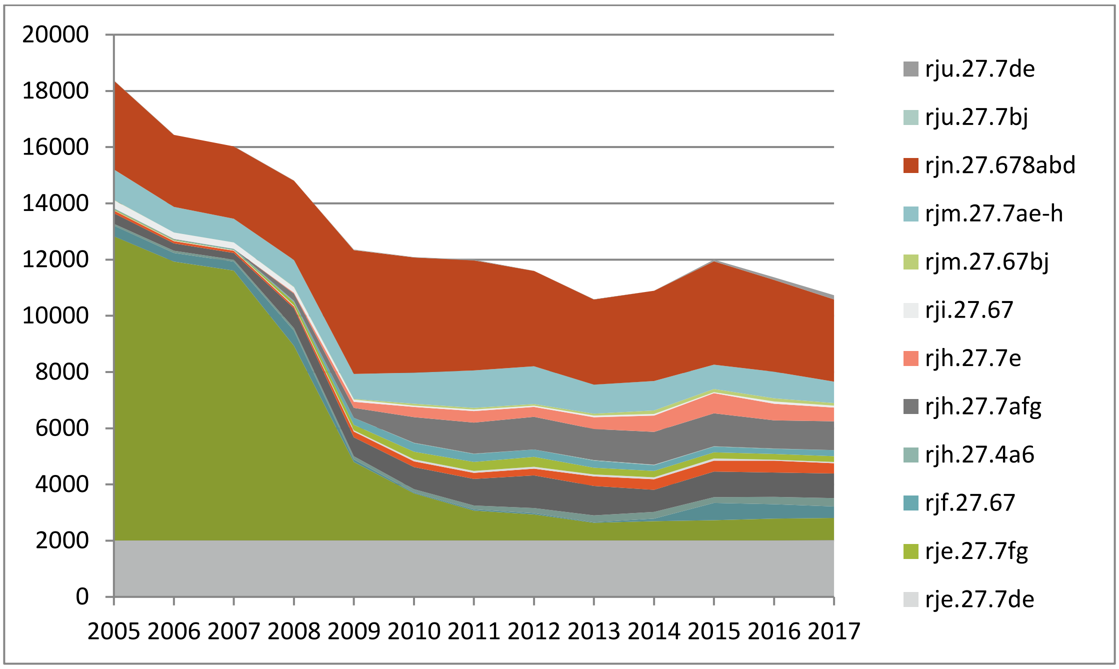

Figure 18.1.c Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) by stock in the Celtic Seas from 2005–2017 (Source: ICES).

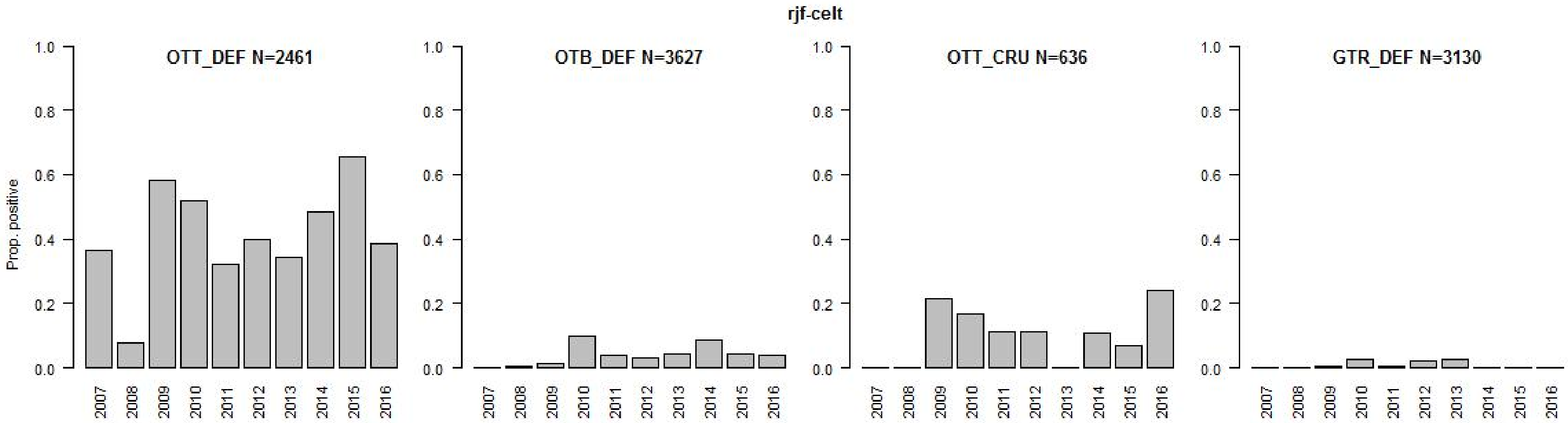

Figure 18.2 Skates and rays in the Celtic Seas. Temporal trends in the proportion of hauls encountering RJF.27.67, based on data collected during French on-board observer trips.

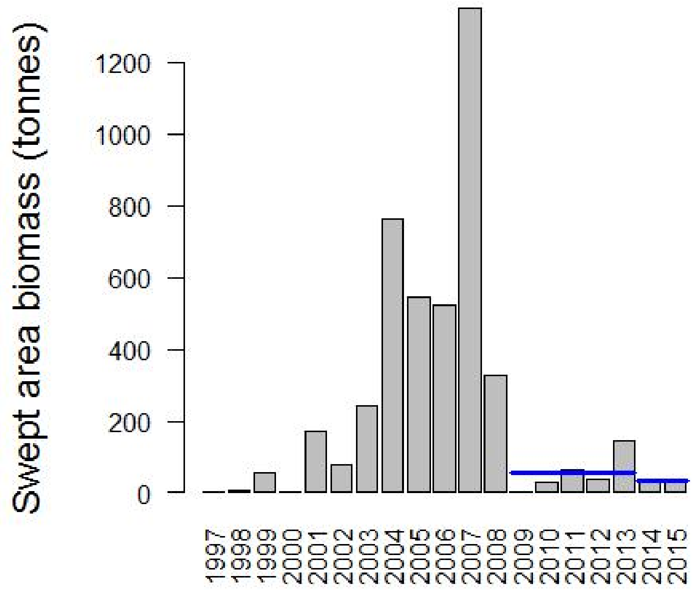

Figure 18.3a. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Leucoraja circularis* (Divisions 7.g-j) from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

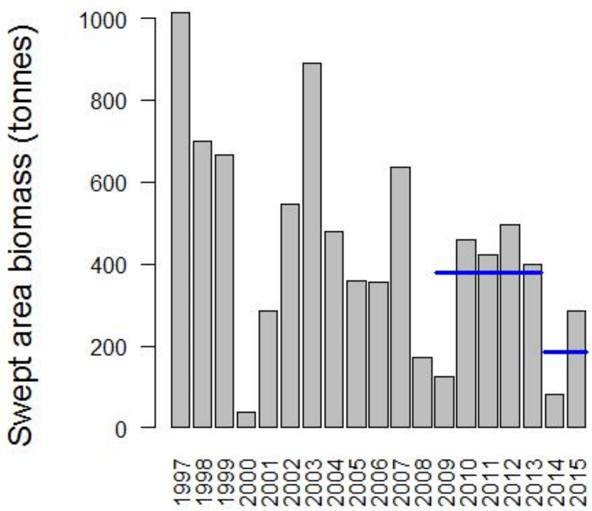

Figure 18.3b. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Leucoraja fullonica* (Divisions 7.g-j) from the French EVHOE (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

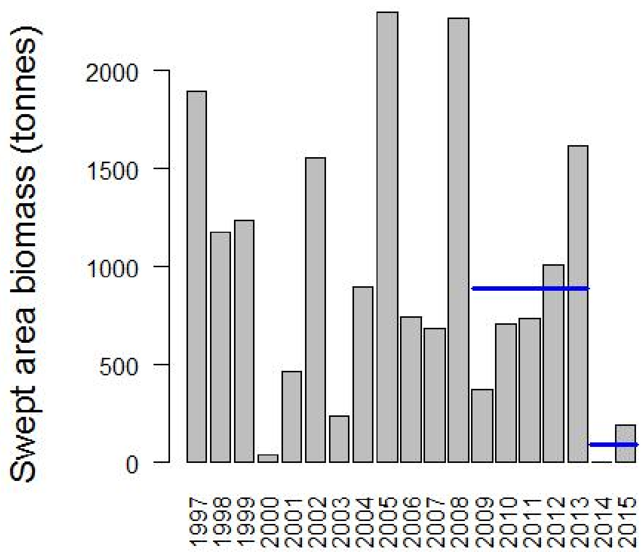

Figure 18.3d. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Raja clavata* (Divisions 7.g-j) from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

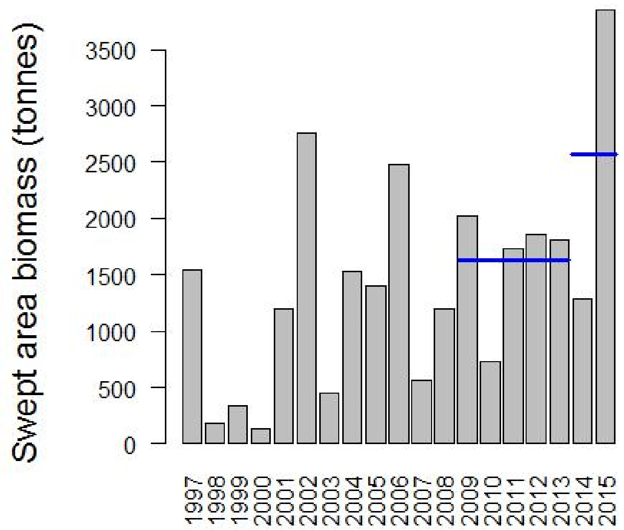

Figure 18.3e. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Raja montagui* (Divisions 7.g-j) from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

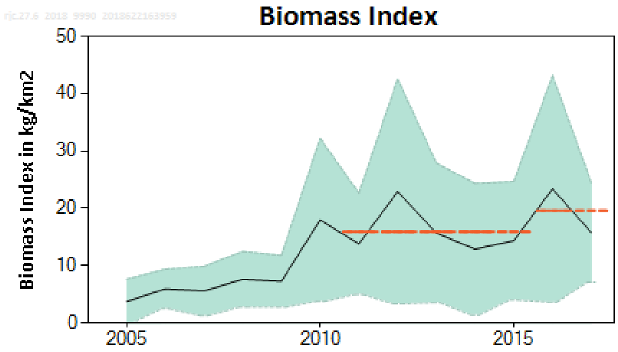

Figure 18.4a. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) biomass index of *Raja clavata* in Division 6.a for 2005–2015. Red lines give average for 2011–2015 and for 2016–2017.

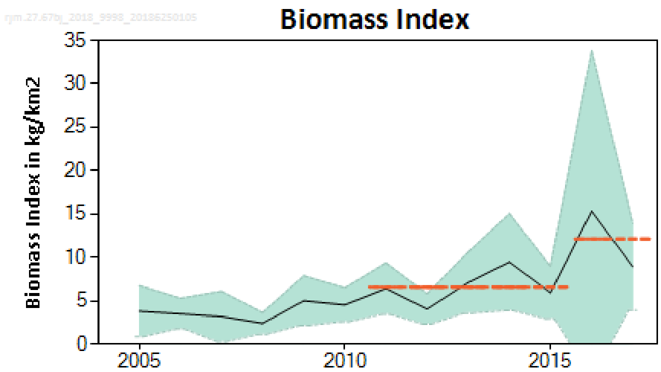

Figure 18.4b. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) mean cpue of *Raja montagui* in Divisions 6.a and 7.b-c for 2005–2017. Red lines give average for for 2011–2015 and for 2016–2017.

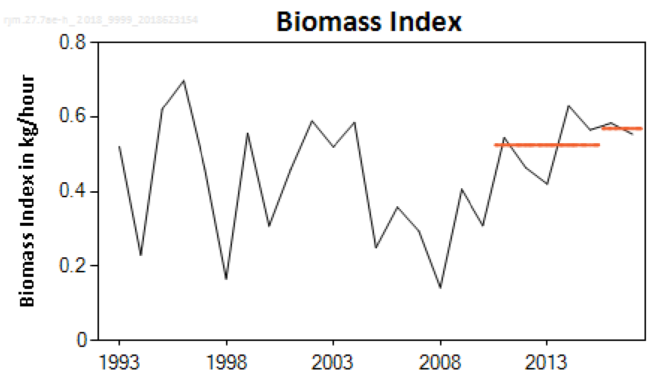

Figure 18.4c. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) mean cpue of *Raja montagui* in Divisions 7.a,e-h for 2005–2017. Red lines give average for for 2011–2015 and for 2016–2017

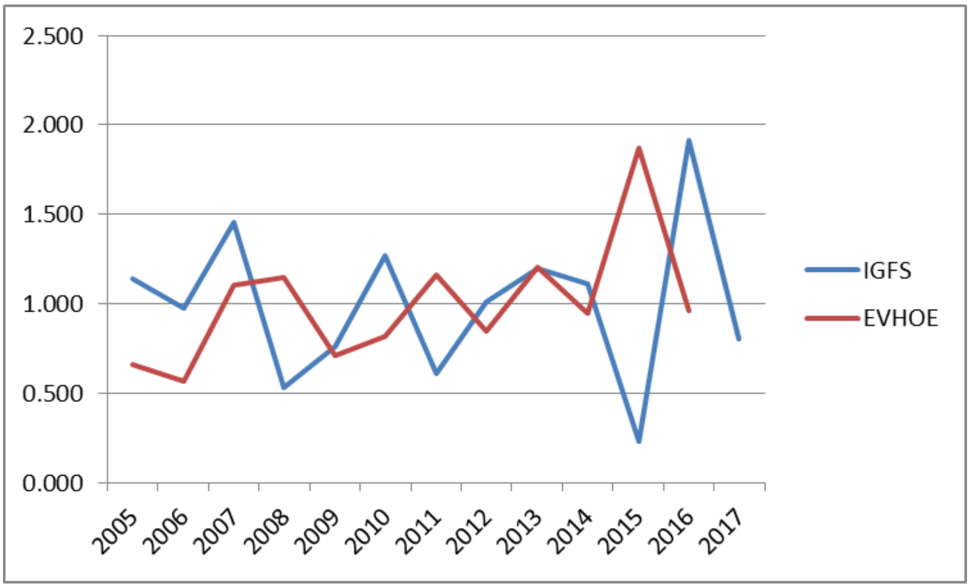

Figure 18.4d. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) (blue) and French EVHOE survey (red) standardized biomasses for of *Leucoraja naevus* in Divisions 6 ,7,8abd. 2005–2017. The French survey did not take place in 2017.

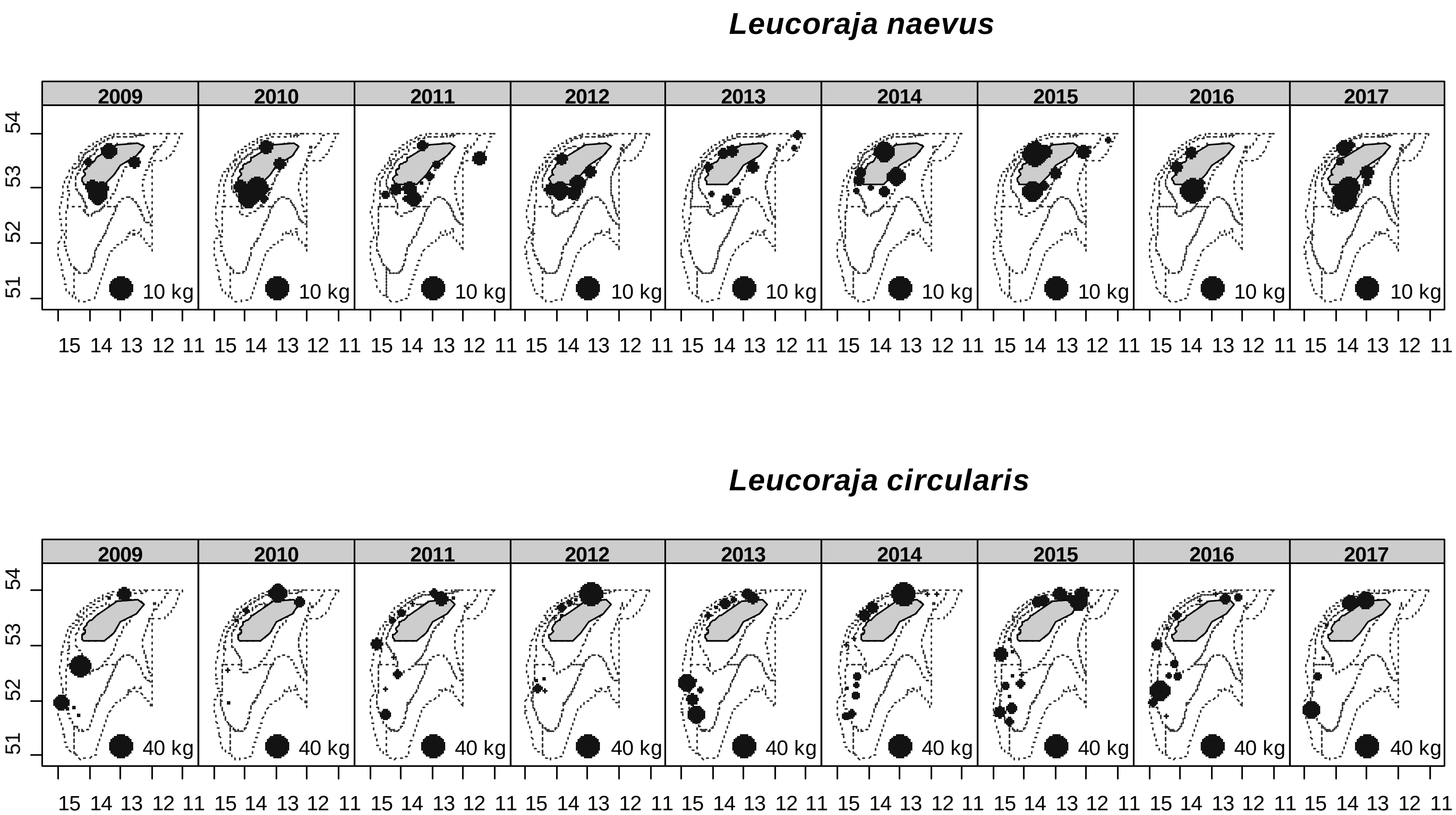

Figure 18.5a. Skates and rays in the Celtic Seas. Geographical distribution of cuckoo ray *Leucoraja naevus* and sandy ray *Leucoraja circularis* catches (kg·haul^{-1}) in Porcupine survey time-series (2009–2017) (Ruiz-Pico *et al.*, 2018 WD).

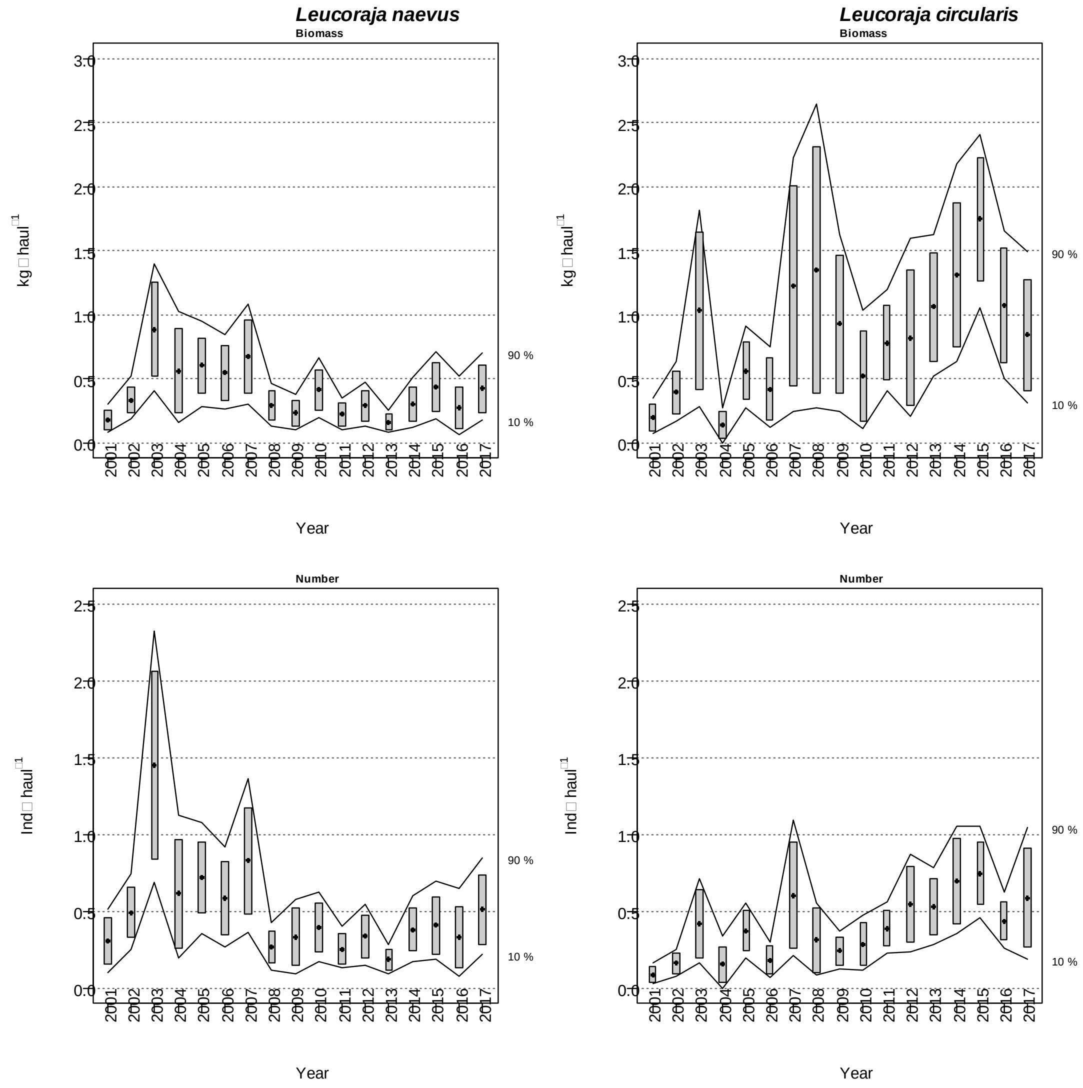

Figure 18.5b. Skates and rays in the Celtic Seas. Temporal changes of cuckoo ray *Leucoraja naevus* and sandy ray *Leucoraja circularis* biomass index (kg·haul⁻¹) during Porcupine survey time-series (2001–2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000) (Ruiz-Pico*et al.*, 2018 WD).

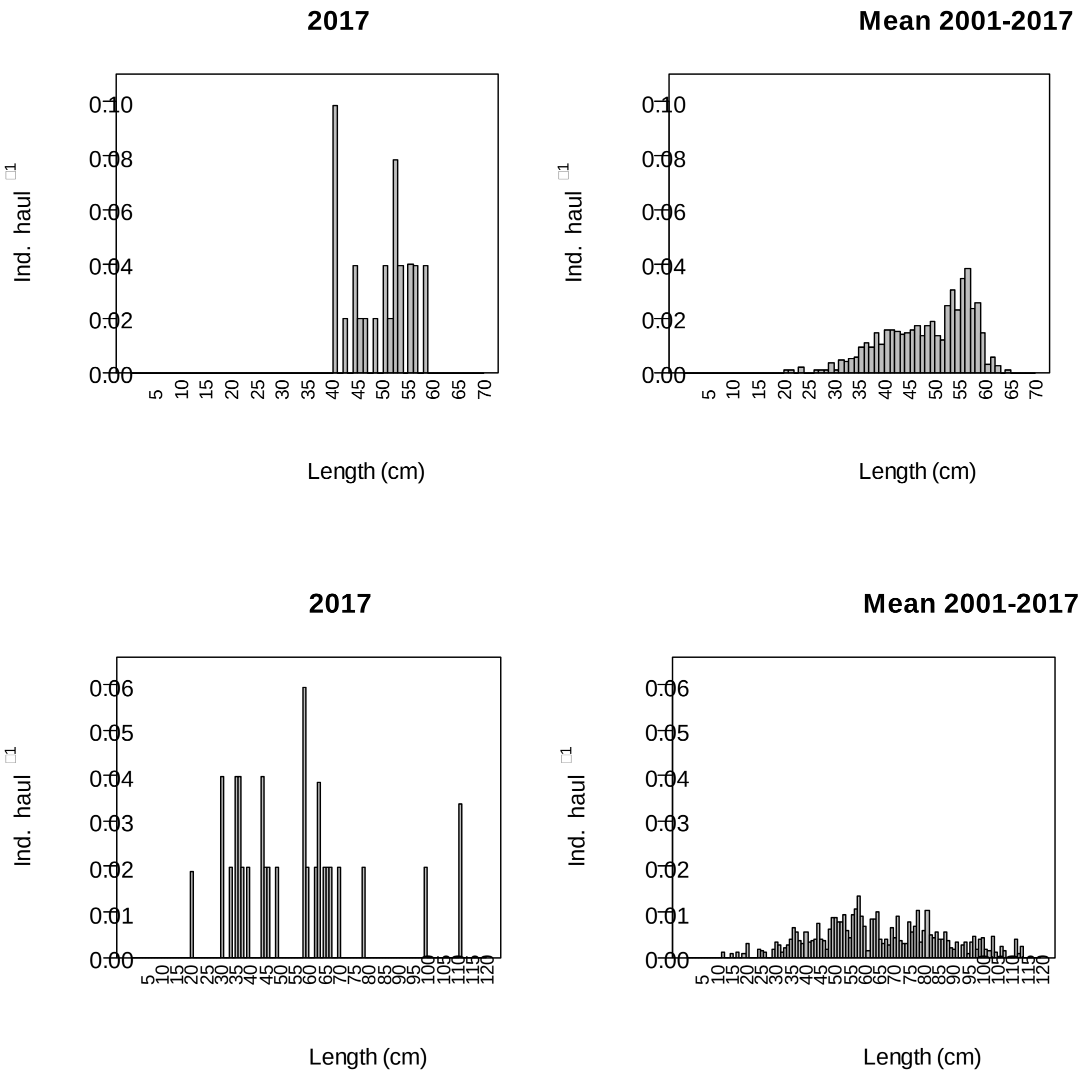

Figure 18.5c. Skates and rays in the Celtic Seas. Stratified length distributions of cuckoo ray *Leucoraja naevus* (top) and sandy ray *Leucoraja circularis* (bottom) in Porcupine survey 2001–2017 (Ruiz-Pico et al. 2018 WD).

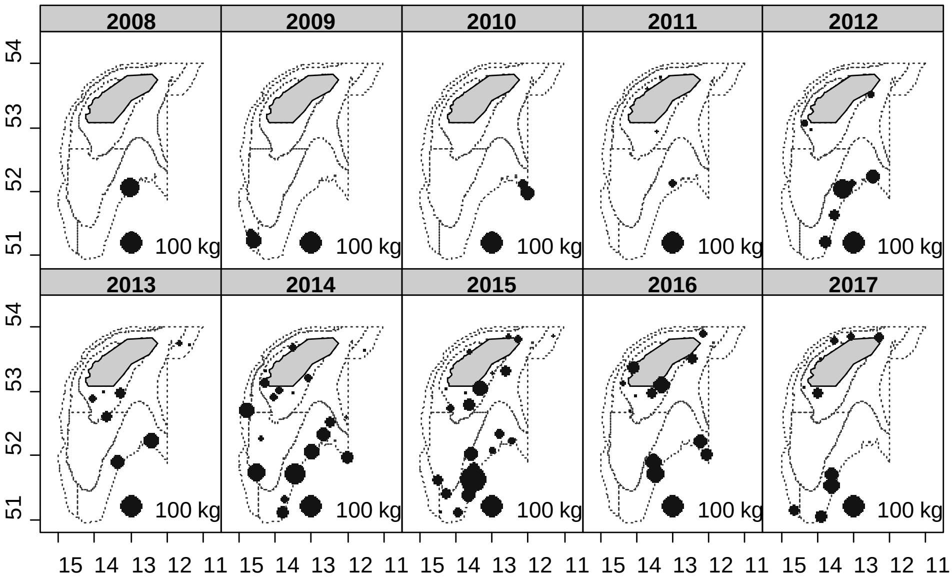

Figure 18.5d. Skates and rays in the Celtic Seas. Geographical distribution of *Dipturus* spp. combined (kg·haul⁻¹) in Porcupine survey time-series (2008–2017) (Ruiz-Pico et al. 2018 WD).

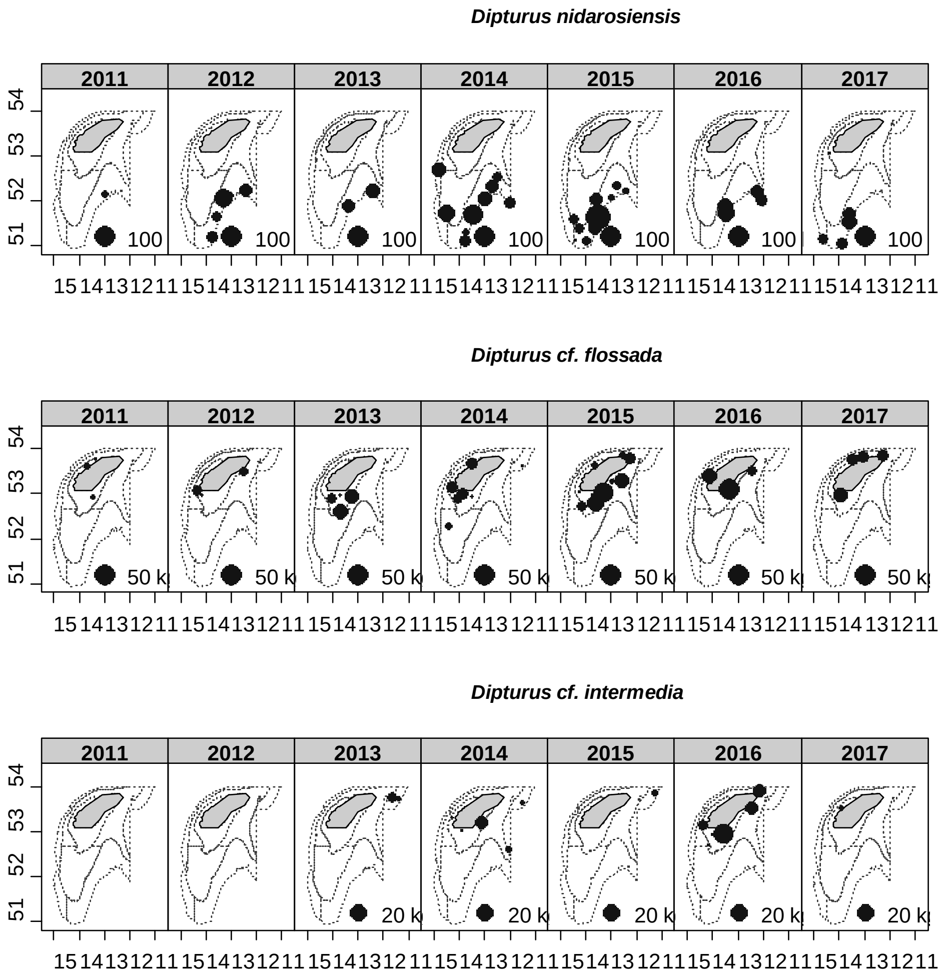

Figure 18.5e. Skates and rays in the Celtic Seas. Geographical distribution of *Dipturus* nidarosiensis, *Dipturus batis* (labelled Dipturus cf. *flossada*) and *Dipturus intermedius* (labelled *Dipturus* cf. *intermedia*) (kg·haul^{-1}) in Porcupine survey time-series (2011–2017) (Ruiz-Pico et al. 2018 WD).

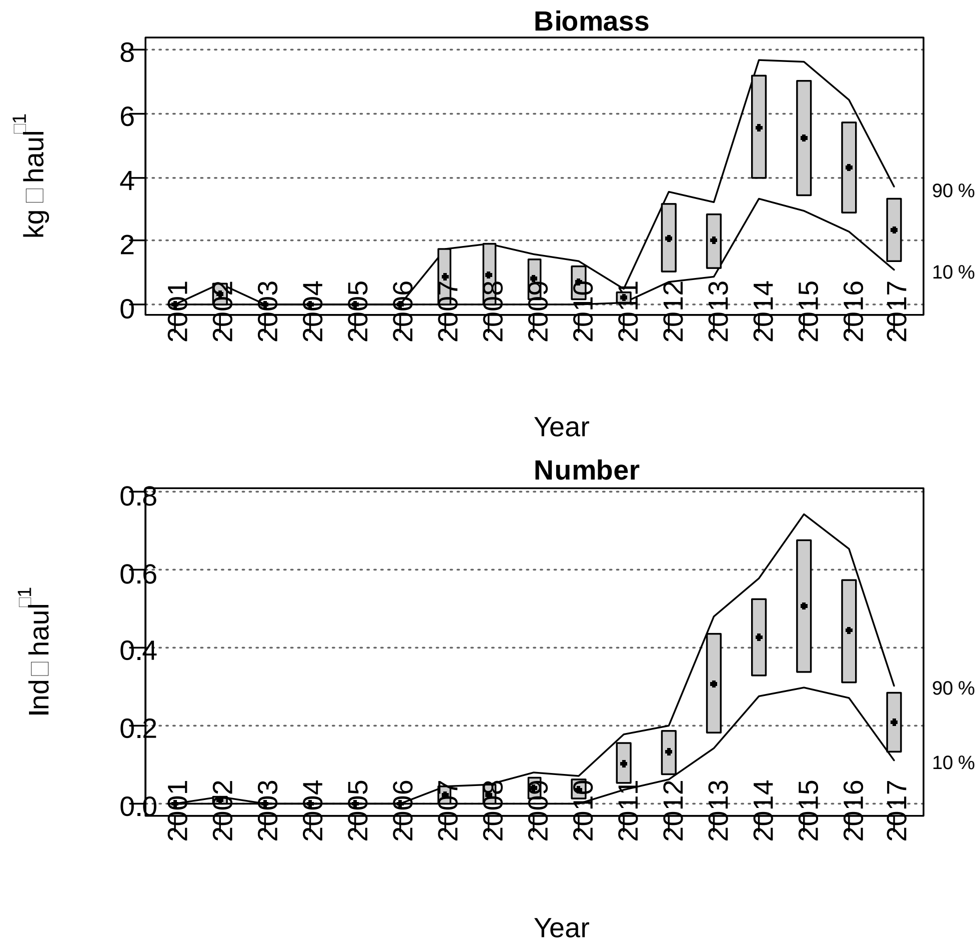

Figure 18.5f. Skates and rays in the Celtic Seas. Changes in *Dipturus* spp. biomass index (kg·haul-1) during Porcupine survey time-series (2001–2017). Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000) (Ruiz-Pico et al. 2018 WD).

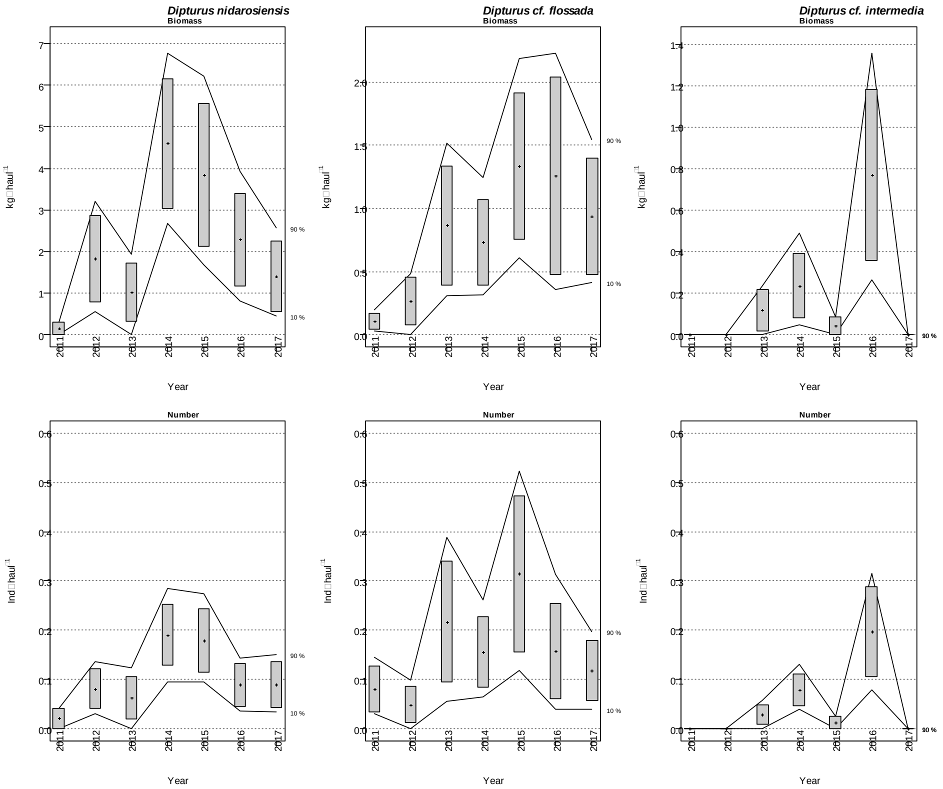

Figure 18.5g. Skates and rays in the Celtic Seas. Changes in *Dipturus* nidarosiensis, *Dipturus batis* (labelled Dipturus cf. *flossada*) and *Dipturus intermedius* (labelled *Dipturus* cf. *intermedia*) biomass index (kg·haul⁻¹) during Porcupine survey time-series (2011–2017). Boxes mark parametric standard error of the stratified index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000) (Ruzi-Pico et al. 2018 WD).

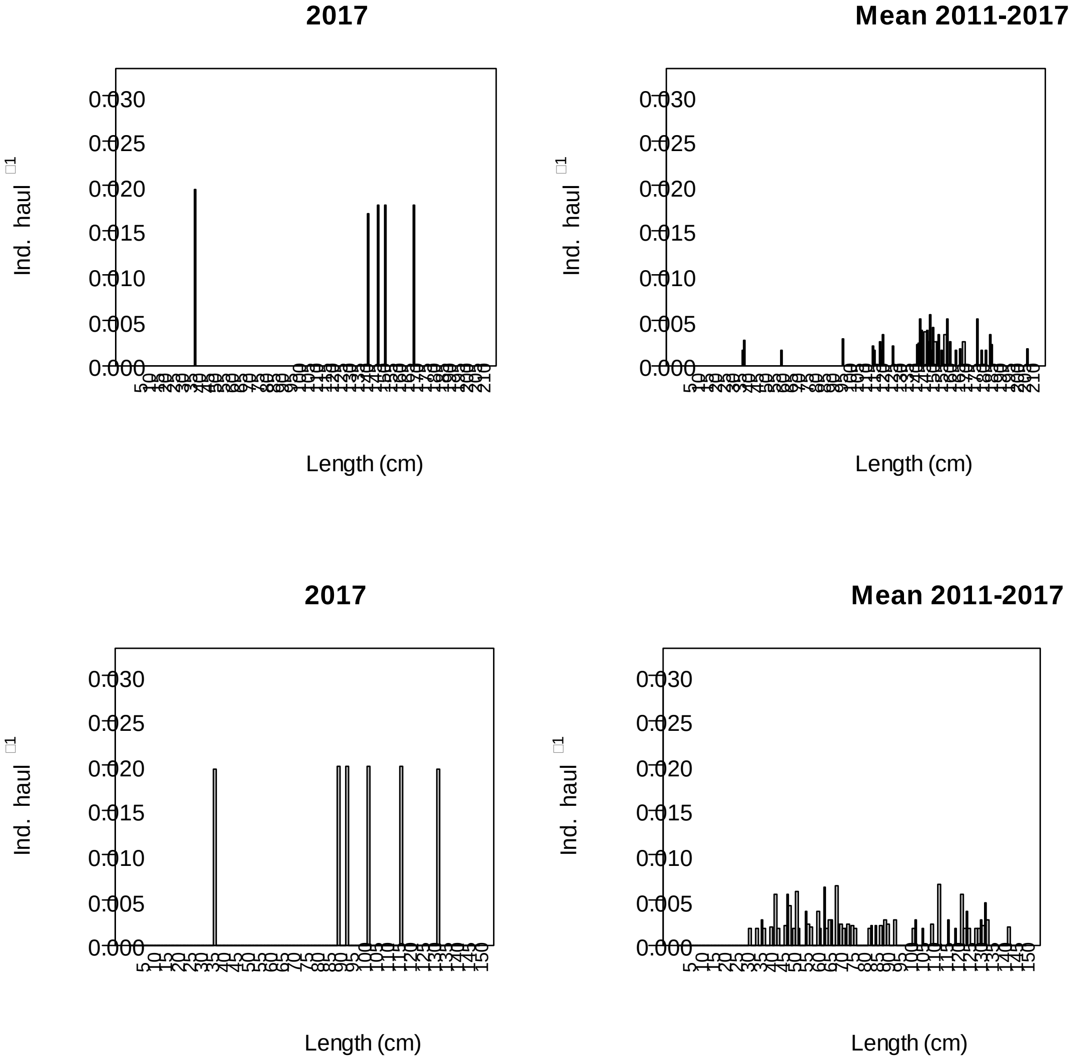

Figure 18.5h. Skates and rays in the Celtic Seas. Mean stratified length distributions of *Dipturus nidarosiensis* (top) and *Dipturus batis* (labelled *Dipturus* cf. *flossada*) from 2017 Porcupine surveys (Ruiz-Pico et al. 2018 WD).

