WORKING GROUP ON ELASMOBRANCH FISHES (WGEF)

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i Executive summary

ICES WGEF meets annually, with advice for a subset of stocks drafted in alternating years. Work in 2019 focused on those stocks for which it was an advisory year: (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).

The following widely-distributed shark stocks were also assessed: (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.

Although all stocks were assessed, advice was not given for the stocks listed below following correspondence with DG-Mare.

- Common skate complex (Blue skate (*Dipturus batis*) and flapper skate (*Dipturus intermedius*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)
- Black-mouth dogfish (*Galeus melastomus*) in subareas 6 and 7 (West of Scotland, southern Celtic Seas, and English Channel)
- Black-mouth dogfish (*Galeus melastomus*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)
- Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.a-b and 8.d (Bay of Biscay)
- Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)
- Greater-spotted dogfish (*Scyliorhinus stellaris*) in subareas 6 and 7 (West of Scotland, southern Celtic Sea, and the English Channel)

WGEF had a Term of Reference on further developing a proposed joint meeting with ICCAT for the assessment of the porbeagle (*Lamna nasus*). 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. One of the important issues for this meeting will be which models and input data will be used. Analyses done by WGEF include a SPiCT model and new tagging and survey data from France.

One of the recurring issues at the WGEF meetings is the **data call** and availability of data. The WGEF data are not submitted to InterCatch, but the group has developed a landings/discard spreadsheet and table in which the data are arranged for ease of assessments. However, there are continuing issues with how the data call is interpreted leading to non-uniform data sets. This results in the WGEF data coordinator, group members and the data deliverers investing time to create a coherent database for the assessments. During the 2019 meeting, the entire process and the use of the spreadsheet table were discussed at length and solutions were suggested. Specifically to ensure that the experience from the 2019 discussions are used to improve the data call and revisit the overall landings table (2005–2018) created at WGEF 2019 and create R codes for the inclusion of new landings data; create a landings data file prior to the WGEF 2020 meeting that is not changed during the meeting. The group recommended to hold a meeting on the landings/discard table used by WGEF with a small dedicated group prior to the 2020 data call.

During the assessments a number of discrepancies in the **survey** data-base were highlighted and the choice of surveys and survey data to be used for each stock assessment was discussed. As this is fundamental to the work of WGEF, it was decided that there should be a workshop on the use of surveys in the stock assessments prior to the 2020 WGEF meeting. This is a large task and

will be staggered, with a meeting in 2020 for the stocks to be assessed in that year, and another one in 2021 for the other stocks. WGEF has prepared a recommendation for a stand-alone workshop on this issue with survey experts, either just prior to the regular WGEF meeting or earlier in the year.

The use of **discard data** in the assessments has been addressed at a workshop in February 2019 – WKSHARK5 (ICES, 2019 *in prep*) and again at the 2019 WGEF meeting. During WKSHARK5 a trial was carried out to include discard information in the advisory process (ICES, 2019 *in prep*). The landings information in the advice sheet for thornback ray North Sea stock for 2017 was updated with discard information and the assessment was recalculated. This resulted in a 30% decrease in landings advice. During the exercise, it was noted that not all countries had supplied discard data for the period covered (2009–2016) so this result was considered only as an indication.

At the WGEF meeting, it was decided to include the discard information for the 2019 stock assessments according to the example carried out at WKSHARK5. Unfortunately, an overview of the available discard data was made and it was noted that there were a high number of discrepancies between years and data were also missing. It was decided by the group that the discard data available to the group are not of sufficient quality to use in the assessments at this stage. Moreover, the issues exposed by both WKSHARK5 and WGEF are too complex to be solved during a workshop or working group meeting and will require a concerted effort to solve. WGEF has formulated a recommendation for ICES to initiate a dialogue with DG Mare to explore the possibility of funding to support a project to address the serious issues surrounding the collection and registration of discard data, as well as how to include survivability, in order for the data to be used in future stock assessments..

The group looked at further developing **MSY proxy reference points** relevant for elasmobranchs and to exploring/applying MSY Proxies analyses for selected stocks. For this, work done in the WKLIFE VIII was presented. The Workshop on the Development of Quantitative Assessment Methodologies based on Life-history traits, exploitation characteristics, and other relevant parameters for stocks in categories 3–6 (WKLIFE VIII) met in Lisbon, Portugal, 8–12 October 2018, to further develop methods for stock assessment and catch advice for stocks in categories 3–6. The resulting ICES report includes a section specifically dedicated to an elasmobranch life history (ICES WKLIFE VIII, 2018; Section 5, Annex 1). The performance of advice rules using length-based indicators and MSY proxy reference points to manage elasmobranch fisheries were investigated within an MSE framework. An operating model was built based on the cuckoo ray life history from the Irish Sea, with alternative scenarios for size of capture relative to size of maturity and advice rules. Advice rules based on the length-based indicator mean length are sensitive to the value of length at capture L_c, the assumption of spawning-stock recruitment relationship, misspecification of the reference point $L_{F=M}$, frequency of assessment and data quality. This is further discussed in Section 26.

The Working Group dealt with a **special request from NEAFC-OSPAR** for advice on deep sea sharks, rays and chimaeras, following a process agreed by WGEF experts, clients and ACOM and addressed the following points: (i) screening of data received from ICES Member States on occurrence of deep water sharks, skates and chimaeras on the extended list provided in the request; (ii) look at the part of request pertaining to the bycatch and mitigation measures and allocate work for the rest of the request; (iii) formulate ToRs for a WKSHARK6 meeting to be held in early 2020.

A questionnaire has been developed to send to experts to gather information on existing management measures, legislation and relevant surveys in order to decide how future management should be. It was asked if measures should be specific to fleet, species/taxa or to habitats, and what human induced pressures could impact the life-cycle of the species. The results will be presented at the 2020 WKSHARK6 workshop.

Data on Life-history traits, incl. aggregating behavior, information from literature is being compiled.

TACMAN information can be summarized to address the ToR on bycatch mitigation

One leader per country will be identified to complete surveys data call and review the data

The WKSHARK6 Workshop on the OSPAR and NEAFC joint advice request to generate species distribution maps for listed deep sea shark species and provide scientific support for ICES advice on bycatch management options has been planned for 20–24 January 2020 in Galway, Ireland.

ii Expert group information

Expert group name	Working Group on Elasmobranch Fishes (WGEF)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chairs	Paddy Walker, The Netherlands
	Sam Shephard, Ireland
Meeting venue and dates	18-27 June 2019, Lisbon, Portugal, (27 participants)

1 Introduction

1.1 Terms of Reference

2018/2/ACOM16 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 Sub-area 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. Follow recommendations from WKSHARK5 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 and then develop a procedure and schedule for subsequent reviews.

j) Address the joint special request from NEAFC-OSPAR for advice on deep sea sharks, rays and chimaeras following the process agreed by WGEF experts, clients and ACOM:

    i) Screening of data received from ICES Member States on occurrence of deep water sharks, skates and chimaeras on the extended list provided in the request.

ii) Advance on part of request pertaining to the bycatch and mitigation measures and allocate work for the rest of the request.

iii) Formulate ToR for a WKSHARK6 meeting to be held in early 2020.

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 8 August 2019 for the attention of ACOM.

1.2 Participants

The following WGEF members attended the meeting:

Jurgen Batsleer	The Netherlands
Loic Baulier	France
Gérard Biais	France
Guzmán Diez	Spain (Basque Country)
Ivone Figueiredo	Portugal
Graham Johnston	Ireland
Claudia Junge	Norway
Pascal Lorance	France
Catharina Maia	Portugal
Inigo Martínez	ICES Secretariat
Teresa Moura	Portugal
Mário Rui Pinho	Portugal (Azores)
Cristina Rodríguez-Cabello	Spain
Joana Silva	UK
Barbara Serra-Pereira	Portugal
Samuel Shephard (Co-chair)	Ireland
Paddy Walker (Co-chair)	The Netherlands

The following WGEF members assisted by correspondence:

Ole Thomas Albert	Norway
Jim Ellis (correspondence)	UK
Klara Jakobsdottir	Iceland
Armelle Jung	France
Tanja Miethe	UK
Harriët van Overzee	The Netherlands
Nicola Walker	UK

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 Regional fisheries management organisations (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.

In 2019, the following species and stocks were assessed and advice drafted (Table 1.1). These stocks will be addressed again in 2021:

- 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 2019 the following species and stocks were also addressed for advice (Table 1.1). These stocks will be addressed again in 2024:

- 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.

In 2018, the following species and stocks were addressed for advice (Table 1.2). 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.

Table 1.1. Elasmobranch stocks with assessments and advice in 2019

ICES stock code	Stock name	EcoRegion	Advice updated	Advice
sho.27.89a	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	2019	Biennial
syc.27.8c9a	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Divisions 8.c and 9.a (Atlantic Iberian waters)	Bay of Biscay and Iberian seas	2019	Biennial
syc.27.8abd	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Divisions 8.a,b,d (Bay of Biscay)	Bay of Biscay and Iberian seas	2019	Biennial
sho.27.67	Black-mouth dogfish (*Galeus melastomus*) in Subareas 6 and 7 (Celtic Sea and West of Scotland)	Celtic Seas	2019	Biennial
syc.27.67a-ce-j	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 6 and Divisions 7.a–c. e–j (Celtic Seas and west of Scotland)	Celtic Seas	2019	Biennial
syt.27.67	Greater-spotted dogfish (*Scyliorhinus stellaris*) in Subareas 6 and 7 (Celtic Sea and West of Scotland)	Celtic Seas	2019	Biennial
rjb.27.3a4	Common skate (*Dipturus batis*-complex) in Subarea 4 and Division 3.a (North Sea and Skagerrak)	North Sea	2019	Biennial
rjn.27.3a4	Cuckoo ray (*Leucoraja naevus*) in Subarea 4 and Division 3.a (North Sea and Skagerrak and Kattegat)	North Sea	2019	Biennial
rjh.27.4a6	Blonde ray (*Raja brachyura*) in Division 4a and Subarea 6 (Northern North Sea and west of Scotland)	North Sea	2019	Biennial
rjh.27.4c7d	Blonde ray (*Raja brachyura*) in Divisions 4c and 7.d (Southern North Sea and eastern English Channel)	North Sea	2019	Biennial
rjc.27.3a47d	Thornback ray (*Raja clavata*) in Subarea 4, and Divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat and eastern English Channel)	North Sea	2019	Biennial
rjm.27.3a47d	Spotted ray (*Raja montagui*) in Subarea 4, and Divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and Eastern English Channel)	North Sea	2019	Biennial
rjr.27.23a4	Starry ray (*Amblyraja radiata*) in Subareas 2, 3.a and 4 (Norwegian Sea, Skagerrak, Kattegat and North Sea)	North Sea	2019	Biennial
raj.27.3a47d	Other skates and rays in the North Sea ecoregion (Subarea 4, and Divisions 3.a and 7.d)	North Sea	2019	Biennial
syc.27.3a47d	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	2019	Biennial
agn.27.nea	Angel shark (*Squatina squatina*) in the Northeast Atlantic	Widely distributed and migratory stocks	2019	Quadrennial
bsk.27.nea	Basking shark (*Cetorhinus maximus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2019	Quadrennial
cyo.27.nea	Portuguese dogfish (*Centroscymnus coelolepis*) in the Northeast Atlantic	Widely distributed and migratory stocks	2019	Quadrennial

ICES stock code	Stock name	EcoRegion	Advice updated	Advice
gag.27.nea	Tope (*Galeorhinus galeus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2019	Biennial
guq.27.nea	Leafscale gulper shark (*Centrophorus squamosus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2019	Quadrennial
por.27.nea	Porbeagle (*Lamna nasus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2019	Quadrennial
raj.27.1012	Rays and skates (mainly thornback ray) in the Azores and Mid-Atlantic Ridge	Widely distributed and migratory stocks	2019	Biennial
sck.27.nea	Kitefin shark (*Dalatias licha*) in the Northeast Atlantic	Widely distributed and migratory stocks	2019	Quadrennial
sdv.27.nea	Starry smooth-hound (*Mustelus* spp.) in the Northeast Atlantic	Widely distributed and migratory stocks	2019	Biennial
rja.27.nea	White skate (*Rostroraja alba*) in the Northeast Atlantic	Widely distributed	2019	Quadrennial
thr.27.nea	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)	Widely distributed	2019	Quadrennial

Table 1.2. Elasmobranch stocks scheduled for assessments and advice in 2020.

ICES stock code	Stock name	EcoRegion	Advice updated	Advice
dgs.27.nea	Spurdog (*Squalus acanthias*) in the Northeast Atlantic	Widely distributed	2018	Biennial
rjb.27.89a	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.27.8c	Cuckoo ray (*Leucoraja naevus*) in Division 8.c (Cantabrian Sea)	Bay of Biscay and Iberian coast	2018	Biennial
rjn.27.9a	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.27.9a	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.27.8	Thornback ray (*Raja clavata*) in Subarea 8 (Bay of Biscay and Cantabrian Sea)	Bay of Biscay and Iberian coast	2018	Biennial
rjc.27.9a	Thornback ray (*Raja clavata*) in Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2018	Biennial

ICES stock code	Stock name	EcoRegion	Advice updated	Advice
rjm.27.8	Spotted ray (*Raja montagui*) in Subarea 8 (Bay of Biscay and Cantabrian Sea)	Bay of Biscay and Iberian coast	2018	Biennial
rjm.27.9a	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.27.8ab	Undulate ray (*Raja undulata*) in Divisions 8.a.b (Bay of Biscay)	Bay of Biscay and Iberian coast	2018	Biennial
rju.27.8c	Undulate ray (*Raja undulata*) in Divisions 8.c (Cantabrian Sea)	Bay of Biscay and Iberian coast	2018	Biennial
rju.27.9a	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.27.89a	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.27.67a-ce-k	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.27.67	Sandy ray (*Leucoraja circularis*) in Subareas 6 and 7 (Celtic Sea and West of Scotland)	Celtic Seas	2018	Biennial
rjf.27.67	Shagreen ray (*Leucoraja fullonica*) in Subareas 6 and 7 (Celtic Sea and West of Scotland)	Celtic Seas	2018	Biennial
rjn.27.678abd	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.27.7afg	Blonde ray (*Raja brachyura*) in Divisions 7.a.f.g (Irish and Celtic Sea)	Celtic Seas	2018	Biennial
rjh.27.7e	Blonde ray (*Raja brachyura*) in Division 7.e (western English Channel)	Celtic Seas	2018	Biennial
rjc.27.7afg	Thornback ray (*Raja clavata*) in Divisions 7a.f.g (Irish and Celtic Sea)	Celtic Seas	2018	Biennial
rjc.27.7e	Thornback ray (*Raja clavata*) in Division 7.e (Western English Channel)	Celtic Seas	2018	Biennial
rjc.27.6	Thornback ray (*Raja clavata*) west of Scotland (Subarea 6)	Celtic Seas	2018	Biennial
rje.27.7de	Small-eyed ray (*Raja microocellata*) in the English Channel (Divisions 7.d.e)	Celtic Seas	2018	Biennial
rje.27.7fg	Small-eyed ray (*Raja microocellata*) in Divisions 7.f.g (Bristol Channel)	Celtic Seas	2018	Biennial

ICES stock code	Stock name	EcoRegion	Advice updated	Advice
rjm.27.67bj	Spotted ray (*Raja montagui*) in Subarea 6 and Divisions 7.b.j (west of Scotland and Ireland)	Celtic Seas	2018	Biennial
rjm.27.7ae-h	Spotted ray (*Raja montagui*) in Divisions 7.a.e.f.g.h (southern Celtic seas)	Celtic Seas	2018	Biennial
rju.27.7bj	Undulate ray (*Raja undulata*) in Divisions 7.b.j (South-west of Ireland)	Celtic Seas	2018	Biennial
rju.27.7de	Undulate ray (*Raja undulata*) in Divisions 7.d.e (English Channel)	Celtic Seas	2018	Biennial
raj.27.67a-ce-h	Other skates and rays in Subareas 6 and 7 (excluding 7.d)	Celtic Seas	2018	Biennial

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. The work was continued in 2018 and 2019 and progress was made with applying MSY proxies to elasmobranch stocks. Following the recommendations made in 2018, WGEF further explored the application of proxy MSY reference points to elasmobranch fishes. Full information on this analysis is available in Miethe (2019, WGEF WD, see Annex 6).

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 historical 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. There is an initiative to carry out a joint ICCAT-ICES meeting to assess porbeagle. Such a meeting could also usefully address thresher shark *Alopias* spp. This issue was addressed again at the 2019 meeting and documented in this report in Section 26.

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	Multinational 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 WKSHARK3 (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 WKSHARK3. 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. This issue has now been resolved. The FAO codes and ValidAlphia Valid codes for the two skate species have been considered and accepted by Last *et al*. (2016) and are now also accepted on the Catalog of Fishes (2019) and WoRMS, and there are now separate FAO codes for the two species:

Common blue skate	*Dipturus batis*	F AO code RJB	Aphia ID 105869
Flapper skate	*Dipturus intermedius*	FAO code DRJ	Aphia ID 711846

6. Progress

In 2017 and 2019 workshops were held to address the issues surrounding the use of discards in the elasmobranch assessments (ICES, 2017; 2019). It was addressed again by WGEF at the 2019 meeting and decided that the issue is too complex to be solved during a workshop or working group meeting and will require a concerted effort to solve. WGEF recommends to initiate a collaborative project to address this issue and has formulated a Recommendation for ICES to initiate a dialogue with DG Mare to explore the possibility of funding to support a project to address the serious issues surrounding the collection and registration of discard data, as well as how to include survivability, in order for the data to be used in future stock assessments.

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 the 2011 WGEF report (ICES, 2011). 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

This stock has last been assessed in 2018 and only minor updates to landings have been made in 2019.

2.1 Stock distribution

Spurdog or the picked dogfish, *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. Nonetheless, recent studies undertaken by Thorburn *et al*. (2018) suggest subpopulations across the UK.

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 (2009a, b) and STECF (2009).

2.2.2 The fishery in 2018

The zero TAC for spurdog for EU vessels has resulted in a major change in the magnitude and spatial distribution of reported landings. Between 2005 and 2017, landings declined across all ICES subareas.

Since 2011 the annual Norwegian landings, which land significantly more spurdog than other countries, have been stable at 216–313 tonnes. Reported landings of spurdog from Norwegian fisheries were 271 tonnes in 2018.

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). During 2017 and 2018, UK reported landings of 37 tonnes spurdog. For UK, traditionally one of the major exploiters of the spurdog stock (prior to 2009), this was a major increase from a level close to zero that has been seen since the zero TAC was introduced in 2011.For other countries which landed spurdog see Table 2.2.

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 summarises ICES advice and actual management applicable for NE Atlantic spurdog during 2001–2018.

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
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
2018	F-0	Stock below possible reference points	0		0	0	342

([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 2018 were 343 t.

2.3.2 Discards

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

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 in the case where other elasmobranch stocks with highly restrictive quotas have been recorded as spurdog. 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

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

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 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.

From French on-board observation data, the occurrence of spurdog 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-c 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.

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 north-western 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 decline over the first part of the time period (1990–2011) with an increase in more recent years (2012 with the exception of 2015) (Figure 2.18). 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 (Ellis et al, 2010). 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-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	2.30	

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 of sex proportions compared to the commercial proportions, but given the residual patterns (a dominance of positive residuals for females, and, more weakly, the opposite for males) it may be possible to estimate sex ratio (not attempted).

Figure 2.24a compares the deterministic and stochastic modelled recruitment, and plots the estimated recruitment residuals normalised by ◎r. The model fits of 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 (1960 and 2005), 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 $B_{trigger}$ 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; figures 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 $F_{prop,\text{MSY}}$ = 0.032 and $MSY\ B_{trigger}$ = 683 340 t (Table 2.12b and Section 2.9.6; this rule fishes at $F_{prop,\text{MSY}}$ = 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 $F_{prop,\text{MSY}}$ = 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 $_{\text{Btrigger}}$ are given in Table 2.15b. Recovery to MSY $_{\text{Btrigger}}$ 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 $_{\text{Btrigger}}$ = 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 age and 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 2018 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 2007, the IUCN world redlist categorised Northeast Atlantic spurdog as 'Vulnerable', 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.

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. Furthermore, females are thought to have restricted movement (Thorburn *et al*., 2015). 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. pre-oral length) that has a high correlation with total length and is more easily measured on live fish are required. Dead spurdog 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.

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 percent 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 some 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 the 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).

2.15 References

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Table 2.1. Northeast Atlantic spurdog. WG estimates of total landings of NE Atlantic spurdog (1947–2018).

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	274
1968	56 043	1993	25 636	2018	343
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 (1980–2018). Data from 2005 onwards revised during WKSHARK2. 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 WKSHARK2. 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 WKSHARK2. From 2005 Scottish landings data are combined with those from England and Whales, and presented as UK (combined)

Country	2016	2017	2018
Belgium	.	.	
Denmark	24	.	
Faroe Islands			
France	1	3	1
Germany	2	+	1
Iceland	8	4	2
Ireland	34	1	24
Netherlands	1	1	6
Norway	270	222	271
Poland			
Portugal	1	1	1
Russia			
Spain	10	5	
Sweden	+	+	+
UK (combined)*	30	37	38
UK (Sc)*			
Total	382	274	343

Table 2.3. Northeast Atlantic spurdog. WG estimates of landings by ICES Subarea (1980–2018). Data from 2005 onwards revised during WKSHARK2.

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 (1980–2018). Data from 2005 onwards revised during WKSHARK2.

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 (1980–2018). Data from 2005 onwards revised during WKSHARK2.

Subarea or Division	2016	2017	2018
Baltic	0	0	0
1 and 2	150	127	164
3 and 4	165	96	109
5	8	4	2
6	5	1	3
7.a	2	0	+
7.b-c	3	+	0
7.d-f	1	14	19
7.g-k	44	26	45
8	1	1	+
9	2	5	1
10	0	0	0
12	0	0	0
14	0	0	0
Other or unspecified	0	0	
Total	382	274	343

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
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

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
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 $P_a'' = \frac{P_{\max}''}{1 + \exp\left[-\ln(19) \frac{l_a^f - l_{mat50}^f}{l_{mat95}^f - l_{mat50}^f}\right]}$ 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

Year	Non-target	Target	Total	Year	Non-target	Target	Total	Year	Non-target	Target	Total
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

	$n_{psur,y}$	16–31	32–54	55–69	70+
Males (continued)					
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	6	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		

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'
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 $B_{trigger}$ is calculated as B_{MSY}/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

	R (pups)	B_{tot} (t)	Catch (t)	F_{prop} (5–30)
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

*** "average 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 $B_{trigger}$ (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

*** "average catch" is the average for the projection period 2019–2047**

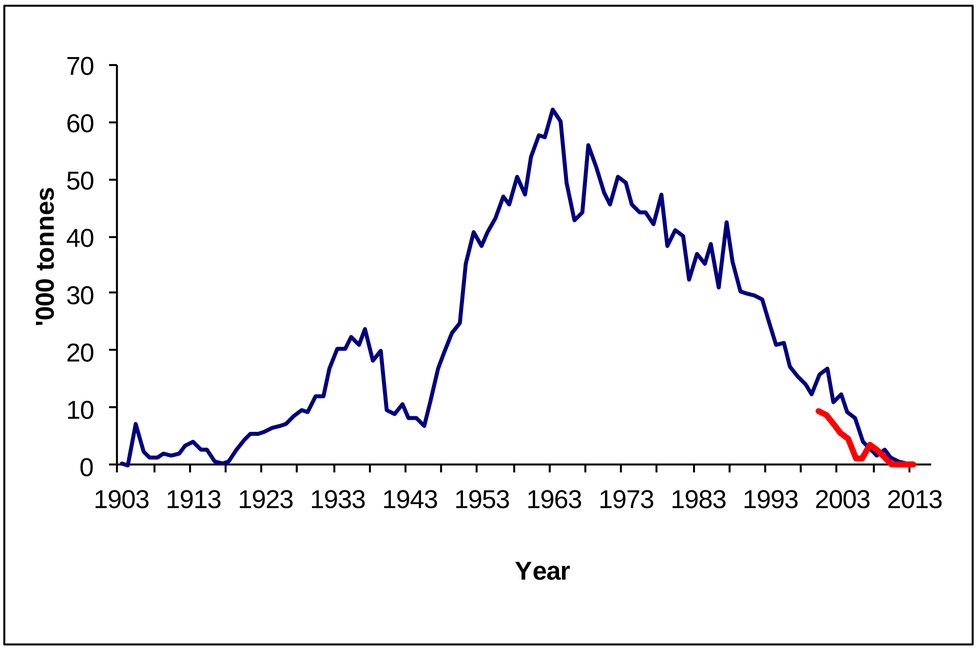


Figure 2.1a. Northeast Atlantic spurdog. WG estimates of total international landings of NE Atlantic spurdog (1903–2013, blue line) and TAC (red line). Restrictive management (e.g. through quotas and other measures) is only thought to have occurred since 2007.

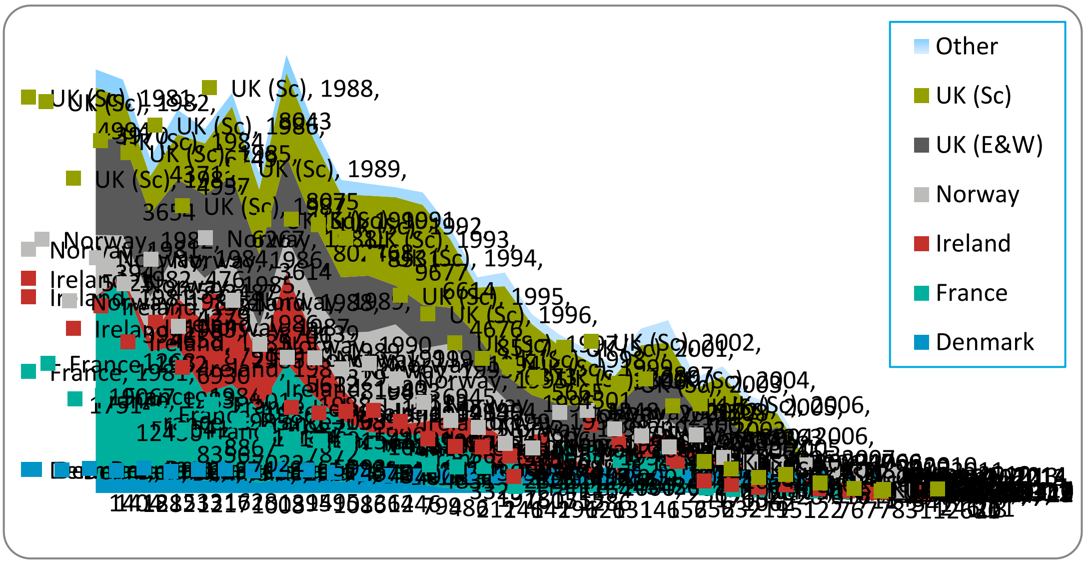


Figure 2.1b. Northeast Atlantic spurdog. WG estimates of landings by nation (1980–2014).

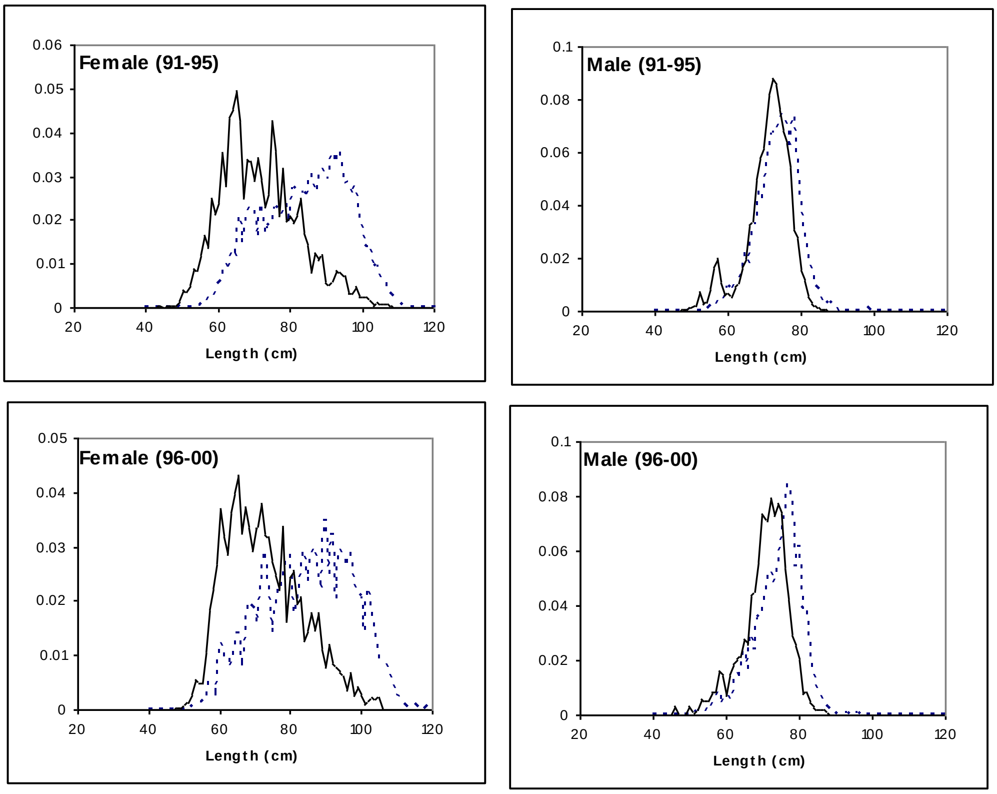


Figure 2.2. Northeast Atlantic spurdog. Comparison of length–frequency distributions (proportions) obtained from market sampling of Scottish (solid line) and UK (E&W) (dashed line) landings data. Data are sex-disaggregated, but averaged over five-year intervals.

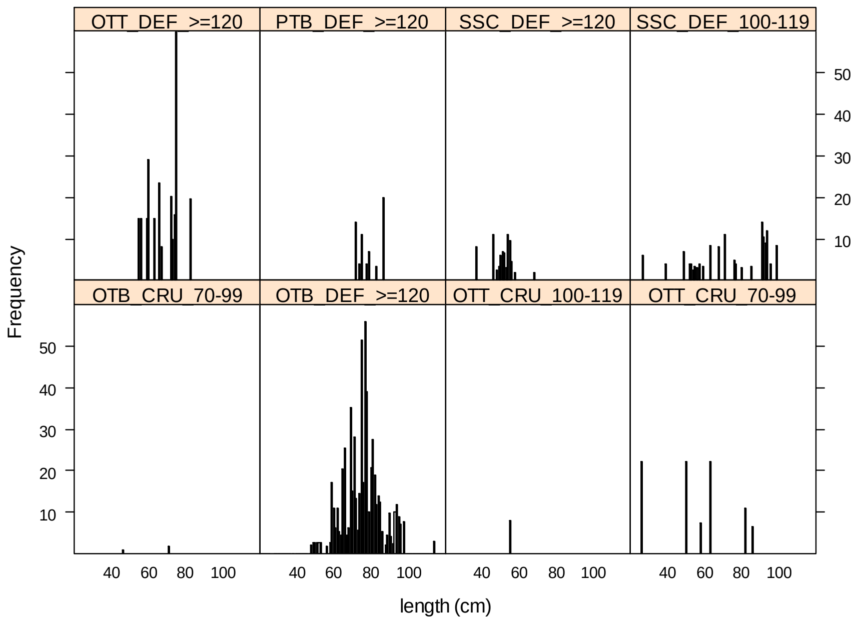


Figure 2.3. Northeast Atlantic spurdog. Length distributions of spurdog caught on Scottish observer trips in 2010. Data are aggregated across trips for each gear category. Gear codes relate to gear type, target species and mesh size. OTT – Otter trawl twin; PTB – Pair trawl bottom; SSC – Scottish Seine;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

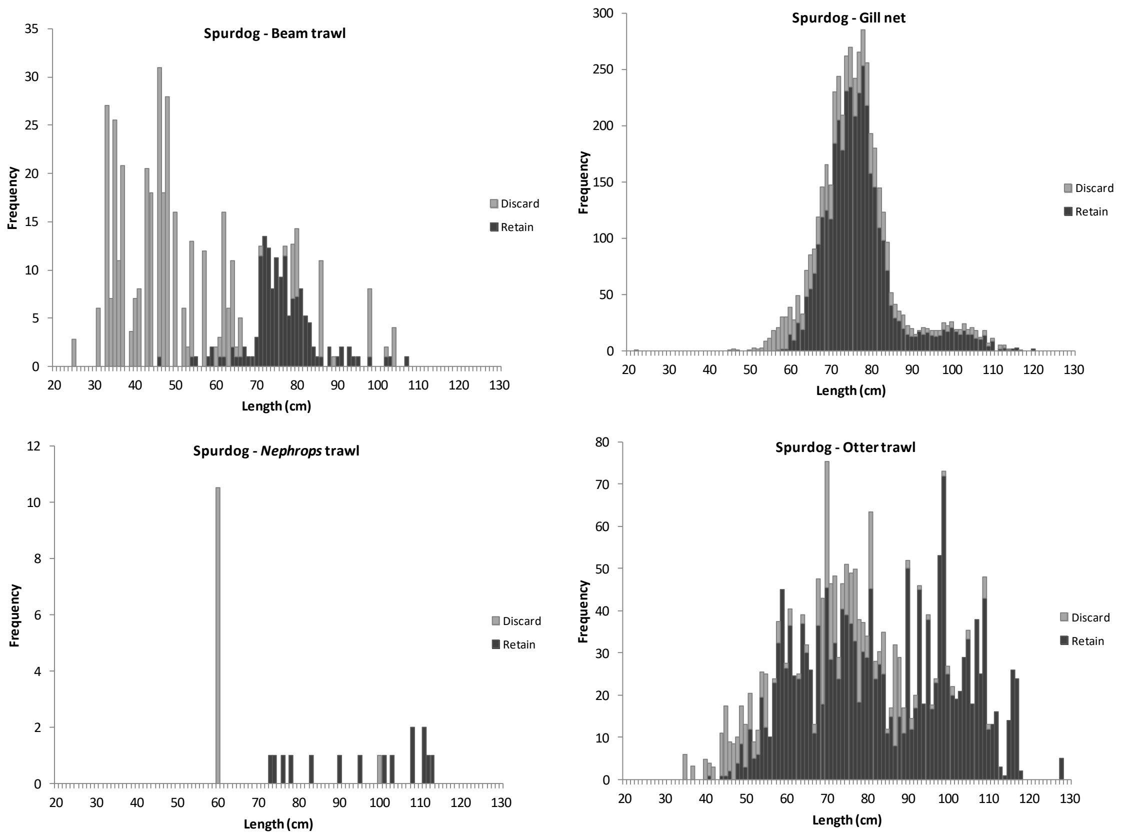


Figure 2.4. Northeast Atlantic spurdog. Discard-retention patterns of spurdog taken in UK (English) vessels using beam trawl, gillnet, Nephrops trawl and otter trawl.

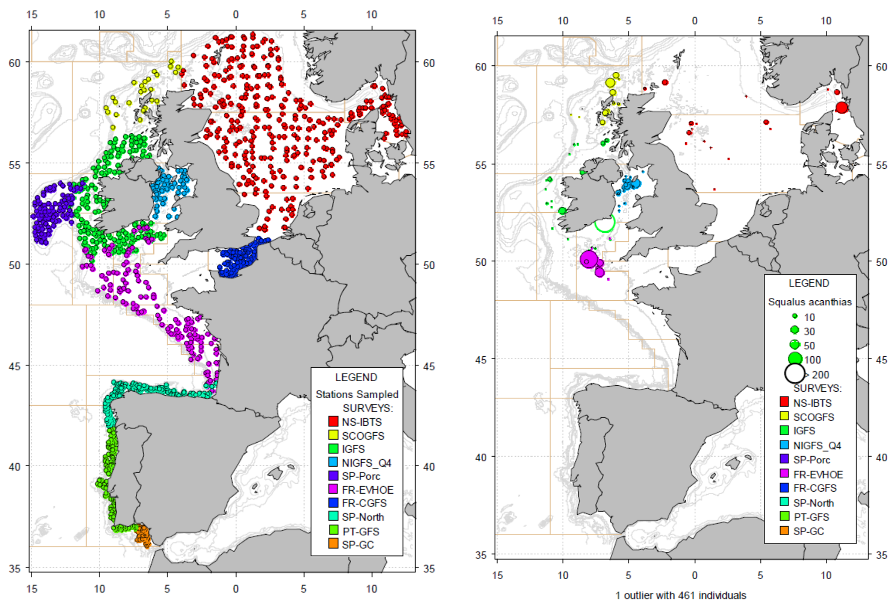


Figure 2.5. Northeast Atlantic spurdog. Overall spatial coverage of the IBTS (left) all surveys combined and (right) captures of spurdog (number per hour, bottom) as reported in the 2013 summer/autumn IBTS. The catchability of the different gears used in the NE Atlantic surveys is not constant; therefore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

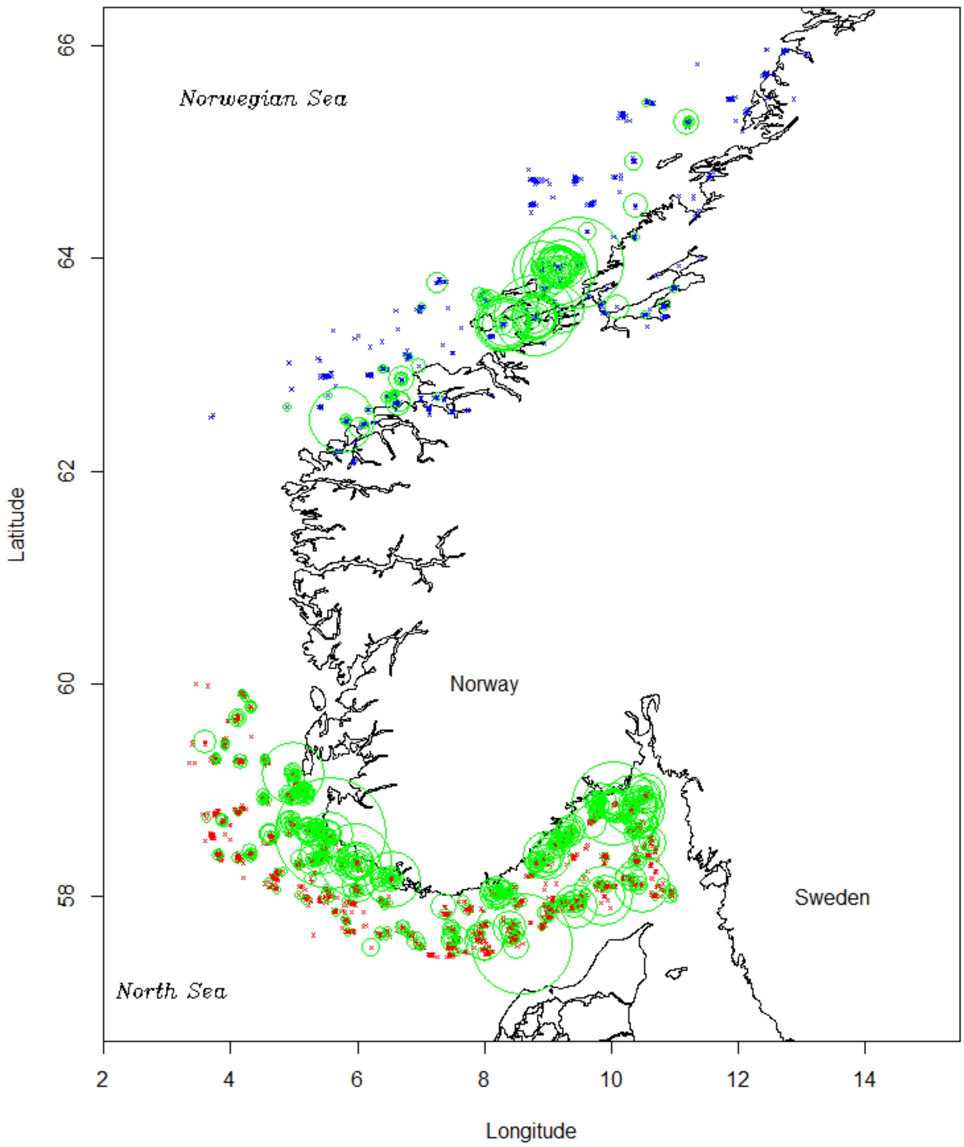


Figure 2.6. Northeast Atlantic spurdog. Map of survey areas with stations 1996–2017/18 for Coastal survey (blue) and Shrimp survey (red) for area 58-66°North. Green circles indicate catches of spurdog; circle area is proportional to catch in number of individuals. Source: Vollen (2014 WD), plus additional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

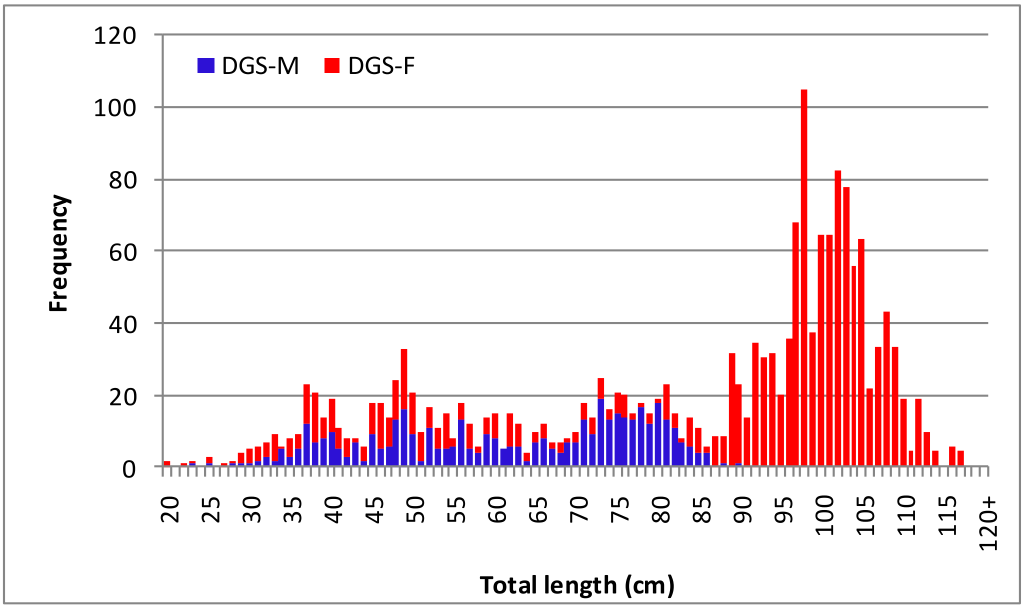


Figure 2.7a. Northeast Atlantic spurdog. Length distribution of spurdog captured in the UK (England and Wales) westerly IBTS in Q4 (2004–2009, all valid and additional tows). Length distribution highly influenced by a single haul of large females.

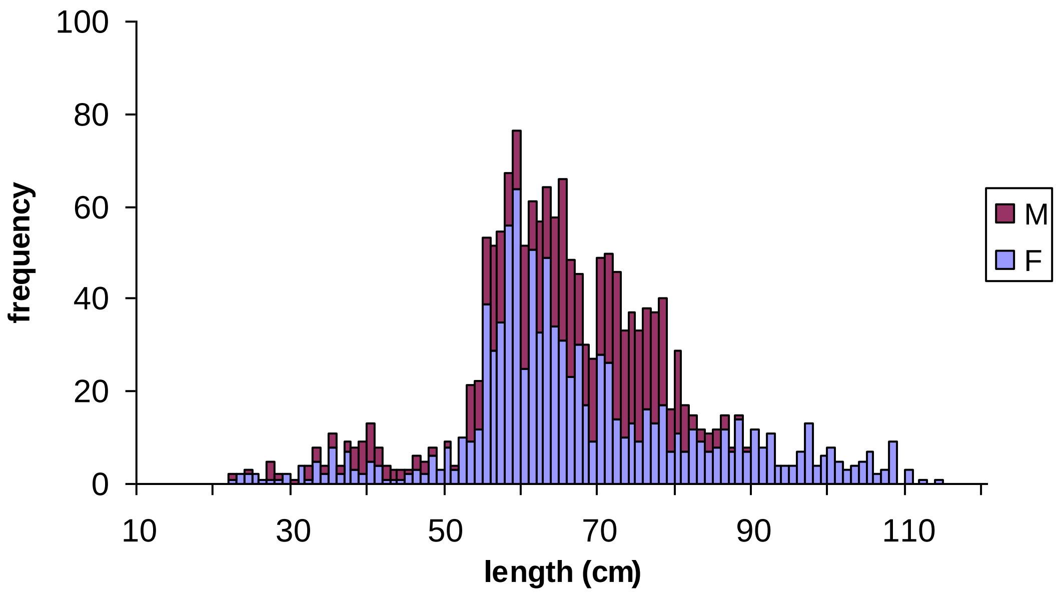


Figure 2.7b. Northeast Atlantic spurdog. Length distribution of spurdog captured in the Irish Q3 Celtic Seas groundfish survey (2003–2009).

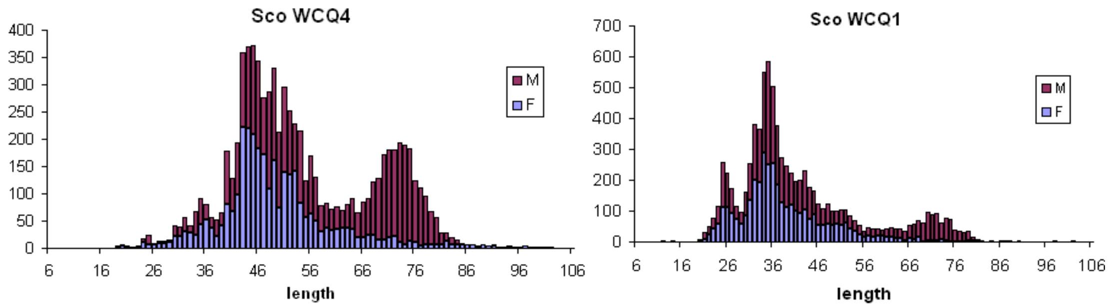


Figure 2.8. Northeast Atlantic spurdog. Length distribution of spurdog captured in the Scottish Q1 and Q4 groundfish surveys (1990–2010). Length-frequency distributions highly influenced by a small number of hauls containing many small individuals.

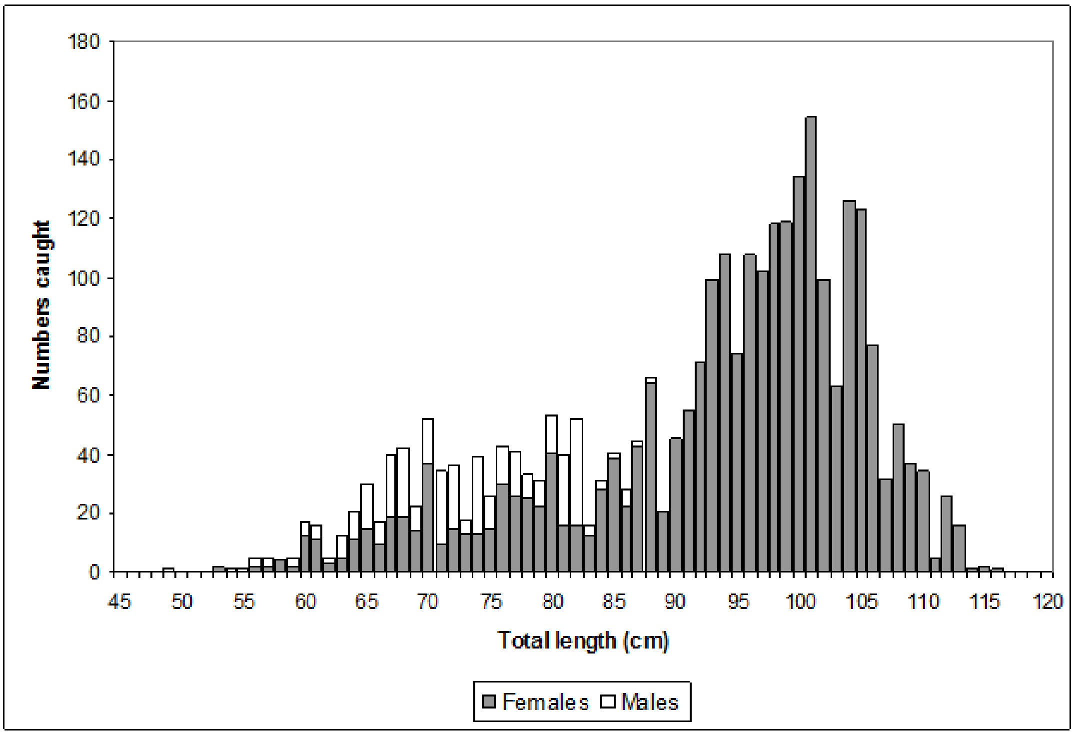


Figure 2.9. Northeast Atlantic spurdog. Total length-frequency of male and female spurdog taken during the UK(E&W) FSP survey, raised for those catches that were sub-sampled (n = 2517 females and 356 males).

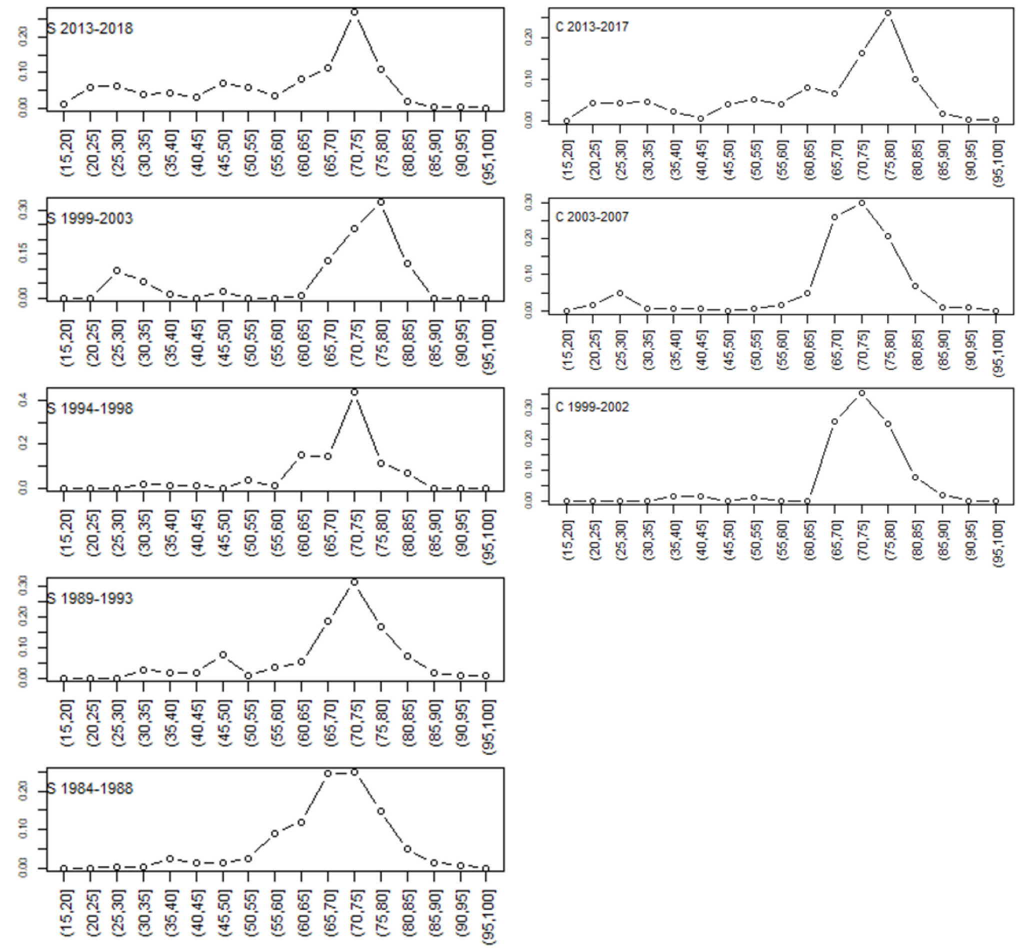
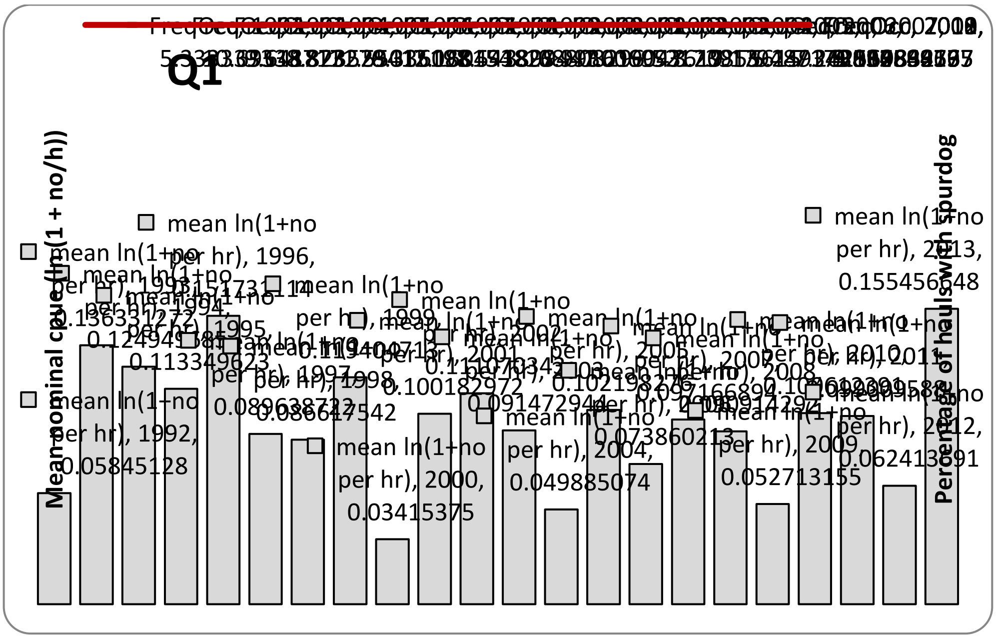


Figure 2.10. Northeast Atlantic spurdog. Relative length–frequency distributions (5 cm length groups and five-year periods) for the Shrimp survey 1985–2018 (left) and Coastal survey 1999–2017 (right).



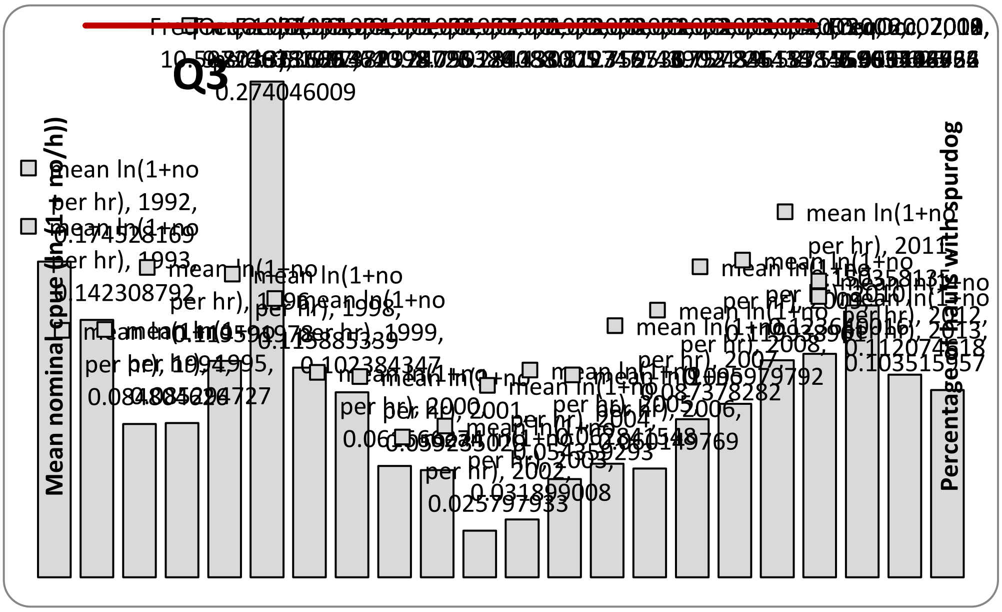


Figure 2.11. Northeast Atlantic spurdog. Nominal catch per unit of effort (grey bars) and frequency of occurrence (red line) of spurdog in the Q1 and Q3 North Sea IBTS (1992–2013). Catch per unit of effort is mean ln(1+n/h) for all stations in roundfish areas 1–9. Data accessed from DATRAS (19 June 2014).

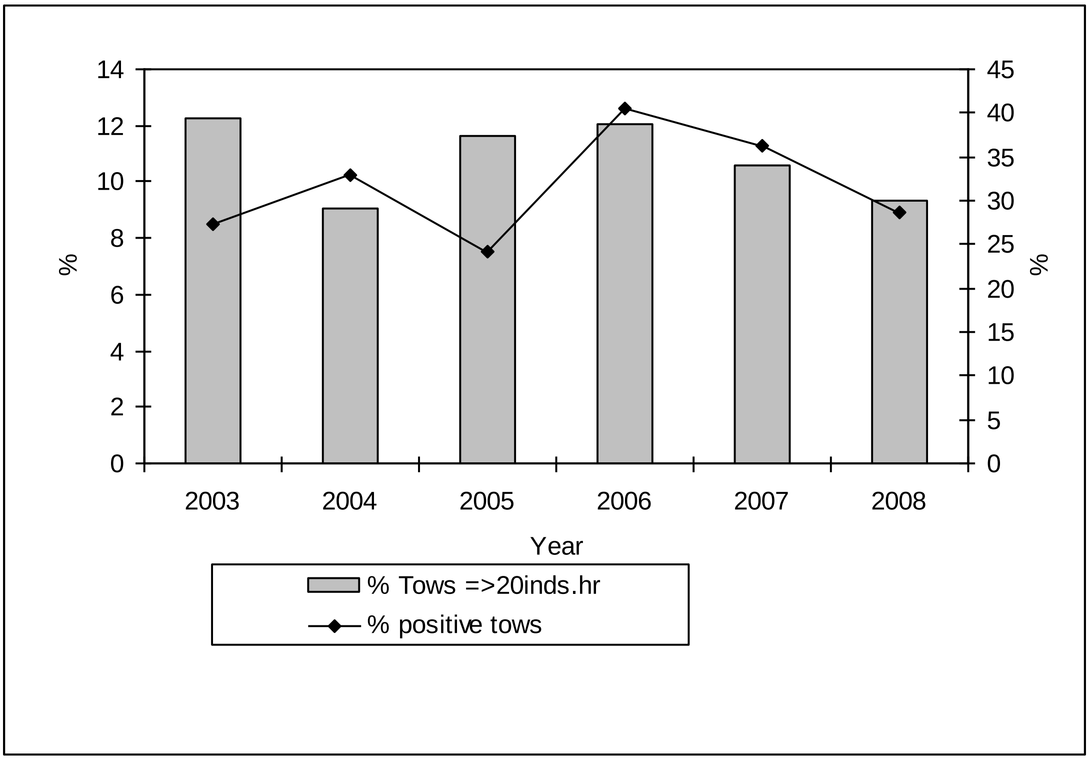


Figure 2.12. Northeast Atlantic spurdog. Proportion of survey hauls in Irish Q3 groundfish survey 2003–2008, ICES Area 7, in which nominal CPUE was ≥ 20 per one hour tow, and percentage of tows in which spurdog occurred.

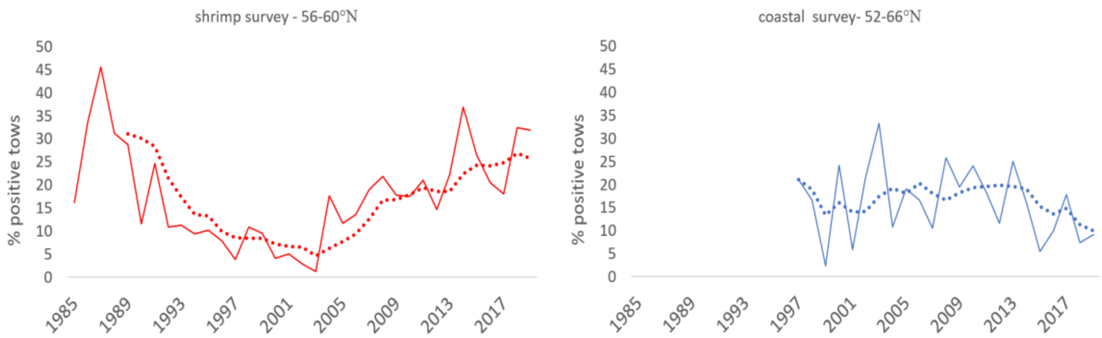


Figure 2.13. Northeast Atlantic spurdog. Percentage of tows in shrimp (left) and coastal (right) survey in which spurdog occurred by year, with moving average (dotted, 5 yrs).

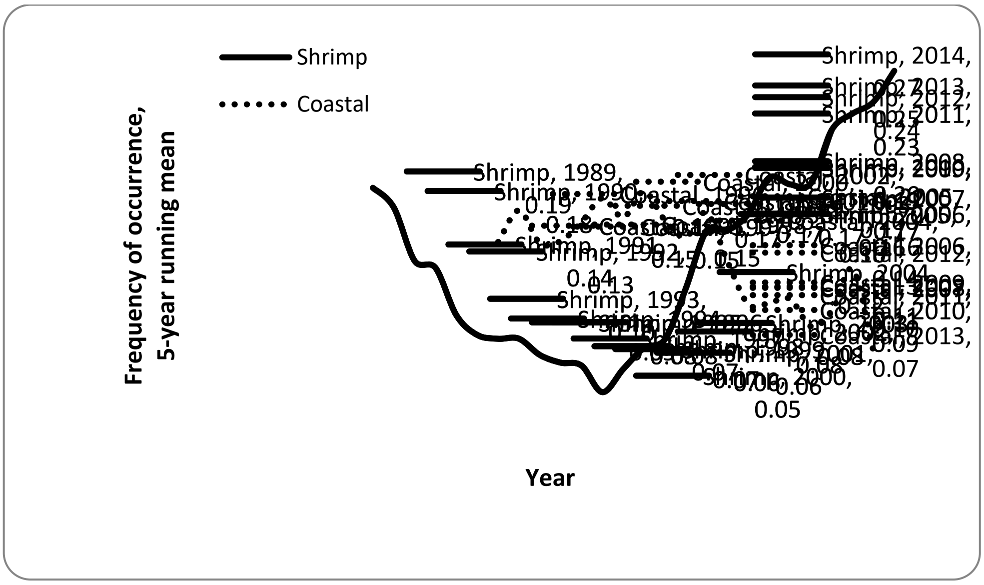


Figure 2.14. Northeast Atlantic spurdog. Frequency of occurrence of spurdog in the Norwegian Coastal survey and Shrimp survey. A five year running mean is used. Source: Vollen (2014 WD).

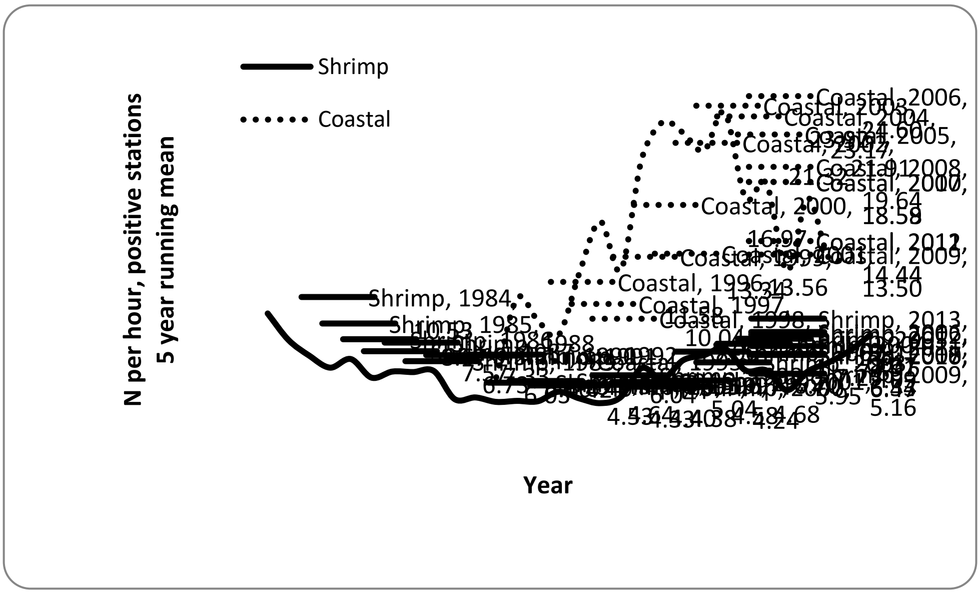


Figure 2.15. Northeast Atlantic spurdog. Mean number of spurdog caught per hour in the Norwegian Coastal survey and Shrimp survey. A five year running mean is used. Source: Vollen (2014 WD).

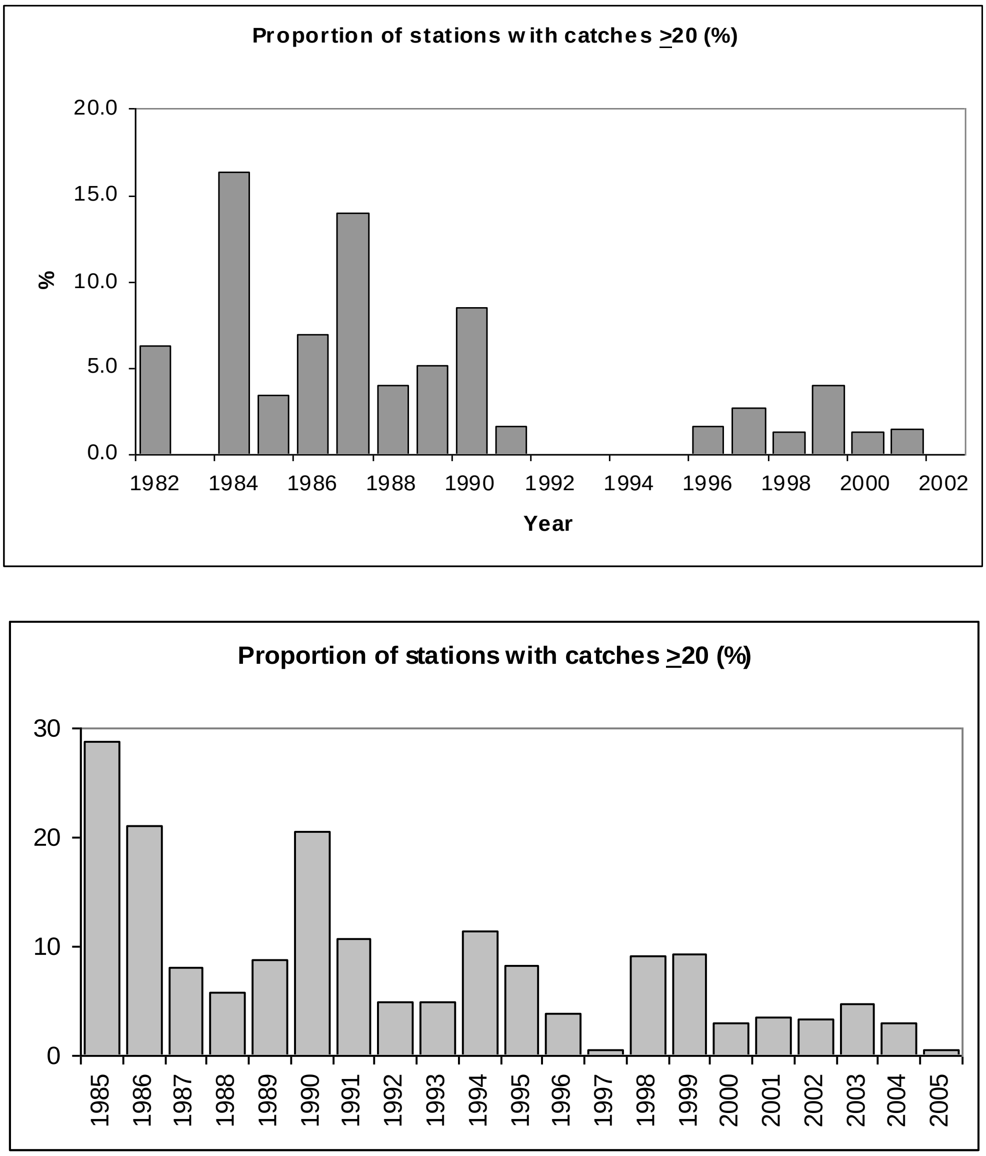
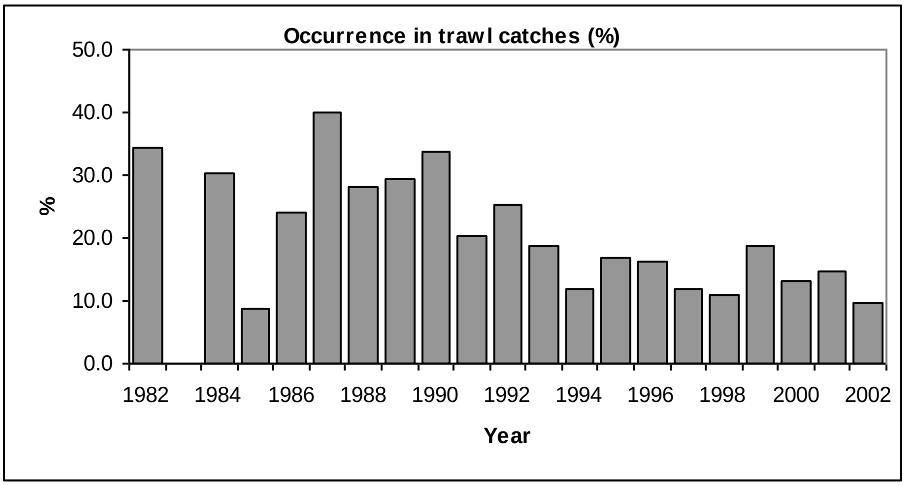


Figure 2.16. Northeast Atlantic spurdog. Proportion of survey hauls in the English Celtic Sea groundfish survey (1982–2002, top) and Scottish west coast (6.a) survey (Q1, 1985–2005, bottom) in which CPUE was ≥ 20 ind. h–1. (Source: ICES, 2006).

a)



b)

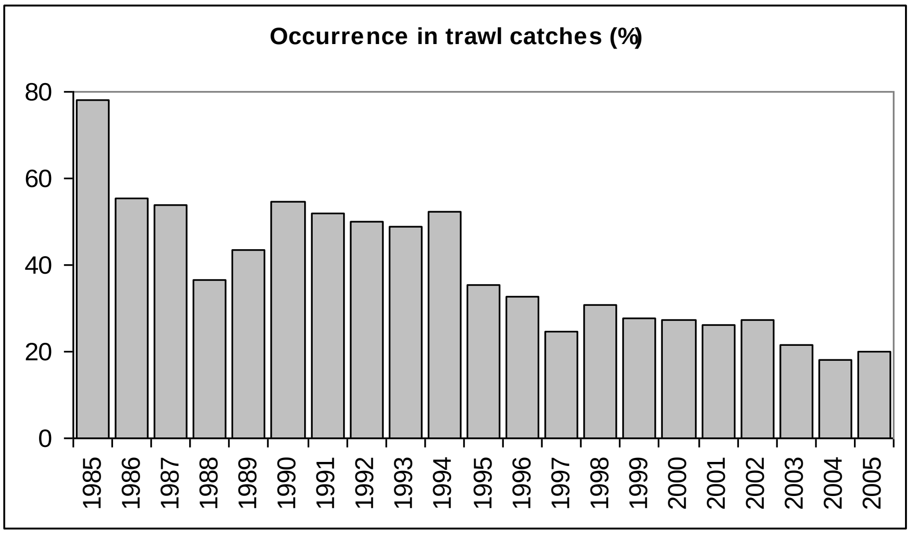


Figure 2.17. Northeast Atlantic spurdog. Frequency of occurrence in survey hauls in a) the English Q1 Celtic Sea groundfish survey (1982–2002), and b) the Scottish west coast (6.a) survey (Q1, 1985–2005).

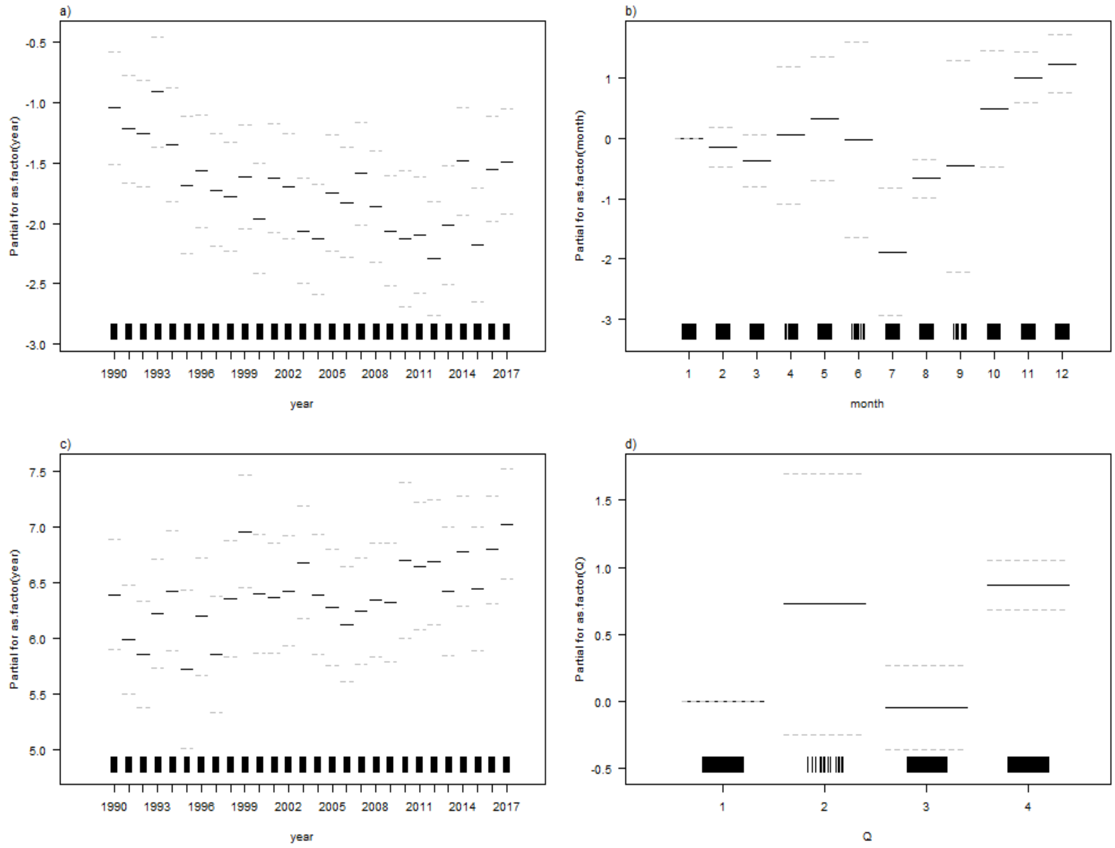


Figure 2.18. Northeast Atlantic spurdog. Estimated year and quarter effects (±1 s.e.) from the delta-lognormal GLM: binomial model shown in a) and b), and lognormal results in c) and d) (log scale).

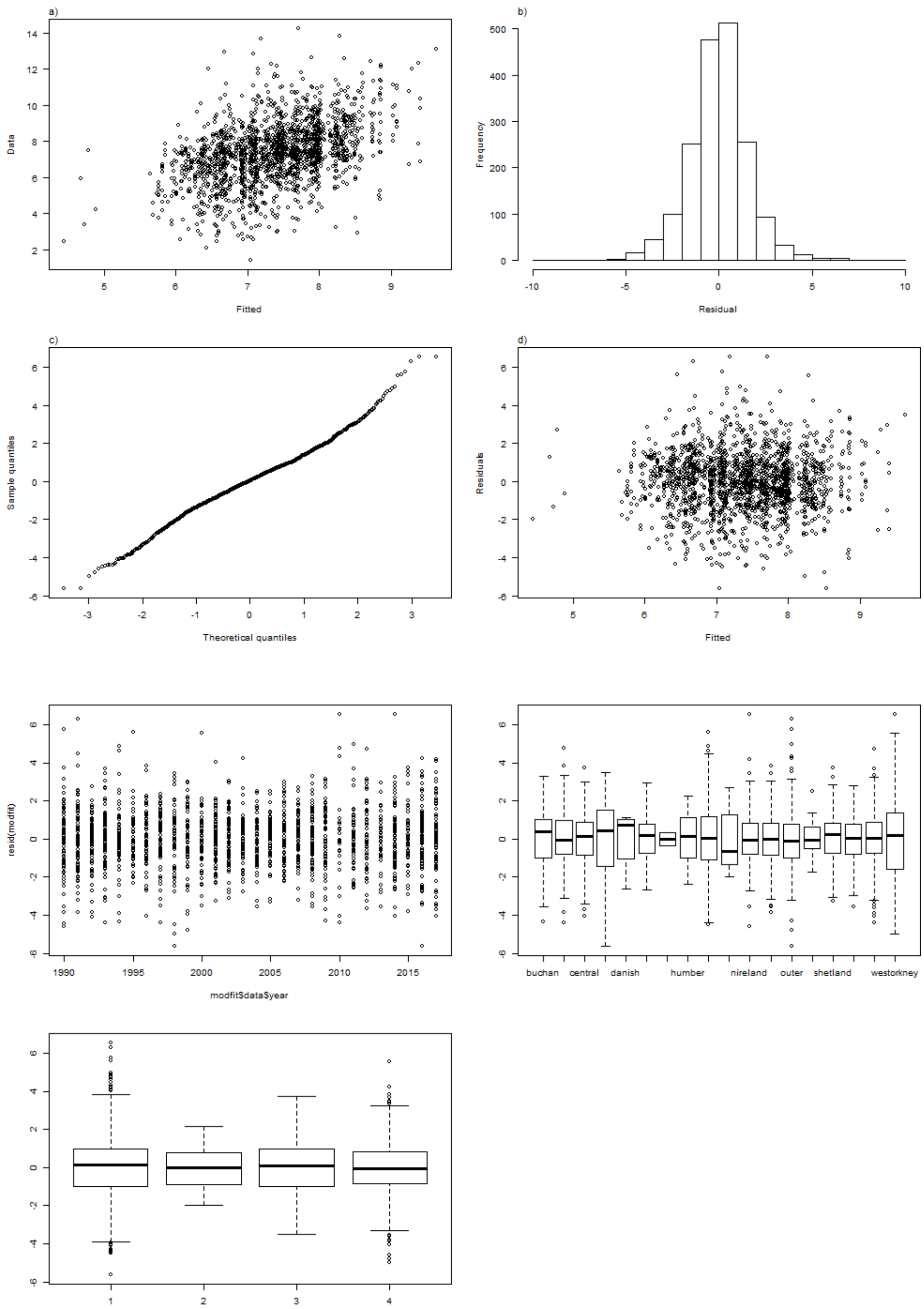


Figure 2.19. Northeast Atlantic spurdog. Analysis of Scottish survey data. Residual plot of final lognormal model fit: a) observed vs. fitted values, b) histogram of residuals, c) normal Q-Q plot, d) residuals vs. fitted values and e), f) and g) residuals vs. year, area and quarter.

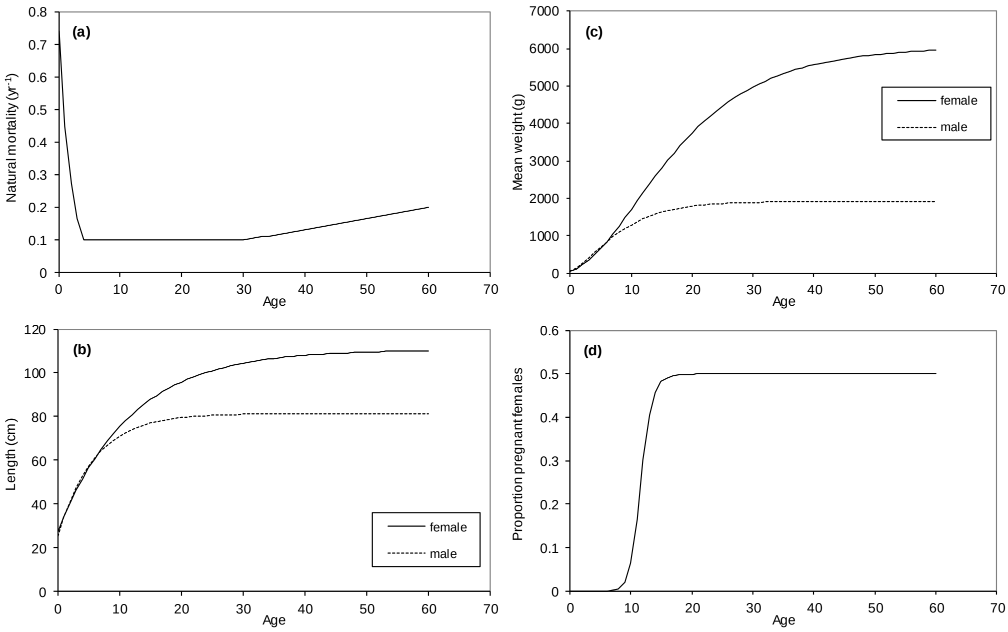


Figure 2.20. Northeast Atlantic spurdog. A visual representation of the life-history parameters described in Table 2.5. [Note, the value of natural mortality-at-age 0 is a parameter derived from the assessment.]

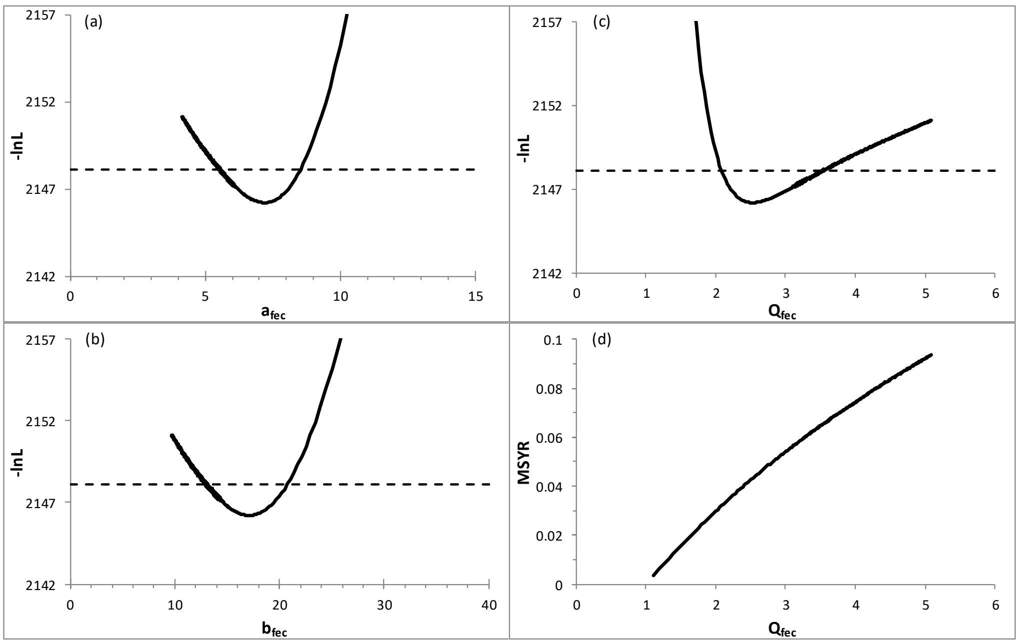


Figure 2.21. Northeast Atlantic spurdog. Negative log-likelihood (-ln*L*) for a range of (a) a_{fec} and (b) b_{fec} values, with (c) corresponding Q_{fec}. Plot (d) shows MSYR (MSY/B_{MSY}) vs. Q_{fec}. Using the likelihood ratio criterion, the hashed line in plots (a)–(c) indicate the minimum –ln*L*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

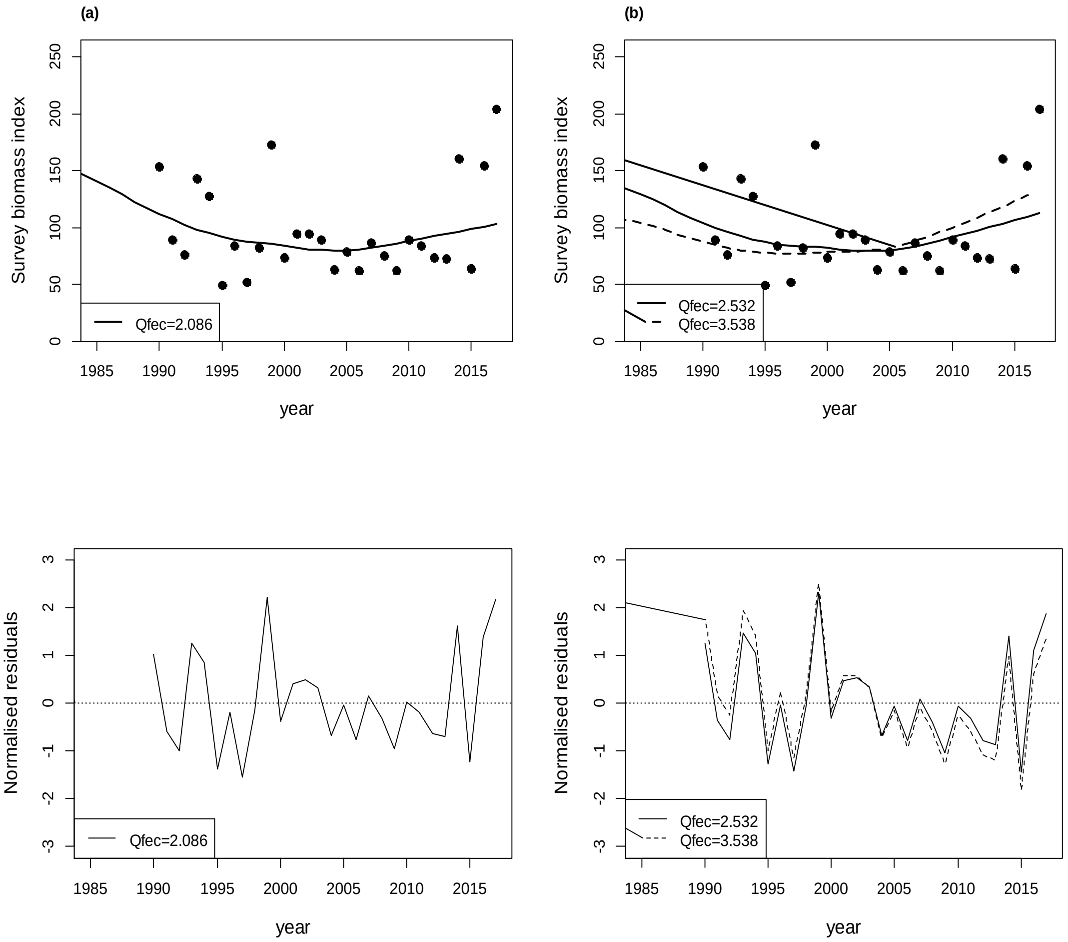


Figure 2.22. Northeast Atlantic spurdog. Model fits to the Scottish surveys abundance index (top panel), with normalised residuals ($\varepsilon_{sur,y}$ in Stock Annex equation 9b) (bottom) for (a) the base-case Qfec=2.000 (the more conservative lower bound in Figure 2.21c) and (b) for two alternatives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

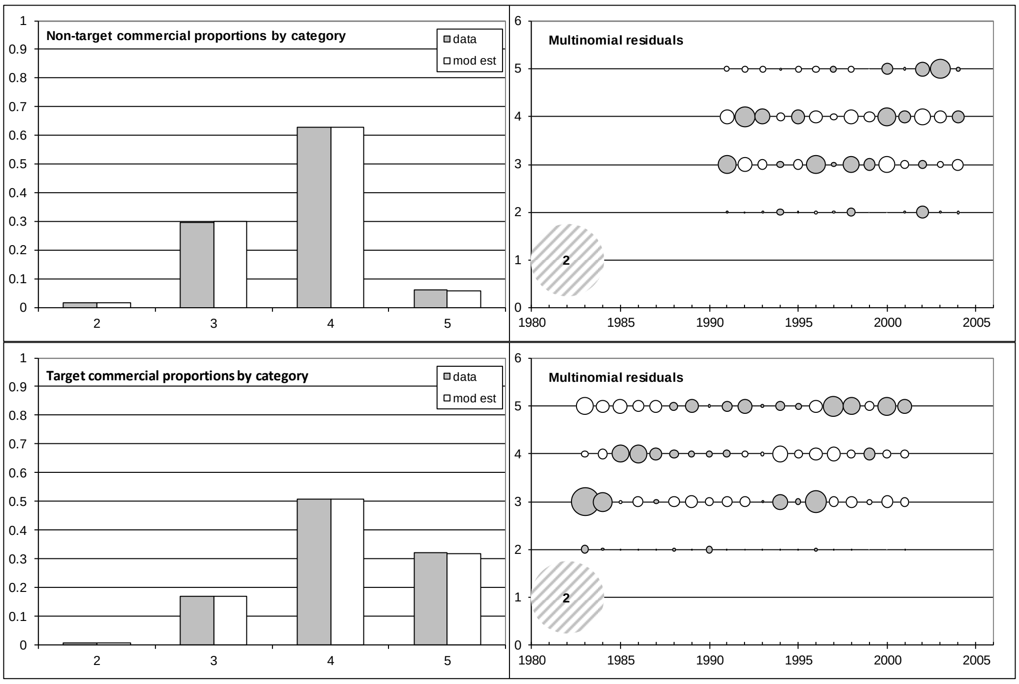


Figure 2.23a. Northeast Atlantic spurdog. Model fits to the non-target (Scottish; top row) and target (England & Wales; bottom row) commercial proportions-by-length category data for the base case run. The left-hand side plots show proportions by length category averaged over the time period for which 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.

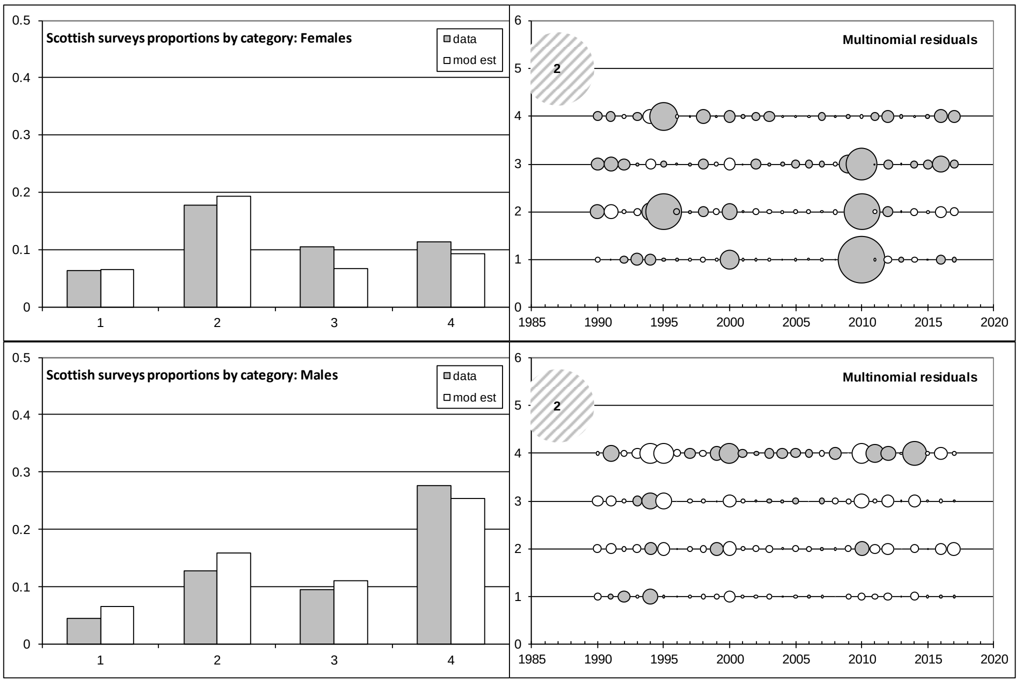


Figure 2.23b. Northeast Atlantic spurdog. Model fits to the Scottish survey proportions-by-length category data for the base-case run for females (top row) and males (bottom row). A further description of these plots can be found in the caption to Figure 2.23a. Length categories considered are 1: 16–31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

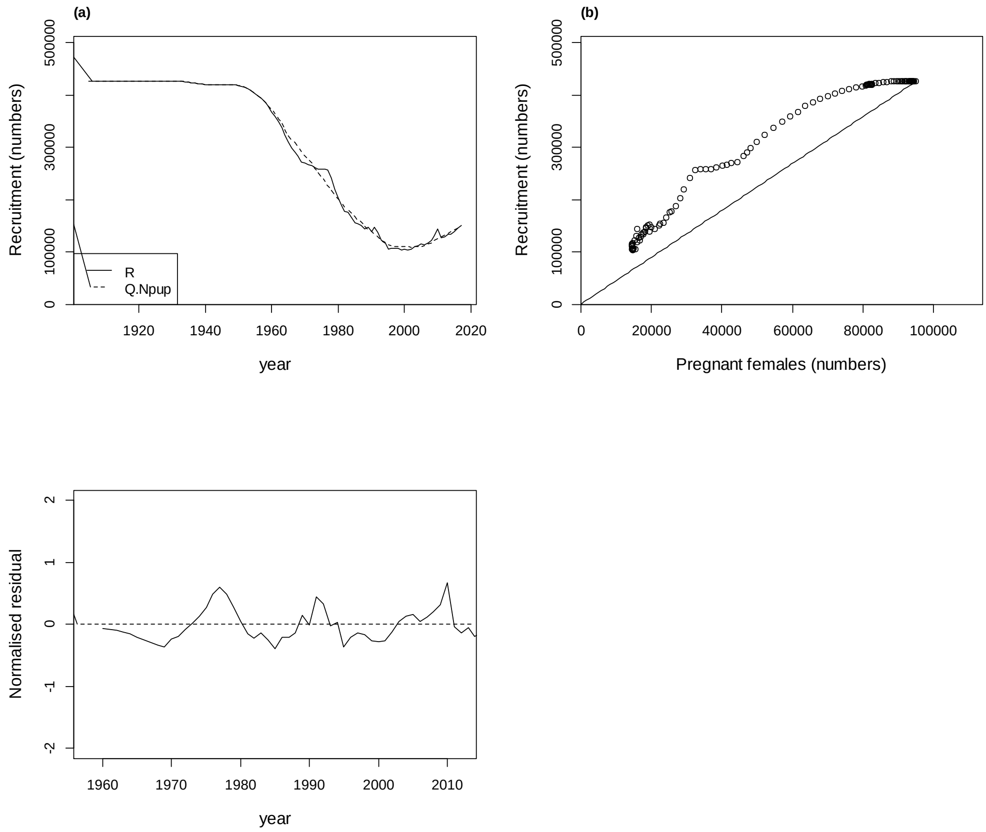


Figure 2.24. Northeast Atlantic spurdog. (a) A comparison of the deterministic (N_{pup}) and stochastic (R) versions of recruitment (Stock Annex equations 2a–c) (top-left panel) with normalised residuals ($\varepsilon_{r,y}/\varepsilon_r$, where $\varepsilon_{r,y}$ are estimable parameters of the model) (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).

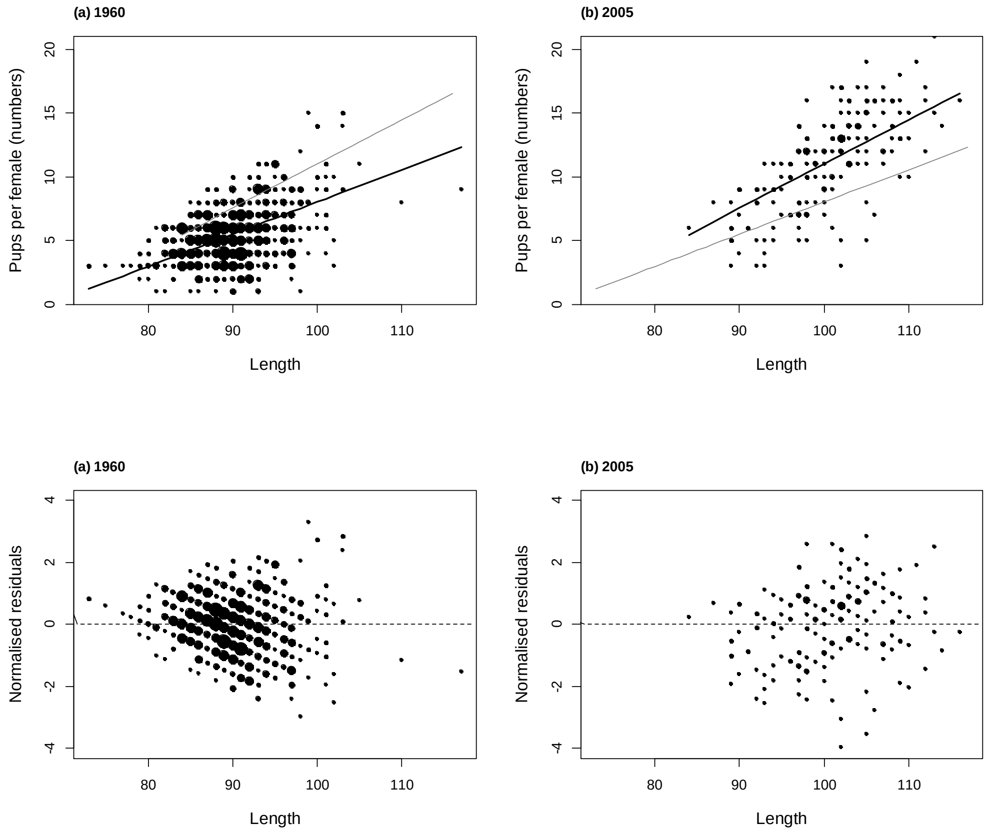


Figure 2.25. Northeast Atlantic spurdog. Fit to fecundity data from two periods (top row) (a) 1960 and (b) 2005, with associated normalised residuals ($\varepsilon_{fec,k,y}$ in Stock Annex equation 11b) (bottom row). For the top plots, the heavy black lines reflect the model estimates for the given 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.

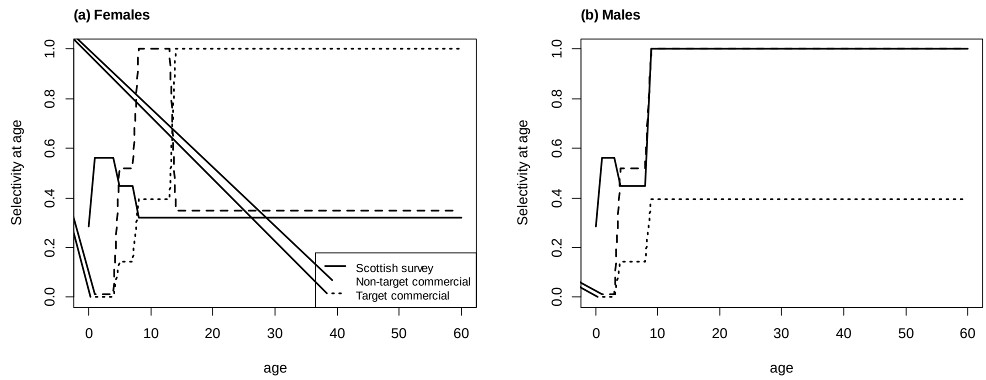


Figure 2.26. Northeast Atlantic spurdog. Estimated selectivity-at-age curves for the base case run for (a) females and (b) males. The two commercial fleets considered have non-target (Scottish) and target (England & Wales) selectivity, which differ by sex because of the life-history parameters for males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

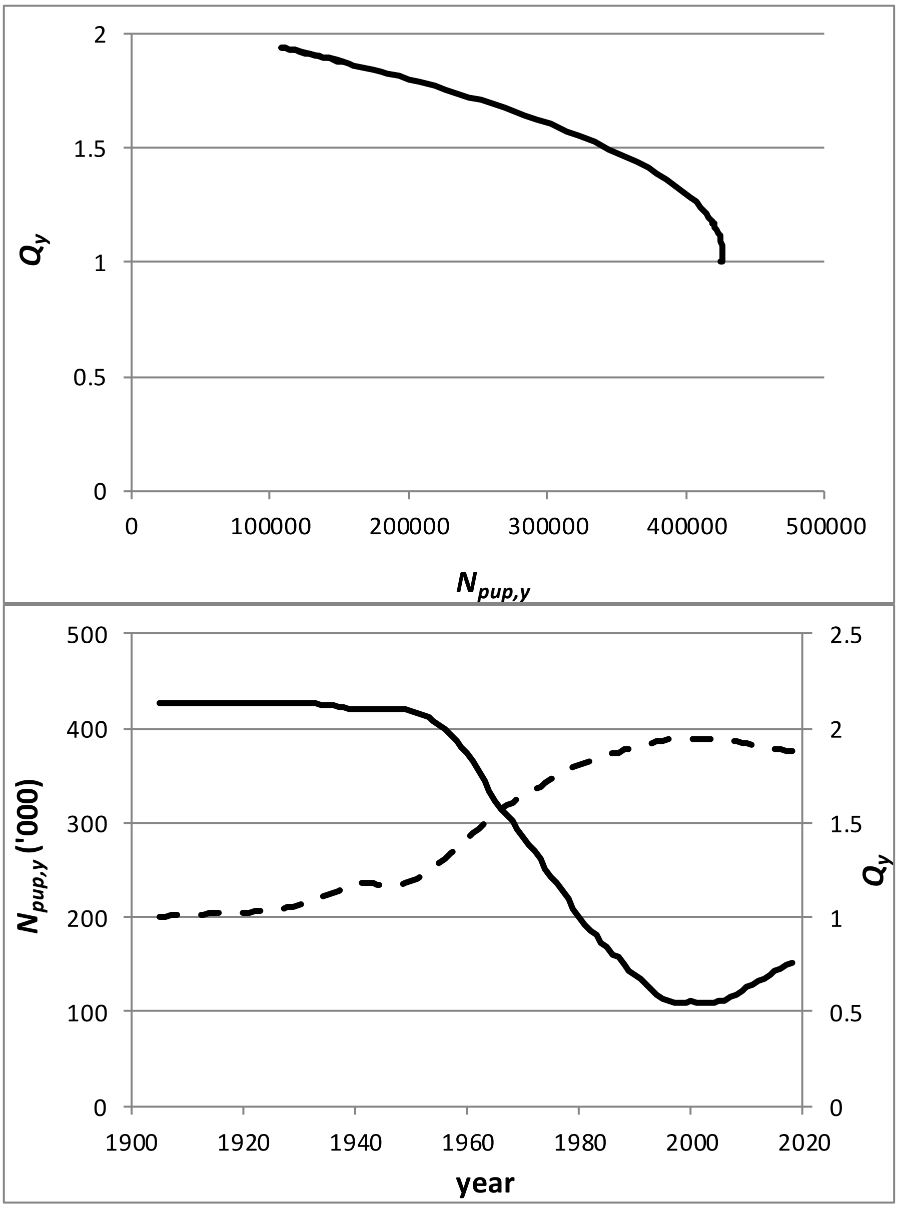


Figure 2.27. Northeast Atlantic spurdog. A plot of the density-dependent factor Q_y (Stock Annex equation 2b) against the number of pups $N_{pup,y}$ (top), and both plotted against time (bottom; solid line for $N_{pup,y}$, and hashed line for Q_y).

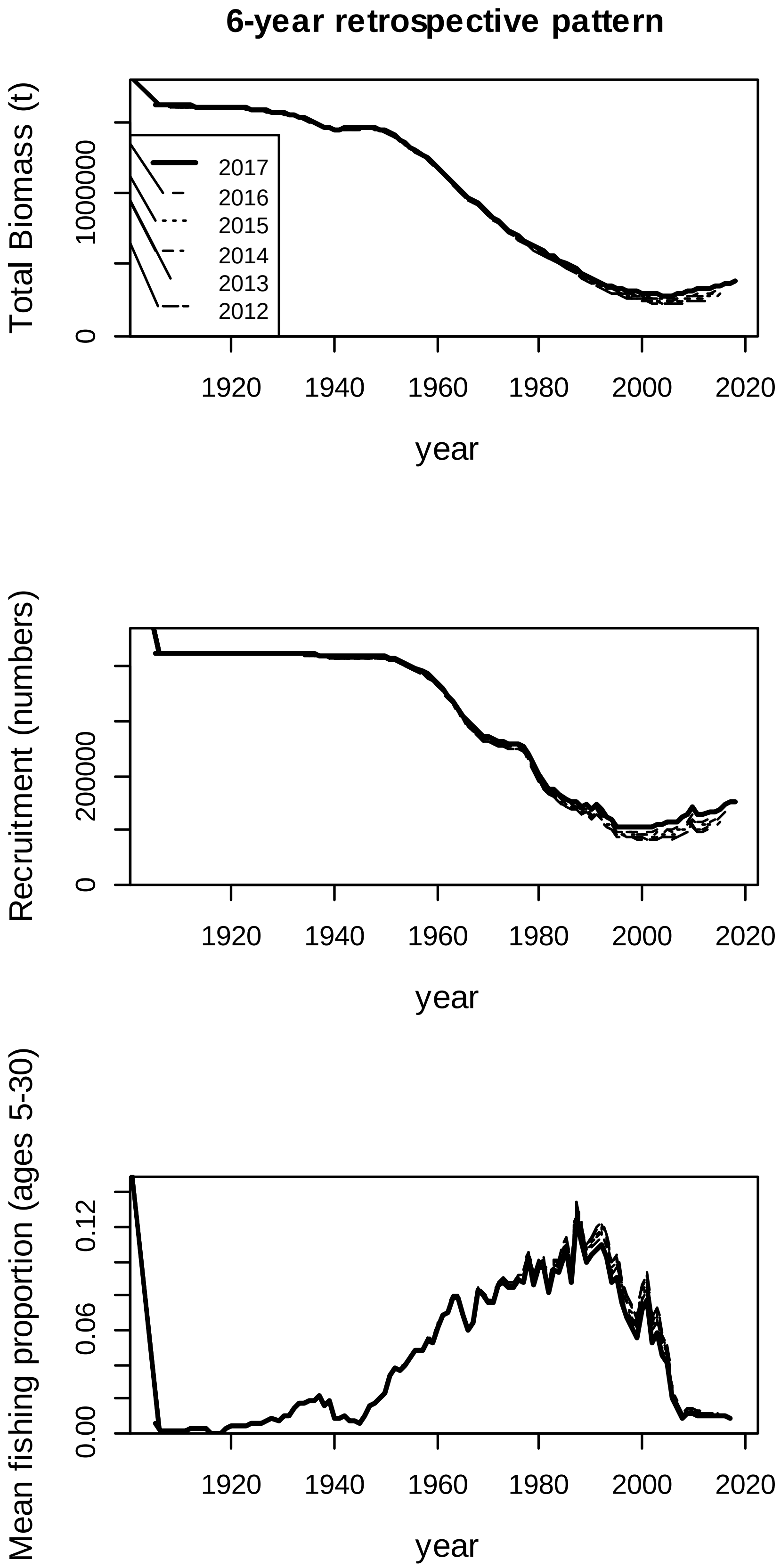


Figure 2.28a. Northeast Atlantic spurdog. Six-year retrospective plots (omitting probability intervals for clarity; the model was re-run, each time omitting a further year in the data).

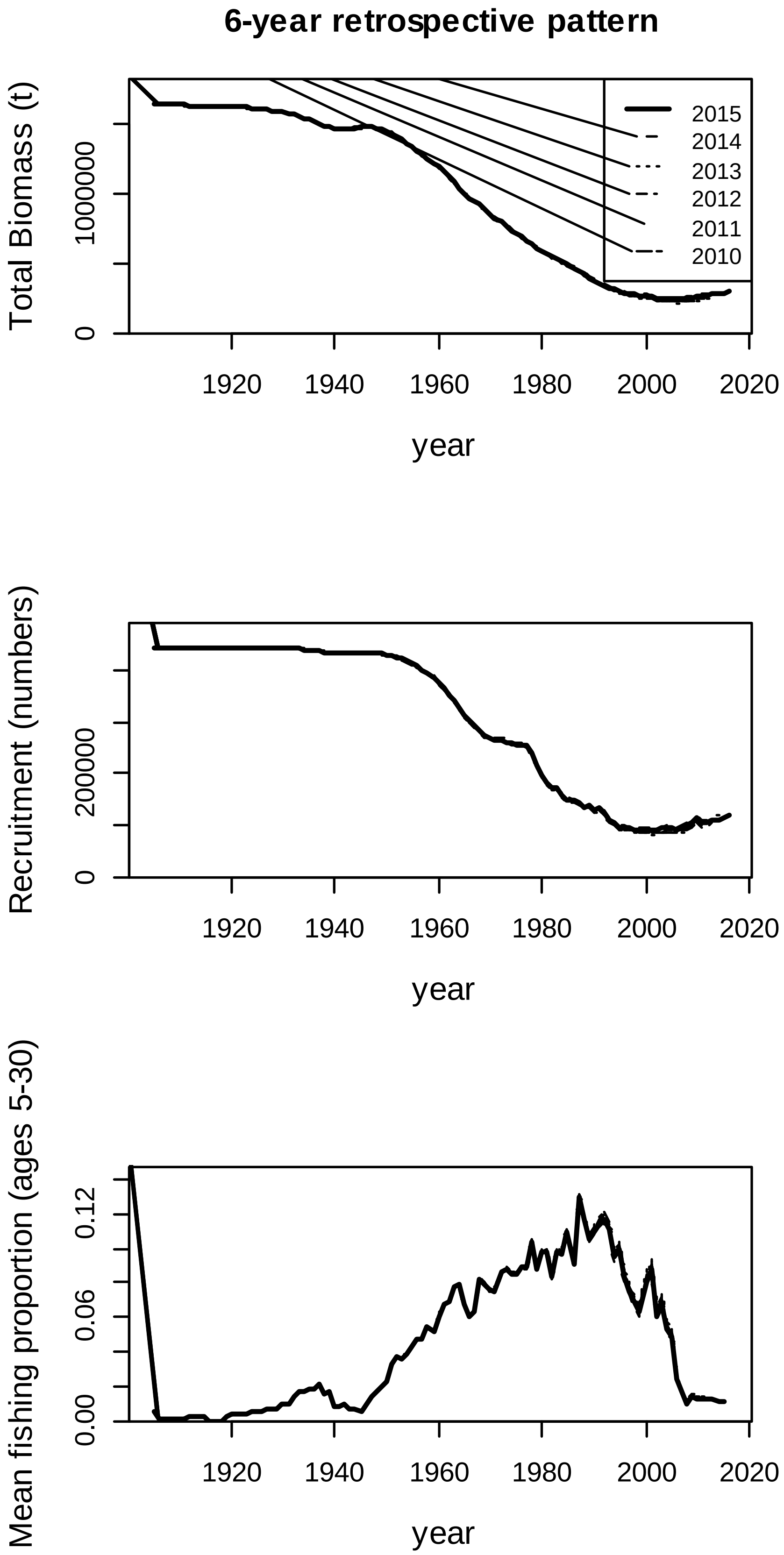


Figure 2.28b. Northeast Atlantic spurdog. As for Figure 2.28, but conducted during WGEF in 2016 (ICES, 2016) with an appropriate adjustment of years.

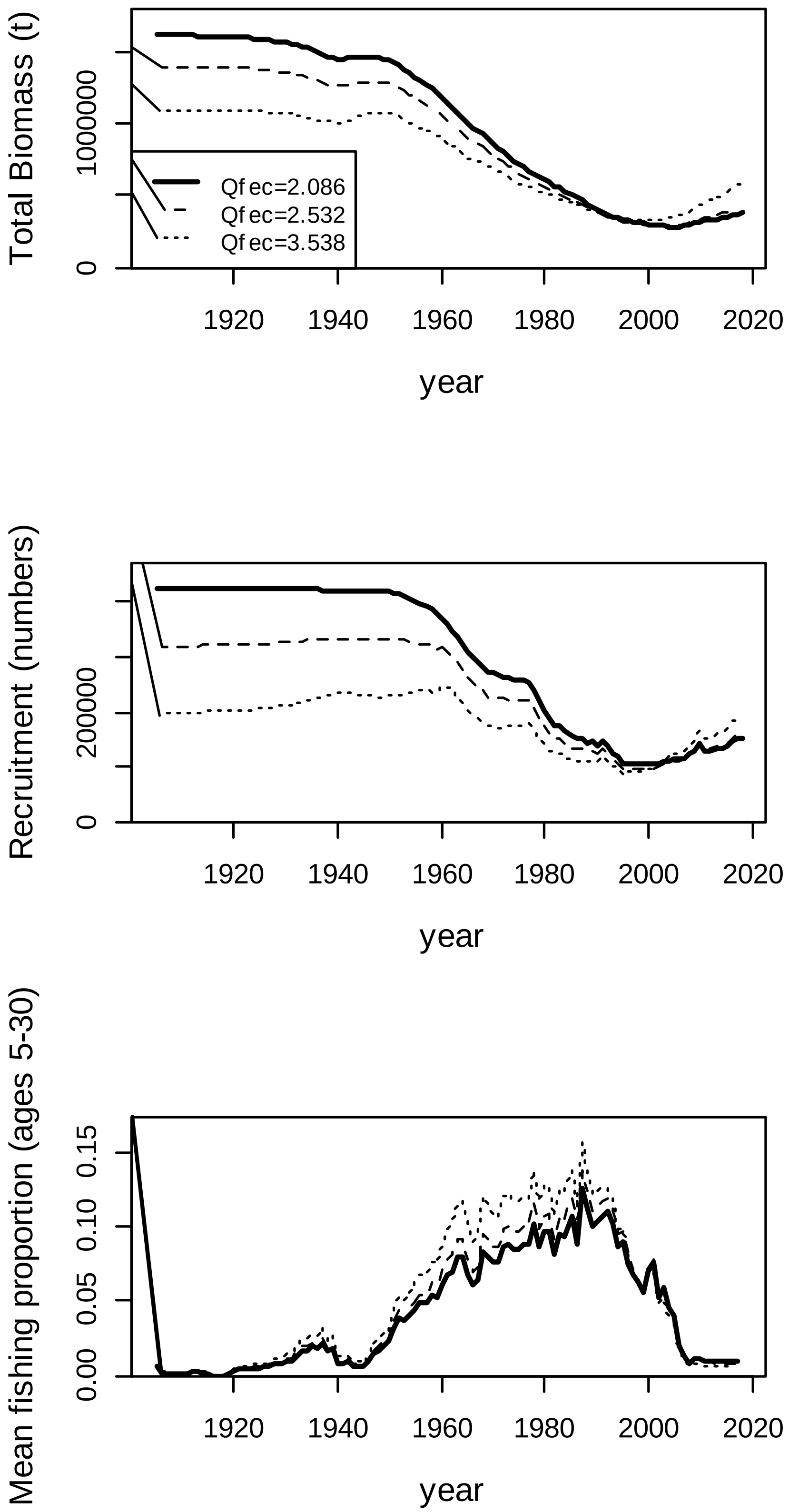


Figure 2.29. Northeast Atlantic spurdog. A sensitivity analysis of the parameter that determines the extent of density-dependence in pup production (Q_{fec}). Three alternative values are considered, related to the smallest, optimum (in terms of lowest -ln*L*) and largest value of Q_{fec} below the hashed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

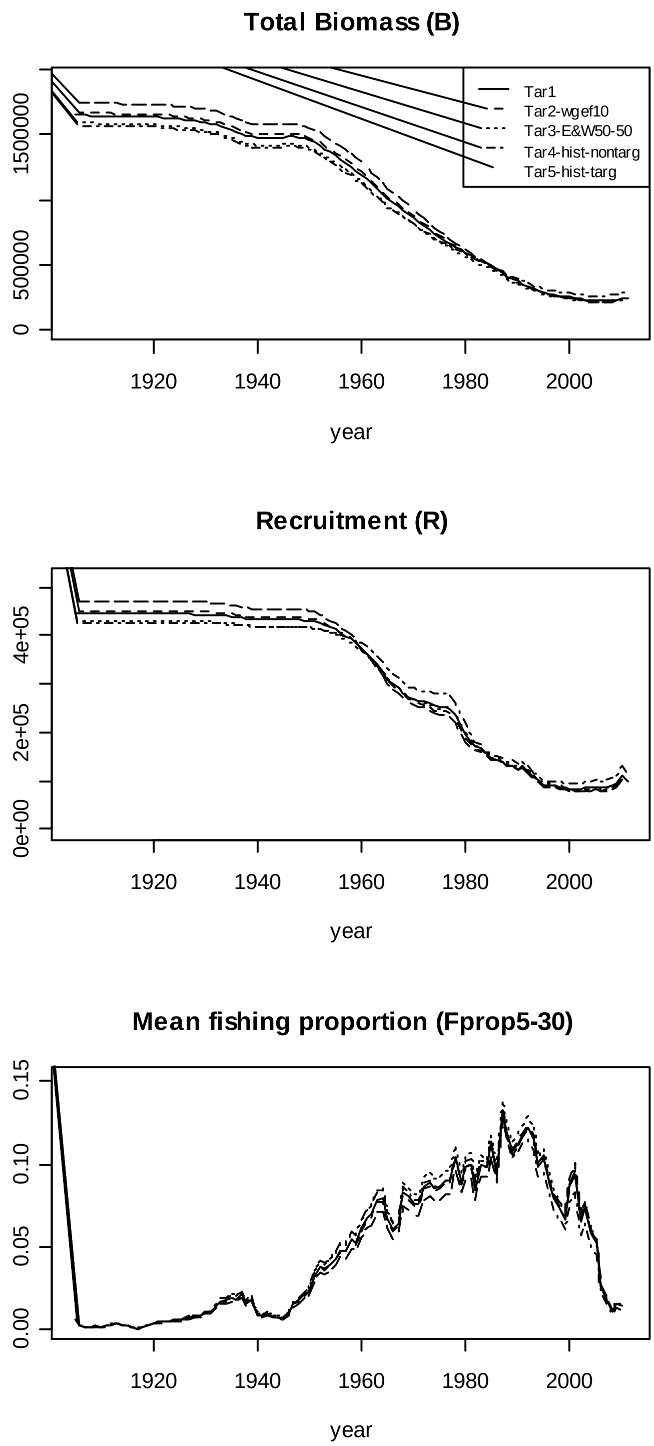


Figure 2.30. Northeast Atlantic spurdog. A comparison of the alternative targeting scenarios, where fishing is defined as either "non-target" (Scottish selectivity) or "target" (England & Wales selectivity). Tar 1 is the base case (each nation is defined "non-target", "target" or a mixture of these, 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.

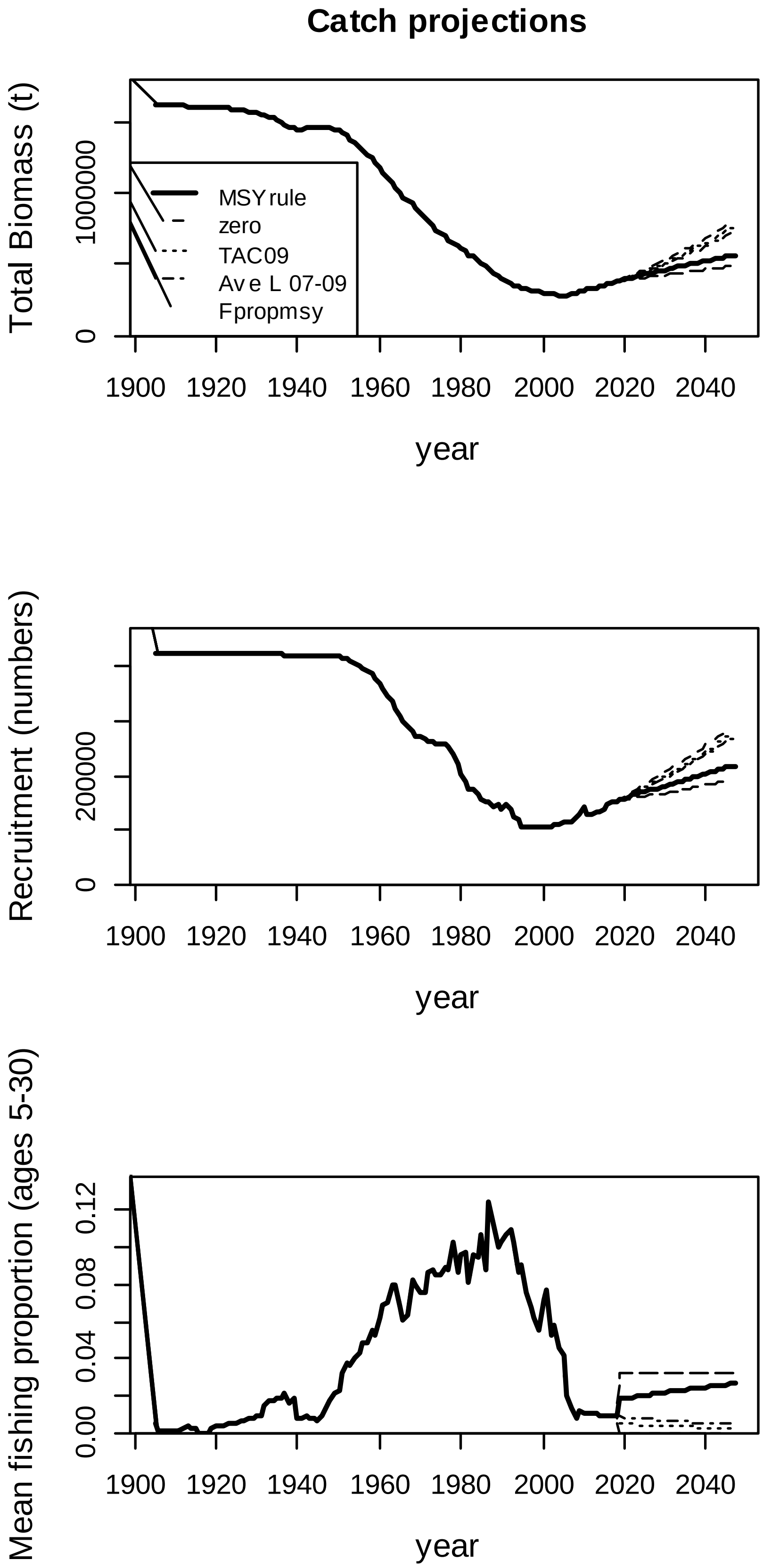


Figure 2.31. Northeast Atlantic spurdog. 30-year projections for different levels of future catch, including zero catch for reference.

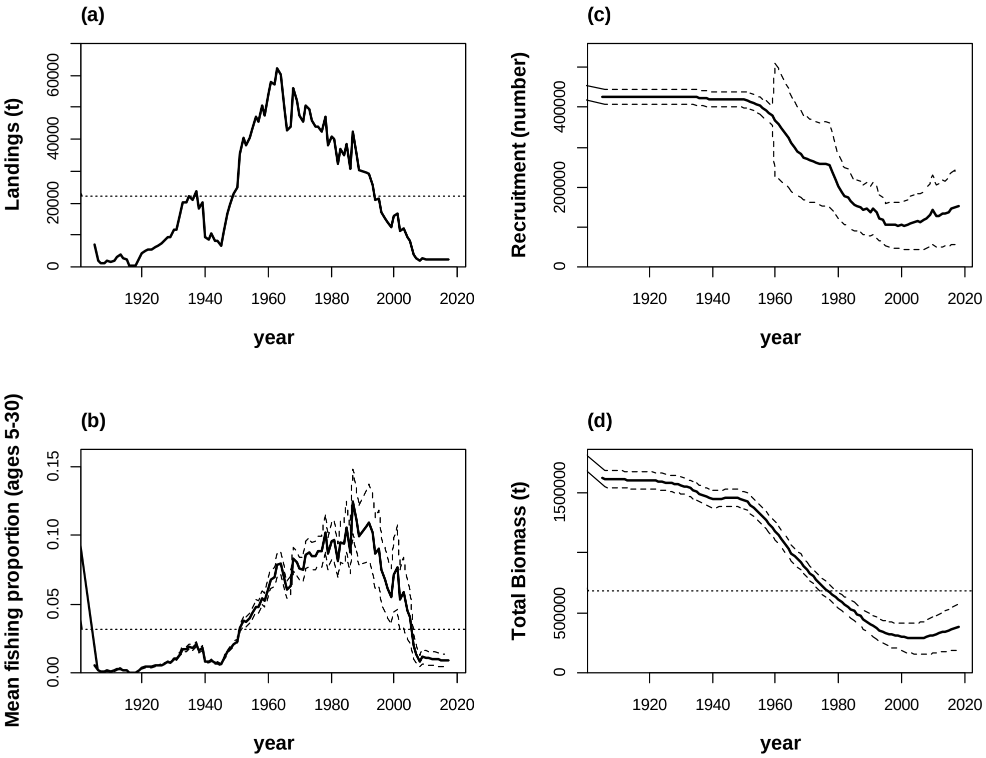


Figure 2.32. Northeast Atlantic spurdog. Summary four-plot for the base-case, showing long-term trends in landings (tons; dotted horizontal line = *MSY* = 22 027 t), recruitment (number of pups), mean fishing proportion (average ages 5–30; dotted horizontal line=$F_{prop,MSY}$=0.032) and total biomass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

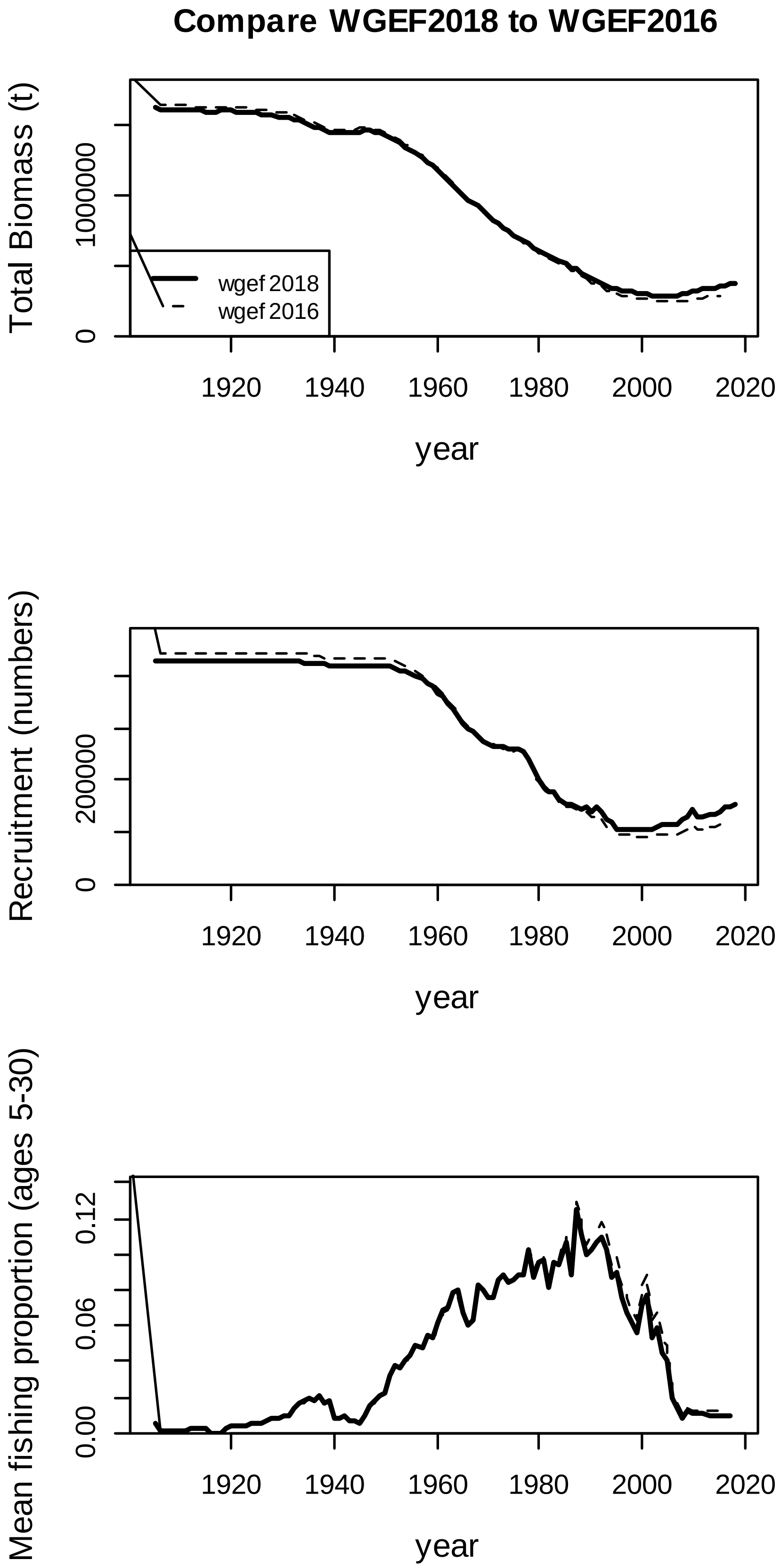


Figure 2.33. Northeast Atlantic spurdog. Comparison with the assessment from WGEF (2016).

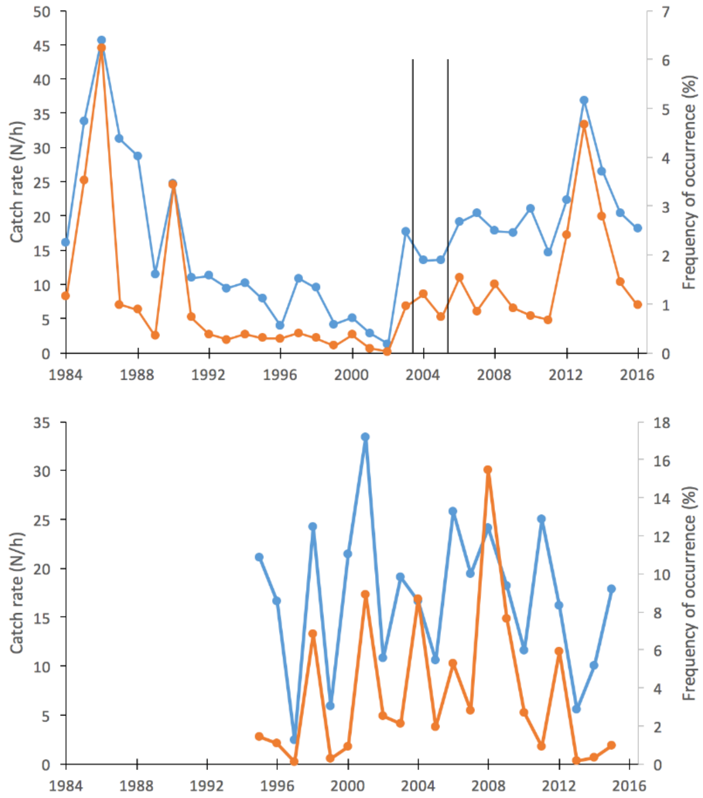


Figure 2.34. Northeast Atlantic spurdog. Survey indices of spurdog in terms of catch rates (orange lines) and frequency of occurrence (blue lines) from the Norwegian Shrimp Survey in South-Norway (top panel) and the Norwegian Coastal Survey in North-Norway (bottom panel). The two vertical lines indicate 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.

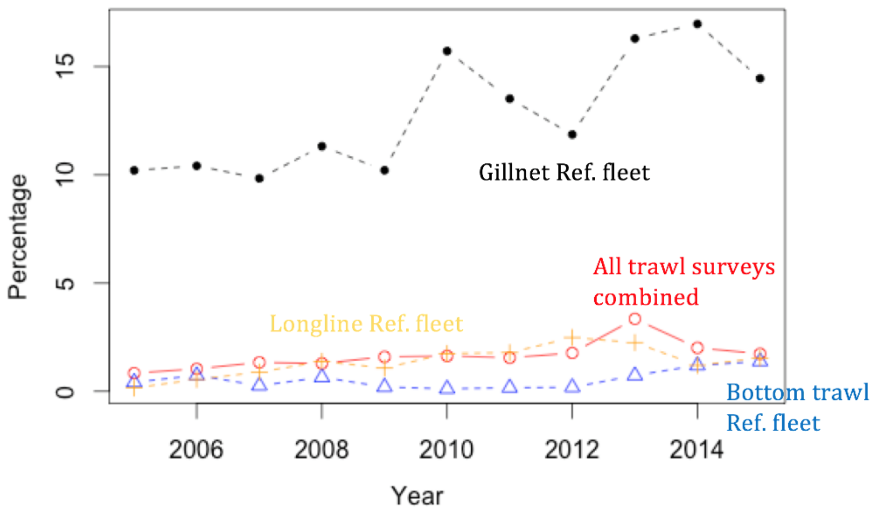


Figure 2.35. Northeast Atlantic spurdog. Percentage occurrence of spurdog in sampled Norwegian commercial catches from each year and from each major fishery groups.

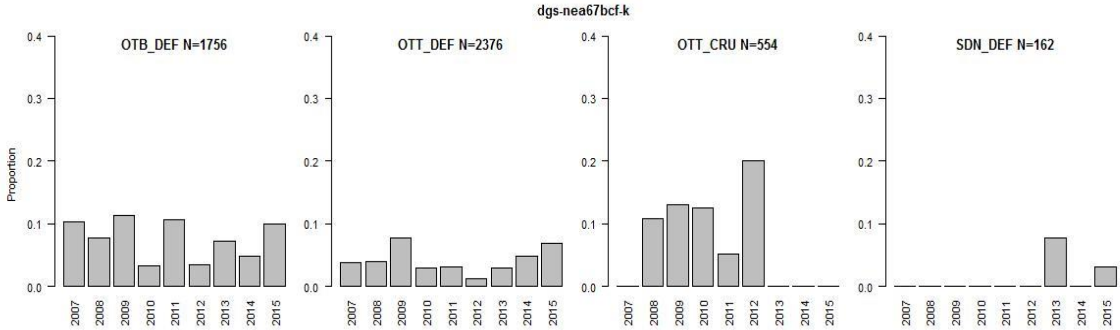


Figure 2.36. Northeast Atlantic spurdog. Proportion of commercial hauls encountering spurdog in French fisheries (main level 5 metiérs catching spurdog) in Subarea 6 and divisions 7.b-c and 7.f-k for the period 2007–2015. N: total number of fishing operations sampled for the métier.

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

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".

3.2 Leafscale gulper shark

The leafscale gulper shark has a wide distribution in the Northeast (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.

3.2.1 Portuguese dogfish

The 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.

3.3 The fishery

3.3.1 History of the fishery

Fisheries taking leafscale gulper shark or Portuguese dogfish are described in their respective stock annexes.

Since 2010, EU TACs for deep-water sharks have been set at zero. Consequently, reported landings for each of the two species since then were very low or zero. Also, as most of these species are taken as bycatch in mixed fisheries, it is likely that discarding has increased.

In 2016, the EU fixed, for 2017 and 2018, a restrictive by-catch allowance, permitting limited landings of unavoidable by-catches of deep-sea sharks in directed artisanal deep-sea longline fisheries for black scabbardfish (Council regulation (EU) 2016/2285). 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. For 2019 and 2020, the allowed by-catch was established as 7 tonnes for each of these areas (Council regulation (EU) 2018/2025).

3.3.2 Species distribution and spatial overlap with fisheries

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). The main objectives of this Project were to evaluate: i) the species distributions; ii) the spatial overlap between deep-sea sharks and black scabbardfish; and iii) the efficiency on deep-water shark by-catch under modifications of the fishing gear.

WGEF considers that this study does not provide sufficiently detailed information on the distribution of deep-water shark species and on their stocks status, as it was restricted to the reduced fishing areas exploited by deep-water longline fisheries targeting black scabbardfish. The data and the low sampling levels were considered insufficient to provide the spatial coverage to allow the evaluation of the spatial overlap between deep-sea sharks and black scabbardfish. Regarding the biomass indexes, they were derived from a combination quite distinct of data sources, particularly logbooks and on-board observations. Each of these two data sources have substantial caveats and their combination have been done without take that into consideration. As a consequence, the results present should be scrutinized with caution; for instance, the trends referred in the report are neither evident nor clearly support by the information available. No technical modifications introduced to minimize the deep-sea sharks bycatch levels on the fishing gear were evaluated.

Geostatistical studies (Veiga *et al*., 2013; Veiga *et al*., 2015 WD) using deep-water longline black scabbardfish fishery data (vessel monitoring systems, logbooks and official daily landings) were conducted with the aim of evaluating the spatial distribution and spatial overlap between i) black scabbardfish and leafscale gulper shark and between ii) black scabbardfish and Portuguese dogfish taken by the longline fishery operating off mainland Portugal (Division 9.a). Results obtained indicated that in fishing grounds where black scabbardfish is more abundant and where fishing takes place, the relative occurrence of both deep-water shark species is reduced. These differences on the relative occurrence have implications for alternative management measures to be adopted in the deep-water longline black scabbardfish fishery, particularly in what concerns the minimization of deep-water shark bycatch.

In 2014, IPMA conducted a short-duration pilot survey on board commercial fishing vessels belonging the Portuguese mainland black scabbard fishery (Veiga, 2015 WD). The aim of the survey was to compile information regarding the study of the spatial overlap between Portuguese dogfish and leafscale gulper shark with the targeted black scabbardfish. Under this survey, ten fishing hauls were performed, half of them located at the fishing grounds exploited by the black scabbardfish fleet (BSF fishing grounds) and the other half located at deeper in areas adjacent to these fishing grounds. Each pair of fishing hauls were carried out by one vessel (five vessels in the total). The proportion of each shark species was estimated (~ 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) for each fishing haul. Within vessels, the proportions of each shark species differed between fishing hauls performed at the BSF fishing grounds and those located deeper. For the two species the values of proportion were higher at the latter locations. For the two species, the results from the Wilcoxon rank sum gave significant p-values (p-value = 0.01 and 0.08 for Portuguese dogfish and leafscale gulper shark, respectively). These results support the existence of differences in the deep-water shark proportions between BSF fishing grounds and deeper fishing grounds.

In addition to the conclusions drawn by these studies, a recent analysis of onboard data collected at commercial vessels belonging to the Portuguese deep-water longline fishery that takes place in ICES 27.9 suggests that *C. squamosus* and *D. calcea* have a higher spatial overlap with fishery than that of *C. coelolepis* (Figueiredo and Moura, 2019 WD). Worth to mention that regarding those two species they have a widespread distribution and undertake migrations associated to reproduction (despite those from the *D. calcea* being less understood).

As a reaction of the restrictive EU management measures adopted for deep-water sharks, fishing vessels also tend to avoid fishing grounds known by fishermen to be areas where the deep-water sharks are more likely to be caught. No survival of sharks when returned to the sea is expected. The only successful notice of survivorship of deep-water sharks was observed for leafscale gulper sharks caught during a tagging Spanish scientific survey. The survey used deep-water longlines which were laid at depths ranging from 900 to 1100 m (Rodríguez-Cabello and Sánchez, 2014). In that study, the soaking time was restricted to 2–3 hours and the lines were hauled back at a very slow speed (0.4–0.5 m s^{-1}). It is important to note that these fishing practices are different from those used by commercial vessels.

3.3.3 The fishery in 2018

No new information.

3.3.4 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 advised 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*".

3.3.5 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 below.

Year	ICES subareas		
	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)	0
2018	10 (4)	10 (4)	0
2019	7 (4)	7 (4)	0
2020	7 (4)	7 (4)	0

(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.

Since 2013, 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)).

Since 2013 under NEAFC Recommendation 7 it was required that Contracting Parties 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 2005, the use of trawls and gillnets in waters deeper than 200 m in the Azores, Madeira and Canary Island areas was banned (Council Regulation (EC) No 1568/2005). In 2007 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 was banned while a maximum bycatch of deep-water shark of 5% in hake and monkfish gillnet catches was allowed (Council Regulation (EC) No 41/2007). 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 NEAFC waters by 1 February 2006.

Since 2009 the "rasco (gillnet)" fishing gear was banned at depths lower than the 600 m isobath (EC Regulation 43/2009,). 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.

A by-catch TAC for deep-water sharks was allowed for each of the years from 2017 to 2020, on a trial basis, in the directed artisanal deep-sea longline fisheries for black scabbardfish (Council regulation (EU) 2016/2285; Council regulation (EU) 2018/2025). According to this limited landing of unavoidable by-catches of deep-sea sharks were allowed and Member States should develop regional management measures for the black scabbardfish fishery and establish specific data-collection measures for deep-sea sharks to ensure their close monitoring. 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 in accordance with ICES indications according to which in the artisanal deep-sea longline fisheries for black scabbardfish, the restrictive catch limits lead to misreporting of unavoidable by-catches of deep-sea sharks, which are currently discarded dead.

The Council regulation (EU) 2016/2285 affects specifically the Portuguese deep-water longline fishery targeting black scabbardfish in ICES Division 9.a and Subarea 10. As a response, Portugal has proposed an action plan focusing the black scabbardfish fishery and this plan is coordinated by the Portuguese General Directorate of Fisheries. Among other objectives, under this plan different management strategies were expected to be evaluated.

3.4 Catch data

3.4.1 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').

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).

For the years before 2005 it was not possible to determine identity to species level and hence the landings presented here are of "siki" sharks. "Siki" landings are a mixed category comprising mainly *C. squamosus* and *C. coelolepis* but also including unknown quantities of other species (Table 3.1). Past efforts made by WGEF to assign mixed landings by species are described in the Stock Annex. Landings estimates from 2005 onwards were revised following WKSHARKS2, and are presented by species (Tables 3.2 and 3.3).

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.

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. Portuguese landings in 2017 and 2018 were within the trial TAC defined by the Council regulation (EU) 2016/2285) for the deep-water sharks by-catch from the artisanal deep-sea longline fisheries for black scabbardfish.

3.4.2 Discards

Since 2010, the EU TACs for deep-water sharks have been set at zero, and consequently it is believed that the discarding in deep-water fisheries has increased. Discard data have been 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 sampling (Fernandes *et al.*, 2011 WD). However, it is considered that spatial coverage by the sampling 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 (Prista *et al.*, 2014 WD). 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 ever sampled. Despite these results, 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).

Estimated discards of leafscale gulper shark in 2018 were 19 tonnes.

Discards of *Centrophorus* spp. are presented in Table 3.4. 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 low and thus a very large raising factor was 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 for only a small percentage of the 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 3.4 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. Estimated discards of Portuguese dogfish from the trawl fleet in 2018 were 172 tonnes.

In 2012 (10 vessels), 2013 (12 vessels) and 2014 (11 vessels) landed >10 tonnes 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, from 2012 to 2014, observers were onboard at 7, 10 and 8 of these vessels, respectively. The fishery for these three deep-water 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 came from divisions 6.a and 7.b-c.

Other deep-water species landings made from 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 (ICES Working Group on the Biology and Assessment of Deep-sea Fisheries Resources) 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 3.5).

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 those fishing effort variables returned different discard estimates, which range from 13–200 tonnes of Portuguese dogfish and from 40–700 tonnes 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 3.6 together with reported landings in those years. A full description of the method used can be found in an earlier report (ICES, 2013).

Ireland. Discard data from Ireland is available since 2009 for the Portuguese dogfish from the trawl fleet operating in ICES divisions 27.6a and 27.7.bgj. Discards are considered negligible as values estimated are <1 tonne in most of the years.

3.4.3 Quality of the catch data

Historically, very few countries have provided landings 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. As an example, the 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.

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

3.4.4 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 after capture (Rodríguez-Cabello and Sánchez, 2014; Rodríguez-Cabello and Sánchez, 2017). According to this study, at-vessel mortality for *C. squamosus* and *C. coelolepis* was lower than expected: 1.2%, and 4.5%, respectively, however, mortality values increased to 18.9%, and 38.6%, respectively, if the specimens arriving on-board in poor condition were also considered.

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

3.5 Commercial catch composition

3.5.1 Species composition

Between 2006 and 2011, WGEF, using catch ratios from various historical sources, made a number of attempts to split mixed landings data by species. 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.

During WKSHARK2 and to better document the decisions to be made when estimating WG landings, landing data provided by each country was revised in relation to data quality (including taxonomic categories) and sampling protocols (ICES, 2016). Since 2005 and following WKSHARK2 outcomes, data is revised annually.

Late in 2018, a joint request from NEAFC and OSPAR for ICES scientific advice on deep sea sharks, rays and chimaeras has been produced. The main purpose in proposing a joint NEAFC/OSPAR advice request to ICES is to generate a scientific knowledge basis that can be used as ICES information/advice by both organizations when respectively considering possible future measures, each within their competence. While the main focus should be on elasmobranchs, it is also requested that deep-sea rays and chimaeras be considered in order to develop a general understanding of the distributions and ecological roles of all deep-sea elasmobranchs. According to the join request, ICES advice should also address the following aspects: a) information on fleets catching elasmobranchs and supporting the development and evaluation of additional approaches for bycatch mitigation. b) information pertinent to management actions related to impacts of pollution, climate change, and ocean acidification. c) information on e.g. seasonal changes in depth utilization profiles, feeding strategies and differences between life stages and reproductive stages of the species with special attention to juveniles and gravid females.

3.5.2 Length composition

No new information is available.

3.5.3 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, significant quantities of the two deep-water shark species under consideration are likely to be discarded by deep-water fisheries. Despite some sampling effort on discards has been undertaken, the sampling effort is clearly insufficient to estimate the quantities caught.

3.6 Commercial catch-effort data

No new data.

3.7 Fishery-independent surveys

Since 1996, Marine Scotland Science has been conducting 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. More information on this survey is presented below.

In September from 2006 to 2008 and in December 2009, Ireland carried out annual deep-water surveys in subareas 6 and 7. Fishing hauls were performed off north-western Ireland and west of Scotland, and the Porcupine Bank area to the west of Ireland at depth strata: 500 m, 1000 m, 1500 m and 1800 m. No further surveys have since taken place. The Irish deep-water survey 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).

A new Irish survey (IAMS) has begun trawl surveys at some deep-water stations along the western slope. However, a time-series is not available.

The 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.

From 2015 to 2018, AZTI conducted a deep-water longline survey (PALPROF) along the Basque Coast onboard a commercial longliner. More information on this survey is presented below.

3.8 Life-history information

No new information.

3.9 Exploratory assessments

3.9.1 Analyses of Scottish deep-water survey data

Since 2012 that, for each species, a standardized CPUE derived from the Scottish deep-water survey has been presented to the WGEF (ICES, 2012; ICES, 2013; ICES, 2014; ICES, 2018).

Generalized additive models (GAM), with a negative binomial distribution were in the standardization of the leafscale gulper shark and the Portuguese dogfish indices of abundance. The data collected at the Scottish deep-water survey from 2000 to 2017 were used (Campbell, 2018 WD).

The Scottish survey covers the continental slope between approximately 55°N and 59°N at depths between 300 and 2040 m (Figs 3.4–3.5). Most of fishing hauls take place at the following depth strata: 500, 1000, 1500 and 1800 m. In any one year, there were usually around 5–6 hauls for each of these depth strata. Occasionally, the survey carried out hauls at Rockall and Rosemary Bank. As the inclusion of the information from these fishing hauls could potentially bias the results, data from these fishing hauls were excluded from the GAM analysis.

The input data for standardization were restricted to fishing hauls held at the “core” depth range of each species. Species “depth” core were defined through visual inspection of the data; the core depth range for Portuguese dogfish was from 700 to 1900 m and for leafscale gulper shark from 500 to 1800 m. The GAM model with the highest deviance explained took the form: no*h^{-1}No ~ s(duration)+ s(depth)+ s(latitude) + as.factor (year)

For the Portuguese dogfish GAM the explained Deviance was 65.0% (R-sq.(adj) = 0.531) while for leafscale dogfish the deviance explained was 53.9% (R-sq.(adj) = 0.472).

The smoothed variables duration, depth and latitude were all significant in the Portuguese dogfish model (Figures 3.6). However, duration had not a significant effect in the Leafscale gulper shark model (Figures 3.7).

For the two species, standardization was done to a fixed duration of 60 minutes but to a depth of 1000 m and 57°N latitude 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 3.8–3.9.

Abundance estimates show no 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).

3.9.2 Analyses of AZTI survey

The main objective of PALPROF was to estimate and assess the inter-annual variation of the abundance and biomass indices of the deep-water sharks and other ichthyofauna. The surveyed area is located in an area 10.5 km North of the Cape Matxitxako (ICES 27.8.c east) close to a narrow canyon of about 28 km length, where the bottom depth progressively increases from 500 to 2500 m. Based on canyon valley depth profile and for a depth range from 600 m to 2400 m, 400 m depth interval strata were considered. In each survey six fishing hauls were performed. To get homogeneous and comparable data series the six hauls were repeated every year in the same position and in the same time of the year.

To minimize the mortality of deep-water sharks, a modified commercial former deep-water-sharks long-line fishing gear previously used by the commercial vessel was used in the survey. The number of hooks of the modified long-line fishing gear was reduced to 300. Five small sensors DST centi and DST CTD (www.star-oddi.com) were used to continuously (every 5 s) monitor depth, temperature and salinity. The sensors were placed in the main line of fishing gear and they are functionally recording at depths down to 2500 m (Figure 3.12).

Data on status of the hook were recorded during the hauling and the recovering of the long line. The categories considered were: i) **E** - Hook with bait ; ii) **C** - Hook with bait partially eaten; iii) **R** - Broken-Tangled hook; iv) **V** - Empty hook (no catch, no bait); v) **P** - Hook with catch and vi) **N.O.** - Hook status not Observed/recorded during recovering of the line.

On board, all fish specimens caught were sorted and species identified to the lowest taxonomic level possible. Also, each specimen was measured (cm), sexed and the condition (dead or alive) recorded. Individual body weight was estimated based on species length/weight relationships. The effective fishing effort performed in each stratum (EFFORTst) corresponded to the number of hooks able to fish during the haul, i.e. P + E + C divided by the total of hooks and multiplied by the soaking time (minutes):

EFFORTst: ((P + E + C) / total hooks) x soak time (minutes)

For each *stratum* the CPUE of species **i** was calculated as the ratio of catch of i^{th} species (kg) and EFFORTst.

Sharks and chimaeras were less frequently caught in the floating sections of the fishing gear than at the bottom sections (Figure 3.12). On the contrary, teleosts were more frequently caught at the floating section. The highest CPUE values were recorded for *Centroscymnus coelolepis*, specially in 2016 and in 2018. *Deania calcea* and *Centrophorus squamosus* presented CPUE values close to

20 kg hook^{-1} min^{-1} in (Figure 3.13). In the first survey, the most abundant species were *C. coelolepis* (31), *Etmopterus princeps* (21) and *D. calcea*. The latter species was mainly captured in the first two depth strata while both *C. coelolepis* and *E. princeps* were mainly caught at the three deepest strata. *Centrophorus squamosus*, *Deania hystricosa*, *Hexanchus griseus*, and *Scymnodon ringens*, only appeared once at the shallowest stratum. Species richness (19 different species) at the bottom section of the fishing gear was higher than at the "floating" section.

3.9.3 Analyses of on-board Portuguese data

IPMA analysed the onboard data collected under Data Collection Framework (PNAB/DCF) for the deep-water sharks *Centroscymnus coelolepis*, *Centrophorus squamosus* and *Deania calcea* (Figueiredo and Moura, 2019WD). The analysis covered a period from 2009 to 2018 during which data on deep-water sharks was collected by observers onboard vessels belonging to the deep-water longline fishery targeting the black scabbardfish (LLD-DWS *métier*).

The sampling effort assigned to LLD-DWS *métier* was settled following the Neyman criterion. According to this, the optimum number of trips to be performed per vessel at Sesimbra landing port was estimated as 3 trips per month (margin of error of 1 with 95% probability). Several factors have been constraining the reach of this target and the sampling effort obtained thought time has been much lower.

Figure 3.14 presents, for each year, the geographic locations of the sampled fishing hauls for the whole set of on-board fishing trips. Before 2014, sampled fishing hauls were mainly located northwards while after, the fishing hauls locations were more disperse, covering a more southern area. Important to note that these spatial differences do not reflect any change on fleet dynamics but are rather related to the opportunistic feature of the LLD-DWS *métier* sampling plan.

The initial objective of this analysis was to estimate the level of by-catch of the main deep-water sharks by year and by area in addition to evaluate any potential trend during this time period, to compare with catch levels prior to 2007 (when the TAC started to restrict landings). However, the sampling effort achieved is considered insufficient to provide reliable information on the abundance or biomass trend of deep-water shark species. The spatial locations of the fishing hauls are heterogeneously dispersed along time and the vessels sampled also changed. It should be noted that given the vessel site fidelity, there is a confounding effect between the fishing vessel and the fishing grounds and with the distribution patterns of each species, difficult to disentangle. The results obtained from the onboard analysis are presents below, by species.

Portuguese dogfish. The relative occurrence of *C. coelolepis* at the sampled fishing hauls, by year, varied between 33 and 100%. The number of specimens caught varied, not only among years, but also among vessels. The highest number of specimens caught by fishing haul were consistently recorded in some places (Figure 3.15). The geographic information of the catches of *C. coelolepis* supports previous studies where it was concluded that the black scabbardfish fishery operate at locations of lower abundance of *C. coelolepis* (Veiga *et al.*, 2015 WD). This species is thought to be able to complete its life cycle in the same geographical area (although sampling data on new-borns is scarce) (Moura *et al.*, 2014) suggesting the existence of local populations.

Leafscale gulper shark. *Centrophorus squamosus* was quite frequently caught but its relative occurrence by fishing haul and by year varied between 17 and 100%. Also, the number of specimens caught per fishing haul varied not only among years but also among vessels. The data available were considered insufficient to estimate the level of by-catch and did not put in evidence any temporal trend. This fact might be associated with the spatial changes of the sampled fishing hauls along time (Figure 3.16).

3.10 Stock assessment

No new assessments were undertaken in 2019 as both fishery dependent and fishery independent data sources are considered to cover restricted areas of the stock distribution area.

3.11 Quality of the assessments

At the North-eastern Atlantic the knowledge on deep-water shark species distribution and on their stock structure are highly deficient. WGEF recognizes that the abundance and biomass index estimates are highly variable and uncertain. Furthermore, the data derived from discards sampling is not adequate to estimate the quantities caught (ICES, 2018). Therefore, a major scientific investment is required to gain a full understanding of the spatial and temporal population dynamics of deep-water sharks to enable estimates of sustainable exploitation levels. Several strategies to be adopted to monitor species abundance and evaluate fishing impact on their populations by the different deep-water fisheries have been discussed in previous meetings and included the: i) increase of close monitoring of deep water shark populations; ii) development of specific studies to assess the distribution patterns of species and estimate the spatial overlap with fisheries; iii) evaluation of the effect on the by catch of deep water sharks of modifications in deep water fishing operations (Figueiredo and Moura, 2016 WD)

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 the Scottish survey 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.

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 by species will remain uncertain. In addition, discards are known to occur, but have not been fully quantified, and survival is expected to be very low.

3.11.1 Historical assessments

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.

3.12 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.

3.13 Conservation considerations

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

3.14 Management considerations

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

Based on 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 started after the fishery being established, and only covers 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.

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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		560
1989	12	0	0	8	0	0	507	0	0	0		527
1990	8	0	140	6	0	6	475	0	0	0		635
1991	10	0	75	1013	265	70	1075	0	1	0		2509
1992	140	1	123	2013	1171	62	1114	0	2	0		4626
1993	63	1	97	2781	1232	25	946	0	7	0		5152
1994	98	0	198	2872	2087	36	1155	0	9	0		6455
1995	78	0	272	2824	1800	45	1354	0	139	0		6512
1996	298	0	391	3639	1168	336	1189	0	147	0		7168
1997	227	0	328	4135	1637	503	1311	0	32	9		8182
1998	81	5	552	4133	1038	605	1220	0	56	15		7705
1999	55	0	469	3471	895	531	972	0	91	0		6484
2000	1	1	410	3455	892	361	1049	0	890	0		7059
2001	3	0	475	4459	2685	634	1130	0	719	0		10105
2002	10	0	215	3086	1487	669	1198	0	1416	12		8093
2003	16	0	300	3855	3926	746	1180	0	849	4		10876
2004	5	0	229	2754	3477	674	1125	0	767	0		9031

Table 3.2. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (subareas 4–14). Working Group estimate of landings of Portuguese dogfish (t) by ICES area. FAO34, FAO area 34, UA, unknown area. 0 = landings <0.5 t.

	27.2	27.4	27.5	27.6	27.7	27.8	27.9	27.10	27.12	FAO34	UA	TOTAL
2005	0	2	149	414	391	5	509	0	8	1	316	1793
2006	0	1	138	233	177	39	472		0		25	1085
2007	0	2	133	186	14	2	136			0		472
2008		0	121	145	7	1	74			0		347
2009		0	27	47	3		33					110
2010		0	31	24	2	0	1			0		59
2011			1		1		1					2
2012			4				0					4
2013			2				0			0		3
2014			5							0		6
2015		0				0	0					1
2016					0	0						0
2017							3					3
2018						0	2					2

Table 3.3. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (subareas 4–14). Working Group estimate of landings of leafscale gulper shark (t) by ICES area. FAO34, FAO area 34; UA, unknown area. 0 = landings <0.5 t.

	27.2	27.4	27.5	27.6	27.7	27.8	27.9	27.10	27.12	FAO34	UA	TOTAL
2005	0	0	32	189	249	154	457	0	1	3	626	1712
2006		0	47	158	93	39	508		0	2	48	896
2007	0	0	44	26	9	0	231			0		310
2008		0	41	38	0	1	87			7		174
2009		0	50	83	4	0	26			13		176
2010		0	58	59	12	0	4			5		139
2011					3		1			3		6
2012					1		1			5		8
2013							0			4		4
2014			32		0		0			3		35
2015		1	9			0	0					10
2016							0					0
2017							7					7
2018							2					2

Table 3.4. 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 6–7)			Iberian Waters (divisions 8.c–9.a))		
	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 3.5. 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 3.6. 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 3.7. 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.

Year	Portuguese Dogfish			Leafscale gulper shark		
	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 3.8. 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

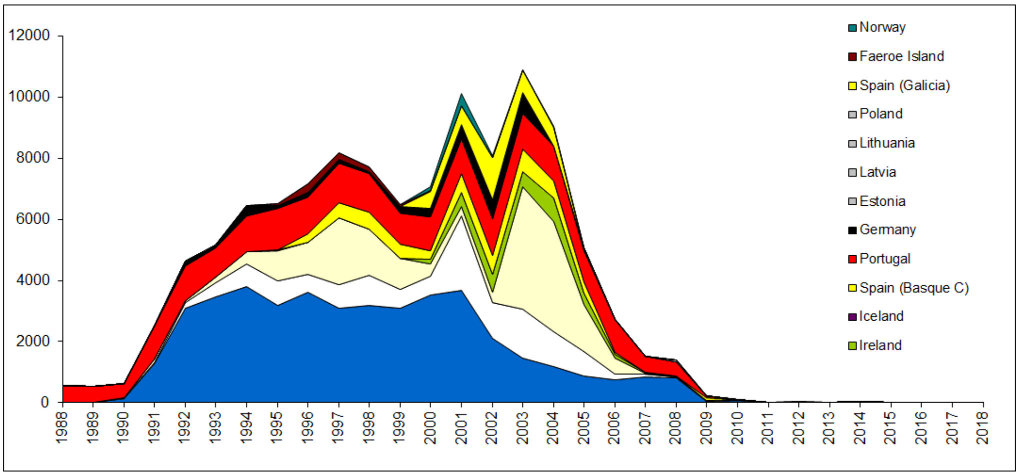

Figure 3.1. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (subareas 4–14). Working Group estimates of combined landings of the two species, by country.

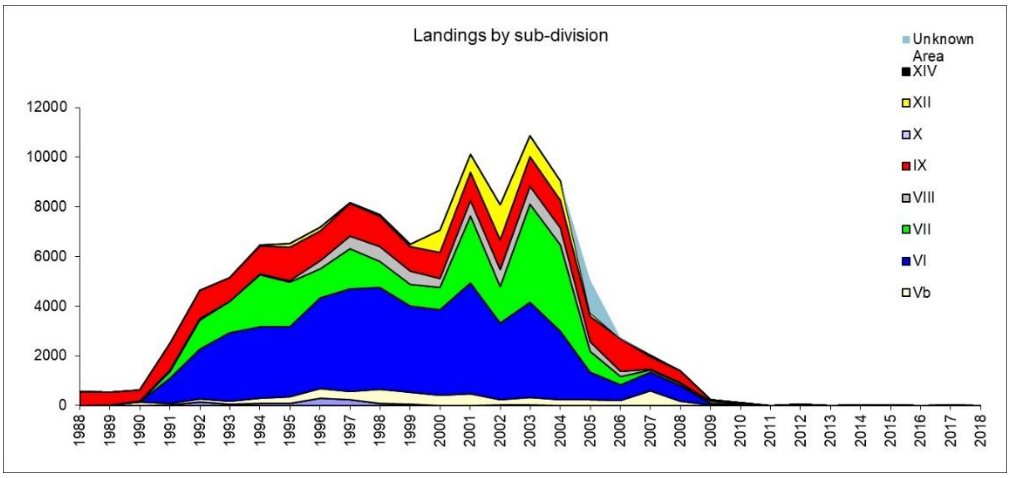

Figure 3.2. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (subareas 4–14). Working Group estimates of combined landings of the two species, by ICES Subarea.

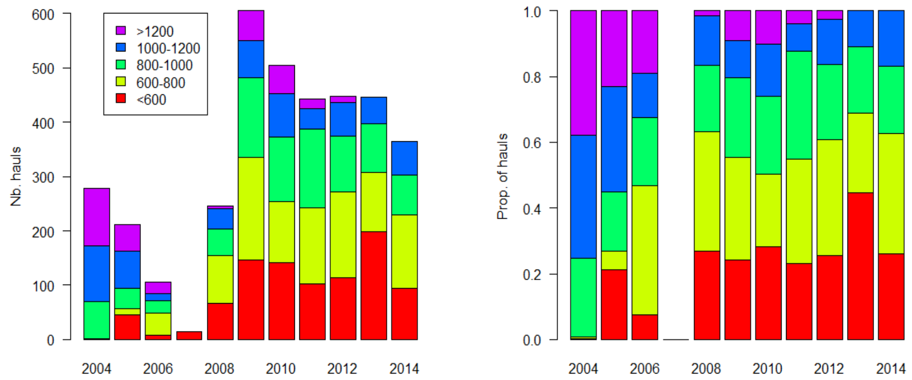

Figure 3.3. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (subareas 4–14). Depth distribution of on-board observation of French deep-water fisheries 2004–2014, number of hauls per 200 m depth range (left) and proportions (right), proportions in 2007 where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

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.

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.

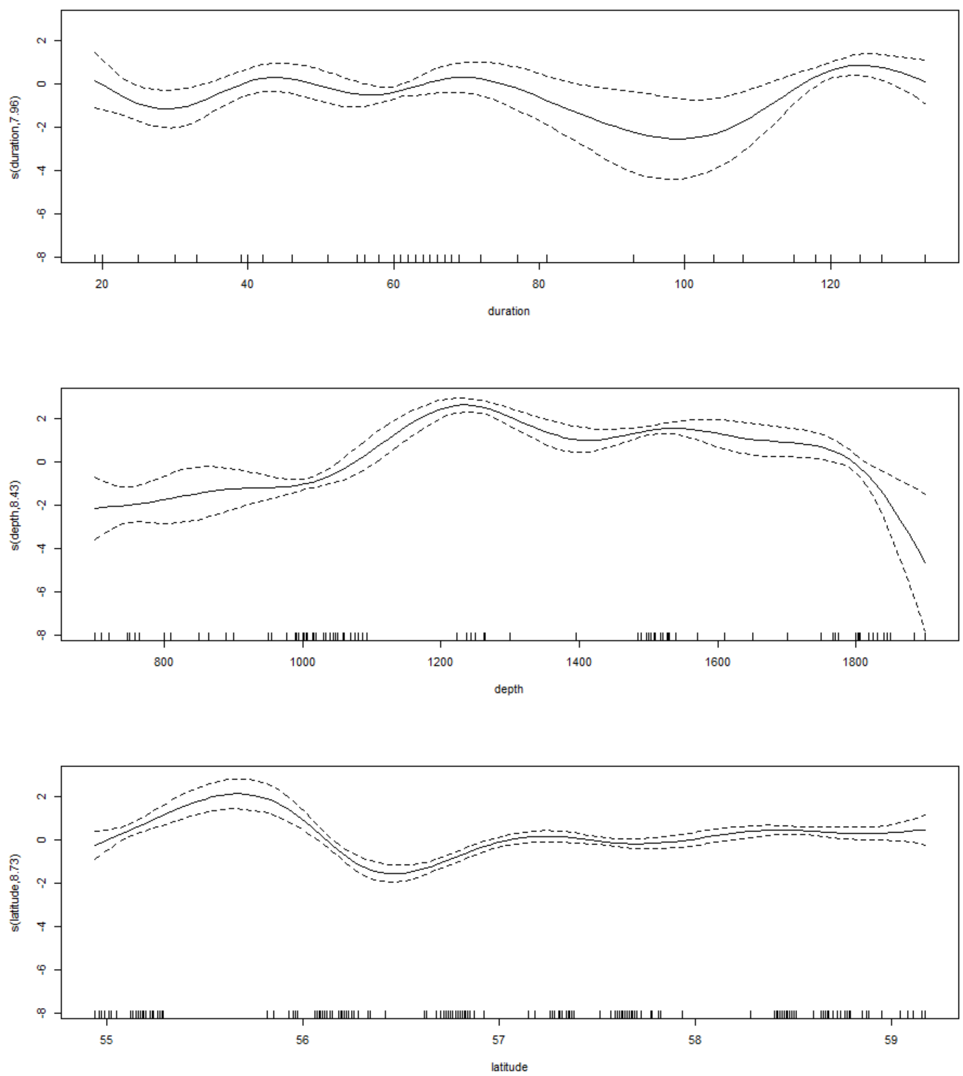

Figure 3.6. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (subareas 4–14). Model fits for smoothed terms in GAM analysis of Portuguese dogfish in Scottish deep-water surveys 2000 to 2017.

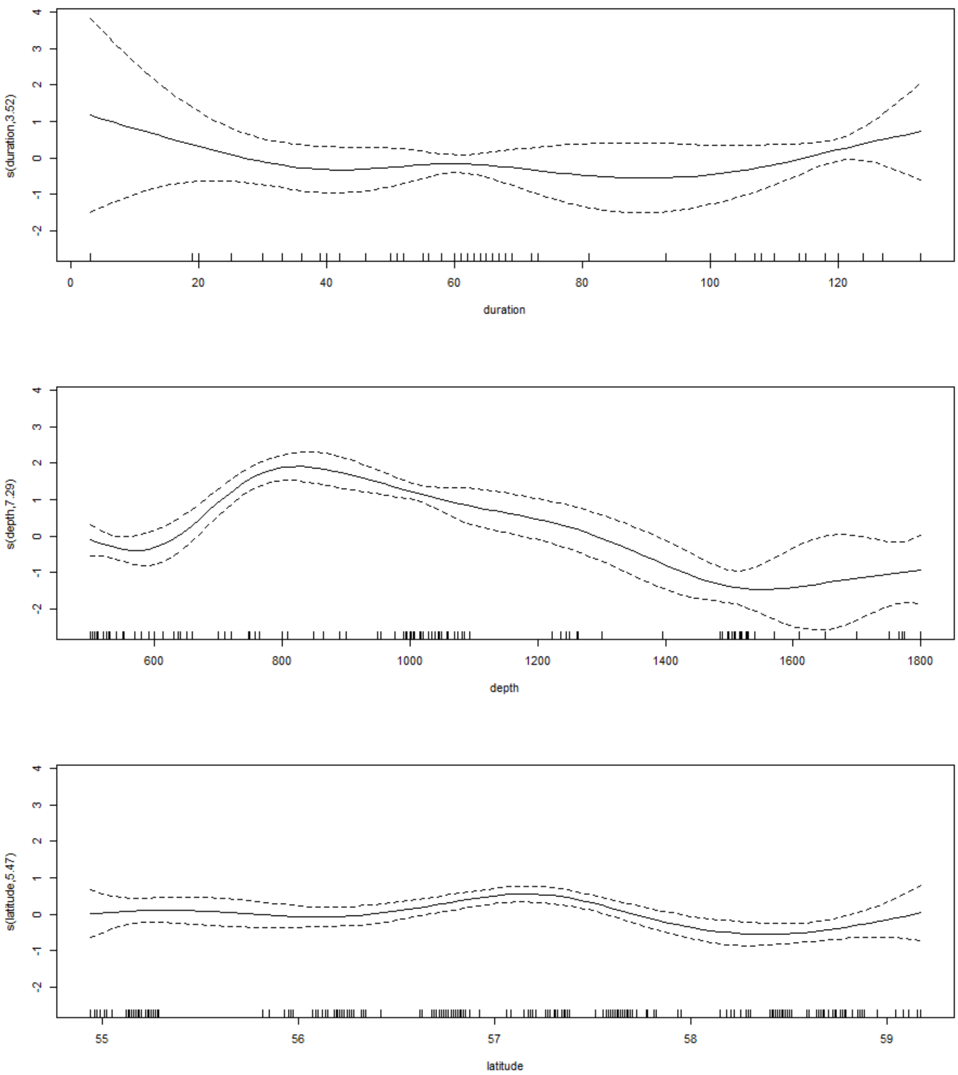

Figure 3.7. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (subareas 4–14). Model fits for smoothed terms in GAM analysis of leafscale gulper shark in Scottish deep-water surveys 2000 to 2017.

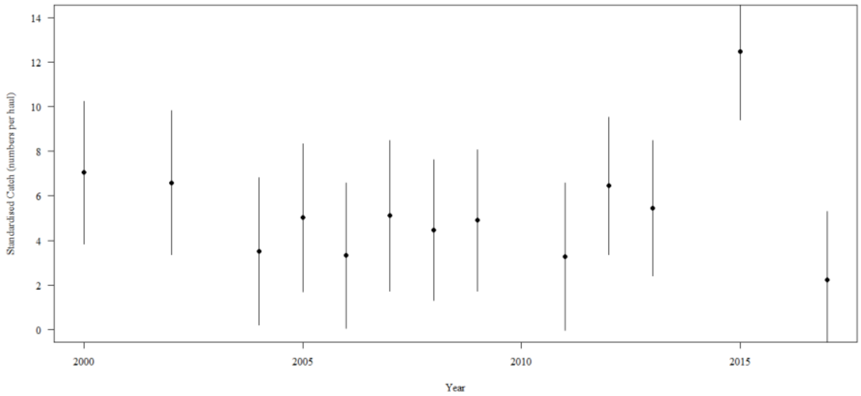

Figure 3.10. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (subareas 4–14). Standardized abundance index for Portuguese dogfish in Scottish deep-water surveys 2000 to 2017.