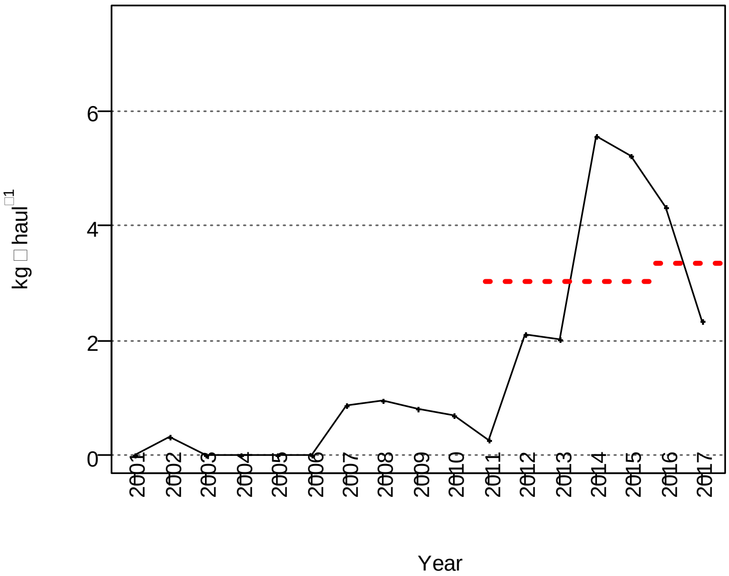

Figure 18.5i. Skates and rays in the Celtic Seas. Changes in *Dipturus* spp. biomass index during Porcupine survey time series (2001–2017). Dotted lines compare mean stratified biomass in the last two years and in the five previous years. (Ruiz-Pico *et al*. 2018 WD).

Figure 18.6. Skates and rays in the Celtic Seas. Temporal trends (1993–2017) in the CPUE by individuals (n.h^{-1}), biomass (kg.h^{-1}), and biomass for individuals ≥50 cm total length (kg.h^{-1}) of skates in the 7.a.f–g beam trawl survey (EngW-BTS-Q3).

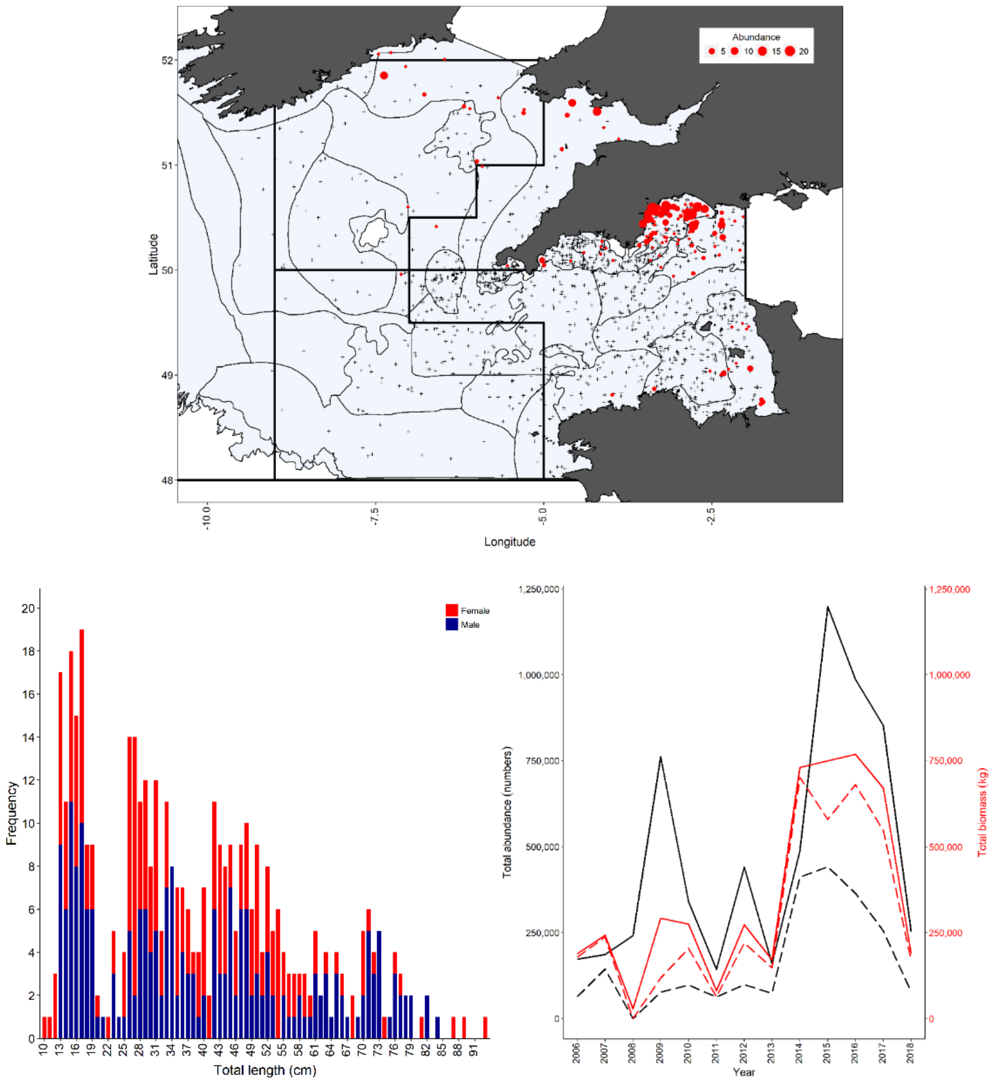

Figure 18.7a. Skates in the Celtic Sea. Distribution and relative abundance (top) and length-frequency by sex (bottom left) and of thornback ray *Raja clavata* in the Q1SWBeam trawl survey. Total biomass (numbers and kg; bottom right) - continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length. (Source: Silva *et al.* 2018WD)

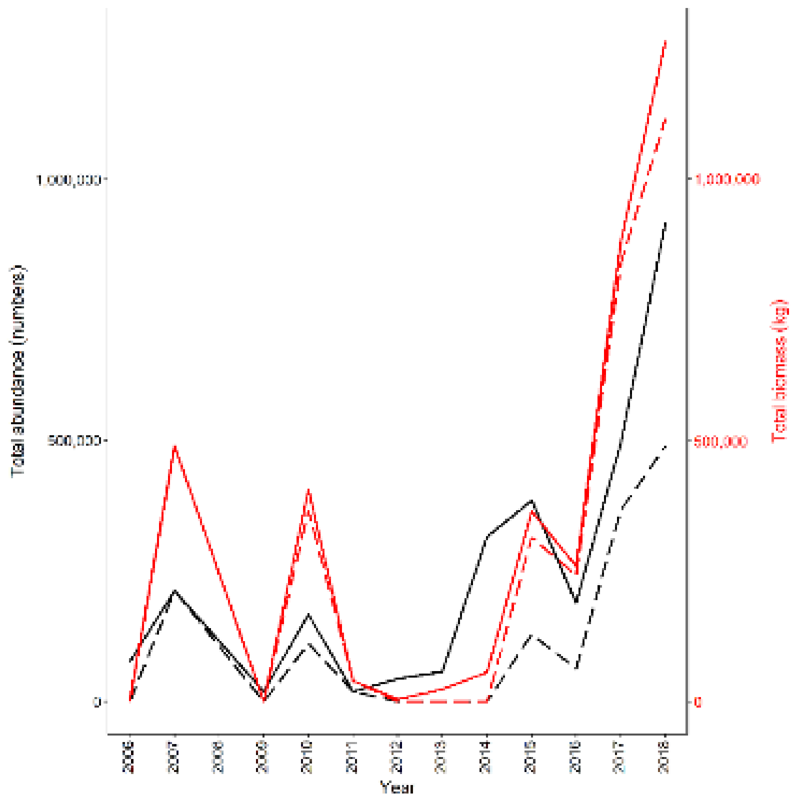

Figure 18.7b. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for common skate *Dipturus batis*-complex. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length. (Source: Silva *et al.* 2018WD)

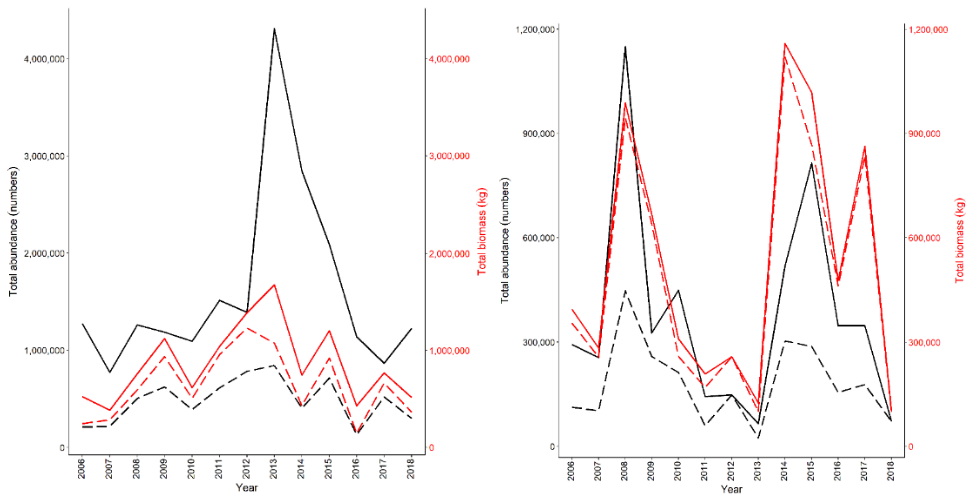

Figure 18.7c. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (left) cuckoo ray *Leucoraja naevus* and (right) blonde ray *Raja brachyura*. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length. (Source: Silva *et al.* 2018WD)

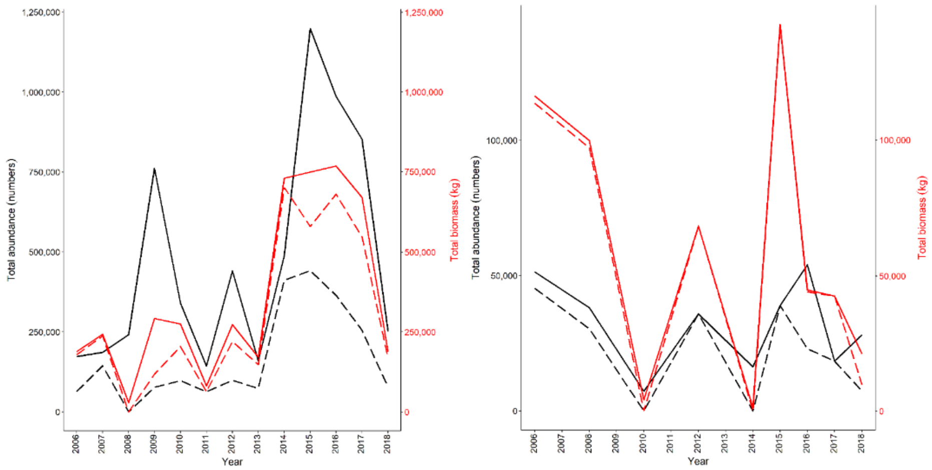

Figure 18.7d. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (left) thornback ray *Raja clavata* and (right) small-eyed ray *Raja microocellata*. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length. (Source: Silva *et al.* 2018WD)

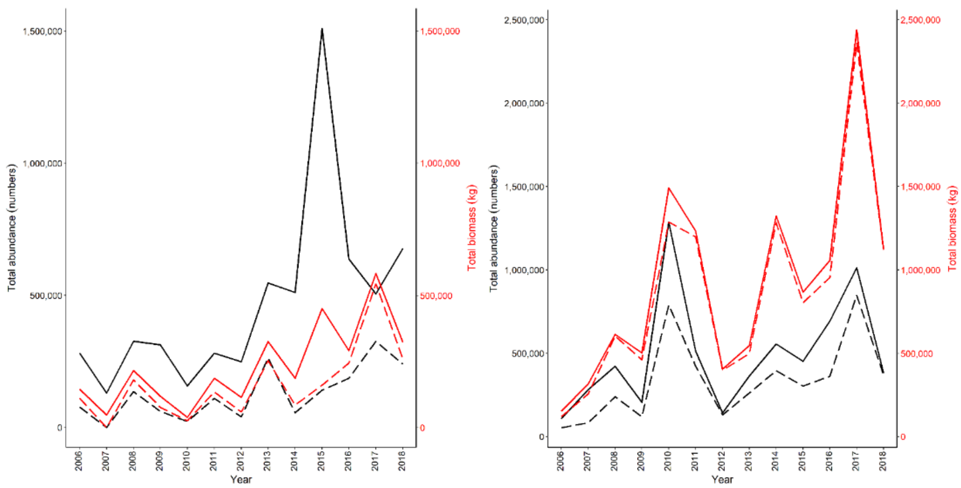

Figure 18.7e. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (left) spotted ray *Raja montagui* and (right) undulate ray *Raja undulata*. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length. (Source: Silva *et al.* 2018WD)

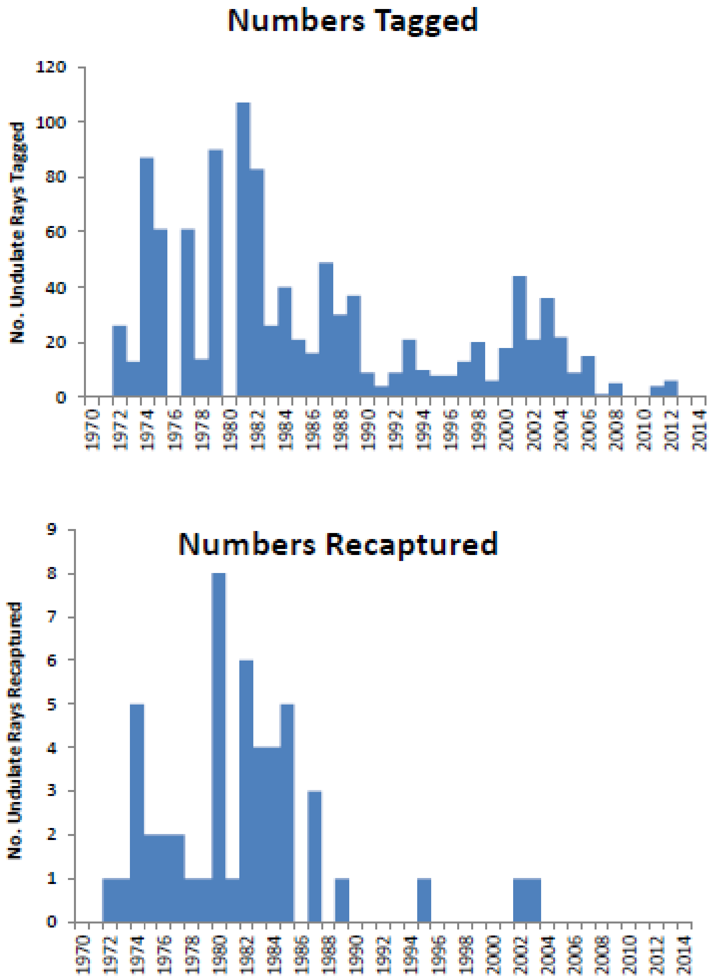

Figure 18.8. Skates in the Celtic Seas. Numbers of *Raja undulata* tagged (top) and recaptured (bottom) in Tralee Bay and surroundings, 1970–2014. Source: Wogerbauer *et al.*, 2014 WD.

19 Skates in the Bay of Biscay and Iberian Waters (ICES Subarea 8 and Division 9.a)

ICES uses the generic term "skate" to refer to all members of the order Rajiformes. The generic term "ray", formerly used by ICES also to refer to Rajiformes, is now only used to refer to other batoid fish, including manta rays and sting rays (Myliobatiformes), and electric rays (Torpediniformes). ICES only provides routine advice for Rajiformes.

19.1 Ecoregion and stock boundaries

The Bay of Biscay and Iberian Waters ecoregion covers the Bay of Biscay (Divisions 8.a-b and 8.d), including the Cantabrian Sea (Division 8.c), and the Spanish and Portuguese Atlantic coast (Division 9.a). This ecoregion broadly equates with the area covered by the South Western Waters Advisory Council (SWWAC). Commercially exploited skates do not occur in the offshore Division 8.e to any major extent.

The northern part of the Bay of Biscay has a wide continental shelf with flat and soft bottom more suitable for trawlers, whilst the Cantabrian Sea has a narrower continental shelf with some remarkable bathymetric features (canyons, marginal shelves, etc.). The Portuguese continental shelf (Division 9.a) is narrow, except for the area located between the Minho River and the Nazaré Canyon, and in the Gulf of Cadíz, where it is about 50 km wide, particularly to the east. The slope is mainly steep with a rough bottom including canyons and cliffs.

Rajidae are widespread throughout this ecoregion but there are regional differences in their distribution as described in earlier reports (ICES, 2010), and this is particularly evident for those species with patchier distributions and limited dispersal (Carrier *et al*., 2004).

Skates in this ecoregion include thornback ray *Raja clavata*, cuckoo ray *Leucoraja naevus*, the less frequent blonde ray *Raja brachyura*, small-eyed ray *R. microocellata*, brown ray *R. miraletus*, spotted ray *R. montagui*, undulate ray *R. undulata*, shagreen ray *Leucoraja fullonica*, common skate *Dipturus batis*-complex, long-nosed skate *D. oxyrinchus*, sandy ray *Leucoraja circularis* and white skate *Rostroraja alba*.

Studies undertaken in the centre of Portugal (Division 9.a; Serra-Pereira *et al*., 2014), and in the Cantabrian Sea (eastern parts of Division 8.c) indicate spatial overlap between *R. clavata* and *L. naevus* (e.g. Sánchez, 1993). In the Bay of Biscay, *L. naevus* is more abundant on the offshore trawling grounds (Sánchez *et al*., 2002). Along the Portuguese coast *R. clavata* and *L. naevus* co-occur in areas deeper than 100 m, on grounds composed of soft bottom, from mud to fine sand (Serra-Pereira *et al*., 2014). *Raja clavata* can also be found from rocky to coarse sandy bottoms. *Raja brachyura* occurs primarily near the coast in shallower depths in areas of rocks surrounded by sand. Juvenile *R. brachyura*, *R. montagui* and *R. clavata* co-occur on grounds shallower than 100 m. In this ecoregion, *R. undulata* and *R. microocellata* occur at depths < 40 m over sandy bottoms. *R. undulata* is locally common in the shallow waters between the Loire and Gironde estuaries (eastern Bay of Biscay; divisions 8.a-b) and occurs along most of the French coastal area.

The geographical distributions of the main skate species in the ecoregion are known, but their stock structure still needs to be more accurately defined. Studies (e.g. tagging and/or genetic studies) to better understand stock structure are required.

A tagging survey of *R. undulata* carried out in the Bay of Biscay (2012–2013) showed that movements of this species were limited to *ca.* 30 km (Delamare *et al*., 2013 WD;

Biais *et al.*, 2014 WD). This result supports the hypothesis that several local stocks exist in European waters and corroborates the assumption of three distinct assessment units (Divisions 8a–b; 8.c and 9.a) in this ecoregion.

For most other skate species, WGEF considers two management units in this ecoregion: Subarea 8 (Bay of Biscay) and Division 9a (Iberian waters). Since 2015, the cuckoo ray from ICES Subareas 6 and 7 in the Celtic seas ecoregion and the Bay of Biscay is considered to form one single stock, cuckoo ray in Subareas 6 and 7 and Divisions 8abd.

19.2 The fishery

19.2.1 History of the fishery

In the Bay of Biscay and Iberian waters, skates are caught mainly as a bycatch in mixed demersal fisheries, which target either flatfish (including sole) or gadiforms (e.g. hake). The main fishing gears used are otter trawl, bottom-set gillnets and trammel nets. The countries involved in these fisheries are France, Spain and Portugal, as detailed below.

France

Skates are a traditional food resource in France, where target fisheries were known to occur during the 1800s. In the 1960s, skates were taken primarily as a bycatch of bottom trawl fisheries operating in the northern parts of the Bay of Biscay, the southern Celtic Sea and English Channel. By this time, *R. clavata* was targeted seasonally by some fisheries, and was the dominant skate species landed. After the 1980s, *L. naevus* became the main species landed. However, landings of both *R. clavata* and *L. naevus* declined after 1986.

Other skates are also landed, including *L. circularis*, *L. fullonica*, *R. microocellata, D. batis* complex and *D. oxyrinchus*. There have been no major annual landings of *Rostroraja alba* by French fleets in the past three decades.

The historical French catches of skates in coastal fisheries are poorly known. Species such as *R. brachyura* were not reported as species-specific landings until the recent EU obligation. The same applies to *Raja undulata,* which was not reported separately before its inclusion on the EU prohibited species list.

Spain

Spanish demersal fisheries operating in the Cantabrian Sea (Division 8.c) and Bay of Biscay (Division 8.a-b and 8.d) catch various skate species using different fishing gears. Most landings are a bycatch from trawl fisheries targeting demersal teleosts, (e.g. hake, anglerfish and megrim). Among the skate species landed, *L. naevus* and *R. clavata* are the most frequent. Historically, due to their low commercial value, most skate species, especially those derived from artisanal gillnetters, were landed under the same generic landing name. There are artisanal gillnet fisheries operating in bays, rias and shallow waters along the Cantabrian Sea and Galician coasts (divisions 8.c and 9.a). *R. undulata* is caught mainly in the coastal waters of Galicia (north part of Division 9.a and western part of Division 8.c). Other skate species caught in Galician waters include *R. brachyura*, *R. microocellata*, R. *montagui*, *R. clavata* and *L. naevus*. The characteristics of Spanish artisanal fleets catching skates are not fully known.

Mainland Portugal

Off mainland Portugal (Division 9.a), skates are captured by trawlers, but mainly by the artisanal polyvalent fleet, which accounts for the highest reported landings. The artisanal fleet operates mostly with trammel nets, but other fishing gears (e.g. longlines and gillnets) are also used. The skate species composition of landings varies along the Portuguese coast. *R. clavata* is the main species landed, but *R. brachyura*, *L. naevus* and *R. montagui* are also caught. Before being prohibited, *R. undulata* was frequently landed, particularly at the northern landing ports. Other species, such as *R. microocellata*, *D. oxyrinchus*, *R. miraletus*, *R. alba* and *L. circularis,* are also caught, albeit less frequently (particularly the latter three species). Further details on fisheries in Division 9.a are given in the Stock Annex.

19.2.2 The fishery in 2017

No specific changes noted for 2016, with descriptions of recent investigations provided below.

France

Landings and on-board observation data confirm that skates are primarily a bycatch in numerous fisheries operating in the Bay of Biscay. French landings statistics from more than 100 métiers (defined at DCF level 6) report landings of *R. clavata* and *R. montagui* in the Bay of Biscay. Trammel nets are the main métier for *R. montagui,* while twin-trawl is the main métier for *R. clavata*.

Spain

The results from the DCF pilot study held from 2011–2013 and conducted in the Basque Country waters (Division 8.c) with the objective of describing and characterizing coastal artisanal fisheries (trammel nets targeting mainly hake, anglerfish and mackerel), showed that several skate species (*R. clavata, R. montagui, L. naevus, L. fullonica, L. circularis, R. brachyura* and *R. undulata*) are caught as bycatch. The Basque artisanal fleet consists of 55 small vessels that use gillnets and trammel nets during some periods of the year. Vessels have a mean average length of 12.7 m and 82.4 kW average engine power. The proportions of skates in the total sampled trips were 30% (2011), 35% (2012) and 16% (2013). The estimated landings of skates by this fleet were 19.3 t in 2012 and 26.9 t in 2013 (Diez *et al.*, 2014 WD).

In the Cantabrian Sea (Division 8.c) most skate landings are also from bycatch from otter trawl (47%) and gillnet gears (43%). The remaining landings are derived from longlines and other fishing gears.

Mainland Portugal

Skates are mainly a bycatch in mixed fisheries, particularly from the artisanal polyvalent fleet (representing around 80% of landings). Set nets, or a combination of set nets and traps, account for most skates' landings (*ca.* 61% in weight and 71% in number of trips in 2017), followed by longline (*ca.* 28% in weight and 20% in number of trips in 2017). Also within the artisanal polyvalent fleet, trawlers may account for 5% of the total skate landings (by weight and number of trips), being only observed in certain landing ports. Methods to estimates landings by skate species were developed during the DCF-funded pilot study focused on skate catches in Portuguese continental fisheries carried out from 2011–2013 (Maia *et al.*, 2013 WD).

The experimental quota of *Raja undulata* assigned to Portugal in 2016 and updated in 2017, involved the assignment of special fishing licenses to vessels, mainly operating close to the coast. This cannot be interpreted as a new fishery as it is a TAC constrained and has as main goal to provide minimum fishery data for future scientific advice.

19.2.3 ICES Advice applicable

Before 2012, ICES provided general advice on skates, however that is inadequate as skate species have different life-history traits. Also, a generic skate TAC does not take into account that several stocks straddle the boundary with other management areas. For instance, *L. naevus* is a stock straddling Subareas 6 and 7 (excl. Division 7.d) and divisions 8.a-b and 8.d.

From 2012–2014, ICES has moved towards providing advice at the individual stock level, giving quantitative advice where possible.

Advice on skates is given biannually and the last advice provided for Bay of Biscay and Iberian Waters ecoregion was given in 2016. A summary of the 2016 ICES advice is summarized in the table below.

It is important to note that this does not sum up to a generic advice for skates in Subareas 8 and 9 and should not be interpreted as advice in relation to the generic skate TAC applicable to this management area.

Scientific name	ICES stock code	Management unit	Advice	Advice 2017 (tonnes)
Raja undulata	rju.27.8ab	8a,b	No target fishery, manage bycatch	-
Raja undulata	rju.27.8c	8c	No target fishery, manage bycatch	-
Raja clavata	rjc.27.8	8	Increase landings 20%	434
Leucoraja naevus	rjn.27.8c	8c	Reduce landings 1%.	27
Raja montagui	rjm.27.8	8	Increase landings 20%	115
Raja montagui	rjm.27.9a	9a	Increase landings 20%	112
Leucoraja naevus	rjn.27.9a	9a	Increase landings 20%	58
Raja clavata	rjc.27.9a	9a	Increase landings 19%	1203
Raja undulata	rju.27.9a	9a	No target fishery, manage bycatch	-
Raja brachyura	rjh.27.9a	9a	Increase landings 4%	177
Dipturus batis complex (Dipturus cf. flossada) (Dipturus cf. intermedia)	rjb.27.89a	8, 9a	Zero catches	0
Other skates	raj.27.89a	8, 9a	ICES cannot provide catch advice	-

19.2.4 Management applicable

An EU TAC for skates (Rajiformes) in Subareas 8 and 9 was first established in 2009, and set at 6 423 t. Since then, the TAC has been reduced by approximately 15% in 2010, 15% in 2011, 9% in 2012, 10% in 2013, 10% in 2014 increased 2% in 2015 and 2016 and increased 9% in 2017. The history of the EU regulations adopted for skates in this ecoregion is summarized below:

Year	TAC for EC waters of Subareas 8 and 9	ICES landing estimates	Regulation
2009	6423 t	4327 t	Council Regulation (EC) No 43/2009 of 16 January 2009
2010	5459 t	4140 t	Council Regulation (EU) No 23/2010 of 14 January 2010
2011	4640 t	4144 t	Council Regulation (EU) No 57/2011 of 18 January 2011
2012	4222 t	3766 t	Council Regulation (EU) No 43/2012 of 17 January 2012
2013	3800 t	3686 t	Council Regulation (EU) No 39/2013 of 21 January 2013
2014	3420 t	3685 t	Council Regulation (EU) No 43/2014 of 20 January 2014
2015	3420 t	3532 t	Council Regulation (EU) No 104/2015 of 19 January 2015 ammended by the Council Regulation (EU) No 523/2015 of 25 March 2015
2016	3420 t	3296 t	Council Regulation (EU) No 72/2016 of 22 January 2016
2017	3762 t	3430 t	Council Regulation (EU) No 2017/127 of 20 January 2017

(1) *Catches of cuckoo ray (Leucoraja naevus) (RJN/89-C), thornback ray (Raja clavata) (RJC/89-C) shall be reported separately.*

(2) *Does not apply to undulate ray (Raja undulata), common skate (Dipturus batis) and white skate (Rostroraja alba). Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.*

(3) *Catches of cuckoo ray (Leucoraja naevus) (RJN/89-C), blonde ray (Raja brachyura) (RJH/89-C), and thornback ray (Raja clavata) (RJC/89-C) shall be reported separately.*

(4) "*Does not apply to undulate ray (Raja undulata). This species shall not be targeted in the areas covered by this TAC. By-catch of undulate ray in area 8 exclusively may be landed provided that it does not comprise more than 20 kg live weight per fishing trip and remain under the quotas shown in the table below".* When accidentally caught in fisheries in Subarea 9, specimens shall not be harmed and shall be released immediately. *"This provision shall not apply for catches subject to the landing obligation. "The former provisions are without prejudice to the prohibitions set out in Articles 12 and 44 of the Regulation"*, which prohibits for Union vessels and third-country vessels, respectively, to fish for, to retain on board, to tranship or to land: common skate (*Dipturus batis*) complex (*Dipturus cf. flossada and Dipturus cf. intermedia*) and white skate (*Rostroraja alba*). "*By-catches of undulate ray shall be reported separately under the following code: (RJU/89-C)."*

(5) "*Does not apply to undulate ray (Raja undulata). This species shall not be targeted in the areas covered by this TAC. In cases where it is not subject to the landing obligation, by-catch of undulate ray in subareas 8 and 9 may only be landed whole or gutted, and provided that it does not comprise more than 20 kilograms of live weight per fishing trip in subarea 8 and 40 kilograms of live weight per fishing trip in subarea 9. The catches shall remain under the quotas shown in the table below. The above provisions are without prejudice to the prohibitions set out in Articles 13 and 46 of the Regulation*", which prohibits for Union vessels and third-country vessels, respectively, to fish for, to retain on board, to tranship or to land: common skate (*Dipturus batis*) complex (*Dipturus cf. flossada* and *Dipturus cf. intermedia*) and white skate (*Rostroraja alba*). "*By-catches of undulate ray shall be reported separately under the codes indicated in the table below."*

Raja undulata	2017	2017
	Union waters of 8 (RJU/8-C)	Union waters of 9 (RJU/9-C)
Belgium	0	0
France	12	18
Portugal	9	15
Spain	9	15
UK	0	0
UE	30	48

19.2.4.1 Regional management measures

Portugal

The Portuguese Administration adopted, on 29 December 2011, national legislation (Portaria no 315/2011) that *prohibits the catch, the maintenance on board and the landing of any skate species belonging to the Rajidae family, during the month of May along the whole continental Portuguese EEZ*. This applies *to all fishing trips, except bycatch of less than 5% in weight*. The legislation was updated on 21 March 2016 (Portaria no 47/2016) by extending the fishing prohibition period to June.

By 22 August 2014, the Portuguese Administration adopted a national legislation (Portaria no 170/2014) that *establishes a minimum landing size of 52 cm total length (L_T) for all Raja spp. and Leucoraja spp*.

On 19 May 2016, Portugal adopted a legislative framework (Portaria no. 96/2016) regarding the 2016 quota of *Raja undulata* in Division 9.a assigned to Portugal. This framework includes a set of conditions for licensing specific fishing permits to vessels on the owner's request, provided that each vessel fulfills the set of specific conditions which include fishing vessel type, fishing license and historical skate landings. Vessels having the specific fishing permit shall comply with a set of rules, which include obligation to transmit, to both the General Directorate of Natural Resources, Maritime Security and Services (DGRM) and to IPMA, specific fishing data using a form designed by DGRM and IPMA to register haul and catch data on a haul-by-haul basis; the obligation to accept scientific observers duly accredited by IPMA onboard, except in situations where, demonstrably, due to vessel's technical characteristics, it affects the normal activity of the vessel. A fishing permit will be assigned to each vessel that has collaborated with IPMA on the UNDULATA Project.

On each fishing trip, vessels with the special fishing permit are prohibited from targeting undulate ray and are obliged to land the species under specific conditions: a maximum of 30 kg of undulate ray live weight is allowed; only whole or gutted specimens can be landed and a minimum (78 cm L_T) and a maximum (97 cm L_T) landing sizes are adopted. During the months of May, June and July of each year the capture, retention onboard and landing of undulate ray is prohibited, but data on catches should be recorded.On 16 January 2017, Portugal updated the 2016 legislative framework regarding the 2017 quota of *Raja undulata* in Division 9.a assigned to Portugal, from 12 to 14 t with no other major differences on the criteria (Portaria no 27/2017).

France

Based on feedback from scientific programs carried out since 2011 in close partnership with fishermen, it was decided in December 2013 to remove undulate ray from the list of prohibited species, without landings permitted (Total Allowable Catch (TAC) zero). In December 2014, thanks to measures proposed by Member States to ensure the sustainable management of local populations of undulate ray, a small TAC has been allowed for France in ICES subareas 7.e-d and 8.a-c, with limited bycatch but no targeted fishing (ICES, 2016). Since then, the French authorities adopted different decrees to regulate bycatch and landings of undulate ray. For more details on the different modalities of this bycatch by year, see table in Section 18.2.5 above.

19.3 Catch data

19.3.1 Landings

Historical series of landings of the Table 19.1e has been updated, revising the allocation of landings by the WGEF Species Name agreed by the WG. The updated table results in an increase of the landings in the first years of the series compared to the table of the WGEF Report edited in 2017.

Tables 19.1a–e and Figures 19.1(a–b) show ICES combined annual landing estimates for all skates, by country. Table 19.1f gives annual ICES landings by stock and country, and Table 19.2 presents the annual ICES landing estimates, by division, for each ray species including *Myliobatis* spp, Dasyatidae, *Rhinobatos* spp and Torpedinidae species (see Section 19.10).

Skates in Bay of Biscay and Cantabrian Sea (Subarea 8)

Historically, approximately 68% of landings in Subarea 8 were assigned to France and 31% to Spain (Basque Country included). Since 1973, skate landings show no clear trend, although at the earlier years of the time-series (1973–1974) and in the period from 1982–1991 remarkably high values were registered. From 2005–2016, annual landings were around 3100–1900 t per year.

In 2017, the Divisions with the highest landings were 8.a–b (80%), and these were mostly from France (1322 t). In Division 8.c, landings represented 20% of the total landing of Subarea 8, and were mainly from Spain (377 t in 2017). Landings from Division 8.d were only 32 t.

Skates in Division 9.a

An update was made to the Portuguese landings by skate species reported for 2014 and 2015, due to a revision of the estimation procedure.

In this Division, Portuguese and Spanish landings account for *ca.* 77% and 23%, respectively of reported skate landings. Since 2005, total landings of skates remained relatively stable, at about 1800–1200 t per year.

Spanish mean annual skate landings were *ca.* 329 t, with a maximum of 481 t in 2013 and a minimum of 134 t in 2008.

From the 1990s until 2010, Portuguese mean annual landings were *ca.* 1200 t per year, but decreased in later years (1138 t in 2017), in line with reductions in the TAC and the national legislation adopted to reduce fishing effort (see Section 19.2.4.1). In 2017, the main commercial species, in decreasing order, were *R. clavata, R. brachyura, R. montagui, R. microocellata*, *D. oxyrinchus* and *L. naevus* (see Section 19.4.2).

19.3.2 Discards

Discard information is available for Divisions 8.a-b, 8.d and 9.a. Although there may be a widespread discarding of skates across fisheries, a proportion of these are likely to survive, particularly in the case of the polyvalent fleets using trammel and gillnets. In these fisheries, discard survivorship varies with soak time.

In WKSHARK3 (February 2017), current sampling programmes for discards were evaluated to examine the suitability for the estimation of discard rates and quantities for the elasmobranch case study considered.

Basque OTB fleet in Subarea 8

Available information indicates that small specimens are commonly discarded. Discards from the Basque OTB (Bottom Otter Trawler) fleet are given in Table 19.3a. Since 2009, species-specific discard information is available for this fleet. *L. naevus* is the most discarded species (representing depending on the year 4–104% of total landings), maximum estimated discards of 120 t occurred in 2016 (Table 19.3a). For the period 2009–2017, discards of *R. clavata* varied from 0–109% of the landed catch (Table 19.3b) with maximum estimated discards of 34 t occurred in 2016. .

Portuguese OTB fleet in Division 9.a

Information on discards of elasmobranchs produced by the Portuguese bottom otter trawl fleets (crustacean and demersal fish bottom otter trawlers) operating in Division 9.a has been collected by the DCF Portuguese on-board sampling program since 2003. Procedures for estimating the probability of a given species being caught in a haul and of a specimen being discarded, as well as the expected number of discarded specimens per haul, are described in the Stock Annex for each species. The overall discard estimates obtained by species for the two fleets were low.

No new information was provided in 2018.

Polyvalent Portuguese fleet in Division 9.a

Discard data for skates were collected during the DCF skate pilot study and the DCF trammel net fishery pilot study targeting anglerfish. The former included fisheries operating in shallow waters (depths < 150 m), whilst the latter examined the fishery operating at depths > 150 m. The frequency of occurrence of rajids was higher in nets operating < 150 m, presumably due to a higher spatial overlap with the species' distributions. For all the skate species, the probability of the species being caught in a haul and a specimen being discarded and the expected number of discarded specimens per haul were low (see Prista *et al.*, 2014 WD and the Stock Annexes for more details).

Under DCF, information on discards from vessels belonging to the polyvalent fleet, particularly those with length overall (LOA) larger than 12 m, using set gillnet and trammel nets to target demersal fish have been collected since 2011, and data were analyzed for the period 2011–2014 (Figueiredo *et al.*, 2017WD). Within the sampled trips (n = 49), seven species of skate were identified in the discards. The main discarded species was *R. clavata,* which occurred in between 13 to 38% of the sampled hauls. The mean proportion in number of skate species discarded by haul on the sampled trips is presented in Table 19.3d. The mean proportion in number of *R. clavata* discarded by haul on the sampled trips was between 0.16 and 0.33. Only *R. clavata* had sufficient sampled individuals to analyze the length-frequency distribution of the retained and discarded fractions (Figure 19.2a). However, even for that species the observed length pattern varied between years.

No new information was provided in 2018.

French fleet in Subarea 8

Gill- and trammel net métiers discard a fraction of large fish, which might be considered as damaged fish (e.g. partly scavenged catch). These discards are dead discards.

In trawl fisheries, due to the low commercial value of small specimens, the mean size of discarded specimens is much smaller than that of landed specimens. It is likely that some discarded specimens may survive.

19.3.3 Discard survival

Table 19.4a shows vitality estimates for *R. clavata*, *L. naevus*, *R. montagui*, and *R. brachyura* based on onboard sampling observations on trammel and gillnet fisheries. Results indicate that the survivorship of all the species addressed after capture is high and that both mesh size and soak time affected survivorship.

In the case of *R. undulata*, onboard observations in the Portuguese polyvalent fleet indicate high vitality after capture (91% were found with “good” health status; 3% were found in “poor” health status; Table 19.4b). The observations also indicated that soak time, mesh size and fish size influenced survival, with larger specimens tending to have higher survival.

WKSHARK3 (February 2017) reviewed available studies to identify where there are existing data on the vessel mortality and post-release mortality of elasmobranch species by gear type and identify important data gaps

19.3.4 Quality of the catch composition data

Species composition of landings in Subarea 8 and Division 9.a, corrected according to the WKSHARKS reporting guidelines (ICES, 2016) are presented (Tables 19.1f and 19.2). In recent years, official landings reported as Rajiformes (indet.) have declined because of the EU mandatory species-specific reporting. In the case of the Portuguese official landings statistics, eight commercial designations were reported in 2017: “raia lenga” (*R. clavata*), “raia pontuada” (*R. brachyura*), “raia manchada” (*R. montagui*), “raia-de-dois-olhos” (*L. naevus*), “raia de S. Pedro” (*L. circularis*), “raia-zimbreira” (*R. microocellata*), “raia-de-quatro-olhos” (*R. miraletus*) and “raia bicuda” (*D. oxyrinchus*).

Landing misidentifications and/or coding errors still occur in Subarea 8 and Division 9.a. To address this, IPMA developed statistical procedures to better estimate species-specific landings during the DCF skate pilot study (2011–2013). Table 19.5 gives updated landing proportions for each skate species (see Stock Annex for more details on the method). As mentioned in section 19.3.1 the estimates reported for the polyvalent fleet in 2014 and 2015 were revised. After this study, DCF sampling effort for skates decreased, and the precision of the estimates have decreased accordingly. An increment in sampling effort is recommended, ideally included in the Portuguese DCF program.

A similar study was implemented by AZTI in Division 8.c. The main objective of the Basque Country pilot study was to characterize the main fishing parameters of the trammel net fishery (fishing gear, métier, effort and LPUE) and to identify the skate species present in the landings, as well as biometric relationships, such as “wing weight/total weight” and “total length/wing width” to better estimate the live weight of the landed skates.

In France, it is requested that all landings be recorded at species level. The quality of species reporting has improved in the last decade. Some misidentification is still likely to occur, because of e.g. local fish names. However, auction markets now use identification guides and record sales accordingly.

19.4 Commercial catch composition

Subarea 8

Length–frequency distributions of the retained and discarded catches of *R. clavata,* and *L. naevus* from the Basque OTB (Bottom Otter Trawler) are presented for the period 2011–2017 (Figures 19.2b). Length–frequencies are extrapolated to the total trips.

Both species are discarded in all the range sizes but only individuals of *L. naevus* and *R. clavata* larger than 30 cm and 37 cm respectively are usually retained.

Division 9.a

Length–frequency distributions of *R. clavata, R. brachyura, R. montagui, R. microocellata* and *L. naevus* from the Portuguese commercial polyvalent and trawl fleets for the period 2008–2017 are presented in figures 19.2c–h.

Length–frequency distributions were extrapolated to the total estimated landed weight of each species. Within each fleet, length distributions and their ranges were similar between years. However, for some species, there were differences in length distributions between the polyvalent and trawl fleets. In the case of *R. brachyura* and *R. microocellata*, landings from trawlers tended to be comprised of a higher density of smaller length classes.

Length–frequency distributions of *R. undulata* collected onboard polyvalent vessels for the period 2008–2013 (Figure 19.2h) showed that the length-structure of the exploited population shifted to larger individuals by the end of this time-series.

In 2018, there were no new data on the length–frequency distribution of *R. clavata* from the Spanish commercial fleet in this Division.

19.5 Commercial catch–effort data

19.5.1 Spanish data for Subarea 8

Limited new data were available in 2016.

An updated nominal LPUE-series for the Basque Country's OTB DEF>=70 in Subarea 8 from 2001–2017 is given for *L. naevus* and *R. clavata* (Table 19.6; Figure 19.3).