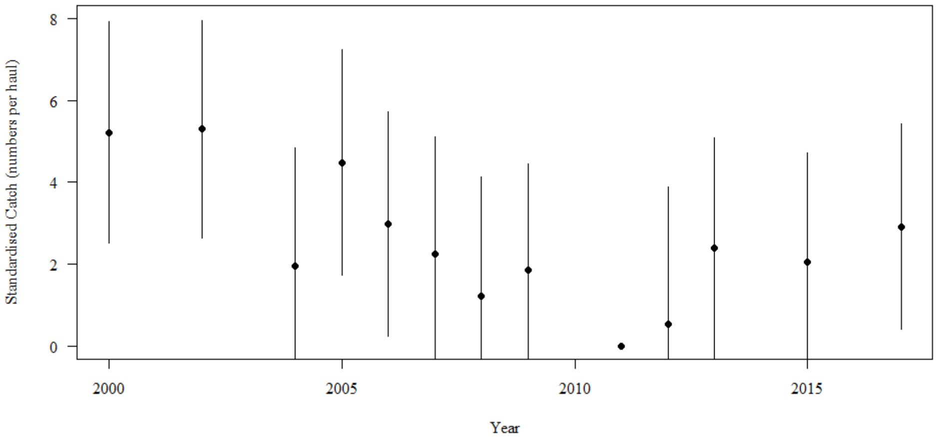

Figure 3.11. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (subareas 4–14). Standardized abundance index for leafscale gulper shark in Scottish deep-water surveys 2000 to 2017.

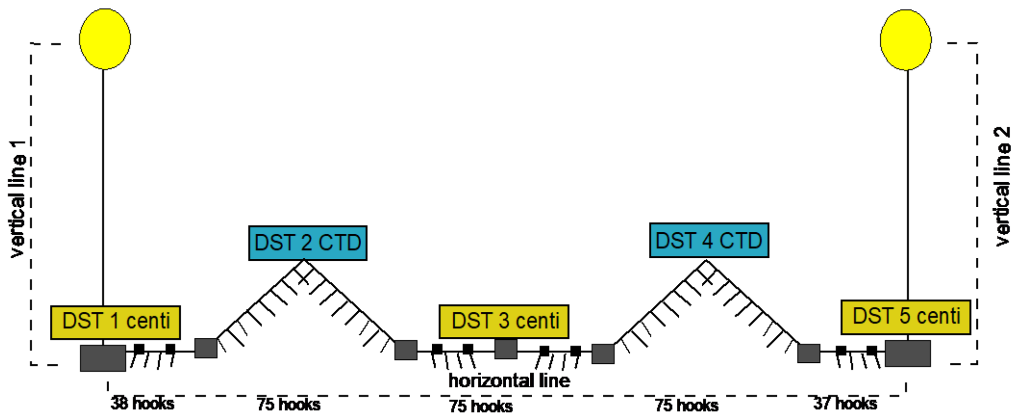

Figure 3.12 Deep-water sharks - Scheme of the final design of long-line fishing gear used in the PALPROF survey.

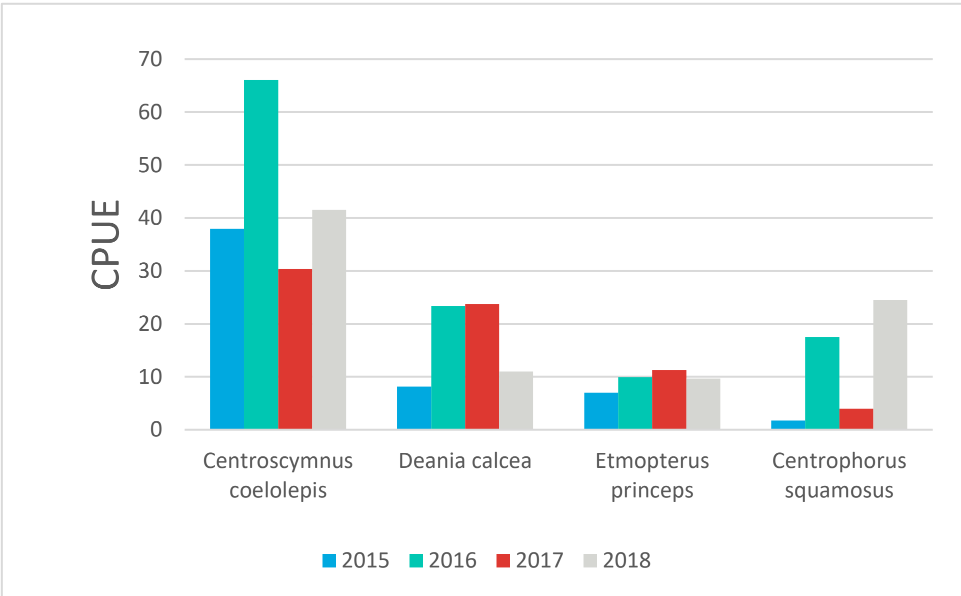

Figure 3.13 Deep-water sharks – CPUE (kghook^{-1}min^{-1}) estimates of the each main deep-water shark species caught by year on PALPROF survey.

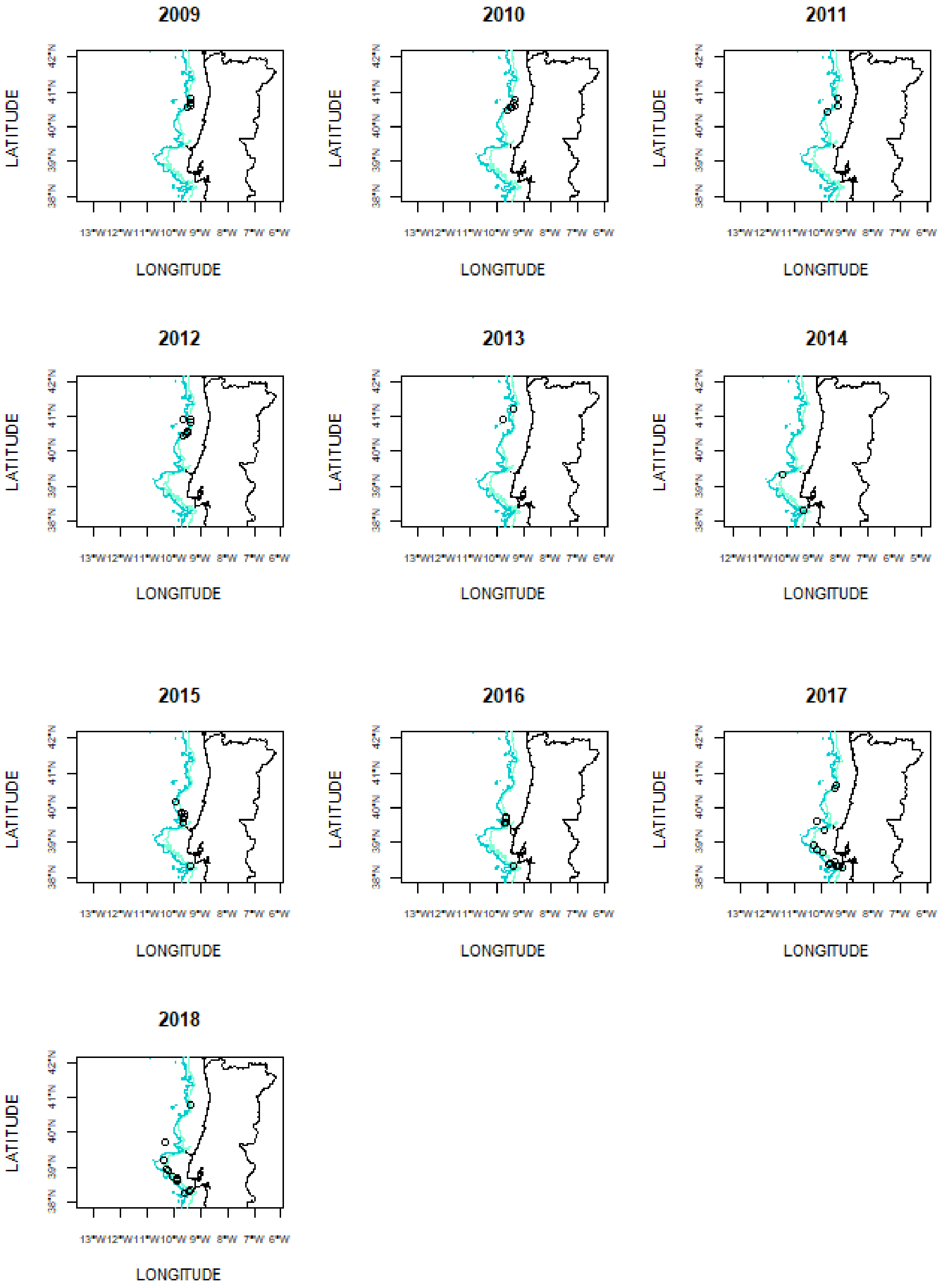

Figure 3.14 Deep-water sharks – Geographic locations of the LLS-DWS métier fishing hauls annually sampled by IPMA from 2009 to 2018.

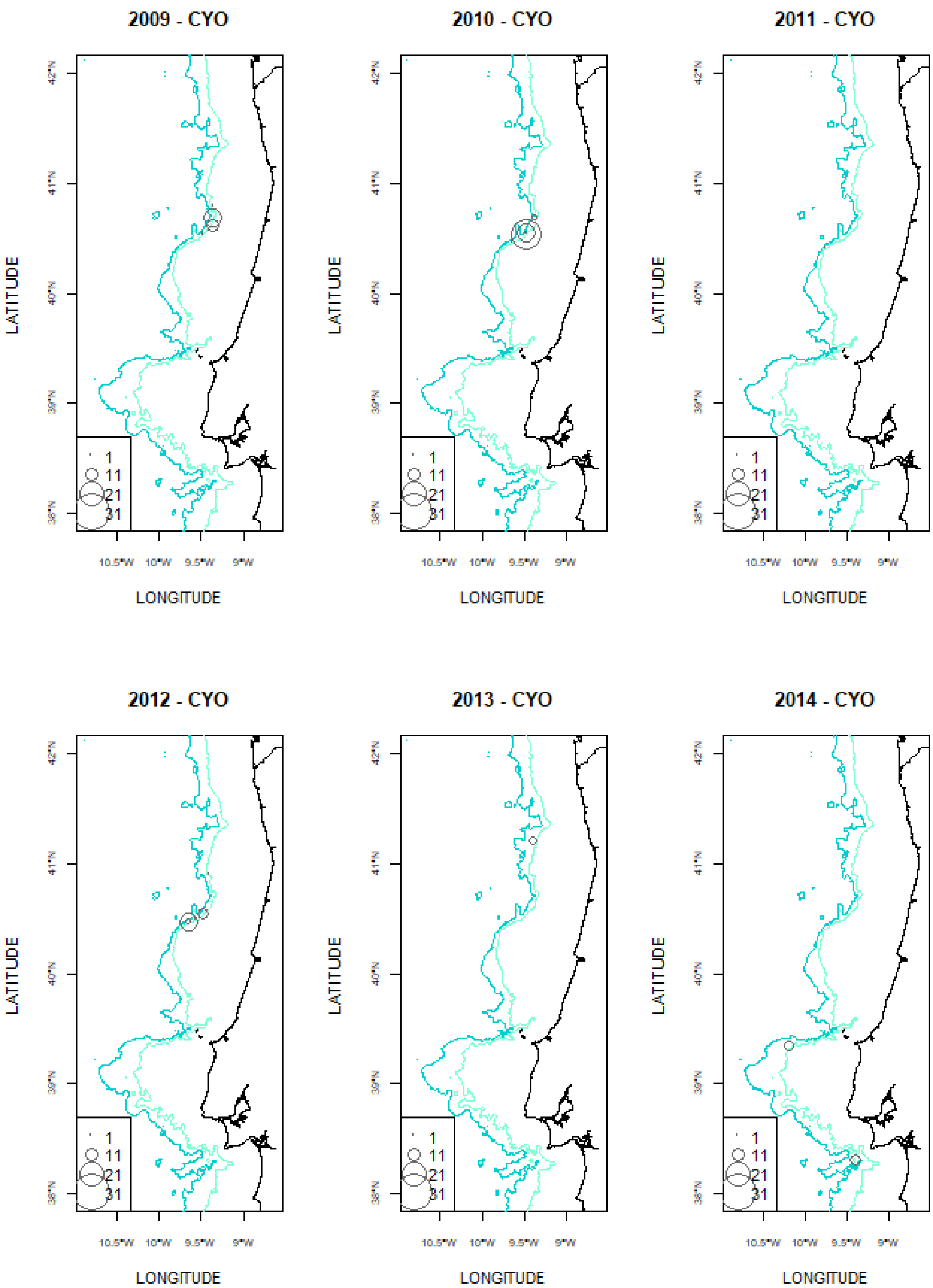

Figure 3.15 Deep-water sharks – Geographic location and number of specimens of *C. coelolepis* caught per fishing haul for the period 2009 to 2018.

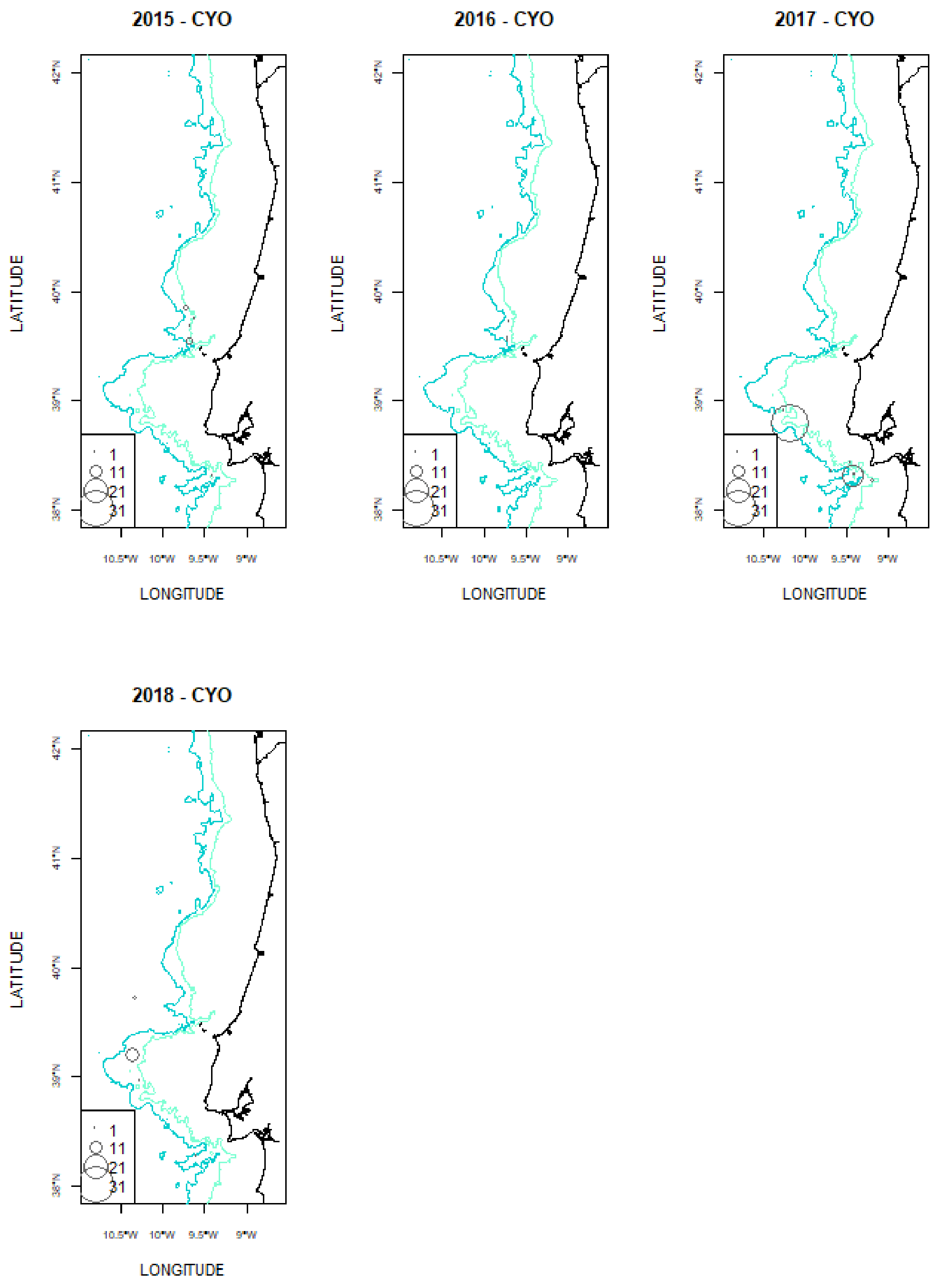

Figure 3.15 *continued* Deep-water sharks – Geographic location and number of specimens of *C. coelolepis* caught per fishing haul for the period 2009 to 2018.

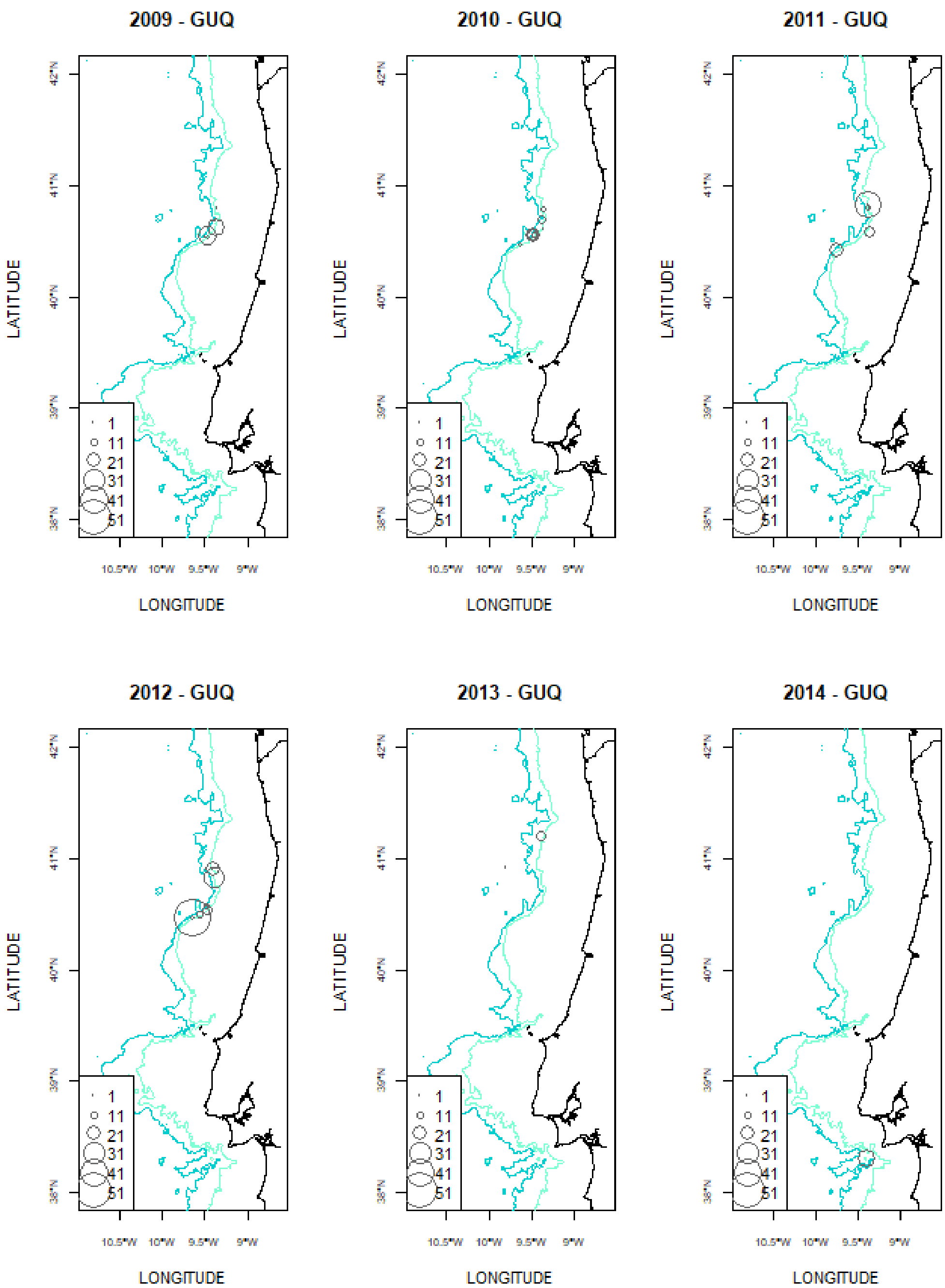

Figure 3.16 Deep-water sharks – Geographic location and number of specimens of *C. squamosus* caught per fishing haul for the period 2009 to 2018.

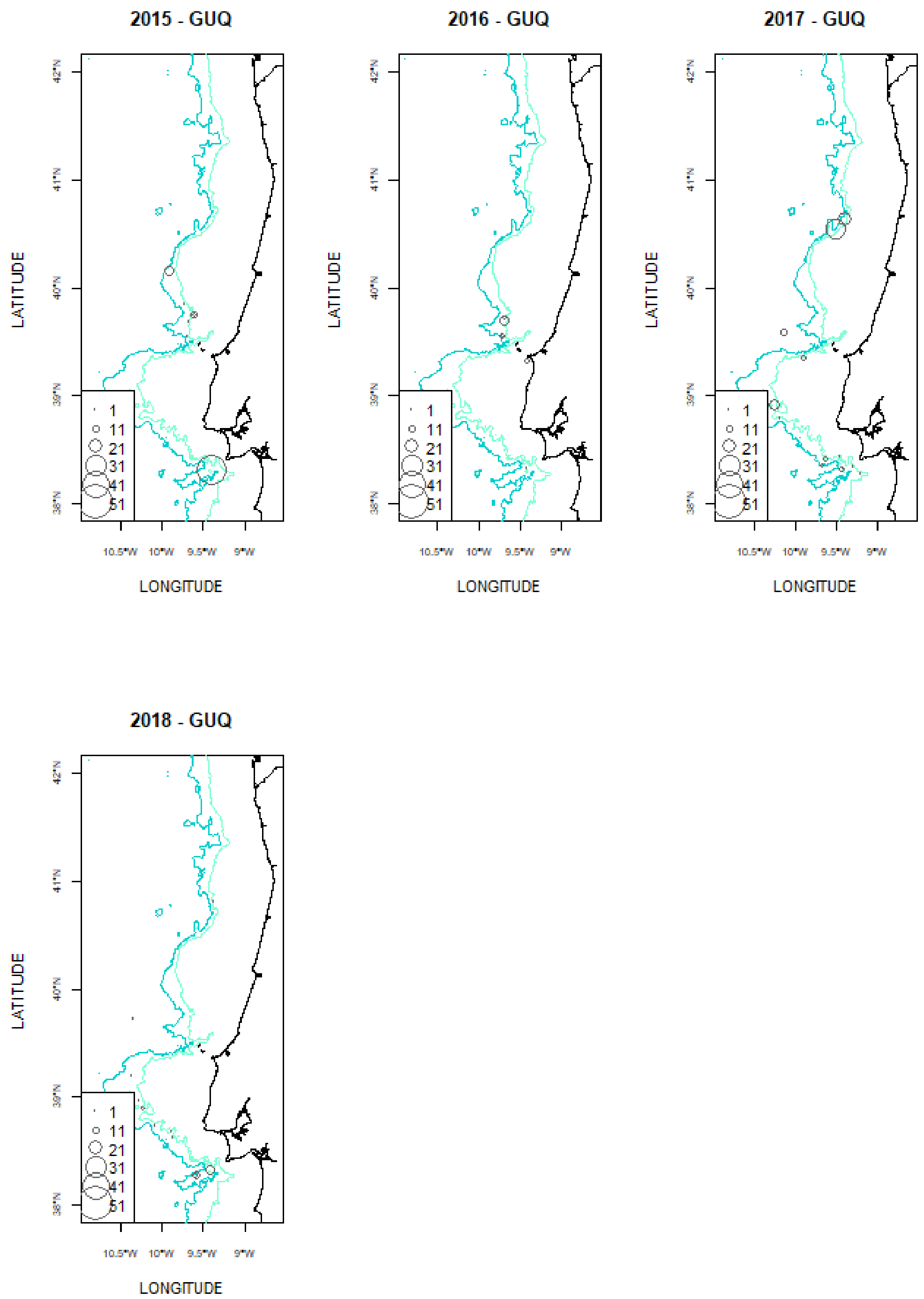

Figure 3.16 *continued* Deep-water sharks – Geographic location and number of specimens of *C. squamosus* caught per fishing haul for the period 2009 to 2018.

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 tonnes in 1981, fluctuating considerably thereafter, at least in part due to market fluctuations. Landings peaked at 937 tonnes in 1984 and 896 tonnes 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 in 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 long-line 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 1 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.

4.9 Stock assessment

The ICES framework for category 6 was applied (ICES, 2012). For stocks without information on abundance or exploitation, ICES considers that a precautionary reduction of catches should be implemented unless there is ancillary information clearly indicating that the current level of exploitation is appropriate for the stock.

Landings have declined after the early 1990s, which is considered to be partly due to market conditions. In line with the zero TAC, landings have been negligible since 2010 and there are no new data to assess the status of the stock. In its most recent advice for 2016–2019, ICES advises that there should be no fisheries for this stock unless there is evidence that the fisheries will be sustainable. There is no information to support this, therefore, ICES advises that when the precautionary approach is applied, fishing mortality should be minimized and no targeted fisheries should be permitted.

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

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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	2018	Total
Germany	7j	6														6
	7k	15														15
France	27						1									1
	5b		1													1
	7b						0									0
	7e											0			0	0
	7g						0									0
	8a		0			0					0		0		0	1
	8b	1	1	1	1	0	0	1	0	0	0		0	0	0	6
	8c		0	0				0								0
UK	5b															0
	6a	19	25	2												46
	6b															0
	7b	0		0												1
	7c	11	0													12
	7h															0
	7j	26	4	1												31
	7k	32		1												33
	8c		1													1
	8d		0	0												0
	8e		1													1
	9b		4													4
Ireland	7b	0	0													0
	7c	5	5													10
	7j	0	1													1
	7k	2	2													5
	10	0														0
Portugal	9a	3	6	3	1	1	0	0	0	0	0		0	0	0	15
	10a	14	10	7	10	6	2	1					0	0	0	49
Total		**137**	**63**	**15**	**12**	**8**	**4**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	241

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

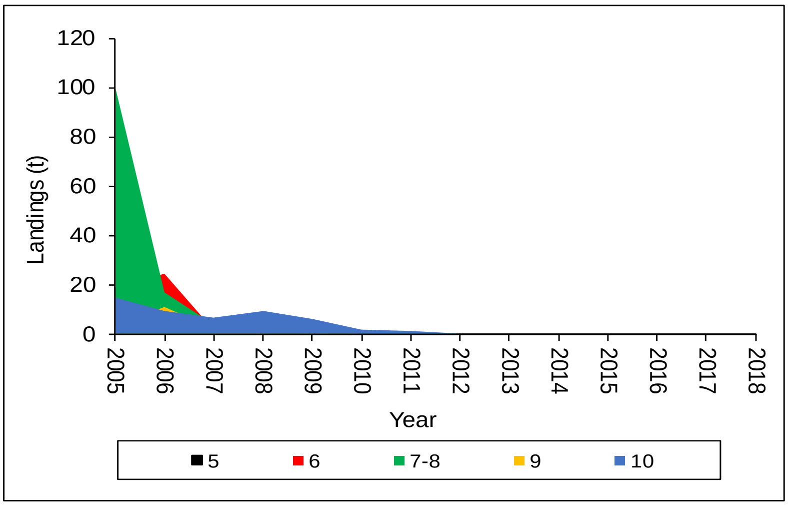

Figure 4.1. Kitefin shark in the Northeast Atlantic. Total landings of kitefin shark by ICES division. Management information is given on the graph.

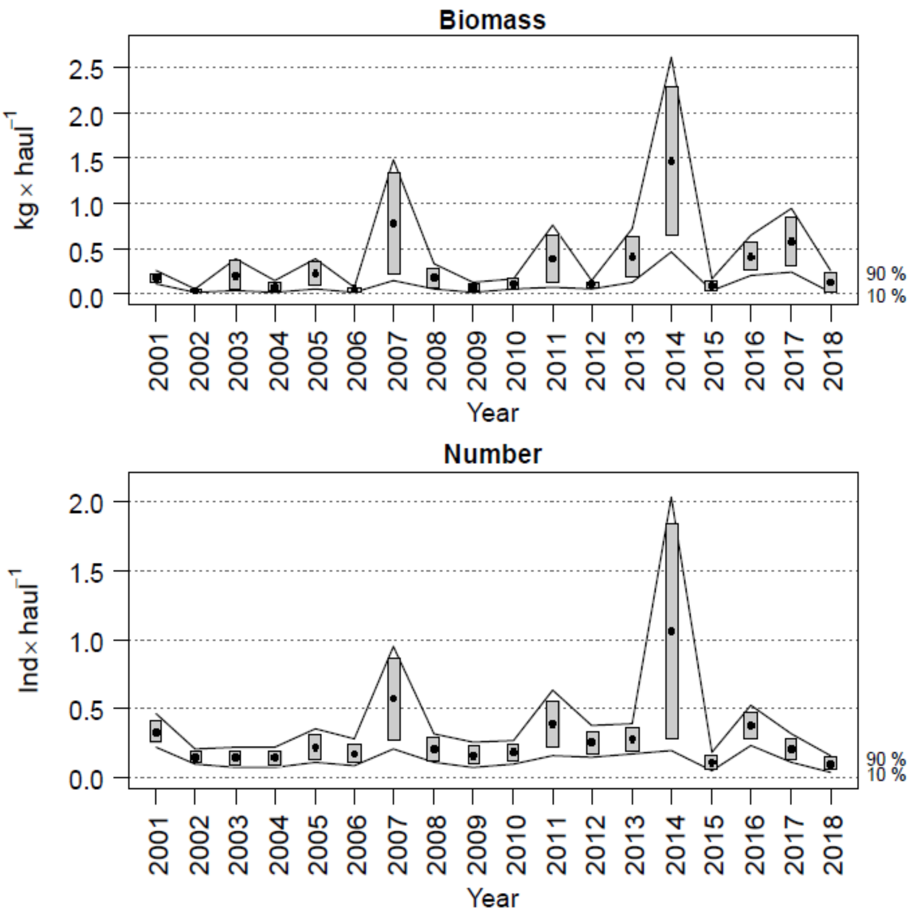

Figure 4.2. Kitefin shark in the Northeast Atlantic. Relative abundance of kitefin shark, in weight (kg/haul) and number from the Spanish groundfish survey on the Porcupine bank. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). Source: Ruiz-Pico *et al.* (2019 WD).

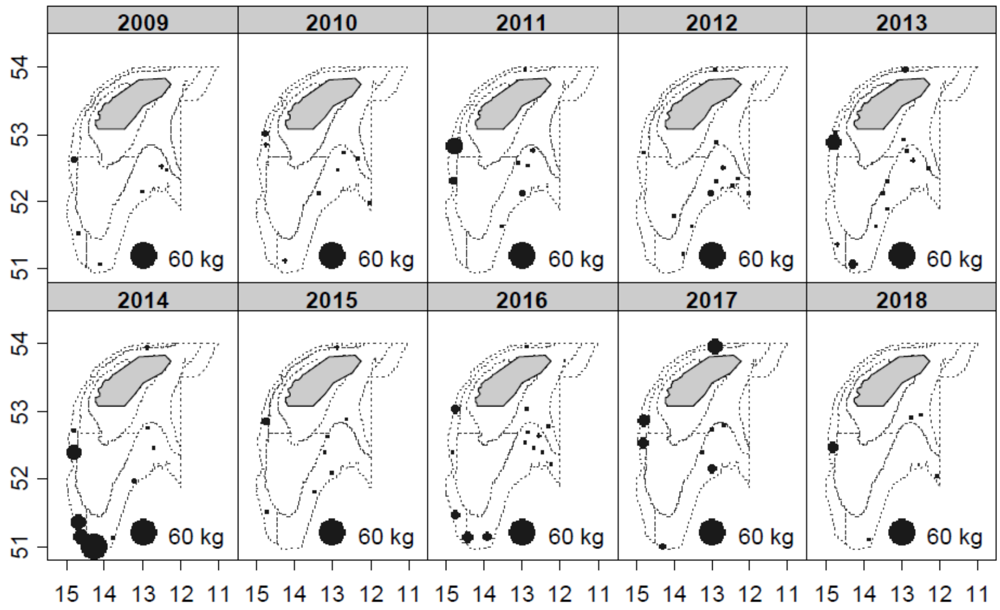

Figure 4.3. Kitefin shark in the Northeast Atlantic. Annual (2009–2018) spatial distribution of kitefin shark (kg/haul) on the Porcupine bank survey. Source: Ruiz-Pico *et al.* (2019 WD).

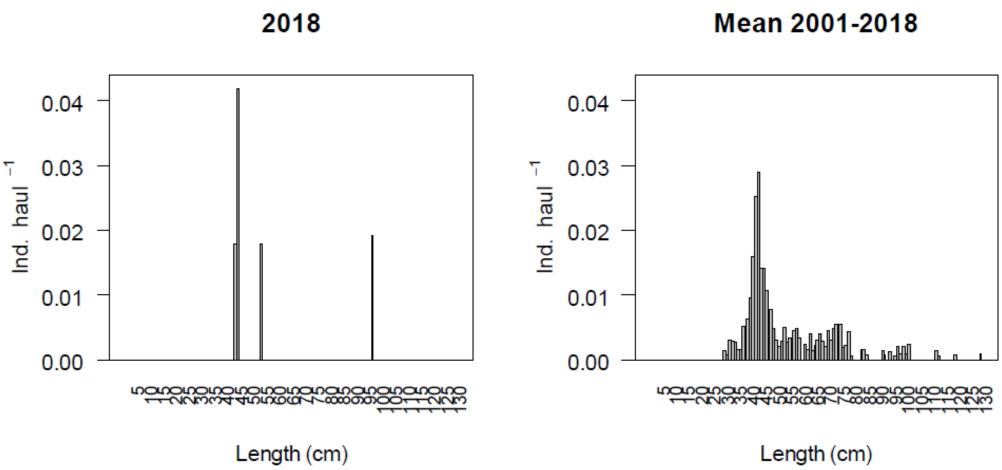

Figure 4.4. Kitefin shark in the Northeast Atlantic. Annual length composition of kitefin shark from the Spanish groundfish survey on the Porcupine Bank. Ruiz-Pico *et al.* (2019 WD).

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 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. Historical catches of knifetooth dogfish *Scymnodon ringens*, arrowhead dogfish *Deania profundorum*, bluntnose sixgill shark *Hexanchus griseus*, mouse catshark *Galeus murinus* velvet belly lanternshark *Etmopterus spinax* and 'aiguillat noir' (which may include *C. fabricii, C. crepidater* and *Etmopterus* spp.) are also presented in the stock annex. 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.*

Fifteen 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 section. The 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 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 species of other deep-water shark and skate species are taken as by-catch in mixed trawl, longline and gillnet fisheries together with Portuguese dogfish, leafscale gulper shark and deep-water teleosts.

5.2.2 The fishery in 2018

Deep-water elasmobranch species were taken as bycatch in mixed fisheries.

Since 2010, EU TACs for deep-water sharks have been set at zero (see Section 5.2.4) and consequently, reported landings of most of the species covered in this chapter in 2018 were very low or zero. As a consequence of this Regulation, it is likely that discarding has increased.

As a consequence of the Council Regulation (EU) 2016/2285, which fixed a restrictive by-catch of 10 tonnes of deep-sea sharks in directed artisanal deep-sea longline fisheries for black scabbardfish, some landings attributed to Portuguese waters are reported for 2017 and 2018.

5.2.3 ICES advice applicable

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

5.2.4 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 below.

Year	ICES subareas		
	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)	0
2018	10 (4)	10 (4)	0
2019	7 (4)	7 (4)	0
2020	7 (4)	7 (4)	0

(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.

Since 2013, 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 2013, under NEAFC Recommendation 7, it was required that Contracting Parties 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 2005, the use of trawls and gillnets in waters deeper than 200 m in the Azores, Madeira and Canary Island areas was banned (Council Regulation (EC) No 1568/2005). In 2007, 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 was banned while a maximum bycatch of deep-water shark of 5% in hake and monkfish gillnet catches was allowed (Council Regulation (EC) No 41/2007). 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 NEAFC waters by 1 February 2006.

Since 2009, the "rasco (gillnet)" fishing gear was banned at depths lower than the 600 m isobath (EC Regulation 43/2009,). 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.

A by-catch TAC for deep-water sharks was allowed for each of the years from 2017 to 2020, on a trial basis, in the directed artisanal deep-sea longline fisheries for black scabbardfish (Council regulation (EU) 2016/2285; Council regulation (EU) 2018/2025). According to this limited landing of unavoidable by-catches of deep-sea sharks were allowed and Member States should develop regional management measures for the black scabbardfish fishery and establish specific data-collection measures for deep-sea sharks to ensure their close monitoring. 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 in accordance with ICES indications according to which in the artisanal deep-sea longline fisheries for black scabbardfish, the restrictive catch limits lead to misreporting of unavoidable by-catches of deep-sea sharks, which are currently discarded dead.

The Council regulation (EU) 2016/2285 affects specifically the Portuguese deep-water longline fishery targeting black scabbardfish in ICES Division 9.a and Subarea 10. As a response Portugal has proposed an action plan focusing the black scabbardfish fishery and this plan is coordinated by the Portuguese General Directorate of Fisheries. Among other objectives, under this plan different management strategies were expected to be evaluated.

5.3 Catch data

5.3.1 Landings

Landings estimates from 2005 onwards were revised following WKSHARK2 (updated in WGEF 2018). Information, by species, is presented below. Past information is presented in the stock annex. Due to the management measures in force for deep-water sharks their landings, in 2018, continued to be low (tables 5.1–5.8).

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

WGEF landings estimates of gulper sharks are presented in tables 5.1 and 5.7.

In 2017 and 2018, under the 10 tonnes TAC, 2 tonnes and 4 tonnes were landed, respectively, by the Portuguese deep-water longline fleet.

Birdbeak dogfish *Deania calcea*

WGEF landings estimates of birdbeak dogfish are presented in tables 5.2, and 5.7.

Five European countries reported landings of birdbeak dogfish: Norway, Ireland, UK, Spain and Portugal. In 2017 and 2018, under the 10 tonnes EU TAC, 2 tonnes and 1 tonne were landed, respectively, by the Portuguese deep-water longline fleet.

Longnose velvet dogfish *Centroscymnus crepidater*

WGEF landings estimates of longnose velvet dogfish are presented in tables 5.3 and 5.7.

In 2017 and 2018, under the 10 tonnes TAC, 1 tonne was landed each year by the Portuguese deep-water longline fleet.

Black dogfish *Centroscyllium fabricii*

Reported landings of black dogfish are presented in tables 5.4 and 5.7.

No landings were reported in 2018.

Lanternsharks *Etmopterus* spp.

Reported landings of velvet belly lanternshark *Etmopterus spinax* are presented in Table 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 tables 5.6 and 5.7. 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 tonnes 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.

Other species

There are landings information for other deep-water shark species, presented in Table 5.7. Other reported landings are sporadic and very low and thus were not presented.

5.3.2 Discards

Historical discards from Portugal (Azores and mainland) and Spain are available in the stock annex.

Ireland: Discard data from Ireland is available since 2009 from the trawl fleet operating in ICES divisions 27.6.a and 27.7.bgj (Table 5.8). Discards are considered negligible as values estimated are <1 tonne in most of the years.

Denmark: Discard data from *E. spinax* is available from 2009 to 2017 (Table 5.8). This species is mostly discarded by the trawl fleet from areas 27.3.a, 27.4.a and 27.4.b. Discards varied among years but has remained around 5-6 tonnes in 2016 and 2017.

5.3.3 Quality of the catch data

Data provided to WGEF since 2017 followed WKSHARK2 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".

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 2017 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 ICES (2017). In 2018, elasmobranchs constituted ~8% of that total fish caught. Results for 2018 are presented in Ruiz-Pico *et al*. (2019a WD). The most abundant deep-water shark species in biomass in these surveys are *D. calcea* (birdbeak dogfish), *S. ringens* (Knifetooth dogfish), *E. spinax* (velvet belly lantern shark), *D. licha* (Kitefin shark), and *H. griseus* (bluntnose six-gill shark).

5.6.3 ICES divisions 8.c and 9.a

The Spanish survey in the Cantabrian Sea and Galician waters (SpGFS-WIBTS-Q4) 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 ICES (2017). In 2018, elasmobranchs represented 8% of the total fish caught Ruiz-Pico *et al*. (2019b WD). 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 elasmobranchs with highest catches are *E. spinax* and *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 and Silva (2017, WD). *Deania spp*. were the most representative (abundant) species in the survey. *Centroscymnus 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 and Silva, 2017 WD).

5.7 Life-history information

See Stock annex for further details.

5.8 Exploratory assessments analyses of relative abundance indices

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

Information previously submitted to WGEF for the black dogfish *C. fabricii*, the longnose velvet dogfish *C. crepidater*, the greater lantern shark *E. princeps*, the small-eye catshark *A. microps*, the pale catshark *A. aphyodes* and other deep-water skates and rays are presented in the stock annex.

5.8.1 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. The biomass and abundance of *Deania* spp. (mainly *D. calcea*) have followed a downward trend since 2016 but remain close to the average values of the time series (Figure 5.1). The biomass and abundance of *D. profundorum* were negligible (Ruiz-Pico *et al*., 2019a WD).

In the SpGFS-WIBTS-Q4, 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 not caught by the survey in the two last years. The biomass of *D. profundorum* remained similar to the previous years (Figure 5.2) (Ruiz-Pico *et al*., 2019b WD).

Knifetooth dogfish *Scymnodon ringens*

In the Spanish Porcupine survey (SpPGFS-WIBTS-Q4) the biomass and abundance of *S. ringens* increased in 2018 (Figure 5.3) (Ruiz-Pico *et al*., 2019a WD). Since 2004, that the values fluctuated with no evident trend.

Biomass values of this species in the SpGFS-WIBTS-Q4 survey in the Cantabrian Sea and Galician waters are very low. This species is mostly caught in the additional deeper hauls. In these, biomass have fluctuated since 2004 with no evident trend (Figure 5.4) (Ruiz-Pico *et al*., 2019b WD).

Velvet belly lanternshark *Etmopterus spinax*

Both the biomass and abundance indexes of *E. spinax* in the Spanish Porcupine survey (SpPGFS-WIBTS-Q4) presented, in 2017 and 2018, values lower than those observed in 2016. The values have been following an up and down trend throughout the time series, without any trend (Figure 5.5; Ruiz-Pico *et al*., 2019a WD).

In the SpGFS-WIBTS-Q4 survey in the Cantabrian Sea and Galician waters, the biomass index shows an increasing trend from 1996 to 2017, decreasing in 2018 (Figure 5.6). A high fraction of the biomass of this elasmobranch is usually found in hauls deeper than 500 m (Ruiz-Pico *et al*., 2019b WD).

Bluntnose six-gill shark *Hexanchus griseus*

Stratified biomass and abundance indices of *H. griseus* in the Spanish Porcupine survey (SpPGFS-WIBTS-Q4) decreased in 2017 and again in 2018. However, the overall series present no trend, being more or less stable along the years (Figure 5.6) (Ruiz-Pico *et al*., 2019a WD).

In the SpGFS-WIBTS-Q4 survey in the Cantabrian Sea and Galician waters the biomass of *H. griseus* reach the highest value of the time series in 2018 (Figure 5.7) (Ruiz-Pico *et al*., 2019b WD).

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 the 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 2019.

5.14 References

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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 WKSHARK2.

	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		+				+
2014		+				+
2015		+				+
2016		+				+
2017		2				2
2018		4				4

+ = 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 WKSHARK2.

	Ireland	Spain	UK	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
2018					1	+	1

+ = 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 WKSHARK2.

	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			33		37
2009	6			27		33
2010	40			+		40
2011						
2012						
2013						
2014				+		+
2015				+		+
2016	+			+		+
2017				1		1
2018				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 WKSHARK2.

	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					+
2018					

+ = 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	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 *Etmopterus* spp. Estimates from 2005 onwards were revised following WKSHARK2.

	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

	Danmark	Norway	France	Spain	Portugal	UK	total
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
2018		106**				4**	110

*** assigned to *Etmopterus pusillus***

*** * assigned to *Etmopterus spinax***

Table 5.7. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings by species since 2005, after revision following WKSHARK2.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gulper shark	64	100	62	56	18	7	2	1	+	+	+	+	2	4
Centroscymnus spp.	545	514	699	537	384									
Birdbeak dogfish	195	96	37	62	25	3	1	3	+	+	+	+	3	1
Longnose velvet dogfish	222	420	131	37	33	40				+	+	+	1	1
Black dogfish	17	3	6	136	101	95	1	3	1	9	2	+		
Lanternshark NEI	27	44	103	72	9	15	5	13	19	47	28	59	129	110
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	+		
Mouse catshark			+	+	3	2	5	1	4	4	2	3		
Unidentified DWS*	110	62	111	51	37	40	42	175	89	118	85	91	131	150

*** Also allocated to “Squaliformes” and “unidentified deep-water squaloid sharks and dogfishes”**

Table 5.8. Other deep-water sharks and skates from the Northeast Atlantic. Discards estimates from Ireland and Denmark. Unspec. DWS = Unspecified deep-water sharks.

Year	Ireland						Denmark
	C. fabricii	*E. princeps*	*H. griseus*	*E. spinax*	Unspec. DWS	*D. nidarosienesis*	*E. spinax*
2009		1.94				0.57	23.49
2010	6.11					1.48	146.61
2011		0.03				4.27	50.70
2012		0.07					16.34
2013						4.26	24.82
2014						1.80	3.63
2015	3.00	3.24				0.80	34.30
2016	12.06	0.68	6.03		0.34	5.40	5.54
2017	0.17		42.30				5.41
2018				5.83			

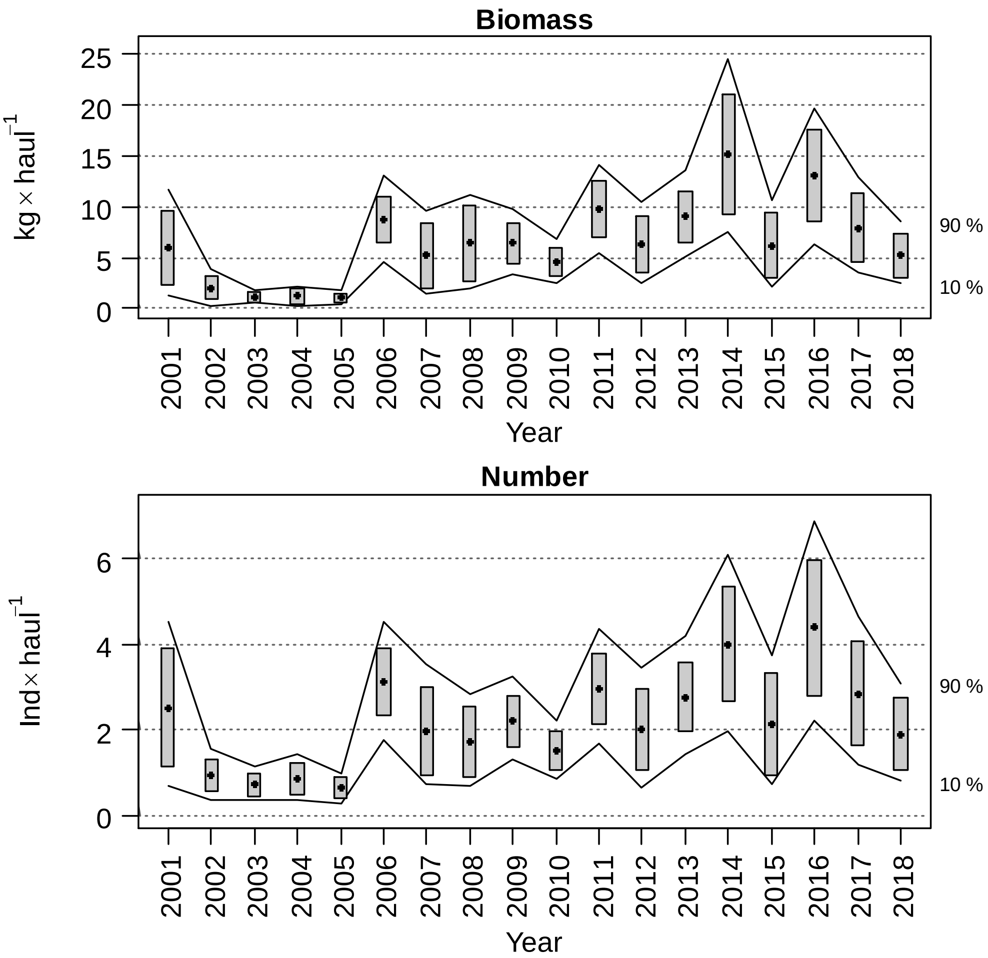

Figure 5.1. Other deep-water sharks and skates from the Northeast Atlantic. *Deania spp*. ,mainly birdbeak dogfish *Deania calcea* biomass index (kg haul^{-1}) from the Spanish Porcupine survey (SpPGFS-WIBTS-Q4) time-series (2001–2018). Boxes show parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al.* (2019a WD).

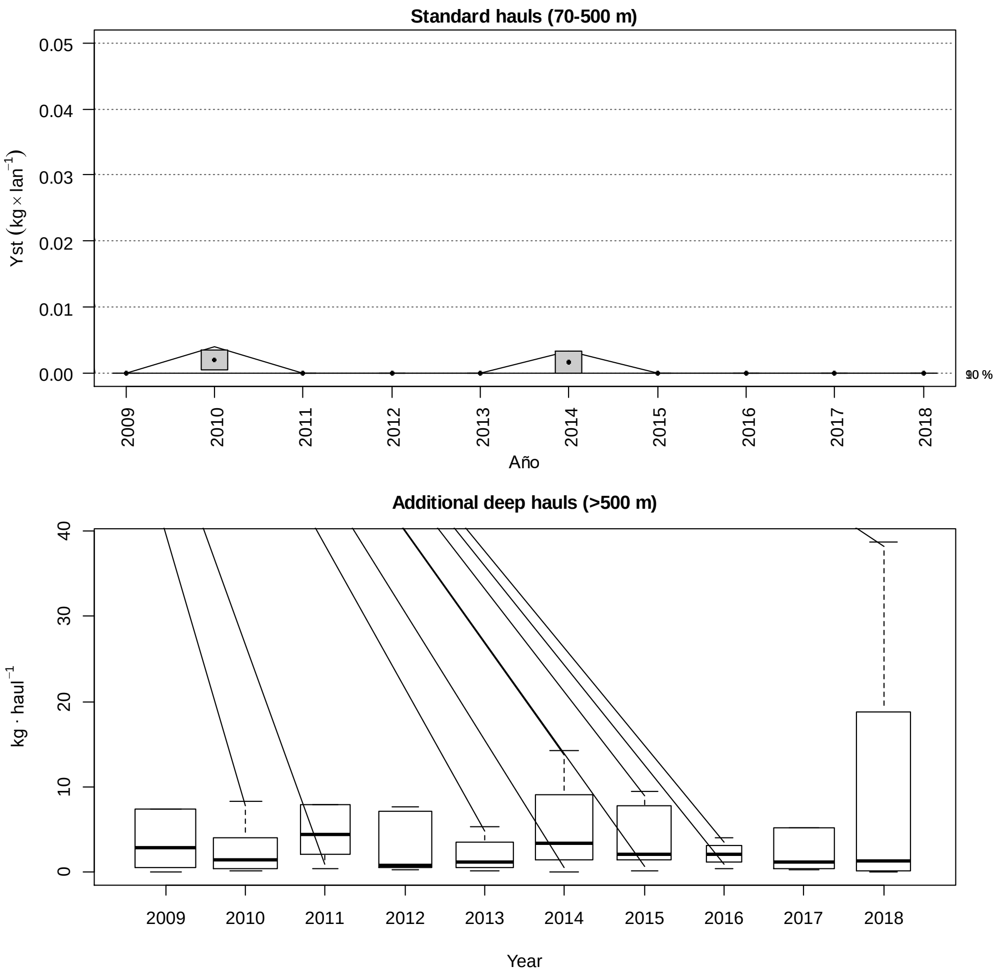

Figure 5.2. Other deep-water sharks and skates from the Northeast Atlantic. Evolution of *Deania profundorum* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series 2009–2018 (SpGFS-WIBTS-Q4). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al.* (2019b WD).

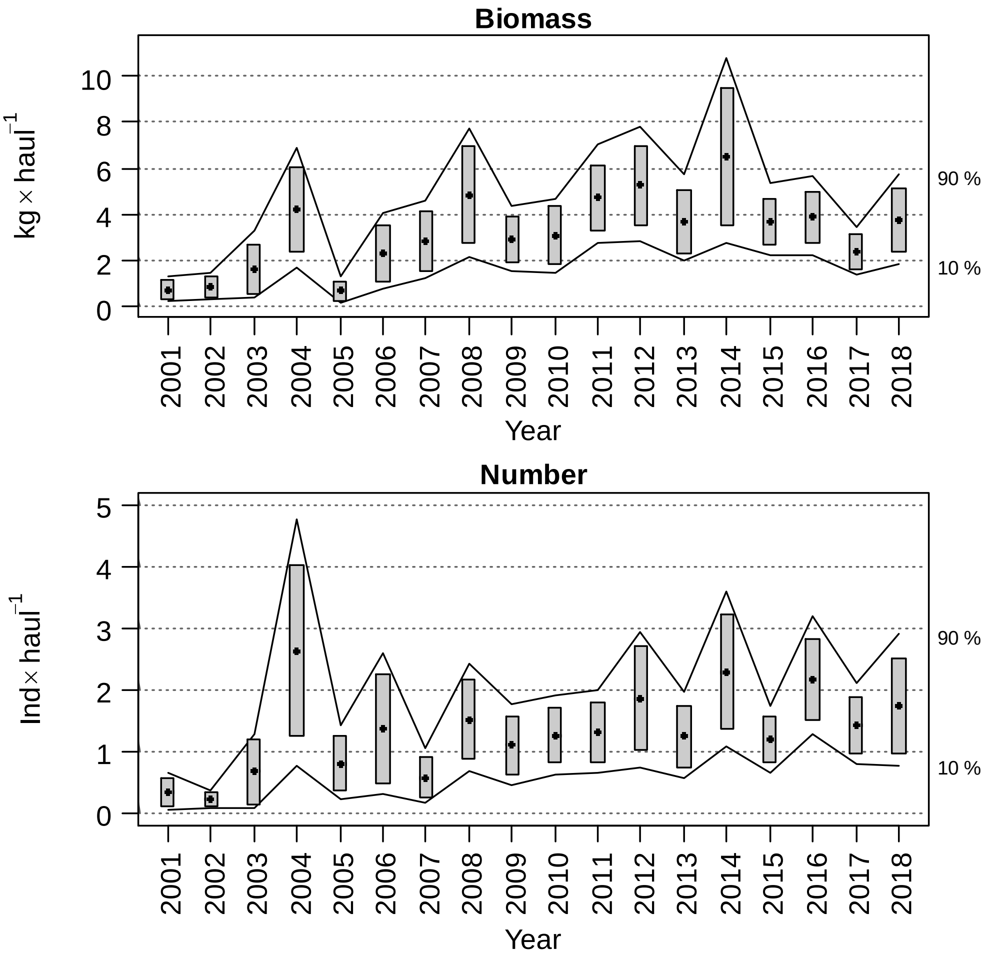

Figure 5.3. Other deep-water sharks and skates from the Northeast Atlantic. Knifetooth dogfish *Scymnodon ringens* biomass index (top, kg·haul^{-1}) and abundance index (bottom, numbers). Haul in the Spanish Porcupine survey (SpPGFS-WIBTS-Q4) time-series (2001–2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al*. (2019a WD).

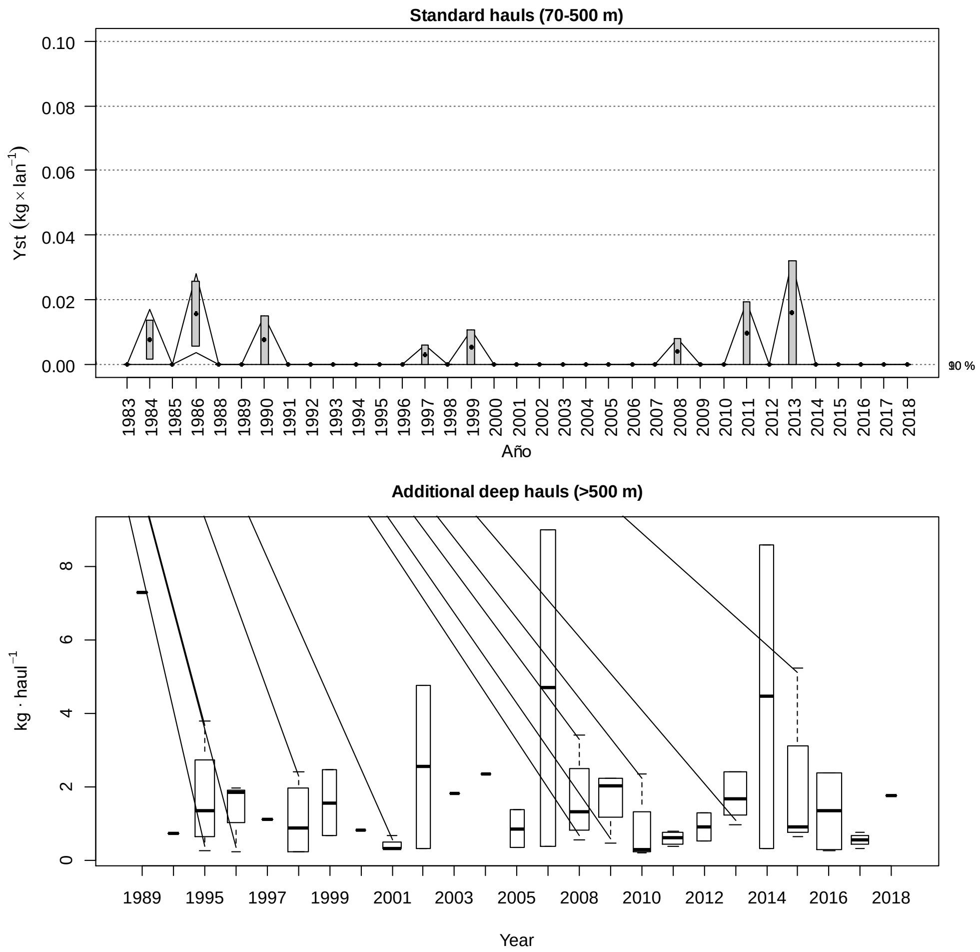

Figure 5.4. Other deep-water sharks and skates from the Northeast Atlantic. Evolution of *Scymnodon ringens* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series (SpGFS-WIBTS-Q4). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al*. (2019b WD).

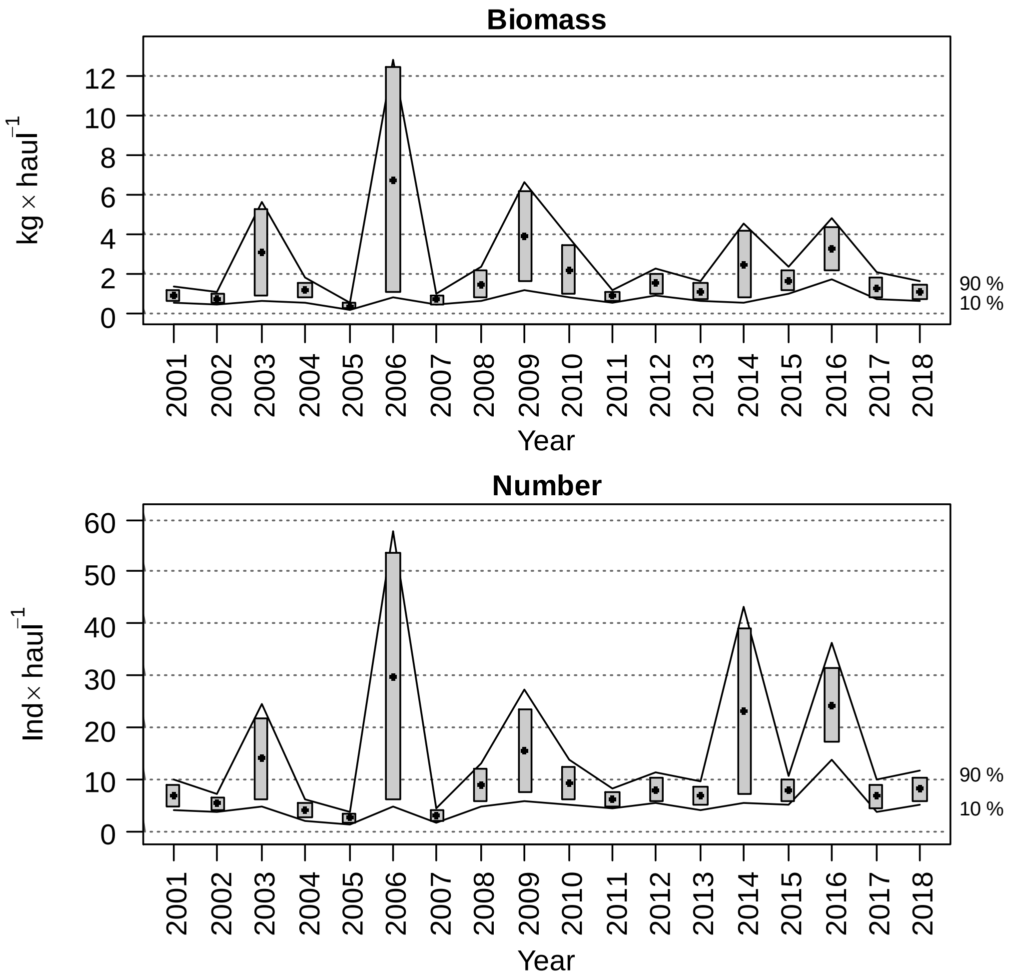

Figure 5.5. Other deep-water sharks and skates from the Northeast Atlantic. *Etmopterus spinax* biomass index (top, kg haul^{-1}) and abundance index (bottom, numbers. haul^{-1}) during Porcupine survey time-series (2001–2018) (SpPGFS-WIBTS-Q4). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al*. (2019a WD).

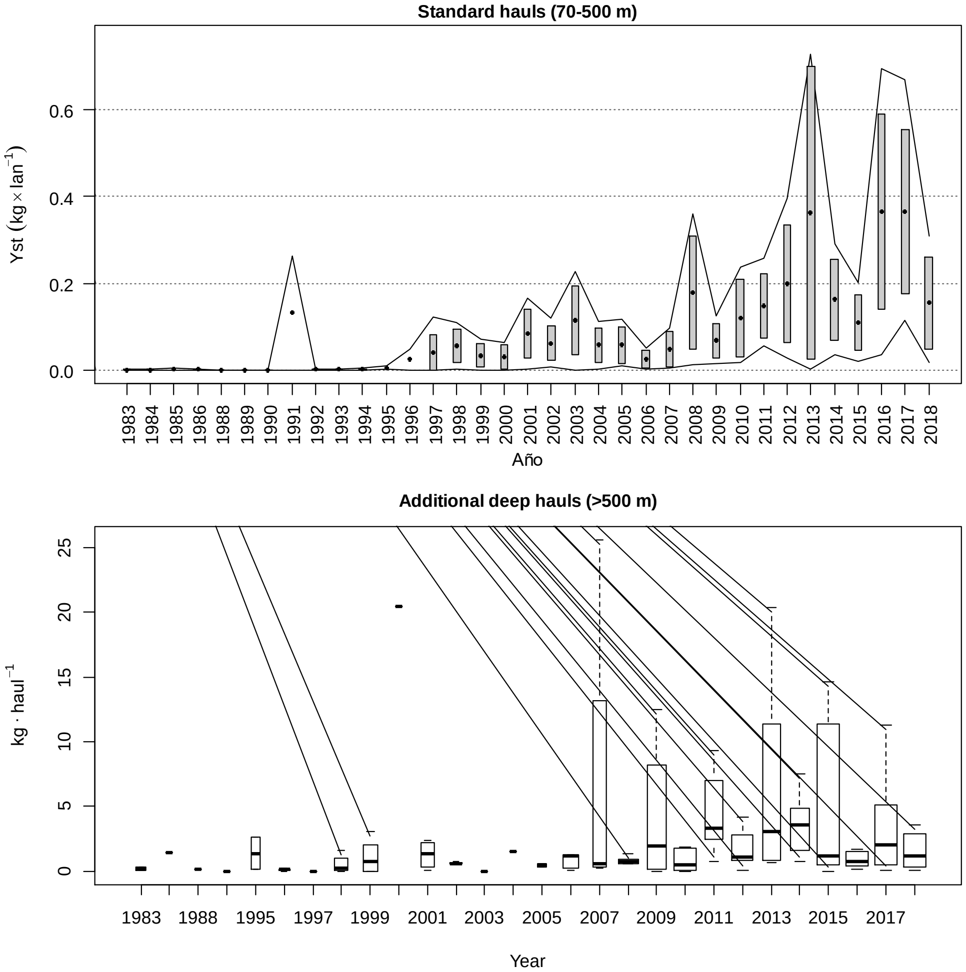

Figure 5.6. Other deep-water sharks and skates from the Northeast Atlantic. Evolution of *Etmopterus spinax* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series (SpGFS-WIBTS-Q4) covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al.* (2019b WD).

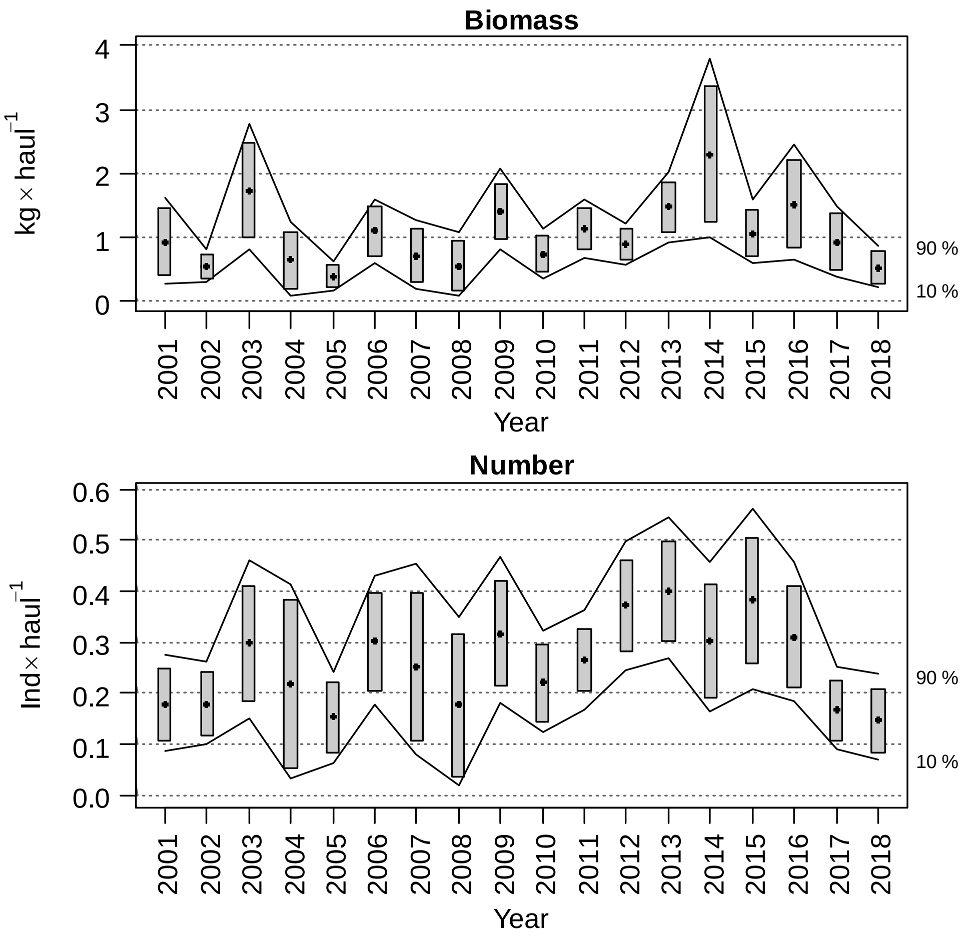

Figure 5.7. Other deep-water sharks and skates from the Northeast Atlantic. Changes in bluntnose six-gill shark *Hexanchus griseus* biomass index (kg haul^{-1}) during Porcupine survey (SpPGFS-WIBTS-Q4) time-series (2001–2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al.* (2019a WD).

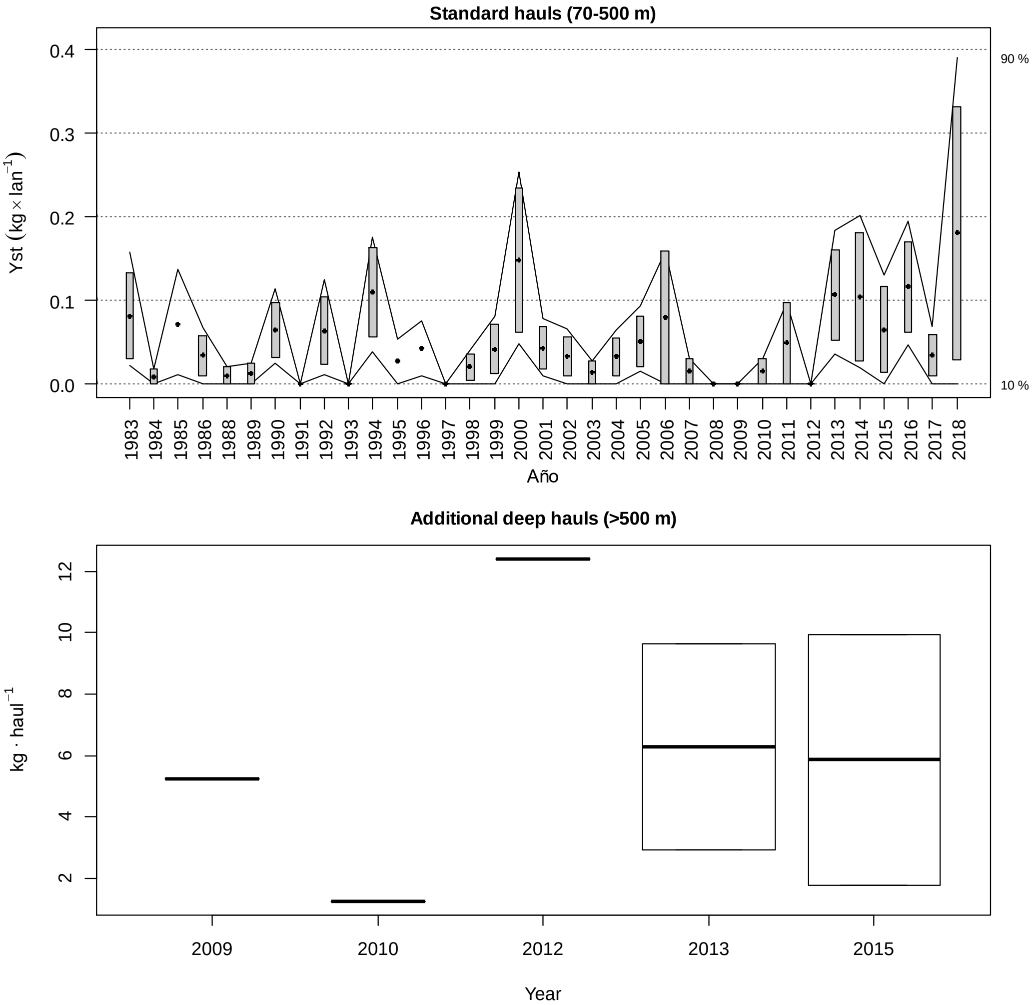

Figure 5.8. Other deep-water sharks and skates from the Northeast Atlantic. Evolution of *Hexanchus griseus* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series (SpGFS-WIBTS-Q4). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000). From Ruiz-Pico *et al.* (2019b WD).

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).

Although there is one record of one porbeagle tagged off Ireland and recaptured in American waters in November (Cameron *et al*., 2018) and genetic studies suggesting that gene flow has occurred across the North Atlantic (Pade, 2009), studies using pop-up satellite archival tags (PSATs) have shown a return migration pattern in the eastern Atlantic without crossing the western boundary of the stock at 42° W (figures 6.1a and 6.1b). Additionally, of ca. 2000 conventional tags deployed in the NW Atlantic, none of the 209 recaptures (up to 2012) showed a transatlantic migration (Campana *et al*., 2013).

Tag deployments have also provided evidence of site fidelity to spring–summer feeding areas (Biais *et al*., 2017; Camaron *et al*., 2019). This result suggests that the connectivity between components that form the porbeagle stock may become an issue for assessment of this stock.

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 2018

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 2019 WGEF estimate is 7 t in 2018 and since the zero TAC was implemented in 2010, the mean WGEF estimate is 34 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, 2018/120 and 2019/124).

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).

A discard estimate is available for France in 2018: 88 t (bottom trawls: 57 t; nets: 26 t; pelagic trawls: 5 t). This estimate suggests that discards are now of the same order of magnitude than the non-directed catches prior to porbeagle being on the fishing ban: 49 t in 2007–09 for trawls and nets. However, it should be noted that this may be an imprecise estimation as the underline data relate to few observations and specimens.

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.

Data analysis on at-sea observer programme for UK (E&W) fisheries, indicate that porbeagle encountered up to the end of 2009 were typically retained (32% discarded) and that since the introduction of the fishing ban, all observed were discarded (Silva and Ellis, 2019).

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.

This species is taken by recreational fishers in some areas, however the full extent of fish captured through this method has not been quantified.

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 and 2019 by France (Ifremer) on board a chartered longliner (Biais, 2019 WD). The longline was the same as that formerly used by commercial vessels, but shorter on average (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) westwards of France. The survey grid includes 32 stations: two by statistical rectangle of the survey area. One to three longline sets were carried out on each of them with the condition to have at least 10 days between two sets. The abundance index (average CPUE) are consistent between them: 3.6 fish/336 hooks in 2018 and 3.0 fish/336 hooks in 2019.

A comparison of these results with a commercial CPUE series was made possible by the availability of a skipper's diaries (Biais, 2019). Detailed information of these diaries allowed several selections of longline sets to get a CPUE series comparable to the survey index:

- If the vessel stays in the same statistical rectangle more than one day, the sets of the following days are not selected before 10 days;
- If two sets are made in the same statistical rectangle the same day, the second set is selected only if the distance between the two sets is larger than the distance between the two stations of the survey in this statistical rectangle;
- If the vessel moves to another statistical rectangle, the set is selected only if its distance from the preceding set is larger than the distance between the two stations of the survey in this statistical rectangle.

Survey indices are close to the mean CPUE of this commercial time series (Figure 6.9). This result and inter-annual consistency of survey indices allow thinking that the design of the survey is relevant to provides abundance indices. Furthermore, the comparison with the commercial CPUE series suggests that the porbeagle mean abundance on the shelf edge westwards of France of 2018–19 is at similar levels than the mean abundance of 2005–2009, if we are considering the recent survey area with previous commercial data. However, it should be noted that the commercial CPUE may be biased upwards because commercial sets are not deployed all over the survey area but in ICES statistical rectangles where the skipper expected the best CPUE (6–12 out of 16, depending of the year).

To show the effect of the possible bias caused by the lack of commercial CPUE for part of the survey area, the survey index was calculated using only data from the 10 statistical rectangles where the CPUE are the largest each year (corresponding to the removal of statistical rectangles with an average CPUE < 1 in 2018 and <= 1.5 in 2019). The reason to look at these data in such a way, relates to the fact that fishermen in order to make fishing activity commercially viable, would likely not operate in areas with low CPUE, even if the ICES statistical rectangles are deemed close to each other. The average survey index for the period 2018–2019 is thus 4.5, which is 30% higher than the average of the commercial CPUE for the period 2005–2009.

Because the increase in modes of the porbeagle length distribution from 2008–2009 to 2018–2019 (Figure 6.10), an increase in biomass from 2009 to 2019 is even more likely.

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 31 porbeagle during the 2018 French abundance survey. Twenty-nine of these 31 PATs popped up at more than 4 months and 12 at one year (average time at liberty is 280 days). Seven additional PATs have been deployed during the 2019 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.

Two catches of gravid females containing large embryos (60–63 and 66–76 cm T_L) were also reported in East-Scotland and around Shetland in May and June, indicating that parturition is in the summer or autumn (Gauld, 1989). They suggest that another pupping ground may be situated in this area with a later parturition than in southern waters.

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, F_{MSY}, B and F.

Figure 6.11 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 F_{MSY} 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 B_{MSY} was smaller and F_{MSY} higher when n was estimated. This resulted in estimated present biomass of 60% above B_{MSY}, compared to slightly below B_{MSY} (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 B_{MSY}. With the present F far below F_{MSY}, 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. The surveys carried out by France in 2018 and 2019 have shown that a fixed stations survey design can provide consistent annual indices. A 2000–2009 commercial series drawn up with selections to make it comparable to the survey indices (elimination of repeated sets of longlines) provides further evidence of consistency of the survey results. The comparison of 2018–19 survey indices with this 2000–2009 CPUE series and the increase in modal length of catches from 2009 to 2019 suggest that the biomass of the population that come back to the Bay of Biscay and the Celtic Sea in spring-summer has increased in recent years.

Continuing this spring-summer survey with an expansion to other areas within the stock distribution would be advantageous, as this would provide the necessary sampling effort to take the large distribution of porbeagle into account in order to monitor stock size.

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. Current fishing ban may prove difficult to obtain a more robust estimate of discards, which are considered to have increased in recent years in the Bay of Biscay as well as in northern part of the distribution area of the stock. 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 (NEA)	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		1400	1088	
1947		3300	2824	
1948		2100	1914	
1949		1700	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

Year	Estimated Spanish data	Denmark	Norway (NEA)	Scotland
1967	8	144	305	7
1968	11	111	677	7
1969	11	100	909	3
1970	10	124	269	5

Table 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															NA
TOTAL	991	1755	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

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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 (E,W, 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	2018
Denmark	<1		0
Faroe Is	5	2	0
France	<1	1	1
Germany	0	0	0
Iceland	2	1	1
Ireland	0	0	0
Netherlands	0	0	0
Norway	6	6	3
Portugal	0	0	0
Spain	0	0	2
Sweden	0	0	0
UK	0	0	0
Japan	NA	NA	NA
TOTAL	14	10	7

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).

Year	% Weight of in the catches of porbeagle:	
	< 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
Convergence	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 B_{final}/B_{MSY} and of F_{final}/F_{MSY} 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
B_{MSYs}	4946	3797	3801	3610	3203	3232	6319	6266	6080	5185
B_{MSYs}_low	111	817	690	2348	1122	862	3634	2794	3875	3477
B_{MSYs}_high	220592	17641	20930	5550	9145	12123	10989	14054	9541	7730
F_{MSYs}	0.2	0.18	0.17	0.19	0.21	0.19	0.12	0.12	0.12	0.17
F_{MSYs}_low	0.02	0.06	0.04	0.13	0.07	0.05	0.05	0.04	0.06	0.08
F_{MSYs}_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
B_{final}/BMSY	0.0004	0.4	0.4	0.4	0.5	1.6	0.86	0.82	0.91	0.32
F_{final}/F_{MSY}	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

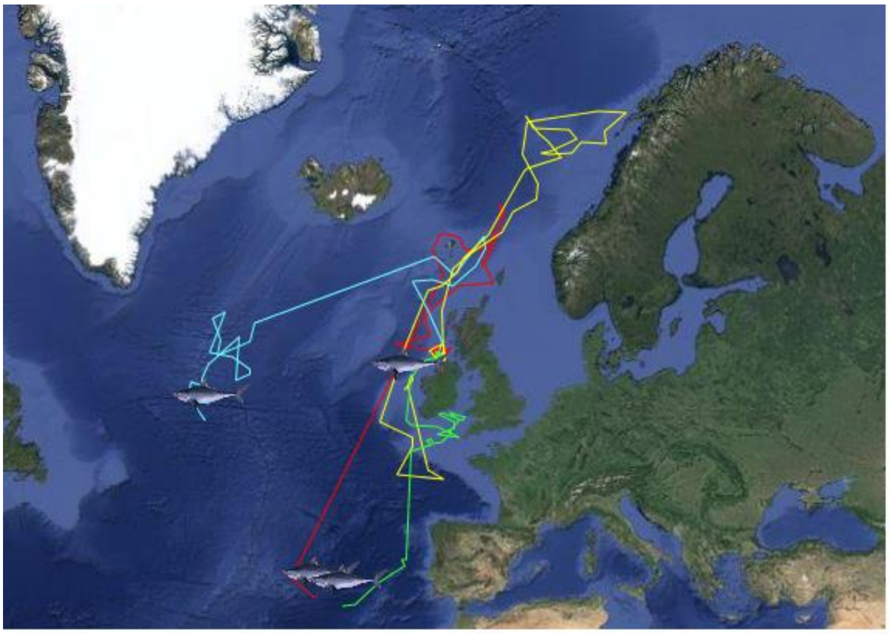

Figure 6.1a. Porbeagle in the Northeast Atlantic. Movement of porbeagle tagged in Irish porbeagle archival tagging programme.

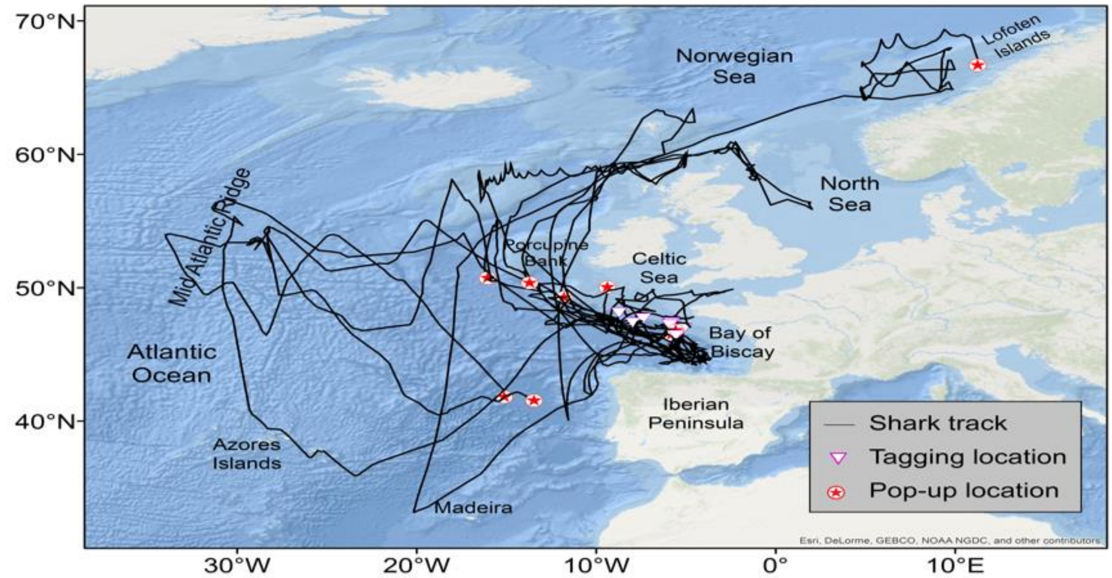

Figure 6.1b. Porbeagle in the Northeast Atlantic. Movement of porbeagle tagged in French porbeagle archival tagging programme (Biais *et al.*, 2017).

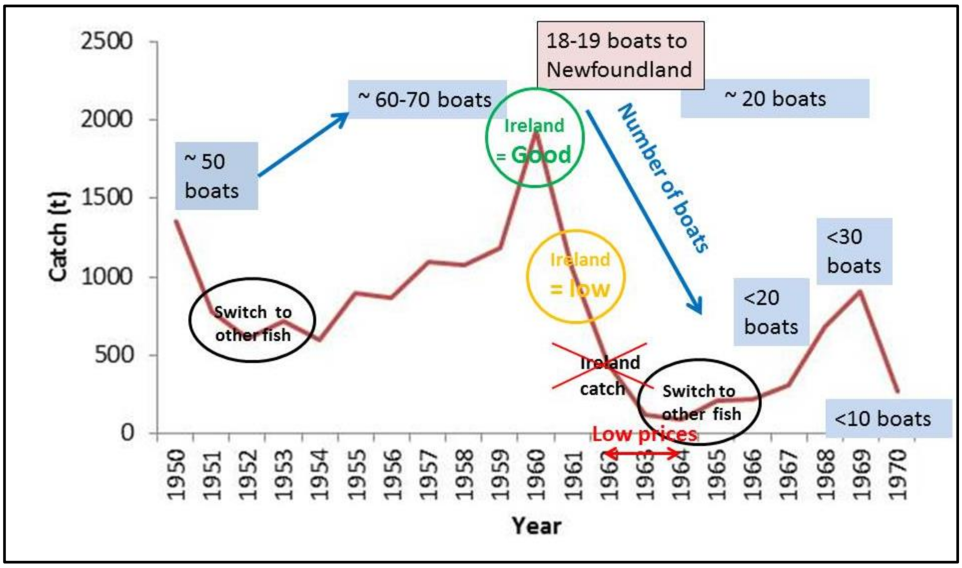

Figure 6.2 Porbeagle in the Northeast Atlantic. Trend in Norwegian catch and information on the fishery. Source: Biais *et al.* (2015a WD).

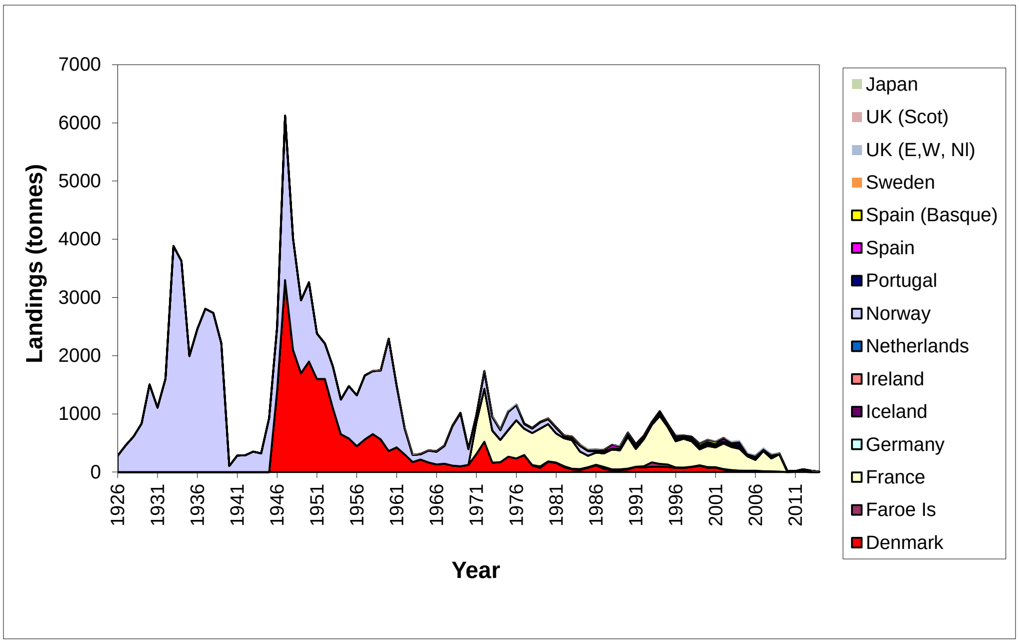

Figure 6.3. Porbeagle in the Northeast Atlantic. Working Group estimates of longer term trend in landings of porbeagle in the Northeast Atlantic.

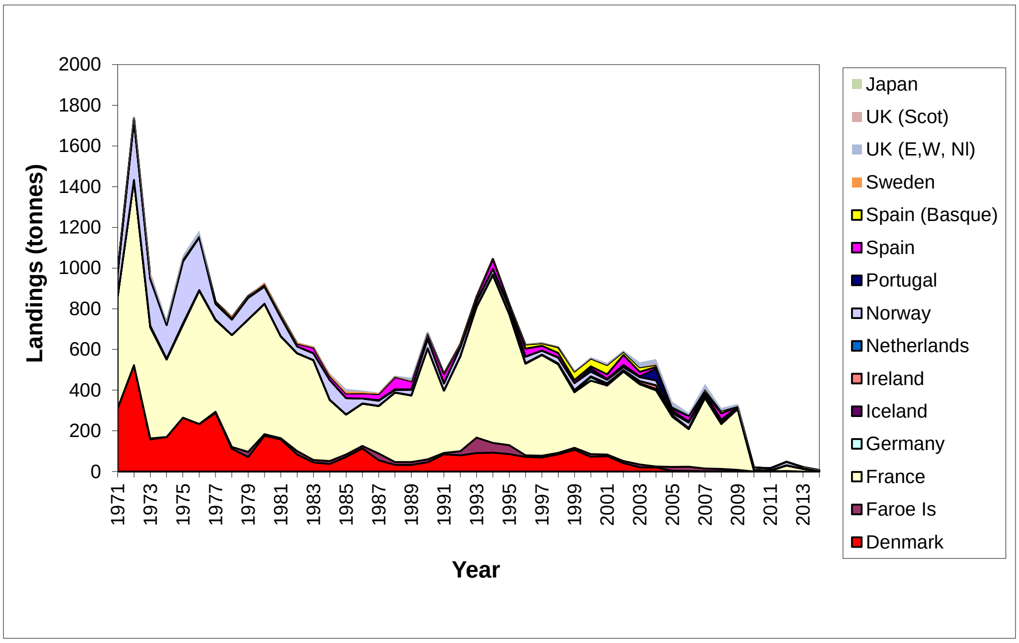

Figure 6.4. Porbeagle in the Northeast Atlantic. Working Group estimates of landings of porbeagle in the Northeast Atlantic for 1971–2014 by country.

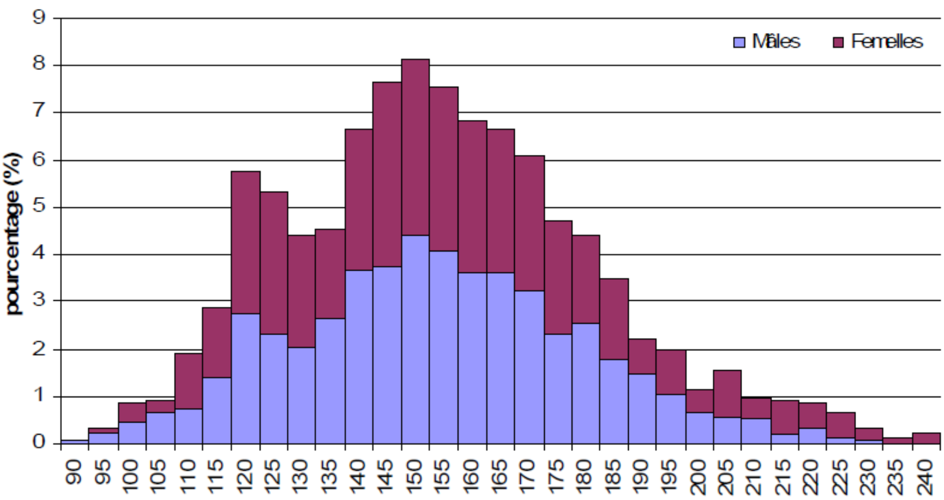

Figure 6.5. Porbeagle in the Northeast Atlantic. Length–frequency distribution of the landings of the Ile d'Yeu target fishery for porbeagle (2008–2009; n =1769). Source: Hennache and Jung (2010).

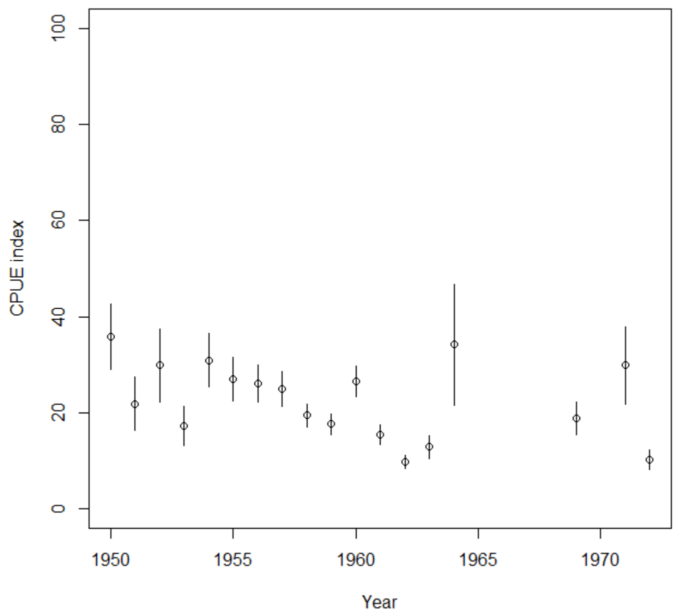

Figure 6.6. Porbeagle in the Northeast Atlantic. Temporal trends in a CPUE index for the Norwegian target longline fishery for porbeagle (1950–1972) in the northern European waters (divisions 2.a, 4.a-b, 5.a and 6.a (North of 59°N)). Source: Biais *et al.* (2015b WD).

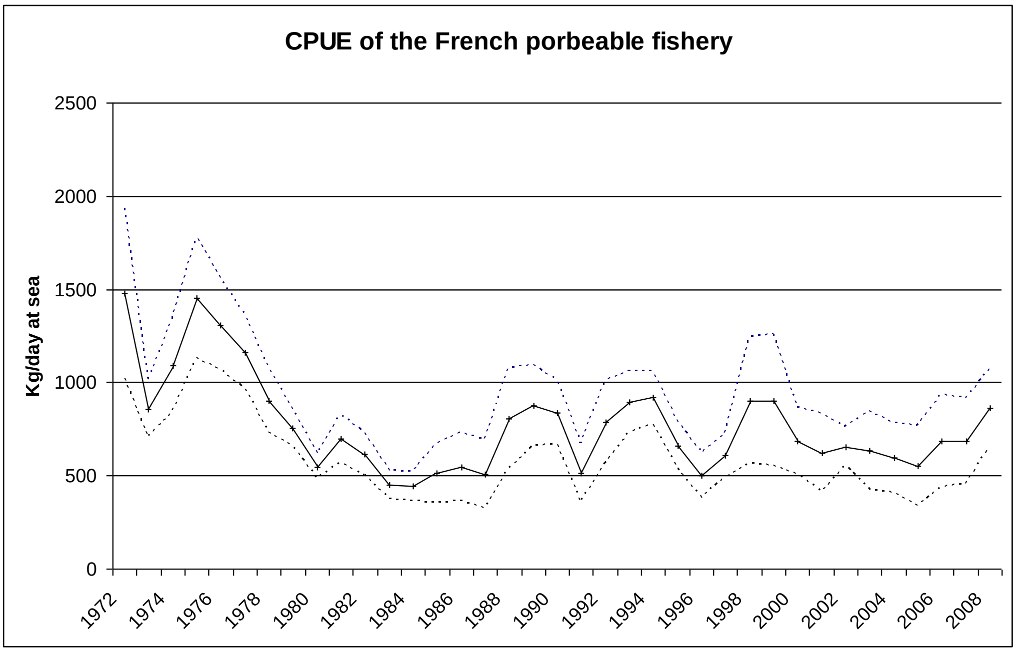

Figure 6.7. Porbeagle in the Northeast Atlantic. Nominal CPUE (kg/day at sea) for porbeagle taken in the French fishery (1972–2008) with confidence interval (± 2 SE of ratio estimate). From Biais and Vollette (2009 WD).

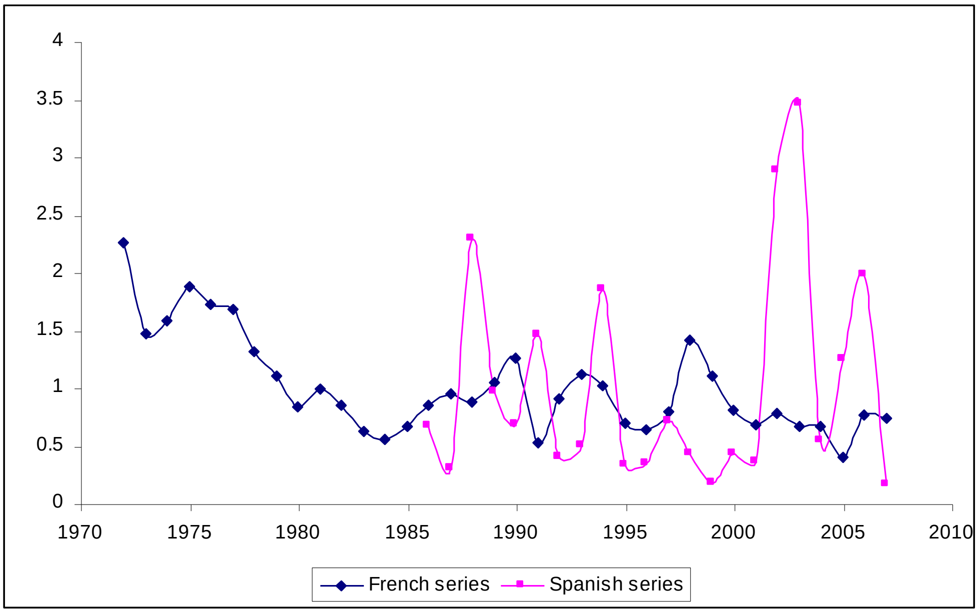

Figure 6.8. Porbeagle in the Northeast Atlantic. Temporal trends in standardized CPUE for the French target longline fishery for porbeagle (1972–2007) and Spanish longline fisheries in the Northeast Atlantic (1986–2007). Source: ICCAT (2009).

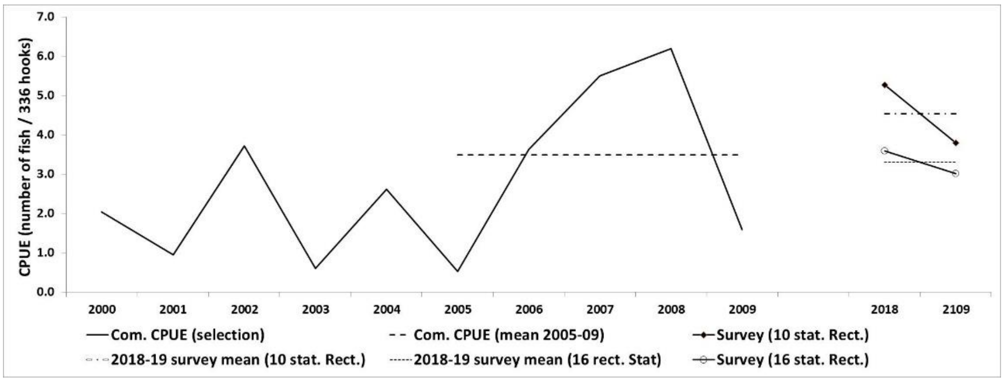

Figure 6.9. 2018-2019 CPUE (in number of porbeagles per long line set of 336 hooks) of the 2018–2019 survey and of a 2000–2009 commercial CPUE series built with selections to make it comparable to the survey indices (from Biais, 2019). Survey CPUEs are shown for the entire survey area (16 statistical rectangles) and for 10 statistical rectangles, excluding those with mean CPUEs of less than 1 fish/336 hooks in 2018 or less than 1.5 fish/336 hooks in 2019.

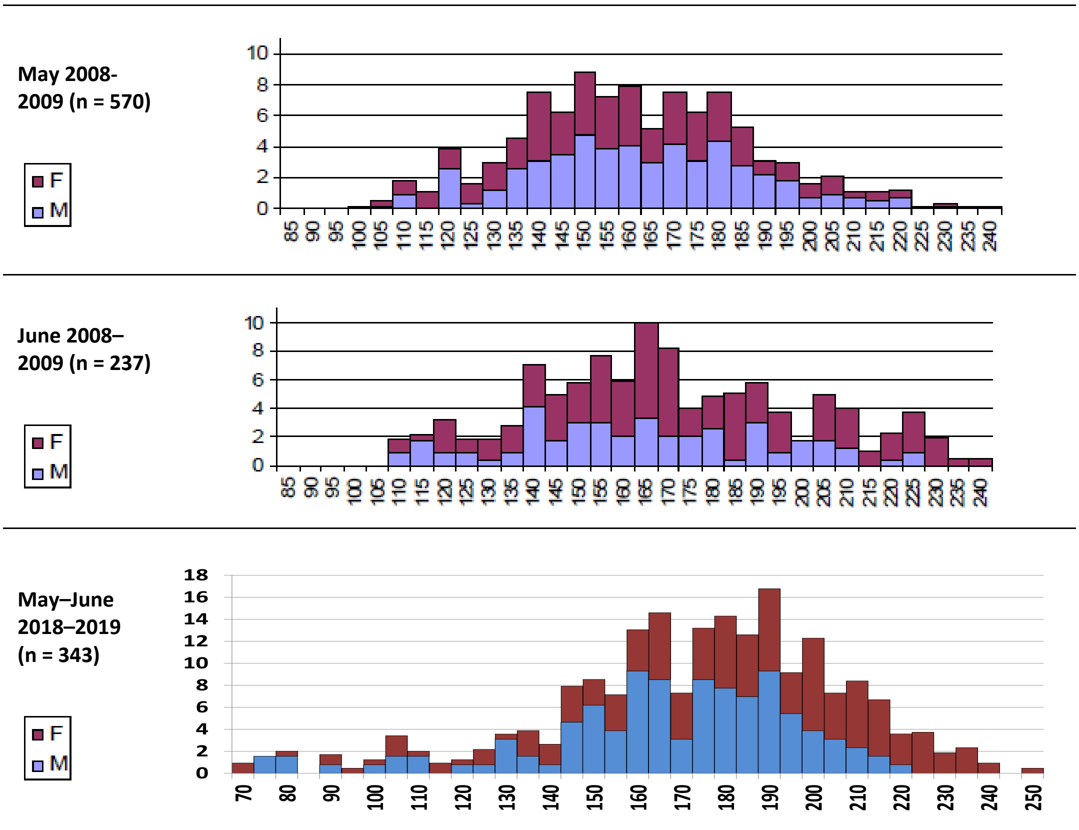

Figure 6.10. Length distribution (in %) of the porbeagle French catches in May and June 2008–2009 (source Hennache and Jung, 2010) and of the porbeagle survey in May and June 2018–2019 (curved forth length in cm).

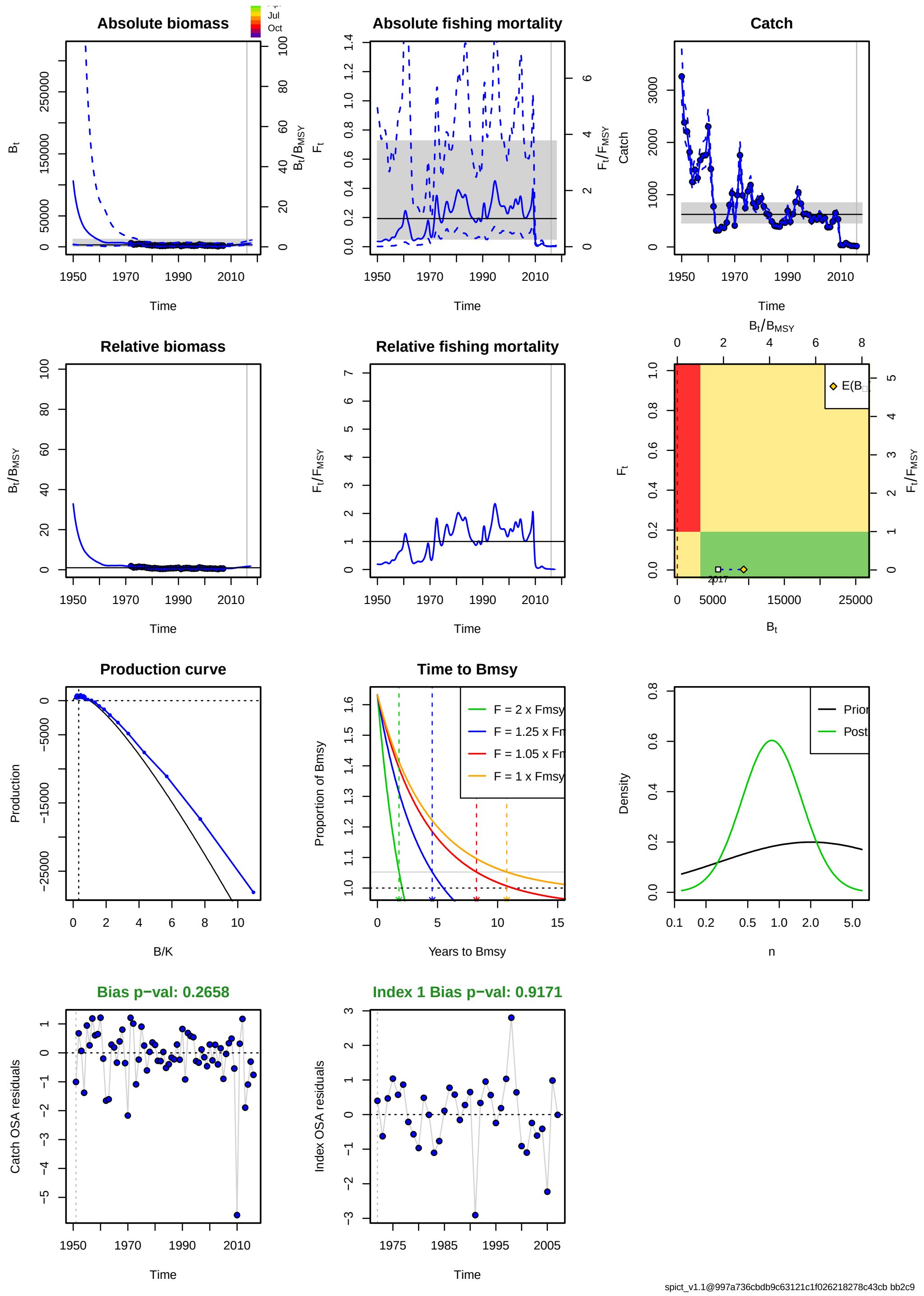

Figure 6.11. Porbeagle in the Northeast Atlantic. Output plots from Run 6 (conf. Table 6.5a and b), see Albert (WD, 2018).

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.*, 2016), 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.*, 2016; 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 (Council Regulation (EC) No 41/2006), for details and currently valid regulation see 7.2.4. Norwegian vessels have not reported landings since 2013, though they may land dead specimens but should release live specimens. Since 2013, reported landings have been < 1 tonne in total from all countries, with its maximum of 0.6 tonnes landed in 2017.

7.2.2 The fishery in 2018

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 14 of Council Regulation (EU) 2019/124 prohibits Union fishing vessels from fishing for, retaining on board, transhiping or landing basking shark in all waters. Article 50 of Council Regulation (EU) 2019/124 prohibits third-country vessels fishing for, retaining on board, transhipping 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 1977–2018 are presented in Table 7.1, and Figure 7.1, since 2014: <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. Landings data from 1975–2014 by ICES subarea are shown in Figure 7.2.

Reported landings data come from UK (Guernsey) in 1984 and 2009, Portugal (1991–2007, 2010–2013, 2016), France (1990–2006, 2008–2010, 2014, 2017–2018) 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 0.02 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 sharks 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.

There were two records of basking shark caught (and discarded) in the English and Welsh commercial fisheries (Silva and Ellis, 2019). Both female specimens were caught (and discarded) by gillnetters, in the western English Channel in 2002 (382 cm T_L) and in Bristol Channel in 2012 (378 cm T_L).

In 2009, observers from French national observer programmes reported three accidentally caught, but released, basking sharks (*ca.* 4 m long). Two basking sharks 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) has collected online public sightings of basking sharks from 2011-2014. The Institute of Marine Research (IMR) started collecting public sighting data through an online reporting system from summer 2019 and bycatch incidents from media reports, and validated data will be provided in 2020.

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 201,1 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 the Shark Trust, https://recording.sharktrust.org/sightings/search_database), 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 northeast Scotland coasts. Basking Shark Scotland collates public sightings data.

7.1 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 kilometres (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.

7.7 Exploratory assessment models

No exploratory assessments have been undertaken.

7.8 Stock assessment

No stock assessment has been undertaken.

7.9 Quality of assessments

No assessments have been undertaken.

7.10 Reference points

No reference points have been proposed for this stock.

7.11 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.

7.12 Management considerations

The current status of the stock is unknown. At present, there is no directed fishery for this species. Section 7.2.4 describes current fisheries management. 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.

7.13 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 (1977–2018)*. "."=zero catch, "+" = <0.5 t. Data for 2018 updated following Data Call.

YEAR	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	+	.	.	.	2	1	2	.	.	.	223
2006	16	.	.	.	.	+	+	+	.	.	.	17
2007	26	.	.	.	.	.	.	+	.	.	.	26
2008	4	.	.	.	.	.	1	.	.	.	.	5
2009	.	.	.	1	+	.	+	.	.	.	.	1
2010	.	.	.	+	1	.		+	.	.	.	1
2011	2	.	.	.	.	.	.	+	.	.	.	2
2012	22	.	.	.	.	.	.	1	.	.	.	24
2013	.	.	.	.	.	.	.	+	.	.	.	+
2014	.	.	.	.	.	+	.	.	.	.	.	+
2015	.	.	.	.	.	.	.	.	.	.	.	.

YEAR	1 & 2	3 &4	5a	5b	6	7	8	9	10	12	14	TOTAL
2016	.	.	.	.	.	.	.	+	.	.	.	+
2017	.	.	.	.	.	1	.	.	.	.	.	1
2018	.	.	.	.	.	.	.	.	.	.	.	.

*** The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.**

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 ICES WGEF 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

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 ICES WGEF 2008
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
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

Nation	Day	Month	Year	Geog. area	Lat	Lon	Gear	Depth	Length	Weight (kg)	Comment	Source
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

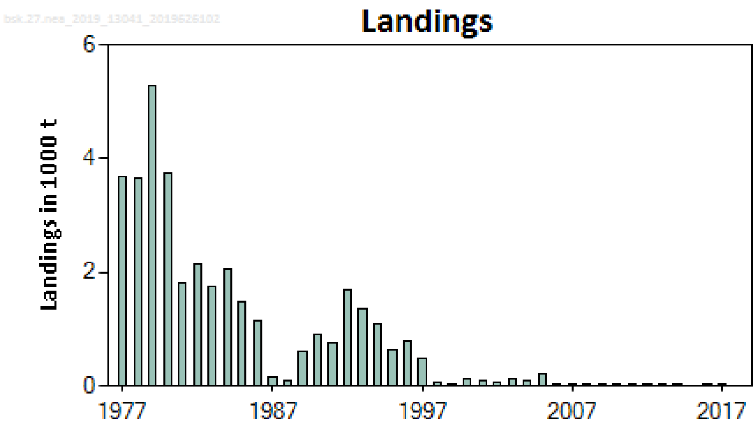


Figure 7.1. Basking shark in the Northeast Atlantic. Total landings (1000 t) of basking sharks in ICES subareas 1–14 from 1977–2018, since 2013: < 1 t landed.

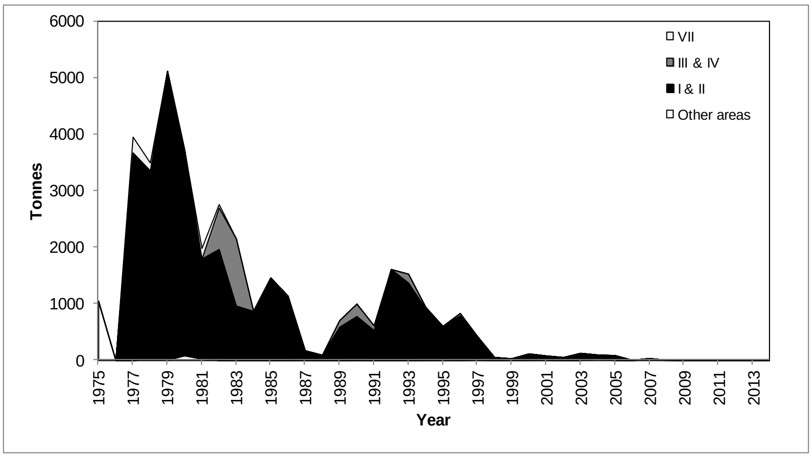


Figure 7.2. Basking shark in the Northeast Atlantic. Total landings (t) of basking sharks by ICES subareas (1–14) from 1975–2014.

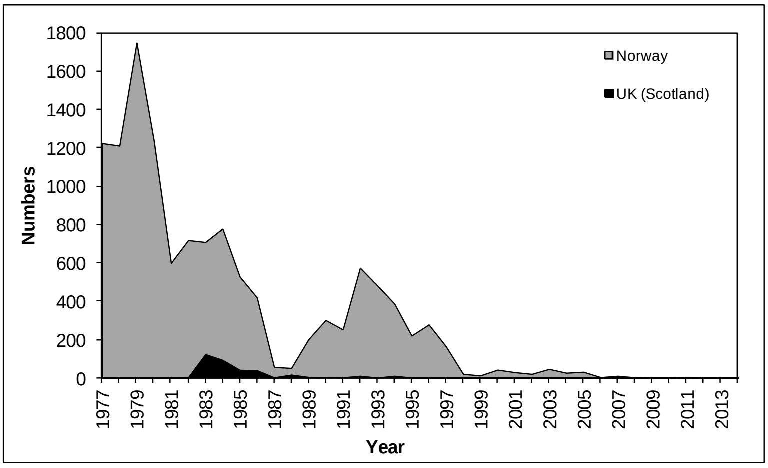
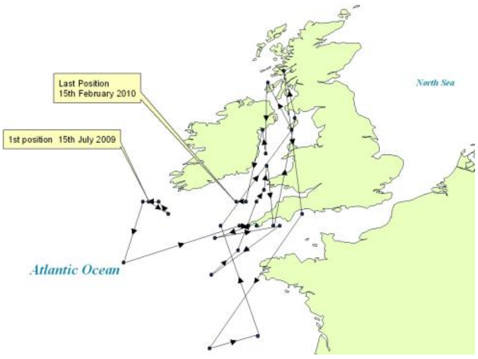


Figure 7.3. Basking shark in the Northeast Atlantic. Numbers of basking sharks landed by Norway and Scotland in ICES subareas 1–14 from 1977–2014.



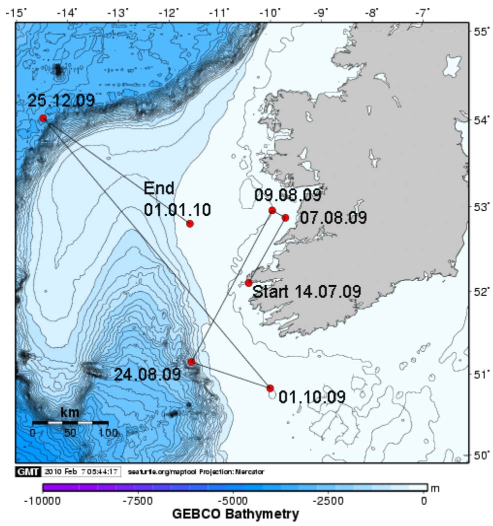


Figure 7.4. Basking shark in the Northeast Atlantic. Geolocations from basking shark A (left, sex = male) and B (right, sex = unknown). Source: Berrow and Jackson (2010 WD).

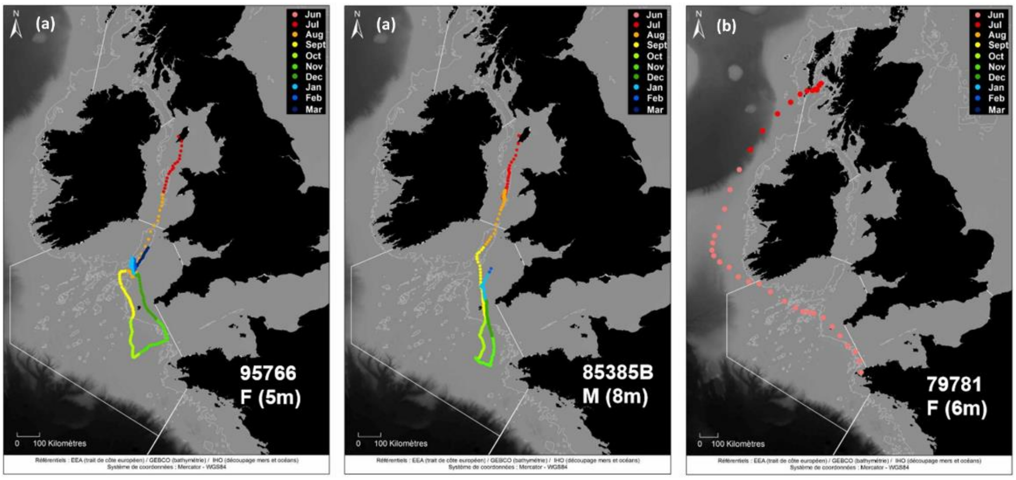


Figure 7.5. Basking shark in the Northeast Atlantic. Most probable tracks for (left) shark 95766 (5 m female) and (centre) shark 85385 (8 m male), tracked for more than 200 days and which stayed in the Irish Sea and Celtic Seas, and (right) most probable track for shark 79781 (6 m female) tracked for 38 days. Source: Stéphan *et al.* (2011).

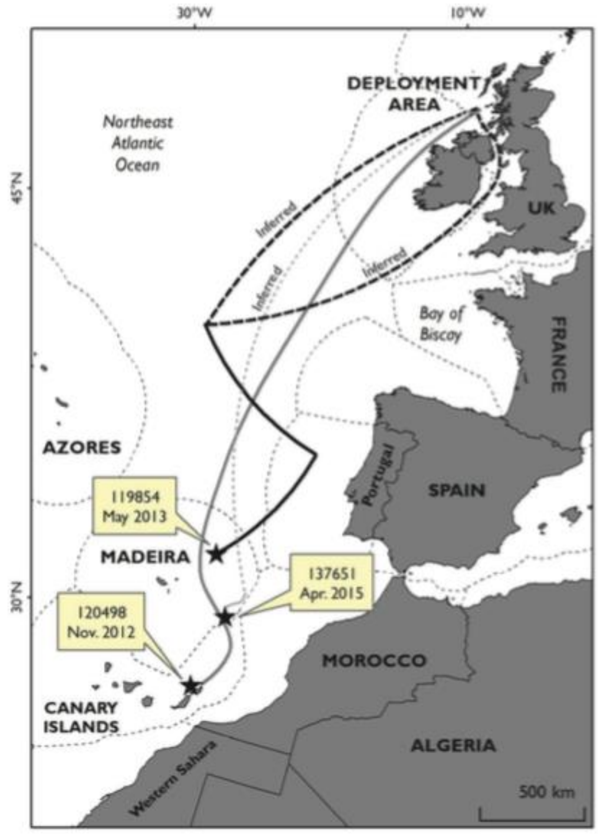


Figure 7.6. Basking shark in the Northeast Atlantic. Long-range movements of basking sharks from Scotland revealed by Argos satellite tracking. Two SPOT-tagged basking sharks in 2012 (119854, 120498) and one SPLASH-F tagged shark in 2014 (137651). Source: Witt *et al.* (2016).

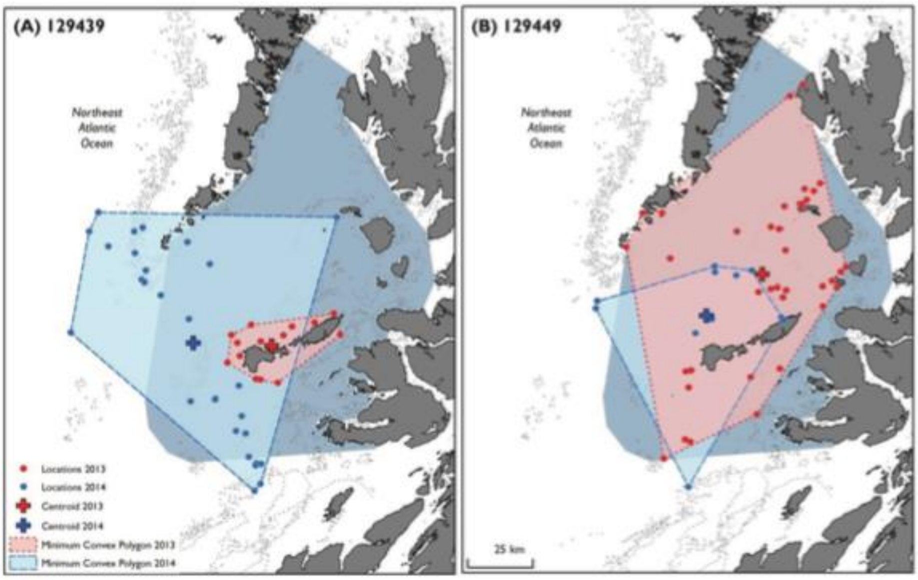


Figure 7.7. Basking shark in the Northeast Atlantic. Example distribution of two sharks showing inter-annual fidelity to the Hebridean Sea. Single highest quality Argos locations per day (red and blue circles for 2013 and 2014 respectively). Minimum convex polygons for data gathered in 2013 and 2014 (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 ~1000s, 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 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 sSection 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 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 day-time 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	Same as Preliminary Run 1 + Adjust CV of S9 (ESP-LL-N)				
CV adjustment	Constant CV of 20% applied to S9 (ESP-LL-N)				
Preliminary Run 3	Same as Preliminary Run 2 + Adjust input sample size for length comp				
Sample size adjustments	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

Within Europe the blue shark is listed as 'Near Threatened' by the IUCN (2014), whereas within the Mediterranean they are listed as 'Critically endangered' (2016).

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.

8.14 References

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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																					
	Brazil																					
	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																					

Stock	Country	1978	1979	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Trinidad and To-bago																					
	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
		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

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	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
	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 8.1. Cont. Blue shark in the North Atlantic. Landings (t) by country 1978–2017 from ICCAT estimated catch (t) data by area, gear and flag (accessed June 2019).

			2017
TOTAL			68011
	ATN		39675
	ATS		28232
	MED		105
Landings	ATN	Longline	38509
		Other surf.	1033
	ATS	Longline	27522
		Other surf.	487
	MED	Longline	92
		Other surf.	13
Discards	ATN	Longline	133
		Other surf.	0
	ATS	Longline	218
		Other surf.	5
Landings	ATN	Barbados	7
		Belize	201
		Brazil	0
		Canada	0
		Cape Verde	0
		China PR	2
		Chinese Taipei	
		EU.Denmark	0
		EU.Spain	27316
		EU.France	124
		EU.Ireland	0

		2017
	EU.Netherlands	
	EU.Portugal	5664
	EU.United Kingdom	11
	FR.St Pierre et Miquelon	0
	Japan	4460
	Korea Rep.	103
	Marocco	1475
	Mexico	0
	Panama	0
	Senegal	4
	St.Vincent and Grenadines	
	Suriname	
	Trinidad and Tobago	2
	U.S.A.	24
	UK.Bermuda	0
	Venezuela	104
Discards ATN	Candada	32
	Chinese Taipei	34
	Korea Rep.	29
	U.S.A.	38
	UK.Bermuda	

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
W_D = (8.04021 x 10–7) LF ^ 3.23189	C	354	75–250 (LF)	García-Cortés and Mejuto, 2002
W_R = (3.1841 x 10–6) LF ^ 3.1313	C	4529		Castro, 1983
W_R = (3.92 x 10–6) LT ^ 3.41	Male	17		Stevens, 1975
W_R = (3.184 x 10–7) LT ^ 3.20	Female	450		Stevens, 1975
W_R = (3.2 x 10–6) LF ^ 3.128	C	720		Campana *et al*., 2005
W_D = (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	JPLLl	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	

Parameter	Values	Sample Size	Area	Reference
	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
	> 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

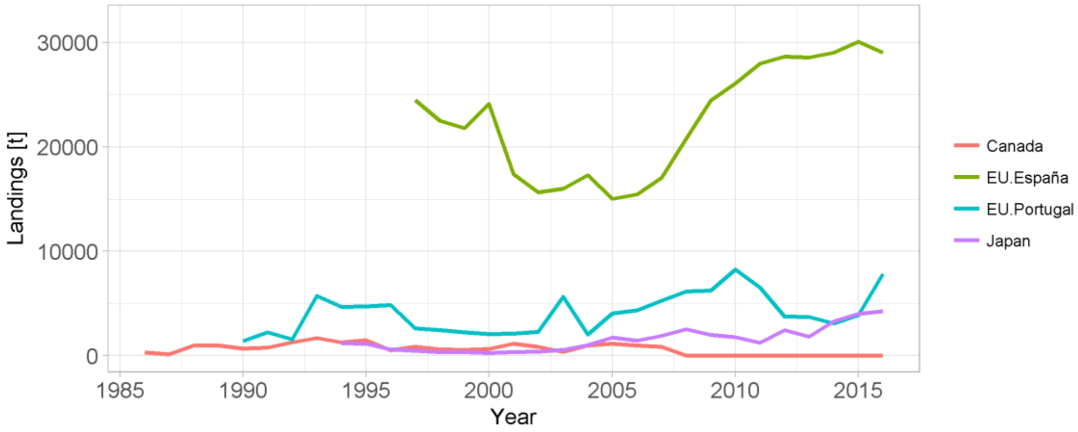


Figure 8.1. Blue shark in the North Atlantic. Preliminary estimates of landings of blue shark in the Atlantic for the four main countries (Source: ICCAT Task I data, Accessed June 2018).

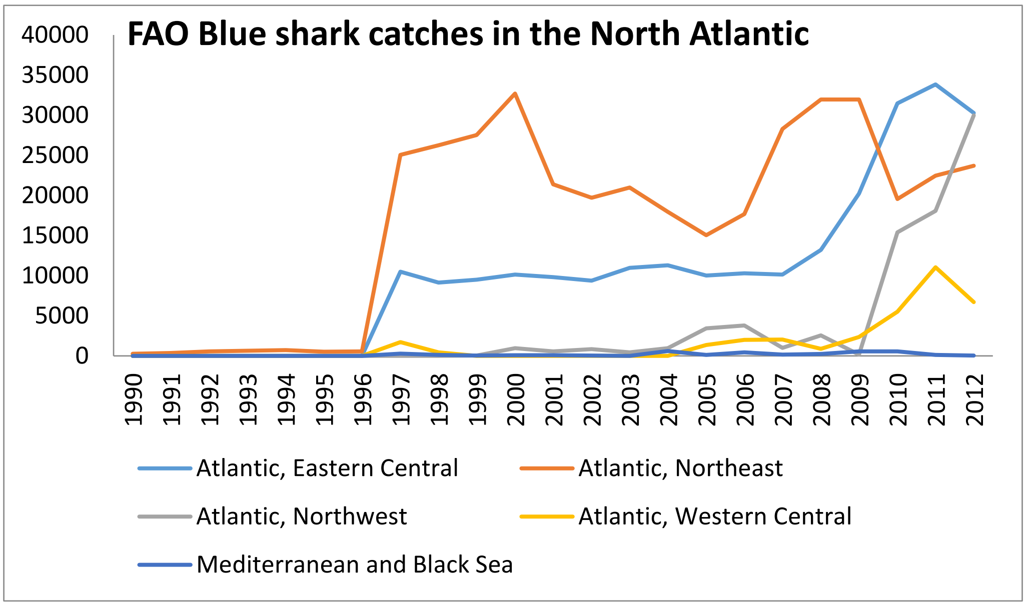


Figure 8.2. Blue shark in the North Atlantic. Preliminary estimates of landings of blue shark in the Atlantic Ocean for the different areas (Source: FAO, 2014).

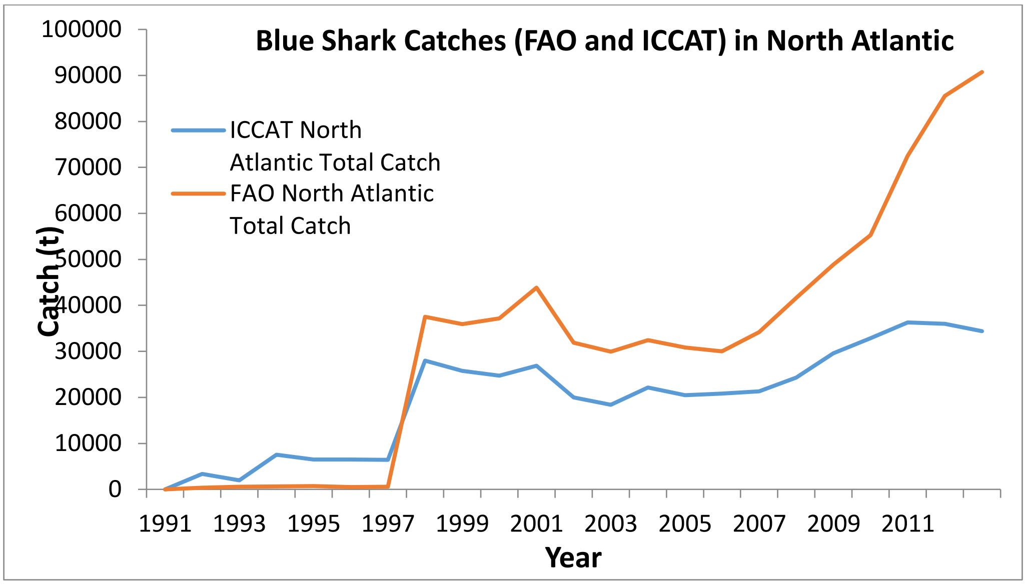


Figure 8.3. Blue shark in the North Atlantic. Blue shark landings in the North Atlantic from FAO and ICCAT data.

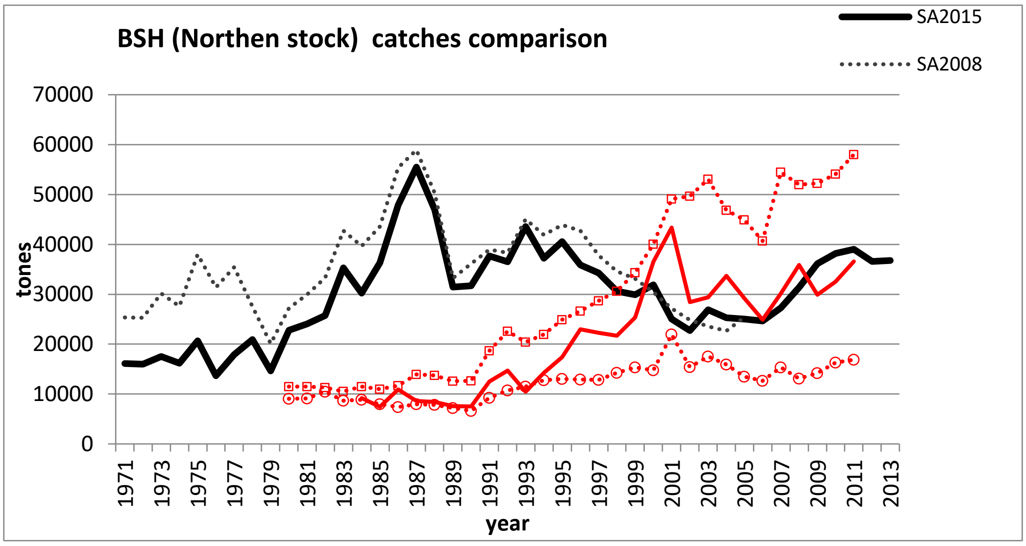


Figure 8.4. Blue shark in the North Atlantic. Comparison of various catch series for the North Atlantic stock of blue shark (1971–2013). In black, the stock assessment catches from the 2008 stock assessment and 2015 estimations. In red, three catch series obtained using shark-fin ratios with three different approaches (area, effort, target level).

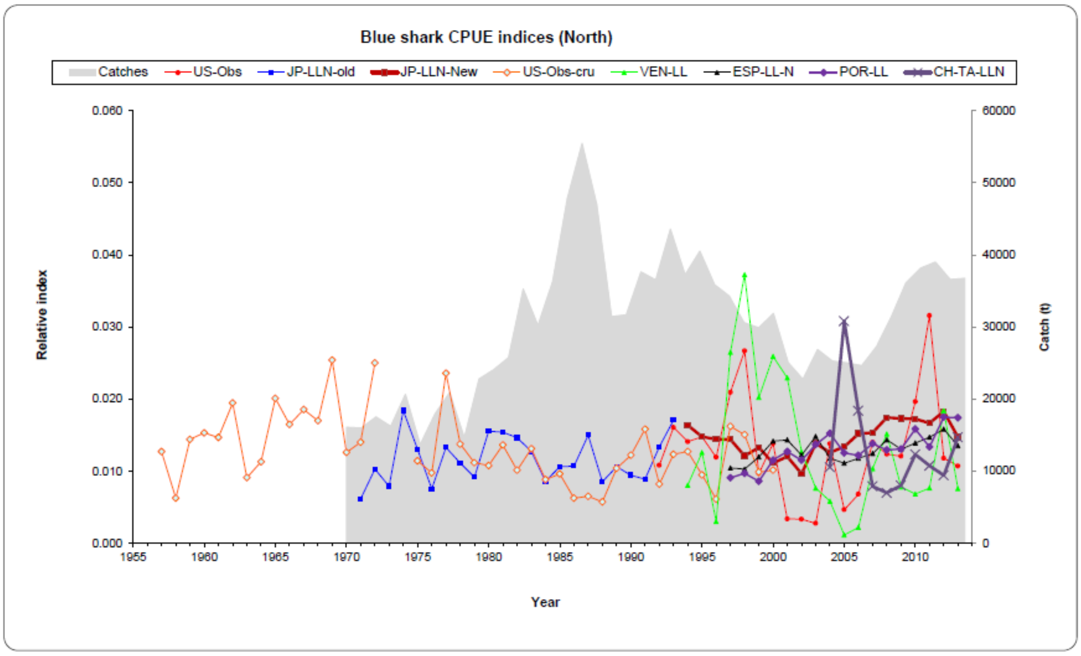


Figure 8.5. Blue shark in the North Atlantic. Indices of abundance and catches. Source: ICCAT (2019).

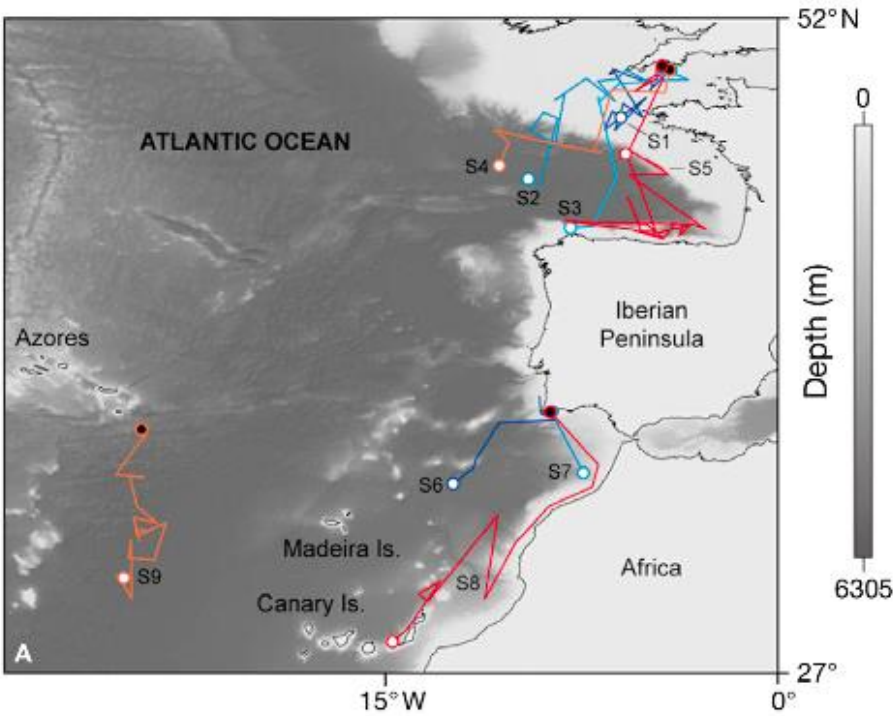
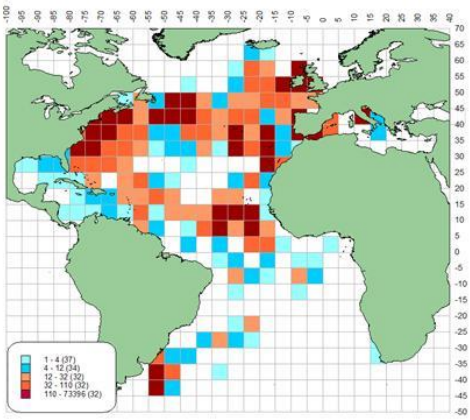
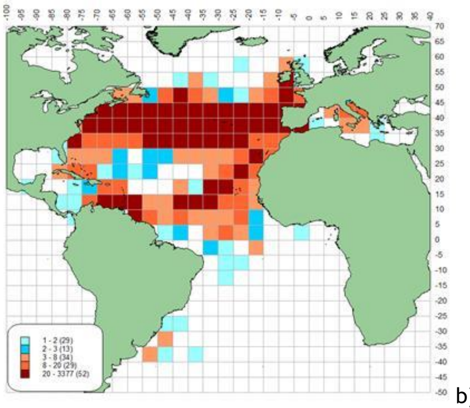


Figure 8.6. Blue shark in the North Atlantic. Pop-off satellite-tagged blue shark movement patterns. (A) General movements overlaid on bathymetry; black circles denote tagging locations and white circles the pop-up/capture locations. (B to J) Individual tracks overlaid on sea surface temperature maps; white circles are geolocated positions with date. Source: Queiroz *et al.* (2010).



a)



b)

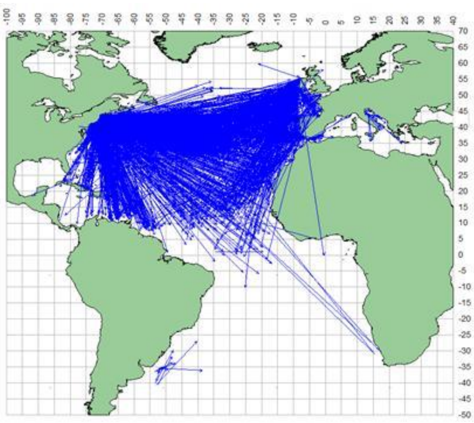

c)

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.

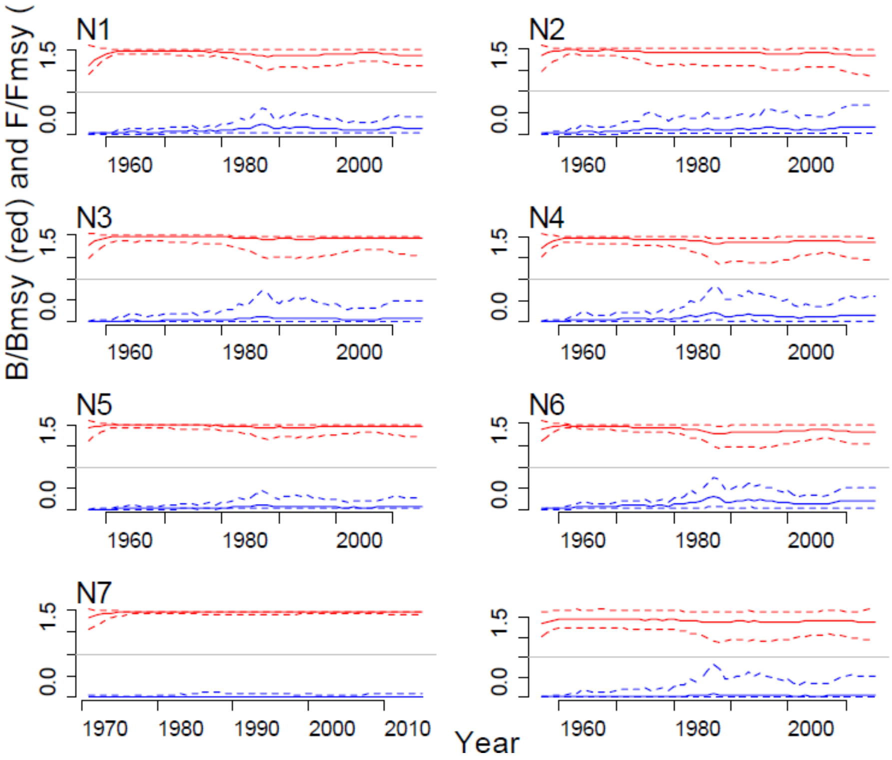


Figure 8.8. Blue shark in the North Atlantic. Estimated biomass relative to B_{MSY} (in red) and harvest rate relative to the MSY level (blue), for the BSP runs. Source: ICCAT (2015).

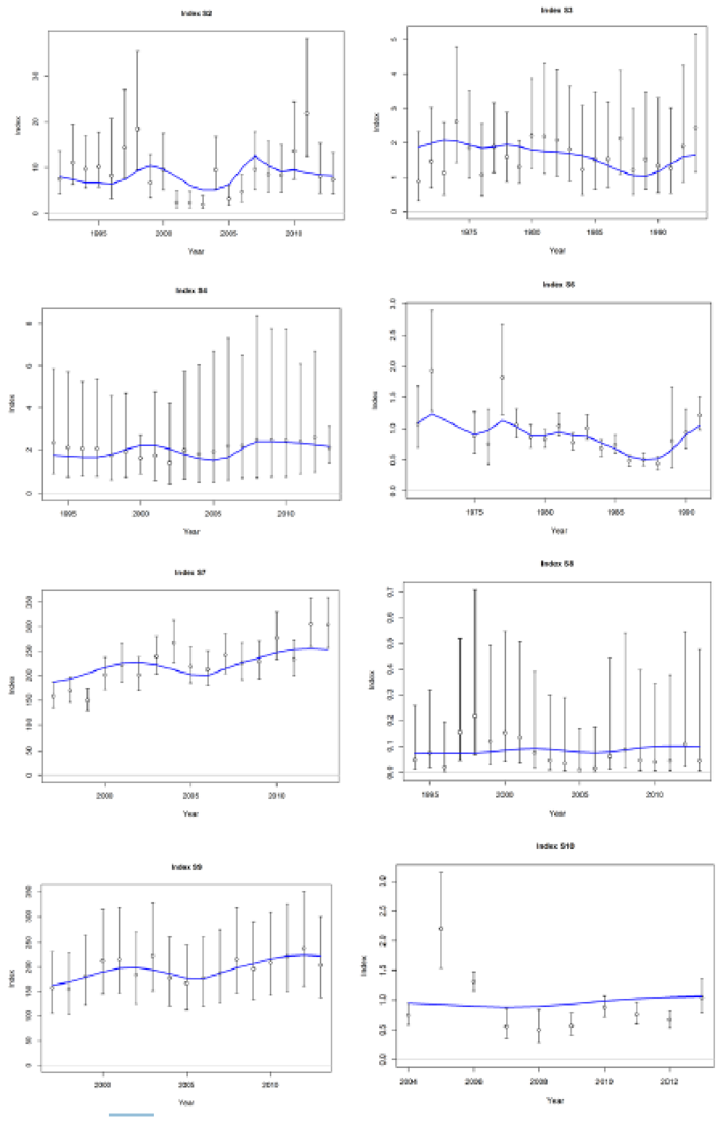


Figure 8.9. Blue shark in the North Atlantic. Preliminary Run 4 observed CPUE (open circles ± 95% confidence intervals assuming lognormal error) and model predicted CPUE (blue line) for abundance indices fit in the model likelihood: S2 (US-Obs, upper left), S3 (JPLL-N-e, upper right), S4 (JPLL-N-l, middle 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).

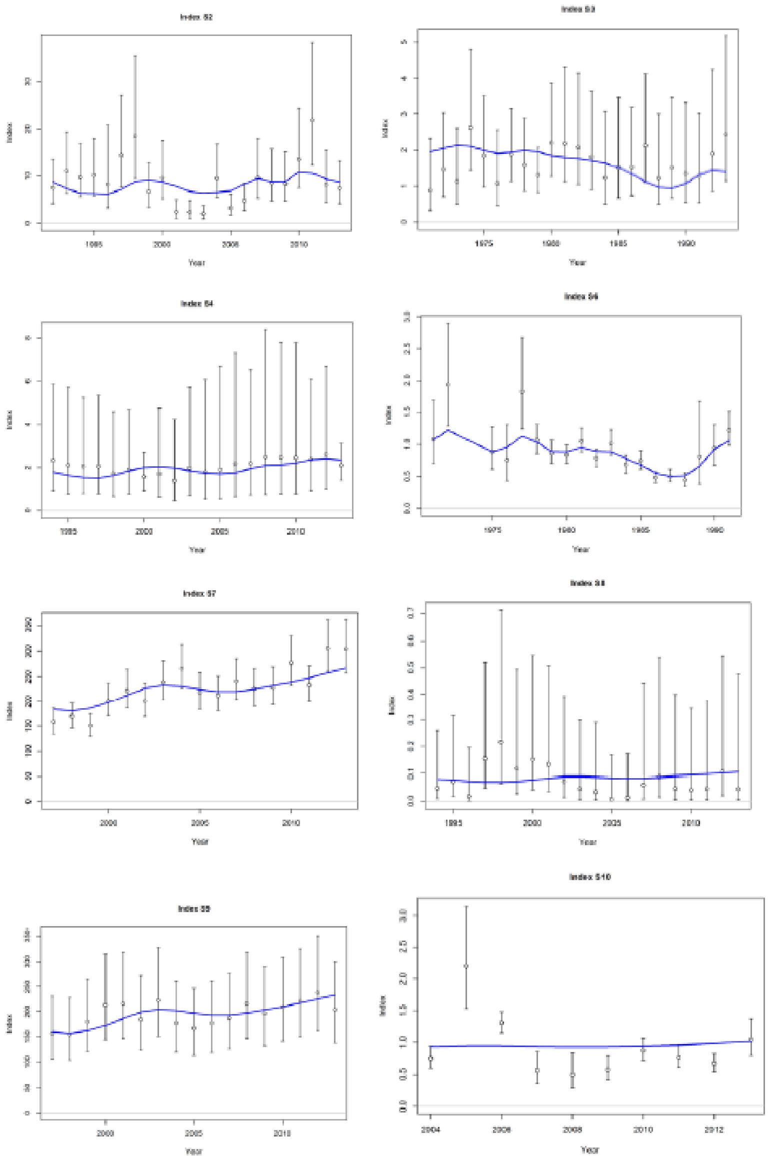


Figure 8.10. Blue shark in the North Atlantic. Preliminary Run 6 observed CPUE (open circles ± 95% confidence intervals assuming lognormal error) and model predicted CPUE (blue line) for abundance indices fit in the model likelihood: S2 (US-Obs, upper left), S3 (JPLL-N-e, upper right), S4 (JPLL-N-l, 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).

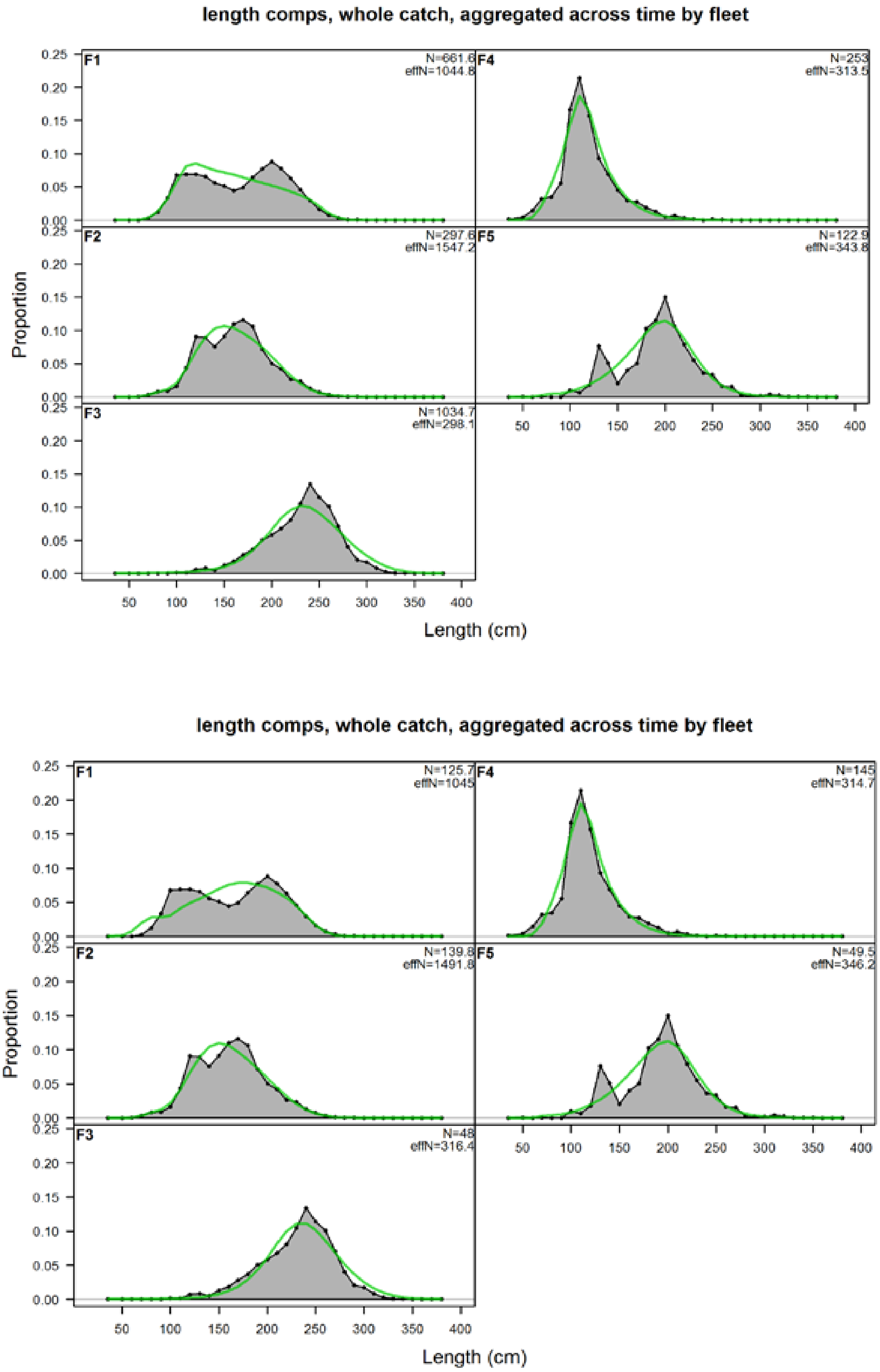


Figure 8.11. Blue shark in the North Atlantic. Model predicted (line) and observed (shaded) aggregated annual length compositions (female + male) for Preliminary Run 4 (upper panel) and Preliminary Run 6 (lower panel). Source: ICCAT (2015).

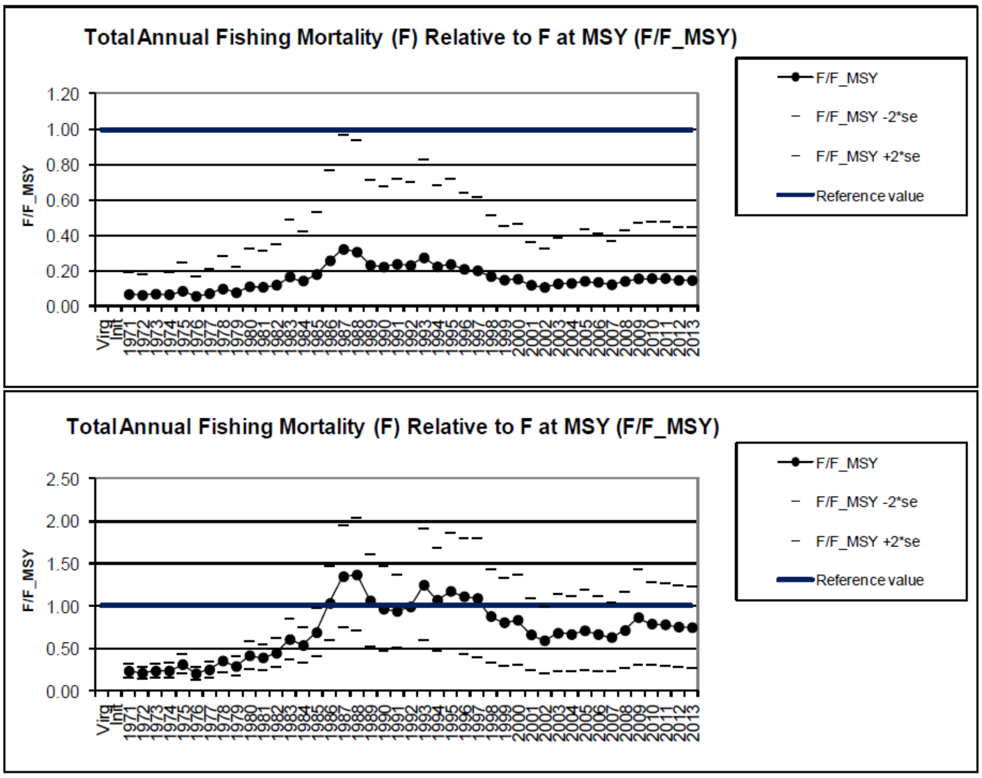


Figure 8.12. Blue shark in the North Atlantic. Estimated annual total exploitation rate in numbers (total fishing mortality for all fleets combined) relative to fishing mortality at MSY (F/F_{MSY}), obtained from Stock Synthesis output for Preliminary Run 4 (upper panel) and Preliminary Run 6 (lower panel). Source: ICCAT (2015).

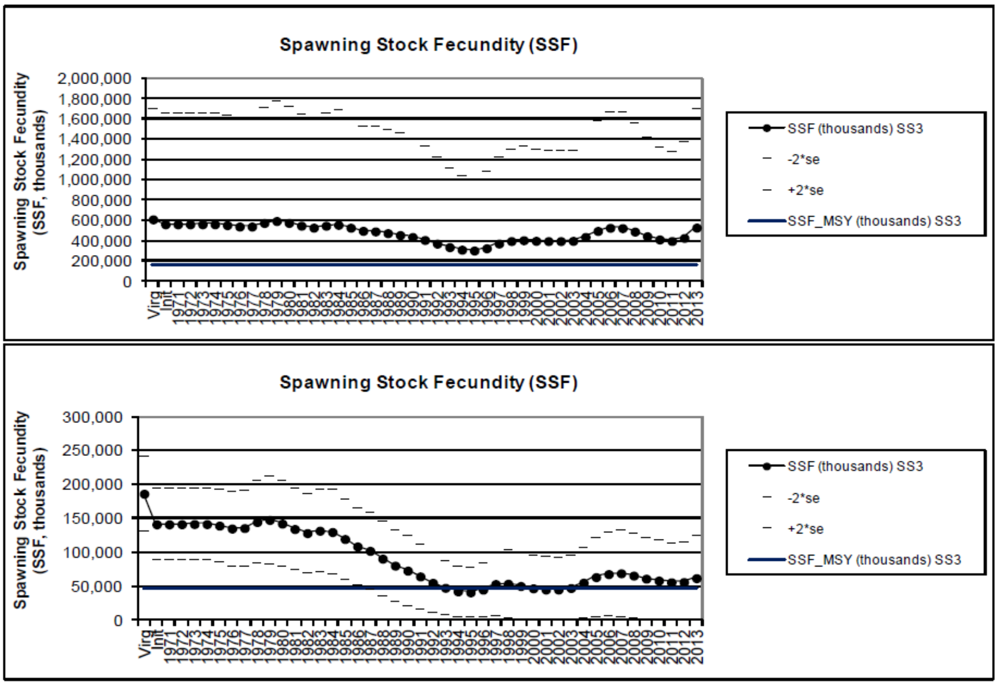


Figure 8.13. Blue shark in the North Atlantic. Estimated spawning stock size (spawning stock fecundity, SSF) along with approximate 95% asymptotic standard errors (+- 2*s.e.) relative to spawning stock size at MSY (SSFMSY) for Preliminary Run 4 (upper panel) and Preliminary Run 6 (lower panel). Source: ICCAT (2015).

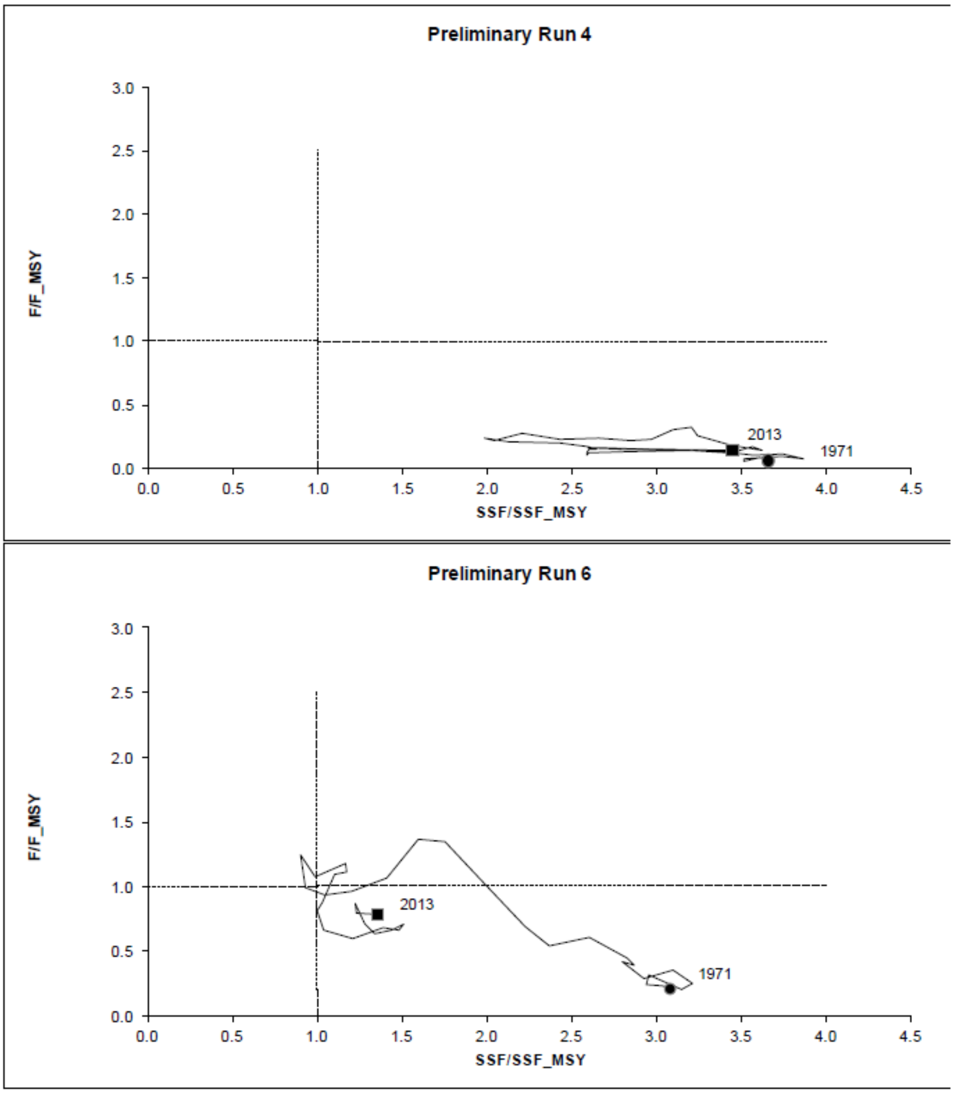


Figure 8.14. Blue shark in the North Atlantic. Kobe Phase plots for Preliminary Run 4 (upper panel) and Preliminary Run 6 (lower panel). The circle indicates the position of the start year of the model (1971) and the square represents the end year of the model (2013). The horizontal (dotted) line identifies 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. Thus, 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% 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 9.a 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 0–2 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 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 1255 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 behaviour, 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}.

ICCAT updated the assessment for shortfin mako in 2019. New projections were made using two Stock Synthesis model scenarios that incorporated important aspects of shortfin mako biology, which had not been available previously (ICCAT, 2019). These projections were considered by the ICCAT Shark Group as a better representation of the stock dynamics. For the North Atlantic stock the Group stated that “it is likely the current status (2018) had a lower B/B_{MSY} and higher F/F_{MSY} than the stock status in 2015 estimated in the 2017 assessment because the population continued to decline due to high catch levels”. A number of catch scenarios are given in the report, but the Group states that “regardless of the TAC (including a TAC of 0 t), the stock will continue to decline until 2035 before any biomass increases can occur” and “although there is large uncertainty in the future productivity assumption for this stock, the Stock Synthesis projections show that there is a long lag time between when management measures are implemented and when stock size starts to rebuild” (ICCAT, 2019).

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.

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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 x 10–6 x L_T 3.46	23	160–260 (L_T)	Manday, 1975
Australia	W = 4.832 x 10–6 x L_T 3.10	80	58–343 (L_T)	Stevens, 1983
South Africa	W = 1.47 x 10–5 x L_{PC} 2.98	143	84–260 (L_{PC})	Cliff *et al*., 1990
NW Atlantic	W_R = (5.2432 x 10–6) L_F 3.1407	2081	65–338 (L_F)	Kohler *et al*., 1995.
NW Atlantic	W = 7.2999 x L_T (m) 3.224	63	2.0–3.7 m (L_T)	Mollet *et al*., 2000
Southern hemisphere	W = 6.824 x L_T (m) 3.137	64	2.0–3.4 m (L_T)	Mollet *et al*., 2000
NE Atlantic	W_D = (2.80834 x 10–6) L_F 3.20182	17	70–175 (L_F)	García-Cortés and Mejuto, 2002
Tropical east Atlantic	W_D = (1.22182 x 10–5) L_F 2.89535	166	95–250	García-Cortés and Mejuto, 2002
Tropical central Atlantic	W_D = (2.52098 x 10–5) L_F 2.76078	161	120–185	García-Cortés and Mejuto, 2002
Southwest Atlantic	W_D = (3.1142 x 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
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

Parameter	Values	Sample Size	Area	Reference
	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

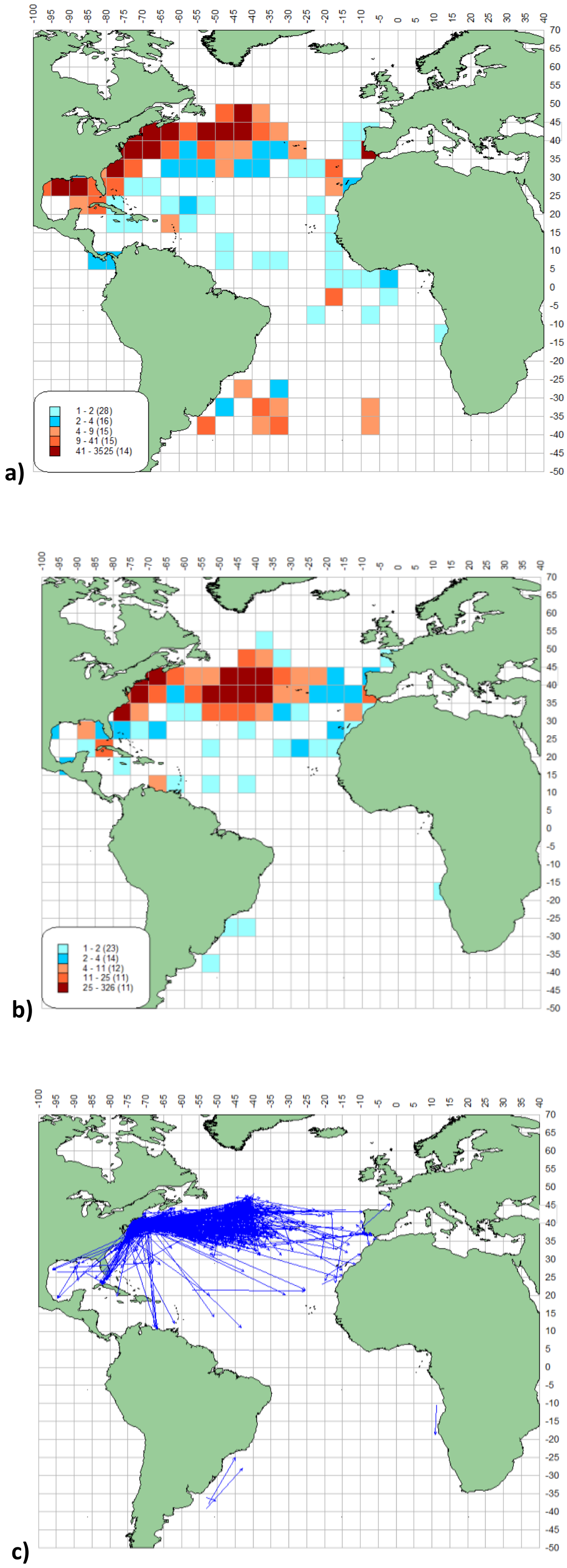

Figure 9.1. Shortfin mako in the North Atlantic. Tag and release distributions for shortfin mako in the Atlantic Ocean showing (a) density of releases, (b) density of recoveries, and (c) straight displacement between release and recovery locations. Recaptures were 13.4%. Source: ICCAT (2014).

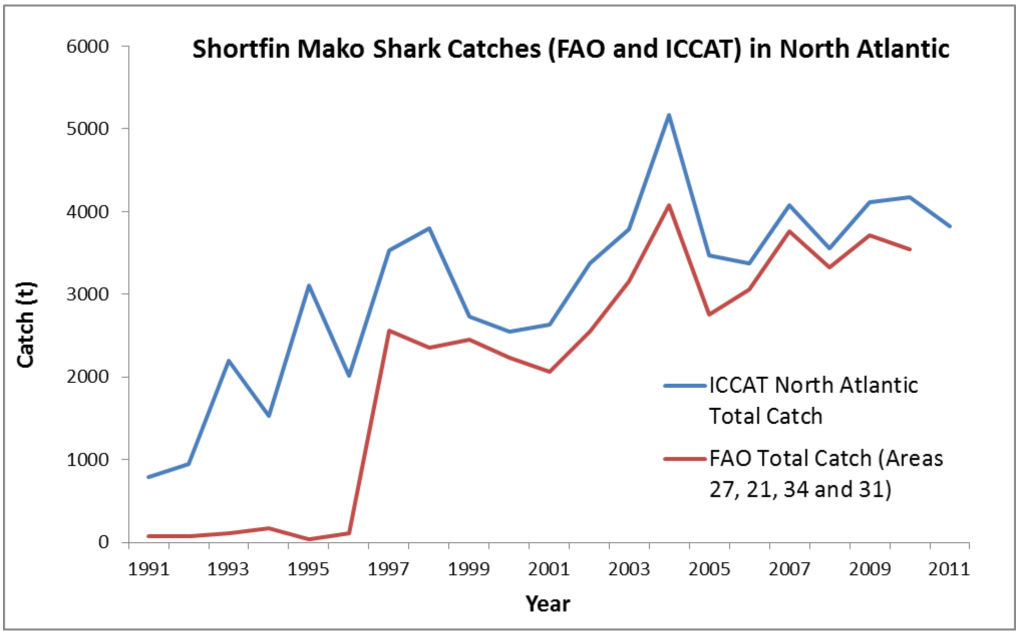

Figure 9.2. Shortfin mako in the North Atlantic. Total catches (t) of shortfin mako in the North Atlantic reported to FAO and ICCAT.

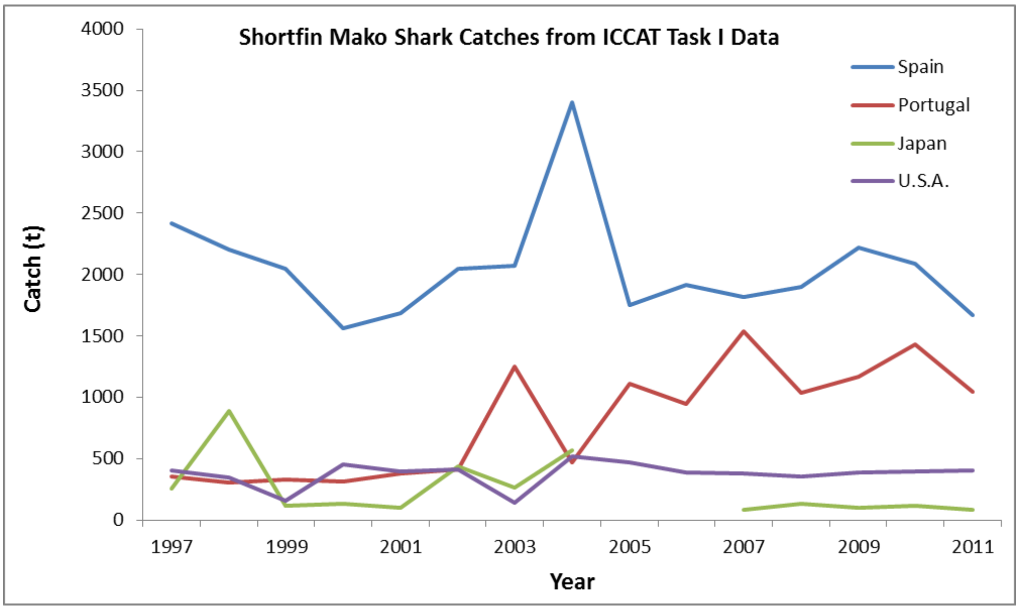

Figure 9.3. Shortfin mako in the North Atlantic. Total catches (t) made by the major countries (accounting for 84% of total landings) landing shortfin mako in the North Atlantic reported to ICCAT.

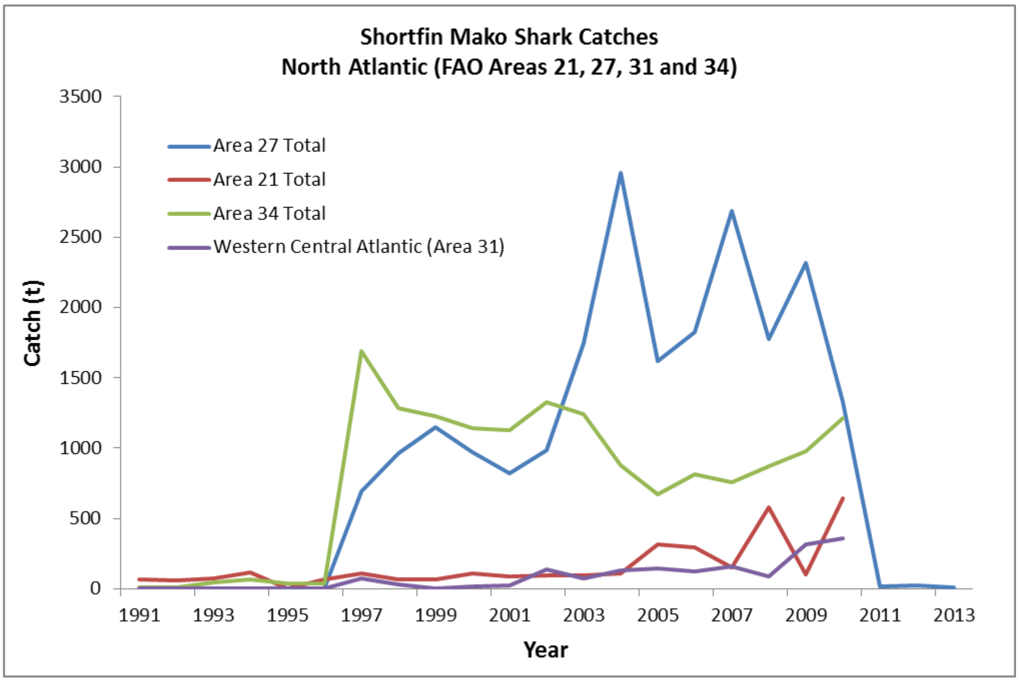

Figure 9.4. Shortfin mako in the North Atlantic. Total catches (t) of shortfin mako reported to FAO by major fishing area.