The LPUE of *L. naevus* was generally > 100 kg per day in the first half of the series, declined from 2009 to 2014 and increased again in 2015 and 2016. The lowest level was observed in 2010 (44 kg per day) and the greatest in 2007 (169 kg per day). In 2017, the value dropped strongly to 58 kg per day. The LPUE of *R. clavata* were smaller and more stable than those recorded for *L. naevus*, ranging from 14–32 kg per day, but in 2017 the highest value of the series (54 kg per day) was recorded

19.5.2 Portuguese data for Division 9.a

Standardized lpue (kg per trip) time-series (2008–2013) for the most representative skate species (*R. clavata, R. montagui, R. brachyura, L. naevus* and *R. undulata)* were determined based on fishery data collected under the DCF skate pilot study on skates in Division 9.a (Figures 19.4a-b). Standardized LPUE indices for *L. naevus* were calculated for both the polyvalent and trawl fleets (the two fleets each contribute *ca.* 50% each of the annual landings). For the remaining species, standardized LPUE indices were only calculated for the polyvalent fleet. Methodological procedures to determined standardized LPUE are described in the Stock Annex.

In 2017, only the LPUE index of *R. brachyura* was updated (Figure 19.4a).

19.5.3 Quality of the catch-effort data

Under the 2011–2013 DCF pilot study on skates developed by IPMA in Division 9.a, the quality of catch and effort data by species has improved greatly. It is recommended that catch-effort data by species continue to be collected, and focused sampling effort be undertaken for more coastal species.

19.6 Fishery-independent surveys

Groundfish surveys provide data on the spatial and temporal patterns in species composition, size composition, relative abundance and biomass for various skates. The fishery-independent surveys operating in the Bay of Biscay and Iberian Waters are discussed briefly below (see Stock Annex for further details).

Due to the patchy (sometimes coastal) distribution and habitat specificity of some skate species (e.g. *R. undulata, R. brachyura* and *R. microocellata*), existing surveys do not provide reliable information on abundance and biomass. In order to gather information on the distribution and spatio-temporal dynamics, and on abundance and biomass for those species, WGEF recommends dedicated surveys using an appropriate fishing gear be developed in this ecoregion.

19.6.1 French EVHOE survey (Subarea 8)

The EVHOE survey has been conducted annually in the Bay of Biscay since 1987 (excluding 1993 and 1996). The survey is usually conducted in October and November (but was undertaken from mid-September to end-October in 1989, 1990, 1992 and 1994, and in May during 1991). In 1988, two surveys were conducted, one in May the other in October. Since 1997, the main objectives have been: i) the construction of time-series of abundance indices for all commercial species in the Bay of Biscay and the Celtic Sea with an emphasis on the yearly assessed species where abundance indices at-age are computed; ii) to describe the spatial distribution of the species and to study their inter-annual variations; and iii) to estimate and/or update biological parameters (e.g. growth, sexual maturity, sex ratio).

Population indices from the French EVHOE survey were calculated for all elasmobranchs caught. Indices of abundance and biomass per year are only considered reliable for *L. naevus* (Figure 19.5a). For other species, the small numbers commonly taken (except in some few occasional hauls with high catches) do not allow reliable estimates. A presence–absence indicator and maps of three years catches by set are considered a useful approach to detect changes in habitats occupied by elasmobranchs (Figures 19.5b–d; see also the Stock Annex).

French EVHOE survey was not carried out in 2017.

19.6.2 Spanish survey data (Divisions 8.c and 9.a)

The Spanish IEO Q4-IBTS annual survey in the Cantabrian Sea and Galician waters (divisions 8.c and 9.a) has covered this area since 1983 (except in 1987), obtaining abundance indices and length distributions for the main commercial teleosts and elasmobranchs. The survey has a stratified random sampling design, with the number of hauls allocated proportionally to the area of each stratum. Results for elasmobranch species sampled in the IEO Q4-IBTS survey on the Northern Iberian shelf (Division 8.c and northern part of 9.a) were presented by Fernández-Zapico *et al*. (2018 WD). Depth stratification ranges from 70–500 m, therefore catch rates of shallower species, such as *R. undulata*, are low and cannot be used to estimate abundance or biomass indices. More information on this survey is given in the Stock Annex.

The Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz (Division 9.a) has been carried out in spring and autumn from 1993–2016 The surveyed area corresponds to the continental shelf and upper-middle slope (depths of 15–800 m) and from longitude 6º20'W to 7º20'W, covering an area of 7224 km².

Note: In 2012, the RV *Miguel Oliver* (owned by the Secretary General for Fisheries) replaced the RV *Cornide de Saavedra* and an inter-calibration was performed. In 2013 the first survey on RV *Miguel Oliver* was carried out after the results of the inter-calibration (Velasco, 2013). In 2014 a new inter-calibration experience was performed with the old vessel, R/V Cornide de Saavedra, to study the 2013 results and adjust again the gear in the new vessel R/V Miguel Oliver where the surveys are carried out (Ruiz-Pico *et al* ,2015).

19.6.3 Portuguese survey data (Division 9.a)

The Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4) has been conducted by IPMA and aims to monitor the abundance and distribution of hake *Merluccius merluccius* and horse mackerel *Trachurus trachurus* recruitment (Cardador *et al*., 1997). In these surveys, *R. clavata* is the most frequent skate species caught (88% of the total weight of skates). For most of the time series the PtGFS-WIBTS-Q4 was conducted onboard the R/V *Noruega* and used a Norwegian Campelen Trawl gear with rollers in the groundrope, and 20 mm codend mesh size (ICES, 2015). In 1996, 1999, 2003 and 2004 the R/V *Noruega* was unavailable, and the surveys were conducted by the RV *Capricórnio,* using a FGAV019 bottom trawl net, with a 20 mm cod-end mesh size and a ground rope without rollers. In 2012, no vessel was available to conduct the survey. Those years in which the PtGFS-WIBTS-Q4 survey was conducted with a different vessel and gear were excluded from abundance and biomass analyses (Figueiredo Serra-Pereira, 2013 WD).

The Portuguese crustacean surveys/*Nephrops* TV Surveys (PT-CTS (UWTV (FU 28–29)), also conducted by IPMA, aim to monitor the abundance and distribution of the main commercial crustaceans. The PT-CTS (UWTV (FU 28–29) is conducted on R/V *Noruega*, and uses a FGAV020 bottom trawl with 20 mm cod-end mesh size. No vessel was available to conduct this survey in 2004, 2010 and 2012 (ICES, 2012).

In 2018, updated information on the distribution (presence/absence), biomass and abundance indices and length range for *R. clavata*, *R. montagui* and *L. naevus* was presented (Serra-Pereira and Figueiredo, 2018 WD). In 2016 new information on other species caught in Portuguese research surveys, i.e. *R. miraletus*, *L. circularis* and *D. oxyrinchus* was also presented (Serra-Pereira and Figueiredo, 2016 WD).

19.6.4 Temporal trends

French EVHOE Survey (Subarea 8)

The biomass of *R. clavata* and *L. naevus* show generally the same trend as abundance. In *R. clavata*, peaks were observed in 2007 and 2014 and in *L. naevus* in 2002, 2004 and 2015 (Figure 19.6a-b).

The abundance of *R. clavata* showed no clear temporal trend over the time series, but several peaks were observed in 2001, 2004, 2007, 2008, 2011 and 2014 (Figure 19.6a). For most years, the abundance of *L. naevus* was higher than that of *R. clavata* and fluctuated over time but the overall trend shows an increase since 1997 (Figure 19.6b).; high values were recorded in 2002, 2004 and 2014. The survey was also used to describe the spatial distribution by species over time (see Stock Annex).

Mean length of both species show no clear trend although in the case of *L. naevus* the highest mean length occurs in the last years of the series (Figure 19.6c).

L. naevus is distributed mainly in the northern area (Division 8.a) of the Bay of Biscay near the continental slope. Its abundance from 1987–1994 was lower than in the remaining part of the time series.

R. brachyura is always found near the coast but was recorded only in a few hauls in the north of Division 8.a. This species was not caught between 1991 and 2010.

R clavata is commonly caught in certain fishing hauls. It is distributed mainly in the northern and central areas of the Bay of Biscay, occurring near the coast and also in waters in the middle areas of the continental shelf.

R. montagui is found mainly in the northern waters of Division 8.a and, less frequently, in the northern parts of Division 8.b. As with *R. clavata,* this species occurs near the coast, but can also be found in the middle areas of the continental shelf.

R. undulata occurs only in a few shallow hauls close to the coast. Its distribution goes from the northern parts of Division 8.a to the southern parts of Division 8.b. *R. undulata* was not caught in 1987, 2002, 2003 and 2004.

Spanish IEO Q4-IBTS survey (Divisions 8.c and 9.a)

In 2017, of the five main elasmobranch catches per haul three were skates: *R. clavata* (4.89 kg per haul), *R. montagui* (1.33 kg·per haul) and *L. naevus* (0.56 kg per·haul), (Ruiz-Pico *et al*., 2017 WD). Compared to 2016 in 2017, all these three species decreased the average catches in biomassin the 8.c and 9.a taken together, although there were differences between both divisions. Information below relates to the 2017 survey:

R. clavata: In 2017, the biomass of this species increased six times the value of the previous year in Division 9.a, 1.62 ± 1.48 kg·per haul against 0.25 ± 0.20 kg·per haul in 2016 and it also increased respect to the previous year in Division 8.c, thought more softly (5.53 ± 1.84 kg·per haul against 4.35± 1.43 kg·per haul in 2016) (Figure 19.7a). The ratio of the mean biomass in the last two years (2016–2017) and the previous five years (2011–2015) was 1.08. Thornback ray caught in 2017 showed a wide length distribution as usual, with greater abundance in the eastern part of the Cantabrian Sea (Figure 19.7b). Sizes ranged from 11 cm to 97 cm in the last decade and during the last survey this range increased slightly for larger individual, until 100 cm. The few smallest specimens, between 11 and 19 cm, found in the last decade were also found this last survey for second consecutive year, after the absence in the two previous years (Figure 19.7c).

R. montagui: In 2017 the biomass slightly increased the values of the previous year, 1.62 ± 0.69 kg·per haul versus 1.41 ± 0.63 kg·per haul in 2016 ((Figure 19.8a) 4) and the last two years also increased the biomass of the previous five. This species is scarce in Division 9.a and widespread in Division 8.c as usual (Figure 19.8b). Spotted ray showed a narrower length distribution in the last survey than that showed for the last decade, shortening the range in both the smallest and largest sizes (from 20 to 69 cm versus the range for the last decade from 13 to 84 cm). Two modes are located in 43 cm and also in 52 cm, similarly the last one to the mode found for the last decade (Figure 19.8c).

L. naevus: In 2017, the biomass of this species increased slightly 0.69 ± 0.23 kg·per haul versus 0.45 ± 0.14 kg·per haul in 2016, maintaining the growing trend since 2015 and reaching the highest biomass in the historical series (Figure 19.9a), The species was absent in Division 9.a and widespread in Division 8.c as usual (Figure 19.9b). Length distribution in 2017 (ranged from 20 to 65 cm) remained similar to 2016 and also similar to that of the last decade (from 19 to 72 cm) (Figure 19.9c).

Portuguese surveys (Division 9.a)

Raja clavata (13–110 cm L_T) is found along the coast, from 23–751 m deep, but more common south off Cabo Carvoeiro and in waters shallower than 200 m deep (Figure 19.10a). Biomass and abundance indices have been relatively stable since 2005 and within the average values for the time-series with an increasing trend since 2015 (Figure 19.10b). The values in 2017 were the highest in the time series. Mean annual biomass index for 2016–2017 (0.52 kg per h) was 41% greater than observed in the preceding five years (2011–2015; 0.37 kg per h). The mean annual abundance index for 2016–2017 (1.36 ind. per h) was 91% greater than observed in the preceding five years (2011–2015; 0.71 ind. per h). The length-distribution was relatively stable along the time series, with the mean length above average in the last two years (Figure 19.10c).

Leucoraja naevus (14–65 cm L_T) is found along the coast, from 55–728 m deep, but is more common south of Cabo Espichel and in waters shallower than 500 m deep (Figure 19.11a). Biomass and abundance indices have been variable in the last seven years, with 2014–2015 showing a slight increasing trend within the average values for the time-series (Figure 19.11b). No *L. naevus* were caught in the 2016. In 2017 the species was only caught in one station. The observed lower catches of *L. naevus* does not follow the increasing trend observed in the Spanish (IBTS-GC-Q1-Q4 (ARSA) bottom trawl survey in the Gulf of Cadiz. No technical reason was found for the low catchability observed for the species in the last two years, apart from the later timing of the survey conducted in 2017, July/August instead of May/June (C. Chaves *pers. com.*). Mean annual biomass index for 2016–2017 (0.03 kg per h) was 83% smaller than observed in the preceding five years (2011–2015; 0.15 kg per h). Mean annual abundance index for 2016–2017 (0.06 ind. per h) was 91% smaller than observed in the preceding five years (2011–2015; 0.64 ind. per h). The length-distribution has been relatively variable during the time series, mainly due to higher catches of juveniles in certain years (Figure 19.11c). Mean length has been above the average since 2015.

Raja montagui (21–71 cm L_T) is found along the coast, from 21–400 m depth, but more common off the southwest coast of Portugal, at depths of 40–150 m (Figure 19.12a). Biomass and abundance indices have been stable over the time series, with an increasing trend since 2014–2015 and stable in 2016–2017 (Figure 19.12b). Mean annual biomass index for 2016–2017 (0.19 kg per h) was 32% greater than observed in the preceding five years (2011–2015; 0.14 kg per h). The mean annual abundance index for 2016–2017 (0.51 ind. per h) was 60% greater than observed in the preceding five years (2011–2015; 0.32 ind. per h). The length-distribution was relatively stable along the time-series, with the mean length above the average in 2016 and slightly below the average in 2017 (Figure 19.12c).

Spanish (IBTS-GC-Q1-Q4 (ARSA) bottom trawl survey in the Gulf of Cadiz (Division 9a South)

In the ARSA survey (1993–2015), the most abundant species were *L. naevus* and *R. clavata*. Both species showed an increasing trend in biomass since 1993, with the highest values reached in 2013. Although since 2013 the biomass shows important peaks and valleys the values in 2017 and 2018 remains very stable around 2.5 kg per h for both species (Figure 19.13a).

The abundance index (ind. per hr) of *R. clavata* and *L. naevus*, despite being quite variable both show an increasing trend over the time series since 1993. The highest abundance values of *R. clavata* were recorded in the autumn 2013, 2015, and 2016 surveys, but decreased in 2017. The abundance of *L. naevus* strongly increased since Spring 2016 to the highest values ever recorded in 2017 and 2018 (Figure 19.13b).

19.7 Life history information

Studies on biological aspects, e.g. age and growth, reproduction, diet and morphometry, of the most frequently landed species, such as *R. clavata*, *R. brachyura*, *R. undulata*, *L. naevus* and *R. montagui* caught in Portuguese Iberian waters (Division 9.a) are available. Table 19.7 compiles the main biological information available. New data on the life-history traits of *R. undulata* in the Bay of Biscay were available (Stéphan *et al.*, 2014a). The length of first maturity was estimated to be 81.2 cm for males (n = 832) and 83.8 cm for females (n = 94). Exploratory growth analyses based on increase in size between tagging and recapture of the small number of tagged *R. undulata* for which size-at-recapture was recorded were consistent with growth estimates for the species in Portuguese waters. More information including diet and a trophodynamic model for the northern part of Division 9.a is available in the Stock Annex.

19.7.1 Ecologically important habitats

Recent studies have provided information on ecologically important habitats for *R. clavata*, *R. brachyura*, *R. montagui*, *R. microocellata*, *R. undulata* and *L. naevus* in Portuguese continental waters (Serra-Pereira *et al.*, 2014). Sites with similar geomorphology were associated with the occurrence of juveniles and/or adults of the same group of species. For example, adult *R. clavata* occurred mainly in sites deeper than 100 m with soft sediment. Those were also considered to be habitat for egg-laying of this species. *Raja undulata* and *R. microocellata* occurred preferentially on sand or gravel habitats. Potential nursery areas for *R. brachyura*, *R. montagui* and *R. clavata* were found in coastal areas with rock and sand substrates. Further details are given in the Stock Annex.

Information from trawl surveys on catches of (viable) skate egg-cases is considered valuable to further identify ecologically important habitats. Further information could be collected in trawl surveys.

19.8 Exploratory assessments

Previous analyses of the skates in this ecoregion were based on commercial LPUE data and on survey data. Updated analyses were conducted in 2016 (see below).

18.1.1 *Raja clavata* in the Bay of Biscay

A Bayesian production model was fitted to total catch in Divisions 8.a-b and 8.d and EVHOE survey biomass indices (Marandel *et al.* 2016 WD; Marandel *et al.*, in press). The Cantabrian Sea, Division 8.c was not considered in this assessment.

19.8.1.1 Data used

The longest time series of commercial skate landings available for the Northeast Atlantic comes from the North Sea (Heessen 2003, Walker and Hislop, 1998), while historic landings of skates in the Bay of Biscay are unreliable with missing data for several countries in many years and unrealistic temporal patterns until the late 1990s. Therefore, a hypothetical time series of *R. clavata* landings from divisions 8.a-b,d was created for the period 1903–2013 by assuming that the overall trend between 1903 and 1995 followed that of total skate landings in the North Sea, and thereafter the landings collated by ICES were considered reliable (ICES, 2014). The overall level was set so that landings in 1995 were about the mean of ICES landings in 1996–1999, that is 400 t.

A biomass index was calculated using data from the EVHOE bottom trawl survey in the Bay of Biscay (1987–2014) and from surveys carried out in 1973 and 1976. Post-stratification was used by first delineating the area occupied by *R. clavata* in each year and then calculating the swept area based total biomass in the occupied area. The post-stratified biomass index was strongly correlated to the usual design-based EVHOE index (not available for 1973 and 1976).

19.8.1.2 Methodology

Population dynamics were represented by a standard biomass production model with a Schaefer production function. It was based on a discrete-time sequential equation that represents the biomass dynamics of the population. The biomass at time *t+1* depends on the biomass at time *t*, the production between times *t* and *t +1* and the cumulative catches during the same period. Production was modelled by the Schaefer production function, which integrates biological processes such as recruitment and growth. This production function has two biological parameters: intrinsic growth rate *r* and carrying capacity *K*. The annual biomass distribution was truncated at both ends leading to a censored likelihood by assuming that the mean biomass cannot be much larger than the carrying capacity and that biomass is always higher than the hypothetical landings for a given time period.

As the hypothetical landings were uncertain but not necessarily biased, catches were modelled by a lognormal distribution with mean equal to the hypothetical landings and the variance corresponding to a constant coefficient of variation (CV) of 20%.

The observation model linked population biomass to the biomass index via a constant catchability. The observation error of the observed biomass index was modelled with a lognormal distribution and a constant variance τ^2, i.e. constant CV. It incorporates sampling variability and random variation in catchability.

In the case where instead of a biomass index time series only an observation of a depletion level was available, the observation model was replaced by a truncated normal distribution. The distributions of priors of all model parameters are detailed in Table 19.8.

For the Bay of Biscay, four runs were made using different data combinations and time periods to explore the sensitivity of the model to different data types. For the full run (FULL), the full hypothetical landings time series (1903–2013) and biomass index time series (1973, 1976, 1987–2013) were used in the model. To avoid having to make too many assumptions for reconstructing the catch time series, a run (SHORT) restricted to the recent time period (2000–2013) was also carried out. For this run the prior Y2000 used instead of that for *Y1903* (see Table 19.8). The landings only run (LANDINGS) represented the case where no biomass index was available, or where it was deemed unusable due to poor quality. The fourth run (DEPLETION) represented a situation where no biomass index but an estimate of the final depletion level d_{2014} was available. Given *R. clavata* in the Bay of Biscay is thought to be overexploited, a relatively small value was chosen (d_{2014}=0.1) with a small standard deviation (ε=0.05). These values are somewhat arbitrary but the aim was to compare the biomass trajectories obtained with a biomass index and with only information for the depletion level in the final year.

19.8.1.3 Results

The posterior density functions of carrying capacity, intrinsic growth rate, catchability and initial relative biomass are presented in Figure 19.14. The posterior biomass estimate trajectories of *R. clavata* for the four model runs are shown in Figure 19.15.

Although estimates of carrying capacity are uncertain, model outputs appeared to be in agreement with the generally accepted over-exploitation of the stock. It also suggests that the biomass has been rather stable since the 2000s. The EVHOE index for *R. clavata* is also uncertain, because of the low numbers caught each year. Lastly, the results are conditioned by strong assumption in particular the assumed constant intrinsic population growth rate, which may not be true as seen for spurdog (see Section 2), where a density-dependent increase in fecundity has been observed.

19.8.1.4 Exploration of length-based indicators

A sample of thornback ray landed from fisheries in the Bay of Biscay was measured as part of a French project aiming at a close-kin estimation of the abundance of the stock (http://www.asso-apecs.org/-GenoPopTaille-.html). This length distribution was used to fit the BLI and LBSPR (see ToR h chapter in this report).

19.8.2 *Raja undulata* in Divisions 8.a-b

Under the scope of the RAIEBECA and RECOAM tagging projects, data collected from 2011 to mid-2014 in the Bay of Biscay contributed greatly to knowledge of the spatial distribution, movements and biology of *R. undulata*. The results obtained showed that *R. undulata* can be found all along the Atlantic French coast, from the Loire estuary to the Spanish boarder, forming several discrete ‘hot spots’ of local abundance. The results obtained highly support that perception that this species has high site fidelity, generally only undertaking seasonal movements between deeper (>20 m deep) and shallow waters (Biais *et al.*, 2014; Stephan *et al.*, 2014a, b).

For the Bay of Biscay and Western Channel, information on the reproductive biology (reproductive cycle, length at first maturity, length at 50% maturity ($L_{50\%}$ = 81.2 cm L_T in the Atlantic coast and 78.2 cm L_T in the western English Channel) and conversion factors were also obtained (Stephan *et al*., 2014b). Under the RECOAM project, information on the population genetic structure was analyzed (Stephan *et al*. 2014a, b). For more details on the methodologies and results obtained, see Biais *et al.* (2014); Leblanc *et al.* (2014); Stephan *et al.* (2014a, b) and Delamare *et al.* (2013) WD.

In the Bay of Biscay and in the western English Channel, 48.7% and 58.4%, respectively of the skates marked and released were later recaptured in the same location. Furthermore, 89.7% and 75.3% of the skates marked and released in the Bay of Biscay and in the western English Channel, respectively, were recaptured less than 20 km from their original release location.

Exploratory assessments were presented by Biais *et al*. (2014 WD). A mark–recapture survey provided a biomass estimate in the Bay of Biscay, particularly for the Gironde Estuary and for the stock of larger fish (>65 cm L_T). The habitat surface (Figure 19.16) and estimated density indices (Table 19.9) were used to determine the biomass of fish >65 cm, which ranged between 87–120 t in the whole central part of the Bay of Biscay.

The tagging survey also provided catch-at-age ratios, using the length distribution to get number-at-age, using age slicing based on the von Bertalanffy growth curve parameters estimated by Moura *et al*. (2007) for the Portuguese stock. Ages between 9 and 10 were considered unaffected either by the gear selectivity, or by a possible decrease in vulnerability to the longline of the larger fish, at least in November–December (Table 19.10). The ratio obtained provided an estimate of total mortality-at-age 4 in 2008, before the landing ban, and of the fishing mortality (0.17) using the natural mortality estimate as 0.27 from central Portugal (Serra-Pereira *et al*., 2013 WD), assuming that fishing mortality was negligible after the ban implemented in 2009.

Abundance-at-ages 4 and 5 in 2008 were estimated using the mark–recapture abundance estimates at ages 10 and 11 at the beginning of 2014 (ages 9 and 10 at the end of 2013) and considering that fishing mortality-at-age 5 is similar to age 4 in 2008 and that the population was subject to natural mortality only from 2009 onwards.

Based on these estimates, catch and spawning biomass may be estimated in 2008 and in following years, making assumptions about the fishing mortality pattern in 2008. The aim was to investigate the biomass trend since the 2009 landings ban and the consistency of mark–recapture estimates regarding in particular the 2008 catch for which a second estimate was available (Hennache, 2013; cited by Delamare *et al*., 2013 WD). The simulations were carried out for the low and the high abundance estimates which were provided by the mark–recapture survey (Table 19.11).

A flat selectivity-at-age was adopted above age 7, assuming that fish large than 73 cm L_T were subject to the same catchability. Fishing mortality-at-age 6 was fixed to the average of fishing mortalities-at-ages 5 and 7 to smooth the transition between these ages.

Fishing mortalities-at-ages 3 and younger ages were assumed negligible considering that these ages are all discarded and may have high survivorship.

Under these assumptions, fishing mortality-at-age 7 is the only missing parameter to estimate the stock numbers at all ages in 2008 from stock numbers-at-ages 5 and 6. It was estimated assuming that recruitment at age 0 was lower than the estimate of egg number released by the females, calculated using the sex ratio observed in tagging surveys and fecundity estimates from Portuguese waters (Figueiredo *et al*., 2014 WD). This constraint requires that the fishing mortality-at-age 7 is less than 0.76 for the low as well as the high abundances-at-ages 5 and 6 estimated from the mark–recapture survey.

The corresponding catches are 43 t and 60 t in 2008, depending on whether the low or the high abundances-at-ages 5 and 6 are used. Catch in 2008 was estimated between 60 and 100 t by Hennache (2013), using fish auction market data (cited by Delamare *et al*., 2013 WD). This latter catch is consequently estimated too high and/or the abundances are underestimated by the mark–recapture survey.

To estimate stock numbers in 2015, constant recruitment was assumed. The spawning–stock biomass was estimated by adopting a knife edge maturity-at-age derived from available age-at-maturity available (Stephan *et al*., 2014a WD). Note that the constant recruitment assumption has no effect on the spawning biomass trend from 2008 to 2015 as maturity is estimated to occur at age 8. At half of the higher fishing mortality-at-age 7, the spawning biomass was estimated to have been multiplied by 4 for both the high and low assumed fishing mortalities (to about 190 t or 270 t respectively for the low and high abundance estimate). These absolute spawning stock biomass estimates are sensitive to abundances estimated by the mark–recapture survey, but the increasing trend in spawning biomass is not.

However, these results must be considered with caution, as several assumptions were made, including the 100% effectiveness of the ban on landing associated with a high survivorship of discards implied by the zero fishing mortality from 2009 to 2015.

19.9 Stock assessment

ICES provided stock-specific advice in 2016 for 2017 and 2018. Given the limited time range of species-specific landing data, and that commercial and biological data are often limited, the status of most skate stocks in this ecoregion is based primarily on survey data, following the Category 3 of the ICES approach to data-limited stocks. Further analyses of survey data (see Section 19.6) and catch rates were undertaken. Due to the absence of survey data for some of the species in this ecoregion (e.g. rjh.27.9a, rju.27.9a), other approached were adopted for the advice (e.g. LPUE or self-sampling data).

In this section, data and analyses are summarized by stock units for which ICES provides advice. No updated assessments were undertaken in 2017, with the information below relating to work conducted in 2016. The next assessments and advice are scheduled for 2018.

19.9.1 Thornback ray (*Raja clavata*) in Subarea 8 (Bay of Biscay and Cantabrian Sea) (rjc.27.8)

In the Spanish IEO Q4-IBTS survey the biomass of the most abundant ray in the area, *Raja clavata,* showed an increasing trend in 2017.

The indicator of occurrence by haul of net set based upon French on-board observations was updated. It shows that *R. clavata* is caught in a significant proportion of hauls only by the OTT_DEF métier, which operates mainly offshore in the Bay of Biscay. For this métier, the indicator suggested an increasing trend since 2007 (Figure 19.16a). The occurrence in other métier is lower and does not show clear signal.

Supporting studies using data from French on-board observations, showed that *R. clavata* is caught in a significant proportion of hauls only by the OTT_DEF métier, which operates mainly offshore in the Bay of Biscay. The indicator suggested an increasing trend (Figure 19.17a). For this stock, however, on-board observations may not sample effectively some of the coastal sites of local abundance that occur in some bays and estuaries, such as the Gironde.

Marandel *et al*. (2016 WD) developed a Bayesian state-space model with landings and limited survey (EVHOE) data to estimate population biomass in the Bay of Biscay. This exploratory assessment concluded that the estimated biomass of *R. clavata* in 2014 was *ca.* 3% of carrying capacity. However, this conclusion should be made carefully because indices of abundance and biomass per year from the EVHOE survey can be highly variable for *R. clavata*, so may not be robust, and there is also uncertainty in the longer time-series of landings data.

A larger sample of tissue (fin clips) of landed thornback ray was collected in the Ifremer GenoPopTaille project, funded by the National Agency for Research (ANR). The length distribution of this sample was considered representative of landings from Divisions 8.ab and 8.d and used for exploratory length-based indicators (LBI and LBSPR, see ToR h chapter in this report). The length-distribution in this sample was not compared to data from Division 8.c.

19.9.2 Thornback ray (*Raja clavata*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz) (rjc.27.9a)

The status of this stock is evaluated based on survey data derived from the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4; Figure 19.9) and the Spanish ARSA survey in Gulf of Cadiz (SpGFS-GC-WIBTS-Q1 and SpGFS-GC-WIBTS-; Figure 19.12b and 19.13a). The biomass index from the PtGFS-WIBTS-Q4 was stable over the overall series. Both ARSA surveys series indicate a long-term increasing trend (from 1997–2017 and 2018 with a stable biomass status since the Spring 2017).

Combined survey data suggest an increasing trend since 1997 with maximum values observed in the most recent years of the series. Following the ICES DLS approach for Category 3 stocks, the annual trend on the combined surveys (each survey scaled to their average for the overall period) has increased consistently for the overall period.

The ratio between the average biomass index for the last two years (2016–2017) and the average of the biomass index for the reference period (2011–2015) was 1.19.

Auxiliary information provided by the Spanish IEO Q4-IBTS survey in 9a North, where *Raja clavata* is the most abundant ray caught in the area, also showed an increasing trend in the biomass. Due to the irregular catches of *R. clavata,* this survey is not used in the assessment.

19.9.3 Cuckoo ray (*Leucoraja naevus*) in Subareas 6-7 (Celtic Sea and West of Scotland) and Divisions 8.a-b,d (Bay of Biscay) (rnj.27.678abd)

This stock is addressed in Section 18.

19.9.4 Cuckoo ray (*Leucoraja naevus*) in Division 8.c (Cantabrian sea) (rjn.27.8.c)

In Division 8.c, the catch rates in the Spanish IEO Q4-IBTS survey showed an important increase (0.67 kg·per haul) in 2017; higher than in the two precedent years (Figure 19.9a). Cuckoo ray length-distribution in 2017 remained similar to the last decade, (Figure 19.9c).

Although this year ICES has not been requested to provide advice on fishing opportunities for this stock, the ratio between the mean biomass index for the last two years (2016–2017) and the mean biomass index for the reference period (2011–2015) was 1.37.

19.9.5 Cuckoo ray (*Leucoraja naevus*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz) (rjn.27.9a)

The status of this stock is evaluated based on survey data from the Spanish ARSA surveys in Gulf of Cadiz (Q1 SP-GCGFS and Q4 SP-GCGFS).

Both ARSA surveys series indicate a long-term increasing trend, with the highest records of abundance and biomass in 2017 and 2018

Although this year ICES has not been requested to provide advice on fishing opportunities for this stock, the ratio between the mean biomass index for the last two years (2016–2017) and the mean biomass index for the reference period (2011–2015) was 1.43.

Although not used in the assessment, due to some missing values in recent years, the data series from the PT-CTS (UWTV (FU 28–29) also indicates an overall stable trend (Figure 19.10b).

19.9.6 Spotted ray (*Raja montagui*) in Subarea 8 (Bay of Biscay and Cantabrian Sea) (rjm.27.8)

The biomass index for *R. montagui* in the Spanish IEO Q4-IBTS survey is the highest recorded in Division 8.c since 2014 (Figure 19.7b).

The ratio between the mean biomass index for the last two years (2016–2017) and the mean biomass index for the reference period (2011–2015) was 1.18.

Supporting studies using data from French on-board observations indicate that *R. montagui* is observed in a small proportion of hauls. There have been more records in recent years (Figure 19.16b). The reliability of this potential indicator may, however, be undermined by confusion between *R. brachyura* and *R. montagui*.

Raja montagui is caught sporadically in the EVHOE survey, mostly in the north (Figure 19.18). The occurrence of this species in the survey does not suggest any recent change in abundance (Figures 19.19).

19.9.7 Spotted ray (*Raja montagui*) in Division 9a (west of Galicia, Portugal, and Gulf of Cadiz) (rjm.27.9a)

The status of this stock is evaluated using data from the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4). The biomass and abundance indexes have been stable along the time-series, with an increasing trend in 2014–2015 and stable in 2016–2017 (Figure 19.12b). The length distribution was relatively stable along the time-series, with the mean length above the average in 2016 and slightly below the average in 2017 (Figure 19.12.c).The ratio between the average biomass index for the last two years (2016–2017) and the average biomass index for the reference period (2011–2015) is 1.32.

The time-series for *R. montagui* in the ARSA surveys is erratic and with many gaps in recent years with an important peak in the biomass and abundance values in 2016 and 2017. There are no records of this species in the Spanish IEO Q4-IBTS survey in Division 9.a over the whole time-series. These surveys are not used in the assessment.

19.9.8 Undulate ray (*Raja undulata*) in Divisions 8a,b (Bay of Biscay) (rju.27.8ab)

The EVHOE survey is uninformative for this stock because the distribution of *R. undulata* is more coastal than the area surveyed. Exploratory assessments were presented by Biais *et al*. (2014 WD) and summarized in Section 19.8.2.

Data collected from the French on-board observation programme indicated that *R. undulata* is caught in a high proportion of hauls in three métiers. The numbers of observations by métiers catching the species are unbalanced. The main métier catching *R. undulata* was GTR_DEF, and data suggested a steady increase in occurrence. This is based upon more than 4000 observations (Figure 19.16c). The three other selected métiers have either a high occurrence of the species with a moderate on-board observations sample size (OTB_SEP, OTB_DEF) or a low occurrence and a high total number of observations (GNS_DEF). No trend was apparent in these métiers.

The trend seen in GRT_DEF is likely the most representative of the stock, because there is a large sample size, the spatial distribution of sampled fishing operations has been fairly stable, and effort covers the main areas of occurrence of the species during the period (Figure 19.20).

19.9.9 Undulate ray (*Raja undulata*) in Division 8.c (Cantabrian Sea) (rju.27.8c)

There are no longer-term survey data to assess temporal trends in this stock.

Scientific studies carried out in the eastern parts of Division 8.c have been conducted to characterize the specific composition of the landed skates, the species-specific CPUE and the geographical distribution of the catches (Diez *et al.*, 2014). During the period 2011–2013, up to 118 trips/hauls of 21 vessels of the trammel net fleet from the nine main ports of the Basque Country were sampled. *Raja undulata* was the fifth most important species caught (5% of the total).

Whilst the total estimated ICES landings from 2005–2014 were 0 t, this period covers several years for which species-specific data were not required and then a period for which *R. undulata* could not be landed legally. Following relaxation of the prohibited status in 2015, and allowance for small quantities of bycatch to be landed, landings of 5 t were reported.

The historical landings data is uninformative and unrepresentative of population levels. According to fishing interviews, this species is locally frequent and widely distributed in the coastal waters of Division 8.c, although not very abundant in catches. This situation may not have changed over the years.

R. undulata is very scarce in the Spanish IEO Q4-IBTS survey in Division 8c and usually lower than 0.1 kg per haul in any year of the series. This due to the fact this species is distributed mainly out of the surveyed ground, in shallower areas not covered because they are not accessible to the vessel and the gear used.

19.9.10 Undulate ray (*Raja undulata*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz) (rju.27.9a)

Raja undulata is absent in the Spanish IEO Q4-IBTS survey in Division 9a and rarely caught in the Portuguese demersal survey (PtGFS-WIBTS-Q4).

The compiled data on this species (Pilot Study on Skates included in DCF) for the period 2011–2013 showed that the species has a patchy distribution along the Portuguese continental coast, and it is locally frequent in specific coastal areas. Along the Portuguese continental waters, the species is more abundant between 30–40 m deep.

Biological data and the relative high discard survivorship indicate that the resilience of the species to exploitation compared to other skate species is at relatively high level.

Given the patchy distribution of the species, the adoption of local management measures e.g. no fisheries on the hotspots of species concentration, will allow the monitoring of the stock.

In the Portuguese official landings, *R. undulata* was landed under a generic category that encompasses several skate species. This situation thus limits the use of Portuguese official landings to evaluate historical landings of the species.

Under the UNDULATA Project, landings of *R. undulata* for the period of 2003–2008 were estimated. The data used consisted on the landed weight by skate species, including *R. undulata*, collected from vessel trips sampled between 2003–2009 at the main Portuguese landing ports: Matosinhos, Póvoa do Varzim, Peniche and Portimão (DCF Portuguese program). The relative weights of *R. undulata* landed at each landing port for each of two main fishing segments (trawl and polyvalent) were estimated annually. The posterior relative weight median estimates, as well as the posterior interquartiles, were obtained through the adjustment of a Bayesian hierarchical GLM model using the sampling data available for each year and port. These estimates were then used to determine Portuguese historical annual landings of *R. undulata*. Due to the localized distribution of the species, in particular close association to shallow sandy bottom, landing ports along the Portuguese continental were first grouped based on the topography and bottom type off their adjacent coastal areas. For each cluster, historical annual landings of *R. undulata* were calculated using the posterior estimates of relative landing weight of the species and the total Rajidae landings. The annual median estimates of *R. undulata* landed in Portugal mainland as well as the interquartile estimates are presented in Figure 19.20 and Table 19.12.

The mark–recapture programme under the UNDULATA project was implemented at Setúbal and Sesimbra (Centre of Portugal), and area where *R. undulata* is concentrated (providing further evidence that it forms local populations). In this region, the main seabed sediment is composed of clean fine sand. There are also areas with mixed type sediments such as mud, gravel and shells (EMODnet Seabed Habitat database http://www.emodnet-seabedhabitats.eu/). Initially a robust sampling design was adopted for the mark–recapture programme design that involved two main tagging periods, followed by a continuous monitoring of the area. In both cases, fishing vessels from Setúbal and Sesimbra were considered as the sea platforms to execute the program. The data collected from the tagging programme were considered insufficient to proceed with the analysis using tag/recapture methods.

Nevertheless, the information collected on board fishing vessels was used to estimate the abundance of *R. undulata* in the study area. An N-mixture model of spatially replicated counts (Royle, 2004) was used to estimate the density based on data of the number of specimens caught at fishing hauls performed by fishing vessels using trammel nets with mesh size <100 mm. The density estimates (number of specimens per square meter) increased from south to north and from west to east (see inset of Table 19.13). Estimates of *R. undulata* abundance for each sub-region and of catchability are presented in Table 19.13 (Figueiredo *et al.*, 2015 WD).

19.9.11 Blonde ray (*Raja brachyura*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz) (rjh.27.9a)

This is a coastal species with a patchy distribution that is caught infrequently by both Spanish and in Portuguese surveys in Division 9.a (usually lower than 0.1 kg per haul in any year of the series). Consequently, abundance indexes derived from these surveys are not considered indicative of stock status. In this case, the status of the stock is assessed based on fishery-dependent data (landings, effort and length structure).

Annual standardized LPUE estimates determined for Portuguese polyvalent fleet (this fleet represents nearly 90% of the species total landings) for the period 2008–2015 do not show any trend.

The yield per recruit (Y/R) and potential spawning ratio (%SPR) curves at long term for different levels of fishing mortality and age of first capture (TC) were estimated using the polyvalent fishing data as described in the Stock Annex.

The actual F (F_{CURR} = 0.17) is at a level correspondent of about 30% of the virgin exploitable spawning biomass ($F_{30\%SPR}$ = 0.15) indicating that the stock has been exploited at a sustainable fishing rate (Figure 19.21).

19.9.12 Common skate *Dipturus batis*-complex (flapper skate *Dipturus batis* and blue skate *Dipturus* cf. *intermedia*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters) (rjb.27.89a)

Recently *D. batis* has been confirmed to comprise two species, and although the nomenclature is still to be ratified, the smaller species (the form described as *D. flossada* by Iglésias *et al.*, 2010) will probably remain as *Dipturus batis* and the larger species may revert to *D. intermedia.*

These species are only caught occasionally in Subarea 8 and might not occur to any degree in Division 9.a.

Despite the *Dipturus batis*-complex being prohibited in EU regulations, some individuals were landed occasionally in French and Spanish fish markets in Subarea 8. In France, sampled specimens in fish markets included an adult female *Dipturus* cf. *intermedia* (200 cm L_T) - a southerly record of the species in recent years; and small individuals of *Dipturus batis* caught at the Glénan archipelago (southern Brittany). As these species are now extirpated from inner shelf areas of their former range, fishermen are not always able to identify them accurately. Available information does not change the perception of the stock status of these species that occur at low levels in this ecoregion.

Differing to other areas, *D. oxyrinchus* was included in 2016 and in 2018 advice for the raj.27.89a and not for rjb.27.89a. It is important to highlight that all landings of the genus *Dipturus* from Portugal in Division 9.a refer to *D. oxyrinchus*, for Spain and France official landings of *D. oxyrinchus* were considered to be correctly identified and all the remaining official landings of the genus *Dipturus* from this ecoregion were allocated to *Dipturus* spp., as species identification problems persist among species of the genus *Dipturus* (Figure 19.22).

19.9.13 Other skates in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters) (raj.27.89a)

Sandy ray *Leucoraja circularis* occurs on the deeper shelf and along the slope of the Bay of Biscay and in minor abundance in Portuguese landings. Minor occurrences of the shagreen ray *Leucoraja fullonica* are also observed to the North of Division 8.a, but this species is largely absent from Division 9.a. Owing to the higher abundance of these two species in the Celtic Seas, the Bay of Biscay may comprise the southern limits of the Celtic Sea stocks.