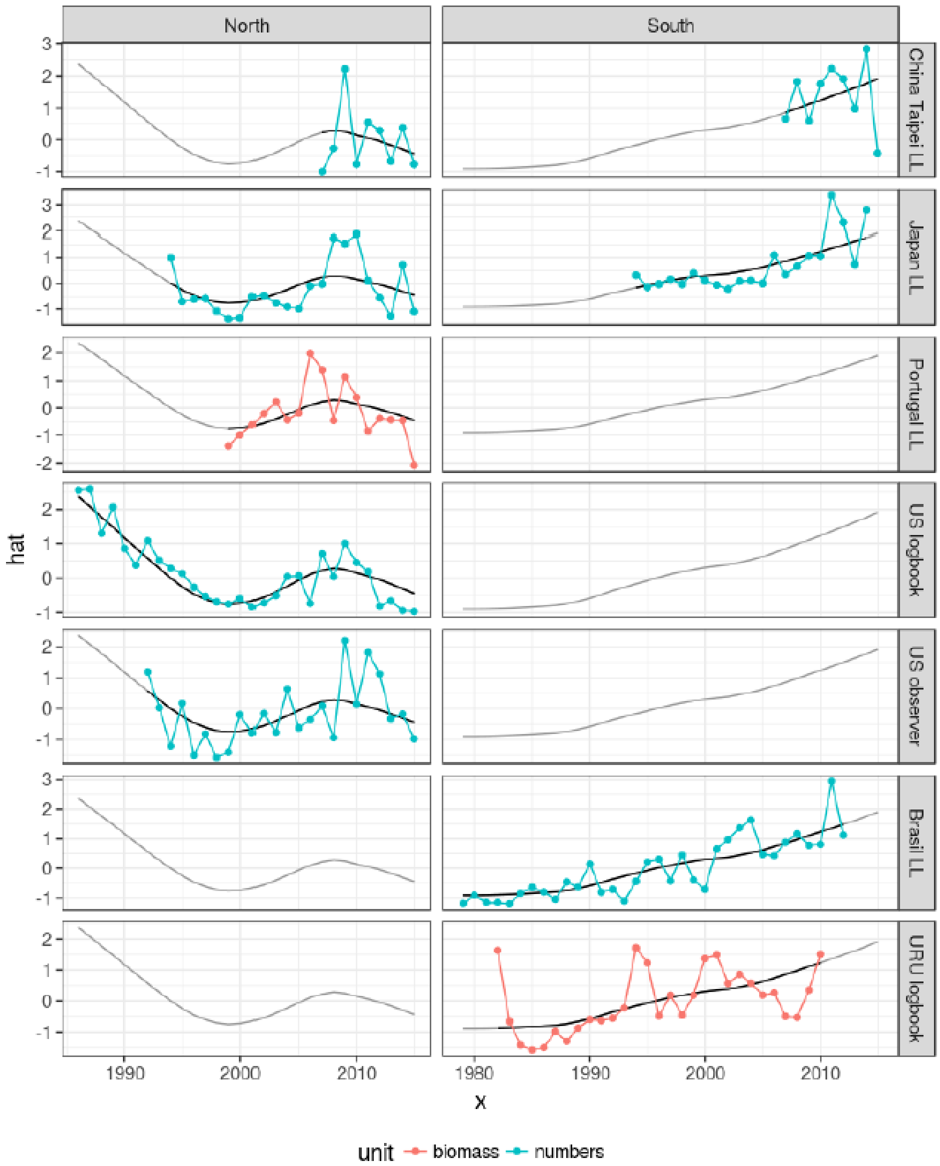

Figure 9.5. Shortfin mako in the North and South Atlantic. Time series of agreed CPUE indices, points are the standardised values, continuous black lines are a loess smoother showing the average trend by area (i.e. fitted to year for each area with series as a factor). X-axis is time, Y-axis are the scaled indices. Source: ICCAT.

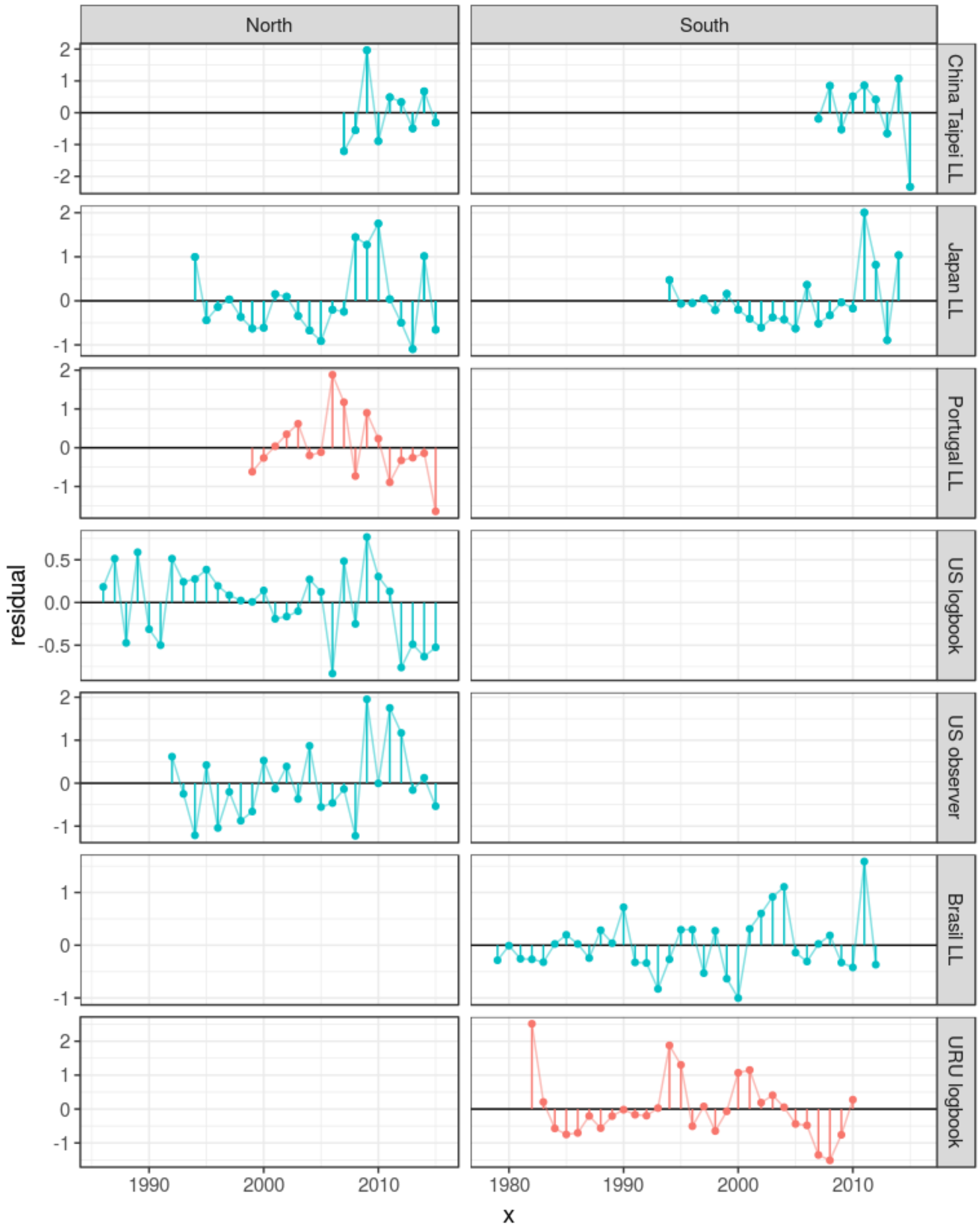

Figure 9.6. Shortfin mako in the North and South Atlantic. North and South Atlantic time series of residuals from the loess fit to agreed indices. X-axis is time, Y-axis are the scaled indices. Source: ICCAT.

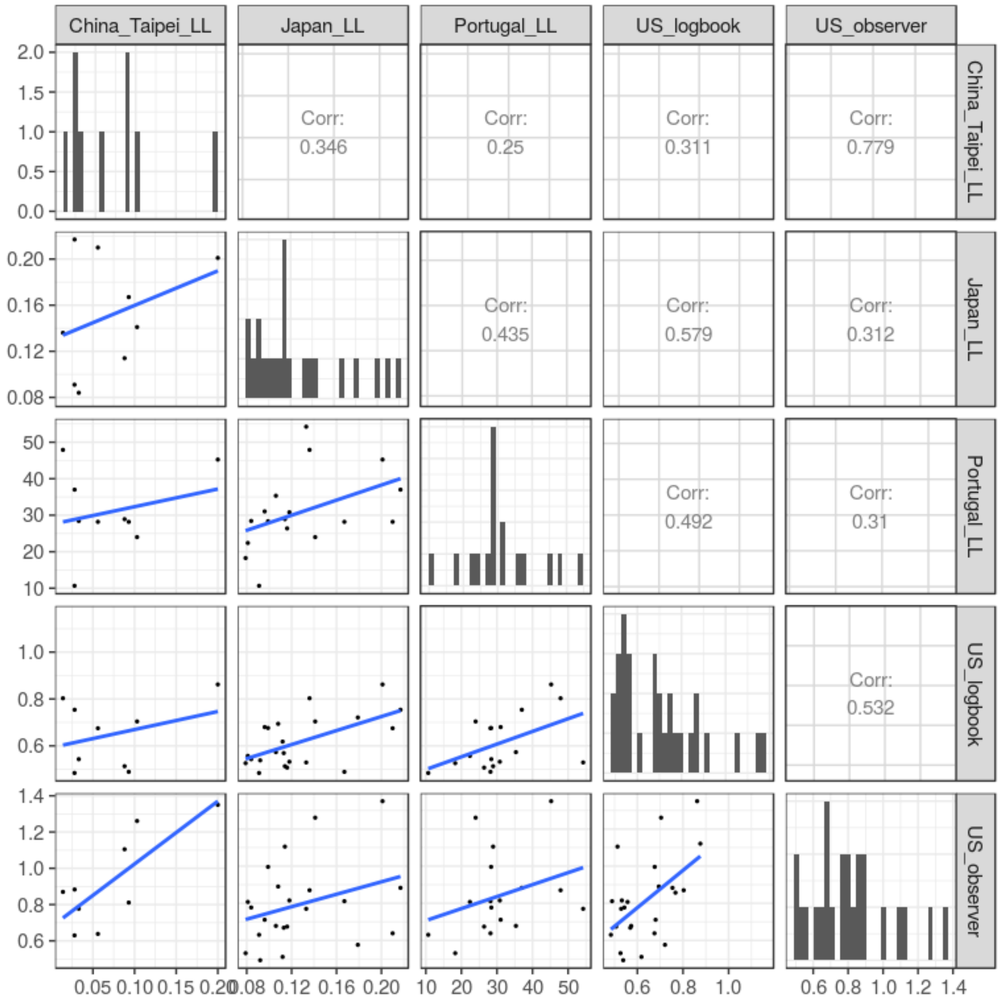

Figure 9.7. Shortfin mako in the North Atlantic. North Atlantic pairwise scatter plots for agreed indices. X- and Y-axis are scaled indices. Source: ICCAT.

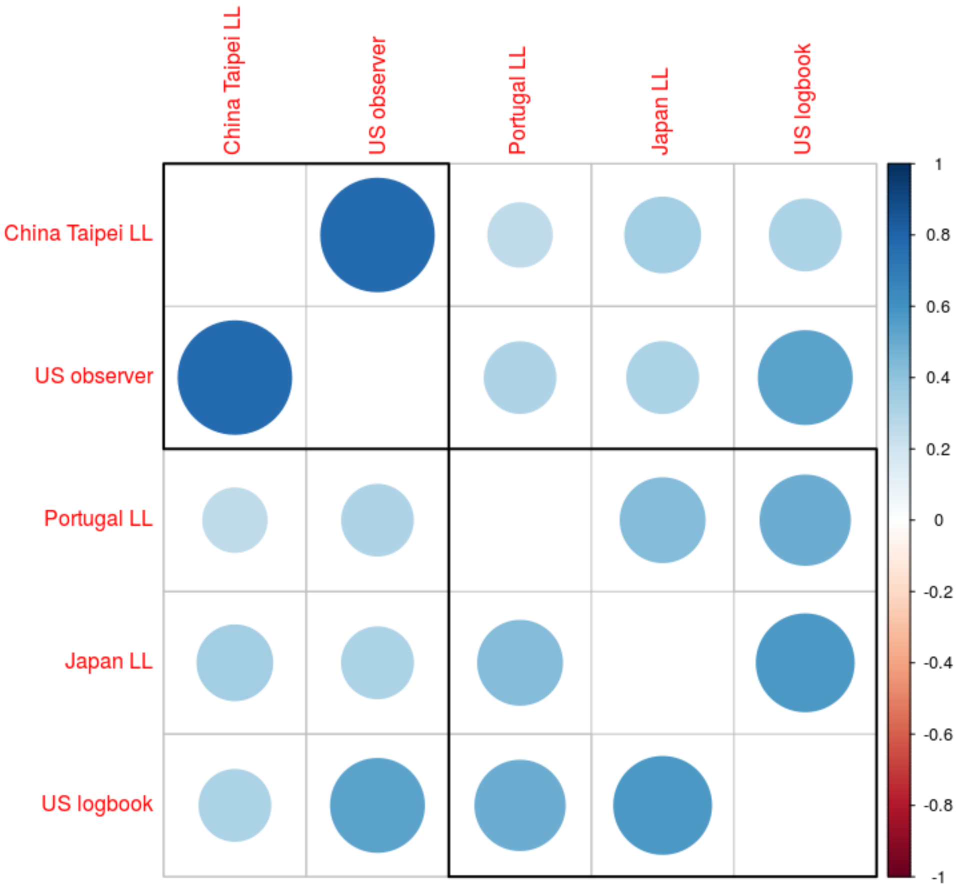

Figure 9.8. Shortfin mako in the North Atlantic. North Atlantic correlation matrix for the agreed indices; blue indicates positive and red negative correlations, the order of the indices and the rectangular boxes are chosen based on a hierarchical cluster analysis using a set of dissimilarities. Source: 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 2018

There were no major changes to the fishery noted in 2018.

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 2018. 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 WKSHARK2 (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 2005–2018 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. 70–80% in 2017 and 2018, 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, which explains values for this year to be less than declared in previous years. The main tope landings are recorded from areas 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.

Data analysis from the UK (E&W) observer programme (Silva and Ellis, 2019) suggested that the introduction of the Tope (Prohibition of Fishing) Order 2008, may have influenced the discard-retention patterns (Figure 10.2). This change was more evident on tope caught in drift and static gillnet fisheries where the proportion of discards increased from 11% (2002–2007) to 67% (2008–2016). No apparent change was observed by otter trawlers, with similar levels for both time periods (ca. 77%).

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 (WKSHARK3) 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 (Figure 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 Fiure 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 2005–2018 (Figure 10.9) and shows an increasing trend from 2012–2016, with a slight decrease in 2017 and 2018. 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. Survey indices for the whole time series were updated with new estimates provided in 2019. The values have differed from the previous survey index as values are now scaled to the survey area rather than the ecoregion.

EVHOE-WIBTS-Q4: Abundance and biomass estimates were calculated for the time series 1997–2016 (Figure 10.10), and fluctuate without trend. Survey did not occur in 2017, and data for 2018 are not shown at present.

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 30 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 7641 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) $R_{i,y} | A_{i,y} \sim \text{Bernouilli}(A_{i,y} * p_{i,y})$

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) $A_{i,y+1} | A_{i,y} \sim \text{Bernouilli}(A_{i,y} * \Phi_y)$
$\text{logit}(\Phi_y) \sim \text{Normal}(\text{logit}(\Phi_{y-1}), \sigma_\Phi)$

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) $R_{i,y} | A_{i,y} \sim \text{Bernouilli}(A_{i,y} * p)$

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 ~ Unif(0, 300 000) and σ_y~ 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)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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 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 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
UK (E&W)	0	0	0	0		1		3	8
UK Scotland									
Subtotal	78	40	46	0	71	77	68	83	34

ICES Area and Nation	1996	1997	1998	1999	2000	2001	2002	2003	2004
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 2005–2018 following WKSHARK2 (ICES, 2016a).

Fishing Area	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
27.2	0.0	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	14.8	4.9
27.5b	0.0	0.0	0.5	0.1	0.0	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	0.7	0.2
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	267.5	302.3
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	67.1	79.6
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	37.2	23.4
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	69.8	41.4
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**	**457.1**	**451.9**

*** 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) 2005–2018 following WKSHARK2 (ICES, 2016a)

Nation	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Belgium												0.1	0.0	0.0
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	312.9	355.8
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	11.6
Norway						0.1	0.2		0.0		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	70.0	41.4
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	30.5
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	13.8	12.6
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**	**387.4**	**451.9**

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

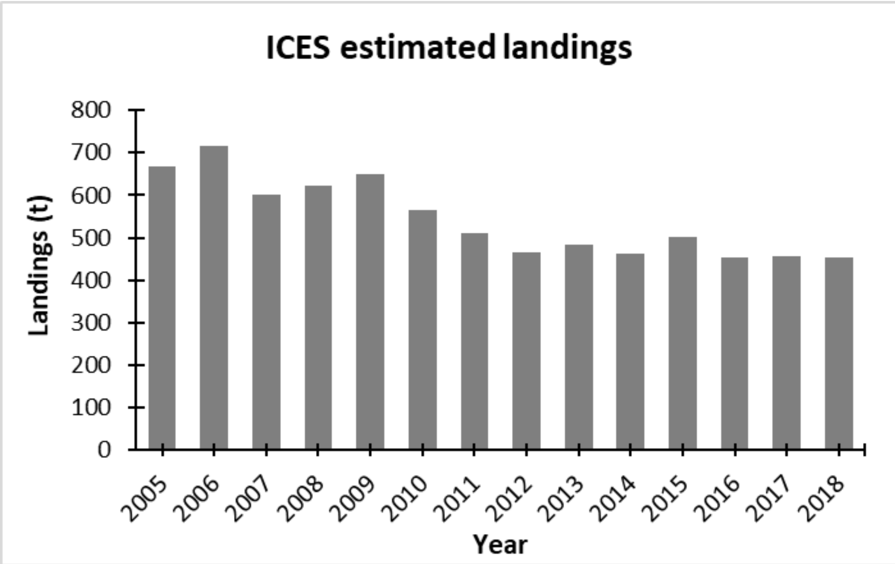

Figure 10.1. Tope in the Northeast Atlantic. ICES species-specific estimated landings 2005–2018.

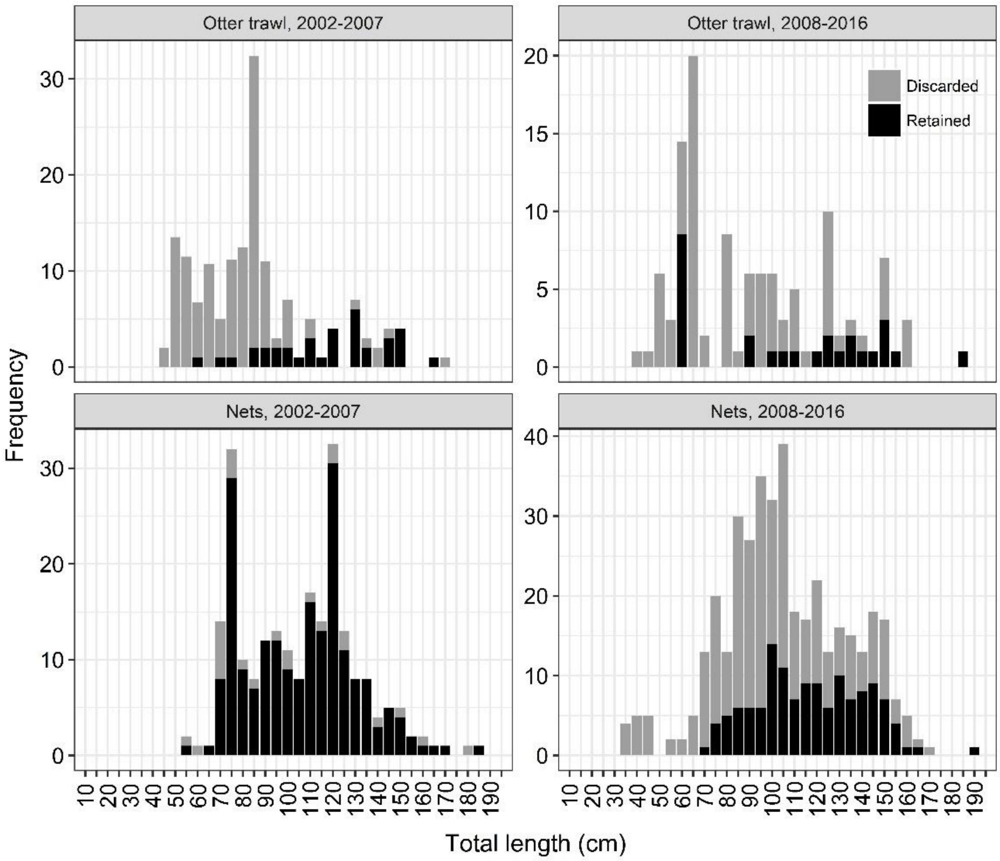

Figure 10.2. Tope in the Northeast Atlantic. Length–frequency of discarded and retained tope *Galeorhinus galeus* (5 cm length classes) caught by otter trawl and gill nets during the periods 2002–2007 and 2008–2016, as recorded in the Cefas observer programme. Source: Silva and Ellis (2019).

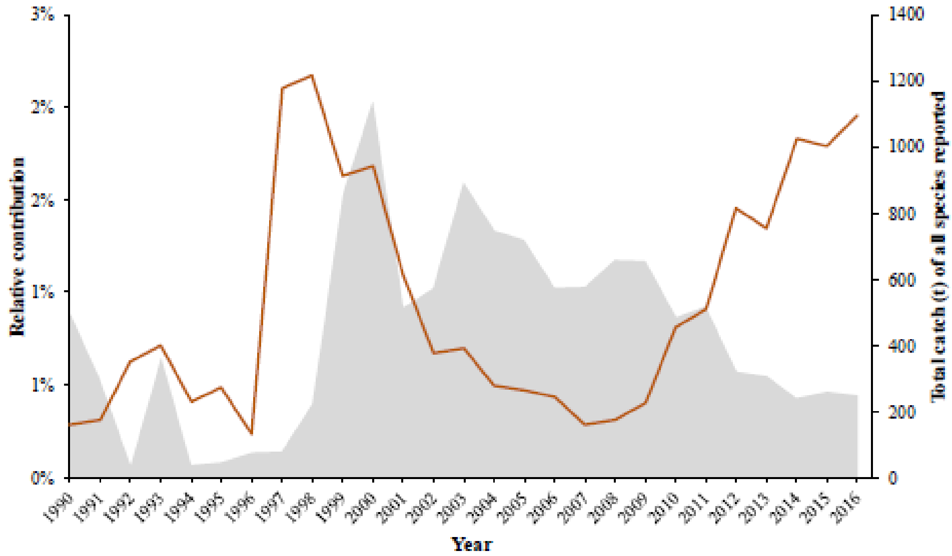

Figure 10.3. Tope in the Northeast Atlantic. Total catch of all species (■) and relative contribution of tope *Galeorhinus galeus* to all species (—) landed by the Azorean bottom longline fleet and sampled by the DCF inquiries.

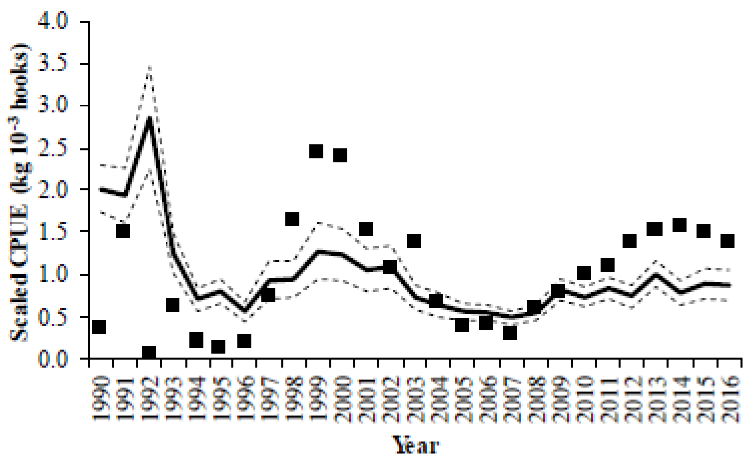

Figure 10.4. Tope in the Northeast Atlantic. Nominal (■) and standardized (—) CPUE (kg 10^{-3} hooks) for tope *Galeorhinus galeus* from the Azorean bottom longline fishery, 1990–2016. Dotted lines represent 95% confidence intervals for the standardized CPUE.

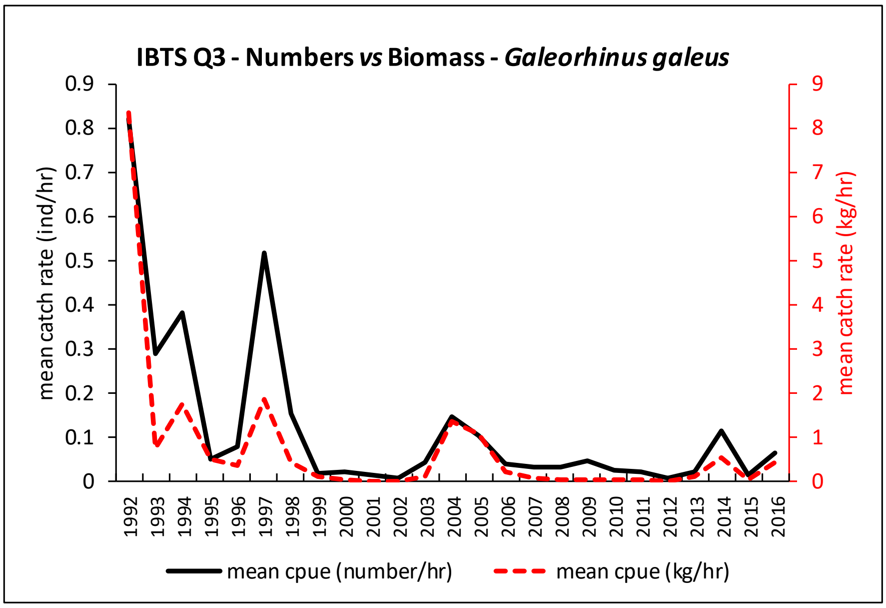

Figure 10.5. Tope in the Northeast Atlantic. Mean catch rate in terms of numbers (ind/hr) and biomass (kg/hr) during the IBTS_Q3 of the North Sea (1992–2016). Note: The large catch in 1992 is largely due to a large catch reported in one haul, and these data should be verified. Some catches of tope are considered to have been reported as *Mustelus* on DATRAS, consequently this time-series does not provide a robust abundance trend.

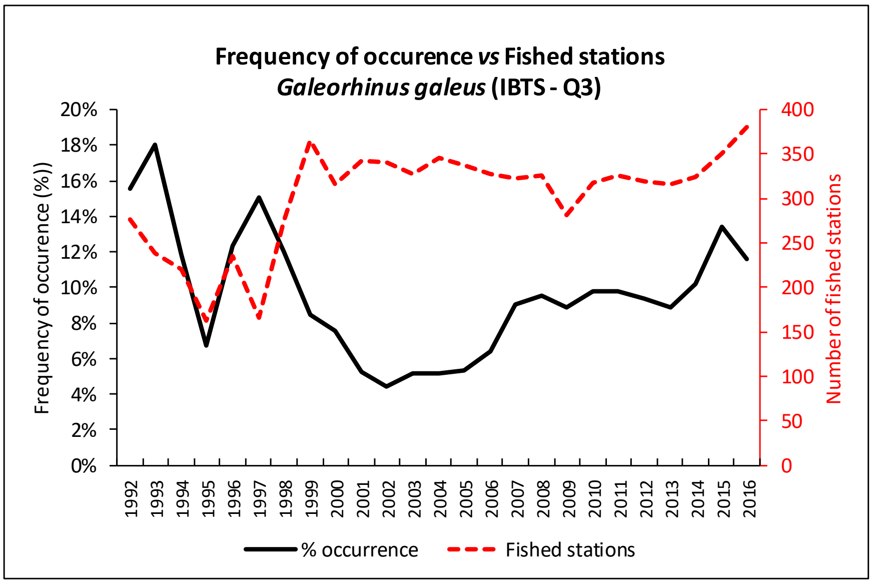

Figure 10.6. Tope in the Northeast Atlantic. Frequency of occurrence and number of fished stations in the IBTS-Q3 of the North Sea (1992–2016).

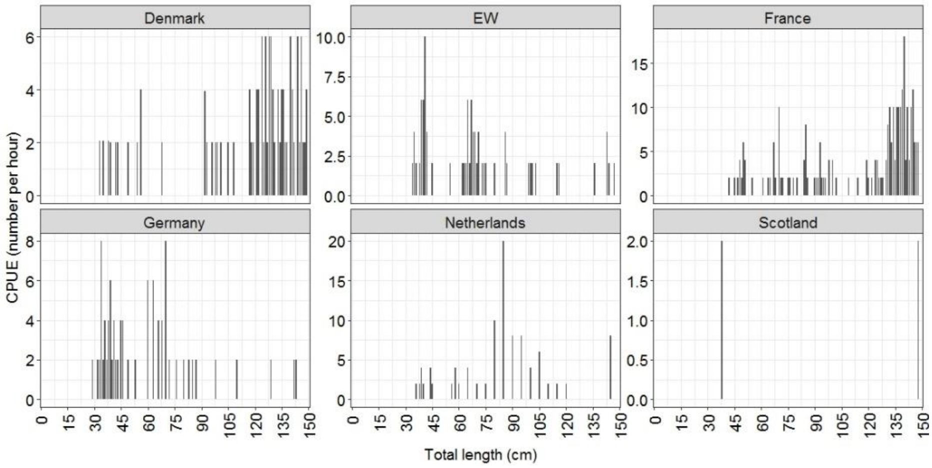

Figure 10.7. Tope in the Northeast Atlantic. Length-frequency distribution of tope by country in the IBTS-Q3 of the North Sea (1992–2016).

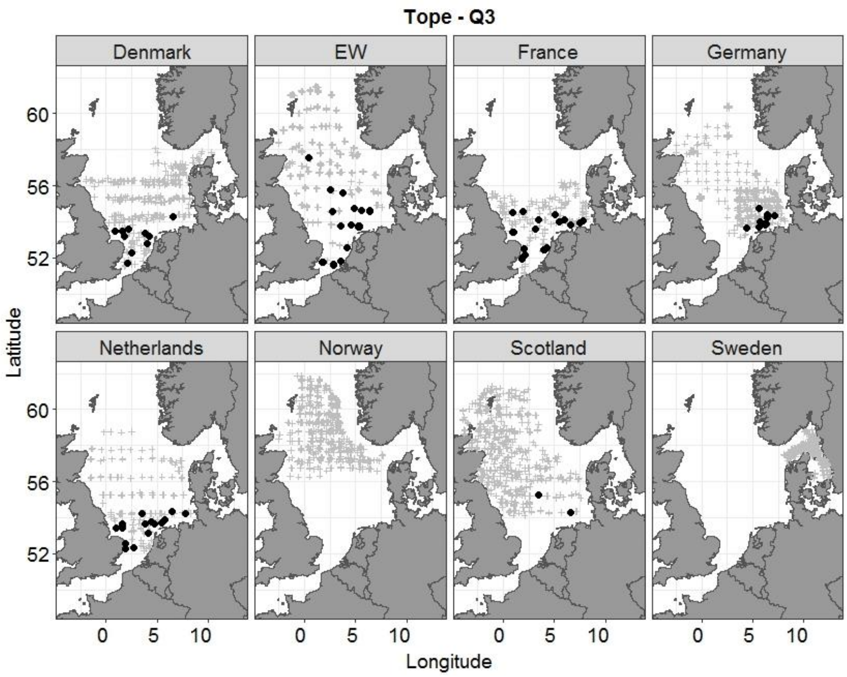

Figure 10.8. Tope in the Northeast Atlantic. Spatial distribution of tope by country in the IBTS-Q3 of the North Sea (1992–2016) (black dots = positive hauls; grey dots = negative hauls).

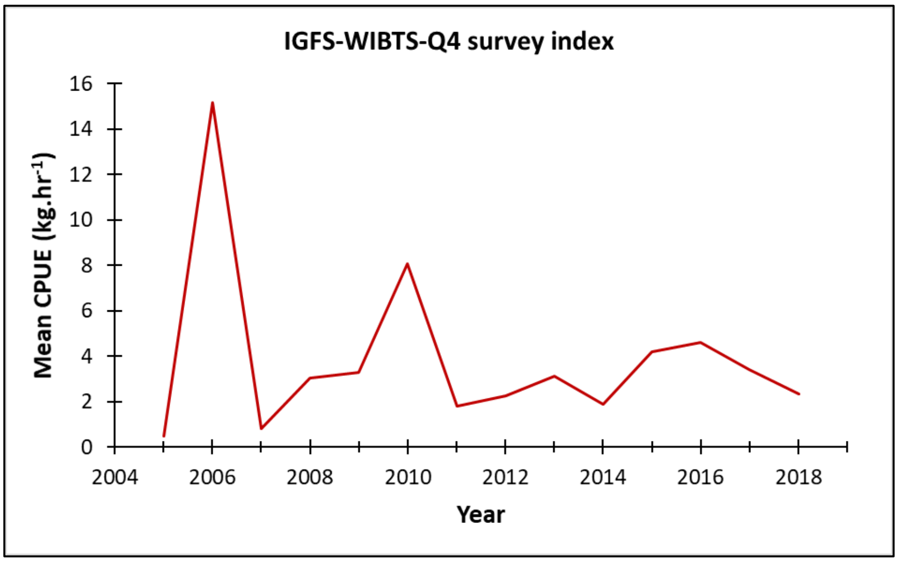

Figure 10.9. Tope in the Northeast Atlantic. Mean catch rate in terms of total biomass (kg/ kg) during the Irish Ground Fish Survey (IGFS-WIBTS-Q4) 2005–2018. (Updated survey index in 2019 for whole time series)

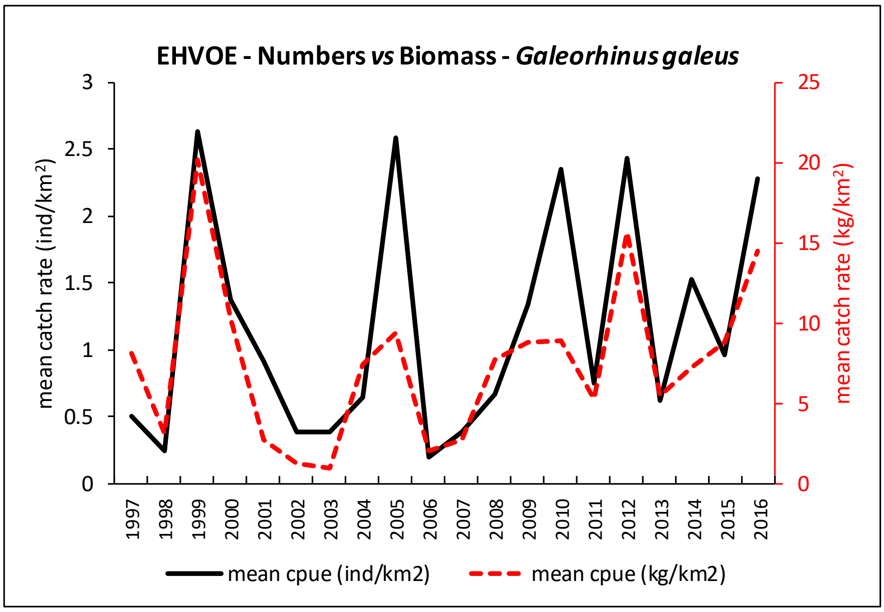

Figure 10.10. Tope in the Northeast Atlantic. Mean catch rate in terms of numbers (ind/km²) and biomass (kg/km²) during the EHVOE-WIBTS-Q4 (1997–2016).

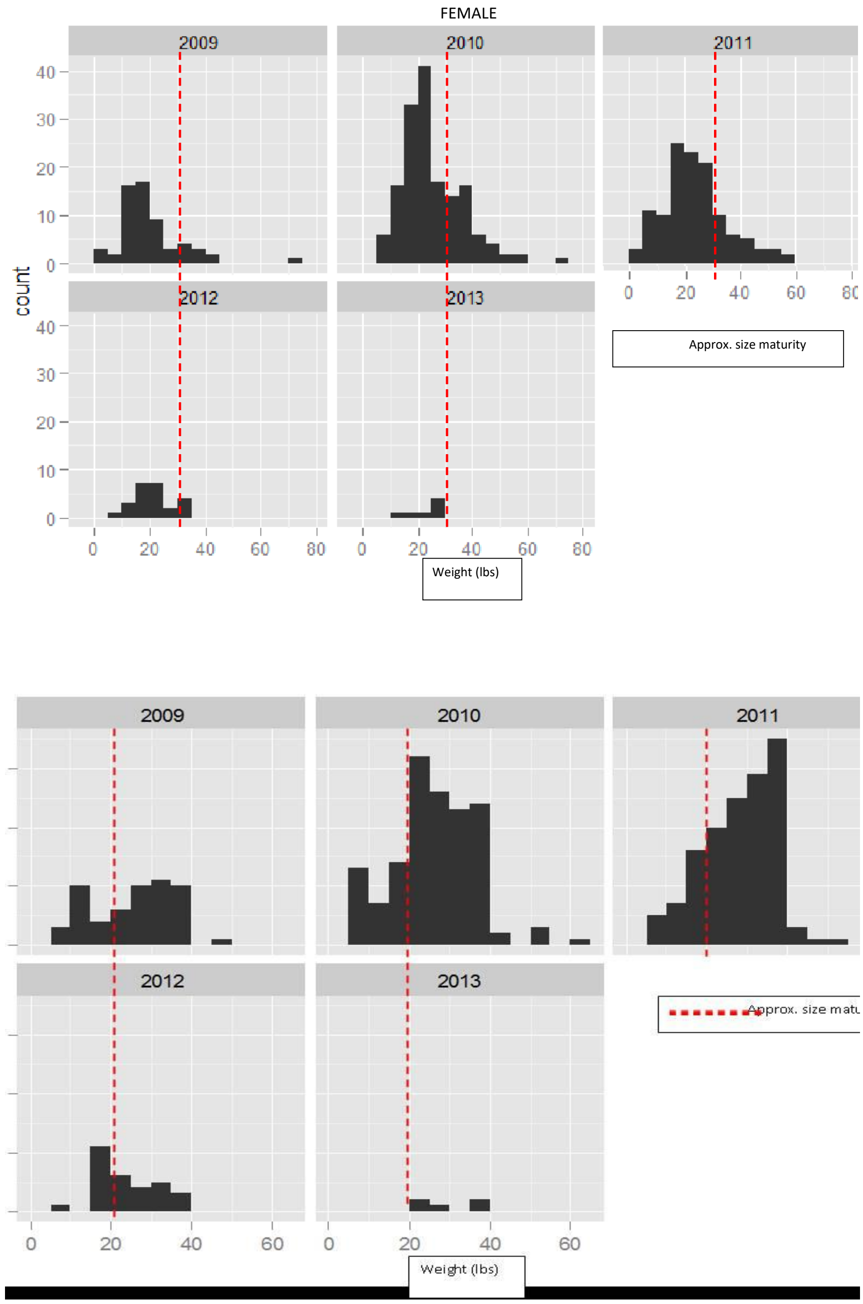

Figure 10.11. Tope in the Northeast Atlantic. Count by year of captures of female (top) and male (bottom) tope by recreational fishery in the Mull of Galloway, Scotland. The red lines show approximate weight-at-maturity. Source: James Thorburn, University of Aberdeen. Unpublished data, 2014.

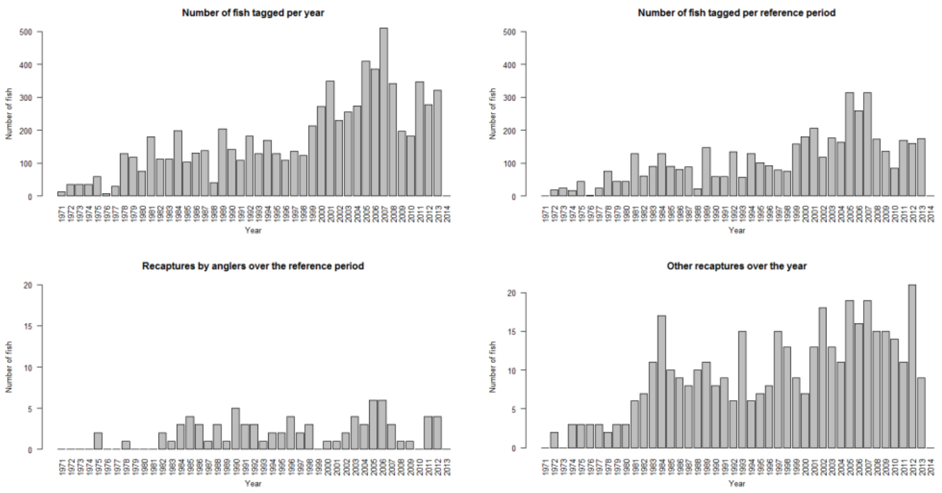

Figure 10.12. Tope in the Northeast Atlantic. Numbers captured, recaptured and newly captured per year. Source: Bal *et al.* (2015 WD).

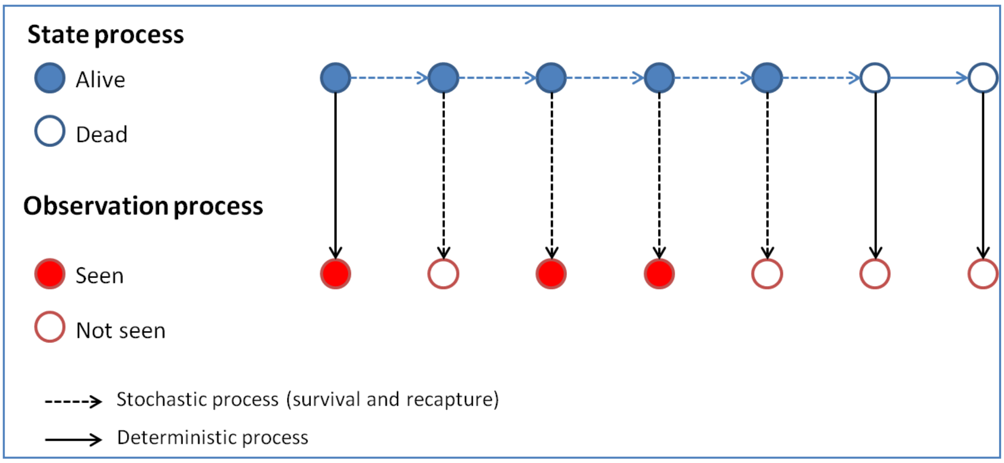

Figure 10.13. Tope in the Northeast Atlantic. Example of the state and observation process of a marked individual over time for the CJS model. The sequence of true states in this individual is A = [1, 1, 1, 1, 1, 0, 0] and the observed capture history is H = [1, 0, 1, 1, 0, 0, 0]. Source: Bal *et al.* (2015 WD).

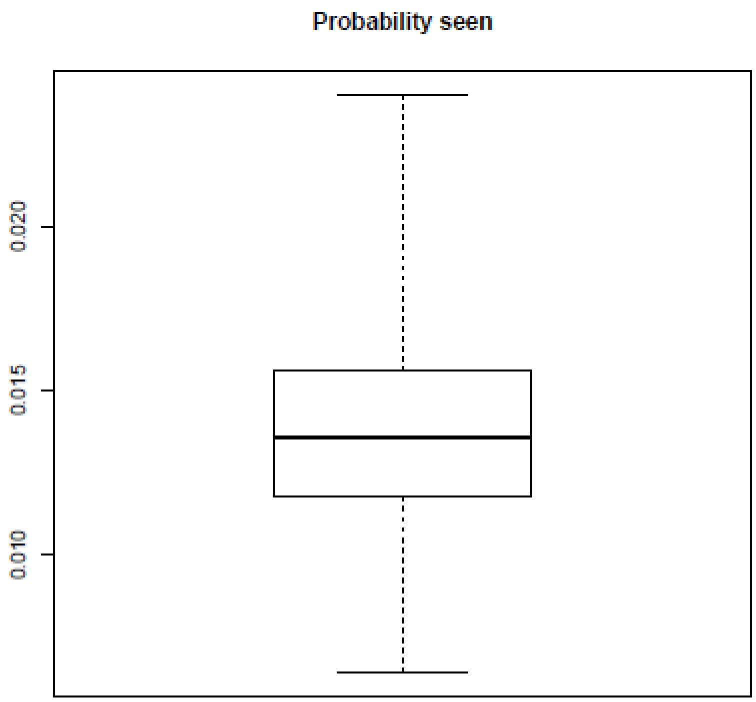

Figure 10.14. Tope in the Northeast Atlantic. Individual capture probability posterior.

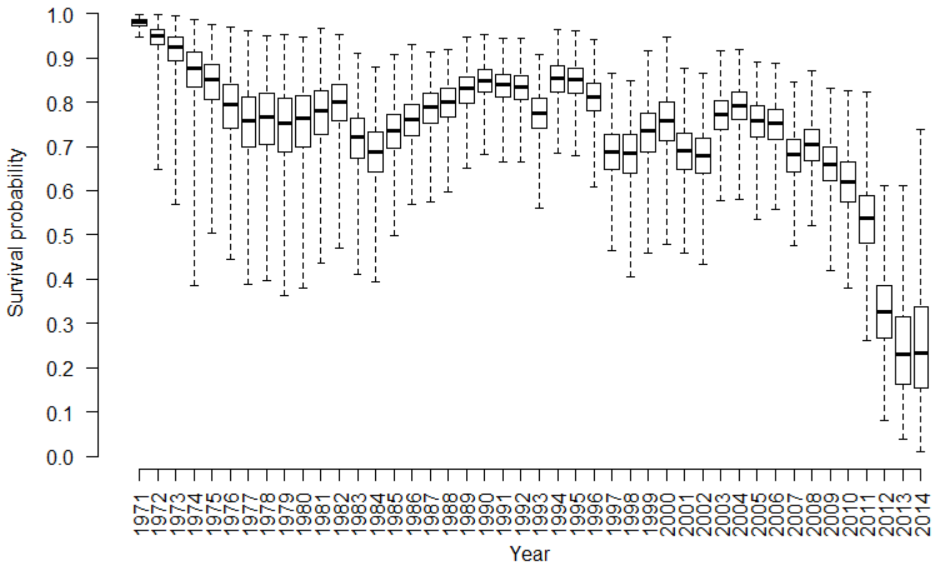

Figure 10.15. Tope in the Northeast Atlantic. Annual survival probabilities posteriors. Source: Bal *et al.* (2015 WD).

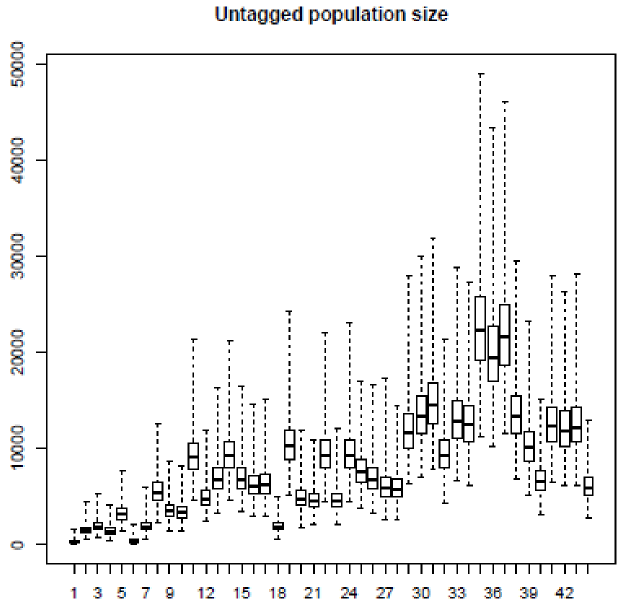

Figure 10.16. Tope in the Northeast Atlantic. Boxplot annual population size posteriors without population dynamics structure, x-axis shows study year (1971–2014).

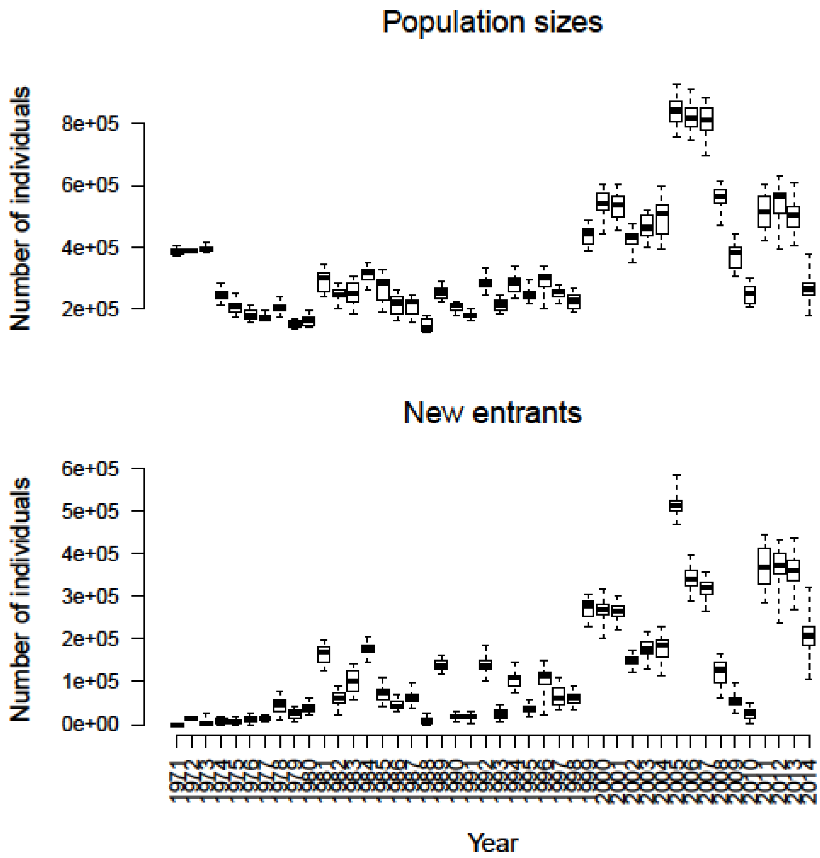

Figure 10.17. Tope in the Northeast Atlantic. Boxplot annual population sizes and number of entrant's posteriors with population dynamics structure (1971–2014).

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 2018

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

In recent years, the EU regulations regarding thresher sharks are in the annual TAC regs in the section marked "SPECIAL PROVISIONS FOR COMMUNITY VESSELS FISHING IN THE ICCAT AREA". I

In 2019, *Alopias superciliosus* was included in the EU list of prohibited species (Article 20 of COUNCIL REGULATION (EU) 2019/124), and target fisheries for all threshers are prohibited.

The EU prohibition on big-eye thresher being retained//landed have been in force since 2009 (COUNCIL REGULATION (EC) No 43/2009)

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 in the following years.

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, 6–9.a.

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 co-operate 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.

Alopias vulpinus

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.

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.

A. superciliosus

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.

Fifteen bigeye threshers were tagged with pop-up satellite archival tags (PSATs) in 2012 and 2014 in the tropical northeast Atlantic, with successful transmissions received from 12 tags for a total of 907 tracking days. Marked diel vertical movements were recorded on all specimens, with most of the daytime spent in deeper colder water and nighttime spent in warmer water closer to the surface. The operating depth of the pelagic longline gear was measured and it was concluded that there is spatial overlap between the fishery and the habitat particularly during the night and overlap is higher for juveniles (Coelho *et al.*, 2014).

11.7.2 Nursery grounds

Further information on potential nursery areas is given in the Stock Annex.

A. superciliosus

Nursery areas for *A. superciliosus* occur off the southwestern Iberian Peninsula and Strait of Gibraltar (Moreno and Moron, 1992).

A. vulpinus

Juvenile *A. vulpinus* are known to occur in the English Channel and southern North Sea (Ellis, 2004).

11.7.3 Diet

Both common thresher and bigeye thresher species feed mostly on small pelagic fish, including mackerel and clupeids, as well as squid and octopus.

11.8 Exploratory assessments

Both species were included in a Productivity-Susceptibility Analysis (PSA) for the pelagic fish assemblage (ICCAT, 2011). However, the lack of reliable landing data, and absence of fishery-independent data hampers the assessment of the two thresher stocks.

The common thresher shark along the west coast of North America are assumed to be a single, well-mixed stock. This assumption is supported by their genetics, tagging data, and seasonal movements. Stock Synthesis modelling platform (v3.24U) was used to conduct the analysis and estimate management quantities in which eight fishing fleets operating in USA and Mexico waters were included (Teo *et al*., 2018).

A Bayesian population modelling tool integrating separable virtual population analysis, per-recruit models and age-structured demographic analysis was developed for the bigeye thresher population in an area subset of the western North Pacific. Risk analyses revealed that only low levels of fishing pressure (10% of the current fishing pressure) over a wide range of ages could maintain a relatively low risk of population decline for bigeye threshers. Sensitivity testing indicated that the model is robust to prior specification (Tai *et al*., 2019).

11.9 Stock assessment

Both common thresher and bigeye thresher stocks were assessed in 2019 under ICES framework for category 6 (ICES, 2012). ICES considers that for stocks without information on abundance or exploitation, as is the case of these two stocks, a precautionary reduction of catches should be implemented unless there is ancillary information clearly indicating that the current level of exploitation is appropriate for the stock.

For the stock assessment species-specific landings are required. Any quantitative assessment should be undertaken in collaboration with ICCAT.

11.10 Quality of assessments

There are no species stock assessments for common thresher and bigeye thresher in the Northeast Atlantic, but ICCAT, in 2019, conducted an Ecological Risk Assessments for elasmobranchs to evaluate the biological productivity of these stocks and a susceptibility analysis to assess their propensity to capture and mortality in pelagic longline fisheries.

Historically, landing data for the entire stock areas are uncertain for both common thresher and bigeye thresher. Some historical commercial catch-per-unit-effort data are available for parts of the stock area, but data for the two species may be confounded. It is unclear as to how representative CPUE data would be for informing on trends in the two stocks' abundance.

Species-specific landings are required and future quantitative assessments should be undertaken in collaboration with ICCAT.

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).

All three species of thresher sharks were listed in Appendix II on 02/01/2017 (Entry into effect delayed by 12 months, i.e. until 04 October 2017). 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 went 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 (Taipei)	MEDI														0	0	0	0	0		
	NE														0	0.2	2	2.1	0.2		
Cote d´Ivoire	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

Flag	Area	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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.

Year	Spain			France			Ireland		Italy	Malta		Portugal			United Kingdom
	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

Year	Spain			France			Ireland		Italy	Malta		Portugal			United Kingdom
	THR	BTH	ALV	THR	BTH	ALV	THR	ALV	ALV	BTH	ALV	THR	BTH	ALV	THR
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

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 2018, 2019 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	2018
France	33.1	36.2	42.1	26.5	38.7	28.0	51.3	34.0	33.6	42.9	38.8	70.5	55.9	44.7
Ireland		0.3												0.6
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	1	0.6	1	0.3
Spain	4.1	17.7	66.8	103.1	96.5	0.2	<0.1	0.1						44.6
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		0.6
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 Northeast 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 southern parts of the ICES areas (subareas 9–10), though some may occasionally range further north into the Bay of Biscay (Subarea 8). Some of these species also occur in the Mediterranean Sea.

In October 2011, a whale shark *Rhincodon typus* was reported from southern Portugal (Rodrigues *et al.*, 2012), and the northern limits of this species also extend to the Azores (Afonso *et al.*, 2014).

12.1.1 Taxonomic changes

A recent treatise on batoids (Last *et al.*, 2016) considers all eight species of manta ray and devil ray to be in a single genus *Mobula,* with two of these species (giant manta ray *Mobula birostris* and giant devil ray *Mobula mobular* shown as occurring in the southernmost part of the ICES area (Subarea 9). Both these species also occur around the Azores (Subarea 10; Santos *et al.*, 1997), with Sobral and Afonso (2014) also indicating that the Chilean devil ray *Mobula tarapacana* also occurred as far north as the Azores.

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 hammerhead and 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 *Mobula* spp.). 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 2018

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 14 of Council Regulation (EU) 2019/124 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;
- Mobulid rays *Mobula* spp. in all waters;
- Whale shark *Rhincodon typus* in all waters.

Article 20 of Council Regulation (EU) 2019/124 also lists prohibited species in relation to fisheries operating in the ICCAT Convention area. The species prohibited include hammerhead sharks (Family Sphyrnidae, except for the *Sphyrna tiburo*), oceanic whitetip *Carcharhinus longimanus* and silky shark *Carcharhinus falciformis*.

The listings on Article 20 of Council Regulation (EU) 2019/124 are in support of ICCAT recommendations 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).

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 tonnes 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 by 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 Northwest 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

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 a range of sources (e.g. Branstetter, 1987, 1990; Stevens and Lyle, 1989; Shungo *et al*., 2003; Piercy *et al*., 2007). A summary of the main biological parameters is given in Table 12.6.

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 Southeast coast of the USA, suggesting offshore nurseries over the continental shelf (Seki *et al*., 1998). Scalloped hammerhead nurseries are usually in shallow coastal waters.

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 of *M. mobular* (estimates varied from 200–500) 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 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 considerations

The recent European Red List of European marine fish (Nieto *et al*., 2015) listed white shark *Carcharodon carcharias* as Critically Endangered, and giant devil ray *Mobula mobular*, oceanic whitetip *Carcharhinus longimanus* and sandbar shark *Carcharhinus plumbeus* as Endangered in European seas. Many other pelagic sharks are listed as Data Deficient in European waters, including silky shark *Carcarhinus falciformis,* blacktip *C. limbatus,* dusky shark *C. obscurus,* tiger shark *Galeocerdo cuvier,* scalloped hammerhead *Sphyrna lewini,* great hammerhead *S. mokarran,* smooth hammerhead *S. zygaena* and longfin mako *Isurus paucus.* Pelagic stingray *Pteroplatytrygon violacea* is listed as Least Concern.

The Convention on the Conservation of Migratory Species of Wild Animals (CMS) lists several elasmobranchs on Appendix I (i.e. Contracting Parties that are a Range State should prohibit the taking of such species) including whale shark *Rhincodon typus, Carcharodon carcharias* and *Mobula* spp. These species are also listed on Appendix II of CMS (i.e. species that require international agreements for their conservation and management), with *Isurus paucus, Carcharhinus falciformis, Carcharhinus obscurus, Sphyrna lewini* and *S. mokarran* also listed on Appendix II.

Carcharodon carcharias, Rhincodon typus, Carcharhinus falciformis, C. longimanus, Sphyrna lewini, S. mokarran, S. zygaena and *Mobula* spp. are also listed on Appenidx II of CITES.

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 considered in this section are included in various conservation initiatives, including CMS and CITES (see above), with some protected in the Mediterranean Sea, through their listing on Appendix II of the Barcelona Convention.

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 fisheries for large pelagic fish in 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).

A subsequent project updated this work, providing updated information on the occurrence of pelagic sharks and rays in different fisheries, updated information on data collection and methodological approaches for assessing their status, a critical review of existing Conservation and Management Measures (CMMs) for sharks and their current conservation status, and approaches to improve and/or provide alternative options for conservation and management of sharks. The final report (Coelho *et al.*, 2019) is available at https://publications.europa.eu/en/publication-detail/-/publication/bb27e867-6185-11e9-b6eb-01aa75ed71a1/language-en.

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).

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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			
			7	8	9	Notes
Lamnidae	White shark	*Carcharodon carcharias*	○	⦿	⦿	[1]
	Longfin mako	*Isurus paucus*	○	○	⦿	
Rhincodontidae	Whale shark	*Rhincodon typus*	○	○	⦿	
Carcharhinidae	Bronze whaler	*Carcharinus brachyurus*	○	○	?	
	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	Giant devil ray	*Mobula mobular*	⦿	⦿	⦿	[5]
	Giant manta ray	*Mobula 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 (2000–2017) as reported to ICCAT (Downloaded August 2019) 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	2017
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								43
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	22
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								4
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 (2000–2017) as reported to ICCAT (Downloaded August 2019) 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: North-east 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	2017
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									

Nation	Category	Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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 (2000–2017) 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	2017
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 falciformis*	NE																	0	29
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								

Nation	Category	Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
France	*Carcharias taurus*	NE										0.06	1	3						
France	*Carcharodon carcharias*	NE												0.07						
France	*Sphyrna lewini*	NE										0.09							<1	2
France	*Sphyrna* spp	NE												0.07						1
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 August 2019) 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	2017
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			
Curacao	*Carcharhinus falciformis*	NE																		4
El Salvador	*Carcharhinus falciformis*	NE																		17
Gabon	Carcharhinidae	ETRO			123															
Ghana	*Carcharhinus longimanus*	ETRO															2	123.0		
Ghana	*Sphyrna* spp	ETRO															10	311		
Guinea Ecuatorial	*Carcharhinus longimanus*	ETRO															3			
Morocco	Carcharhinidae	NE															238	922		89
Morocco	Carcharhinidae	MEDI															32	533		4
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					
Panama	*Carcharhinus falciformis*	NE																		4

Nation	Category	Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Senegal	Carcharhinidae	CVER																154		
Senegal	Carcharhinidae	NE	1714	1806	1045	1387	1651	5401	1035	1221	1253	375	426	898			728	150	524	56
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	29

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								
Northeast Atlantic	*Carcharhinus* spp.	*Sphyrna* spp.	*Galeocerdo cuvier*	*Isurus paucus*	*Mobula* spp.	Total by-catch	% 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
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
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
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
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

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
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
Gian devilray *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 tonnes (average of 1250 tonnes per year). *A. radiata* accounted for 90–95% of the total skate bycatch.

13.2.2 The fishery in 2018

No new information. Since 2012, Norwegian declared landings have sharply increased and both in 2015 and 2017 they doubled compared to the previous year (157 tonnes to 369 tonnes, 374 tonnes to 704 tonnes, respectively). The reason for this increase is unknown. Norwegian skate landings from this area decreased again in 2018 (582 tonnes). Germany reported between <0.1 tonnes and 5 tonnes landed for the years 2013–2018.

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 released (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). 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, and Figure 13.1 shows their landings from 1973 to 2017. However, 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 tonnes, 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*) adds potential identification errors. The depth distribution of the two species in Dolgov *et al*. (2005a) and *L. fullonica* in the Barents Sea has 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. A workshop series in 2019 established the basis for an updated identification guide to be used for surveys and by the reference fleet.

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 4 and 19 over the last five and eight years, respectively, with a peak in 2017. 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 (1973–2018); "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 (1973–2018); "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	172	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	2018
Belgium	.	.	.	.
France	.	.	.	.
Germany	5	2	+	2
Iceland	.	.	.	.
Norway	369	374	704	582
Portugal	.	.	.	.
USSR/Russian Fed.	n.a.	n.a.	n.a.	n.a.
Spain	.	.	.	.
UK(E&W)	.	.	.	.
UK(Scotland)	.	.	.	.
Total	374	376	704	584

Table 13.2. Demersal elasmobranchs in the Barents Sea. Estimated Norwegian landings (t) of skates and rays by species in ICES Subarea 1. 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

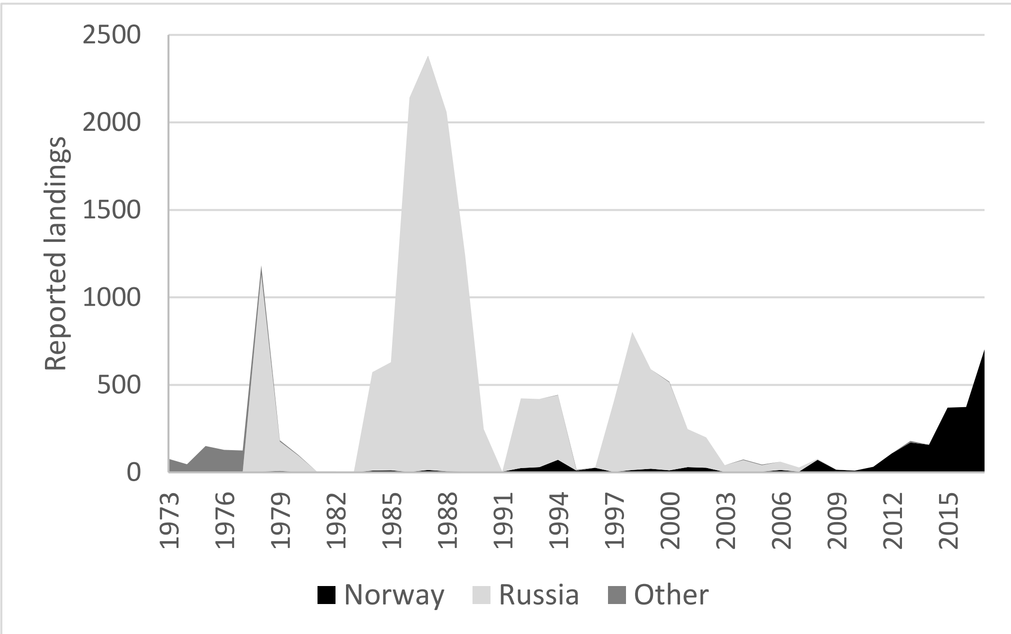

Figure 13.1. Demersal elasmobranchs in the Barents Sea. Reported landings (t) of skates from ICES Subarea 1 (1973–2017).

Q1 **Q3**

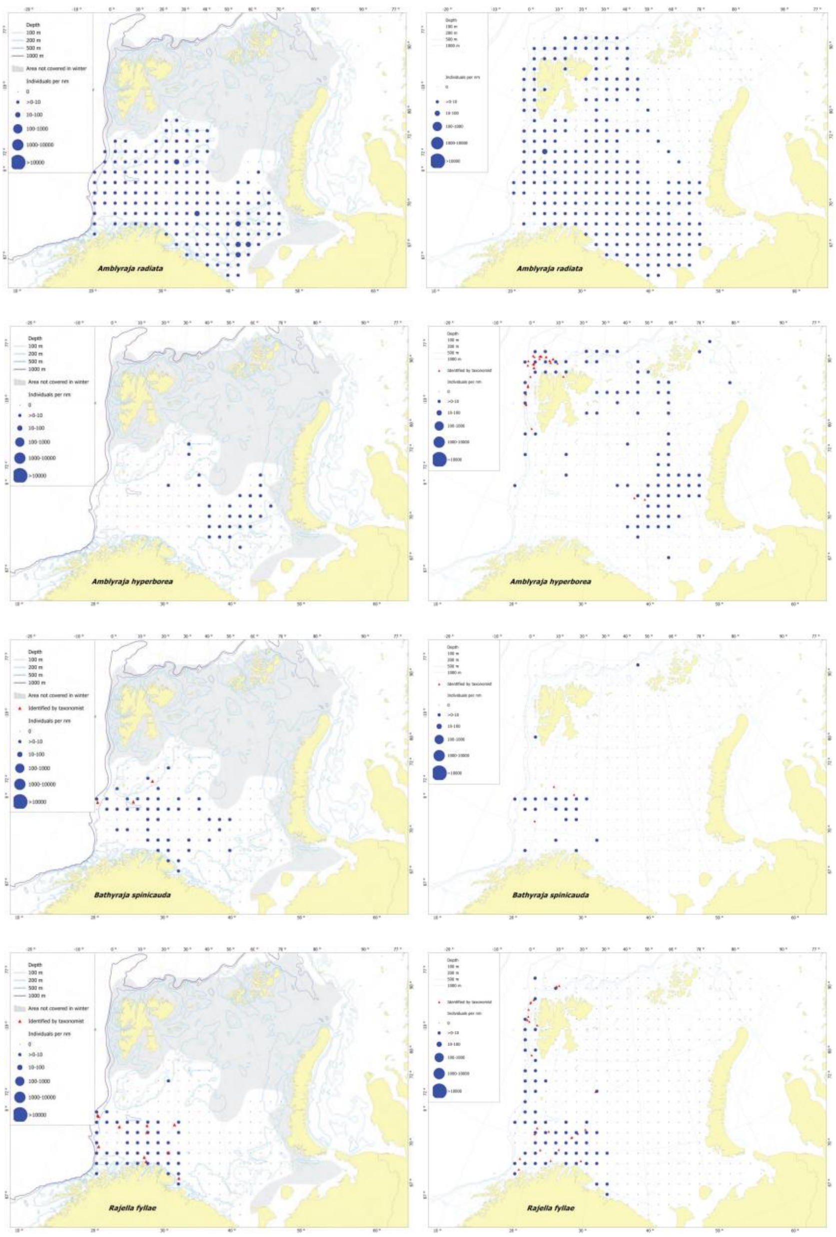

Figure 13.2. Demersal elasmobranchs in the Barents Sea. Spatial distribution of *A. radiata*, *A. hyperborea*, *B. spinicauda* and *R. fyllae* (top to bottom) in Q1 (left) and Q3 (right) Joint Russian–Norwegian surveys. Source: Wienerroither *et al*. (2011, 2013).

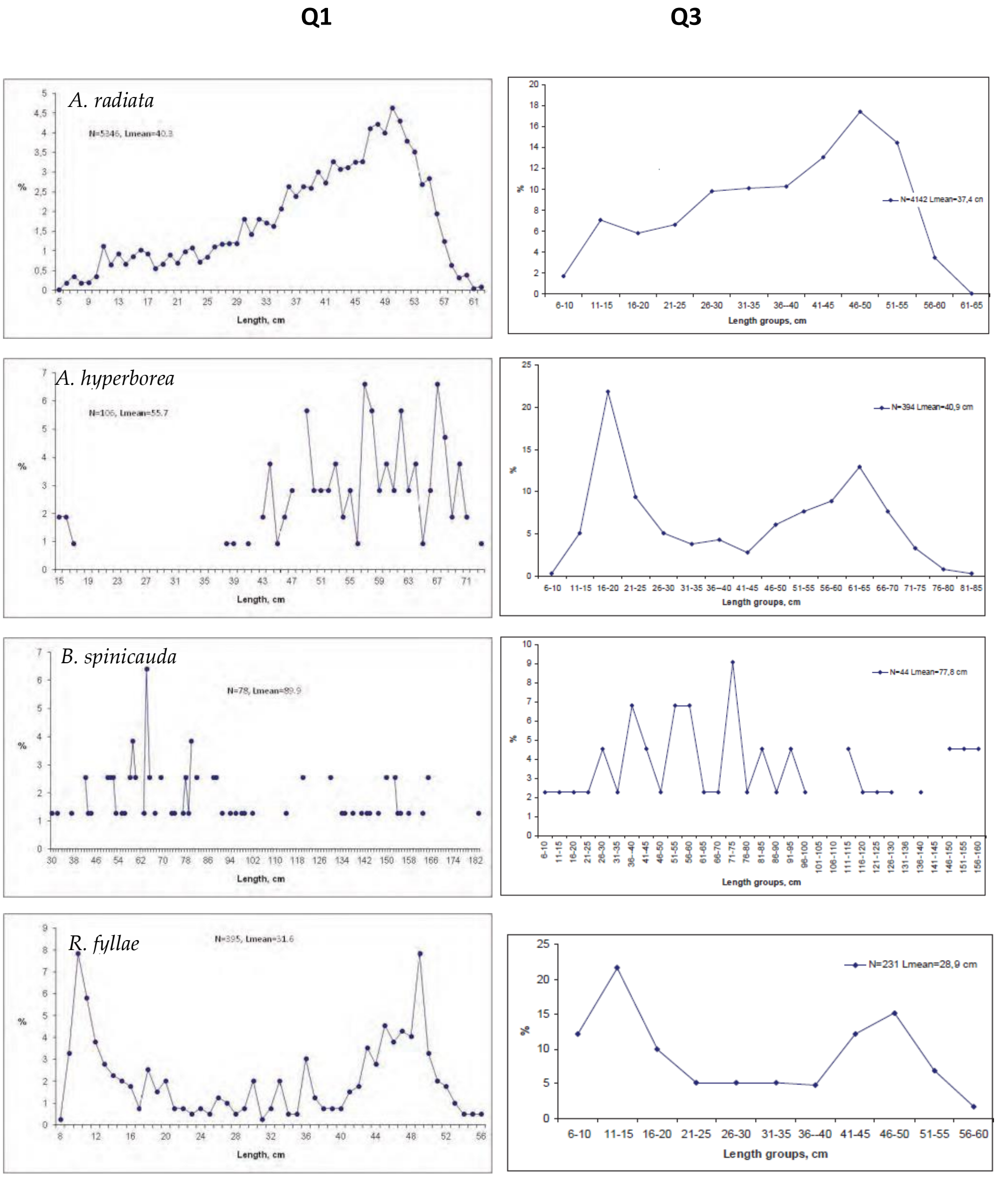

Figure 13.3. Demersal elasmobranchs in the Barents Sea. Length distributions of *A. radiata*, *A. hyperborea*, *B. spinicauda* and *R. fyllae* (top to bottom) in Q1 (left) and Q3 (right) Joint Russian–Norwegian surveys. Note that length distributions are not directly comparable between the two surveys. 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 (most likely *Dipturus intermedius* (Junge/Lynghammar, pers. comm)), 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 2018

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 1973–2018 (Table 14.1. For ICES Subarea 2, landings data are limited and, for skates, aggregated across all species. 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 and Figure 14.1 shows their landings from 1973 to 2016.

Landings data (usually not discriminated at species level) since 2010 have been provided by Norway (2010–2018), France (2010–2013), Germany (2010, 2013–2018), the UK (2010–2011, 2013, 2015–2016), Spain (2010, 2012–2014) and the Netherlands (2015) and. 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 (most likely 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 (most likely *Dipturus intermedius* (Junge/Lynghammar, pers. comm)), *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.*

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. A workshop series in 2019 established the basis for an updated identification guide to be used for surveys and by the reference fleet.

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; Europe: 2015) – this complex comprises *Dipturus batis* and *Dipturus intermedius* but their status has not been assessed on a species level yet;
- "Endangered": *L. circularis* (2014);
- "Vulnerable": *L. fullonica* (2014);
- "Near threatened": *B. spinicauda* (2006), *D. nidarosiensis* (2014), *D. oxyrinchus* (2014) and *R. clavata* (2005; Europe: 2014).

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 1973–2018. "n.a." = no data available, "." = means zero catch, "+" = < 0.5 tonnes. Countries with only occasional catches are not included by country 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

Table 14.1 cont'. Demersal elasmobranchs in the Norwegian Sea. Total landings (t) of skates from ICES Subarea 2 (and Division 2.a and 2.b) from 1973–2018. "n.a." = no data available, "." = means zero catch, "+" = < 0.5 tonnes. Countries with only occasional catches are not included by country 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).

	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	5	1	1	+	+
Germany	.	2	2	7	1	.	.	.	+	1	.	.	1	2
Norway	233	118	111	142	133	146	189	259	258	250	198	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**	**2018**
Faroe Islands	.	.	.	
France	.	.	.	
Germany	2	1	1	6
Norway	112	198	111	213
Portugal	.	.	.	
USSR/Russ. Fed.	.	.	.	
Spain	.	.	.	
UK (combined)*	2	+	.	
Other	+	.	.	
Total	115	200	112	

Table 14.2. Demersal elasmobranchs in the Norwegian Sea. Estimated Norwegian landings (tonnes) 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 (most likely *Dipturus intermedius*)	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 (most likely *Dipturus intermedius*)	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).**

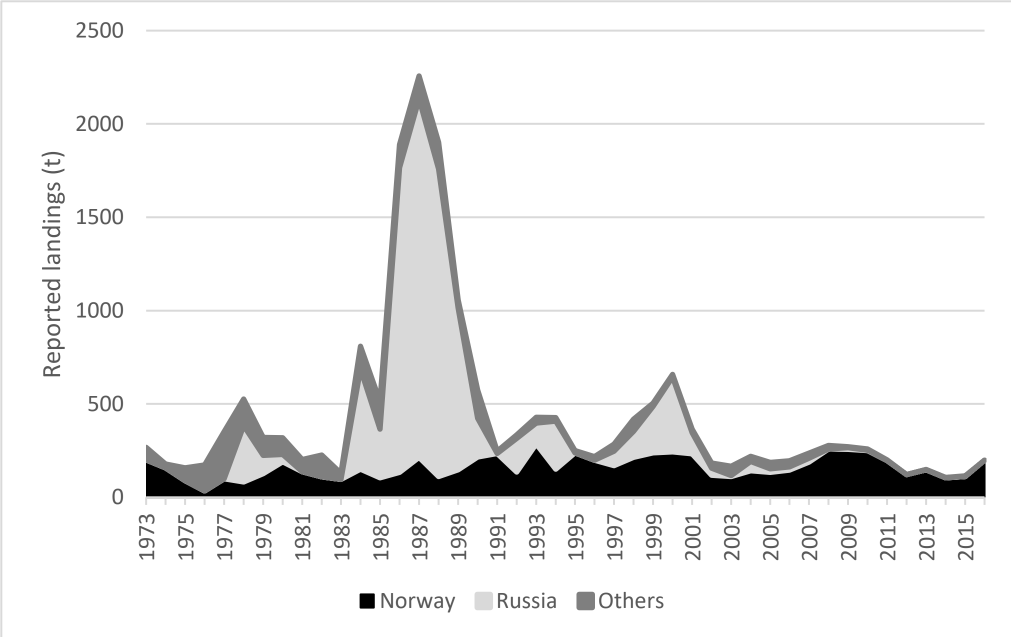

Figure 14.1. Demersal elasmobranchs in the Norwegian Sea. Total landings (t) of skates from ICES Subarea 2 (1973–2016).

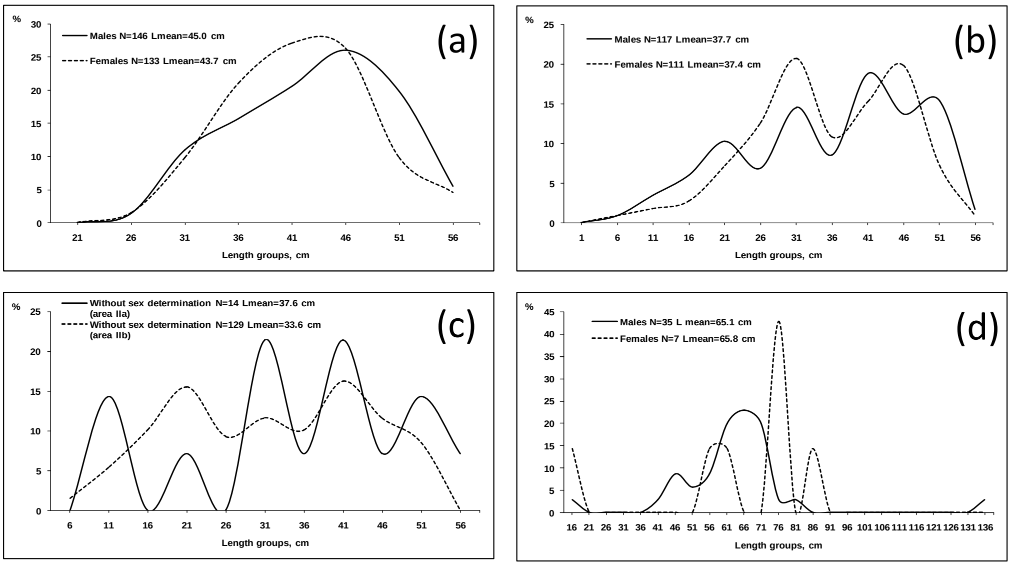

Figure 14.2. Demersal elasmobranchs in the Norwegian Sea showing the length composition of *A. radiata* in (a) commercial bottom-trawl catches in the Norwegian Sea in 2009, (b) Russian demersal survey (October–December 2009) and (c) the Norwegian Sea based on data from the joint Russian–Norwegian ecosystem 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 about 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).

Dipturus batis, frequently referred to as common skate, has recently been confirmed to comprise of two species being erroneously synonymised in the 1920s (Iglésias *et al.*, 2010; Griffiths *et al.*, 2010). The smaller species (previously described as *Dipturus flossada* by Iglésias *et al.*, 2010) is the common blue skate (*Dipturus batis* (FAO code RJB)) and the larger species may revert to the flapper skate (*Dipturus intermedius* (FAO code DRJ)). The member of the common skate complex present in the northern North Sea is *Dipturus intermedius*, which is generally considered the more vulnerable to fishing pressure. Both species were accepted by Last et al. (2016) and are now also accepted on the Catalog of Fishes (Fricke et al., 2019) and WoRMS. The distribution and stock boundaries of the two species 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 2018

The landings generally peaked in the middle of the 1980s and declined steadily thereafter in the North Sea (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

This year, ICES provided stock-specific advice for several species/stocks in this region, see table below (and Section 15.9).

ICES stock code	Stock description	ICES Data Category	Previous ICES advice
rjb.27.3a4	Common skate *Dipturus batis-complex* Subarea 4 and Division 3.a	6.3.0	ICES advises that when the precautionary approach is applied, there should be no landings for these stocks and measures should be taken to minimize bycatch. This advice is valid for 2016 to 2019.
rjc.27.3a47d	Thornback ray *Raja clavata* Subarea 4 and divisions 3.a and 7.d	3.2	ICES advises that when the precautionary approach is applied, landings should be no more than 2574 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches.
rjh.27.4a6	Blonde ray *Raja brachyura* Subarea 6 and divisions 4.a	5.2	ICES advises that when the precautionary approach is applied, landings should be no more than 6 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches.
rjh.27.4c7d	Blonde ray *Raja brachyura* Divisions 4.c and 7.d	3.2	ICES advises that when the precautionary approach is applied, landings should be no more than 195 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches.
rjm.27.3a47d	Spotted ray *Raja montagui* Subarea 4 and divisions 3.a and 7.d	3.2	ICES advises that when the precautionary approach is applied, landings should be no more than 291 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches.
rjn.27.3a4	Cuckoo ray *Leucoraja naevus* Subarea 4 and Division 3.a	3.2	ICES advises that when the precautionary approach is applied, landings should be no more than 116 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches.
rjr.27.23a4	Starry ray *Amblyraja radiata* Subareas 2, 4 and Division 3.a	3.1.5	ICES advises that when the precautionary approach is applied, there should not be a targeted fishery for this stock and measures should be taken to reduce bycatch. This advice is valid for 2016 to 2019.
raj.27.3a47d	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 collection of species-specific landings data for more species of rays and skates should be introduced to help inform on the status of these stocks.

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.

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 since 2009, but has been stable 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. The stock size indicator has increased during the last decade and has been above the long-term average since 2011.

A. radiata**:** 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 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 the 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 brachyuran)* 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 RJU 7.d-e	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)	2519
2016	2326	1313 (6,8,9)	966 (iii, vii, ix)		47 (e)	2677
2017	2488	1378 (6,8,9)	1063 (iii, vii, ix)		47 (e)	2660
2018	2977	1654 (6,8,9,10)	1276 (v,x,xi,xii)		47 (e)	3254
2019	3105	1654(6,8,9,10)	1404(v,x,xi,xiii)	234(1a)	47 (e)	

***Data from 2005 onwards revised following 2016–2018 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. This 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.

(xiii) Not applicable to undulate ray *Raja undulata*

1a) This species shall not be targeted in the areas covered by this TAC. This species may only be landed whole or gutted. The former provisions are without prejudice to the prohibitions set out in Articles 14 and 50 of this Regulation for the areas specified therein.

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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 which may varying throughout the year to control the quota uptake. Restriction can vary between 100 and 250 kg dead weight. In 2018, the weekly landings were capped to 160 kg rays per trip.

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 2018 Data Call, with appropriate corrections made, following the recommendations of WKSHARK2 (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 from Division 3.a and Subarea 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, 80–90% 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 is 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). Preliminary data from the SUMARiS[1] project (Interreg 2 Seas programme 2014–2020) shows that immediate at-vessel mortality is low and delayed mortality after 3 weeks of monitoring in the lab generally is no more than 50%.

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). Preliminary data from the SUMARiS[1] project (Interreg 2 Seas programme 2014–2020) show that immediate at-vessel mortality for beam trawls, otter trawls, gillnets and tangle nets is low, and delayed mortality after 3 weeks of monitoring in the lab generally is no more than 50%.

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. 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

[1] https://www.interreg2seas.eu/nl/sumaris

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 2013–2018.

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 WKSHARK2 (ICES, 2016), and some of the 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 sometimes 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 1970s to the early 1980s, 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 are generally 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 nine survey years (2010–2018). Historical data (prior to 2010) are being prepared for uploading to Datras. Catch rates (n. h^{-1} and n. km^{-2}) are available for this survey. This North Sea survey is organized yearly at the end of August and beginning of September since 1992 on-board of the RV Belgica and covers an important area in the south-western part of the North Sea (i.e. Greater Thames estuary and the

Wash). The most abundant elasmobranch species observed in the survey are small spotted cat-shark (*Scyliorhinus canicula*), thornback ray (*Raja clavata*) and spotted ray (*Raja montagui*). Figure 15.6.8 (a–c) shows the distribution plots for these species from all BTS surveys in the central-southern North Sea and shows that the highest concentrations (numbers per km^2) are covered by the Belgian BTS. Other elasmobranchs such as smooth-hound (*Mustelus sp.)* and blonde ray (*Raja brachyura*) are also caught in the Belgian BTS, but in smaller numbers.

15.6.4 Index calculations

The survey data for the IBTS, BTS, and CGFS surveys were downloaded from DATRAS on 12 June 2019. For the IBTS and BTS data, CPUE per length per haul was downloaded. For the CGFS, exchange data was downloaded.

For IBTS and BTS, 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}.

For CGFS, indices were calculated in biomass.km^{-2}. Starting from exchange data, individual smaller than 50 cm were excluded, catches in weight per haul of larger individuals were calculated using a length-weight relationship from McCully et *al.* (2012).

The average catch per km^2 (including zero observations) was calculated by ICES rectangle (ICES rectangle are the strata of the sampling design in CGFS). The biomass index is the weighted stratified mean, where strata weight are surfaces. This index calculation is the same as in 2017 except that some correction of the strata surfaces were made and DATRAS data are used instead of national files from Ifremer. Strata surface which are not in DATRAS were taken from an Ifremer file. There are minor difference with population indices presented on the Ifremer website, where some strata are excluded because they have not been sampled in all years from 1988 to 2018.

The biomass index calculation is as follows:

$$B = \left\{ \sum_{i=1}^{m} A_i \left(\sum_{k=1}^{n_i} C_{k,i} \middle/ \sum_{k=1}^{n_i} a_{k,i} \right) \right\} / \sum A_i$$

Where: B is the swept area biomass in the survey area; A_i is the area of stratum i; m is the number of strata; n_i in the number of hauls in stratum i, $C_{k,i}$ is the catch in weight in haul k of stratum i; $a_{k,i}$ is the area swept by haul k and stratum i.

$$var(B) = \left\{ \sum_{i=1}^{n_i} \frac{1}{n_i} \frac{A_i^2}{n_{i-1}} \left(\sum_{k=1}^{n_i} \left(\frac{C_{k,i}}{a_{k,i}} - \frac{\sum_{k=1}^{n_i} C_{k,i}}{\sum_{k=1}^{n_i} a_{k,i}} \right)^2 \right) \right\} / \left(\sum A_j \right)^2$$

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. In all tables ndices for FR-CGFS are per km^2 instead of hours. 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 15.6.9). 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 15.6.10). These maps were made for 5-year periods, so that changes in spatial distribution can be detected.

15.6.5 Issues with the fisheries independent data

BTS-ENG-Q3

At the 2019 WGEF meeting, an error was found within the data product (CPUE per length per Hour and Swept Area) when compared with the exchange data (data uploaded by each Nation to ICES). The problem consisted in multiplication (in cases up to 3 times) of the original records for the numbers at length per sex in each haul for the years 2010–2018, which if used would result on an index not reflecting the real survey catches. The overall trend would be similar, but the magnitude of increase/decrease would be affected by the repetition of records. The issue of multiplications could not be resolved during the WGEF. As such, the group decided to leave the English beam trawl survey of the eastern English Channel (ICES Division 7.d) and southern North Sea (ICES Division 4.c) out of the assessment until CEFAS was able to provide an update of the survey indices and their calculations using the internal national data.

The error was reported to ICES post-meeting and corrections have been made within the ICES database. By now, CEFAS has provided the update of the survey indices (Silva and Ellis, 2019) and the English Beam Trawl survey was again included in the assessments. In recent years, this survey time-series has also suffered a major Quality Assurance, Quality Control within the UK national database, which further added to the decision of providing the survey indices using the latest national dataset.

CGFS-Q4

During the 2019 WGEF meeting, CGFS Q4 data were extracted and analysed as described above. However, the 2019 output did not match with the output in the 2017 advice and corresponding SAG-template (ICES Standard Graphs). The numbers presented in the SAG-template were changed during the Elasmobranch Stocks Advice Drafting Group (ADGEF) in 2017 and a sentence was added to the advice to explain that changes in the CGFS survey had taken place: "*The CGFS-Q4 has used a larger trawl since 2015 and the results of intercalibration studies have been used to adjust the stock size indicator (ICES, 2017)*". Unfortunately, no further documentation or calculations for the adjustments could be found during the 2019 WGEF and as such, the stock size index used for the 2017 advice could not be reproduced.

The group requested a clarification on the CGFS Q4 data, but decided to use the CGFS data as extracted from DATRAS as a basis for the stock size indicator.

Probably a mistake may have occurred in the calculations of the CGFS index during the ADGEF in 2017. It appears, that within the RJH 27.4c.7d advice in 2017, the actual CPUE numbers for exploitable biomass (kg hr^{-1} for individuals >50 cm) and the relative biomass (standardized by the long term mean) have been mixed up. In Figure 1 and Table 8 of the 2017 advice, the biomass index was referred to as the mean Biomass index from the CGFS-Q4 trawl survey (individuals larger than 50 cm total length) relative to the long term mean. However, the caption under Figure 1 of the 2017 advice does not mention numbers being standardized, in addition, for 1998–2013, the stock size indicator is equal to the exploitable biomass, labelled as "(kg hr^{-1} for individuals >50 cm), and not standardised to the mean. After 2013, the two series diverge. The last point (2016) in the time series in the 2017 advice is 1.001, while the exploited biomass index calculated this year for 2016 is 2.283 (Table 15.6.21). The latter number is also the number that was obtained in the WGEF 2019 by working up the CGFS data in the usual way.

Also, the calculation in kg hr^{-1} is problematic for the CGFS because there was a change of vessels in 2015. In 1998–2014, the survey was carried out on Gwen Drez and the trawl had a mean wing spread of 10 m. Since 2015, the survey is carried out with Thalassa and a trawl with wingspread of about 15 m. Therefore weight caught per hour in recent year cannot be compared to older years. It is assumed this is why, in the 2017 advice, the inter-calibration is mentioned, however calculations are lacking.

In general, Ifremer calculates indices based on the swept area. The average catch per km^2 is calculated by strata (strata for CGFS are ICES rectangle), then the survey index is a weighted average over strata, strata weights are surfaces. Calculating the index in this way returns a different view of the stock development over time. Looking at the RJH 27.4c.7d stock, the biomass increased between 2010 and 2014 to higher level than in previous years (until 2014, only the smaller vessel Gwen Drez was used for the survey) and then stabilised. This index calculation is similar to that used in 2017, except for the three last years of the previous advice, 2014–2016.

After the 2019 WGEF, new index calculations based on swept area were provided and used for calculating the stock size indicator.

The new indices for the four North Sea stocks affected by the errors are presented in tables 15.6.22–25:

- Thornback ray in 4, 3.a and 7.d (RJC.27.3a47d)
- Blonde ray in 4.c and 7.d (RJH.27.4c7d)
- Spotted ray in 4, 3.a and 7.d (RJM.27.3a47d)
- Lesser-spotted dogfish in 4, 3.a and 7.d (SYC.27.3a47d)

15.6.6 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 provide useful 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 stocks fall into ICES Data 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).

As addressed in Section 15.6.5, the North Sea assessments could not be fully concluded during the WG due to a number of discrepancies in the survey data-base. The DATRAS product data CPUE per length per Hour and Swept Area of the BTS-ENG-Q3 suffered from multiplications of original records for the numbers at length per sex in each haul for the years 2010–2018. In addition, the CGFS-Q4 data obtained from the exchange file in DATRAS did not match the data presented in the 2017 advice. For the assessment methods it was discussed to standardize and revise methods for calculation of indicators.

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) includes 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 has increased slightly.

At-vessel mortality is low for 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 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 2016–2018 Data Call. Note that "+" indicates landings <0.05. Danish landings data from 2017 onwards 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
2018	-	+	0.1	51.8	0.1	52.1

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 <0.05. Data from 2005 onwards from the 2016–2018 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	755.5	1871.0
2009	302.5	30.0	79.5	22.1	378.5	120.7	0.1	662.3	1595.8
2010	309.8	30.0	100.3	32.4	390.5	105.2	0.3	659.7	1627.8
2011	236.2	38.0	60.2	19.0	211.6	55.8	0.5	779.3	1400.6
2012	187.0	21.0	47.7	16.7	431.1	69.2	+	660.7	1433.4
2013	212.9	45.0	52.7	25.1	312.0	73.5	0.3	803.6	1525.3
2014	197.6	44.0	51.5	32.2	225.5	88.3	0.3	778.3	1417.8
2015	244.2	39.9	22.3	25.1	273.7	62.4	-	665.1	1332.7
2016	183.4	41.0	38.9	49.6	280.7	69.3	+	663.3	1326.2
2017	175.7	-	37.9	41.5	287.2	90.9	0.1	699.7	1333.0
2018	157.7	-	37.8	54.9	363.0	117.5	+	808.7	1539.7

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 <0.05. Data from 2005 onwards from the 2016–2018 Data Call.

Year	BEL	FRA	IRL	NLD	UK	Total
1999	93	558	-	0	437	1088
2000	69	693	-	0	355	1117
2001	79	729	-	0	169	977
2002	113	725	-	0	140	978
2003	153	796	-	0	186	1135
2004	96	695	-	0	157	948
2005	100.5	934.0	0.1	8.6	144.1	1187.3
2006	112.8	732.4	-	12.1	144.0	1001.2
2007	157.6	918.4	-	18.0	203.6	1297.6
2008	170.7	871.4	-	12.3	206.8	1261.3
2009	119.3	1102.4	-	10.0	160.8	1392.4
2010	105.4	939.9	-	10.5	136.6	1192.4
2011	102.8	911.3	-	12.1	149.1	1175.2
2012	101.6	1018.9	-	14.4	169.3	1304.2
2013	125.0	1047.0	-	4.4	189.5	1365.9
2014	107.3	1043.8	-	5.7	190.0	1346.9
2015	109.0	855.6	-	3.1	144.4	1112.2
2016	127.5	923.0	-	8.2	189.0	1247.7
2017	125.3	904.3	-	8.6	226.6	1264.9
2018	148.1	1147.2	-	24.6	287.2	1607.2

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
2018	4.3	10.8		4.6	31.2			169.4		220.4

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			0.1	0.7	0.0	0.0	0.8
2018	0.0		0.0	0.2	0.5		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	195.8	33.8	2.7	890.5	518.0	185.2		0.0	1826.0
2017	173.5	27.3		829.3	595.9	162.7			1788.7
2018	193.3	33.0		1117.1	663.8	211.3		0.1	2218.6

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		36.8	113.7	87.4	259.2
2018	27.1	10.8		16.0	188.6	112.5	355.0

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	65.2	0.0		35.6	21.6	24.8	147.2
2017	75.1	0.0		50.2	29.4	43.9	198.6
2018	107.8	0.2		46.3	32.3	64.6	251.2

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	1.1	5.4	6.8
2018				1.2	2.8	23.0	27.0

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	154.3		155.0
2018	0.2			0.1	179.6		179.9

rjr.27.23a4							
Year	**BEL**	**DE**	**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
2018		0.1	0.9	0.4	0.0		1.3

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^{-1}) for *Amblyraja radiata*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and several BTS surveys 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
1987	3.717	NA	0.101	NA	NA
1988	1.762	NA	0.178	NA	NA
1989	7.244	NA	0.382	NA	NA
1990	4.964	NA	1.472	NA	NA
1991	3.956	7.899	0.447	NA	NA
1992	7.278	2.280	0.184	NA	NA
1993	11.221	1.681	0.053	NA	NA
1994	3.792	1.931	0.045	NA	NA
1995	8.016	1.852	0.188	NA	NA
1996	5.694	2.338	0.118	20.452	NA
1997	4.816	2.177	0	16.279	NA
1998	5.090	2.193	0	23.308	NA
1999	6.725	2.757	0.143	34.190	NA
2000	7.769	3.088	0	34.000	NA
2001	2.692	5.157	0.037	21.217	NA
2002	4.173	2.925	0.031	25.459	0.865
2003	4.613	3.407	0.067	18.726	0.517
2004	4.332	1.851	0.071	20.762	0.375
2005	3.690	2.102	0.303	19.343	0.098
2006	2.288	2.348	0.179	13.729	NA
2007	4.231	3.850	0	14.557	17.412
2008	3.129	2.516	NA	15.174	15.396
2009	1.333	2.982	0.897	14.759	10.693
2010	1.400	2.204	0	15.478	9.950
2011	1.281	2.415	0	13.842	8.783
2012	1.670	1.944	0.091	13.239	18.278
2013	1.191	1.413	0.069	13.379	13.372
2014	1.088	1.539	0.817	12.298	1.462
2015	1.941	2.045	0.172	10.101	9.518
2016	1.374	1.738	0.469	8.315	11.737
2017	0.968	1.209	NA	4.059	8.463
2018	0.284	1.236	NA	4.293	6.158
2019	0.495	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^{-1}) for *Leucoraja naevus*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and several BTS surveys 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
1987	0.151	NA	0	NA	NA	NA
1988	0.617	NA	0.034	NA	NA	NA
1989	0.736	NA	0	NA	NA	NA
1990	0.529	NA	0	NA	NA	NA
1991	0.444	0.292	0	NA	NA	NA
1992	0.749	0.414	0	NA	NA	NA
1993	0.806	0.108	0	0	NA	NA
1994	0.620	0.186	0	0	NA	NA
1995	0.533	0.087	0	0	NA	NA
1996	0.432	0.120	0	0	0.905	NA
1997	0.268	0.416	0	0.015	1.302	NA
1998	0.458	0.08	0	0	3.115	NA
1999	0.327	0.38	0	0	3.841	NA
2000	0.444	0.433	0	0	2.169	NA
2001	0.309	0.569	0	0	1.478	NA
2002	0.451	0.477	0	0	2.840	NA
2003	0.250	0.290	0	0	3.015	NA
2004	0.330	0.306	0	0	0.972	NA
2005	0.329	0.404	0	0	1.659	NA
2006	0.372	0.465	0	0	1.420	NA
2007	0.449	0.329	0	0	2.507	NA
2008	0.431	1.112	NA	0.015	4.400	NA
2009	0.352	0.587	0	0	2.013	NA
2010	0.438	0.65	0	0.853	0.576	0
2011	0.407	0.608	0	0.343	0.958	0
2012	0.658	0.731	0	0.278	1.013	0
2013	0.782	0.532	0	0.357	1.22	0
2014	0.459	0.435	0	1.343	1.465	0
2015	0.765	0.45	0	0.127	0.702	0
2016	0.481	0.493	0	NA	1.332	0.128
2017	0.852	0.674	NA	1.238	1.772	0
2018	0.387	0.722	NA	0.265	1.827	0
2019	0.456	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^{-1}) for 'common skate complex'. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and several BTS surveys 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	0.021	0
2019	0.101	NA	NA

Table 15.6.4. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates for *Raja clavata*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys and eastern Channel CGFS Q4 in the period 1987–2018. All data are abstracted from DATRAS. Estimates are in n.hr^{-1} for all surveys except CGFS where n.km^{-2} are used.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI Q3	BTS GFR Q3	BTS BEL Q3	CGFS Q4
1987	1.855	NA	0	NA	NA	NA	NA	NA
1988	0.319	NA	0.023	NA	NA	NA	NA	40.91
1989	1.852	NA	0.741	NA	NA	NA	NA	57.509
1990	1.364	NA	0.981	NA	NA	NA	NA	32.263
1991	42.436	1.269	0	NA	NA	NA	NA	15.124
1992	2.165	1.216	0.579	NA	NA	NA	NA	34.623
1993	0.531	1.043	0	3.011	NA	NA	NA	14.55
1994	0.702	0.113	0.030	2.405	NA	NA	NA	19.297
1995	0.124	0.041	0.083	1.693	NA	NA	NA	15.201
1996	0.711	0.687	0.162	2.314	0.048	NA	NA	8.734
1997	1.144	0.270	0.825	2.802	0	NA	NA	33.033
1998	1.106	0.050	0.023	2.344	0.269	NA	NA	23.572
1999	0.399	0.143	2.057	4.317	0	NA	NA	25.682
2000	0.879	0.040	0.357	3.742	0.197	NA	NA	26.559
2001	0.904	0.166	0	4.103	0.087	NA	NA	28.973
2002	1.062	0.721	0.078	2.697	0.972	0	NA	36.441
2003	1.029	0.054	0.100	3.53	0.558	0	NA	37.161
2004	0.475	0.133	0	3.141	0.085	0	NA	24.998
2005	1.034	0.054	0.182	3.913	0.091	0	NA	55.007
2006	1.167	0.640	0	4.870	0.181	NA	NA	41.368
2007	0.519	0.129	0.024	3.115	0.647	0	NA	50.873
2008	2.016	0.623	NA	4.136	0.03	0	NA	66.172
2009	2.576	0.706	0	3.242	0.091	0	NA	49.066
2010	0.550	0.565	0.062	14.516	0.214	0	1.678	45.408
2011	0.194	0.355	0.040	13.302	0.085	0	2.162	50.264
2012	2.926	0.787	0.030	19.409	1.713	0	3.044	94.8
2013	1.063	2.243	0.034	25.38	0.557	0	4.257	123.704
2014	1.310	2.141	0.320	46.729	0.257	0	6.375	133.217
2015	1.822	4.533	0.368	35.292	0.481	0.066	4.775	93.663
2016	1.035	5.796	0.260	NA	1.306	0	5.662	118.236
2017	2.884	0.734	NA	36.462	0.287	0	8.246	73.503
2018	1.2	3.568	NA	44.44	2.798	0.033	8.437	119.003
2019	2.555	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 for *Raja montagui*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys and eastern Channel CGFS Q4 in the period 1987–2018. All data are abstracted from DATRAS. Estimates are in n.hr^{-1} for all surveys except CGFS where n.km^{-2} are used.

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	15.349
1989	0.298	NA	0.592	NA	NA	NA	6.469
1990	0.213	NA	0.278	NA	NA	NA	10.278
1991	2.477	0.360	0.579	NA	NA	NA	2.725
1992	0.281	0.396	0.184	NA	NA	NA	0.451
1993	0.302	0.414	0.637	0.543	NA	NA	3.594
1994	0.268	0.650	0	0.493	NA	NA	5.921
1995	0.633	0.211	0	0.879	NA	NA	3.099
1996	0.244	0.253	0.824	0.263	0.667	NA	3.343
1997	0.699	0.003	0.226	0.598	0	NA	4.29
1998	0.314	0.197	0	0.902	1.123	NA	3.019
1999	0.237	0.991	0	0.543	1.079	NA	0.567
2000	0.233	0.032	0.029	0.500	0.648	NA	1.274
2001	0.181	0.098	0	0.248	1.014	NA	1.285
2002	0.528	0.065	0	0.517	0.361	NA	0.637
2003	0.462	0.086	0.033	0.659	0.247	NA	2.596
2004	0.371	0.143	0	0.878	0.359	NA	0.261
2005	0.652	0.364	0	0.071	0.136	NA	3.425
2006	0.182	0.356	0	0.274	0.536	NA	1.385
2007	0.663	0.753	0	0.261	0.239	NA	1.441
2008	1.876	0.269	NA	0.328	0.167	NA	0.229
2009	0.979	0.905	0	0.184	0.242	NA	0
2010	1.111	0.861	0	6.586	0.273	1.117	0.29
2011	0.775	1.009	0	2.500	0.928	1.056	4.398
2012	1.566	1.123	0	4.005	1.305	1.166	2.169
2013	1.502	1.327	0.046	5.089	0.841	0.993	2.047
2014	0.989	2.313	0.160	4.484	0.543	1.899	4.248
2015	1.198	0.510	0.057	6.597	0.550	2.580	2.514
2016	0.975	1.091	0.135	NA	2.444	2.609	0.671
2017	1.274	0.826	NA	12.089	0.911	4.132	1.28
2018	1.312	1.412	NA	4.828	1.366	5.248	0.729
2019	1.427	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^{-1}) 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	0
2019	0.026	NA

Table 15.6.7. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates for *Raja brachyura* in 4.c and 7.d. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and several BTS surveys and eastern Channel CGFS Q4 in the period 1987–2018. All data are abstracted from DATRAS. Estimates are in n.hr^{-1} for all surveys except CGFS where n.km^{-2} are used.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI Q3	BTS BEL Q3	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	3.914
1990	0	NA	0	NA	NA	NA	0.468
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	1.381
1995	0	0	0	0.049	NA	NA	2.161
1996	0	0	0	0.047	0	NA	0
1997	0	0	0	0.015	0	NA	1.042
1998	0	0	0	0.045	0	NA	2.644
1999	0.030	0	0	0.25	0	NA	1.665
2000	0	0	0.056	0.081	0	NA	1.646
2001	0	0	0	0.168	0	NA	1.998
2002	0	0	0	0.113	0	NA	3.984
2003	0.015	0	0	0.148	0	NA	4.294
2004	0	0	0	0.126	0.242	NA	3.654
2005	0.030	0	0.071	0.128	0	NA	0
2006	0.091	0	0	0.03	0.323	NA	2.257
2007	0.121	0	0	0.092	0.6	NA	3.42
2008	0.333	0	NA	0.059	0	NA	0.262
2009	0.044	0	0	0.131	0	NA	3.679
2010	0.03	0	0	0.757	0	0.414	1.454
2011	0.022	0	0	0.812	0	0.117	5.023
2012	0.212	0.083	0.071	0.517	0	0.379	6.294
2013	0.091	0	0	1.857	0	0.614	3.129
2014	0.756	0	0	1.829	0	0.417	12.36
2015	0.268	0	0	0.922	1.239	0.762	4.415
2016	0.153	0.375	0	NA	0	0.987	5.204
2017	0.333	0.264	NA	3.182	0	0.579	20.039
2018	0.597	0.472	NA	3.002	0.091	0.690	5.337
2019	0.648	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^{-1}) for *Amblyraja radiata*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and several BTS surveys 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
1987	3.717	NA	0.101	NA	NA
1988	1.762	NA	0.178	NA	NA
1989	3.729	NA	0.075	NA	NA
1990	2.483	NA	0.387	NA	NA
1991	2.001	3.553	0.124	NA	NA
1992	3.355	1.240	0.038	NA	NA
1993	5.677	0.876	0.014	NA	NA
1994	1.853	0.966	0.023	NA	NA
1995	4.116	0.763	0.102	NA	NA
1996	2.853	1.062	0.237	4.493	NA
1997	2.333	1.031	0	4.383	NA
1998	2.755	1.275	0	6.313	NA
1999	2.728	1.182	0.059	8.558	NA
2000	3.383	1.353	0	8.015	NA
2001	1.074	1.724	0.016	4.733	NA
2002	1.605	1.035	0.035	5.947	0.179
2003	1.973	1.320	0.034	4.486	0.164
2004	1.569	0.615	0.015	5.140	0.111
2005	1.400	0.764	0.171	5.407	0.036
2006	0.942	0.865	0.112	4.089	NA
2007	1.946	1.667	0	5.191	6.359
2008	1.504	1.151	NA	6.182	5.996
2009	0.753	1.575	0.494	6.321	4.587
2010	0.733	1.178	0	6.176	3.765
2011	0.664	1.232	0	4.709	2.789
2012	0.783	0.802	0.051	3.467	5.721
2013	0.488	0.556	0.047	3.253	2.753
2014	0.591	0.655	0.318	3.475	0.535
2015	0.849	1.094	0.074	4.071	3.039
2016	0.667	0.823	0.165	2.700	3.112
2017	0.490	0.536	NA	1.558	2.829
2018	0.139	0.502	NA	1.236	1.956
2019	0.208	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^{-1}) for *Leucoraja naevus*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and several BTS surveys 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
1987	0.129	NA	0	NA	NA	NA
1988	0.599	NA	0.021	NA	NA	NA
1989	0.611	NA	0	NA	NA	NA
1990	0.508	NA	0	NA	NA	NA
1991	0.340	0.161	0	NA	NA	NA
1992	0.720	0.434	0	NA	NA	NA
1993	0.752	0.085	0	0	NA	NA
1994	0.422	0.169	0	0	NA	NA
1995	0.453	0.108	0	0	NA	NA
1996	0.385	0.063	0	0	0.496	NA
1997	0.203	0.600	0	0.001	0.718	NA
1998	0.369	0.083	0	0	1.382	NA
1999	0.275	0.261	0	0	0.944	NA
2000	0.306	0.331	0	0	0.928	NA
2001	0.192	0.252	0	0	0.379	NA
2002	0.232	0.277	0	0	0.573	NA
2003	0.141	0.163	0	0	1.080	NA
2004	0.160	0.163	0	0	0.453	NA
2005	0.191	0.253	0	0	0.544	NA
2006	0.243	0.260	0	0	0.460	NA
2007	0.254	0.204	0	0	0.854	NA
2008	0.238	0.818	NA	0.001	1.473	NA
2009	0.175	0.383	0	0	0.795	NA
2010	0.279	0.455	0	0.269	0.258	0
2011	0.276	0.450	0	0.06	0.489	0
2012	0.471	0.540	0	0.069	0.514	0
2013	0.532	0.378	0	0.065	0.449	0
2014	0.302	0.266	0	0.658	0.564	0
2015	0.633	0.356	0	0.084	0.279	0
2016	0.348	0.346	0	NA	0.577	0.013
2017	0.609	0.470	NA	0.515	0.798	0
2018	0.296	0.460	NA	0.230	0.689	0
2019	0.307	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^{-1}) for 'common skate complex'. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and BTS survey 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	0.028	0
2019	0.499	NA	NA

Table 15.6.11. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of biomass estimates for *Raja clavata*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 in the period 1987–2018. All data are abstracted from DATRAS. Estimates are in kg hr^{-1} for all surveys except CGFS where kg km^{-2} are used.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI Q3	BTS GFR Q3	BTS	CGFS Q4
1987	3.341	NA	0	NA	NA	NA	NA	NA
1988	0.359	NA	0.004	NA	NA	NA	NA	75.411
1989	1.885	NA	0.418	NA	NA	NA	NA	131.633
1990	1.497	NA	0.806	NA	NA	NA	NA	72.959
1991	19.556	1.507	0	NA	NA	NA	NA	24.315
1992	1.760	0.792	0.698	NA	NA	NA	NA	70.055
1993	0.558	0.702	0	1.175	NA	NA	NA	19.387
1994	0.368	0.062	0.008	0.958	NA	NA	NA	51.056
1995	0.140	0.143	0.011	0.895	NA	NA	NA	37.565
1996	0.487	1.273	0.233	1.084	0.111	NA	NA	6.76
1997	1.009	0.440	0.583	2.186	0	NA	NA	52.832
1998	0.246	0.018	0.004	1.274	0.130	NA	NA	49.922
1999	0.232	0.358	1.095	2.116	0	NA	NA	40.793
2000	0.471	0.089	0.298	1.711	0.074	NA	NA	54.157
2001	0.568	0.187	0	2.078	0.053	NA	NA	46.535
2002	0.637	0.690	0.088	1.063	0.831	0	NA	58.713
2003	0.688	0.088	0.055	1.784	0.407	0	NA	41.03
2004	0.285	0.074	0	2.500	0.058	0	NA	36.431
2005	0.787	0.071	0.471	1.519	0.094	0	NA	93.751
2006	1.610	0.653	0	1.968	0.149	NA	NA	75.334
2007	0.371	0.031	0.022	1.472	0.540	0	NA	104.09
2008	3.149	0.655	NA	2.222	0.013	0	NA	106.548
2009	2.293	0.566	0	1.736	0.142	0	NA	102.489
2010	0.501	0.427	0.004	7.129	0.196	0	1.409	105.152
2011	0.093	0.530	0.096	5.980	0.056	0	1.353	76.359
2012	3.553	0.439	0.084	8.558	0.741	0	2.011	152.863
2013	0.973	2.797	0.012	10.81	0.305	0	2.366	232.341
2014	1.506	3.017	0.263	22.046	0.296	0	4.959	250.389
2015	1.811	3.625	0.489	12.405	0.650	0.141	2.766	214.205
2016	0.787	4.522	0.499	NA	0.525	0	3.846	260.255
2017	3.436	1.185	NA	17.034	0.758	0	4.649	156.923
2018	1.018	3.463	NA	15.324	1.251	0.027	4.765	272.982
2019	2.562	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 for *Raja montagui*. Information from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys and eastern Channel CGFS Q4 in the period 1987–2016. All data are abstracted from DATRAS. Estimates are in kg hr^{-1} for all surveys except CGFS where kg km^{-2} are used.

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	22.215
1989	0.203	NA	0.163	NA	NA	NA	6.007
1990	0.240	NA	0.055	NA	NA	NA	9.587
1991	0.821	0.267	1.125	NA	NA	NA	3.364
1992	0.318	0.373	0.153	NA	NA	NA	0.721
1993	0.286	0.459	0.422	0.172	NA	NA	4.426
1994	0.310	0.820	0	0.175	NA	NA	9.903
1995	0.620	0.247	0	0.170	NA	NA	3.027
1996	0.253	0.175	0.584	0.138	0.401	NA	0.653
1997	0.351	0.002	0.246	0.250	0	NA	4.61
1998	0.418	0.126	0	0.146	0.504	NA	2.767
1999	0.274	1.177	0	0.114	0.638	NA	0.266
2000	0.189	0.029	0.013	0.331	0.063	NA	1.586
2001	0.192	0.061	0	0.067	0.091	NA	1.376
2002	0.393	0.052	0	0.204	0.198	NA	0.447
2003	0.359	0.048	0.058	0.057	0.072	NA	1.863
2004	0.228	0.195	0	0.181	0.215	NA	0.047
2005	0.426	0.317	0	0.086	0.108	NA	2.535
2006	0.086	0.212	0	0.111	0.482	NA	2.999
2007	0.612	0.691	0	0.090	0.215	NA	1.27
2008	1.765	0.244	NA	0.090	0.118	NA	0.055
2009	0.582	0.677	0	0.072	0.103	NA	0
2010	0.901	0.664	0	1.272	0.154	0.287	0.058
2011	0.609	0.818	0	0.827	0.434	0.743	3.359
2012	1.196	1.002	0	0.852	0.873	0.370	1.621
2013	1.110	1.036	0.043	0.983	0.644	0.369	2.363
2014	0.981	2.533	0.128	1.427	0.542	0.621	1.74
2015	1.222	0.566	0.057	1.552	0.566	0.567	1.63
2016	0.862	1.045	0.097	NA	0.798	0.832	0.329
2017	1.028	0.728	NA	2.483	0.500	1.013	5.443
2018	1.316	1.361	NA	0.949	0.391	1.433	0.877
2019	1.191	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^{-1}) for *Raja brachyura* 4.a. Information is obtained from the IBTS Q1 and IBTS Q3 (roundfish areas 1–7), survey 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	0
2019	0.018	NA

Table 15.6.14. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of biomass estimates for *Raja brachyura* in 4.c and 7.d. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys and eastern Channel CGFS Q4, in the period 1987–2018. All data are abstracted from DATRAS. Estimates are in kg hr^{-1} for all surveys except CGFS where kg km^{-2} are used.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI Q3	BTS BEL Q3	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	2.609
1990	0	NA	0	NA	NA	NA	0.14
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	0.539
1995	0	0	0	0.004	NA	NA	3.686
1996	0	0	0	0.006	0	NA	0
1997	0	0	0	0.002	0	NA	1.458
1998	0	0	0	0.005	0	NA	4.16
1999	0.066	0	0	0.084	0	NA	1.909
2000	0	0	0.025	0.013	0	NA	0.975
2001	0	0	0	0.059	0	NA	3.045
2002	0	0	0	0.095	0	NA	2.79
2003	0.027	0	0	0.048	0	NA	5.591
2004	0	0	0	0.085	1.316	NA	1.586
2005	0.080	0	0.062	0.067	0	NA	0
2006	0.019	0	0	0.013	0.224	NA	2.409
2007	0.28	0	0	0.119	1.868	NA	8.055
2008	0.603	0	NA	0.013	0	NA	0.314
2009	0.062	0	0	0.092	0	NA	6.319
2010	0.008	0	0	0.724	0	0.125	3.14
2011	0.005	0	0	0.716	0	0.15	6.673
2012	0.980	0.214	0.062	0.144	0	0.095	19.648
2013	0.339	0	0	0.741	0	0.107	4.263
2014	1.068	0	0	2.014	0	0.108	20.067
2015	0.462	0	0	0.418	0.129	0.169	17.213
2016	0.233	0.257	0	NA	0	0.159	17.43
2017	0.808	0.476	NA	1.070	0	0.113	20.423
2018	1.483	0.343	NA	1.244	0.439	0.262	12.675
2019	1.638	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^{-1} for individuals ≥50 cm) for *Amblyraja radiata*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and several BTS surveys, 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
1987	0.358	NA	0	NA	NA
1988	0.366	NA	0	NA	NA
1989	0.258	NA	0	NA	NA
1990	0.247	NA	0	NA	NA
1991	0.227	0.2	0	NA	NA
1992	0.28	0.078	0	NA	NA
1993	0.214	0.064	0	NA	NA
1994	0.172	0.14	0	NA	NA
1995	0.524	0.034	0	NA	NA
1996	0.147	0.086	0.205	0.167	NA
1997	0.273	0.061	0	0.215	NA
1998	0.299	0.179	0	0.573	NA
1999	0.252	0.052	0	0.48	NA
2000	0.34	0.065	0	0.24	NA
2001	0.043	0.111	0	0.203	NA
2002	0.104	0.033	0.035	0.125	0.037
2003	0.215	0.033	0	0.194	0
2004	0.059	0.044	0	0.146	0
2005	0.069	0	0	0.034	0
2006	0.006	0.018	0.045	0	NA
2007	0.037	0.06	0	0	0
2008	0.064	0	NA	0	0.047
2009	0.021	0	0	0.038	0.056
2010	0.007	0.133	0	0.07	0.168
2011	0.061	0.022	0	0.102	0.1
2012	0.018	0.014	0	0.11	0.056
2013	0.025	0	0	0	0
2014	0.106	0.046	0	0.04	0
2015	0.013	0.027	0	0	0
2016	0.028	0	0	0	0
2017	0.042	0	NA	0.03	0
2018	0.015	0	NA	0	0.063
2019	0	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^{-1} for individuals ≥50 cm) for *Leucoraja naevus*. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and several BTS surveys, 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
1987	0.113	NA	0	NA	NA	NA
1988	0.518	NA	0	NA	NA	NA
1989	0.404	NA	0	NA	NA	NA
1990	0.428	NA	0	NA	NA	NA
1991	0.240	0.081	0	NA	NA	NA
1992	0.604	0.359	0	NA	NA	NA
1993	0.602	0.074	0	0	NA	NA
1994	0.255	0.157	0	0	NA	NA
1995	0.338	0.099	0	0	NA	NA
1996	0.300	0.031	0	0	0.384	NA
1997	0.141	0.579	0	0	0.409	NA
1998	0.258	0.060	0	0	0.782	NA
1999	0.207	0.177	0	0	0.375	NA
2000	0.229	0.239	0	0	0.359	NA
2001	0.097	0.085	0	0	0.026	NA
2002	0.094	0.114	0	0	0.168	NA
2003	0.066	0.080	0	0	0.213	NA
2004	0.059	0.037	0	0	0.180	NA
2005	0.054	0.106	0	0	0.158	NA
2006	0.115	0.110	0	0	0.113	NA
2007	0.127	0.104	0	0	0.411	NA
2008	0.098	0.517	NA	0	0.060	NA
2009	0.072	0.249	0	0	0.188	NA
2010	0.156	0.271	0	0.155	0.027	0
2011	0.137	0.289	0	0	0.190	0
2012	0.296	0.360	0	0	0.213	0
2013	0.322	0.235	0	0	0.124	0
2014	0.128	0.117	0	0.462	0.218	0
2015	0.487	0.271	0	0.082	0.097	0
2016	0.240	0.215	0	NA	0.186	0
2017	0.414	0.318	NA	0.097	0.191	0
2018	0.215	0.325	NA	0.164	0.211	0
2019	0.192	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^{-1}) for individuals ≥50 cm) for 'common skate complex'. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) and BTS survey, 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	0.022	0
2019	0.496	NA	NA

Table 15.6.18. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of exploitable biomass index (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, in the period 1987–2018. All data are abstracted from DATRAS. Estimates are in kg hr^{-1} for all surveys except CGFS where kg km^{-2} are used.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI Q3	BTS GFR Q3	BTS BEL	CGFS Q4
1987	3.131	NA	0	NA	NA	NA	NA	NA
1988	0.302	NA	0	NA	NA	NA	NA	12.628
1989	1.538	NA	0.228	NA	NA	NA	NA	114.088
1990	1.119	NA	0.418	NA	NA	NA	NA	59.89
1991	6.674	1.103	0	NA	NA	NA	NA	19.443
1992	1.178	0.429	0.610	NA	NA	NA	NA	59.386
1993	0.452	0.441	0	0.516	NA	NA	NA	16.308
1994	0.123	0.056	0	0.583	NA	NA	NA	45.292
1995	0.124	0.143	0	0.555	NA	NA	NA	31.705
1996	0.293	1.179	0.207	0.675	0.111	NA	NA	3.03
1997	0.711	0.435	0.434	1.655	0	NA	NA	39.613
1998	0	0	0	0.716	0.045	NA	NA	44.863
1999	0.079	0.355	0.599	1.031	0	NA	NA	34.246
2000	0.196	0.077	0.186	0.888	0.031	NA	NA	45.256
2001	0.254	0.164	0	1.399	0.040	NA	NA	38.375
2002	0.271	0.531	0.085	0.423	0.675	0	NA	47.978
2003	0.433	0.081	0	1.049	0.245	0	NA	33.701
2004	0.129	0.065	0	1.757	0.031	0	NA	29.056
2005	0.540	0.070	0.471	0.606	0.072	0	NA	81.301
2006	1.405	0.480	0	1.359	0.129	NA	NA	65.815
2007	0.253	0.018	0.022	0.868	0.374	0	NA	91.374
2008	2.913	0.507	NA	1.398	0	0	NA	88.835
2009	1.687	0.386	0	1.206	0.138	0	NA	86.281
2010	0.417	0.300	0	4.668	0.146	0	1.118	89.675
2011	0.071	0.457	0.096	3.439	0.028	0	0.907	61.751
2012	3.020	0.259	0.084	4.544	0.245	0	1.197	117.078
2013	0.759	2.404	0	6.446	0.213	0	1.344	192.083
2014	1.261	2.741	0.096	13.554	0.252	0	3.831	207.057
2015	1.440	2.238	0.454	6.675	0.626	0.141	1.663	188.85
2016	0.598	2.798	0.482	NA	0.165	0	2.753	231.484
2017	2.929	1.114	NA	10.241	0.749	0	3.385	136.69
2018	0.803	2.863	NA	10.013	0.499	0	3.530	248.193
2019	2.036	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 (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, in the period 1987–2018. All data are abstracted from DATRAS. Estimates are in kg hr^{-1} for all surveys except CGFS where kg km^{-2} are used.

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	0.514
1989	0.128	NA	0.025	NA	NA	NA	1.347
1990	0.220	NA	0	NA	NA	NA	2.123
1991	0.493	0.148	1.048	NA	NA	NA	0.84
1992	0.276	0.303	0.078	NA	NA	NA	0.205
1993	0.217	0.412	0.260	0.099	NA	NA	1.257
1994	0.271	0.737	0	0.064	NA	NA	2.438
1995	0.505	0.213	0	0.072	NA	NA	0.748
1996	0.216	0.138	0.284	0.096	0.234	NA	0
1997	0.238	0	0.150	0.138	0	NA	0.686
1998	0.395	0.008	0	0.023	0.383	NA	0.651
1999	0.247	1.068	0	0	0.548	NA	0
2000	0.135	0.011	0	0.252	0	NA	0.333
2001	0.146	0.022	0	0.038	0	NA	0.276
2002	0.270	0.033	0	0.121	0.081	NA	0.103
2003	0.266	0.016	0.058	0	0	NA	0.201
2004	0.173	0.179	0	0.011	0.093	NA	0
2005	0.219	0.224	0	0.086	0.060	NA	0.669
2006	0.049	0.133	0	0.087	0.379	NA	0.699
2007	0.466	0.489	0	0.079	0.159	NA	0.327
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	0.796
2012	0.824	0.708	0	0.255	0.492	0.218	0.08
2013	0.836	0.577	0.031	0.269	0.399	0.192	0.716
2014	0.851	2.263	0.051	0.739	0.424	0.443	0.158
2015	1.120	0.545	0.039	0.539	0.526	0.217	0.279
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	1.708
2018	1.092	1.119	NA	0.259	0.172	0.549	0.228
2019	0.916	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^{-1} for individuals ≥50 cm) for *Raja brachyura* 4.a. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7) survey, 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	0
2019	0	NA

Table 15.6.21. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of exploitable biomass index (individuals ≥50 cm) for *Raja brachyura* 4.c and 7.d. Information is obtained from IBTS Q1, IBTS Q3 (roundfish areas 1–7), several BTS surveys, and eastern Channel CGFS Q4 in the period 1989–2018. All data are abstracted from DATRAS. Estimates are in kg hr^{-1} for all surveys except CGFS where kg km^{-2} are used.

Year	IBTS Q1	IBTS Q3	BTS ISI Q3	BTS ENG Q3	BTS TRI Q3	BTS BEL Q3	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	1.377
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	0.35
1995	0	0	0	0	NA	NA	3.342
1996	0	0	0	0	0	NA	0
1997	0	0	0	0	0	NA	1.662
1998	0	0	0	0	0	NA	4.204
1999	0.066	0	0	0	0	NA	2.249
2000	0	0	0	0	0	NA	0.345
2001	0	0	0	0.028	0	NA	3.028
2002	0	0	0	0.047	0	NA	2.314
2003	0.027	0	0	0.018	0	NA	6.414
2004	0	0	0	0.030	1.316	NA	0.624
2005	0.080	0	0	0.036	0	NA	0
2006	0	0	0	0	0.198	NA	2.423
2007	0.249	0	0	0.100	1.868	NA	7.968
2008	0.582	0	NA	0	0	NA	0.243
2009	0.053	0	0	0.049	0	NA	5.925
2010	0	0	0	0.570	0	0.030	3.341
2011	0	0	0	0.630	0	0.147	6.539
2012	0.970	0.214	0	0.024	0	0.040	19.885
2013	0.338	0	0	0.428	0	0	4.203
2014	0.905	0	0	1.597	0	0.080	20.573
2015	0.443	0	0	0.296	0	0.059	17.178
2016	0.219	0.122	0	NA	0	0	16.905
2017	0.728	0.413	NA	0.486	0	0	19.311
2018	1.383	0.303	NA	0.695	0.439	0.063	13.829
2019	1.545	NA	NA	NA	NA	NA	NA

Table 15.6.22. Annual mean CPUE by numbers (n. h^{-1}) and biomass (kg h^{-1}), and for individuals ≥50 cm LT by numbers (*n. h^{-1}) and biomass (*kg h^{-1}) of *Raja brachyura* in the 7.d and 4.c English beam trawl survey (1993–2018). Data are abstracted from National Data.

Year	n. h^{-1}	kg h^{-1}	*n. h^{-1}	*kg h^{-1}
1993	0.159	0.182	0.095	0.161
1994	0.125	0.013	0.000	0.000
1995	0.053	0.008	0.000	0.000
1996	0.054	0.006	0.000	0.000
1997	0.027	0.003	0.000	0.000
1998	0.080	0.009	0.000	0.000
1999	0.164	0.051	0.000	0.000
2000	0.107	0.013	0.000	0.000
2001	0.160	0.072	0.027	0.034
2002	0.110	0.079	0.027	0.029
2003	0.137	0.069	0.027	0.046
2004	0.141	0.046	0.000	0.000
2005	0.262	0.118	0.066	0.072
2006	0.057	0.028	0.029	0.026
2007	0.167	0.292	0.056	0.263
2008	0.081	0.009	0.000	0.000
2009	0.159	0.071	0.027	0.030
2010	0.027	0.020	0.000	0.000
2011	0.144	0.099	0.021	0.089
2012	0.149	0.067	0.027	0.043
2013	0.194	0.070	0.028	0.027
2014	0.247	0.082	0.027	0.039
2015	0.137	0.048	0.000	0.000
2016	0.280	0.129	0.053	0.074
2017	0.491	0.163	0.027	0.045
2018	0.548	0.318	0.110	0.229

Table 15.6.23. Annual mean CPUE by numbers (n. h^{-1}) and biomass (kg h^{-1}), and for individuals ≥50 cm LT by numbers (*n. h^{-1}) and biomass (*kg h^{-1}) of *Raja clavata* in the 7.d and 4.c English beam trawl survey (1993–2018). Data are abstracted from National Data.

Year	n. h^{-1}	kg h^{-1}	*n. h^{-1}	*kg h^{-1}
1993	3.060	1.088	0.333	0.589
1994	2.845	1.005	0.375	0.581
1995	1.653	0.793	0.293	0.569
1996	3.324	1.377	0.568	0.837
1997	2.533	1.143	0.349	0.711
1998	2.883	1.189	0.240	0.587
1999	4.055	1.846	0.603	1.163
2000	3.840	1.534	0.453	0.900
2001	4.876	1.578	0.578	0.909
2002	2.839	1.084	0.329	0.523
2003	3.840	1.786	0.552	1.110
2004	4.159	2.522	0.811	1.551
2005	4.115	1.557	0.443	0.601
2006	5.041	1.554	0.520	0.873
2007	4.743	2.203	0.813	1.376
2008	5.134	2.899	1.177	1.929
2009	4.676	2.249	0.852	1.465
2010	8.353	3.434	1.102	2.199
2011	9.972	2.543	0.665	1.302
2012	6.011	3.099	1.094	1.866
2013	9.146	2.445	0.740	1.066
2014	15.021	5.063	1.794	2.926
2015	12.911	4.861	1.644	2.831
2016	12.003	4.151	1.319	2.042
2017	15.820	4.343	1.459	2.217
2018	24.606	5.223	1.619	2.675

Table 15.6.24. Annual mean CPUE by numbers (n. h^{-1}) and biomass (kg h^{-1}), and for individuals ≥50 cm LT by numbers (*n. h^{-1}) and biomass (*kg h^{-1}) of *Raja montagui* in the 7.d and 4.c English beam trawl survey (1993–2018). Data are abstracted from National Data.

Year	n. h^{-1}	kg h^{-1}	*n. h^{-1}	*kg h^{-1}
1993	0.349	0.065	0.000	0.000
1994	0.625	0.218	0.063	0.109
1995	0.533	0.200	0.080	0.120
1996	0.405	0.173	0.081	0.099
1997	0.593	0.300	0.162	0.208
1998	0.560	0.154	0.027	0.036
1999	0.712	0.149	0.000	0.000
2000	0.347	0.130	0.053	0.067
2001	0.352	0.085	0.032	0.045
2002	0.603	0.291	0.110	0.195
2003	0.110	0.033	0.000	0.000
2004	0.296	0.069	0.028	0.029
2005	0.066	0.079	0.066	0.079
2006	0.211	0.109	0.071	0.103
2007	0.125	0.008	0.000	0.000
2008	0.338	0.119	0.081	0.084
2009	0.203	0.091	0.000	0.000
2010	0.431	0.056	0.027	0.028
2011	0.321	0.148	0.083	0.113
2012	0.185	0.134	0.054	0.081
2013	0.246	0.188	0.125	0.175
2014	0.164	0.087	0.055	0.051
2015	0.325	0.144	0.082	0.108
2016	1.067	0.205	0.080	0.107
2017	0.405	0.141	0.081	0.097
2018	0.384	0.215	0.110	0.158

Table 15.6.25. Revised annual biomass index (kg km²) for individuals ≥50 cm LT of *Raja brachyura* and *Raja clavata* in the 7.d French Channel groundfish survey (1988–2018).

Year	*Raja Brachyura*	*Raja clavata*
	kg km²	kg km²
1993	0.000	12.628
1994	1.377	114.088
1995	0.000	59.890
1996	0.000	19.443
1997	0.000	59.386
1998	0.000	16.308
1999	0.350	45.292
2000	3.342	31.705
2001	0.000	3.030
2002	1.662	39.613
2003	4.204	44.863
2004	2.249	34.246
2005	0.345	45.256
2006	3.028	38.375
2007	2.314	47.978
2008	6.414	33.701
2009	0.624	29.056
2010	0.000	81.301
2011	2.423	65.815
2012	7.968	91.374
2013	0.243	88.835
2014	5.925	86.281
2015	3.341	89.675
2016	6.539	61.751
2017	19.885	117.078
2018	4.203	192.083

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), and 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																		

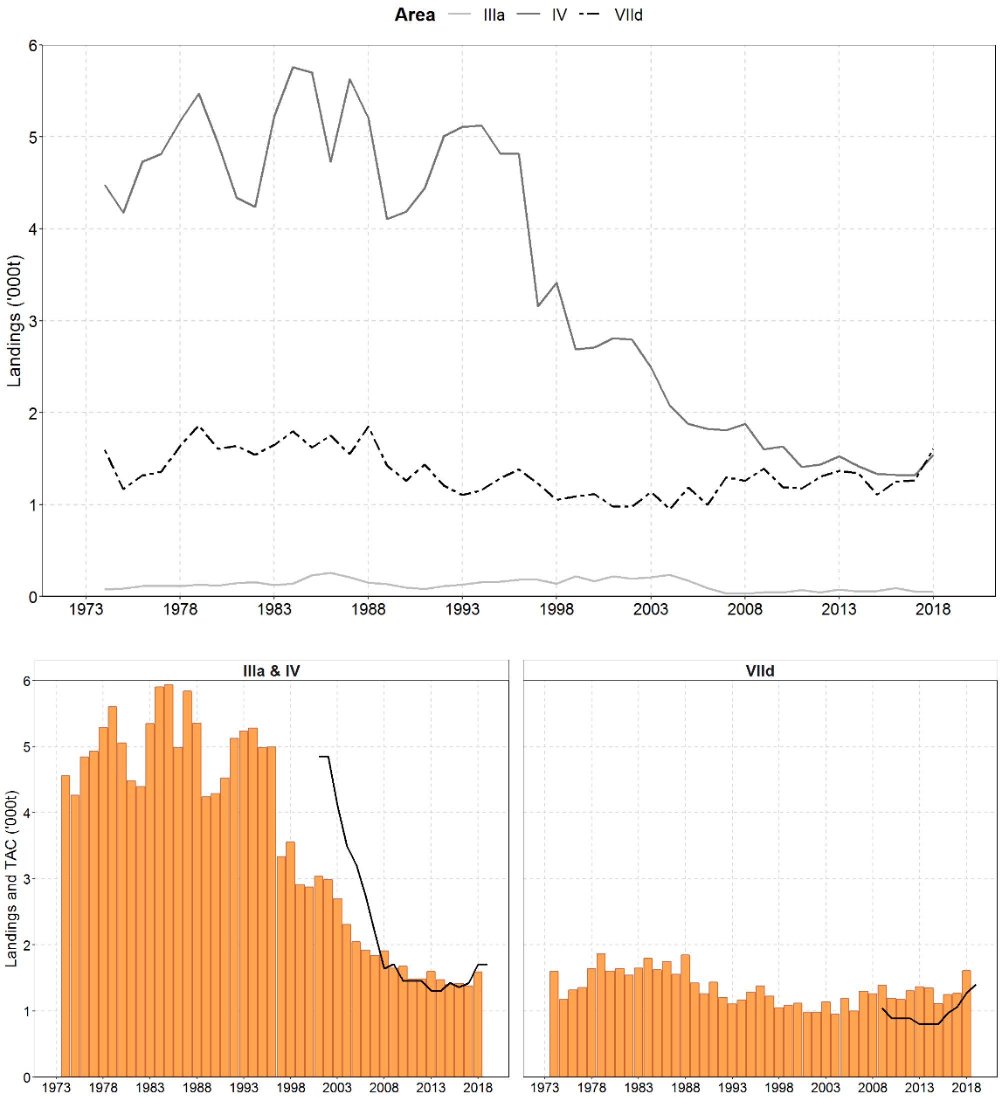


Figure 15.3.1. Top: Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel: total international landings of rays and skates in Division 3.a and Subarea 4 and Division 7.d since 1973, based on WG estimates. Bottom: Landings of area 3.a and 4 (combined) and 7.d, including the TACs for both areas (black lines).

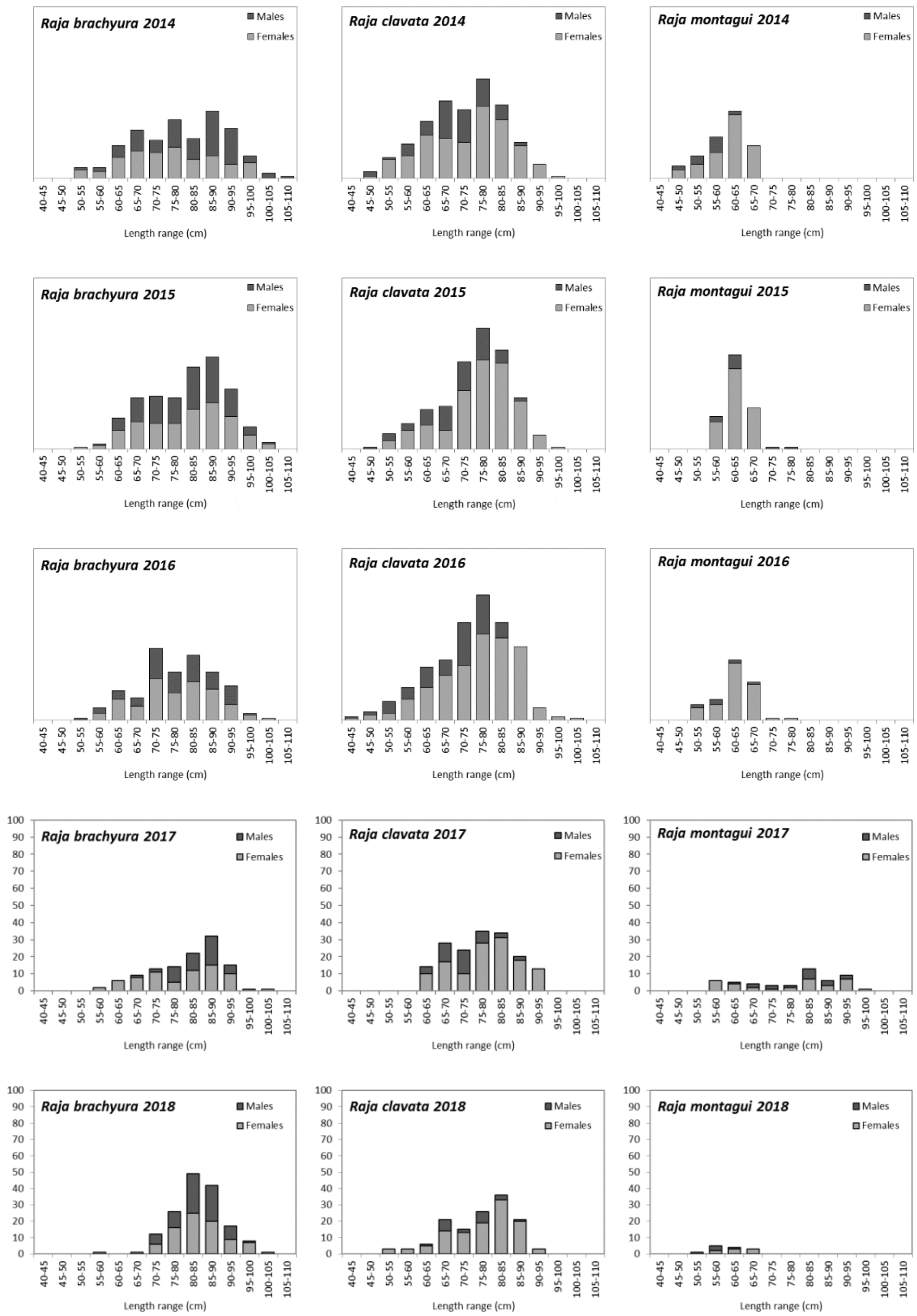


Figure 15.3.2. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Length–frequency distribution of the number of *R. brachyura*, *R. clavata* and *R. montagui* individuals measured during the market sampling programme of the Dutch beam trawl fleet in 2014–2018.

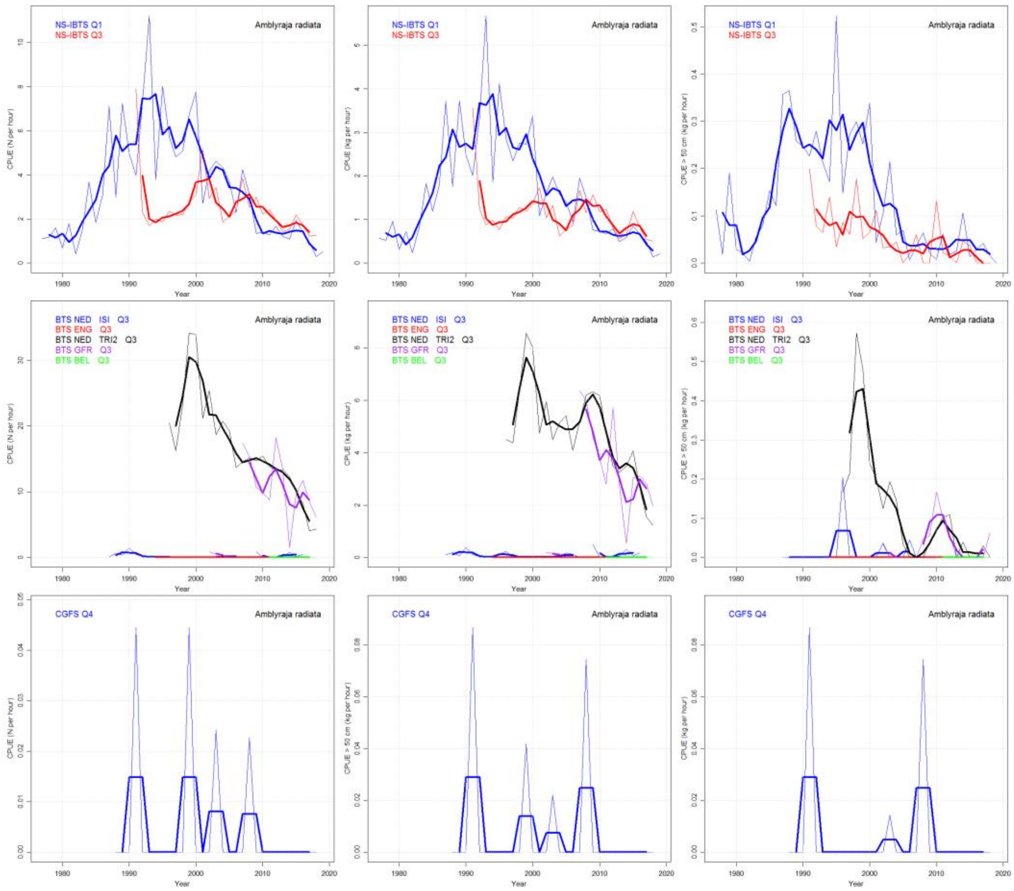


Figure 15.6.1. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Amblyraja radiata*. Abundance index (n. hr^{-1}), biomass index (kg hr^{-1}) and exploitable biomass (kg hr^{-1}), including their three year running means, during the North Sea IBTS (in roundfish areas 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 12 June 2019.

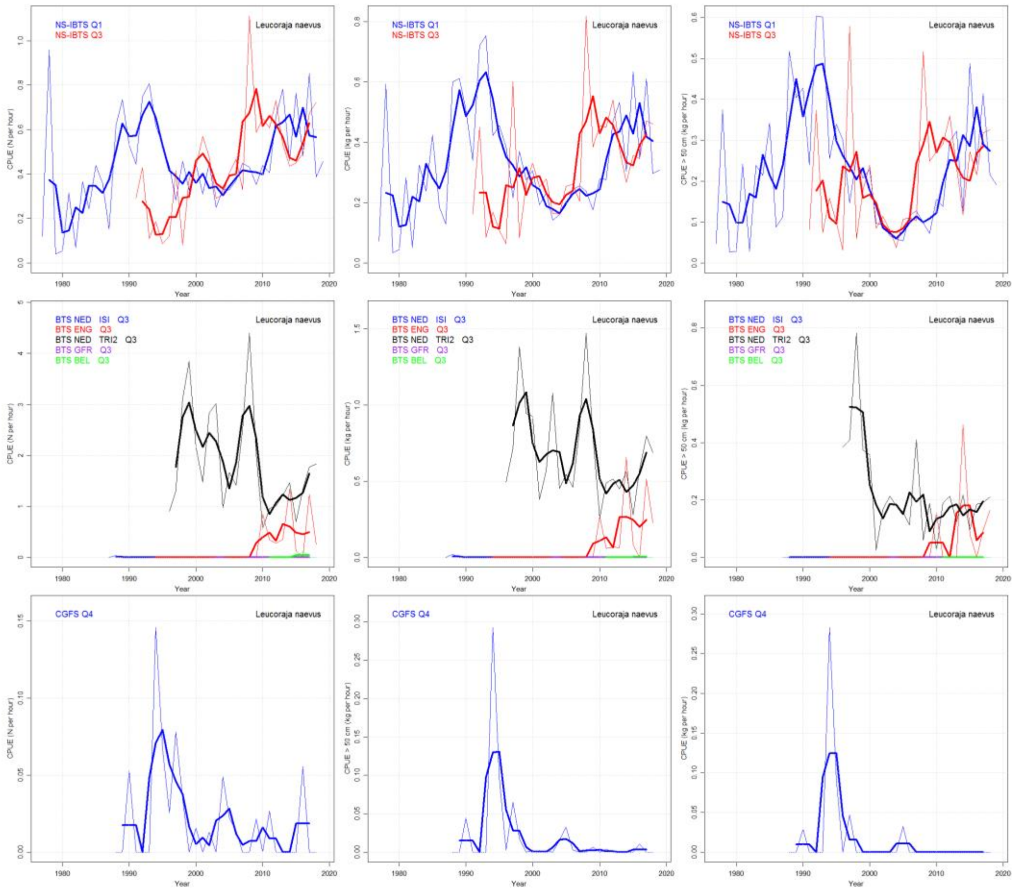


Figure 15.6.2. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Leucoraja naevus*. Abundance index (n. hr-1), biomass index (kg hr-1) and exploitable biomass (kg hr-1), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2018. Data extracted from the DATRAS database (selected for CPUE per length per haul) on 12 June 2019.

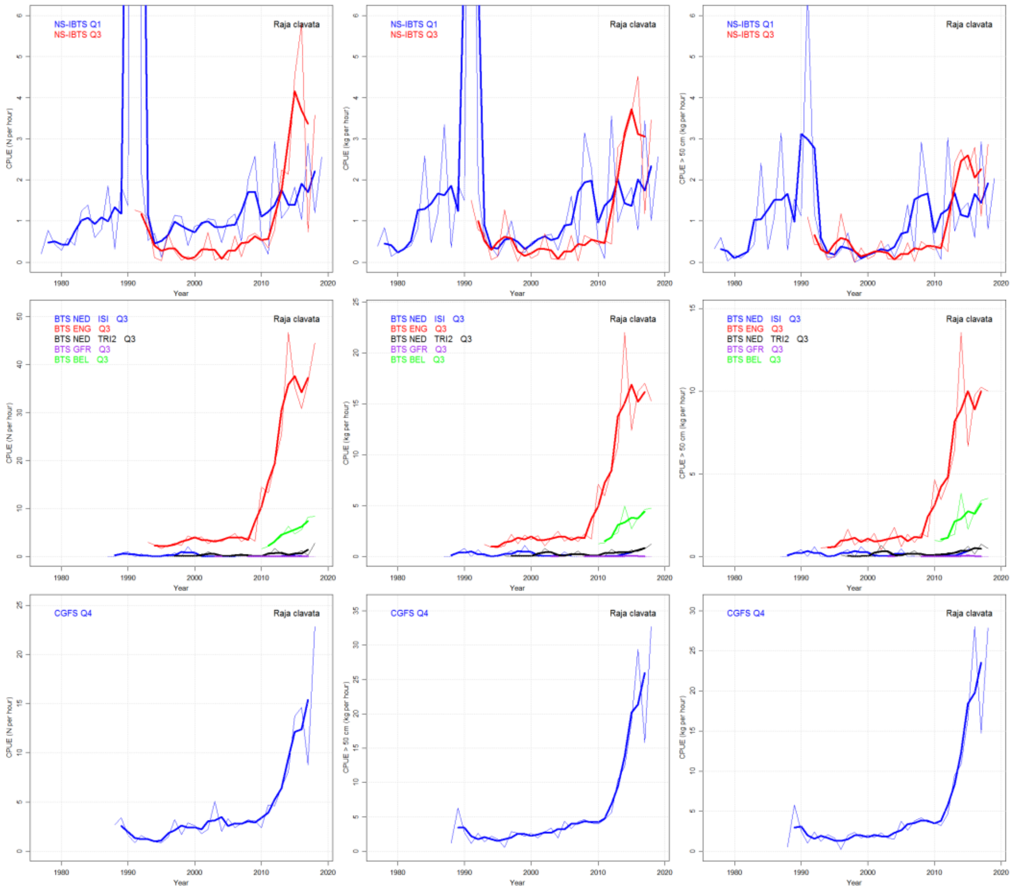


Figure 15.6.3. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Raja clavata*. Abundance index (n. hr^{-1}), biomass index (kg hr^{-1}) and exploitable biomass (kg hr^{-1}), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2018. Data extracted from the DATRAS database (selected for CPUE per length per haul) on 12 June 2019.

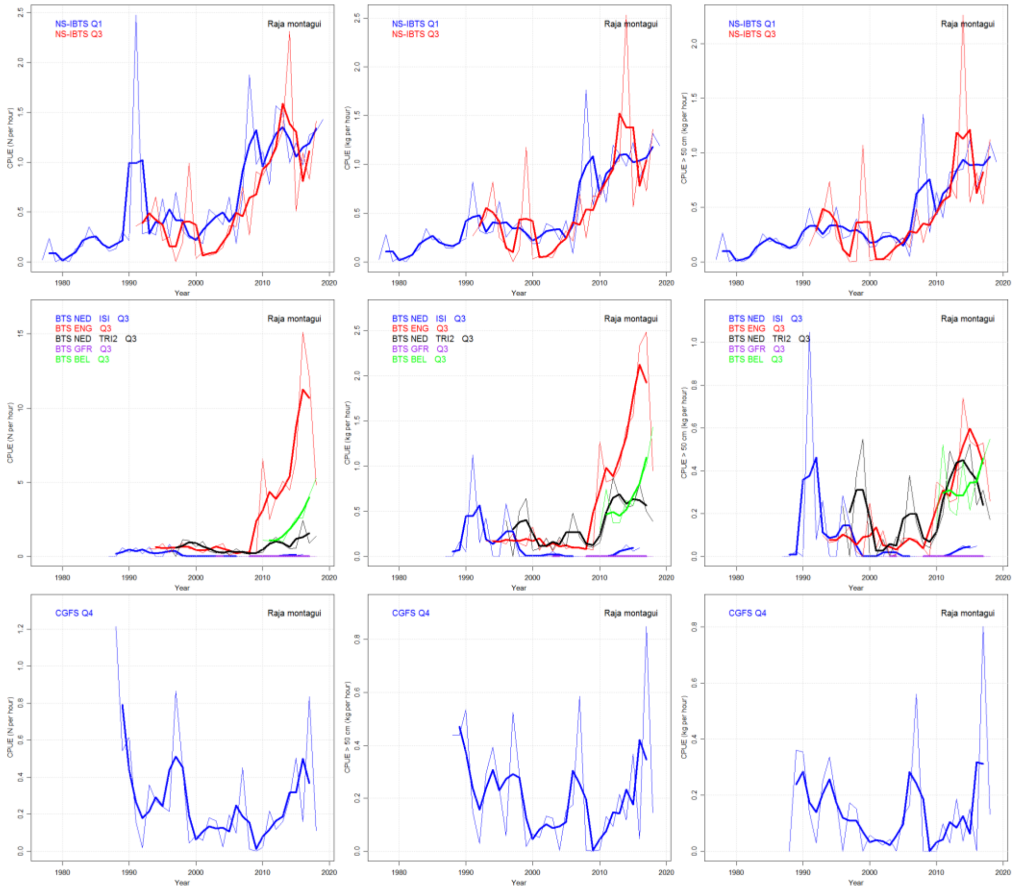


Figure 15.6.4. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Raja montagui*. Abundance index (n. hr^{-1}), biomass index (kg hr^{-1}) and exploitable biomass (kg hr^{-1}), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2018. Data extracted from the DATRAS database (selected for CPUE per length per haul) on 12 June 2019.

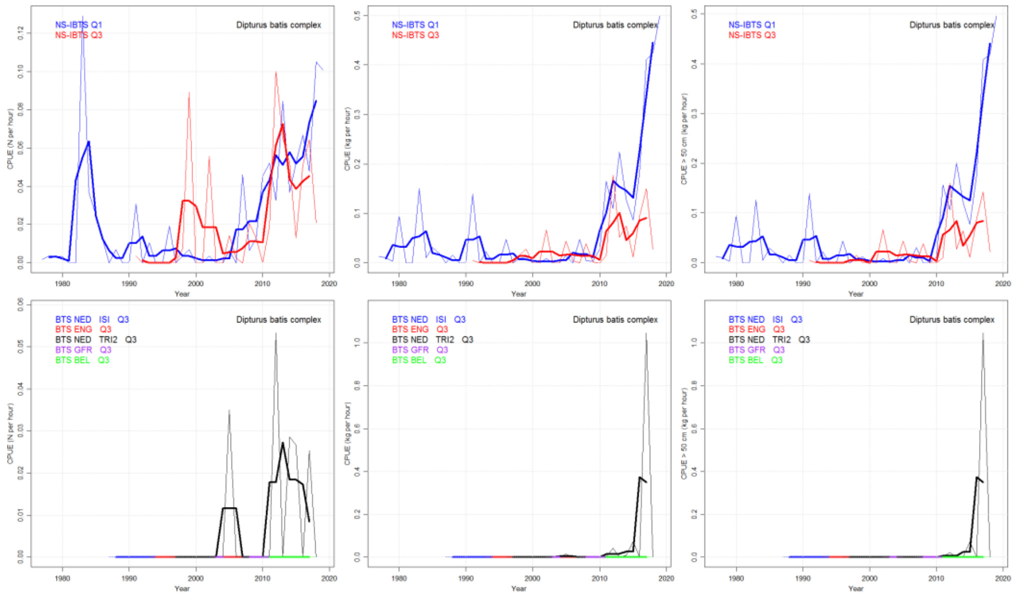


Figure 15.6.5. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. 'Common skate complex'. Abundance index (n. hr^{-1}), biomass index (kg hr^{-1}) and exploitable biomass (kg hr^{-1}), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2018. Data extracted from the DATRAS database (selected for CPUE per length per haul) on 12 June 2019.

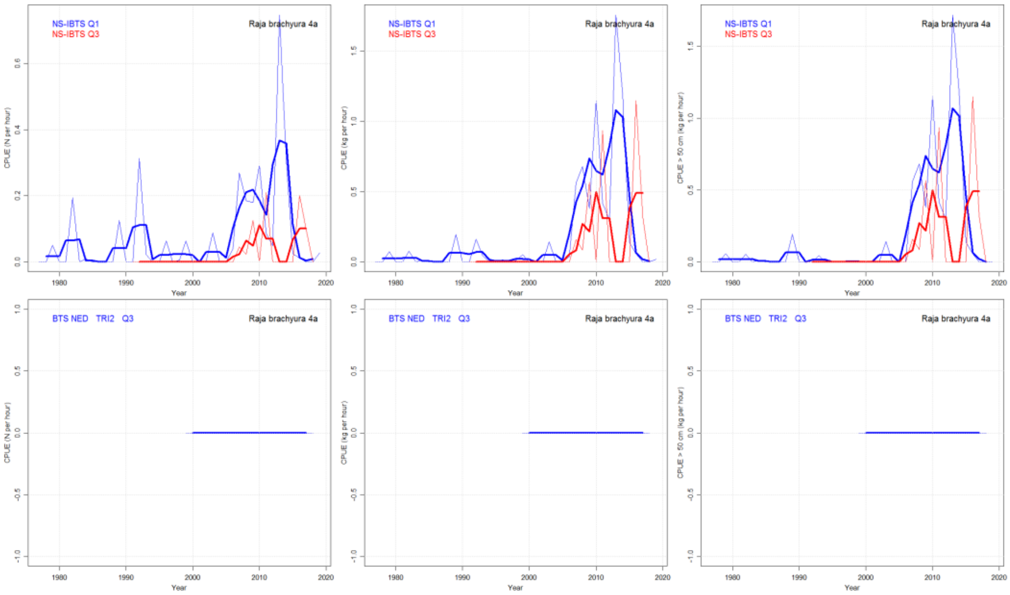


Figure 15.6.6. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Raja brachyuran* in 4.a. Abundance index (n. hr^{-1}), biomass index (kg hr^{-1}) and exploitable biomass (kg hr^{-1}), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2018. Data extracted from the DATRAS database (selected for CPUE per length per haul) on 12 June 2019.

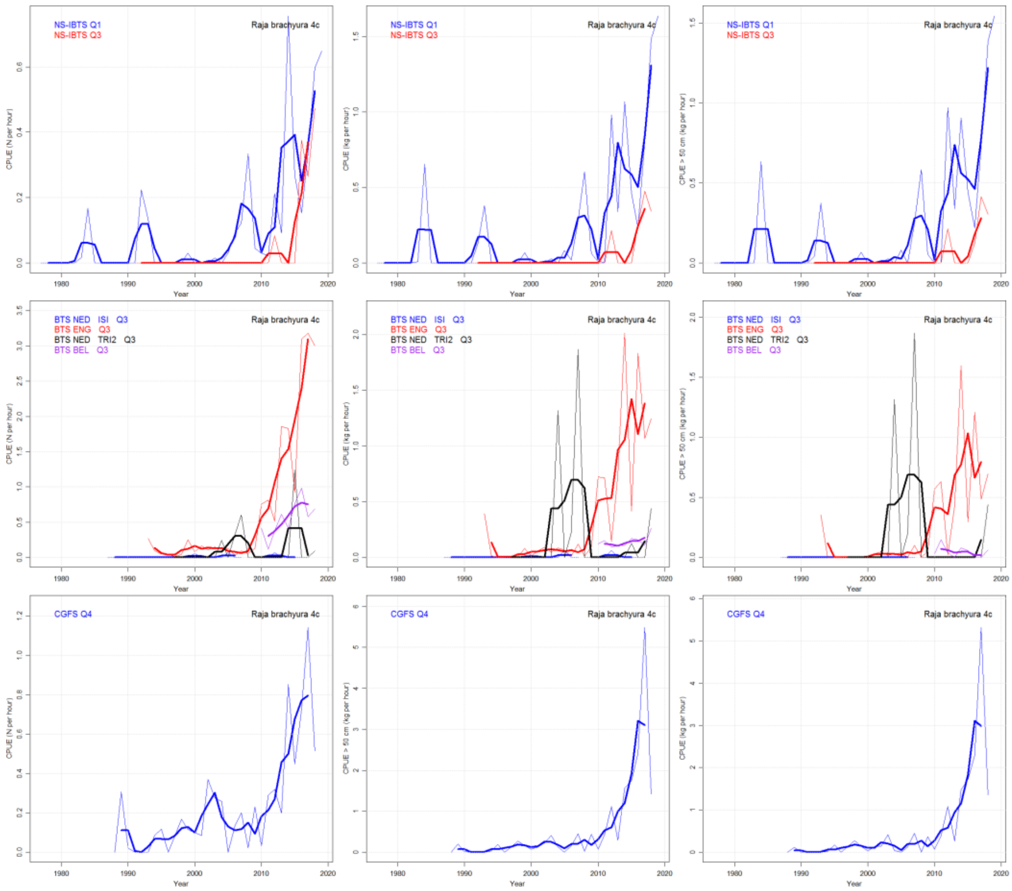
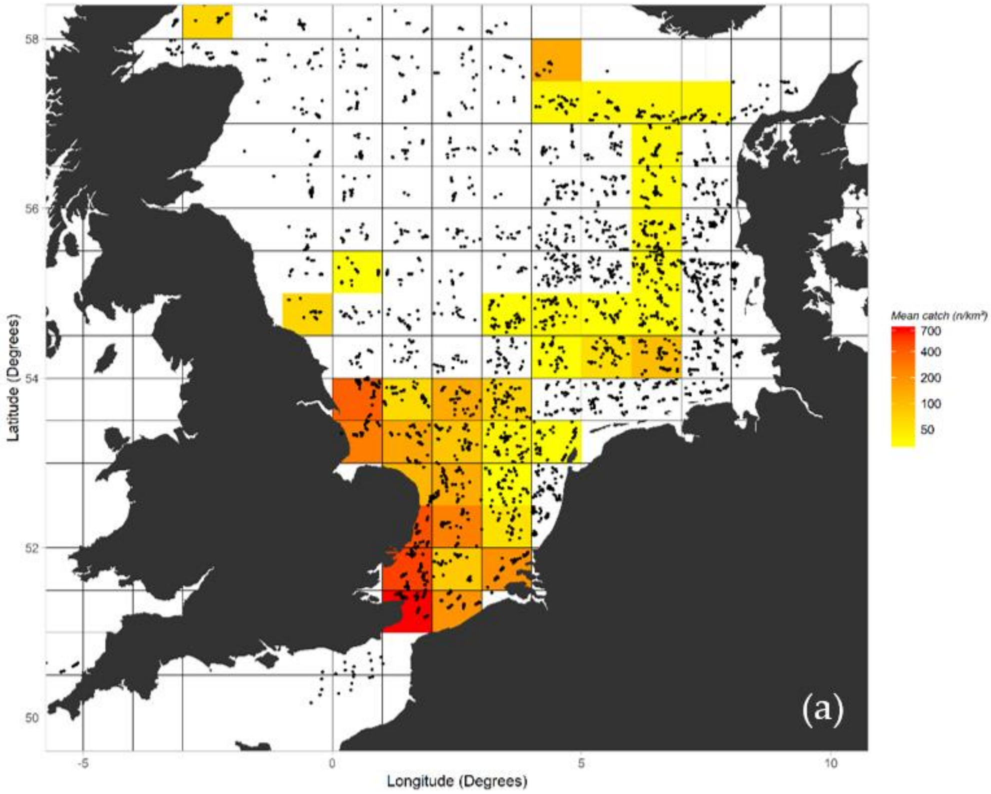
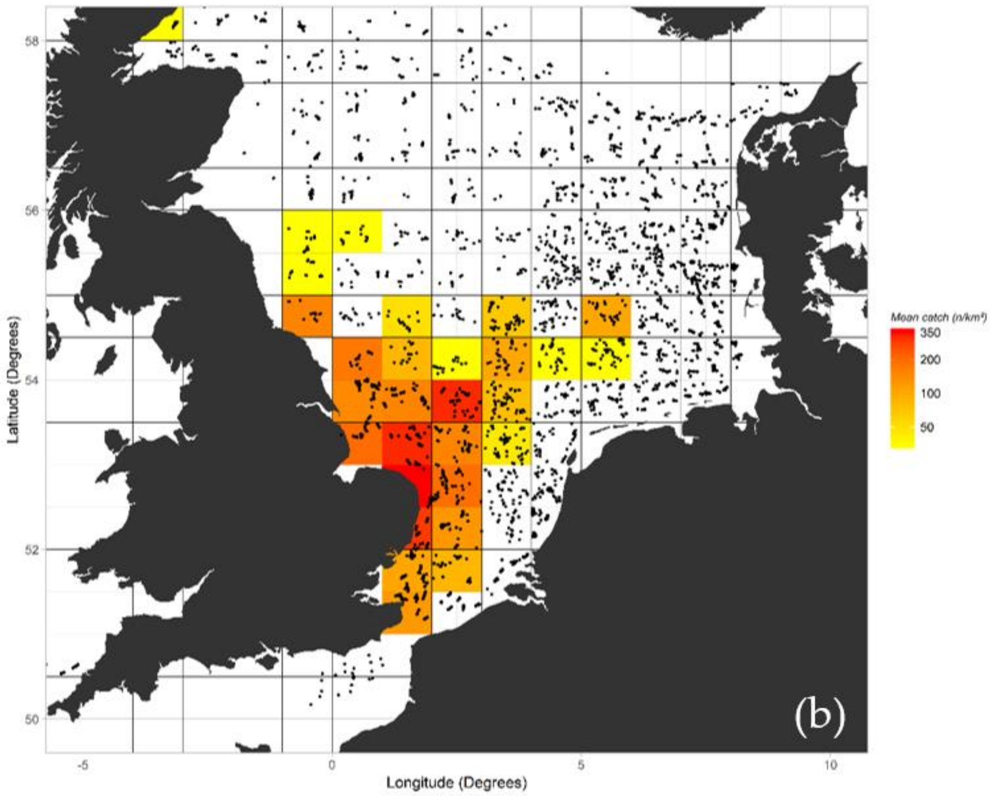


Figure 15.6.7. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Raja brachyura* 4.c. Abundance index (n. hr^{-1}), biomass index (kg hr^{-1}) and exploitable biomass (kg hr^{-1}), including their three year running means, during the North Sea IBTS (in roundfish areas 1–7), BTS, and CGFS surveys in the years 1977–2018. Data extracted from the DATRAS database (selected for CPUE per length per haul) on 12 June 2019.


Latitude (Degrees)
Longitude (Degrees)
Mean catch (n/km²)
700
400
200
100
50
(a)


Latitude (Degrees)
Longitude (Degrees)
Mean catch (n/km²)
350
200
100
50
(b)

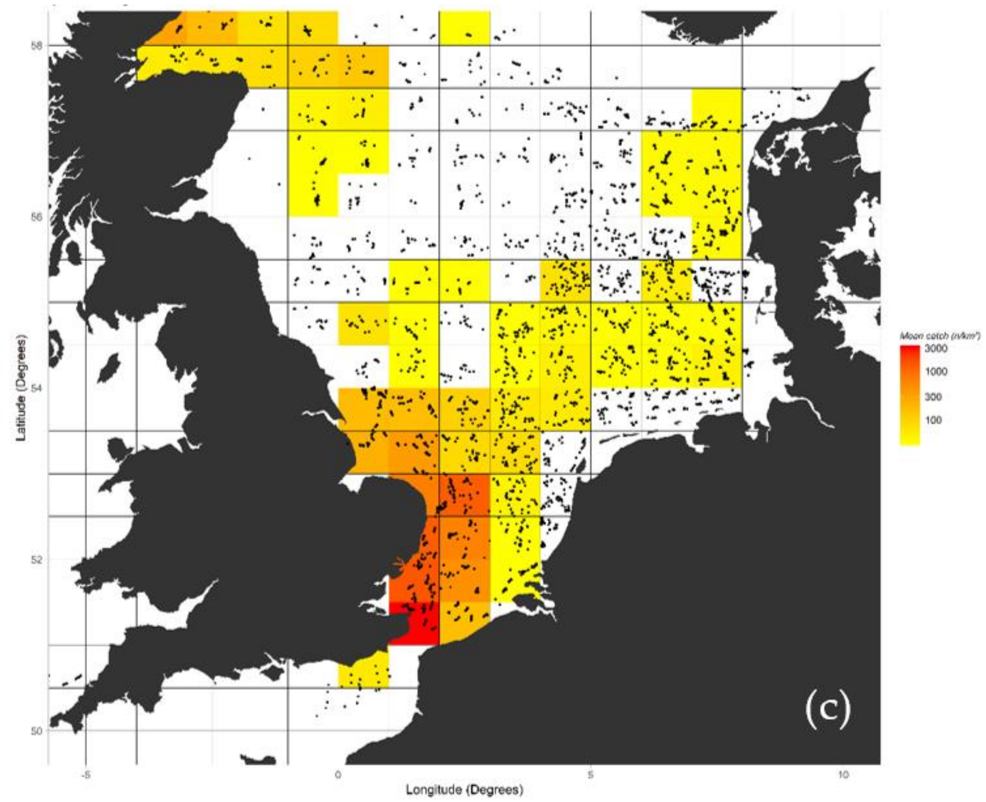


Figure 15.6.8: Average (a) thornback ray, (b) spotted ray, (c) small spotted catshark catches (numbers per km²) from all BTS surveys (German, Dutch and Belgian) in the central-southern North Sea (ICES Areas 27.4.b and 27.4.c) for the period 2004–2018. Black dots show the different shooting positions from the survey hauls over the entire period. Data was obtained from Datras, except for the Belgian data between 2004 and 2009 which was provided from the national database at ILVO.