In divisions 8.a-b, occasional catches of *Raja brachyura* and *Raja microocellata* are found at the coast by artisanal fisheries. These two species are scarce in the historical time-series of the Spanish IEO Q4-IBTS survey in divisions 8.c and 9.a.

All four of these species are caught in too small numbers in the EVHOE survey to calculate reliable population indices.

In Division 9.a, *Raja microocellata*, *Raja miraletus* and *D. oxyrinchus* appear occasionally in landings. The two latter species are caught in low numbers in Portuguese surveys.

As mentioned in the previous section, landings allocated to *D. oxyrinchus* were included in this stock.

19.9.14 Summary of the status of skates stocks in the Bay of Biscay and Atlantic Iberian waters

The following table provides a summary of stock status for the main species evaluated in 2016 and using ICES DLS approach.

SPECIES	ICES STOCK CODE	ICES DLS CATEGORY	PERCEIVED STATUS
Thornback ray *Raja clavata*	rjc.27.8	3	Survey indices increasing in Subarea 8
	rjc.27.9a	3	The stock size indicator shows an increasing trend since 1999
Cuckoo ray *Leucoraja naevus*	rjn.27.67	3	The stock size indicator, has been relatively stable with an increase in recent years.
	rjn .27.8c	3	The stock size indicator has been fluctuating with no trend
Spotted ray *Raja montagui*	rjm.27.8	3	The stock size indicator is variable. Recent survey estimates are among the highest of the series
	rjm.27.9a	3	The stock size indicator has increased and in the 2015 was the highest in the time-series.
Undulate ray *Raja undulata*	rju.27.8ab	6	Survey data are not informative for this stock
	rju.27.8c	6	Survey data are not informative for this stock
	rju.27.9a	6	Survey data are not informative for this stock
Blonde ray *Raja brachyura*	rjh.27.9a	3	The stock size indicator is stable in relation to five previous years
Common skate *Dipturus batis* complex	rjb.27.89a	6	Data are available do not inform on stock dynamics, species composition, catch, or landings. There are currently no robust stock size indicators.
Other skates	raj.27.89a	6	There are insufficient e data available to assess these species. The decline in landings is due primarily to the improved species-specific reporting.

19.10 Quality of assessments

No full analytic stock assessments have been conducted for skates in Subarea 8 and Division 9.a.

LPUE data for *L. naevus and R. clavata* are available for Divisions 8abd since 2001. Since 2008 LPUE were available for *R. clavata*, *R. microocellata*, *R. montagui*, *R. undulata* and *R. brachyura* in Division 9.a.

In the last five years, a lot of effort has been made by the countries involved in the demersal elasmobranch fisheries on this ecoregion to provide species-specific landings of skates. As a result of this improvement in the data, 19 different species have been identified (plus a general category "Rajidae") from catches in Subareas 8 and 9. A summary of the information available of the species-specific landings of skates by country is shown in Tables 19.1f and 19.2.

The French DCF programme of on-board observations was used as supporting information to appraise temporal trends in the stocks abundance. Abundance was assessed by the proportion of fishing operations (trawl haul or net set) with catch (discards, landings or both) of the species in the stock area from 2007–2015. Fishing operations were aggregated by DCF level 5 métiers. The four top ranking métiers (limited to those with more than 50 sampled hauls) were used to indicate stock status.

As for surveys in other ecoregions, surveys in Subarea 8 and Division 9.a were not specifically designed for elasmobranchs, producing a high frequency of zero-catch data. The fishing gear used and survey design are not the most appropriate to sample elasmobranchs, especially for species with patchy distributions. The survey effort in coastal areas is very scarce and does not cover a wide range of depths. Nevertheless, for some species, it is possible to estimate some valuable abundance data and by that derive temporal trends on abundance.

Efforts have been made to overcome these data limitations in order to standardize the fishery-independent abundance indexes, using as an example the estimates for *R. clavata* data from the autumn survey (PTGFS-WIBTS-Q4) in Division 9.a (Figueiredo and Serra-Pereira, 2013 WD). To deal with the large amount of zero-catches a generalized linear mixed model (GLMM) was fitted to the data, assuming a Tweedie distribution for the observations. One of the main purposes of applying a GLMM was to incorporate in the model variables that could account for differences between years, namely the difference between stations, depths, survey methodology, etc. Some decisions/assumptions had to be taken in order to proceed with the analysis of the data, including the determination of a subset of the available data which is better represents the geographical distribution of the species.

Tagging studies of *R. undulata* have shown that the distribution of this species is discontinuous, confirming the 2013 tagging results and the need to assess the state of the stocks of this species for areas that fit with the limited movements that this species may make. This behavior may be a benefit for obtaining mark–recapture stock estimate as the one provided for central part of the Bay of Biscay. Results allow an exploratory analysis including a lot of assumptions. Consequently, it must be regarded as only indicative of the biomass trend.

19.11 Reference points

No reference points have been proposed for the stocks in this ecoregion.

19.12 Conservation considerations

Initial Red List assessments of North-east Atlantic elasmobranchs were summarized by Gibson *et al.* (2008). In 2015, the European Red List of Marine Fishes was published (Nieto *et al.*, 2015), and relevant listings given below (noting that these are on a Europe-wide scale for each species, and are not stock-based):

Species	IUCN Red List Category
Dipturus batis	Critically Endangered
Rostroraja alba	Critically Endangered
Leucoraja circularis	Endangered
Leucoraja fullonica	Vulnerable
Dipturus oxyrinchus	Near Threatened
Raja brachyura	Near Threatened
Raja clavata	Near Threatened
Raja microocellata	Near Threatened
Raja undulata	Near Threatened
Leucoraja naevus	Least Concern
Raja miraletus	Least Concern
Raja montagui	Least Concern

19.13 Management considerations

A TAC for skates in this region was only introduced in 2009, along with requirements to provide species-specific data for the main commercial species (initially *L. naevus* and *R. clavata* and, since 2013, *R. brachyura*). Consequently, there is only a relatively short time-series of species-specific landings. In the case of Portugal, estimates of species-specific landings, based on DCF sampling data, are available since 2008.

Landings of *Raja undulata* were not allowed between 2009 and 2014 (inclusive) with a bycatch allowance only established for Subarea 8 since 2015, which was then extended to Division 9.a. in 2016. Consequently, landings data for *Raja undulata* are not indicative of stock status. However, landings and discards data could be indicative of stock status for this species along with several monitoring's years according to self-sampling program (French and Portuguese) in these areas.

Currently, fishery-independent trawl survey data provide the longest time-series of species-specific information. These surveys do not sample all skate species effectively, with more coastal species (e.g. *R. brachyura, R. microocellata* and *R. undulata*) not sampled representatively.

The status of more offshore species, such as *L. circularis* and *L. fullonica*, are poorly understood, but these two species may be more common in the Celtic Seas ecoregion (see Section 18).

Some of the larger-bodied species in this ecoregion are from the genus *Dipturus*, but data are limited for all these species, with some potentially more common further north.

19.13.1 Fishery-science projects to estimate abundance of *Raja undulata* stocks

In 2015, a monitoring plan for *R. undulata* was required by WGEF. This would involve the design of a fishery scientific survey (e.g. sentinel fishery) which would function in cooperation with commercial fishermen in particular small-sized vessels and inshore where the species tend to concentrate. A detailed description of the sentinel fishery regarding main aspects in the sampling plan design and data requirements was presented in ICES WGEF Reports 2015 and 2016.

Data requirements are summarized below:

Vessel	Vessel name and registration number Vessel technical characteristics (e.g. LOA, tonnage, power, etc.) Registration port Skipper identity and experience
Trip	Date and time of departure/arrival Fishing port of departure/arrival Observer's Identification
Environment condition	Tidal state, sea conditions (e.g. wave height, wind strength) Water temperature
Gear characteristics	Gear type, state (new, good state) For gillnet and trammelnets: length and height in meters, mesh in millimeters, number of net units, length of a net unit sheet For longline: length in meters, number, size and type of hooks, type of bait For trawl, dredge: gear dimensions, mesh size, trawling speed, presence of tickler chains, description of gear
Fishing haul	Operation ID Date/time of gear deployment and retrieval Geographic location of the fishing haul (including set and hauling) Fishing depth Soaking/trawling time
Biological data	From all the target species, data collected should include: Coordinates of the capture location Biometric measurements such as total length (from nose to tip of tail), width (from one wing to the other) and body weight Health status (lively, sluggish or dead) Sex Maturity stage (whenever possible) Collected tissue samples of specimen (if from live fish, in accordance with appropriate animal welfare protocols) Survivorship of discarded individuals If marked, the number of the mark should be recorded

19.13.2 Monitoring of *Raja undulata* captures

In 2016, Council Regulation (EU) 2016/458 of 30 March 2016 amended Regulations (EU) 2015/523 as regards individual TACs for *R. undulata* in ICES Divisions.

The use of these *R. undulata* individual quotas is guided by scientific protocols *"to ensure the continuity of scientific studies and to assess the state of the resource and ensure, in the future, its sustainable exploitation"* (COUNCIL REGULATION (EU) 2016/72 of 22 January 2016). Under this regulation, only vessels possessing a compulsory fishery license were allowed to catch *Raja undulata*. Simultaneously, licensed vessels are obliged to record information on species captured by fishing haul and report it to national agencies (Direction des Pêches Maritimes et de lAquaculture, DPMA) of the French Ministry for Agriculture and Fisheries and to the General Directorate for Natural Resources, Safety and Maritime Services (DGRM) in France and Portugal respectively).

Portugal:

A by-catch quota of 12 t was established for *R. undulata* in Portuguese continental waters. The use of this quota was then regulated by Portuguese legislation (Portaria no 96/2016, of 19 April 2016). The Information to be collected by fishermen includes: i) date of the fishing haul; ii) fishing haul geographic locations; iii) fishing haul technical characteristics (number and mesh size of the gear and duration); iv) total catch in number and in weight; v) total number of specimens with total length smaller than 780 mm and larger than 970 mm; and vi) number of reproducing females (not mandatory). In 2016, a total of 49 fishing permits were attributed to vessels, from 10 different fishing associations, distributed along the Portuguese continental coast. The following table summarizes the number of reported fishing hauls from each region by month:

Region	**Month**					
	Aug	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
North	0	0	1	0	0	1
Centre	59	98	96	55	5	313
Southwest	42	44	41	24	37	188
South	4	10	0	0	0	14
Total	105	152	138	79	42	516

Data from centre and southwest regions were preliminarily analysed. A total of 313 (305 performed with trammel nets and 8 with gillnets) and 186 (130 performed with trammel nets and 56 with gillnets) fishing hauls were reported for the centre and southwest regions respectively. The preliminary analysis only considered trammel nets, as the number of gillnets hauls was low. In both regions, preliminary results considering trammel nets showed that the species is mainly caught in depths < 50 m deep and the number of individuals per haul were higher in hauls closer to shore. Mean effort (using soaking time as unit) and mean CPUE (determined as the mean of the ratios of catch by the fishing effort for each haul) were estimated for two groups of mesh sizes, < 150 mm and > 150 mm, considered to display different catchability:

Region	**Effort unit**	**Trammel nets mesh size (mm)**	**Number of hauls**	**Mean effort**	**Standard deviation**	**Mean CPUE**	**Mean distance to coast**
Centre	Soak time (h)	<150	65	8.65	3.07	0.45	3608.0
		>150	25	14.04	3.79	0.41	2676.5
South-west	Soak time (h)	<150	90	14.40	6.14	1.42	1153.2
		>150	31	24.83	7.12	0.54	2096.3

It is important to note that the data collected under the present legislation are by-catches of *Raja undulata* derived from hauls in areas targeting other species. Regardless of this, all the information gathered clearly suggests that the species is not uniformly distributed but has a patchy distribution. It is likely that the abundance of the species is higher at other fishing grounds located in more favourable habitats. This is also evident by looking at the high variability of the CPUEs within and between regions (Figure 19.23). The CPUE between the centre and southwest regions show differences in abundance; higher abundances are registered in the southwest. These differences are in agreement with what is known to be the habitat preferences of the species. At the southwest region, the sandy bottom area is more extended than in the centre, which is mainly characterized by the existence of pocket beaches.

It is important to note that the available time series is short but can be considered a starting point for the monitoring of the species stock status. With the development of the monitoring plan for the species, and with the collection of more geo-referenced data on abundance, together with data on the species distribution along the Portuguese coast, it will be possible to estimate the exploitable biomass.

During the first year of licensing, some fishermen appear to have misunderstood the information required. In particular, in what concerns hauls where the species was not caught, as they did not provide information for those hauls. The role of fishermen in the monitoring process is a key element and they need to be aware of their importance on the process, in particular in providing reliable information. Some of the weaknesses identified on the first fishermen' reports are expected to be overcome in the second year, particularly in what concerns the lack of the length data from which F_{msy} proxies are expected to be derived.

France:

First results are described in more detail in Gadenne (2016 WD).

The data collected during the self-sampling 2016 monitoring program indicate that 64 vessels participated in the protocol out of 125 authorizations issued. A total of 7079 hauls were reported, but only 64% were considered valid for analysis.

In 2016, a total of 41.5 t were landed and 117.7 t were declared discards. They were captured by 7 types of fishing gear (GND, GNS, GTR, LL, LLS, OTB, OTT).

In the list of 26 authorized gears, seven gears were used by vessels participating in the self-sampling, with bottom trawls (OTB) and trammel nets (GTR) being predominant. Considering the average weight caught by fishing haul, nets (trammel and gillnets) and longlines appear to be the most suitable gears for catching Undulate ray. However, longlines showed a higher rate of discards (85%), followed by trawls (~76%).

Data indicate that the species by-catch is mainly coastal in the Bay of Biscay. The monthly evolution of catches raises questions about high catch rates in the first months of the year compared to the rest of the self-sampling period. Following the protocol carefully and consistently over time is an essential condition to validate the trends observed.

In conclusion, the main benefit of this self-sampling program is the possibility of quantifying landings, discards and fishing effort for the species, which are crucial for proper stock evaluation and management.

19.14 References

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Table 19.1a. Skates in the Bay of Biscay and Iberian Waters. Nominal landings (t) of skates by division and country (Source: ICES). Total landings (t) of Rajidae in Divisions 8.a-b.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	12	15	9	9	12	4	9	4	6	8	5	4	3
France	2405	1960	1884	1799	1693	1461	1294	1202	1179	1349	1541	1220	1322
Netherlands					0								
Spain	423	334	408	428	295	190	247	235	242	243	212	262	210
UK	10	40	7	4	0	0	1	2	0	0.119	43	0	0
Ireland											35	28	
Norway		15	4										
Total	2850	2364	2312	2239	2000	1656	1551	1443	1427	1601	1836	1514	1534

*** Included in Spanish landings; * * Includes 8d.**

Table 19.1b. Skates in the Bay of Biscay and Iberian Waters. Total landings (t) of Rajidae in Division 8.d.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France	110	63	71	94	72	68	71	76	57	66	61	44	32
Spain	16	10	16	8	0	1	2	2	8	6	6		0
UK				0	0	0	1	0	0	0			
Ireland								0					
Total	127	73	86	103	72	69	74	78	66	72	66	44	32

Table 19.1c. Skates in the Bay of Biscay and Iberian Waters. Total landings (t) of Rajidae in Division 8.c.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France	1	0	1	0	0	0	1	1	0	2	0	0	0
Spain	177	194	420	433	533	551	663	654	608	528	364	407	377
Total	178	194	421	433	533	552	663	655	608	530	364	408	377

*** Included in Spanish landings.**

Table 19.1d. Skates in the Bay of Biscay and Iberian Waters. Total landings (t) of Rajidae in Division 9.a.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France					1						0		
Portugal	1303	1544	1444	1439	1444	1454	1425	1122	1104	1026	1012	1026	1138
Spain	301	283	139	134	276	409	429	468	481	455	253	304	348
Ireland					0								
Total	1604	1827	1583	1573	1721	1863	1853	1590	1585	1481	1265	1330	1487

Table 19.1e. Skates in the Bay of Biscay and Iberian Waters. Combined Landings (t) of Rajidae in Biscay and Iberian Waters.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	12	15	9	9	12	4	9	4	6	8	5	4	3
France	2517	2023	1955	1893	1766	1529	1367	1279	1236	1418	1602	1265	1354
Netherlands					0								
Portugal	1303	1544	1444	1439	1444	1454	1425	1122	1104	1026	1012	1026	1138
Spain	918	823	985	1004	1104	1152	1342	1359	1339	1233	835	973	935
UK	10	43	8	4	1	0	1	2	0	0	43	0	0
Ireland				0	0			0			35	28	
Norway		15	4										
Total	4760	4462	4405	4349	4327	4140	4144	3766	3686	3685	3532	3296	3430

Table 19.1f. Skates in the Bay of Biscay and Iberian Waters. Combined Landings (t) of Rajidae in Biscay and Iberian Waters. Landings by ICES stock and country since 2005. Totals by country are presented in bold.

Country	ICES Stock name	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium		**12**	**15**	**9**	**3**	**4**	**2**	**5**	**2**	**3**	**3**	**2**	**2**	**1**
	raj.27.89a	12	15	9	1	2	1	2	0	1	0	1	0	0
	rjc.27.8				2	2	1	2	2	3	3	1	2	1
	rjh.27.9a													0
	rjm.27.8				0	0	0	0	0					0
France		**1226**	**1096**	**952**	**911**	**654**	**549**	**446**	**419**	**482**	**569**	**574**	**494**	**609**
	raj.27.89a	783	662	610	613	391	244	175	151	179	238	202	181	243
	rjb.27.89a	11	5	3	5	1	0	0	0	0	0	0	0	0
	rjc.27.8	276	300	215	187	195	217	178	179	194	202	212	166	191
	rjm.27.8	155	130	124	106	64	86	91	86	109	121	149	132	153
	rjn.27.8c	0	0		0	0	0	0	0	0	2	0	0	0
	rjn.27.9a											0		
	rju.27.8ab	1	0		0	3	2	2	3	0	7	11	14	22
Netherland						0								
	raj.27.89a					0								
Portugal		**1298**	**1538**	**1444**	**1439**	**1444**	**1454**	**1425**	**1122**	**1104**	**1026**	**1012**	**1026**	**1138**
	raj.27.89a	104	123	38	307	308	293	276	240	144	132	113	99	116
	rjc.27.9a	480	569	472	746	740	611	812	571	644	586	581	564	620
	rjh.27.9a	495	586	459	193	163	221	161	165	179	174	236	221	235
	rjm.27.9a	76	90	119	144	184	275	121	108	111	101	67	68	94
	rjn.27.9a	43	51	79	50	50	55	56	39	27	34	20	57	39
	rju.27.9a	100	119	277									23	35
Spain		**918**	**823**	**985**	**1005**	**911**	**1032**	**1283**	**1285**	**1137**	**1029**	**651**	**748**	**766**

Country	ICES	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	raj.27.89a	918	823	985	1000	707	627	840	762	616	461	299	367	396
	rjb.27.89a			0	1							0	0	
	rjc.27.8		0	0	4	136	214	243	268	286	284	183	198	176
	rjc.27.9a					29	115	139	194	166	215	120	123	124
	rjh.27.9a					1	2	1	0	3	0	0	1	0
	rjm.27.8					11	26	22	19	28	40	28	26	27
	rjm.27.9a			0		7	10	3	2	4	2	1	5	5
	rjn.27.8c					18	34	24	26	33	27	15	13	15
	rjn.27.9a					3	4	12	13	2	0	0	1	2
	rju.27.8c											5	7	8
	rju.27.9a												8	12
UK		**10**	**43**	**8**	**4**	**1**	**0**	**1**	**2**	**0**	**0**	**42**	**0**	**0**
	raj.27.89a	10	43	8	2	0	0		0	0		1		
	rjb.27.89a										0			
	rjc.27.8							1	2			17	0	0
	rjm.27.8				1	1	0	0				1	0	
Ireland					**0**	**0**			**0**			**33**	**27**	
	raj.27.89a				0	0						4	5	
	rjb.27.89a											13	15	
	rjc.27.8								0			4	7	
	rjm.27.8											12	1	
Total		3464	3515	3398	3361	3014	3038	3160	2831	2726	2627	2315	2299	2514

Table 19.2. Skates in the Bay of Biscay and Iberian Waters. Species-specific landings (in t) in Divisions 8abde, 8.c and 9.a since 2005. Last table includes landings of Skates (*Myliobatis* spp, Dasyatidae, *Rhinobatos* spp, Torpedinidae) in the same period.

8abd	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Dipturus spp	11	5	3	5	0	0	0	0	0	0	13	15	0
Dipturus oxyrinchus	12	10	2	3	1	6	6	0	0	0	0	0	0
Leucoraja circularis	84	53	58	69	20	28	16	20	20	25	49	22	0
Leucoraja fullonica	14	8	7	7	45	37	36	30	30	38	47	40	27
Leucoraja naevus	1290	927	1002	987	1310	1102	982	935	959	1057	1214	996	916
Raja brachyura				0	11	11	18	7	27	67	65	76	144
Raja clavata	276	300	215	190	239	246	217	227	244	241	266	211	232
Raja microocellata	0	0	0	1	3	2	4	13	20	38	21	30	54
Raja montagui	155	130	124	107	65	86	92	86	109	121	162	133	153
Raja undulata	1	0		0	3	2	2	3	0	7	11	14	22
Rajella fyllae									0				
Rajiformes (indet)	1133	1008	990	974	373	206	252	199	83	79	52	19	18
Rostroraja alba	1		0	0	3	0	1	1	0	1	3	1	0
Total	2977	2441	2401	2343	2072	1725	1626	1520	1493	1673	1902	1558	1566

8c	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Dipturus spp	0	0	0	1							0	0	
Dipturus oxyrinchus								0	0	0	3	0	
Leucoraja circularis		0		4	1	2	1	1	1	0	0	0	
Leucoraja fullonica		0		0	0					0			0
Leucoraja naevus	0	0		0	18	34	24	27	33	29	16	13	15

Raja brachyura					0	5	1	0	0	0	1	1	0
Raja brachyura	0	0	0	4	94	186	206	224	238	248	150	161	136
Raja clavata													0
Raja montagui					11	25	22	19	28	40	28	26	27
Raja undulata											5	7	8
Rajiformes (indet)	178	194	420	426	409	299	409	385	308	213	162	199	190
Total	178	194	421	433	533	552	663	655	608	530	364	408	377

9a	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Dipturus spp											0		
Dipturus oxyrinchus				72	75	20	68	24	64	33	74	26	41
Leucoraja circularis	0	0	0	1	2	11	1	0	0	0	0	2	1
Leucoraja fullonica								0			0		
Leucoraja naevus	43	51	79	50	53	59	68	53	29	34	20	59	41
Raja brachyura	495	586	459	193	164	223	162	165	182	174	236	222	236
Raja clavata	480	569	472	746	769	726	951	766	810	801	701	687	744
Raja microocellata	88	105	35	19	45	43	29	36	41	45	32	63	68
Raja miraletus	16	19		4	2	6	5	5	1	2	0	2	0
Raja montagui	76	90	119	144	191	284	124	110	115	103	68	73	99
Raja undulata	100	119	277									31	46
Rajiformes (indet)	301	283	142	344	420	490	445	431	344	288	136	167	210
Rostroraja alba	5	6											
Total	1604	1827	1583	1573	1721	1863	1853	1590	1585	1481	1265	1330	1487

89a	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Dasyatidae	1	2	0	0	0	0	0	0	0	0		0	0
Myliobatis aquila	2	2	1	2	1	1	2	1	1	2	2	2	24
Rhinobatos spp	0	0	0	0	0		0	0	0	0	0	0	
Torpedo marmorata	27	24	25	28	25	22	20	20	23	14	18	16	14
Torpedo spp	39	49	45	46	39	50	54	39	43	46	43	49	63
Total	69	76	71	76	66	74	77	60	67	63	63	67	102

Table 19.3a. Skates in the Bay of Biscay and Iberian. *Leucoraja naevus* and *R. clavata* discard estimates (t) of the Basque OTB (Bottom otter trawl) in Subarea 8.

SUBAREA 8	*L. NAEVUS*	*R. CLAVATA*
2003		
2004		
2005		
2006		
2007		
2008		
2009	6	
2010	7	1
2011	18	3
2012	8	0
2013	23	3
2014	15	1
2015	50	4
2016	120	34
2017	87	14

Table 19.3b. Skates in the Bay of Biscay and Iberian Waters. Estimate of the percentage of the elasmobranch discarded/landed by the Basque OTB (Bottom otter trawl) in Divisions 8a,b,d.

YEAR	*L. NAEVUS*	*R. CLAVATA*
2009	4%	0%
2010	12%	5%
2011	17%	10%
2012	10%	0%
2013	23%	11%
2014	14%	4%
2015	44%	16%
2016	104%	109%
2017	100%	18%

Table 19.4a. Skates in the Bay of Biscay and Iberian Waters. Percentage of individuals by health status (1=Good; 2=Moderate; 3=Poor) in relation to mesh size and soak time in the Portuguese polyvalent fleet for *Raja clavata*, *Raja montagui*, *Raja brachyura* and *Leucoraja naevus*. The total length range is also given.

	Mesh Size (mm)	Soak Time (h)	Health Status			N	TL range (cm)
			1	2	3		
Raja clavata	<180	<24	100%	0%	0%	17	23–72
		>24	72%	12%	16%	25	39–80
	>180	<24	92%	4%	4%	26	48–88
		>24	52%	23%	24%	103	40–96
Raja montagui	<180	<24	100%	0%	0%	18	21–64
		>24	67%	21%	12%	42	10–60
	>180	<24	40%	30%	30%	20	46–62
		>24	37%	33%	30%	43	37–68
Raja brachyura	<180	<24	67%	22%	11%	9	39–66
		>24	92%	4%	4%	24	27–75
	>180	<24	57%	19%	24%	21	49–95
		>24	70%	20%	10%	143	18–106
Leucoraja naevus	<180	<24	100%	0%	0%	1	53–53
	>180	<24	100%	0%	0%	1	61–61
		>24	58%	21%	21%	24	46–62

Table 19.4b. Skates in the Bay of Biscay and Iberian Waters. Percentage of individuals of *R. undulata* by health status by length class (cm), soak time (h) and mesh size (mm) in the Portuguese polyvalent fleet. Total sample size = 100 individuals; size range = 36–88 cm L_T.

		Length class (cm)		Soak Time (h)		Mesh Size (mm)	
Health Status	Total	<50 cm	>50 cm	<24 h	>24 h	<180 mm	>180 mm
1	91%	83%	92%	86%	92%	82%	93%
2	6%	0%	8%	7%	8%	9%	7%
3	3%	17%	0%	7%	0%	9%	0%

Table 19.5. Skates in the Bay of Biscay and Iberian Waters. Relative landed weight (%) for skate species for the Portuguese polyvalent and trawl fleets (2008–2017).

	Polyvalent									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Raja miraletus	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Raja clavata	48%	48%	40%	54%	44%	56%	53%	53%	52%	55%
Raja microocellata	2%	4%	3%	3%	4%	5%	5%	4%	7%	7%
Raja brachyura	15%	11%	16%	13%	18%	19%	20%	27%	25%	23%
Leucoraja circularis	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Raja montagui	10%	13%	19%	8%	9%	10%	10%	7%	6%	8%
Leucoraja naevus	2%	3%	3%	3%	3%	2%	3%	1%	5%	3%
Dipturus oxyrinchus	6%	5%	1%	4%	3%	5%	3%	8%	3%	4%
Rajidae	17%	16%	16%	15%	19%	4%	6%	0%	0%	0%

	Trawl									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Raja miraletus	1%	0%	1%	0%	1%	0%	0%	0%	0%	0%
Raja clavata	64%	60%	47%	66%	71%	66%	76%	77%	71%	64%
Raja microocellata	0%	0%	2%	0%	0%	0%	2%	0%	3%	1%
Raja brachyura	8%	12%	13%	5%	6%	8%	8%	7%	10%	14%
Leucoraja circularis	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Raja montagui	10%	11%	17%	8%	11%	12%	4%	4%	8%	12%
Leucoraja naevus	7%	6%	8%	8%	6%	4%	5%	5%	7%	8%
Dipturus oxyrinchus	3%	6%	3%	8%	1%	8%	4%	6%	0%	1%
Rajidae	7%	5%	7%	5%	3%	2%	0%	0%	0%	0%

Table 19.6. Skates in the Bay of Biscay and Iberian Waters. Lpue (kg.day^{-1}) of the *L. naevus* and *R. clavata* caught by the Basque Country OTB DEF >= 70 (Bottom otter trawl) in Subarea 8.

YEAR	L. NAEVUS	R. CLAVATA
2001	112	27
2002	91	16
2003	136	19
2004	120	21
2005	134	23
2006	140	24
2007	169	29
2008	137	24
2009	84	18
2010	44	14
2011	115	25
2012	33	21
2013	72	18
2014	79	19
2015	130	28
2016	119	32
2017	58	54

Table 19.7. Skates in the Bay of Biscay and Iberian Waters. Life-history information): Table 2. Biological parameter estimates available for skate species inhabiting Portuguese Iberian waters. Growth models: VBR – von Bertalanffy Growth Model; GG – Gompertz Growth Model.

Species	TL range (cm)	L50 (cm) F	L50 (cm) M	I50 (years) F	I50 (years) M	Fecundity	Reproductive period	Growth model	Growth parameters estimates						Period	Region	Source
									L∞ (cm)	k (y–1)	t0 (years)	Lmax (cm)	Imax (years)	I∞ longevity (years)			
R. undulata	19.4–88.2	76.2	73.6	8.98	7.66	-	-	VBG	110.2	0.11	–1.58	88.2	13	-	1999–2001	Algarve	[1,2]
	23.7–90.5	83.8	78.1	9	8	-	Feb–May	VBG	113.7	0.15	–0.01	90.5	12	23.6	2003–2006	Centre	[3]
	32.0–83.2	-	-	-	-	-	-	VBG	119.3	0.12	–0.41	83.2	9	28.9	1999–2001	Algarve	[3]
	23.5–95.9	86.2 ±2.6	76.8 ±2.4	8.7 ±0.3	7.6 ±0.4	69.8 ± 3.4	Dec–May	-	-	-	-	-	-	-	2003–2013	North /Centre	[4]
R. clavata	14.3–91.3	-	-	-	-		-	VBG	128.0	0.112	–0.62	91.3	10	-	2003–2007	All	[5]
	12.5–105.0	78.4	67.6	7.5	5.8	136	May–Jan		-	-	-	-	-	-	2003–2008	All	[6]
R. brachyura	37.4–106.1	97.9	88.8	-	-	-	Mar–jul	VBG	110.51	0.12	0.26	106.1	-	-	2003–2004	All	[7]
	37.6–108.8	96.6	88.6	-	-		Mar–Jul		-	-	-	-	-	-	2003–2012	North /Centre	[10]
R. montagui	25.2–76.1	59.4	50.4	-	-	-	Apr–Jun	VBG	75.9	0.23	0.16	76.1	7	-	2003–2004	All	[8]
	36.8–70.2	56.7	48.0	-	-		Apr-Jul	-	-	-	-	-	-	-	2003–2012	All	[10]
L. naevus	12.7–71.8	55.6	56.5	-	-		-	VBG	79.2	0.24	0.12	71.8	-	-	2003–2004	All	[7]
	13.3–71.8	56.5	56.0	-	-	63	Jan-May		-	-	-	-	-	-	2003–2010	All	[9]

[1] Coelho and Erzini, 2002; [2] Coelho and Erzini, 2006; [3] Moura *et al*., 2008; [4] Serra-Pereira *et al*., 2015; [5] Serra-Pereira *et al*., 2008; [6] Serra-Pereira *et al*., 2011; [7] Farias, 2005; [8] Serra-Pereira, 2005; [9] Maia *et al*., 2012; [10] Pina Rodrigues, 2012).

Table 19.8. Skates in the Bay of Biscay and Iberian Waters. Model parameters and prior distributions for the application to *R. clavata* in the Bay of Biscay.

Parameter	Description	Prior
r	Intrinsic population growth rate	Beta (34, 300) mean=0.1, CV=0.16
K	Carrying capacity	Uniform (20 000, 100 000)
Y1903	Initial relative biomass in 1903	Beta (17, 4) mean=0.84, CV=0.1
Y2000	Initial relative biomass in 2000	Beta (2,6) mean=0.4, CV=0.6
$1/\sigma^2$	Process error precision (inverse variance)	Gamma (400, 1) mean=399, CV=0.05
q	Survey catchability	Uniform (0.01, 0.6)
$1/\tau^2$	Observation error precision (inverse variance)	Gamma (44,2) mean=22
CV	Uncertainty of landings	0.2 (constant)

Table 19.9. Skates in the Bay of Biscay and Iberian Waters. - Abundance estimate of the stock of *Raja undulata* in the Bay of Biscay potentially exploitable by the longliners in the central part of the Bay of Biscay according to the low (A1) and high (A2) estimates by mark–recapture in the Gironde estuary area.

Abundance in other areas are derived from this estimate by the following formula:

$$A\ (\text{area } x) = \frac{DI\ (\text{area } x)}{DI\ (GE)} \cdot \frac{S\ (\text{area } x)}{S\ (GE)} \cdot Ai\ (GE)$$

Where Ai is one of the two interval limits of the abundance estimated by mark–recapture in the Gironde Estuary (GE), Density index (DI) are area coefficients obtained by a variance analysis of standardized CPUE and, Surface (S) is habitat area shown by the catch and tagging data.

Area	Surface (S in nm2)	Density index (DI)	Abundance (A1)	Abundance (A2)
Gironde Estuary (GE)	560	1.45	10214	14 188
West Oléron (WO)	300	1.42	5348	7429
Pertuis d'Antioche (PA)	65	0.62	507	704
Pertuis Breton (PB)	180	0.78	1763	2449
Total	1105	-	17 832	24 770
Biomass (t)	-	-	87	120

Table 19.10. Skates in the Bay of Biscay and Iberian Waters. *Raja undulata* in the Bay of Biscay – Mean length-at-age and estimation of longline catch-at-age in November 2013 (chartered trip) with their log ratios.

Age	Mean length (Nov.)	Catch at age	Log catch ratio
5	66.1	7	–1.95
6	72.6	37	–1.67
7	78.2	95	–0.94
8	83.1	138	–0.37
9	87.3	215	–0.44
10	90.9	139	0.44
11	94.0	24	1.76
12	96.7	13	0.61
13	99.0	4	1.18

Table 19.11. Skates in the Bay of Biscay and Iberian Waters. *Raja undulata* in the Bay of Biscay-Stock number in 2008 derived from the 2014 mark–recapture abundance estimates (lower estimates in the upper table and higher estimates in the lower table), assuming no fishing mortality below age 4 and a flat fishing pattern above age 6 in 2008, no fishing from 2009 to 2015 (example given for half of the highest possible fishing mortality-at-age 7 and above in 2008 according to a recruitment constraint based on the number of eggs released). Biomass in 2009 and 2015 assuming constant recruitments.

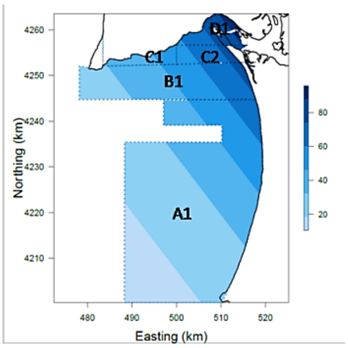
YEAR	2008	2008	2008	2009	2014	2015	2015
Age	Stock Number	F	Catch (t)	Biomass (t)	Mark–recapture estimate	Stock Number	Biomass (t)
0	100 621	0.00	0	0		100 621	0
1	76 812	0.00	0	5		76 812	5
2	58 637	0.00	0	17		58 637	17
3	44 762	0.00	0	30		44 762	30
4	34 171	0.17	6	42		34 171	42
5	22 092	0.17	6	41		26 085	49
6	14 228	0.27	8	37		19 913	52
7	8254	0.38	8	28		15 201	52
8	4313	0.38	5	18	Lower	11 604	49
9	2253	0.38	3	11	estimates	8858	44
10	1177	0.38	2	7	5705	6762	39
11	615	0.38	1	4	3688	4355	28
12	321	0.38	1	2		2816	20
13	168	0.38	0	1		1633	13
Total	267 803		39	245		412 232	441
Spawning	8848		12	44		36 029	194
Year	2008	2008	2008	2009	2014	2015	2015
Age	Stock Number	F	Catch (t)	Biomass (t)	Mark–recapture estimate	Stock Number	Biomass (t)
0	139 771	0.00	0	0		139 771	0
1	106 698	0.00	0	7		106 698	7
2	81 451	0.00	0	23		81 451	23
3	62 178	0.00	0	42		62 178	42
4	47 465	0.17	8	58		47 465	58
5	30 687	0.17	8	58		36 234	68
6	19 764	0.27	11	52		27 660	73
7	11 465	0.38	11	39		21 115	72
8	5991	0.38	7	25	Higher	16 119	68
9	3130	0.38	4	16	estimates	12 305	62
10	1636	0.38	3	9	7925	9393	54
11	855	0.38	2	6	5124	6050	39
12	447	0.38	1	3		3911	28
13	233	0.38	1	2		2269	18
Total	371 999		55	340		572 620	613
Spawning	12 291		17	61		50 047	269

Table 19.12. Skates in the Bay of Biscay and Iberian Waters. Annual estimates of the posterior median, 25% and 97.5% quartiles of the total landed weight of *Raja undulata* for the period 2003–2008 along the Portuguese mainland (Division 9.a)

YEAR	MEDIAN	P2.5	P97.5
2003	164.3	137.1	197.0
2004	197.0	164.2	235.8
2005	171.7	141.2	208.4
2006	271.3	232.6	315.1
2007	156.7	132.3	185.6
2008	208.3	178.4	243.4

Table 19.13. Skates in the Bay of Biscay and Iberian Waters. Estimates of *Raja undulata* abundance by sub-region and of catchability. Map of the study area with the estimated density (number of *R. undulata per* square meter).

SUB-REGION	ABUNDANCE ESTIMATE (Nº OF SPECIMENS)	AREA ESTIMATE (KM2)	PC ESTIMATE
A1	34353.15	1139.147	0.0003558456
C1	1591.102	36.15782	0.01121087
C2	3591.321	53.92095	0.007517688
D2	4578.088	58.37388	0.00694421
B1	13612.26	293.2451	0.001382327
TOTAL	57725.921	1580.845	



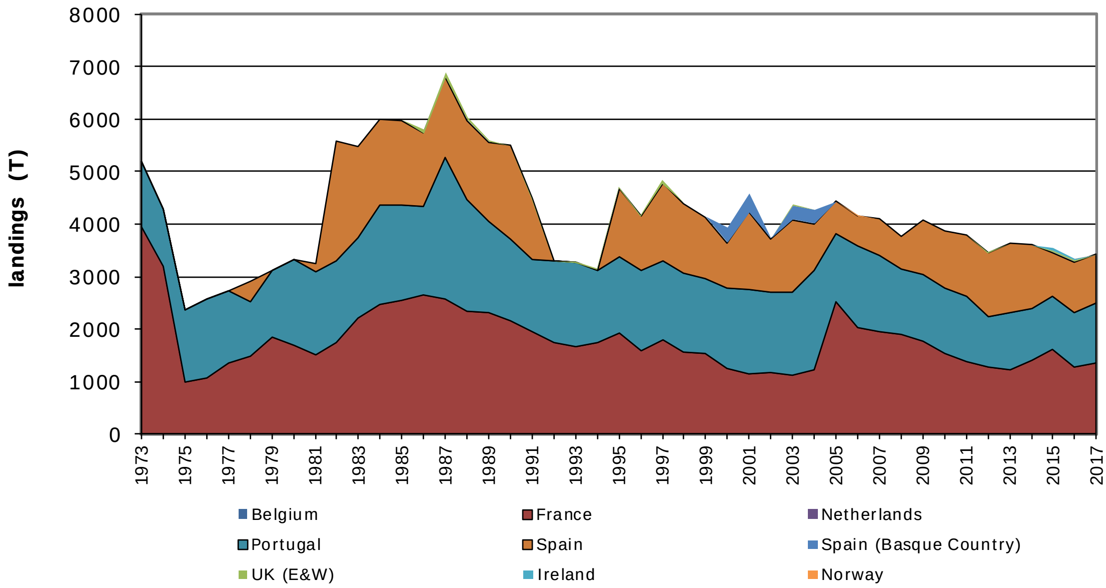


Figure 19.1. Skates in the Bay of Biscay and Iberian Waters. Historical trend in landings of Rajidae in Subarea 8 and Division 9.a.

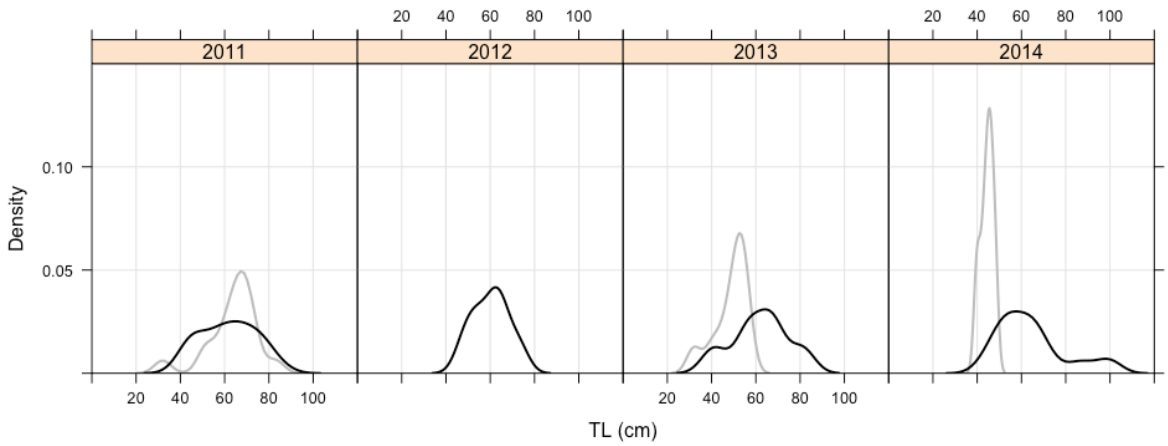
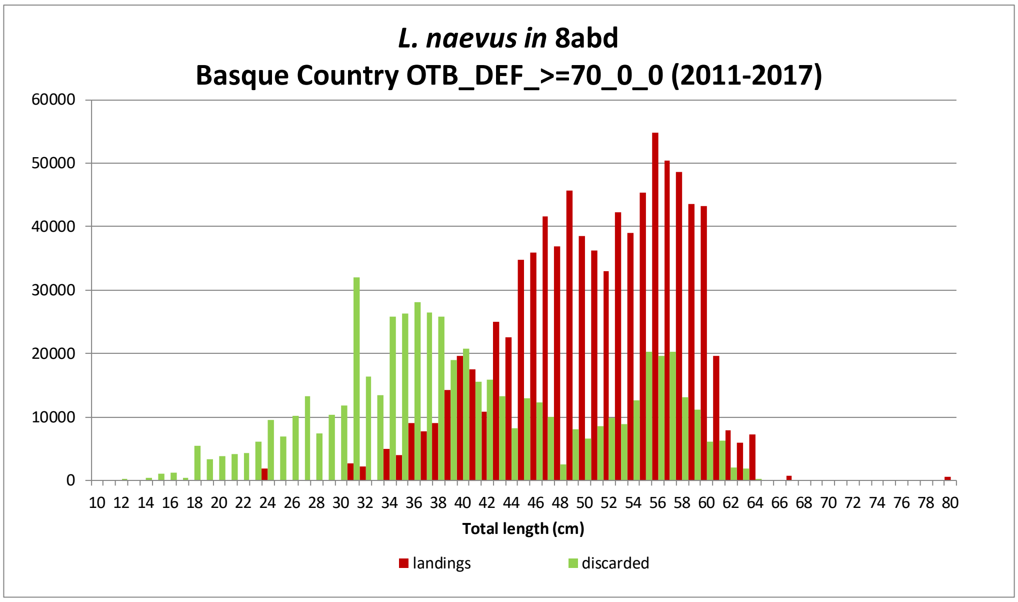


Figure 19.2a. Length frequency distribution of R. clavata retained (black) and discarded (grey) fractions observed onboard vessels with LOA >12 m and with fishing permit to operate with gillnets and/or trammel nets, between 2011 and 2014. The length frequencies were not raised to the total landings. n=204 sampled individuals.



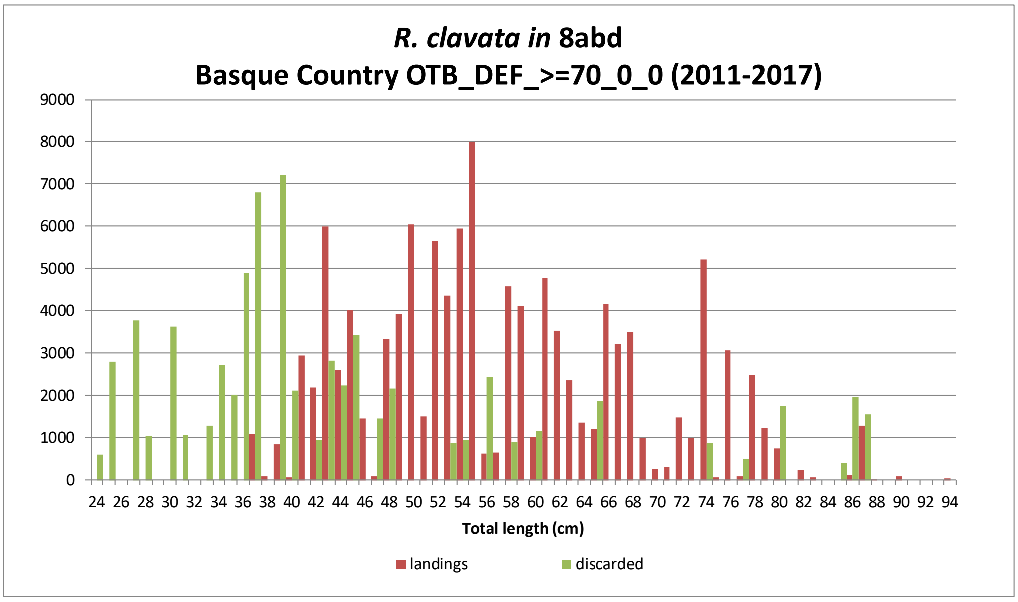


Figure 19.2b. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of the *Leucoraja naevus* and *Raja clavata* for the period from 2011–2017 of the Basque OTB (Bottom Otter Trawler).

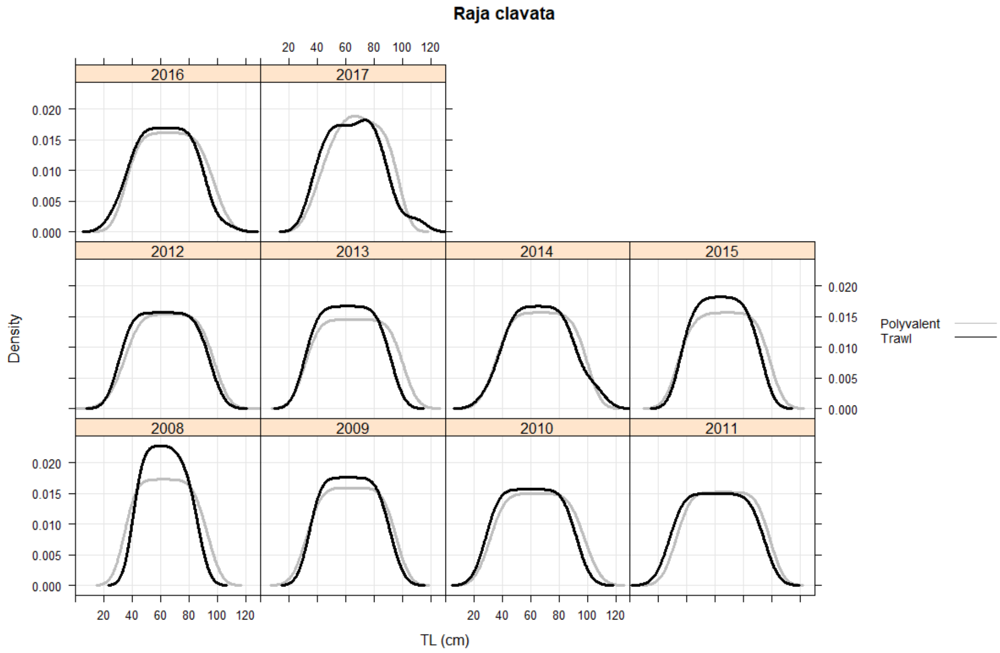


Figure 19.2c. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja clavata* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n=2410 for the polyvalent segment and n=642 for the trawl segment.

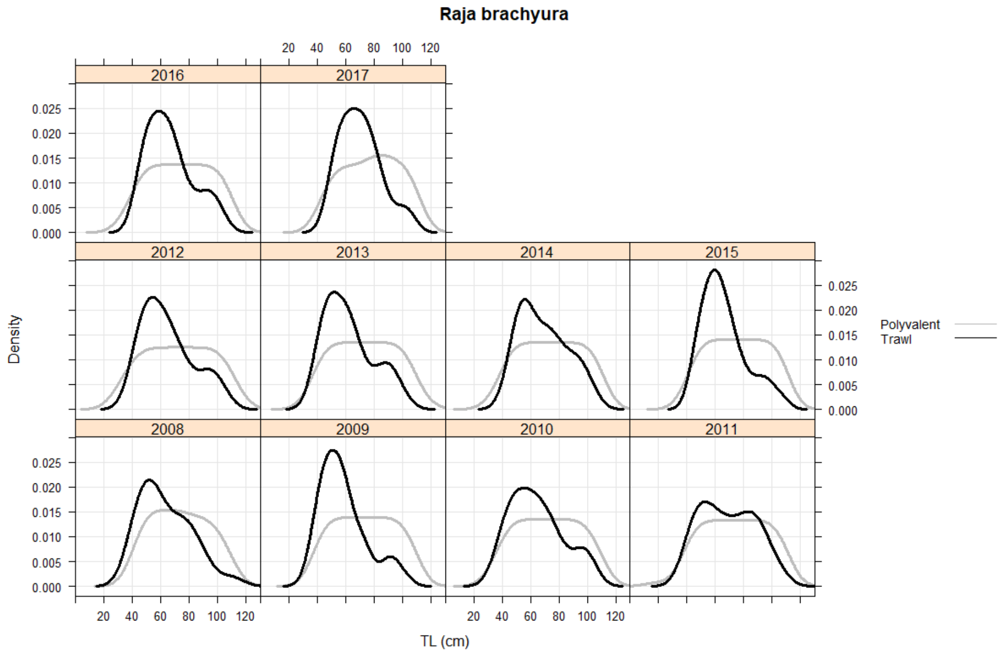


Figure 19.2d. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja brachyura* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n=1466 for the polyvalent segment and n=187 for the trawl segment.

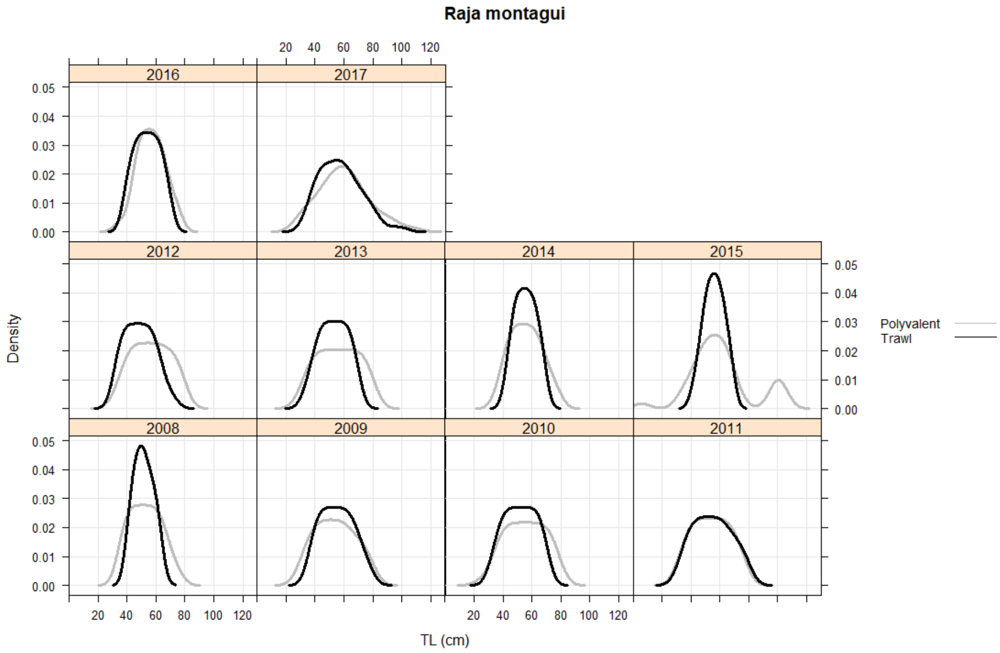


Figure 19.2e. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja montagui* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n=1061 for the polyvalent segment and n=320 for the trawl segment.

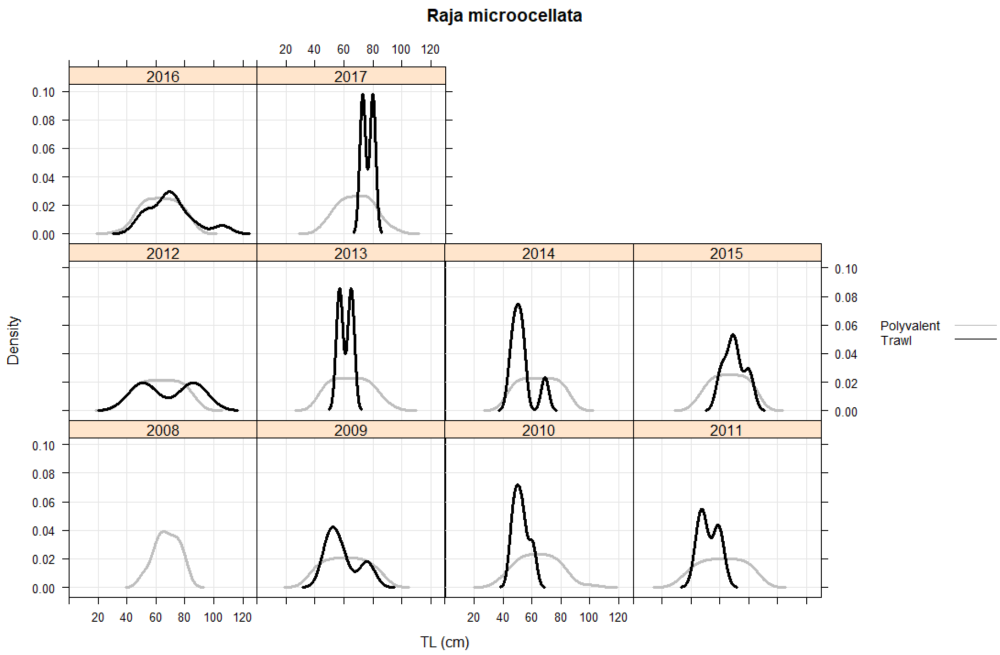


Figure 19.2f. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja microocellata* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n=638 for the polyvalent segment and n=18 for the trawl segment.

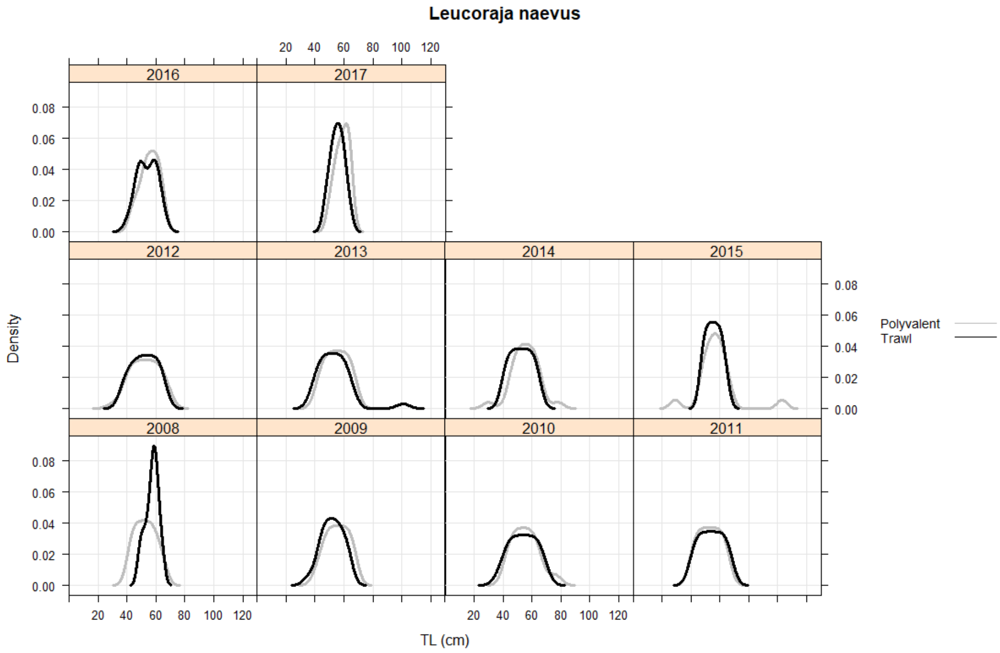


Figure 19.2g. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Leucoraja naevus* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n=299 for the polyvalent segment and n=158 for the trawl segment.

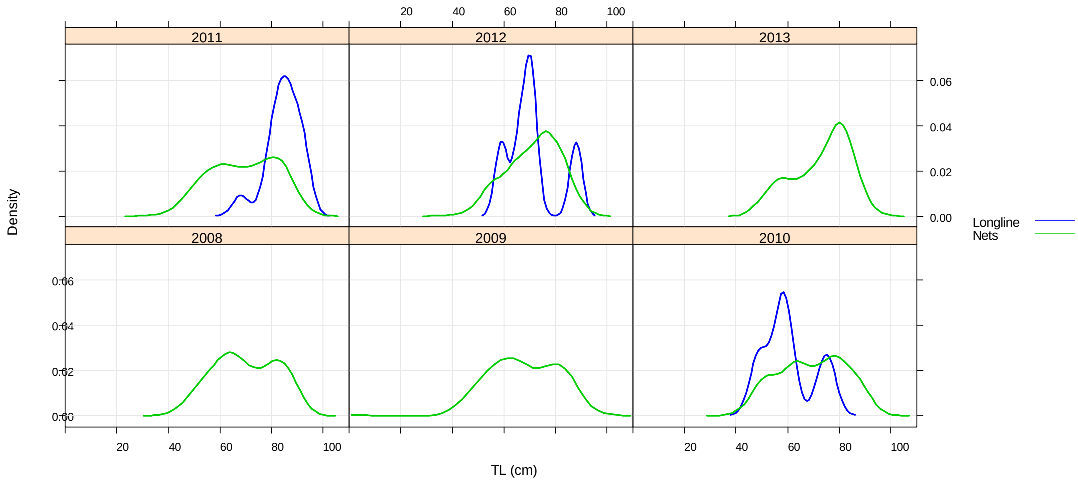


Figure 19.2h. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja undulata* by fishing gear (longline and nets) for the period 2008–2013 in mainland Portugal (Division 9.a).

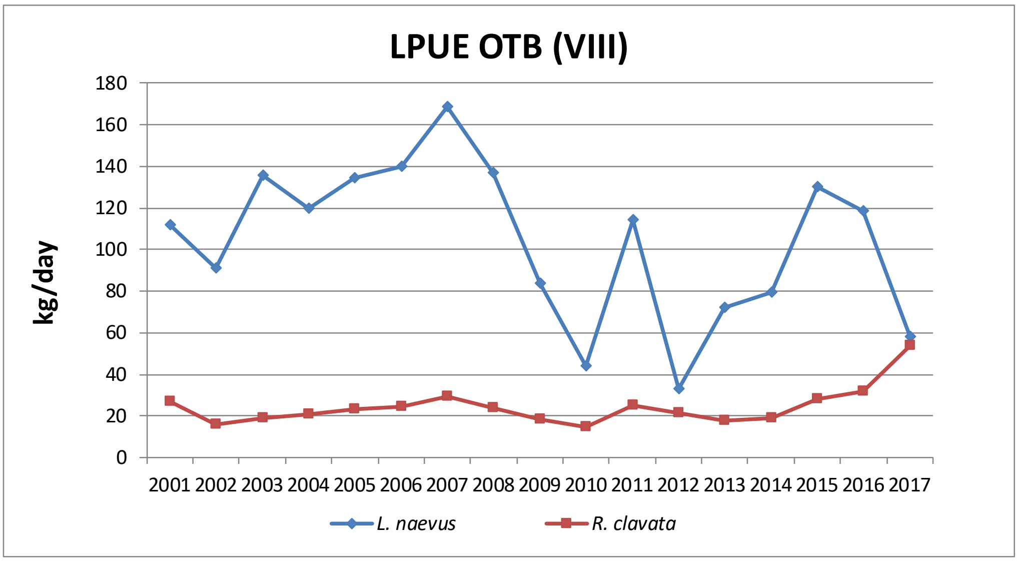


Figure 19.3. Skates in the Bay of Biscay and Iberian Waters. Nominal LPUE (kg.day^{-1}) of *Leucoraja naevus* and *Raja clavata* caught in the OTB DEF >= 70 Basque fleet in Subarea 8 (2001–2017).

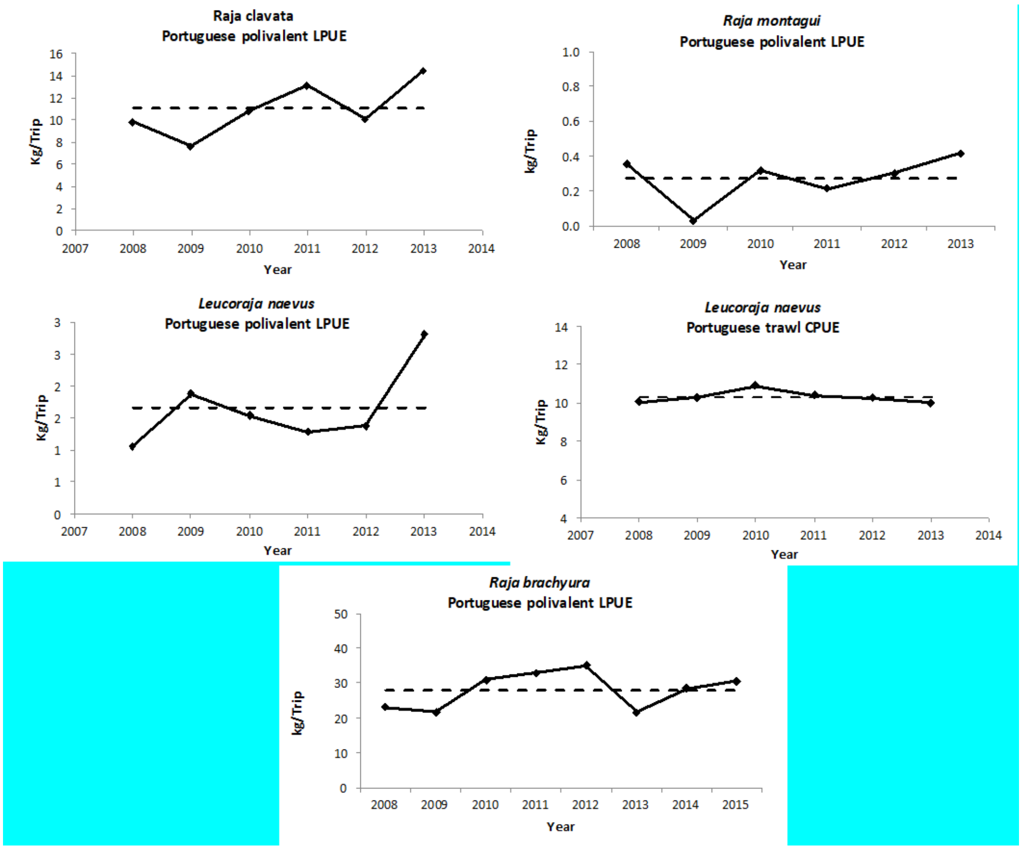


Figure 19.4a. Skates in the Bay of Biscay and Iberian Waters. Standardized LPUE (kg.trip^{-1}) by species for the period 2008–2013: *R. clavata, R. montagui* and *L. naevus*. For *R. brachyura* the data series was updated for the period 2008-2015. The considered reference fleet is indicated. Dashed line: average of the entire time-series.

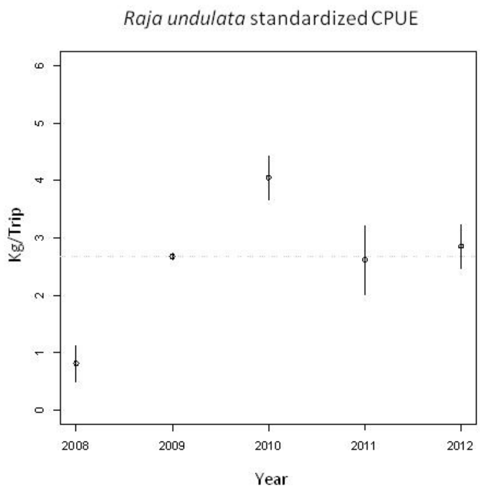


Figure 19.4b. Skates in the Bay of Biscay and Iberian Waters. Standardized CPUE (kg.trip^{-1}) of *Raja undulata* for the period 2008–2013. Dashed line: average of the entire time-series.

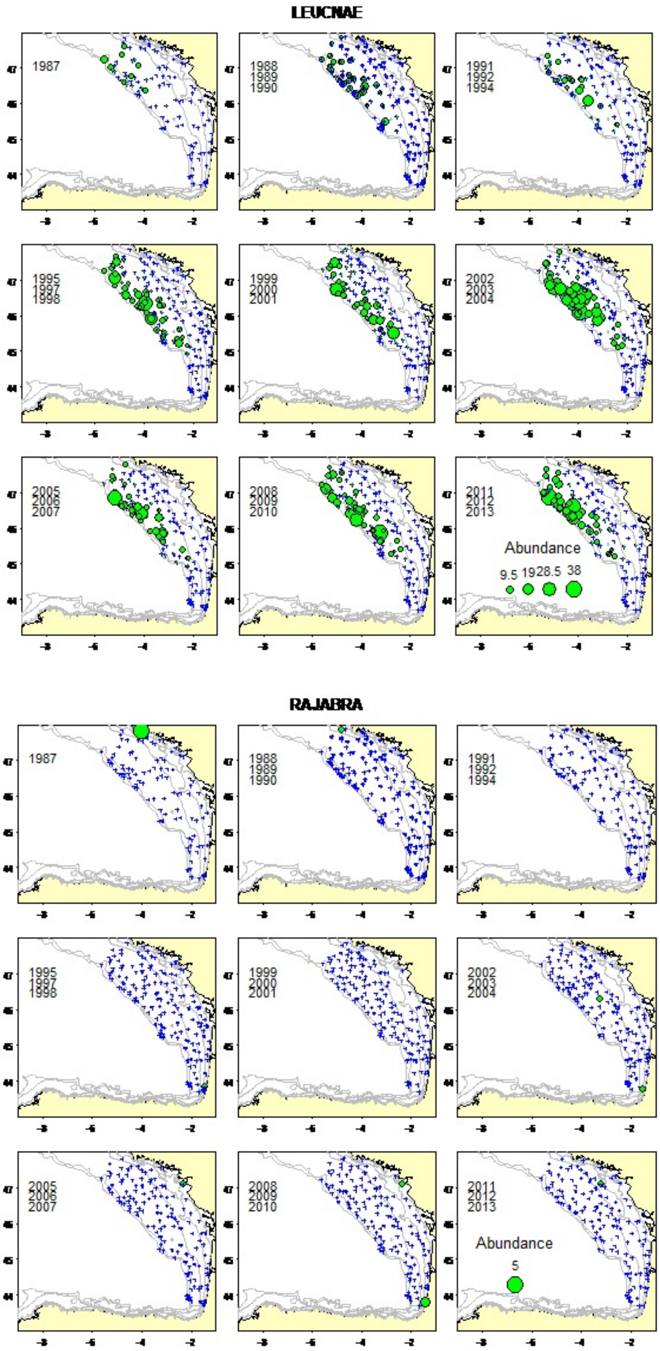
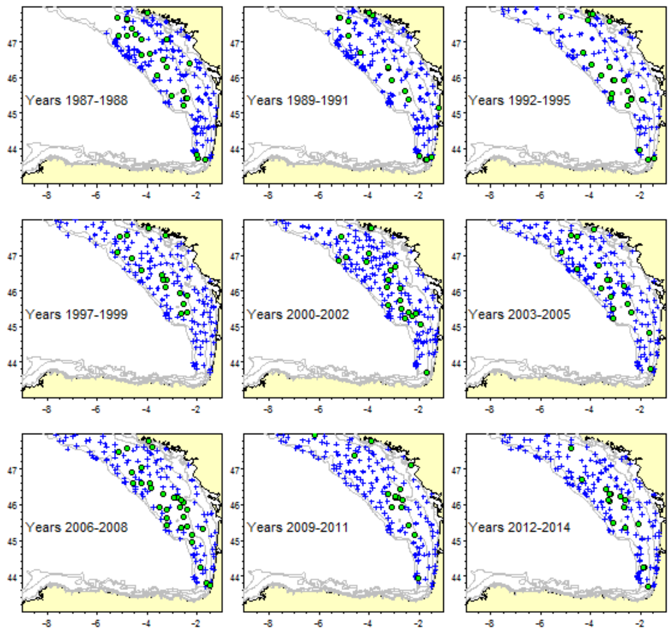


Figure 19.5a. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *L. naevus* (top) and *R. brachyura* (bottom), as observed in the French EVHOE survey.



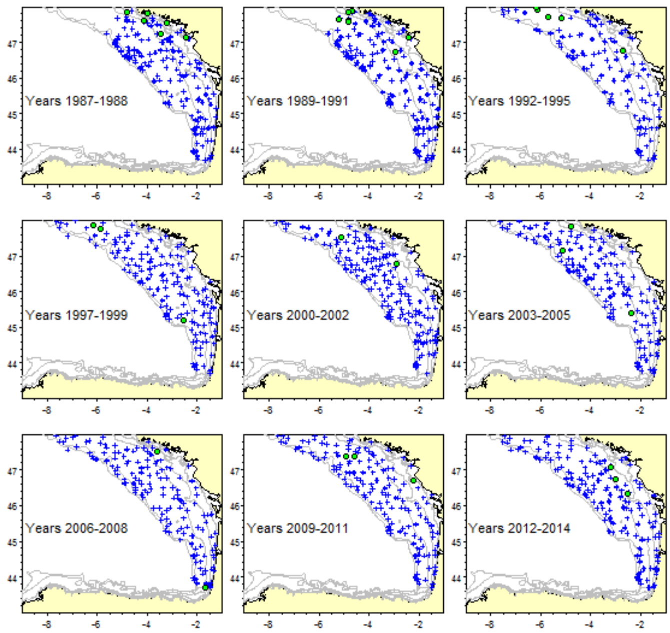


Figure 19.5b. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *R. clavata* (top) and *R. montagui* (bottom), as observed in the French EVHOE survey.

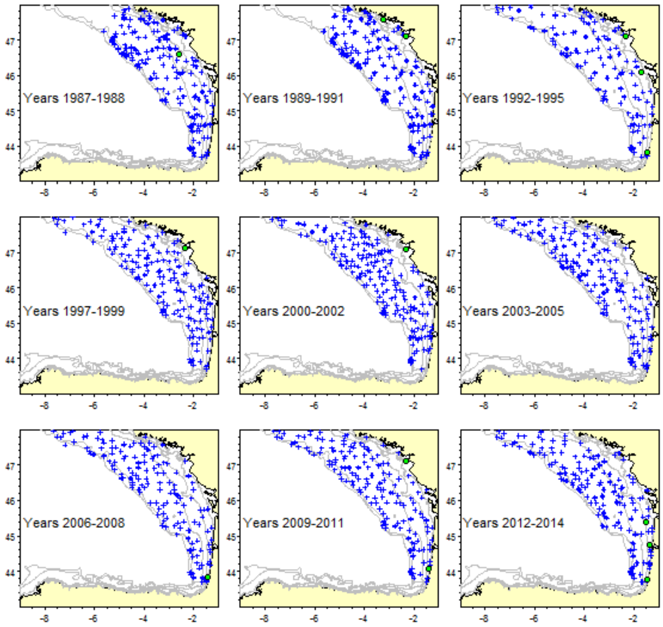


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Figure 19.5c. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *R. undulata,* as observed in the French EVHOE survey.

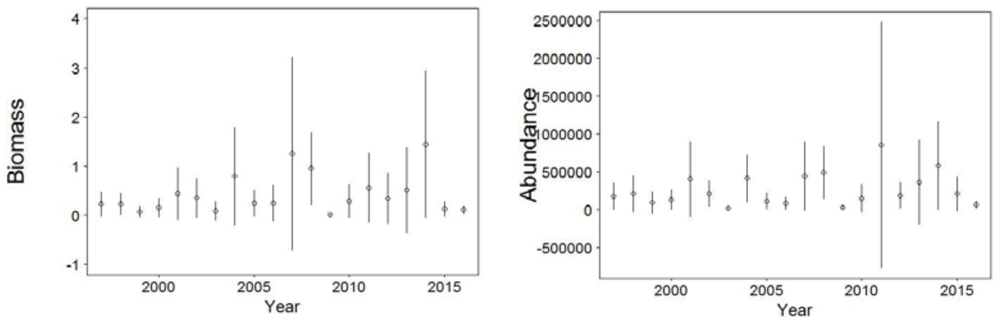

Figure 19.6a. Skates in the Bay of Biscay and Iberian Waters. EVHOE survey indices 1987–2016 of *R. clavata* in the Celtic Sea and Bay of Biscay (Divisions 8.a-c). Abundance and biomass are raised to the total area surveyed (swept area method) but should be considered relative and not absolute estimates.

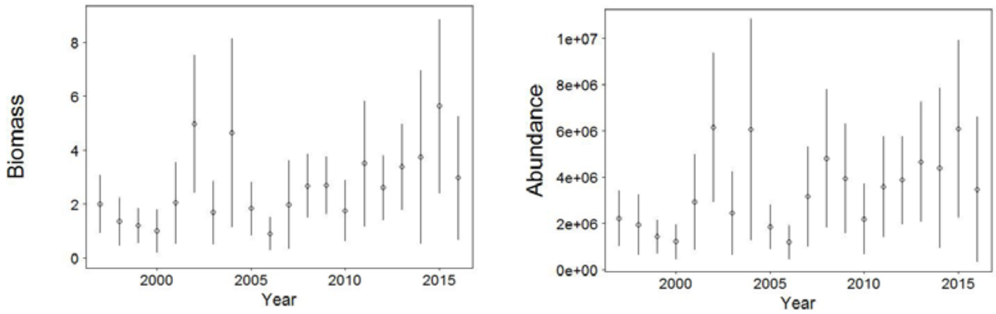

Figure 19.6b. Skates in the Bay of Biscay and Iberian Waters. EVHOE survey indices 1987–2015 of the *L. naevus* in the Bay of Biscay (Divisions 8.a-c). Abundance and biomass are raised to the total area surveyed (swept area method) but should be considered relative and not absolute estimates.

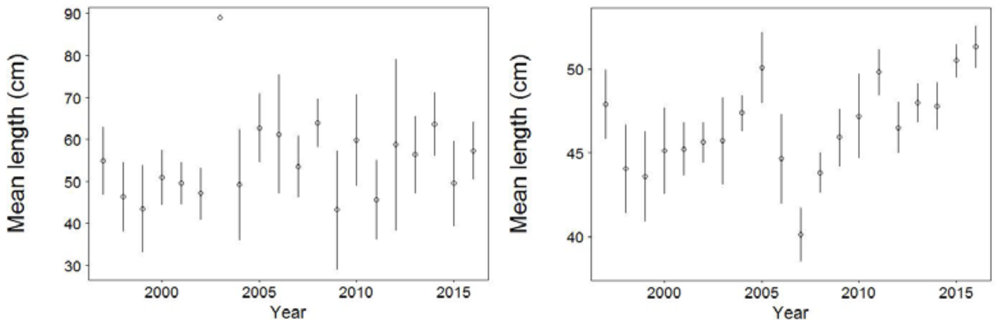

Figure 19.6b. Skates in the Bay of Biscay and Iberian Waters. EVHOE mean length of *R. clavata* and *L. naevus* in the Bay of Biscay Divisions 8abc) in the period 1987-2016.

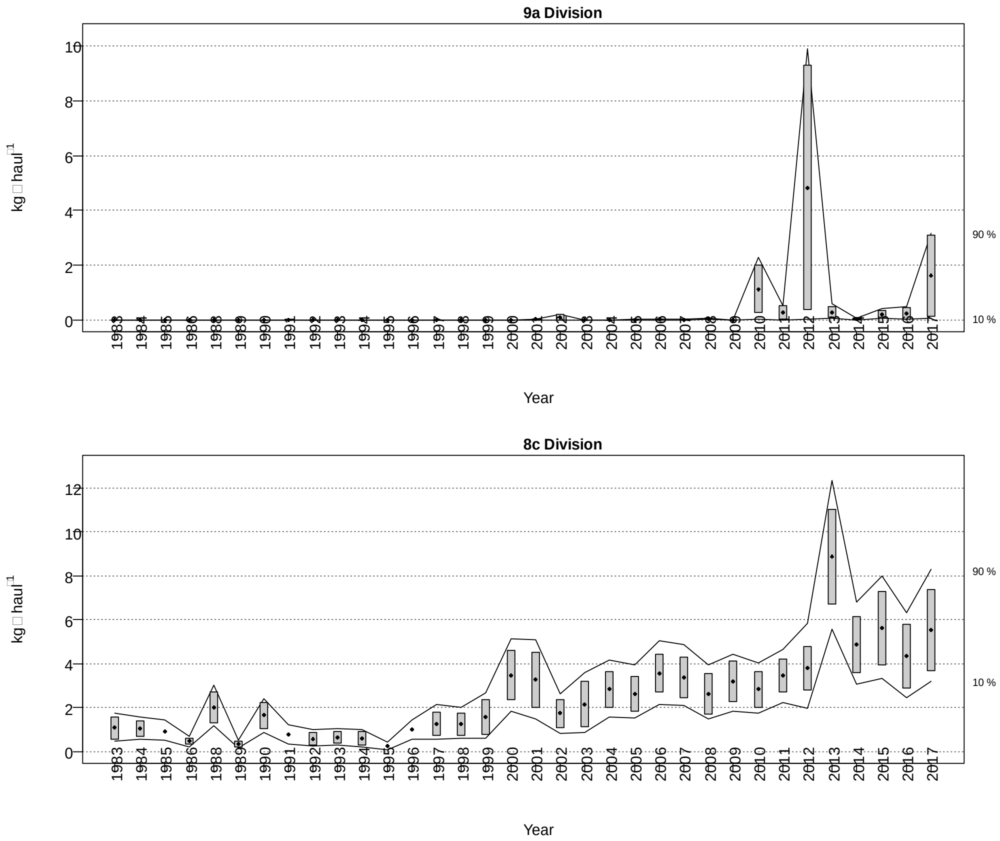

Figure 19.7a. Skates in the Bay of Biscay and Iberian waters. Changes in *Raja clavata* biomass indices, in ICES Divisions 9.a and 8.c, during the North Spanish bottom trawl survey time-series (1983–2017). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

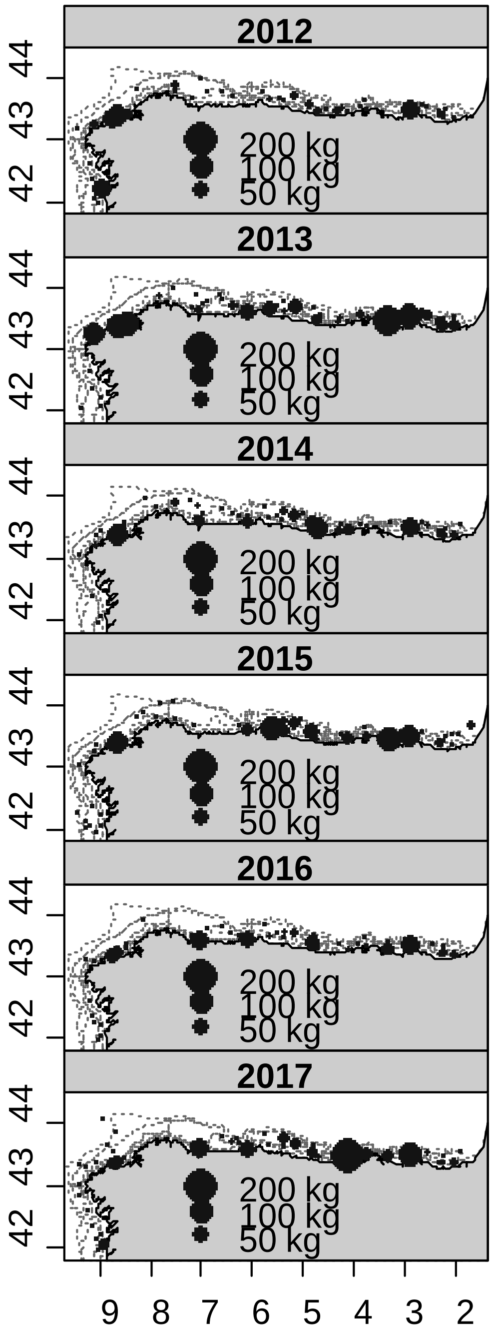

Figure 19.7b. Skates in the Bay of Biscay and Iberian waters. Geographical distribution of *R. clavata* catches (kg/30 min haul) in North Spanish continental shelf from bottom trawl surveys for the period (2013–2017).

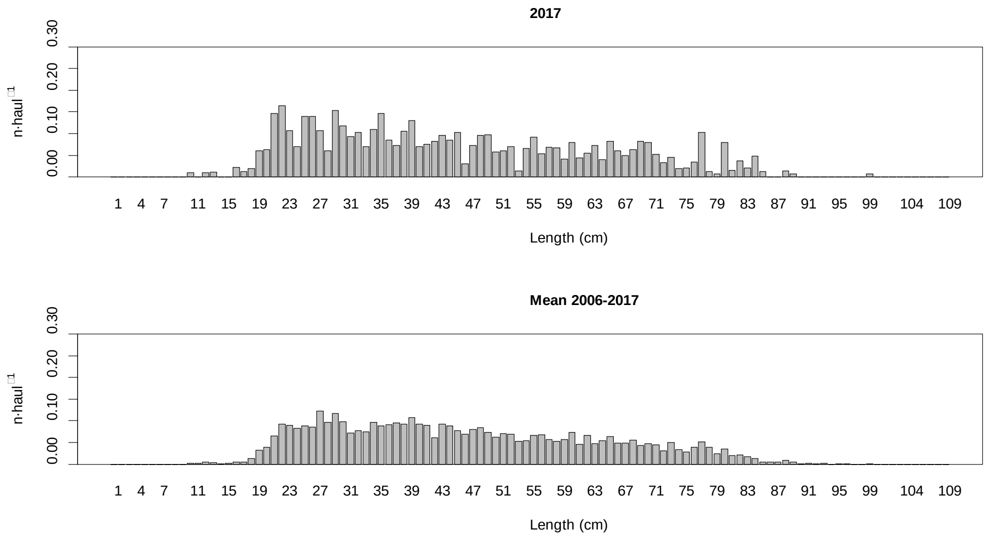

Figure 19.7c. Skates in the Bay of Biscay and Iberian waters. Stratified length distribution of R. clavata obtained from Spanish bottom trawl surveys time-series in the last survey (above) and in the last decade (below) in 8c Division of the North Spanish Shelf.