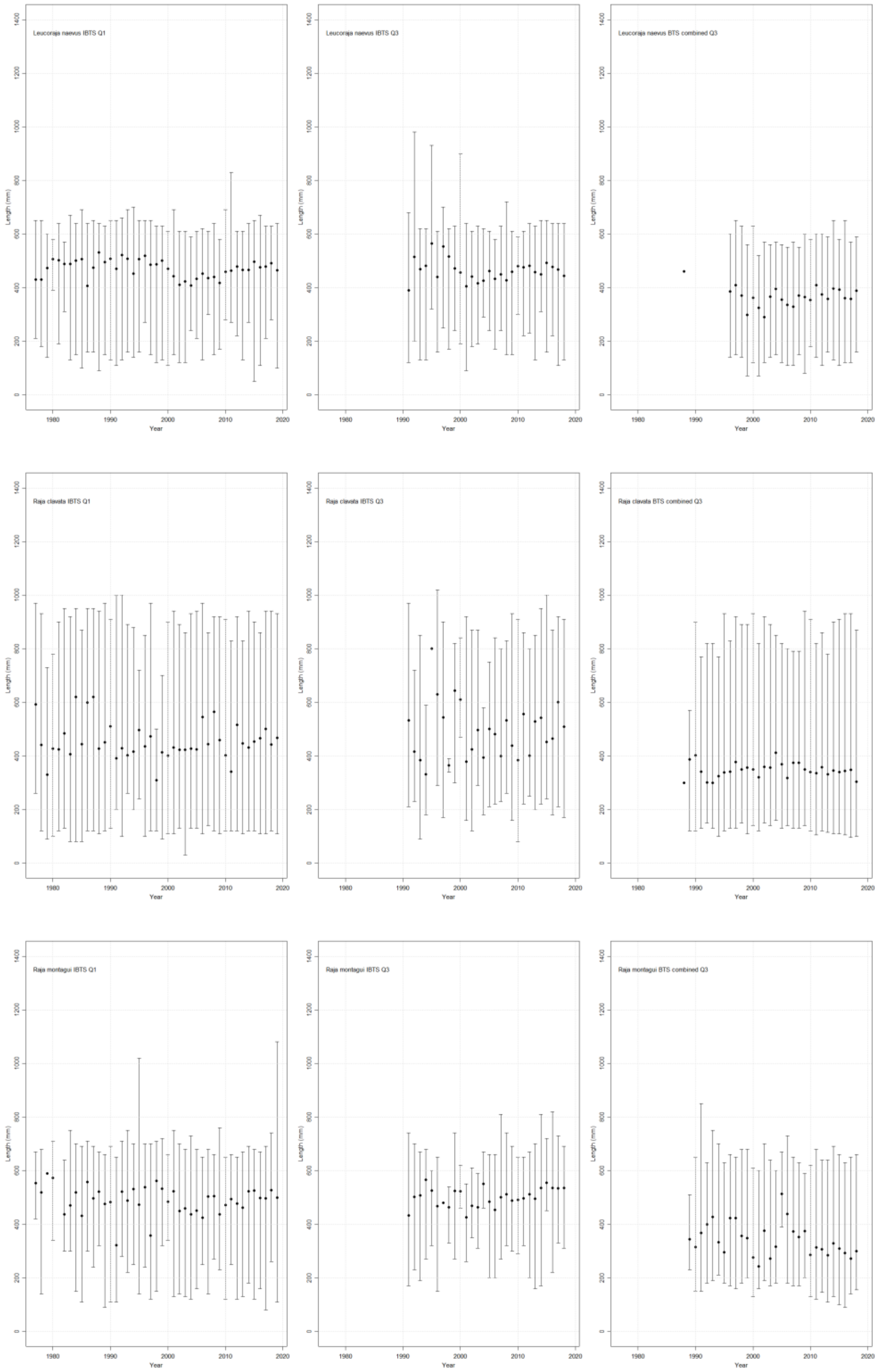


Figure 15.6.9. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Average length (dots) and length range during the North Sea IBTS (roundfish areas 1–7) and BTS surveys. Data extracted from the DATRAS database (selected for CPUE per length per statrec) on 12 June 2019. NOTE: There are still some incorrect data in DATRAS, with some length records of all species (except *R. clavata*) that are >L_{max}.

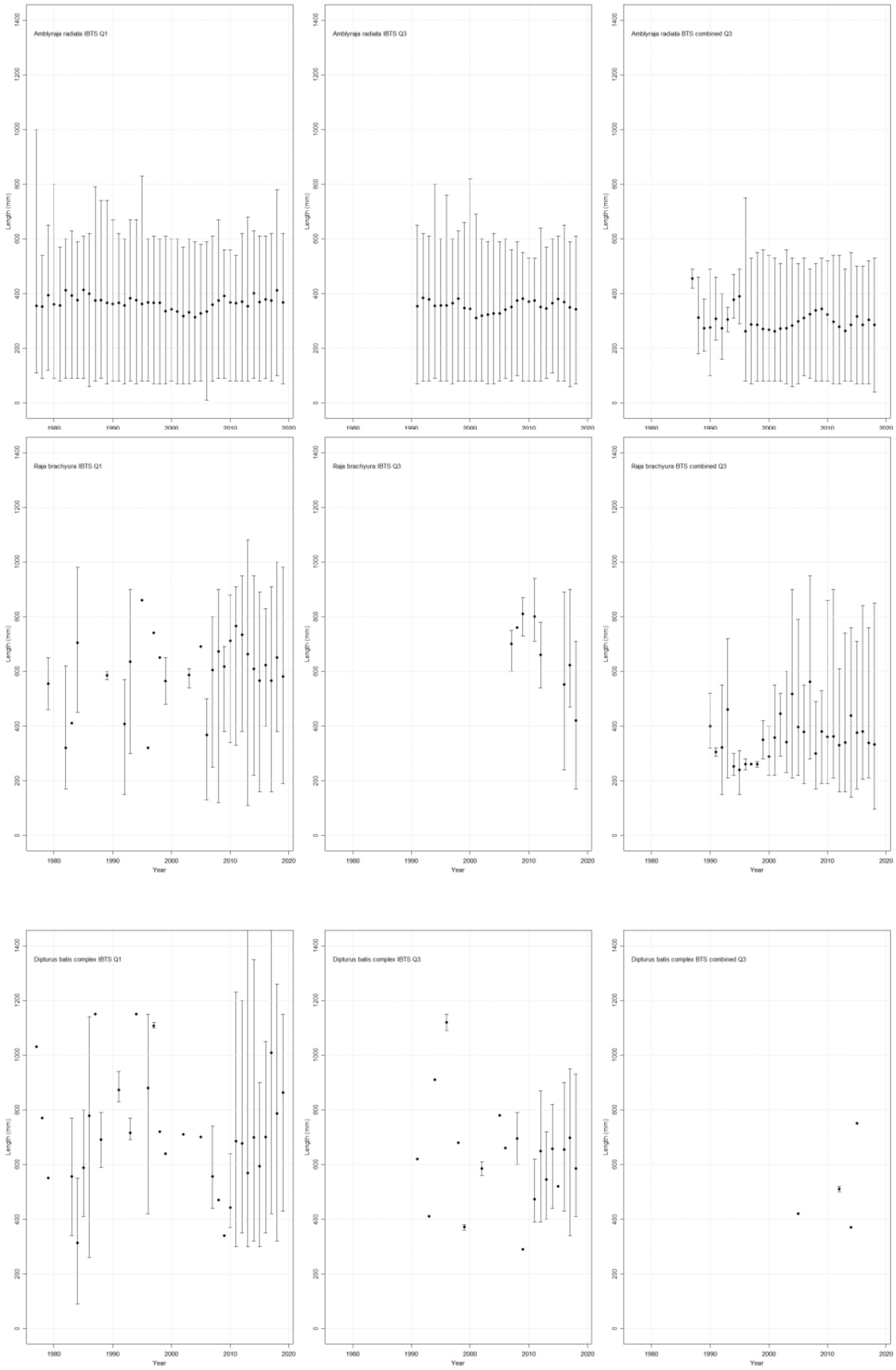


Figure 15.6.9. continued

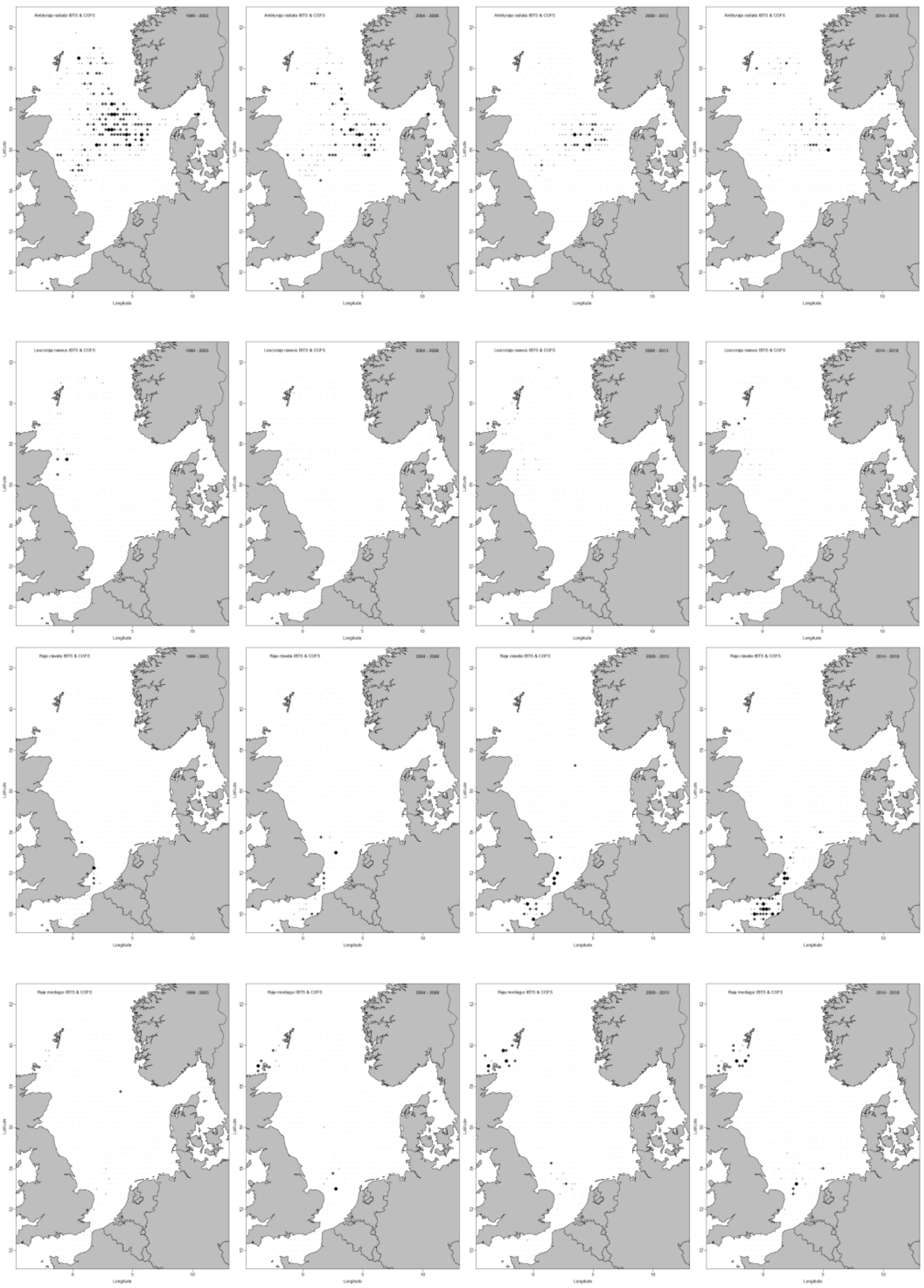


Figure 15.6.10. Distribution plots of the main demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and Eastern Channel. Plots are based on IBTS Q1, IBTS Q3, and eastern Channel CGFS Q4 data. Plots cover four periods: 1999–2003 (left panels), 2004-2008 (centre-left panels), and 2009–2013 (centre right panels) and 2014-2018 (right panels). All data are abstracted from DATRAS. Data for IBTS are extracted as CPUE per length per statistical rectangle) on 12 June 2019, while data for CGFS are extracted as exchange data. Bubble scale is equal in all panels.

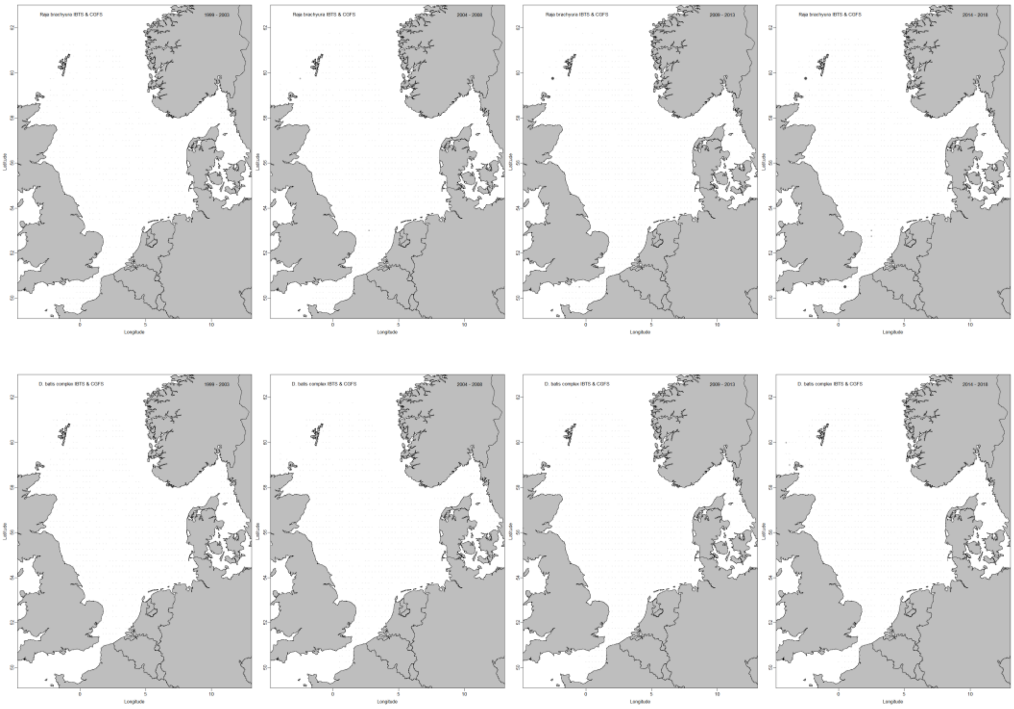


Figure 15.6.10. Continued.

16 Demersal elasmobranchs - 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*, small-eye 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 in 2016, followed by an abrupt decline to appr. 600 tonnes in 2018. A relatively large proportion of the landings is for local consumption.

16.2.2 The fishery in 2018

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 (Figure 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 a few years.

16.14 References

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Table 16.1. Demersal elasmobranchs - 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

		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 - 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	2018
common skate complex	Iceland	82	59	120	145	166	136	123	126	128	117	125	145	153	141	165	143	147	127
	Norway	0	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	615
Rajella lintea	Iceland	0	0	10	8	1	8	7	0	8	12	9	9	7	4	11	3	5	4
***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	0	8	3	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	13	10	12
	Norway	6	5	1	0	0	7	0	1	2	4	4	0	0	0	1	1	0	0
	Portugal	1	0	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	NA
	Spain	0	0	15	0	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	0	0
Raja clavata	France								0	0	0	1	0	0	0	0	0	0	0
Total		1340	1878	1655	1200	855	726	650	786	1043	1183	1520	2039	1917	1788	1595	1433	817	761

Table 16.2. Demersal elasmobranchs - 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 - 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		2018	
	N	%O	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	10	1
Amblyraja radiata	1569	48	1590	39	1399	46	295	42	918	34	1142	41	1289	52	1066	49	1268	48	1026	45	1218	42
Rajella lintea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	0
Amblyraja hyperborea	90	9	103	9	86	10	27	8	73	7	63	8	95	9	68	5	79	8	43	5	54	6
Rajella fyllae	106	5	48	10	70	7	36	5	24	17	35	4	71	10	30	6	46	6	33	9	41	7
Bathyraja spinicauda	18	2	11	2	1	2	2	0	11	1	4	2	11	2	5	1	4	1	5	1	7	1
Rajella bathyphila	2	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	<1	0	0
Rajella bigelowi	1	<1	0	0	0	0	0	0	0	0	0	0	0	0	1	<1	0	0	1	<1	0	0
Malacoraja kreffti															2	<1	3	<1	3	<1	0	0

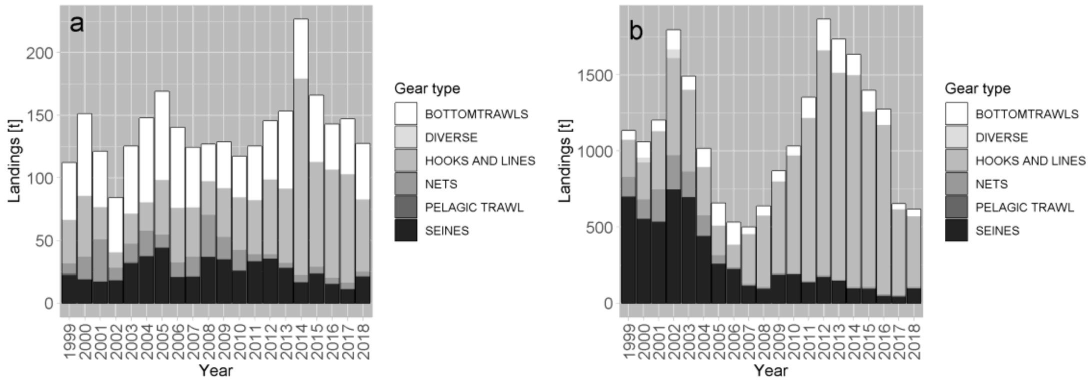

Figure 16.1. Demersal elasmobranchs - Iceland and East Greenland. Icelandic landings of (a) common skate complex and (b) starry ray *A. radiata* by fishing gear). Note different scales at the y-axis.

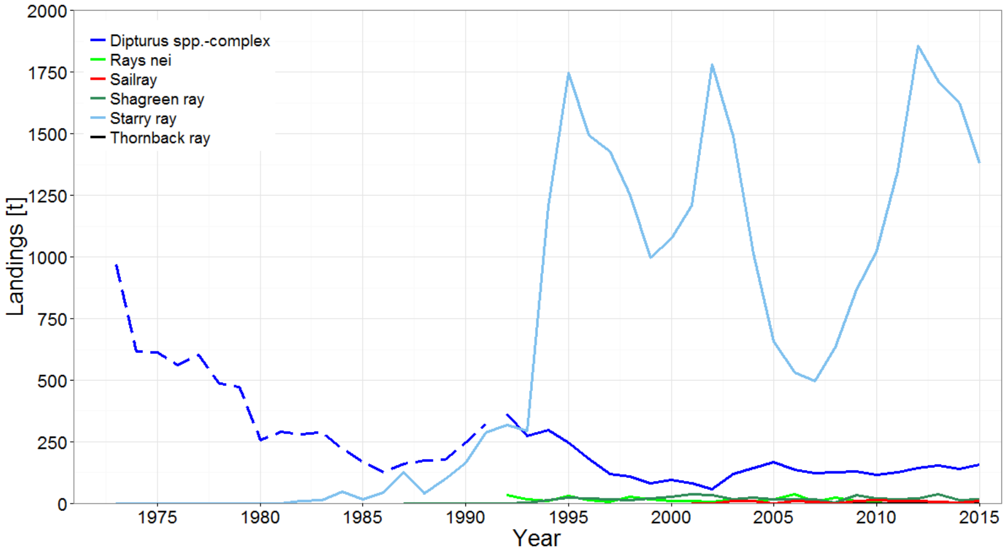

Figure 16.2. Demersal elasmobranchs - Iceland and East Greenland. Landings of skates (Division 5.a and Subarea 14). Prior to 1992, all skates nei are assumed to belong to common skate complex (see earlier reports). WG estimates of the most commonly reported skates, 1973–2015. (ICES, 2016a), national landings data provided to the WG, and Faroese statistical database www.hagstova.fo).

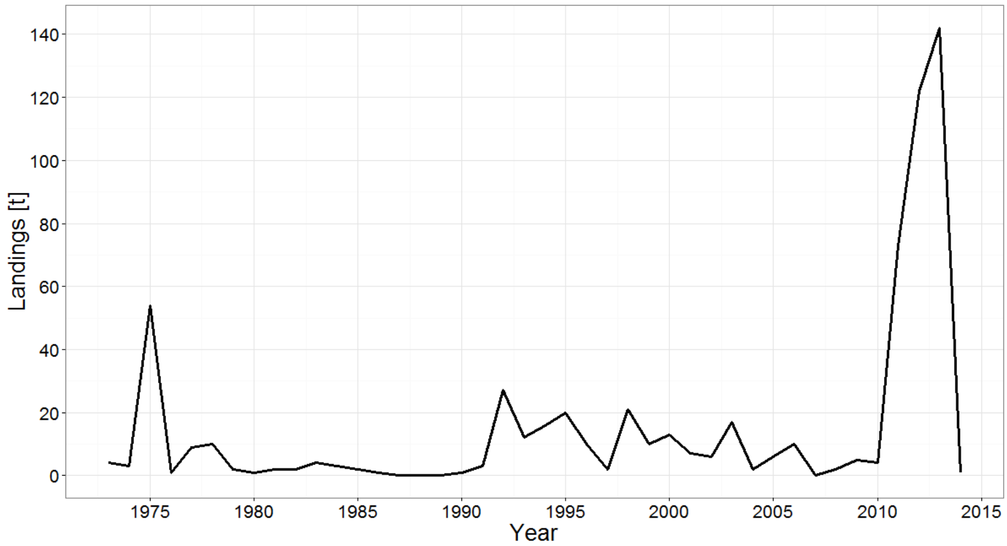

Figure 16.3. Demersal elasmobranchs - Iceland and East Greenland. Combined landings of rays and skates from East Greenland (Subarea 14). The peak landings in 2011–2013 originate from *Amblyraja radiata* (FAO Code RJR). Data from ICES (2016a, b).

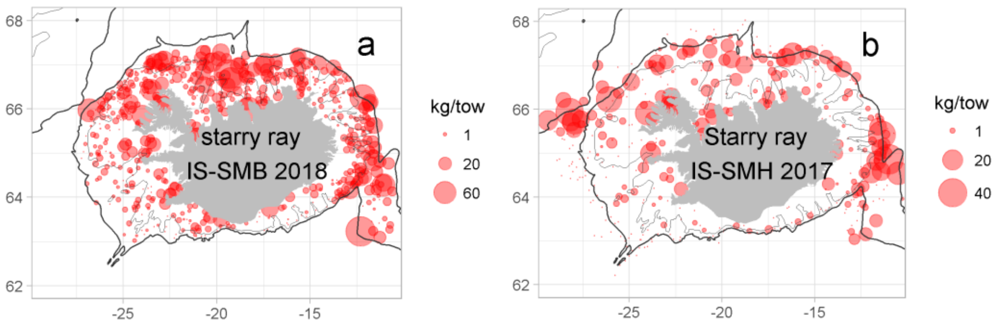

Figure 16.4. Demersal Elasmobranchs - Iceland and East Greenland. Spatial distribution of starry ray *A. radiata* in Icelandic waters (Division 5.a). a: Spring survey (IS-SMB) 2018. b: Autumn survey (IS-SMH) 2017.

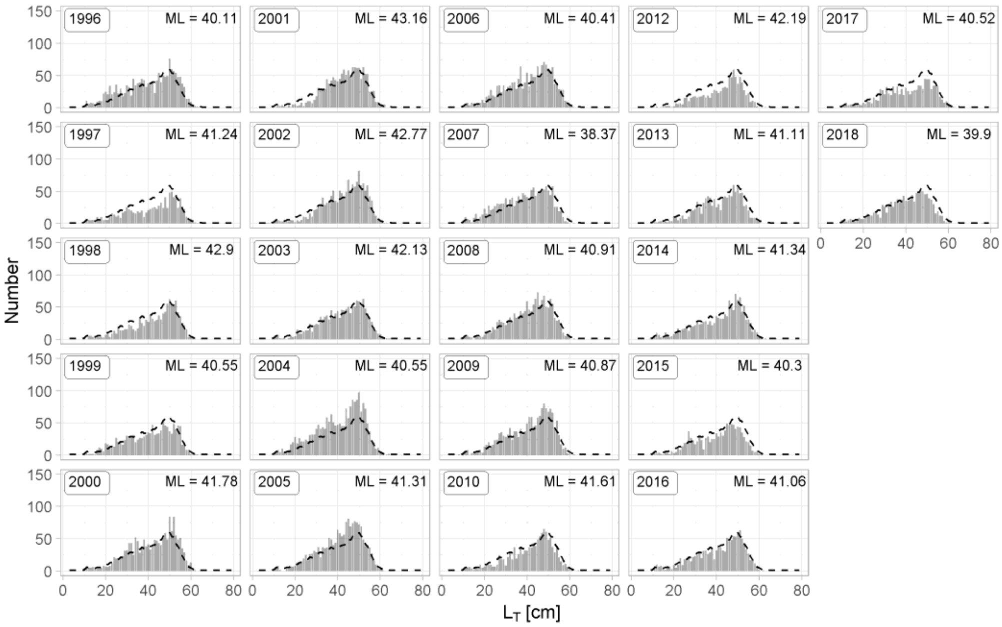

Figure 16.5. Demersal elasmobranchs - Iceland and East Greenland. Length distribution of starry ray *A. radiata* in Icelandic waters (Division 5.a) each year as observed in the annual autumn survey. Broken line denotes average value. Mean length each year is denoted in the upper right corner of each 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 2018

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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ICES. 2016. Official Nominal Catches 2006–2014. Version 18-06-2016. Accessed 18-06-2016 via http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx ICES, Copenhagen.

http://www.hagstova.fo Accessed 21th June 2018.

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 1990–2018 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 1990–2018 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 1990–2018 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 1990–2018 were extracted from Faroese national statistics database available on www.hagstova.fo. *Total catch (live weight). + : < 0.5 tonnes.

Species	Country	2014	2015	2016	2017	2018
Raja rays nei	Faroe Islands*	150	114	126	139	138
	France	0	5	0	2	6
	Germany	0	0	0		
	Norway	19	13	23	22	40
	UK	0	0	0		
Common skate complex	Norway	0	0	0		
	France	0	0	0	+	+
	UK	0	1	1	5	1
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	171	185

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	*	*	**	***	***	***	**

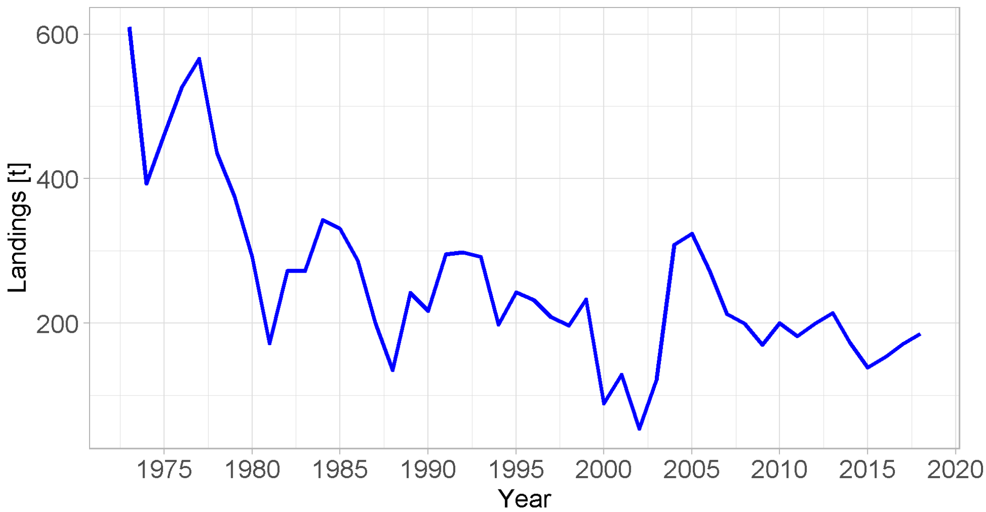

Figure 17.1. Demersal elasmobranchs at the Faroe Islands (Subarea 5.b). Reported landings of skates (1973–2018) based on ICES database (ICES, 2017), national landings data and Faroese national statistics database (www.hagstova.fo).

18 Skates and rays in the Celtic Seas (ICES subareas 6 and 7 (except Division 7.d))

Advice for stocks in this ecoregion was last provided in 2017 and will next be provided in 2020. Therefore, this chapter only contains minor edits and updates to landings tables and figures. The advice for 2019 and 2020 is reproduced in Section 18.2.3.

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 2018

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 2018 as summarized in Table below.

Stock	Stock code	Assessment category	Advice basis	Advised Landings in 2019 and 2020
Blonde ray *Raja brachyura* Divisions 7.a and 7.f-g	rjh.27.7afg	5.	Precautionary approach	716 t
Blonde ray *Raja brachyura* Division 7.e	rjh.27.7e	5.	Precautionary approach	266 t
Thornback ray *Raja clavata* Subarea 6	rjc.27.6	3	Precautionary approach	174 t
Thornback ray *Raja clavata* Divisions 7.a and 7.f-g	rjc.27.7afg	3	Precautionary approach	1663 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	40 t
Spotted ray *Raja montagui* Subarea 6 and Divisions 7.b and 7.j	rjm.27.67bj	3	Precautionary approach	80 t
Spotted ray *Raja montagui* Divisions 7.a and 7.e-h	rjm.27.7ae-h	3	Precautionary approach	1296 t
Cuckoo ray *Leucoraja naevus* Subareas 6–7 and Divisions 8.a-b and 8.d	Rjn.27.678abd	3	Precautionary approach	3281 t
Sandy ray *Leucoraja circularis* Celtic Seas and adjacent areas	rji.27.67	5	Precautionary approach	34 t
Shagreen ray *Leucoraja fullonica* Celtic Seas and adjacent areas	rjf.27.67	5	Precautionary approach	168 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.	115 t
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	ICES was not requested to provide advice on fishing opportunities for these stocks.	NA
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,
2019	10,184 t	1,3,6,7,8,10	Council Regulation (EU) No 2019/124 of 30 January 2019,

[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].
[10] 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 = 192 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

A high-survivability exemption to the Landings Obligation was provided for skates and rays in the Celtic Seas ecoregion until 31 December 2021, with *L. naevus* only exempted until 31 December 2019. An extension to the exemption would only be possible with additional supporting information being provided by the NWWAC. This particularly applies to *L. naevus*, which had a shorter deadline for the provision of evidence of high-survivability than the other species. Several meetings have been held by the NWWAC to discuss and advance this. As of writing, reports are not yet available.

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 licensing 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 WKSHARK2 (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 resubmitted in 2017, therefore there may be slight differences in landings figures between this and previous reports.

The 2018 and 2019 data calls followed the procedures above.

18.3.1 Landings

Discussion of the landings below has not been updated since 2018.

Landings data for skates (Rajidae) were supplied by all nations fishing in shelf waters within this ecoregion. Data for 2018 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, to better identify where improved training and/or market sampling may improve data quality.

18.3.3 Discards

WKSHARK3 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 and 2019 data calls. 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 underrepresented 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 2018 for 2019 and 2020. The assessments outlined below have not been updated in 2019. 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 north-western 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 survey 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 its 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 their 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 and 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 quantitative 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.

WKSHARK5, a workshop called mainly to examine undulate ray in the English Channel, took place in January 2019. See that report for further details on this stock (ICES, 2019).

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 red-list 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 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, tonnes) 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	2018
BEL	raj.27.67a-ce-k	1568	1328	1405	413	416	333	227	74	8	1	1	3	3	0.2
	rjb.27.67a-ce-k				0	0	0			0	0				0.03
	rjc.27.7afg			0	328	216	197	302	441	391	240	350	241	212	197
	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	0.1
	rjh.27.4a6					0	0								
	rjh.27.7afg				166	170	210	313	404	406	351	359	313	338	348
	rjh.27.7e				7	6	3	5	5	6	3	6	11	9	14
	rji.27.67							0	0	0	0	0	0	2	72
	rjm.27.67bj						0								
	rjm.27.7ae-h				78	63	55	120	70	3	0	1	7	2	15
	rjn.27.678abd			0	86	81	70	112	93	97	48	51	27	26	28
	rju.27.7de												5	24	15
BEL Total		1568	1328	1405	1083	953	917	1204	1219	1022	737	893	753	762	689
DE	raj.27.67a-ce-k	39	7	26	60	2	4	3	1						0.5
DE Total		39	7	26	60	2	4	3	1						0.5
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	119
	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	43
	rjc.27.7afg											5	6	9	0.1

Country	ICES Stock Code	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	rjc.27.7e						0	0							
	rjf.27.67					62	42	29	20	33	20	34	15	26	20
	rjh.27.4a6					0									
	rji.27.67	86	74	40	7	30	16	22	8	10	5	3	5	11	9
	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	335
	rju.27.7bj												1	1	
ES Total		2341	2648	2392	1986	1103	603	477	365	471	438	1207	1162	963	525
FRA	raj.27.67a-ce-k	2048	1740	1757	1669	548	314	174	160	139	128	123	130	183	170
	rjb.27.67a-ce-k	351	295	308	414	68	30	15	23	21	32	33	17		0
	rjc.27.6	64	78	73	82	39	24	19	39	28	10	2	1	1	3
	rjc.27.7afg	379	264	238	181	147	131	133	106	95	107	70	121	147	101
	rjc.27.7e	95	86	82	64	122	101	114	108	181	224	225	213	176	212
	rje.27.7de	21	19	19	22	32	28	28	24	26	24	24	8	8	9
	rje.27.7fg	27	23	18	21	29	21	16	30	30	65	31	5	57	69
	rjf.27.67	32	25	33	28	144	150	152	147	127	131	151	130	124	128
	rjh.27.4a6					1					1	1	1	0	1
	rjh.27.7afg					36	73	131	87	52	170	218	275	257	172
	rjh.27.7e					56	148	205	169	191	281	304	223	240	396
	rji.27.67	199	152	185	178	46	35	25	35	26	33	34	37	34	43
	rjm.27.67bj	13	7	3	4	2	4	7	5	17	53	43	47	40	23
	rjm.27.7ae-h	1080	902	833	870	785	934	1062	1135	899	912	745	819	661	834
	rjn.27.678abd	3164	2565	2575	2507	3217	3069	2909	2571	2195	2515	2621	2233	2142	2288
	rju.27.7bj					0				0		0	1	1	0

Country	ICES Stock Code	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	rju.27.7de					19	9	20	6	3	10	50	58	79	86
FRA Total		7473	6157	6123	6041	5294	5071	5010	4646	4031	4695	4674	4319	4149	4535
GBR	raj.27.67a-ce-k	2773	2454	2398	1478	508	290	168	153	101	77	46	34	30	30
	rjb.27.67a-ce-k				96	22	1	19	12	1	63	118	116	106	211
	rjc.27.6				1	56	61	57	67	120	120	114	147	113	201
	rjc.27.7afg			0	204	300	371	384	483	416	252	309	274	276	324
	rjc.27.7e	0	0		3	82	98	98	129	151	151	158	195	172	206
	rje.27.7de				4	18	40	28	33	32	36	39	19	15	12
	rje.27.7fg			0	91	157	214	189	208	117	79	78	69	31	55
	rjf.27.67				13	44	108	97	79	85	55	25	39	21	14
	rjh.27.4a6				7	5	7	17	4	0	1	3	2	1	3
	rjh.27.7afg		0	0	97	138	226	273	261	262	229	245	245	270	328
	rjh.27.7e		0		32	159	215	204	175	222	295	396	352	241	323
	rji.27.67				0	2	0	0	3	25	22	1	35	17	31
	rjm.27.67bj				5	16	27	32	30	27	29	43	49	44	62
	rjm.27.7ae-h	0		0	12	38	102	88	85	90	80	70	80	89	93
	rjn.27.678abd				225	321	421	402	306	269	262	266	254	259	272
	rju.27.7de				2	2			0			5	22	36	43
GBR Total		2773	2454	2399	2270	1868	2179	2056	2031	1919	1752	1917	1933	1721	2208
IRL	raj.27.67a-ce-k	2117	1728	1581	1283	1007	547	394	410	243	219	227	230	284	188
	rjb.27.67a-ce-k			0		2	4	17	1	0	0	9	7	9	9
	rjc.27.6					3	33	56	69	71	85	87	99	130	90
	rjc.27.7afg					8	80	126	134	146	191	169	220	232	219
	rjc.27.7e									0		2		2	4
	rje.27.7de													2	
	rje.27.7fg						0	0	0	0	0	0	0		

Country	ICES Stock Code	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	rjf.27.67						1	6	7	6	4	2	2	49	62
	rjh.27.4a6					0	4	1	1	24	9	9	11	5	23
	rjh.27.7afg	3	6			5	402	382	407	377	420	351	171	154	228
	rjh.27.7e								0			2		2	3
	rji.27.67						0	4	0						
	rjm.27.67bj					1	20	18	25	24	43	28	20	12	19
	rjm.27.7ae-h					0	19	63	53	40	49	48	41	10	58
	rjn.27.678abd					12	55	106	108	93	83	79	69	69	115
	rju.27.7bj														3
IRL Total		2120	1734	1581	1283	1038	1165	1173	1218	1025	1104	1012	871	961	1022
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	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	0
NOR	raj.27.67a-ce-k	50	101	89	77	96	131	62	107	99	157	272	312	153	30
NOR Total		50	101	89	77	96	131	62	107	99	157	272	312	153	30
Grand Total		16364	14429	14016	12800	10355	10071	9986	9587	8568	8883	9975	9350	8710	9040

Table 18.2. Skates and rays in the Celtic Seas. Regional total landings (ICES estimates, tonnes) 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	2018
raj.27.67a-ce-k	BEL	1568	1328	1405	413	416	333	227	74	8	1	1	3	3	0.2
	DE	39	7	26	60	2	4	3	1						0.5
	ES	2231	2568	2340	1946	210	52	24	20	32	92	45	61	134	138
	FRA	2048	1740	1757	1669	548	314	174	160	139	128	123	130	183	170
	GBR	2773	2454	2398	1478	508	290	168	153	101	77	46	34	30	30
	IRL	2117	1728	1581	1283	1007	547	394	410	243	219	227	230	284	188
	NLD	0	1	0	0	0	0	0	0	0					
	NOR	50	101	89	77	96	131	62	107	99	157	272	312	153	30
raj.27.67a-ce-k Total		10826	9926	9597	6928	2787	1671	1053	924	623	674	714	770	787	557
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	211
	IRL			0		2	4	17	1	0	0	9	7	9	9
rjb.27.67a-ce-k Total		375	301	319	535	93	35	51	37	22	95	609	516	415	220
rjc.27.6	ES					16	2	10	6	23	21	12	12	50	43
	FRA	64	78	73	82	39	24	19	39	28	10	2	1	1	3
	GBR				1	56	61	57	67	120	120	114	147	113	201
	IRL					3	33	56	69	71	85	87	99	130	90
rjc.27.6 Total		64	78	73	82	114	120	141	181	241	236	213	260	294	337
rjc.27.7afg	BEL			0	328	216	197	302	441	391	240	350	241	212	197
	ES											5	6	9	0
	FRA	379	264	238	181	147	131	133	106	95	107	70	121	147	101
	GBR			0	204	300	371	384	483	416	252	309	274	276	324

ICES Stock Code	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	IRL					8	80	126	134	146	191	169	220	232	219
	NLD												0		
rjc.27.7afg Total		379	264	238	713	671	780	944	1165	1048	790	903	861	876	840
rjc.27.7e	BEL				5	2	8	3	4	4	3	9	14	21	14
	ES						0	0							
	FRA	95	86	82	64	122	101	114	108	181	224	225	213	176	212
	GBR	0	0		3	82	98	98	129	151	151	158	195	172	206
	IRL									0		2		2	4
	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	437
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	9
	GBR				4	18	40	28	33	32	36	39	19	15	12
	IRL													2	
rje.27.7de Total		21	19	19	26	50	70	61	62	65	67	72	36	36	21
rje.27.7fg	BEL						37	117	124	99	83	106	123	116	0
	FRA	27	23	18	21	29	21	16	30	30	65	31	5	57	69
	GBR			0	91	157	214	189	208	117	79	78	69	31	55
	IRL						0	0	0	0	0	0	0		0
rje.27.7fg Total		27	23	18	112	187	272	323	362	247	227	216	198	204	124
rjf.27.67	ES					62	42	29	20	33	20	34	15	26	20
	FRA	32	25	33	28	144	150	152	147	127	131	151	130	124	127
	GBR				13	44	108	97	79	85	55	25	39	21	14
	IRL						1	6	7	6	4	2	2	49	65
rjf.27.67 Total		32	25	33	41	250	301	283	253	251	211	212	186	219	225

ICES Stock Code	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
rjh.27.4a6	BEL					0	0								
	DK											0			
	ES					0									
	FRA					1					1	1	1	0	1
	GBR				7	5	7	17	4	0	1	3	2	1	3
	IRL					0	4	1	1	24	9	9	11	5	23
rjh.27.4a6 Total					7	6	10	17	5	24	10	14	14	7	27
rjh.27.7afg	BEL				166	170	210	313	404	406	351	359	313	338	348
	FRA					36	73	131	87	52	170	218	275	257	172
	GBR		0	0	97	138	226	273	261	262	229	245	245	270	328
	IRL	3	6			5	402	382	407	377	420	351	171	154	228
rjh.27.7afg Total		3	6	0	263	350	910	1099	1160	1097	1170	1172	1004	1019	1077
rjh.27.7e	BEL				7	6	3	5	5	6	3	6	11	9	14
	FRA					56	148	205	169	191	281	304	223	240	396
	GBR		0		32	159	215	204	175	222	295	396	352	241	31
	IRL								0			2		2	
	NLD								0	0				0	
	ES														9
rjh.27.7e Total			0		39	221	365	414	349	419	579	708	587	492	732
rji.27.67	BEL							0	0	0	0	0	0	2	71
	ES	86	74	40	7	30	16	22	8	10	5	3	5	11	9
	FRA	199	152	185	178	46	35	25	35	26	33	34	37	34	42
	GBR				0	2	0	0	3	25	22	1	35	17	31
	IRL						0	4	0						

ICES Stock Code	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
rji.27.67 Total		285	226	226	185	78	51	51	46	61	61	38	77	63	154
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	23
	GBR				5	16	27	32	30	27	29	43	49	44	32
	IRL					1	20	18	25	24	43	28	20	12	19
rjm.27.67bj Total		13	7	3	16	27	62	63	61	68	125	114	116	96	104
rjm.27.7ae-h	BEL				78	63	55	120	70	3	0	1	7	2	16
	ES						0				0	0			
	FRA	1080	902	833	870	785	934	1062	1135	899	912	745	819	661	834
	GBR	0		0	12	38	102	88	85	90	80	70	80	89	93
	IRL					0	19	63	53	40	49	48	41	10	58
	NLD					0		0		0			0		
rjm.27.7ae-h Total		1080	902	833	960	887	1110	1332	1344	1032	1042	864	947	762	1001
rjn.27.678abd	BEL			0	86	81	70	112	93	97	48	51	27	26	28
	ES				1	778	480	387	311	373	300	659	688	433	335
	FRA	3164	2565	2575	2507	3217	3069	2909	2571	2195	2515	2621	2233	2142	2288
	GBR				225	321	421	402	306	269	262	266	254	259	272
	IRL					12	55	106	108	93	83	79	69	69	115
	NLD						0			0	0			0	
rjn.27.678abd Total		3164	2565	2575	2819	4408	4096	3916	3388	3028	3209	3675	3270	2929	3038
rju.27.7bj	ES												1	1	
	IRL														3
	FRA					0				0		0	1	1	0

ICES Stock Code	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
rju.27.7bj Total						0				0		0	2	2	3
rju.27.7de	BEL												5	24	15
	FRA					19	9	20	6	3	10	50	58	79	86
	GBR				2	2			0			5	22	36	43
rju.27.7de Total					2	21	9	20	6	3	10	55	84	139	143
Grand Total		16364	14429	14016	12800	10355	10071	9986	9587	8568	8883	9975	9350	8710	9040

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

Year	MgtArea	CatchWgtKg	ci_l	ci_u
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).

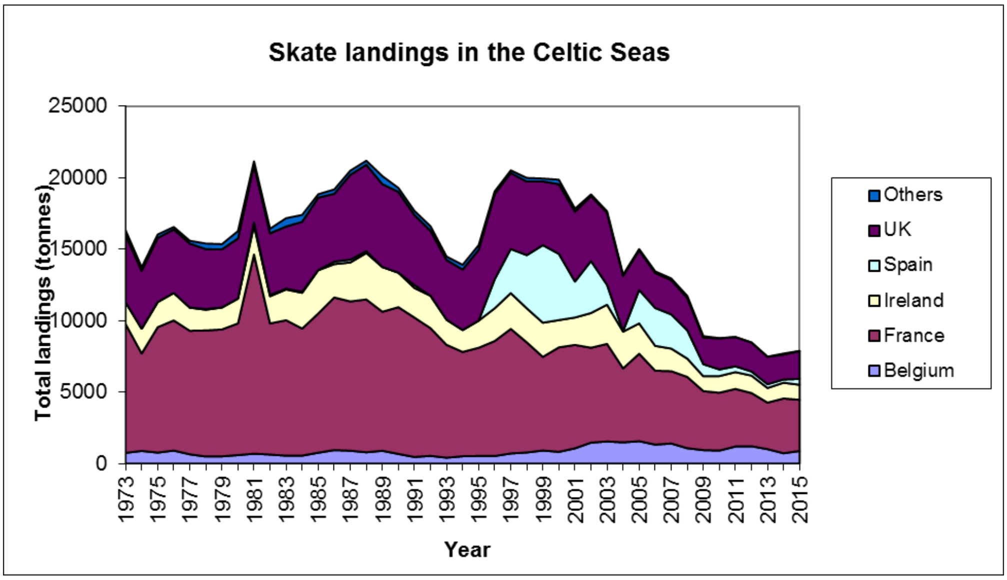

Figure 18.1b. Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) by nation in the Celtic Seas from 1973–2015 (Source: ICES).

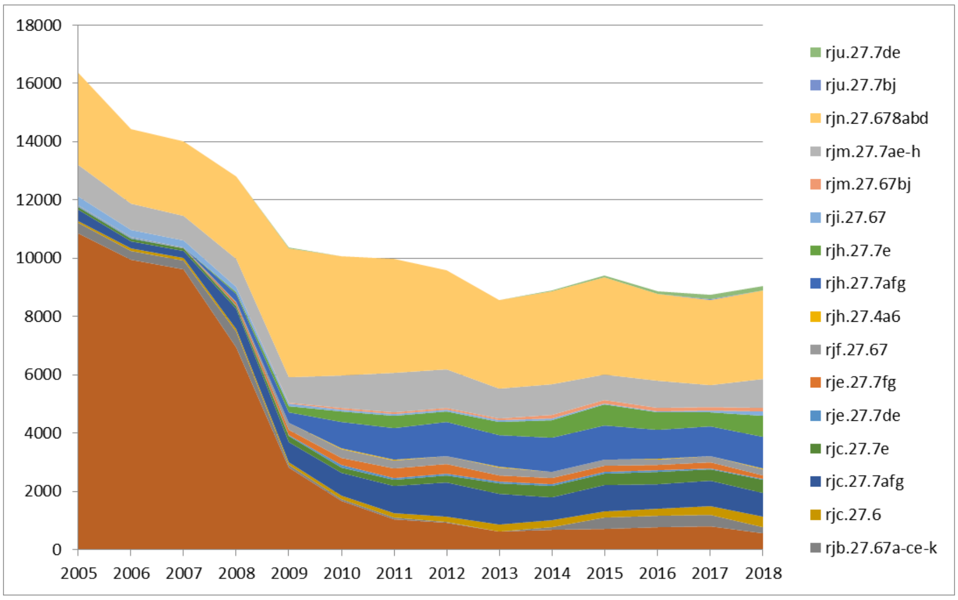

Figure 18.1.c Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) by stock in the Celtic Seas from 2005–2018 (Source: ICES).

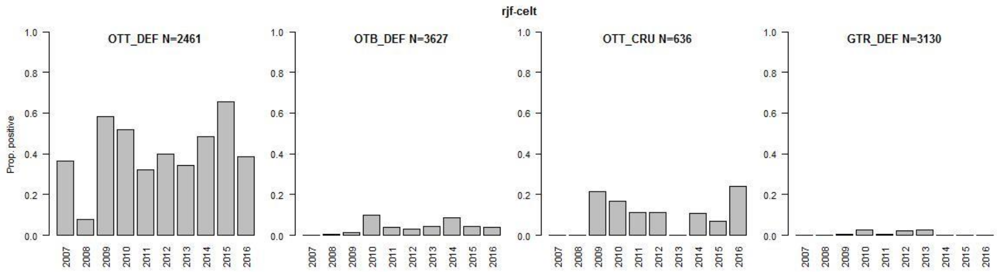

Figure 18.2 Skates and rays in the Celtic Seas. Temporal trends in the proportion of hauls encountering RJF.27.67, based on data collected during French on-board observer trips.

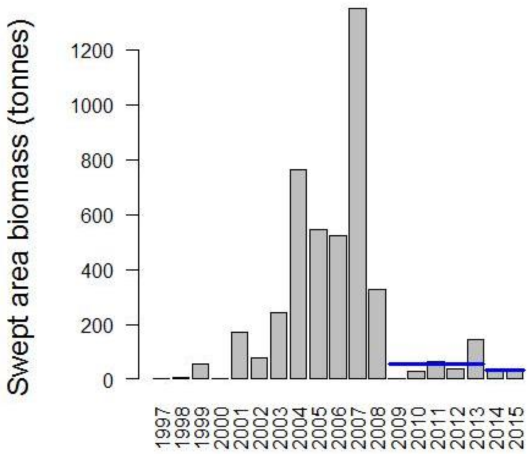

Figure 18.3a. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Leucoraja circularis* (divisions 7.g–j) from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

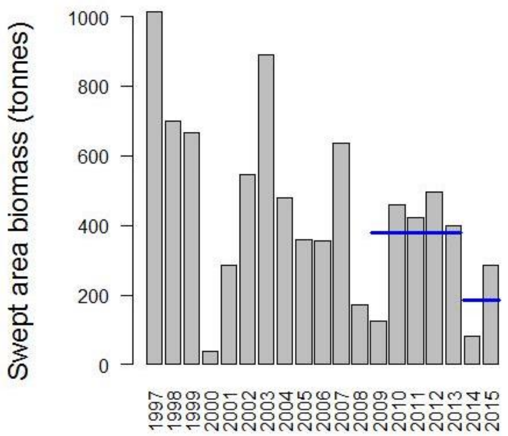

Figure 18.3b. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Leucoraja fullonica* (divisions 7.g-j) from the French EVHOE (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

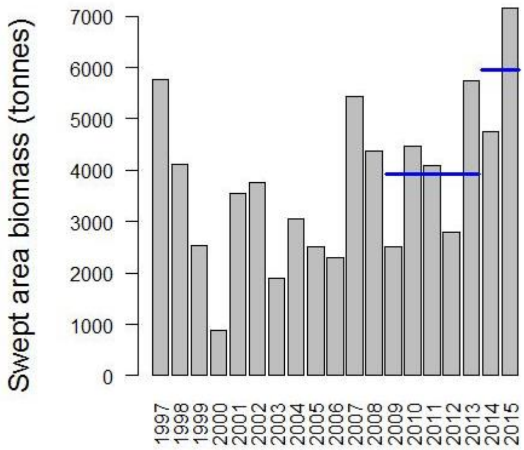

Figure 18.3c. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Leucoraja naevus* from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

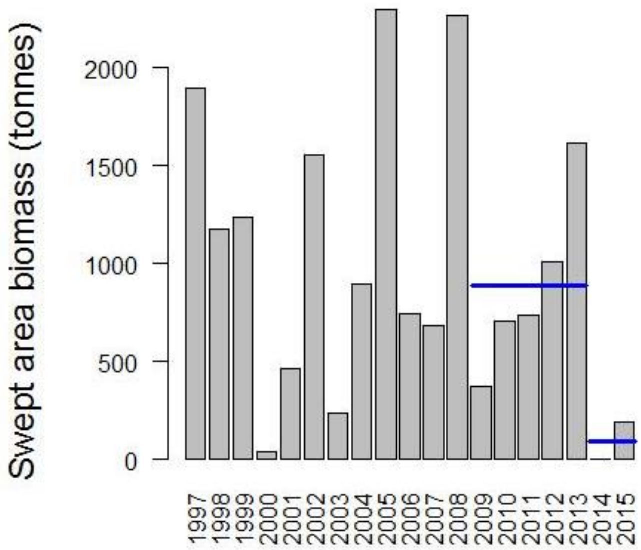

Figure 18.3d. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Raja clavata* (divisions 7.g-j) from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

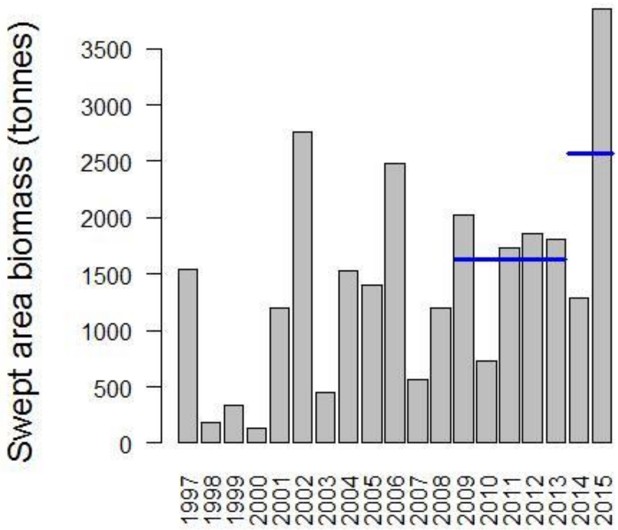

Figure 18.3e. Skates and rays in the Celtic Seas. Mean swept-area biomass of *Raja montagui* (divisions 7.g-j) from the French EVHOE survey (1997–2015). Blue lines indicate mean annual biomass for 2014–2015 and mean annual biomass for 2009–2013.

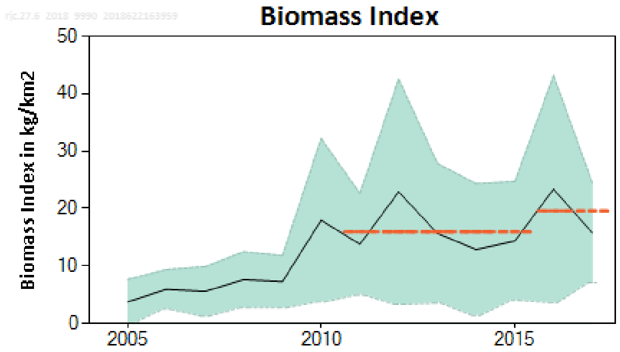

Figure 18.4a. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) biomass index of *Raja clavata* in Division 6.a for 2005–2015. Red lines give average for 2011–2015 and for 2016–2017.

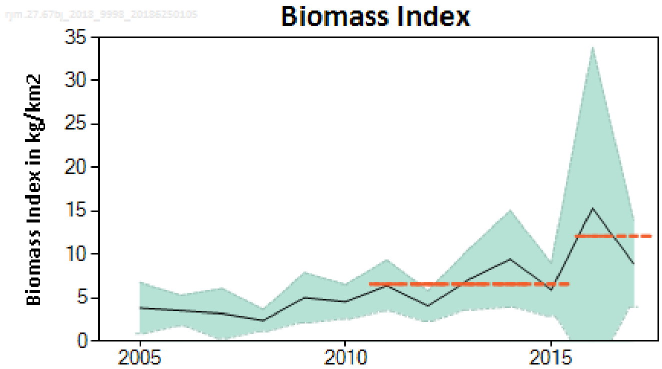

Figure 18.4b. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) mean cpue of *Raja montagui* in Divisions 6.a and 7.b-c for 2005–2017. Red lines give average for 2011–2015 and for 2016–2017.

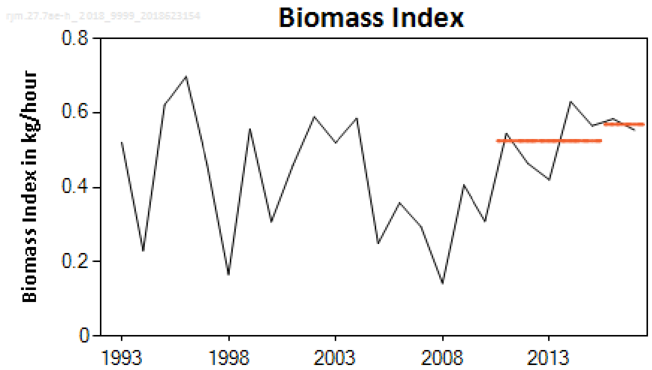

Figure 18.4c. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) mean cpue of *Raja montagui* in Divisions 7.a,e-h for 2005–2017. Red lines give average for 2011–2015 and for 2016–2017.

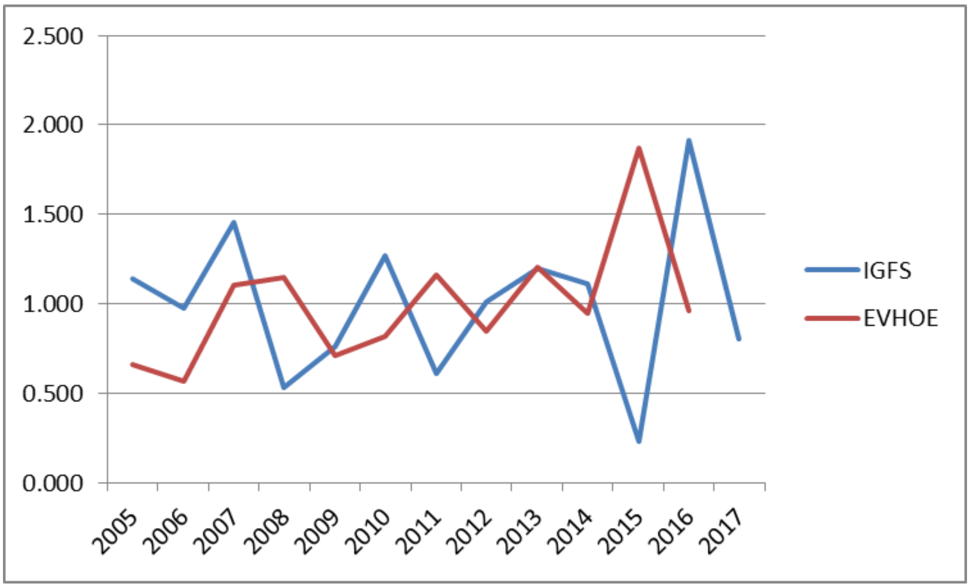

Figure 18.4d. Skates and rays in the Celtic Seas. Irish Groundfish Survey (IGFS-WIBTS-Q4) (blue) and French EVHOE survey (red) standardized biomasses for of *Leucoraja naevus* in divisions 6, 7, 8.abd. 2005–2017. The French survey did not take place in 2017.

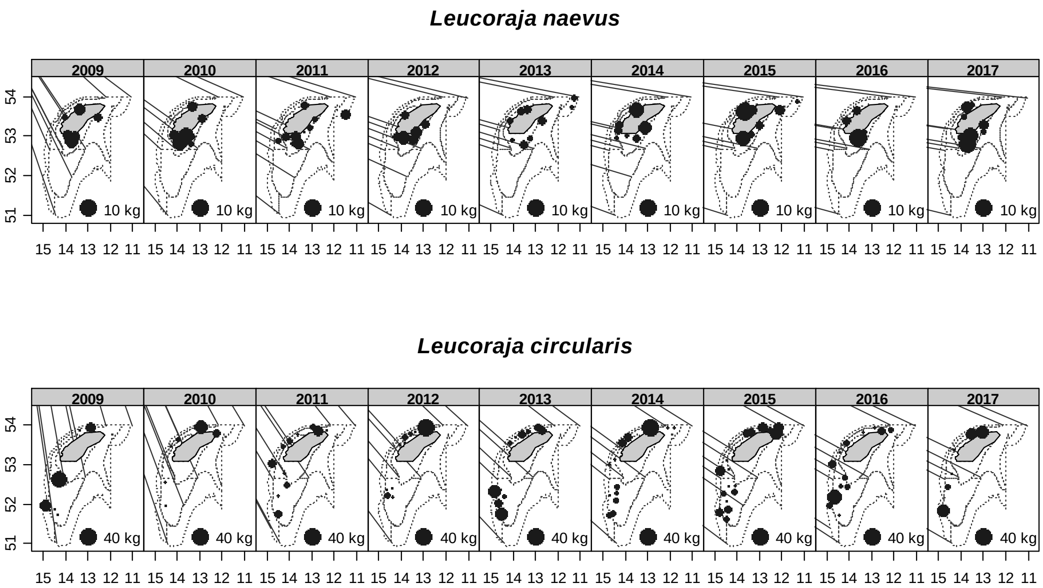

Figure 18.5a. Skates and rays in the Celtic Seas. Geographical distribution of cuckoo ray *Leucoraja naevus* and sandy ray *Leucoraja circularis* catches (kg·haul^{-1}) in Porcupine survey time-series (2009–2017) (Ruiz-Pico *et al.*, 2018 WD).

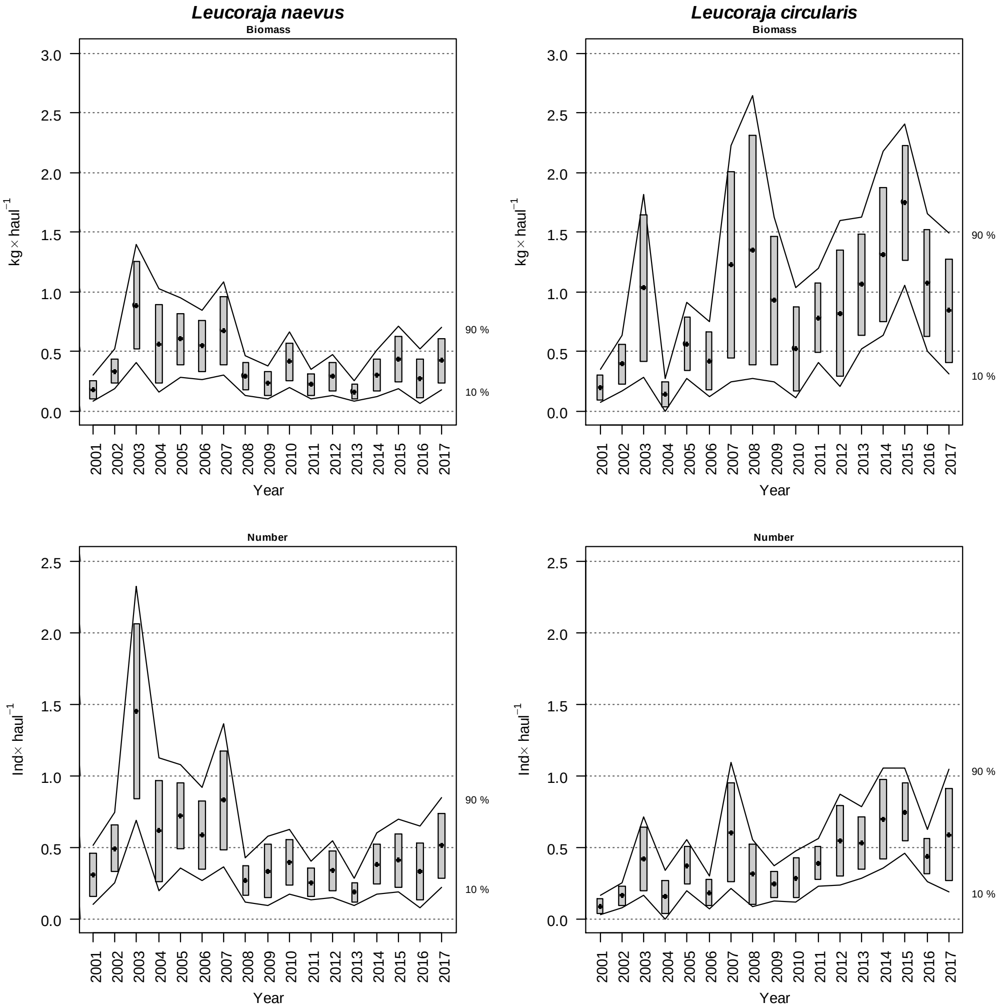

Figure 18.5b. Skates and rays in the Celtic Seas. Temporal changes of cuckoo ray *Leucoraja naevus* and sandy ray *Leucoraja circularis* biomass index (kg·haul^{-1}) during Porcupine survey time-series (2001–2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000) (Ruiz-Pico*et al.*, 2018 WD).

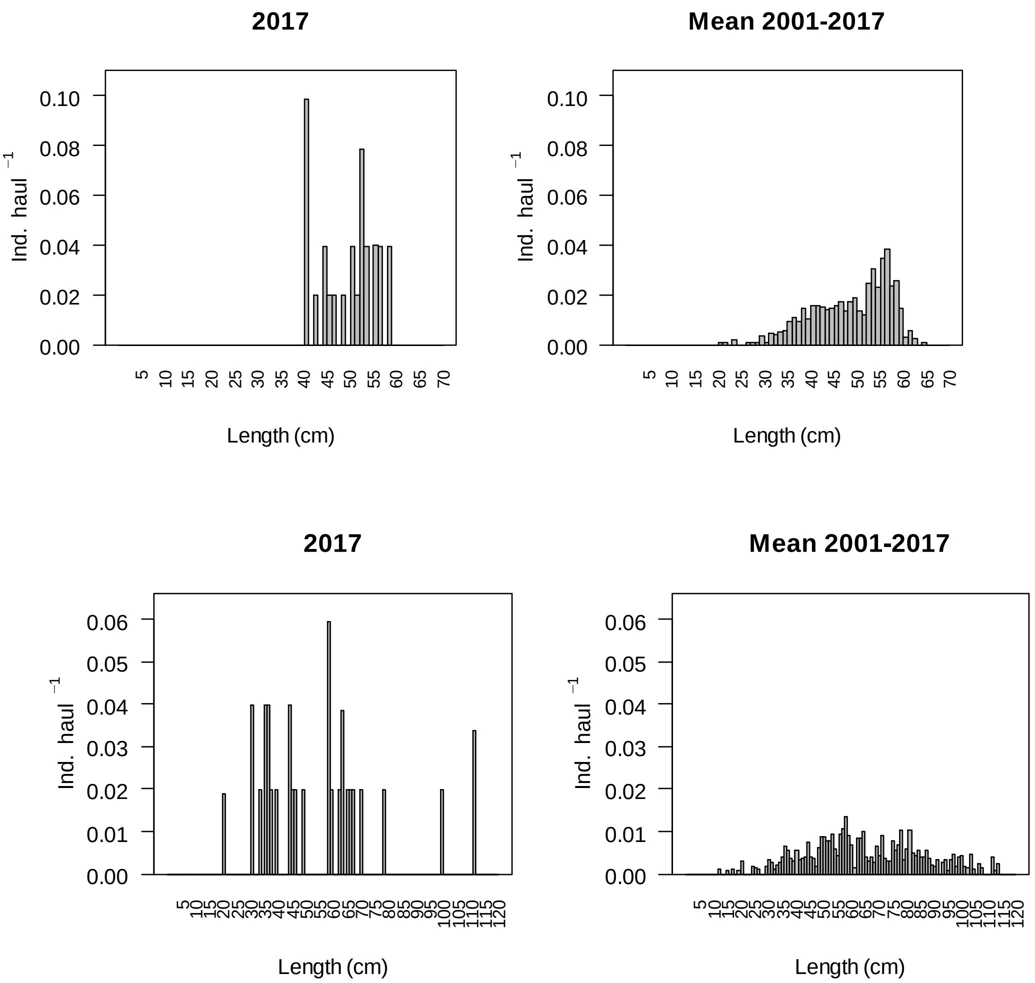

Figure 18.5c. Skates and rays in the Celtic Seas. Stratified length distributions of cuckoo ray *Leucoraja naevus* (top) and sandy ray *Leucoraja circularis* (bottom) in Porcupine survey 2001–2017 (Ruiz-Pico *et al.* 2018 WD).

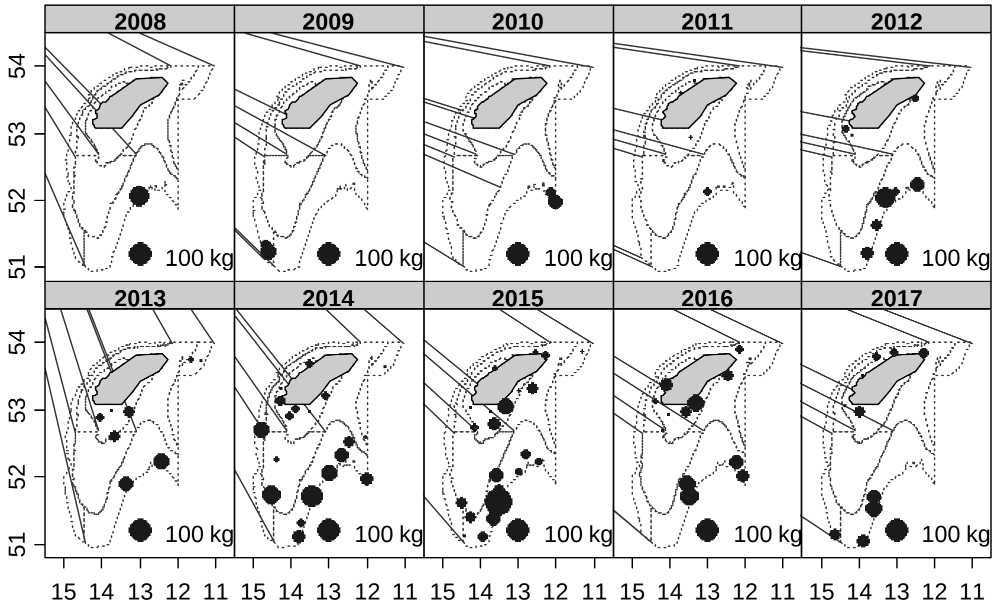

Figure 18.5d. Skates and rays in the Celtic Seas. Geographical distribution of Dipturus spp. combined (kg haul–1) in Porcupine survey time-series (2008–2017) (Ruiz-Pico et al. 2018 WD).

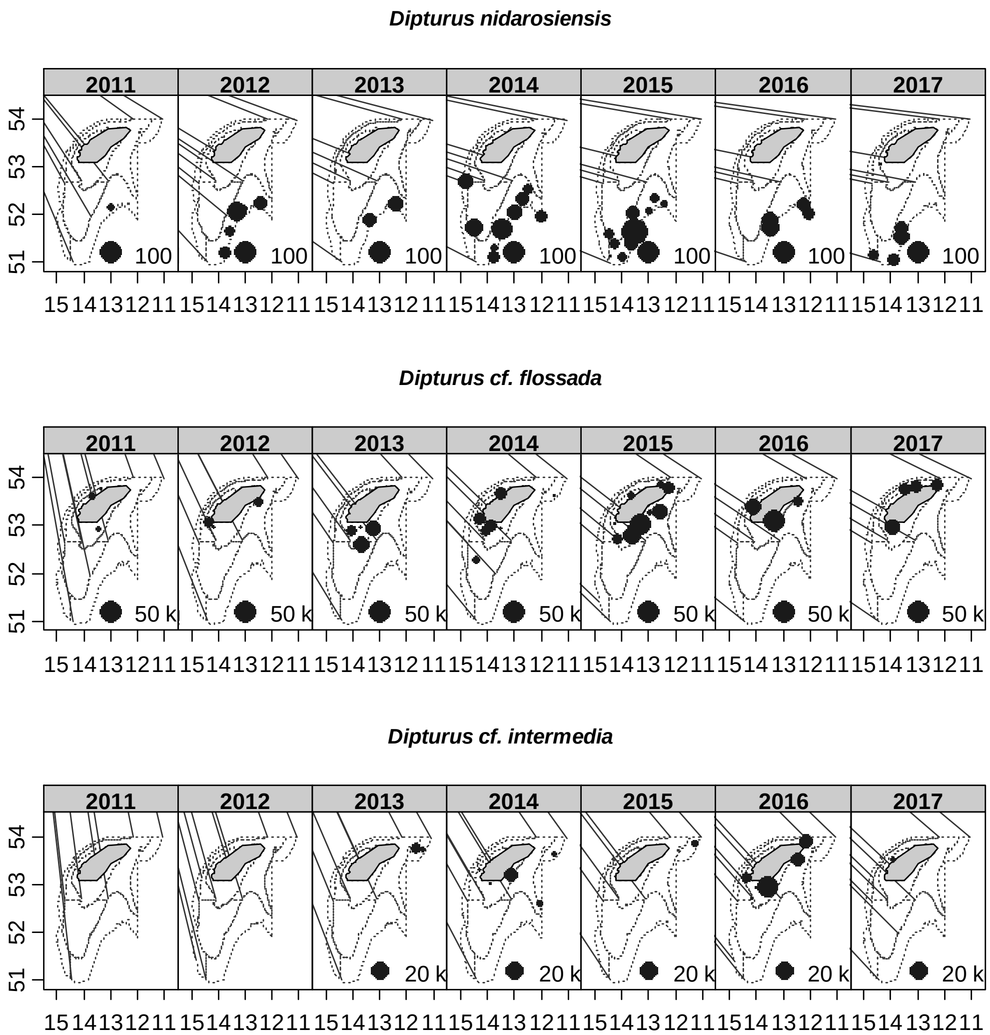

Figure 18.5e. Skates and rays in the Celtic Seas. Geographical distribution of *Dipturus* nidarosiensis, *Dipturus batis* (labelled Dipturus cf. *flossada*) and *Dipturus intermedius* (labelled *Dipturus* cf. *intermedia*) (kg·haul^{-1}) in Porcupine survey time-series (2011–2017) (Ruiz-Pico *et al.* 2018 WD).

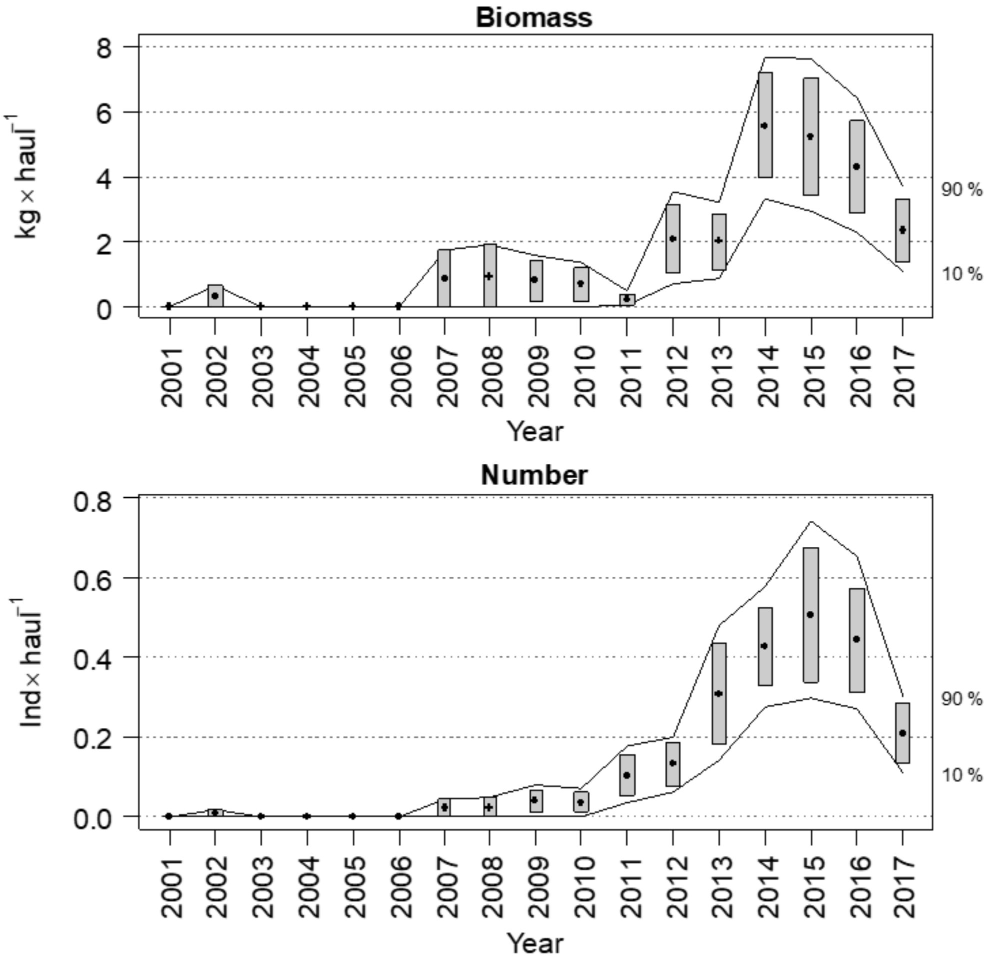

Figure 18.5f. Skates and rays in the Celtic Seas. Changes in *Dipturus* spp. biomass index (kg·haul^{-1}) during Porcupine survey time-series (2001–2017). Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000) (Ruiz-Pico *et al.* 2018 WD).

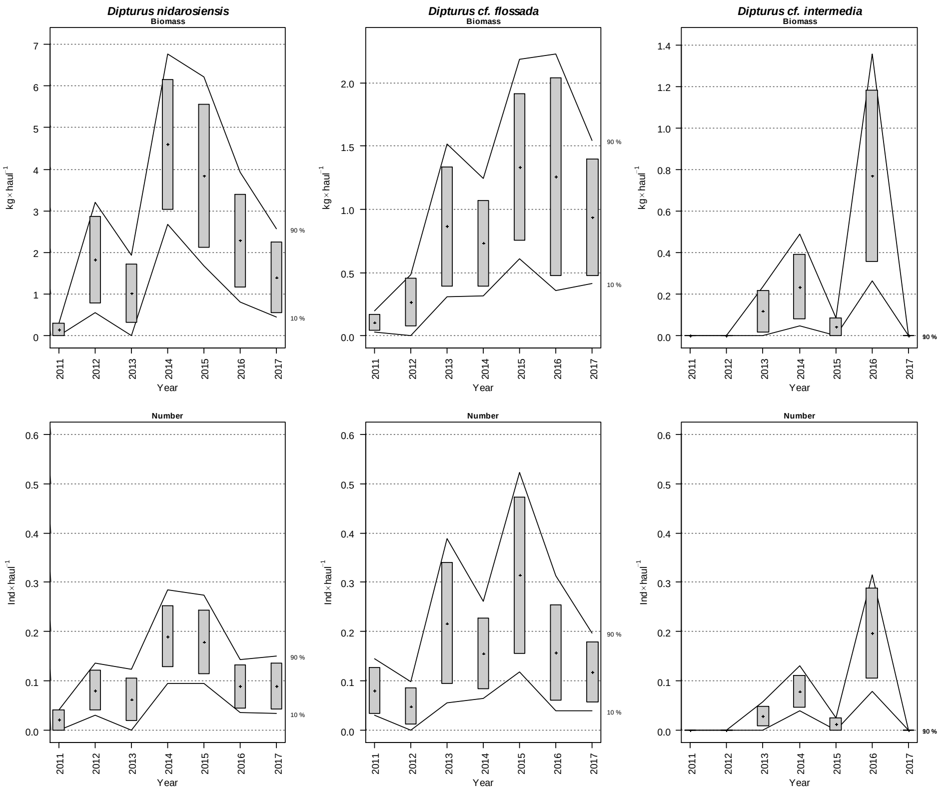

Figure 18.5g. Skates and rays in the Celtic Seas. Changes in *Dipturus nidarosiensis*, *Dipturus batis* (labelled Dipturus cf. *flossada*) and *Dipturus intermedius* (labelled *Dipturus* cf. *intermedia*) biomass index (kg·haul^{-1}) during Porcupine survey time-series (2011–2017). Boxes mark parametric standard error of the stratified index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000) (Ruzi-Pico *et al.* 2018 WD).

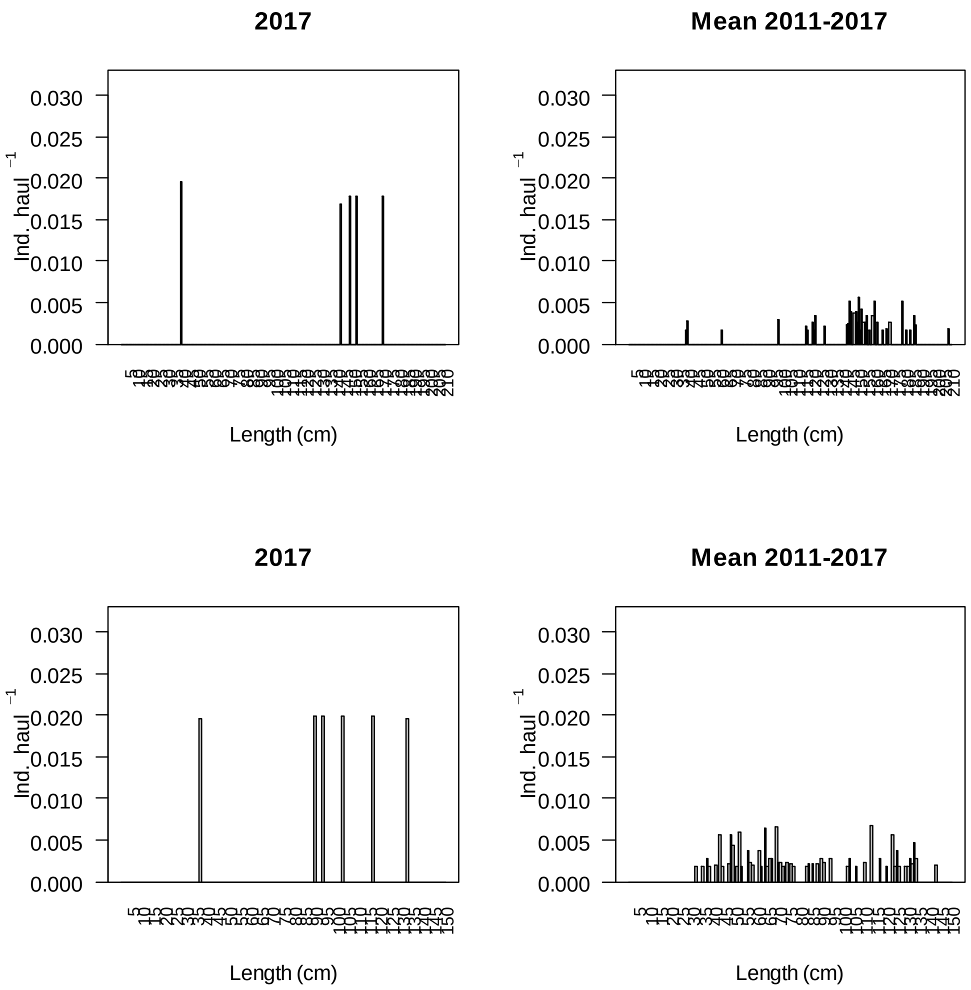

Figure 18.5h. Skates and rays in the Celtic Seas. Mean stratified length distributions of *Dipturus nidarosiensis* (top) and *Dipturus batis* (labelled *Dipturus* cf. *flossada*) from 2017 Porcupine surveys (Ruiz-Pico *et al.* 2018 WD).

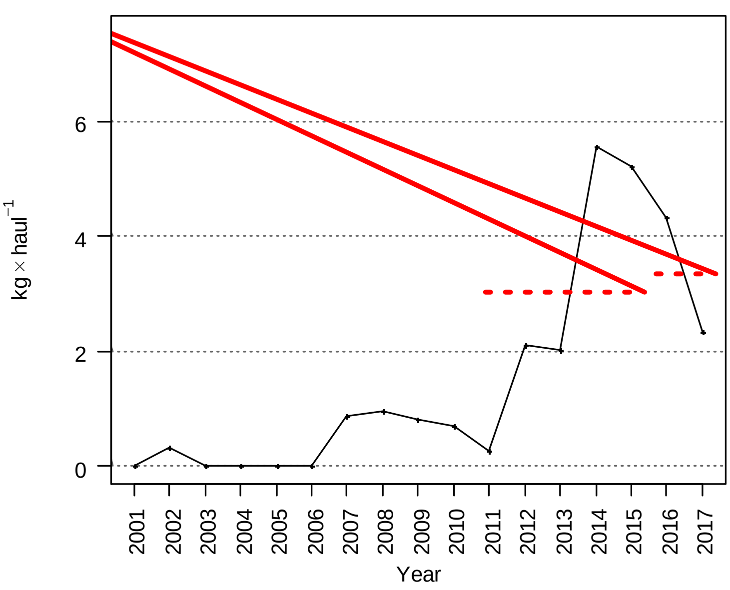

Figure 18.5i. Skates and rays in the Celtic Seas. Changes in *Dipturus* spp. biomass index during Porcupine survey time series (2001–2017). Dotted lines compare mean stratified biomass in the last two years and in the five previous years. (Ruiz-Pico et al. 2018 WD).

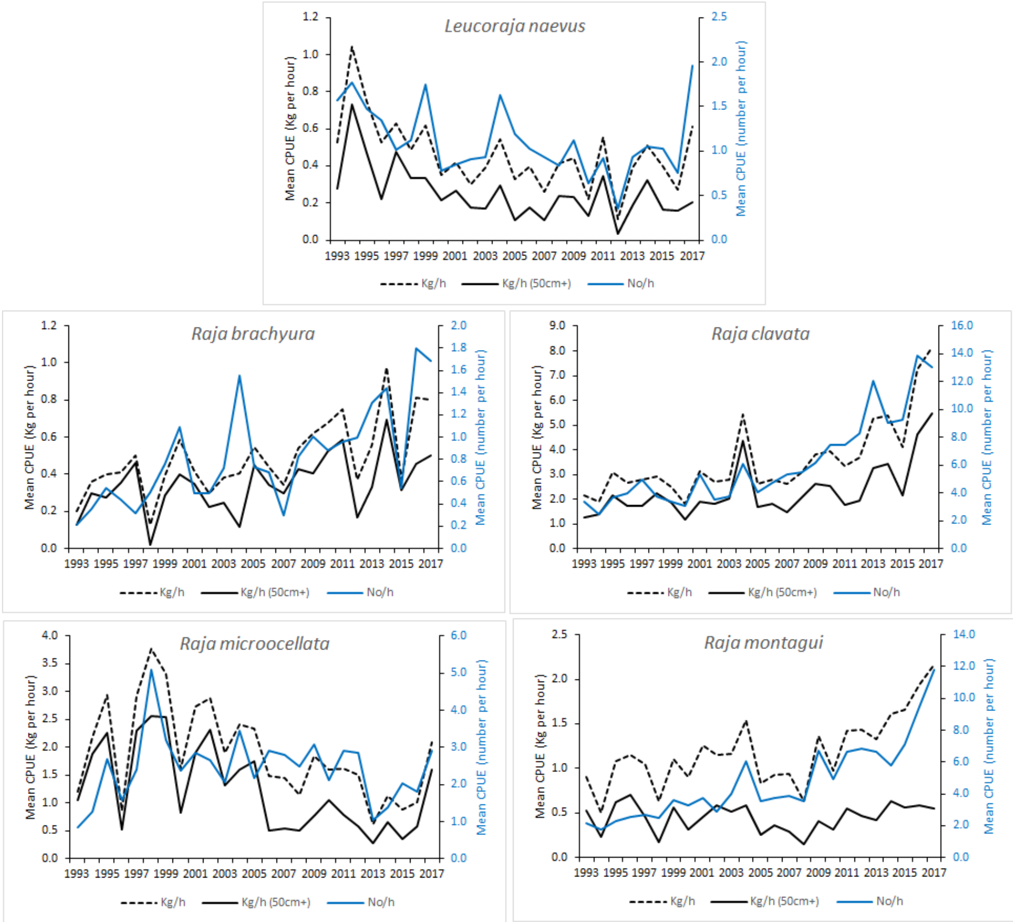

Figure 18.6. Skates and rays in the Celtic Seas. Temporal trends (1993–2017) in the CPUE by individuals ($n\ h^{-1}$), biomass ($kg\ h^{-1}$), and biomass for individuals ≥ 50 cm total length ($kg\ h^{-1}$) of skates in the 7.a.f–g beam trawl survey (EngW-BTS-Q3).

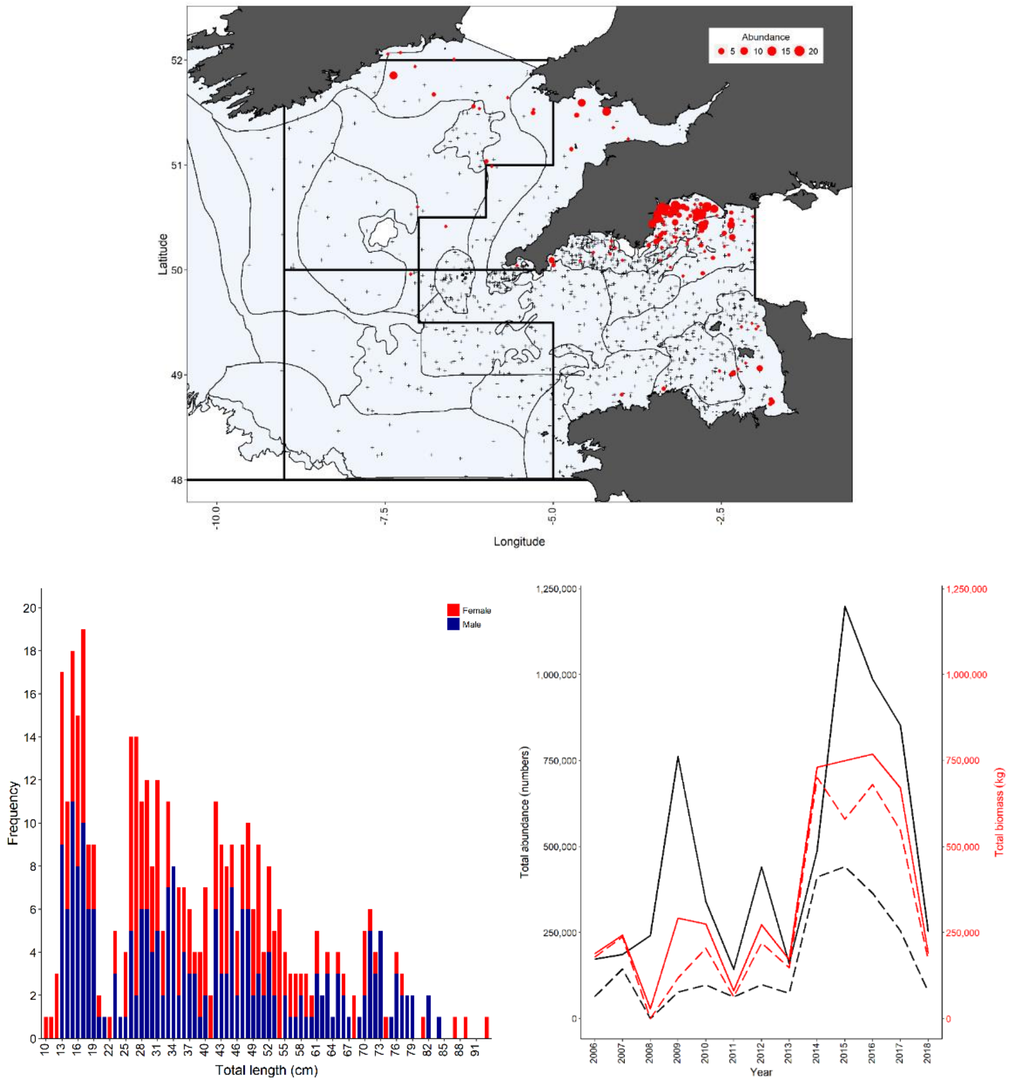

Figure 18.7a. Skates in the Celtic Sea. Distribution and relative abundance (top) and length-frequency by sex (bottom left) and of thornback ray *Raja clavata* in the Q1SWBeam trawl survey. Total biomass (numbers and kg; bottom right) - continuous line relates to all specimens, dashed line relates to individuals ≥ 50 cm total length. (Source: Silva *et al.* 2018WD)

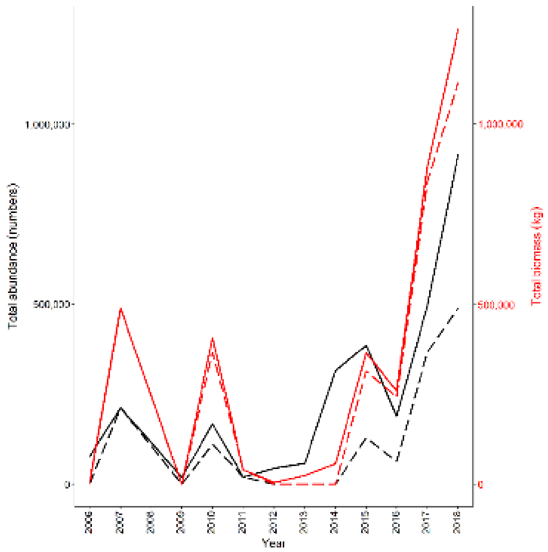

Figure 18.7b. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for common skate *Dipturus batis*-complex. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length. (Source: Silva *et al.* 2018WD).

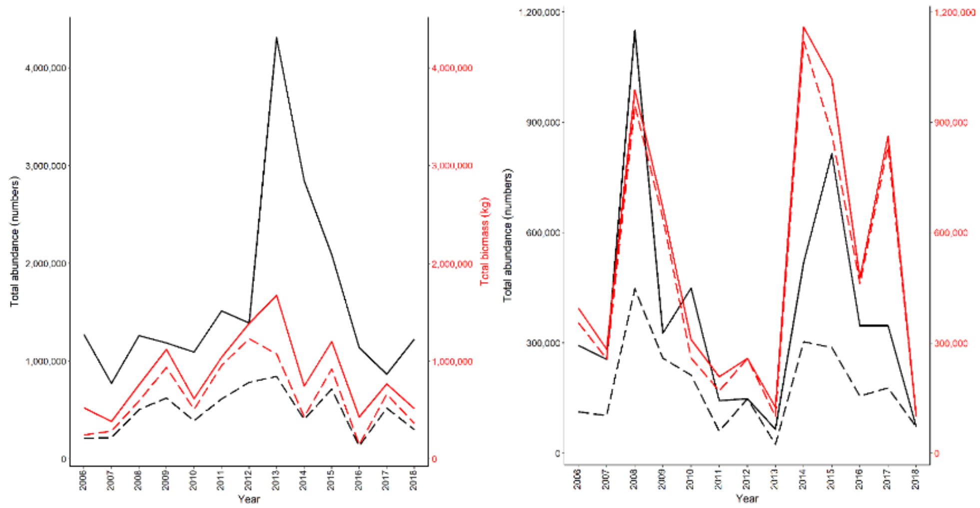

Figure 18.7c. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (left) cuckoo ray *Leucoraja naevus* and (right) blonde ray *Raja brachyura*. Continuous line relates to all specimens, dashed line relates to individuals ≥ 50 cm total length. (Source: Silva *et al.* 2018WD).

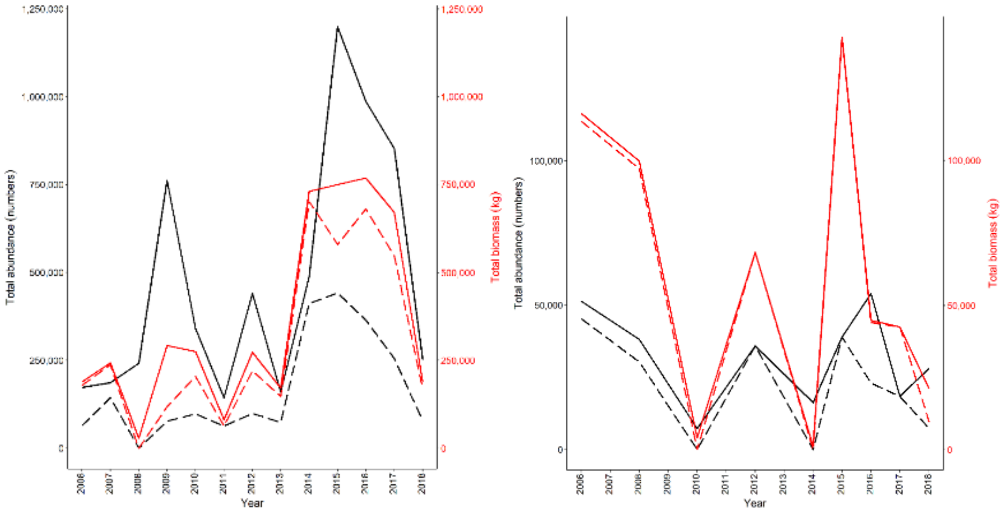

Figure 18.7d. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (left) thornback ray *Raja clavata* and (right) small-eyed ray *Raja microocellata*. Continuous line relates to all specimens, dashed line relates to individuals ≥ 50 cm total length. (Source: Silva *et al.* 2018WD).

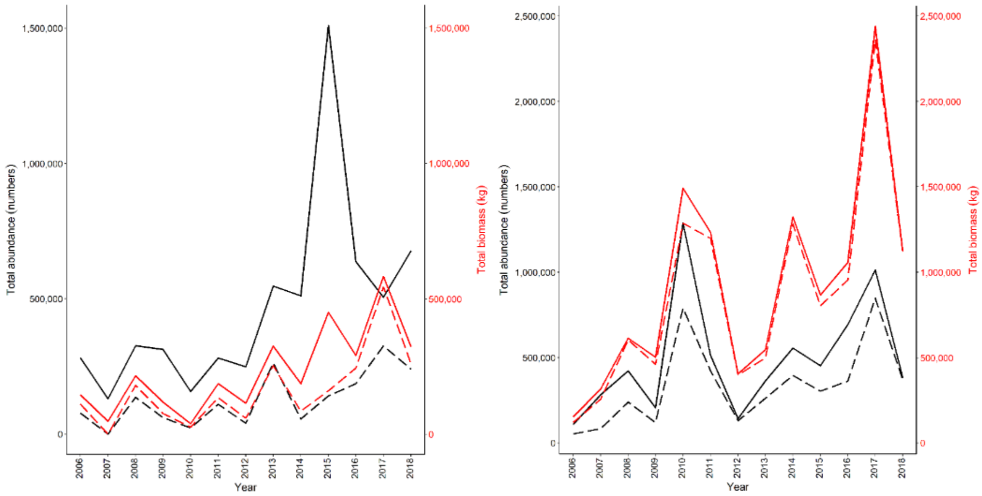

Figure 18.7e. Skates in the Celtic Sea. Demersal elasmobranchs in the Q1SWECOS indicating the total abundance (numbers) and total biomass (kg) for (left) spotted ray *Raja montagui* and (right) undulate ray *Raja undulata*. Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length. (Source: Silva *et al.* 2018WD)

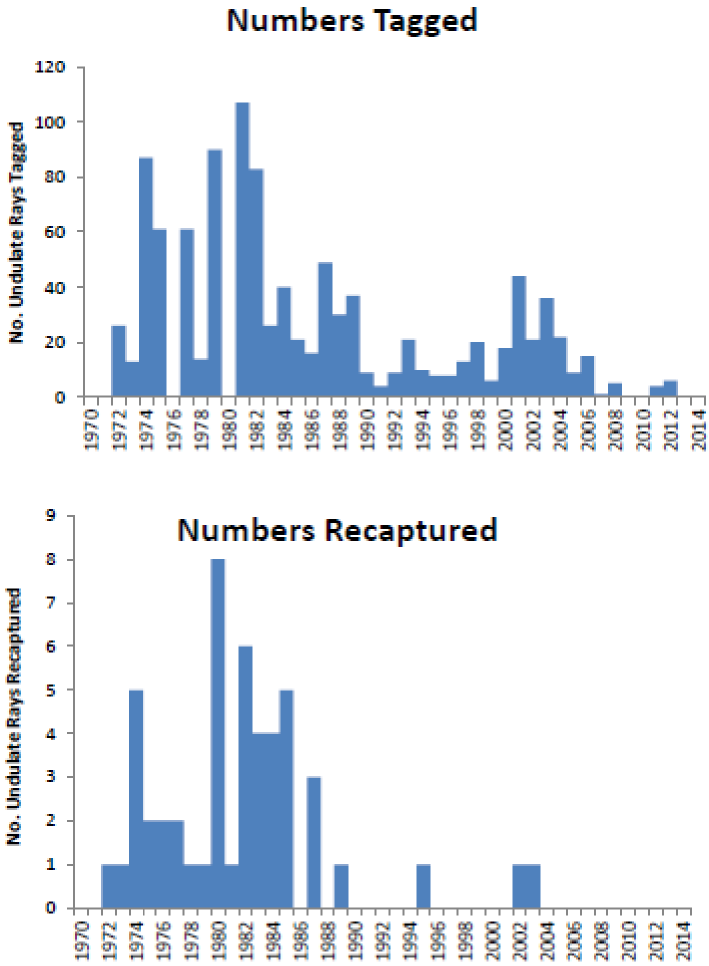

Figure 18.8. Skates in the Celtic Seas. Numbers of *Raja undulata* tagged (top) and recaptured (bottom) in Tralee Bay and surroundings, 1970–2014. Source: Wögerbauer *et al.*, 2014 WD.

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 8.a–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 9.a (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 2018

No specific changes noted for 2018, 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 (mainly trammel 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 *R. 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 2018. A summary of the 2018 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 2018 (tonnes)
Raja undulata	rju.27.8ab	8.a,b	Catches should be no more than 202 tonnes	13
Raja undulata	rju.27.8c	8.c	No target fishery, manage bycatch	-
Raja clavata	rjc.27.8	8	Reduce landings 36%	276
Leucoraja naevus	rjn.27.8c	8.c	Reduce landings 4%	26
Raja montagui	rjm.27.8	8	Reduce landings 5.9%	108
Raja montagui	rjm.27.9a	9.a	Reduce landings 4%	108
Leucoraja naevus	rjn.27.9a	9.a	Increase landings 20%	70
Raja clavata	rjc.27.9a	9.a	Increase landings 19%	1431
Raja undulata	rju.27.9a	9.a	Landings should be no more than 31 tonnes	31
Raja brachyura	rjh.27.9a	9.a	Increase landings 20%	212
Dipturus batis complex	rjb.27.89a	8, 9.a	No advice requested	
(Dipturus cf. flossada)				
(Dipturus cf. intermedia)				
Other skates	raj.27.89a	8, 9.a	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, 9% in 2017 and 15% in 2018. 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	4231	Council Regulation (EC) No 43/2009 of 16 January 2009
2010	5459 t	4091	Council Regulation (EU) No 23/2010 of 14 January 2010
2011	4640 t	4056	Council Regulation (EU) No 57/2011 of 18 January 2011
2012	4222 t	3619	Council Regulation (EU) No 43/2012 of 17 January 2012
2013	3800 t	3622	Council Regulation (EU) No 39/2013 of 21 January 2013
2014	3420 t	3651	Council Regulation (EU) No 43/2014 of 20 January 2014
2015	3420 t	3412	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	3270	Council Regulation (EU) No 72/2016 of 22 January 2016
2017	3762 t	4500	Council Regulation (EU) No 2017/127 of 20 January 2017
2018	4314 t	3757	Council Regulation (EU) No 2018/120 of 23 January 2018

(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 2018 and under Regulation (EU) No 2018/120) 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	**2018**	**2018**
	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 15 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 2018.

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 and in a separate table also landings of Dasyatidae, Myliobatidae, Rhinobatidae and Torpedinidae species (see Section 19.10).

Skates in Bay of Biscay and Cantabrian Sea (Subarea 8)

Historically, since 2005 approximately 69% of landings in Subarea 8 were assigned to France and 30% 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 2005–2018, annual landings were around 1900–3100 tonnes y^{-1}.

In 2018, the divisions with the highest landings were 8.a–b (75%), and these were mostly from France (1463 tonnes). In Division 8.c, landings represented 23% of the total landing of Subarea 8 and were mainly from Spain (541 tonnes). Landings from Division 8.d were only 48 tonnes.

Skates in Division 9.a

In this division, Portuguese and Spanish landings account for *ca.* 85% and 15%, respectively of reported skate landings. Since 2005, total landings of skates remained relatively stable, at about 1200–1850 tonnes y^{-1}.

Spanish mean annual skate landings were *ca.* 333 tonnes, with a maximum of 481 tonnes in 2013 and a minimum of 134 tonnes in 2008.

From the 1990s until 2018, Portuguese mean annual landings were *ca.* 1200 tonnes y^{-1},. In 2018, the main commercial species, in decreasing order, were *R. clavata, R. brachyura, R. microocellata, R. montagui, D. oxyrinchus, R. undulata* 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 – ICES, 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 4–51% of total catches), with a maximum estimated discards of 120 tonnes occurred in 2016 (Table 19.3a, 3b). For the period 2009–2017, discards of *R. clavata* varied from 0–52% of the catches (Table 19.3a,3b) with maximum estimated discards of 34 tonnes occurred in 2016.

Spain (IEO) OTB fleet in Subarea 8 and 9

The IEO "Spanish Discards Sampling Programme" started in 1988, focused on the Spanish trawl fleets operating in the "Celtic Seas" (ICES Subareas 6 and 7) and the "Bay of Biscay and the Iberian coast" (ICES subareas 8 and 9) Ecoregions. However, it did not have annual continuity until 2003, after the Data Collection Regulation (DCR) implementation. Information on discards of skates at species specific level is shown on (Table 19.3c).

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 2019.

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 2019.

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.

In the table 19.3d the discards of the main skate species by stock in Subarea 8 for the period 2016–2018 is presented. The main species discarded in 2016 and 2017 were *L. naevus* and *R. clavata*, although *R. undulata* was also discarded in significant amounts between 230–416 t y^{-1}, due to the restrictive quota.

Belgium fleet in subarea 8

Beam trawl reported 33.7 t of discards in 2018 of *L. naevus.*

19.3.3 Discard survival

WKSHARK3 (ICES, 2017) and WKSHARK 5 (ICES, 2019) reviewed available studies to identify where there are existing data on the vessel mortality and post-release mortality of elasmobranch species by area, gear type and identify important data gaps.

Discard survival data available on skates caught in trammel net fisheries (mesh size ≥ 100 mm) in ICES Division 27.9.a, collected under the Portuguese DCF pilot study on skates (2011–2013), and presented in previous reports was re-analyzed and the results summarized in Serra-Pereira and Figueiredo (2019a WD). Experiments were conducted on categorical vitality assessment (CVA) after capture of *R. clavata, L. naevus, R. montagui, R. brachyura* and *R. undulata* and indicate that it is generally high for all species, as the percentage of skates in Excellent and Good vitality status was above 75% for all species, mesh size and soak time considered (Table 19.4a).

- ***R. clavata*** - specimens caught in both mesh size groups with soak time < 24h were mainly found in Excellent conditions (100% and 92%, respectively), while those from hauls with > 24h, although most specimens were caught in Excellent conditions (72% and 52%), the percentage of Poor/Dead vitality status was comparatively higher (16% and 24%, respectively for each mesh size);
- ***R. brachyura*** - most specimens were caught in Excellent conditions, representing 67% of the observations from mesh size < 180 mm and soaking time < 24h, 92% for the same mesh and soaking time > 24h, 57% and 70% for mesh size > 180 mm for each soaking time period, respectively. The highest percentage of specimens in Poor/Dead status for that species was observed for mesh size > 180 mm and soaking time < 24h (24%);
- ***R. montagui*** - specimens caught with mesh size < 180 mm and in Excellent vitality represented 100% and 67% depending on the soaking time; specimens caught with mesh size > 180 mm and in in Excellent vitality represented 40% and 37%. The percentage of specimens in Poor/Dead conditions was higher for the larger mesh size group (30%) than for the smaller one (0% and 12%);

- ***L. naevus*** - representative data was only obtained for mesh size > 180 mm and soaking time > 24h. Under this situation 58% was the percentage of specimens in Excellent condition while 21% and 21% corresponded to specimens in Good and 21% Poor/Dead condition respectively;
- ***R. undulata*** - the percentage of specimens in Excellent conditions was higher than 79% for all mesh sizes and soak times; highest values observed for mesh size > 180 mm and soaking time > 24h (96%). The percentage of specimens in Poor/Dead conditions was 2% and 5% for mesh size < 180 mm and 3% and 14% for mesh size > 180 mm, respectively for each of the two soaking times considered.

Results suggest that the vitality after capture of a specimen is not related to its size, as for all the species, and regardless of specimens' size (TL < 52 cm and > 52 cm), the majority was found in Excellent vitality conditions (60–92%). This indicate that fish below the currently established minimum landing size of 52 cm for all Rajiformes (except *R. undulata*) and 78 cm for *R. undulata* and above the maximum landing size 97 cm for the latter, if released immediately to the water after capture have a potentially high survival capacity.

Additionally, a mark-recapture study (UNDULATA project, 2014–2015) of *R. undulata* caught by trammel nets obtained a return rate of 11% and the mean observed time-at-liberty was of 54 days and maximum of 313 days. These results are a good indication that the species has a potential high long-term survival.

In 2018, new experiments were conducted onboard PTGFS-WIBTS-Q4 and PT-CTS (UWTV (FU 28–29)) surveys to collect CVA and short-term survival estimates (only in the former) for *R. clavata* caught by otter trawl. Overall, most of the specimens were found in Excellent or Good conditions (60–72%), with an at-vessel-mortality of 6–7% (Table 19.4b). All specimens in Excellent vitality status showed tail grab, spiracles and body flex reflexes. The percentage of body flex and tail grab reflexes decreased with vitality status, 71% to 29% and 48% to 29%, respectively. The preliminary estimated survival, based on captivity observations of *R. clavata* during a maximum of 4 days, was 64%.

To note that all the experiments conducted followed the procedures described in previous studies on the survival of this group of species and the recommendations made by the STECF and the ICES Working Group on Methods to Estimate Discard Survival.

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 in the same period 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, L. naevus*, *R. montagui and R. undulata* from Basque (Bottom Otter Trawler) and French fleets (bottom trawl and nets) are presented (figures 19.2a-b).

In the Basque Bottom trawl *L. naevus* and *R. clavat*a are discarded in all size range and only the individuals larger than 30–35 cm are retained.

In the French fleets, only the individuals of *R. clavata* and *R. montagui* larger than 50 cm are 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–i.

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

An updated nominal LPUE-series for the Basque Country's OTB DEF>=70 and OTB DEF=100 in Subarea 8 from 2001–2018 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 201 and 2018, the values dropped strongly to 58 and 51 kg day^{-1} respectively. The LPUE of *R. clavata* were smaller and more stable than those recorded for *L. naevus*, ranging from 14–54 kg day^{-1}, with the highest value of the series recorded in 2017 and 2018.

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 2018, only the LPUE index of *R. brachyura* was updated (Figure 19.4a).

No updates were available in 2019.

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 (mainly 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, 1996 and 2017). 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;).

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 Ruiz-Pico *et al*. (2019 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. In 2018, due to mechanical problems in R/V *Noruega*, part of the PtGFS-WIBTS-Q4 survey (i.e. 12 stations) was conducted onboard the commercial trawler *Calypso* (Dimensions = 24.8 m - 7.8 m, Ton = 215 tonnes), using a FGAV019 bottom trawl net, with a 20 mm codend mesh size and a ground rope without rollers, which covered the Alentejo coast (strata LIS, SIN, MIL and ARR) (Serra-Pereira and Figueiredo, 2019b WD). 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; Serra-Pereira and Figueiredo, 2019b 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 codend mesh size. No vessel was available to conduct this survey in 2004, 2010 and 2012 (ICES, 2012).

In 2019, 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, 2019b 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 index of *L. naevus* show continuous peaks with values from 10 to 50. *R. clavata* showed no clear temporal trend over the time series with in general index values lower than 10 with a peak in 2001 (Figure 19.6a-b).

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 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 2018, of the five main elasmobranch catches per haul three were skates: *Raja clavata (14%), R. montagui (6%)* and *Leucoraja naevus (2%)* (Ruiz-Pico *et al*., 2019 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:

In 2018, the biomass of *R. montagui* increased, *L.naevus* remained similar and *R. clavata* decreased compared to previous year, although remained high in the time series. Only a few specimens of *L. circularis* were found as usual. There was no increase of any of the elasmobranchs in 9.a Division this last survey or they were absent such as *L. naevus*

R. clavata: In 2018 the biomass of the most abundant skate in the area, *R. clavata*, decreased in both divisions. In Division 9.a, *R. clavata* is scarcer than in Division 8.c, only 1.3% of the biomass was found this last survey in the former. In Division 8.c, the biomass index has been fluctuating up and down with an increasing trend. Since 2012, the values have remained high compared with the time series (Figure 19.7a). The mean biomass of the last two years was very similar to the previous five years in Division 9.a and slightly lower in Division 8.c. The geographical distribution of *R. clavata* remained similar to the previous year, with greater abundance in the Cantabrian Sea, specifically from the central to the eastern part, but the large spot of biomass found in the previous year in one shallower haul (85 m depth) close to 4º W longitude was smaller this last survey (Figure 19.7b). The length distribution showed a reduction in abundance of large specimens in 2018. Sizes ranged as usual from 15 to 96 cm but there were fewer specimens larger than 44 cm (Figure 19.7c).

R. montagui: The biomass of *R. montagui*, scarcer than *R. clavata*, raised this last survey, following the increasing trend from 2016 (Figure 19.8a). *R. montagui* has not been found in Division 9.a in the time series but in Division 8.c has been frequent, specifically in the central area of the Cantabrian Sea. More spots of biomass were found this last survey in the western part of the Cantabrian Sea compared to previous year (Figure 19.8b). The length distribution of *R. montagui* remained similar to the previous years, with specimens from 22 cm to 66 cm, although more abundance of large specimens, from 56 to 64 cm, was found (Figure 19.8c).

L. naevus: In 2018, the biomass of *L. naevus* decreased although remained among the high values of the time series. The mean biomass of the last two years was well above than the previous five years (Figure 19.9a). *L. naevus* was absent in Division 9.a and widespread in Division 8.c as usual. A large spot of biomass was found in the Cantabrian Sea between 6º and 7º W longitude (Figure 19.9b). Cuckoo ray length distribution remained similar to previous years. A total of 62 specimens were found this last survey, most of them ranged from 48 to 65 cm, but also fourteen specimens ranged from 35 to 44 cm and four small specimens from 18 to 24 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 and 2018 were the highest in the time series. Mean annual biomass index for 2017–2018 (0.60 kg h^{-1}) was 56% greater than observed in the preceding five years (2012–2016; 0.39 kg h^{-1}). The mean annual abundance index for 2017–2018 (1.68 ind. h^{-1}) was 103% greater than observed in the preceding five years (2012–2016; 0.83 ind h^{-1}). The length-distribution was relatively stable along the time series, with the mean length above average in 2017 and 2018 (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 2017–2018 (0.08 kg h^{-1}) was 12% smaller than observed in the preceding five years (2012–2016; 0.09 kg h^{-1}). Mean annual abundance index for 2017–2018 (0.44 ind h^{-1}) was 46% higher than observed in the preceding five years (2012–2016; 0.30 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 21–455 m depth, but more common off the southwest coast of Portugal, at depths of 40–150 m (Figure 19.12a). In 2018, the species was only caught by the commercial trawler used to do additional stations in the southwest coast. Therefore, the estimated survey index, considering only the stations from R/V *Noruega*, was 0 (Serra-Pereira and Figueiredo, 2019b WD). Biomass and abundance indices have been stable since 2014, and above the average values for the time-series (Figure 19.12b). Mean annual biomass index for 2017–2018 (0.09 kg h^{-1}) was 52% smaller than observed in the preceding five years (2012–2016; 0.18 kg h^{-1}). The mean annual abundance index for 2017–2018 (0.25 ind h^{-1}) was 40%

smaller than observed in the preceding five years (2012–2016; 0.41 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.

Data on the life-history traits of *R. undulata* in the Bay of Biscay are also 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.

19.8.1.4 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 for the Group in 2018 to fit the BLI and LBSPR.

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 2018 for 2019 and 2020. 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 2019, with the information below relating to work conducted in 2018. The next assessments and advice are scheduled for 2020.

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 a decrease trend in 2018.

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 19.17a). 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 Geno-PopTaille 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 in 2018 a decrease although remain among the high values of the series (0.62 kg haul^{-1}); (Figure 19.9a). Cuckoo ray length-distribution in 2018 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)

In 2018 the biomass index for *R. montagui* in the Spanish IEO Q4-IBTS survey is the highest recorded in Division 8.c since 2002 (Figure 19.8a).

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 9.a (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 and decreases in 2018. 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 8.a-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 biomass index of the EVHOE survey showed values lower than 3, with many years of the series with no reported catches (Figure 19.6c).

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 programme, *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 (t) (n*average weight)
North	2017	236034.2	1525.3	154.7	1426.5
Center	2017	10772.8	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 2008–2017 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)

Dipturus 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 former 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 skate 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 2018 and using ICES DLS approach.

Species	ICES stock code	ICES DLS Category	Perceived status
Thornback ray *Raja clavata*	rjc.27.8	3	Survey indices decreasing in Subarea 8
	rjc.27.9a	3	The stock size indicator shows an increasing trend since 1999
Cuckoo ray *Leucoraja naevus*	rjn.27.9a	3	The stock size indicator shows an increasing trend since 1998
	rjn .27.8c	3	The stock size indicator has been fluctuating with increasing trend since 2011
Spotted ray *Raja montagui*	rjm.27.8	3	The stock size indicator has been stable over the longer time series
	rjm.27.9a	3	The stock size indicator shows an increasing trend since 2011.
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 shows an increasing trend since 2011.
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 8.abd since 2001. Since 2008 LPUE were made 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 the 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 better represent 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 the 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. In addition, the small by-catch 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 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 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 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 (2017 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	2018
Belgium	12	15	9	9	12	4	9	4	6	8	5	4	3	20
France	2396	1956	1881	1794	1693	1461	1294	1202	1179	1349	1541	1220	2406	1463
Nether-lands					0									
Spain	422	332	373	352	275	163	228	113	242	243	212	262	210	256
UK	10	40	7	4	0	0	1	2	0		0	0	0	0
Ireland											35	28		
Norway		15	4											
Total	2840	2358	2274	2159	1980	1628	1532	1320	1427	1601	1793	1514	2618	1739

*** 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	2018
France	110	62	70	93	71	68	71	76	57	66	61	44	59	46
Spain	16	12	17	9	0	1	4	2	8	6	6		0	1
UK	0	3	1	0	0	0	1	0	0	0				
Ireland				0				0			0			
Total	126	76	89	103	72	69	75	78	66	72	66	44	59	48

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	2018
France	1	0	1	0	0	0	1	1	0	2	0	0	0	0
Spain	177	194	420	433	533	551	663	654	608	528	361	407	377	541
Total	178	194	421	433	533	552	663	655	608	530	361	407	377	541

*** 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	2018
France					1						0		0	0
Portugal	1298	1538	1444	1366	1370	1434	1357	1098	1041	992	938	1001	1097	1049
Spain	301	283	139	134	276	409	429	468	481	455	253	304	348	381
Ireland					0									
Total	1599	1821	1583	1501	1647	1843	1786	1566	1521	1448	1191	1305	1446	1430

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	2018
Belgium	12	15	9	9	12	4	9	4	6	8	5	4	3	20
France	2506	2018	1951	1888	1765	1529	1366	1279	1236	1418	1602	1264	2465	1510
Netherlands					0									
Portugal	1298	1538	1444	1366	1370	1434	1357	1098	1041	992	938	1001	1097	1049
Spain	916	821	950	928	1085	1124	1323	1237	1339	1233	832	973	935	1179
UK	10	43	8	4			1	2		0	0			
Ireland											35	28		
Norway		15	4											
Total	4743	4450	4366	4195	4231	4091	4056	3619	3622	3651	3412	3270	4500	3757

Table 19.1f. Skates in the Bay of Biscay and Iberian Waters. Combined Landings (t) of Rajidae in Biscay and Iberian Waters (included Division 8e). Landings by ICES stock and country since 2005. Totals by country are presented in bold.

Country	ICES Stock code	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Belgium		**12**	**15**	**9**	**9**	**12**	**4**	**9**	**4**	**6**	**8**	**5**	**4**	**3**	**20**
	raj.27.89a	12	15	9	1	2	1	2	0	1	0	1	0	0	0
	rjc.27.8				2	2	1	2	2	3	3	1	2	1	1
	rjh.27.9a													0	
	rjm.27.3a47d														9
	rjm.27.8				0	0	0	0	0					0	
	rjn.27.678abd				6	8	3	4	2	3	5	3	2	1	10
France		**2507**	**2018**	**1952**	**1888**	**1765**	**1529**	**1367**	**1279**	**1236**	**1418**	**1602**	**1264**	**2465**	**1510**
	raj.27.89a	783	662	610	613	391	244	175	151	178	238	202	181	1354	255
	rja.27.nea	1		0	0	3	0	1	1	0	1	3	1	0	
	rjb.27.89a													0	0
	rjc.27.8	276	300	215	187	195	217	178	179	194	202	212	166	191	229
	rjc.27.9a													0	0
	rjh.27.9a													0	0
	rjm.27.8	155	130	124	106	64	86	91	86	109	121	149	132	153	172
	rjm.27.9a													0	0
	rjn.27.678abd	1290	927	1002	981	1109	980	920	859	754	848	1025	769	745	837
	rjn.27.8c	0	0		0	0	0	0	0	0	2	0	0	0	0
	rjn.27.9a											0		0	0
	rju.27.8ab	1	0		0	3	2	2	3	0	7	11	14	22	17
	rju.27.8c													0	0
	rju.27.9a													0	0
	raj.27.89														0
Netherland	NLD					**0**									
	raj.27.89a					0									
Portugal	PRT	**1303**	**1544**	**1444**	**1439**	**1444**	**1454**	**1425**	**1122**	**1104**	**1026**	**1012**	**1026**	**1138**	**1195**
	raj.27.89a	104	123	38	307	308	293	276	240	144	132	113	99	116	142
	rja.27.nea	5	6												
	rjb.27.89a														90
	rjc.27.9a	480	569	472	745	739	611	811	570	643	585	578	559	620	654
	rjh.27.9a	495	586	459	193	163	221	161	165	179	174	236	221	235	191
	rjm.27.9a	76	90	119	144	184	275	121	108	111	101	67	68	94	57
	rjn.27.9a	43	51	79	50	50	55	56	39	27	34	20	57	39	23
	rju.27.9a	100	119	277									23	35	38
Spain		**916**	**821**	**950**	**928**	**1085**	**1124**	**1323**	**1237**	**1299**	**1210**	**812**	**940**	**520**	**1179**
	raj.27.89a	916	821	949	924	691	614	821	677	585	446	285	355	1	422
	rjc.27.8		0	0	4	134	213	242	243	276	275	179	191	176	299
	rjc.27.9a					29	115	139	194	166	215	120	123	124	152

Country	**ICES Stock code**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Spain cont'	rjh.27.9a					1	2	1	0	3	0	0	1	0	4
	rjm.27.8					11	26	22	19	28	40	27	25	27	44
	rjm.27.9a			0		7	10	3	2	4	2	1	5	5	5
	rjn.27.678abd					191	106	59	62	203	204	184	225	169	205
	rjn.27.8c					18	34	24	26	33	27	15	13	15	23
	rjn.27.9a					3	4	12	13	2	0	0	1	2	2
	rju.27.8c														9
	rju.27.9a														15
UK		**10**	**43**	**8**	**4**	**1**	**0**	**1**	**2**	**0**		**0**	**0**	**0**	**0**
	raj.27.89a	10	43	8	2	0	0		0	0					
	rjc.27.8							1	2			0	0	0	0
	rjm.27.8				1	1	0	0				0	0		
	rjn.27.678abd							0				0			
Ireland					**0**	**0**			**0**			**0**			
	raj.27.67a-ce-k											0			
	raj.27.89a				0	0									
	rjc.27.8								0						
Total		4748	4441	4362	4268	4307	4112	4125	3644	3646	3661	3432	3234	4127	3813

Table 19.2. Skates in the Bay of Biscay and Iberian Waters. Species-specific landings (in t) in divisions 8.abde, 8.c and 9.a since 2005. Last table includes landings of Skates (*Myliobatis* spp, Dasyatidae, *Rhinobatos* spp, Torpedinidae) in the same period.

8.abd	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Dipturus oxyrinchus	12	10	2	3	1	6	6	0	0	0	0	0		
Dipturus spp.													0	0
Leucoraja circularis	84	53	58	69	20	28	16	20	20	25	24	20	0	
Leucoraja fullonica	14	8	7	7	45	37	36	30	30	38	42	37		
Leucoraja naevus	1290	927	1002	987	1308	1089	983	923	959	1057	1212	995	915	1052
Raja brachyura				0	11	11	18	7	27	67	65	76	0	
Raja clavata	276	300	215	190	237	245	217	202	244	241	246	205	232	273
Raja microocellata	0	0	0	1	3	2	4	13	20	38	21	30	0	
Raja montagui	155	130	124	107	65	86	92	86	109	121	149	132	153	181
Raja undulata	1	0		0	3	2	2	3	0	7	11	14	22	17
Rajiformes (indet)	1133	991	950	898	357	193	234	113	83	79	52	19	1354	263
Rostroraja alba	1		0	0	3	0	1	1	0	1	3	1	0	0
Total	2967	2420	2359	2262	2052	1698	1608	1398	1493	1673	1825	1530	2677	1787

Table 19.2 cont'. Skates in the Bay of Biscay and Iberian Waters. Species-specific landings (in t) in divisions 8.abde, 8.c and 9.a since 2005. Last table includes landings of Skates (*Myliobatis* spp, Dasyatidae, *Rhinobatos* spp, Torpedinidae) in the same period.

8.c	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dipturus oxyrinchus											3	0		
Dipturus spp.													0	
Leucoraja circularis		0		4	1	2	1	1	1	0	0	0		
Leucoraja fullonica		0		0	0					0				
Leucoraja naevus	0	0		0	18	34	24	27	33	29	15	13	15	23
Raja brachyura					0	5	1	0	0	0	1	1	0	
Raja clavata	0	0	0	4	94	186	206	224	229	239	146	154	136	256
Raja microocellata													0	
Raja montagui					11	25	22	19	28	40	27	25	27	44
Raja undulata													0	9
Rajiformes (indet)	178	194	420	426	409	299	409	385	278	198	149	187	0	210
Total	178	194	421	433	533	552	663	655	568	507	342	382	179	541

Table 19.2 cont'. Skates in the Bay of Biscay and Iberian Waters. Species-specific landings (in t) in divisions 8.abde, 8.c and 9.a since 2005. Last table includes landings of Skates (*Myliobatis* spp, Dasyatidae, *Rhinobatos* spp, Torpedinidae) in the same period.

9.a	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dipturus spp.											0			56
Dipturus oxyrinchus				72	75	20	68	24	64	33	74	26	41	0
Leucoraja circularis	0	0	0	1	2	11	1	0	0	0	0	2	1	0
Leucoraja fullonica								0			0			
Leucoraja naevus	43	51	79	50	53	59	68	53	29	34	20	59	41	25
Raja brachyura	495	586	459	193	164	223	162	165	182	174	236	222	236	195
Raja clavata	480	569	472	746	769	726	951	766	810	801	701	687	744	806
Raja microocellata	88	105	35	19	45	43	29	36	41	45	32	63	68	82
Raja miraletus	16	19		4	2	6	5	5	1	2	0	2	0	0
Raja montagui	76	90	119	144	191	284	124	110	115	103	68	73	99	62
Raja undulata	100	119	277									31	46	52
Rajiformes (indet)	301	283	142	344	420	490	445	431	344	288	136	167	210	207
Rostroraja alba	5	6												
Total	1604	1827	1583	1573	1721	1863	1853	1590	1585	1481	1265	1330	1487	1485

Table 19.2 cont'. Skates in the Bay of Biscay and Iberian Waters. Species-specific landings (in t) in divisions 8.abde, 8.c and 9.a since 2005. Last table includes landings of Skates (*Myliobatis* spp, Dasyatidae, *Rhinobatos* spp, Torpedinidae) in the same period.

89.a	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dasyatidae	1	2	0	0	0	0	0	0	0	0		0	0	0
Dasyatis pastinaca	4	3	6	5	3	3	2	2	3	5	6	4		
Myliobatidae														43
Myliobatis aquila	2	2	1	2	1	1	2	1	1	2	2	2	23	15
Rhinobatos spp	0	0	0	0	0		0	0	0	0	0	0		0
Torpedinidae												16	7	18
Torpedo marmorata	27	24	25	28	25	22	20	20	23	14	18	16		
Torpedo spp	39	49	45	46	39	50	54	39	43	46	43	33	45	32
Total	73	80	77	80	69	77	79	62	70	68	69	71	75	108

Table 19.3a. Skates in the Bay of Biscay and Iberian. ***L 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
2018	95	5

Table 19.3b. Skates in the Bay of Biscay and Iberian Waters. Estimate of the percentage of the elasmobranch discarded in the total catch by the Basque OTB (Bottom otter trawl) in Divisions 8a,b,d.

Year	*L. naevus*	*R. clavata*
2009	4%	0%
2010	11%	3%
2011	14%	11%
2012	9%	1%
2013	18%	10%
2014	12%	3%
2015	30%	13%
2016	51%	52%
2017	50%	15%
2018	53%	12%

Table 19.3c. Skates in the Bay of Biscay and Iberian waters. *R. clavata, R. montagui* and *Leucoraja naevus* discard estimates (t) obtained from the Spanish (IEO) discard sampling program.

Species	*Raja clavata*		*Raja montagui*		*Leucoraja naevus*	
Year/ICES area	8	9.a	8	9.a	8.c	9.a
2015	73	31	1	1	11	4
2016	79	43	34	41	11	41
2017	12	7	2	12	3	22

Table 19.3d. Skates in the Bay of Biscay and Iberian Waters. Discard estimates (t) by stock of the main species (rajidae, Common skate complex, *R. montagui, L. naevus, R. undulata*) in the French fleet during the period 2016-2018.

Year	raj.27.89a	rjb.27.89a	rjm.27.8	rjn.27.678abd	rju.27.8ab
2016	713		71	820	416
2017	882		85	1030	230
2018		19	0		271
Total	1595	19	156	1850	918

Table 19.4a. Skates in the Bay of Biscay and Iberian Waters. Percentage of individuals by vitality status after capture (1 = Good; 2 = Moderate; 3 = Poor) in relation to mesh size and soak time in the Portuguese polyvalent fleet operating with trammel nets for *Raja clavata*, *Raja montagui*, *Raja brachyura*, *Leucoraja naevus* and *Raja undulata.* The total length range is also given.

			Vitality status				
Species	Mesh size (mm)	Soak time (h)	1	2	3	n	TL range (cm)
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 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
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
Leucoraja naevus	< 180	< 24	1	-	-	1	53
	> 180	< 24	1	-	-	1	61
		> 24	58%	21%	21%	24	46-62
Raja undulata	< 180	< 24	82%	16%	2%	44	40-89
		> 24	90%	5%	5%	58	43-92
	> 180	< 24	79%	7%	14%	71	32-92
		> 24	96%	1%	3%	174	44-92

Table 19.4b. Skates in the Bay of Biscay and Iberian Waters. Percentage of individuals by vitality status (1 = Excellent; 2 = Good; 3 = Poor; 4= Dead) of each species assessed onboard IPMA's otter trawl surveys, for different deck times. For n ≤ 5, observed numbers by vitality are shown instead of percentages.

Species	Survey	Deck time	Length class	1	2	3	4	n	TL range (cm)
Raja clavata	PT-CTS	< 108 min	< 52 cm	47%	13%	33%	7%	30	
		< 108 min	> 52 cm	4	-	1	-	5	
		> 108 min	< 52 cm	0%	0%	0%	100%	25	
		> 108 min	> 52 cm	-	1	-	3	4	
	PTGFS-WIBTS-Q4	< 108 min	< 52 cm			1	1	2	
		< 108 min	> 52 cm	26%	46%	23%	6%	35	

Table 19.5. Skates in the Bay of Biscay and Iberian Waters. Relative estimated 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	2018
Raja miraletus	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Raja clavata	48%	48%	40%	54%	44%	56%	53%	53%	52%	55%	57%
Raja microocellata	2%	4%	3%	3%	4%	5%	5%	4%	7%	7%	9%
Raja brachyura	15%	11%	16%	13%	18%	19%	20%	27%	25%	23%	18%
Leucoraja circularis	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
Raja montagui	10%	13%	19%	8%	9%	10%	10%	7%	6%	8%	5%
Leucoraja naevus	2%	3%	3%	3%	3%	2%	3%	1%	5%	3%	1%
Dipturus oxyrinchus	6%	5%	1%	4%	3%	5%	3%	8%	3%	4%	6%
Rajidae	17%	16%	16%	15%	19%	4%	6%	0%	0%	0%	0%

	Trawl										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Raja miraletus	1%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%
Raja clavata	64%	60%	47%	66%	71%	66%	76%	77%	71%	64%	72%
Raja microocellata	0%	0%	2%	0%	0%	0%	2%	0%	3%	1%	0%
Raja brachyura	8%	12%	13%	5%	6%	8%	8%	7%	10%	14%	14%
Leucoraja circularis	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Raja montagui	10%	11%	17%	8%	11%	12%	4%	4%	8%	12%	7%
Leucoraja naevus	7%	6%	8%	8%	6%	4%	5%	5%	7%	8%	5%
Dipturus oxyrinchus	3%	6%	3%	8%	1%	8%	4%	6%	0%	1%	1%
Rajidae	7%	5%	7%	5%	3%	2%	0%	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 and OTB DEF = 100 (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
2018	51	41

Table 19.7. Skates in the Bay of Biscay and Iberian Waters. Life-history information. 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	l50 (years) F	l50 (years) M	Fecundity	Reproductive period	Growth model	Growth parameters estimates						Period	Region	Source
									L∞ (cm)	k (y–1)	t0 (years)	Lmax (cm)	lmax (years)	l∞ 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 estimates	11 604	49
9	2253	0.38	3	11		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 estimates	16 119	68
9	3130	0.38	4	16		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

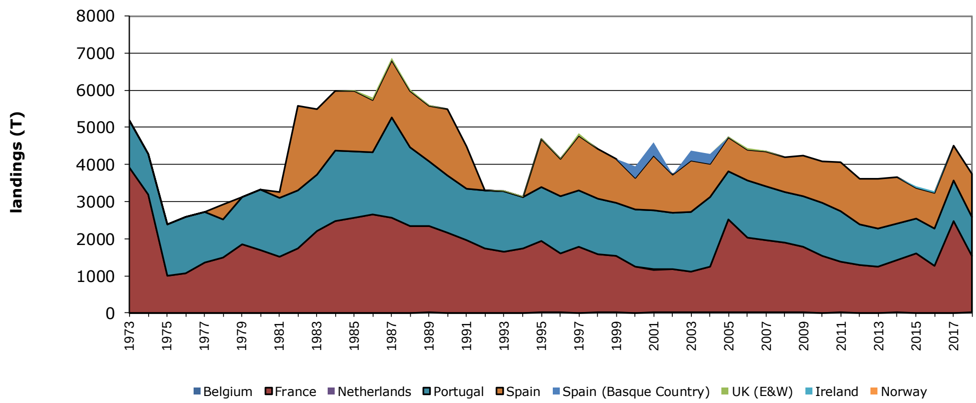


Figure 19.1. Skates in the Bay of Biscay and Iberian Waters. Historical trend in landings of Rajidae in Subarea 8 and Division 9.a since 1973.

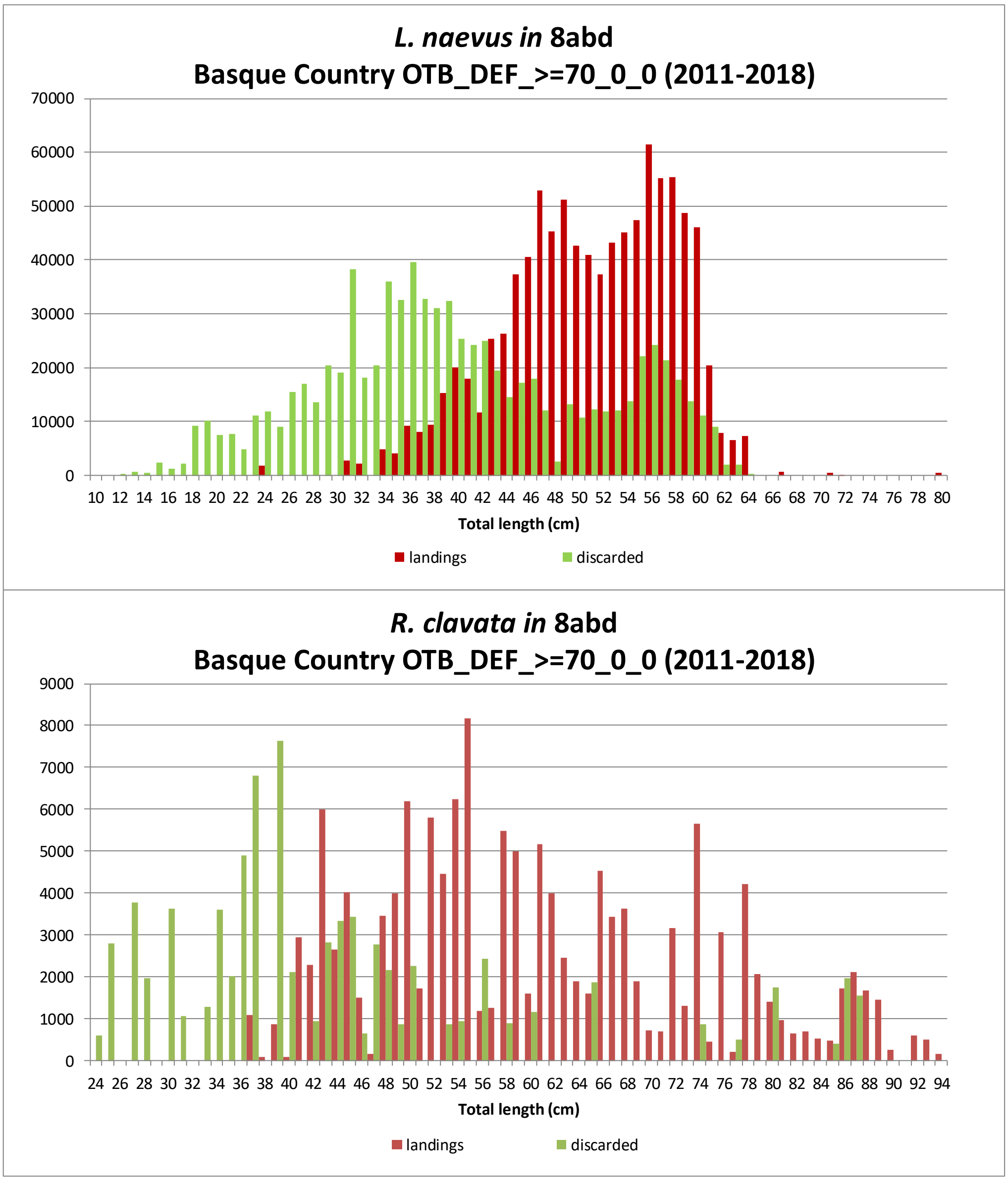


Figure 19.2a. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of the *Leucoraja naevus* and *Raja clavata* for the period from 2011–2018 of the Basque OTB (Bottom Otter Trawler).

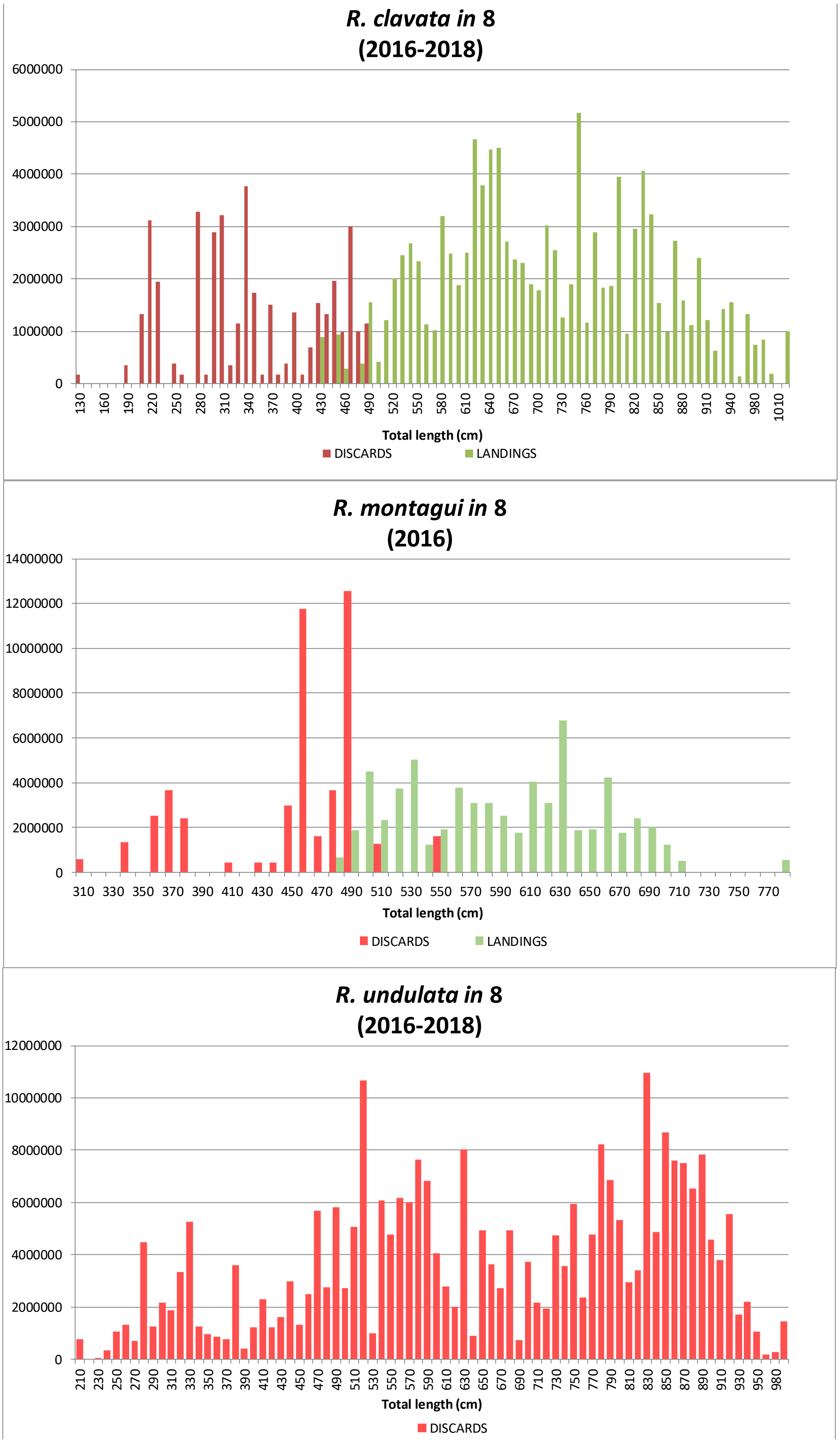


Figure 19.2b. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja clavata, R. montagui and R. undulata* by the commercial French fleet (bottom trawl and nets) for the period 2016–2018 in Subarea 8.

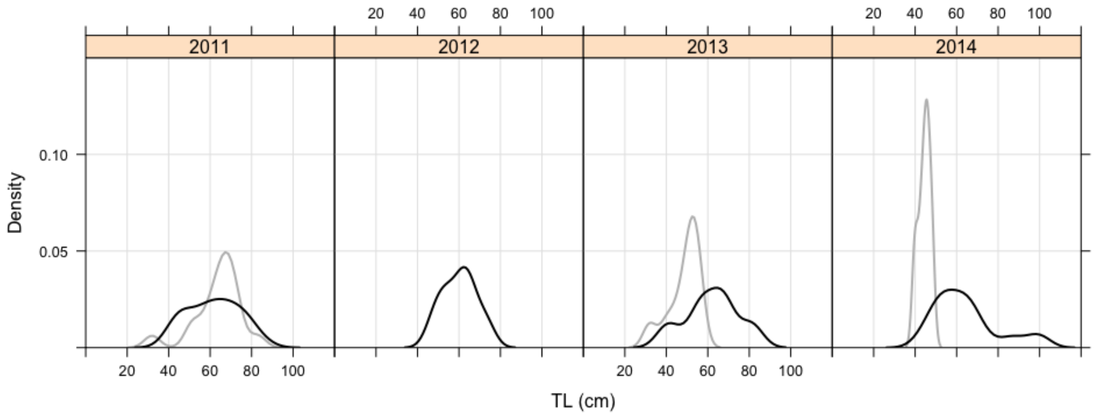


Figure 19.2c. Length frequency distribution of *R. clavata* retained (black) and discarded (grey) fractions observed onboard vessels with LOA >12 m and with fishing permit to operate with gillnets and/or trammel nets, between 2011 and 2014. The length frequencies were not raised to the total landings. n = 204 sampled individuals.

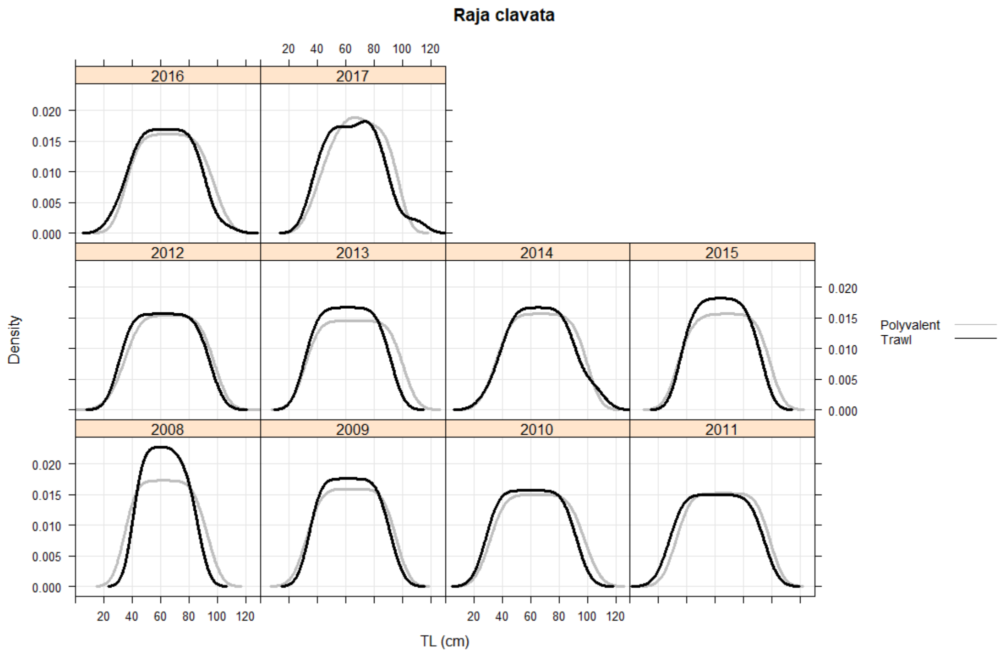


Figure 19.2d. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja clavata* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n = 2410 for the polyvalent segment and n = 642 for the trawl segment.

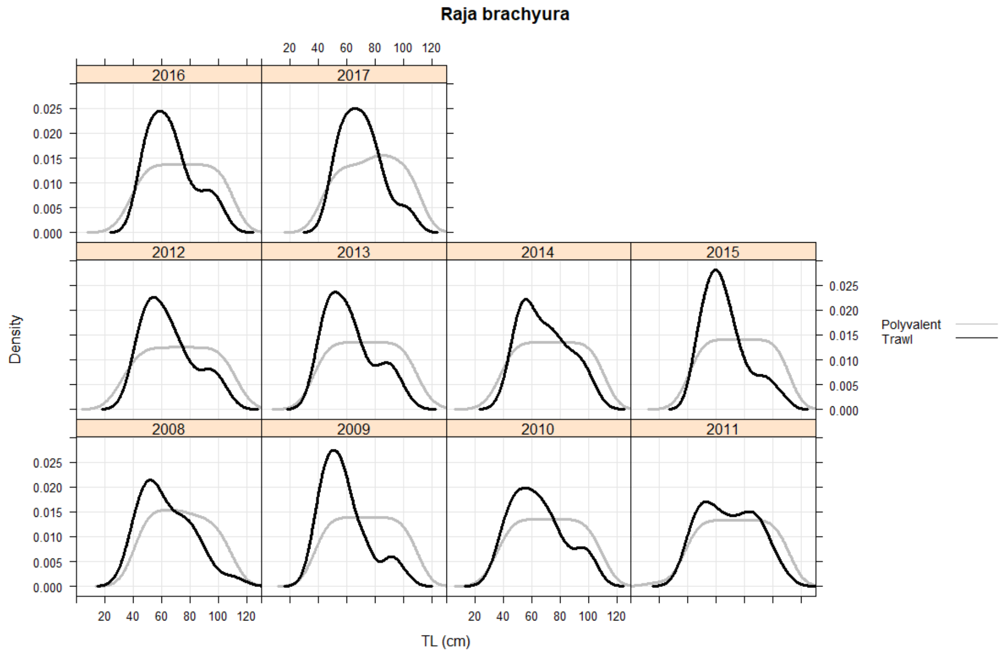


Figure 19.2e. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja brachyura* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n = 1466 for the polyvalent segment and n = 187 for the trawl segment.

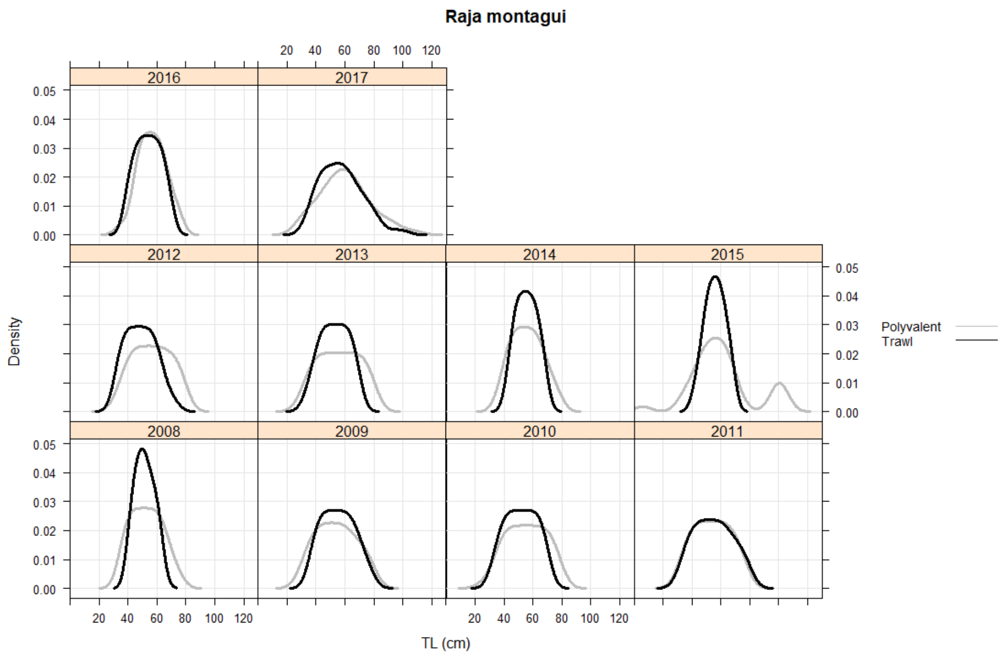


Figure 19.2f. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja montagui* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n = 1061 for the polyvalent segment and n = 320 for the trawl segment.

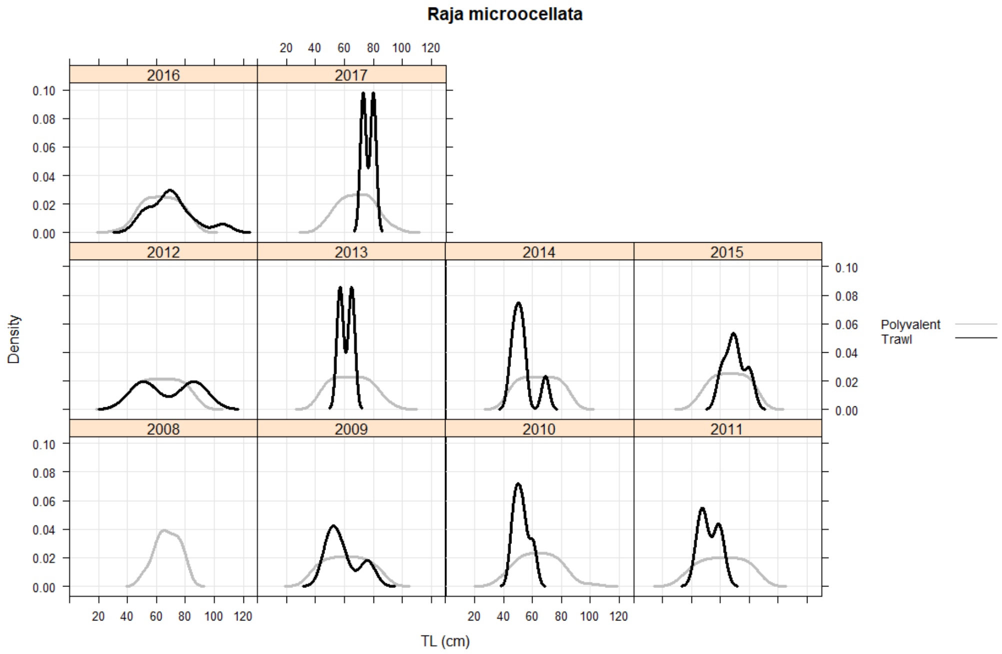


Figure 19.2g. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja microocellata* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n = 638 for the polyvalent segment and n = 18 for the trawl segment.

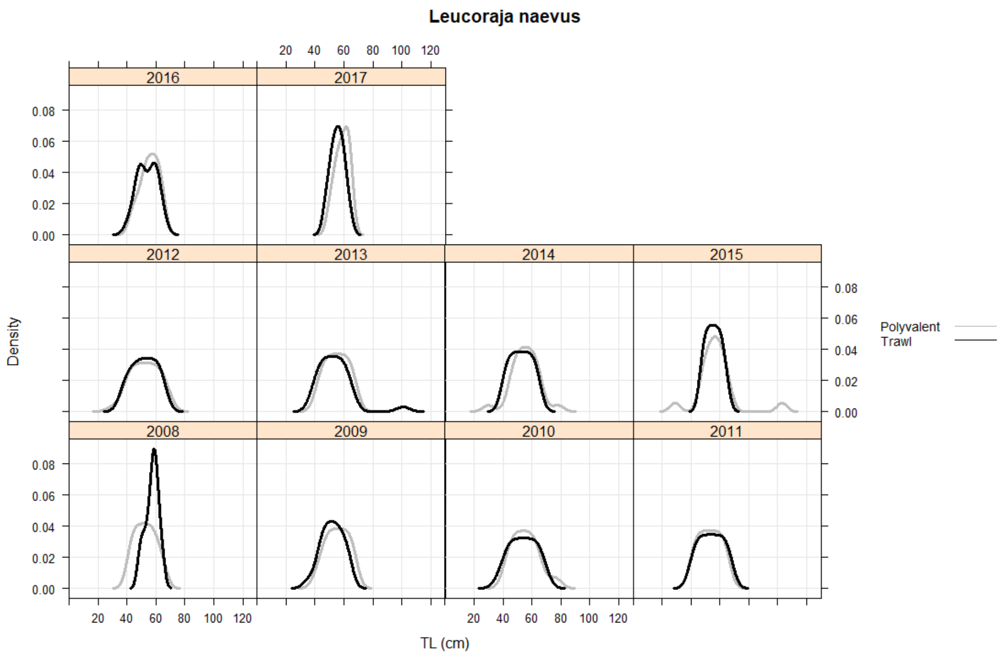


Figure 19.2h. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Leucoraja naevus* for the period from 2008–2017 in mainland Portugal (Division 9.a). Total number of sampled trips was n = 299 for the polyvalent segment and n = 158 for the trawl segment.

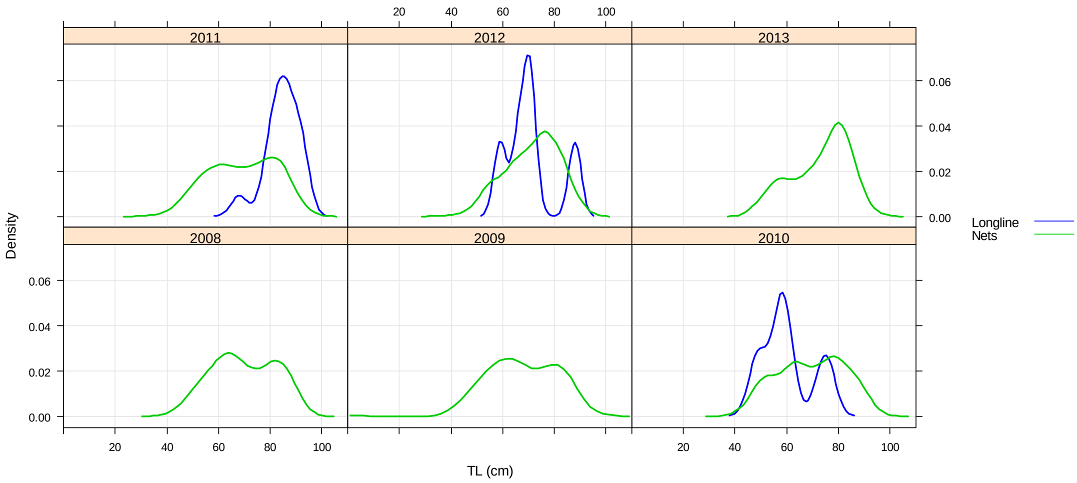


Figure 19.2i. Skates in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja undulata* by fishing gear (longline and nets) for the period 2008–2013 in mainland Portugal (Division 9.a).

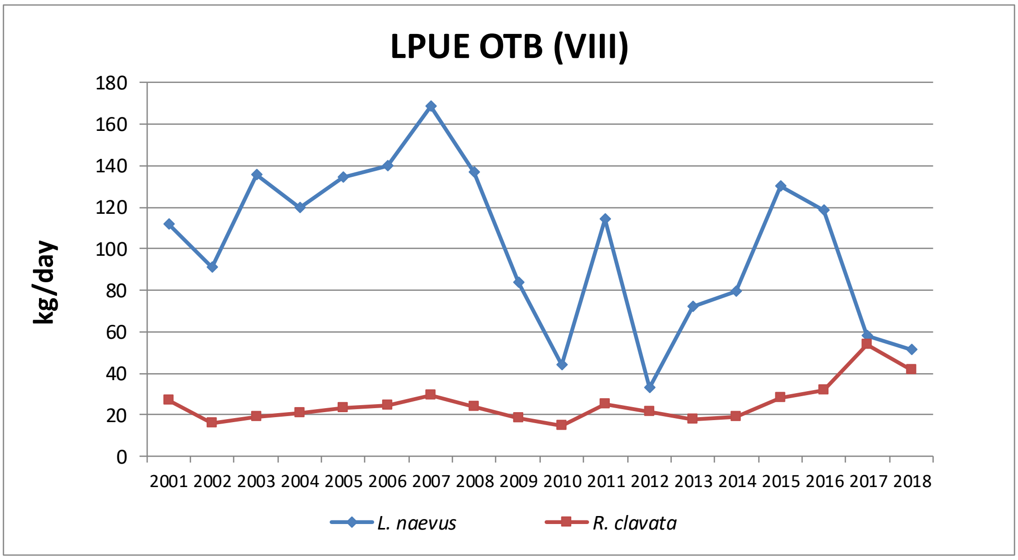


Figure 19.3. Skates in the Bay of Biscay and Iberian Waters. Nominal LPUE (kg day^{-1}) of *Leucoraja naevus* and *Raja clavata* caught in the OTB DEF >= 70 and OTB DEF = 100 Basque fleet in Subarea 8 (2001–2018).

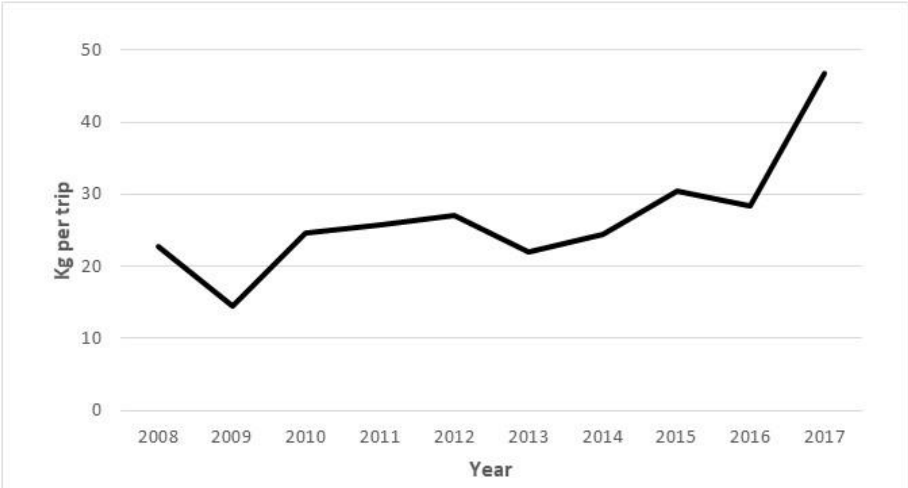


Figure 19.4a. Skates in the Bay of Biscay and Iberian Waters. Standardized LPUE (kg trip^{-1}) of *R. brachyura* in the Division 9.a for the period 2008–2017.

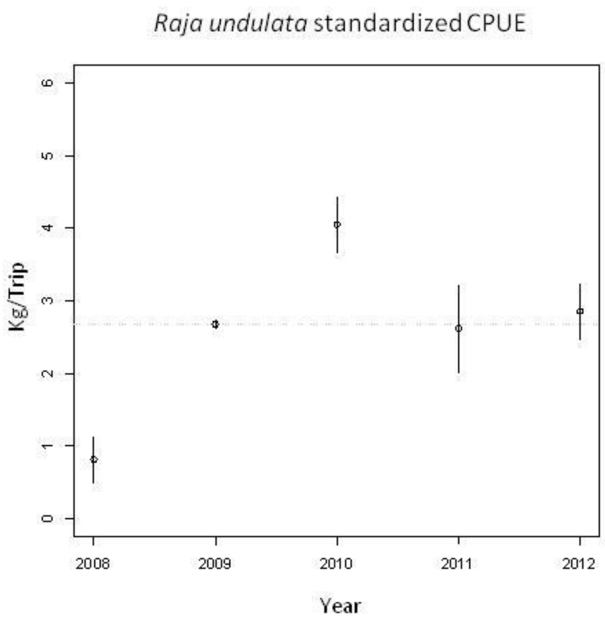


Figure 19.4b. Skates in the Bay of Biscay and Iberian Waters. Standardized CPUE (kg trip^{-1}) of *Raja undulata* for the period 2008–2013 in mainland Portugal (Division 9.a). Dashed line: average of the entire time-series.

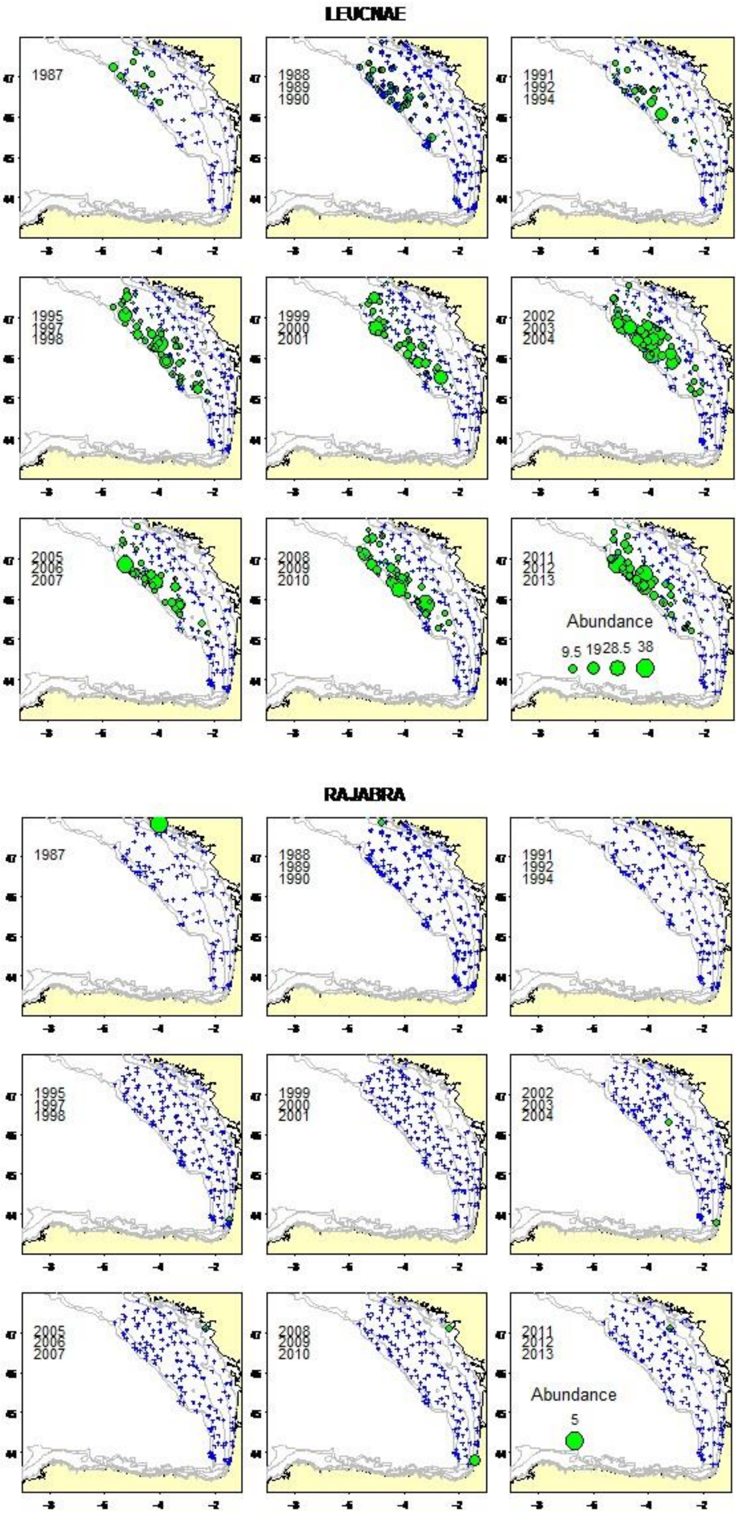


Figure 19.5a. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *L. naevus* (top) and *R. brachyura* (bottom), as observed in the French EVHOE survey.

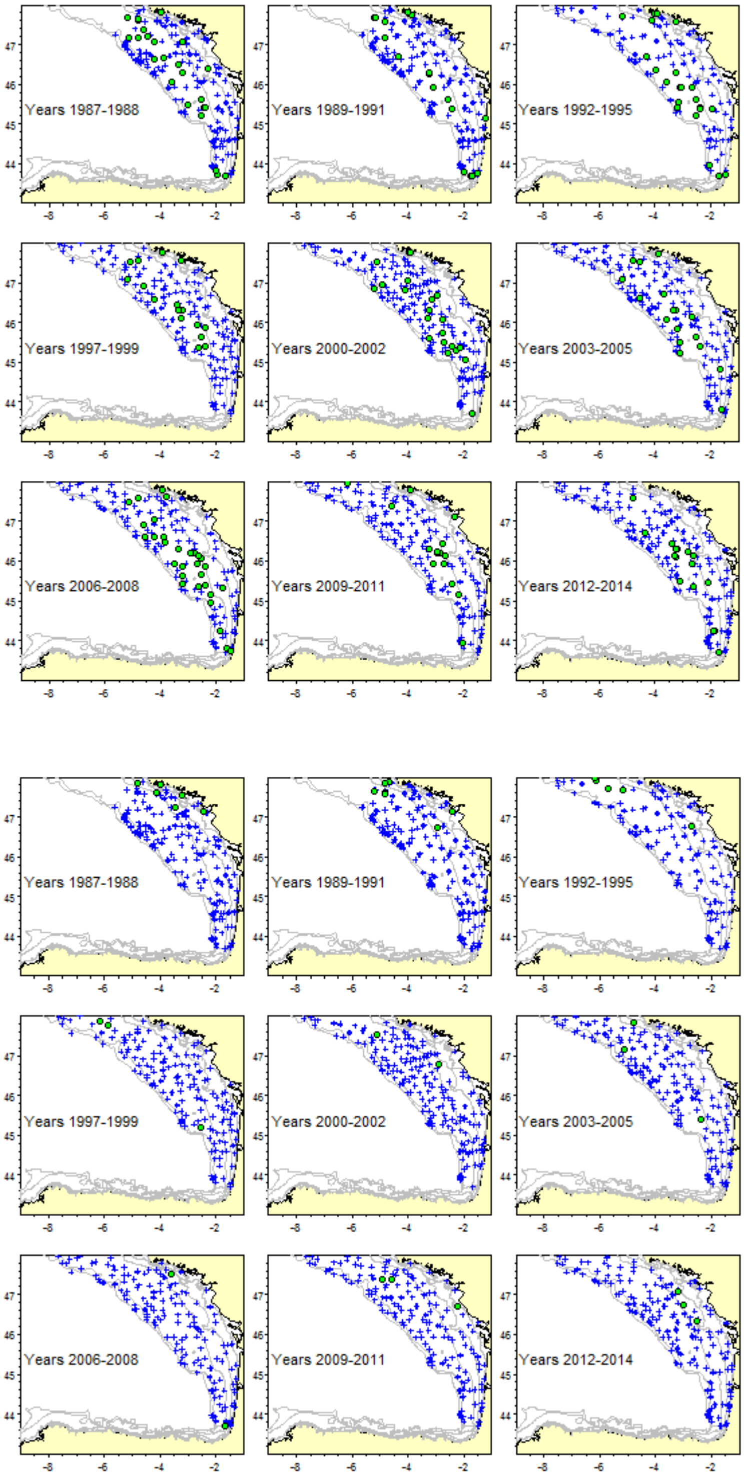


Figure 19.5b. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *R. clavata* (top) and *R. montagui* (bottom), as observed in the French EVHOE survey.