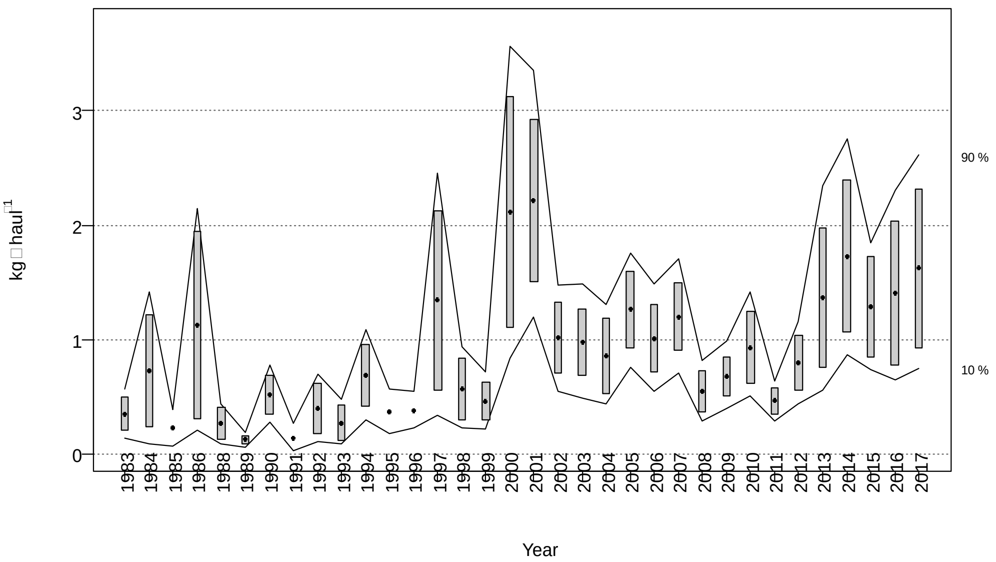

Figure 19.8a. Skates in the Bay of Biscay and Iberian Waters. Changes in *Raja montagui* biomass index during North Spanish shelf bottom trawl survey time-series (1983–2017) in 8c Division covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

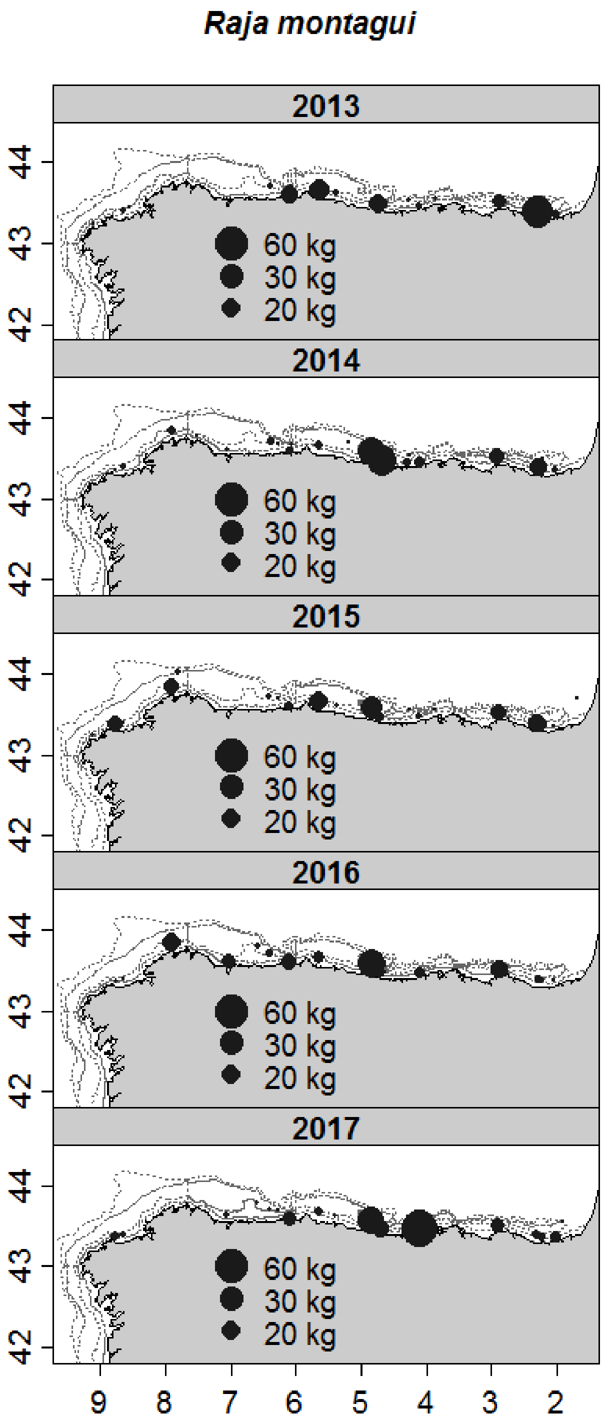

Figure 19.8b. Skates in the Bay of Biscay and Iberian Waters. Geographical distribution of *R. montagui* catches (kg/30 min haul) in North Spanish continental shelf bottom trawl surveys for the period (2013–2017).

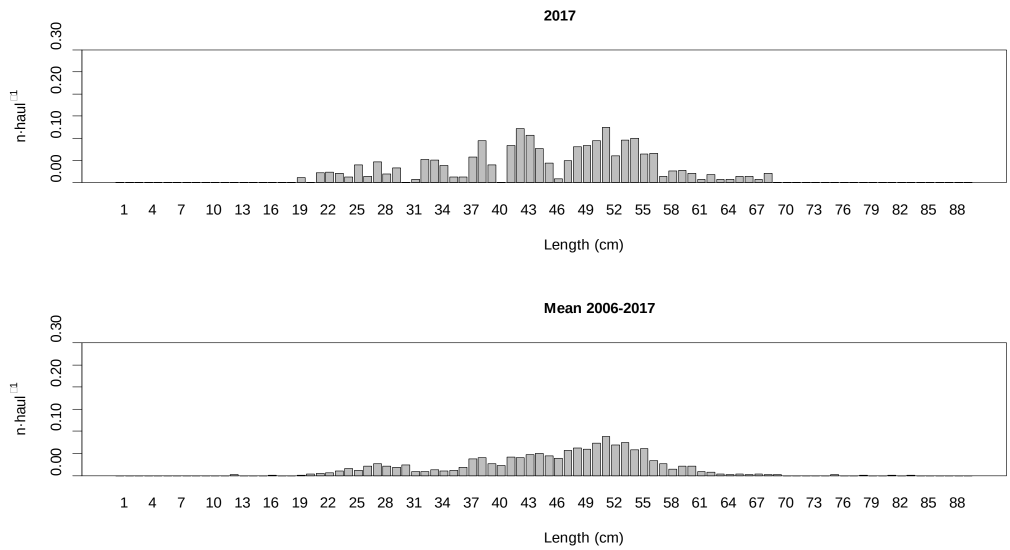

Figure 19.8c. Skates in the Bay of Biscay and Iberian waters. Mean stratified length distribution of Raja montagui in the last survey (above) and in the last decade (below) in 8c Division of the North Spanish Shelf.

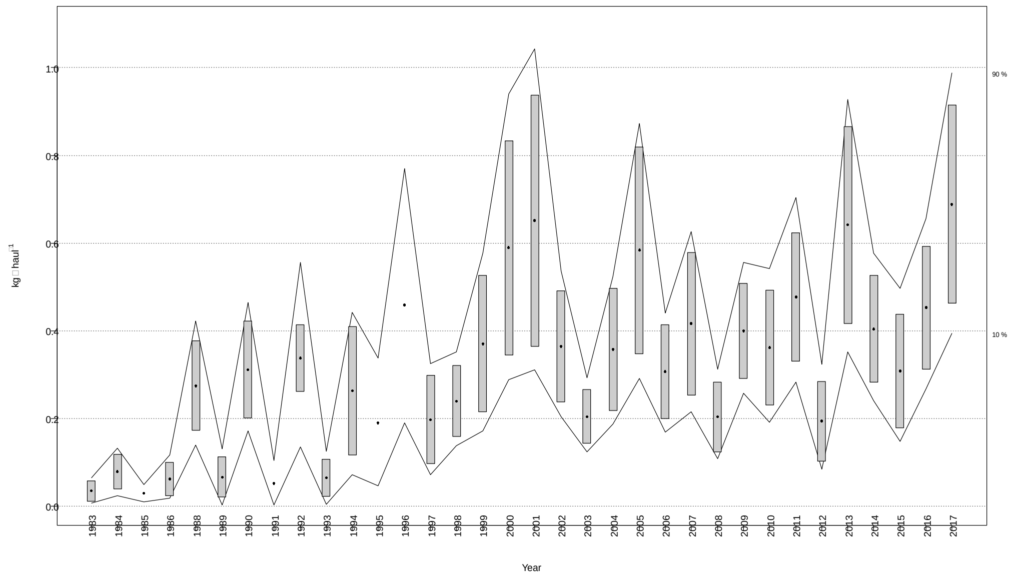

Figure 19.9a. Skates in the Bay of Biscay and Iberian Waters. Changes in *Leucoraja naevus* biomass index during North Spanish shelf bottom trawl survey time-series (1983–2017) in ICES division 8c. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

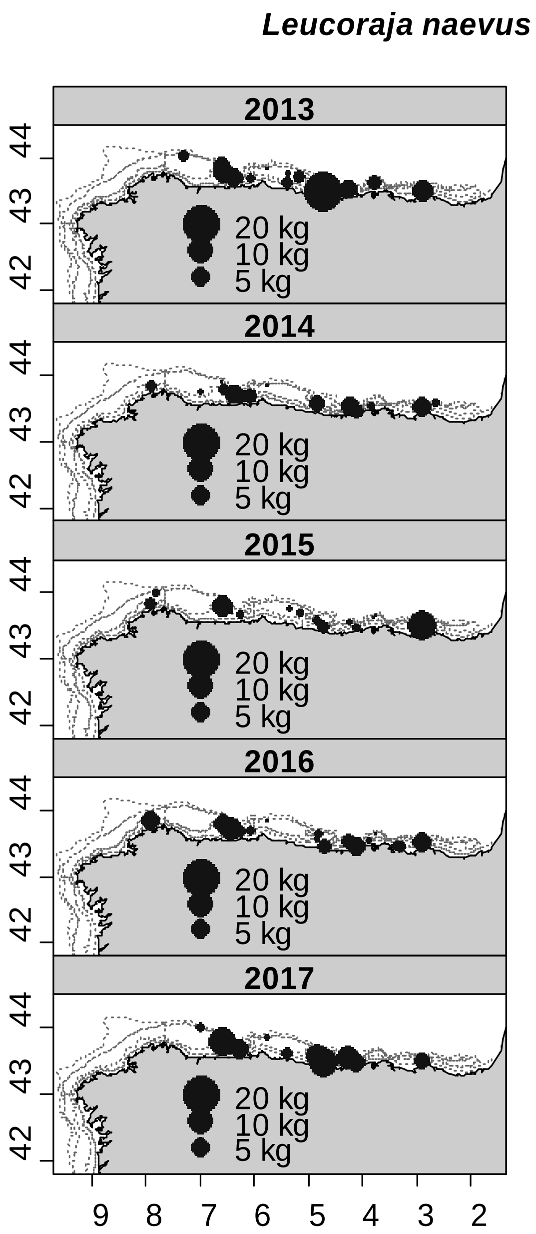

Figure 19.9b. Skates in the Bay of Biscay and Iberian Waters. Geographical distribution of *L. naevus* catches (kg/30 min haul) in North Spanish continental shelf bottom trawl surveys for the period (2013–2017).

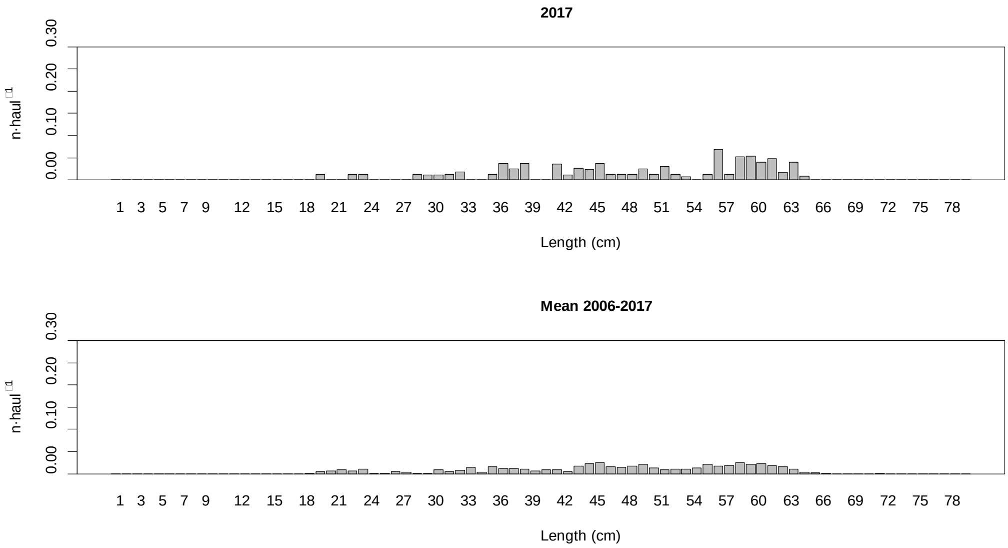

Figure 19.9c Skates in the Bay of Biscay and Iberian waters. Mean stratified length distribution of *Leucoraja naevus* in the last survey (above) and in the last decade (below) in 8c Division of the North Spanish Shelf.

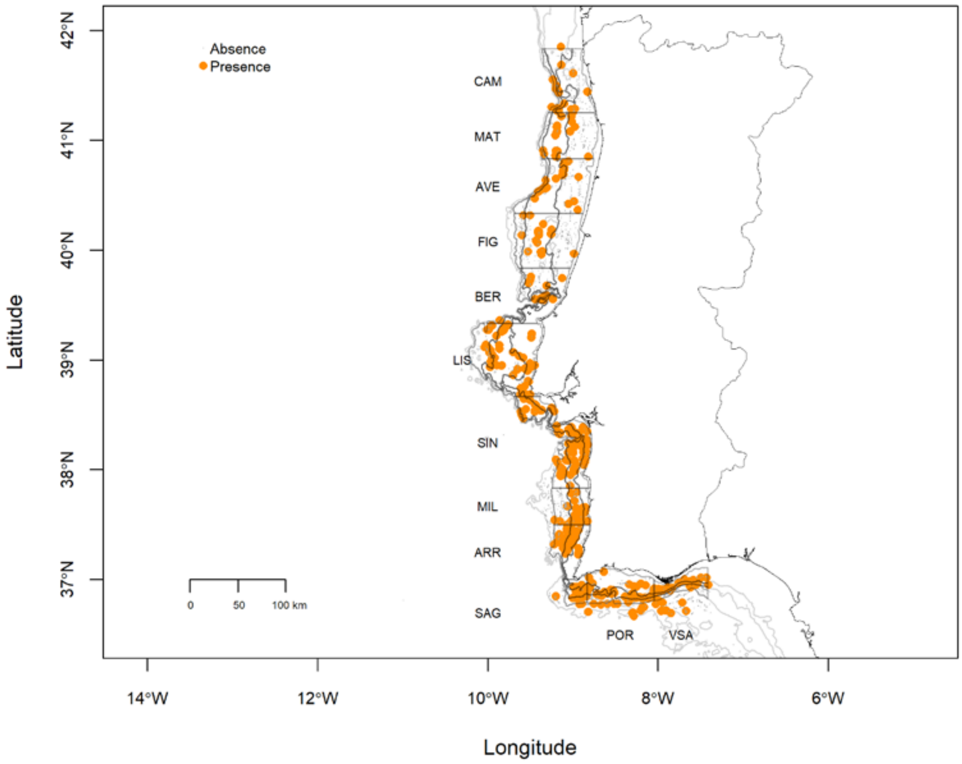

Figure 19.10a. Skates in the Bay of Biscay and Iberian Waters. *Raja clavata* distribution from 1981 to 2017 in the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4), and Portuguese crustacean surveys/*Nephrops* TV surveys (PT-CTS (UWTV), FU 28-29).

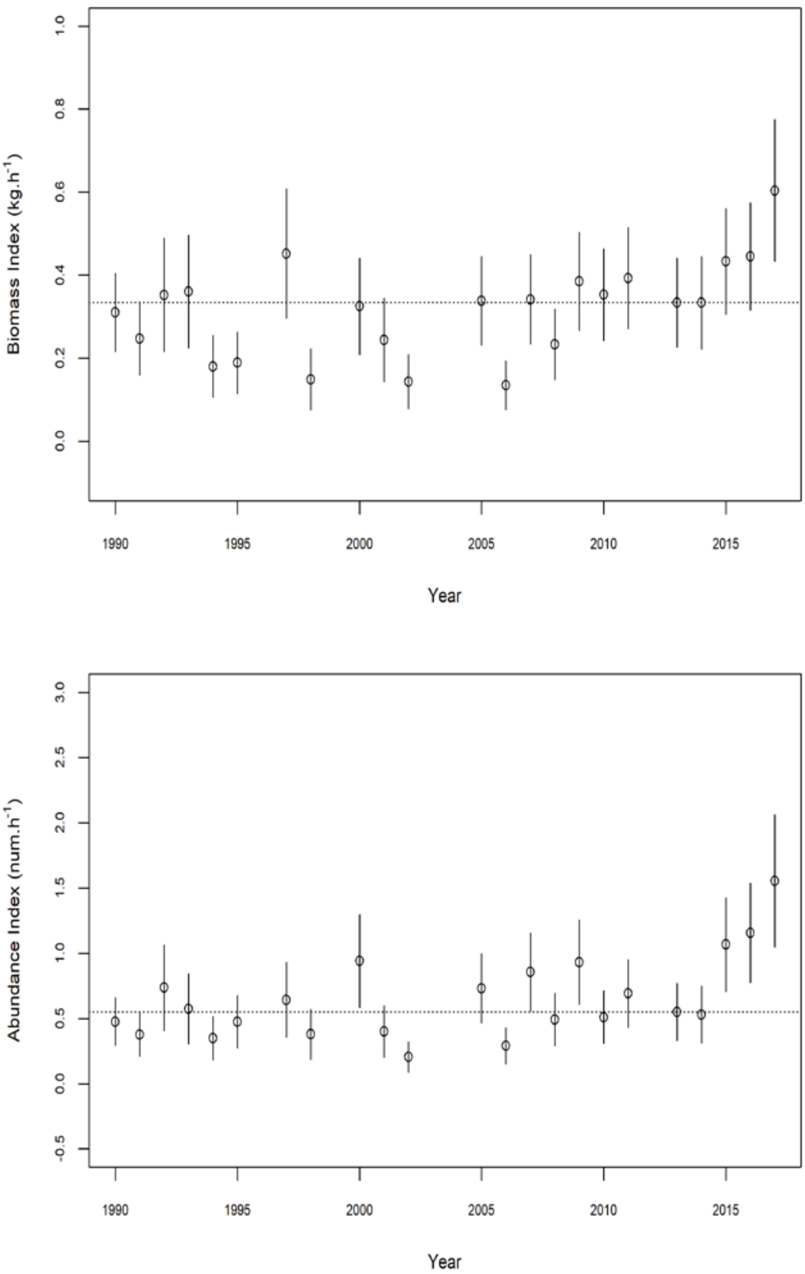

Figure 19.10b. Skates in the Bay of Biscay and Iberian Waters. *Raja clavata* biomass index (kg.hour^{-1}) and abundance (ind.hour^{-1}) on PtGFS-WIBTS-Q4from 1990 to 2017. Dashed line represents the mean annual abundance for the considered period.

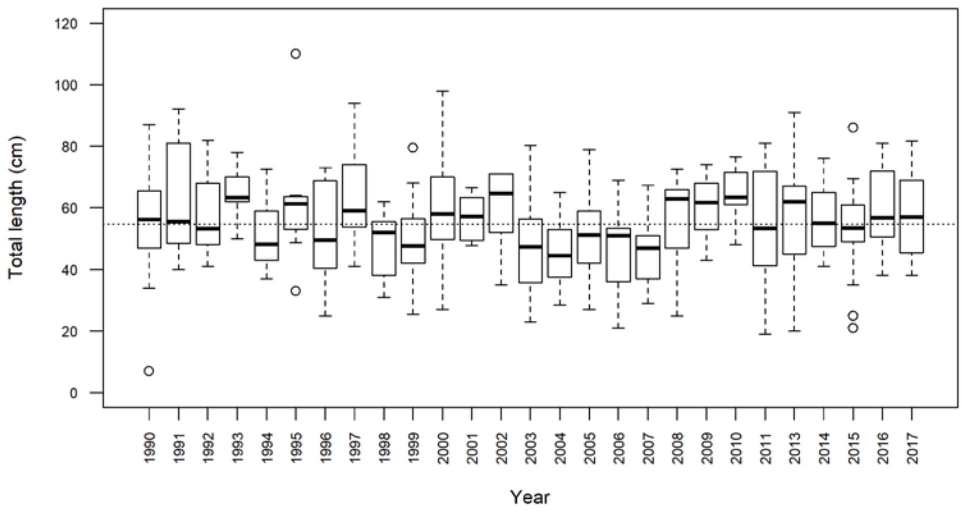

Figure 19.10c. Skates in the Bay of Biscay and Iberian Waters. Total length variation of *Raja clavata*, by year on PtGFS-WIBTS-Q4 (dashed line represents the mean annual length for 1990-2017).

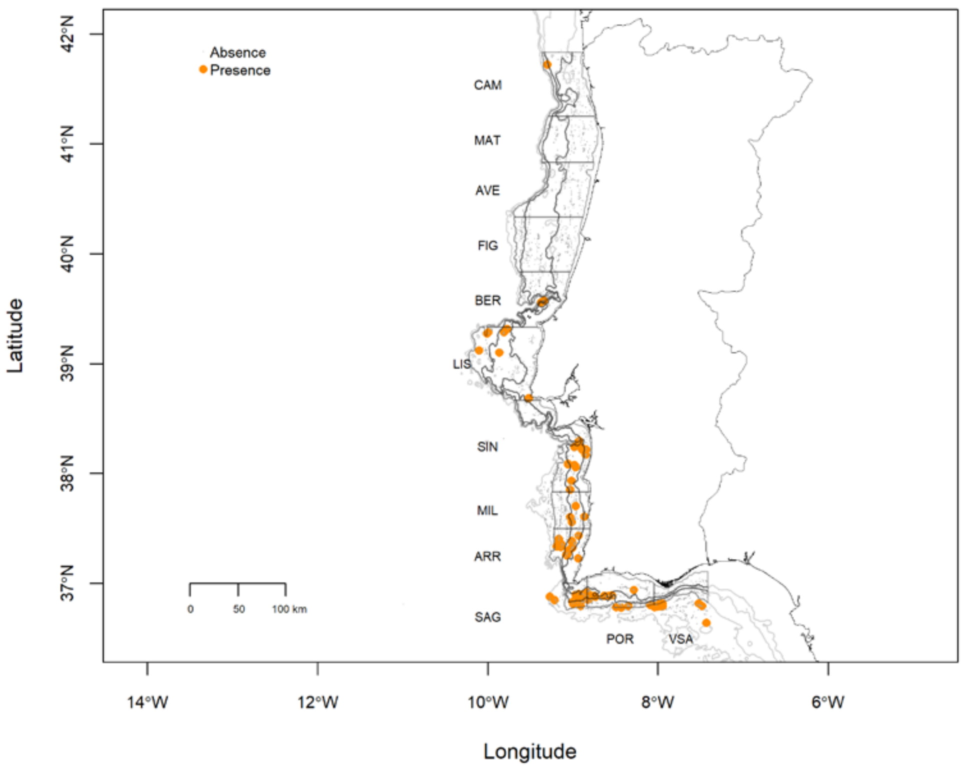

Figure 19.11a. Skates in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* distribution from 1981 to 2017 in the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4), and Portuguese crustacean surveys/Nephrops TV surveys (PT-CTS (UWTV (FU 28-29).

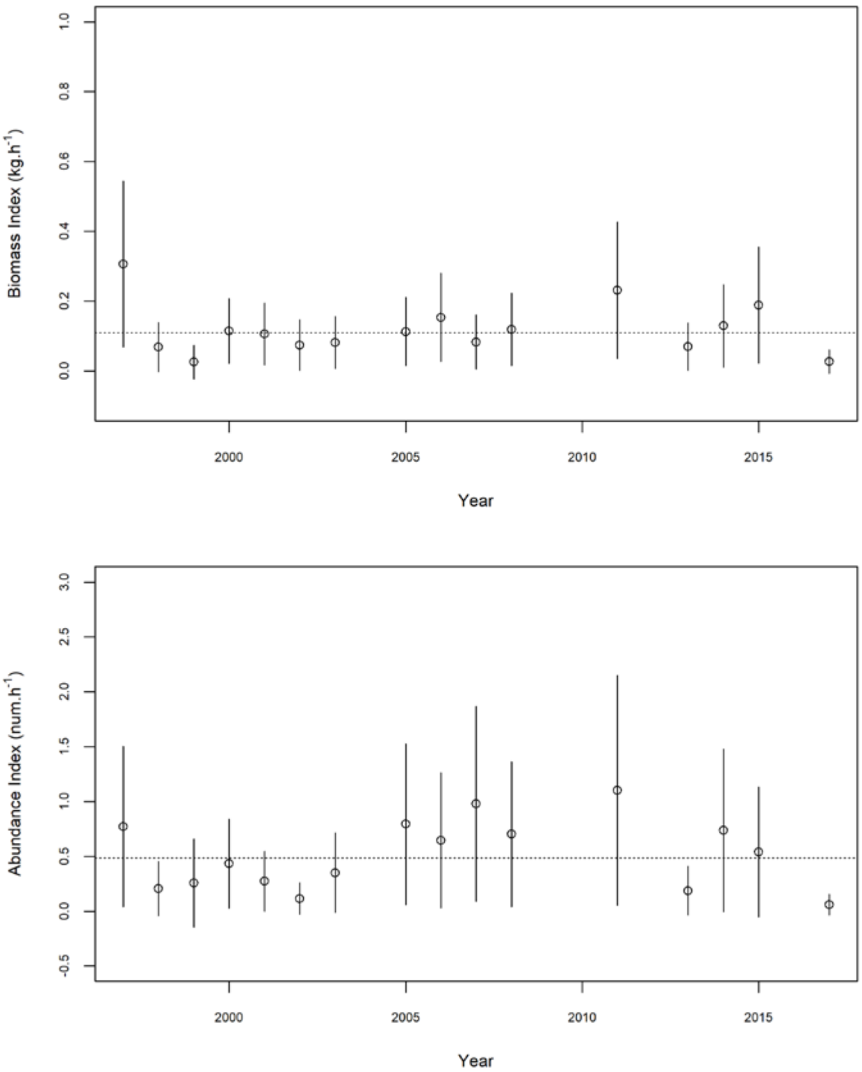

Figure 19.11b. Skates in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* biomass index (kg.hour^{-1}) and abundance (ind.hour^{-1}) on PT-CTS (UWTV (FU 28-29) from 1997 to 2015. Dashed line represents the mean annual abundance for the considered period.

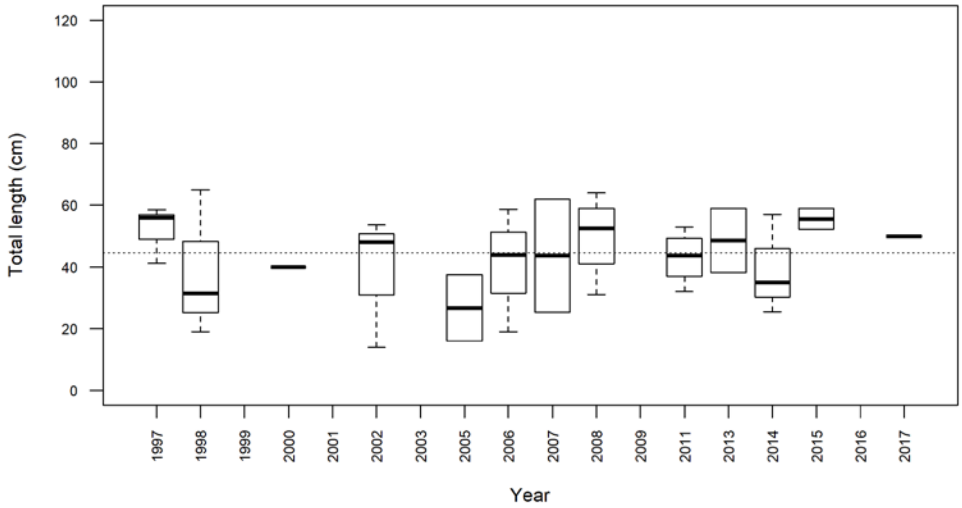

Figure 19.11c. Skates in the Bay of Biscay and Iberian Waters. Total length variation of *Leucoraja naevus*, by year on PT-CTS (UWTV (FU 28-29) (dashed line represents the mean annual length for 1997-2017).

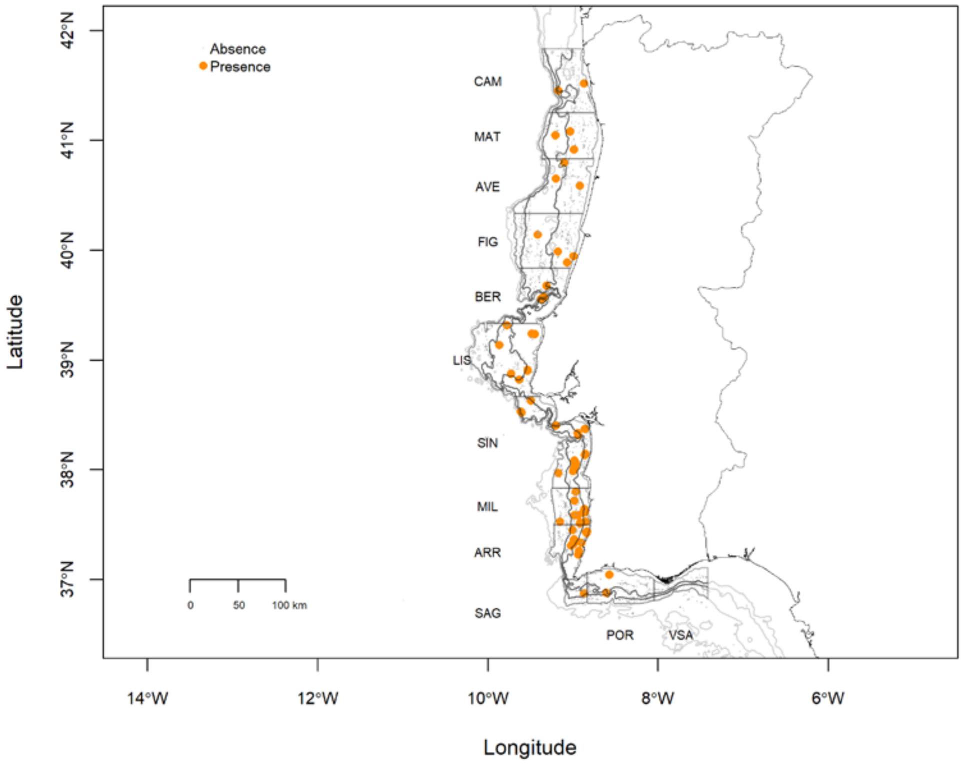

Figure 19.12a. Skates in the Bay of Biscay and Iberian Waters. *Raja montagui* distribution from 1981 to 2017 in the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4).

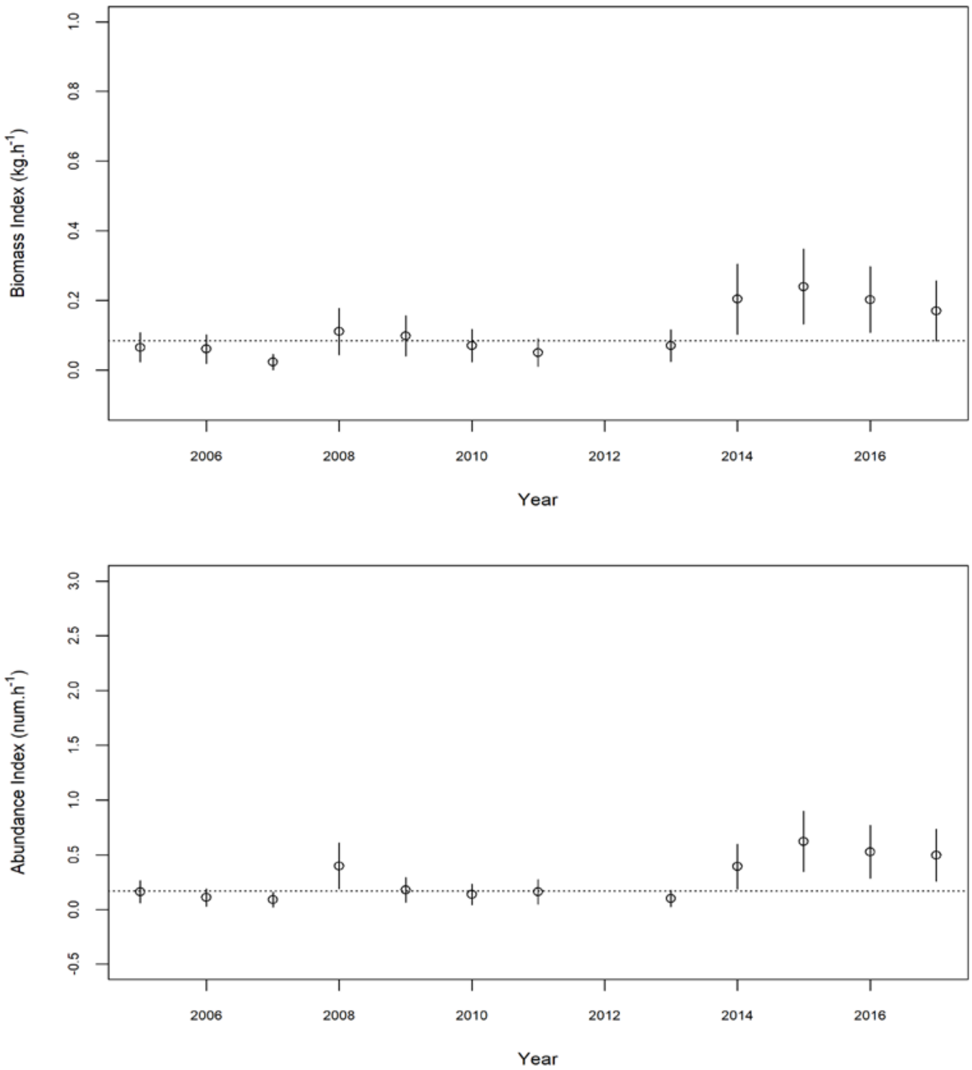

Figure 19.12b. Skates in the Bay of Biscay and Iberian Waters. *Raja montagui* biomass index (kg.hour^{-1}) and abundance (ind.hour^{-1}) on PtGFS-WIBTS-Q4from 1990 to 2017. Dashed line represents the mean annual abundance for the considered period.

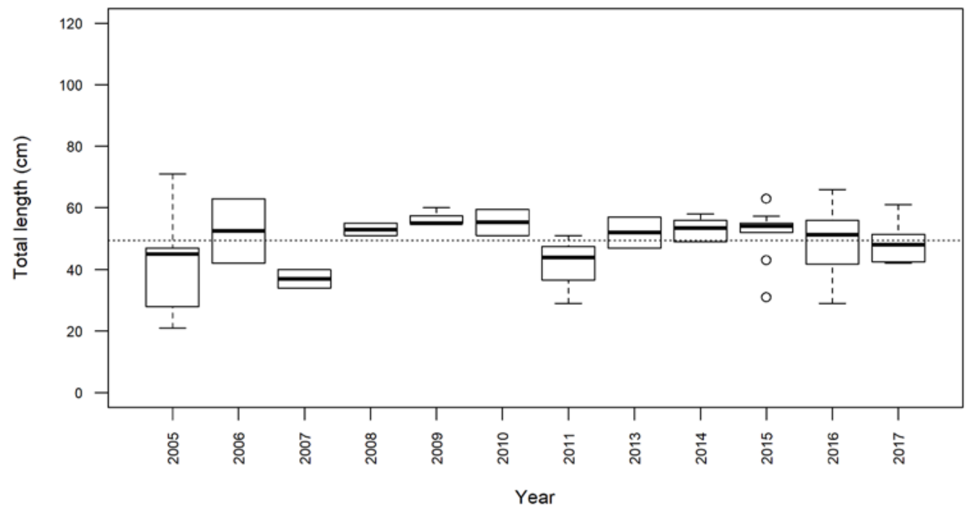

Figure 19.12c. Skates in the Bay of Biscay and Iberian Waters. Total length variation of *Raja montagui*, by year on PtGFS-WIBTS-Q4 (dashed line represents the mean annual length for 1990-2017).

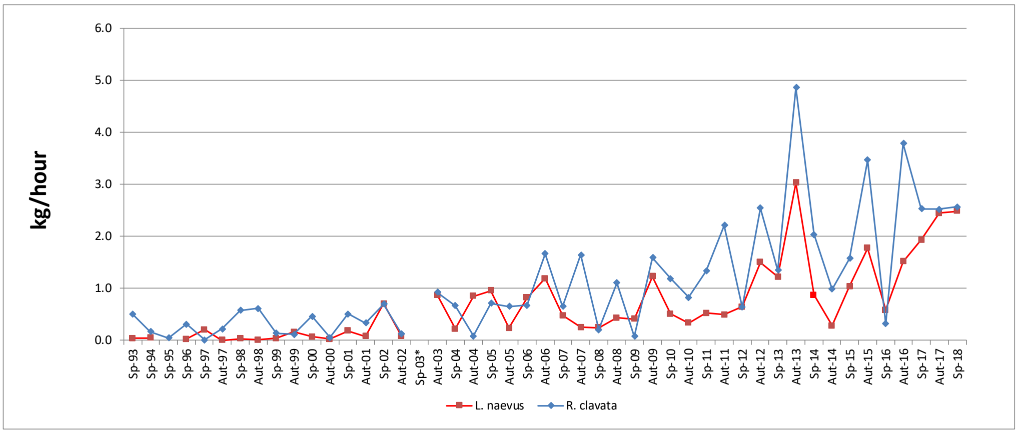

Figure 19.13a. Skates in the Bay of Biscay and Iberian Waters. Trend of the yield of *R. clavata* and *L. naevus* expressed as kg/hour from the Spanish bottom trawl survey ARSA carried out in spring and autumn in the Gulf of Cadiz (9.a South) from 1993 to 2018.

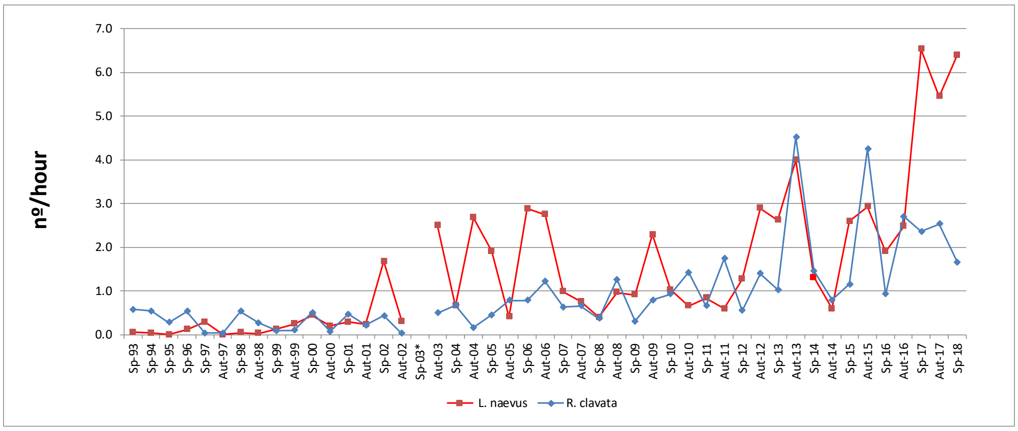

Figure 19.13a-b. Skates in the Bay of Biscay and Iberian Waters. Trend of the yield of *R. clavata* and *L. naevus* expressed as nº/hour from the Spanish bottom trawl survey ARSA carried out in spring and autumn in the Gulf of Cadiz (9.a South) from 1993 to 2018.

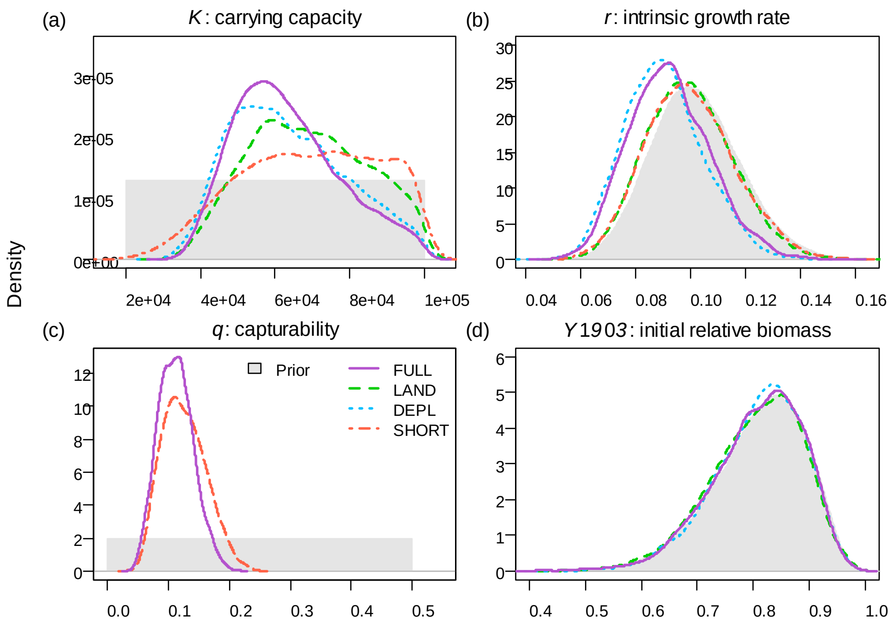

Figure 19.14 Skates in the Bay of Biscay and Iberian Waters. Comparison of prior and marginal posterior parameter distributions for *R. clavata* in the Bay of Biscay for four model runs using different data combinations. FULL: landings and biomass index; LAND: landings only; DEPL: landings and depletion estimated for final year; SHORT: as in FULL but using data for the years 2000-2013 only.