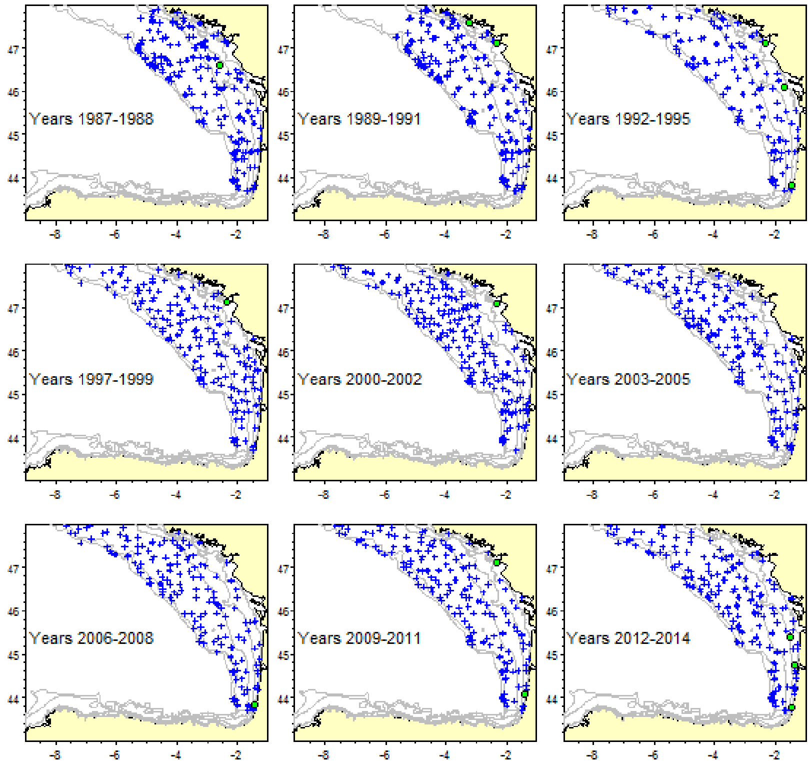


Figure 19.5c. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *R. undulata*, as observed in the French EVHOE survey.

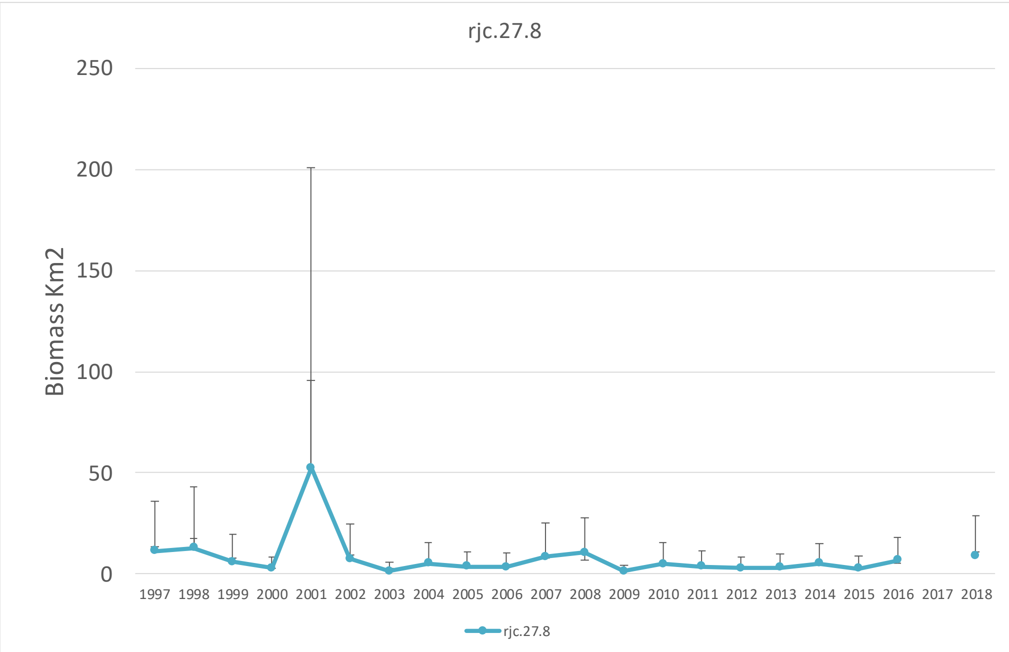


Figure 19.6a. Skates in the Bay of Biscay and Iberian Waters. EVHOE survey indices 1987–2018 of *R. clavata* in Subarea 8. Abundance and biomass are raised to the total area (km²) surveyed (swept area method) but should be considered relative and not absolute estimates.

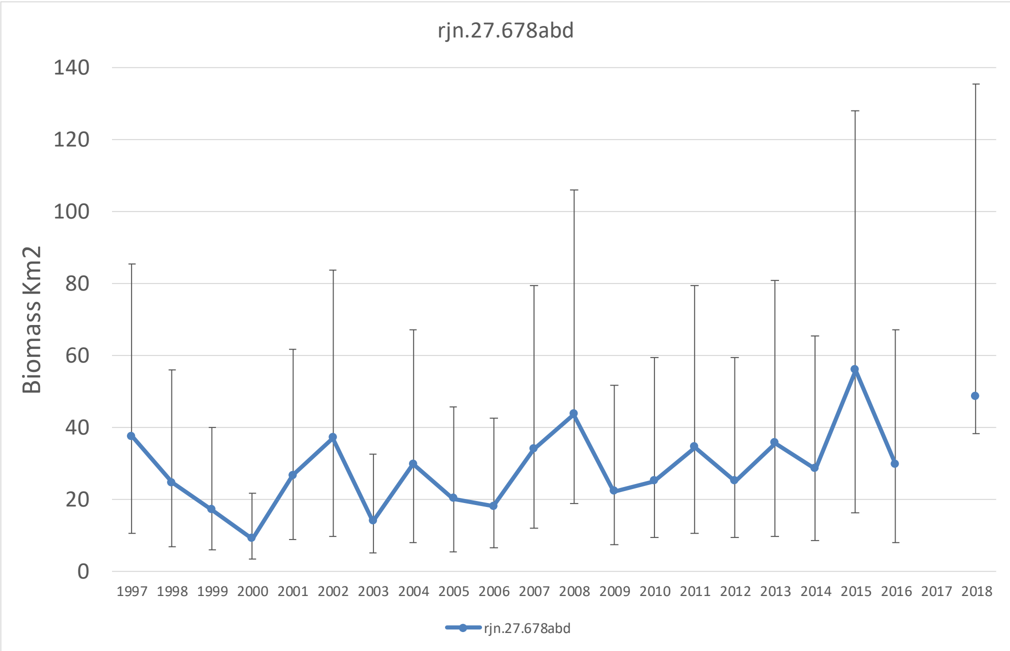


Figure 19.6b. Skates in the Bay of Biscay and Iberian Waters. EVHOE survey indices 1987–2018 of the *L. naevus* in the Bay of Biscay (divisions 8.abd). Abundance and biomass are raised to the total area (km²) surveyed (swept area method) but should be considered relative and not absolute estimates.

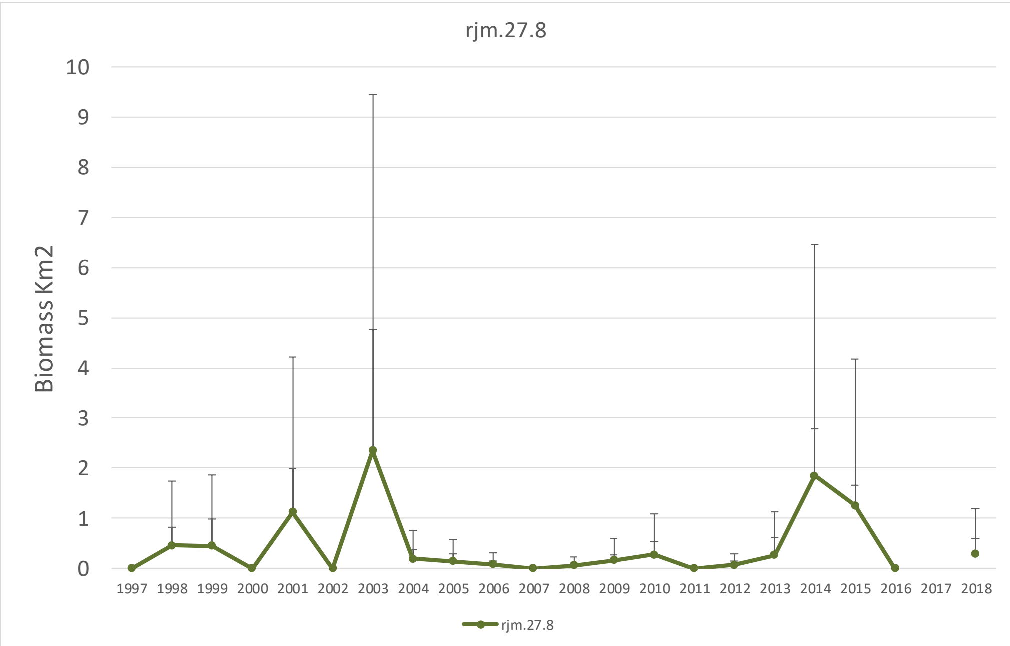


Figure 19.6c. Skates in the Bay of Biscay and Iberian Waters. EVHOE survey indices 1987–2018 of the *R. montagui* in the Subarea 8. Abundance and biomass are raised to the total area (km²) surveyed (swept area method) but should be considered relative and not absolute estimates.

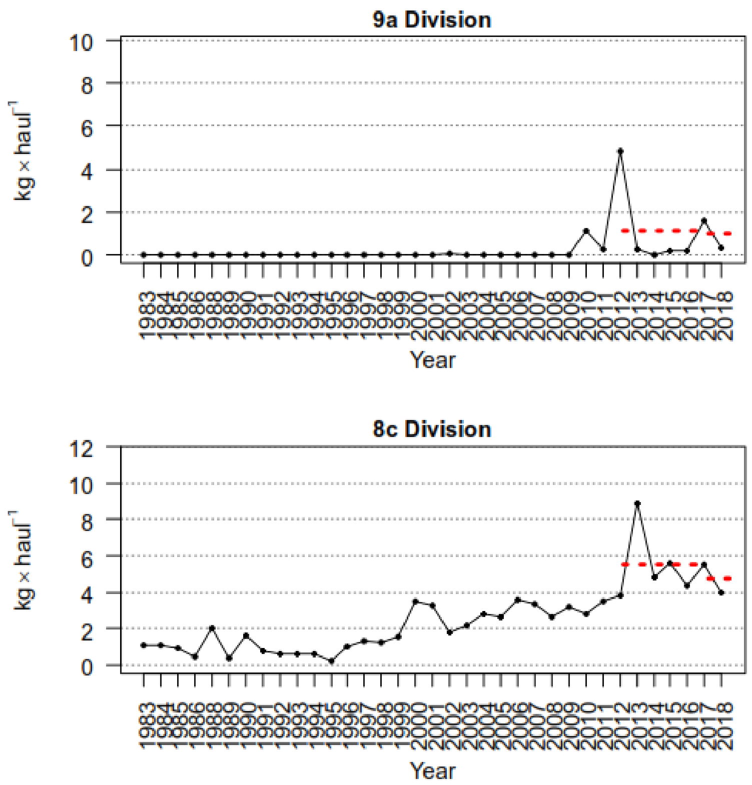


Figure 19.7a. Skates in the Bay of Biscay and Iberian waters. Changes in *Raja clavata* biomass indices, in ICES divisions 9.a and 8.c, during the North Spanish bottom trawl survey time-series (1983–2018). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

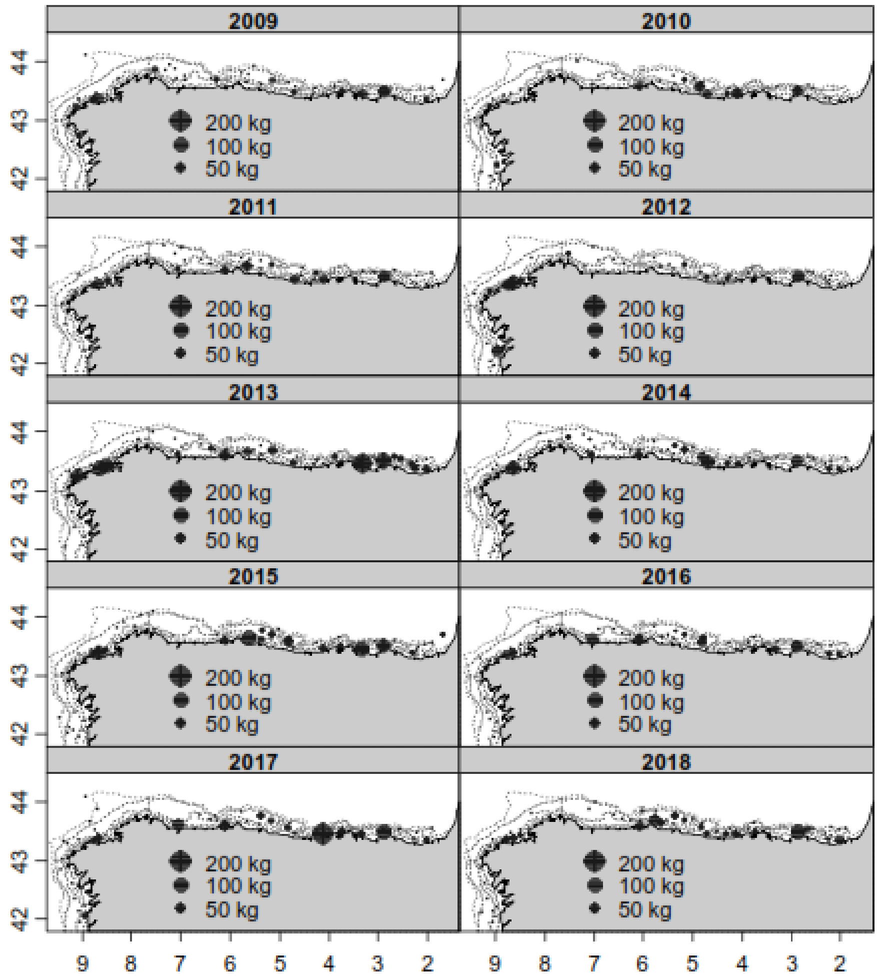


Figure 19.7b. Skates in the Bay of Biscay and Iberian waters. Geographical distribution of *R. clavata* catches (kg/30 min haul) in North Spanish continental shelf from bottom trawl surveys for the period (2013–2018).

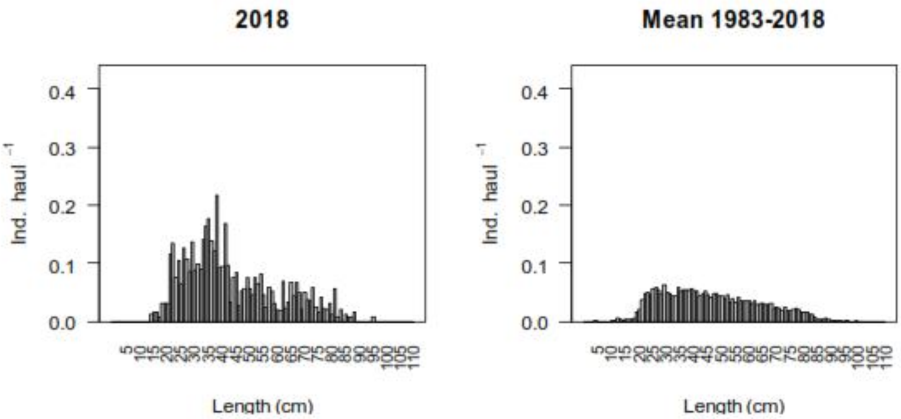


Figure 19.7c. Skates in the Bay of Biscay and Iberian waters. Stratified length distribution of *R. clavata* obtained from Spanish bottom trawl surveys time-series in the last survey (left) and in the period 1983-2018 (right) in Division 8c of the North Spanish Shelf.

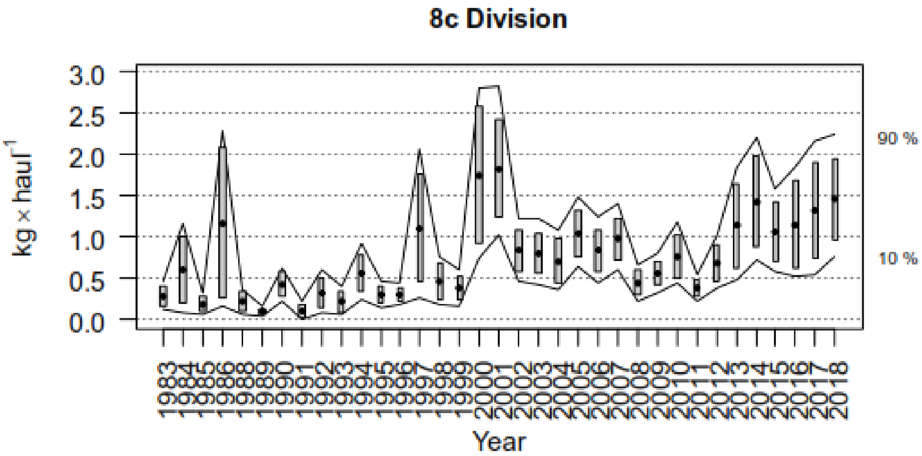


Figure 19.8a. Skates in the Bay of Biscay and Iberian Waters. Changes in *Raja montagui* biomass index during North Spanish shelf bottom trawl survey time-series (1983–2018) in Division 8.ccovered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

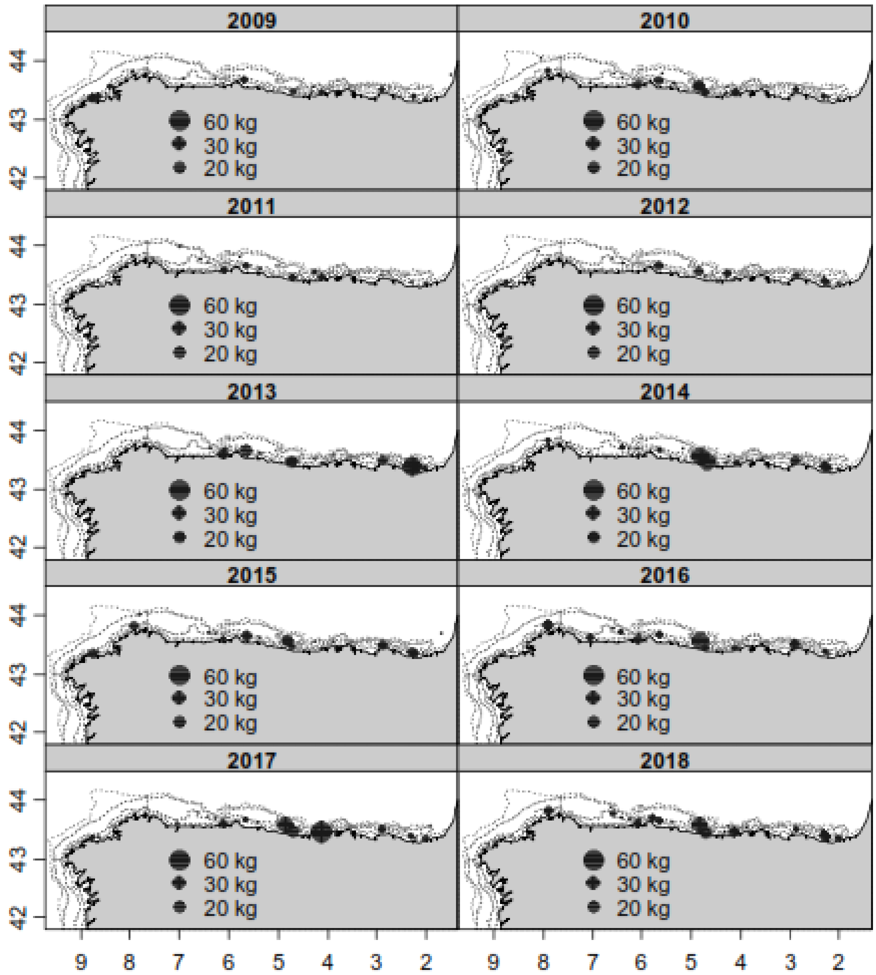


Figure 19.8b. Skates in the Bay of Biscay and Iberian Waters. Geographical distribution of *R. montagui* catches (kg/30 min haul) in North Spanish continental shelf bottom trawl surveys for the period (2013–2018).

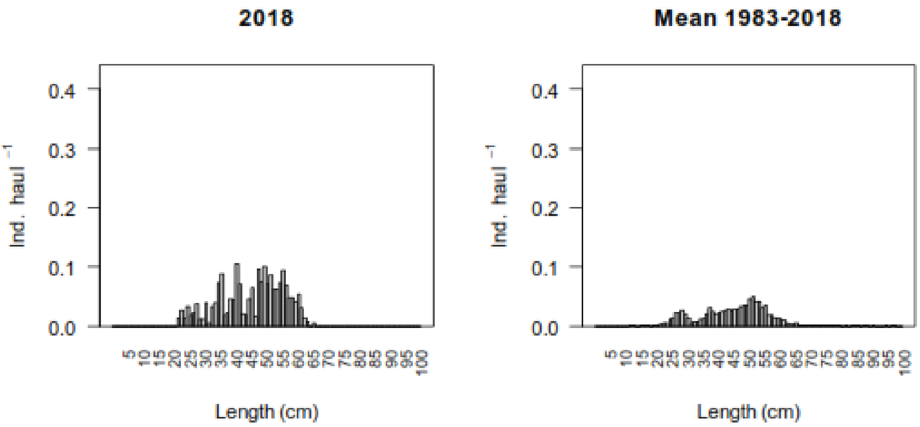


Figure 19.8c. Skates in the Bay of Biscay and Iberian waters. Mean stratified length distribution of *Raja montagui* in the last survey and in the period 1983–2018 (right) in Division 8.c of the North Spanish Shelf.

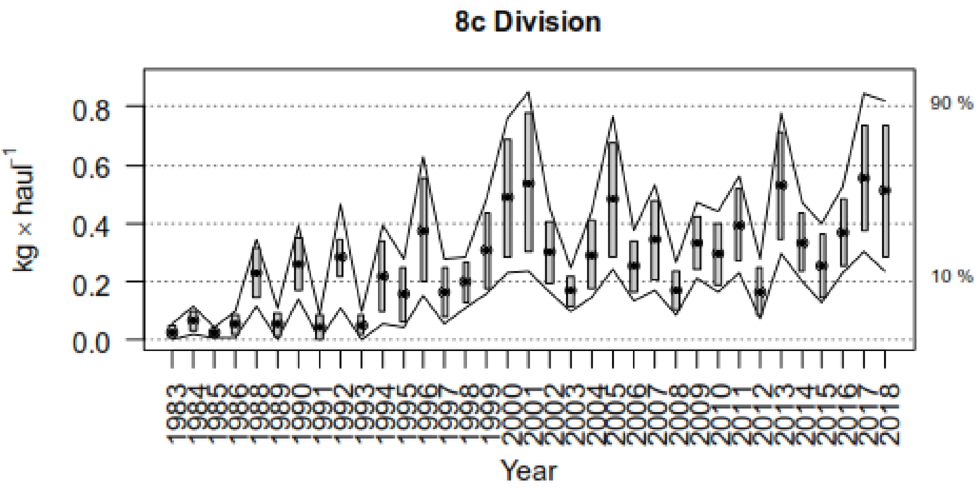


Figure 19.9a. Skates in the Bay of Biscay and Iberian Waters. Changes in *Leucoraja naevus* biomass index during North Spanish shelf bottom trawl survey time-series (1983–2018) in ICES Division 8.c. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

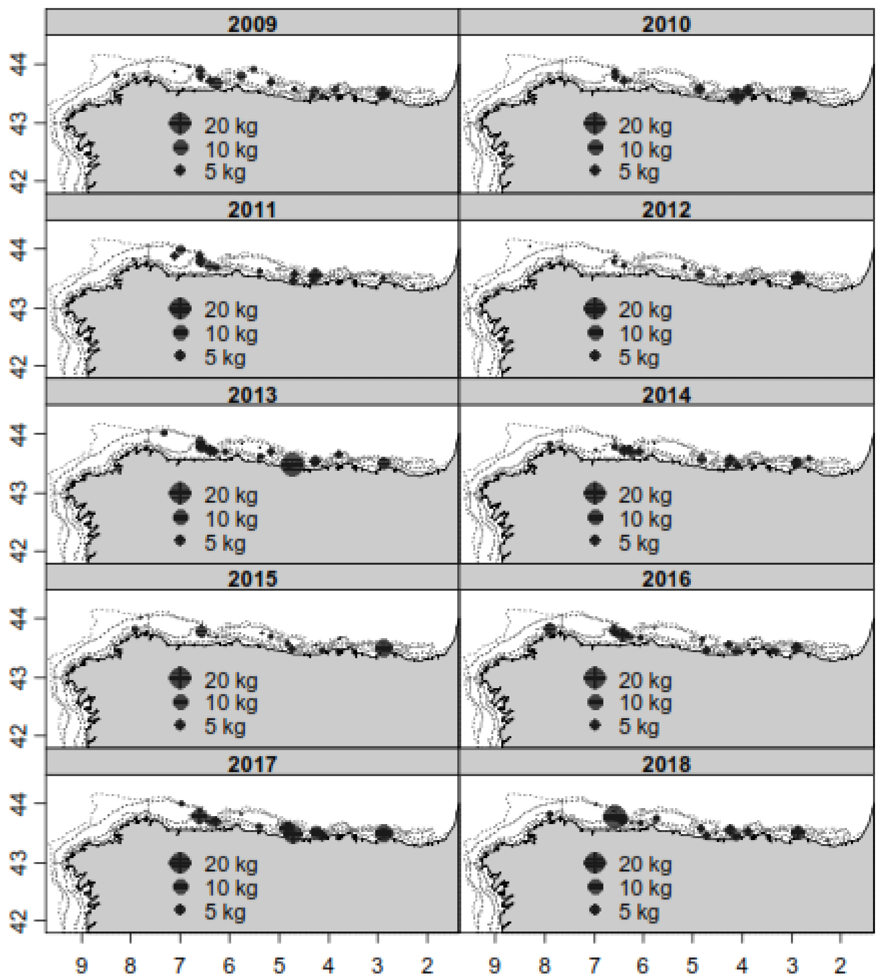


Figure 19.9b. Skates in the Bay of Biscay and Iberian Waters. Geographical distribution of *L. naevus* catches (kg/30 min haul) in North Spanish continental shelf bottom trawl surveys for the period (2013–2018).

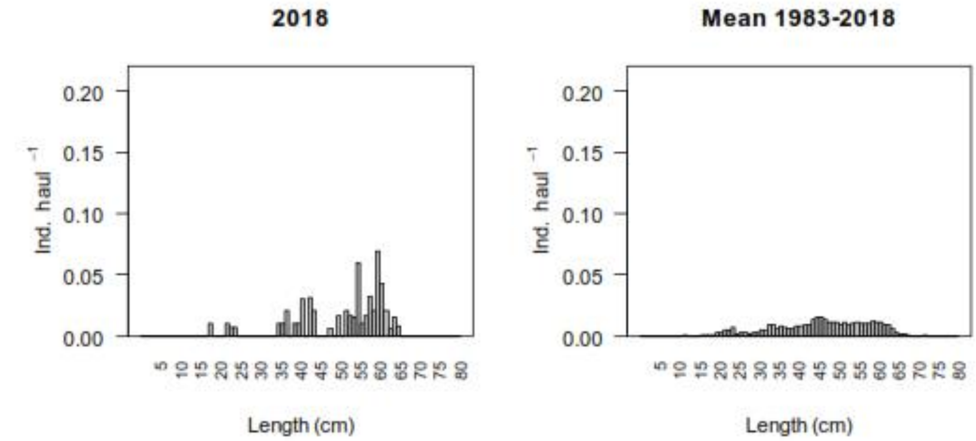


Figure 19.9c Skates in the Bay of Biscay and Iberian waters. Mean stratified length distribution of *Leucoraja naevus* in the last survey (left) and in the period 1983–2018 (right) in Division 8.c of the North Spanish Shelf.

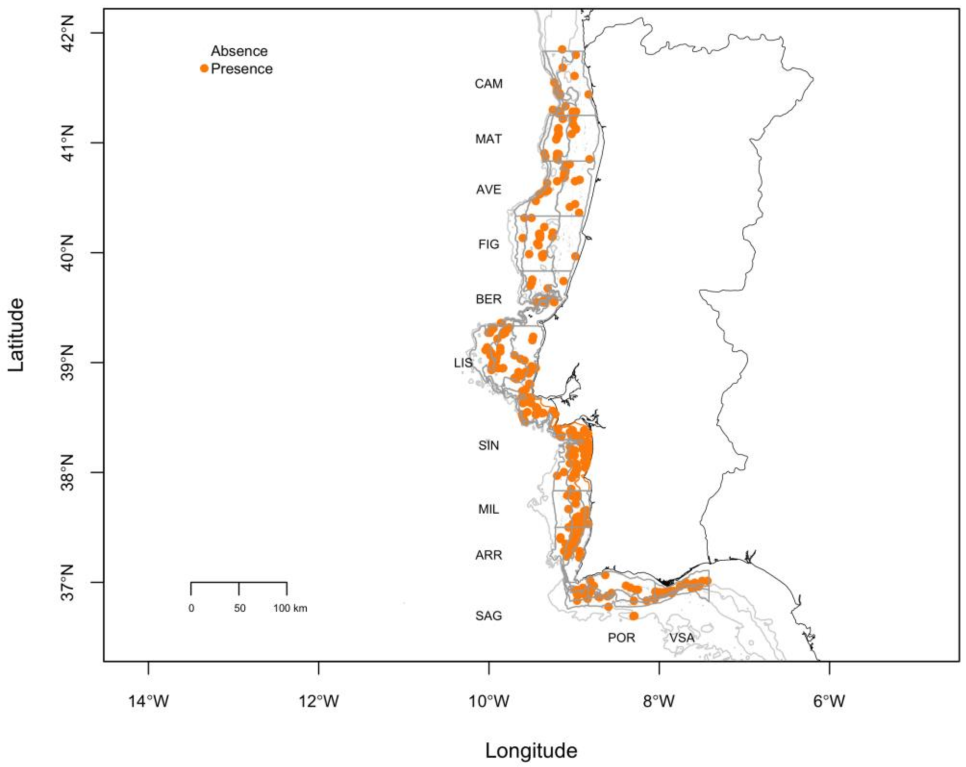


Figure 19.10a. Skates in the Bay of Biscay and Iberian Waters. *Raja clavata* distribution from 1981 to 2018 in the Portuguese Autumn Groundfish Survey (PtGFS-WIBTS-Q4.

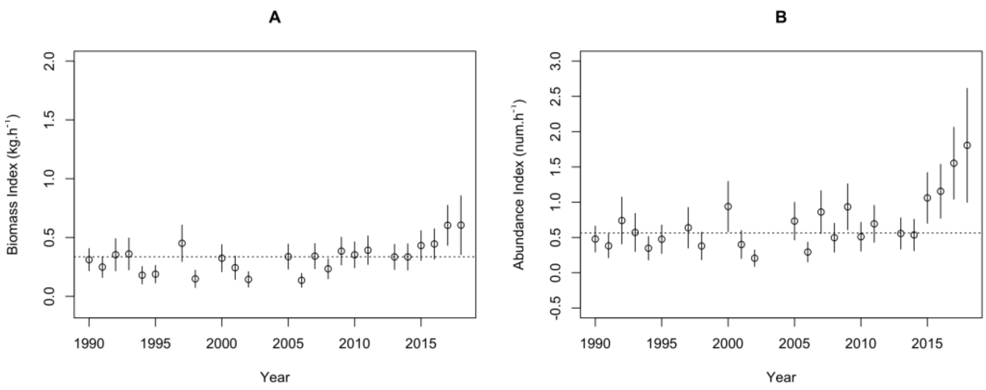


Figure 19.10b. Skates in the Bay of Biscay and Iberian Waters. *Raja clavata* A) biomass index (kg hour^{-1}) and B) abundance (ind.hour^{-1}) on PtGFS-WIBTS-Q4from 1990 to 2018. Dashed line represents the mean annual abundance for the considered period.

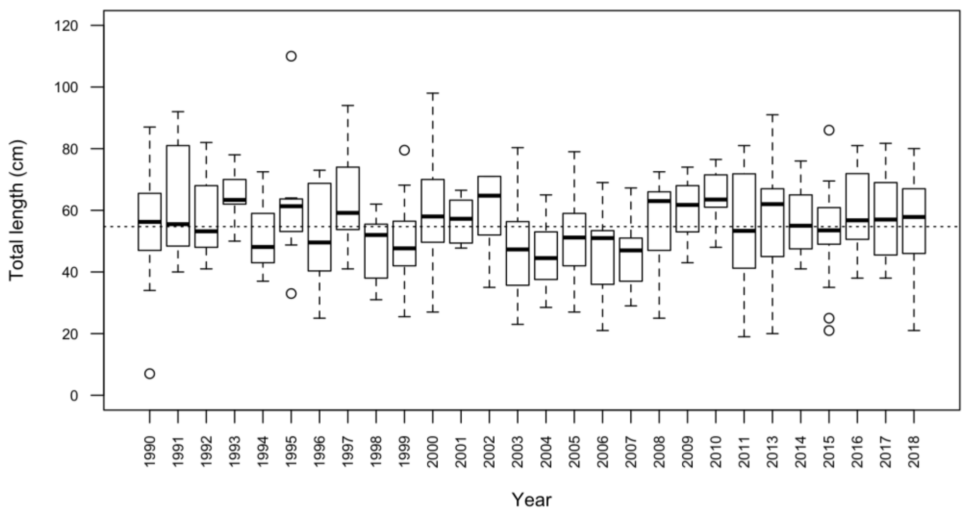


Figure 19.10c. Skates in the Bay of Biscay and Iberian Waters. Total length variation of *Raja clavata*, by year on PtGFS-WIBTS-Q4 (dashed line represents the mean annual length for 1990–2018).

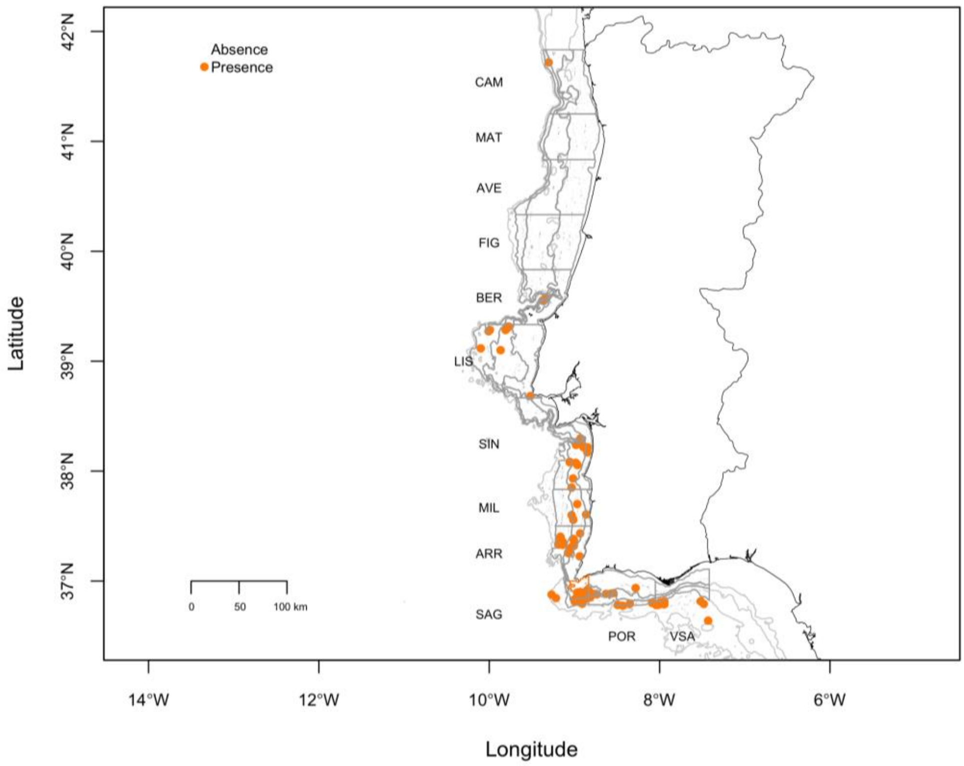


Figure 19.11a. Skates in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* distribution from 1981 to 2018 in the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4), and Portuguese crustacean surveys/Nephrops TV surveys (PT-CTS (UWTV (FU 28-29).

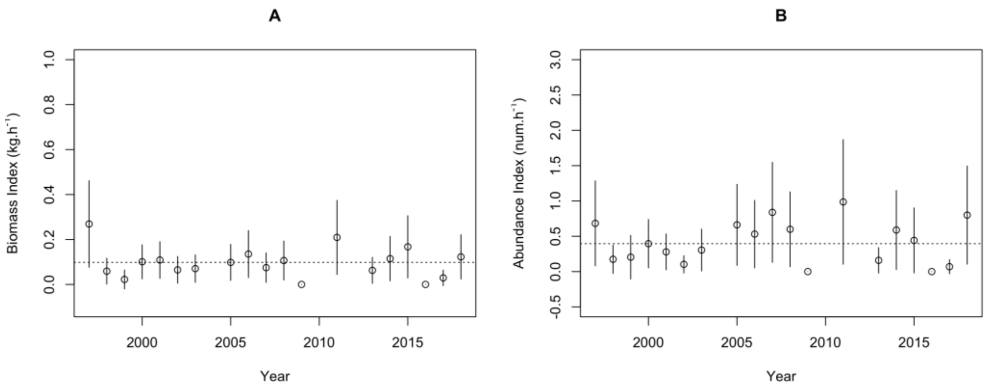


Figure 19.11b. Skates in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* A) biomass index (kg.hour^{-1}) and B) abundance (ind. hour^{-1}) on PT-CTS (UWTV (FU 28-29) from 1997 to 2018. Dashed line represents the mean annual abundance for the considered period.

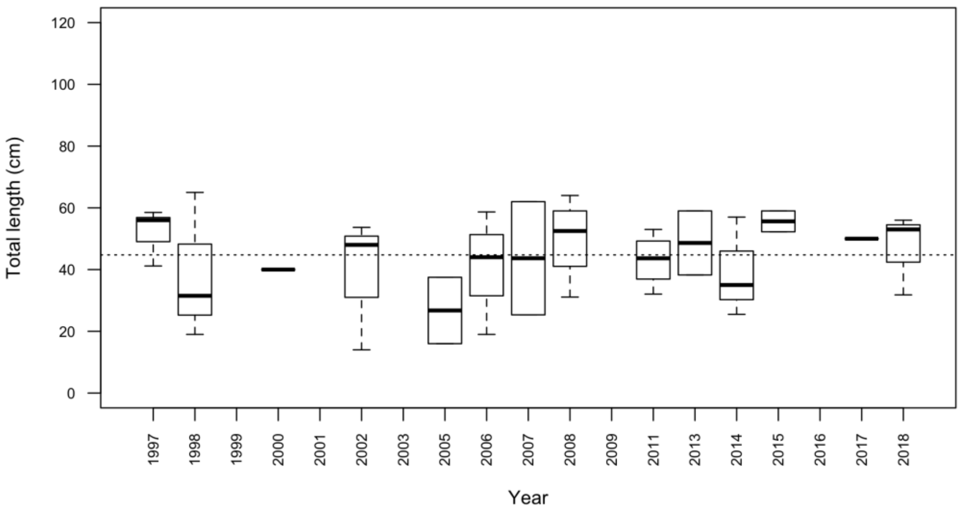


Figure 19.11c. Skates in the Bay of Biscay and Iberian Waters. Total length variation of *Leucoraja naevus*, by year on PT-CTS (UWTV (FU 28-29) (dashed line represents the mean annual length for 1997–2018).

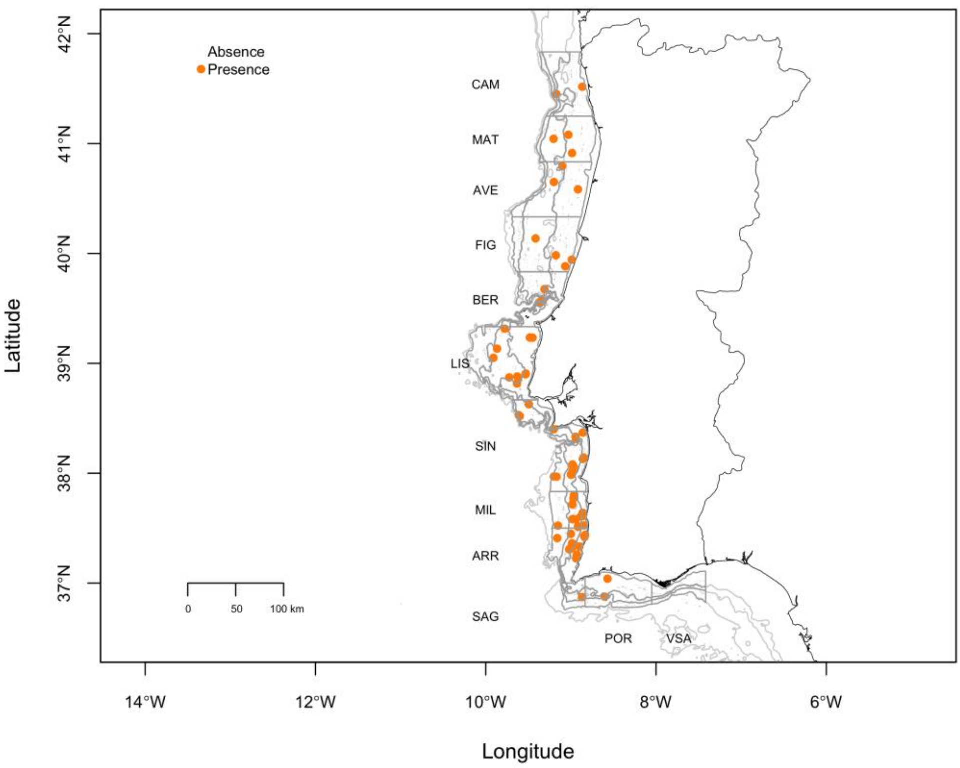


Figure 19.12a. Skates in the Bay of Biscay and Iberian Waters. *Raja montagui* distribution from 1981 to 2018 in the Portuguese Autumn Groundfish Surveys (PtGFS-WIBTS-Q4).

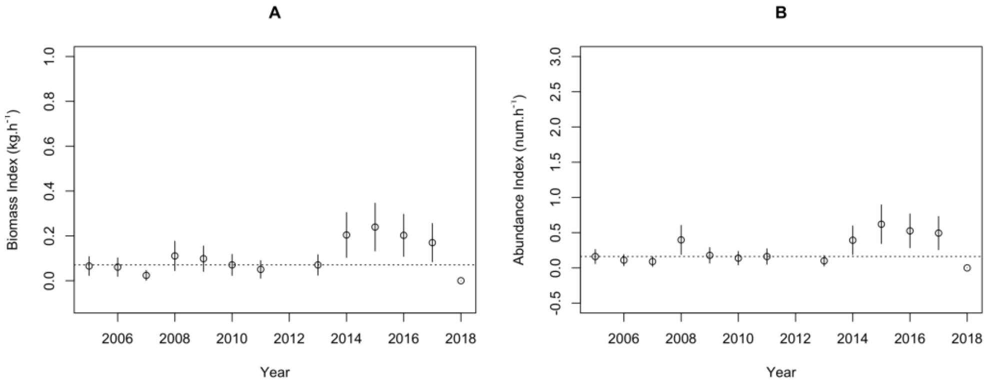


Figure 19.12b. Skates in the Bay of Biscay and Iberian Waters. *Raja montagui* biomass index (kg. hour^{-1}) and abundance (ind. hour^{-1}) on PtGFS-WIBTS-Q4from 1990 to 2018. Dashed line represents the mean annual abundance for the considered period.

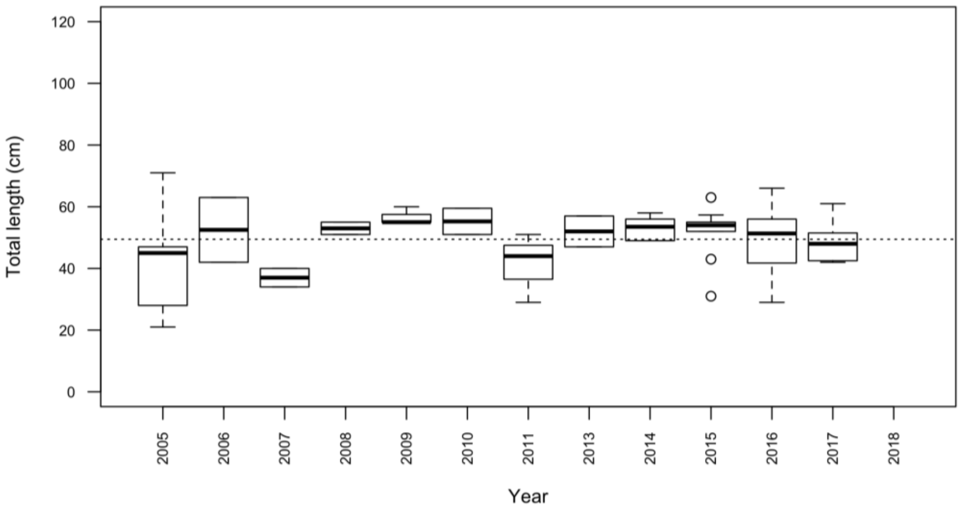


Figure 19.12c. Skates in the Bay of Biscay and Iberian Waters. Total length variation of *Raja montagui*, by year on PtGFS-WIBTS-Q4 (dashed line represents the mean annual length for 1990–2018).

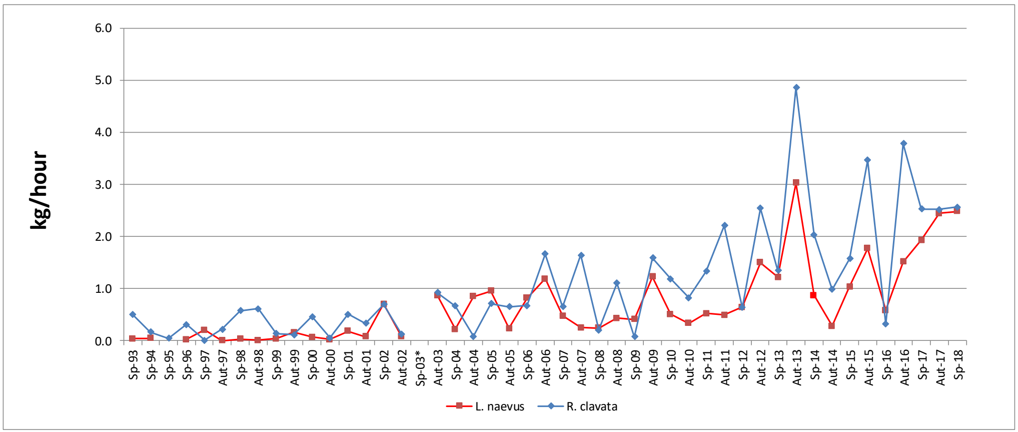


Figure 19.13a. Skates in the Bay of Biscay and Iberian Waters. Trend of the yield of *R. clavata* and *L. naevus* expressed as kg/hour from the Spanish bottom trawl survey ARSA carried out in spring and autumn in the Gulf of Cadiz (9.a South) from 1993 to 2018.

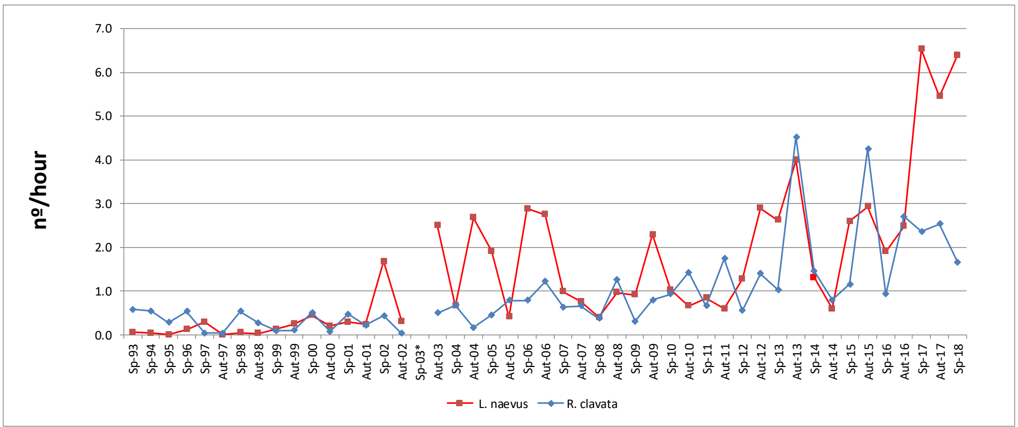


Figure 19.13a-b. Skates in the Bay of Biscay and Iberian Waters. Trend of the yield of *R. clavata* and *L. naevus* expressed as nº/hour from the Spanish bottom trawl survey ARSA carried out in spring and autumn in the Gulf of Cadiz (9.a South) from 1993 to 2018.

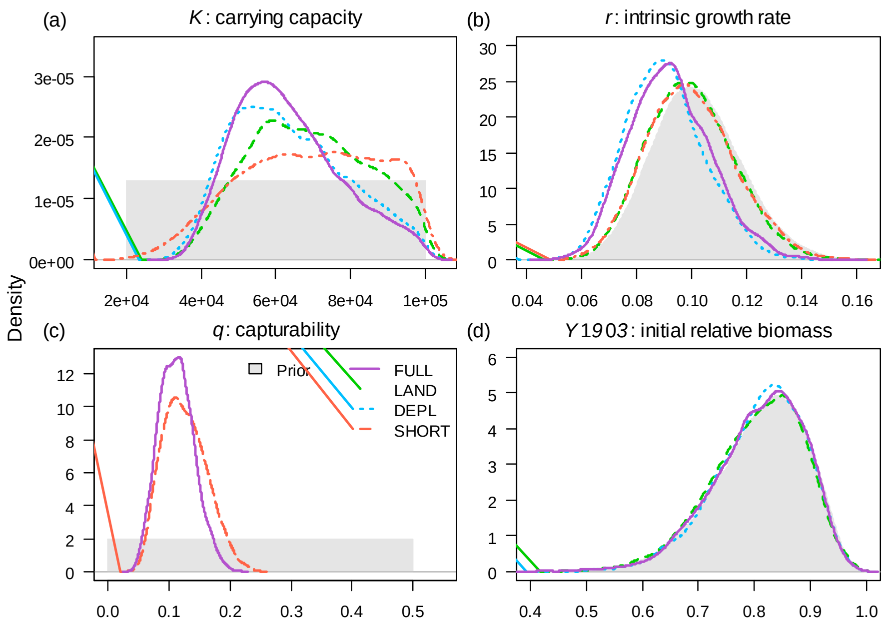


Figure 19.14 Skates in the Bay of Biscay and Iberian Waters. Comparison of prior and marginal posterior parameter distributions for *R. clavata* in the Bay of Biscay for four model runs using different data combinations. FULL: landings and biomass index; LAND: landings only; DEPL: landings and depletion estimated for final year; SHORT: as in FULL but using data for the years 2000–2013 only.

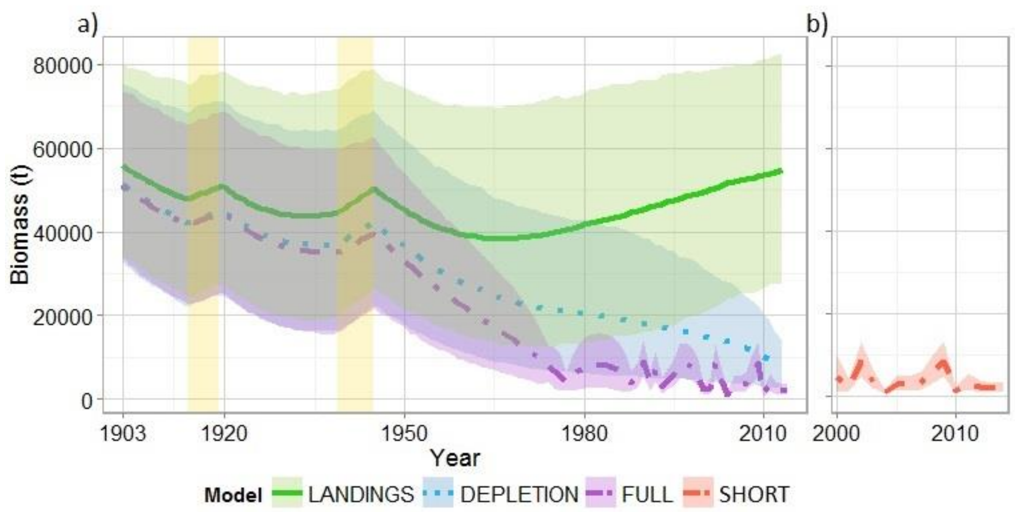


Figure 19.15. Skates in the Bay of Biscay and Iberian Waters. a) Estimated biomasses trajectories for *R. clavata* in the Bay of Biscay for model runs using different data series. LANDINGS: landings only; DEPLETION: landings and final year depletion rate; FULL: landings and biomass index for the years 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).

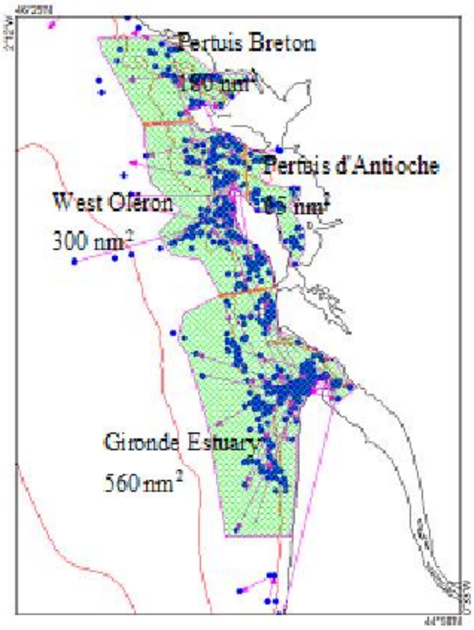


Figure 19.16. Skates in the Bay of Biscay and Iberian Waters. Habitat areas of *R. undulata* in the centre of the Bay of Biscay from 2011–2014 tagging and recapture positions.

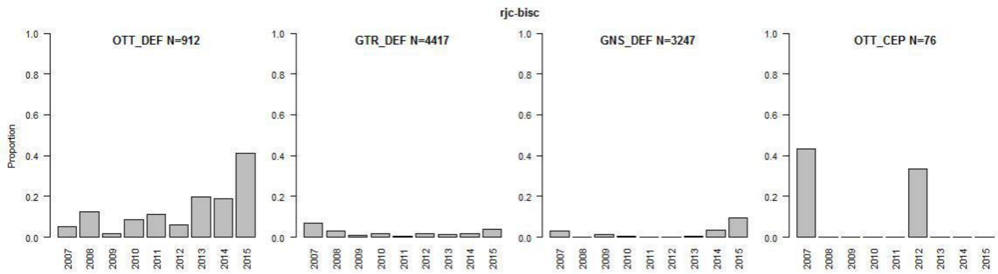


Figure 19.17a. Skates in the Bay of Biscay and Iberian Waters. *Raja clavata* in Subarea 8 (Bay of Biscay), rjc-bisc. Occurrence indicators from the French on-board observations programme in 8abd. N: total number of fishing operations observed for the métier from 2007–2015.

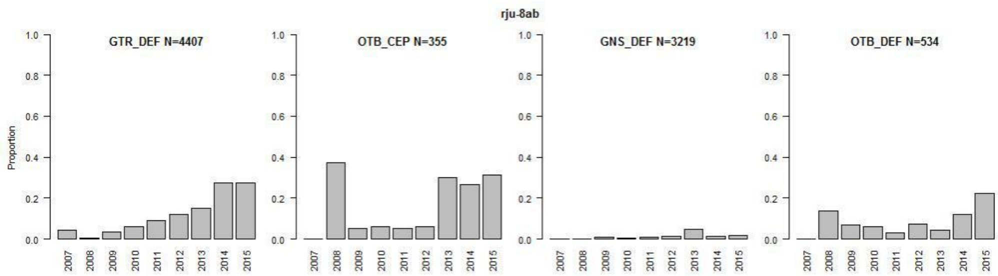


Figure 19.17b. Skates in the Bay of Biscay and Iberian Waters. *Raja undulata* in divisions 8.a-b (Bay of Biscay North and Central), rju-8ab. Occurrence indicators from the French on-board observations programme in 8.abd. N: total number of fishing operations observed for the métier from 2007–2015.

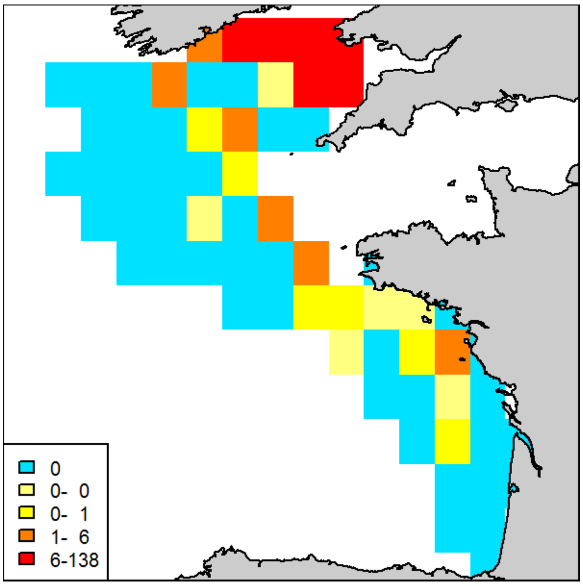


Figure 19.18. Skates in the Bay of Biscay and Iberian Waters. Spatial distribution of *Raja montagui* in ICES divisions 7.f-k and 8.a-c, based on catch in the EVHOE survey.

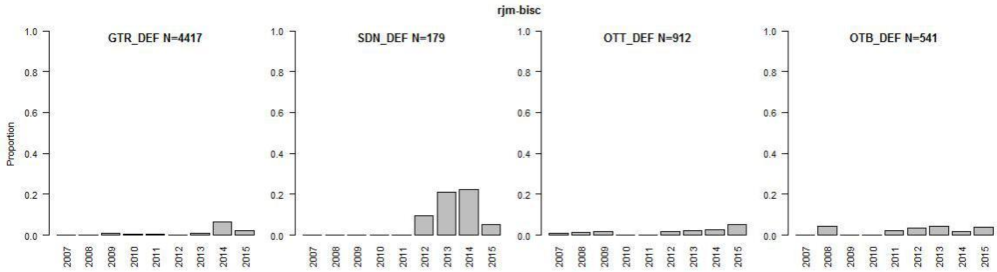


Figure 19.19. Skates in the Bay of Biscay and Iberian Waters. *Raja montagui* in Subarea 8 (Bay of Biscay), rjm-bisc. Occurrence indicators from the French on-board observations programme in 8.abd. N: total number of fishing operations observed for the métier from 2007–2015.

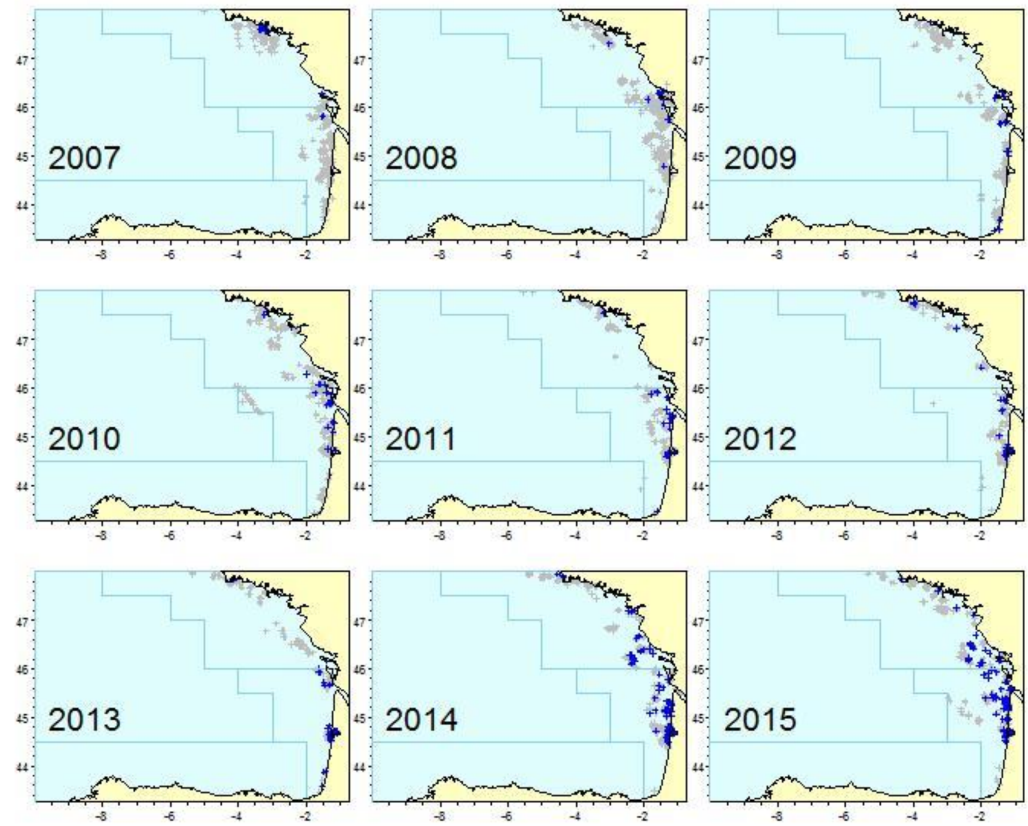


Figure 19.20. Skates in the Bay of Biscay and Iberian Waters. Occurrence of *Raja undulata* in divisions 8.a-b (Bay of Biscay) (rju-8ab) showing the spatial distribution based on occurrence in trammel net catches (DCF level 5 métier GTR_DEF) from 2007–2015, used to estimate the frequency of occurrence (see Figure 19.17b).

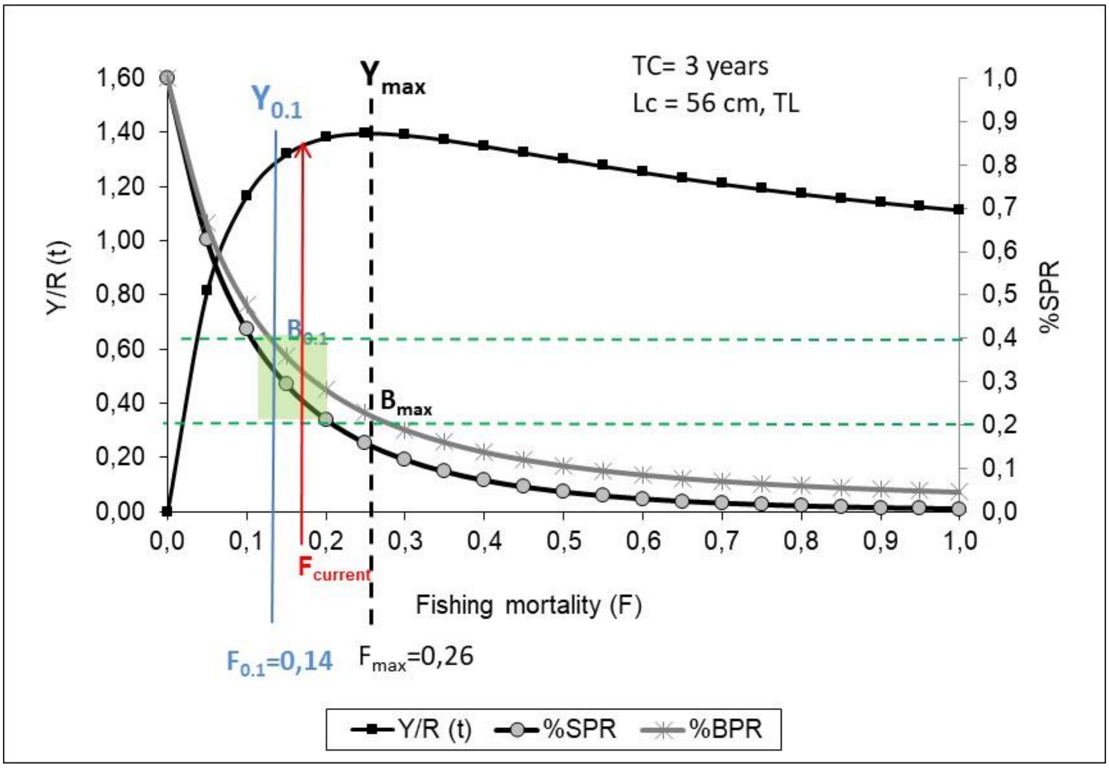
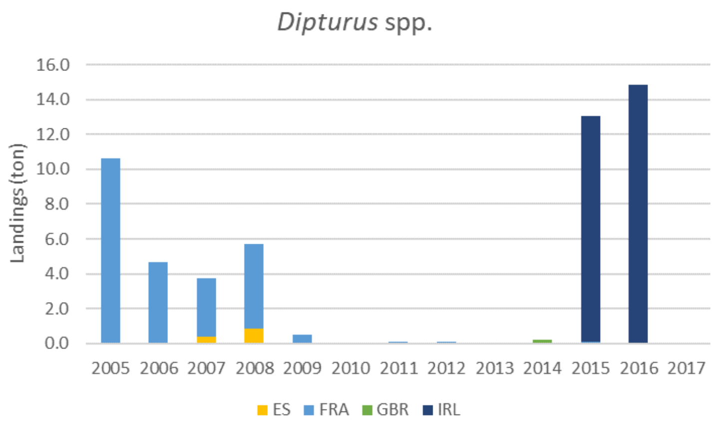


Figure 19.21. Skates in the Bay of Biscay and Iberian Waters. *Raja brachyura* yield per recruit (Y/R and potential spawning ratio (%SPR) curves for different levels of fishing mortality and an age of first capture = 3 years (TC). Red line shows $F_{current}$. *Raja brachyura*.



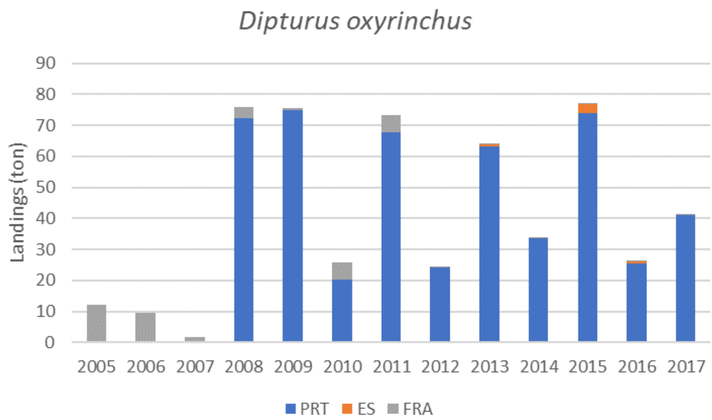


Figure 19.22. Landings (t) of *Dipturus* spp. and *Dipturus oxyrinchus by country* for divisions 8 and 9.a (2004–2016).

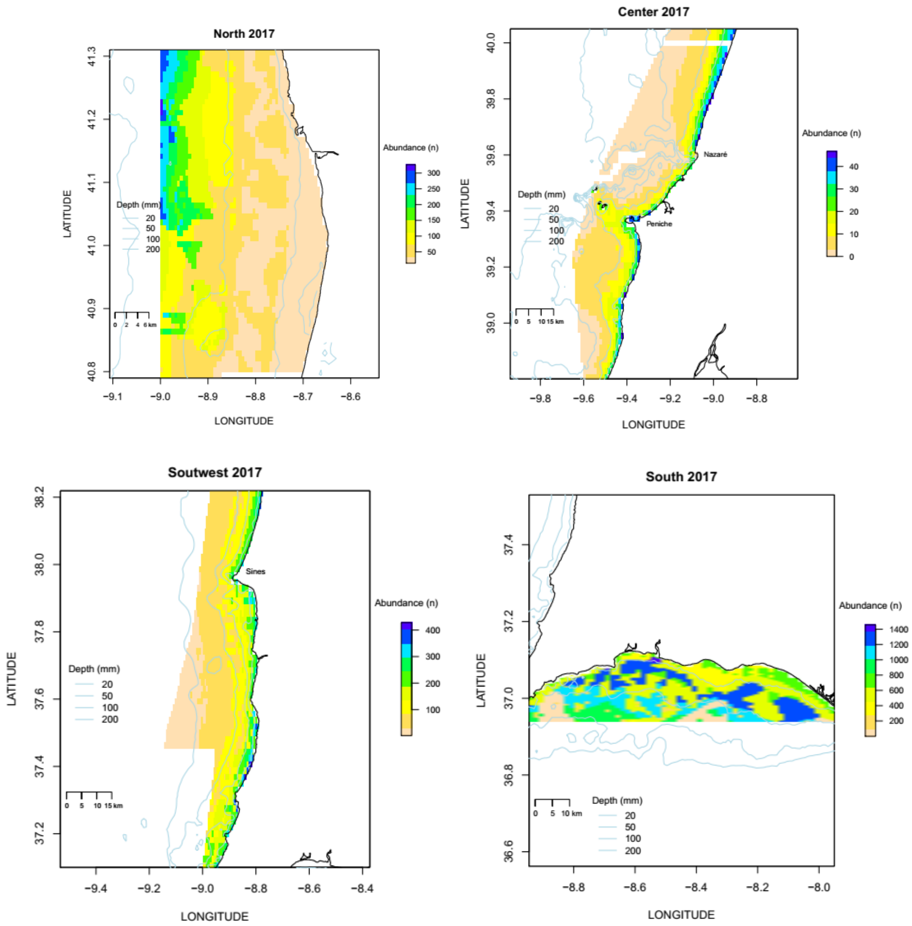


Figure 19.23: ***Raja undulata*** **potential abundance by region for 2017.**

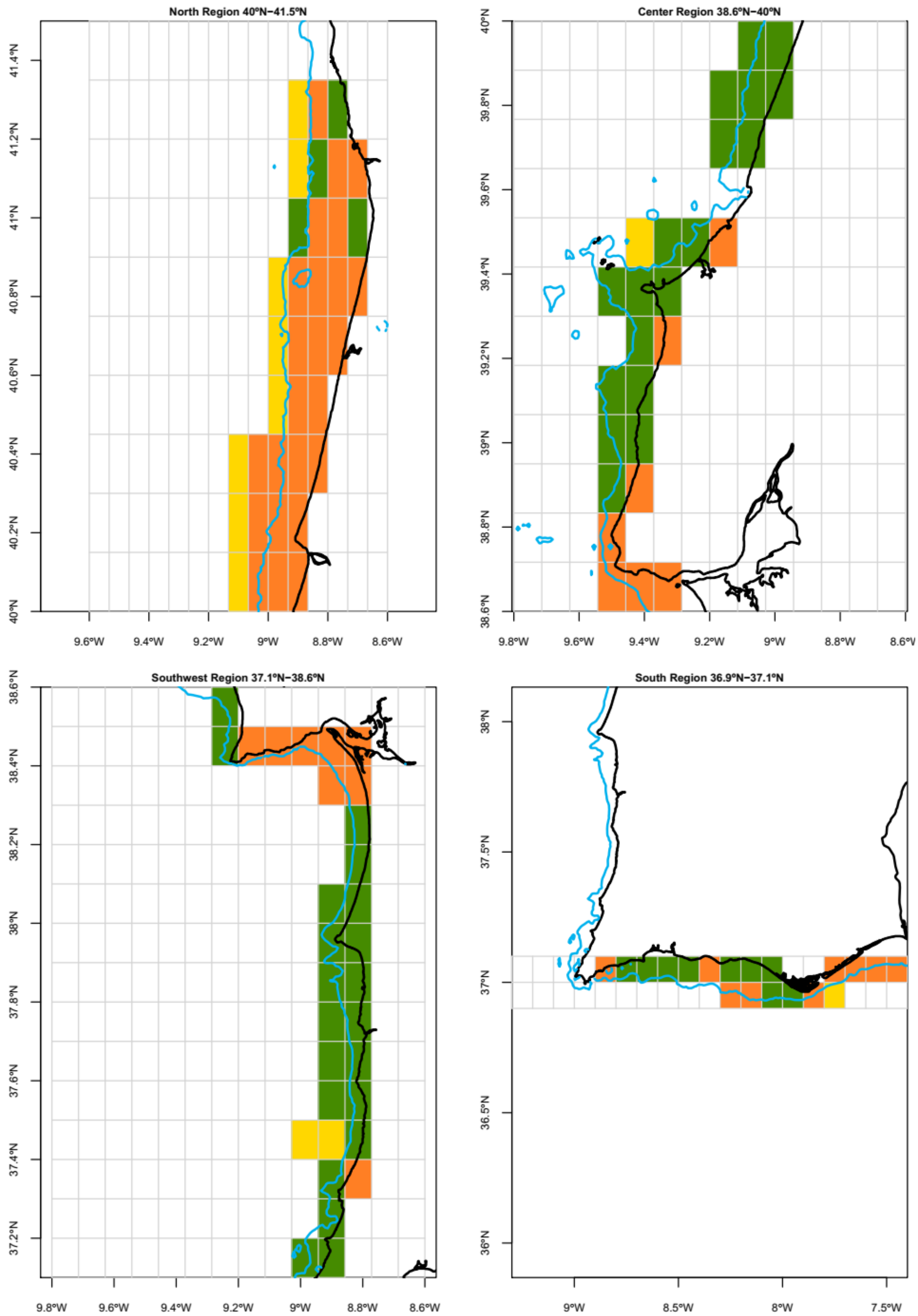


Figure 19.24. Sampling requirements for full spatial coverage of *Raja undulata* spatial distribution. Green - Spatial cells already sampled in 2016 and/or 2017 that need to continue to be monitored; Orange: - Spatial cells not sampled yet that need to be sampled with priority and; Yellow: Spatial cells not sampled yet that need to be sampled with lower priority.

20 Skates and Rays in the Azores 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 2018

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 thereafter (tables 20.1–20.2; Figure 20.1). The landing values during 2017 and 2018 are similar to the initial historical values, because the market for these species is very limited, with little domestic consumption, limited demand for export and management measures.

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

In 2017, ICES advised, "*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 2018 that are relevant to skates in this region include:

- Recommendation 7. Deep-Sea Fisheries within the NEAFC Regulatory Area
- Recommendation 11. to Amend Article 22.3 of the NEAFC Scheme of Control and Enforcement
- Recommendation 12. to Amend Article 23 of the NEAFC Scheme of Control and Enforcement.
- Recommendation 13. to Amend Article 25.1 of the NEAFC Scheme of Control and Enforcement
- Recommendation 14. to Add a New Annex XII C) to the NEAFC Scheme of Control and Enforcement
- Recommendation 16. to Adopt the UN/CEFACT International Standard for Communications between the NEAFC Secretariat and Fisheries Monitoring Centres

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 and 2018 (Pinho *et al*., 2019 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

No new information is available.

Relative indices of abundance for the thornback ray species were estimated last year for the period 1990–2016 using a Generalized Linear Modelling 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 modelling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modelling the positive catch rates on successful trips.

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 2018, including the annual abundance index (Figure 20.4) and length–frequency distribution (Figure 20.5). This year the entire survey abundance index series was re-calculated excluding the statistical area of the western islands (Flores and Corvo), because this statistical area had not been covered in some years.

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.

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. Studies to demonstrate what sustainable exploitation levels for these species might be should be initiated.

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	65
2010	68	0.066	5.106	0.275			0	74
2011	91	0.156	1.764	0.358			0	93
2012	103	0.002	0.671	0.26			0	104
2013	115	0.081	0.485	0			0	116
2014	187	0.03	2.481	0.189			0	190
2015	171	0	0	0.055	0.02	0	0	171
2016	127	0	0	0				127
2017	64	0	0	0			0	64
2018	61	0	0	0	0	0	0	61

Table 20.3 Rays and skates in subareas 10 and 12. Assessment summary. Abundance index (catch per unit effort relative abundance index weighted by the size of the strata) of thornback ray (*Raja clavata*) from the Azores (ICES Subarea 10) from the Portuguese bottom longline survey (ARQDACO(P)-Q1).

Year	Lower	Abundance index	Upper
1995	4.46	10.91	16.93
1996	3.67	7.44	10.22
1997	3.15	5.36	6.74
1998	NA	NA	NA
1999	3.11	4.77	6.34
2000	1.53	4.08	6.92
2001	1.97	4.29	6.74
2002	10.39	17.16	24.92
2003	11.15	26.78	37.88
2004	9.12	13.75	18.30
2005	8.96	23.30	31.07
2006	NA	NA	NA
2007	9.76	16.33	27.01
2008	4.24	8.91	11.93
2009	NA	NA	NA
2010	4.62	7.29	9.86
2011	2.47	4.90	7.49
2012	4.43	6.67	8.88
2013	1.53	2.77	3.97
2014	NA	NA	NA
2015	NA	NA	NA
2016	2.29	4.02	5.11
2017	3.56	8.45	13.39
2018	2.37	4.11	5.98

NA = not available.

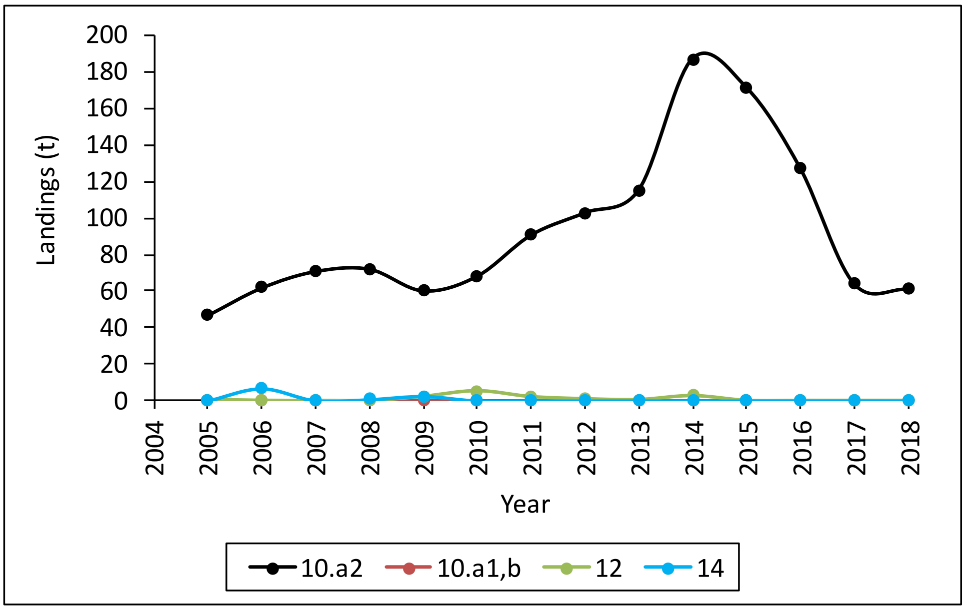

Figure 20.1. Skates and Rays in the Azores and Mid-Atlantic Ridge. Historical landings of skates and rays from Azores (ICES Division 10.a2) and MAR (ICES subareas 10, 12 and 14).

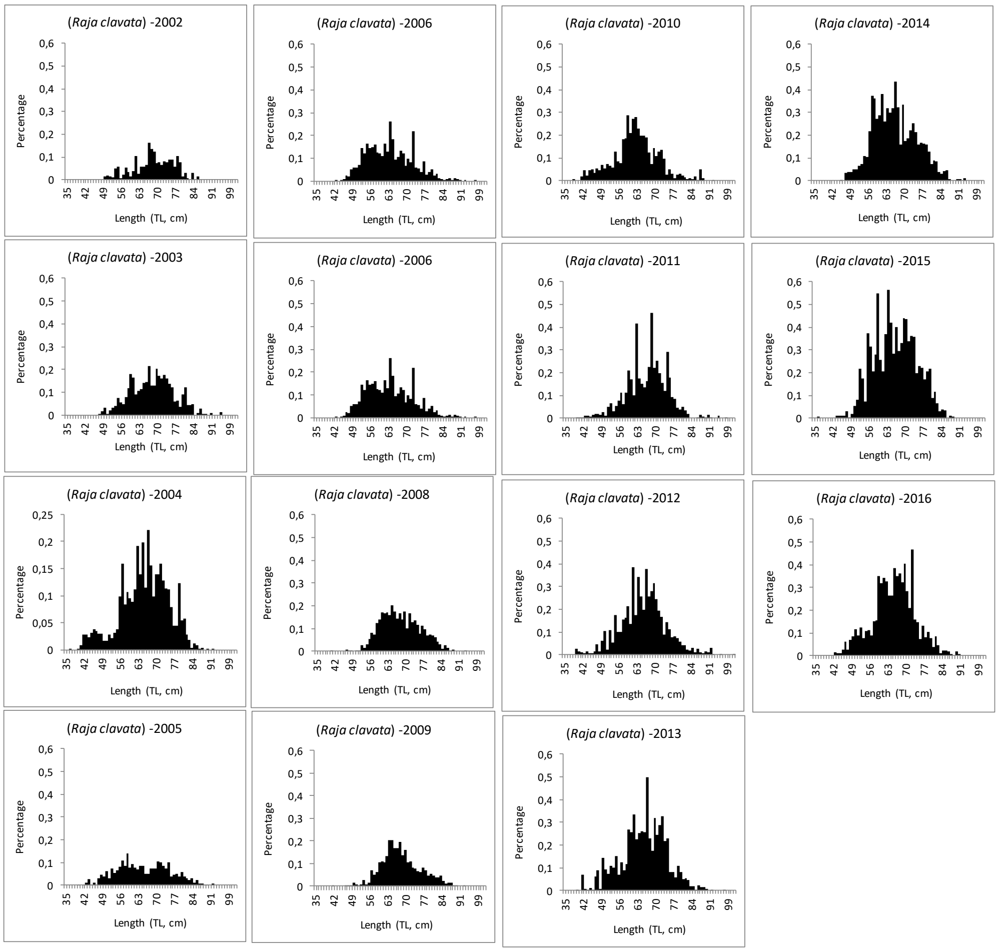

Figure 20.2. Skates and Rays in the Azores and Mid-Atlantic Ridge. Length-frequency of *Raja clavata* landed in the Azorean for the period 2002–2016.

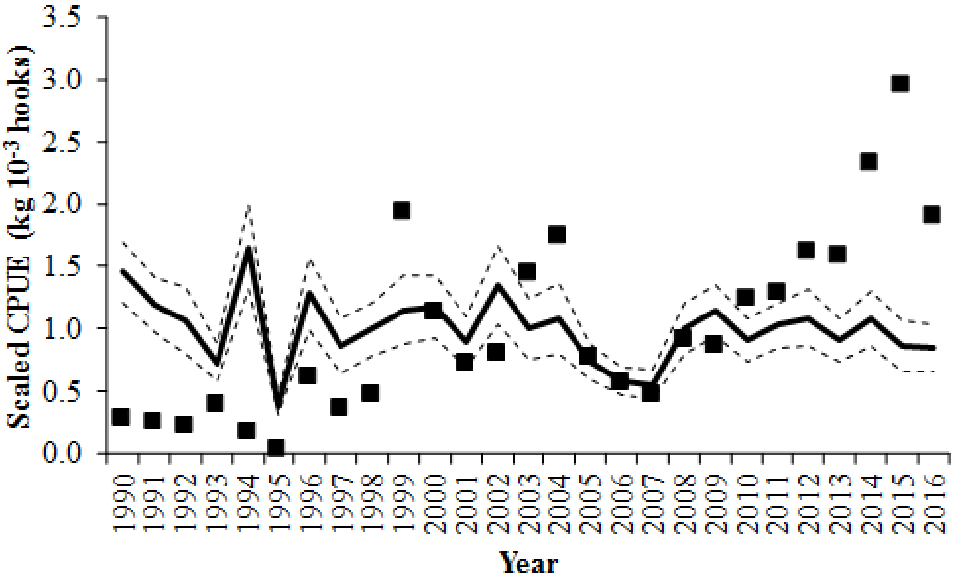

Figure 20.3. Skates and Rays in the Azores and Mid-Atlantic Ridge. Standardized fishery CPUE of *Raja clavata* landed in the Azorean for the period 1990–2016. Square points are observed nominal CPUE; Black line: Standardized CPUE and dashed lined 95% confidence interval.

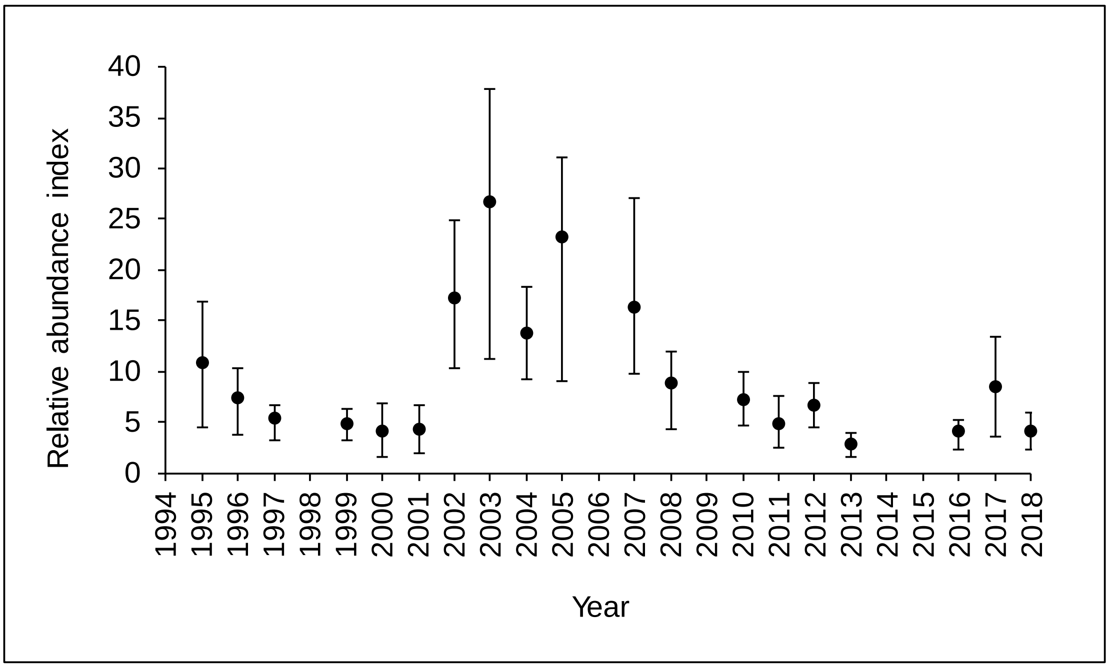

Figure 20.4. Skates and Rays in the Azores and Mid-Atlantic Ridge. Annual abundance, in numbers, of *Raja clavata* from the Azores (ICES subarea 10) from the Azorean demersal spring bottom longline survey (1995–2018).

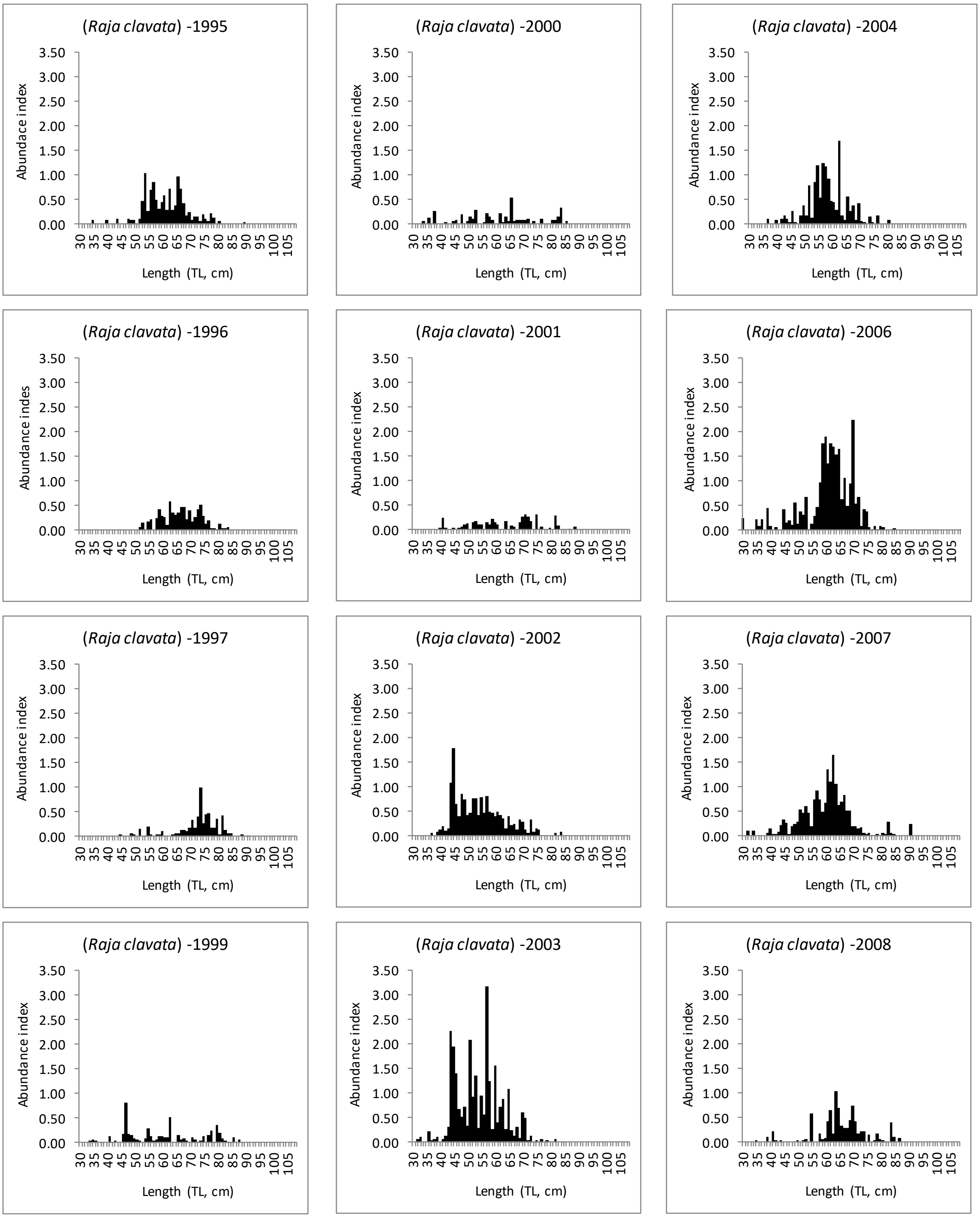

Figure 20.5. Skates and Rays in the Azores and Mid-Atlantic Ridge. Length-frequency of *Raja clavata* caught in the Azorean demersal spring bottom longline survey for the period 1995–2008.

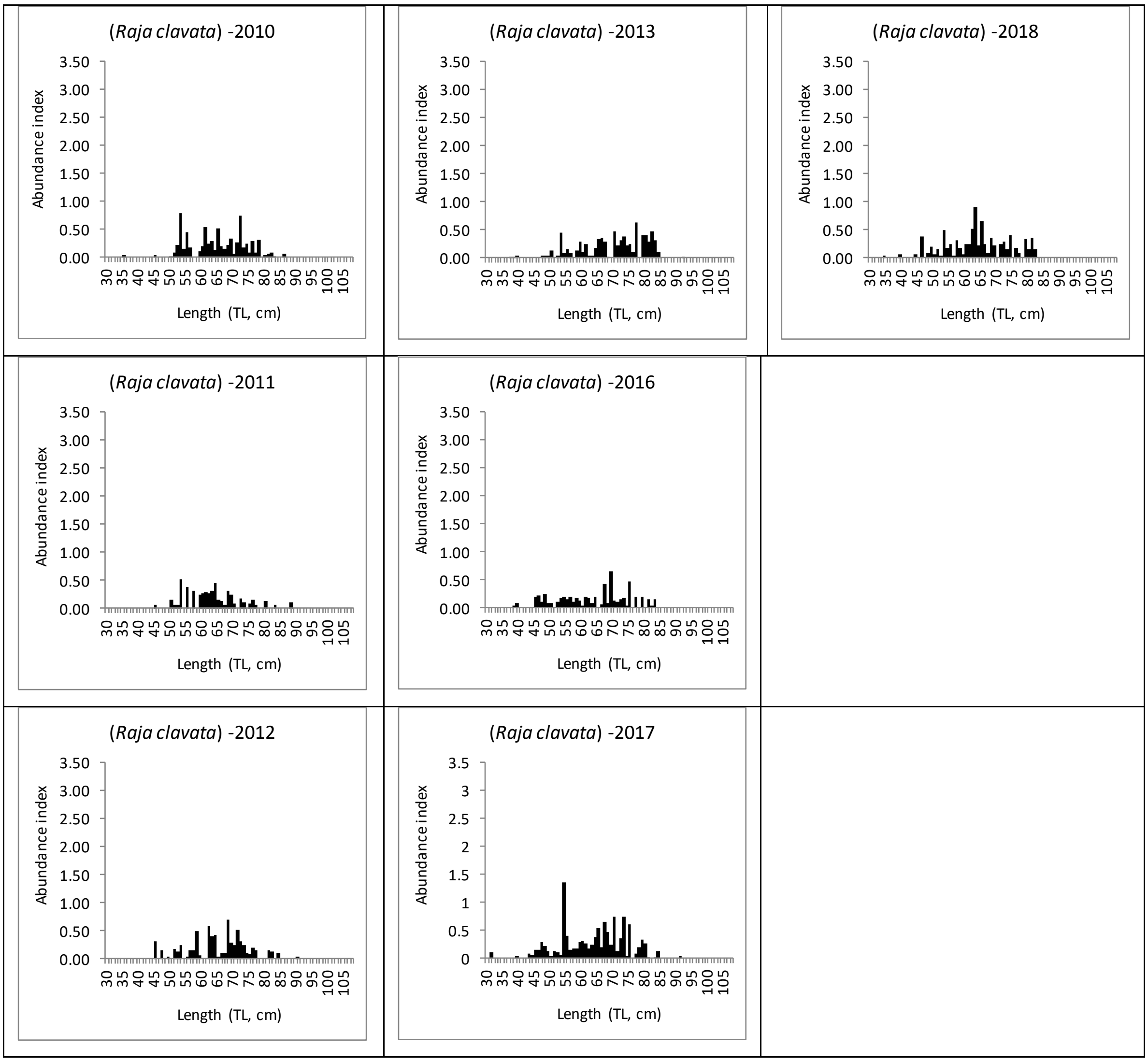

Figure 20.5.Cont. Skates and Rays in the Azores and Mid-Atlantic Ridge. Length-frequency of *Raja clavata* caught in the Azorean demersal spring bottom longline survey for the period 2010–2018.

21 Smooth-hounds in the Northeast Atlantic

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 belived 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 believed 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 2018

There were no major changes to the fishery noted in 2018. 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 WKSHARK2 (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 and Ellis, 2019a). *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 70–110 cm L_T, with fish <60 cm L_T usually discarded. Otter trawl catches covered a broad length range, and *M. asterias* <60 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 and Ellis (2019a) also noted that a greater proportion of *M. asterias* were retained since landing opportunities for spurdog had become restrictive. In the years 2002–2009, the retention of *M. asterias* ≥70 cm L_T was 59% and 44% in gillnet and otter trawl fisheries, respectively. In the period 2010–2016, however, retention increased to 85% (gillnets) and 66% (otter trawl). In addition, length at retention for otter trawl dropped from 41 cm L_T (2002–2009) to 34 cm L_T (2010–2016).

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 2020.

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 and Ellis (2019a) 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, <60 cm L_T) were also apparent in otter trawls, where about 63–71% of the total catches were discarded in the North Sea and Celtic Seas, 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 and 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).

IBTS-Q1 and IBTS-Q3: 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).Data presented for these surveys include all national data for Q1 and Q3, with the exception of Danish data for Q3 time-series as per issues described in Section 21.6.3.

EVHOE-WIBTS-Q4: This survey of ICES divisions 7.g–k and 8.a.b.d has a 21-year time-series of data (1997–2016, 2018), and this was included in the assessment in 2019 (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). Survey indices for the whole time series were updated with new estimates provided in 2019. The values have differed from the previous survey indices as values are presented for both total and exploitable biomass (individuals ≥50 cm T_L) with further quality assurance procedures occurring prior to WGEF to the national database.

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 23 years out of the 26-year time-series; Silva and Ellis, 2019b 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 increased slightly compared to the preceding five years. Both abundance and estimated biomass showed similar trends (Figure 21.9). Survey indices for the whole time series were updated with new estimates provided in 2019. This is the result of on-going quality assurance procedures for information held in the national database at Cefas. Although there are minor differences to previous data provided at the WGEF 2017, the overall trend is similar, and therefore it is not considered to have an impact on the advice for this species.

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 (75 stations fished at least 23 years out of the 26-year time-series, Silva and Ellis 2019c 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). Survey indices for the whole time series were updated with new estimates provided in 2019 and compiled after the 2019 WGEF meeting. This was mainly due to problems arising from the ICES DATRAS data product *CPUE per length per Hour and Swept Area* that was previously used in the calculations for the survey indices and used as supporting information on advice for this species.

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. Survey indices for the whole time series were updated with new estimates provided in 2019. The values have differed from the previous survey index as values are now scaled to the survey area rather than the ecoregion.

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.

For stock assessment purposes, in 2019 the IBTS-Q1 index included all national data, with IBTS-Q3 using all national data excluding Danish data.

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.

The indices used previously for BTS-Eng-Q3 (in 7.d and 4.c) were calculated using the ICES DATRAS data product *CPUE per length per Hour and Swept Area*. However, while at the WGEF meeting in 2019, an error was found within the data product when the *CPUE per length per hour and swept area* was compared with the exchange data (data uploaded by each Nation to ICES).

The problem consisted in multiplication (in cases up to 3 times) of the original records for the numbers at length per sex in each haul for the years 2010–2018, which if used would result on an index not reflecting the real survey catches. The overall trend would be similar, but the magnitude of increase/decrease would be affected by the repetition of records. Although the error was reported to ICES post-meeting and corrections have been made within the ICES database, it was agreed at the WGEF that an update of the survey indices and their calculations would be provided using the internal national data. In recent years, this survey time-series has also suffered a major QA/QC within the national database, which further added to the decision of providing the survey indices using the latest national dataset.

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 by 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.

An analysis of samples collected in waters around the British Isles between 2009–2019 provides preliminary estimates of L_∞ = 94.6 cm for males (n = 159, L_T = 24–100 cm ages 0–14) and L_∞ = 130.1 cm females (n = 163, L_T = 28–124 cm ages 0–17) (Ellis *et al.*, 2019 WD), although it should be noted that this study had more fish at age 0. Further work is required to evaluate the estimated ages and, in terms of stock assessment modelling, the results of Farrell *et al.* (2010a) should still be used at the present time.

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 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). A subsequent study, collected primarily from the southern North Sea and English Channel, estimated 50% maturity for males at 70.4 cm L_T (smallest mature = 65 cm; largest immature = 74 cm) and females at 81.9 cm L_T (smallest mature = 69 cm; largest immature = 87 cm) (McCully Phillips and Ellis, 2015; Figure 21.15). A recent analysis of samples collected between 2009–2019 by fishery-independent trawl surveys conducted by Cefas in waters around the British Isles estimated 50% maturity for males at 73.5 cm L_T (smallest mature = 64 cm; largest immature = 99 cm), with 100% maturity attained at ca. 90 cm, and females at 85.4 cm L_T (smallest mature = 75 cm; largest immature = 91 cm), with 100% maturity attained at ca. 92 cm (Ellis *et al*., 2019 WD).

The smallest mature female that Farrell *et al*. (2010b) reported was 83 cm; a lot larger than the smallest females (69 cm and 75 cm L_T; summarised above) recorded by McCully Phillips and Ellis (2015) and Ellis *et al*. (2019 WD). This is interesting, as the 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).

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 number of mature follicles ranged from 0–28 in the mature females (McCully Phillips and Ellis, 2015). 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 increased with total length and ranged from 4–20 (McCully Phillips and Ellis, 2015), 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. Furthermore, there were also positive linear relationships identified between maternal length and average pup length and weight (Figure 21.13; McCully Phillips and Ellis, 2015).

A combined dataset on uterine fecundity, using data from Henderson *et al.* (2003), Farrell *et al.* (2010b), McCully Phillips and Ellis (2015) and additional samples collected during fishery-independent trawl surveys conducted by Cefas is given in Table 21.4 (Ellis *et al*., 2019). Of the 74 early- to late-gravid females in this combined study, the uterine fecundity ranged from 2–20 (mean = 8.5) which is similar to the initial studies of subsets of this combined dataset (summarised above). Uterine fecundity (F) had a linear relationship with L_T, as described by the equation $F = 0.28390.L_T - 19.18583$ (n = 74; $r^2 = 0.4295$; Figure 21.16).

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, Ellis *et al*., 2019 WD). 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).

Cefas have tagged-and-released specimens of *M. asterias* from fishery-independent trawl surveys since 2003 (Burt *et al*., 2013). In 2019, a total of 1613 (744 females and 868 males, one unsexed) had been tagged and released, of which 40 (2.48%) have been recaptured and details returned (Ellis *et al*., 2019 WD). Results suggest that the species is wide ranging in northern European seas and displays seasonal migrations, which are likely related to its reproductive cycle (Figure 21.17; Ellis *et al*., 2019 WD).

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 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

Recent data on overall length-weight relationships for male and female *M. asterias* caught between 2009–2019 by Cefas fishery-independent trawl surveys around the British Isles are illustrated in Figure 21.19.

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

An analytical age-, sex- and length-structured assessment model is currently being developed for *M. asterias* following the approach of De Oliveira *et al.* (2013) for spurdog. Four life history stages have been suggested: pups (20–45 cm), juveniles (46–65 cm), sub-adults and adults (66–99 cm) and large mature fish (mostly female; ≥100 cm), although further work is required. The model assumes two commercial fleets (otter trawl and gillnet) using landings data from the UK and France, with size composition data from the UK England and Wales-at-sea observer programme informing the estimation of selectivity. Fishery-independent inputs include a biomass index from the IBTS-Q3 and associated length-compositions from the English portion of the survey. Inclusion of additional surveys or a combined survey index with representative length compositions should be considered for a better representation of the overall stock and improved estimation of survey selectivity.

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 2019 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 for the IBTS-Q3, 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, was included in 2019, as this survey covers more south-western parts of the stock area (divisions 8.a.b.d; Figure 21.7). Data were available for 1997–2019 and indicate an increasing total and exploitable biomass. The total biomass was calculated using the weight from on-board catch weight per species, as no individual weight is available for most of the years. Exploitable biomass was calculated using the length-weight relationship with $W_T = 0.0016. L_T^{3.1753}$.

Summary: Each of the three survey indices was standardised in relation to its long-term mean for the common time period (1997–2018), and an average taken for the three surveys to derive an annual index of stock size. Except for 2017 as EHVOE-WIBTS-Q4 did not occur, with average for the annual index of stock size being based only on IBTS-Q1 and IBTS-Q3. All three surveys were given equal weighting. The mean index for the years 2017–2018 was 1.73, whilst the mean index for the preceding five years (2012–2016) was 1.42, with the most recent 2-year period being 1.22 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 in 2017 (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), <u>further studies to understand the dynamics of this stock are required</u>.

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). <u>Further studies on the at-vessel mortality and post-release mortality, including of juveniles, are needed</u>.

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 and 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; 2005–2018), 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	2018
Belgium	-	-	-	-	-	-	-	-	1	1	1	3	2	1
Denmark	-	-	-	-	-	-	-	-	-	-	-	<0.1	-	-
Spain	112	134	138	200	297	129	106	120	80	70	42	40	43	36
France	2685	2722	2958	3403	3082	3204	3241	2821	2942	2836	2963	2855	2730	3136
UK	171	130	155	171	199	275	315	339	325	331	303	469	376	390
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	70
Portugal	44	57	57	41	45	38	43	42	41	17	15	18	55	51
Total*	3013	3043	3308	3816	3628	3655	3709	3345	3415	3280	3349	3407	3228	3684

*** Includes neglible landings reported to Fishing Area 34 and 37.**

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 Henderson *et al.* (2003), Farrell *et al.* (2010b), McCully Phillips and Ellis (2015) and Ellis *et al.* (2019 WD).

Source	Total length (cm)	Uterine fecundity	Maturity stage[1]
Henderson *et al.* (2003)	87	10	D
	89	2	D
	109	10	D
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)	80	4	D
	83	7	D
	86	10	E
	88	9	D
	90	7	D
	91	6	F
	92	6	D
	93	4	F
	96	14	F
	97	9	F
	97	5	E
	97	11	D
	98	10	F
	98	10	D
	101	7	F
	101	11	E
	101	10	F
	101	12	D
	102	11	F

[1] Maturity stage as per described in McCully Phillips and Ellis, 2015.

Source	Total length (cm)	Uterine fecundity	Maturity stage[1]
	103	12	F
	104	13	F
	105	17	F
	105	8	F
	106	11	F
	110	17	F
	115	12	F
	116	20	F
	116	15	E
	124	13	F
Cefas unpublished[2] in Ellis *et al.* (2019 WD)	101	5	F
Cefas (Ciro 2/02) in Ellis *et al.* (2019 WD)	88	4	D
	92	2	D
	93	2	D
	101	9	F
	111	14	F
Cefas trawl surveys (CEnd 2/13) in Ellis *et al.* (2019 WD)	93	4	F
	97	10	E
Cefas trawl surveys (CEnd 4/18) in Ellis *et al.* (2019 WD)	81	3	F
	85	5	F
	87	4	F
	88	4	F
	89	5	F
	89	5	F
	90	4	F
	90	6	F
	91	7	E
	93	8	F
	97	10	F
	99	9	F
	100	12	F
	101	4	F
Cefas trawl surveys (CEnd 3/19) in Ellis *et al.* (2019)	82	6	F
	99	10	F
	100	12	F
	100	9	E
	108	2	D

[2] April 2019, 101 cm, 3671 g total weight

Table 21.5 Smooth-hounds in the Northeast Atlantic. Exploitable biomass indices for *M. asterias* from IBTS-Q1 and IBTS-Q3 (kg/h) and EVHOE-WIBTS-Q4 (kg/km²) normalized by their long-term means and, the combined stock size indicator (the annual mean of the three surveys, 1997–2018).

Year	IBTS-Q1 (kg/h)	IBTS-Q3 (kg/h)	EVHOE-WIBTS-Q4 (kg/km²)	Combined stock size indicator
1997	0.132	0.74	0.0177	0.30
1998	0.200	0.029	0.197	0.142
1999	1.41	0.0121	0.69	0.70
2000	0.195	0.52	0.147	0.29
2001	0.54	0.00	0.25	0.26
2002	0.62	1.67	0.40	0.90
2003	0.47	0.86	0.34	0.56
2004	0.41	0.74	1.11	0.75
2005	0.32	0.87	0.64	0.61
2006	0.63	0.82	0.24	0.56
2007	0.78	0.58	1.08	0.81
2008	0.31	1.37	1.56	1.08
2009	2.5	1.25	0.86	1.54
2010	1.60	0.95	2.1	1.57
2011	0.97	2.4	1.18	1.53
2012	1.36	1.03	1.47	1.29
2013	1.07	1.84	0.31	1.07
2014	2.4	1.16	1.20	1.58
2015	0.70	0.34	2.4	1.15
2016	2.7	0.79	2.5	2.00
2017*	1.60	1.29		1.44*
2018	1.15	2.7	2.2	2.0

*** based on the mean between IBTS-Q1 and IBTS-Q3 since EHVOE-WIBTS-Q4 did not occur in 2017.**

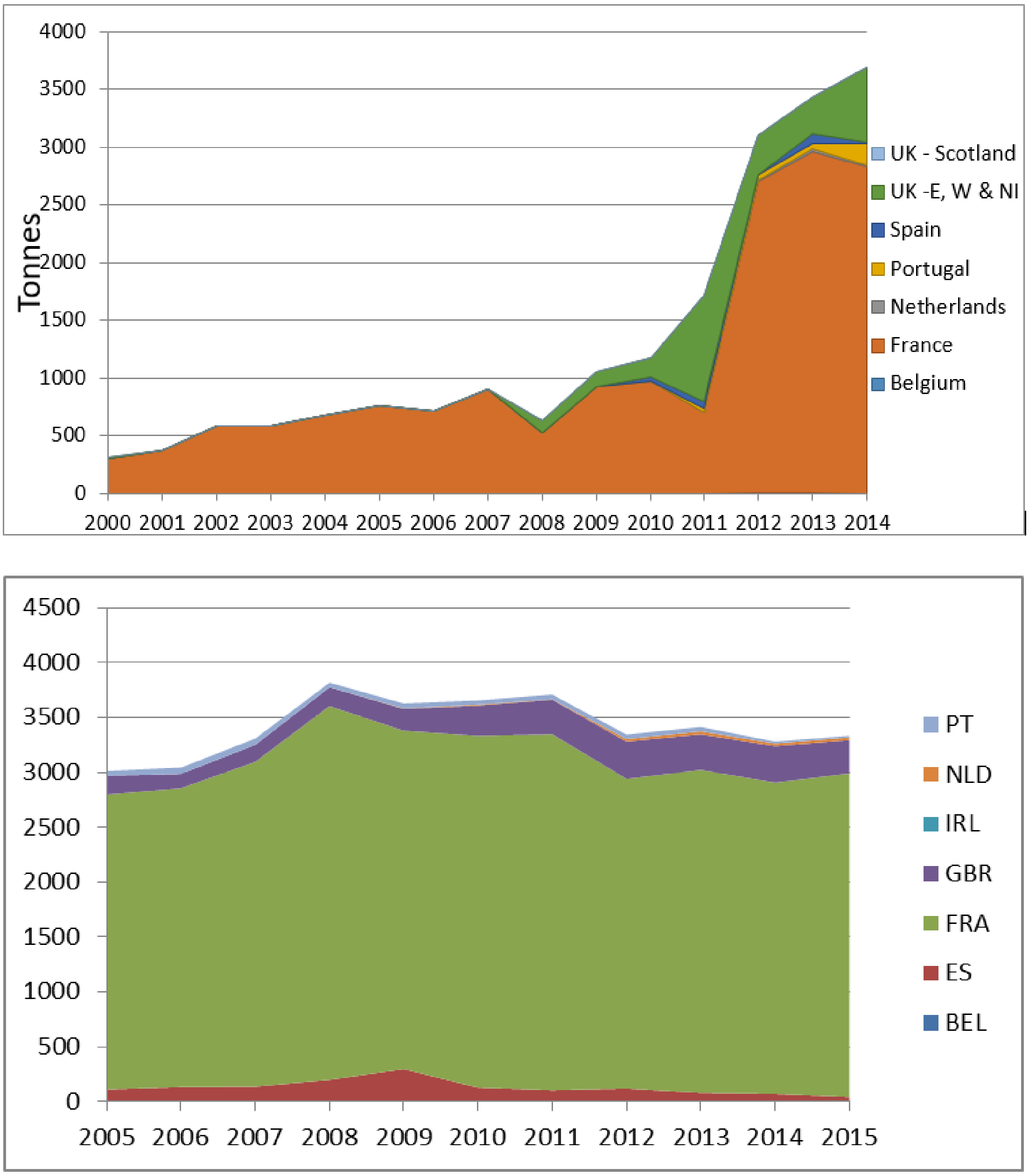


Figure 21.1. Smooth-hounds in the Northeast Atlantic. Earlier ICES estimates of overall *Mustelus* spp. landings by country (2000–2014; top) and revised ICES estimates (2005–2015; bottom). Data are considered underestimates.

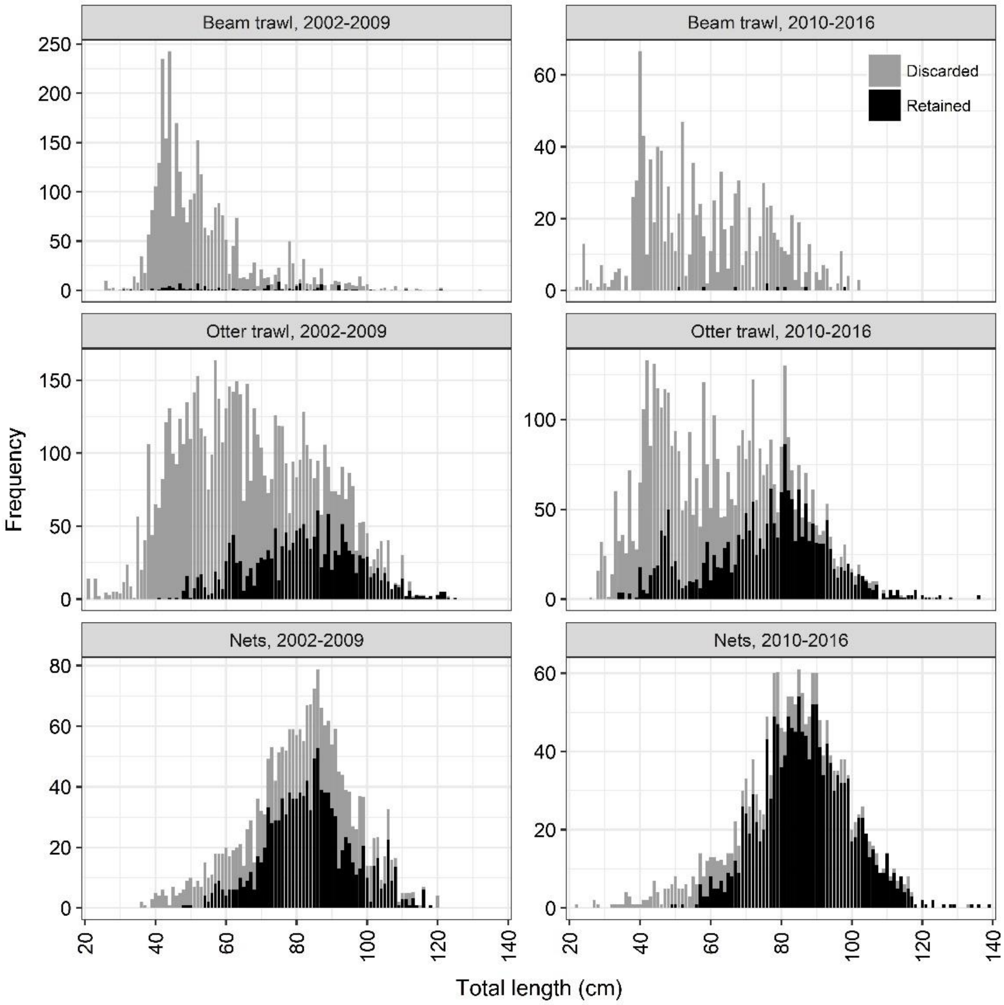


Figure 21.2. Smooth-hounds in the Northeast Atlantic. Length–frequency of discarded (pale grey) and retained (dark grey) starry smooth-hound *Mustelus asterias* caught by beam trawl, otter trawl and gillnets during the periods 2002–2009 and 2010–2016, as recorded in the Cefas observer programme. Data aggregated across North Sea and Celtic Seas ecoregions. (Source: Silva and Ellis, 2019a).

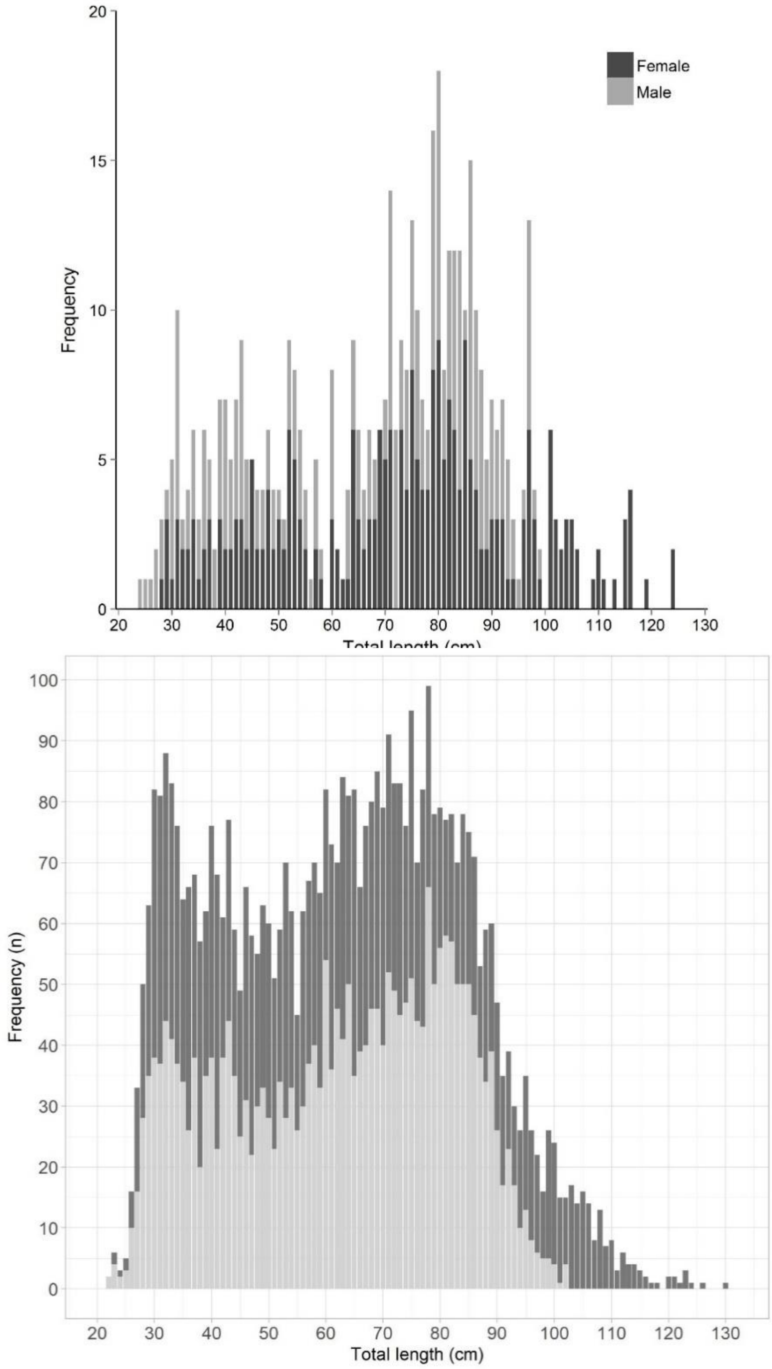


Figure 21.3. Smooth-hounds in the Northeast Atlantic. Number of starry smooth-hounds biologically sampled by length and sex (top) n = 504 from McCully Phillips and Ellis (2015) and (bottom) n = 4951 from Ellis *et al.* (2019 WD).

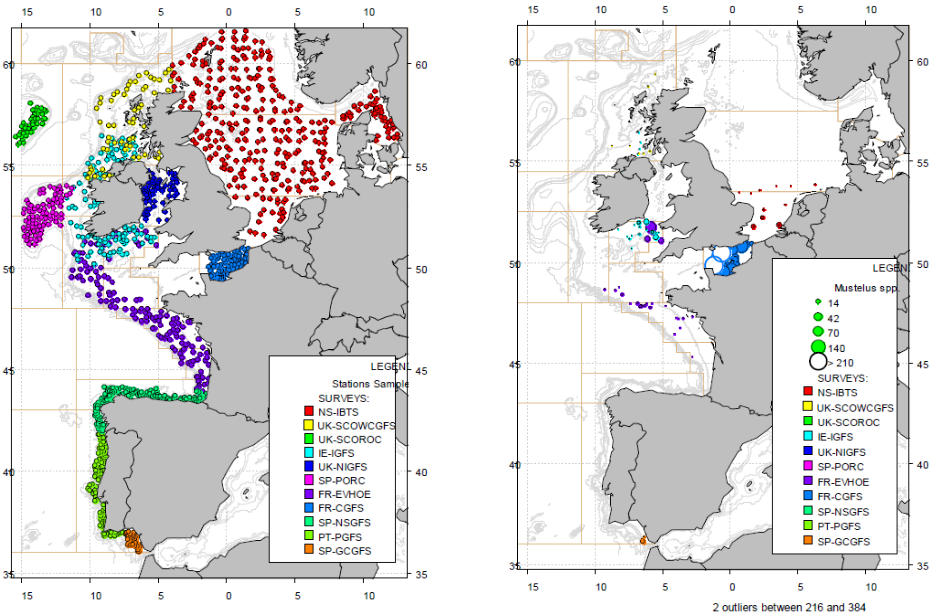


Figure 21.4. Smooth-hounds in the Northeast Atlantic. IBTS hauls undertaken in Q3 and Q4 2015 (left) and corresponding catches of *Mustelus* spp. (right). The catchability of the different gears used in the NE Atlantic surveys is not constant; therefore the map does not reflect proportional abundance in all the areas but within each survey. Source: ICES (2016b).

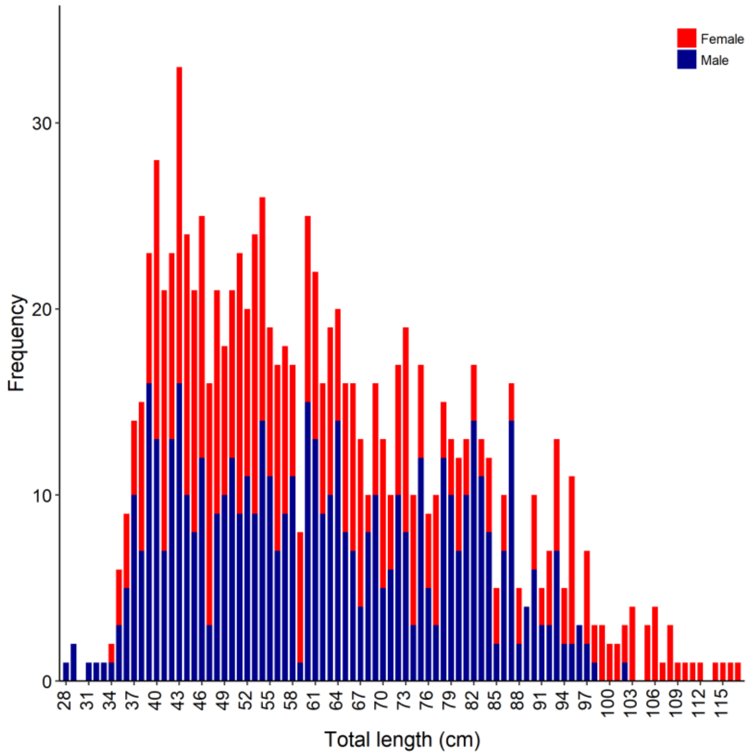


Figure 21.5. Smooth-hounds in the Northeast Atlantic. Length–frequency by sex of smooth-hounds *Mustelus* spp. From the UK Western Channel Q1 Beam-trawl survey. Source: Silva *et al*. (2018 WD).

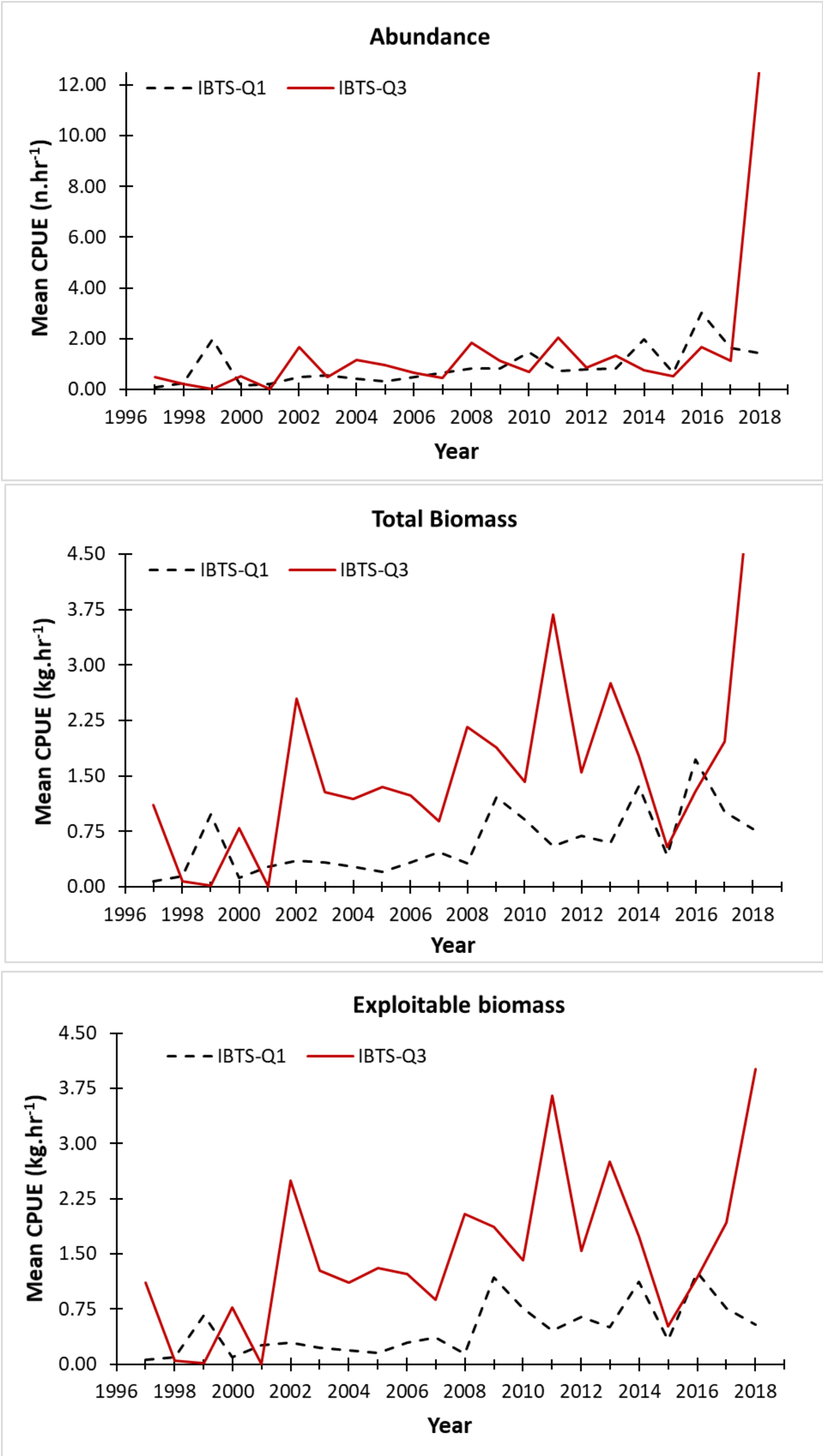


Figure 21.6. Smooth-hounds in the Northeast Atlantic. Survey indices (number per hour; estimated biomass per hour; and estimated exploitable biomass (fish ≥50 cm total length) in Q1-IBTS and Q3-IBTS of the North Sea. Updated survey index in 2019 for whole time series.

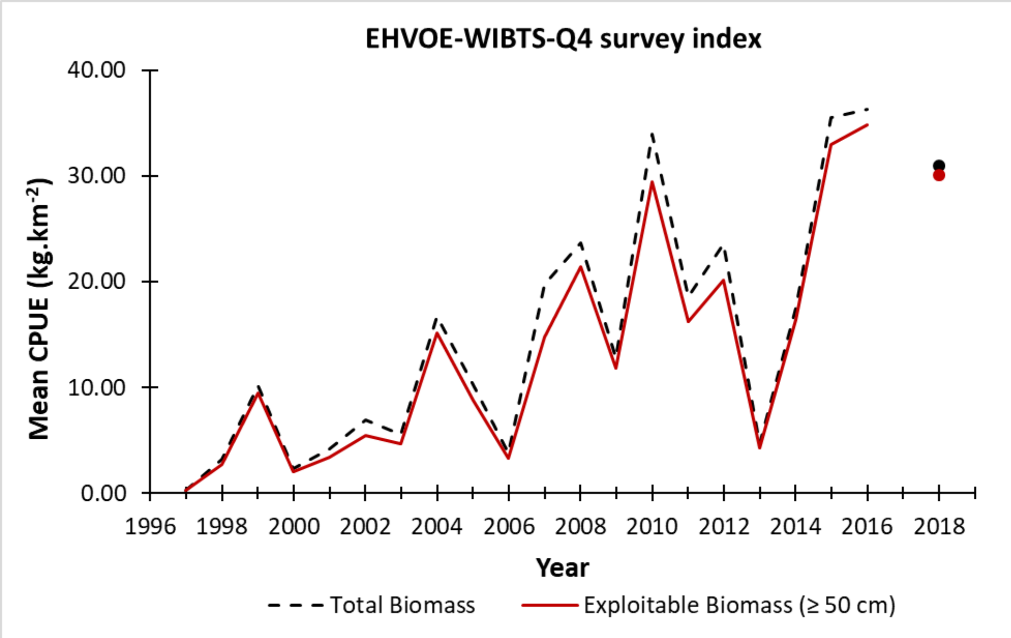
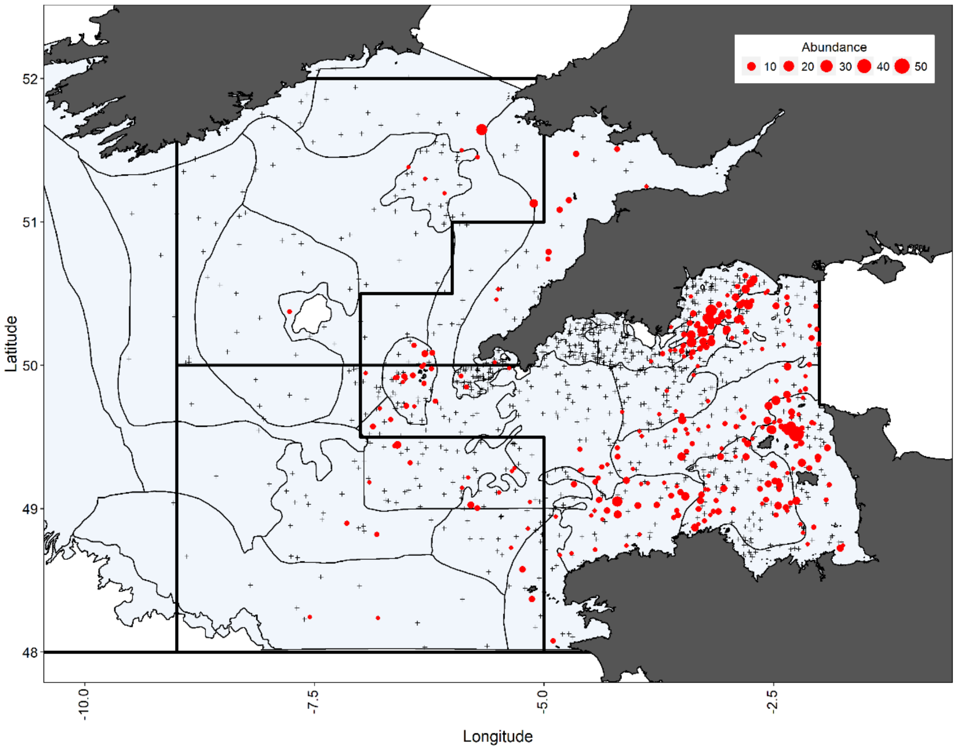


Figure 21.7. Smooth-hounds in the Northeast Atlantic. Biomass index of *Mustelus* spp. from the EVHOE-WIBTS-Q4 survey in divisions 7.g-j, 8.abd. Updated survey index in 2019 for whole time series, survey did not occur in 2017.



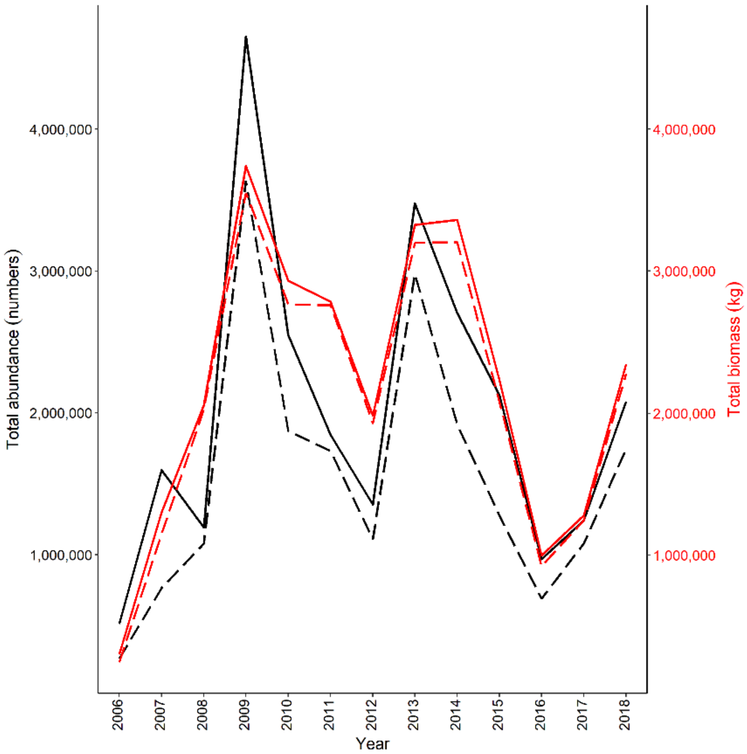
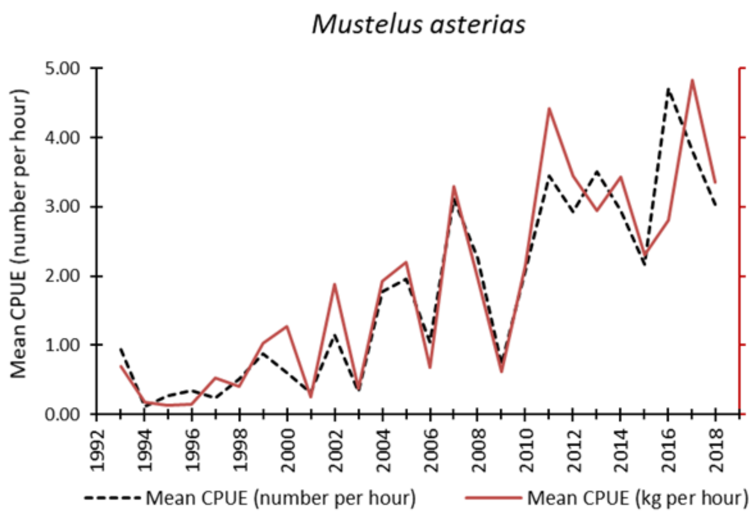


Figure 21.8. Survey grid of the Q1SWECOS survey (2006–2018) indicating the distribution and relative abundance of *Mustelus* spp. (top), and the total abundance (numbers) and total biomass (kg) for *Mustelus* spp (bottom). Continuous line relates to all specimens, dashed line relates to individuals ≥50 cm total length. Source: Silva *et al*. (2018 WD).



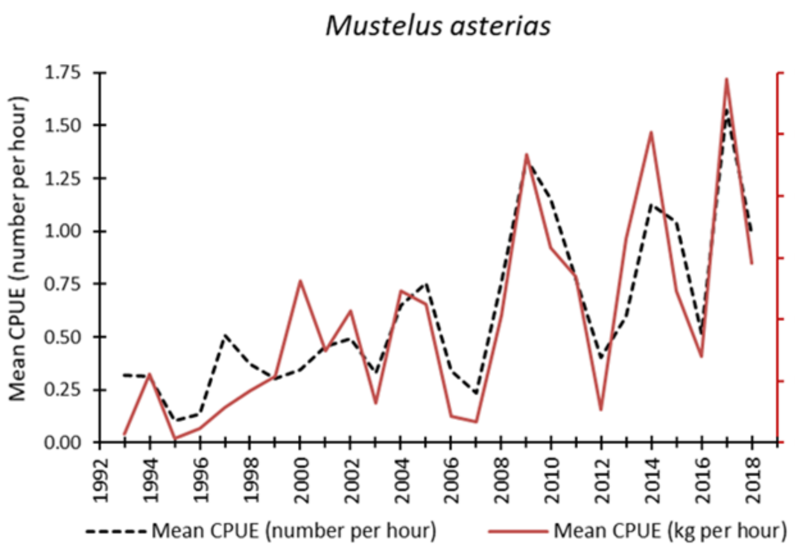


Figure 21.9. Smooth-hounds in the Northeast Atlantic. Survey indices (number per hour and estimated biomass per hour) from BTS-UK (E&W)-Q3 in the Bristol Channel and Irish Sea (top) and BTS-Eng-Q3 in the eastern English Channel and southern North Sea (bottom). Updated survey indices in 2019 for whole time series.

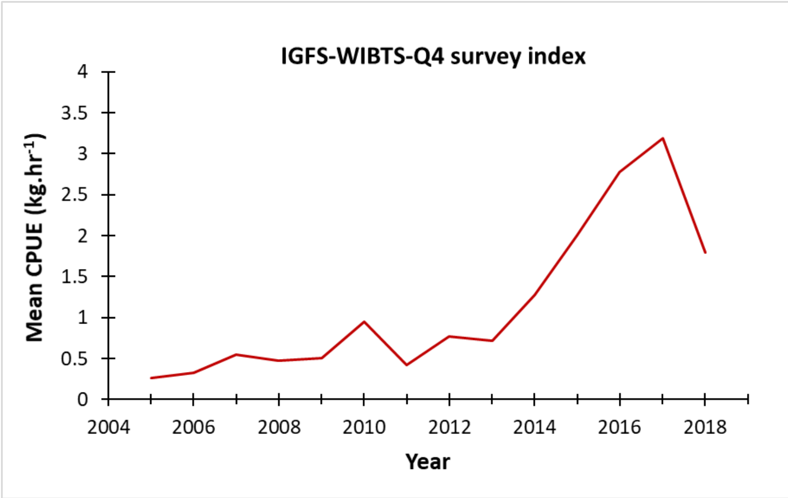


Figure 21.10. Smooth-hounds in the Northeast Atlantic. Survey indices (estimated biomass per hour) from the IGFS-WI-BTS-Q4. Updated survey index in 2019 for whole time series.

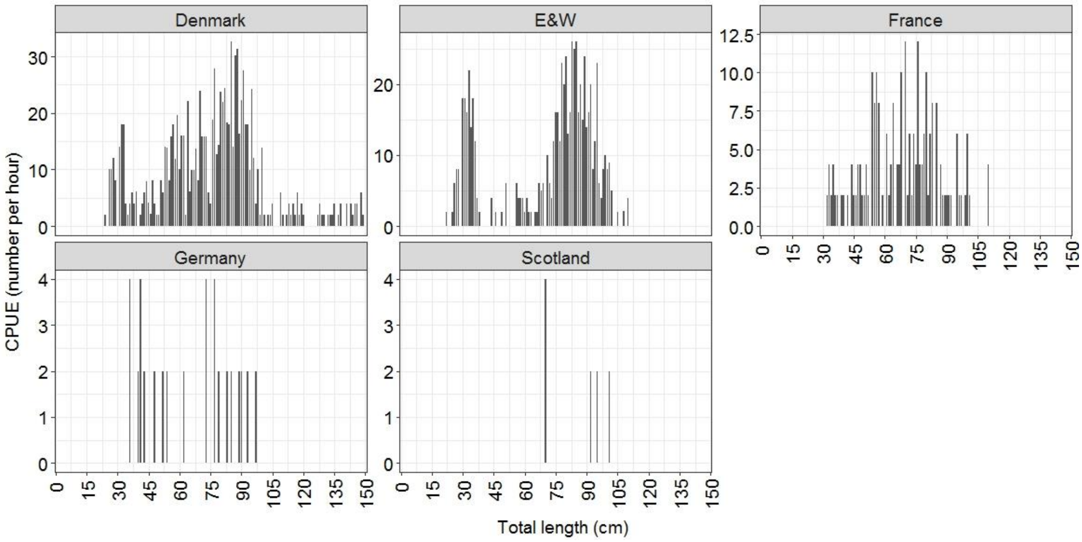


Figure 21.11. Smooth-hounds in the Northeast Atlantic. Length distributions of *Mustelus* spp., in the Q3-IBTS of the North Sea by nation. Most nations record *Mustelus* spp. up to 110 cm, while Danish data (to 149 cm) suggests there may be misidentification with *Galeorhinus galeus* or coding errors.

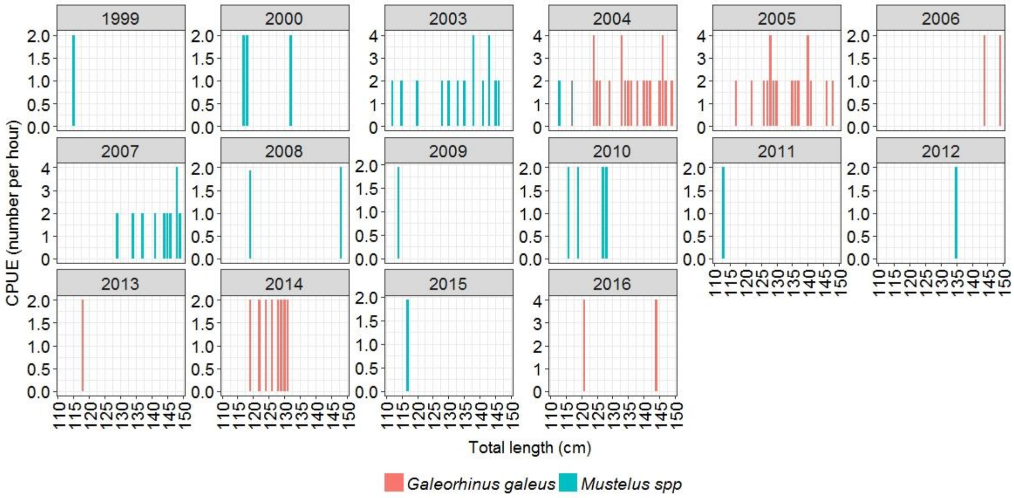


Figure 21.12. Smooth-hounds in the Northeast Atlantic. Length distributions of triakid sharks ≥110 cm as reported on DATRAS for the RV *Dana*. Large specimens of triakid sharks (i.e. *Mustelus* spp. or *Galeorhinus*) are not usually captured in the same year, which suggests potential identification issues or coding errors.

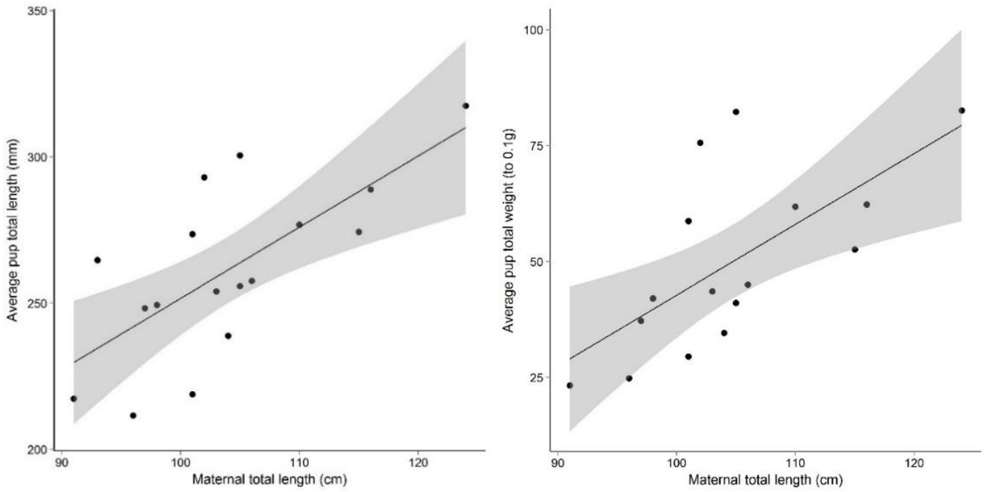


Figure 21.13. Smooth-hounds in the Northeast Atlantic. Relationship between maternal total length and average length and weight of term pups. Source: McCully Phillips and Ellis (2015).

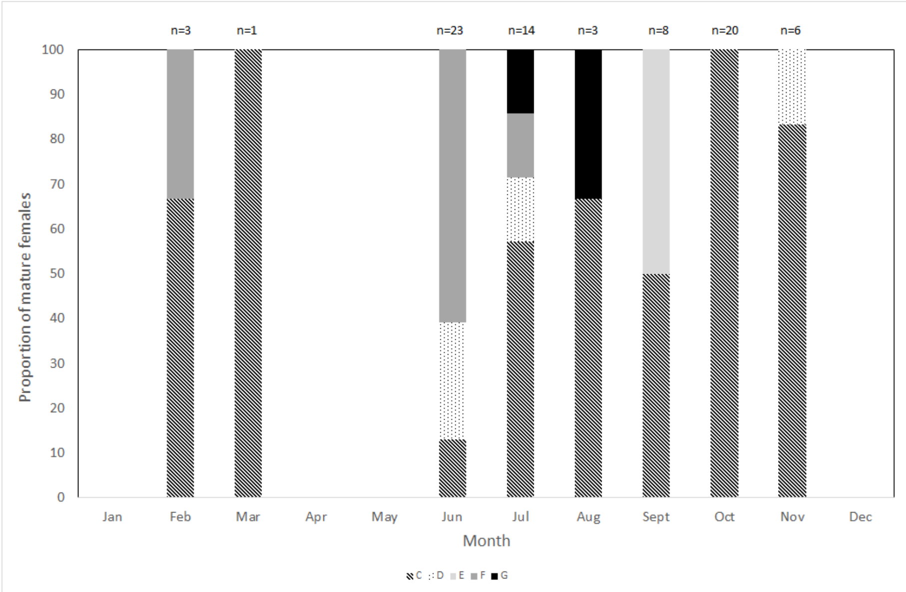


Figure 21.14. Smooth-hounds in the Northeast Atlantic. Percentage of mature females at each developmental stage (D: early gravid; E: mid-gravid; F: late gravid; G: post-partum) by month. Source: McCully Phillips and Ellis (2015).

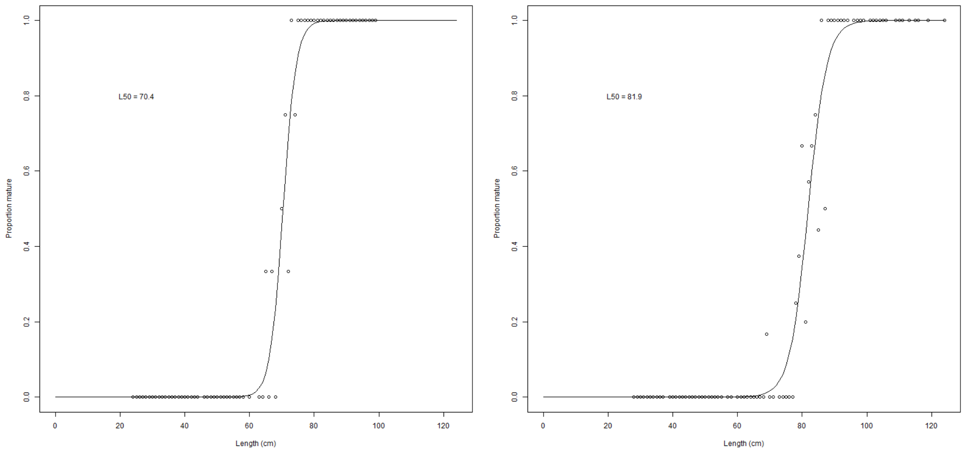


Figure 21.15. Smooth-hounds in the Northeast Atlantic. Maturity ogive for male (n = 237; L_{50} = 70.4 = cm L_T) and female (n = 248; L_{50} = 81.9 cm L_T) *M. asterias*. Source: McCully Phillips and Ellis (2015).

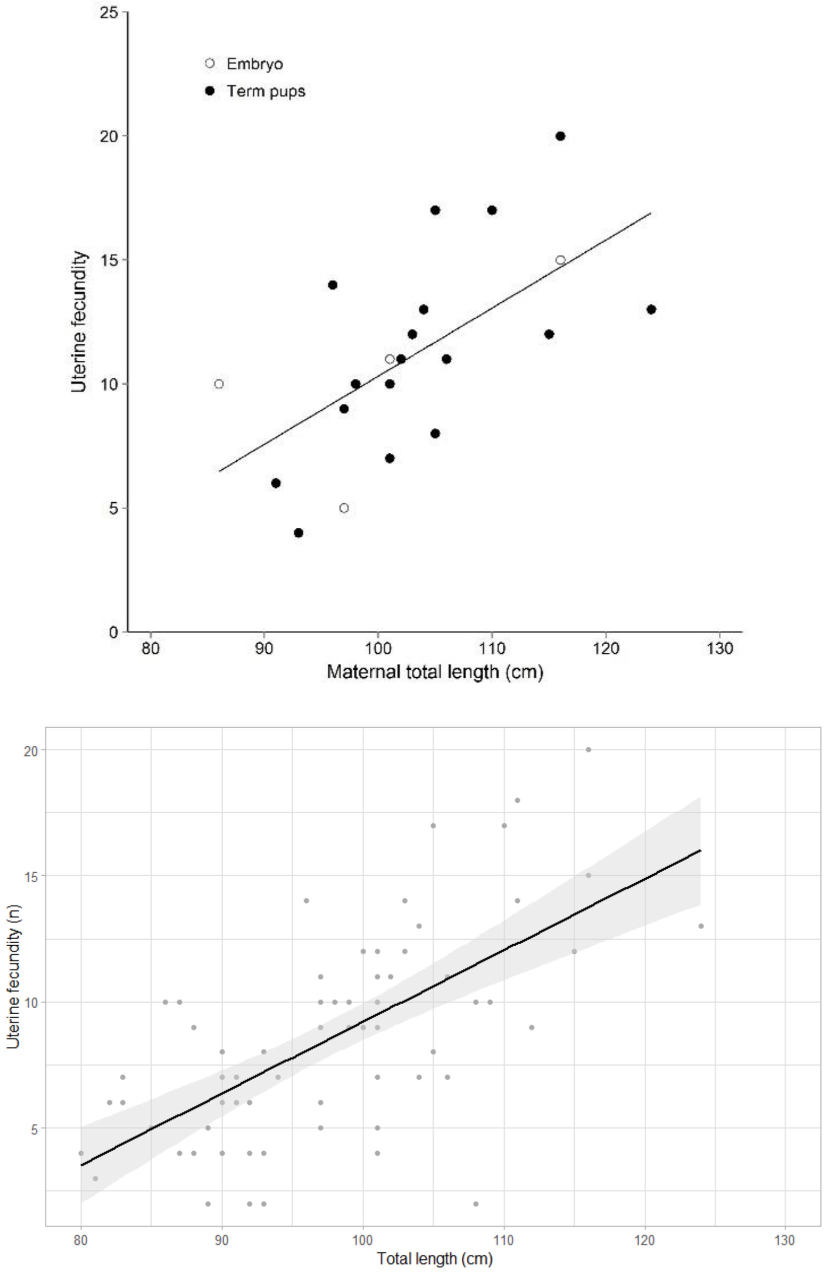


Figure 21.16. Smooth-hounds in the Northeast Atlantic. Relationship between maternal total length and uterine fecundity (top) from McCully Phillips and Ellis (2015) and (bottom) from Ellis *et al.* (2019 WD).

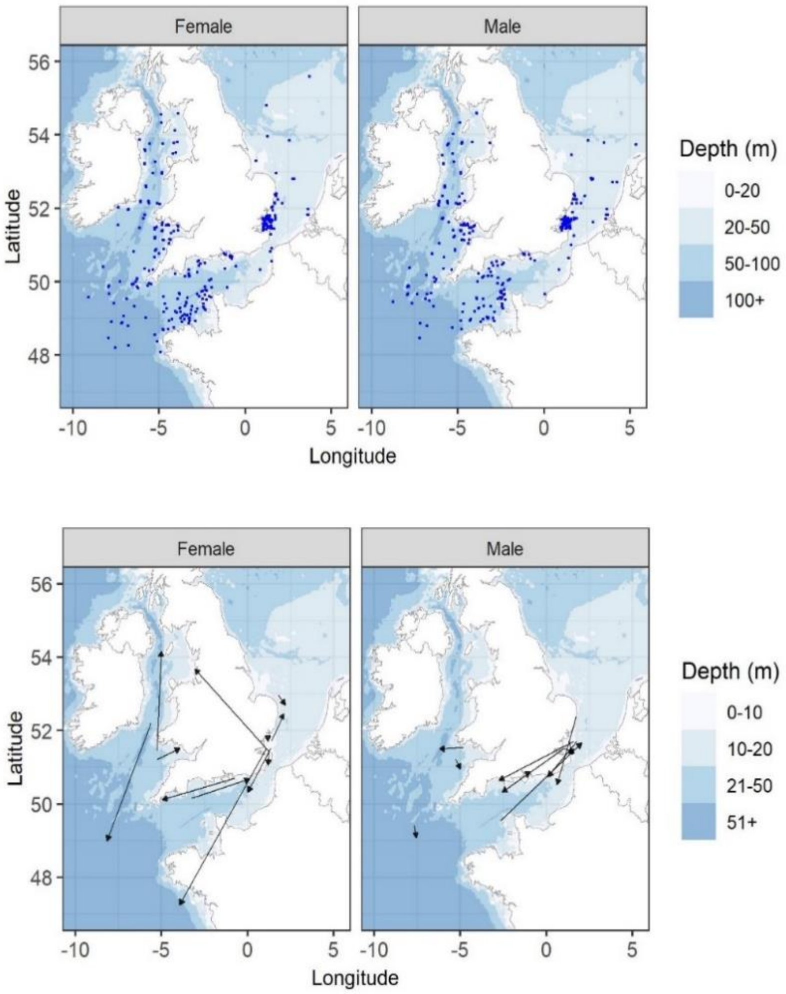


Figure 21.17. Smooth-hounds in the Northeast Atlantic. Tagging locations (top) and displacement vectors (bottom) for male and female *M. asterias*. Source: Ellis *et al.* (2019 WD).

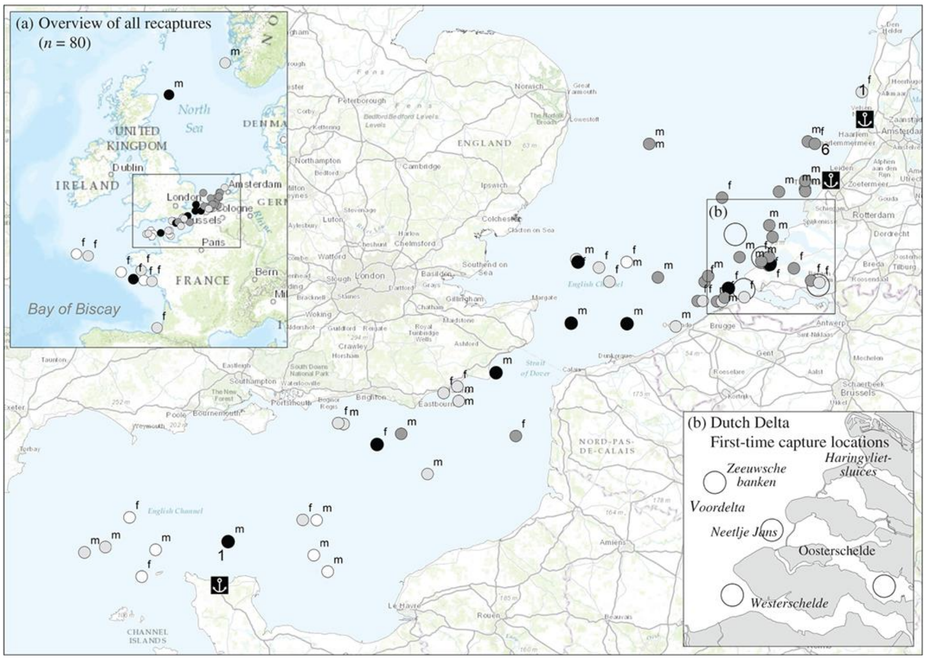


Figure 21.18. Smooth-hounds in the Northeast Atlantic. The main map shows the more detailed distribution of recaptures in the English Channel and southern North Sea. From three fish markets (indicated with anchors), eight tagged *M. asterias* were reported (numbers next to the anchors represent the number of sharks from each fish market) with unknown re-capture 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).

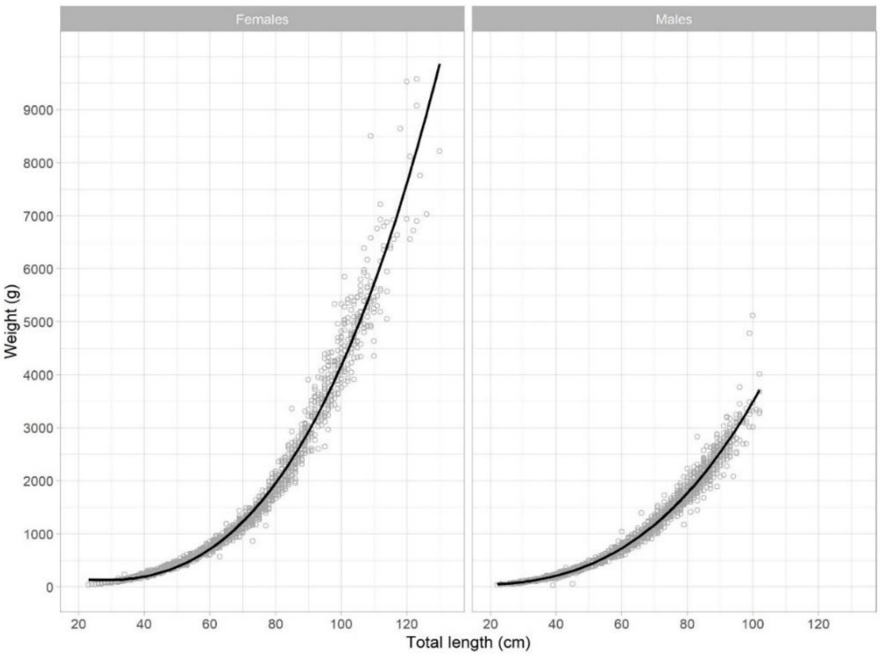


Figure 21.19. Smooth-hounds in the Northeast Atlantic. Length–weight relationships for female and male *M. asterias* caught in fishery-independent trawl surveys conducted by Cefas between 2009–2019. Relationships are described by the equations: females, $M_T = 0.002\ T_L^{3.1}$ ($r^2 = 0.992$, n = 2323); males, $M_T = 0.003\ T_L^{3.0}$ ($r^2 = 0.991$, n = 2471). M_T = Total weight (g), L_T = Total length (cm). Source: Ellis *et al*. (2019 WD).

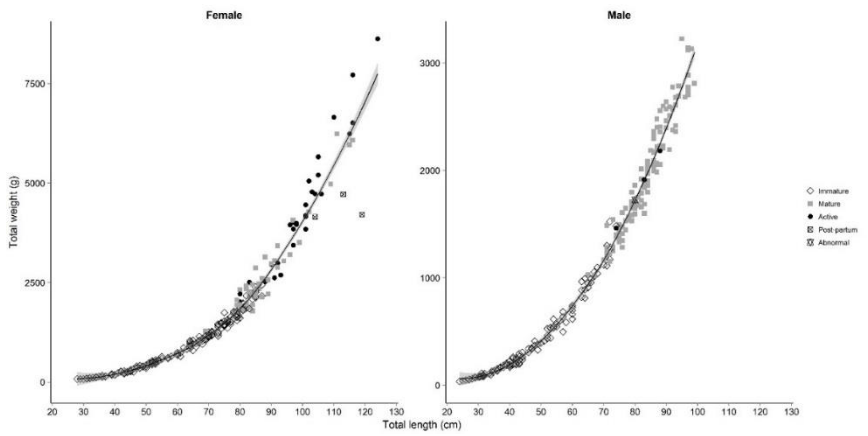


Figure 21.20. Smooth-hounds in the Northeast Atlantic. Length–weight relationship for female (n = 248) and male (n = 237) *M. asterias* by maturity stage (shaded region showing 95% confidence intervals). Source: McCully Phillips and Ellis (2015).

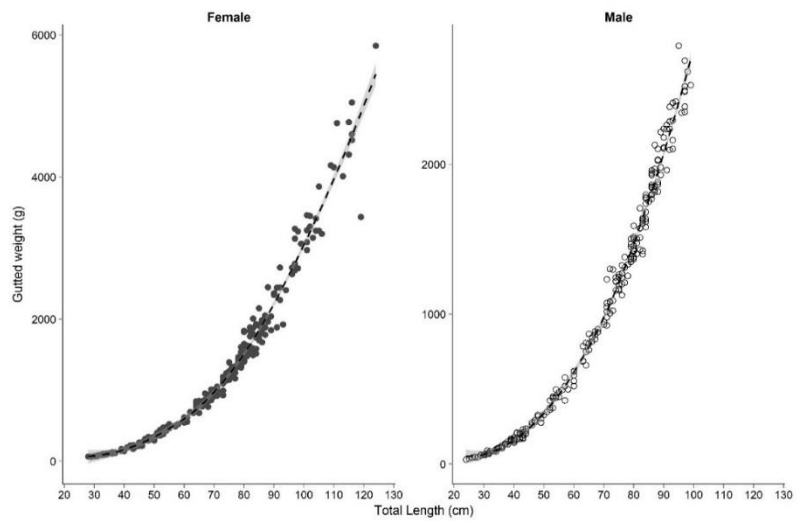


Figure 21.21. Smooth-hounds in the Northeast Atlantic. Total length to gutted weight relationship for female (n = 249) and male (n = 235) *M. asterias* (shaded region showing 95% confidence intervals). Source: McCully Phillips and Ellis (2015).

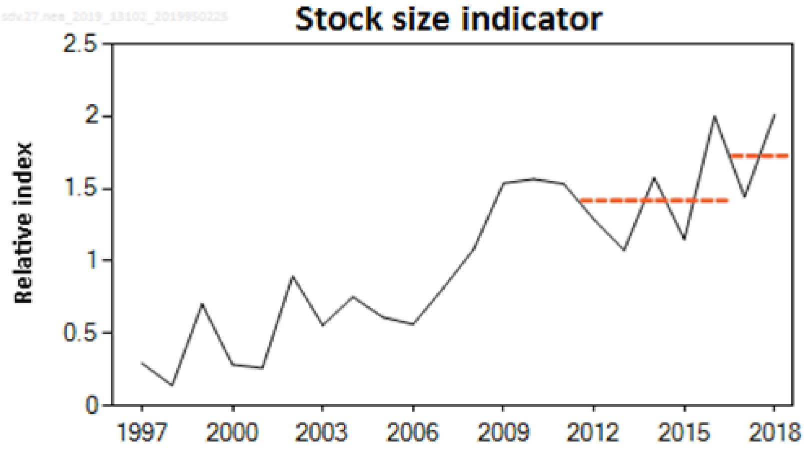


Figure 21.22. Smooth-hounds in the Northeast Atlantic. Stock size indicator based on the average standardised indices from three surveys (Q1-IBTS, Q3-IBTS and EVHOE-WIBTS-Q4). The horizontal lines show the average of the most recent two-years (2017–2018) and the preceding five-years (2012–2016).

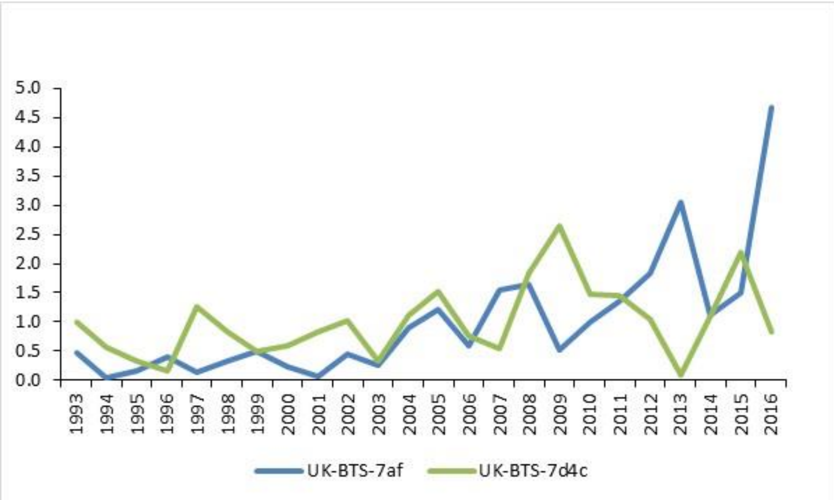


Figure 21.23. Smooth-hounds in the Northeast Atlantic. Annual catch rate of pups (<35 cm) in the BTS-UK(E&W)-Q3 (Bristol Channel and Irish Sea) and BTS-Eng-Q3 (eastern English Channel and southern North Sea), each standardised to the long-term mean for the survey.

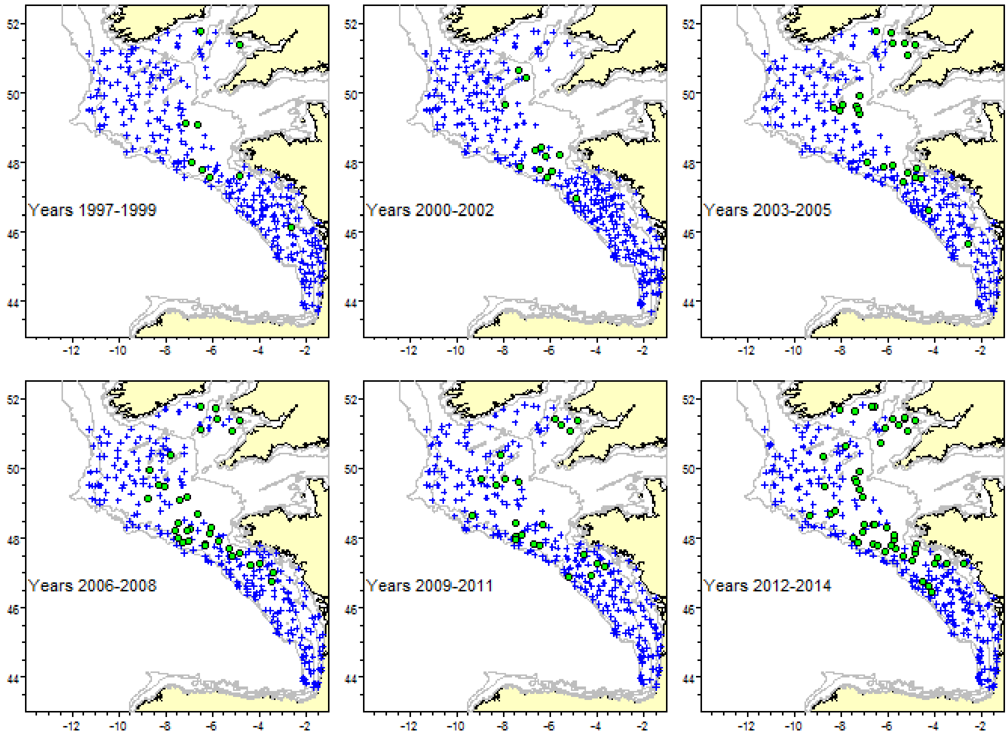


Figure 21.24. Smooth-hounds in the Northeast Atlantic. Distribution of *Mustelus* spp. in catches (green points *vs.* blue points for all sampling stations) in the EVHOE-WIBTS-Q4 (1997–2014).

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 2018

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.

In 2017, angel shark was added to Appendices I and II of CMS (see Section 22.12).

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.*, 2019), 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.

WKSHARK3 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. This exercise suggested that the number of specimen individuals 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. The Irish angler tagging and specimen catch data have recently been combined with effort data from charter angling vessels to explore the apparent extirpation of this species from two former hotspots: Clew Bay and Tralee bay. This study showed a decline close to zero, despite apparent stable or increasing angler effort (Figure 22.5; Shephard *et al.*, 2019).

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. Angel sharks are thought to be nocturnally active (Standora and Nelson, 1977).

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). There are ongoing studies, coordinated by Zoological Society of London (ZSL) and Natural Resources Wales (NRW) to collate historic and recent sightings data around the Welsh coastline, especially Cardigan Bay.

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 presented in full in the WGEF 2015 report. In summary, Bal *et al*. (2015) suggested 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. This trend is robust and indicates an important decline starting in the 1980s, concurring with anecdotal reports on angel shark abundance.

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.

Recent studies using recreational catch data have shown that the stock has declined dramatically in Clew and Tralee Bays - two former hotspots on the west of Ireland (Shephard *et al*., 2019). Angler catches of angel shark are now extremely rare at these locations, with only occasional anecdotal reports. Although it is not possible to conduct a quantitative stock assessment, it is evident that the species is in a critically poor state even in important areas of its original geographic range. The Irish Marine Institute is currently undertaking a multi-disciplinary research project on Angel shark in Tralee Bay, and this study may further clarify current stock abundance, as well as produce information on migration, nursery grounds, feeding etc.

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 organizations (including conservation bodies and academic departments) are developing an Eastern Atlantic and Mediterranean Conservation Strategy for angel sharks (see www.angelsharknetwork.com).

Angel shark was listed on both Appendices I and II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) at the 12th Meeting of the Conference of the Parties to (COP12) in 2017. Contracting Parties to CMS that are Range States of species listed on Appendix I should prohibit the taking of such species, whilst the Appendix II listing indicates that international cooperation and agreements should be developed to aid the conservation and management of the listed species (https://www.cms.int/en/convention-text).

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	2018
Belgium	.	.
France	0.02	.
UK	.	.
Total	0.15	0.00

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 1st 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]

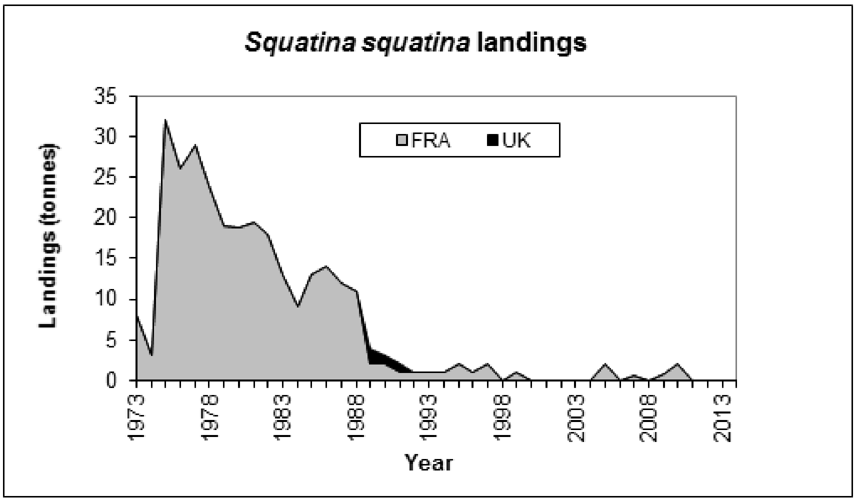

Figure 22.1. Angel shark in the Northeast Atlantic. Total reported landings of *Squatina squatina* (1973–2012). Angel shark has been listed as a non-retained/prohibited species on European fisheries regulations since 2009 and so this species is now reported very rarely in landing statistics.

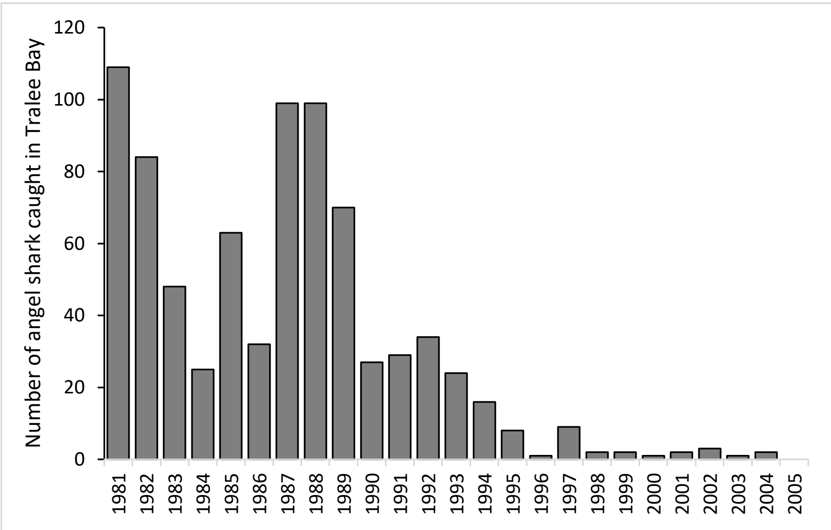

Figure 22.2. Angel shark in the Northeast Atlantic. Numbers of angel shark caught by two charter boats in Tralee Bay 1981–2005. Adapted from Irish Central Fisheries Board data presented in ICES (2008).

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.

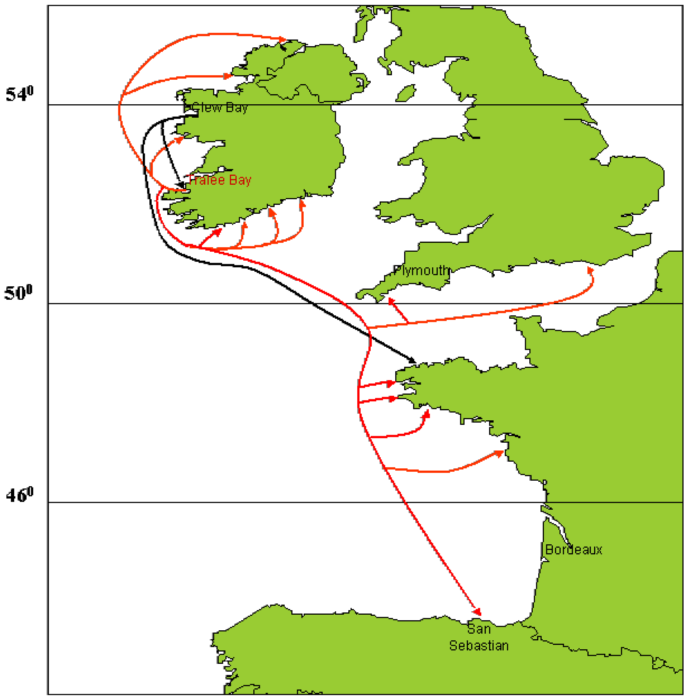

Figure 22.4. Angel shark in the Northeast Atlantic. Longer-distance movements of angel shark tagged off the west coast of Ireland, 1970–2006. Source: Irish Central Fisheries Board.

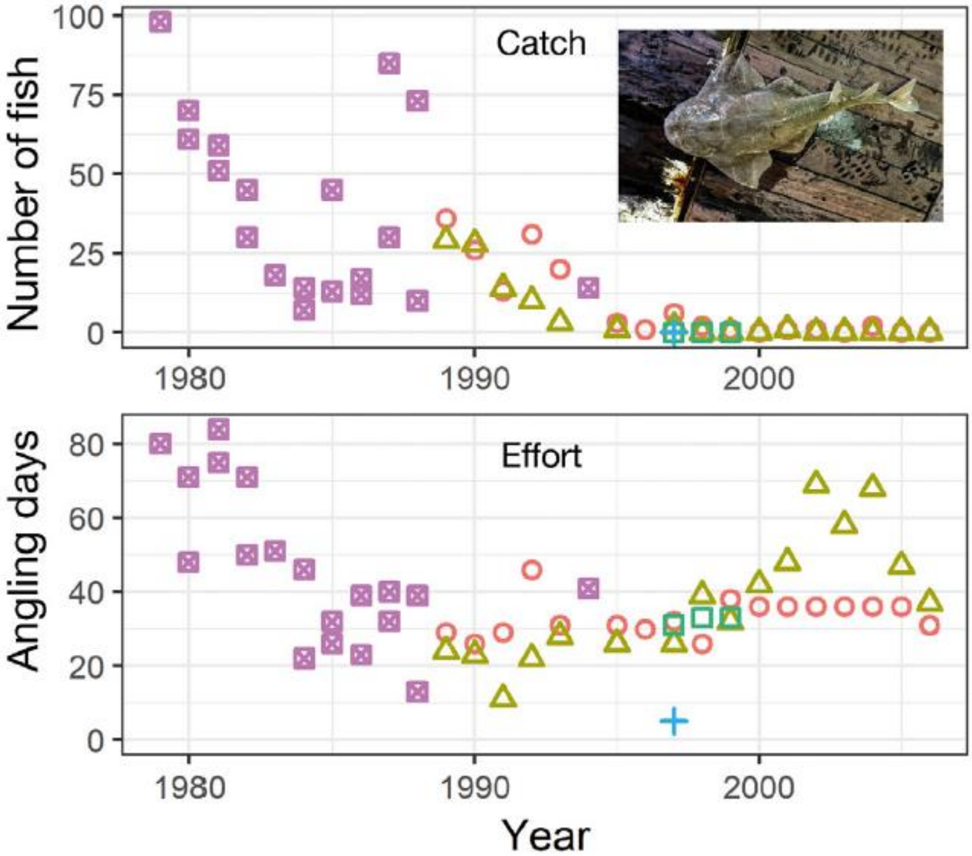

Figure 22.5. ***Squatina squatina*** **annual angling catch and effort for charter vessels in Tralee Bay, Ireland. Inset photograph of *S. squatina* (100 cm total length) caught and released alive from FV 'Eblana' in 2016. Colours of the data points refer to different vessels. Figure from Shephard *et al*. (2019).**

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 and 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 tonnes 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 4110 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 2018

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 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 tranship 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 and 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 and 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	2018
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	7.1
Ireland	-	-	-	-	-	-	-	-	-	0.26	0.02	0.12	-	0.4
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	7.5

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 and 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 and 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 and 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 2018

No specific changes in the fishery were apparent in 2018. National landings data are available from Iceland, which have been 25 tonnes on average since 2009. Nine tonnes were landed in 2018. 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 tonnes (2007) to 87 tonnes (1998). Monthly Icelandic landings of Greenland shark (2005–2015) indicate a peak during the summer (Figure 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 and Orlov, 2013). Despite limited data on Greenland shark bycatch in the commercial trawl fishery, Rusyaev and Orlov (2013) estimated an annual catch of 140–150 tonnes 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 tonnes (Gunnarsdóttir and 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 900–1100 m (Rodríguez-Cabello and Sánchez, 2014). 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, Figure 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 and 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 and Stehmann, 2013). Confirmed observations cover a broad depth range from abyssal depths of at least 1560 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 and 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 and 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 and Stehmann, 2013). Bigelow and 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 years-old (Nielsen *et al.*, 2016).

24.7.4 Reproductive biology

The Greenland shark is an aplacentally viviparous species (Carrier *et al.*, 2004; Ebert and 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 and Koefoed, 1957; Ebert and 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 display 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 and 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 1992–2018). Data were updated with landings from ICES historic nominal landings database (ICES, 2016) and national landings data provided to the WG (June 2019). 2018 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	60	8			68
2015	30	17			47
2016	26				26
2017	18				18
2018	9				9

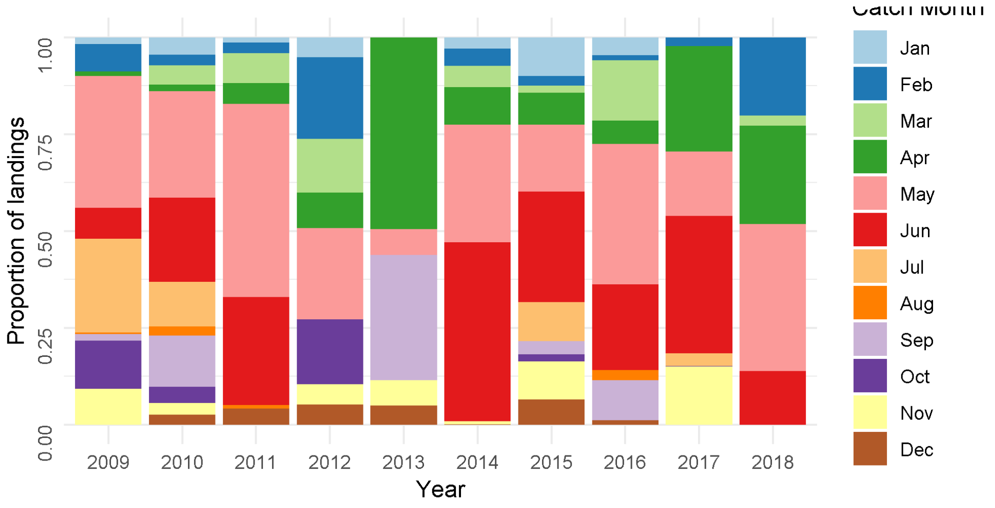

Figure 24.1. Greenland shark (*Somniosus microcephalus*) in the Northeast Atlantic. Monthly Icelandic landings of Greenland shark 2009–2018. Data from www.hagstofa.is

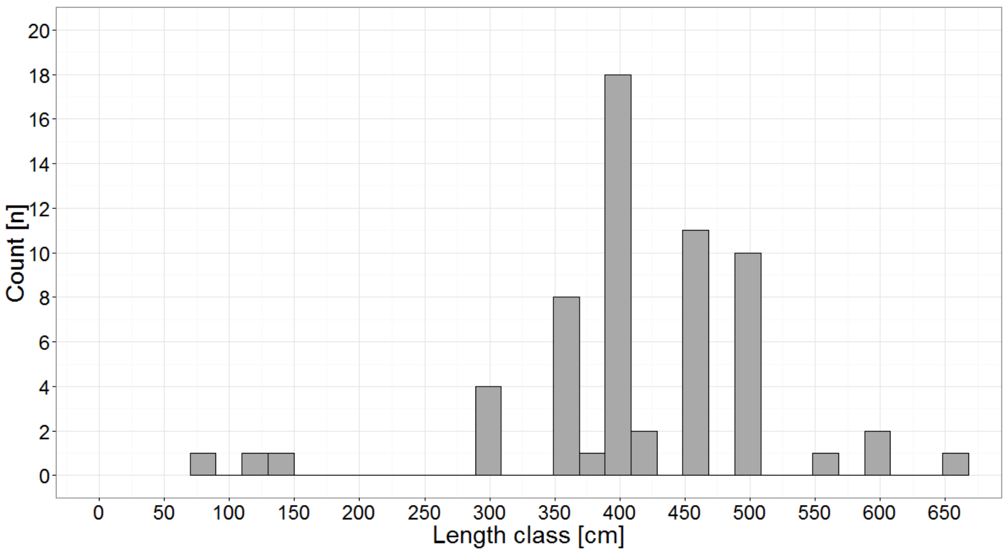

Figure 24.2. Greenland shark (*Somniosus microcephalus*) in the Northeast Atlantic. Length distribution of Greenland shark captured during the annual German Greenland Groundfish Survey (1982–2015; n = 61).

25 Catsharks (*Scyliorhinidae*) in the Northeast Atlantic

25.1 Stock distribution

This section addresses four species of catsharks 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*

<u>Lesser-spotted dogfish</u>: *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).

See stock annexes for information about *S. canicula* in northern Bay of Biscay (divisions 8.a–b and 8.d) and in the Cantabrian Sea and Atlantic Iberian waters (divisions 8.c and 9.a).

<u>Greater-spotted dogfish</u>: *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.

See stock annex for information about *S. stellaris* in subareas 6 and 7.

<u>Black-mouth dogfish</u>*: 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).

See stock annex for information about *Galeus melastomus* in 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 2018

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 previous assessments of catsharks were published in 2017 for 2018 and 2019 and were based on the ICES approach to data-limited stocks. The table below presents a summary of these assessments.

STOCK	STOCK CODE	ASSESSMENT CATEGORY	ADVICE BASIS	ADVISED LANDINGS
Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea 4 and divisions 3.a and 7.d	Syc.27.3a47d	3	Precautionary	3380 tonnes
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 tonnes
Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.a-b and 8.d	Syc.27.8abd	3	Precautionary	Catches should be no more than 5592 tonnes in each of the years 2018 and 2019. If discard rates do not change from the average of the last three years (2014–2016), this implies landings of no more than 611 tonnes.
Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.c and 9.a	Syc.27.8c9a	3	Precautionary	1178 tonnes
Greater-spotted dogfish (*Scyliorhinus stellaris*) in subareas 6 and 7	Syt.27.67	3	Precautionary	Decrease by 36% compared to the average of 2014–2016.
Black-mouth dogfish (Galeus melastomus) in subareas 6 and 7 (West of Scotland, southern Celtic Seas, and English Channel)	Sho.27.67	3	Precautionary	Could be increased by no more than 20% compared to the average catches in 2014–2016.
Black-mouth dogfish (*Galeus melastomus*) in Subarea 8 and Division 9.a	Sho.27.89a	3	Precautionary	156 tonnes

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 previous data calls, the updated 2018 data call and the 2019 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 and Spain, while those from divisions 8.c and 9.a are reported by Spain and Portugal (Table 25.1d).

Nominal landings data for *G. melastomus* from subareas 6 and 7 (Celtic Seas) have only been declared by France and Spain (Table 25.1e) and amount to zero in the last two years. 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 both the Portuguese and the Spanish fleets (Table 25.1f). In 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 increased to reach their highest value in 2018 (181 tonnes).

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 WKSHARK3, 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 WKSHARK3) 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. A review of survival studies on this species and other sharks can be found in Ellis *et al*., 2016. 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 and 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). To date, the results have been only partially communicated.

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). This however, does not seem to apply for *S. canicula* in areas where is species is mostly landed as bait for pot fisheries (Silva and Ellis, 2019).

The length distributions for *S. canicula* from France (divisions 7.a-c.e.k, for stocks syc.27.3a47d and syc.27.8abd; 2011–2015) and Spain (OTB Basque fleet for stock syc.27.8abd; 2011–2015) were shown in ICES (2017a). 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 50 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-range 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 2001–2018, with a more stable trend (ca. 200 kg day^{-1}) since 2009 except for the peaks in 2015 and 2017.

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	IBTS-Q1 and Q3, UK (E&W)-BTS-Q3 and CGFS-Q4
syc.27.67a-ce-j	EVHOE-WIBTS-Q4, IGFS-WIBTS-Q4, Spanish Porcupine Bank survey SpPGFS-WIBTS-Q4, and UK (E&W)-BTS-Q3 (2001-2018).
syc.27.8abd	EVHOE-WIBTS-Q4
syc.27.8c9a	Spanish surveys in the South (Gulf of Cadiz) SpGFS-GC-WIBTS-Q1-Q4 (ARSA) and in the North of Spain (SpNGFS-WIBTS-Q4) and Portuguese survey (PtGFS-WIBTS-Q4)
syt.27.67	UK (E&W)-BTS-Q3
sho.27.67	Spanish Porcupine Bank survey SpPGFS-WIBTS-Q4
sho.27.89a	EVHOE-WIBTS-Q4 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 (E&W)-BTS-Q3 in 7enot 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 (E&W)-BTS-Q3 is one of the few surveys to encounter this species regularly, especially around Anglesey and Lleyn Peninsula and in Cardigan Bay.

For syc.27.8c9a, three surveys provide reliable time series of abundance or biomass index which are used in the assessment of this stock. These are the Spanish bottom trawl survey carried out in the north of Spain waters (Galician and Cantabrian Sea shelf) (Ruiz-Pico *et al.*, 2019 WD) and in the south of Spain (Gulf of Cádiz) which is carried out in two seasons in Spring (Q1) and Autumn (Q4). The Portuguese survey (PtGFS-WIBTS-Q4) also included covers all the central area of Division 9a.

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 (E&W)-BTS-Q3 in 7dand the French CGFS-Q4. 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 Division 8.c (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-Q1 and Q3 survey stations are <200 m deep, and so catch rates may not be informative of stock size.

25.7 Life-history information

There is no recent information available. Summaries of knowledge on life history of the various species are provided in the corresponding stock annexes.

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.

A large nursery ground for *G. melatomus* was found in an Irish offshore Special Area of Conservation in 2018 (Marine Institute, 2018).

25.8 Exploratory assessment models

ICES (2014) report GAM analyses of survey trends for *S. canicula* in the CGFS-Q4, UK (E&W)-BTS-Q3 in 7d, 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 PtGFS-WIBTS-Q4. 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 show diverging trends. The index from IBTS-Q1 showed a 36% decrease while IBTS-Q3 index increased by 23%. During WGEF, discrepancies were found between the data extracted from DATRAS and national data for both the UK (E&W)-BTS-Q3 and CGFS-Q4. These discrepancies as well as adjustments to the survey indices have been discussed in Section 15 (North Sea Demersals) of this report. The index of the UK (E&W)-BTS-Q3 is in line with the IBTS Q1 index showing an 21% decrease, whereas the CGFS-Q4 show a minor 2% decrease. The combined index (Figure 25.5a) showed that catch rates for 2017–2018 were 12% lower than the five preceding years (2012–2016). In addition, the precautionary buffer has been applied (last applied prior to 2015).

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 2019 analyses indicated a stability of the survey index from IGFS-WIBTS-Q4 (+0.5%), the indices from the SpPGFS-WIBTS-Q4 decreased by 5% while the UK(E&W)-BTS-Q3 showed a 3% increase in its index (Figure 25.6a). The index based on the EVHOE-WIBTS-Q4 survey shows the higher rate of change, with an increase of 31% (Figure 25.6a). However, no value being available for 2017, this index is based on the comparison of its 2018 value with its average between 2012 and 2016. The combined index (Figure 25.6a) showed an overall stability, with catch rates for 2017–2018 being 4% higher than the five preceding years (2012–2016).

25.9.4 Lesser-spotted dogfish (*S. canicula*) in divisions 8.a–b and 8.d (Bay of Biscay)

The results of 2019 analyses indicated that survey indices in the EVHOE-WIBTS-Q4 survey (Figure 25.7) for 2018 (no data was available for year 2017) were 13% lower than the five preceding years (2012–2016). After an increase leading to a peak in 2008, the survey index seems to have been decreasing. However, the biomass index remains at least twice higher than its values at the beginning of the time series (1997–2006).

25.9.5 Lesser-spotted dogfish (*S. canicula*) in divisions 8.c and 9.a (Atlantic Iberian waters)

The results of 2019 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 2017–2018 were 28% higher than the five preceding years (2012–2016).

25.9.6 Greater-spotted dogfish (*S. stellaris*) in subareas 6 and 7 (Celtic Seas and West of Scotland)

The results of 2019 analyses indicated that catch rates for 2018–2017 were 21% lower than the five preceding years (2012–2016), and the abundance index does not display any trend since 2013 (Figure 25.9). However, this 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 2017–2018 were 8% lower than the five preceding years (2012–2016) (Table 25.4 and 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 2017–2018 were 34% higher than the five preceding years (2012–2016). This is related to the strong increases observed in EVHOE-IBTS-Q4 and in PT-CTS UWTV (FU 28–29). The ARSA survey indicate a longer-term slow 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 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 (IUCN, 2019) and in the 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. Discarding is known to occur for most of these Scyliorhinidae species and is known to be very high and variable between fleets. Therefore, further efforts are needed to best estimate discard rates.

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.

25.14 References

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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). Values prior to 2017 are based on WGEF revised landings. 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	2018
Belgium	238	267	264	337	309	290	311	249	231	325	416	343	338	305
France	2265	1857	1843	1822	1758	2055	2150	2061	2021	2189	2090	2039	1641	1580
UK	92	121	104	94	118	146	185	181	184	146	185	330	286	275
Netherlands	56	48	32	29	37	37	47	35	36	45	85	122	141	180
Total	2652	2293	2243	2282	2222	2528	2693	2526	2472	2705	2776	2834	2406	2340

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). Values prior to 2017 are based on WGEF revised landings. 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	2018
Belgium	240	225	199	165	168	165	227	236	216	141	252	194	209	181
Spain	34	33	37	12	17	28	48	109	26	18	20	9	12	25
France	2936	2873	3101	2728	2479	2368	2359	2060	2284	2292	2024	1919	1677	1518
UK	123	22	115	191	226	111	111	241	380	389	1282	1333	1067	1628
Ireland	92	42	128	248	190	232	317	221	310	336	367	425	524	411
Netherlands		0			0	6	1	1	4	0	3	1	0	
Total	3426	3195	3579	3344	3080	2909	3064	2868	3219	3176	3948	3881	3489	3763

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	2018
Belgium	10	13	13	18	24	28	28	32	23	26	27	32	26	25
Spain	355	338	327	460	445	302	303	472	54	92	130	239	498	369
France	1229	1247	1352	1382	1117	1085	1000	912	883	720	734	705	671	698
UK	3						0	2						
Total	1597	1598	1691	1863	1586	1415	1330	1418	960	838	891	976	1195	1092

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	2018
France	1	1	1	1	1		0	0	0	0	0	0	0	0
Spain	297	333	327	272	229	336	354	555	577	464	417	398	505	504
Portugal	568	591	595	546	535	522	551	544	520	521	554	589	619	530
Total	866	925	923	819	765	858	905	1099	1097	985	971	987	1124	1035

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 2017.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
France	.	.	.				0.1	0	0.4	0.05	0.02	0		0.26	0.13	0	0
Spain	9	1	.	0.1	2.9	0.4							0				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	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 2017.

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Subarea 8	France										1	1	2	2	3	0	0	1	0	1			0	0
	UK																1							
	Spain							4	3	6	36	46	67	74	53	21		8	13	49	47	37	34	44
	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	44
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	31
	Spain										17	22	37	29	22	3		0	2	5	76	104	90	106
	Total	17	17	16	20	37	29	35	29	57	53	50	61	41	38	10	2	2	3	25	101	130	124	137
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	31
	Spain	0	0	0	0	0	0	4	3	6	53	68	103	103	75	24		8	15	54	123	141	124	150
	Spain (Basque Country)	4	3	6	2	3	1	1	1	1	*	*	*	*	*	*	*	*	*	*	+	*	*	
	France										1	1	2	2	3	0	0	1	0	1			0	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	181

*** 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	1864	534	N.A.	8616		11014
2016	1072	389	69*	8821		10351
2017	699		0	6102		6812
2018	686	744	0	5574	52	7056

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
2017	251		40		291
2018	242	0	31		273

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.

Year	*G. melastomus*	*G. melastomus*	*S. canicula*
	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

Table 25.4 Black-mouthed dogfish in subareas 6 and 7. Assessment summary. Biomass index from the SpPGFS-WIBTS-Q4 trawl survey (in kg tow^{-1}).

Year	kg tow^{-1}
2001	5.40
2002	7.16
2003	11.33
2004	18.52
2005	22.74
2006	14.59
2007	17.91
2008	19.46
2009	24.31
2010	29.91
2011	26.04
2012	59.03
2013	43.76
2014	51.09
2015	62.88
2016	54.14
2017	38.49
2018	61.35

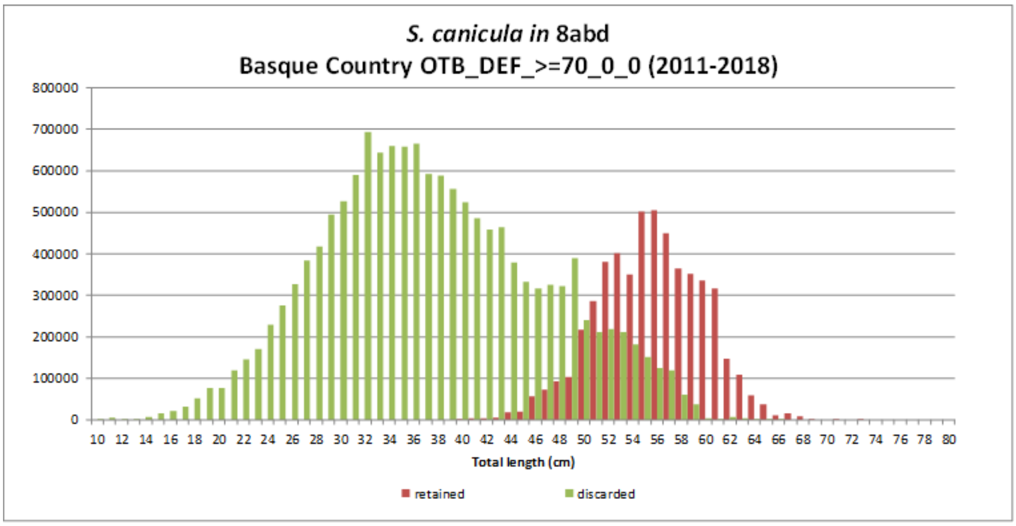

Figure 25.1. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length frequencies of *S. canicula* retained (in red) and discarded (green) recorded from the trawl fleet of the Basque country from 2011 to 2018 in ICES divisions 8.a-b, d.

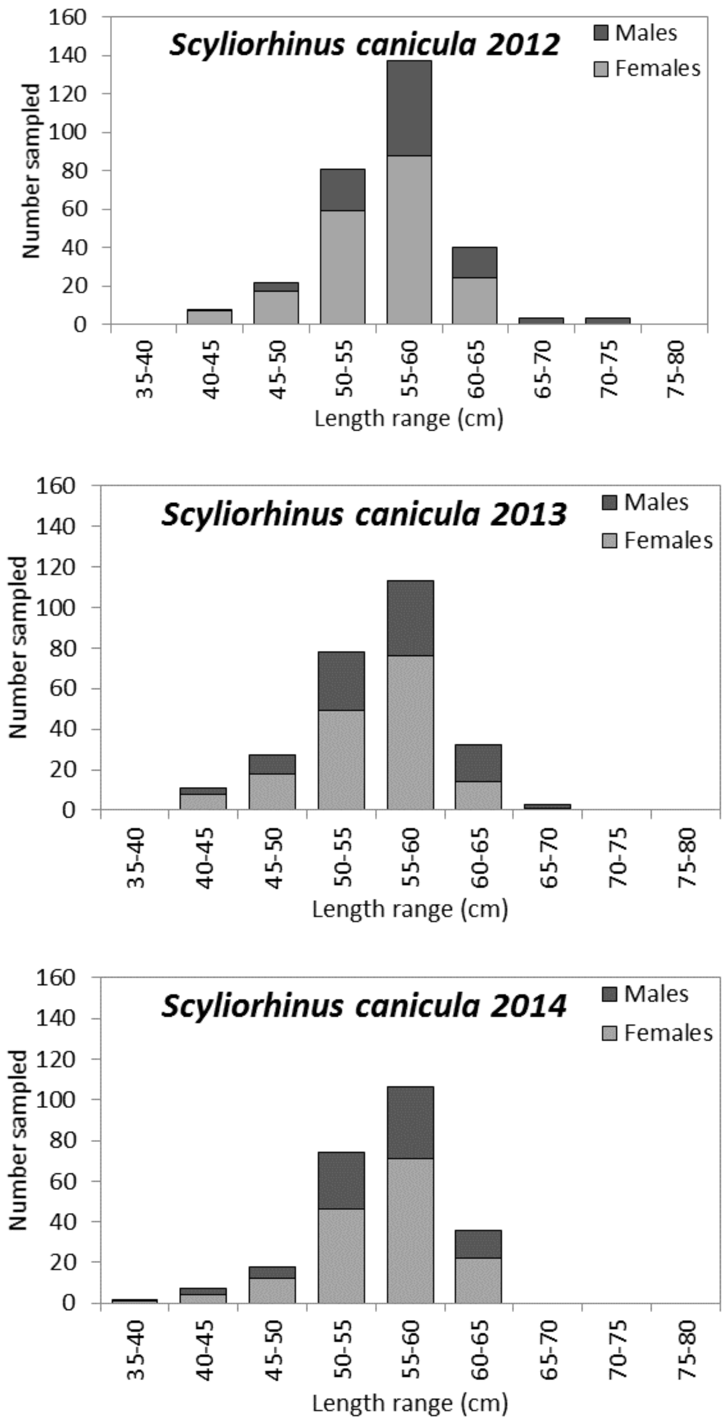

Figure 25.2. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length–frequency distribution of *S. canicula* measured during a pilot market sampling programme of the Dutch beam trawl fleet (2012–2014).

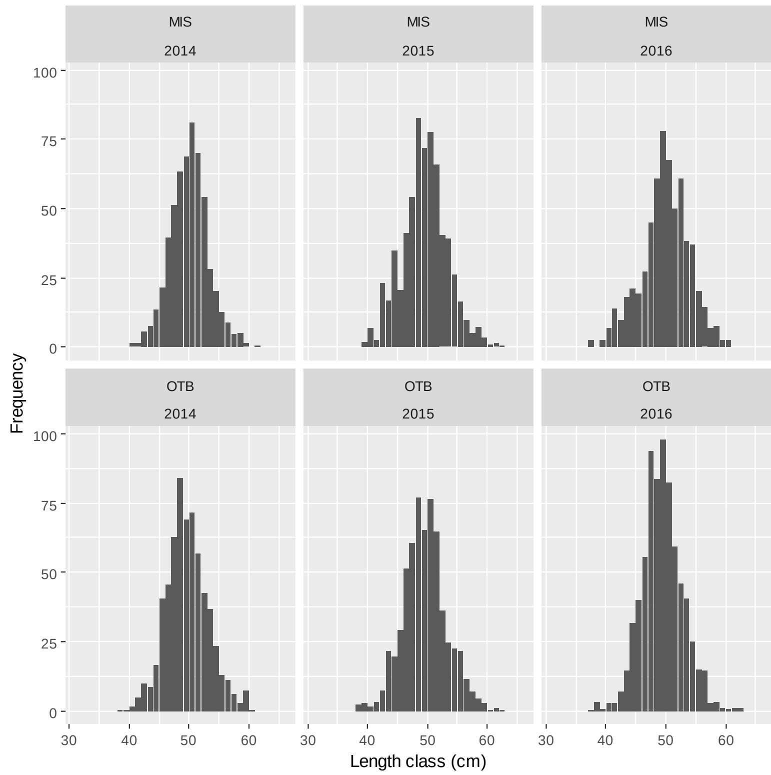

Figure 25.3a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length–frequency distribution of *S. canicula* from specimens sampled at Portuguese landing ports from artisanal (MIS) and trawl (OTB) fleets (2014–2016).

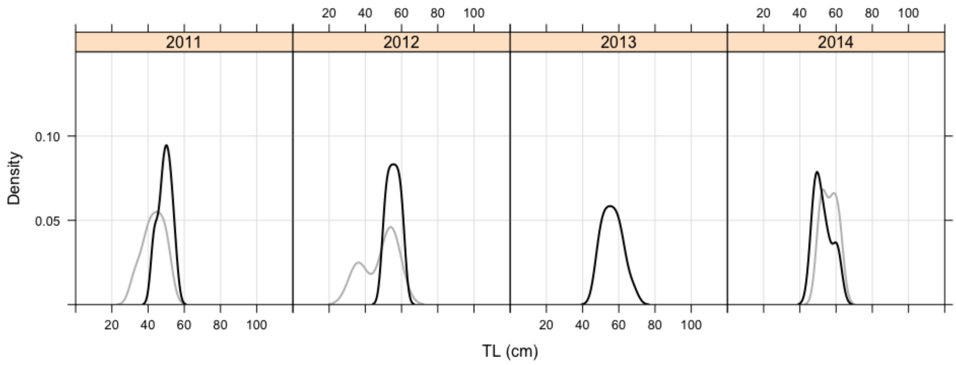

Figure 25.3b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length frequency distribution of *S. canicula* retained (black) and discarded (grey) fractions observed onboard vessels using set nets, between 2011 and 2014. The length frequencies were not raised to the total landings. n = 227 sampled individuals.

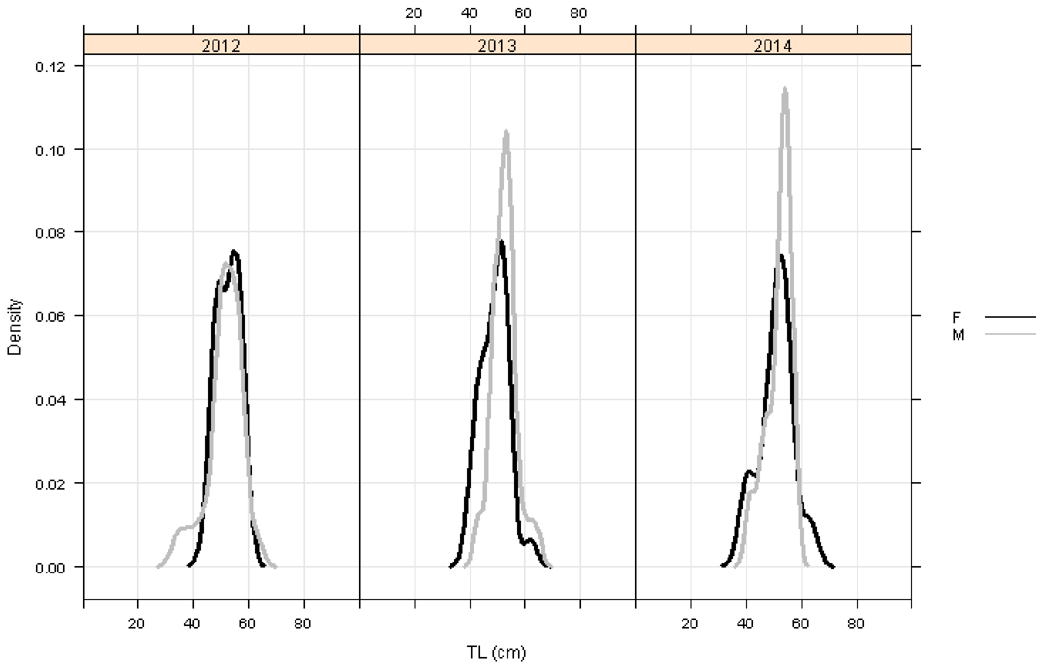

Figure 25.3c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length frequencies of *S. canicula* catches during the DCF pilot study on Portuguese trammel net fisheries (GTR_DEF_>=100_0_0; on-board sampling 2012–2014).

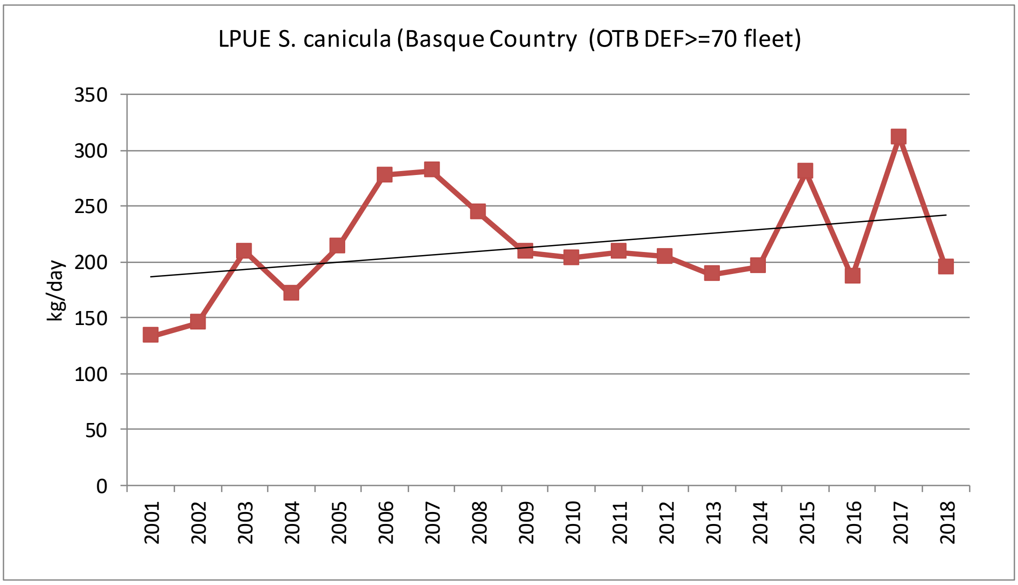

Figure 25.4. Landings per unit of effort data (LPUE) from the Basque Country trawl fleet (OTB_DEF_70) in ICES divisions 8.a-b, d) for *S. canicula*.

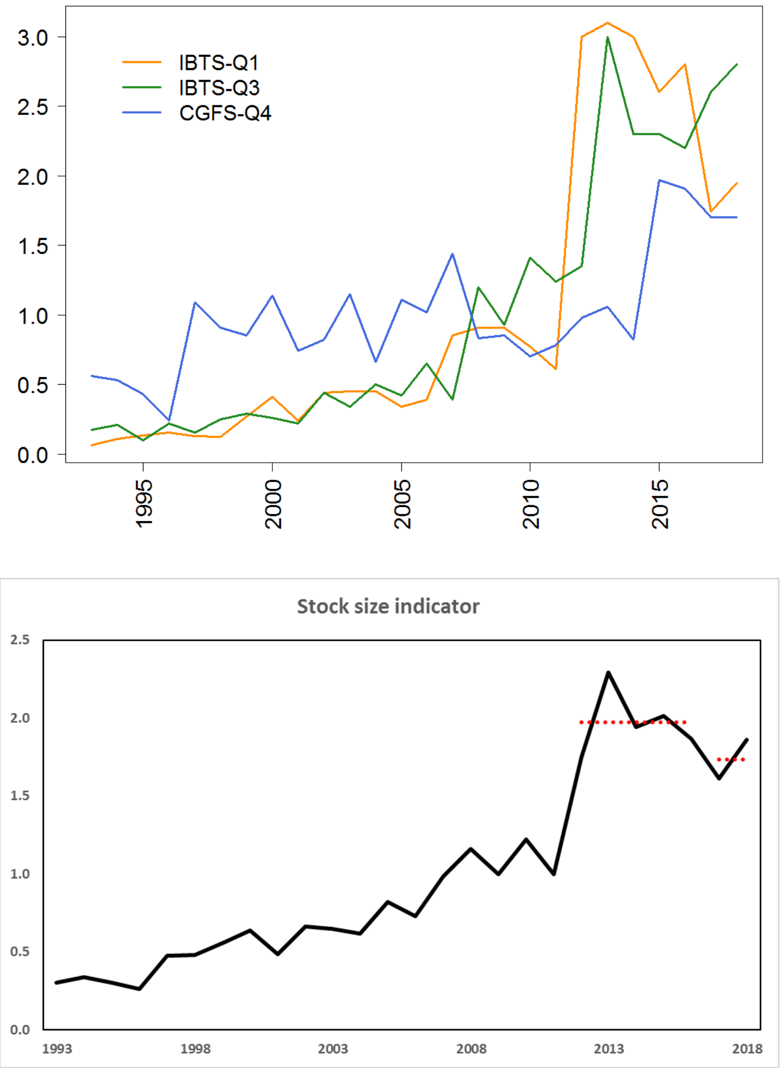

Figure 25.5a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus canicula* in the North Sea, Skagerrak, Kattegat and eastern Channel. Standardised survey indices from four surveys IBTS-Q1, IBTS-Q3and CGFS-Q4 (top) and overall stock size indicator (bottom) for the time period 1993–2018. Dotted lines indicate the average of the last two years and the average catch for the preceding five years.

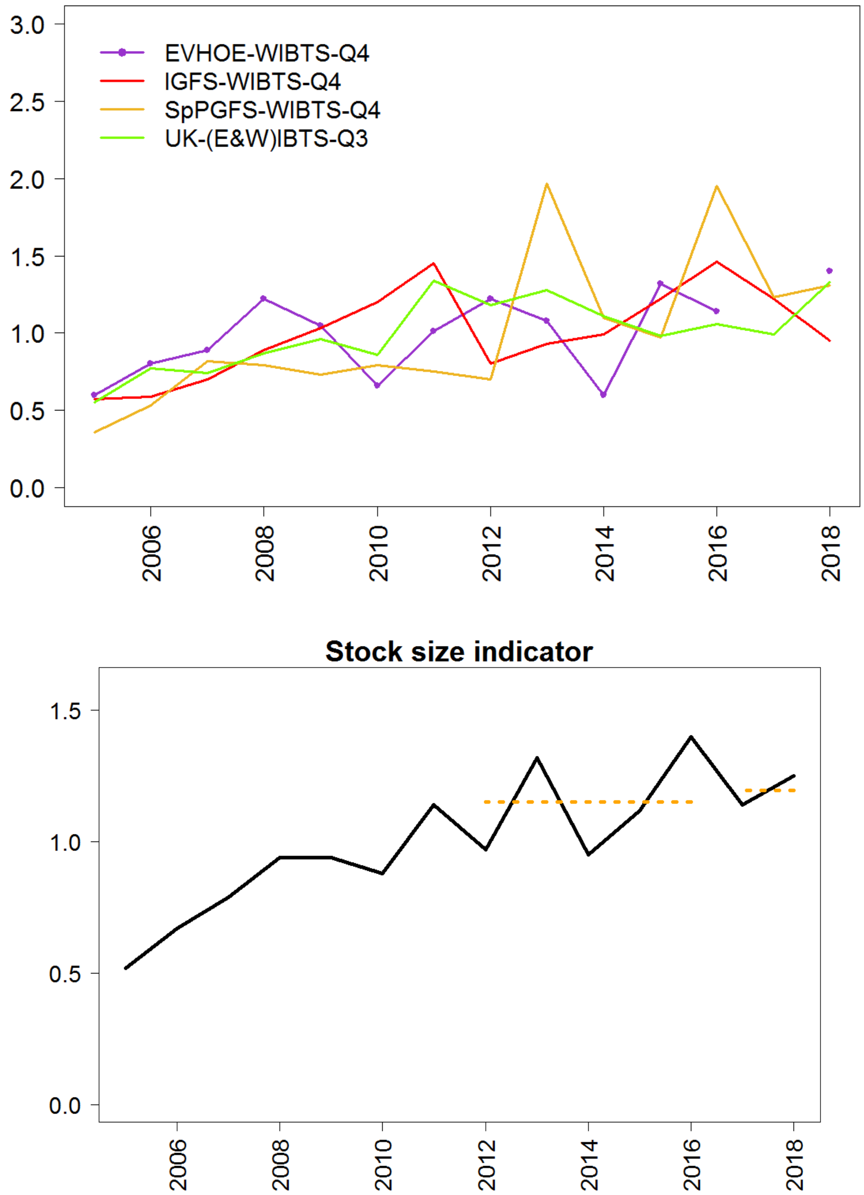

Figure 25.6a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus canicula* in the Celtic Seas Ecoregion. Standardised survey indices from four surveys IGFS-WIBTS-Q4, Spanish Porcupine Bank survey SpPGFS-WIBTS-Q4, UK-(E&W)-BTS-Q3, EVHOE-WIBTS-Q4 (top) and overall stock size indicator (bottom) for the time period 2005–2018. Dotted lines indicate the average of the last two years and the average catch for the preceding five years.

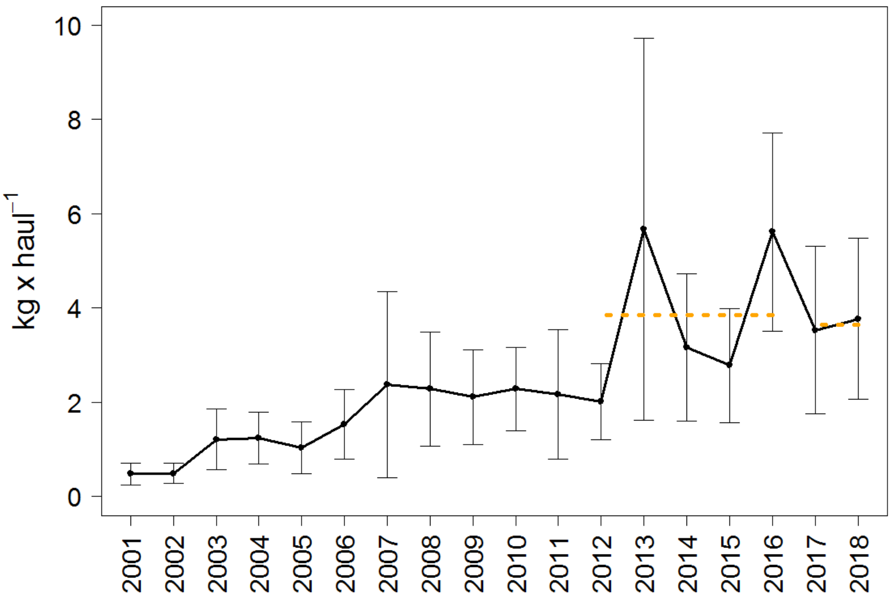

Figure 25.6b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in the *S. canicula* biomass index during the Porcupine Bank survey (2001–2018). Vertical bars correspond to the associated 95% confidence intervals. Dotted lines compare mean stratified biomass in the last two years compared 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 divisions 8.a-b, d), as estimated from the EVHOE survey.

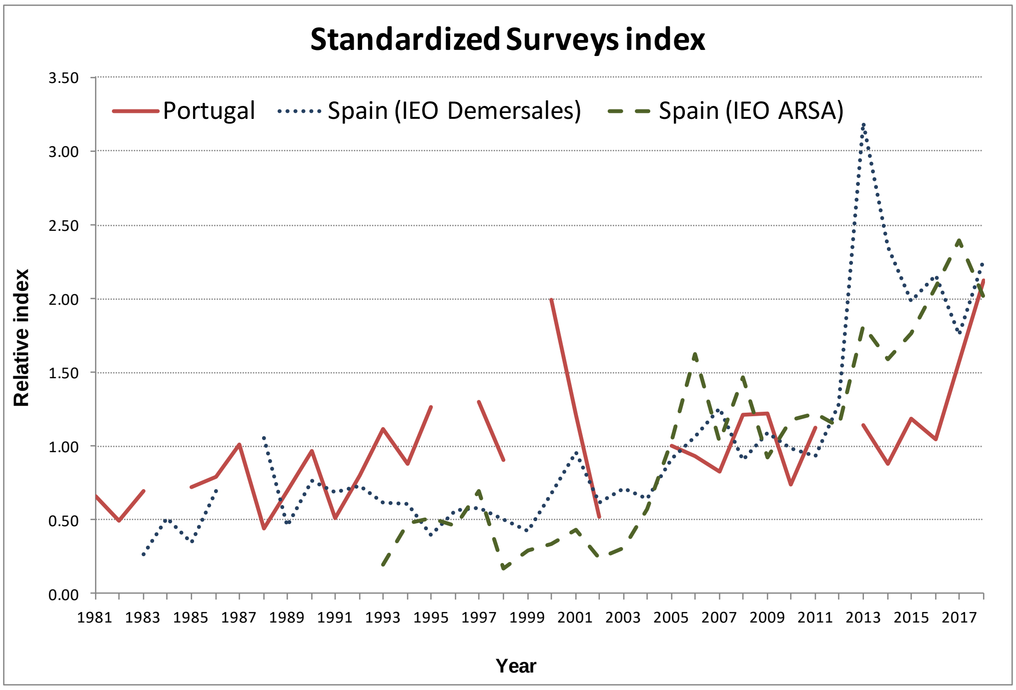

Figure 25.8a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus canicula* in the Atlantic Iberian waters (divisions 8.c and 9.a). Standardised survey indices from three surveys ARSA (average of spring and summer surveys), Portuguese PT-GFS and North Spanish Shelf bottom survey (top).

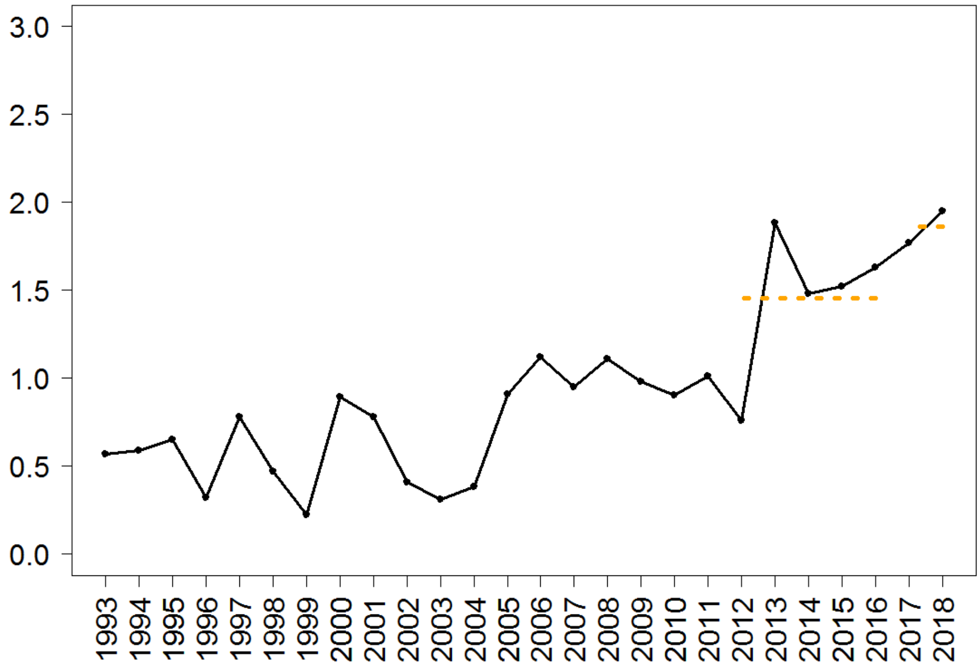

Figure 25.8b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus canicula* in the Atlantic Iberian waters (divisions 8.c and 9.a). Overall stock size indicator combined for these surveys (bottom). Dotted lines indicate the average of the last two years and the average catch for the preceding five years.

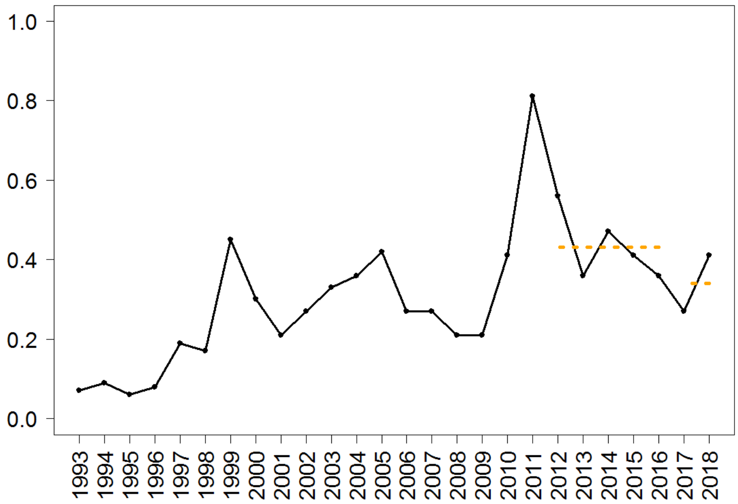

Figure 25.9. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus stellaris* in subareas 6 and 7 (Celtic Seas and West of Scotland). Overall stock size indicator from UK (E&W)-WIBTS-Q3. Dotted lines indicate the average of the last two years and the average catch for the preceding five years.

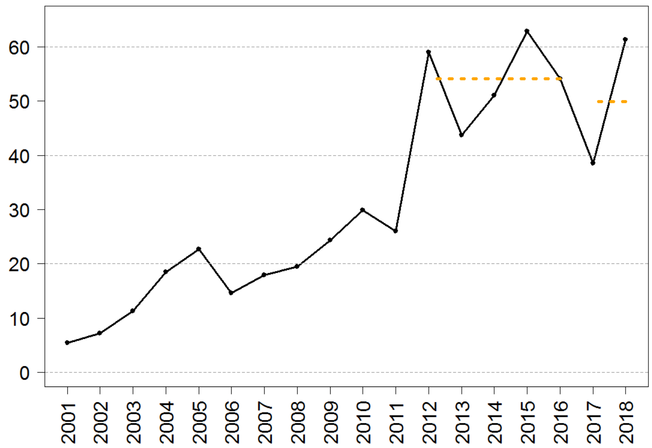

Figure 25.10. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in the biomass index in kg per haul of *Galeus melastomus* during the Porcupine Bank survey SpPGFS-WIBTS-Q4 (2001–2018). Dotted lines compare mean stratified biomass in the last two years and in the preceding five years.

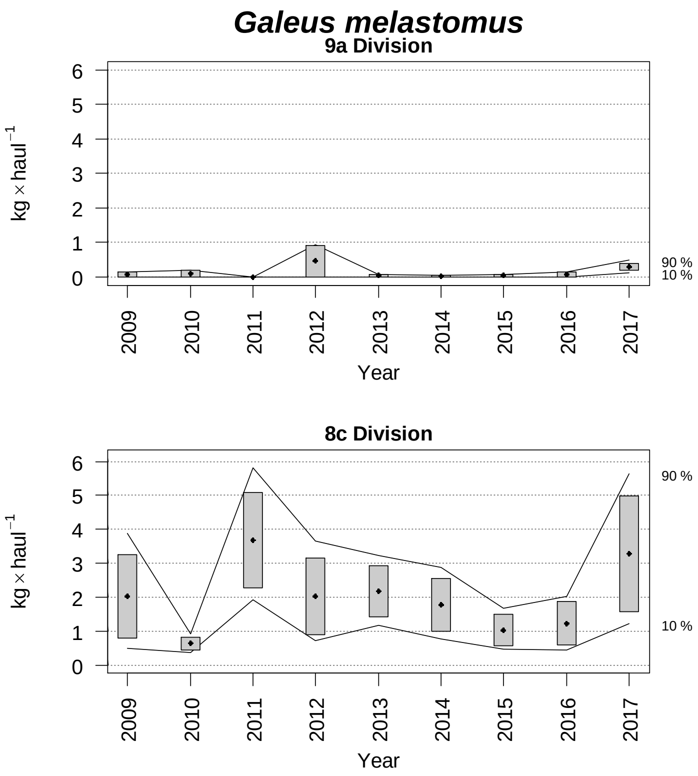

Figure 25.11a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in *Galeus melastomus* stratified biomass index (only with standard hauls between 70 and 500 m) during the North Spanish shelf bottom trawl survey (SpGFS-WIBTS-Q4) between 2009 and 2017 in the two ICES divisions. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (P = 0.80 bootstrap iterations = 1000).

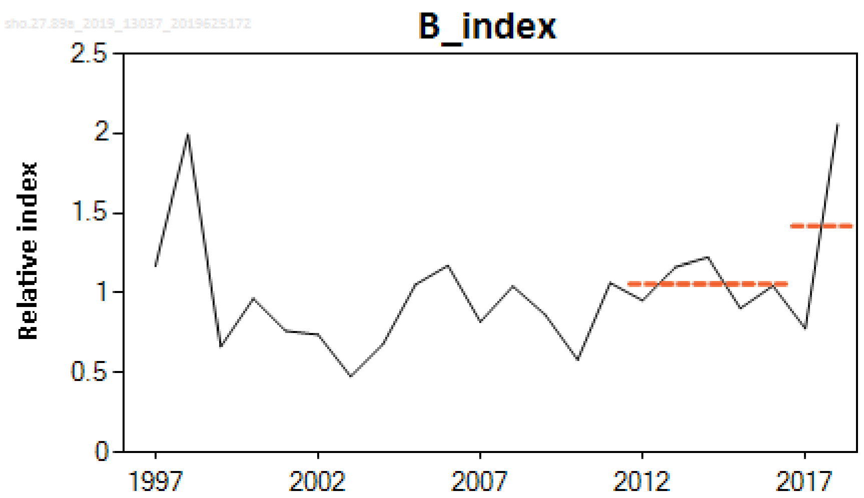

Figure 25.11b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Galeus melastomus* in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian Waters). Standardised survey indices for ARSA (SpGFS-GC-WIBTS-Q1-Q4), Portuguese 9.a (PT-CTS UWTV (FU 28-29)), and EVHOE-WIBTS-Q4. Dotted lines indicate the average of the last two years and the average catch for the preceding five years.

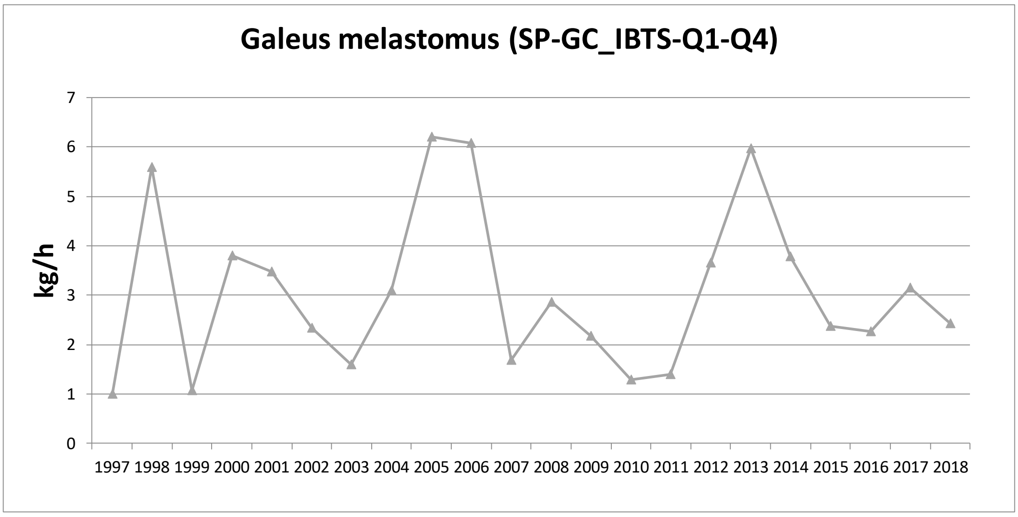

Figure 25.11c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Temporal trends in the biomass index during the South Spanish shelf bottom trawl survey (ARSA) in the Gulf of Cadiz ICES Division 9.a) time-series (1997–2018) in Division 9.a. Average Biomass Index of the spring Q1 (top) and autumn Q4 (bottom) surveys respectively.

26 Other issues

26.1 ToR j: NEAFC-OSPAR Special Request for advice on deep sea sharks, rays and chimaeras

Introduction

This Sections addresses WGEF ToR j):

j) Address the joint special request from NEAFC-OSPAR for advice on deep sea sharks, rays and chimaeras following the process agreed by WGEF experts, clients and ACOM:

  i) Screening of data received from ICES Member States on occurrence of deep water sharks, skates and chimaeras on the extended list provided in the request.

  ii) Advance on part of request pertaining to the bycatch and mitigation measures and allocate work for the rest of the request.

  iii) Formulate ToR for a WKSHARK6 meeting to be held in early 2020.

This joint NEAFC/OSPAR advice request to ICES is intended to "generate a scientific knowledge basis that can be used as ICES information/advice by both organizations when respectively considering possible future measures, each within their competence. Using the same scientific information will provide common understanding of species status and could help facilitate respective efforts by the two conventions in aiming to ensure healthy populations of deep-sea elasmobranchs. While the main focus should be on elasmobranchs, it is also requested that deep-sea rays and chimaeras be considered in order to develop a general understanding of the distributions and ecological roles of all deep-sea elasmobranchs."

The Special Request asks that "The primary deliverable should be species distribution and relative abundance maps for the relevant deep-sea elasmobranchs species based on best available knowledge. Important outcomes of the exercise could be identification of key areas (cf. hot spots) for the species and a more detailed and accurate understanding of their general distribution and their critical habitats."

In order to address this request ICES has identified a two-year work process which will include a workshop early in 2020.

26.1.1 (i) Screening of data received from ICES Member States on occurrence of deep water sharks, skates and chimaeras on the extended list provided in the request

A questionnaire has been developed to send to experts to gather information on existing management measures, legislation and relevant surveys in order to decide how future management should be. It was asked if measures should be specific to fleet, species/taxa or to habitats and what human induced pressures could impact the life-cycle of the species.

Questionnaire for the OSPAR/NEAFC request on deep sea sharks, chimaeras and rays, following consultation with relevant ICES Working Groups.

1. Management measures should be at national or regional level?
2. Should be tailored to species, taxa, or fleet?
3. Should be habitat specific?
4. Are you aware of relevant national surveys that gather data on these species?
5. Are you aware of legislation that makes reference to bycatch?
6. Assuming that TAC-0 on the deepwater TAC and quota regulation for deep sea sharks prevent the landings but may promote discards, what **other specific measures** (even if need further scientific evaluation) could be adopted to mitigate bycatches of deep sea sharks, rays and chimaeras?
7. What human activities (other than fisheries) have a significant impact on the life-cycles of these species?

Responses to this questionnaire by WGEF 2019 members and previous ICES Advice (see TAC-MAN, EU request for ICES to provide advice on a revision of the contribution of TACs to fisheries management and stock conservation for selected deep-water stocks, ICES 2018) will feed into the WKSHARK6 in January 2020 to address the request questions in relation to management meassures and mitigation of bycatch. **At this point this opinions do not constitute ICES Advice**.

This is ongoing and the results will be presented at the 2020 WKSHARK6 workshop. The preliminary responses following discussions with experts are show below.

Summary of preliminary responses:

Question 1. Management measures should be at national or regional level?

Question 1 aims to inform about the framework in which measures should apply.

Measures may be easier to implement on a national level. However, the biology of species affected, which are widely distributed, and the nature of the fisheries call for regional level management. Therefore, management measures should be tailored taking into account the species biology, population structure and the geographical distribution of the species and fisheries. National or EU level legislation should support regional or international coordinated action.

Question 2. Should be tailored to species, taxa, or fleet?

Question 2 aims to inform about the nature of the management measures.

This is a multi-species problem with species that are often bycatch in other target fisheries at different depths. Measures should therefore be by fishery and hence by gear (bottom trawl, longline, net, etc.). Measures should also take into account that this species are often misreported/misidentified and that discards data is often unknown according to ICES advice. In addition, elasmobranchs with different status of vulnerability may need additional species-specific measures.

Question 3. Should be habitat specific?

At the moment, ICES has not enough information to answer this. All we have control of is the fishery, so we focus on that. However, this request may be the first step to offer alternative options. Some habitat specific options may be identified from the compilation of survey data and maps generated in WKSHARK6. In the future trade-offs options may be generated by defining vulnerabilities and impacts together with distribution maps.

Question 4. Are you aware of relevant national surveys that gather data on these species?

For this a table will be created and onboard observations and other projects will be included.

Question 5. Are you aware of legislation that makes reference to bycatch?

All the deepwater sharks are subject to 0-TAC advice under the deepwater TAC and quota regulation (EU2019/124). That effectively is a license to discard them (dead because survival from being caught at such depths is very low). The legislation is not designed to mitigate by-catch.There is also an allowed by-catch in target fisheries for other species e.g. black scabbardfish fishery, and again this is a license to discard the sharks, with low probability of survive. This was meant to inform management and evaluate how to minimize bycatch.

There are EU bans on deep-water gillnets below 600 m and bottom-trawling in waters deeper than 800 m implemented since 2016. This legislation was in part designed to reduce bycatch. However, long-lining is not subject to depth or spatial limits and could target deep-water sharks. However, at regional level other legislations may apply (in Norway, Iceland, Russia, etc...).

Question 6. Assuming that TAC-0 on the deepwater TAC and quota regulation for deep sea sharks prevent the landings but may promote discards, what **other specific measures** (even if need further scientific evaluation) could be adopted to mitigate bycatches of deep sea sharks, rays and chimaeras?

Bycatch mitigation measures are difficult to implement for chondrichthyans since many species would fall in a similar size range as the target species in mixed fisheries (exemptions include the greenland shark *Somniosus microcephalus*). Possible yet to be evaluated mitigation measures may be deterrent measures “triggering” electromagnetic senses of elasmobranchs (hook material, net material etc.), as well as acoustics and light-based technologies.

Avoidance

The most efficient way to reduce bycatch is to avoid catching the fish in the first place. Avoidance has featured very little in bycatch studies but should be considered when developing bycatch mitigation measures. It might be necessary to trial new methodologies or to improve knowledge on where to best deploy fishing gears. For example, identify and avoid known aggregation and nursery areas in specific seasons, and use of footage from ROVs to identify new nursery areas in conjunction with permanent or temporary closures.

Selectivity

Gear-based technical measures can be applied to improve the selectivity for sharks. For example, use of hooks at different depths, alternative hooks which and/or deployment of magnets on hooks, alternative mesh sizes and shapes, new materials, grids and escape windows to reduce bycatch. Novel grid panels designed to facilitate flatfishes (e.g. ‘Freshwind’ https://vimeo.com/channels/801304) may have potential to reduce some skates bycatches with similar body morphology. These measures should always be subjected to proper scientific evaluation.

Survival

Although deep-water elasmobranchs are unlikely to survive being fished from depth, it might be possible to identify ways of treating or handling sharks so that they have a higher chance of survival following return to the sea. Check with WGMEDS (Working Group on Methods for Estimating Discard Survival) before WKSHARK6.

Question 7. What human activities (other than fisheries) have a significant impact on the life cycles of these species?

It is difficult to assess other human activities of comparable direct effect to fisheries; however, other activities have indirect effects through oil spills, deep-sea mining, marine litter, contamination from heavy metals and POPs (persistent organic pollutants), electromagnetic fields from cables and underwater noise. Potentially, other indirect effects linked to environmental changes like increase temperatures and associated potential changes in species distribution, changes in ocean currents and therefore change in feeding grounds etc., are likely to increase in future years.

26.1.2 (ii) Advance on part of request pertaining to the bycatch and mitigation measures and allocate work for the rest of the request

- Data on life-history traits, incl. aggregating behavior, information from literature is being compiled.
- TACMAN information can be summarized to address the ToR on bycatch mitigation.
- One leader per country will be identified to complete surveys data call and review the data.

26.1.3 (iii) Formulate ToR for a WKSHARK6 meeting to be held in early 2020

The following ToRS were formulated.

The workshop **on the OSPAR and NEAFC joint advice request to generate species distribution maps for listed deep sea shark species and provide scientific support for ICES advice on bycatch management options (WKSHARK6),** chaired by Maurice Clarke (Ireland) will meet in Galway, Ireland from 20–24 January 2020 to:

a) Review the first drafts of the species distribution maps and, where possible, identify key areas for the species;
b) Review and, where necessary, update the table on overview of surveys;
c) Create a table with the following: complete list of species; overview of fleets taking the species as bycatch both past (from mid-1980s) until present; and area covered by the fleet (see also WKSHARK1)
d) Summarise ICES advice for species/stocks where applicable;

Start to formulate potential options that can contribute to improving the status of the species and mitigate bycatch (using information from questionnaire in WGEF Report 2019 and the "EU request for ICES to provide advice on a revision of the contribution of TACs to fisheries management and stock conservation" (TACMAN)).

This workshop is part of a 2-year process to answer the NEAFC/OSPAR request on Deep Sea Sharks, rays and chimaeras.

WKSHARK6 will report by 02 of March 2020 for the attention of FRSG and ACOM.

26.2 ToR h): potential joint ICES-ICCAT meeting

h) Further development of proposed ToRs for a potential joint ICES-ICCAT meeting in 2020 to (i) assess porbeagle shark and (ii) collate available biological and fishery data on thresher sharks in the Atlantic

Introduction

This section addresses WGEF ToR h):

h) Further development of proposed ToRs for a potential joint ICES-ICCAT meeting in 2020 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, had been proposed for 2019. However, ICCAT postponed the meeting in order to focus on an update of the shortfin mako assessment. WGEF provided advice on porbeagle in 2019, according to plan. At the ICCAT SCRS meeting in October the ICCAT Shark Working Group planned a porbeagle assessment for June 2020, in consultation with WGEF. Members of WGEF will attend part of this meeting to further discuss how to collaborate on a future assessment or a benchmarking process after 2020.

Detailed information on the porbeagle and both species of thresher shark is given in sections 6 and 11 of this report.

26.3 ToR f): Follow recommendations from WKSHARK5

Introduction

This section addresses WGEF ToR f):

f) Collate discard data from countries and fleets according to the ICES data call to follow recommendations from WKSHARK5 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;

These issues were also addressed at the WKSHARK5 meeting (ICES, 2019 (*in prep*)). The main outcomes from the workshop were:

Raising methods and data quality, discard retention and survival

During the meeting, the group looked at different observer data on discards and discussed raising procedures and developed scripts for these. The conclusion was that each country use different raising method adjusted to their fleets and sampling programmes. This is also the case with round fish. Case studies from the UK, Norway, France, the Netherlands and Belgium were presented.

In order to explore the robustness of different raising procedures given different data source for ToR a) two case studies on thornback ray (*Raja clavata*) in the North Sea were carried out, using data from The Netherlands and Belgium. For the case study from The Netherlands three different raising methods were compared:

1. raising discards of the stock to fishing effort, hp-effort or total landings of all species;
2. raising discards of the stock including bootstrapping;
3. regression model

The conventional method (1) and bootstrapping method (2) result in similar estimates, those derived from the regression model give higher results. It is not possible to infer a general procedure for all countries based on these results.

In the Belgian case study, four methods were compared:

1. raising of raw discard data by effort
2. raising of raw discard data by effort X engine power
3. raising of raw discard data by landings
4. spatio-temporal modelling of discards per unit effort

In general, the different raising procedures result in similar outcomes in terms of estimated quantities and width of the confidence intervals. However, the spatio-temporal showed a strong decline in discards per unit effort, which can be explained by the spatio-temporal dynamics of the observer programme. The comparison illustrated that this method seems to be more robust in situations where the spatio-temporal coverage of the observer programme is limited.

Evaluate and define the data quality and onboard coverage; discard retention patterns between fleets and countries; discard survival, as well as the definition of acceptable types/sources of data required for advice.

For ToR b) a matrix was developed, based on work from WGCATCH, to characterize and record each source of data (this is still work in progress) including quality checks.

In terms of acceptable sources of data and self-sampling programs, there is not any official ICES, nor expert group guidelines. However, minimum requirements used in other cases to accept industry collected data in assessments include:

- The time series must have a time-span of a minimum of five years.
- Normally new data always has to go through a benchmark (or interbenchmark) process before they can be included in the assessment. Generally, short updates are given each year on progress to the WGs and the scientist involved publish a working document for the benchmark/WG.

WKSHARK5 recommends that the same matrix as for on-board programmes is filled in and entries compared before accepting any new data.

While observer data are available from many countries, not all métiers are sampled to a level that can allow patterns in discard/retention ratios to be observed. Similarly, few métiers have been intensively sampled enough to allow changes in pattern to be determined. Otter trawl-based métiers have the most number of samples for almost all examined species. These are most likely to be of use in stock assessments. Whilst some nations have large samples sizes for various gillnet métiers, the length-distributions are influenced greatly by mesh size, which would need to be considered in future evaluations of length-based indicators.

Propose how to include discard information into the advisory process for elasmobranch fishes

The North Sea thornback ray (*Raja clavata*) was used as an example stock to test the raising procedure and advice method prepared in the other ToRs. Here the regular advice for 2018 and 2019 for *R. clavata* in Subarea 4 and divisions 3.a and 7.d based on previous landings is compared an advice for 2018 and 2019 when catch data would have been used. The advice was recalculated using an estimated discard rate of 0.34. The landings corresponding to the catch advice are 30% lower when this discard rate is applied. Issues, which could influence this estimate, such as survivability, discard retention and the length-frequency of catches and landings are discussed. It is recommended to develop a length-based model for future work on including discards in advice.

Species under a moratorium

In the ICES area some elasmobranch stocks have been under highly restrictive management measures, including being included on the EU list of prohibited species, and/or have had null TACs for several years. As a direct consequence of these restrictive measures, there is a lack of fishery dependent data. Current ICES DLS methods recommend catches or landings based on the previous advice or catches and the variation of a biomass index. In the situation where there was no or very small landings for several years in order to rebuild a larger stock, there is no ICES procedure to set the advice at a sustainable level.

Three different procedures were presented and their adequacy to provide scientific advice on sustainable catch when a species was under moratorium was discussed. These differ according to the sources and data availability, survey and/or fishery data (see report):

- No survey data but georeferenced catches derived from self-sampling programs to derive acceptable mortality.
- Deriving advisable landings for a species under moratorium based on biomass indices from a reference species:

$$Adv(mor) = \left[\frac{B\ (mor)}{B\ (ref)}\right] \times \frac{r(mor)}{r(ref)} \times Adv(ref)$$

- Long-time series survey and reliable historical catch with contrasting biomass/mortality periods:

$$F_{proxy} = \text{Yield/Survey biomass.}$$

The value and potential use of self-sampling data that do not meet the requirement listed in the above have to be scrutinized case by case. However, as these data may also provide ancillary information about the stock of concern such as the self-sampling data from French coastal vessels, which reported numbers of individuals and body lengths, even though this was only carried out during the first year of the programme).

(ii)) advise on how to include discard information in the advisory process

During WKSHARK5, a trial was carried out to include discard information in the advisory process (ICES, 2019 (*in prep*)). The landings information in the advice sheet for thornback ray North Sea stock for 2017 was updated with discard information and the assessment was recalculated. This resulted in a 30% decrease in landings advice. During the exercise, it was noted that not all countries had supplied discard data for the period covered (2009-2016) so this result was considered only as an indication.

At the WGEF meeting it was decided to include the discard information for the 2019 stock assessments according to the example carried out at WKSHARK5. Unfortunately, an overview of the available discard data was made and it was noted that there were a high number of discrepancies between years and data were also missing. It was decided by the group that the discard data available to the group are not of sufficient quality to use in the assessments at this stage. Moreover, the issues exposed by both WKSHARK5 and WGEF are too complex to be solved during a workshop or working group meeting and will require a concerted effort to solve. WGEF recommends to initiate a collaborative project to address this issue and has formulated a Recommendation for ICES to initiate a dialogue with DG Mare to explore the possibility of funding to support a project to address the serious issues surrounding the collection and registration of discard data, as well as how to include survivability, in order for the data to be used in future stock assessments.

26.4 ToR g): MSY proxy reference points

Introduction

This section addresses WGEF ToR g):

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

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.

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 this analysis is available in Miethe (2019, WGEF WD). An overview with general conclusions is presented here.

26.4.1 Methods

The Workshop on the Development of Quantitative Assessment Methodologies based on Life-history traits, exploitation characteristics, and other relevant parameters for stocks in categories 3–6 (WKLIFE VIII) met in Lisbon, Portugal, 8-12 October 2018, to further develop methods for stock assessment and catch advice for stocks in categories 3-6. The resulting ICES report includes a section specifically dedicated to an elasmobranch life history (ICES (2018a); section 5, Annex 1). The performance of advice rules using length-based indicators and MSY proxy reference points to manage elasmobranch fisheries were investigated within an MSE framework. An operating model was built based on the Cuckoo ray life history from the Irish Sea, with alternative scenarios for size of capture relative to size of maturity and advice rules. Discussions and further work recommended by external reviewers during the workshop resulted in the following recommendations of an advice rule for bycatch elasmobranch stocks:

$$TAC_{y+1} = TAC_y * r * f \tag{1}$$

Table 1. Definition and use of advice rule in equation 1

Component	Definition and use
r	The rate of change in the catch-per-unit-effort (CPUE) based on the average of the two most years of recent data (*y*-2 to *y*-1) relative to the average of the five years prior to the most recent two (*y*-3 to *y*-7), termed the "2 over 5" rule.
f	The ratio of the mean length in the observed catch above the length of first capture relative to the target reference length ($L_{F=M}$). At high data variability, a recent year average of the ratio can be considered.
Stability clause	Limits the amount the TAC can change upwards or downwards between years. The recommended values are +5% and -25% where the TAC would be limited to increase by 5% or decrease by 25% relative to the previous year's TAC.

Further details of the analyses are summarized in the following sections.

26.4.2 Fisheries selectivity

In initial simulations, an advice rule was tested based only on the ratio of mean length and its reference point (f)

$$TAC_{y+1} = TAC_y * f. \tag{2}$$

The results indicated that the advice rule is sensitive to the value of length at capture L_c. Fishing only on mature individuals of the stock (L_c>L_{mat}) ensures successful recovery of an overexploited stock in simulations using this simple advice rule. In contrast, the risk of stock collapse remains high when L_c is below the length at maturity, L_{mat}. The reference point $L_{F=M}$ appears to be inappropriate at low values of L_c which confirms results by Jardim *et al.* (2015). The assumption of F=M on all exploited length classes in the calculation of the mean length reference point $L_{F=M}$ leads to different overall exploitation levels with varying number of fished size classes (varying value of L_c). At L_c<L_{mat} more individuals are subject to fishing at F=M, increasing the overall exploitation level as compared to a scenario with L_c>L_{mat}. If possible, the fishery should be managed such that L_c>L_{mat}. However, for many bycaught elasmobranchs stocks L_c is typically lower than L_{mat} (ICES, 2018c). If the fisheries' selectivity cannot be altered, the probability of the stock declining below SSB thresholds can be reduced including information of the trend in a CPUE index (reflecting trends in stock biomass) and the mean length ratio in the advice rule (equation 1).

The reference point $L_{F=M}$ is calculated with the assumption of asymptotic, knife-edge selectivity. Therefore, it is assumed that there is no exploitation on individuals smaller than L_c. For indicator calculation L_c is often defined as the length at 50% of the mode of the size distribution approximating the inflexion point of the selectivity ogive (Jennings *et al.*, 2001; ICES, 2012). Alternatively, L_c has been calculated as the mode of the size distribution representing the maximum selectivity of the ogive and full selectivity (ICES, 2018c; ICES, 2018b). Overestimating L_c, in particular when using the mode of the distribution, should lead to overestimated reference points thereby reducing the risk to fall below biomass thresholds when applying the advice rule.

At dome-shaped selectivity, largest individuals are subject to lower/no fishing mortality. This can be due to spatial segregation of life stages and spatial limitation of fisheries relative to the stock distribution. Under dome-shaped selectivity, larger individuals are missing from the catch and the observed mean length is lower than expected from asymptotic selectivity. In this case, an advice rule based on asymptotic selectivity would lead to a lower risk to fall below biomass thresholds as the lower observed mean length in the catch will trigger a stronger downward TAC adjustment (and potentially a loss of yield). It is recommended to confirm the selectivity assumptions.

26.4.3 Spawning stock recruitment relationship

In elasmobranch life history, recruitment is closely linked to the number of mature females. As recruitment decreases with decreasing number of mature females in the population, the potential of replenishment by large incoming cohorts is small limiting the recovery potential from overfishing (Cailliet *et al.*, 2005). Instead of maximizing yield, the focus of management for elasmobranch stocks should therefore be on the protection of the reproductive potential.

The MSY proxy reference point, $L_{F=M}$, relies on the assumption that recruitment is constant overtime. However, the steepness of the stock-recruitment relationship critically influences the performance of the advice rule. A Beverton-Holt spawner-recruitment relationship was applied, directly linking mature females to recruits. An alternative parameterization of the stock-recruitment relationship developed specifically for elasmobranch life-histories has been suggested (Taylor *et al.*, 2013) and was included in further simulation testing. In comparison, the selected Beverton–Holt relationship showed a stronger reduction in recruitment with decreasing stock size as expected for elasmobranch life histories. Therefore, simulations to test advice rules were performed using Beverton-Holt relationship linking the number of mature females to recruitment. If the simulated recruitment is relatively constant or decreases little with decreasing SSB, the advice rules are expected to perform better in the simulations and can lead to overly optimistic results. In contrast, with a strong reduction in recruitment with decreasing SSB, the advice rule would perform worse. This can be explained by the fact that under strongly decreasing recruitment, the overexploited stock cannot replenish itself easily and furthermore a lack of small individuals in the catch affects indicator calculation under non-equilibrium conditions (slightly increasing mean length in the catch and ratio *f*).

26.4.4 Misspecification of the reference point

A misspecification of natural mortality M to calculate the reference point $L_{F=M}$, can lead to changes in the performance of the advice rule, in terms of risk to fall below biomass thresholds. If M is significantly underestimated, the reference point is calculated with the assumption of higher survival leading to more extended equilibrium size distributions at F=M, and the respective reference point value of $L_{F=M}$ will be overestimated. With overestimated reference points the advice rule will lead to a lower risk to fall below biomass thresholds, as the stock is managed to achieve larger mean lengths in the catch. In contrast, if M is overestimated, the unexploited length distribution of an unexploited stock is expected to be more truncated at F=M, and the respective reference point is underestimated. An overestimation of M would lead to a higher level of advised fishing mortality and a higher risk of stocks falling below biomass thresholds. The misspecification of M directly changes the M/k ratio which describes the shape of the expected length distribution for a particular stock and enters the calculation of $L_{F=M}$ (Hordyk *et al.*, 2015; Jardim *et al.*, 2015). Similarly, any other parameter misspecification, of k or L_c, which leads to underestimation of the reference point can affect the performance of the advice rule and increase the risk of a stock to fall below biomass thresholds.

In elasmobranch stocks, often dimorphic growth between the sexes is observed. It is therefore recommended to calculate the reference point based on the biology of the larger growing sex (with larger L_∞).

26.4.5 Data quality

For the advice rules to perform properly, observation data should be of high quality. Sampling of length distributions should be unbiased and representative of total catches of all major fleets. The reliability of the observed catch length distribution is influenced by the sample size. At low sample size, the number of sampled individuals from rare size classes is likely to be more variable leading to variable indicator values and variable estimates of L_c. Sufficient sampling should be ensured. To reduce the effect of data variability, the indicator ratio to be used in the advice rule can be calculated as a recent year average.

The performance of the harvest control rule is also dependent upon the accuracy of the CPUE index, which is used to identify the recent trends in the stock biomass or abundance. An advice rule based on the trend on the CPUE index using the average of the previous two years relative to the average of the preceding five years (2-over-5 rule) performed better than an advice rule using the average of the previous two years relative to the average of the preceding 3 years (2-over-3 rule). Applying index rule in the advice rule covering trends over a longer time period is advised (2-over-5 rule), as longer-term reductions in the CPUE index will have a stronger effect on the TAC adjustment. The longer term dynamics are important in particular for stocks with a long generation time.

Simulations with higher observation error showed that a highly asymmetric stability clause governing the percentage of change allowed in the TAC between years was beneficial to the performance of the advice rule. The advice rule should be able to apply larger reductions to the TAC based on the CPUE and length data when warranted relative to amount allowed for increases in the TAC. The recommended asymmetric stability clause allows for TAC reductions up to 25% downwards but limits an increase by up to 5% in the TAC for next year relative to the current year's TAC. This limits the probability of overshooting the sustainable catch, while allowing for strong reductions in TAC in any case.

26.4.6 Frequency of assessment

When comparing simulation scenarios with different assessment frequencies, it was found that the more frequent biennial assessment and update of the TAC advice performed better than a quadrennial assessment. A more frequent TAC adjustment led to reduced variability in SSB between simulations. In an overexploited stock, more frequent adjustment allowed a stronger reduction in TAC overtime and a faster stock recovery.

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Annex 1: List of participants

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Annex 2: Recommendations

Recommendation	Addressed to
One of the recurring issues at the WGEF meetings is the **data call** and availability and quality of data. The WGEF data are not submitted to InterCatch, but the group has developed a landings/discard spreadsheet and table in which the data are arranged for ease of assessments. However, there are continuing issues with how the data call is interpreted leading to non-uniform data sets. This results in the WGEF data coordinator, group members and the data deliverers investing time to create a coherent database for the assessments. During the 2019 meeting the entire process and the use of the spreadsheet table were discussed at length and solutions were suggested. *WGEF recommends to hold a meeting on the landings/discard table used by WGEF with a small dedicated group, and including input from the ICES Data Centre prior to the 2020 data call.*	ACOM
During the assessments a number of discrepancies in the **survey** database such as faulty survey indices in DATRAS, were highlighted and the choice of surveys and survey data to be used for each stock assessment was discussed. For the assessment methods, it was discussed to standardize and revise methods for calculation of indicators. As this is fundamental to the work of WGEF, it was decided that there should be a workshop (WKSKATE) on the use of surveys in the stock assessments prior to the 2020 WGEF meeting. This is a large task and will be staggered, with a meeting in 2020 for the stocks to be assessed in that year, and another one in 2021 for the other stocks. Once the recommendation has been passed, the ToRs for the workshop can be drafted. *WGEF recommends to organise a stand-alone workshop on the use of surveys for the assessment of elasmobranch fishes (WKSKATE), together with survey experts (not necessarily WGEF members), and together with the ICES Data Centre, either just prior to the regular WGEF meeting or earlier in the year.*	ACOM
Despite having had two dedicated workshops on the use of discard data in stock assessments (WKSHARK 3 and WKSHARK5), it is still not possible to move forward on this issue. An overview of the available discard data has shown that there are a high number of discrepancies between years and data are inconsistent or missing. It was decided by the group that the discard data available to the group were not of sufficient quality to use in the assessments at this stage. Moreover, the issues exposed by both WKSHARK5 and WGEF are too complex to be solved during a short workshop or during the working group meeting and will require a concerted effort to solve. WGEF recommends to initiate a collaborative project to address this issue *WGEF recommends that a wider process is needed to address the serious issues surrounding the collection and registration of discard data and to evaluate the use of discard data, including survivability, for the application in future stock assessments.*	ACOM

Annex 3: Terms of Reference for next meeting

WGEF – Working Group on Elasmobranch Fishes

The **Working Group Elasmobranch Fishes** (WGEF), chaired by Jurgen Batsleer* (Netherlands) and Pascal Lorance* (France), will meet in Horta, Azores, Portugal, from 16–25 June 2020 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 2020 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 2021;

e) Collate landings and discard data from countries and fleets according to the ICES data call to follow recommendations from WKSHARK5 to: (i) address the following issues: data quality and onboard coverage; raising factors; discard retention patterns between fleets and countries; discard survival; (ii) advise on how to include discard information in the advisory process; and (iii) develop a coherent data-base for landings/discard information used in the assessments.

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

g) Further develop the ToR for the proposed joint ICCAT-ICES meeting in 20XX to (i) assess porbeagle shark and (ii) collate available biological and fishery data on thresher sharks in the Atlantic;

h) Work intersessionally to draft/update stock annexes and then develop a procedure and schedule for subsequent reviews.

i) Review and complete the work done by WKSHARK6 in order to answer the special request from NEAFC-OSPAR for scientific advice on deep sea sharks, rays and Chimaeras.

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 10 August 2020 for the attention of ACOM.

Annex 4: Audits

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

Date: 11 September 2019
Auditor: Bárbara Serra Pereira

General

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: Survey-based trends (ICES, 2019)
3) **Forecast**: No forecast.
4) **Assessment model**: No assessment model
5) **Data issues:** The CGFS-Q4 has used a larger trawl since 2015 and the results of intercalibration studies have been used to adjust the stock size indicator (ICES, 2017). A problem with duplication of data in DATRAS product was found with the UK BTS Q3 data. A retrospectice analysis of the index from 1993-2018 was carried out and the revised dataset was applied to calculate the stock size index.
6) **Consistency**: Consistent.
7) **Stock status**: The stock size indicator has been increasing since 2009 but has leveled off in recent years.
8) **Management Plan**: ICES is not aware of any agreed precautionary management plan for skates and rays in this area.

General comments

The draft report section for this stock was not available at time of the audit, mainly due to the data issues on CGFS-Q4 and UK BTS Q3 surveys.

The area for which discard survival data is available should be inlcuded in the section 'Issues relevant for the advice'.

In this stock, as in all the remaining stocks advised in 2019, the sentence about the generic TAC (i.e. "** There is no specific TAC for this stock. Fishing opportunities are managed through an overall TAC by management unit, which includes all species of skates and rays.*") was not inlcuded in the end of Table 5 (i.e. table with estimated landings) as in previous years for Celtic and Biscay and Iberia stocks. That was added in the current advice sheet.

There is no information on when the PA buffer was last applied. Following the criteria used in previous advice years it should be considered to apply it this year, as the stock is also showing a stable trend and not a consistent increase.

Technical comments

The advice sheet has been updated as required, and appears to cover the available information.

Conclusions

The assessment has been performed correctly, following ICES guidance for assessing data-limited stocks. Nevertheless, the application of a PA buffer could be further discussed in the ADG. All tables and figures are presented correctly.

Audit of Rays and skates (Rajidae), mainly thornback ray (Raja clavata), in subareas 10 and 12 (Azores grounds and north of Azores)

Date: 09 September 2019

Auditor: Bárbara Serra Pereira

General

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: Survey-based trends (ICES, 2019)
3) **Forecast**: No forecast.
4) **Assessment model**: No assessment model
5) **Data issues:** In the current assessment, the entire survey abundance index series was re-calculated excluding the statistical area of the western islands (Flores and Corvo), because this statistical area had not been covered in some years. That justifies the differences observed betwwen the survey index data presented in the current advice and that from 2017's advice, being the former considered more accurate.
   Also, in the landings reported differences were also identified to occur between the 2017' and the current advice. Those different result on an update of French and Spanish landings allocated to that stock.
6) **Consistency**: Consistent.
7) **Stock status**: although with lower levels that those observed between 2002 and 2007, the stock status has been relatively stable in the last 10 years.
8) **Management Plan**: ICES is not aware of any agreed precautionary management plan for skates and rays in this area.

General comments

The draft report section for this stock was available at time of the audit, and contain all the information referred in the advice sheet.

In this stock, as in all the remaining stocks advised in 2019, the sentence about the generic TAC (i.e. "** There is no specific TAC for this stock. Fishing opportunities are managed through an overall TAC by management unit, which includes all species of skates and rays.*") was not inlcuded in the end of Table 5 (i.e. table with estimated landings) as in previous years. That was added in the current advice sheet.

Technical comments

The advice sheet has been updated as required, and appears to cover the available information.

Conclusions

The assessment has been performed correctly, strictly following ICES guidance for assessing data-limited stocks. All tables and figures are presented correctly.

Audit of Other rays and skates (Rajidae) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)

Date: 03-07-2019

Auditor: Loïc Baulier

General

For single stock summary sheet advice:

1) **Assessment type:** No assessment
2) **Assessment**: No assessment
3) **Forecast**: No forecast
4) **Assessment model**: No assessment model was presented for other rays and skates in Subarea 4 and in divisions 3.a and 7.d. Survey and catch trends are considered unreliable.
5) **Data issues:** Landings combine data for Rajidae (indeterminate Rajiformes) and skate species that do not belong to any of the other stocks assessed by ICES. While some nations report species-specific landings of these species, other nations report them as generic skate landings; landings data by stock are therefore incomplete. The available data series for landings is believed to reflect progressive changes in the level of species-specific reporting.
6) **Consistency**: No assessment in previous years
7) **Stock status:** Unknown, because reference points have not been defined
8) **Management Plan:** No management plan exists for this stock

General comments

The draft report section for this stock was available at time of the audit. No advice could be provided for this stock as both landings and survey data are considered unreliable. Hence, the advice sheet is straightforward. In "Issues relevant to the advice", comments essential to the the understanding of this stock assessment are made. From this, it may be suggested to exclude the term "rays" from the name of the stock. It could indeed be misleading, as all reported data pertain to skates only.

Technical comments

Conclusions

The advice sheet has been filled out correctly, all requested information has been provided.

Audit of Spotted ray (*Raja montagui*) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel)

Date: 11/09/2019

Auditor: Nicola Walker

General

For single stock summary sheet advice:

9) **Assessment type:** Update
10) **Assessment**: Survey-based trends
11) **Forecast**: Not presented
12) **Assessment model**: Survey-based trends (two-over-five rule) informed by three indices (NS-IBTS-Q1, NS-IBTS-Q3 and BTS-Eng-Q3).
13) **Data issues:** A problem with duplication of BTS-Eng-Q3 data in the DATRAS data product was found during the working group. This index was therefore recalculated after the meeting using national data and the revised index used to calculate the stock size indicator.
14) **Consistency**: Consistent with the advice provided in 2017. A precautionary buffer was applied in 2017, and was therefore not applied again.
15) **Stock status**: The stock size indicator is increasing.
16) **Management Plan**: No management plan.

General comments

The draft report section for this stock was not available at the time of audit, mainly due to the issues with the BTS-Eng-Q3 index. The advice sheet contains all the information required.

Technical comments

Advice sheet:

- Acronyms for the UK beam trawl survey are not consistent throughout the advice sheet (i.e. BTS-Eng-Q3 / UK-7d-BTS / UK BTS-Q3).
- The column heading for Table 5 should be 'Landings corresp. to advice'.
- The 8% in Table 6 and some values in the last column of Table 8 are not rounded according to ICES rounding rules.

Conclusions

The assessment has been performed correctly and all requested information is provided in the advice sheet.

Audit of Cuckoo ray (*Leucoraja naevus*) in Subarea 4 and Division 3.a (North Sea, Skagerrak, and Kattegat)

Date: 23-07-2019
Auditor: Loïc Baulier

General

For single stock summary sheet advice:

1) **Assessment type:** Cat. 3 stock, based on survey indices
2) **Assessment**: No assessment required in 2019
3) **Forecast**: No forecast
4) **Assessment model**: No model
5) **Data issues:** There is insufficient information to present species-specific landings for this stock prior to 2008 when legal obligations to report the main commercial skates to species level were introduced. A greater proportion of data have been reported to the species level since 2008, but data remain incomplete..
6) **Consistency**: No assessment required in 2019, but updated survey indices are presented
7) **Stock status:** No reference points exist for this stock. The 2 year over 5 year-ratio of the combined survey index is >1, but this was not used to update the stock status, as no assessment is required.
8) **Management Plan:** ICES is not aware of any agreed precautionary management plan for cuckoo ray in Subarea 4 and Division 3.a.

General comments

The draft report section for this stock was available at time of the audit. No advice was requested for this stock in 2019. Nevertheless, the advice sheet provides updates of the landing series and of the survey indices.

Technical comments

Conclusions

The advice sheet has been filled out correctly, all requested information has been provided.

Audit of Black-mouthed dogfish (*Galeus melastomus*) in subareas 6 and 7 (Celtic Seas and English Channel) (sho.27.67)

Date: 01 July 2019
Auditor: Ivone Figueiredo

General

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: Survey trends-based assessment (ICES, 2019).
3) **Forecast**: not presented
4) **Assessment model**:
5) **Data issues:**
6) **Consistency:** Consistent with previous advice
7) **Stock status**: Qualitative assessment: stock has increased from a low level being now relatively stable
8) **Management Plan**: ICES is not aware of any agreed precautionary management plan for black-mouthed dogfish

General comments

ICES has not been requested to provide advice on fishing opportunities for this stock
The draft report section for this stock was available at time of the audit.

Technical comments

Advice sheet:

The advice sheet has been updated as required, and appears to cover the available information.

Conclusions

The assessment has been performed strictly following ICES guidance for assessing data-limited stocks. All tables and figures are presented correctly.

Audit for Black-mouthed dogfish (*Galeus melastomus*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)

Date: 15 July 2019
Auditor: Teresa Moura

General

This species is usually discarded but the amount of discards and discard survival is unknown.

For single stock summary sheet advice:

17) **Assessment type:** update
18) **Assessment**: Survey trends-based assessment (Surveys EVHOE-WIBTS-Q4, PT-CTS(UWTV(FU 28-29)), SPGFS-caut-WIBTS-Q1, and SPGFS-caut-WIBTS-Q4)
19) **Forecast**: not presented
20) **Assessment model**:
21) **Data issues:**
22) **Consistency:** Consistent with previous advice
23) **Stock status**: qualitative assessment - the biomass index has fluctuated over the time-series; the maximum value was attained in 2018.
24) **Management Plan**: ICES is not aware of any agreed precautionary management plan for this species

General comments

ICES has not been requested to provide advice on fishing opportunities for this stock. Assessment in accordance to the available stock annex. The draft report section for this stock was available at time of the audit.

Technical comments

Advice sheet:

The advice sheet has been updated as required and covers the available information.

Conclusions

The assessment has been performed following ICES guidance for assessing data-limited stocks.

Audit for Lesser-spotted dogfish *(Scyliorhinus canicula)* in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

Date: 15 July 2019
Auditor: Teresa Moura

General

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: Survey trends-based assessment.
3) **Forecast**: not presented
4) **Assessment model**:
5) **Data issues:**
6) **Consistency:** Consistent with previous advice
7) **Stock status**: qualitative assessment - increasing trend since 2004; highest values of the time series registered since 2013 (the maximum value was attained in 2018).
8) **Management Plan**: ICES is not aware of any agreed precautionary management plan for this species

General comments

ICES has not been requested to provide advice on fishing opportunities for this stock. No stock annex available at this date. The draft report section for this stock was available at time of the audit.

Technical comments

<u>Advice sheet:</u>

The advice sheet has been updated as required and covers the available information.

Conclusions

The assessment has been performed following ICES guidance for assessing data-limited stocks.

Annex 5: List of Stock Annexes

The table below provides an overview of the WGEF Stock Annexes. Stock annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year, ecoregion, species*, and *acronym* of the relevant ICES expert group.

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	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	Thornback ray (*Raja clavata*) in the Bay of Biscay VIIIa–c	June 2015	rjc-bisc_SA
rjc-echw	Thornback ray (*Raja clavata*) in Division 7.e (western English Channel)	June 2015	rjc-echw_SA
rjc-pore	Thornback ray (*Raja clavata*) in Division 9.a (Atlantic Iberian waters)	June 2015	rjc-pore_SA
rje-ech	Small-eyed ray (*Raja microocellata*) in divisions 7.d and 7.e (English Channel)	June 2015	rje-ech_SA
rjh-pore	Blonde ray (*Raja brachyura*) in Division 9.a (Atlantic Iberian waters)	June 2015	rjh-pore_SA
rjm-bisc	Spotted ray (*Raja montagui*) in Subarea 8 (Bay of Biscay)	June 2015	rjm-bisc_SA
rjm-pore	Spotted ray (*Raja montagui*) in Division 9.a (Atlantic Iberian waters)	June 2015	rjm-pore_SA
rjn-bisc	Cuckoo ray (*Leucoraja naevus*) in Division 8.c (Cantabrian Sea)	June 2015	rjn-bisc_SA
rjn-pore	Cuckoo ray (*Leucoraja naevus*) in Division 9.a (Atlantic Iberian waters)	June 2015	rjn-pore_SA
rju-9a	Undulate ray (*Raja undulata*) in Division 9.a (Atlantic Iberian waters)	June 2015	rju-9a_SA
rju-ech	Undulate ray (*Raja undulata*) in divisions 7.d and 7.e (English Channel)	June 2015	rju-ech_SA
sck-nea	Kitefin shark (*Dalatias licha*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	June 2015	sck-nea_SA
bsk-nea	Basking shark (*Cetorhinus maximus*) in Subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	June 2015	bsk-nea_SA
cyo-nea	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	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	Porbeagle (*Lamna nasus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters)	June 2015	por-nea_SA
sho.27.89a	Black-mouth dogfish (*Galeus melastomus*) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)	June 2019	sho.27.89a_SA
syc.27.8abd	Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.a-b and 8.d (Bay of Biscay)	June 2019	syc.27.8abd_SA
syc.27.8c9a	Lesser-spotted dogfish (*Scyliorhinus canicula*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	June 2019	syc.27.8c9a_SA
syt.27.67	Greater-spotted dogfish (*Scyliorhinus stellaris*) in subareas 6 and 7 (West of Scotland, southern Celtic Sea, and the English Channel)	June 2019	syt.27.67_SA
Other deep water sharks	Other deep-water sharks and skates from the Northeast Atlantic (ICES Subareas 4–14)	June 2019	

Annex 6: Working Documents

Working documents presented at WGEF 2019	Author
Summary WKLIFE for elasmobranchs	Tanja Miethe
WD2019_Biais_Porbeagle_survey_updated	Gérard Biais
WD-WGEF2019_RJUDATA_PT	Catarina Maia and Ivone Figueiredo
WGEF 2019_WD Pintarroja biphasic model	L. Modica, C. Rodríguez-Cabello, F. Velasco, and F. Sánchez
WGEF_2019_WD_French_LandingsMislabelling_MNHN	Sophie Elliot
WGEF2019__Silva Ellis_Cefas BTS survey in 4c7d	Silva, J. F. and Ellis, J. R.
WGEF2019_Demersales	S. Ruiz-Pico, M. Blanco, O. Fernández-Zapico, F. Velasco, C. Rodríguez-Cabello,I. Preciado, and A. Punzón
WGEF2019_Landins Azores	Mario Pinho
WGEF2019_Porcupine	S. Ruiz-Pico, M. Blanco, O. Fernández-Zapico, F. Baldó, F. Velasco, and C. Rodríguez-Cabello
WGEF2019_WD_01_Ellis et al_Mustelus life history parameters_rev1	Ellis, J. R., Maia, C., Hampton, N., Eastley, G., Silva, J. F. and McCully Phillips, S. R.
WGEF2019_WD_02_Ellis_Galeorhinus bibliography	Jim Ellis
WGEF2019_WD_03_SilvaEllis_Scyliorhinus trends	Silva, J. F. and Ellis, J. R.
WGEF2019_WD_04_PT_Serra-PereiraFigueiredo_surveys_skates	Barbara Serra-Pereira and Ivone Figueiredo
WGEF2019_WD_05_PT_Serra-PereiraFigueiredo_Survival_skates	Barbara Serra-Pereira and Ivone Figueiredo
WGEF2019_WD_MNHN_SkateAbundance_190622	Sophie A. M. Elliott, Alexandre Carpentier, Thomas Trancart, Eric Feunteun
WGEF2019_WD_MNHN_SkateHabitat_190622	Sophie A. M. Elliott, Alexandre Carpentier, Eric Feunteun, Thomas Trancart
WGEF2019_WD06_Figueiredo_DWS onboard	Ivone Figueiredo and Teresa Moura
Working document BEL BTS elasmo_Vandecasteele	Loes Vandecasteele and Lies Vansteenbrugge

Summary of WKLIFE 2018 on elasmobranchs for WGEF 2019 ToR g

The Workshop on the Development of Quantitative Assessment Methodologies based on Life-history traits, exploitation characteristics, and other relevant parameters for stocks in categories 3–6 (WKLIFE VIII) met in Lisbon, Portugal, 8-12 October 2018, to further develop methods for stock assessment and catch advice for stocks in categories 3-6. The resulting ICES report includes a section specifically dedicated to an elasmobranch life history (ICES (2018a); section 5, Annex 1). The performance of advice rules using length-based indicators and MSY proxy reference points to manage elasmobranch fisheries were investigated within an MSE framework. An operating model was built based on the Cuckoo ray life history from the Irish Sea, with alternative scenarios for size of capture relative to size of maturity and advice rules. Discussions and further work recommended by external reviewers during the workshop resulted in the following recommendations of an advice rule for bycatch elasmobranch stocks:

$$TAC_{y+1} = TAC_y * r * f. \tag{1}$$

Table 1. Definition and use of advice rule in equation 1

Component	**Definition and use**
r	The rate of change in the catch-per-unit-effort (CPUE) based on the average of the two most years of recent data (*y*-2 to *y*-1*)* relative to the average of the five years prior to the most recent two (*y*-3 to *y*-7), termed the “2 over 5” rule.
f	The ratio of the mean length in the observed catch above the length of first capture relative to the target reference length ($L_{F=M}$). At high data variability, a recent year average of the ratio can be considered.
Stability clause	Limits the amount the TAC can change upwards or downwards between years. The recommended values are +5% and -25% where the TAC would be limited to increase by 5% or decrease by 25% relative to the previous year’s TAC.

Further details of the analyses are summarized in the following sections.

1. Fisheries selectivity

In initial simulations an advice rule was tested based only on the ratio of mean length and its reference point (f)

$$TAC_{y+1} = TAC_y * f. \tag{2}$$

The results indicated that the advice rule is sensitive to the value of length at capture L_c. Fishing only on mature individuals of the stock (L_c>L_{mat}) ensures successful recovery of an overexploited stock in simulations using this simple advice rule. In contrast, the risk of stock collapse remains high when L_c is below the length at maturity, L_{mat}. The reference point $L_{F=M}$ appears to be inappropriate at low values of L_c which confirms results by Jardim *et al.* (2015). The assumption of F=M on all exploited length classes in the calculation of the mean length reference point $L_{F=M}$ leads to different overall exploitation levels with varying number of fished size classes (varying value of L_c). At L_c<L_{mat} more individuals are subject to fishing at F=M, increasing the overall exploitation level as compared to a scenario with L_c>L_{mat}. If possible, the fishery should be managed such that L_c>L_{mat}. However, for many bycaught elasmobranchs stocks L_c is typically lower than L_{mat} (ICES, 2018c). If the fisheries' selectivity cannot be altered, the probability of the stock declining below SSB thresholds can be reduced including information of the trend in a CPUE index (reflecting trends in stock biomass) and the mean length ratio in the advice rule (equation 1).

The reference point $L_{F=M}$ is calculated with the assumption of asymptotic, knife-edge selectivity. Therefore, it is assumed that there is no exploitation on individuals smaller than L_c. For indicator calculation L_c is often defined as the length at 50% of the mode of the size distribution approximating the inflexion point of the selectivity ogive (Jennings *et al.*, 2001; ICES, 2012). Alternatively, L_c has been calculated as the mode of the size distribution representing the maximum selectivity of the ogive and full selectivity (ICES, 2018c; ICES, 2018b). Overestimating L_c, in particular when using the mode of the distribution, should lead to overestimated reference points thereby reducing the risk to fall below biomass thresholds when applying the advice rule.

At dome-shaped selectivity, largest individuals are subject to lower/no fishing mortality. This can be due to spatial segregation of life stages and spatial limitation of fisheries relative to the stock distribution. Under dome-shaped selectivity, larger individuals are missing from the catch and the observed mean length is lower than expected from asymptotic selectivity. In this case, an advice rule based on asymptotic selectivity would lead to a lower risk to fall below biomass thresholds as the lower observed mean length in the catch will trigger a stronger downward TAC adjustment (and potentially a loss of yield). It is recommended to confirm the selectivity assumptions.

2. Spawning stock recruitment relationship

In elasmobranch life history, recruitment is closely linked to the number of mature females. As recruitment decreases with decreasing number of mature females in the population, the potential of replenishment by large incoming cohorts is small limiting the recovery potential from overfishing (Cailliet *et al.*, 2005). Instead of maximizing yield, the focus of management for elasmobranch stocks should therefore be on the protection of the reproductive potential.

The MSY proxy reference point, $L_{F=M}$, relies on the assumption that recruitment is constant overtime. However, the steepness of the stock-recruitment relationship critically influences the performance of the advice rule. A Beverton-Holt spawner-recruitment relationship was applied, directly linking mature females to recruits. An alternative parameterization of the stock-recruitment relationship developed specifically for elasmobranch life-histories has been suggested (Taylor *et al.*, 2013) and was included in further simulation testing. In comparison, the selected Beverton–Holt relationship showed a stronger reduction in recruitment with decreasing stock size as expected for elasmobranch life histories. Therefore, simulations to test advice rules were performed using Beverton-Holt relationship linking the number of mature females to recruitment. If the simulated recruitment is relatively constant or decreases little with decreasing SSB, the advice rules are expected to perform better in the simulations and can lead to overly optimistic results. In contrast, with a strong reduction in recruitment with decreasing SSB, the advice rule would perform worse. This can be explained by the fact that under strongly decreasing recruitment, the overexploited stock cannot replenish itself easily and furthermore a lack of small individuals in the catch affects indicator calculation under non-equilibrium conditions (slightly increasing mean length in the catch and ratio *f*).

3. Misspecification of the reference point

A misspecification of natural mortality M to calculate the reference point $L_{F=M}$, can lead to changes in the performance of the advice rule, in terms of risk to fall below biomass thresholds. If M is significantly underestimated, the reference point is calculated with the assumption of higher survival leading to more extended equilibrium size distributions at F=M, and the respective reference point value of $L_{F=M}$ will be overestimated. With overestimated reference points the advice rule will lead to a lower risk to fall below biomass thresholds, as the stock is managed to achieve larger mean lengths in the catch. In contrast, if M is overestimated, the unexploited length distribution of an unexploited stock is expected to be more truncated at F=M, and the respective reference point is underestimated. An overestimation of M would lead to a higher level of advised fishing mortality and a higher risk of stocks falling below biomass thresholds. The misspecification of M directly changes the M/k ratio which describes the shape of the expected length distribution for a particular stock and enters the calculation of $L_{F=M}$ (Hordyk *et al.*, 2015; Jardim *et al.*, 2015). Similarly, any other parameter misspecification, of k or L_c, which leads to underestimation of the reference point can affect the performance of the advice rule and increase the risk of a stock to fall below biomass thresholds.

In elasmobranch stocks, often dimorphic growth between the sexes is observed. It is therefore recommended to calculate the reference point based on the biology of the larger growing sex (with larger L_∞).

4. Data quality

For the advice rules to perform properly, observation data should be of high quality. Sampling of length distributions should be unbiased and representative of total catches of all major fleets. The reliability of the observed catch length distribution is influenced by the sample size. At low sample size, the number of sampled individuals from rare size classes is likely to be more variable leading to variable indicator values and variable estimates of L_c. Sufficient sampling should be ensured. To reduce the effect of data variability, the indicator ratio to be used in the advice rule can be calculated as a recent year average.

The performance of the harvest control rule is also dependent upon the accuracy of the CPUE index, which is used to identify the recent trends in the stock biomass or abundance. An advice rule based on the trend on the CPUE index using the average of the previous two years relative to the average of the preceding five years (2-over-5 rule) performed better than an advice rule using the average of the previous two years relative to the average of the preceding 3 years (2-over-3 rule). Applying index rule in the advice rule covering trends over a longer time period is advised (2-over-5 rule), as longer-term reductions in the CPUE index will have a stronger effect on the TAC adjustment. The longer term dynamics are important in particular for stocks with a long generation time.

Simulations with higher observation error showed that a highly asymmetric stability clause governing the percentage of change allowed in the TAC between years was beneficial to the performance of the advice rule. The advice rule should be able to apply larger reductions to the TAC based on the CPUE and length data when warranted relative to amount allowed for increases in the TAC. The recommended asymmetric stability clause allows for TAC reductions up to 25% downwards but limits an increase by up to 5% in the TAC for next year relative to the current year's TAC. This limits the probability of overshooting the sustainable catch, while allowing for strong reductions in TAC in any case.

5. Frequency of assessment

When comparing simulation scenarios with different assessment frequencies, it was found that the more frequent biennial assessment and update of the TAC advice performed better than a quadrennial assessment. A more frequent TAC adjustment led to reduced variability in SSB between simulations. In an overexploited stock, more frequent adjustment allowed a stronger reduction in TAC overtime and a faster stock recovery.

Cailliet, G. M., Musick, J. A., Simpfendorfer, C. A., and Stevens, J. D. 2005. Chapter 3 Ecology and Life History Characteristics of Chondrichthyan Fish. *In* Sharks, Rays and Chimaeras: The Status of Chodrichtyan fishes, Satus Survey, p. 461pp. Ed. by S. L. Fowler, R. D. Cavanagh, M. Camhi, G. H. Burgess, G. Cailliet, S. V. Fordham, C. A. Simpfendorfer *et al.* IUCN/Shark Specialist Group, IUCN, Gland, Switzerland and Cambridge, UK.

Hordyk, A., Ono, K., Valencia, S., Loneragan, N., and Prince, J. 2015. A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries. ICES Journal of Marine Science, 72: 217-231.

ICES 2012. Report of the Workshop to finalise the ICES data-limited Stocks (DLS) methodologies documentation in an operational form for the 2013 advice season and to make recommendations on target categories for data-limited stocks (WKLIFE II), 20-22 November 2012, Copenhagen, Denmark. ICES CM2012/ACOM:79: 46 pp.

ICES 2018a. Report of the Eighth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE VIII) 8-12 October 2018, Lisbon, Portugal. ICES CM 2018/ACOM:40: 172 pp.

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

ICES 2018c. Report of the Workshop on Length-Based Indicators and Reference Points for Elasmobranchs (WKSHARK4), 6-9 February 2018, Ifremer, Nantes (France). ICES CM/ACOM: 37: 112pp.

Jardim, E., Azevedo, M., and Brites, N. M. 2015. Harvest control rules for data-limited stocks using length-based reference points and survey biomass indices. Fisheries Research, 171: 12-19.

Jennings, S., Kaiser, M. J., and Reynolds, J. D. 2001. Marine Fisheries Ecology, Blackwell Publishing.

Taylor, I. G., Gertseva, V., Methot, R. D., and Maunder, M. N. 2013. A stock–recruitment relationship based on pre-recruit survival, illustrated with application to spiny dogfish shark. Fisheries Research, 142: 15-21.

Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 18–27 2019

Porbeagle abundance survey in the Bay of Biscay and the Celtic Sea in 2018 and 2019

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Summary
In May-June 2018 and 2019, a porbeagle abundance survey was carried out in partnership with the fishing industry on the shelf edge westwards of France. The two abundance indices that were obtained are consistent between them: 3.6 fish/336 hooks in 2018 and 3.0 fish/336 hooks in 2019. A comparison of these results with a commercial CPUE series was made possible by the availability of a skipper's diaries. Detailed information of these diaries allowed several selections of longline sets to get a CPUE series comparable to the survey index. Survey indices are close to the mean CPUE of this time series. This result and inter-annual consistency of survey indices allow thinking that the design of the survey provides relevant abundance indices. Furthermore, according to the comparison with the commercial CPUE series, porbeagle abundance on the shelf edge westwards of France in 2018-19 is likely at or above the 2005-2009 abundance. Because this result and the increase in modes of porbeagle length distribution from 2008-2009 to 2018-2019, an increase in biomass from 2009 to 2019 is likely.

Introduction

In 2016, the project of a porbeagle abundance survey in 2017-2019 was presented to the WGEF. A partnership with the fishing industry made this possible, as it was necessary to have a skipper and a crew with experience in longline fishing for porbeagle. ICES has recommended such a survey for years, but this recommendation has been hampered by the difficulty of coordinating a NEA-wide survey and, in particular, of obtaining funding for such a project. However recent observations of porbeagle site fidelity in the Bay of Biscay and the southern Celtic Sea, revealed by archived satellite tag deployments (PSAT) (Biais et al., 2017), suggest that the population of porbeagle that returns to western European waters in the spring summer may have partial or total autonomy. A survey of abundance in these areas and seasons could therefore provide a meaningful index, although it is limited to a portion of the porbeagle shark NEA stock.

The project, named CATaupe (Campagnes scientifiques de suivi de l'Abondance du requin-Taupe en Atlantique Nord-Est), must originally start in 2017, but its beginning was postponed to 2018 for administrative reasons. Considering that the knowledge of the porbeagle stock structure still needs to be further improved, the project combined standardised fishing for abundance estimation with PSAT deployments (31 in 2018 and 7 in 2019). The objective was to confirm the porbeagle site fidelity and **validate the relevance of the time-space window**

chosen for the abundance survey. The analysis of this relevance cannot be presented in this WD because the 2018 survey was in May-June and, and the pop-ups are scheduled to 365 days. Consequently track reconstitutions for a full year will not be available before the last quarter of 2019.

The survey was planned for two consecutive years. This reiteration aimed at **validating the sampling design** by observing inter-annual variations of the abundance indices. Indeed, considering that porbeagle stocks have a low dynamic, the two consecutive abundance indices must be closed one to the other.. In that case, it was expected that a **comparison of the survey catches with past commercial CPUE** could provide useful information for the stock assessment when no fishing data has been available for nearly a decade. This WD presents a comparison exercise made possible by the availability of a skipper's diaries.

Survey design

The **same vessel** was chartered for 2018 and 2019: a 22.40 m long fishing vessel, based in Port Joinville on Yeu Island.

The fishing gear is a **longline** consisting of 4 segments of 84 hooks each. The duration of the set is fixed to **3 hours**.

According to an analysis of past commercial CPUE (Biais, 2016), the **survey period** was set for **May-June**.

The **survey area** was also designed according to past commercial CPUE and submitted to some fishermen for validation (Figure 1). The adding of statistical rectangles in the southern part of the Bay of Biscay was not retained, although suggested by reconstructed tracks of tagged porbeagles. A preliminary survey carried out in 2016 showed that porbeagle is likely too rare in this area to allow positive catches with a limited number of longline sets. However, 2 additional days were allocated to the statistical rectangle 24D8 in 2018 because mature female catches have been reported in this rectangle in May (Hennache and Jung, 2010). Furthermore, an extension of the survey area to the south was decided during the 2018 survey because the largest catches were made in the south-eastern part of the primitive area.

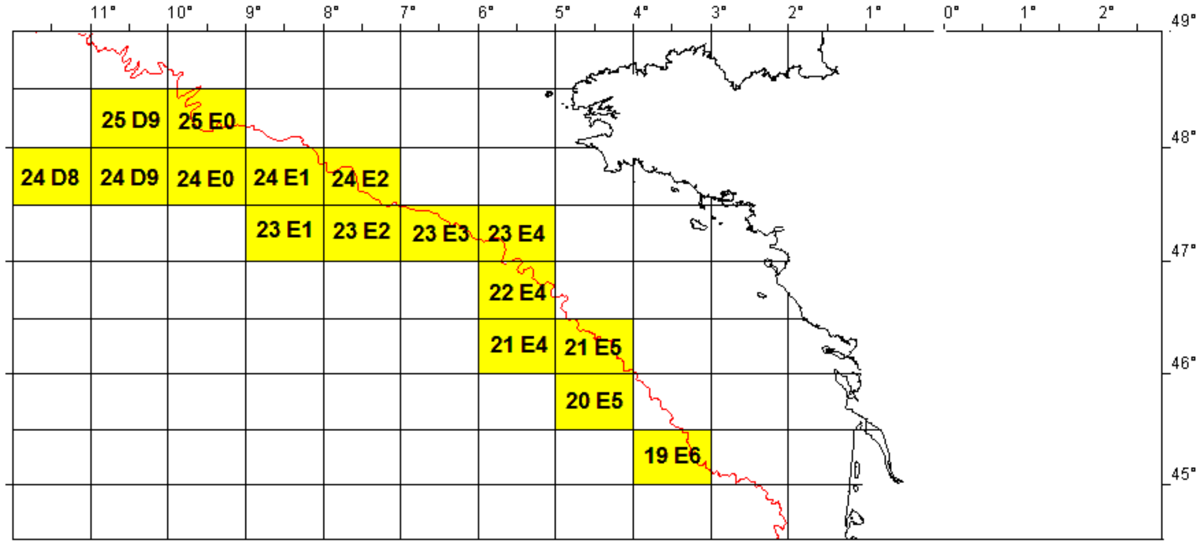


Figure 1: Statistical rectangles forming the survey area

The duration of the survey was set to allow an average of 2 fishing days per statistical rectangle (4 longline sets). This seemed a minimum because the very patchy distribution of commercial catches. As a result, the survey was planned to last about one month at sea with **minimum work plan of 27 fishing days** and a maximum of 35 days, depending on weather conditions.

In each statistical rectangle, two fishing positions were chosen based on the information provided in skippers' personal diaries and the knowledge of the skipper in charge of the survey (Figure 2). Originally, the number of sets on each position was fixed in proportion of past CPUE, with a variation limited from 1 to 3. However, the carrying out of the survey in 2018 shows that it is much more realistic and time-efficient to plan **2 sets on each position**, with the possible reduction to 1 on some position if time is lacking to go back to one position. The additional constraint of having **at least 10 days between two sets** was decided to avoid a set on the same fish aggregation and thus to obtain more independent samples.

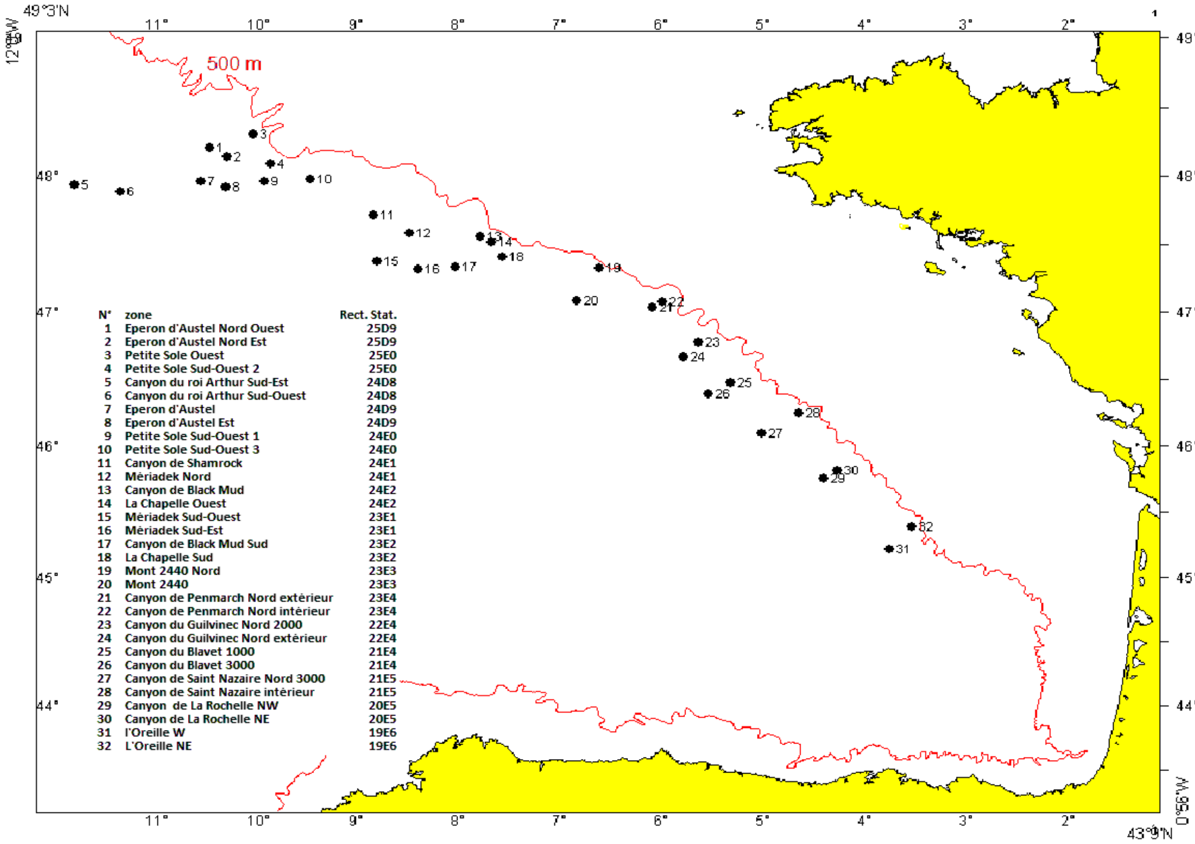


Figure 2: Positions of the survey stations

A stretcher was designed to carry sharks on board carefully (Figure 3). Once on board, sharks are measured (curved and straight, total and at fork lengths), the sex is determined and a small piece of the dorsal fin (1 cm^2) is removed for genetic analysis. According to their state (important vivacity, no wound), length and sex, they can be tagged (Figure 4). As far as possible, a blood sample is collected for hormonal analysis and a sonography is performed.

Figure 3: Taking on board of a shark and measurement.

Figure 4: Shark tagging and blood sampling

All the living porbeagles are released as soon as possible. Biological samples are only collected on the sharks being dead before being brought on board or on sharks that have no chance to survive if released. Vertebrae, entire stomachs, liver, reproductive organs, and muscular samples are taken on these individuals.

Survey abundance index

The 2018 and the 2019 survey were carried out at the same period, from May 11 to June 24). 57 and 54 longline sets were respectively made during the 2018 and the 2019 survey in 37 days at sea.

In all the statistical rectangles in 2018 and for 15 out of 16 in 2019, the longline was set on the 2 fixed positions of each rectangle at least once, allowing comparing CPUE (total catch in number per 336 hooks) between the 2 positions of the statistical rectangles. In 2018 as well in 2019, there is a significant evidence of a difference between the paired daily CPUE in each statistical rectangle (Wilcoxon signed rank test). There is also a significant evidence of a difference between the paired mean CPUE for successive longline deployments (Wilcoxon signed rank test). They were performed two or three times for 18 stations in 2018 and 24 in 2019, meeting the requirement to repeat deployments after more than 10 days (the average

time interval is 17 days in 2018 and 24 in 2019), with the exception two repetitions (one working day) who were made 8 days apart. As a result, longline sets on a different position in the same statistical rectangle are considered to be independent observations as well as longline sets on the same position after a time interval larger than 8 days. In all other cases (sets not in the same day and not on the same position), sets were assumed to be independent observations of abundance, because estimated tracks from PSAT data do not show any oriented movement along the shelf edge. Consequently, **all observations were considered to be independent and the average of the CPUE retained for the annual abundance index.** In **2018**, this average is **3.6 fish/set** (n=57) and in **2019**, it is **3.0 fish/set** (n=54).
Although the large variability of CPUE (from 0 to 33 fish/set) and the spatial heterogeneity of CPUE (32% of zero catch/set in 2018 and 24% in 2019), the survey design seems to allow to get similar abundance index in successive years, as expected for a stock that has a low dynamic. **The sampling design appears consequently satisfactory**.

Trend of the Bay of Biscay porbeagle population

Comparing the survey CPUE with previous commercial CPUE required detailed data: positions, catches and numbers of hooks by set. Mandatory declarative logbooks are filled in by day with not always the number of hooks and, if present, they can be reported in different ways. Skippers' personal diaries are therefore necessary for this analysis. A fisherman from Yeu Island provided a collection of diaries from 1990, but the information it contained did not correspond to the accuracy required. A second series of diaries was obtained from NGO APECS which kindly agreed to provide the data file that it made with these diaries during the EPPARTIY project (Hennache and Jung, 2010). This data are for years 2000 to 2009 and are relative to one of the five Yeu Island fishing vessels which were participating each year to the porbeagle fishery before its closure in 2010. This vessel contributed to total French landing for about 10% each year from 2000 to 2008 and it ranks third in the French fleet for the annual porbeagle landing. Therefore, the skipper of this vessel can be considered a specialist of the porbeagle fishing.

This vessel has deployed long lines with 252 to 840 hooks on the survey area in May-June from 2000 to 2009, the mean being at 525 hooks, when 336 are used during the survey to limit mortality. Consequently, its sets were standardised by multiplying them by the ratio of 336 hooks to the number of hooks of the set.
More than 900 sets are fully informed in the time series, but a selection on months May and June and on the statistical rectangles of the survey reduced this number to 347. Three other selections were made to get fishing CPUE of this boat as far as possible comparable to the survey CPUE:
- if the vessel stays in the same statistical rectangle more than one day, the sets of the following days are not selected before 10 days,
- if two sets are made in the same statistical rectangle the same day, the second set is selected only if the distance between the two sets is larger than the distance between the two positions of the survey in this statistical rectangle,
- if the vessel moves to another statistical rectangle, the set is selected only if its distance from the preceding set is larger than the distance between the two positions of the survey in this statistical rectangle.

These three conditions for set selection have reduced the number of sets to 141. The commercial time series provides consequently an annual index based on a much lower number of sets than the survey and, moreover, sets are not made in all the 16 statistical rectangles of the survey area: 7 to 12 from 2000 to 2004, 6 to 8 from 2005. This low sampling of the area explains likely the large annual changes in commercial vessel CPUE that we obtained (Figure 5). However the means over the last 5 years or over the whole time span of **the commercial series confirms the relevance of the survey plan for providing an abundance index**, the 2018-2019 survey indices being close to these means.

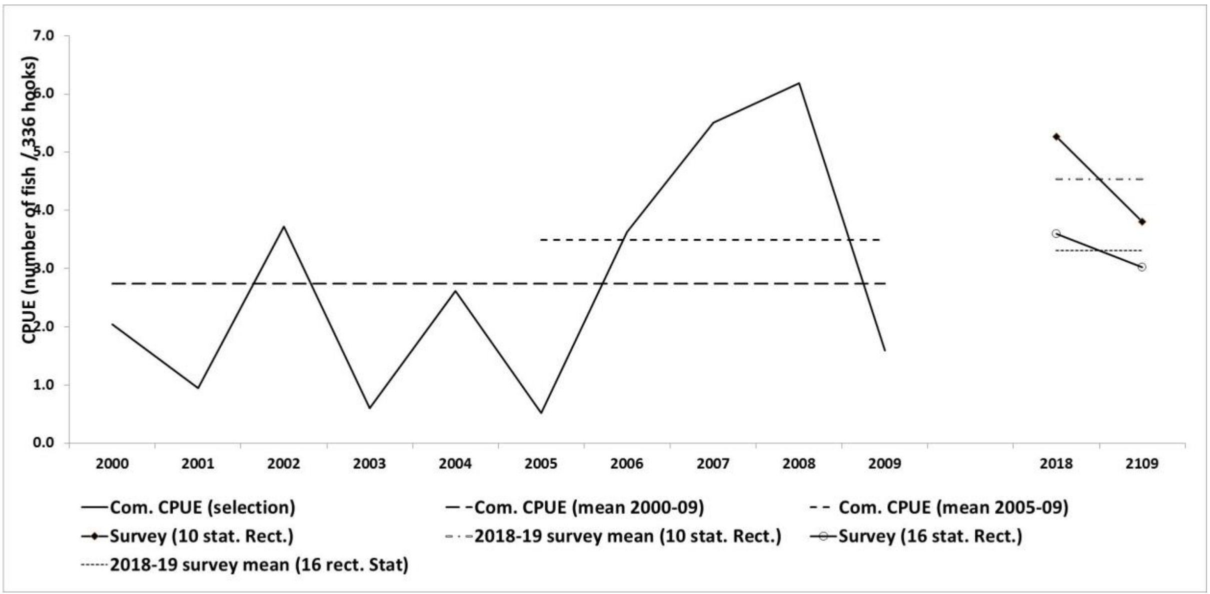


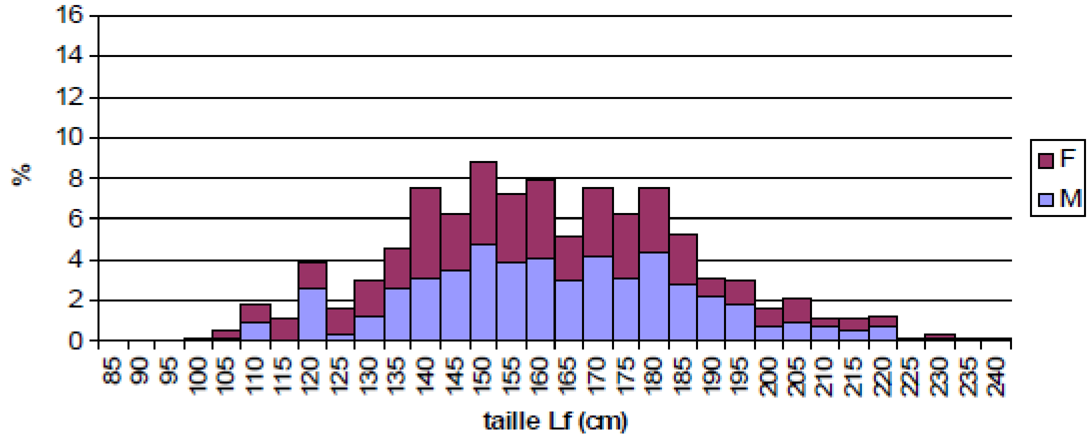
Figure 5: 2018-2019 Survey CPUE and 2000-2009 commercial CPUE

To show the effect of the possible bias caused by the lack of commercial CPUE for a part of the survey area, the survey mean was calculated using only the data obtained in the 10 statistical rectangles where the survey CPUE are the larger (corresponding to the removal of statistical rectangles with a mean CPUE<1 in 2018 and <=1.5 in 2019). Indeed, it is unlikely that a commercial fishing vessel will work in statistical rectangles with such low CPUE, and even when they are close to each other (23E1, 24D8, 24D9, 24E0, 24E1, 25D9 in 2018 and 23E1, 23E2, 24D9, 24E0, 24E1 in 2019). The mean CPUE are consequently increased to from 3.6 to 5.3 in 2018 and from 3.0 to 3.8 in 2019, i.e. by 47% and 26%. According to these results, **porbeagle abundance on the shelf edge westwards of France in 2018-19 is likely at or above the 2005-2009 abundance.**

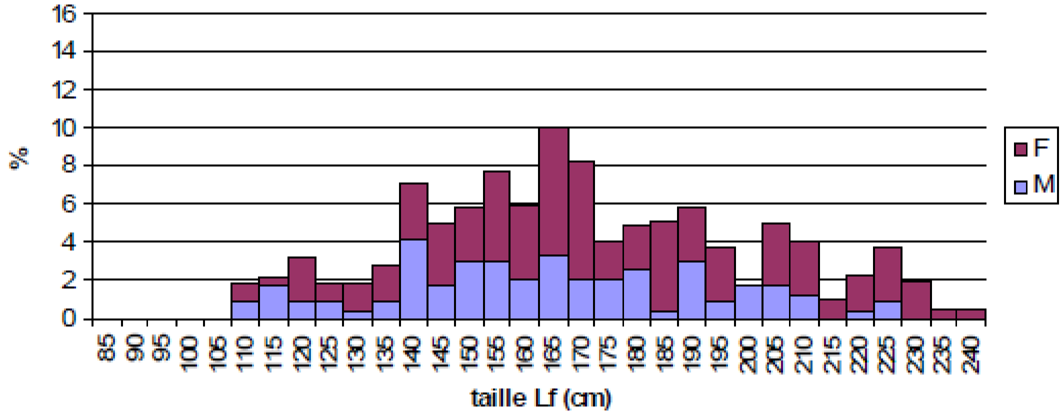
Length distribution

The comparison of the 2018 survey length distribution and the 2008-2009 distribution (Hennache and Jung, 2010) shows an increase in modal length that moved from 150-165 to 175-190 cm (Figure 6; data from the same months and curved forth length in both distribution). As a result, an **increase in biomass from 2009 to 2019 is very likely**, as survey indices show that the abundance has not decreased even though it is difficult to assess its possible increase.

May 2008-2009 (n=570)



June 2008-2009 (n=237)



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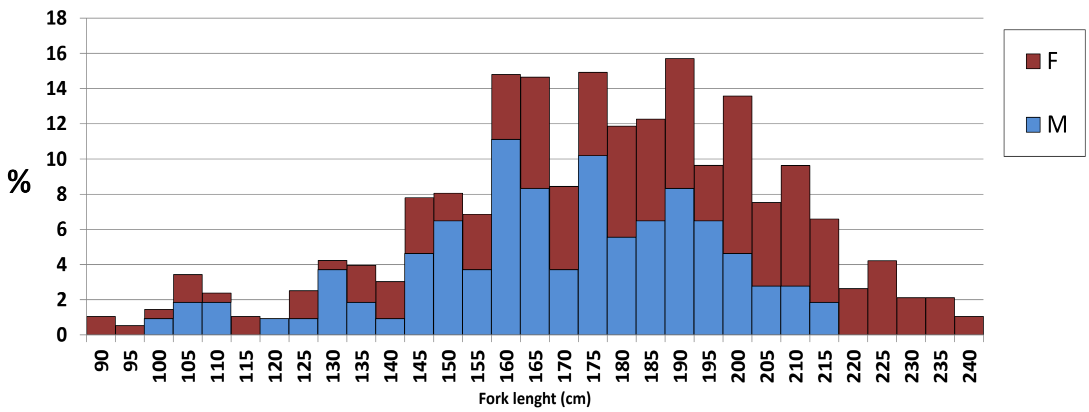

Figure 6: Change of porbeagle length distribution from 2008-2009 (source Hennache and Jung, 2010) to 2018-2018 on the Bay of Biscay shelf break.

References

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Raja undulata Portuguese Monitoring Plan – data collected during 2019

Catarina Maia and Ivone Figueiredo

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In 2016, as a result of the species EU by-catch allowance in ICES 9.a the Portuguese authorities adopted a special license scheme under which fishermen are obliged to provide fishery data to science (Portaria no 96/2016 and 27/2017). The information provided by fishermen during 2016-2017 was critically analyzed and a statistical approach was developed by IPMA to model the spatial distribution and abundance of *Raja undulata* in Portuguese waters. A summary of the procedures followed and the main results obtained was presented during the WGEF 2018 meeting (Maia and Figueiredo, 2018). The results obtained enabled to initiate a time series on the species abundance along the Portuguese coast. However, the data collected during 2018 was insufficient to allow the continuation of the scientific studies which are fundamental for assessing the size of the populations of this species. In this context and in order to increase the quantity of data reported, in addition to the legislation governing in previous years regarding the obligations of the licensed vessels, a new scenario for the remaining vessels was established. For the former vessels, a total of one specimen by trip is now allowed providing that the species fishery data are properly reported (Portaria no 4/2019).

Data collected so far for 2019 is summarized below (Tables 1-2, Figures 1-4). Only hauls containing the required information for the adjustment of the model were considered: fishing haul geographic location, fishing haul technical characteristics, as gear type and its mesh size, and; total catch in number of specimens of *Raja undulata*. It is important to note that the information reported only contain hauls with capture of the species which can jeopardize the developed model adjustment.

Table 1: Total number of hauls reported by region (North, Center, Soutwest and South) and gear type (A=Trawl, E=gilnets, P=longline and T=trammel nets).

Region	A	E	P	T
North	31			75
Center	6		1	106
Southwest		2		597
South	1	4		126

Table 2: Total number of hauls performed with trammel nets with mesh size > < 150 mm.

Region	<150mm	>150mm
North	75	
Center	79	27
Southwest	528	69
South	126	

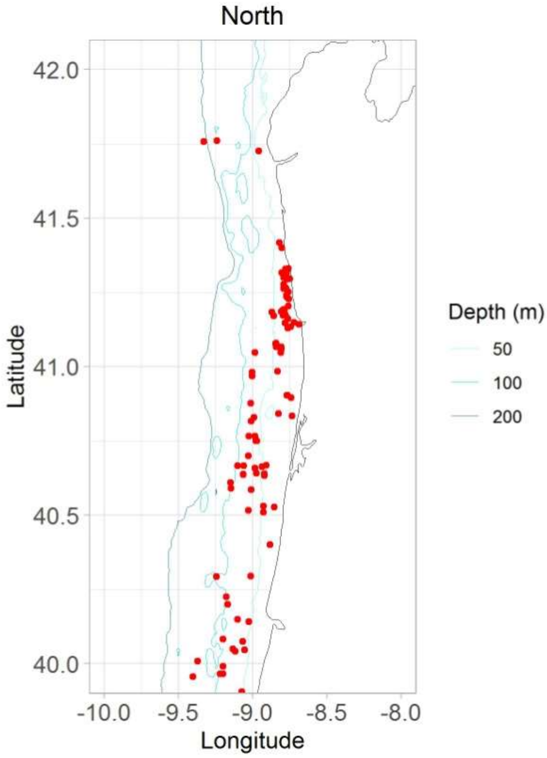

Figure 1: Spatial distribution of fishing hauls performed in the North region with trammel nets with mesh size <150 mm.

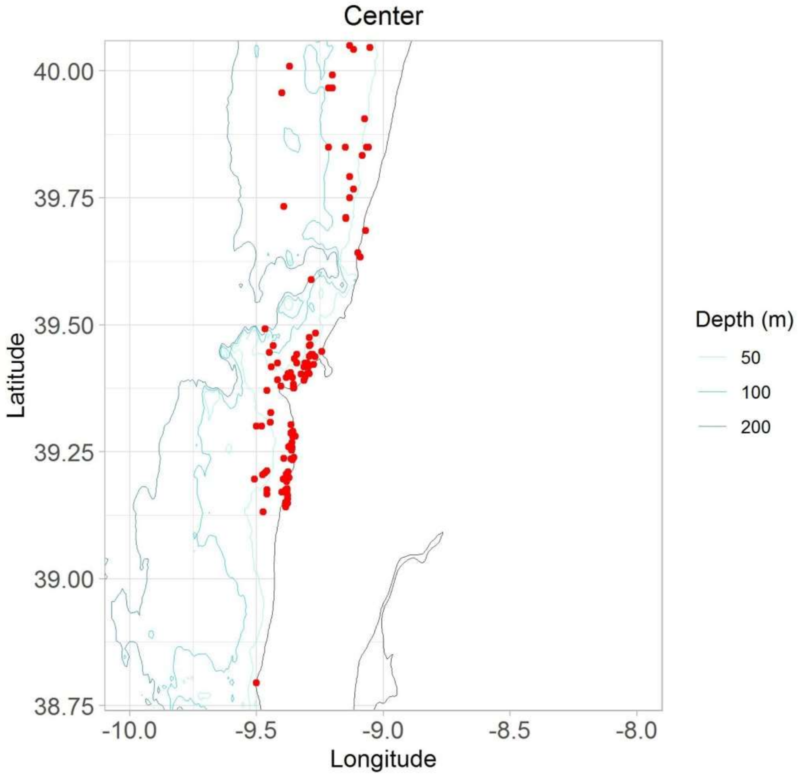

Figure 2: Spatial distribution of fishing hauls performed in the Center region with trammel nets with mesh size <150 mm.

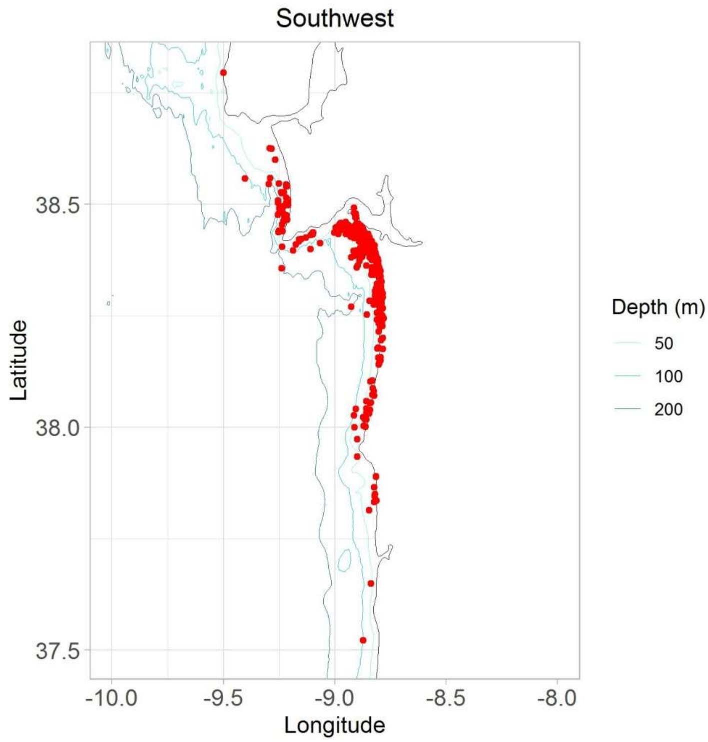

Figure 3: Spatial distribution of fishing hauls performed in the Southwest region with trammel nets with mesh size <150 mm.

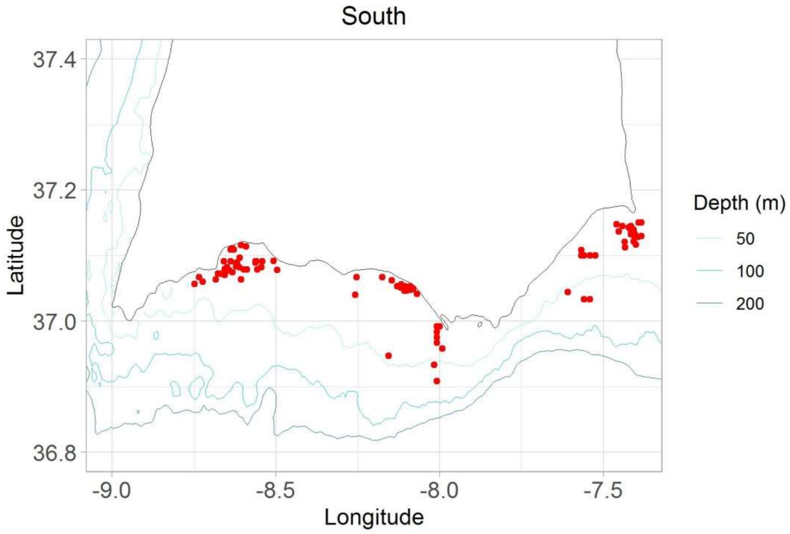

Figure 4: Spatial distribution of fishing hauls performed in the South region with trammel nets with mesh size <150 mm.

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ICES WGEF, 18th - 27th June 2019, Lisbon, Portugal.

Fitting a biphasic growth model to the elasmobranch *Scyliorhinus canicula* (Linnaeus, 1758).

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Abstract

This working document presents the results obtained by fitting a biphasic growth model to describe lifetime growth of *Scyliorhinus canicula* population in the Cantabrian Sea (ICES Division 8c). Data used were based on tag-recapture database maintained up to date since 1993, from a tagging program conducted in the study area. A total of 14091 lesser spotted dogfish have been tagged during this period, 7638 males and 6453 females respectively, 496 of which were recaptured and 374 (214 males and 160 females) could be used for growth analysis. Parameters obtained from Lester growth model (LGM) provided a juvenile annual growth rate (h= 57.4 ±1.2 mm) and reproductive investment (g~ 0.20). Besides after conversion the following von Bertalanffy growth parameters (VBGC) for sexes combined, valid only for breeding lifetime, after the first reproduction, were: Linf=84.5 cm; k=0.083, t_0=-2.25. Finally mortality estimates (M) based on previous growth models were calculated (0.19-0.23). Parameters derived from growth models could be used to estimate important life history traits.

Introduction

A number of different models have been developed to describe growth (e.g., von Bertalanffy, Gompertz, Logistic), however no single growth model provides the best fit for describing a population growth. Despite the lack of consensus on the best fitting growth model, the von Bertalanffy (von Bertalanffy, 1938, Beverton and Holt, 1957) growth model (VBGM) is prevalent in the elasmobranch literature and in many cases is the only growth model considered in a given study (Cailliet *et al.* 2006).

Numerous authors have proposed the use of two-phase growth models for describing the lifetime growth of fishes (e.g. Soriano *et al.*, 1992, Day and Taylor 1997, Lester *et al.* 2004, Araya and Cubillos, 2006; Braccini *et al.* 2007). A review of the literature suggests that a two-phase growth model could better describe growth in elasmobranchs (Araya and Cubillos, 2006; Lester *et al.*, 2004, Brian, 2015). Changes in growth rate may be brought on by changes in habitat use and feeding, but there is also strong support for the reproduction energy-allocation hypothesis (Carlson and Baremore 2005, Araya and Cubillos 2006, Braccini *et al.* 2007). Several new growth models have been proposed to account for the life-history trade-offs that occur when indeterminately growing species allocate energy in somatic growth and reproduction. These models can improve the understanding of lifetime growth and life history, but can be more difficult to fit than conventional growth models (Wilson *et al.*, 2017).

Tag-recapture data, besides other applications, (Jones, 1976; Thorsteinsson, 2002) is one of the most important methods for estimating growth parameters (K and L_∞) especially for species that cannot be aged directly for the lack of hard parts, such as elasmobranches. However, some problems could be associated with these methods as well. They can give biased results if measurements taken, are not accurate, both at tagging or recapture, or because individual growth is variable, time at liberty is too short, sample size is small or not representative of all ages, and finally if the tag or the tagging procedure has a significant effect on growth.

Lesser spotted dogfish (*Scyliorhinus canicula*) is one of the most wide spread and abundant elasmobranch inhabiting the continental shelf of European waters. A lot of studies have been carried out with this species for estimating different life-history parameters, diet, survival rates, behavior, etc. In particular age and growth studies on this species have been attempted enhancing growth bands from vertebrae (e.g. Machado, 1996; Henderson and Casey, 2001; Moreira *et al.*, 2018), from length frequency (e.g. Zupanovic, 1961, Rodríguez-Cabello *et al.*, 1998; Ozcan & Başusta, 2018) or from tag- recapture data (Rodríguez-Cabello *et al.*, 2005).

Accurate age determination is necessary for both the assessment and management of any species because it is the basis for calculations of growth and mortality rates, age at maturity, age at recruitment and longevity. The ability to accurately describe elasmobranches lifetime growth and indirectly estimate mortality is crucial for the proper assessment of the size and health of stocks (Simpfendorfer, 2005).

Recently, the need to provide management advice, especially in relation to maximum sustainable yield (MSY), for an increasing number of fish species caught in commercial fisheries has led to a proliferation of data-limited assessment methodologies, reflecting differing data availabilities and intended use of assessment (Walker *et al.*, 2018; ICES, 2015).

Biological features such as fecundity and natural mortality or fishery selection are related to size , thus length data can contain substantial information both on stocks and the fisheries impacting on them (Walker *et al.*, 2018; ICES, 2015). The current ICES assessment for this species (at present 4 stocks) is generally based on survey trends (Category 3). Currently, the length based indicators (LBI) to provide additional demographic information are useful tool for managers. However length-based methods are quite sensitive to life history parameters and thus the quality of the input data will influence the quality of the results.

The main objective of this paper was to evaluate the adequacy of using the biphasic Lester growth model (LM) on *Scyliorhinus canicula* population in the Cantabrian Sea (ICES Division 8c) to describe lifetime growth of this elasmobranch. Besides growth parameters obtained from other traditional methods based on the von Bertalanffy growth model (VB) were used for comparative analysis. Estimates of mortality based on parameters derived from previous equations were also provided.

Material and Methods

Data

Since 1993 a tagging program was implemented in the scientific bottom trawls carried out annually in the North of Spain by the Spanish Institute of Oceanography (IEO) with the principal aim of estimate the biomass and abundance of the main commercial species. Inside this programme, a total of 14091 lesser spotted dogfish have been tagged (7638 males and 6453 females), comprising a size range from 15 to 73 cm (Figure 1). Sharks were tagged with T-bar anchor tags using a Mark II regular tagging gun. For each specimen total length was measured to the nearest cm and sex was noted. Date, depth and release location were also recorded. Up to date 496 individuals were recaptured, those with no length information or doubtful data were excluded resulting in 374 records (214 males and 160 females) that were used in the growth analysis. Lengths of the specimens tagged and recapture (25-71 cm males and 27-68 cm females) are shown on Figure 1.

Lester growth model

Lester biphasic growth model (LM) is based on the principle that sexual maturation in fishes represents a change in energy allocation such that lifetime growth is divided in two phases one before and one after maturity (Lester *et al.*, 2004). The pre-maturity period, in which all energy is devoted to somatic growth is described by linear equation, whereas the von Bertalanffy (VB) growth equation provides a good description of somatic growth after maturity (Lester *et al.*, 2004). Thus, the LM describes immature growth in the lead-up to maturity as a straight line and mature growth as a VB curve:

$$L_t = h\,(t - t_1) \qquad \text{when } t \leq T$$

$$L_t = L_\infty\,(1 - e^{-K\,(t - to)}) \qquad \text{when } t > T$$

where L_t is length at time t, h is juvenile growth rate (length per unit time), t_1 is the LM (immature) hypothetical age at length 0, T is last immature age (LM parameter for age-at-maturity), $L\infty$ is asymptotic length, K is the VB (Brody) growth coefficient, and t_0 is the VB (adult) hypothetical age at length 0 (Wilson *et al.*, 2018).

Lester *et al.*, (2004) further showed that L_∞, K and t_0 reflect known trade-offs between growth, reproduction and mortality:

$$L_\infty = \frac{3h}{g}$$

$$K = \ln(1 + \tfrac{g}{3})$$

$$t_0 = T + \frac{\ln(1 - \frac{g\,(T - t_1)}{3})}{\ln\,(\,1 + \frac{g}{3})}$$

where g is the cost to somatic growth of maturity (often assumed to be dominated by investment in reproduction. According to LM the feasible range for g is: $\frac{3}{T-t_1}$ Growth is indeterminate if g < $\frac{3}{T-t_1}$ and determinate if g = $\frac{3}{T-t_1}$. Following Wilson *et al.*, (2017) the parameter g captures the proportion of surplus energy allocated into direct (e.g. gonad development) and indirect (e.g. migration, nesting, displaying, metabolic costs of storing gonads) reproductive investment. The connection between g and M could be expressed as:

$$g \sim 1.18\,(1 - e^{-M})$$

$$T \sim \frac{1.95}{e^{M} - 1} + t_1$$

where, M is the instantaneous rate of late-stage juvenile and adult natural mortality.

They key assumptions of the LM are 1) growth is indeterminate 2) body mass increases with length cubed ($W \approx L^3$), gonad mass is proportional to somatic mass (GW≈TW) and metabolism scales with mass to the two-thirds power (Lester *et al.*, 2004).

Input data for Lester Model fitting

T_{mat} intended as the age at sexual maturity used in this analysis came from previous studies carried out with this species in the same study area (Rodríguez-Cabello *et al.*, 1998; Rodríguez-Cabello, 2008). These studies provided a Length at maturity, L_{mat} = 54.2 cm (range 49.7– 59.1 cm) for females and L_{mat}=55.9 cm (49.9 – 56.5 cm) for males respectively. Thus, L_{mat} was converted into T_{mat} by using a length at age curve based on VBGC parameters Linf=69.3 and k=0.21 ,calculated for the same population in the Cantabrian Sea (Rodríguez-Cabello *et al.*, 2005), the estimated T_{mat} was 7 years. Following Wilson *et al.*, (2017) lags between the onset of investment in reproduction and maturity data or metrics (e.g. age-at-50%-maturity or A_{50}) should be corrected before fitting maturity-based biphasic models. Thus taken this into consideration (T_{mat} = A_{50} – 1) the T_{mat} value used in the model was T_{mat}= 6. This input practically coincides with that of the Lester Model (6.08) expressed as: $T_{mat} = L_{mat}/h+t_1$, where L_{mat} is the Length at maturity, h is the mean annual growth before maturity is reached, and $t_1 = -L_0/h_{true}$ where we assumed that L_0~10 cm is length at birth (e.g. Leloup and Oliverau, 1951; Mellinger and Wrisez, 1984; Ellis and Shackley, 1997) and h_{true} is observed annual growth. The model also requests to input a parameter which is $t_{1\ true}$. This parameter is interpreted as the age of the individuals when their size is 0, and biologically it could be assimilated to the gestation period. This parameter was calculated as $t_{1true} = -L_0/h_{true}$. Finally we used a cv of of 15%, which is a very typical observation for the coefficient of variation in length-at-age among most fishes (Wilson *et al.*, 2017).

Considering that the idea of this model is to quantify the energetic investment due to the start of reproduction, and that this investment is likely to be higher in females than in males as previous studies of comparative gonado-somatic indices indicate this (Rodríguez-Cabello, 2008), the LGM model was also fitted for males and females separately.

Results

Maximum observed lengths were always larger in males than females (Figure 1). Nearly the 88 percent of the specimens were recaptured during the first 5 years at liberty (Figure 2) however maximum time at liberty recorded had been 14.6 years for a male of 50 cm total length thus longevity could be estimated at least or close to 20 years.

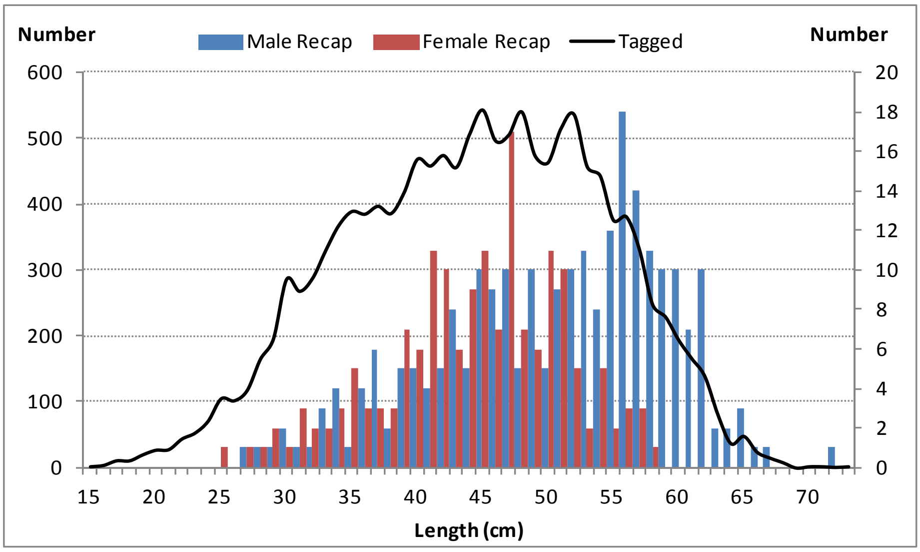

Figure 1. Length distribution of *Scyliorhinus canicula* tagged and recaptured since 1993-2018 in the Cantabrian Sea (NE Atlantic).

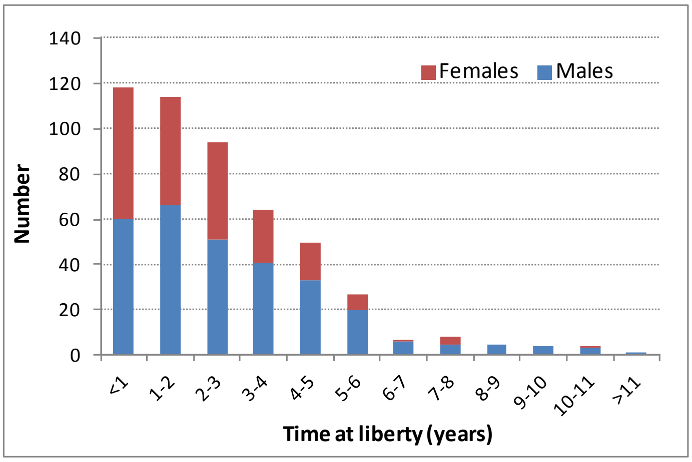

Figure 2. Number of *S. canicula* recaptured according to time at liberty expressed in years for both males and females

Growth curve obtained with input parameters is represented in Figure 3. The shape of this curve presents a break in correspondence of the age in which maturity is reached (6 years).

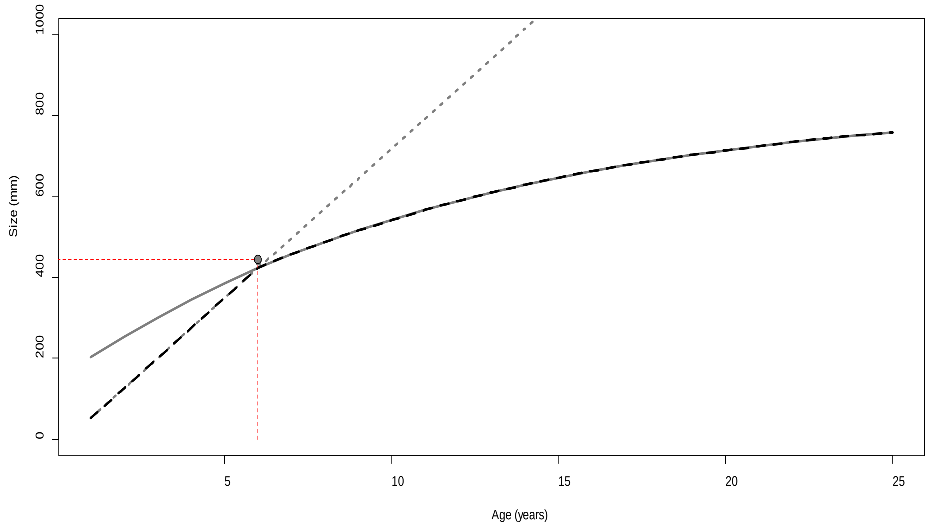

Figure 3. Growth curve built up with Lester biphasic growth model. Grey point represents the break point at which slope and shape of the curve are assumed to change.

The second step is to check if the available data followed the same shape as the LGM curve obtained with the input values (Figure 4). The point's distribution had a shape reasonably similar to that of LGM, although sizes should be higher to have a perfect coincidence at least for the first twelve years.

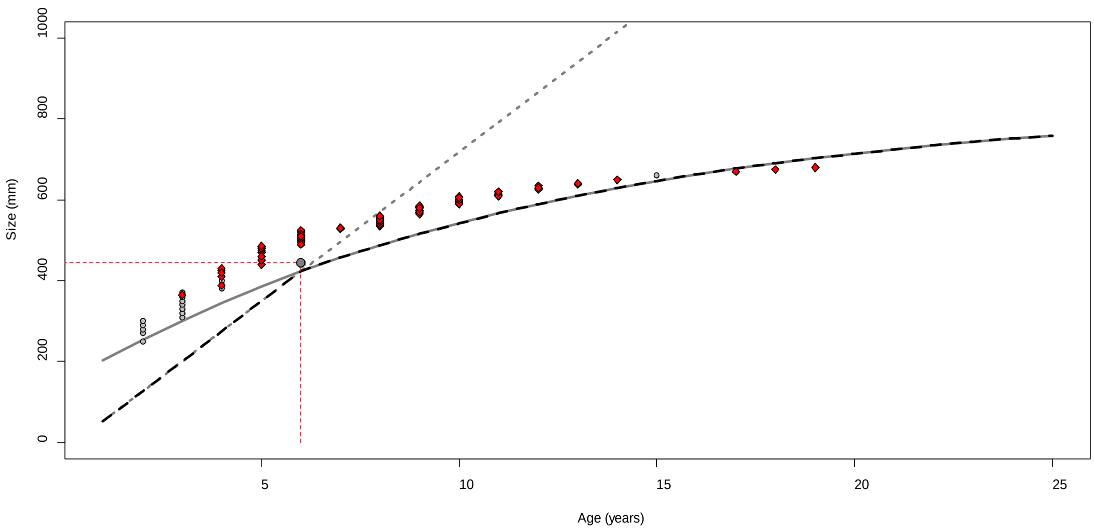

Figure 4. Lester growth curve plotted against real length at age data. Grey points represents tag and release data, while red points represents capture data.

Successively, we subsetted the data into two datasets: the immature and the mature to evaluate a direct interpretation which is linear growth for the juveniles and nonlinear, asymptotic growth for mature individuals that follows a von Bertalanffy growth curve. We fit the linear model and obtained the following results listed in Table 1 and showed in Figure 5.

Table 1. Linear intercept with x-axis and annual growth rate *h* (mm) for immature obtained from LGM.

Coefficients	Sex	Estimate	Std. Error	t value	Prob.(>|t|)
Intercept	Both	174.958	5.099	34.31	<2e-16 ***
h (mm)		57.421	1.21	47.46	<2e-16 ***

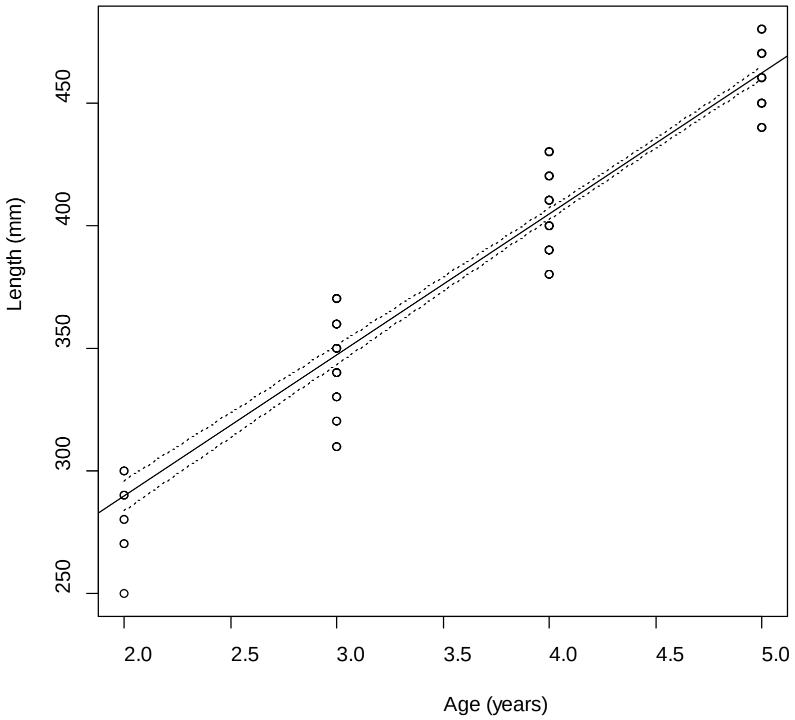

Figure 5. Solid line represents the fitted linear model, dotted lines represent the 95% confidence intervals and the points represent the real catch and release data per age class.

Bootstrapping gave a standard deviation of 1.2 mm (57.4 ±1.2 mm) therefore mean growth rate varies between 56.2 y 58.6 mm per year considering the whole immature period. Although a growth rate of 56 -58 mm per year could seem low, it does make sense if we consider this is the average for the whole immature period. Besides the lack of observations within the first year after birth (very few specimens tagged and no recaptured) when the growth would be surely faster and could be model separately if we had that information. Specifically assuming length at birth of 100 mm, we have calculated that individuals between 250 and 300 mm could correspond to age 2, but we are missing information on the early growth between the birth and 1 year old since we lack data of length and thus of growth between birth (10 cm) and age 2 (~25-30 cm).

Fitting the model we obtained also the estimated value for the parameter t1 which represent the age of the shark when its size is 0. This value was equal to -3.04. This does not make sense if we do not take into account what explained before. A gestation time too much long, but if we assume that we lack the first year of life size in this data set, could be probably a gestation time of two years. Nevertheless, the t1 parameter will be among the more uncertain parameters as it is one of the only free parameters of the model that is allowed to vary much for fitting to the noisy size-at-age data. So it can jump around a fair bit compared to *h* and *g*. Afterwards, we used the R package (nls) to estimate the nonlinear adult growth. The second part of the curve was fitted obtaining the results showed on Table 2.

Table 2. Estimated reproductive investment for mature individuals obtained from LM.

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)
g	0.209114	0.002484	84.19	<2e-16 ***

Where g is the estimated reproductive investment which at the length of maturity leads to a drop of the annual growth rate as evidenced in the curve.

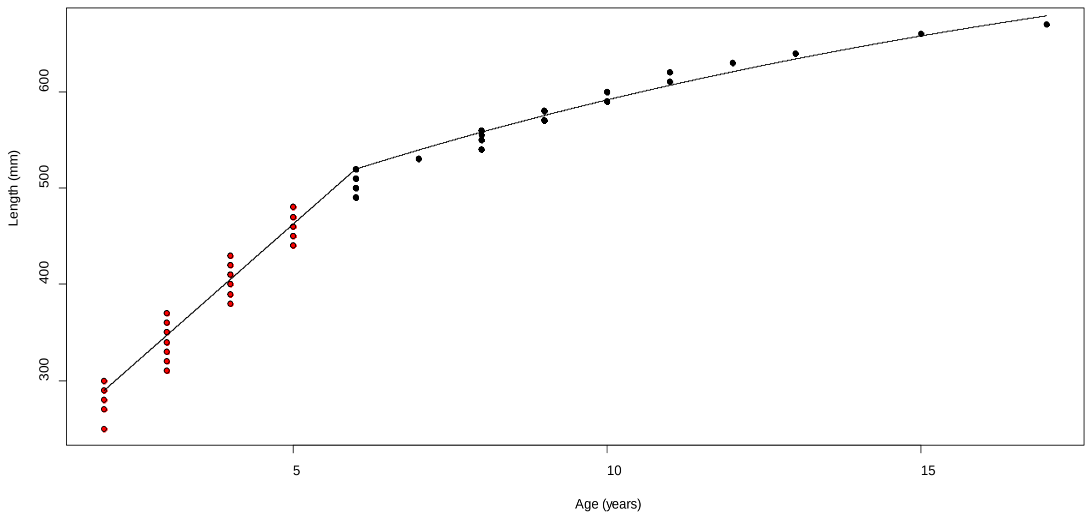

Figure 6. Final Lester biphasic Growth model for the whole population.

The final fit for both sexes combined returned the following values with their 95% confidence intervals Table 2.

Table 3. Results of applying Lester biphasic growth model to the data considering both sexes.

	Parameters		
Both sexes	**h**	**t1**	**g**
Value	57.42	-3.04	0.2
Lower-Upper 95 CI	47.420-67.410	-5.410--0.670	0.204-0.214

Furthermore some diagnostics of the model were done in order to evaluate how biased the estimates of the growth parameters were in comparison to the true data available (Figure 7).

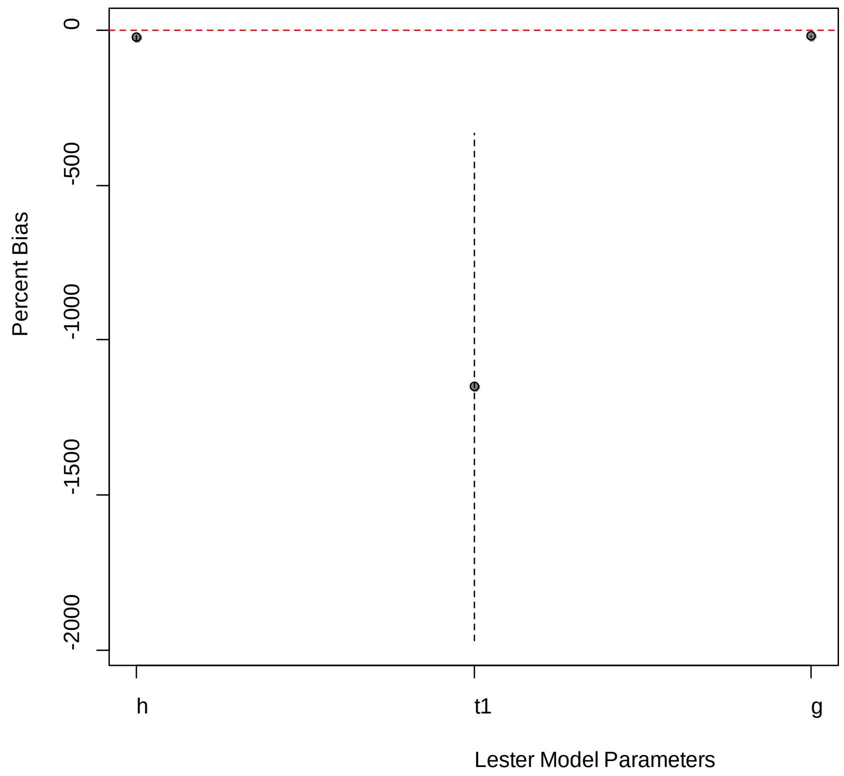

Figure 7. Bias estimates (expressed as percentage) of each of the parameters obtained from LGM.

As in the case of the study of Wilson et al. (2017), most of the bias goes into t_1 while both h and g are estimated reasonably well. Lastly, we visualize standardized residuals for both the juvenile and adult model phases (Figure 8). The residuals appear normally distributed suggesting no systemic bias in the model fitting and the assumptions of normality for the statistical models are met.