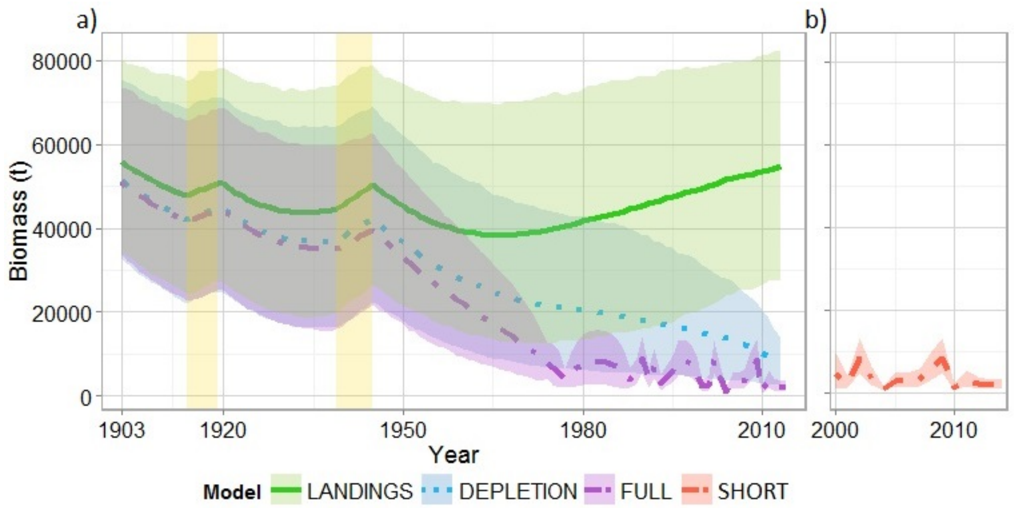

Figure 19.15. Skates in the Bay of Biscay and Iberian Waters. a) Estimated biomasses trajectories for *R. clavata* in the Bay of Biscay for model runs using different data series. LANDINGS: landings only; DEPLETION: landings and final year depletion rate; FULL: landings and biomass index for the years 1973-2013. Coloured areas: credible intervals between 2.5 and 97.5 percentiles. Vertical rectangles: World War I and II periods. b) Estimated biomasses trajectories for *R. clavata* in the Bay of Biscay by using only catches and biomass index time series from 2000 to 2013 (SHORT run).

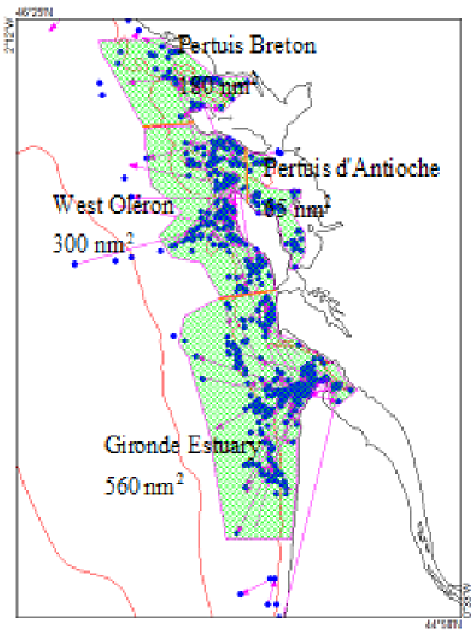

Figure 19.16. Skates in the Bay of Biscay and Iberian Waters. Habitat areas of *R. undulata* in the centre of the Bay of Biscay from 2011–2014 tagging and recapture positions.

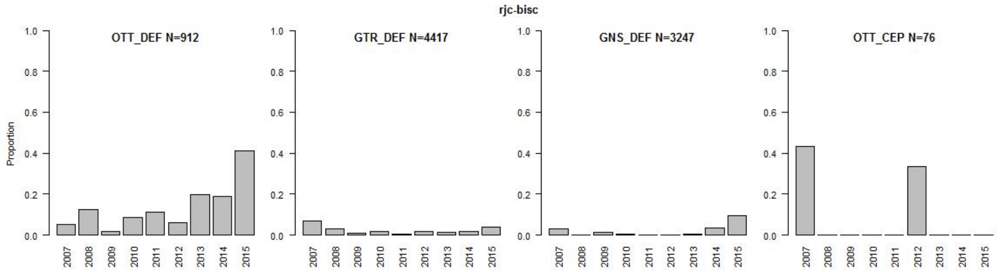

Figure 19.17a. Skates in the Bay of Biscay and Iberian Waters. *Raja clavata* in Subarea 8 (Bay of Biscay), rjc-bisc. Occurrence indicators from the French on-board observations programme in 8abd. N: total number of fishing operations observed for the métier from 2007–2015.

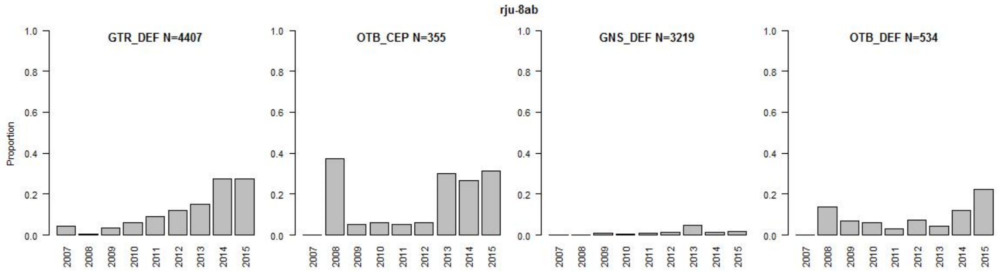

Figure 19.17b. Skates in the Bay of Biscay and Iberian Waters. *Raja undulata* in Divisions 8.a-b (Bay of Biscay North and Central), rju-8ab. Occurrence indicators from the French on-board observations programme in 8abd. N: total number of fishing operations observed for the mé-tier from 2007–2015.

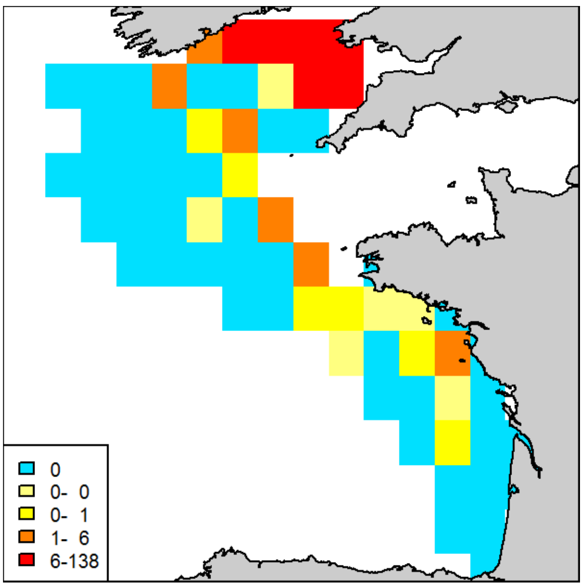

Figure 19.18. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *Raja montagui* in ICES Divisions 7.f-k and 8.a-c, based on catch in the EVHOE survey.

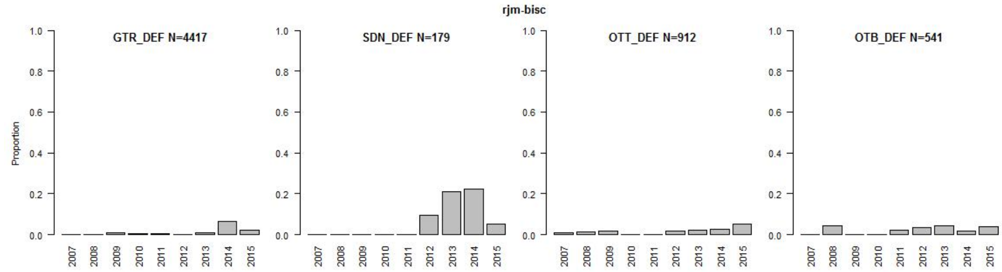

Figure 19.19. Skates in the Bay of Biscay and Iberian Waters. *Raja montagui* in Subarea 8 (Bay of Biscay), rjm-bisc. Occurrence indicators from the French on-board observations programme in 8abd. N: total number of fishing operations observed for the métier from 2007–2015.

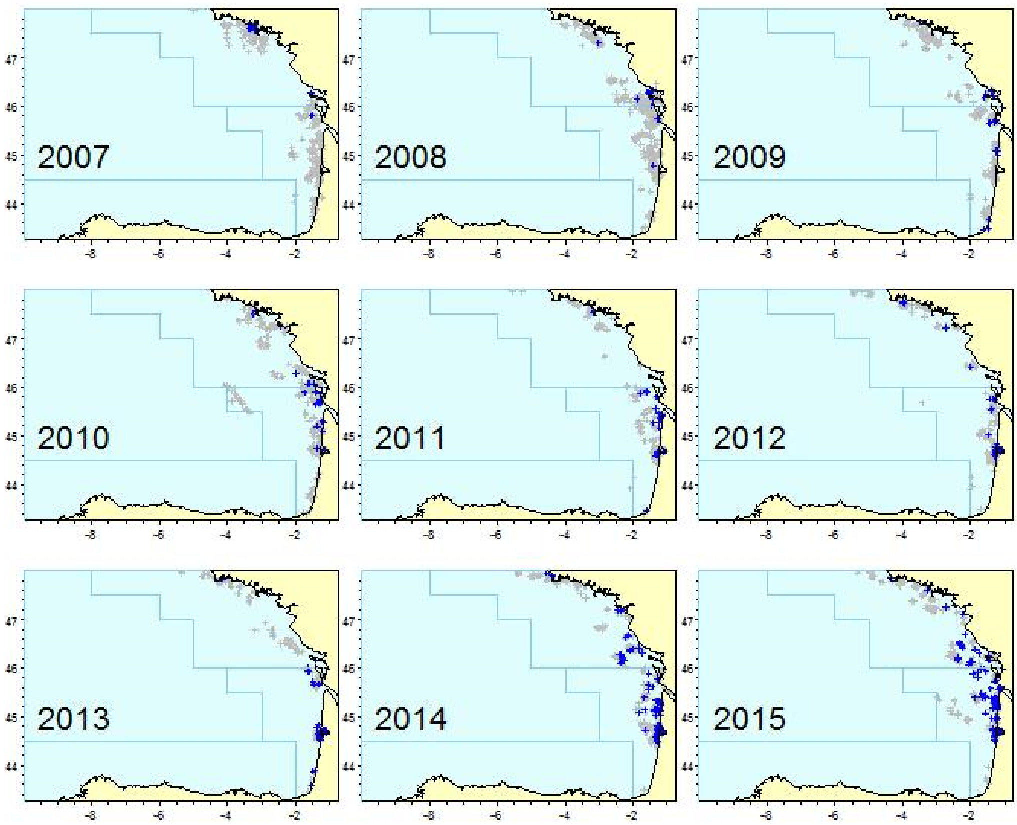

Figure 19.20. Skates in the Bay of Biscay and Iberian Waters. Occurrence of *Raja undulata* in Divisions 8a-b (Bay of Biscay) (rju-8ab) showing the spatial distribution based on occurrence in trammel net catches (DCF level 5 métier GTR_DEF) from 2007–2015, used to estimate the frequency of occurrence (see Figure 19.17b).

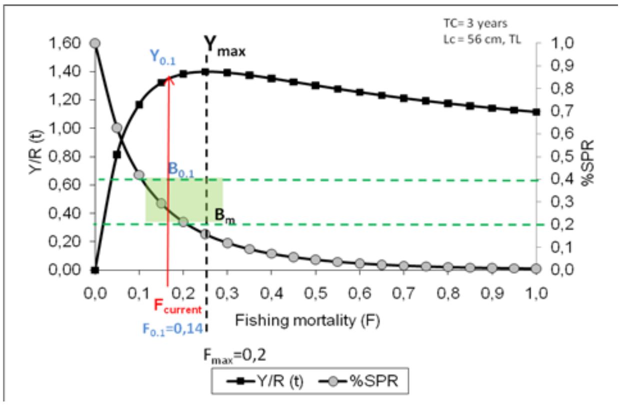

Figure 19.21. Skates in the Bay of Biscay and Iberian Waters. *Raja brachyura* yield per recruit (Y/R and potential spawning ratio (%SPR) curves for different levels of fishing mortality and an age of first capture = 3 years (TC). Red line shows $F_{current}$. *Raja brachyura*.

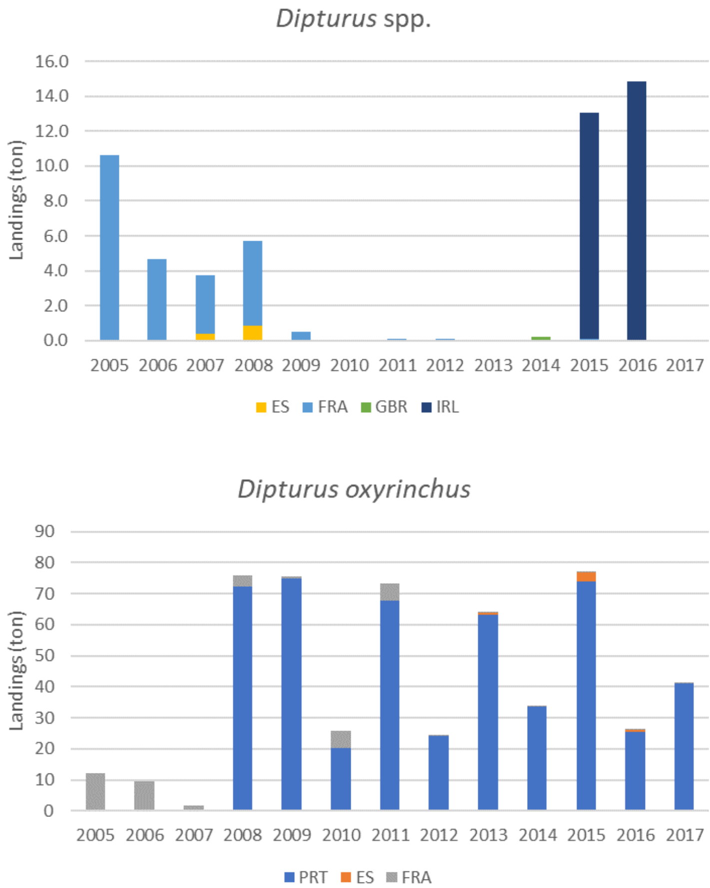

Figure 19.22. Landings (t) of *Dipturus* spp. and *Dipturus oxyrinchus by country* for Divisions 8 and 9a (2004-2016).

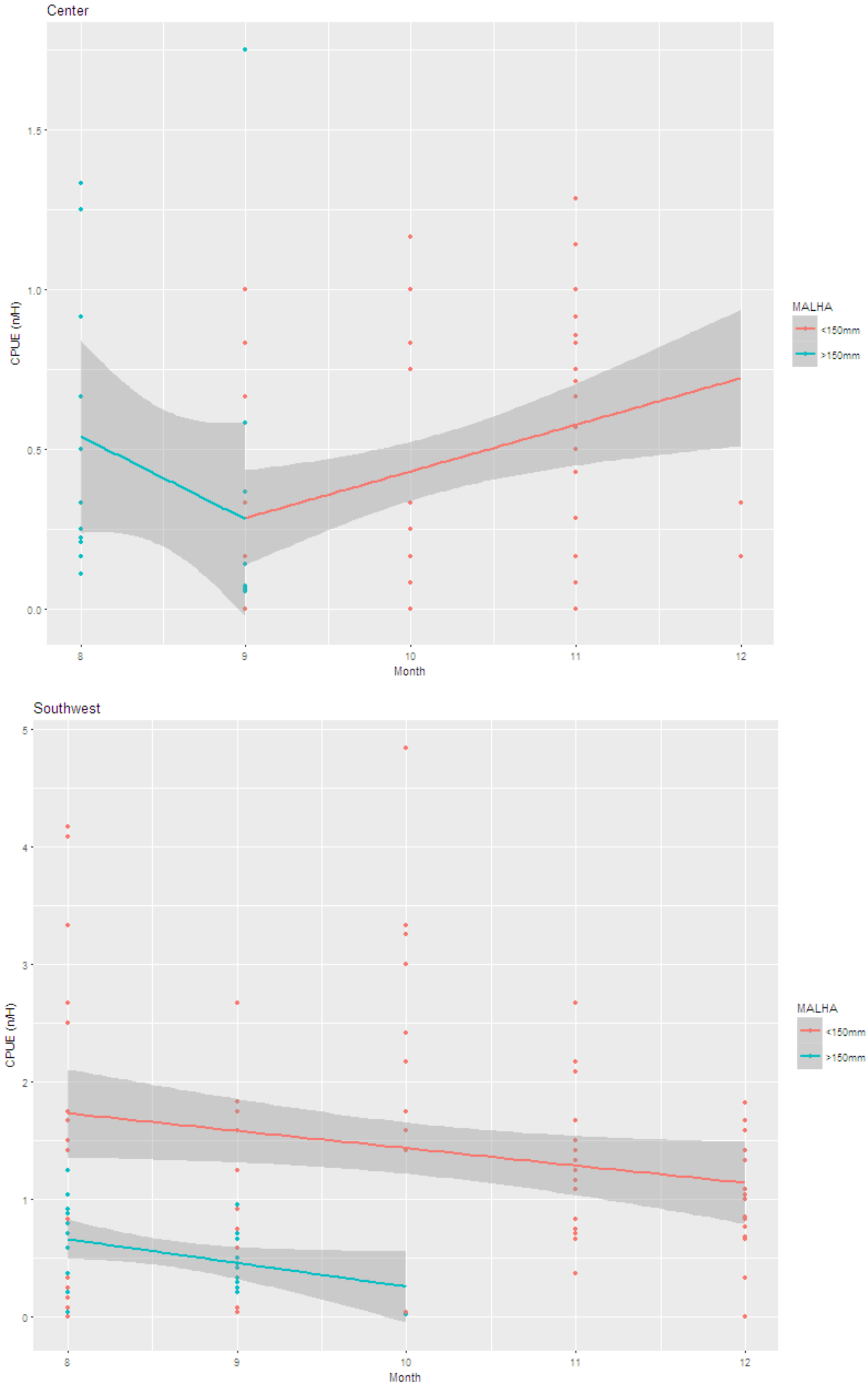

Figure 19.23: CPUE monthly variation in the centre and southwest regions. Effort unit: soaking time. Standard errors represented in dark grey.

Reviewers' comments

External reviewer report on the French request for a revision of the 20016 advice on *Raja undulata* in 7.de and 8.ab

Reviewer 1: Hans Gerritsen, Marine Institute, Ireland. 06/07/2018

Context

The advice issued in 2016 was based on recent landing figures, which were very strongly constrained by the total allowable catch (TAC). France has provided data on discards so that the entire catch can be taken into account.

The Reviewers are asked to assure that the WG has answered the Terms of Reference relevant to providing advice and the main conclusions are in accordance with the WG report, to highlight points where the report may contain errors and to include suggestions for future work.

WGEF was tasked with

i) Validating new data provided by France from:
   - industry self-sampling programme
   - observer programme

ii) Update the catch advice for 2018 based on the results of the data validation, the STECF report on survivability and updated assessment. Prepare a draft advice document for these two stocks.

Reviewer's comments:

The timing of the French request leaves no doubt that the motivation for this work is to obtain an enormous uplift to the TAC when the landing obligation will to apply to these stocks in 2019. The EU has been funding observer data collection since 2002 and yet France has not provided these data until now. Despite this I will assume that the French scientists have provided the best available data in an impartial and unbiased way.

- The WGEF report section on the self-sampling programme was not available
- Data from the observer programme were presented, however no uncertainty estimates were provided and insufficient information was presented to judge the quality of the data (see detailed comments below). The working document provides the number of observer trips, which is relatively high and therefore the precision of the estimates is likely to be acceptable. However this should be explicitly presented and discussed in the report.
- No data on survivability is presented
- The advice for rju.27.7de was updated for 2018, 19 and 20. This advice was based on the same survey index that the 2016 advice was based on. However the 2/3 rule is now applied to the estimated average catches of 2011-17 whereas the 2016 advice was based on recent landings. It is clear that recent landings were strongly constrained by the TAC and using the catch data makes more sense. The catches were estimated to have been between 1000 and 2500 tonnes during a period of considerable increase in biomass. It is therefore assumed that these catch levels are not detrimental to the stock.
- The advice for rju.27.8ab was also updated. There was no advised catch or landings provided in 2016. The advice for 2018 19 and 20 is based on the estimated average catches of 2012-17. Again this seems a sensible basis for the advice (as long as the PA buffer is applied).

Conclusion: While WGEF was not able to address all the ToRs relevant to the request; they draft advice sheets appear to be based on sufficiently reliable data.

Detailed comments on the WGEF report section

1.3 Landings and Discards

Assuming that the biomass is proportional to the catches is indeed a strong assumption and the bullet points in section 1.3.2 highlight many reasons why this assumption may violated. I do not believe that this is an appropriate method to assess the biomass and should not be used as the basis for the advice.

Estimating sustainable landings of undulate ray using the catch of a reference species would only be valid if the catches of this reference species are sustainable and if the ratio of the catches of the two species is representative of the relative abundance and productivity of the two species. No evidence for this is provided here.

The species codes are not explained in the figure headings or elsewhere. Also the figure legends often obscure the actual plots.

The estimated landings and discards are presented without precision estimates, making it impossible to judge the quality of the estimates. The working document indicates that the number of observer trips was quite high (table 2) but this information is not provided in the report.

1.4 Biomass index

Here there finally is a justification for the sustainability of the catches of thornback and blonde ray in 7d (but not in 7e!). Using the survey proportions is less problematic than the catch proportions but may still be imprecise; again no measure of precision is provided. Also no information is provided on the survey coverage (spatial and depth range) and suitability for providing an index for ray species (e.g. gear selectivity, catch numbers etc).

Why use Lmax here and Lmat in section 1.3?

Detailed comments on the Advice sheet for rju.27.7de

Advice on fishing opportunities

- *"If discard rates do not change from 2017, this implies landings of no more than 115 tonnes."* – this is a strange thing to say considering the LO will be in place for this stock in 2019; therefore this would only apply to the remainder of 2018.
- "*Targeted fishing on this stock is not permitted*." – is this advice or a statement of fact? If it is advice it should read: "*..should not be permitted*".

Stock development over time

- Why are there no error bars on the biomass index? This makes it difficult to judge the reliability of the index.

Catch scenarios

- I don't think that an dramatic increase in the index is an appropriate reason not to apply the buffer according to the ICES guidelines, but this is something for the ADG to discuss.
- The text refers to the 2015 landings; presumably this is a mistake.

Quality of the assessment

- WGEF 2017 stated that the main part of the stock occurs in 7e (section 15.6.2). If there is no stock indicator for 7e, how can the WG/ADG claim that the CGFS-Q4 covers a representative portion of the stock? This section needs more information on the survey, its coverage and suitability. There needs to be enough information to decide whether it is appropriate to base the advice on this index.

Issues relevant for the advice

- *"Catch rates in the UK-7d-BTS survey are low and not used as a stock indicator, but this survey has shown a recent increase, similar to that seen in the CGFS-Q4 (ICES, 2016a)."*
  This is contradicted by the report:
  "For rju.27.7 (Cat.3) the biomass index comes from the FR-CGFS survey in Division 7.d and from UK-BTS-Q3 (?) in division 7.e. The former shows a clear increasing trend since 2011 while the latter does not show a clear trend."

Summary of the assessment

Table 8 should also include the estimated landings and discards

Stock annex

There is no stock annex for rju 7de. This makes it difficult to judge whether the biomass indicator is appropriate as the basis for the advice. It has been used before as the basis of the advice and therefore I will assume that it is appropriate. However a stock annex needs to be produced and the suitability (including precision and potential biases) of the survey needs to be discussed there.

Detailed comments on the Advice sheet for rju.27.8ab

Advice on fishing opportunities

Same comments as rju.27.7de

Catch scenarios

Presumably the second paragraph will be deleted?

Information from stakeholders

An experimental fishery for undulate ray appears to be illegal as the TAC regulation states that this species should not be targeted.

History of the advice

Is 2018 advice not being updated? If not then the first sentence of the advice sheet needs to be corrected.

Review of the WGEF report concerning the special request from France to revise the advice provided in 2016 on fishing opportunities for 2018 for the stocks of undulate ray (Raja undulata) in 7.de and in 8.ab

Reviewer 2

In the light of new data availability, France send a special request to review of the 2016 advice of 2 undulate ray stocks (rju.7de, rju.8ab). This request was answered by the ICES Working Group of elasmobranch fishes (WGEF), as they evaluate and validate the new data and produce 2 updated advice sheets according to their evaluation. This review evaluates the criteria followed by WGEF.

More precisely the request has 2 parts and the WGEF was tasked with:

Address the special request from France to revise the advice provided in 2016 on fishing opportunities for 2018 for the stocks of undulate ray (Raja undulata) in 7.de and in 8.ab by:

i) *Validating new data provided by France from:*
- *industry self-sampling programme*
- *observer programme*

ii) *Update the catch advice for 2018 based on the results of the data validation, the STECF report on survivability and updated assessment. Prepare a draft advice document for these two stocks.*

Reviewer comments related to the ToR's:

i)

The evaluation of the industry self-sampling programme was not available for the reviewer at the time of review. Instead, the WGEF report focusses on the suitability for the observer programme (on-board observations) as a basis for the estimation of landings compatible with the ICES MSY approach. In general the discussion focusses more on the suitability of the data as input for the advice, rather than on the quality and reliability / uncertainty concerning the data. WGEF concludes that the on-board observation data is welcome, but there are some issues on raising the data. These issues are adequately described in the WGEF report (section 1.3.2). One assumption that WGEF mentions explicitly is that the biomass is proportional to the catches. Different potential problems with this assumptions are discussed. Furthermore the main other assumptions regarding the raising of the data are discussed, such as the different relative abundance for ray species in 7d 7e (analysis is carried out separately in these two areas) and the big proportion of vessels with 100% discard of undulate ray (leading to the choice of total discards (not total catch?), as ratio estimator) . However, the uncertainty and of the data is not thoroughly discussed. Moreover, the report does not discuss whether it is problematic or not that there is only data from the French fleet. Also there is no discussion on survivability. Finally it is unclear to me if the chosen approach to estimate the potential sustainable landings for undulate ray in the divisions 7d, 7e and 8ab is applicable. In it unclear if the catches of the chosen reference species are sustainable.

ii)

Given the issues, with raising the on-board observer data, the WGEF concludes that the data cannot yet be included in the advisory process and cannot be used to update the catch advices for 2018. Instead, it is advised that a benchmark process is carried out to determine how the on-board observation data and self-sampling data can be incorporated in the advisory process using undulate ray as an example. I agree with this conclusion and the report provides enough supporting information to derive this conclusion. However, it seems that the justification not to use the data could be more elaborated (see also the reviewer's comment on the first ToR). For example, the STECF advice is seemingly not explicitly taken into account. Furthermore, it is unclear to me whether update on the advice sheets is performed regarding the newly provided French data.

Annex 9: Special Request - Revision of the contribution of TACs to fisheries management and stock conservation

The European Commissions' DG MARE has requested ICES to carry out a revision of the contribution of Total Allowable Catch (TAC) levels to fisheries management and stock conservation.

Background to the request:

Management of stocks in the multi-fleet and multi-species context is complex. Traditionally the use of TAC levels as a management tool to limit the impact on the stocks has been applied. As of today, the north-east Atlantic waters (including North Sea and Baltic Sea) are managed under TAC regime for over 140 TACs.

These management interventions are all based on individual stock or management area considerations, which occasionally lacks application of the optimized combination of management instruments (both TACs and other tools). In light of the complexities of the mixed fisheries situations, of the introduction of multiannual plans for demersal mixed fisheries in the Baltic and North Sea and in the Western waters, and of the challenges that the landing obligation pose to the management of these fisheries, there is a need to address the question on the added value of TACs for a number of stocks and management units. In this context it is useful to ask ICES for a review of how the TACs continue to be the most adequate instrument for the management of these identified stocks. This review should be done within the confines of the objectives of the CFP.

Request:

ICES is requested to analyse for a *list of stocks* (as specified below) the role of the TAC instrument. It is asked to assess the *risks* of removing TAC for each case, analysed in light of the requirement to ensure that the stock concerned remains within safe biological limits in the short and middle term. ICES is further requested to assess the potential contribution of the application of *other conservation tools* in absence of TACs to the requirement that the stock concerned remains within safe biological limits.

In cases where the uses of TAC should be continued, ICES is asked to analyse a possible approach to contribute to inter-annual stability of TACs.

The request has been handled by a range of assessment working groups, including WGEF, each dealing with relevant stocks. The relevant elasmobranch stocks are shown in Table 1. Deep sea sharks have been dealt with by WGDEEP.

Table 1. Overview of elasmobranch stocks for the DG-Mare request for the revision of the contribution of TACs to fisheries management and stock conservation. Deep sea sharks have been dealt with by WGDEEP.

Bycatch TAC	TAC area		Current TAC (t)
Skates and rays	6, 7.a-c,e,k	Celtic Seas	9,699
Skates and rays	7.d,e	English Channel	1,276
Skates and rays	8,9	Biscay and Iberian Coast	4,326
Skates and rays	2.a, 4	Norwegian Sea and North Sea	1,425
Picked dogfish (spurdog)	1,5,6,7,8,12 and 14		270
Spurdog	NE Atlantic		Prohibited in North Sea

In order to address the issue in a coherent way, six overarching questions were formulated:

1. Was the TAC restrictive in the past?
2. Is there a targeted fishery for the stock or are the species mainly discarded?
3. Is the stock of large economic importance or are the species of high value?
4. How are the most important fisheries for the stock managed?
5. What are the fishing effort and stock trends over time?
6. What maximum effort of the main fleets can be expected under management based on FMSY (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

The expert groups will respond to as many of the 6 questions as possible for the relevant stocks. Information for skates and rays is shown in Table 2, and for the spurdog in Table 3.

Table 2. Information on TACs and management for skate and ray stocks in the areas designated in the request.

Question	Generic information on skates and rays	Regional differences
1. Was the TAC restrictive in the past?	TACs for skates and rays were introduced in 1999 (North Sea), and 2009 (Celtic Seas, Biscay-Iberia, eastern Channel, and Skagerrak). Reductions in the TACs led to quota being restrictive for fisheries, although the degree to which quota restricts fisheries varies between nations and fisheries.	North Sea: The North Sea TAC was set much greater than landings, and was then decreased over time. From 2007/2008, the quota likely became restrictive, at least for some fisheries, That the stock size indicator for thornback ray in this area (rjc.27.3a47d) has increased since quota became restrictive may be indicative of the stock responding to reduced fishing pressure.
		Eastern Channel: There is the ability for nations to transfer 5% of their quota for Subarea 6 and divisions 7.a-c, e-k to Division 7.d. That this has occurred regularly, so that the reported landings of skates from 7.d is greater than the TAC for 7.d alone is indicative that TAC has been restrictive.
		Celtic Seas:The TAC was set higher than both landings and ICES advice for several years. The TAC became restrictive from 2015 onwards.
		Biscay-Iberian: The TAC was set (6423 t in 2009) much greater than reported landings (4326 t) in this ecoregion, and has been strongly reduced over the years, to 3762 t in 2017. The TAC has been restrictive since 2013, and in 2014 and 2015 the reported landings were higher than the TAC.

<table>
<tr>
<td>2.</td>
<td>Is there a targeted fishery for the stock or are the species mainly discarded?</td>
<td>Some species (thornback ray, blonde ray, undulate ray, small-eyed ray) are taken in species-specific targeted fisheries in some parts of their range, often in inshore fisheries using nets, lines and trawl.

Such gears are also used in fisheries that target the skate complex (including the aforementioned skate species, and also spotted ray, cuckoo ray).

Trawl and net fisheries operating offshore, along the edge of the continental shelf, have a bycatch of skates, including cuckoo ray, shagreen ray, sandy ray and long-nosed skate. Skates are not thought to be routinely targeted in these areas, although if vessels encountered any areas of high abundance (for the skate complex) would conceivably be targeted.

Smaller individuals (< 40-50 cm) of all skates are generally discarded (Silva et al., 2012), and a wider part of the length range of smaller-bodied species (cuckoo ray and spotted ray) may also be discarded.

Some species are of different economic value in different countries, so the same species may be retained by vessels of one nationality but discarded by another, even when fishing in the same location.

Targeted species:
Raja brachyura, Raja clavata, (Raja undulata)
Species retained when caught:
Raja montagui, Leucoraja naevus, Raja microocellata.</td>
<td>North Sea: There are target fisheries for thornback ray in the southern North Sea. Blonde ray is also an important, marketable bycatch in some of these fisheries. Target fisheries are undertaken by the inshore fleet, as vessels >X m LOA have a bycatch restriction. The main target fishery is currently in the Outer Thames area, where the fleets use longlines and nets. Thornback ray is, along with sole, also one of the main catches in demersal trawl fishery (including twin-rig trawl) in this area. There have also been target fisheries in The Wash and North Norfolk coast.

Elsewhere in the North Sea, various skates (thornback, blonde, spotted and cuckoo ray) are a bycatch in various trawl fisheries. These fisheries discard smaller skates, and may also be limited by the bycatch quota.<hr>Eastern Channel: There are target fisheries for thornback ray in the eastern Channel. Blonde ray and small-eyed ray are also important, marketable bycatch species in some of these fisheries. Target fisheries are often undertaken by the inshore fleet, and generally use nets. Undulate ray is also locally abundant in some areas, and whilst targeted formerly, quota restrictions have restricted this species to a bycatch.

Elsewhere in the Eastern Channel, various skates (thornback, blonde, undulate, spotted and small-eyed ray) are a bycatch in various fisheries, including trawls and nets. These fisheries discard the smaller skates taken as bycatch and retain marketable species and sizes.<hr>Celtic Seas: There are target fisheries for blonde ray. Most other species are retained as important, marketable bycatch in mixed demersal fisheries.
Cuckoo ray in the Irish Sea are targeted by French vessels, but mainly discarded by Irish vessels targeting blonde ray in the same area.
There have been targeted fisheries for blonde ray in area 6, while spotted and thornback ray are important bycatch species in both inshore and offshore fisheries.</td>
</tr>
</table>

	Other species that may be retained or discarded *Leucoraja fullonica, Leucoraja circularis, Dipturus oxyrinchus, Raja miraletus* **Species required to be discarded (may only apply to specific ICES divisions):** *Dipturus batis, Dipturus intermedius, Dipturus nidarosiensis, Amblyraja radiata, Raja undulata* (see section on undulate ray) , *Rostroraja alba.*	Biscay-Iberian: In the Bay of Biscay and Iberian waters, skates are caught mainly as a bycatch in mixed demersal fisheries, including trawl and artisanal fleets (using mainly set nets, although some use longline) which target either flatfish (including sole) or gadiforms (e.g. hake). There are no target fisheries in the subarea 8, although coastal species are retained when they are caught by the artisanal fleet (gillnetters) in 8c. Trawl fleet operating in 8abd retain mainly largest individuals of *L. naevus* and *R. clavata*.

3.	Is the stock of large economic importance or are the species of high value?	The overall TAC management unit is of high economic importance. The value of the constituent species depends on a range of factors (e.g. fish size, thickness of wings, ease of skinning). Species such as undulate and blonde ray are often of higher value, whilst the more common species, such as thornback and cuckoo ray, are important in terms of the value of total landings. The estimated value of landings of skates and rays in the Celtic Seas ecoregion in 2017 was €13,696,816 (Source: MI stockbook 2017).	France: The estimated value of skates and rays landed in France (excluding the Mediterranean Sea) was €13.2 million in 2016 and €13.6 million in 2017. Ireland. The estimated value of all skates and rays landed by Irish vessels in 2016 was €1.78 million. Netherlands: The estimated value of all skates and rays in 2016 was € 1,311 433 (€ 1.31 million) Portugal: The estimated annual value of all skates and rays landed in Portuguese continental waters was about €2.7 million Spain: The value (€/kg) of the species caught by the artisanal fisheries in the 8c is normally higher than species coming from trawl fisheries in the 8abd. Average price is 2 €/kg. Among the skate species landed (Divisions 8.c and 9.a), R. clavata, L. naevus and R. montagui are the most frequent. Regarding the average prize by species for the same period in those areas were this information is available shows that there are hardly no differences among species, although high fluctuations exist in the mean prize of commercial species among time season and fishing gears. In 2017, the estimated annual value of all skates and rays landed by Spain from Subarea 8 and Division 9a is €1.87 million UK: Skates are of economic importance to the UK. MMO (2017) reported that UK fisheries (2012-2016) landed 2.4-2.6 thousand tonnes annually, with an estimated value of 2.7-3.5 million pounds per annum. In addition to being nationally important, skates can also be proportionally more important in some regions (e.g. Bristol Channel and Outer Thames).

4. How are the most important fisheries for the stock managed?	Quota availability influences the degree of fishing effort in those fisheries targeting skates. There are minor local restrictions in some fisheries. A range of skate species are taken as commercial bycatch in mixed demersal fisheries fishing for roundfish and flatfish, the proportion discarded/retained will be influenced by quota availability, whilst management regimes for the main target species will influence effort levels.	North Sea: Quota management is the main management tool at the present time, with some areas having local regulations on minimum landing sizes. There are also bycatch limits for larger vessels in this area.
		Eastern Channel: Quota management is the main management tool at the present time, with some areas having local regulations on minimum landing sizes.
		Celtic Seas: Quota management is the main management tool at the present time.
		Biscay-Iberian: Quota management is the main management tool. The TAC in 8 and 9 is shared (quota) among five countries. For some countries there is national legislation specific for rays and skates in place (e.g. Portuguese measures such as areas closure, minimum landing size and specific licensing for certain species) .
5. What are the fishing effort and stock trends over time?	There are no accurate trends in fishing effort for target skate fisheries. Stock trends are available for some of the commercial skate stocks. Many of these have increased in recent years, which may be due to the TAC management in place being restrictive. Some of the species that are (or were for a time) listed as 'prohibited' have shown signs of recovery.	North Sea: The main commercial skate stocks (e.g. thornback ray) have been increasing in this area, which may reflect the quota management in place restricting fishing effort. Survey catches of the common skate complex have also increased in recent years. Whilst starry ray has shown a recent decrease in survey catch rates, this is a non-commercial species that is also a prohibited species. Whilst there are no estimates of fishing effort for target fisheries, the TAC has increased in recent years as stocks have increased.
		Eastern Channel: The main commercial skate stocks have been increasing in this area, which may reflect the quota management in place restricting fishing effort. Thornback ray and undulate ray have shown increasing catch rates in trawl surveys. Whilst there are no estimates of fishing effort for target fisheries, the TAC has increased in recent years as stocks have increased.
		Celtic Seas: Overall survey catches (biomass) of the main species have been increasing in recent years, although with inter-annual variation. Cuckoo ray has been the main species showing a decline NEED TO EXAMINE 2018 DATA FOR THIS STILL.

		Biscay-Iberian: Since rays and skates are mainly by-catches, the fishing effort over rays is closely related to the fishing effort of the fleets targeting other species. For most of the stocks in this region the biomass trends have been increasing in recent years .
6. What maximum effort of the main fleets can be expected under management based on FMSY (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?	No data available	

Table 3. Information on TACs, fisheries and management for Spurdog (Picked dogfish) *Squalus acanthias* in the areas designated in the request.

Question	Information on spurdog
1. Was the TAC restrictive in the past?	The TAC was first established for the North Sea only in 2000, and other TAC areas established for other parts of the stock range from 2007 onwards. These TACs were reduced over time, and management measures are thought to have become restrictive from 2007. The introduction of associated regulations, including bycatch limits (2007-2008) and a maximum landing length (2009) deterred the target fishery. The (non-zero) TAC was probably only restrictive for a few years until fishing opportunities were withdrawn, firstly through a zero-TAC (2010) and then prohibited listing (2017).
2. Is there a targeted fishery for the stock or are the species mainly discarded?	There is currently no target fishery for spurdog, as it is a prohibited species with only a small allowance for vessels engaged in a 'bycatch avoidance scheme', although the efficacy of this scheme was questioned recently by STECF (2018). Consequently, the species is mainly discarded due to regulatory measures. It is landed in Norwegian waters. However, spurdog is increasing in abundance, as noted in the latest stock assessment.
3. Is the stock of large economic importance or are the species of high value?	The stock, when subject to target fisheries, was of high economic value to some nations (including UK, Ireland and Norway) and for some coastal communities. This was traditionally the most valued of the smaller sharks and dogfishes occurring in EU waters.
4. How are the most important fisheries for the stock managed?	Spurdog was traditionally targeted in longline fisheries and, in some areas, gillnet fisheries. Whilst TAC management was in place, this was only applied to the whole stock areas from 2007 onwards, and so only in place for a few years before fishing opportunities were withdrawn (2010). Other management measures, such as the maximum landing length (to deter fisheries targeting large mature females) and bycatch limits, prevented target fisheries when a non-zero TAC was still in place. Spurdog is currently a bycatch in a range of fisheries, including trawl fisheries (demersal otter trawl, *Nephrops* trawl and midwater trawl), gillnet fisheries and in near-shore, artisanal longline fisheries (this metier generally deploys lines for a mixed fishery, and spurdog may be a seasonal catch component).
5. What are the fishing effort and stock trends over time?	Fishing effort has declined since the cessation of the target fishery. The stock declined during the 1970s through to the early 2000s, but has now shown signs of recovery.