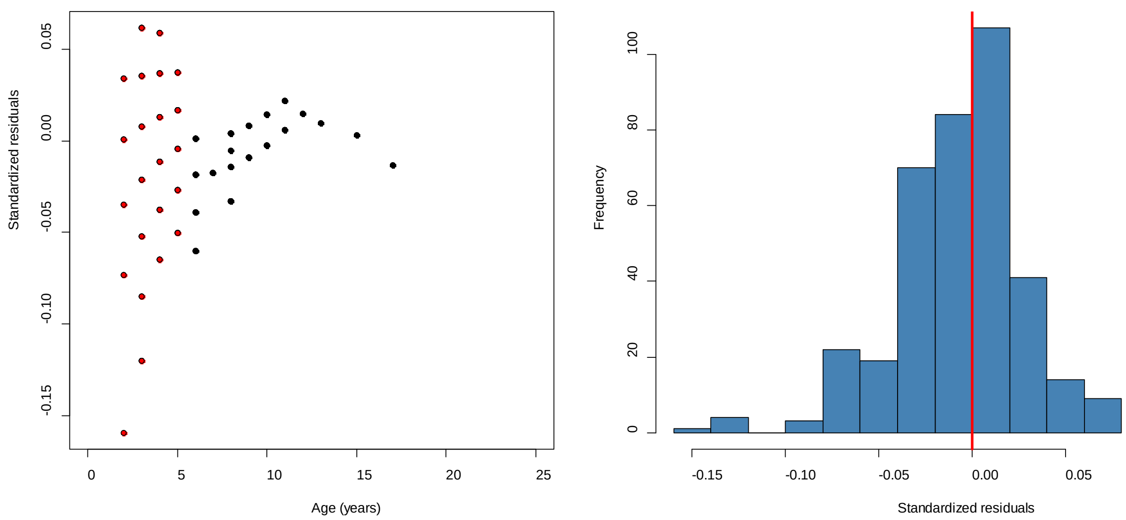

Figure 8. Standardized residuals obtained for both juvenile and adult phases. In the left residuals with respect to age (red points represent juveniles, and black points adults) and in the right there are the standardized residuals for both juvenile and adult phases.

Our residuals showed an almost bell curve centered on 0, with a few outliers. It looks like there is more variability in size-at-age in early life than later in life. This could be due to different factors, the most plausible one could be the faster growth rate and consequently more variability of length inside the same age class for juvenile phase.

Model was fitted also for females and males separately. Results are included in Table 4 and Figures 9 and 10 respectively.

Table 4. Linear intercept with x-axis and annual growth rate (mm) for immature obtained from LM for males and females individuals.

Coefficients	Sex	Estimate	Std. Error	t value	Prob.(>|t|)
Intercept	Females	168.483	6.981	24.13	<2e-16 ***
h (mm)		58.761	1.652	35.58	<2e-16 ***
Intercept	Males	182.388	7.448	24.49	<2e-16 ***
h (mm)		55.9	1.774	31.51	<2e-16 ***

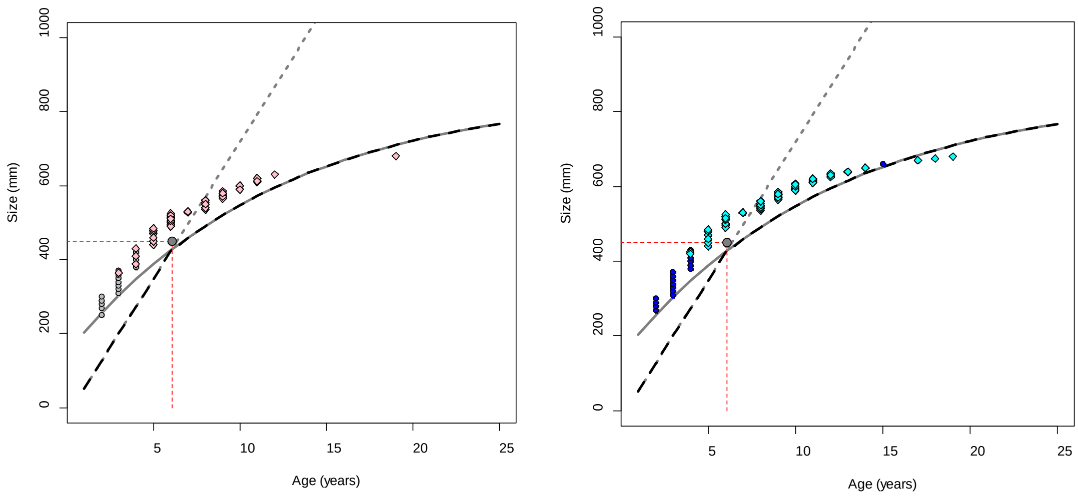

Figure 9. Lester growth curve plotted against real length at age data. On the left females and on the right males. Females, grey points represent tag and release data, while pink points represent capture data. Males, blue points represent tag and release data, while cyan points represent capture data.

Bootstrapping gave a Standard deviation of 1.89 mm (58.76 ± 1.89 mm) which mean growth rate varies between 56.87 and 60.65 mm per year for females while for males s.d. obtained was 1.72 mm (55.90 ± 1.72 mm), thus mean growth rate varies between 54.18 and 57.62 mm per year; these estimates could raise the mean considerably, as explained above for the case of the whole population.

Afterward, we used `nls()` to estimate the nonlinear adult growth both for females and males. The second part of the curve was fitted obtaining the followings results:

Table 5. Results obtained fitting Lester biphasic growth model to the data considering both sexes separately.

		Parameters		
		h	**t1**	**g**
Females	Value	58.76	-2.86	0.24
	Lower-Upper 95 CI	45.078-72.444	-6.104-0.370	0.213-0.272
Males	Value	55.9	-3.26	0.20
	Lower-Upper 95 CI	41.302-70-498	-6.740-0.215	0.196-0.206

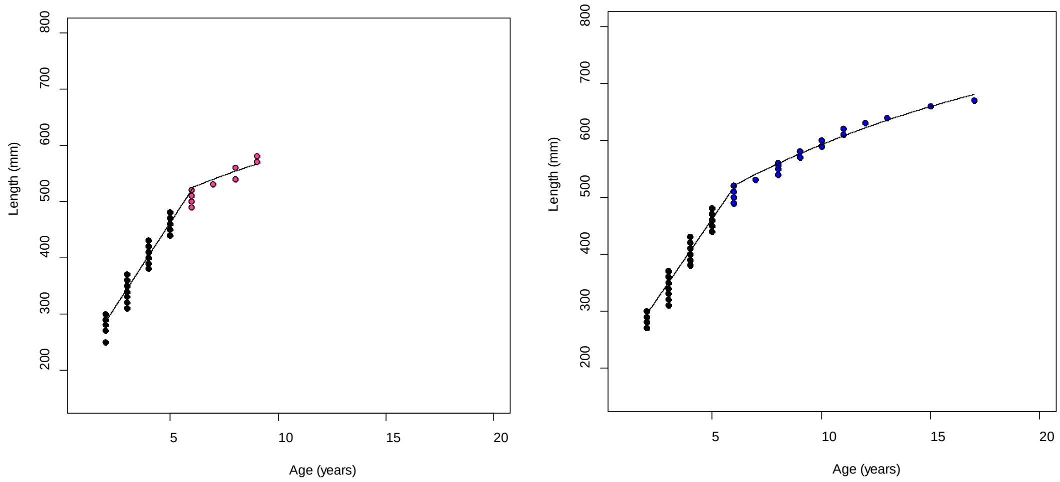

Figure 10. Final Lester biphasic Growth model population studied females at left and males at right.

These results confirmed a biological difference which was already known, i.e. the higher amount of energy allocated in female gonads production in this elasmobranch, which in this model is reflected in the differences in braking of the growth rate and consequently turned into a different slope of the growth rate and shape of the growth curve.

We did some further diagnostics of the model by evaluating how biased the estimates of the growth parameters were in comparison to the true parameters we used to simulate the fake data. To do this we use percent bias and we obtained the graph below.

As in the case of Wilson et al., 2017, most of the bias goes into t1 while both h and g are estimated reasonably well. Lastly, we visualize standardized residuals for both the juvenile and adult model phases. The residuals appear normally distributed suggesting no systemic bias in the model fitting and the assumptions of normality for the statistical models are met.

Our residuals showed an almost bell curve centered on 0, with a few outliers. It looks like there is more variability in size-at-age in early life than later in life

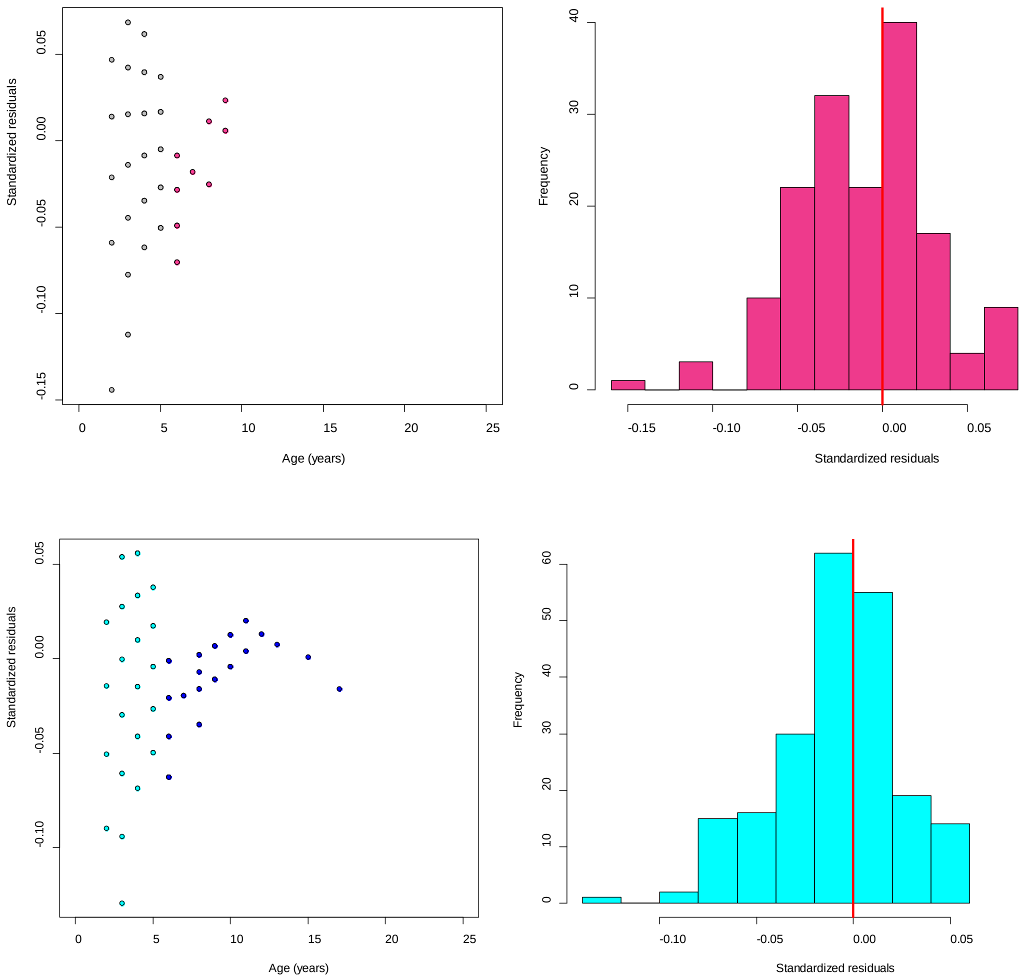

Figure 11. Standardized residuals obtained for both juvenile and adult phases for females (up) and males (below). In the left residuals with respect to age (red points represents juveniles, and black points adults) and in the right there are the standardized residuals for both juvenile and adult phases.

A conversion from LM to VBGC parameter was attempted by using the equation proposed in Wilson et al. (2018), for the whole population it was obtained a Linf=85.35 cm and a K=0.065; take into account that this K is valid only for the second part of the curve, i.e. after reproduction began.

Finally mortality estimates based on previous LGM results following equations (see material and methods) obtained for both sexes are shown on Table 6

Table 6- The instantaneous mortality rates estimates obtained with proposed by Lester et al., (2004).

	Sex combined	Females	Males
M	0.20	0.23	0.19

Discussion

It is often assumed that the VB growth model is appropriate to describe growth in length at age of elasmobranchs. However a review of the literature suggests that it may not be always the most suitable function for describing growth in elasmobranchs, and that a two phase growth model could be better. According to the study of Araya and Cubillos, (2006) growth rate in length at age tends to decrease near the age at first maturity in several species of elasmobranchs.

Several biphasic growth models have been proposed for or are commonly applied to fishes (see Wilson *et al.*, 2017 for a review). These models vary in complexity and tend to describe either abrupt or smooth transition between growth phases (Wilson *et al.*, 2017). Shifts between both phases can be associated with changes in maturity, age, diet or habitat, although investment in reproduction is the major biological explanation considered in most of these models and in particular LM (Lester, 2004). A comparative analysis of different growth models on thirty elasmobranch populations showed that LM is a reasonable approach to describing lifetime growth in sharks and tends to outcompete traditional models (Brian, 2015). According to this author the major caveat is that ages must be validated in order to accurately describe lifetime growth.

Tagging studies have been proved to be an important tool in estimating population variables such as abundance, migration, growth and mortality rates (Jones, 1976; Thorsteinsson, 2002). In our case this valuable data allowed us to fit a biphasic growth model comparing the estimated growth obtained fitting the model and real data of observed growth. This represents an important validation for using this kind of model in lesser spotted dogfish. The very high significance obtained by fitting the model in the 3 cases (whole population, females and males) demonstrate the model goodness. Results tell us that the cost of reproduction is evident in the whole population, and that it is higher in females tan in males. These results are bear out by the gonadosomatic índices obtanied for both sexes in (Rodríguez-Cabello, 2008 and others). Even if the lack of growth data for the first year of life could have contributed to bias the estimation of the t1 parameter (interpreted as the time of gestation), data such as the length at birth and some faster growth data we had for the smaller individuals helps to explain the estimation obtained. Finally since in the 3 cases residuals appear normally distributed, it is plausible that no systemic bias in the model fitting have occurred and the assumptions of normality for the statistical models are met.

Linearity in the lead-up to maturity is an important distinction that allows for ontogenetic shifts in juvenile diet, which have been observed in a number of elasmobranchs (e.g., Wetherbee & Cortes, 2004; Carrason et al., 1992; Olaso et *al,* 2005*; Velasco &* Olaso*,* 1996; Farias *et al.* 2006,). In particular, the diet of *S. canicula* in the study area has been well studied and ontogenic changes are described (Olaso et *al,* 2005*;* Olaso *et al.*, 2002). *S. canicula* can be considered as a generalist species with a wide diversity of preys including scavenging behavior. In juveniles an early phases the diet is mostly based on euphasiacea, whereas as they growth the percentage of euphasiacea decrease and other crustacean preys and fish increase. Futhermore, apart from changes in diet shifts in feeding intensity and number of empty stomachs are also evident between specimens < 50 cm and > 50 cm (Olaso et *al,* 2005).

Studies on elasmobranchs life-history traits are essential for understanding their population dynamics, especially as they relate to how they will respond to fishing pressure. Accurate age estimates provide valuable information on age-specific recruitment, maturity, reproductive output, mortality rates, longevity and growth rates of fished populations (Caillet, 2015)

As a result these estimates can be used to estimate biological reference points intended to guide further stock assessments such as those included in Data Limited Stocks (ICES) (Smith *et al.* 1998). Thus, it is extremely important to be able to accurately and appropriately describe elasmobranch lifetime growth.

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Mislabelled landings data collected by MNHN

21/06/19

Under the EU Data Collection Framework (DCF) a dedicated national programme of fish market data is collected by the Museum National d'Histoire Naturelle (MNHN - France) on chondrichthyans. Within these programme samples of chondrichthyans length, weight, sex and male maturity is collected in addition to any potential miss-identification. This programme is different from Ifremer ObsVente (fish market sampling) which collects data on common stock species. However, measures are being taken to combine these data into the same database. Species which overlap with Ifremer collected species include: *L naevus, R.clavata, R. montagui, R. bracyura*. The database currently contains information on a total of 42 chondrichthyans from 13 families.

Table 1 highlights some commonly miss-labelled species which have been collected by MNHN. The data is from a period of five years of data collection (2013 to 2016 and 2018) across 33 fish markets throughout France, where approximately 70% (depending on the quantity of landings) of a fish market's landings is recorded. During 2012 and 2017 due to resource issue, only a few months of fish market data were sampled, these data have therefore been excluded from Table 1.

Table 1. Summary table of some commonly miss-identified species.

	Species	**Total sampled**	**Total number and percent mislabelling**	**% mislabelled species placed under a generic name**	**Species and % commonly miss-labelled with**
1	*Scyliorhinus stellaris*	3136	1367 (44%)	Divers 0.6%	*Scyliorhinus canicula* 42%
2	*Scyliorhinus canicula*	8065	359 (4%)	Scyliorhinus spp. 1.5%	NA
3	*Galeorhinus galeus*	1645	55 (3%)	Mustelus spp. 0.8%	*Mustelus asteria* 1.5%
4	*Mustelus asterias*	9966	3583 (36%)	22% Mustelus spp.	NA
5	*Squalus acanthias*	58	43 (74%)	50% *Scyliorhinus* spp.	NA
6	*Leucoraja naevus*	7260	233 (3%)	Raja spp. + Diverse 0.3%	NA
7	Raja clavata	5142	560 (11%)	Raja spp. 7.5%	NA
8	*Leucoraja*	3916	631 (16%)	Raja spp. 1.7%	*Raja circularis*

	fullonica				12%
9	*Leucoraja circularis*	1107	302 (27%)	Raja spp. 0.27%	*Raja Fullonica* 23%
10	*Raja montagui*	3207	962 (30%)	Raja spp. 0.9%	*Raja brachyura* 19%

Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 18-June 27, 2019

New updated survey index for elasmobranchs caught in the English beam trawl survey of the eastern English Channel (ICES Division 7.d) and southern North Sea (ICES Division 4.c)

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Abstract: The present document refers to an update of data provided by UK (England) to the ICES WGEF 2017 on thornback ray *Raja clavata*, blonde ray *R. brachyura*, spotted ray *R. montagui*, lesser-spotted dogfish *Scyliorhinus canicula* and starry smooth-hound *Mustelus asterias* (Ellis, 2017a,b). This working document was compiled after the 2019 WGEF meeting, due to problems arising from the ICES DATRAS data product *CPUE per length per Hour and Swept Area* that was previously used in the calculations for the survey indices and advice for these species.

Introduction

The indices used previously for the annual beam trawl survey in the eastern English Channel (ICES Division 7.d) and southern North Sea (ICES Division 4.c), were calculated using the ICES DATRAS data product *CPUE per length per Hour and Swept Area*. However, while at the WGEF meeting in 2019, an error was found within the data product when the *CPUE per length per hour and swept area* was compared with the exchange data (data uploaded by each Nation to ICES).

The problem consisted in multiplication (in cases up to 3 times) of the original records for the numbers at length per sex in each haul for the years 2010–2018, which if used would result on an index not reflecting the real survey catches. The overall trend would be similar, but the magnitude of increase/decrease would be affected by the repetition of records. Although the error was reported to ICES post-meeting and corrections have been made within the ICES database, it was agreed at the WGEF that an update of the survey indices and their calculations would be provided using the internal national data. In recent years, this survey time-series has also suffered a major QA/QC within the national database, which further added to the decision of providing the survey indices using the latest national dataset.

The English beam trawl survey of the eastern English Channel and southern North Sea samples a variety of demersal elasmobranchs. The three most common and of commercial interest skate species caught in this survey are thornback ray *Raja clavata*, blonde ray *R. brachyura* and spotted ray *R. montagui.* Meanwhile, the two most common shark species within this survey are lesser-spotted dogfish *Scyliorhinus canicula* and starry smooth-hound *Mustelus asterias*.

Although skate species such as small-eyed ray *R. microocellata* and undulate ray *R. undulata* are also recorded in this survey their stocks extend to the western English Channel (Celtic Seas ecoregion) and therefore, not included in this working document with the main focus being for species with stocks within the North Sea ecoregion or widely distributed.

Methods

The English beam trawl survey in ICES Divisions 7.d and 4.c has been conducted since 1989, although only with a standardized survey grid since 1993 (Parker-Humphreys, 2005). The gear used is a 4 m beam trawl with chain mat, as described by Burt *et al*. (2013). Therefore, the index here presented has only been calculated from 1993 onwards using the Cefas Fishing Survey System (FSS) and R software (2017).

The survey of the eastern English Channel and southern North Sea is conducted each July (although surveys in any one given year may extend into August), and 75 fixed stations were fished consistently over time (during at least 23 years of the 26-year study period). The fixed stations used in the present analysis were prime stations 1, 4, 6–12, 16–24, 27, 29, 35–40, 42–45, 47, 50–80, 82–83, 94–100 and 102–105. From these primes, only data from successfully fished stations are considered in the survey index calculation. Data from other stations were excluded from the present analysis of temporal trends, in order to ensure that data were as standardised as possible.

Data for common smooth-hound *Mustelus mustelus* and starry smooth-hound *M. asterias* were aggregated and considered to relate to the latter starry smooth-hound.

Catch rates for this survey are based on abundance (mean $n.h^{-1}$) and biomass (mean $kg.h^{-1}$) for all five species in this study. Numbers at length were raised to biomass using the length-weight relationships in Silva *et al.* (2013) (Table 1). Data for all fish are included in these calculations, with additional mean cpue calculated for fish ≥ 50 cm total length (L_T) considered as the exploitable biomass for most skates (Silva *et al.* 2012). The same length cut-off was used to calculate catch rates of exploitable biomass for *M. asterias* though not considered for *S. canicula*, as the latter advice is based on the total biomass.

Numbers at length and biomass are aggregated across sex and length class per station and raised to one-hour tow duration. These results are then divided by the number of successfully fished prime stations in a given year (including zero catch stations) in order to provide the final survey index as the mean catch rate by abundance (mean $n.h^{-1}$) and biomass (mean $kg.h^{-1}$) for fish above and below 50 cm L_T.

Results and discussion

The temporal trends in catch rates were broadly consistent for skate species, whether using individuals or biomass (Table 2, Figure 1 and 3). However, data become more limited for most skate species when excluding fish < 50 cm L_T, except for *R. clavata* (Table 2, Figure 3). This species has shown an overall increase in 'exploitable biomass' over the survey time-series, with the mean annual cpue (biomass of specimens ≥ 50 cm L_T, Table 2 and Figure 3) for the two most recent years (2017–2018) being 2.45 $kg.h^{-1}$, which is 1.14 times the mean annual cpue for the preceding five years (2.15 $kg.h^{-1}$).

The annual cpue for *R. montagui* increased by 1.22 (2017–2018 = 0.13 kg.h^{-1}; 2012–2016 = 0.10 kg.h^{-1}, Table 2, Figure 3). However, this survey index on 'exploitable biomass' for this species, though used for advice in conjunction with IBTS-Q1 and IBTS-Q3, is only based on few caught individuals for the majority of the years, with less than a total of 10 individuals (when raised to the hour), except for one year (with a total of 12 individuals raised to the hour).

The survey indices for *R. brachyura* are only shown as indicative as the increase for the two most recent years comparatively to the preceding five years would be biologically implausible (Table 2, Figure 1 and 3). The highly variability of these trends are to be expected considering the nature of this species patchy spatial distribution and the low catchability of larger specimens in the gear used.

The trends for both biomass and abundance were similar for both *M. asterias* and *S. canicula* (Table 3, Figure 2 and 4).

Mustelus asterias occurs over a range of habitats, with beam trawl surveys sampling primarily juveniles, with proportionally fewer mature fish capture by this type of gear. The mean annual cpue increased over the overall time-series in the eastern English Channel and southern North Sea (Table 3, Figure 2 and 4). However, data suggest a recent decrease in 2018. The mean annual cpue of 'exploitable biomass' for 2017–2018 (compared to the preceding 5-year period) has shown a recent increase of 1.83 (abundance) and 1.73 (biomass).

Scyliorhinus canicula occurs over a range of bathymetric and sedimentary environments and is distributed widely across the survey area. The mean annual cpue of *S. canicula* in the beam trawl survey of the eastern English Channel and southern North Sea has shown a longer-term increase over the entire time-series (Table 3, Figure 2). Although, there were contrasting signals in relation to the mean annual cpue for 2017–2018 when compared to the preceding 5-year period, with a small increase in terms of the abundance (1.03) but a slight decrease in terms of biomass (0.79).

Considerations and Recommendations

Using similar approach to Silva & Ellis (2019), it was confirmed that by using an index from 1993, not all primes consistently fished in recent years are included as not fished in early years of the time-series. In the case of the survey in ICES Divisions 7.d and 4.c, prime 26 was disregarded. Therefore, it should be considered that future assessments should derive survey indices from 1995 onwards, with more data, and with the knowledge that the overall trend for these species should not be affected by the exclusion of the 1993 and 1994 data (Figure 1–4).

It should be noted that by using only 'exploitable biomass' for advice for certain species on beam trawl surveys, as per request at the Advice Drafting Group (2016), survey indices for some species are based on low numbers of individuals, hence the reflection of the stock status may not be deemed sufficiently robust, if not compared with the overall trend of both total numbers and biomass. Beam trawl surveys are known to have a higher catchability for smaller individuals, with lower numbers of fish ≥ 50 cm L_T.

Future work is highly recommended in terms of having a workshop on survey indices used for advice within WGEF, a step forward to produce a more robust and consistent index where similar considerations to be made (if deemed appropriate) and further enhancements on how to use better these survey data for advice.

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Table 1: Length-weight parameters (a and b) used to convert length to weight for *Raja brachyura*, *R. montagui, R. clavata*, *Mustelus asterias* and *Scyliorhinus canicula* (source: Silva *et al.*, 2013)

Species	a	b
Raja brachyura	0.0027	3.2580
Raja montagui	0.0041	3.1152
Raja clavata	0.0045	3.0961
Mustelus asterias	0.0030	3.0349
Scyliorhinus canicula	0.0022	3.1194

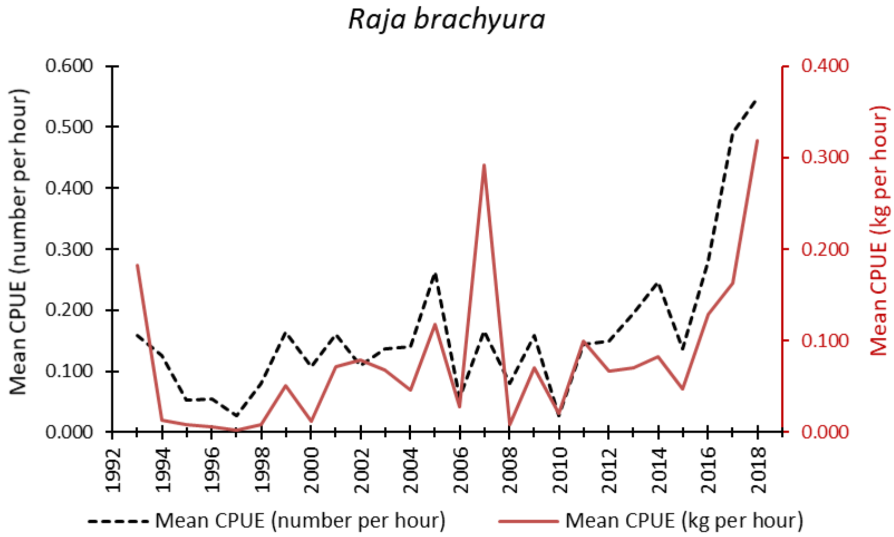
Table 2: Annual mean CPUE by numbers (n.h^{-1}) and biomass (kg.h^{-1}), and for individuals ≥ 50 cm L_T by numbers (*n.h^{-1}) and biomass (*kg.h^{-1}) of *Raja brachyura*, *R. montagui* and *R. clavata* and number of successfully fished prime stations per year in the 7.d and 4.c English beam trawl survey (1993–2018).

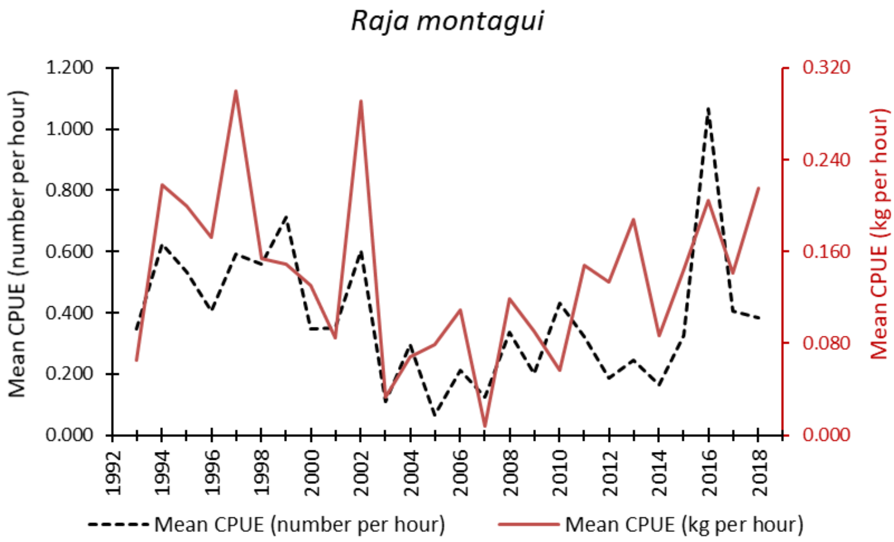
Year	Stations	*Raja brachyura*				*Raja montagui*				*Raja clavata*			
		n.h^{-1}	**kg.h^{-1}**	***n.h^{-1}**	***kg.h^{-1}**	**n.h^{-1}**	**kg.h^{-1}**	***n.h^{-1}**	***kg.h^{-1}**	**n.h^{-1}**	**kg.h^{-1}**	***n.h^{-1}**	***kg.h^{-1}**
1993	63	0.159	0.182	0.095	0.161	0.349	0.065	0.000	0.000	3.060	1.088	0.333	0.589
1994	64	0.125	0.013	0.000	0.000	0.625	0.218	0.063	0.109	2.845	1.005	0.375	0.581
1995	75	0.053	0.008	0.000	0.000	0.533	0.200	0.080	0.120	1.653	0.793	0.293	0.569
1996	74	0.054	0.006	0.000	0.000	0.405	0.173	0.081	0.099	3.324	1.377	0.568	0.837
1997	74	0.027	0.003	0.000	0.000	0.593	0.300	0.162	0.208	2.533	1.143	0.349	0.711
1998	75	0.080	0.009	0.000	0.000	0.560	0.154	0.027	0.036	2.883	1.189	0.240	0.587
1999	73	0.164	0.051	0.000	0.000	0.712	0.149	0.000	0.000	4.055	1.846	0.603	1.163
2000	75	0.107	0.013	0.000	0.000	0.347	0.130	0.053	0.067	3.840	1.534	0.453	0.900
2001	75	0.160	0.072	0.027	0.034	0.352	0.085	0.032	0.045	4.876	1.578	0.578	0.909
2002	73	0.110	0.079	0.027	0.029	0.603	0.291	0.110	0.195	2.839	1.084	0.329	0.523
2003	73	0.137	0.069	0.027	0.046	0.110	0.033	0.000	0.000	3.840	1.786	0.552	1.110
2004	71	0.141	0.046	0.000	0.000	0.296	0.069	0.028	0.029	4.159	2.522	0.811	1.551
2005	61	0.262	0.118	0.066	0.072	0.066	0.079	0.066	0.079	4.115	1.557	0.443	0.601
2006	70	0.057	0.028	0.029	0.026	0.211	0.109	0.071	0.103	5.041	1.554	0.520	0.873
2007	72	0.167	0.292	0.056	0.263	0.125	0.008	0.000	0.000	4.743	2.203	0.813	1.376
2008	74	0.081	0.009	0.000	0.000	0.338	0.119	0.081	0.084	5.134	2.899	1.177	1.929
2009	75	0.159	0.071	0.027	0.030	0.203	0.091	0.000	0.000	4.676	2.249	0.852	1.465
2010	74	0.027	0.020	0.000	0.000	0.431	0.056	0.027	0.028	8.353	3.434	1.102	2.199
2011	72	0.144	0.099	0.021	0.089	0.321	0.148	0.083	0.113	9.972	2.543	0.665	1.302
2012	74	0.149	0.067	0.027	0.043	0.185	0.134	0.054	0.081	6.011	3.099	1.094	1.866
2013	72	0.194	0.070	0.028	0.027	0.246	0.188	0.125	0.175	9.146	2.445	0.740	1.066
2014	73	0.247	0.082	0.027	0.039	0.164	0.087	0.055	0.051	15.021	5.063	1.794	2.926
2015	73	0.137	0.048	0.000	0.000	0.325	0.144	0.082	0.108	12.911	4.861	1.644	2.831
2016	75	0.280	0.129	0.053	0.074	1.067	0.205	0.080	0.107	12.003	4.151	1.319	2.042
2017	74	0.491	0.163	0.027	0.045	0.405	0.141	0.081	0.097	15.820	4.343	1.459	2.217
2018	73	0.548	0.318	0.110	0.229	0.384	0.215	0.110	0.158	24.606	5.223	1.619	2.675
Index A (2017-2018)		0.52	0.24	0.07	0.14	0.39	0.18	0.10	0.13	20.21	4.78	1.54	2.45
Index B (2012-2016)		0.20	0.08	0.03	0.04	0.40	0.15	0.08	0.10	11.02	3.92	1.32	2.15
Index A / Index B		2.58	3.03	2.52	3.75	0.99	1.18	1.20	1.22	1.83	1.22	1.17	1.14

Table 3: Annual mean CPUE by numbers (n.h^{-1}) and biomass (kg.h^{-1}) of *Mustelus asterias* and *Scyliorhinus canicula*, and individuals ≥ 50 cm L_T by numbers (*n.h^{-1}) and biomass (*kg.h^{-1}) of *M. asterias* and number of successfully fished prime stations per year in the 7.d and 4.c beam trawl survey (1993–2018).

Year	Stations	*Mustelus asterias*				*Scyliorhinus canicula*	
		n.h^{-1}	kg.h^{-1}	*n.h^{-1}	*kg.h^{-1}	n.h^{-1}	kg.h^{-1}
1993	63	0.317	0.022	0.000	0.000	1.603	0.854
1994	64	0.313	0.168	0.125	0.151	2.094	1.068
1995	75	0.107	0.010	0.000	0.000	2.400	1.190
1996	74	0.135	0.035	0.027	0.017	2.568	0.987
1997	74	0.510	0.086	0.051	0.050	4.684	1.025
1998	75	0.373	0.128	0.053	0.086	2.133	1.263
1999	73	0.301	0.162	0.055	0.134	2.712	1.403
2000	75	0.347	0.392	0.133	0.369	3.920	1.248
2001	75	0.453	0.224	0.133	0.185	2.760	1.231
2002	73	0.493	0.321	0.137	0.282	4.521	2.017
2003	73	0.329	0.096	0.082	0.054	2.356	1.172
2004	71	0.648	0.371	0.169	0.311	5.906	1.854
2005	61	0.754	0.337	0.230	0.290	5.628	2.627
2006	70	0.339	0.065	0.057	0.035	2.620	1.196
2007	72	0.236	0.050	0.028	0.028	4.375	2.202
2008	74	0.759	0.310	0.135	0.255	7.047	3.499
2009	75	1.344	0.701	0.373	0.610	5.254	2.515
2010	74	1.153	0.475	0.351	0.336	7.228	3.705
2011	72	0.775	0.406	0.234	0.338	6.033	2.486
2012	74	0.405	0.080	0.027	0.047	6.846	3.511
2013	72	0.597	0.497	0.292	0.424	11.340	4.393
2014	73	1.125	0.755	0.372	0.623	8.986	3.835
2015	73	1.041	0.368	0.192	0.271	11.334	4.554
2016	75	0.520	0.210	0.147	0.163	7.333	3.554
2017	74	1.574	0.886	0.480	0.711	8.603	2.720
2018	73	0.986	0.435	0.274	0.347	10.256	3.571
Index A (2017–2018)		1.28	0.66	0.38	0.53	9.43	3.15
Index B (2012–2016)		0.74	0.38	0.21	0.31	9.17	3.97
Index A / Index B		1.73	1.73	1.83	1.73	1.03	0.79

Figure 1: Temporal trends in the CPUE (n.h^{-1} and kg.h^{-1}) of *R. brachyura*, *R. montagui* and *R. clavata* as observed in the 7.d and 4.c English beam trawl survey (1993–2018).





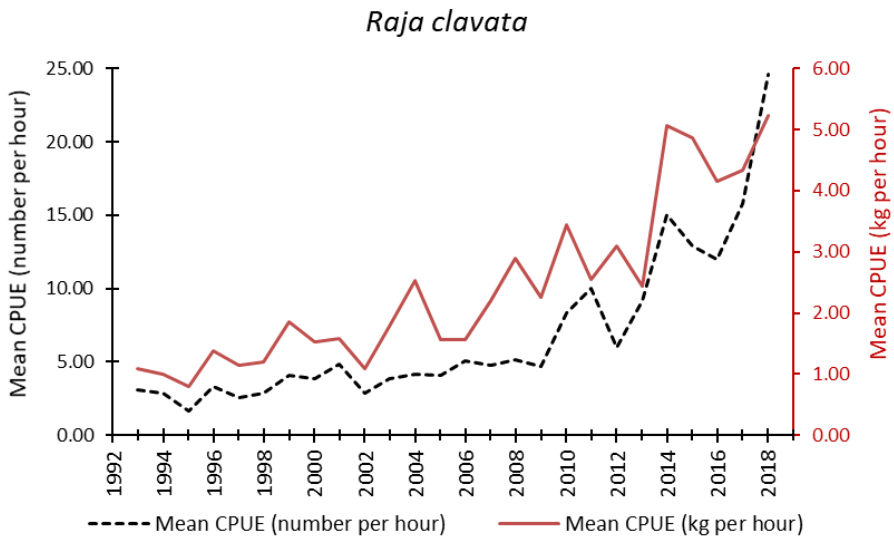
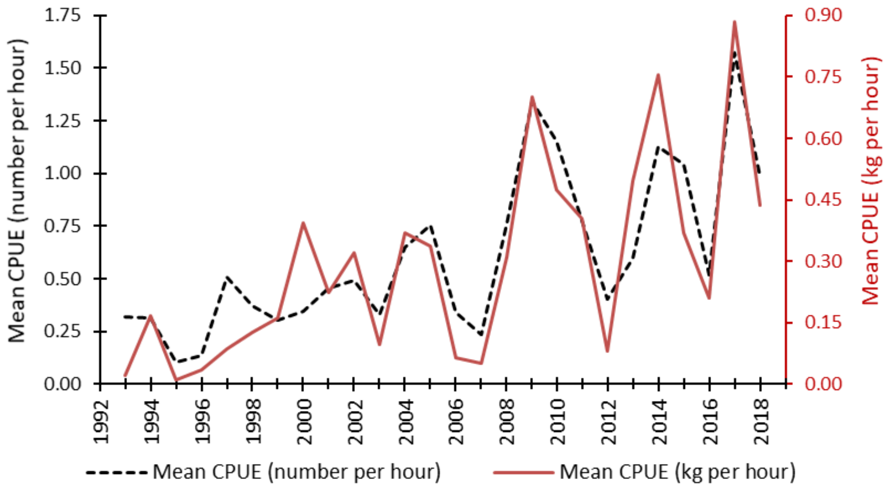


Figure 2: Temporal trends in the CPUE (n.h^{-1} and kg.h^{-1}) of *M. asterias* and *S. canicula* as observed in the 7.d and 4.c English beam trawl survey (1993–2018).

Mustelus asterias



Scyliorhinus canicula

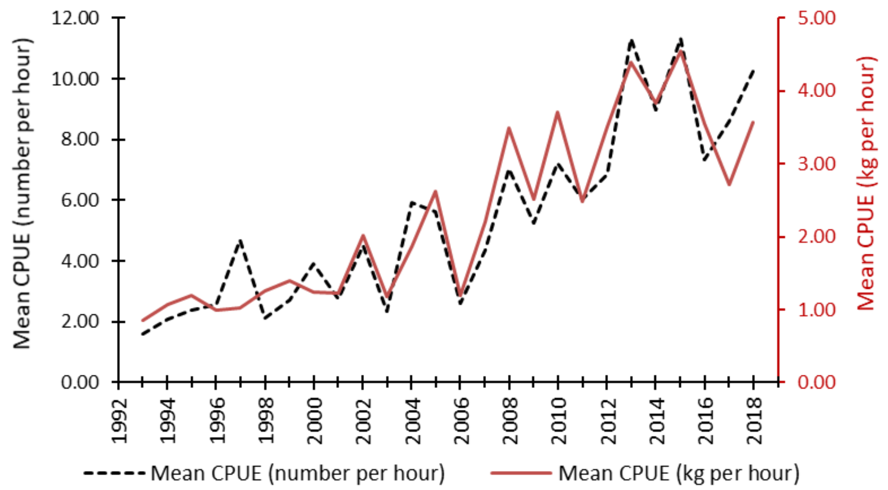


Figure 3: Temporal trends in the CPUE for individuals ≥ 50 cm L_T ($*n.h^{-1}$ and $*kg.h^{-1}$) of *R. brachyura*, *R. montagui,* and *R. clavata*¸ as observed in the 7.d and 4.c English beam trawl survey (1993–2018).

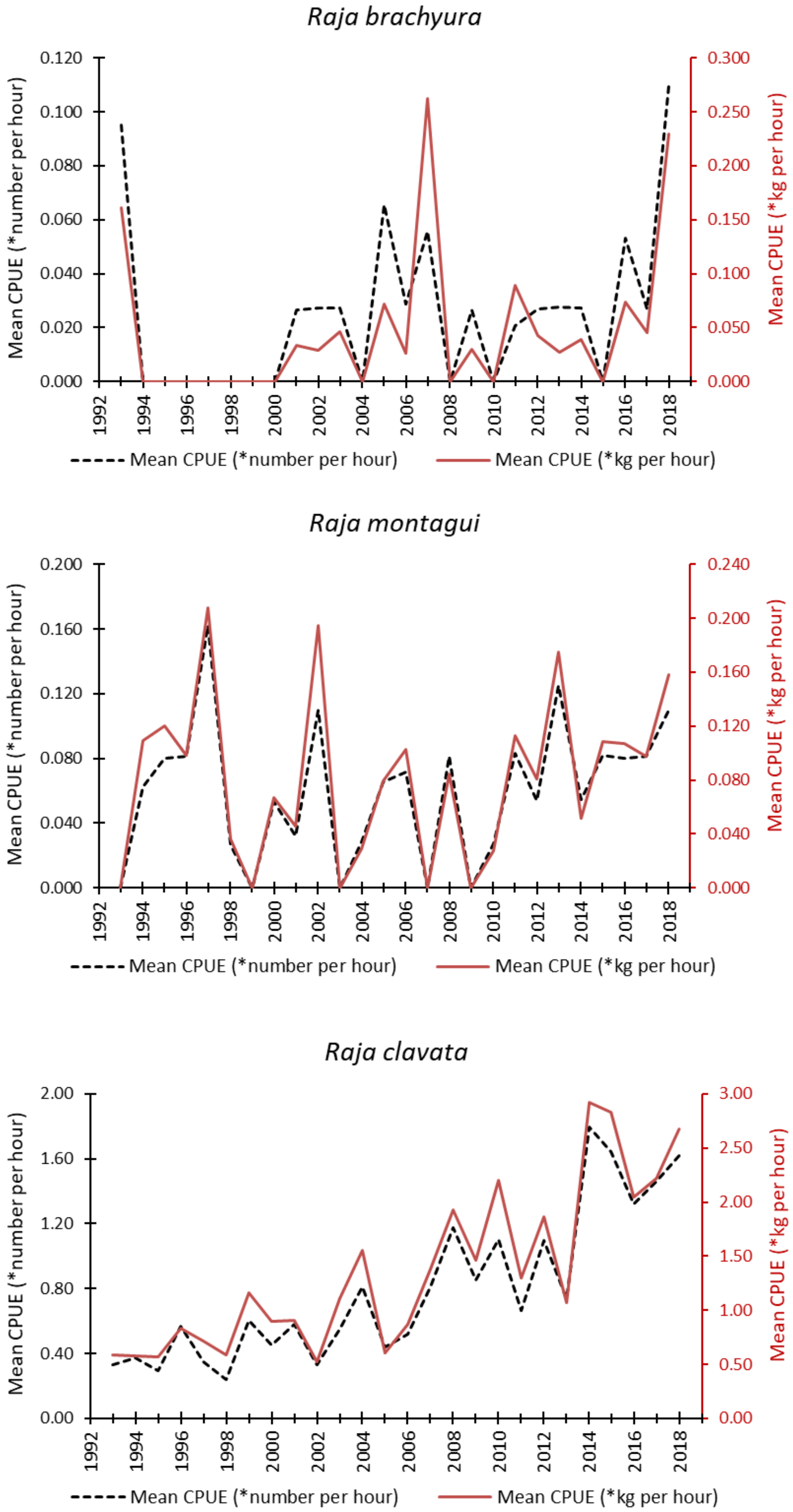
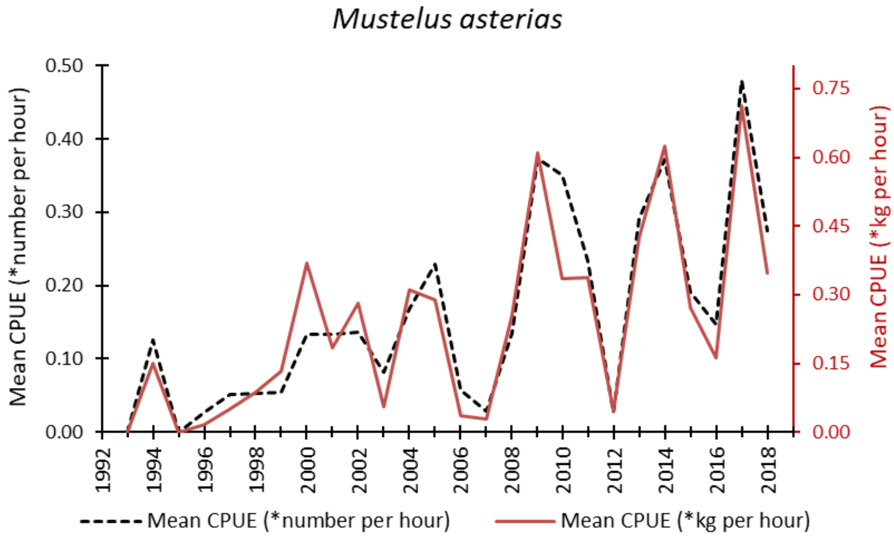


Figure 4: Temporal trends in the CPUE for individuals ≥ 50 cm L_T (*n.h^{-1} and *kg.h^{-1}) of *M. asterias*¸ as observed in the 7.d and 4.c English beam trawl survey (1993–2018).



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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 2018 Spanish Groundfish Survey on Northern Spanish shelf. Biomass, spatial distribution and length ranges were analysed for *Scyliorhinus canicula* (lesser spotted dogfish), *Galeus melastomus* (blackmouth catshark), *Etmopterus spinax* (velvet belly), *Raja clavata* (thornback ray), *R. montagui* (spotted ray), *Leucoraja naevus* (cuckoo ray) and other scarce elasmobranchs. In general the biomass of these species remained similar to previous years or increased this last survey, despite the decline of some of them such as *G. melastomus*, *E. spinax* and *R. clavata*. A few more specimens of the scarce elasmobranchs *Hexanchus griseus, Mustelus mustelus* and *Leucoraja circularis* were found this last survey while *Raja undulata* and *Raja brachyura* were not. Signs of recruitment were found for *S. canicula*, *G. melastomus* and *E. spinax*.

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 surveys on the Northern Spanish Shelf, after the results presented previously (Fernández-Zapico et al., 2018; 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), *Raja clavata* (thornback ray), *Raja montagui* (spotted ray), *Leucoraja naevus* (cuckoo ray) and some other scarce species as *Scymnodon ringens* (knifetooth dogfish), *Dalatias licha* (kitefin shark), *Deania calcea* (birdbeak dogfish), *Deania profundorum* (arrowhead dogfish), *Mustelus mustelus* (smoth-hound) and *Leucoraja circularis* (sandy ray).

Material and methods

The Northern Spanish Shelf Groundfish Survey on the Cantabrian Sea and Off Galicia (Divisions 8c and Northern part of 9a; SPNGFS) has been carried out annually since 1983 except in 1987. The area covered 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) (Figure 1, ICES, 2017). Depth stratification was changed in 1997 from 30-100 m, 101-200 m, 200-500 m to 70-120 m, 121-200 m and 201-500 to overcome the shortage of grounds shallower than 70 m that hindered the coverage of this stratum.

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 calculations of the stratified abundance indices, since the coverage of these grounds (shallower and deeper) are not considered representative of the area. Nevertheless the information from these depths is considered 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.

Results

In 2018, 132 valid hauls were carried out; 113 standard hauls and 17 extra hauls were carried out (2 of them shallower than 70 m, 12 of them between 500 m and 800 m and 3 in “zero fishing effort areas”) (Figure 1).

In the last survey, fish represented about 94% of the total stratified catch and elasmobranchs 8% of the total stratified fish catch with the following percentages per species: *Scyliorhinus canicula* (67%), *Raja clavata* (14%), *Galeus melastomus* (8%), *R. montagui* (6%), *Leucoraja naevus* (2%), *Hexanchus griseus* (0.1%), *Etmopterus spinax* (0.1%). The species *G. melastomus, E. spinax* and other scarce elasmobranchs in the area like *Deania profundorum, Scymnodon ringens, Dalatias licha* and *Leucoraja circularis* 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 2018, the biomass of *S. canicula*, *H. griseus*, *R. montagui* increased, *D. profundorum* and *L. naevus* remained similar to the previous year and *Galeus* spp., mainly *G. melastomus*, *E. spinax* and *R. clavata* decreased compared to previous year, although remained high in the time series. Only a few specimens of *S. ringens, D. licha, Mustelus mustelus* and *L. circularis* were found as usual. There was no increase of any of the elasmobranchs in 9a Division this last survey or they were absent such as *H. griseus*, *S. ringens*, *D. licha*, *R. montagui* and *L. naevus.* Regarding recruitment, small specimens increased slightly in *S. canicula* and remarkably in *G. melastomus* and *E. spinax,* despite their biomass decline.

Scyliorhinus canicula (lesser spotted dogfish) and *Scyliorhinus stellaris* (nursehound)

The biomass of *S. canicula* in 9a Division has been followed a downward trend since 2012, further decreasing this last survey. On the contrary, in 8c Division, *S. canicula* has been more or less stable with an increasing trend, particularly in the last 5 years, fluctuating up and down within the highest values of the time series. In this last survey, the biomass index in Division 8c increased (Figure 2) and the average biomass of the last two years was similar to the previous five years whereas in Division 9a the ratio was much lower (Figure 3).

S. canicula was widespread in the study area, although the highest concentration of biomass was found as usual from Finisterre to Coruña and in the central and eastern area of the Cantabrian Sea, but with greater biomass than the previous year (Figure 4). *S. stellaris* is quite scarcer than *S. canicula* in the area, being absent in 9a and mainly found in 8c, specifically in the central part of Cantabrian Sea, but with low abundance (Figure 5 and Figure 6).

Most specimens of *S. canicula* in 9a were small and juvenile, whereas in 8c mainly adults were found. In 2018, the decrease in biomass of *S. canicula* in 9a Division is reflected in fewer specimens by size in general. However, in 8c Division the length distribution showed the highest abundance of small specimens (around 19 cm) in the time series (Figure 7). Adults from 35 to 55 cm were also more abundant this last survey than the previous years. The few specimens of *S. stellaris*, a total of 29, ranged from 16 to 45 cm as usual (Figure 8).

***Galeus melastomus* (blackmouth catshark) and *Galeus atlanticus* (Atlantic sawtail catshark)**

Although *G. atlanticus* was rather scarcer than *G. melastomus* in the area, it has been found every survey since *G. atlanticus* was first identified in 2009 after its redescription and validation in 2007 (Castilho et al., 2007).

The biomass in standard and additional hauls was reported like previous years, because the catches in additional deep hauls (>500 m) are significant. In 2018, 33% of the hauls with presence of *G. melastomus* were found deeper than 500 m and they contained 52% of the biomass. In standard hauls, the mean biomass of *Galeus* spp., mainly *G. melastomus*, of the last two years remained higher than the previous five years (Figure 9), but this last survey the biomass decreased in both Divisions. *G. atlanticus* decreased in 8c and was no present in 9a (Figure 10). In additional deeper hauls, *G. atlanticus* was found in both Divisions as well as *G. melastomus* but with lower abundances than the previous year (Figure 11).

Smaller spots of biomass of *G. melastomus* were found in Galician area (sector MF corresponding to 9a Division and sector FE in 8c Division), whereas the spots of biomass in the Central part of Cantabrian Sea were similar to previous year (Figure 12). *G. atlanticus* was also found in Galician area, but also in the eastern part of the Cantabrian Sea where the species was not usually found (Figure 13).

Despite the general decrease, small specimens were found. In 8c, the length distribution of *G. melastomus* showed more abundance of specimens around 22 cm than the two previous years. In 9a, where small specimens have been scarce since 2012, signs of recruits were shown with specimens around 19 cm (Figure 14). In additional deeper hauls most of the specimens were adults, from 36 to 56 cm in 9a and from 28 to 69 cm in 8c, a wider size range in the latter with a main mode around 47 cm and a smaller mode around 60 cm (Figure 15). Small specimens of *G. atlanticus* (around 22 cm) were also found, being this last survey the highest abundance in the time series. Most specimens of *G. atlanticus* ranged as usual from 18 to 48 cm, although two large specimens of 71 cm were found (Figure 16).

***Etmopterus spinax* (velvet belly)**

In 2018, most of the hauls where *E. spinax* was found were additional hauls deeper than 500 m (79%) and contained half of the biomass. This last year the biomass decreased both in standard and additional hauls (Figure 17). In standard hauls, *E. spinax* has been only found in 8c Division since the beginning of time series. Despite the decrease this last survey, the mean biomass of the last two years remained similar to the previous five years (Figure 18).

The geographical distribution of *E. spinax* remained similar to previous years, in hauls deeper than 500 m close to 9º W and 5º W longitude. However the usual spot of biomass in the southern Galician waters was small this last survey (Figure 19).

Specimens of *E. spinax* ranged from 11 to 29 cm in standard hauls, but the length distribution showed more abundance of specimens around 16 cm than previous years and fewer large specimens (Figure 20). As usual a narrower length distribution is found in standard hauls than in additional deep hauls (10-50 cm).

***Hexanchus griseus* (bluntnose sixgill shark)**

This last year, the biomass of this scarce shark increased sharply reaching the highest value of the time series (Figure 21). *H. griseus* has not been found in 9a Division since 2001, while in 8c has been frequent, although scarce (average 3.5 individuals per survey), in the time series. A total of 9 specimens from 63 to 89 cm were found in two hauls at around 430 m depth in north of Galicia waters (8c) (Figure 22 and Figure 23).

***Deania profundorum* (arrowhead dogfish) and *Deania calcea* (birdbeak dogfish)**

Both species have been mainly found in additional hauls in the time series since 2009 when was identified *D. profundorum* for the first time in the area. In general *D. calcea* is more abundant than *D. profundorum*, but it has been absent in this last survey and in the previous year. The biomass of *D. profundorum* remained similar to the previous years (Figure 24).The specimens were found in Galician area as usual (Figure 25) and ranged from 25 to 98 cm, most of them small specimens around 29 cm (Figure 26).

Other shark species

Other shark species scarcely caught in the survey were *Scymnodom ringens, Dalatias licha* and *Mustelus mustelus*. The first two elasmobranchs were only found in additional hauls in 2018, as previous years (Figure 27 and Figure 28). Six specimen of *S. ringens* and just one of *D. licha* were found in the last survey. The specimens of *S. ringens*, from 33 to 41cm, were found in one haul at 560 m depth in the north of Galicia and the specimen of *D. licha* (49 cm) was found at 594 m depth in the Cantabrian Sea as the previous year (Figure 29). *M. mustelus* had not been found since 2012, but this last year two specimens of 44 and 47 cm were found in two standard hauls in Galician area (Figure 30).

***Raja clavata* (thornback ray)**

In 2018 the biomass of the most abundant ray in the area, *R. clavata,* decreased in both Divisions. In Div. 9a, *R. clavata* is scarcer than in 8c, only 1.3% of the biomass was found this last survey in the former. In Div. 8c, the biomass index has been fluctuating up and down with an increasing trend. Since 2012 the values have remained high compared with the time series (Figure 31). The mean biomass of the last two years was very similar to the previous five years in 9a and slightly lower in 8c.

The geographical distribution of *R. clavata* remained similar to the previous year, with greater abundance in the Cantabrian Sea, specifically from the central to the eastern part, but the large spot of biomass found in the previous year in one shallower haul (85 m depth) close to 4º W longitude was smaller this last survey (Figure 32).

The length distribution showed a reduction in abundance of large specimens in 2018. Sizes ranged as usual from 15 to 96 cm but there were fewer specimens larger than 44 cm (Figure 33 and Figure 34).

***Raja montagui* (spotted ray)**

The biomass of *R. montagui*, scarcer than *R. clavata*, raised this last survey, following the increasing trend from 2016 (Figure 35). *R. montagui* has not been found in 9a Division in the time series but in 8c has been frequent, specifically in the central area of the Cantabrian Sea. More spots of biomass were found this last survey in the western part of the Cantabrian Sea compared to previous year (Figure 36).

The length distribution of *R. montagui* remained similar to the previous years, with specimens from 22 cm to 66 cm, although more abundance of large specimens, from 56 to 64 cm, was found (Figure 37).

Leucoraja naevus **(cuckoo ray)**

In 2018 the biomass of *L. naevus* decreased although remained among the high values of the time series. The mean biomass of the last two years was well above than the previous five years (Figure 38). *L. naevus* was absent in the 9a Division and widespread in the 8c as usual. A large spot of biomass was found in the Cantabrian Sea between 6º and 7º W longitude (Figure 39).

Cuckoo ray length distribution remained similar to previous years. A total of 62 specimens were found this last survey, most of them ranged from 48 to 65 cm, but also fourteen specimens ranged from 35 to 44 cm and four small specimens from 18 to 24 cm (Figure 40).

Other skates species

Although scarce skates such as *Leucoraja circularis*, *Raja microcellata*, *Raja undulata* or *Raja brachyura* have been found in the time series, this last year *Leucoraja circularis* was the only one found. A total of four specimens of *L. circularis* were found, two of 47 and 70 cm in two additional hauls in Galician area (at 550 and 577 m depth) and two of 79 and 89 cm in one standard haul in the eastern area of Cantabrian Sea at 200 m (Figure 41 and Figure 42).

Acknowledgements

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Figures

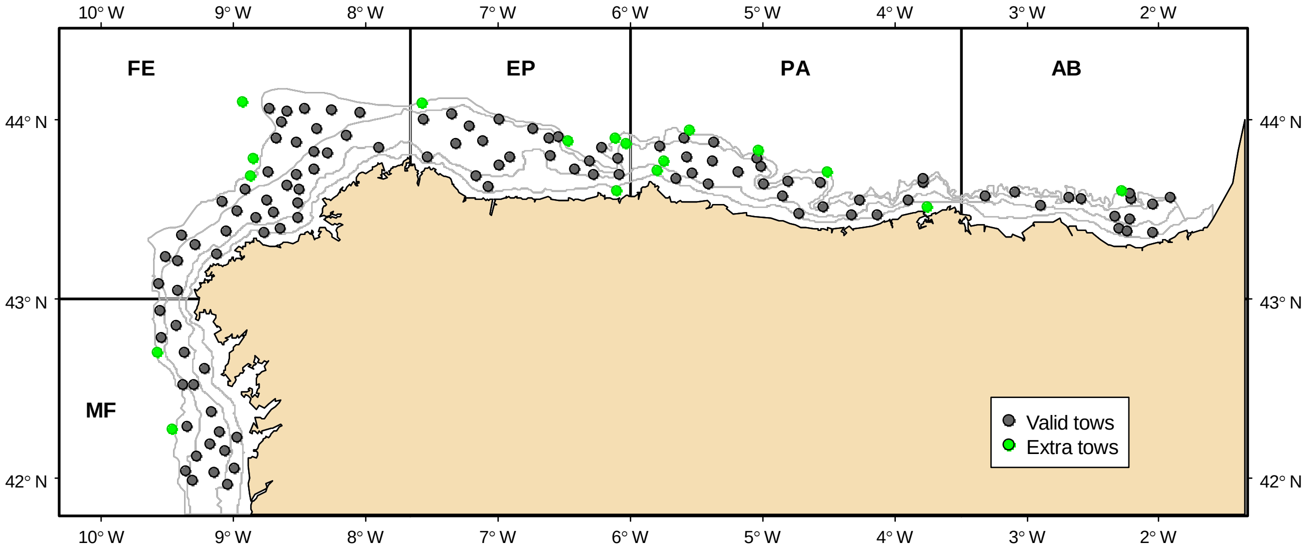


Figure 1 Stratification design and hauls on the Northern Spanish shelf groundfish survey in 2018; Depth strata are: A) 70-120 m, B) 121 – 200 m and C) 200 – 500 m. Geographic sectors are MF: Miño-Finisterre, FE: Finisterre-Estaca, EP: Estaca-cabo Peñas, PA: Peñas-cabo Ajo, and AB: Ajo-Bidasoa.

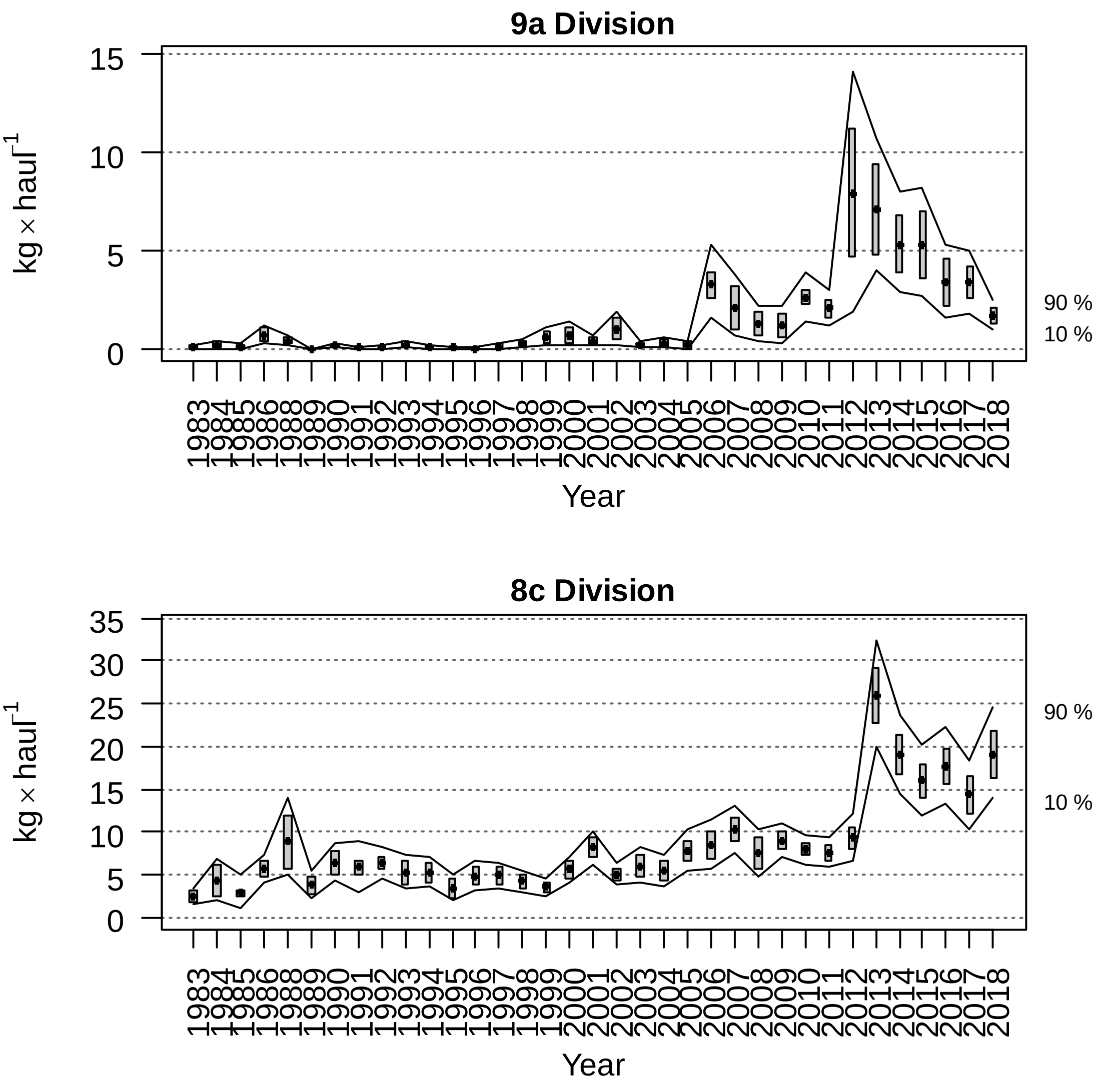


Figure 2 Evolution of *Scyliorhinus canicula* biomass index during the North Spanish shelf bottom trawl survey time series in the two ICES Divisions covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

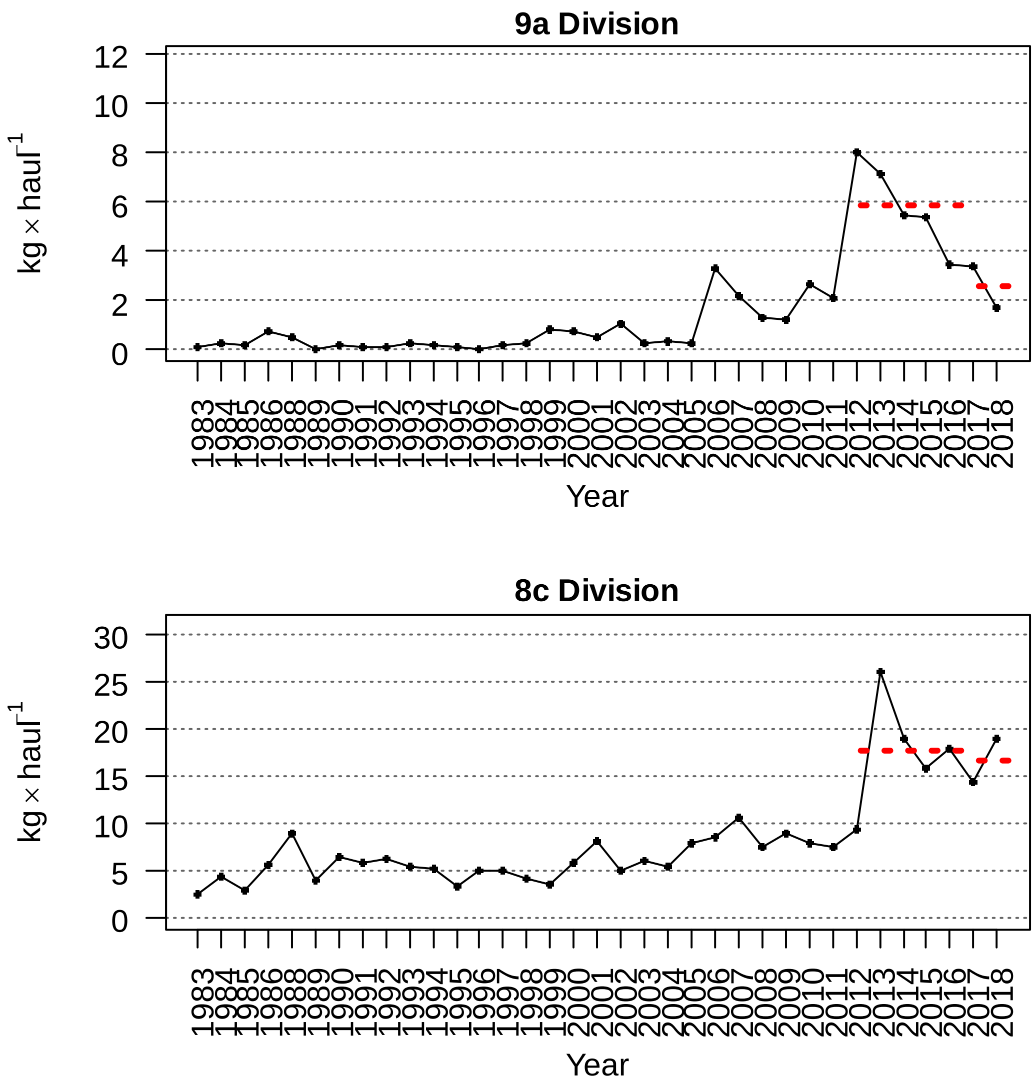


Figure 3 Evolution of *Scyliorhinus canicula* biomass index during the North Spanish shelf bottom trawl survey time series in the two ICES Divisions covered by the survey. Red lines mark a comparative between last two years and the five previous

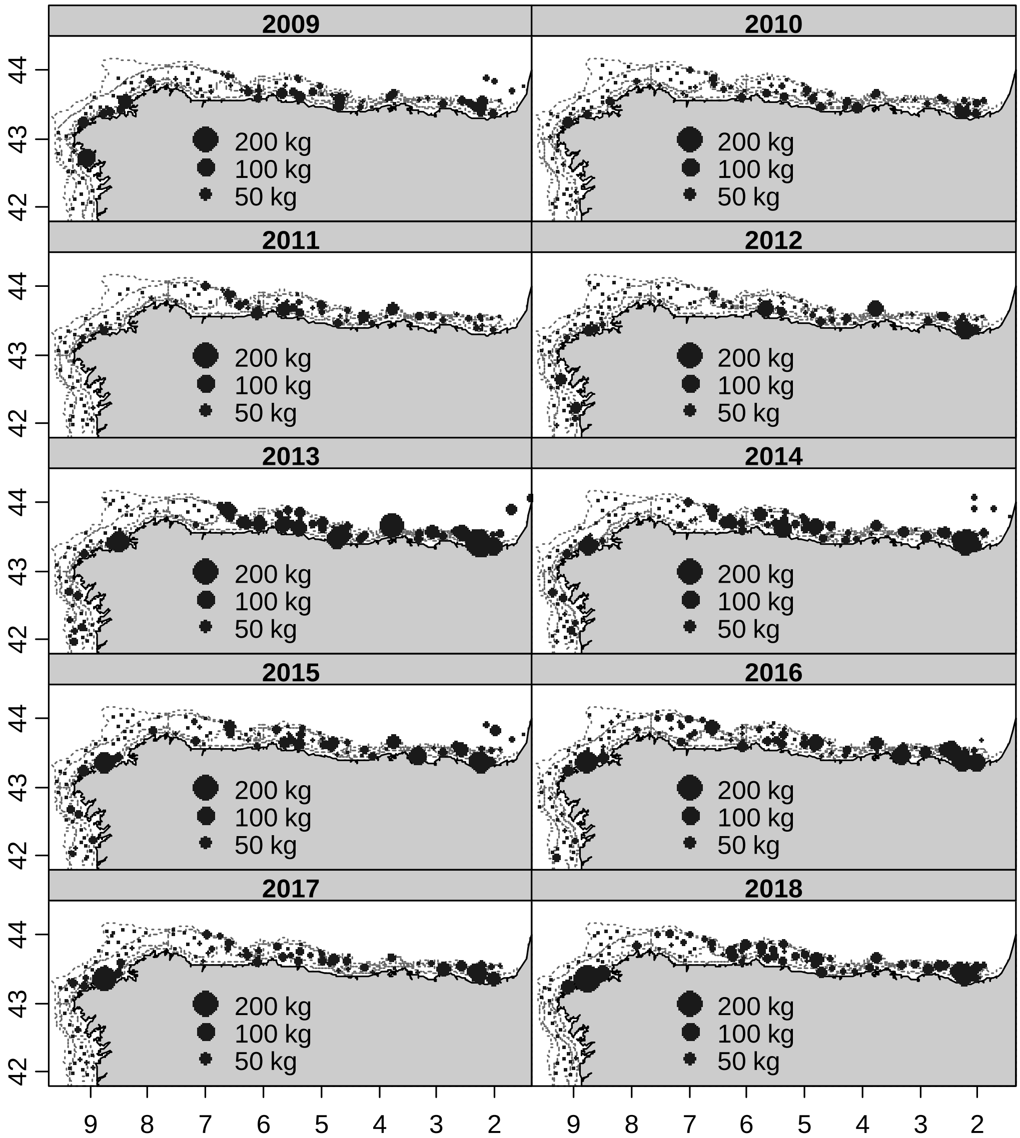


Figure 4 Geographic distribution of *Scyliorhinus canicula* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018

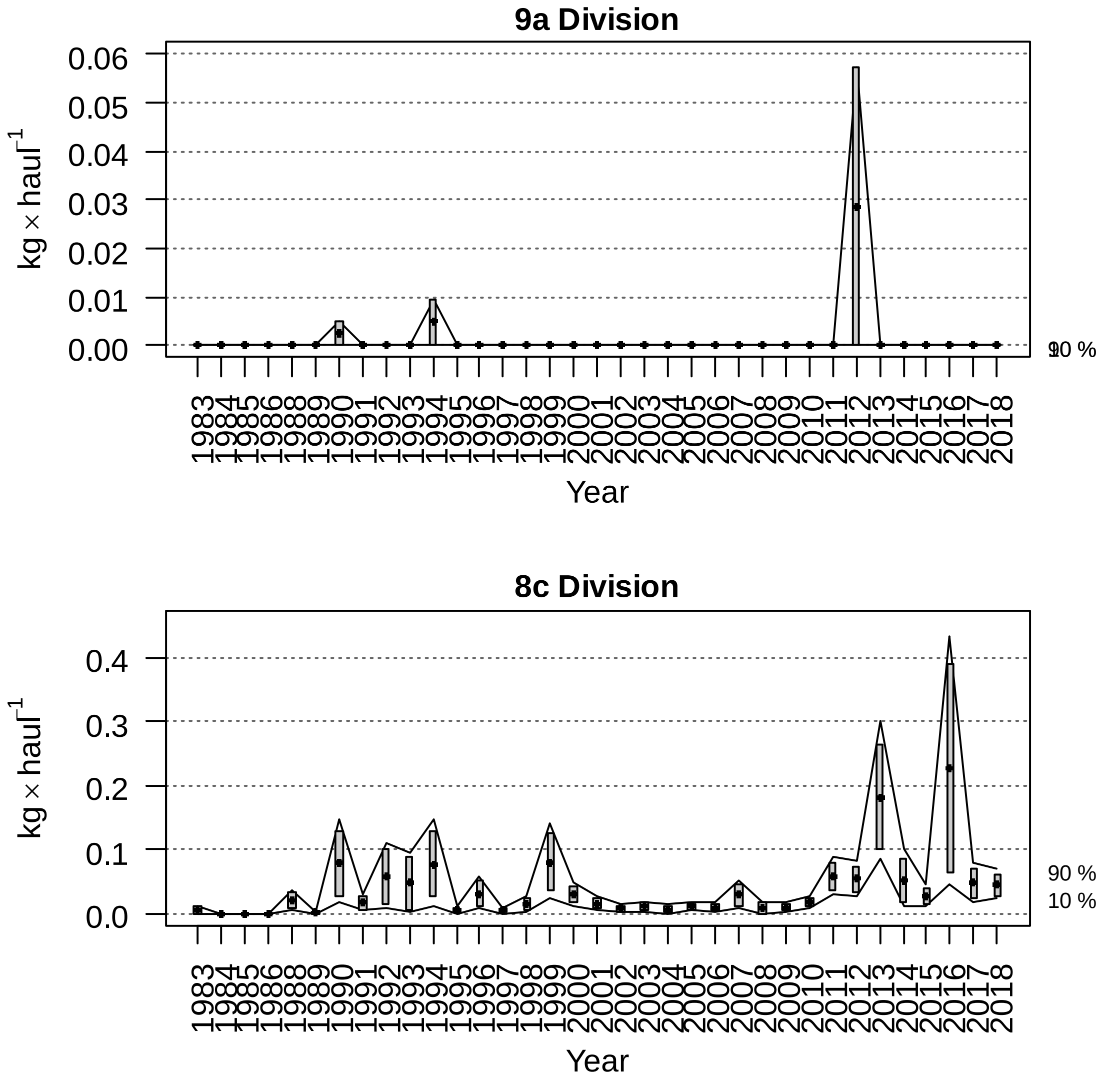


Figure 5 Evolution of *Scyliorhinus stellaris* biomass index during the North Spanish shelf bottom trawl survey time series in the two ICES Divisions covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

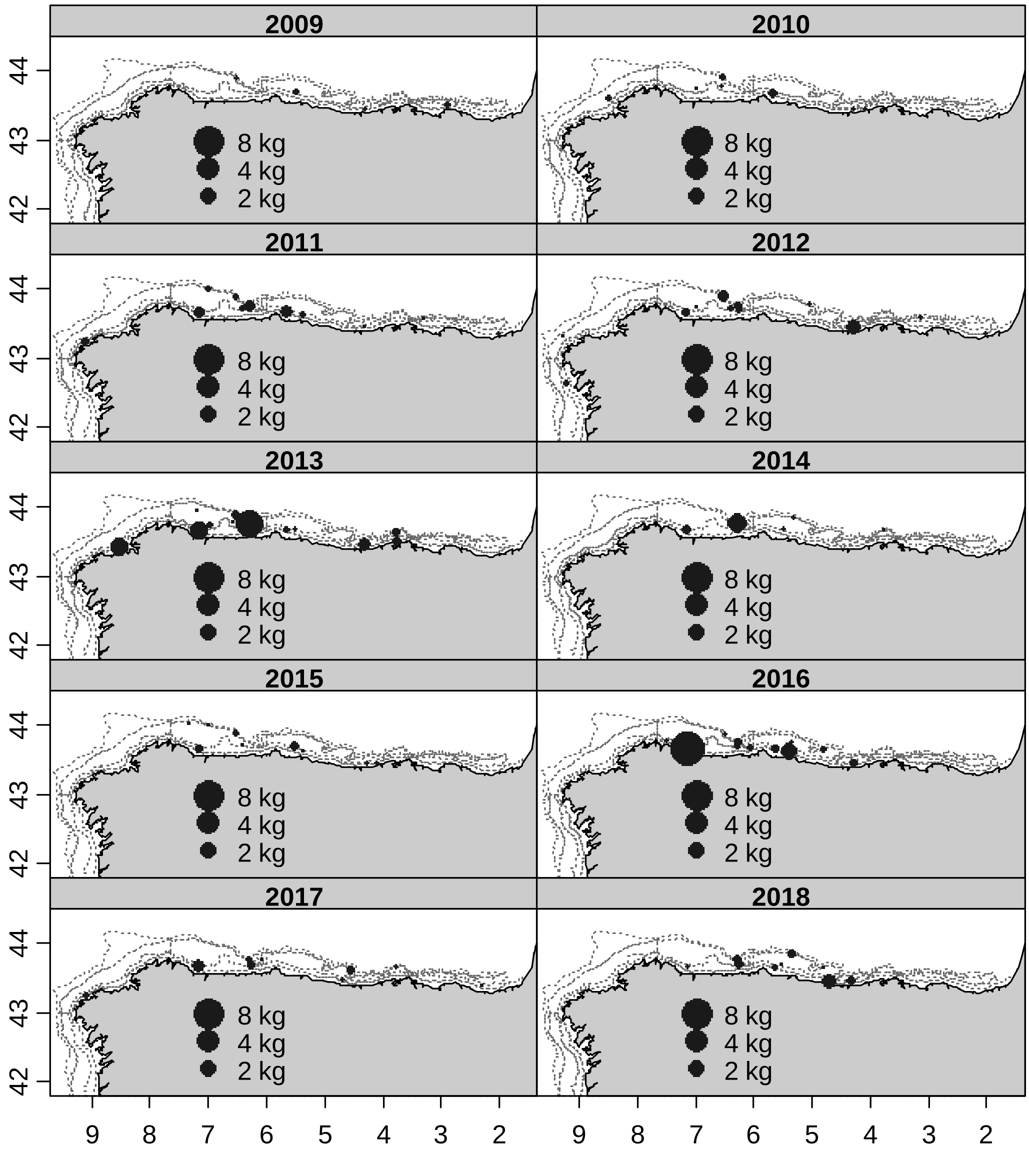


Figure 6 Geographic distribution of *Scyliorhinus stellaris* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018

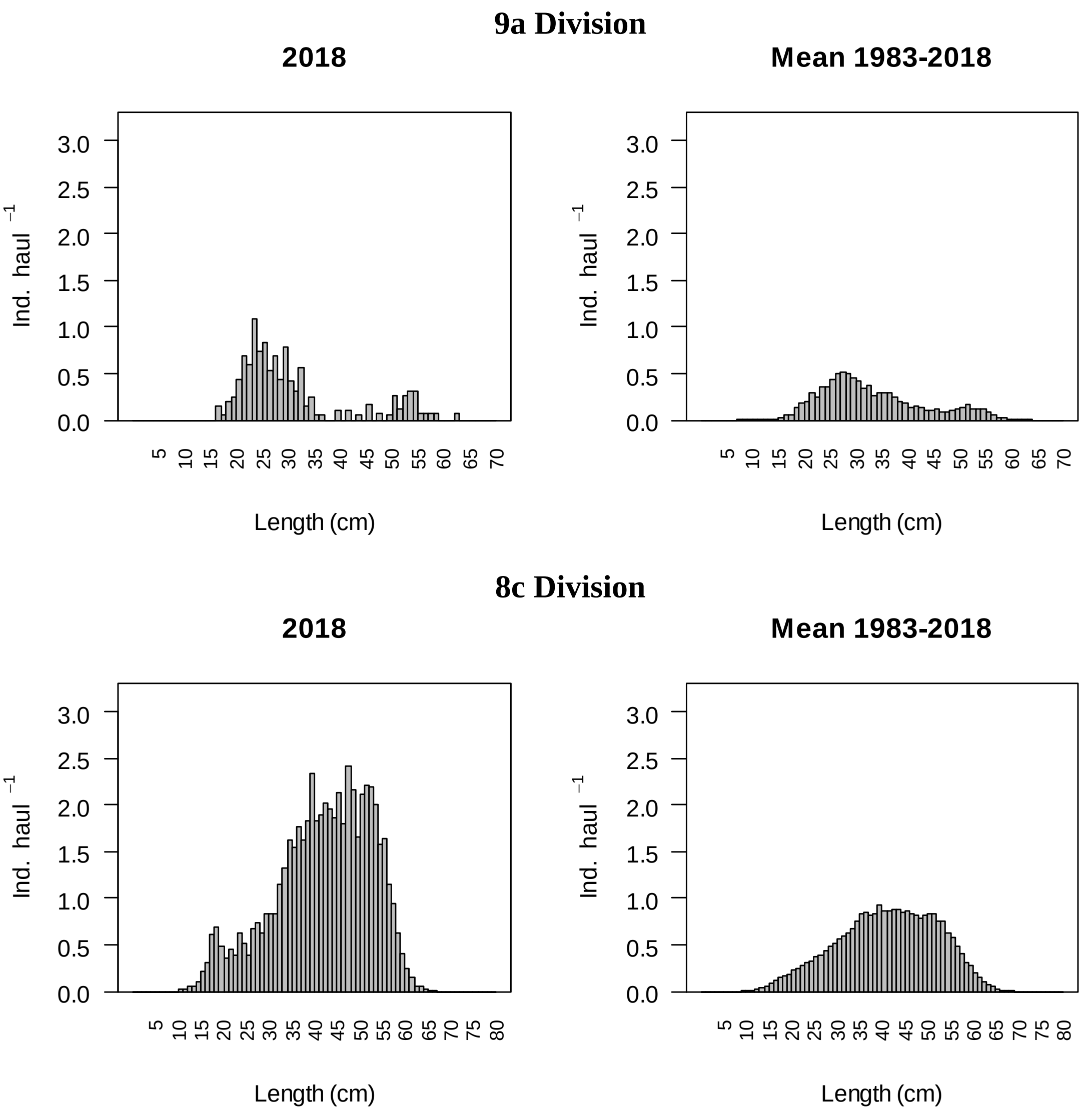


Figure 7 Stratified length distributions of *Scyliorhinus canicula* in 2018 in the two ICES Divisions covered by the North Spanish Shelf bottom trawl survey, and the mean values for the time seies in both areas.

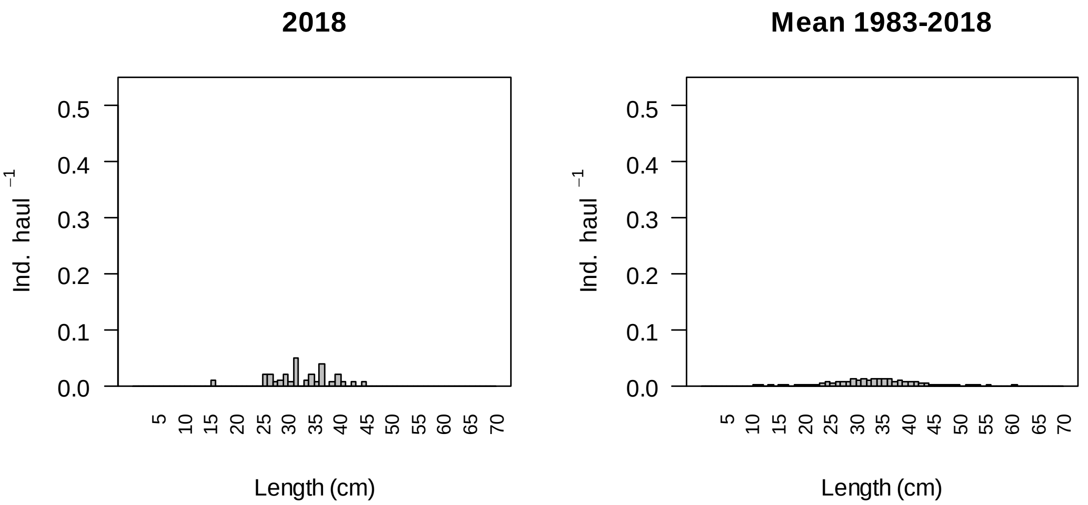
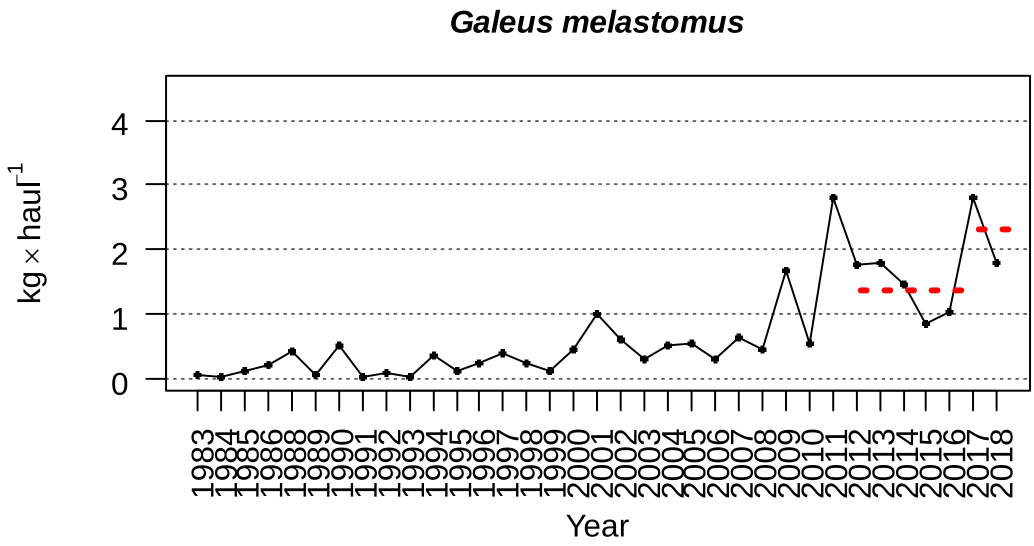


Figure 8 Stratified length distributions of *Scyliorhinus stellaris* in 2018 in 8c Division covered by the North Spanish Shelf bottom trawl survey, and the mean values for the time series in the area.



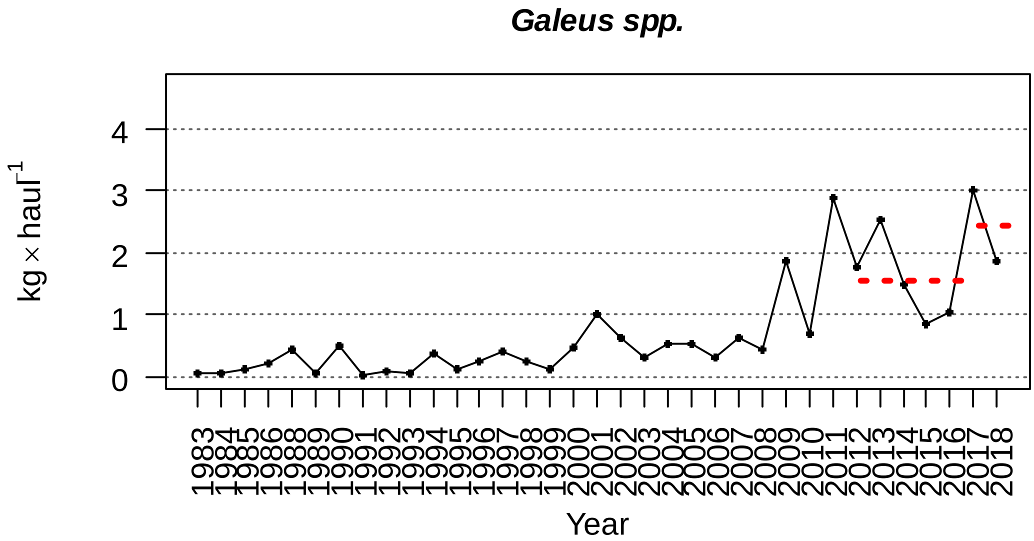


Figure 9 Evolution of *Galeus melastomus* and *Galeus* spp. biomass index during the North Spanish shelf bottom trawl survey time series in the two ICES Divisions. Red lines mark a comparative between last two years and the five previous

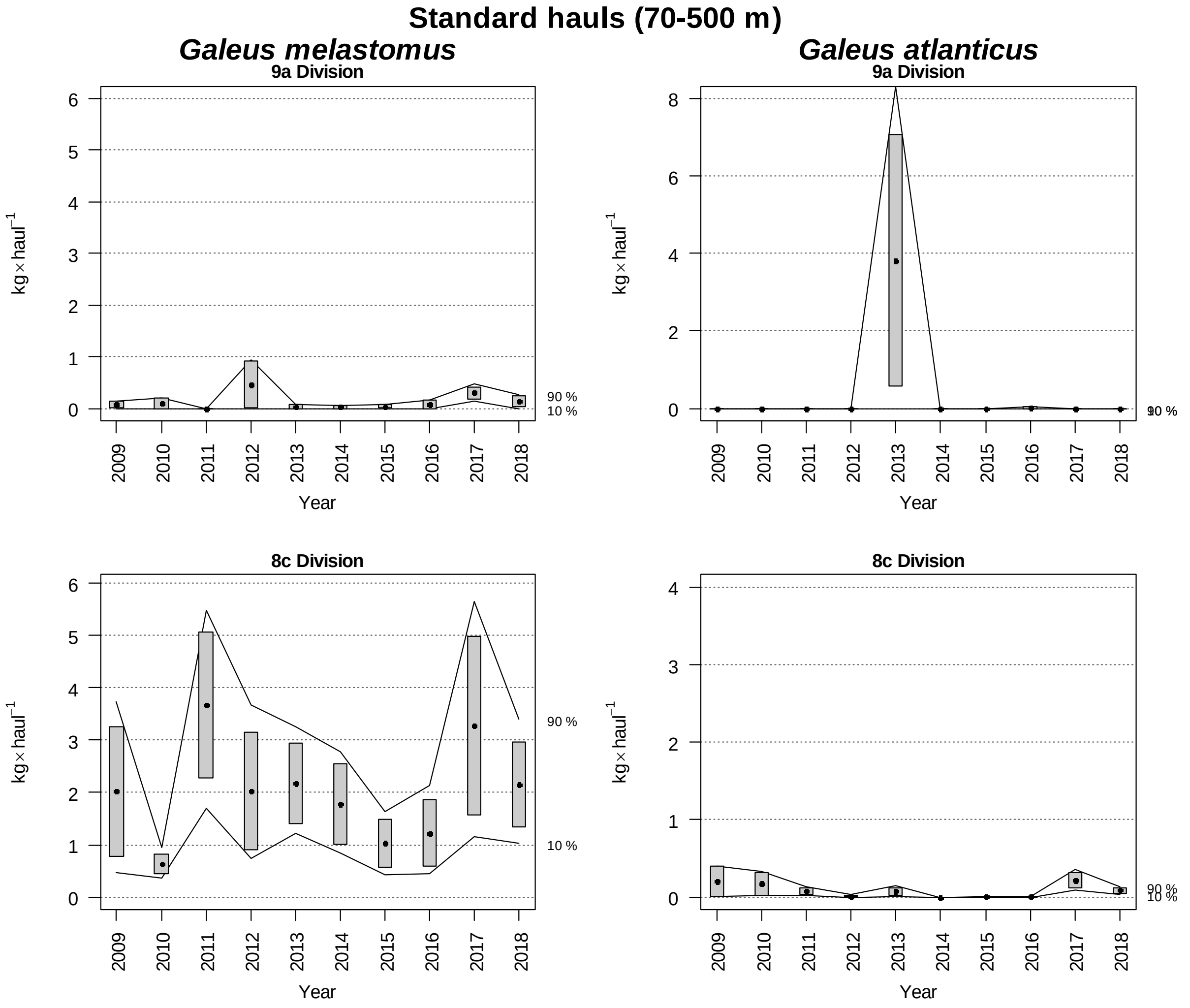


Figure 10 Evolution of *Galeus melastomus* and *Galeus atlanticus* stratified biomass index in standard hauls (70- 500 m) during the North Spanish shelf bottom trawl survey between 2009 and 2018 in the two ICES Divisions. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80 bootstrap iterations = 1000)

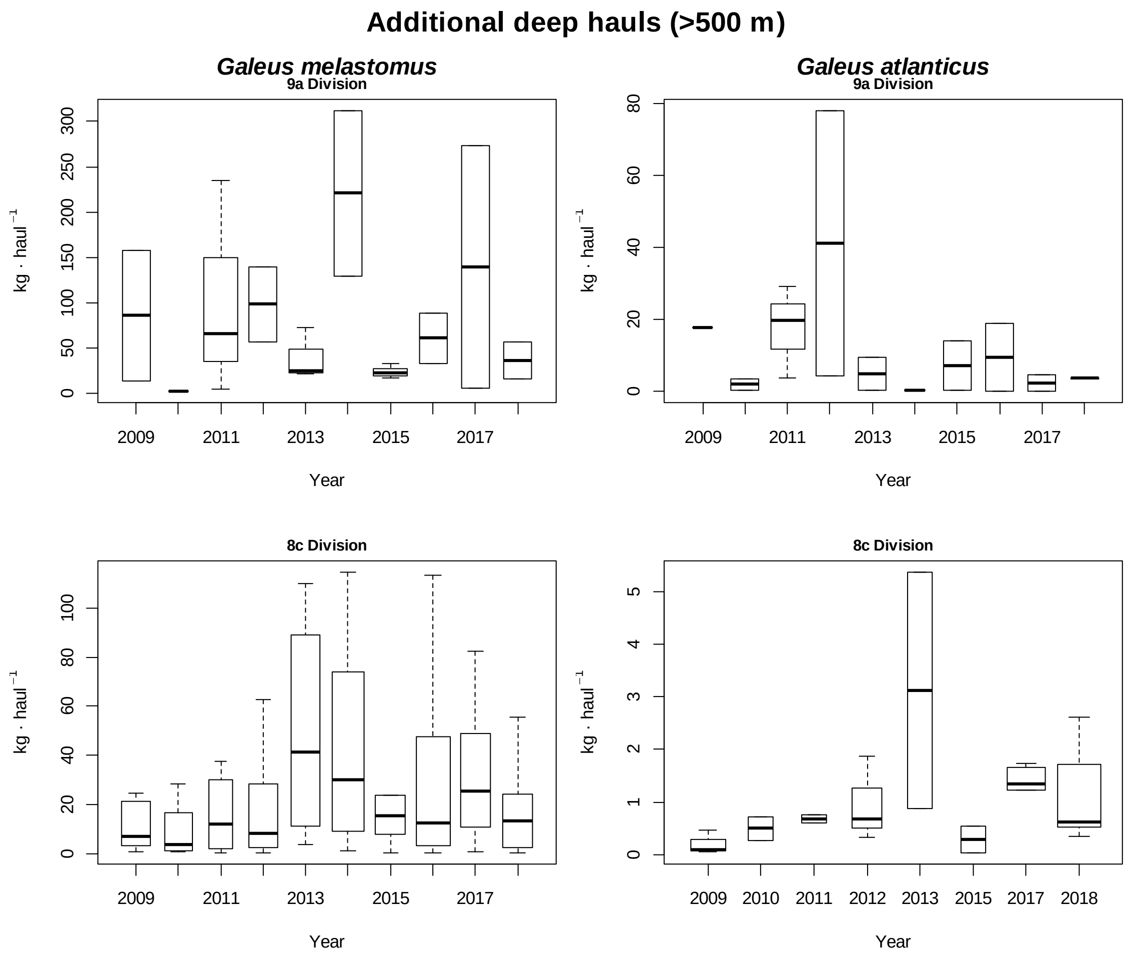


Figure 11 Evolution of *Galeus melastomus* and *Galeus atlanticus* catches in additional hauls out of the standard stratification (>500 m) between 2009 and 2018 in the two ICES Divisions. Boxes mark parametric standard error of the biomass in additional hauls. Lines mark the median and whiskers the interquartile range

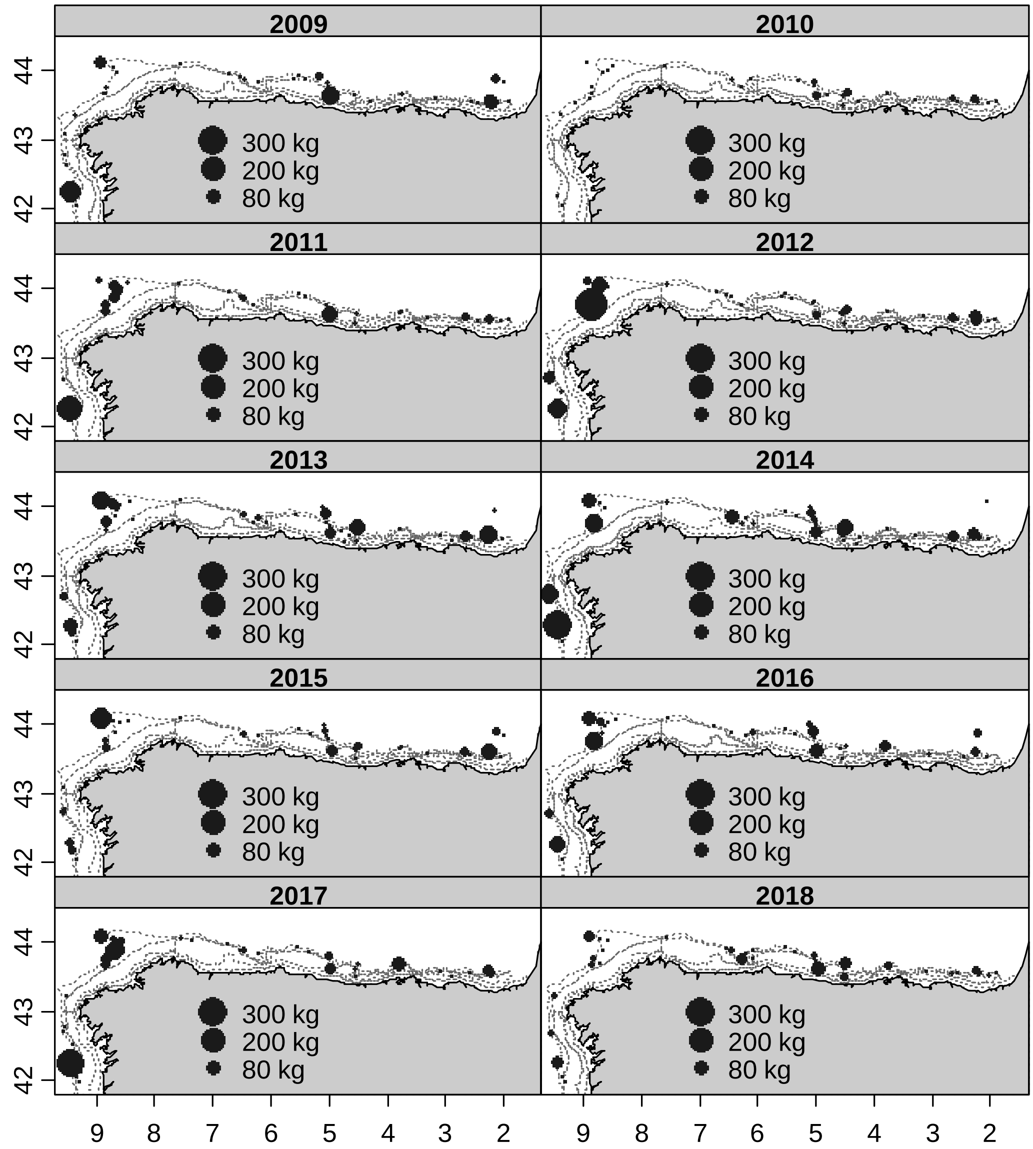


Figure 12 Geographic distribution of *Galeus melastomus* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018.

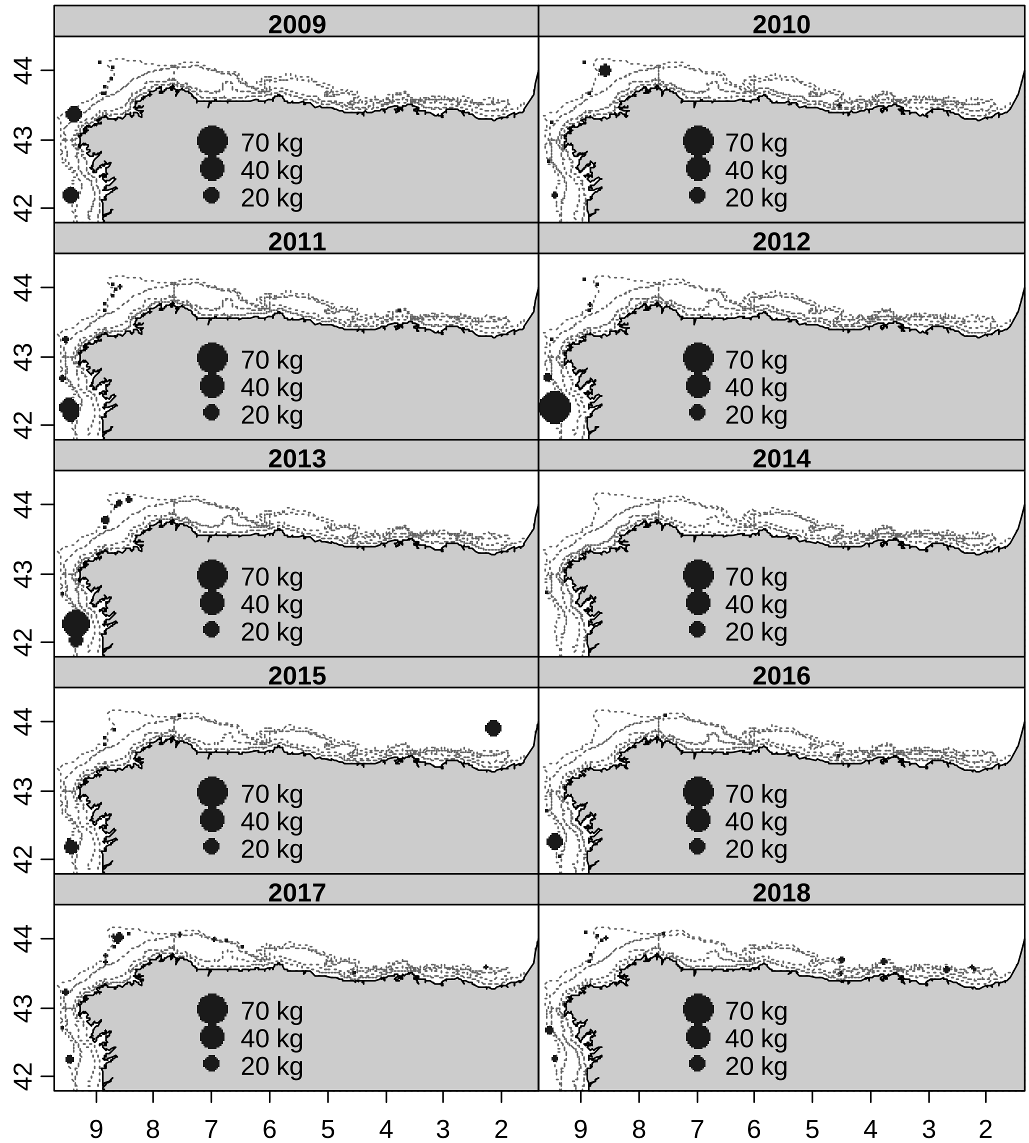


Figure 13 Geographic distribution of *Galeus atlanticus* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018.

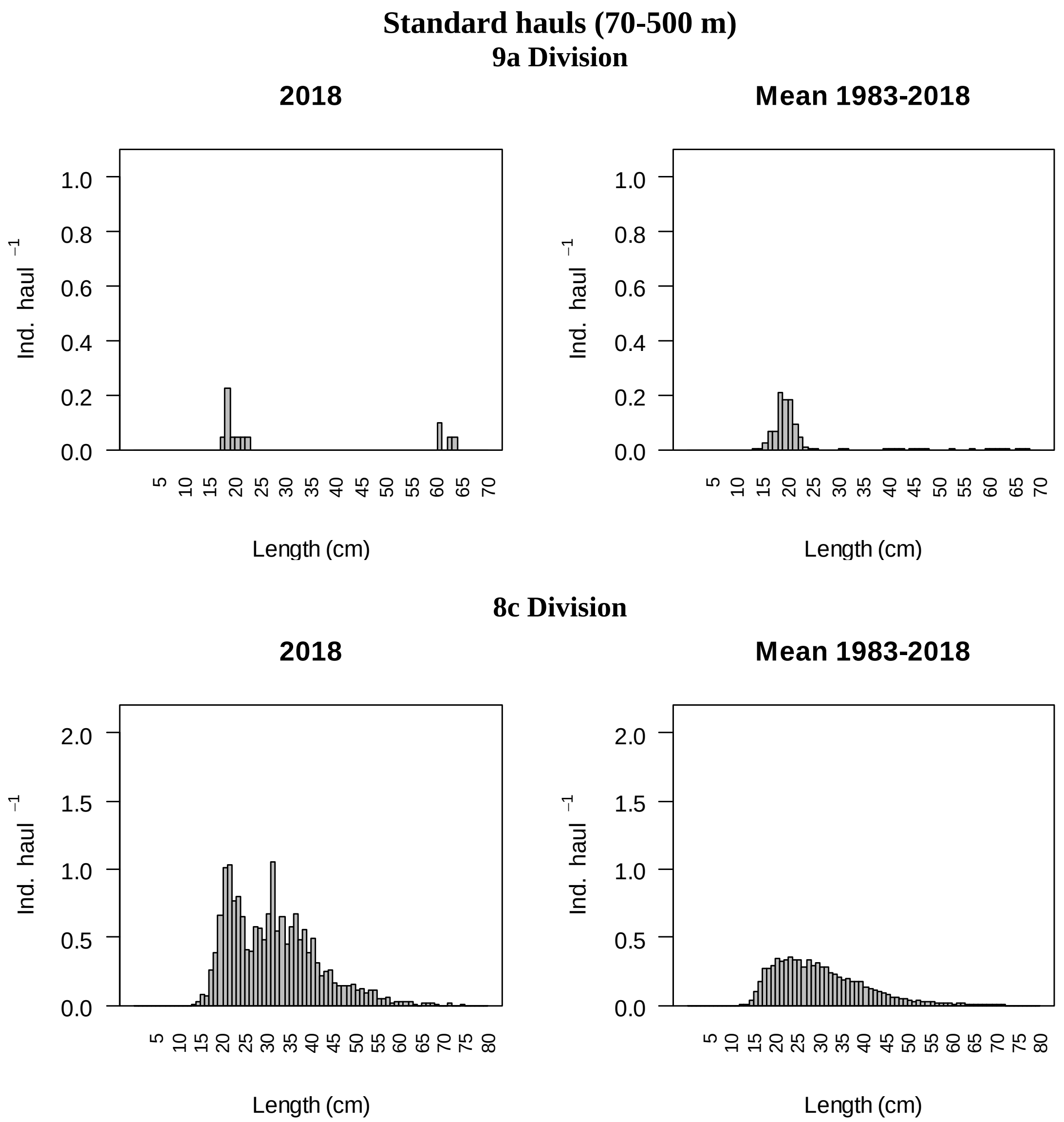


Figure 14 Stratified length distributions of *Galeus melastomus* in standard hauls (70-500 m) in the two ICES Divisions covered by the North Spanish Shelf bottom trawl survey in 2018, and the mean values for the time series in both areas.

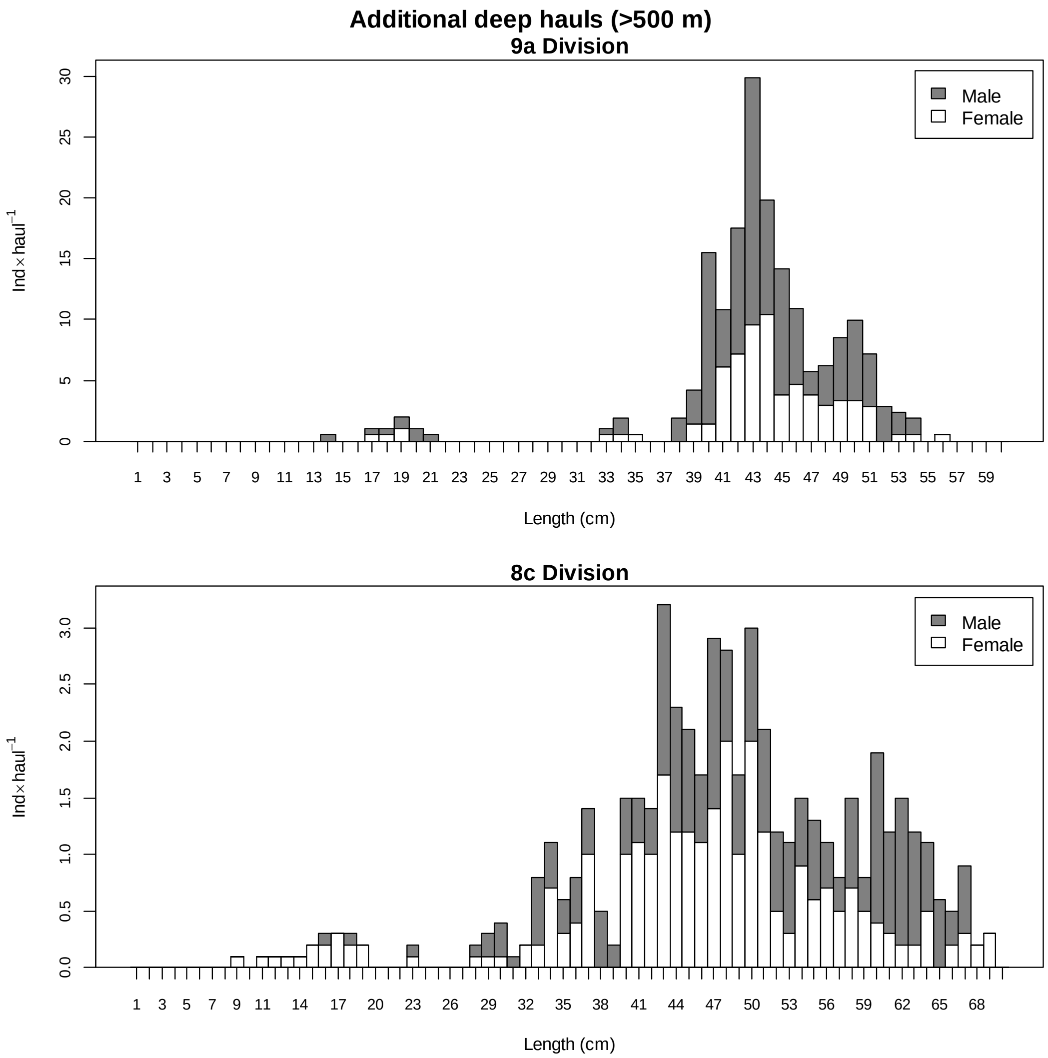


Figure 15 Mean length distributions of *Galeus melastomus* in additional hauls (>500 m) in the North Spanish Shelf survey 2018 by ICES areas.

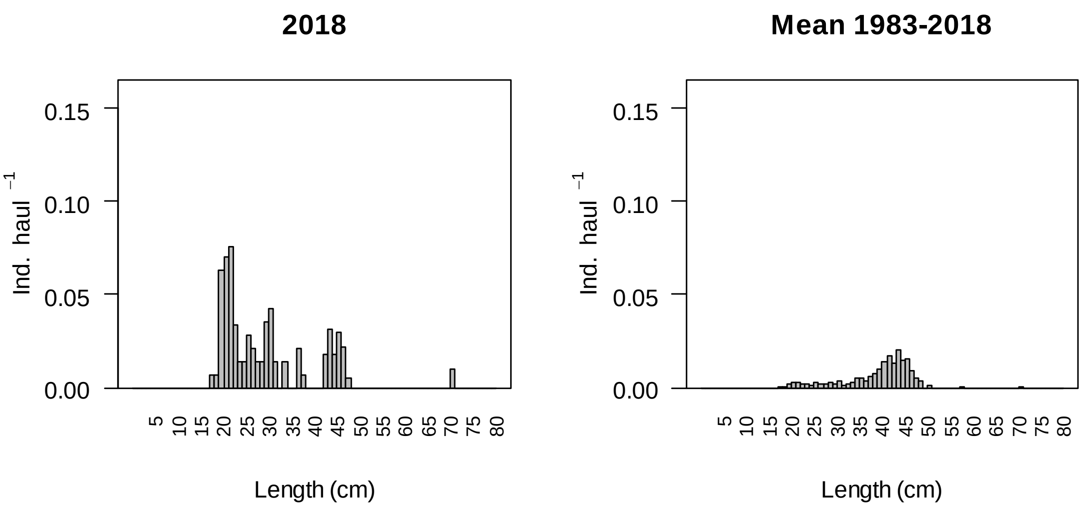


Figure 16 Stratified length distributions of *Galeus atlanticus* in standard hauls (70-500 m) covered by the North Spanish Shelf bottom trawl survey in 2018, and the mean values for the time series in both areas.

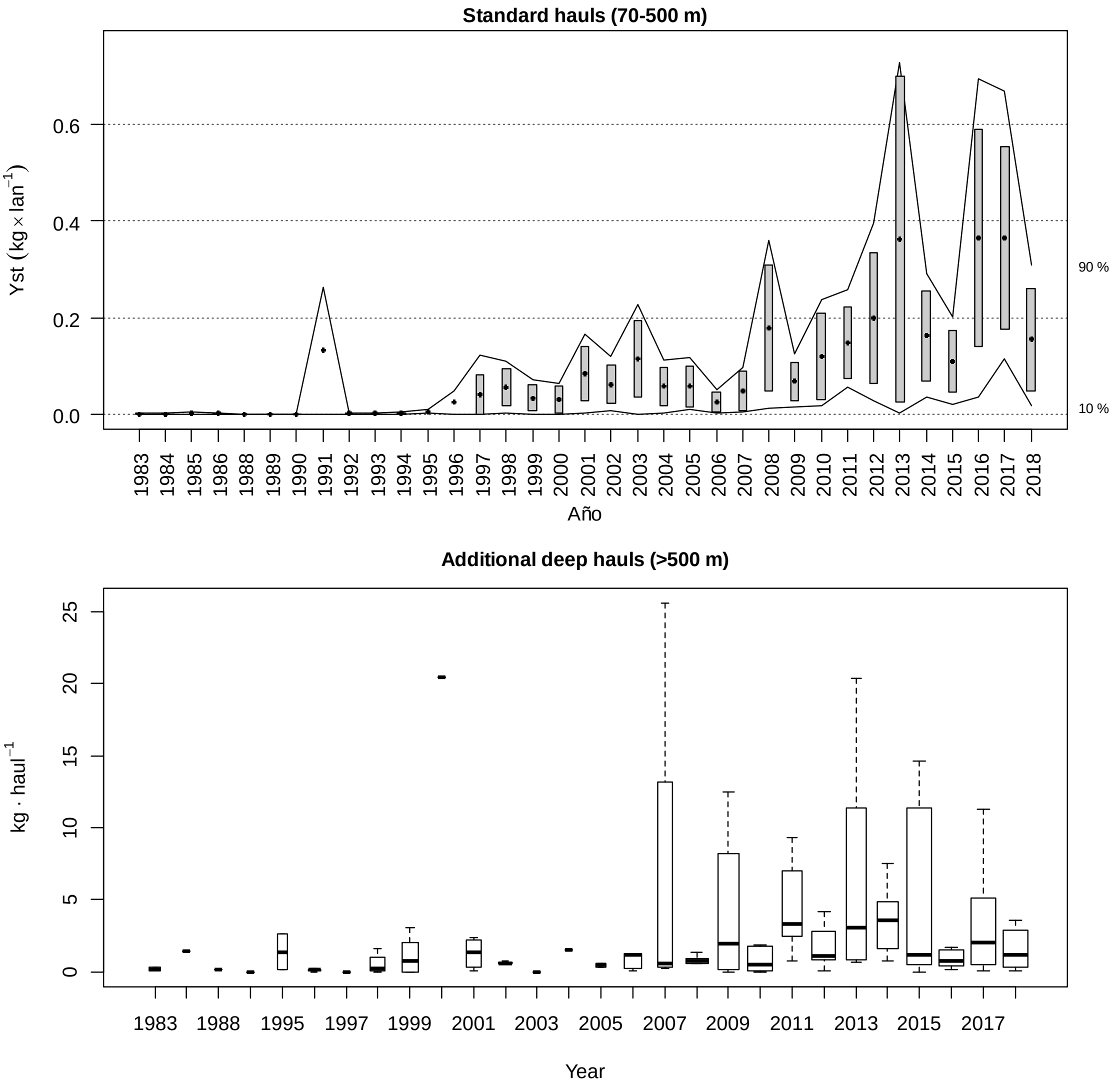
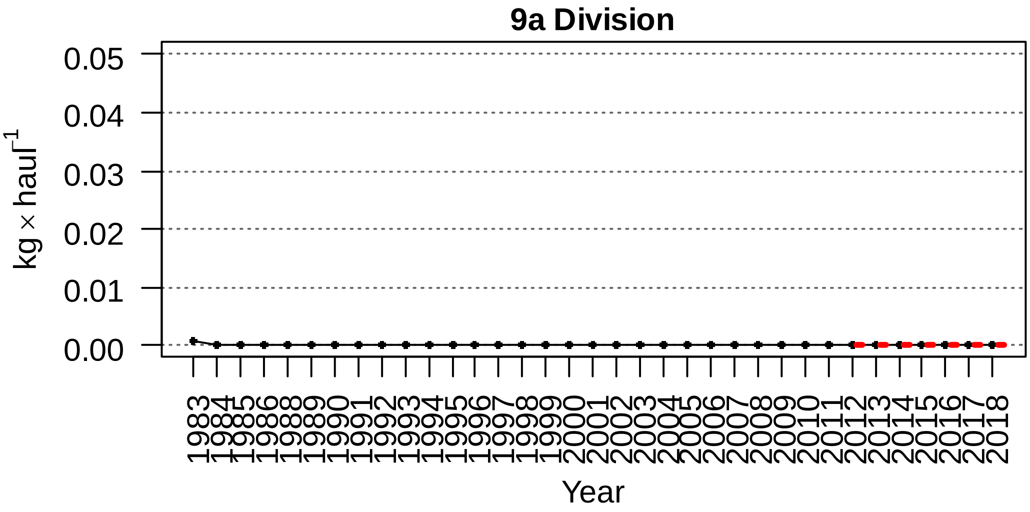


Figure 17 Evolution of *Etmopterus spinax* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)



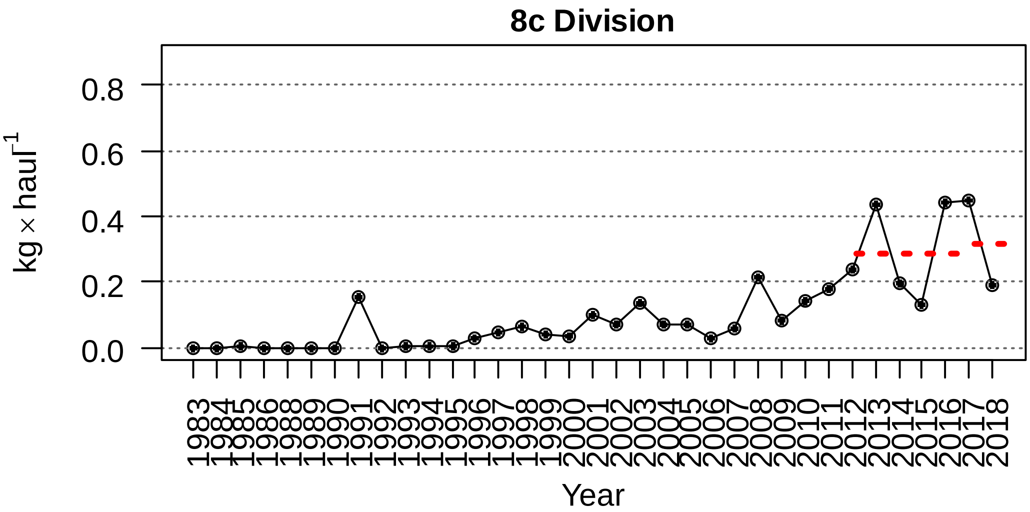


Figure 18 Evolution of *Etmopterus spinax* biomass index during the North Spanish shelf bottom trawl survey time series in both Division covered by the survey. Red lines mark a comparative between last two years and the five previous.

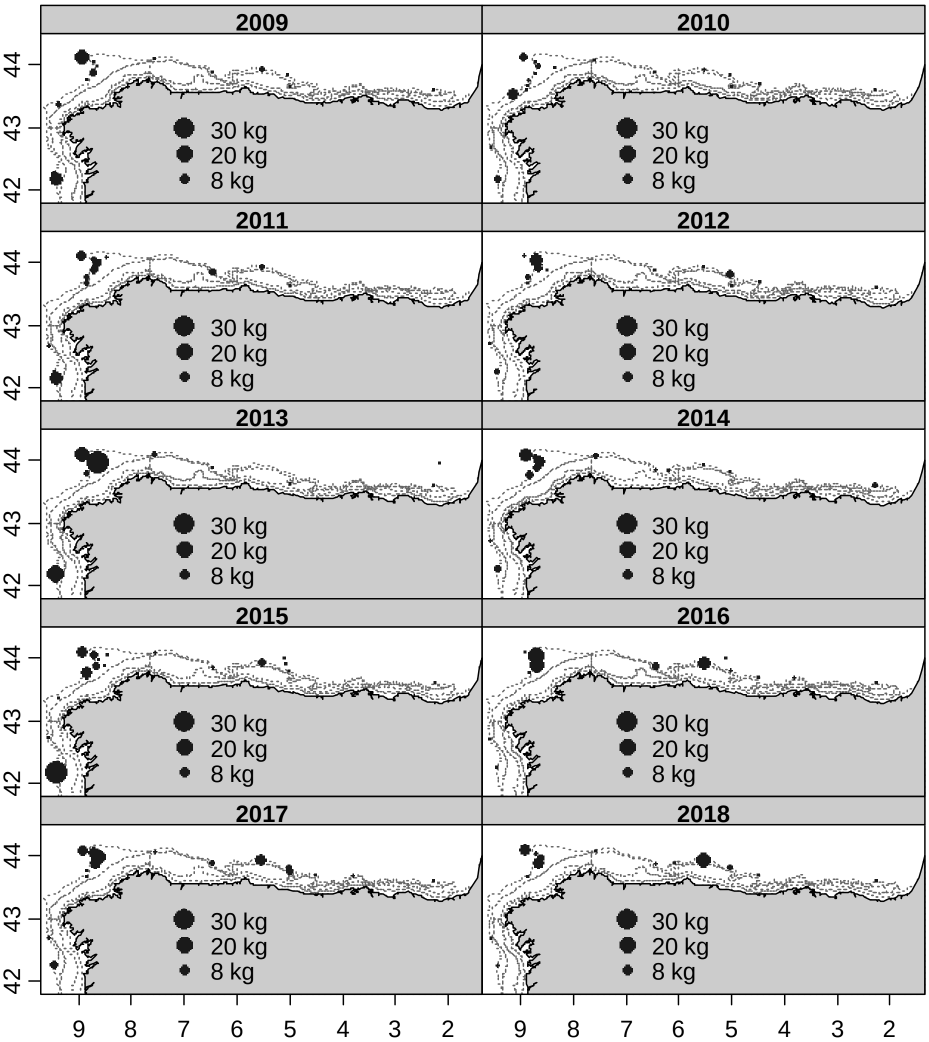


Figure 19 Geographic distribution of *Etmopterus spinax* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018.

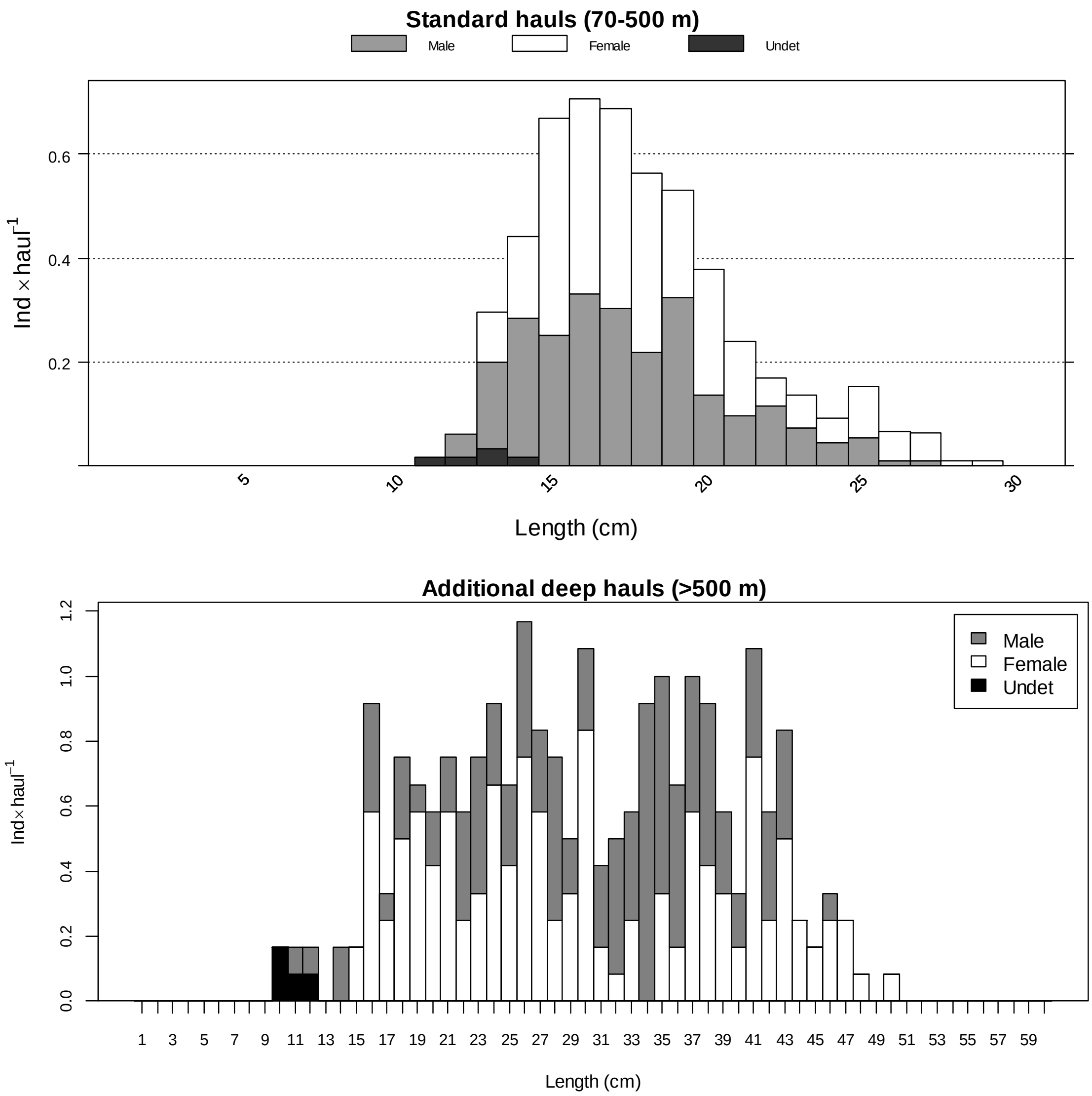


Figure 20 Mean length distributions of *Etmopterus spinax* caught in standard hauls (70-500 m) and in the additional hauls (>500 m) during the North Spanish Shelf survey 2018.

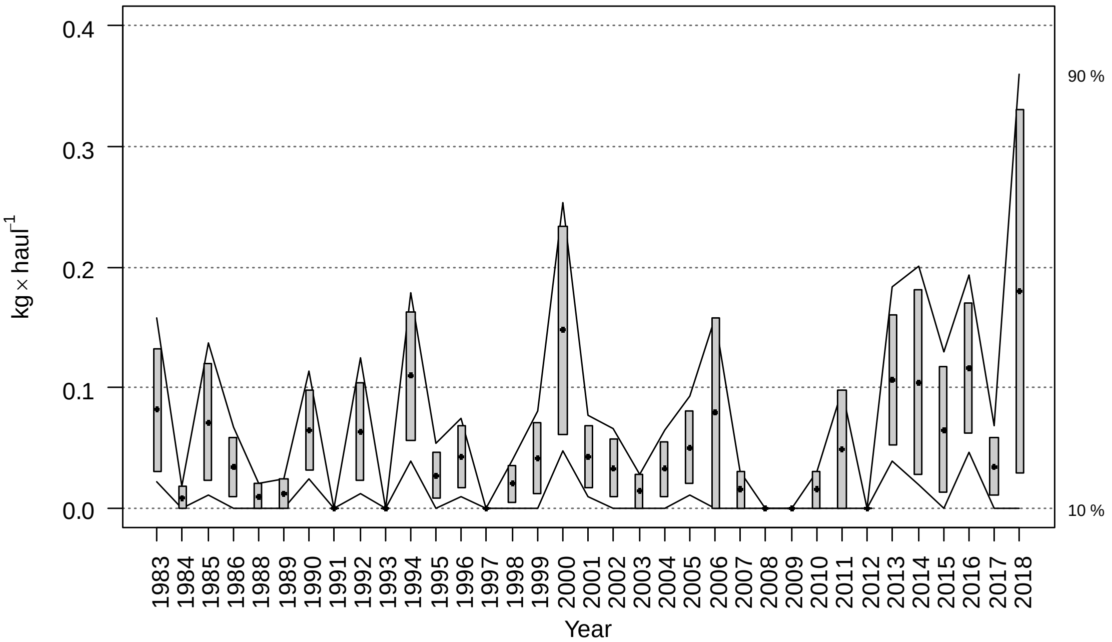


Figure 21 Evolution of *Hexanchus griseus* biomass index during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

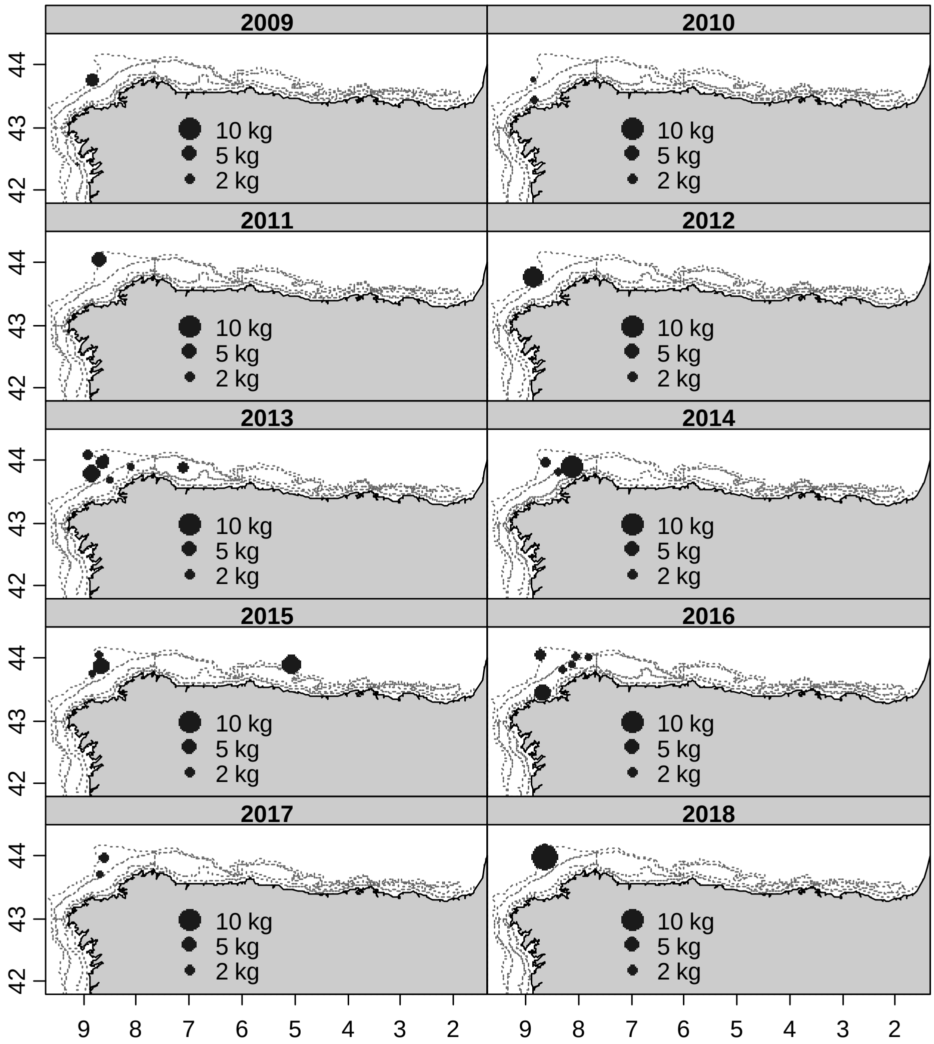


Figure 22 Geographic distribution of *Hexanchus griseus* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018.

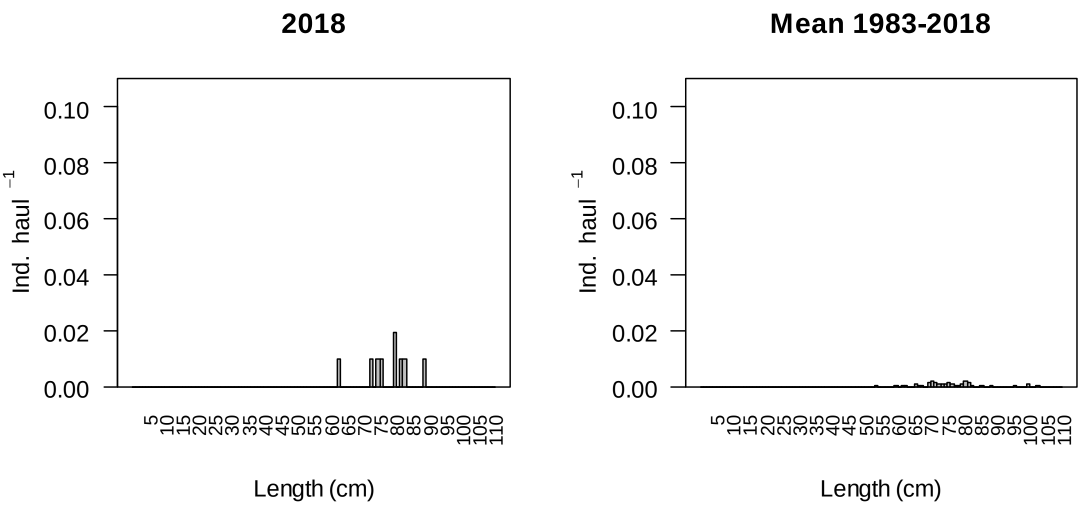


Figure 23 Stratified length distributions of *Hexanchus griseus* in standard hauls (70-500 m) covered by the North Spanish Shelf bottom trawl survey in 2018, and the mean values for the time series in both areas.

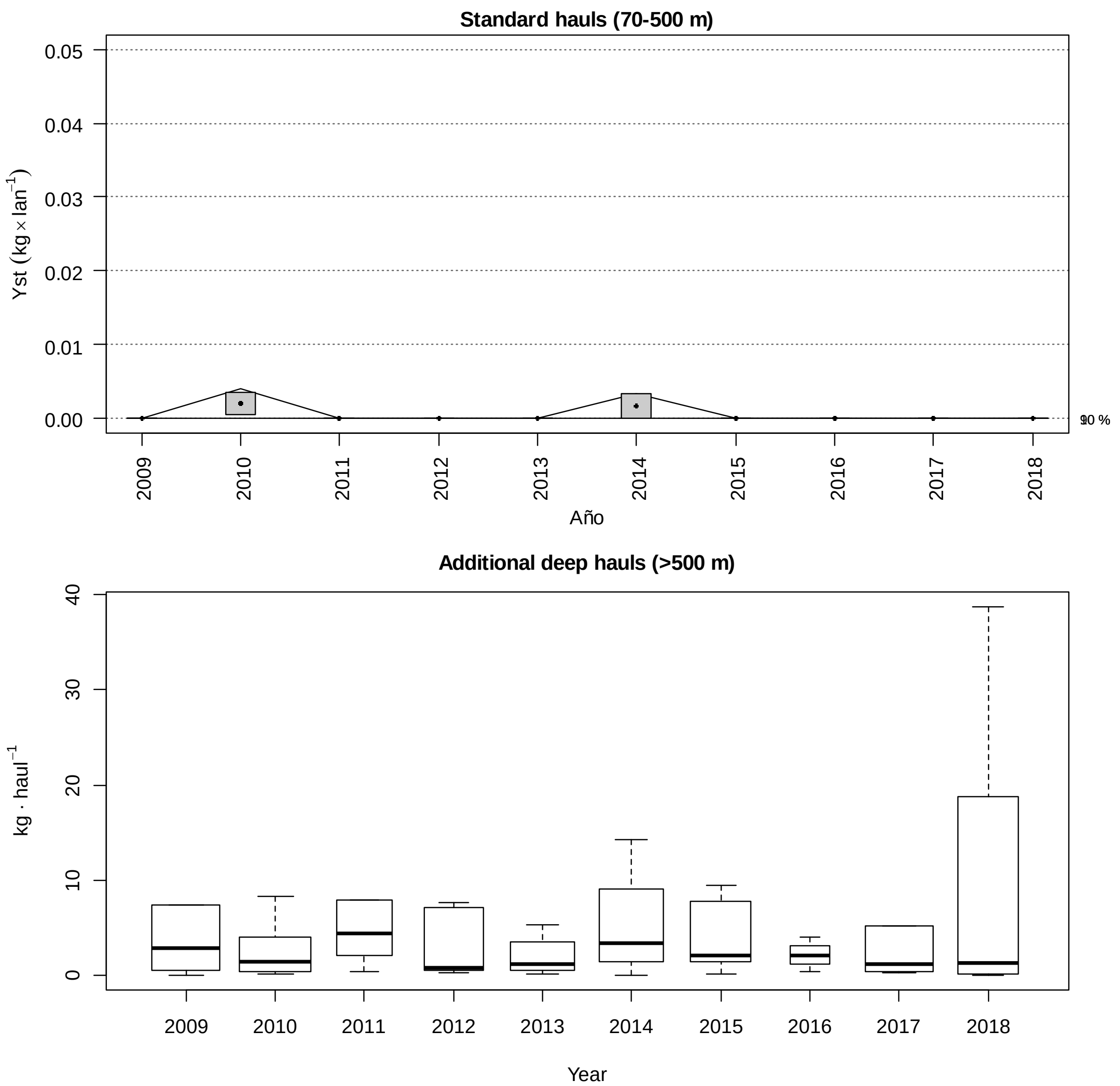


Figure 24 Evolution of *Deania profundorum* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series 2009-2018. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

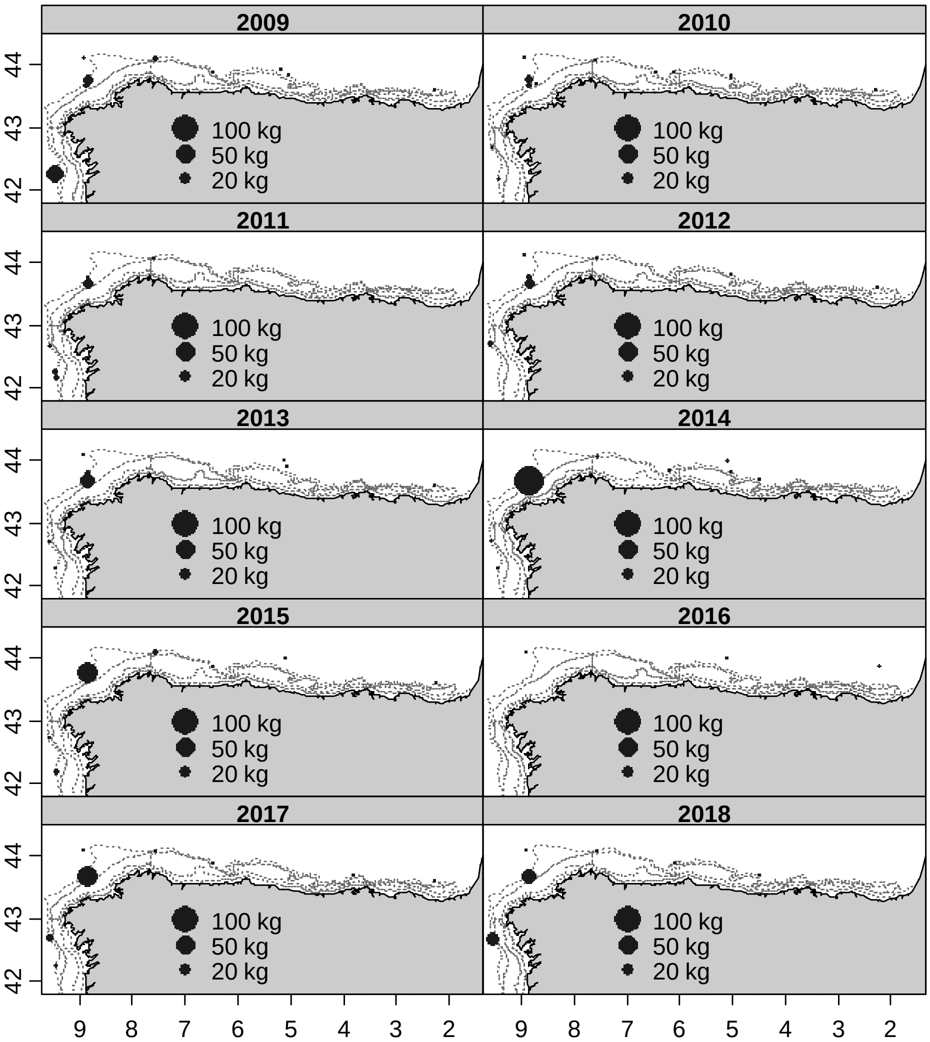


Figure 25 Geographic distribution of *Deania profundorum* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018.

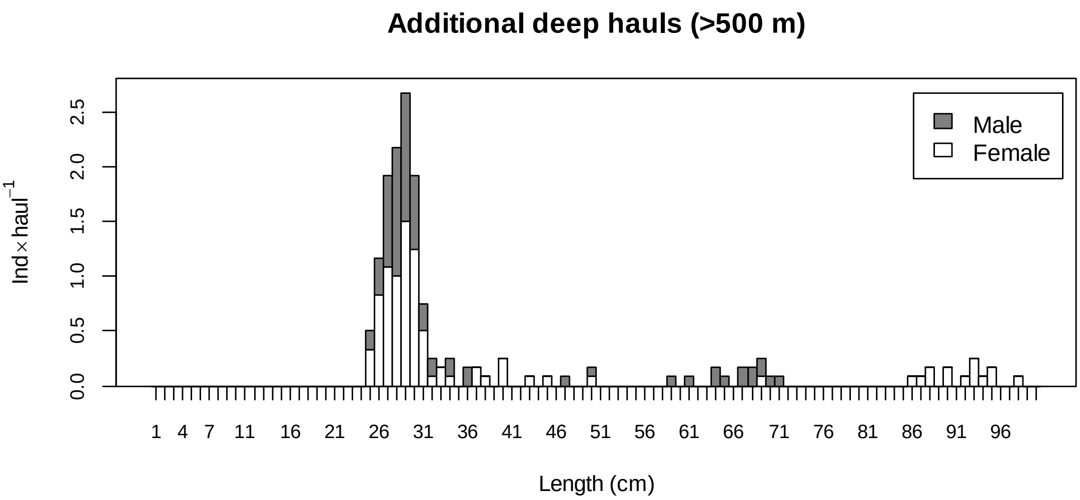


Figure 26 Stratified length distributions of *Deania profundorum* in additional deep hauls (>500 m) covered by the North Spanish Shelf bottom trawl survey in 2018.

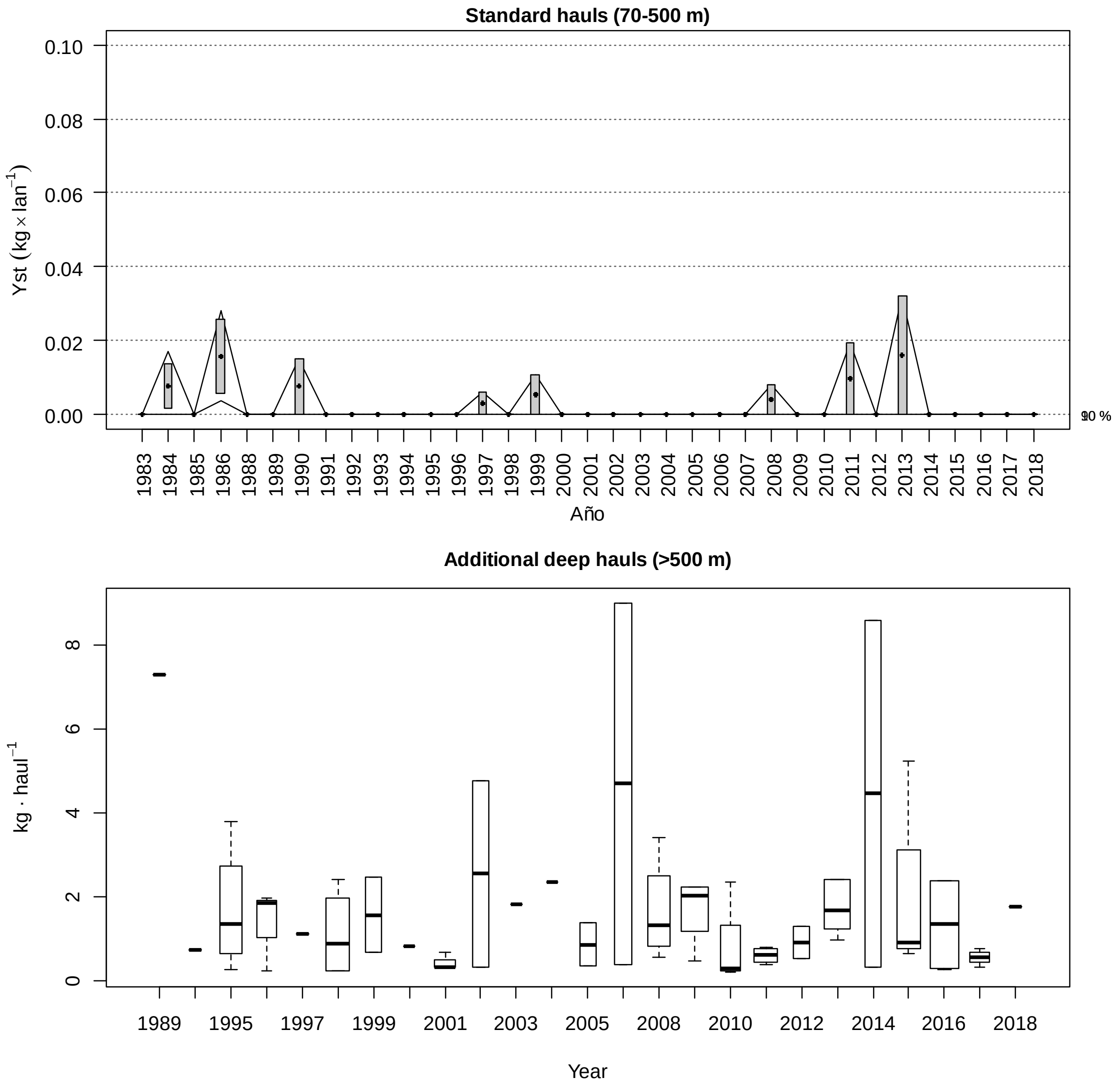


Figure 27 Evolution of *Scymnodom ringens* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

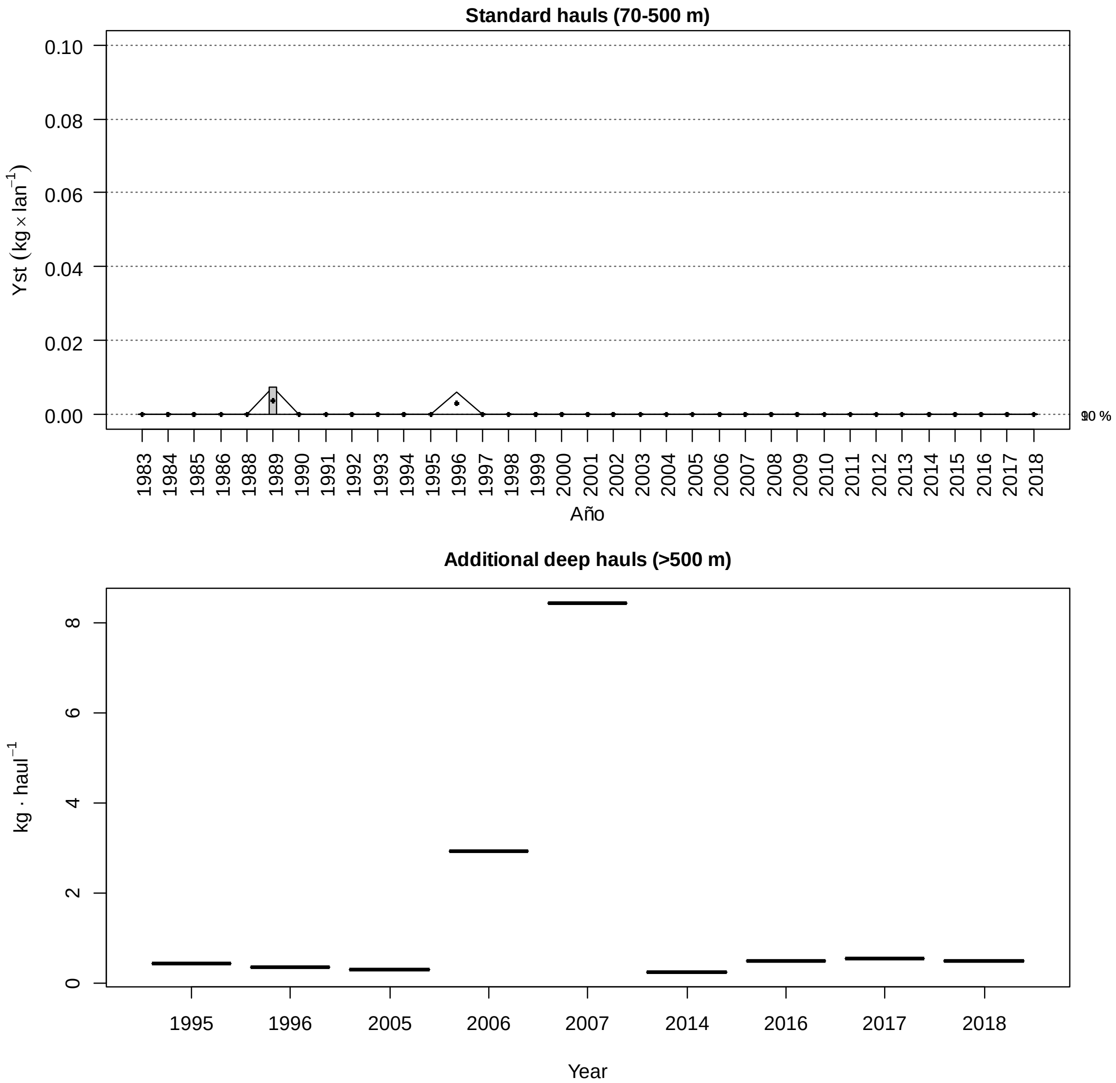


Figure 28 Evolution of *Dalatias licha* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

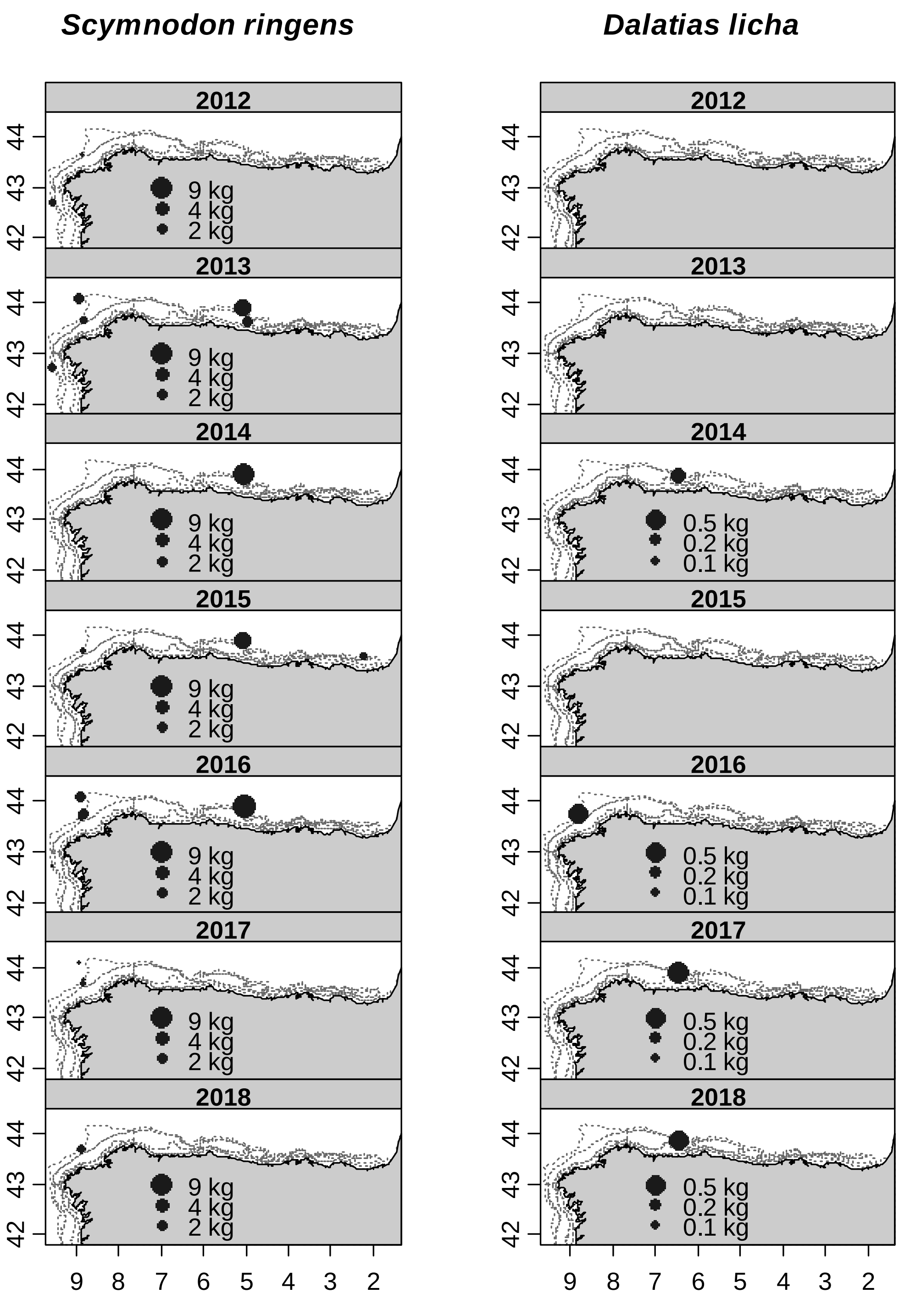


Figure 29 Geographic distribution of *Scymnodon ringens* and *Dalatias licha* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2012 and 2018

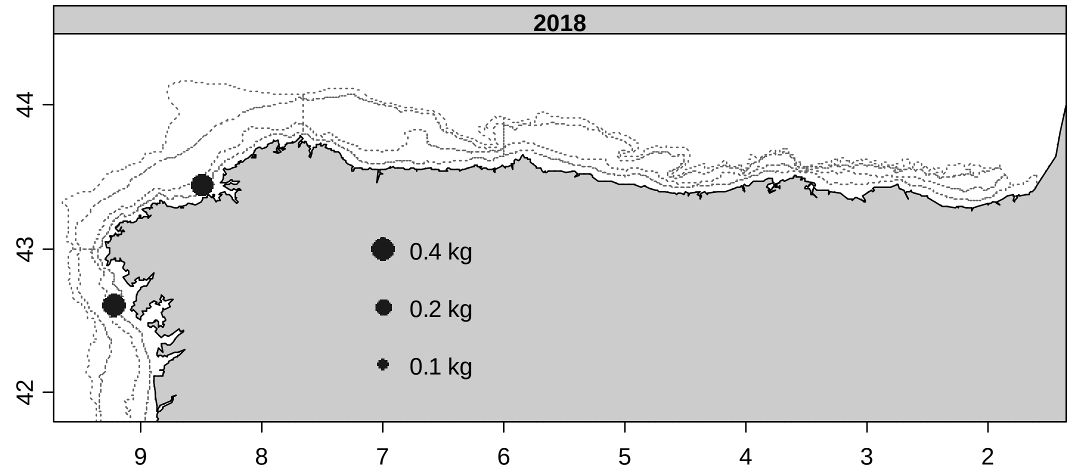


Figure 30 Geographic distribution of *Mustelus mustelus* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys in 2018

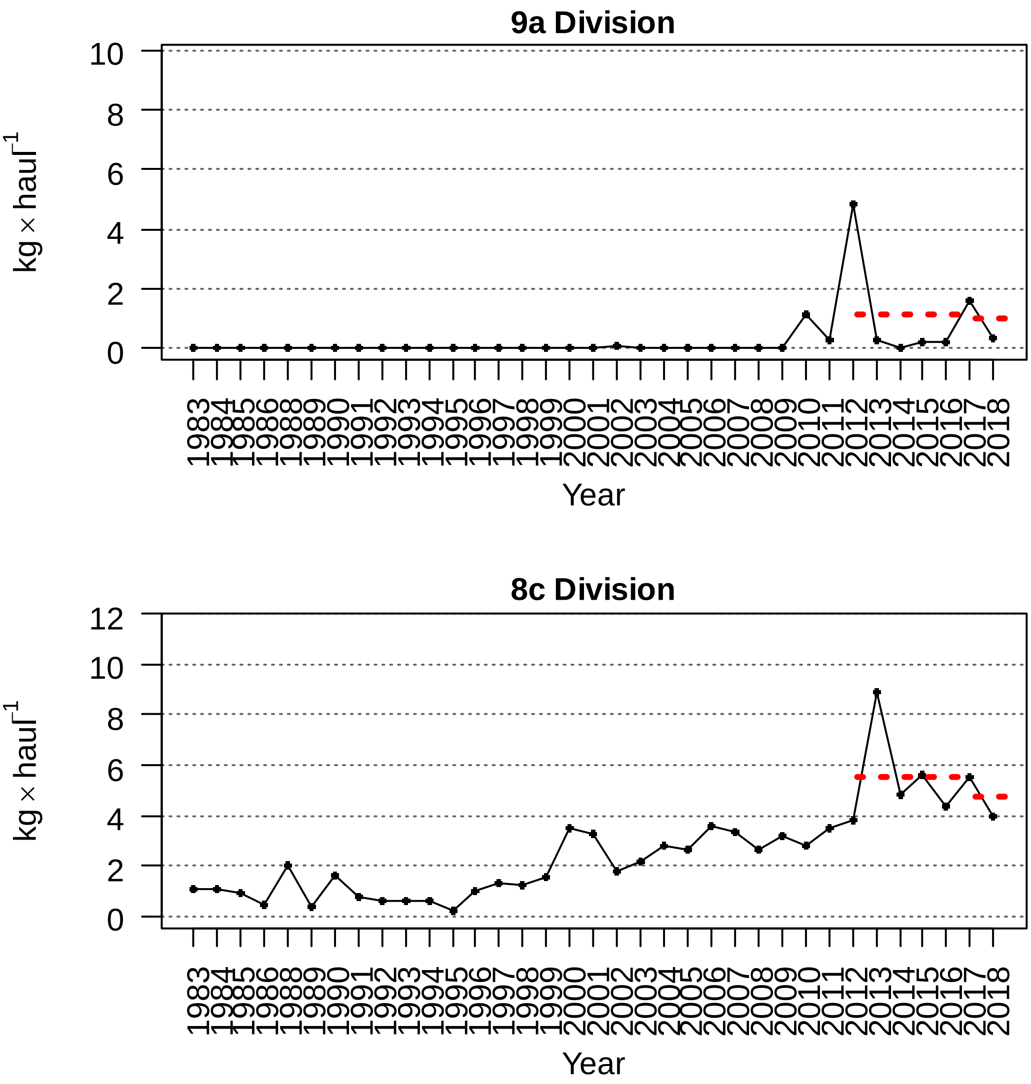


Figure 31 Evolution of *Raja clavata* biomass index during the North Spanish shelf bottom trawl survey time series. Red lines mark a comparative between last two years and the five previous

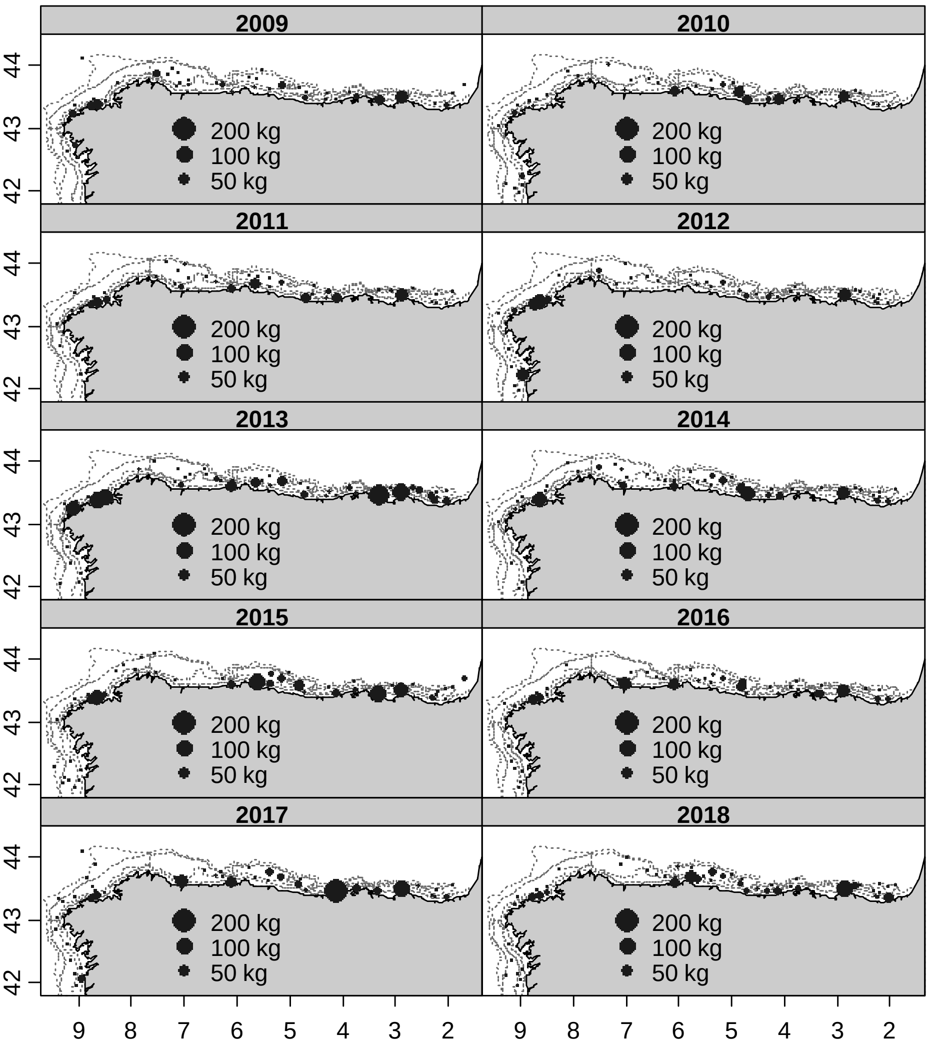


Figure 32 Geographic distribution of *Raja clavata* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018.

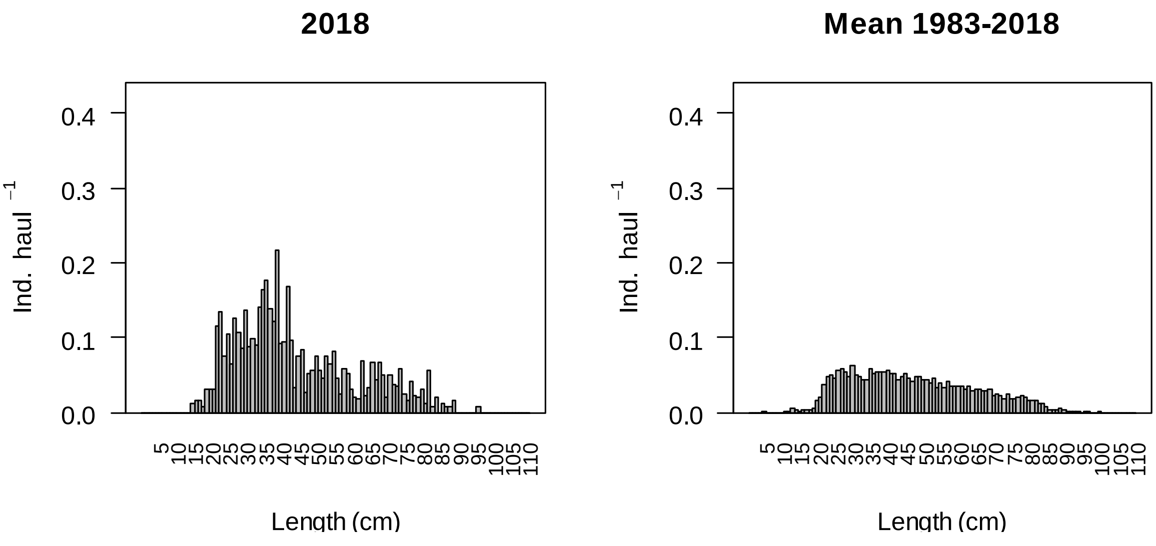


Figure 33 Mean stratified length distribution of *Raja clavata* in the last survey and in the time series in 8c Division of the North Spanish Shelf

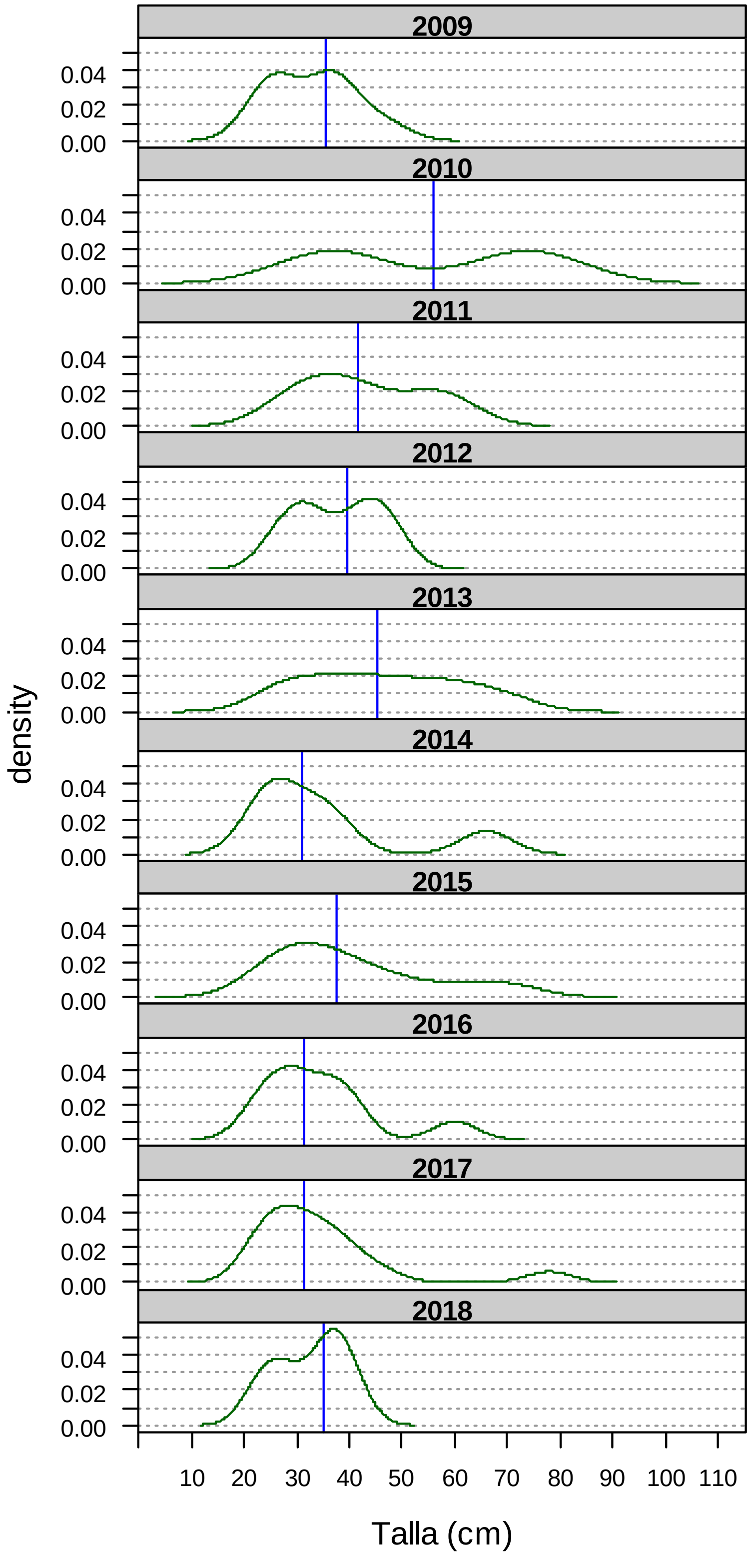


Figure 34 Mean stratified length distributions of *Raja clavata* in 8c Division of the North Spanish Shelf

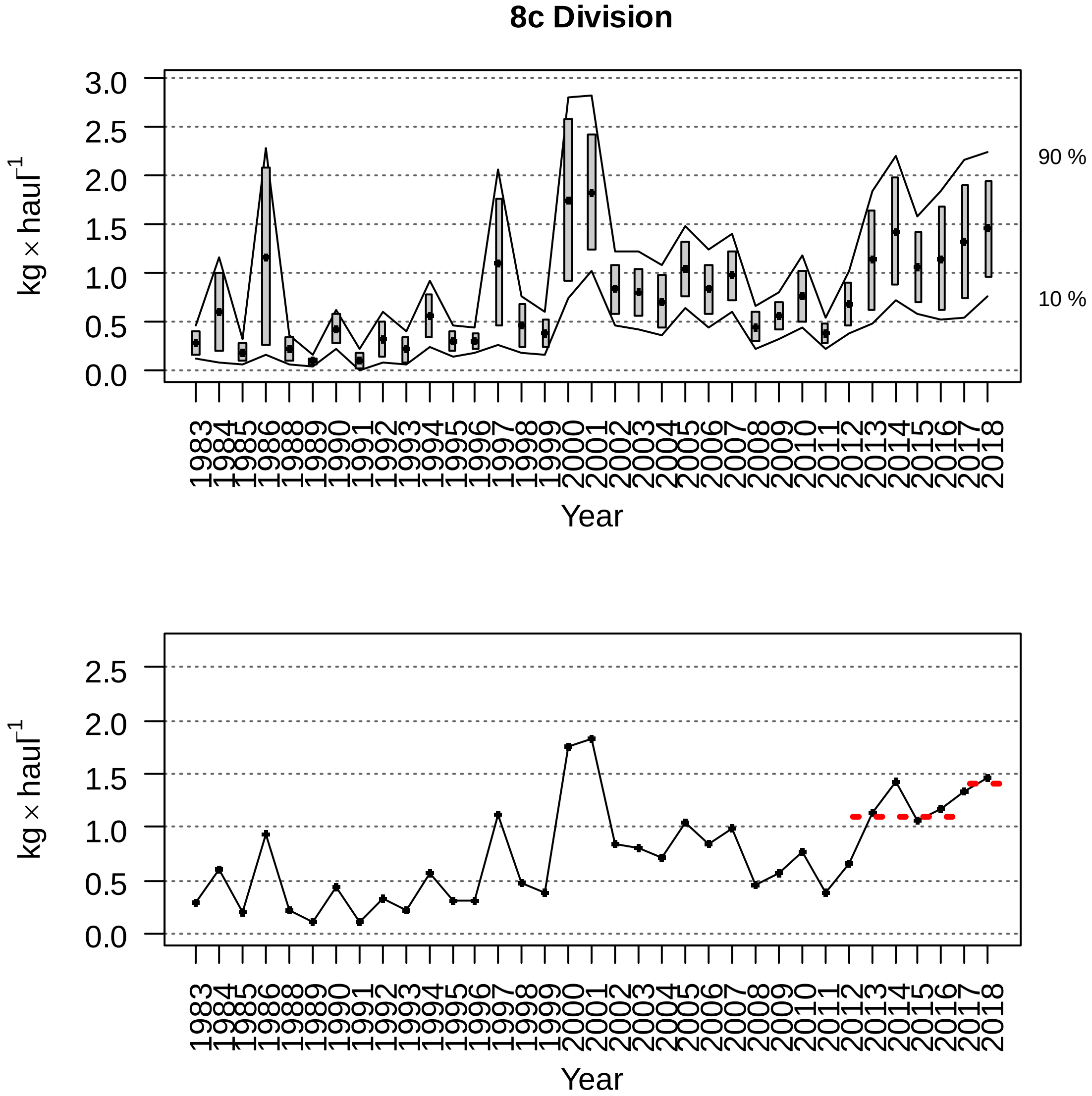


Figure 35 Evolution of *Raja montagui* biomass index during the North Spanish shelf bottom trawl survey time series in 8c Division covered by the survey. Boxes mark parametric standard error of the stratified biomass index and black lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). Red lines mark a comparative between last two years and the five previous.