Question	Information on spurdog
6. What maximum effort of the main fleets can be expected under management based on FMSY (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?	NA

Following discussions within ICES a few high-level queries to synthesise the conclusions on the questions in the request were added to provide a consistent process and summary approach:

1. Has the species/stock/group (hereafter just called stock) got characteristics that places it at high relative risk?
    a. In terms of its general biology e.g. aggregating, sex change, long lived, low productivity, forage fish, ecosystem importance
    b. In terms of its catchability e.g. degree of population overlap with key fisheries, presence of refuges, ability to be directly targeted
2. Is the present TAC/management influenced by past unsustainable practices?
    a. If yes, are those fisheries still active?
    b. Was the stock targeted?
3. Can these or new unsustainable practices return if the TAC is removed?
    a. Can they be targeted with present fleet?
    b. Are they heavily discarded?
    c. Is the stock valuable?
4. Are there alternatives to a TAC to manage this stock?
    a. Can they be managed as companion species through target TACs (if applicable)?
    b. Can they be spatially managed?
    c. Any other mechanism?

Information for the relevant skate and rays stocks is shown in Table 4, and for spurdog in Table 5.

Table 4. Information on the effectivity of TAC management for skate and ray stocks.

1. Has the species/stock/group (hereafter just called stock) got characteristics that places it at high relative risk? a. In terms of its general biology e.g. aggregating, sex change, long lived, low productivity, forage fish, ecosystem importance; \\ b. In terms of its catchability e.g. degree of population overlap with key fisheries, presence of refuges, ability to be directly targeted.	Skates have biological characteristics that make them susceptible, including long-lived, low productivity (cf most teleost stocks), and often have an aggregating nature. Coastal species (e.g. undulate ray, small-eyed ray and blonde ray) have a high overlap with fisheries (including target fisheries). The main species on the continental shelf (thornback ray, spotted ray, cuckoo ray) have a high overlap with fisheries. The bathymetric ranges and geographical distributions of species on the continental margin and slope (e.g. sandy ray, long-nosed skate) are uncertain, and so the degree of overlap with fisheries is uncertain.
2. Is the present TAC/management influenced by past unsustainable practices? a. If yes, are those fisheries still active? b. Was the stock targeted?	Present TAC management has been influenced by past fisheries in which the elasmobranch component was unmanaged. Some of these were unsustainable, given the loss of common skate complex from former habitat. Various stocks have been subject to target fisheries, either historically (e.g. white skate, now extirpated from parts of its range, and common skate complex, which have shown contractions in geographical range) or currently (e.g. thornback ray, blonde ray).
3. Can these or new unsustainable practices return if the TAC is removed? a. Can they be targeted with present fleet? b. Are they heavily discarded? c. Is the stock valuable?	Removing the TAC for skates and rays would likely result in unsustainable fisheries by the present fleet. Skates are marketable.
4. Are there alternatives to a TAC to manage this stock? a. Can they be managed as companion species through target TACs (if applicable)? b. Can they be spatially managed? c. Any other mechanism?	Spatial management may be appropriate on a local scale, but the potential impact on fisheries has not been evaluated. Potential other management measures discussed by STECF

Table 5. Information on the effectivity of TAC management for skate and ray stocks.

1. Has the species/stock/group (hereafter just called stock) got characteristics that places it at high relative risk? c. In terms of its general biology e.g. aggregating, sex change, long lived, low productivity, forage fish, ecosystem importance; \\ d. In terms of its catchability e.g. degree of population overlap with key fisheries, presence of refuges, ability to be directly targeted.	Spurdog have biological characteristics that make them susceptible, being a long-lived species with a low productivity. They also have sexual and size-based aggregations, with the former target fishery targeting aggregations of mature females. Spurdog occurs over wide areas of the continental shelf, from the Barents Sea to the Bay of Biscay, and from the Skagerrak to Rockall. Whilst it has a high spatial overlap with fisheries, the main areas of overlap can vary seasonally.
2. Is the present TAC/management influenced by past unsustainable practices? c. If yes, are those fisheries still active? d. Was the stock targeted?	Recent TAC management was influenced by past fisheries and a lack of management during the peak of the fishery. Reductions in the TAC impacted on target and bycatch fisheries, with associated measures (bycatch limits and maximum landing length) deterring target fisheries. Spurdog was traditionally targeted in longline fisheries and, in some areas, gillnet fisheries. It is currently a bycatch in a range of fisheries, including trawl fisheries (demersal otter trawl, *Nephrops* trawl and midwater trawl), gillnet fisheries and in near-shore, artisanal longline fisheries (this metier is generally a mixed fishery, of which spurdog may be a seasonal catch component).
3. Can these or new unsustainable practices return if the TAC is removed? d. Can they be targeted with present fleet? e. Are they heavily discarded? f. Is the stock valuable?	Spurdog has been listed as a prohibited species since 2017, albeit with a small TAC to allow some (dead) bycatch to be landed ("*a vessel engaged in the by-catch avoidance programme that has been positively assessed by the STECF may land not more than 2 tonnes per month of picked dogfish that is dead at the moment when the fishing gear is hauled on board*"). STECF (2018) reported that "*there is little evidence that UK bycatch avoidance programme has resulted in a reduction in catches of picked dogfish (through the avoidance provisions) relative to the catches that would occur in the absence of the programme. This is likely the result that when the bycatch allowance is reached the vessels are allowed to continue discarding dead picked dogfish catches*." Spurdog is a valuable species and a bycatch in many fisheries, with varying levels of survival. If fishing opportunities were to be re-established, TAC management alone may regulate

	fishing pressure to a certain degree, but other measures may be required to fully deter fisheries targeting aggregations of mature females.
4. Are there alternatives to a TAC to manage this stock? d. Can they be managed as companion species through target TACs (if applicable)? e. Can they be spatially managed? f. Any other mechanism?	Spurdog is a highly mobile and migratory species. Their migratory patterns have been suggested to change over time. Furthermore, many of the key areas for spurdog (e.g. where aggregations of gravid females occur, pupping grounds, nursery grounds) are not delineated. Hence, whilst there are theoretical benefits of spatio-temporal management, there are insufficient data to inform on this. Trip limits (*x* kg/day) and a maximum landing length may serve as useful measures to deter fisheries fishing on grounds where (mature female) spurdog aggregate.

Management measures discussed by STECF

The Elasmobranch Working Group of STECF produced an overview of possible management measures for skates and rays[1]. In the report each of the management measures has been evaluated according to: information needed as a basis for implementation; data availability and limits; pros and cons for controlling fishing mortality; pros and cons for control and enforcement; potential issues related to compliance; possibility of choke; sources of uncertainty; potential performance indicators.

Table 6. Overview of main conclusions from STECF following the report from the Elasmobranch Working Group (EWG) (STECF, 2017).

Management measure	General conclusions from STECF (2017)
Skates and rays generalized TAC (status quo)	STECF observes that four methods of TAC setting were considered: general skate and rays TACs by region (status quo), general TACs with sub-TACs for particular stocks, TACs by genus and stock based TACs. The EWG note that ICES produces advice that allows the setting of landing TACs at stock level, but to set TACs on a catch basis, it will be necessary to get better estimates of dead discards. Related to this, the misidentification at species level and uses of generic categories in the reporting of landings and discard data also needs to be addressed. STECF observes that it would be useful to determine the level of confidence in the landing and discard data for the different stocks. The EWG noted that the control of fishing mortality by stock will be higher in the case of TACs set at stock level and lower in the case of TACs combining all species. The current general skate and ray

[1] https://stecf.jrc.ec.europa.eu/documents/43805/1853075/STECF+17-16+-+LTM+skates+and+rays.pdf

	TACs may not offer adequate protection for stocks that require reductions in F and conversely, may limit catch opportunities for stocks in good condition. The EWG also report that incentives to misreport are likely to be lower for general TACs since the possibility of a TAC to become limited increases with the number of TACs – this has particular relevance in the context of the LO. However, while this true, STECF observes that the argument against splitting a TAC for a group of skate species to reduce the likelihood of reaching a choke point is essentially the same as that for grouping similar species to reduce the risk of choke, so this argument must be carefully considered.
Landing trip limit (outside the quota system and applied to selected species)	This management measure would limit the quantities landed of selected species on a trip by trip basis. STECF observe that this measure was considered outside a quota limit system, but recognise that total removals would need to be managed to control fishing mortality. The main observation was that the utility of the approach was dependent on the species demonstrating good survival on release when the landing threshold is exceeded, and this evidence is currently limited.
Effort	The EWG conclude that effort management may have fewer control and enforcement issues compared with other options. However, measuring (and limiting) increase in fishing efficiency is extremely difficult, which would undermine this approach. Moreover, it would difficult to reconcile effort management for skates caught in combination with other species managed with quotas.
Minimum size	Size restrictions of landings (minimum and/or maximum) would need to be specific to each species. The EWG noted that this measure would be in contradiction with the landing obligation if implemented in association with catch limits, unless exemptions on the basis of high survival are in place.
Maximum size	
Minimum and maximum size combined	
Gear selectivity	Gear selectivity improvement could be used to avoid or reduce the catch of a species (for instance unwanted or prohibited species) or increase size selectivity (change in exploitation pattern). It could mitigate bycatch and also improve discard survival. Several gear-based technical measures could potentially be considered depending on the area and/or the fishery.
Spatio-temporal management	The EWG reports that spatio-temporal measures are useful only where they demonstrably control fishing mortality. These can be used to reduce mortality on stocks on a case-by-case basis and may be complemented by other generalised management measures. STECF observes that the tables presented listing species by ICES area could be used to build an evidence map which could then be used to demonstrate where data are sufficient to assess different management options. The EWG reports that the areas likely to be affected by spatio-temporal measures are potentially quite large with associated effects on wider fisheries. STECF observes that, in terms of species identification, the spatial distribution of commercial catches of different species could be validated using survey data.

Prohibited species list	The EWG states that the prohibited species list should be used for species which are biologically sensitive to any exploitation. STECF observe also that "Prohibited species" by their nature are sensitive species, mostly CITES listed, where even limited fishing activity could result in a serious risk to their conservation. There is currently no procedure on which to base decisions to include or exclude species from the prohibited list in the TACs and quota regulations. Moreover, the benefits of classifying species as prohibited are unknown without more information of the discard survival of incidental catches, and do not necessarily lead to a decrease in mortality.

The overall conclusion of the STECF is that although the current TAC system may not be ideal, as there may not be adequate protection for stocks that need F to be reduced and catch opportunities for stocks in good condition may be limited, there is not yet an alternative. The management options discussed by the EWG all need more work. Quantitative estimates of discarding and discard survival were recommended to be carried out with some urgency as these are necessary to be able to advise on catches. Research priorities have been elucidated on in the report (STECF, 2017).

Other issues

Loss of TAC for all or some skate species could impact on the collection of species-specific landings data.

The current TAC regulations are associated with requirements to report species-specific data for the main species.

Discards and discard survival

Catchpole *et al*. (2017) described the scientific evidence on the discard survival rate of rays caught in commercial fisheries in the UK. The approach was three-fold and covered:

- A critical review of available discard survival estimates
- Enhancing estimates of ray discard survival from previous captive observation experiments
- An analysis of tagged rays to derive original discard survival estimates of rays

The authors carried out a critical review according to published protocols as applied by the ICES Workshop on Methods for Estimating Discard Survival (WKMEDS; ICES, 2014). Following a re-analysis of data according to the principles shown above, Catchpole *et al*. (2017) made enhanced discard survival estimates for three species of ray in three different fisheries. See Table 7.

Table 7. Enhanced estimates of discard survival. Source: Catchpole *et al.* (2017).

Species	**Area**	**Métier**	**Survival**
Thornback ray *Raja clavata*	Bristol Channel ICES Division 7.f	Otter trawl	57–69%
Blonde ray *R. brachyura*	Western Channel ICES Division 7.e	Beam trawl	41–44%
Cuckoo ray *Leucoraja naevus*	Western Channel ICES Division 7.e	Beam trawl	34–35%
Thornback ray *R. clavata*	Southern North Sea ICES Division 4.c	Trammel net	95%

These estimates can be considered the most reliable estimates for the species-métier and area combinations at the present time.

Using the categories for estimating survival described by Catchpole *et al.* (2017) and WKMEDS (ICES, 2014), the existing literature has been analysed for information. See Table 8 for an overview of the data sources.

Table 8. Overview of available published information on estimates of discard survival. Categories for mortality estimates are from Catchpole *et al.* (2017).

Mortality estimate	Species	Métiers	Area	Reference
At vessel mortality (AVM)	*Raja clavata*	Longline, otter trawl, drift trammel net, tangle net	Southern North Sea	Ellis *et al*. (2018)
	R. undulata *R. montagui* *R. clavata*	Tangle net	English Channel	
	R. undulata *R. brachyura*	Otter trawl	English Channel	
	Dipturus batis complex	Trammel nets and gill nets	NE Atlantic Celtic Sea	Bendall *et al*. (2012)
	Amblyraja radiata	Otter trawl	NW Atlantic	Mandelman *et al*. (2013)
Short-term survival (2–5 days) in tanks/pens	*R. brachyura,* *R. clavata,* *R. microocellata* *Leucoraja naevus*	Otter trawl	Bristol Channel	Enever *et al*. (2009 and 2010)
	Leucoraja naevus	Beam trawl	Dulas Bay, North Wales	Kaiser & Spencer (1995)
	*Rajidae (*in particular *R. clavata)*	Eurocutter beam trawl	North Sea (4.c)	Depestele *et al*. (2014)
	Amblyraja radiata	Otter trawl	NW Atlantic	Mandelman *et al*. (2013)
Medium-term survival (up to 3 weeks) in tanks/pens	*R. clavata* *R. montagui*	Electric trawl	North Sea	Molenaar, in progress
Evidence of longer-term survival - based on mark-recapture tagging	*R. brachyura* *R. clavata* *R. montagui* *R. undulata*	Nets	Southern North Sea and English Channel	Ellis *et al*. (2018)
	R. brachyura *R. clavata* *R. undulata*	Otter trawl	Southern North Sea and English Channel	
	R. brachyura *R. clavata* *R. montagui* *R. undulata*	Longline	Southern North Sea and English Channel	
Quantified data on longer-term survival - based on electronic tagging	*R. clavata*	Trammel net	English Channel	Catchpole *et al*. (2017)
	R. brachyura	Otter trawl	Bristol Channel	Catchpole *et al*. (2017)

Summary for skates and ray (rajidae)

Vulnerabililty

The members of this family are thought to be able to sustain only moderate fishing mortality, lower than the main demersal species in the TAC management areas. This is due to their life-history of late maturation and relatively small numbers of offspring making them susceptible to over-exploitation, and their large size and distribution making them vulnerable to capture in fisheries

Knowledge gap *(including the limited data available)*

For all the stocks considered in this request discarding occurs to some extent but has not been fully quantified. The survival of discards is also largely unknown. The information in Tables 7 and 8 gives an overview of the most up to date information, but more research is necessary.

Survey data are informative for some skate stocks. Stock size indicators for various skate species have shown increasing trends in recent years, which may relate to the TAC acting as a restrictive management measure. Where longer-term time-series data are available, the recent increases in the stock size indicators follow earlier declines, suggesting the increasing trend to be a recovery of populations. The stock-size indicator for the thornback ray (*Raja clavata*) in the North Sea is shown in Figure 1.

Inclusion of industry data

With the upcoming implementation of the Landing Obligation for demersal fisheries in January 2019, there have been collaborative projects with industry to estimate survival of discards. Also self-sampling programmes by industry provide information on discard rates. WGEF has suggested that a process is started on how to include the latter for informing on stock status.

Potential reaction of fishery to the removal of TAC *(Is a target fishery likely to develop)*

Various skates have a moderate/high price, as detailed in Tables 2 and 3. It is likely that fishing effort on skates would increase if the TAC is removed, particularly if effort on other stocks becomes limited under the Landing Obligation.

For stocks which have been declining in survey indices in the past years, such as Cuckoo ray in 6,7 and 8abd, it is not considered likely that removing the TAC will increase protection for these stocks. Removing the TAC for these species (especially in 8abd) could led to increase the discard of small-medium size individuals because they fetch a lower price in the market to larger individuals.

In some coastal fisheries species are targeted within the group TAC, see Table TARGET_BYCATCH in Appendix 1. Removal of the group TAC will likely lead to an increase in targeting and a corresponding increase in fishing effort and mortality. For undulate ray and small-eyed ray sub-TACs allowing a small bycatch have been developed to address the local distribution and vulnerability of the species, following their inclusion on the prohibited species list. There is some discussion on the perceived low level of the advice provided by ICES for the stocks (e.g. UND 7de and 8ac) and removing these sub-TACs will almost certainly lead to the development of a target fishery and a corresponding increase in fishing mortality.

In Figure 1 the stock size indicator for the thornback ray, the most numerous in the landings, is shown in relation to the trend in TAC. It is clear that the stock has increased since the TAC was set at the current level from around 2008/2009.

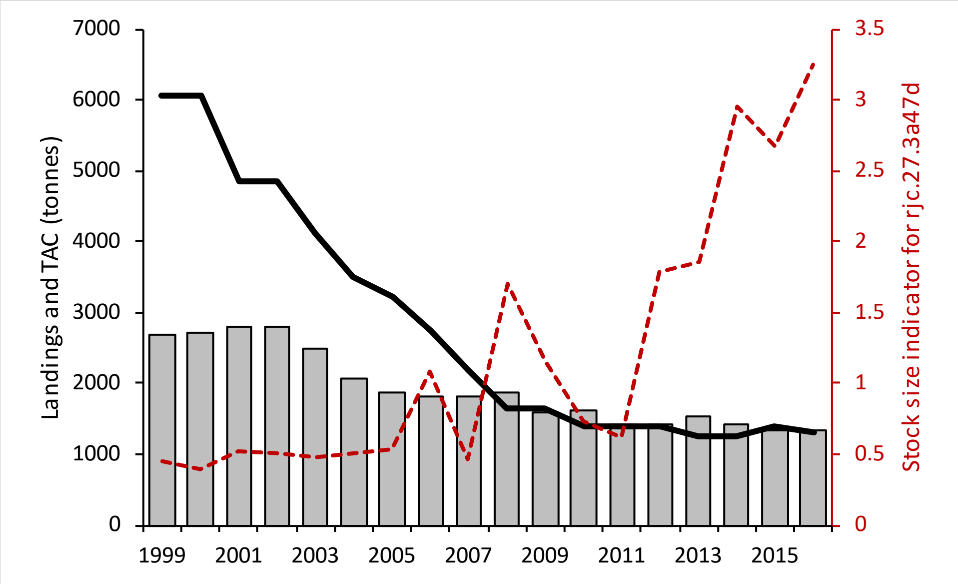

Figure 1. Temporal changes in the landings of skates (grey columns) and their TAC (black line) in the North Sea, and the stock size indicator for thornback ray (rjc.27.3a47d; dotted red line).

Special Case – Management of stocks after being in a moratorium system – ***Raja undulata*** **stocks in ICES area**

The coastal and fragmented distribution of undulate ray together its biological characteristics make this species vulnerable to fishing and, in particular, to be easily targeted by fisheries. Those facts were considered for the inclusion, in 2010, of undulate ray stocks in the EU list of prohibited species (Section 6 of CEC, 2010). As stated at the STEFC Long-term management of skates and rays report *There is currently no procedure on which to base decisions to include or exclude species from the prohibited list in the TACs and quota regulations. Moreover, the benefits of classifying species as prohibited are unknown without more information of the discard survival of incidental catches, and do not necessarily lead to a decrease in mortality* (STECF-17-16).

As a consequence of the inclusion of undulate ray in the EU list of proihibited species several countries react, claiming *that the species was locally abundant, in particular in the Normano-Breton Gulf (area VIIde) and in the Pertuischarentais (area VIIIab), the French fishermen set up fisheries-science partnerships (Raimouest, RaieBeca and RECOAM) to study the abundance of the undulate ray in these areas and the final results were delivered in 2014. A similar Portuguese initiative in area IXa is still ongoing in 2015.*

In the 2015 EU Commission request on *Possible by-catch provisions for undulate ray in ICES areas VIIde, VIIIab and IX* STECF noted that *lack of basic catch and effort data and the limited survey coverage remains a barrier to the development of an analytical assessment based on fishery dependent and independent data…* and … *that it is not in a position to determine* *whether such landings levels are in accordance with the provisions of the CFP (STECF-15-03).* As a consequence, STECF has advised that …*If managers decide upon a limited TAC … catches and effort be closely monitored and used as the basis of an adaptive management approach.* Such rationale has implicitly the answering of the main questions: i) What is the current stock status? ii) What are the sustainable fishing levels for the stock?

The initial EU legislative framework adopted for some of the undulate stocks in ICES areas included the setting of highly restrictive TAC and quotas accompanied by additional measures … This species shall *not be targeted in the areas covered by this TAC. In cases where it is not subject to the landing obligation, by-catch of undulate ray in the area covered by this TAC may only be landed whole or gutted, and provided that it does not comprise more than 20 kilograms live weight per fishing trip. The catches shall remain under the quotas shown in the table below. …. By-catches of undulate ray shall be reported separately ….*(COUNCIL REGULATION (EU) 2016/72 of 22 January 2016). The latest EU decision regarding undulate stocks adopted the restrictive TAC and quotas and only maintained that *this species shall not be targeted in the areas covered by this TAC …by-catch of undulate ray in area … may only be landed whole or gutted…*and…*By-catches of undulate ray shall be reported separately* (COUNCIL REGULATION (EU) 2017/127).

ICES considers that by-catch allowance as a step to collect the necessary information to future inform on the stock status and in consequence on the formulation of scientific advice on the possible fishing opportunities in line with CFP should be considered and that the by-catch levels should be adopted under precautionary principle and taking into account the sampling effort required by the scientific pre-assessed close-fishery monitoring program in course.

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Apendix 1. From Chapter 26.1.1 of the WGEF 2018 report

Overview bycatch and target stocks

The stocks for which the WGEF gives advice have been designated by the group as being 'bycatch' or 'target' according to known information on fishing activities (Table A1). All the skate and ray stocks are managed through a group TAC, and if targeting occurs it is driven by local conditions of abundance and/or commercial value. The TAC for skates and rays is primarily a group TAC. In specific circumstances, such as to deal with regional differences, there is a TAC for a stock. Undulate ray and small-eyed ray, which were prohibited for a number of years and which have a regional, coastal distribution, are examples. There is a sub-TAC for *Raja undulata* in Areas 7.d and e and 8.a and c ?? as this species was previously on the prohibited species list. *Raja microocellata* in 7.f and g had a non-retention footnote. In both cases a species-specific approach is required. There have been stock TACs for the shark species in the past, but currently only the spurdog has a TAC. Of the 55 stocks for which ICES gives advice, only 10 are actually being targeted as described above in 2018. In the past this was 27 stocks.

Table A1. Sharks skate and ray stocks designated as 'bycatch' or 'target'. Skate and ray species which have the designation 'target' are targeted within the group TAC by certain fleets. ICES does not have a clear definition of bycatch. In making this table the WGEF has considered as bycatch stocks that are not directly targeted.

Stock Key Description	Has TAC ever been applied at stock level	Target or bycatch 2018	Target or bycatch in the past?
Angel shark (*Squatina squatina*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Basking shark (*Cetorhinus maximus*) in Subareas 1-10, 12 and 14 (Northeast Atlantic and adjacent waters)	Yes	Bycatch	Target
Black-mouth dogfish (*Galeus melastomus*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	No	Bycatch	Target
Black-mouth dogfish (*Galeus melastomus*) in subareas 6 and 7 (West of Scotland, southern Celtic Seas, and English Channel)	No	Bycatch	Bycatch
Blonde ray (*Raja brachyura*) in Division 7.e (western English Channel)	No	Target	Target
Blonde ray (*Raja brachyura*) in Division 9.a (Atlantic Iberian waters)	No	Bycatch	Target
Blonde ray (*Raja brachyura*) in divisions 4.c and 7.d (southern North Sea and eastern English Channel)	No	Bycatch	Bycatch

Stock Key Description	**Has TAC ever been applied at stock level**	**Target or by-catch 2018**	**Target or by-catch in the past?**
Blonde ray (*Raja brachyura*) in divisions 7.a and 7.f-g (Irish Sea, Bristol Channel, Celtic Sea North)	No	Target	Target
Blonde ray (*Raja brachyura*) in Subarea 6 and Division 4.a (North Sea and West of Scotland)	No	Target	Target
Common skate (*Dipturus batis*-complex flapper skate (*Dipturus cf. Flossada*) and blue skate (*Dipturus cf. intermedia*) in Subarea 6 and divisions 7.a-c and 7.e-k (Celtic Seas and western English Channel)	No	Bycatch	Target
Common skate (*Dipturus batis*-complex) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	No	Bycatch	Bycatch
Common skate (*Dipturus batis*-complex) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	No	Bycatch	Target
Cuckoo ray (*Leucoraja naevus*) in Division 8.c (Cantabrian Sea)	No	Bycatch	Bycatch
Cuckoo ray (*Leucoraja naevus*) in Division 9.a (Atlantic Iberian waters)	No	Bycatch	Bycatch
Cuckoo ray (*Leucoraja naevus*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	No	Bycatch	Bycatch
Cuckoo ray (*Leucoraja naevus*) in subareas 6–7 and divisions 8.a-b and 8.d (West of Scotland, southern Celtic Seas, and western English Channel, Bay of Biscay)	No	Bycatch	Bycatch
Greater-spotted dogfish (*Scyliorhinus stellaris*) in subareas 6 and 7 (West of Scotland, southern Celtic Sea, and the English Channel)	No	Bycatch	Bycatch
Kitefin shark (*Dalatias licha*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Leafscale gulper shark (*Centrophorus squamosus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.a-b and 8.d (Bay of Biscay)	No	Bycatch	Bycatch

Stock Key Description	**Has TAC ever been applied at stock level**	**Target or by-catch 2018**	**Target or by-catch in the past?**
Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	No	Bycatch	Bycatch
Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 4 and Divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)	No	Bycatch	Bycatch
Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 6 and divisions 7.a-c and 7.e-j (West of Scotland, Irish Sea, southern Celtic Seas)	No	Bycatch	Bycatch
Porbeagle (*Lamna nasus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	Yes	Bycatch	Target
Portuguese dogfish (*Centroscymnus coelolepis, Centrophorus squamosus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Rays and skates (Rajidae) (mainly thornback ray (Raja clavata)) in subareas 10 and 12 (Azores grounds and north of Azores)	No	Bycatch	Bycatch
Rays and skates (Rajidae) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)	NA	NA	NA
Rays and skates (Rajidae) in Subarea 6 and divisions 7.a-c and 7.e-h (Rockall and West of Scotland, southern Celtic Seas, western English Channel)	NA	NA	NA
Rays and skates (Rajidae) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	NA	NA	NA
Sandy ray (*Leucoraja circularis*) in subareas 6-7 (West of Scotland, southern Celtic Seas, English Channel)	No	Bycatch	Bycatch
Shagreen ray (*Leucoraja fullonica*) in subareas 6-7 (West of Scotland, southern Celtic Seas, English Channel)	No	Bycatch	Bycatch
Small-eyed ray (*Raja microocellata*) in divisions 7.d and 7.e (English Channel)	No	Bycatch	Bycatch
Small-eyed ray (*Raja microocellata*) in divisions 7.f and 7.g (Bristol Channel, Celtic Sea North)	Yes	Target	Target

Stock Key Description	**Has TAC ever been applied at stock level**	**Target or by-catch 2018**	**Target or by-catch in the past?**
Smooth-hound (*Mustelus* spp.) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Target	Bycatch
Spotted ray (*Raja montagui*) in Subarea 8 (Bay of Biscay)	No	Bycatch	Bycatch
Spotted ray (*Raja montagui*) in Division 9.a (Atlantic Iberian waters)	No	Bycatch	Bycatch
Spotted ray (*Raja montagui*) in divisions 7.a and 7.e-h (southern Celtic Seas and western English Channel)	No	Bycatch	Bycatch
Spotted ray (*Raja montagui*) in Subarea 4 and Divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)	No	Bycatch	Bycatch
Spotted ray (*Raja montagui*) in Subarea 6 and divisions 7.b and 7.j (West of Scotland, west and southwest of Ireland)	No	Bycatch	Bycatch
Spurdog (*Squalus acanthias*) in Subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	Yes	Bycatch	Target
Starry ray (*Amblyraja radiata*) in Subareas 2 and 4, and Division 3.a (Norwegian Sea, North Sea, Skagerrak and Kattegat)	No	Bycatch	Bycatch
Thornback ray (*Raja clavata*) in Division 7.e (western English Channel)	No	Target	Target
Thornback ray (*Raja clavata*) in Division 9.a (Atlantic Iberian waters)	No	Bycatch	Bycatch
Thornback ray (*Raja clavata*) in divisions 7.a and 7.f-g (Irish Sea, Bristol Channel, Celtic Sea North)	No	Target	Target
Thornback ray (*Raja clavata*) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)	No	Target	Target
Thornback ray (*Raja clavata*) in Subarea 6 (West of Scotland)	No	Bycatch	Bycatch
Thornback ray (*Raja clavata*) in Subarea 8 (Bay of Biscay)	No	Target	Target

Stock Key Description	**Has TAC ever been applied at stock level**	**Target or by-catch 2018**	**Target or by-catch in the past?**
Thresher sharks (*Alopias* spp.) in Subareas 10, 12, Divisions 7.c-k, 8.d-e, and Subdivisions 5.b.1, 9.b.1, 14.b.1 (Northeast Atlantic)	No	Bycatch	Target
Tope (*Galeorhinus galeus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target
Undulate ray (*Raja undulata*) in Division 8.c (Cantabrian Sea)	Yes	Bycatch	Target
Undulate ray (*Raja undulata*) in Division 9.a (Atlantic Iberian waters)	Yes	Bycatch	Target
Undulate ray (*Raja undulata*) in divisions 7.b and 7.j (west and southwest of Ireland)	No	Bycatch	Target
Undulate ray (*Raja undulata*) in divisions 7.d and 7.e (English Channel)	Yes	Bycatch	Target
Undulate ray (*Raja undulata*) in divisions 8.a-b (northern and central Bay of Biscay)	Yes	Bycatch	Target
White skate (*Rostroraja alba*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	No	Bycatch	Target

Reviewers' comments

Review 1:

Review report of provision of advice on a revision of the contribution of TACS to fisheries management and stock conservation:

Executive Summary

ICES requested that a list of species be analysed in terms of the risk (whether it is biologically safe in the short and medium term) of removing TACs for each case and to assess the potential use of other conservation tools in the place of TACs. Specific questions to be addressed were:

- A general impression of the evaluation method (questions asked, data looked at)
- Stock by stock impression of whether the summary of the questions and data provide a solid background to say y/n to lifting TAC
- Any thoughts on additional comments from experts (valid concerns, etc.)
- The EC have set which species are target/bycatch; is this definition critical to the outcome of the evaluation?

The review report follows the above structure and addressed each question below.

A general impression of the evaluation method (questions asked, data looked at)

The following questions were addressed for each stock:

1) Was the TAC restrictive in the past?
2) Is there a targeted fishery for the stock or are the species mainly discarded?
3) Is the stock of large economic importance or are the species of high value?
4) How are the most important fisheries for the stock managed?
5) What are the fishing effort and stock trends over time?
6) What maximum effort of the main fleets can be expected under management based on FMSY (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

Although these questions are very informative, how these questions link to the key issue at hand (removing the TAC) is important. Therefore, for this review, a few high-level queries to synthesise the conclusions were added to provide a consistent process and summary approach:

1. Has the species/stock/group (hereafter just called stock) got characteristics that places it at high relative risk?
    - In terms of its general biology e.g. aggregating, sex change, long lived, low productivity, forage fish, ecosystem importance
    - In terms of its catchability e.g. degree of population overlap with key fisheries, presence of refuges, ability to be directly targeted

2. Is the present TAC/management influenced by past unsustainable practices?
    - If yes, are those fisheries still active?
    - Was the stock targeted?
3. Can these or new unsustainable practices return if the TAC is removed?
    - Can they be targeted with the present fleet?
    - Are they heavily discarded?
    - Is the stock valuable?
4. Are there alternatives to a TAC to manage this stock?
    - Can they be managed as companion species through target TACs (if applicable)?
    - Can they be spatially managed?
    - Any other mechanism? E.g. Multi-Year TACs (MYTAC).
5. Comment on the conclusions

As can be seen from these points, most of the questions posed within the report inform the high-level queries well, except for the companion species component. To help the reviewer, the information from the 6 question was added to the 5 questions above to see whether the information provided could address the issues therein.

The report addressed the removal of TACs on a single species case-by-case basis. In reality, the issue of removing a TAC can be much more complex. For example, there is a distinction between a low or zero TAC being removed to reduce administrative overheads compared to its removal to avoid choke TACs. It was not clear to this reviewer why this particular list was chosen on a species by species basis. There may be value in sequencing the questions a bit differently. This may reflect a non-ICES reviewer needing more background information than may be the case for a reviewer more familiar with ICES history.

Similarly, adding a web link to the latest ICES advice (if available) would be useful. Many of the reports added more information, including figures and tables that comprehensively addressed this question. This approach did not assume a certain level of knowledge from the reader.

On the other hand, few reports provided biological information and the overall relative riskiness of the species and their interactions with the fisheries. This would have helped place the riskiness of making a potentially incorrect decision to keep a TAC or not in context.

The authors struggled with question 6. This question did get placed in the form of reference points which would be difficult for several to address. Several of the species provided an analysis comparing fishing effort on the key target species with the catch on the stock of concern. This was very useful, but there would be several caveats to this work (also presented in many of the reports). The key one being that the relationship between target effort and associated stock landings were linear (in most cases) and would remain the same if the TAC is lifted. Without a full assessment and fleet dynamics models it would be difficult to suggest more sophisticated approaches. On the other hand, looking at alternative management approaches and their pros and cons (as was done for skates and rays, for example) would be useful here, so perhaps the question was more complicated than it needed to be.

Finally, there is a policy issue highlighted by some small inconsistencies in the final recommendations that should be discussed. As an example, two overfished and overfishing stocks had opposite recommendations (keep the TAC, and no risk to removing TAC). The difference was that the landings for the one species was being restricted by the TAC whereas for the other, landings were well below the TAC. In both cases, discarding was large and not prohibited. Superficially one would agree that the one TAC is restrictive but not the other. However, in terms of total catch neither are restrictive and therefore nor is fishing mortality (F). Is the difference not therefore about the relative value of the stock concerned rather than the effectiveness of the TAC? i.e. the one stock is worth keeping at least until the TAC is met and then it is discarded, whereas the other is not worth keeping at all. In the case where the TAC was recommended not to be kept, alternative input control measures were not successful, yet F did need to be reduced on the species to ensure recovery. In this case, therefore, one would want to discuss adding effective management measures either by making the TAC work through restricting discarding (and allowing the stock to become a potential choke species) or clearly articulating workable alternatives.

On a related point, most of the MSY reference points provided were based on single species assessments. It is now becoming clear that not all stocks in an ecosystem can reach their single species MSY together and at the same time, so another question not addressed one species at a time is the ecosystem interactions between these species and whether all species in the present system can be sustainably managed at single species MSY levels. Although it was pleasing to see the inclusion of more companion species work and analyses attempting to address how useful the management of one bycatch stock is through the management of the target stock, this work needs much further research.

Species: stock by stock impression of whether the summary of the questions and data provide a solid background to say y/n to lifting TAC.

Skates and rays 6,7.a-c,e,k; Skates and rays 7.d,e; Skates and rays 8,9; Skates and rays 2.a, 4; Picked dogfish 1,5,6,7,8,12 and 14; Spurdog.

These stocks are discussed together in the report and also in this review. This is the most comprehensive report that addressed the question. Information is clear and comprehensive, given the complexity and number of species included in these assemblages. It should be noted that all the questions below were also addressed in the report. The report also discussed the pros and cons of alternative management measures.

1. Has the species/stock/group (hereafter referred to as stock) got characteristics that places it at high relative risk?
    - In terms of its general biology e.g. aggregating, sex change, long lived, low productivity, forage fish, ecosystem important
    - In terms of its catchability e.g. degree of population overlap with key fisheries, presence of refuges, ability to be directly targeted

Skates and rays: This question is directly addressed in the report and highlights that there is an inherent high relative risk to skates.

Spurdog: This question is directly addressed in the report and highlights that there is an inherent high relative risk to Spurdog.

2. Is the present TAC/management influenced by past unsustainable practices?
    - If yes, are those fisheries still active?
    - Was the stock targeted?

Skates and rays: Some of the species/stocks are targeted in species-specific fisheries, whereas others are bycatch of the trawl and net offshore fisheries. For the latter, smaller skates are discarded.

The TACs have generally become restrictive as the TACs have been reduced, although the degree of this restriction differs between species and nation. Quota trading between regions has occurred. Species targeted, retained when caught and retained or targeted are provided. Also included is the list of species that are required to be discarded.

There are no reliable trends in fishing effort for target skate fisheries. Survey stock trends for some have increased in recent years, including some of the species listed as 'prohibited'.

Spurdog: Spurdog was placed on the 'prohibited' list in 2017. Before that TACs were reduced and became binding as they became smaller. Associated bycatch limit and maximum landing length limited the target fisheries. The stock declined during the 1970s and through to the early 2000s and has recently been showing signs of recovery. This is likely due to reduced effort and subsequent cessation of the target fishery.

3. Can these or new unsustainable practices return if the TAC is removed?
    - Can they be targeted with present fleet?
    - Are they heavily discarded?
    - Is the stock valuable?

Skates and rays: Cumulatively, skates and rays are valuable. At a species level, their value is dependent on its characteristics such as wing thickness etc. As stated in the report, their conclusion that unsustainable practices would return without a TAC on skates is a reasonable assumption.

Spurdog: Currently, it is on the 'prohibited' list and there is no targeted fishery. Its catch is also limited by a small allowance as part of the bycatch avoidance scheme. There have been some queries recently on the efficacy of this scheme due to discarding. The population has recently increased in size. The stock was a valuable component when it was targeted. The report recommendation is that TAC management alone might mitigate pressure on Spurdog, but will not be successful as a sole management measure.

4. Are there alternatives to a TAC to manage this stock?
    - Can they be managed as companion species through target TACs (if applicable)?
    - Can they be spatially managed?
    - Any other mechanism? E.g. Multi-Year TACs (MYTAC).

There is an extensive discussion on the pros and cons of different alternative management measures. Most of these require further thought and might only be partially effective. Several good recommendations on further work are provided.

Skates and rays: The TAC influences fishing effort in the fisheries that target skate. In addition, there may be local regulation on MLS or bycatch limits to larger vessels. For the bycatch fleets, effort on these are based on management for their main target species. There is no stock or F information that could help address question 6. This question is directly addressed, and spatial management and other management measures are discussed, but their impact had not been reviewed.

Spurdog: maximum landing sizes prevented catching of mature females and bycatch limits prevented target fishing when a non-zero TAC was in place. It is also caught as a bycatch in other fisheries. There may be opportunities for spatio-temporal management to align with spurdog migration but there is a stated insufficiency of data to inform this. But trip limits and maximum landing length may usefully deter fishing on grounds where mature female Spurdog aggregate.

5. Conclusion

An overall conclusion is provided after discussing different management options. The stated conclusion that the current TAC system is not ideal, but there is not yet a clear alternative is supported. The alternative options discussed and that these need further work is supported by the review. This report is extremely comprehensive and informative.

Review 2

The key question here is whether total allowable catches (TACs) can be removed for any of the stocks in question, or should be retained for all stocks. The disparate documents would be improved by an overall grammar check, and efforts to ensure that the data provided are in similar formats to allow decisions to be made fairly across stocks. I first make some overall points, and then summarize my thoughts on individual stocks.

1. Overall, I am sceptical that removing TACs for any stock is a good idea. Any stock with no TAC can be targeted with unlimited catches, and the EU has a large amount of latent fishing effort combined with ready markets. In such circumstances, a new market, technology, or stock can lead to rapid deployment of latent effort, leading to stock collapses in a short period of time. If the current TACs are too precautionary, TACs should be increased rather than abolished. For pilot fisheries, TACs could be set at levels that are economically viable but low enough to avoid substantial and rapid depletion.
2. TACs should be set separately for each species. TACs set on species complexes (such as “skates”) risk targeting on the most valuable species within the complex, resulting in overfishing of that species even as TACs are not exceeded.
3. TACs should be set for management areas that correspond to stock boundaries. In a few instances, the TACs are set for areas that include portions of two stocks, rather than separate TACs being set for each stock. It is, of course, reasonable to set TACs for subareas of a single stock to ensure that catches are not concentrated in a single part of the stock range.
4. A major weakness in the current approach is that TACs are applied only to landings, not to total catch (landings + discards). In a multispecies fishery managed by TACs on individual species, some species will become choke species that constrain landings of other species. When discards are not accounted for in TAC advice, and are not measured, this provides incentives to discard catches that are over the TAC (or over individual quotas), and this is especially true for those stocks at lowest levels that currently have a “zero” TAC. A key part of management should be measuring and holding fishers accountable for discards, and then setting TACs for total catches instead of just for landings.
5. In a few cases, the bulk of catches, biomass, and habitat is outside EU waters, but TACs are still set at very low levels inside EU waters. These nominal TACs could be increased for stocks that are not targeted, have little EU commercial value, and are currently managed by TACs that are so low as to have a negligible impact on stock status. Increasing TACs would ensure that bycatch does not constrain catches of more valuable target species.
6. In cases where choke species are healthy, and current catches do not constitute overfishing, but catches are close to TACs, the TACs could be increased so that fewer fishers are constrained by catches of these choke species.

A stock-by-stock review follows.

Skates and Rays

As is often the case, elasmobranch stocks are treated shabbily by the TAC system, with a large number of species grouped together, some of obvious conservation concern and others of little concern. As is well known, and pointed out here, the low fecundity of skates and rays, combined with them being often caught as bycatch while targeting more productive species, can lead to substantial depletion. For such a valuable complex (tens of millions of euros), this is worrisome. While recognizing the issues associated with species misidentification, I recommend that separate TACs be set for species that are at risk and targeted within this complex. Removing TAC limits would be a bad idea for this complex.

Spurdog

Spurdog is a prohibited species, now showing some signs of recovery. Formerly it was the most valuable of the elasmobranchs. It seems likely that removing the prohibition on landings would lead to a rapid increase in catches and targeting, resulting in overfishing.