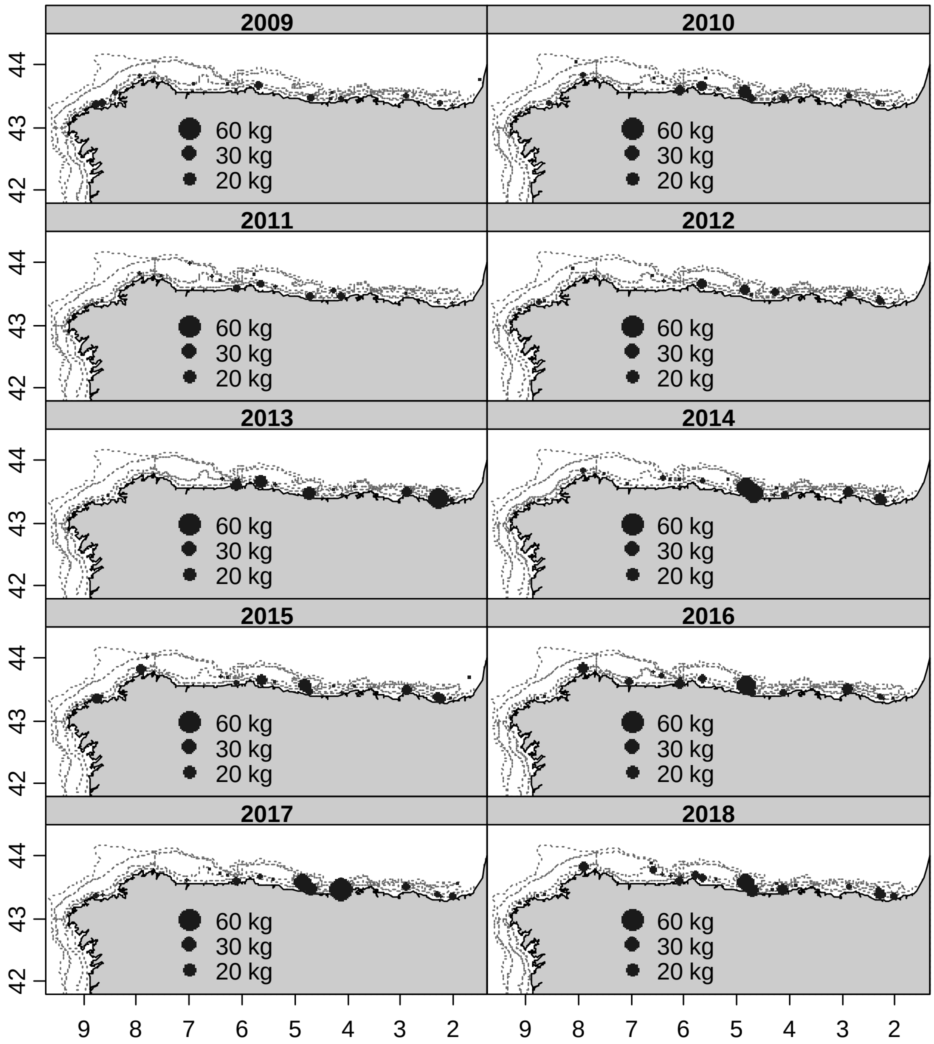


Figure 36 Geographic distribution of *Raja montagui* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018

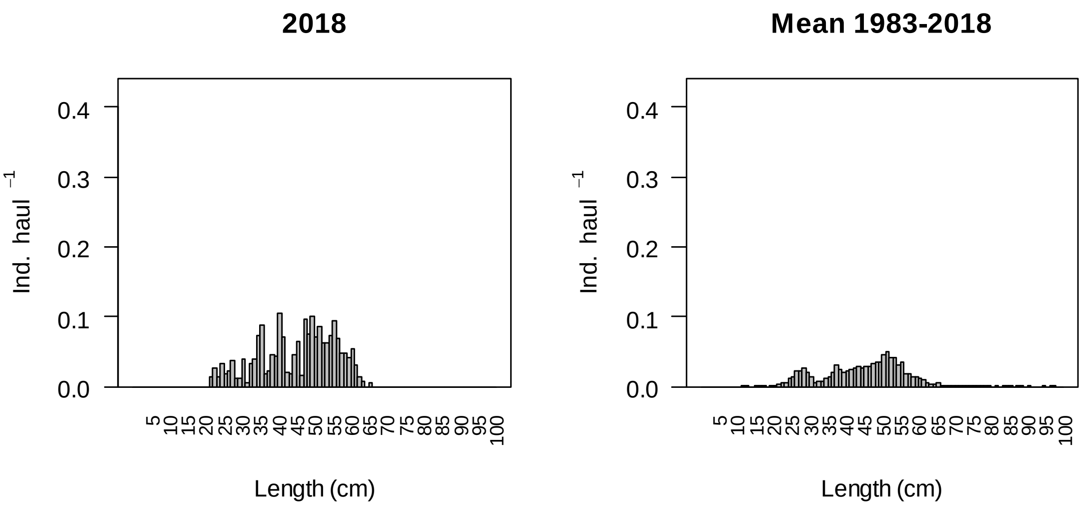


Figure 37 Mean stratified length distribution of *Raja montagui* in the last survey and in the time series in 8c Division of the North Spanish Shelf

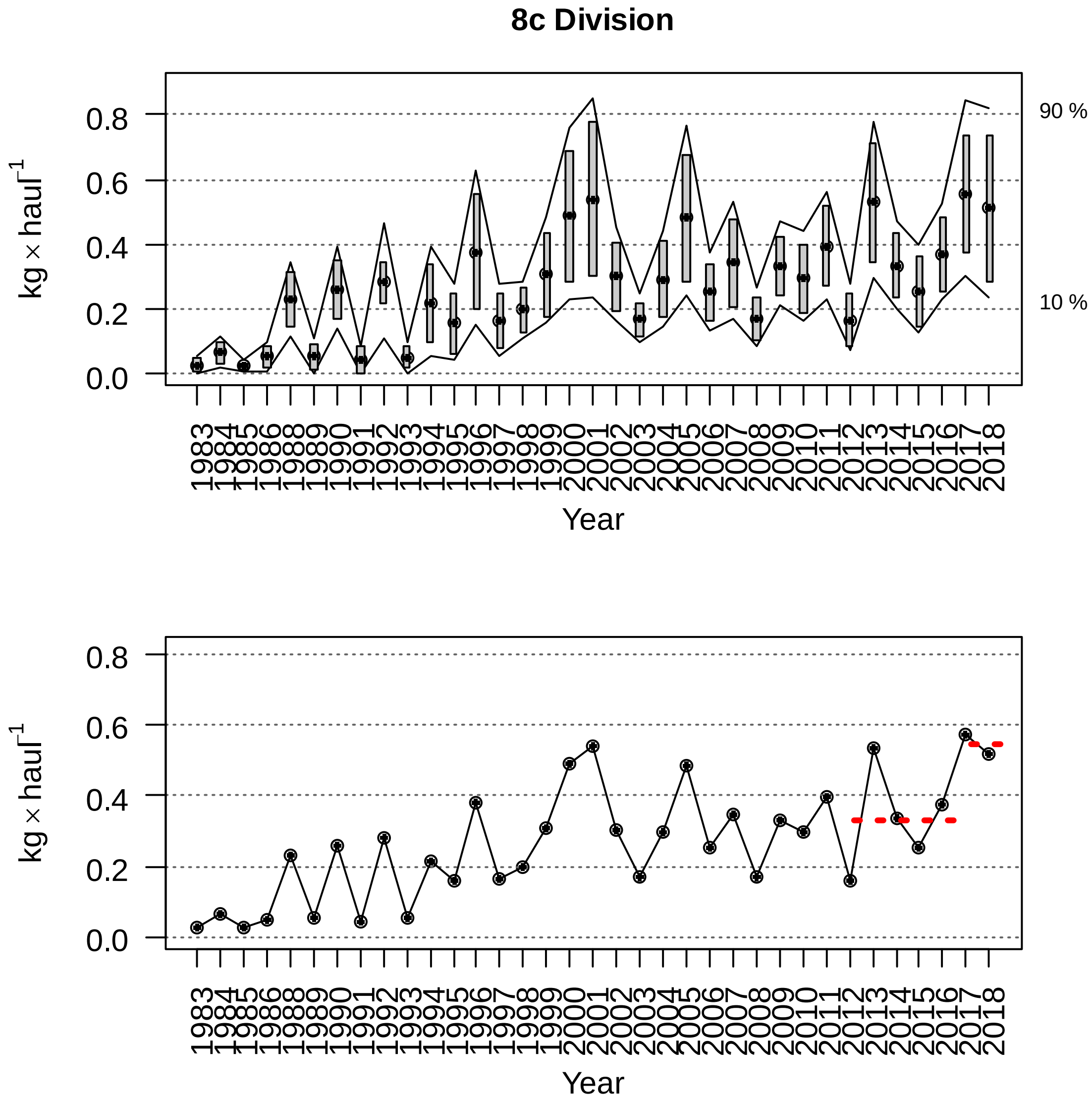


Figure 38 Evolution of *Leucoraja naevus* biomass index during the North Spanish shelf bottom trawl survey time series in 8c Division covered by the survey. Boxes mark parametric standard error of the stratified biomass index and black lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). Red lines mark a comparative between last two years and the five previous.

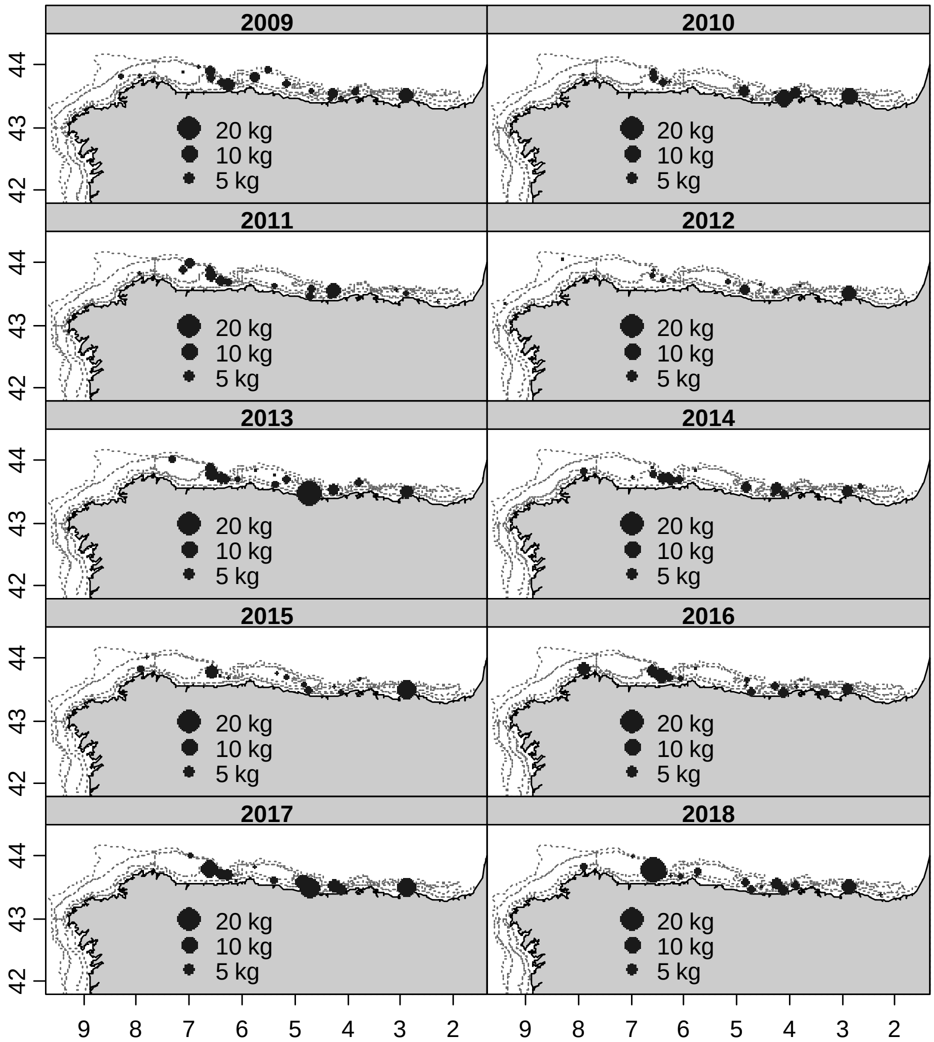


Figure 39 Geographic distribution of *Leucoraja naevus* catches (kg/30 min haul) in North Spanish shelf bottom trawl surveys between 2009 and 2018

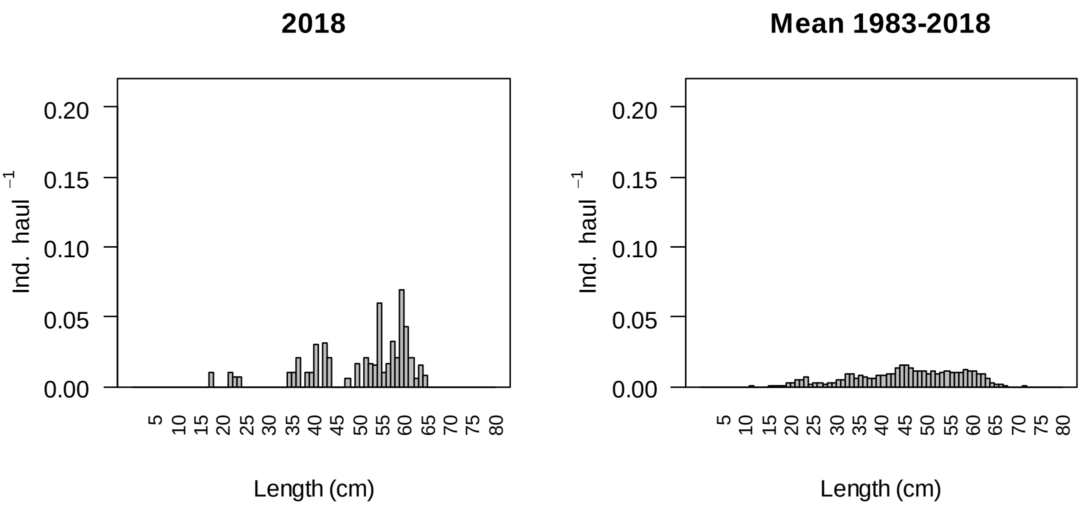


Figure 40 Mean stratified length distribution of *Leucoraja naevus* in the last survey and in the time series in 8c Division of the North Spanish Shelf

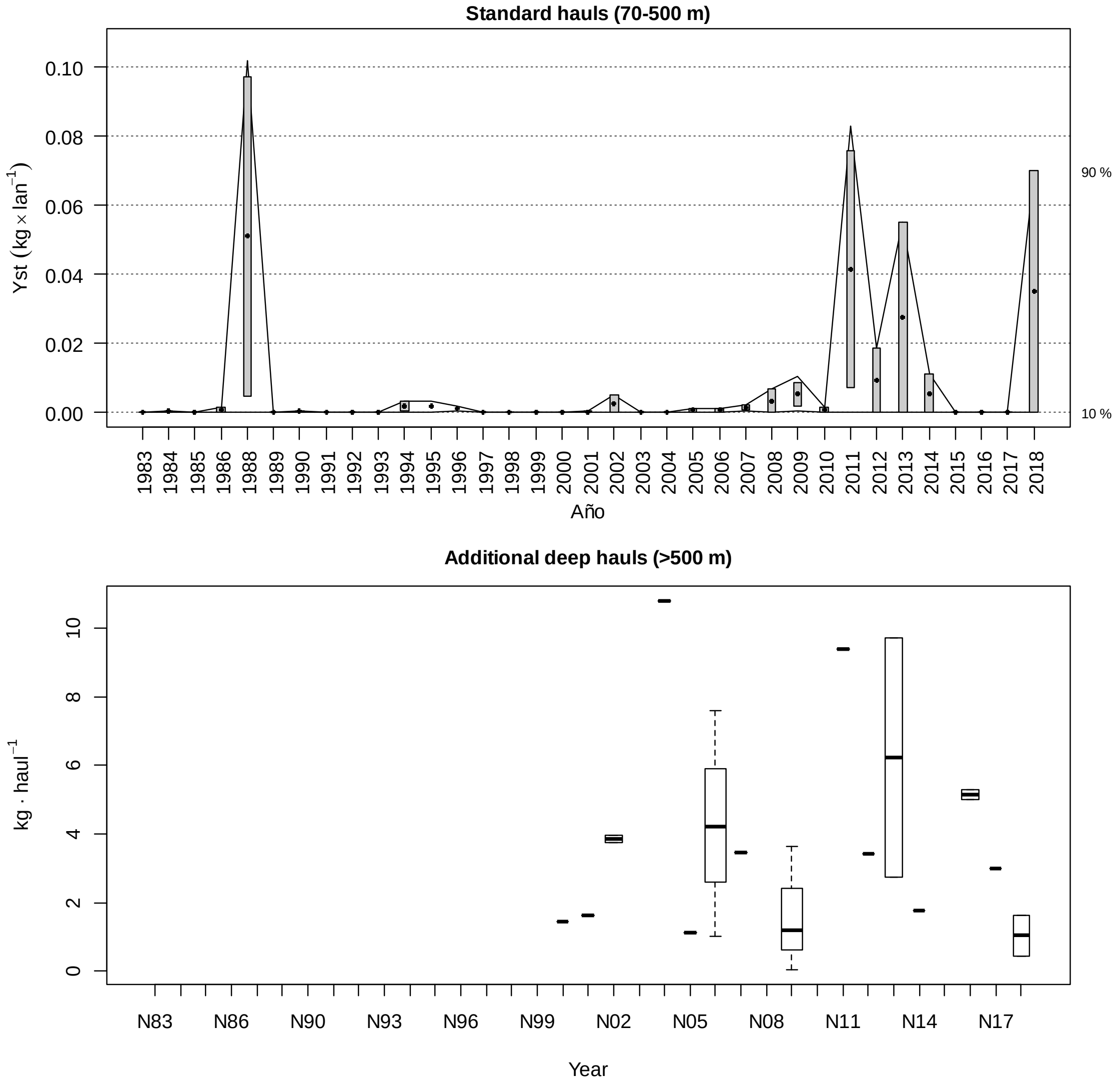


Figure 41 Evolution of *Leucoraja circularis* stratified biomass index in standard hauls and in additional deep hauls during the North Spanish shelf bottom trawl survey time series covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

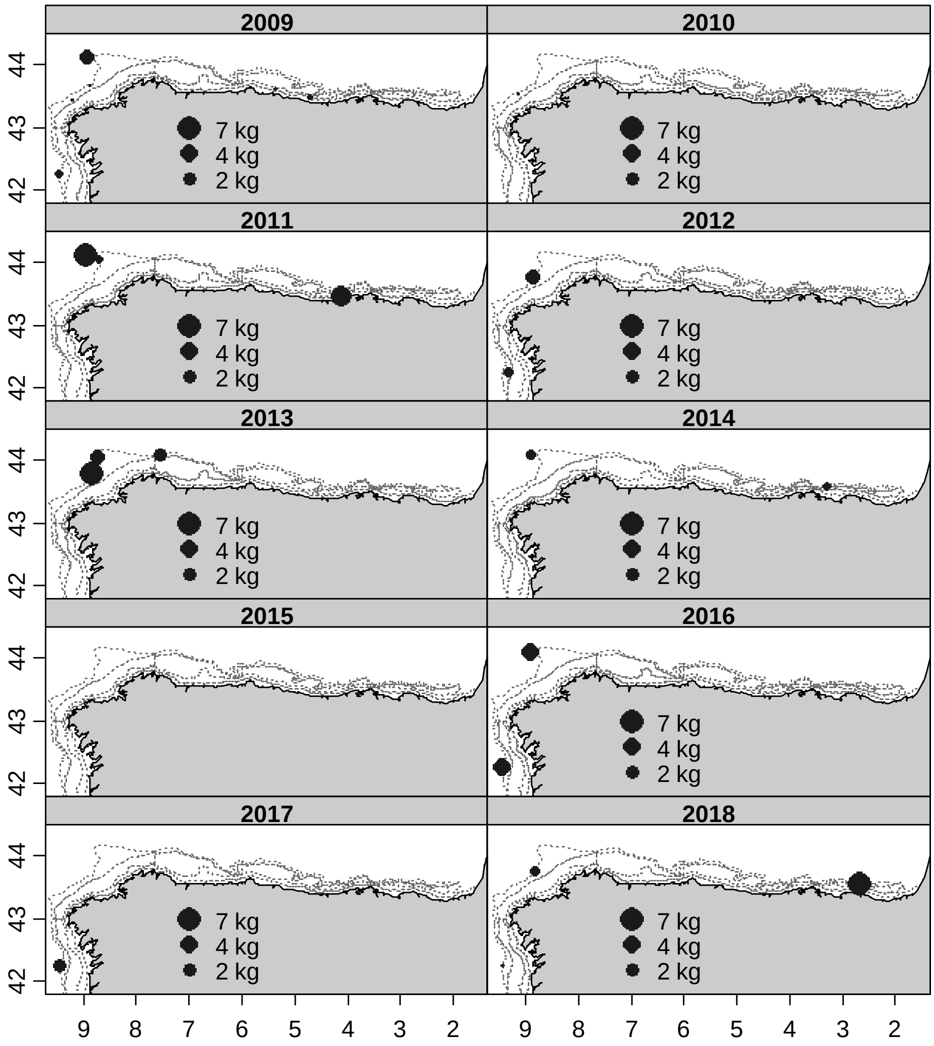


Figure 42 Geographic distribution of *Leucoraja circularis* catches (kg/30 min haul) in North Spanish Shelf bottom trawl surveys between 2009 and 2018

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ELASMOBRANCHS LANDINGS OF THE AZORES (ICES AREA 27.10)

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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 to the group for the recent years, although some data may be available from scientific projects. 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 from the landings for the year 2017 and 2018. 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. Some data may be available from scientific projects such as DiscardLess (http://www.discardless.eu/).

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 2016 and 2017 years was resumed from the Regional Statistical Service (SREA).

Length compositions from the national sampling program (DCF) to the landings was not updated for the year 2017 and 2018 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 occurred very irregularly 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.

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 eigth 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 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 (2018) around the 137 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 was not available for the last two years.

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Table 1. Elasmobranchs landings (weight and value) from the Azores for the period 2010-2017.

	Azorean common name	Scientific name	Code	Landings (t)									Price/Kg (€)								
				2010	2011	2012	2013	2014	2015	2016	2017	2018	2010	2011	2012	2013	2014	2015	2016	2017	2018
Demersal	RAIA	*Raja sp.*	*RJC*	68.3	90.7	102.9	115.3	186.9	171.2	127.3	64.3	61.2	1.0	1.0	0.8	0.7	1.0	1.2	1.5	1.6	1.5
	GATA LIXA	*Dalatias licha*	*CSK*	1.9	1.1	0	0	0	0	0	0	0	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SAPATAS [1)]	*Deania sp.*		2.55	0	0	0	0	0	0	0	0	0.09	0	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	0	0
	SAPATA-PRETA	*Centroscymnus crepidater*	*CZI*	0.2	0	0	0	0	0	0	0	0	0.1	0	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	0	0
Benthopelagic	BICO DOCE (Tubarão rosa)	*Heptranchias perlo*	*HXT*	0.2	0.4	0.3	0.4	0.1	0.2	0.0	0.0	0.0	0.6	0.9	0.4	0.3	0.1	0.6	0.0	0.0	0.0
	BARROSO	*Cetrophorus granlosus*	*GUP*	0.9	0.5	0	0	0	0	0	0	0	0.8	0.7	0	0	0	0	0	0	0
	ALBAFAR	*Hexanchus griseus*	*SBL*	0.6	1.2	0	0	0	0	0	0	0	0.4	0.0	0	0	1	0	0	0	0
	CAÇÃO	*Galeorhinus galeus*	*GAG*	41.3	43.5	47.4	45.7	65.4	71.0	84.9	69.8	41.2	2.1	1.7	1.6	1.9	1.4	1.7	2.1	2.2	2.0
Pelagic	CORNUDA (Tubarão martelo)	*Sphyrna zygaena*	*SPZ*	2.3	1.1	0.7	0.7	0.2	0.1	0.0	0.0	0.0	0.5	0.4	0.4	0.4	0.4	2.1	0.0	1.5	0.0
	TINTUREIRA	*Prionaca glauca*	*BSH*	16.2	129.8	292.6	109.9	25.8	37.7	42.3	13.2	30.0	0.3	0.4	0.4	0.6	0.3	0.4	0.4	2.2	0.3
	RINQUIM	*Isurus oxyrhinchus*	*SMA*	9.7	15.6	24.0	8.8	4.6	3.1	4.1	1.8	4.3	2.7	2.5	2.4	2.6	2.3	2.8	3.1	3.6	4.0
	TUBARÃO-RAP-OLHUDO	*Alopias superciliosus*	*BTH*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
	Others	*Not identified or mixed*		1.9	4.6	31.0	69.7	0.0	0.0	0.0	0.0	0.0	0.2	1.5	1.5	1.0	0.0	0.0	0.0	0.0	0.0
	TOTAL			146	288	499	351	283	283	259	149	137	1.27	0.91	0.77	0.93	1.03	1.25	1.52	1.97	1.48

[1)] Include all species from the genera "Deania" identified as "sapatas" on the landings (*D. profundorum* , *D. calceus* and *Deania sp* .)

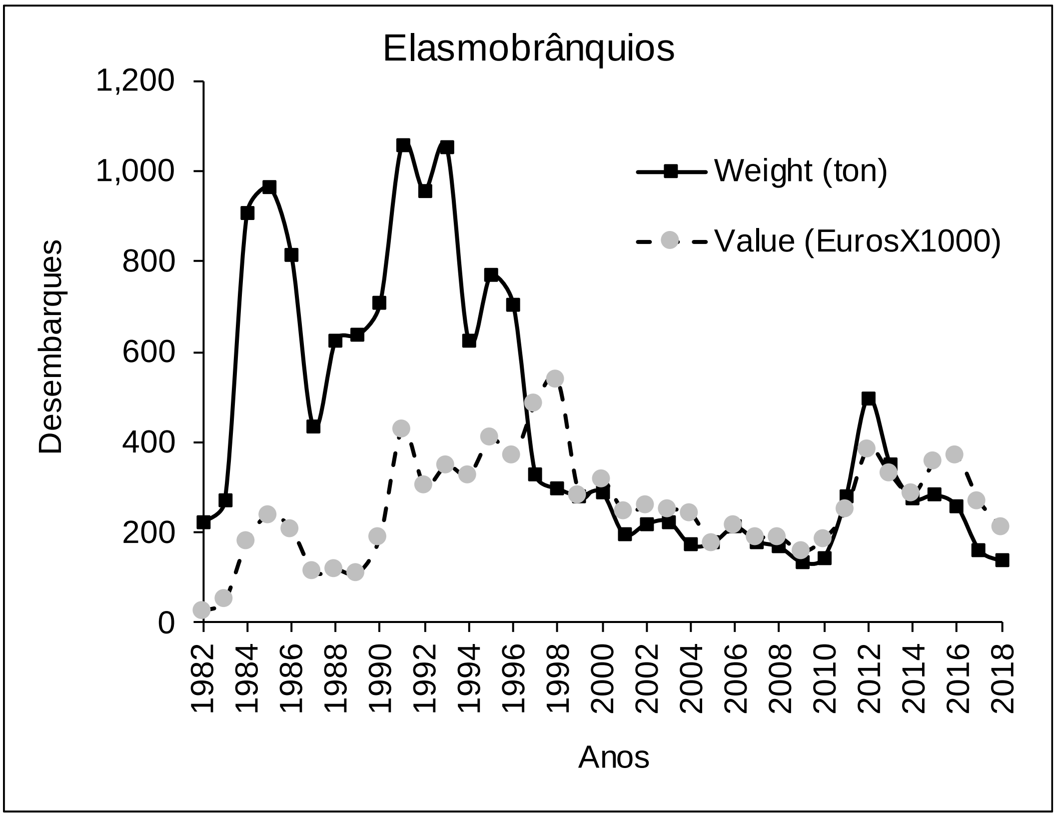

Figure 1. Total landings of elasmobranchs on the Azorean auctions for the period 1982-2017.

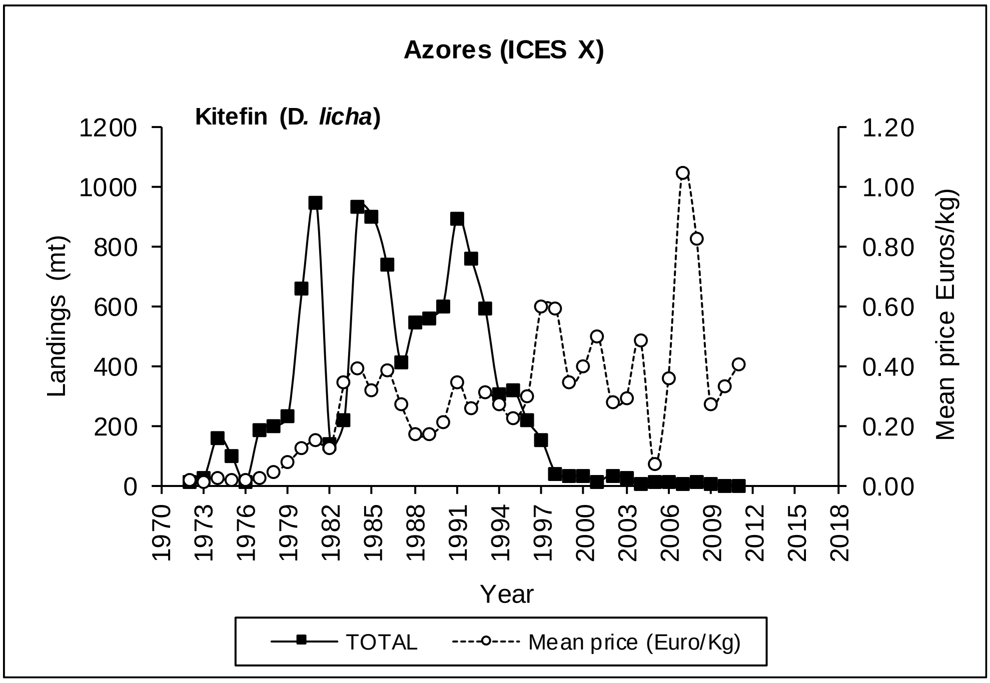

Figure 2. Historical annual landings in weight and value of *kitefin shark* (*Dalatias licha*) in the Azores (ICES 10.a).

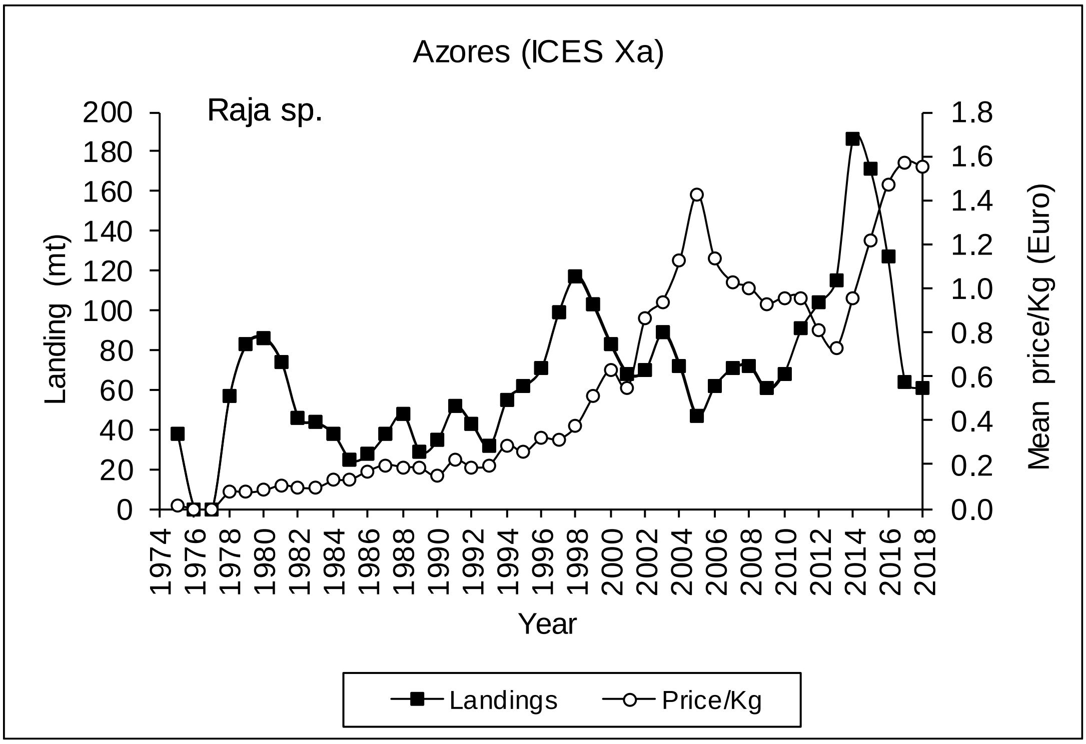

Figure 3. Annual landings in weight and value of *Rajas sp*. in the Azores.

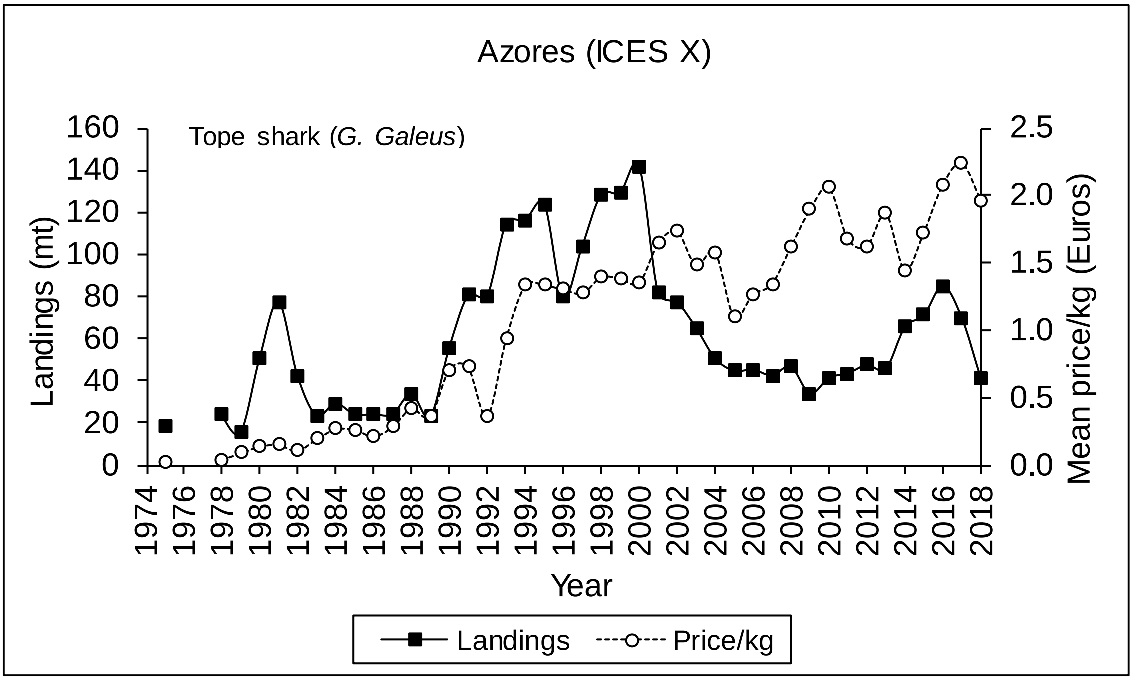

Figure 4. Annual landings in weight and value of Tope shark (*G. galeus*) from the Azores.

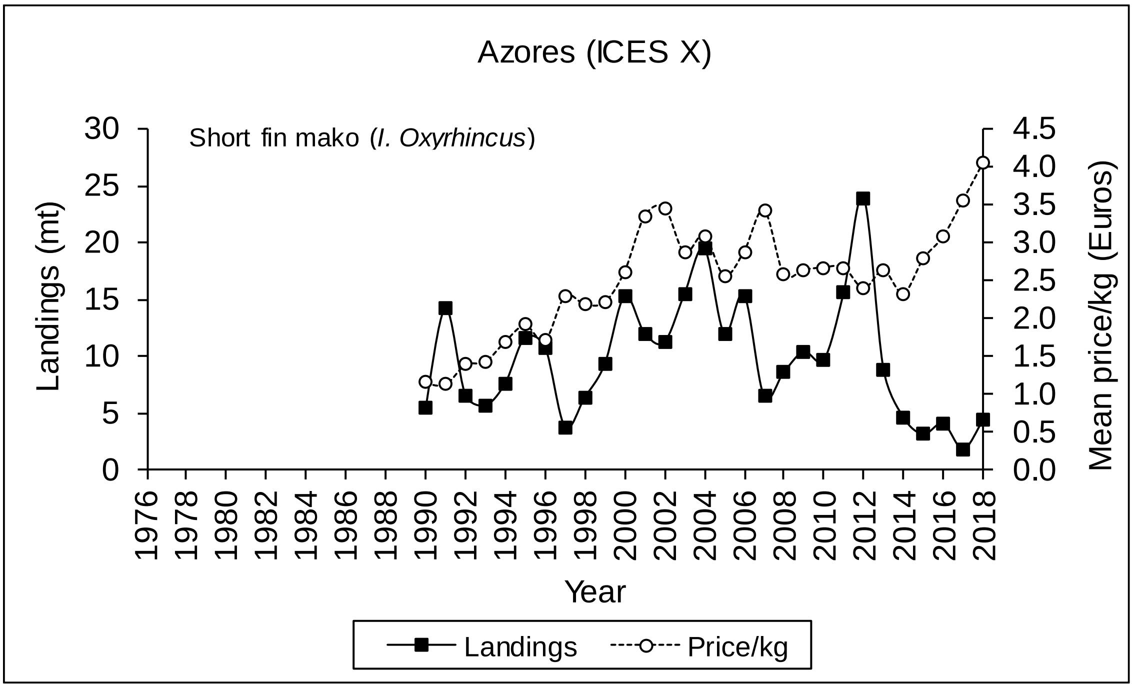

Figure 5 Annual landings in weight and value of Short fin mako (*I. oxyrhincus*) from the Azores.

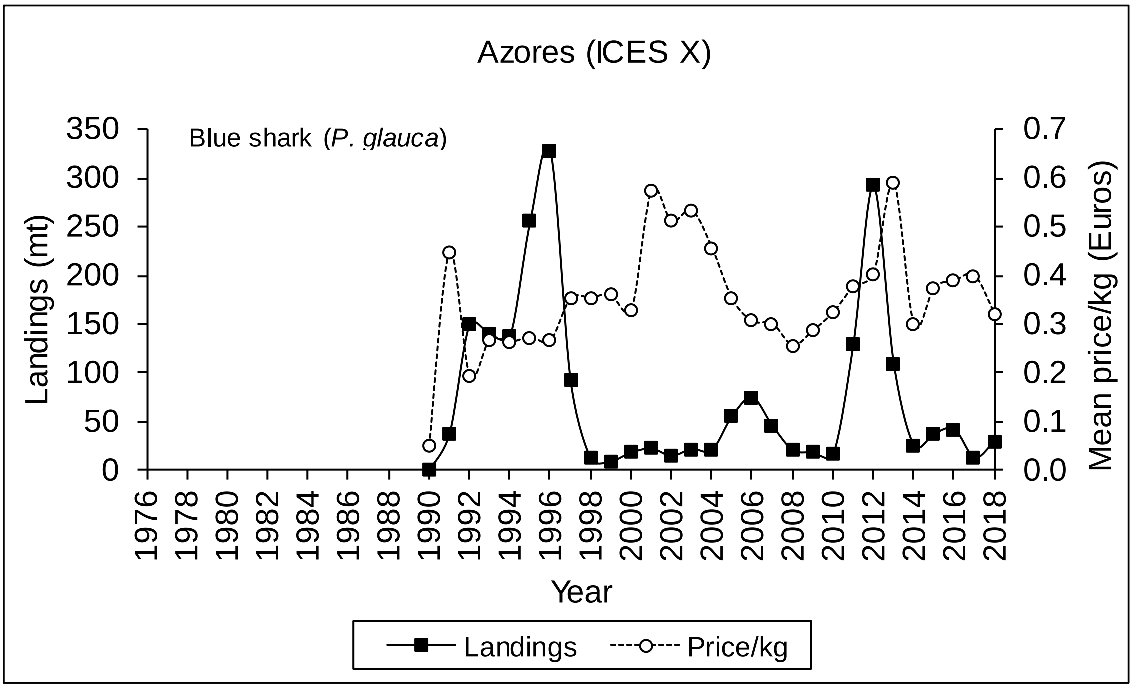

Figure 6. Annual landings in weight and value of blue shark (*P. glauca*) from the Azores.

Working Document presented to the Working Group on Elasmobranch Fishes
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Results on main elasmobranches species from 2001 to 2018 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 2018 and also updates previous documents presented. Biomass, abundance, distribution and length frequency 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 intermedius* (common skate), *Leucoraja circularis* (sandy ray) and *Leucoraja naevus* (cuckoo ray). The abundance of *G. melastomus*, and *D. cf. flossada* reached the highest value of the time series in 2018. Biomass index of *S. ringens*, *S. canicula*, *L. naevus* and *D. intermedius* increased slightly, while the rest of the species decreased or remained similar to the previous year. Some other scarce elasmobranchs such as *Squalus acanthias*, *Raja clavata* and *Raja montagui* were 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, 2017).

The aim of this working document is to update the results (abundance indices, length frequency and geographic distributions) of the most common elasmobranch species on Porcupine bottom trawl surveys, after the results presented previously (Ruiz-Pico *et al.* 2014; Fernández-Zapico *et al.* 2015; Ruiz-Pico *et al.* 2016; Fernández-Zapico *et al.* 2017; Ruiz-Pico *et al.* 2018). 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 intermedius* (common skate).

Material and methods

The Spanish Ground Fish Survey on the Porcupine bank (SP-PORC-Q3) has been annually carried out since 2001 onboard the R/V *Vizconde de Eza*, a stern trawler of 53 m and 1800 Kw. The area covered extends from longitude 12° W to 15° W and from latitude 51° N to 54° N (Figure 1), following the standard IBTS methodology for the western and southern areas (ICES, 2017). 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) (Figure 2). 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. More details on the survey design and methodology are presented 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 tow duration (20 instead of 30 minutes) applied since 2016 worked successfully. Now the catches have been reduced and are easier to handle for the team who sort it, but they are still abundant enough to be representative samples. The biomass indices of the entire 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 up the time series.

Results and discussion

In 2018, 80 standard hauls and 3 additional hauls were carried out (Figure 2).

The total mean catch per haul decreased slightly the last year (Figure 3). Fish represented about 93% of the total stratified catch and the elasmobranchs considered constituted the 8% of that total fish catch, with the following percentages per species: *Galeus melastomus* (77%), *Deania calcea* (6.6%), *Scymnodon ringens* (4.7%), *Scyliorhinus canicula* (4.7%), *Etmopterus spinax* (1.4%), *Hexanchus griseus* (0.6%), *Dalatias licha* (0.2%) and *Squalus acanthias* (0.1%). The skate and rays species were: *Leucoraja naevus* (0.6%), *Leucoraja circularis* (0.8%), *Raja montagui* (0.08%), *Raja clavata* (0.01%), *Dipturus nidarosiensis* (1.5%), *Dipturus cf. flossada* (1.4%) and *Dipturus intermedius* (0.09%).

In 2018, the biomass of *G. melastomus*, *S. ringens*, *L. naevus* and *D. cf flossada* increased, *S. canicula* and *E. spinax* remained similar to the previous year and *Deania* spp., *H. griseus*, *L. circularis* and *D. nidarosiensis* decreased. Only a few specimens of *D. licha*, *S. acanthias*, *D. intermedius*, *R. clavata* and *R. montagui* were found. Regarding recruitment, small specimens remained low in general, except for *D. cf flossada*, with the most remarkable peak in abundance of small/juveniles specimens in the time series and for *E. spinax* with a slight rise of juveniles.

***Galeus melastomus* (blackmouth catshark)**

The biomass and abundance of *G. melastomus* increased this last year, reaching the highest value of the time series (Figure 4). Although in 2017 there was a decrease, values have been high since 2012, when a remarkable rise was found (Figure 5).

The species was distributed in the southern deepest area, similarly to the previous year but with larger spots of biomass (Figure 6).

Blackmouth catshark length distribution ranged from 10 cm to 78 cm. The usual three modes were not clearly shown in this last survey. The remarkable increase in biomass is reflected in more specimens by size in general, specifically specimens around 28 cm, from 34 to 45 cm, around 51 cm and around 64 cm (Figure 7). However, small specimens (<20 cm) remained low.

***Deania calcea* (birdbeak dogfish) and *Deania profundorum* (arrowhead dogfish)**

Although *D. profundorum* was rather scarcer than *D. calcea* in the area, it has been found every survey since *D. profundorum* was first identified in 2012.

The biomass and abundance of *Deania spp.* (mainly *D. calcea*) have followed a downward trend since 2016, further decreasing this last survey (Figure 8 and Figure 9). The biomass and abundance of *D. profundorum* were negligible (Figure 10).

The specimens of *D. calcea* were distributed in the southern and western deepest strata of the study area this last survey (Figure 11) and ranged from 67 cm to 112 cm, most of them from 83 to 92 cm (Figure 12). Only two specimens of *D. profundorum* of 34 and 67 cm were found in one haul in the west and another in the south. The usual spot of biomass for both species in the north was not found.

***Scymnodon ringens* (knifetooth dogfish)**

The biomass and abundance of *S. ringens* have followed an up and down trend since 2012. In the last survey, the values increased after the decrease of the previous year (Figure 13). Even so, the mean biomass of the last two years remained lower than the previous five years (Figure 14).

As usual *S. ringens* was mainly found in the deepest strata in the southeast of the study area, although two spots of biomass were also shown in the west (Figure 15).

The length distribution of *S. ringens* remained similar to the previous years, with specimens from 34 cm to 77 cm and seven large specimens from 93 cm to 112 cm. Specimens around 75 cm, the usual mode throughout the time series, remained low in this last survey (Figure 16).

***Scyliorhinus canicula* (lesser spotted dogfish)**

The biomass and abundance of *S. canicula* increased this last survey, reaching the third highest value of the time series (Figure 17). The rise in abundance was slightly higher than in biomass due to the increase of juveniles this last survey. The mean biomass of the last two years was very similar to the previous five years (Figure 18).

The geographical distribution of *S. canicula* remained similar to the previous year, around the bank and on the Irish shelf (Figure 19).

Signs of recruits (around 20 cm) were found in 2016 but were not in 2017 or in 2018. However, this last survey, juveniles from 30 to 50 cm were more abundant than previous year. The usual mode of adults around 62 cm was also found (Figure 20).

***Etmopterus spinax* (velvet belly)**

The biomass and abundance of *E. spinax* remained low in the last survey since the peak in 2016 (Figure 21). The mean biomass of the last two years was lower than the previous five years (Figure 22). A small rise in abundance was shown due to the slight increase of juveniles.

The specimens of *E. spinax* were mainly found southeast of the bank, as usual. There were also a few spots of biomass in the deepest west strata of the study area and one in the north of the bank (Figure 23).

The length distribution of *E. spinax* showed more abundance of specimens around 23 cm than previous years and fewer large specimens (> 41 cm) and recruits (around 14 cm) (Figure 24).

***Hexanchus griseus* (bluntnose sixgill shark)**

The biomass and abundance of this scarce shark have further decreased in 2018 (Figure 25). The mean biomass of the last two years was far below the value of the five previous years (Figure 26).

The geographical distribution remained without an unclear pattern, some specimens north of the bank, some southeast of the bank and some in the deepest south of the study area (Figure 27).

A total of eight specimens were found. Seven were from 63 to 98 cm and one larger of 130 cm (Figure 28).

***Dalatias licha* (kitefin shark)**

The biomass and abundance of *D. licha*, scarcer than *H. griseus*, decreased this last survey. The abundance followed the decreasing trend from 2016, whereas biomass decreased sharply after the 2017 increase (Figure 29). Only 5 specimens were found, the largest (97 cm) in the deepest west of the study area and the other from 44 to 54 cm in the deepest south and east of the study area (Figure 30 and Figure 31).

***Squalus acanthias* (picked dogfish)**

This last year, the biomass and abundance of this scarce elasmobranch *S. acanthias* decreased sharply after the peak of the previous year (Figure 32). Only two specimens of 37 cm and 89 cm were found in one haul in the shallow strata in the south of the bank (Figure 33).

***Leucoraja circularis* (sandy ray) and *Leucoraja naevus* (cuckoo ray)**

L. naevus has been slightly scarcer than *L. circularis* in the area, although in the last survey, the abundance of the former is higher and the biomass of both species was quite similar, around 0.5 kg $haul^{-1}$. The biomass and abundance of *L. naevus* slightly increased while *L. circularis* decreased following the downward trend from 2016 (Figure 34).

In 2018, as usual, the specimens of *L. naevus* were found in the shallower strata around the bank, whereas *L. circularis* was in the western area, deeper than *L. naevus* (Figure 35, Figure 36 and Figure 37).

This last survey, specimens of *L. naevus* mainly ranged from 39 to 60 cm as usual, although two small specimens of 23 and 28 cm were found. In contrast, only fourteen large specimens of *L. circularis* were found while small/juveniles were not. They ranged from 65 to 97 cm (Figure 38 and Figure 39).

***Dipturus* spp. (common skate)**

Dipturus nidarosiensis, *Dipturus cf. flossada* and *Dipturus cf. intermedia* were comparatively analysed since 2011 as in previous reports, when *D. batis* was split into *D. cf. flossada* and *D. cf. intermedia.* The three rays together as *Dipturus* spp. were also analysed.

The biomass of *Dipturus* spp. remained similar whereas abundance increased sharply (Figure 40). The mean biomass of the last two years was lower than the previous five years (Figure 41). *D. cf. flossada* and *D. intermedius* increased while *D. nidarosiensis* decreased following the downward trend of the three previous years. The most remarkable rise was the abundance of *D. cf. flossada* due to the increase of small/juvenile specimens (Figure 42).

Some spots of biomass of *Dipturus spp.* were distributed around the bank and other in the southeast of the study area (Figure 43). In particular, a total of five specimens of *D. nidarosiensis* were found in the southeastern area, 39 specimens of *D. cf. flossada* around the bank, mainly in the south, and two of *D. intermedius* in the northernmost area of the Irish shelf (Figure 44). The spots of biomass shown in the previous year, in the north of the bank and in the deepest south of the study area, were not found in this last survey. As usual, *D. cf. flossada* and *D. intermedius* were found shallower than *D. nidarosiensis* (Figure 45).

The length distribution of *D. nidarosiensis* showed a specimen of 29 cm, the smallest of the time series, and other four specimens which ranged from 116 to 153 cm (Figure 46). An increase in the abundance of small/juveniles of *D. cf. flossada* was shown, the most remarkable in the time series. Most of them were from 50 to 71 cm and a few smaller from 31 to 40 cm (Figure 47). In contrast, only two specimens of *D. intermedius* of 60 and 74 cm were shown (Figure 48).

***Raja clavata* (thornback ray) and *Raja montagui* (spotted ray)**

One specimen of *R. clavata* and three of *R. montagui* were found in the last survey. The latter had not been found since 2002, while *R. clavata* has been frequent, although scarce, in the time series (Figure 49). The specimen of *R. clavata* (44 cm) was found in the northernmost area of the Irish shelf and the three specimens of *R. montagui* (48, 55 and 60 cm) were on the Irish shelf as well, but also in the south of the bank (Figure 50).

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

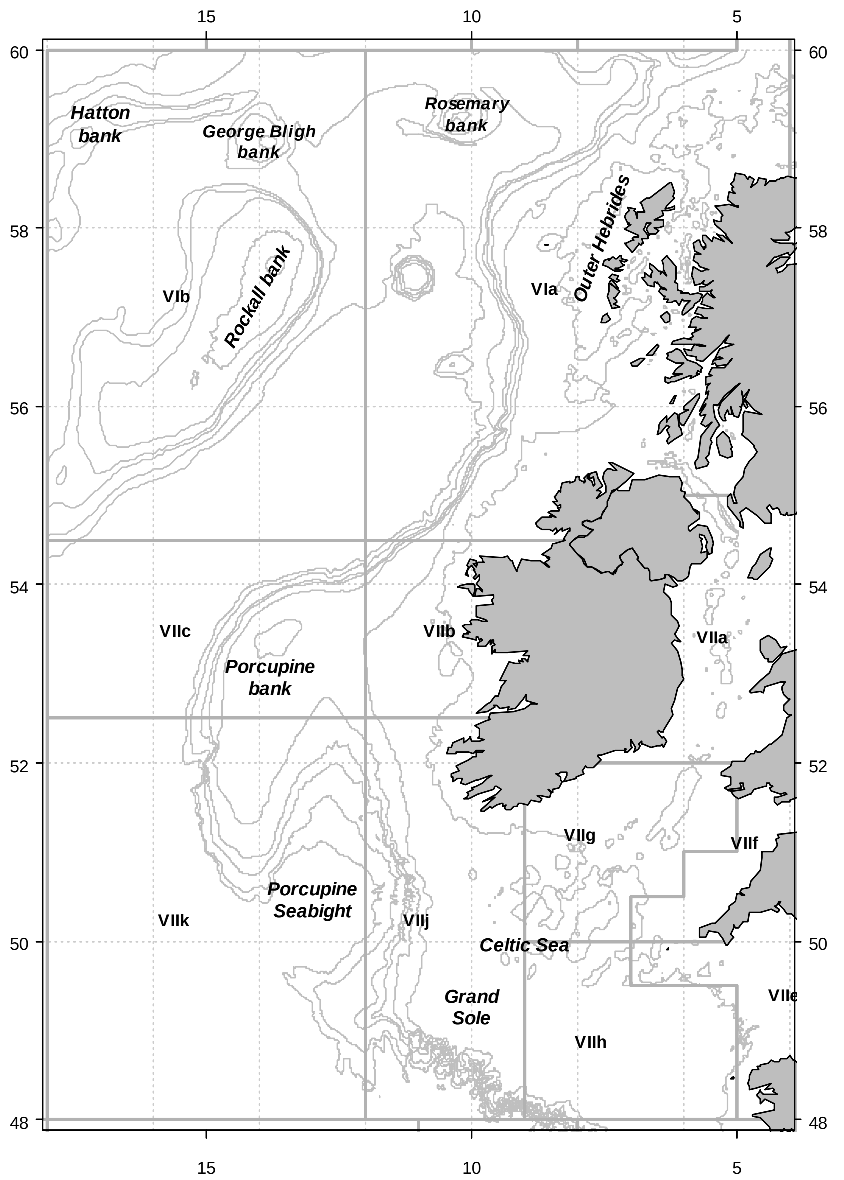


Figure 1 North eastern Atlantic showing the Porcupine bank, Porcupine Seabight, and ICES divisions

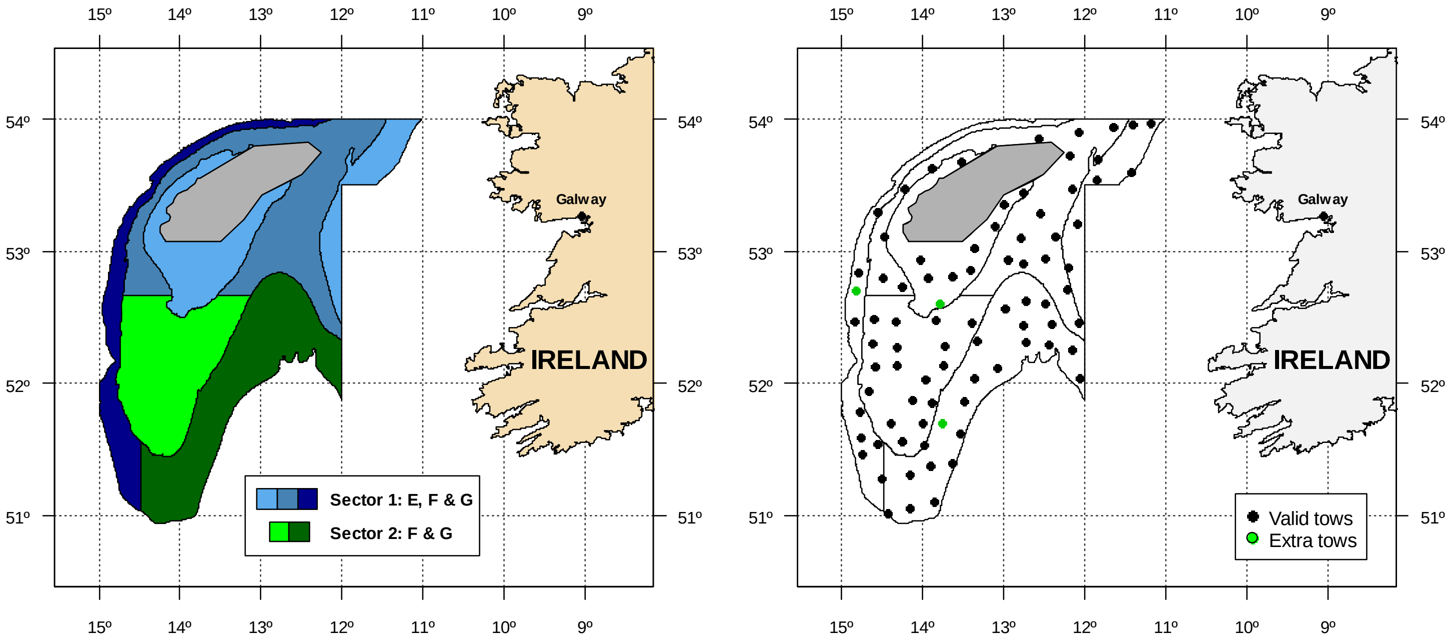


Figure 2 Left: Stratification design used in Porcupine surveys from 2003, previous data were re-stratified. Depth strata are: E) shallower than 300 m, F) 301 – 450 m and G) 451 – 800 m. Grey area in the middle of Porcupine bank corresponds to a large non-trawlable area, not considered for area measurements and stratification. Right: distribution of hauls performed in 2018

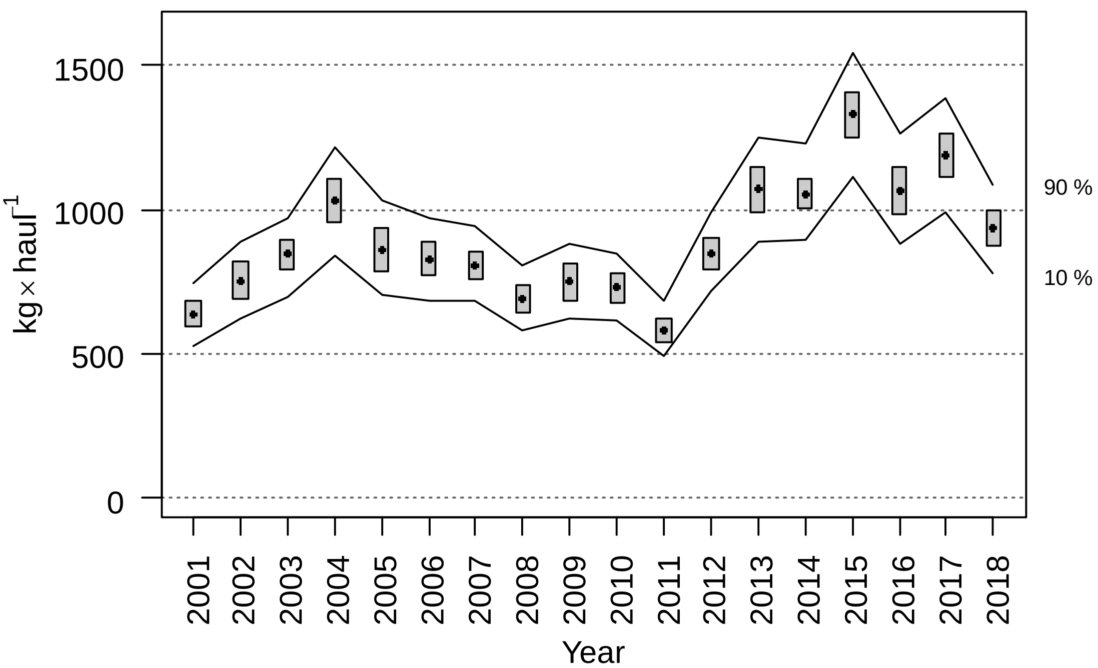


Figure 3 Evolution of the total stratified catch in Porcupine surveys (2001-2018)

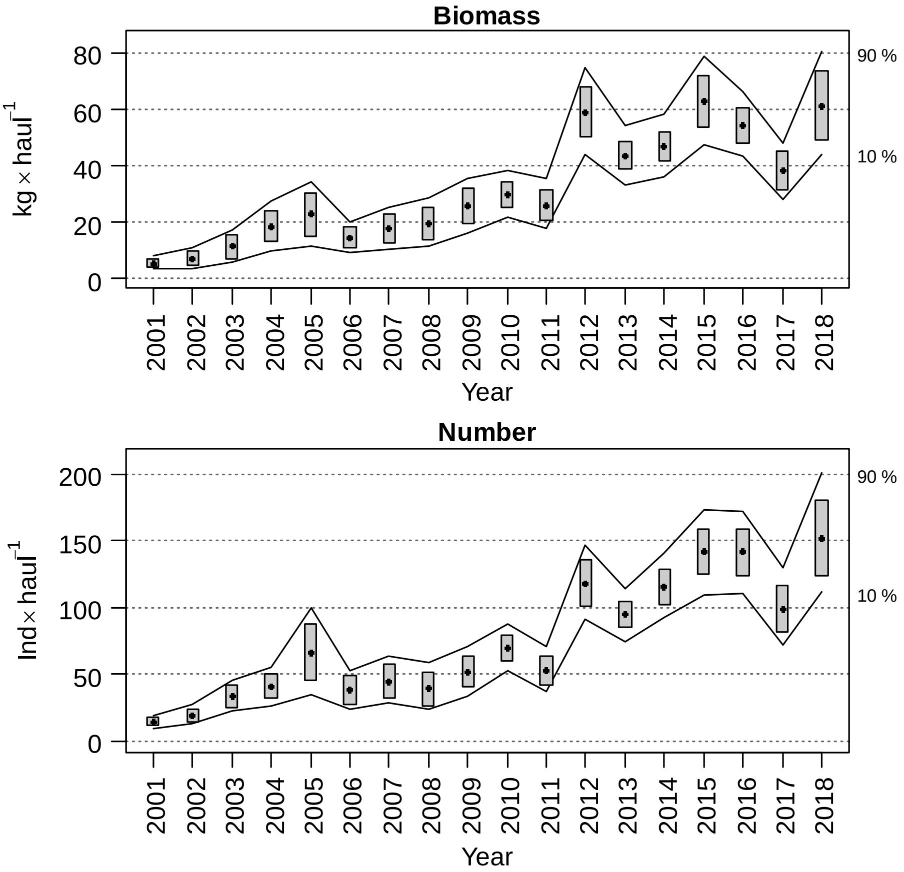


Figure 4 Evolution of *Galeus melastomus* biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

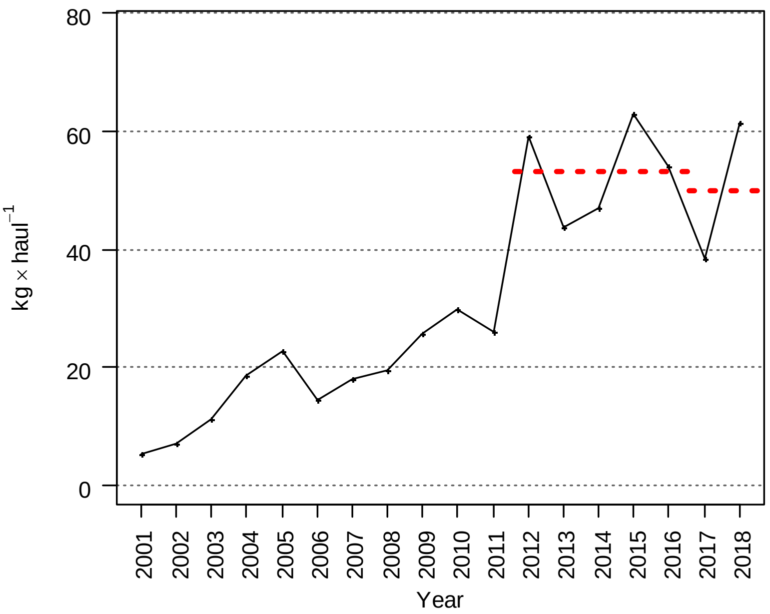


Figure 5 Evolution of *Galeus melastomus* biomass index in Porcupine surveys (2001-2018). Dotted lines compare mean stratified biomass in the last two years with the five previous years

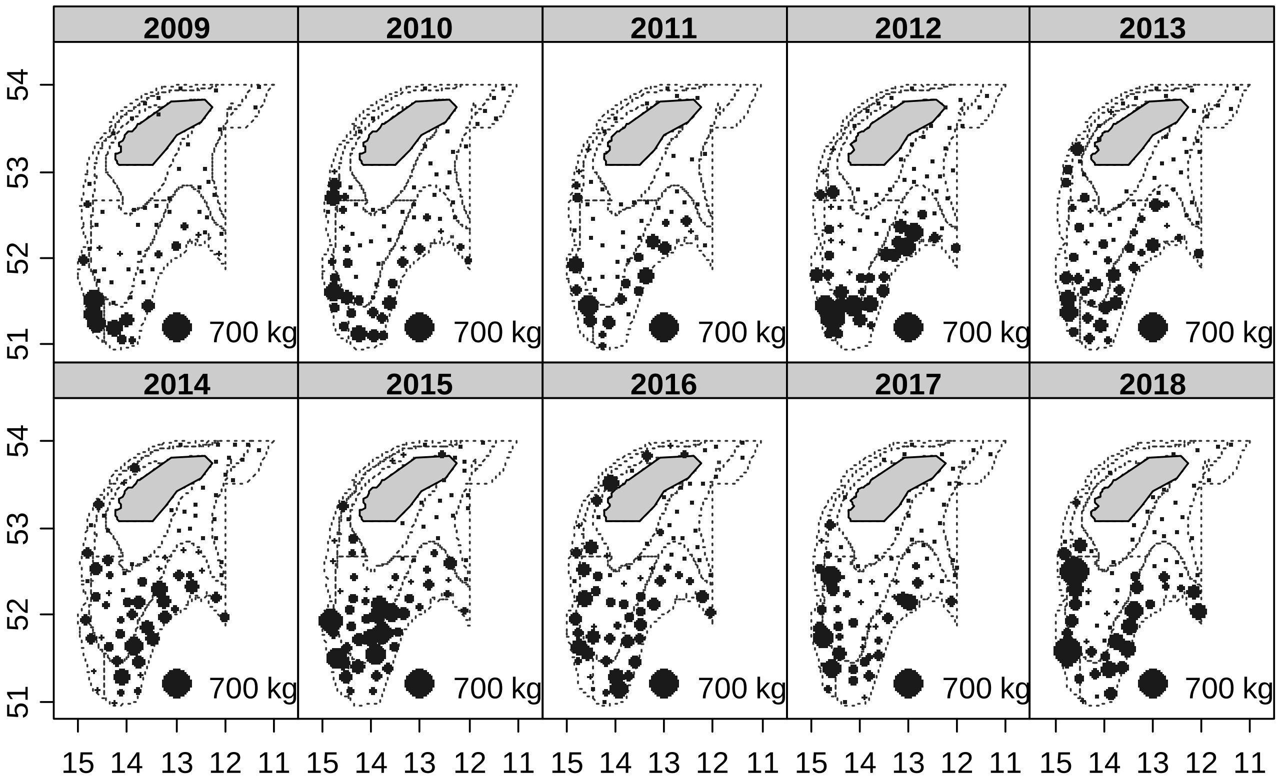


Figure 6 Geographic distribution of *Galeus melastomus* catches (kg·haul^{-1}) in Porcupine surveys (2009-2018)

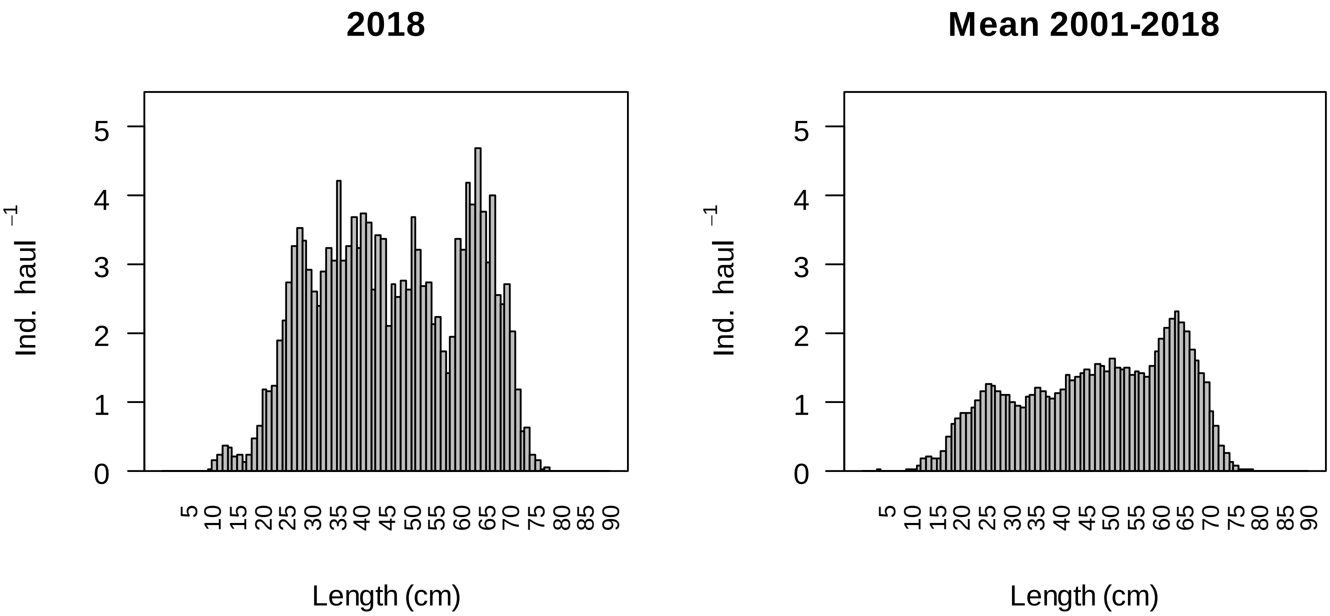


Figure 7 Stratified length distributions of *Galeus melastomus* in 2018 Porcupine survey, and mean values in Porcupine surveys (2001-2018)

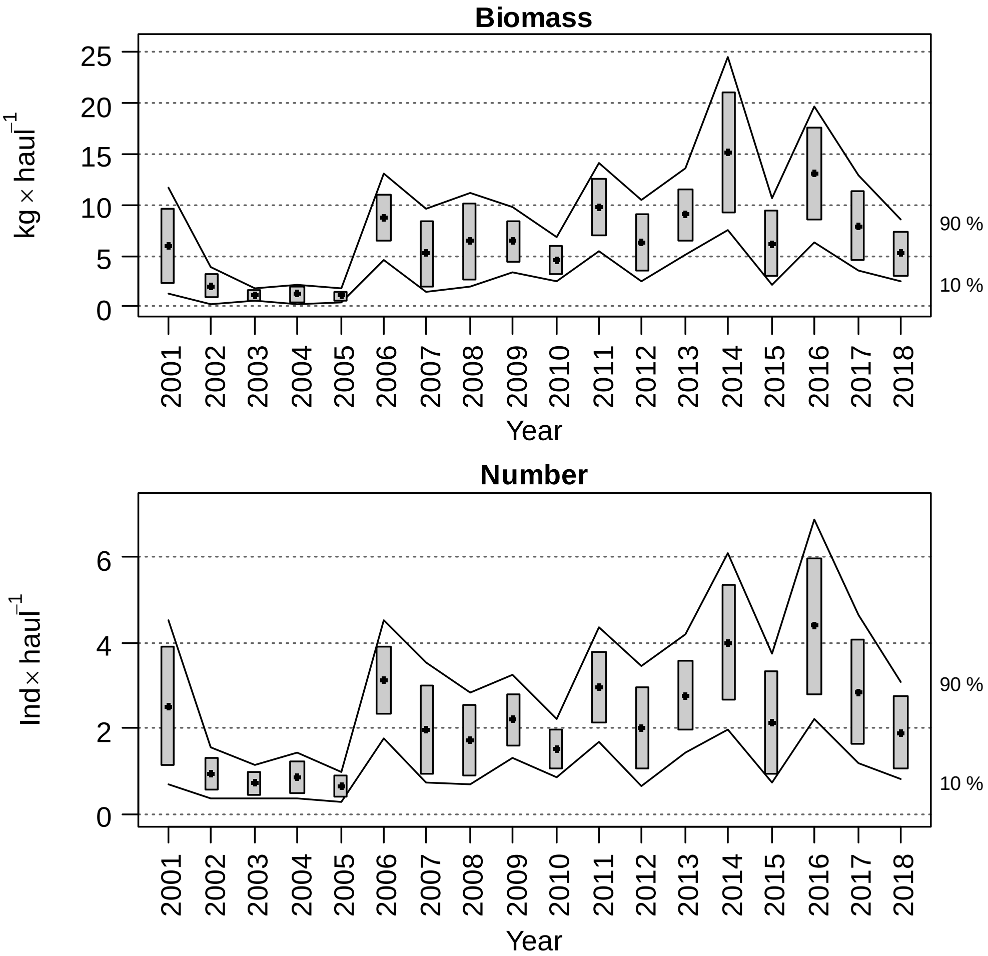


Figure 8 Evolution of *Deania* spp. (mainly *D. calcea)* biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000)

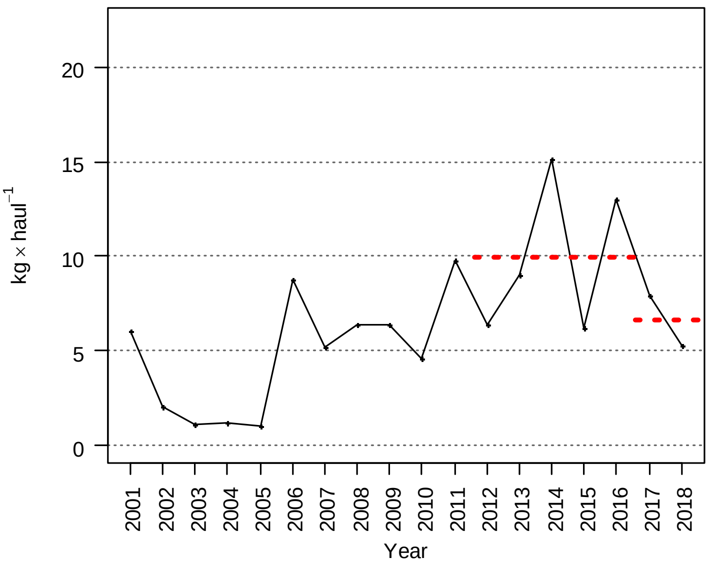


Figure 9 Evolution in *Deania* spp. (mainly *D. calcea)* biomass index in Porcupine surveys (2001-2018). Dotted lines compare mean stratified biomass in the last two years with the five previous years

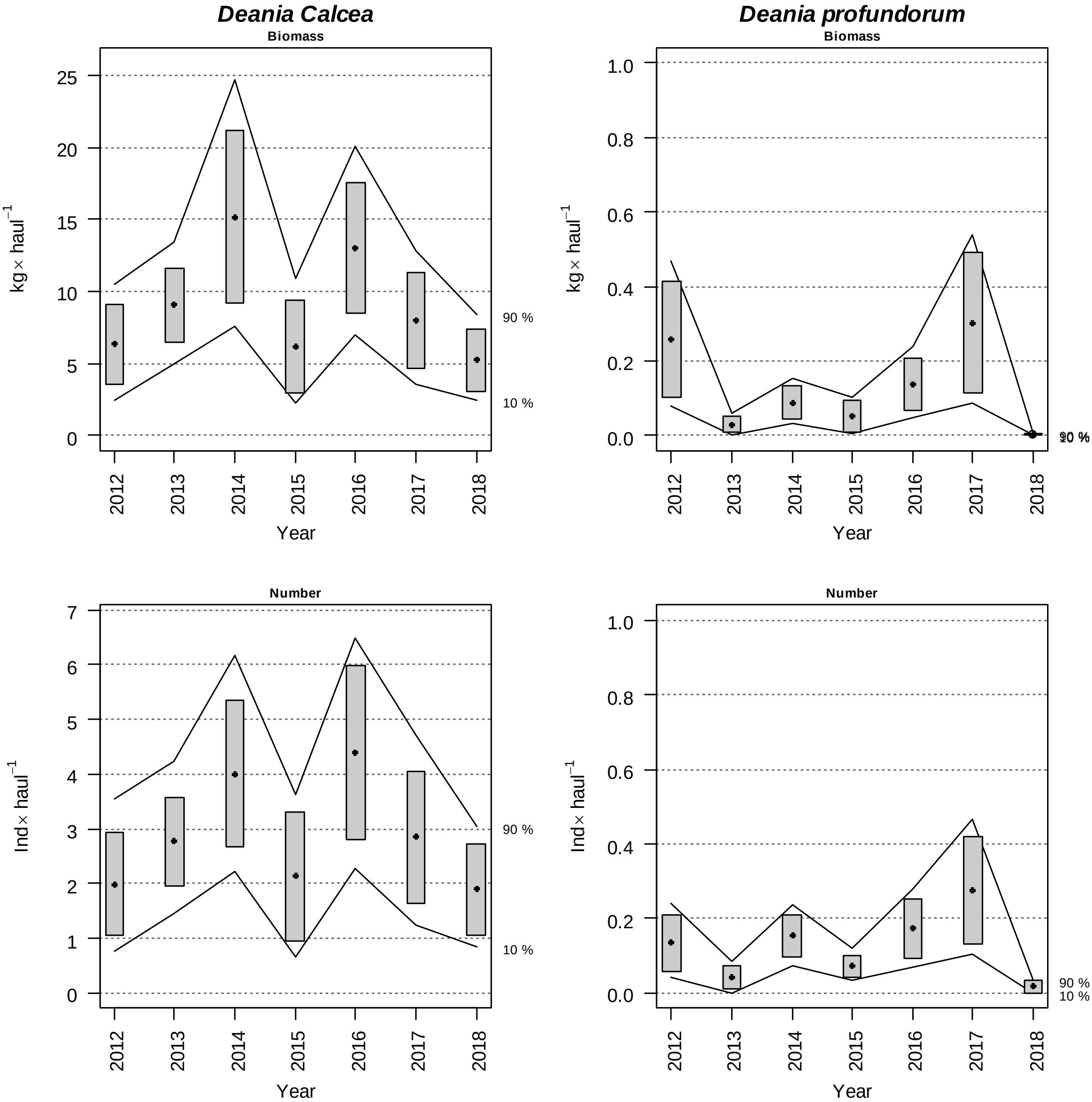


Figure 10 Evolution of *Deania calcea* and *Deania profundorum* biomass and abundance indices from 2012 and 2018 Porcupine surveys. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000)

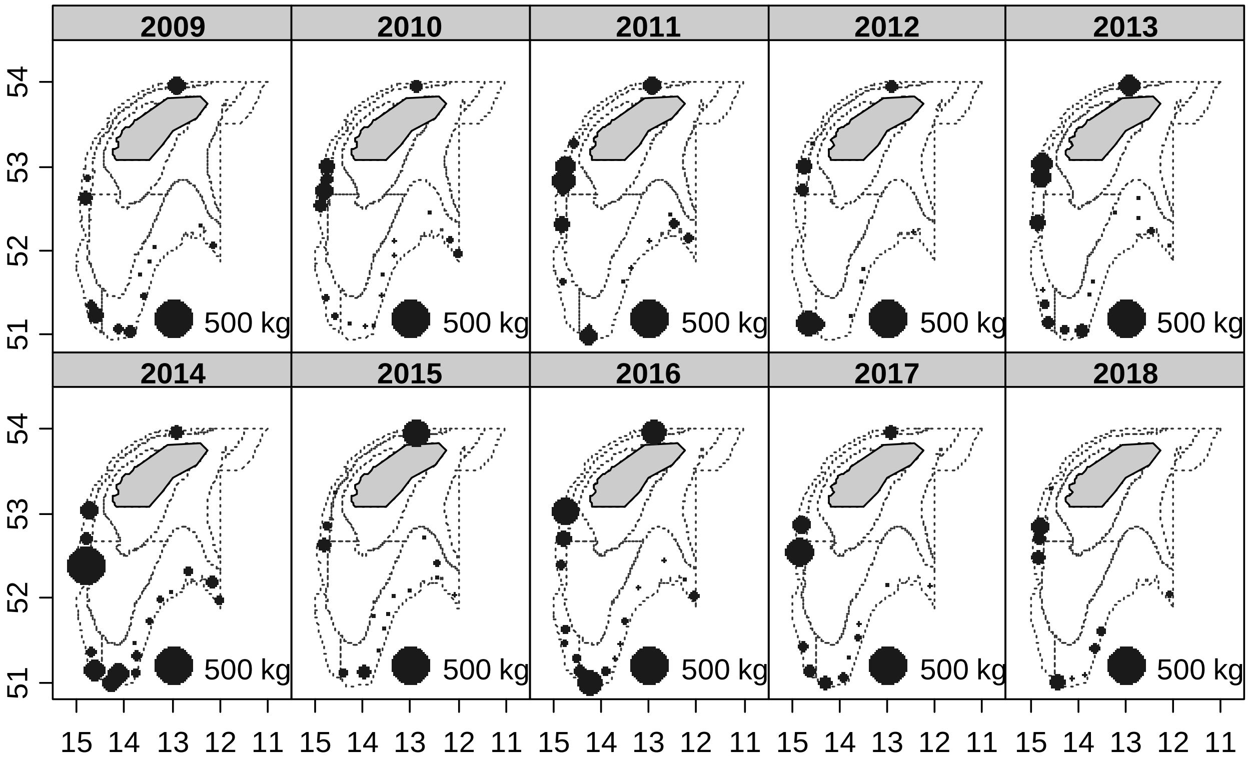


Figure 11 Geographic distribution of *Deania* spp. (mainly *D. calcea*) catches (kg·haul^{-1}) in Porcupine surveys (2009-2018)

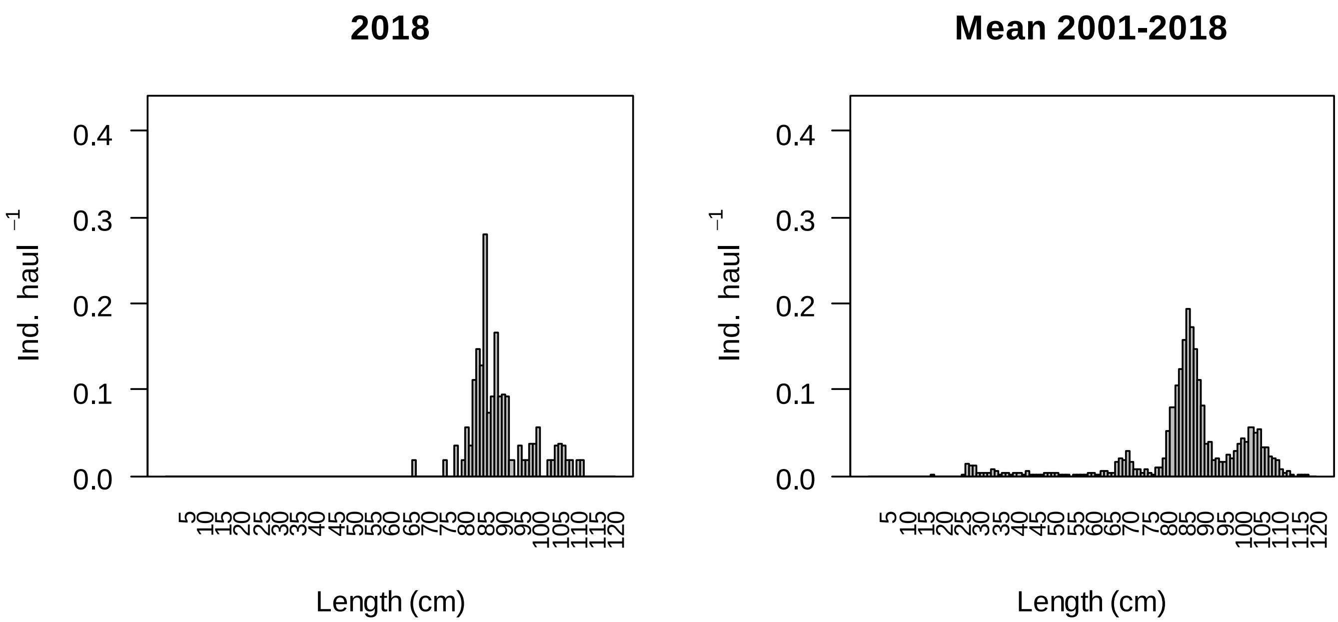


Figure 12 Stratified length distribution of *Deania calcea* in 2018 compared with mean values in Porcupine surveys (2001-2018)

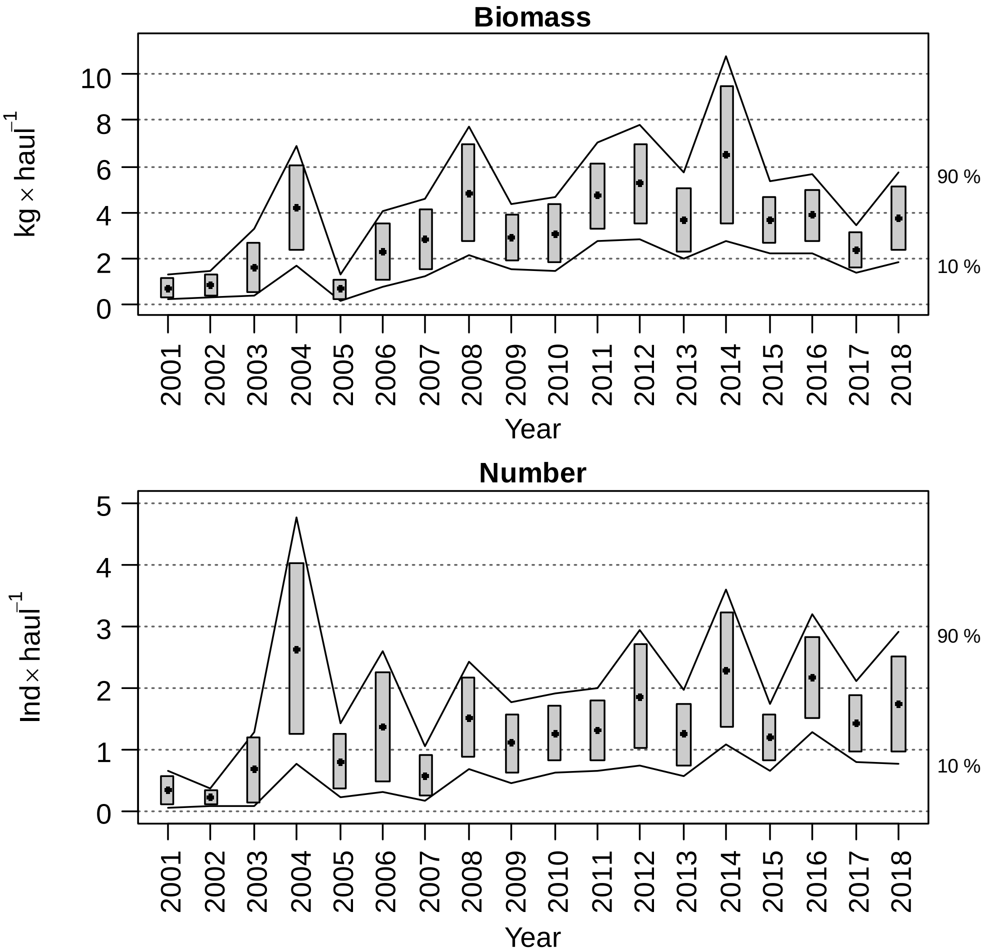


Figure 13 Evolution of *Scymnodom ringens* biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

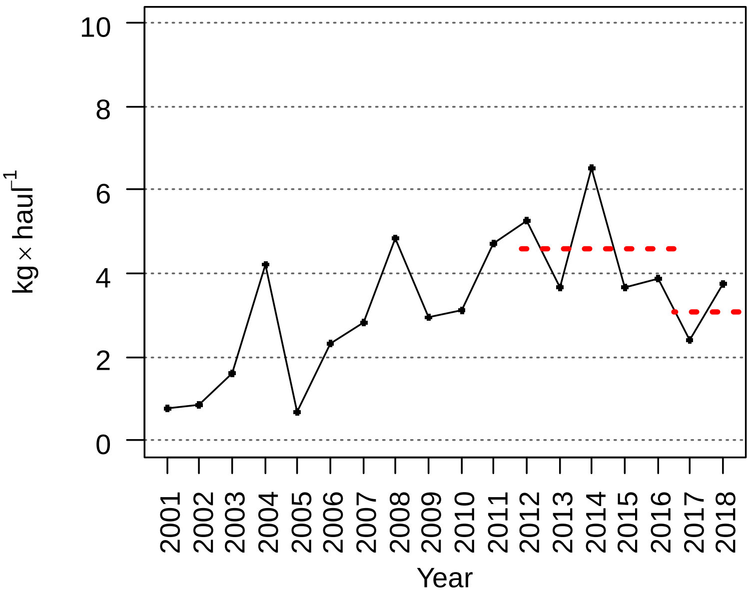


Figure 14 Evolution in *Scymnodom ringens* biomass index in Porcupine surveys (2001-2018). Dotted lines compare mean stratified biomass in the last two years with the five previous years

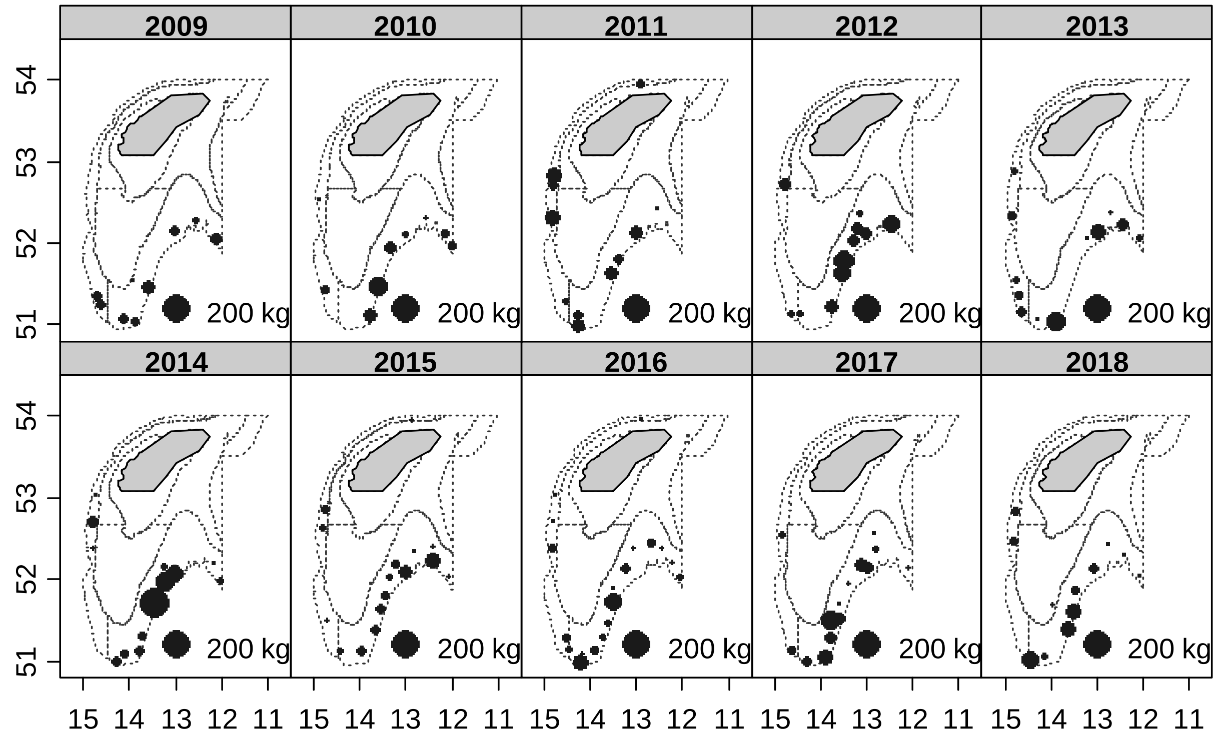


Figure 15 Geographic distribution of *Scymnodon ringens* catches (kg·haul^{-1}) in Porcupine surveys (2009-2018)

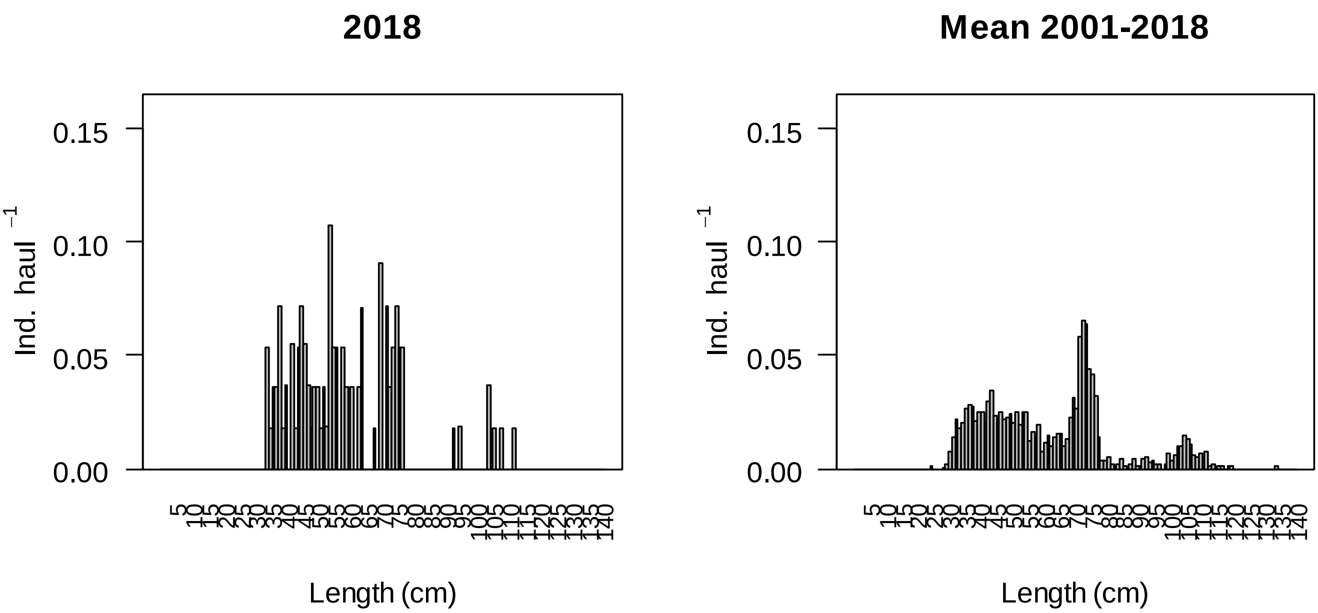


Figure 16 Stratified length distributions of *Scymnodon ringens* in 2018 in Porcupine survey, and mean values in Porcupine surveys (2001-2018)

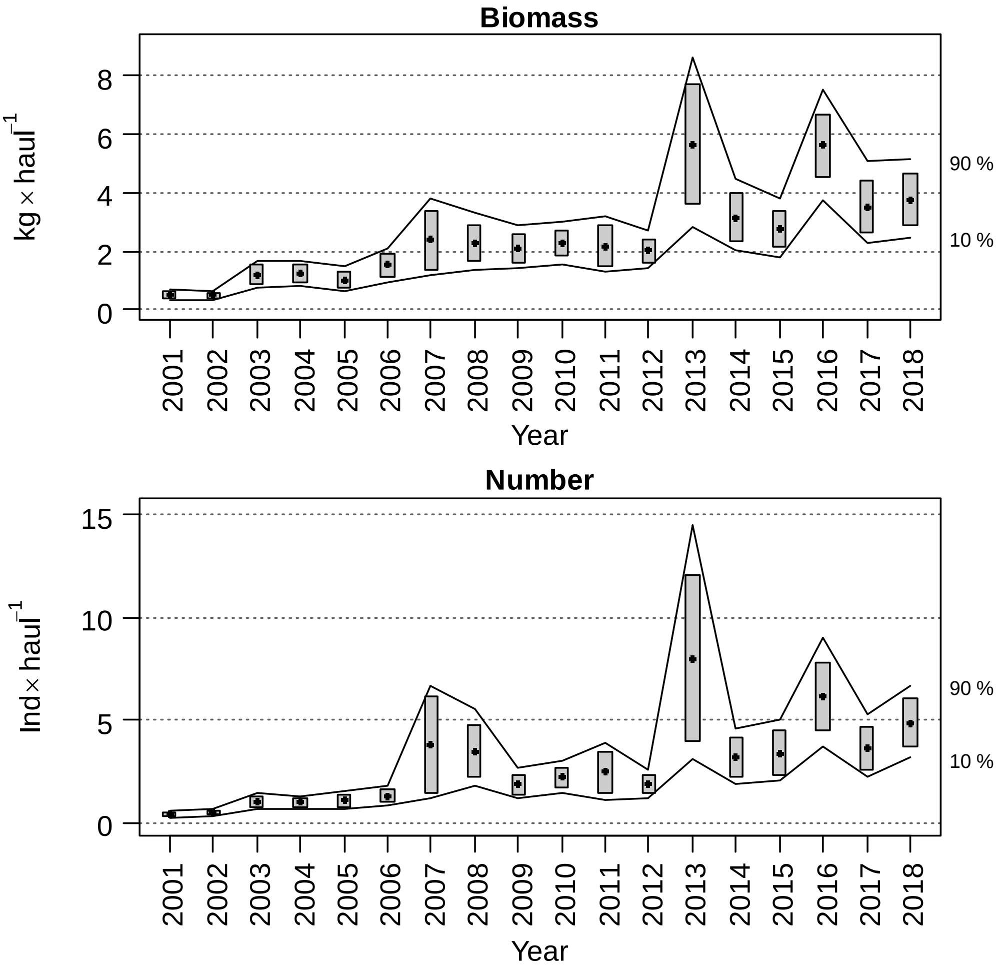


Figure 17 Evolution of *Scyliorhinus canicula* biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

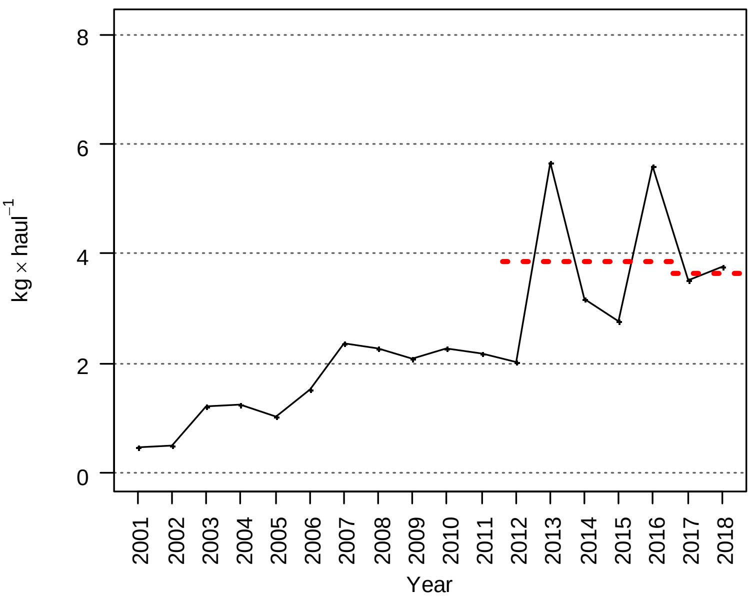


Figure 18 Evolution in *Scyliorhinus canicula* biomass index in Porcupine surveys (2001-2018). Dotted lines compare mean stratified biomass in the last two years with the five previous years

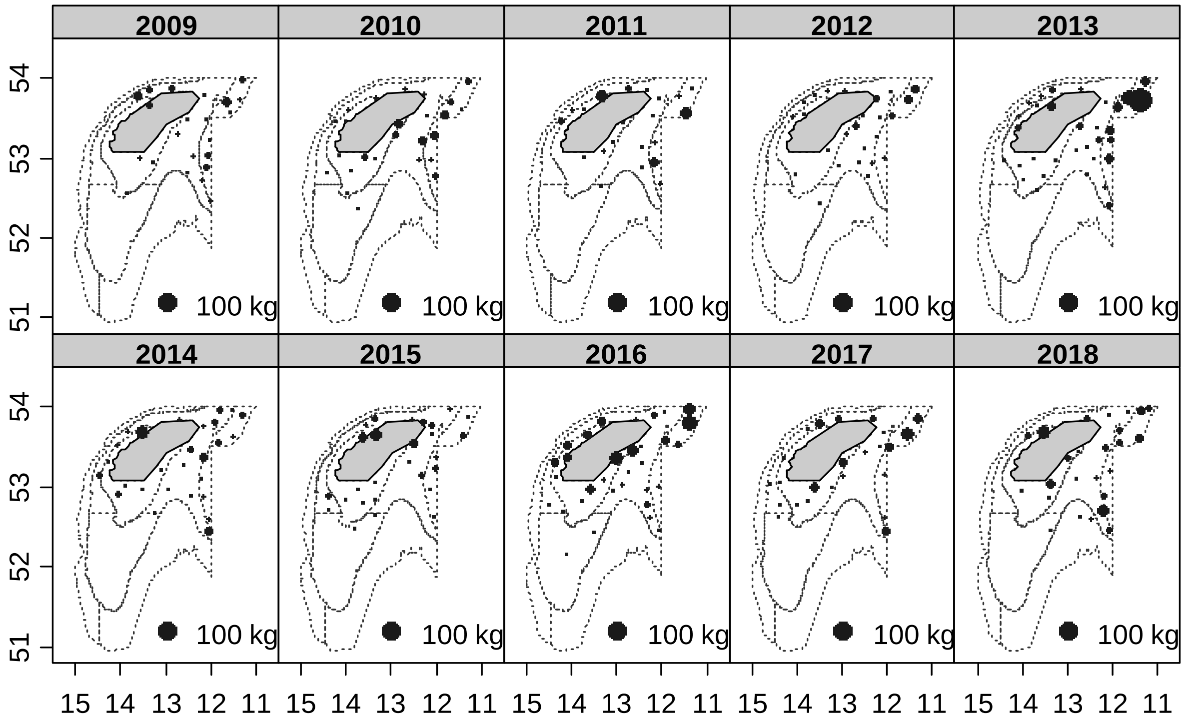


Figure 19 Geographic distribution of *Scyliorhinus canicula* catches (kg·haul^{-1}) in Porcupine surveys (2009-2018)

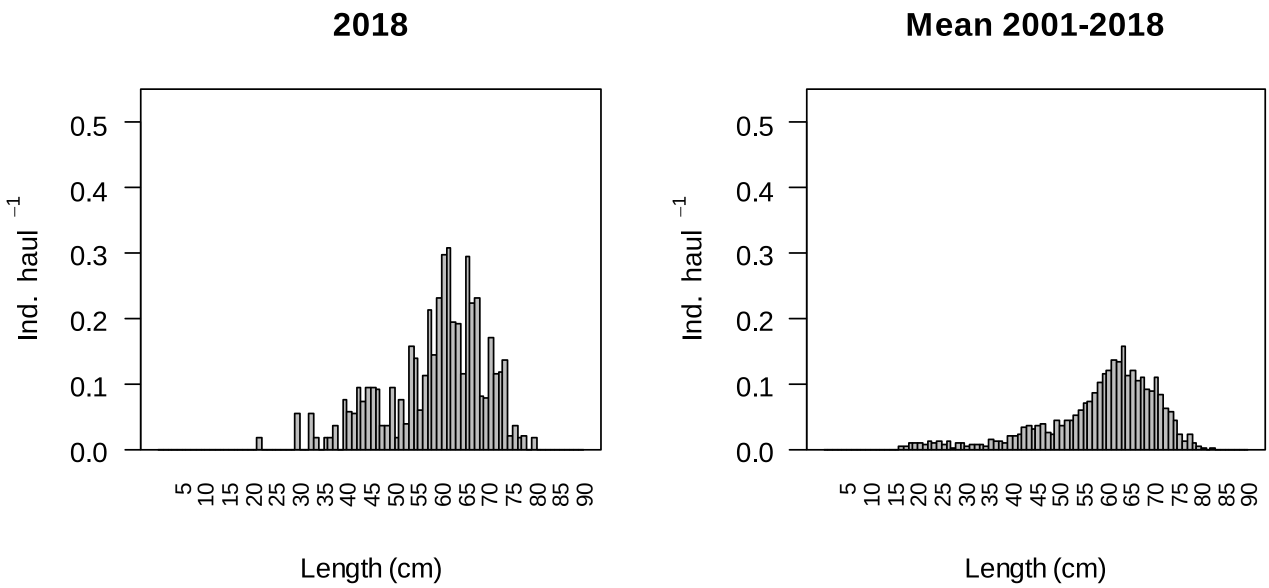


Figure 20 Stratified length distribution of *Scyliorhinus canicula* in 2018 in Porcupine survey, and mean values in Porcupine surveys (2001-2018)

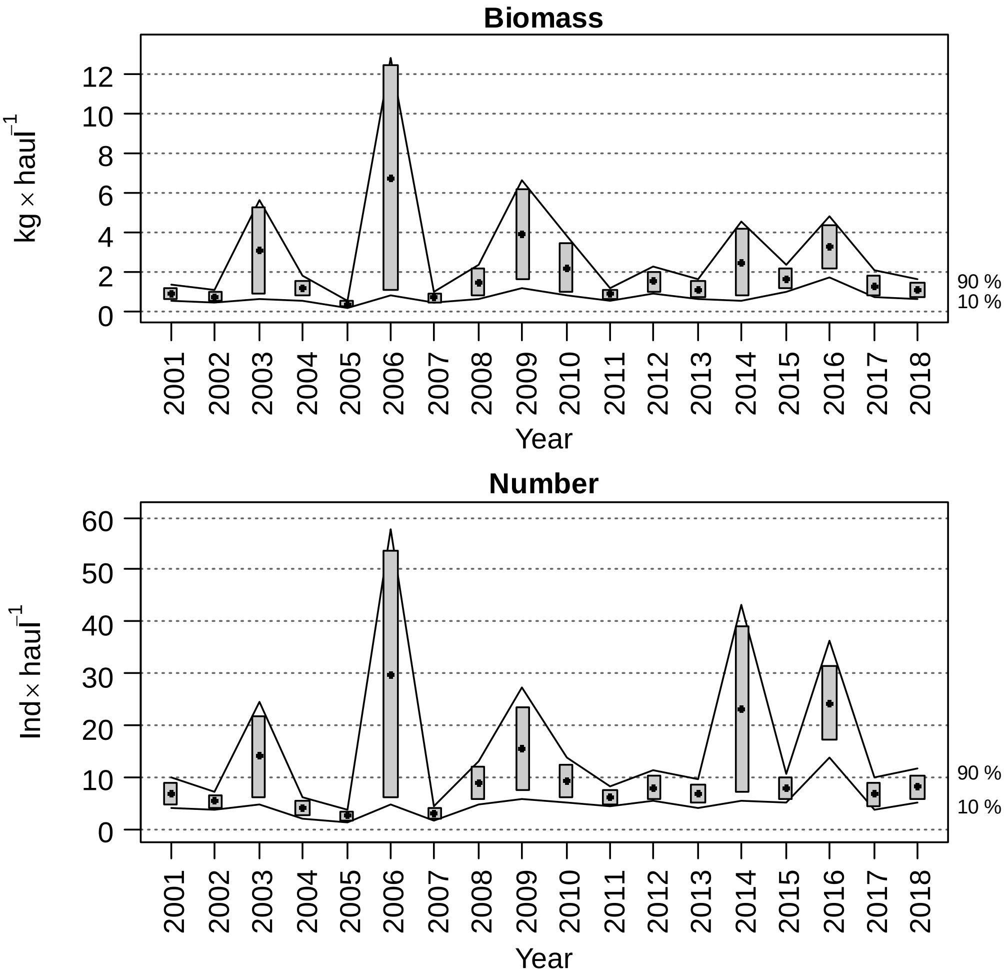


Figure 21 Evolution of *Etmopterus spinax* biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

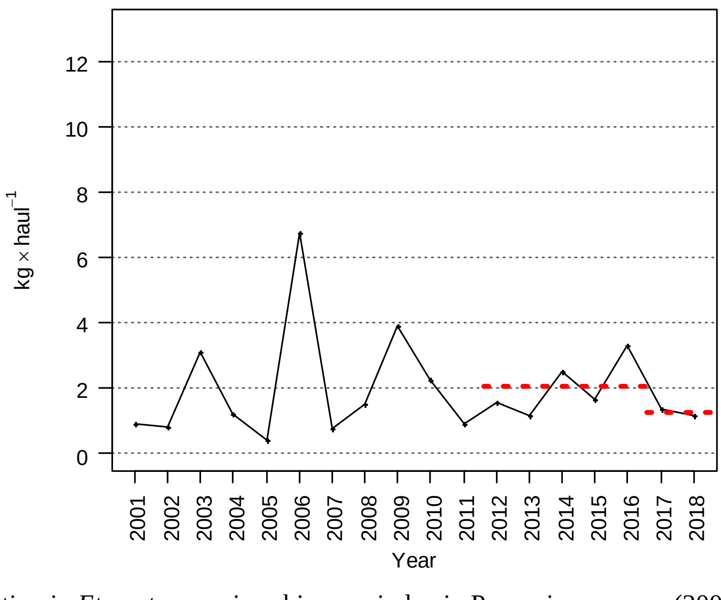


Figure 22 Evolution in *Etmopterus spinax* biomass index in Porcupine surveys (2001-2018). Dotted lines compare mean stratified biomass in the last two years with the five previous years

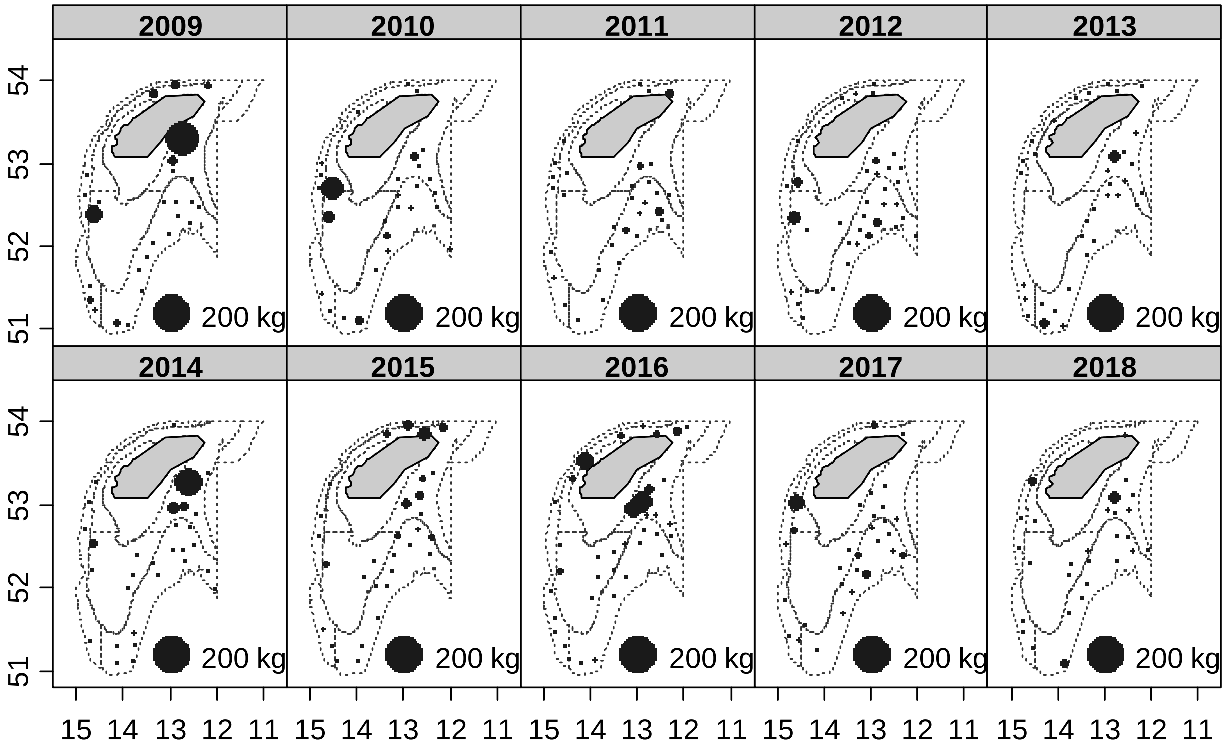


Figure 23 Geographic distribution of *Etmopterus spinax* catches (kg·haul^{-1}) in Porcupine surveys (2009-2018)

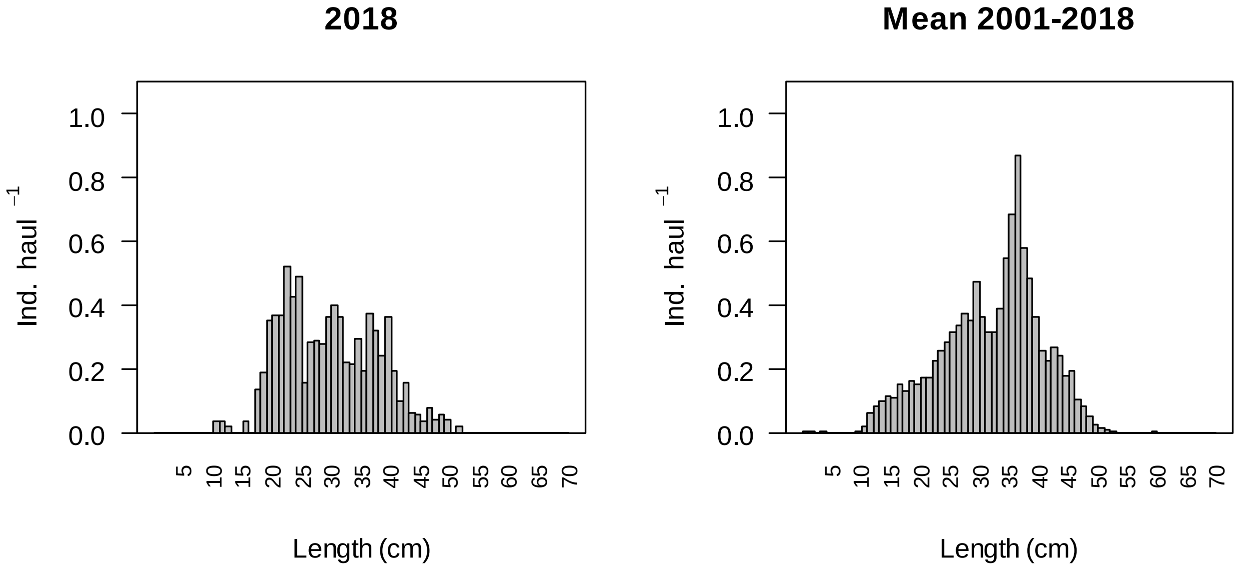


Figure 24 Stratified length distribution of *Etmopterus spinax* in 2018 in Porcupine survey, and mean values in Porcupine surveys (2001-2018)

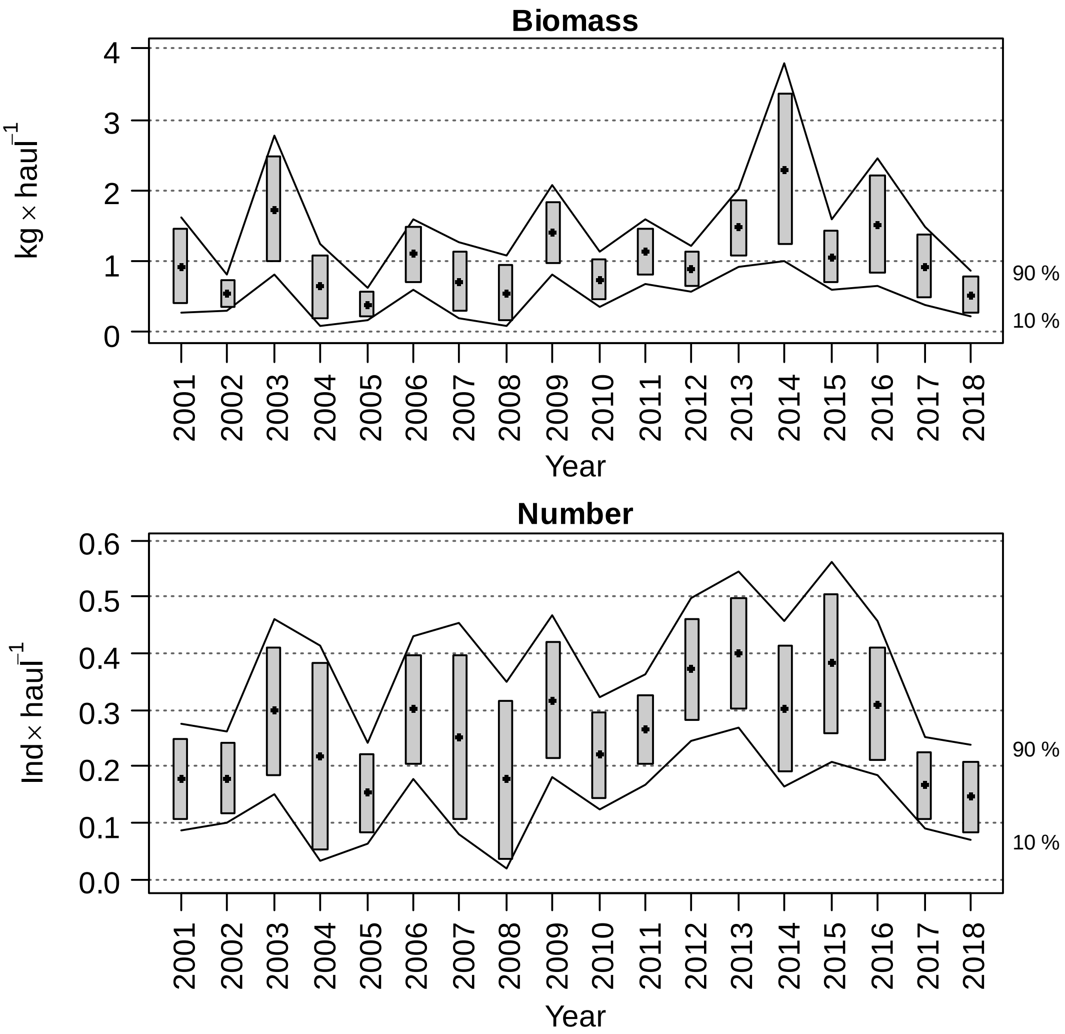


Figure 25 Evolution of *Hexanchus griseus* biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

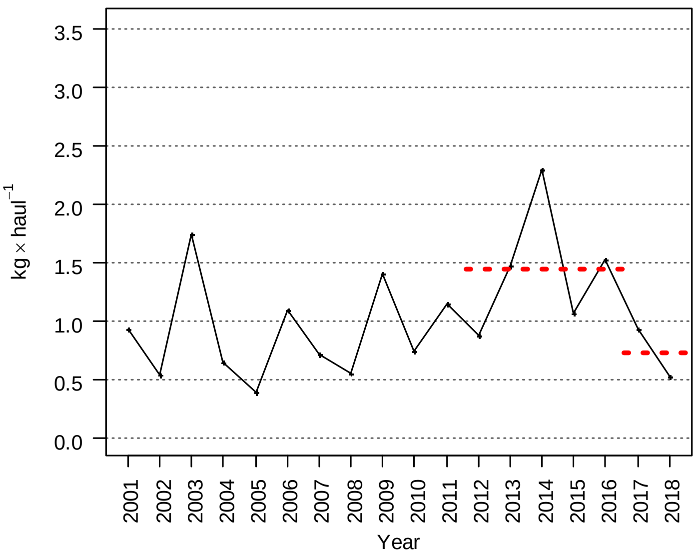


Figure 26 Evolution in *Hexanchus griseus* biomass index in Porcupine surveys (2001-2018). Dotted lines compare mean stratified biomass in the last two years with the five previous years

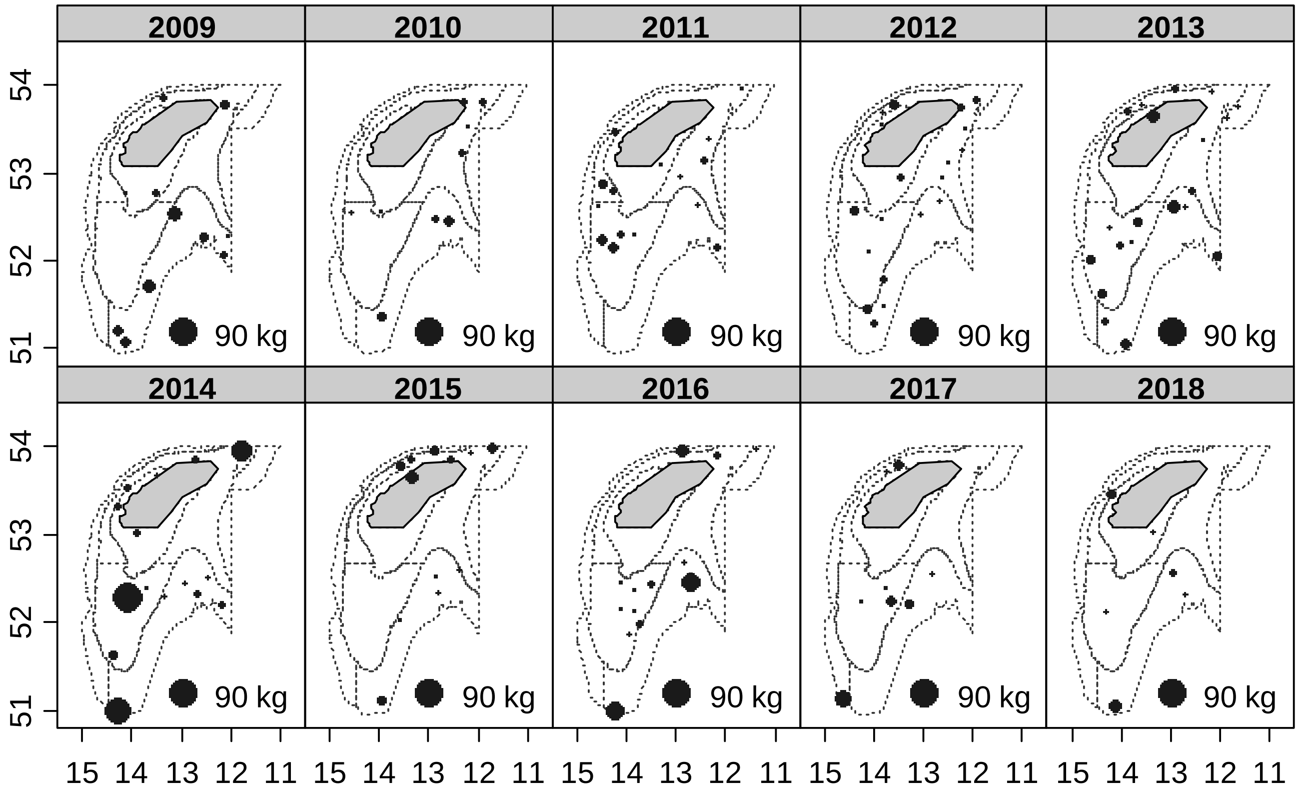


Figure 27 Geographic distribution of *Hexanchus griseus* catches (kg×30 min haul^{-1}) in Porcupine surveys (2009-2018)

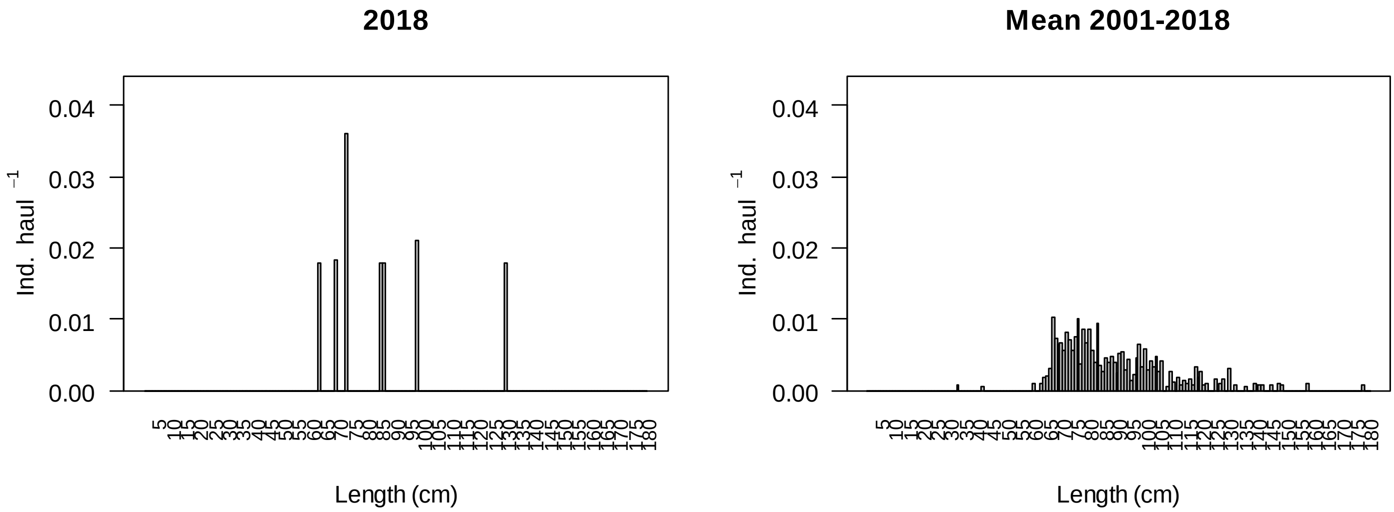


Figure 28 Stratified length distribution of *Hexanchus griseus* in 2018 Porcupine survey, and mean values in Porcupine surveys (2001-2018)

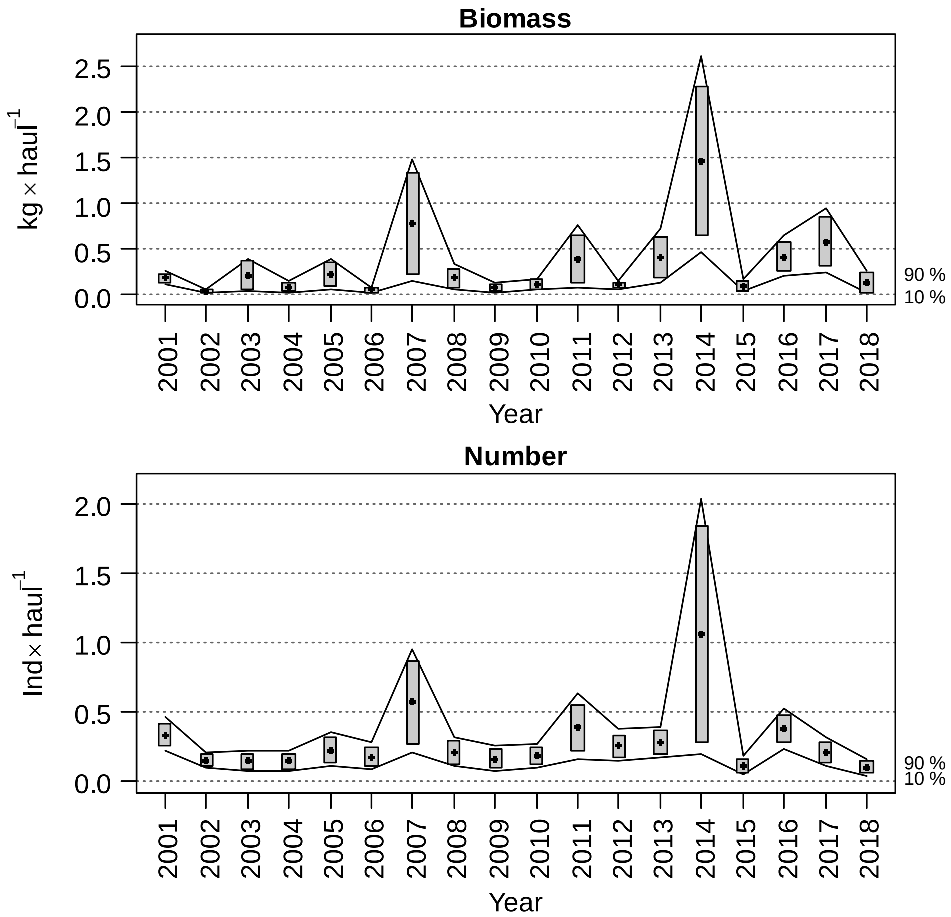


Figure 29 Evolution of *Dalatias licha* biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

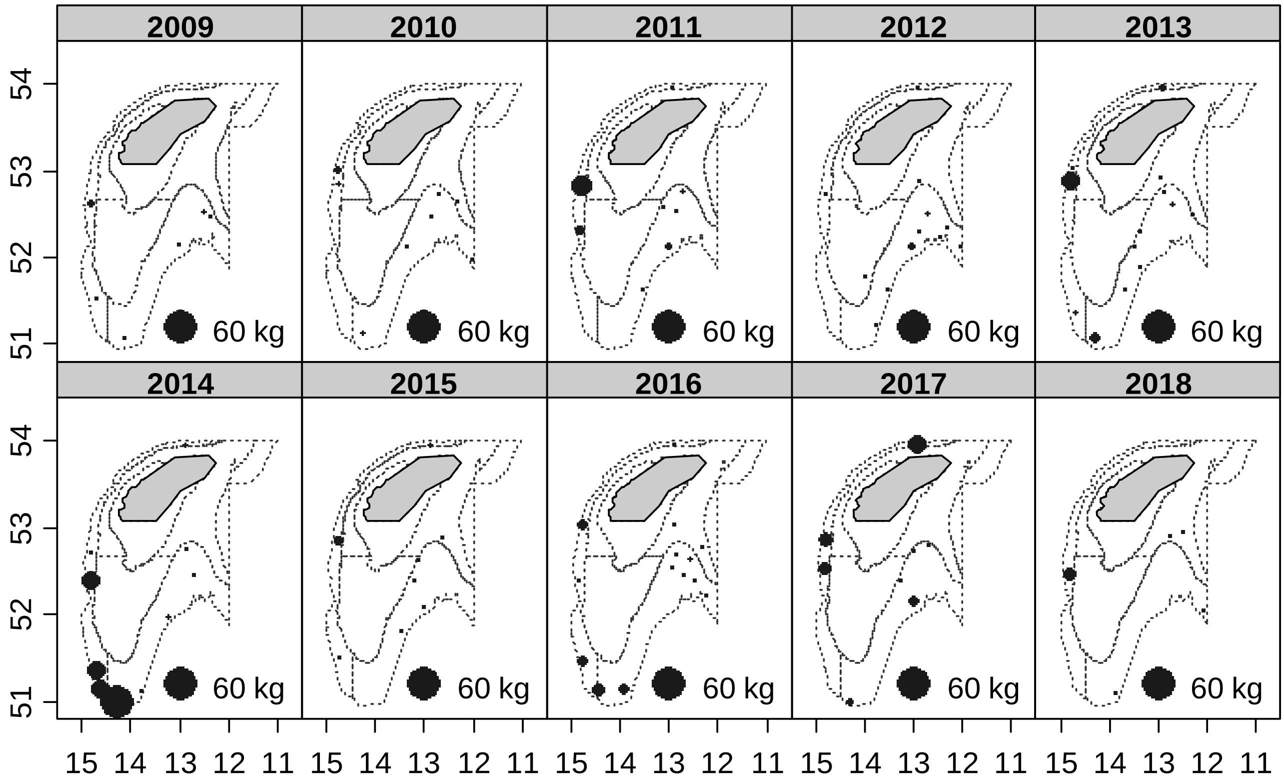


Figure 30 Geographic distribution of *Dalatias licha* catches (kg×30 min haul^{-1}) in Porcupine surveys (2009-2018)

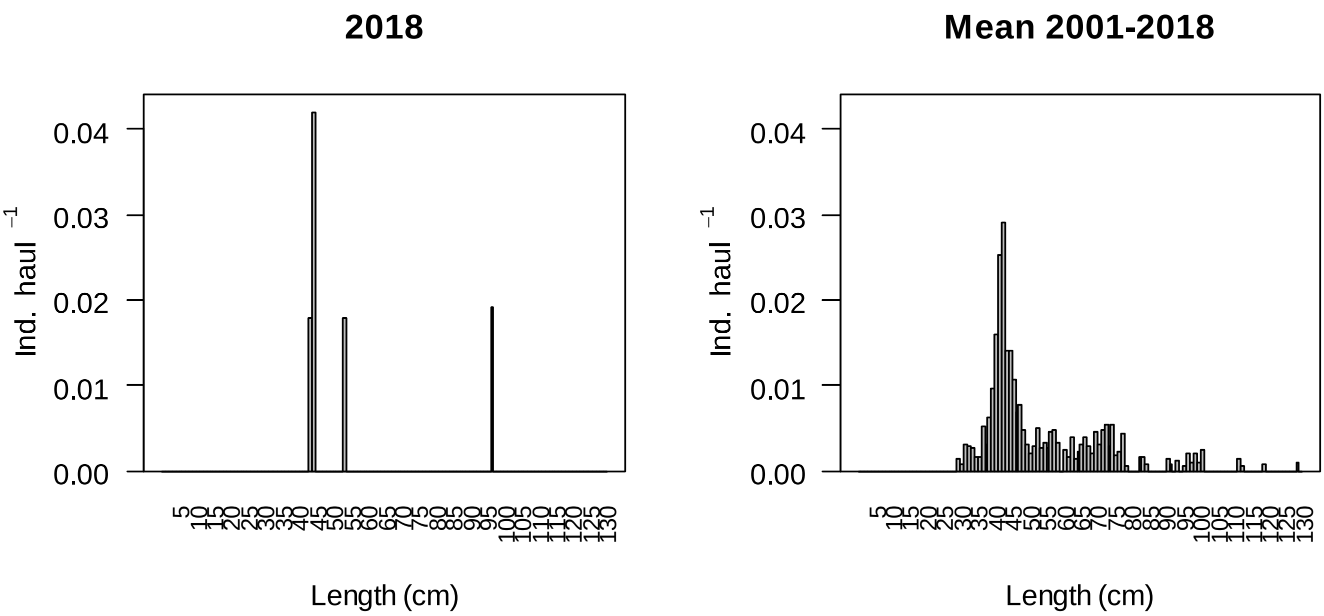


Figure 31 Stratified length distribution of *Dalatias licha* in 2018 Porcupine survey, and mean values in Porcupine surveys (2001-2018)

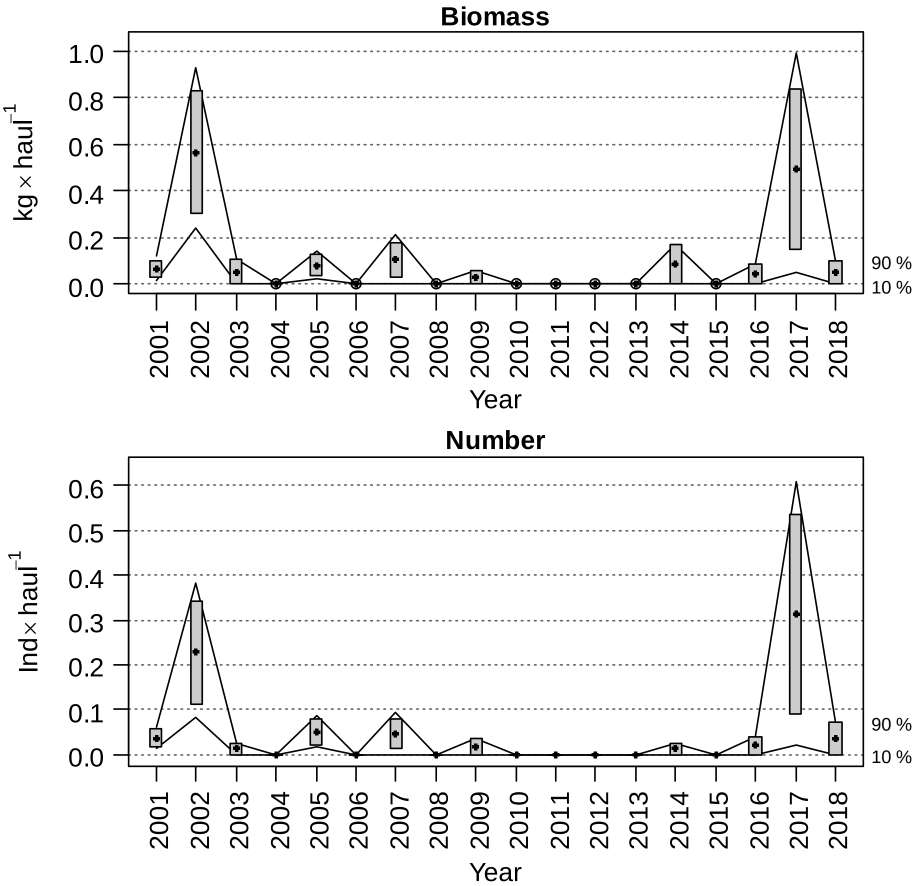


Figure 32 Evolution of *Squalus acanthias* biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

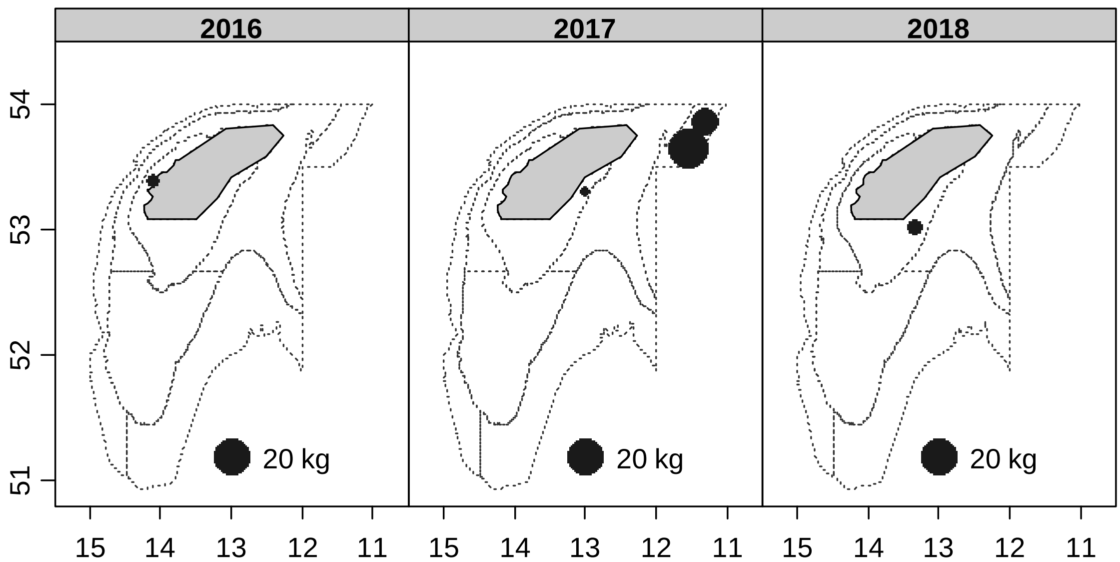


Figure 33 Geographic distribution of *Squalus acanthias* catches (Kg· haul^{-1}) in Porcupine surveys 2016-2018

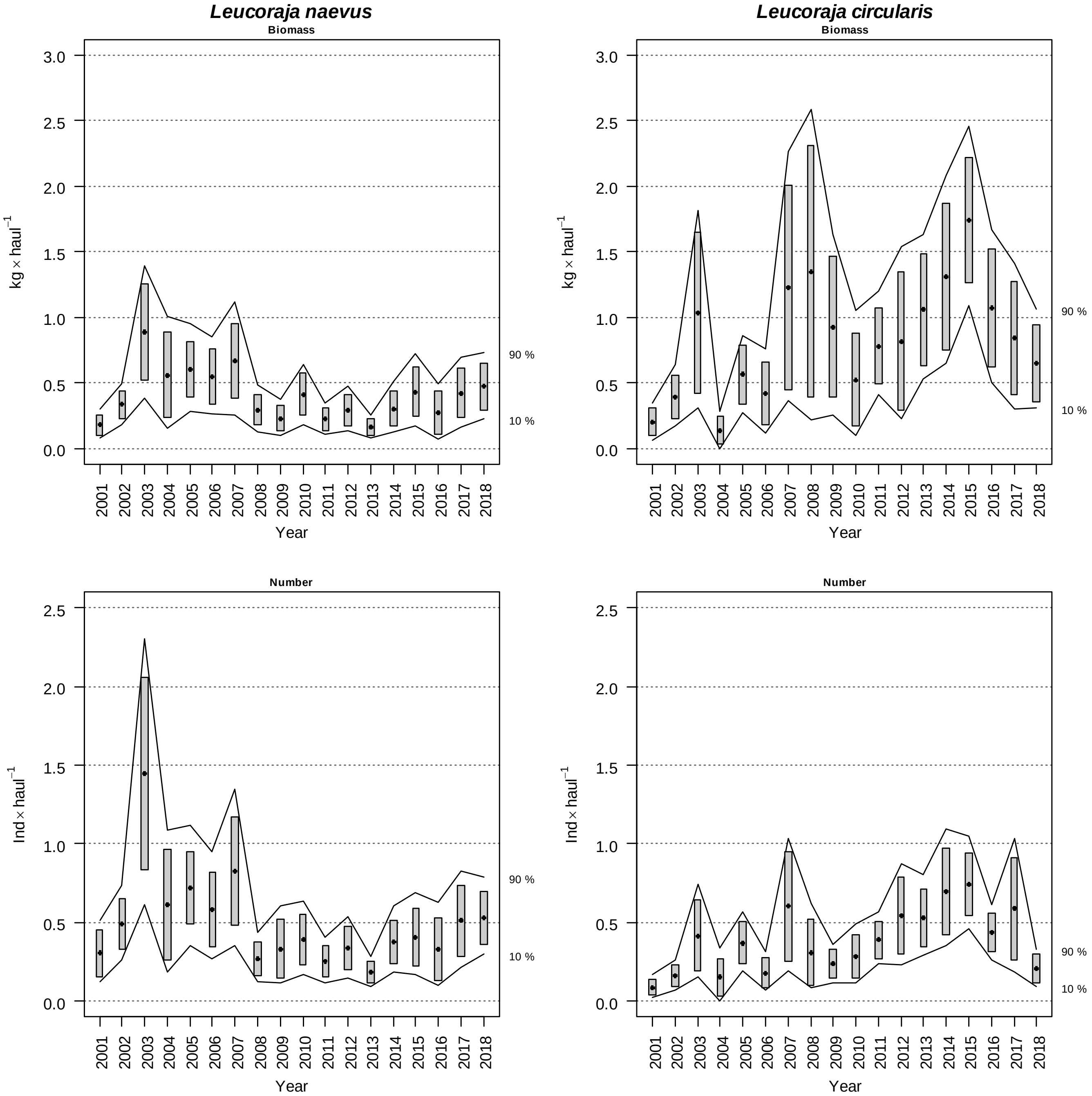


Figure 34 Changes in *Leucoraja naevus* and *Leucoraja circularis* biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000)

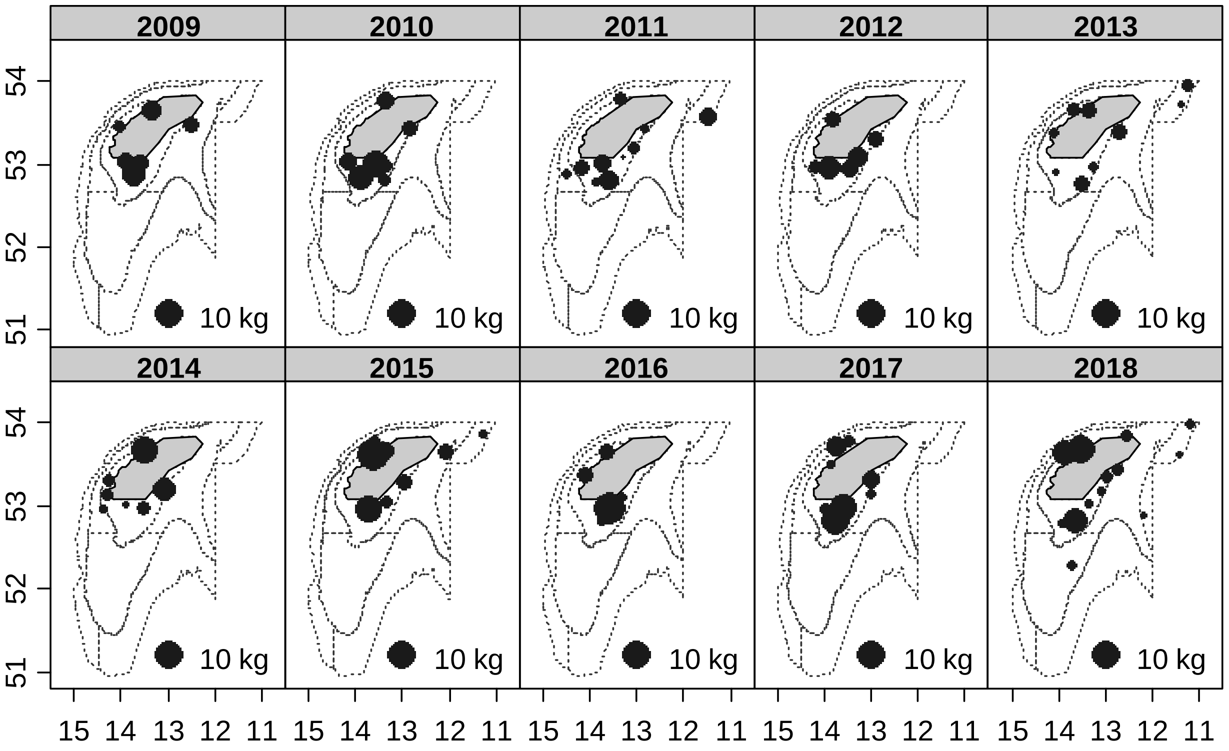


Figure 35 Geographic distribution of *Leucoraja naevus* catches (kg·haul^{-1}) in Porcupine surveys (2009-2018)

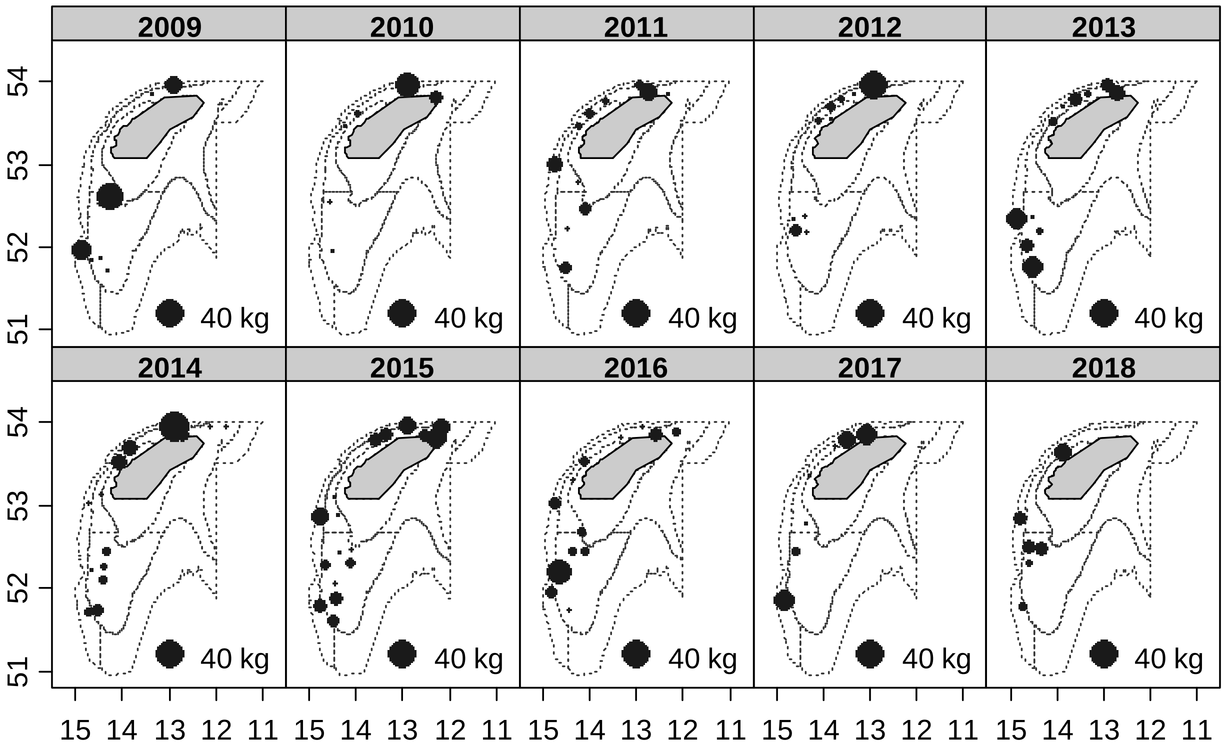


Figure 36 Geographic distribution of *Leucoraja circularis* catches (kg·haul^{-1}) in Porcupine surveys (2009-2018)

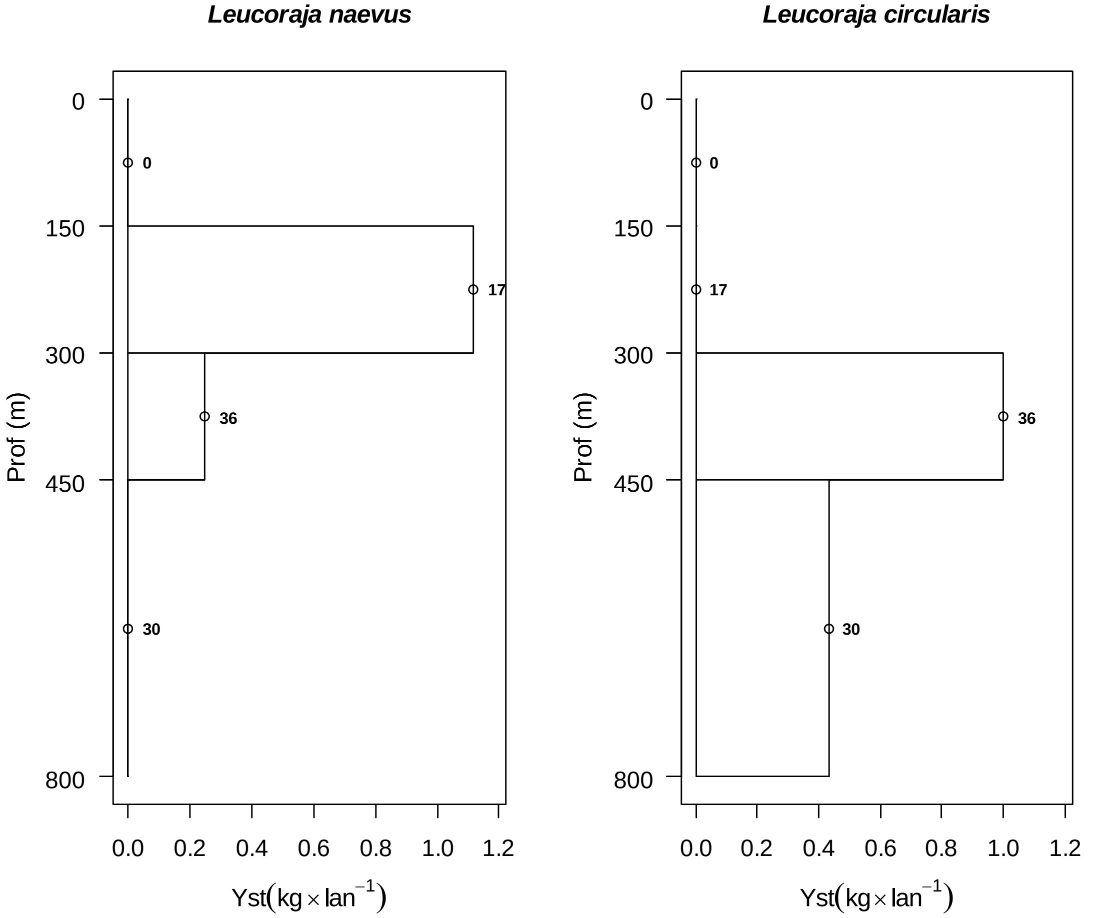


Figure 37 Depth distribution of *Leucoraja naevus* and *Leucoraja circularis* in Porcupine survey 2018. Numbers mark total hauls

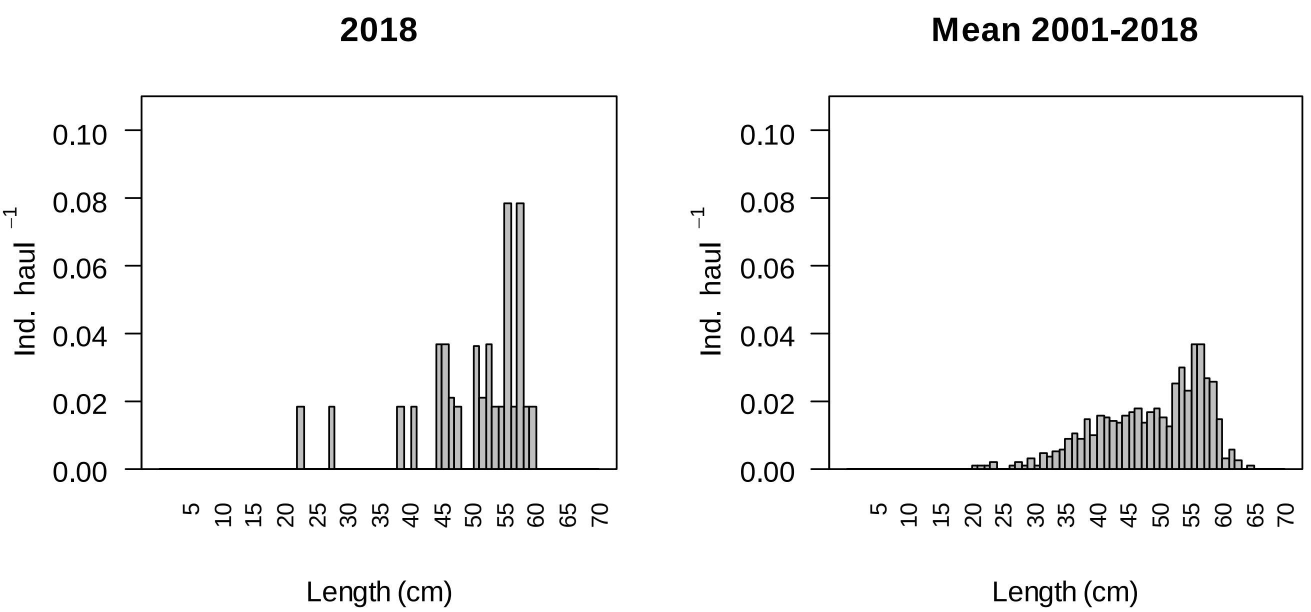


Figure 38 Stratified length distribution of *Leucoraja naevus* in 2018 Porcupine survey, and mean values in Porcupine surveys (2001-2018)

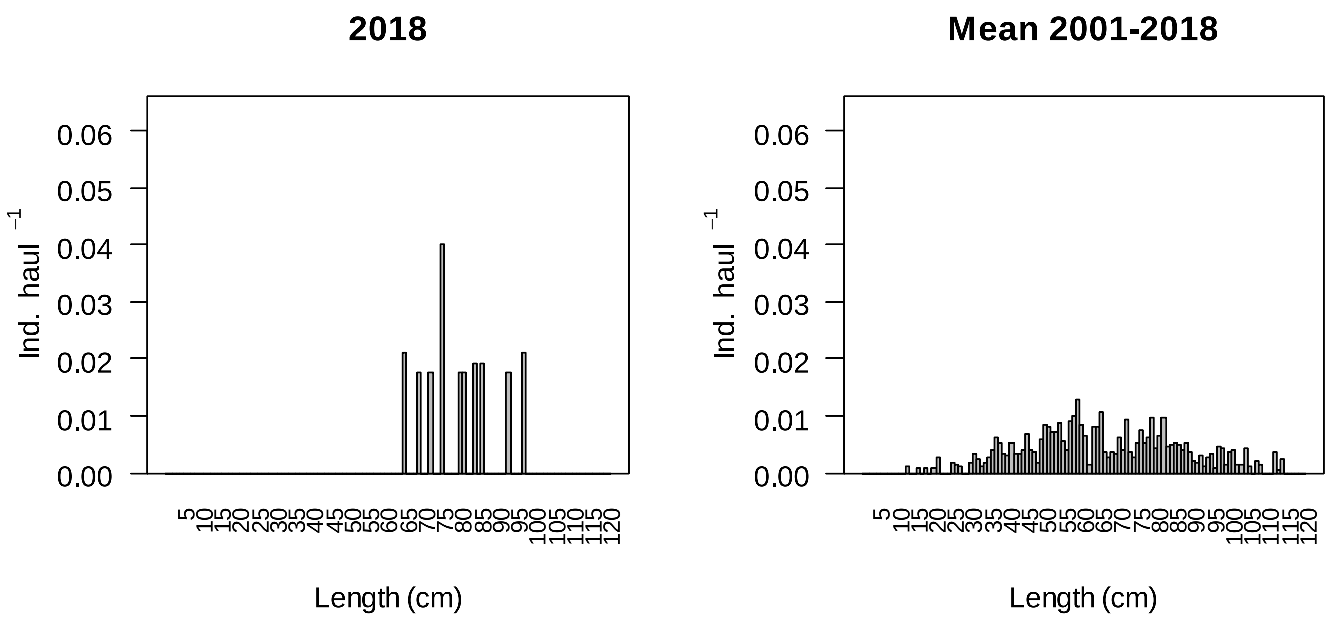


Figure 39 Stratified length distribution of *Leucoraja circularis* in 2018 Porcupine survey, and mean values in Porcupine surveys (2001-2018)

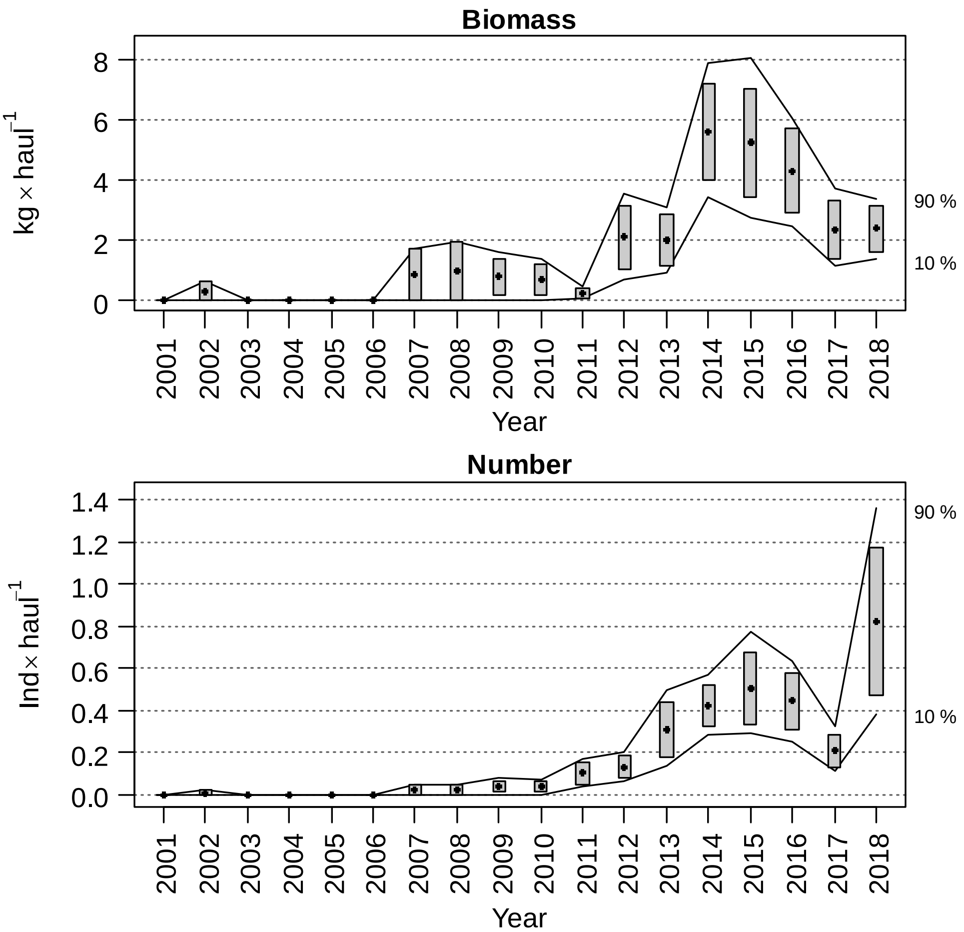


Figure 40 Evolution of *Dipturus* spp. biomass and abundance indices in Porcupine surveys (2001-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

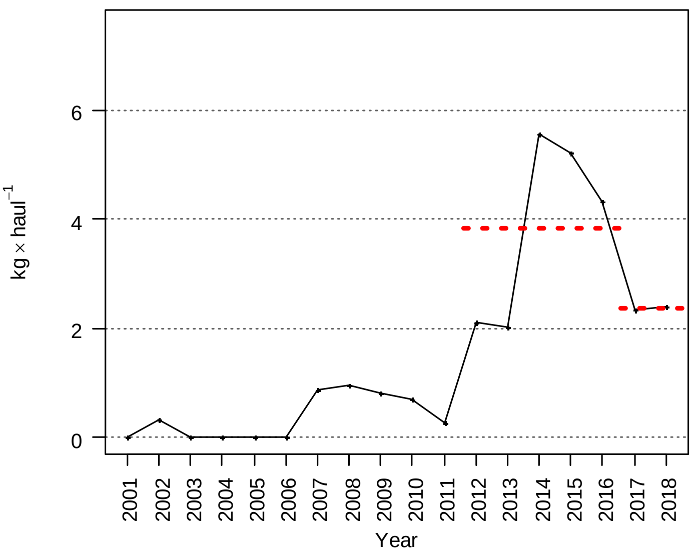


Figure 41 Evolution in *Dipturus* spp. biomass index in Porcupine surveys (2001-2018). Dotted lines compare mean stratified biomass in the last two years with the five previous years

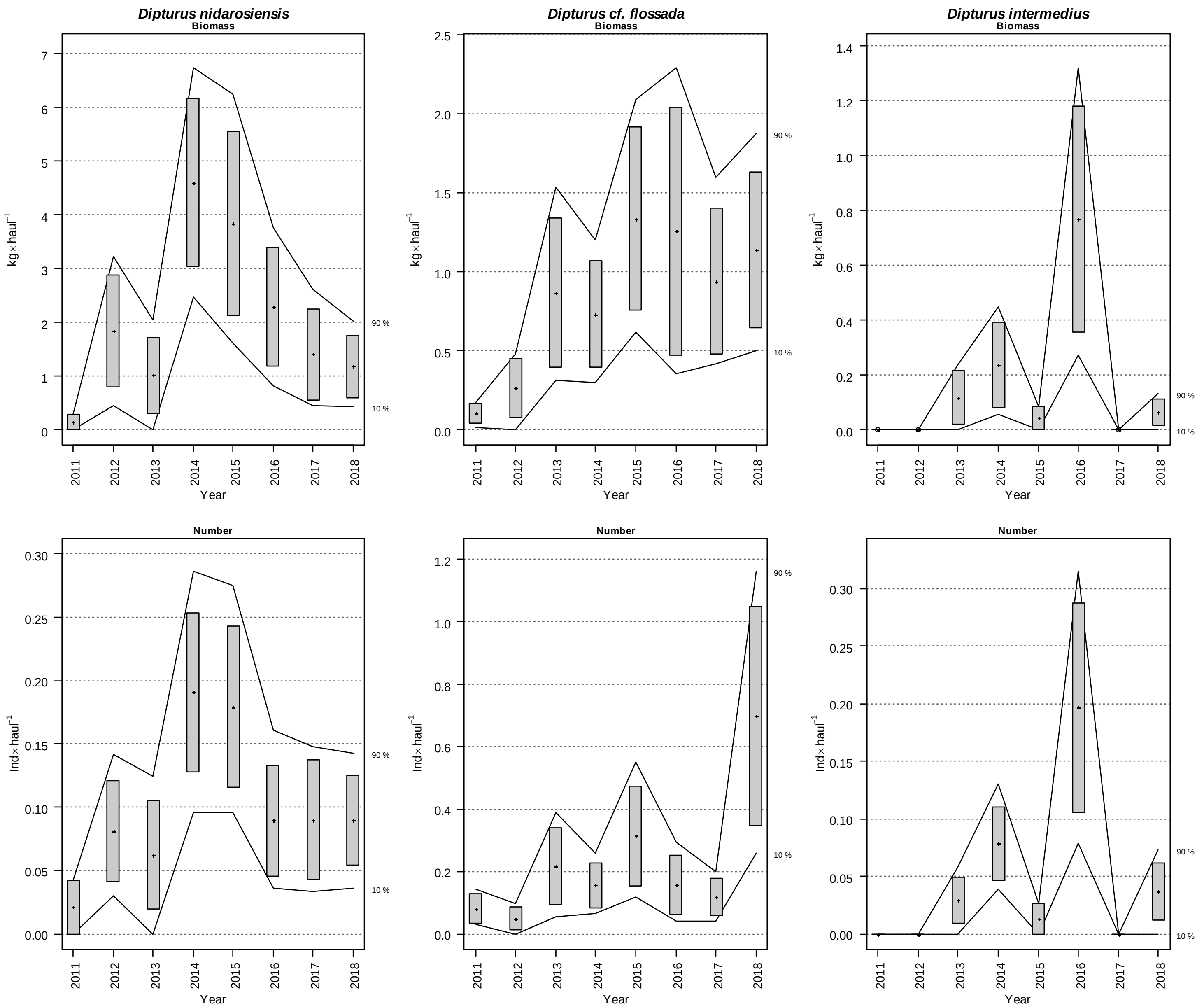


Figure 42 Evolution of *Dipturus nidarosiensis*, *Dipturus cf. flossada* and *Dipturus intermedius* biomass and abundance indices in Porcupine surveys (2011-2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000)

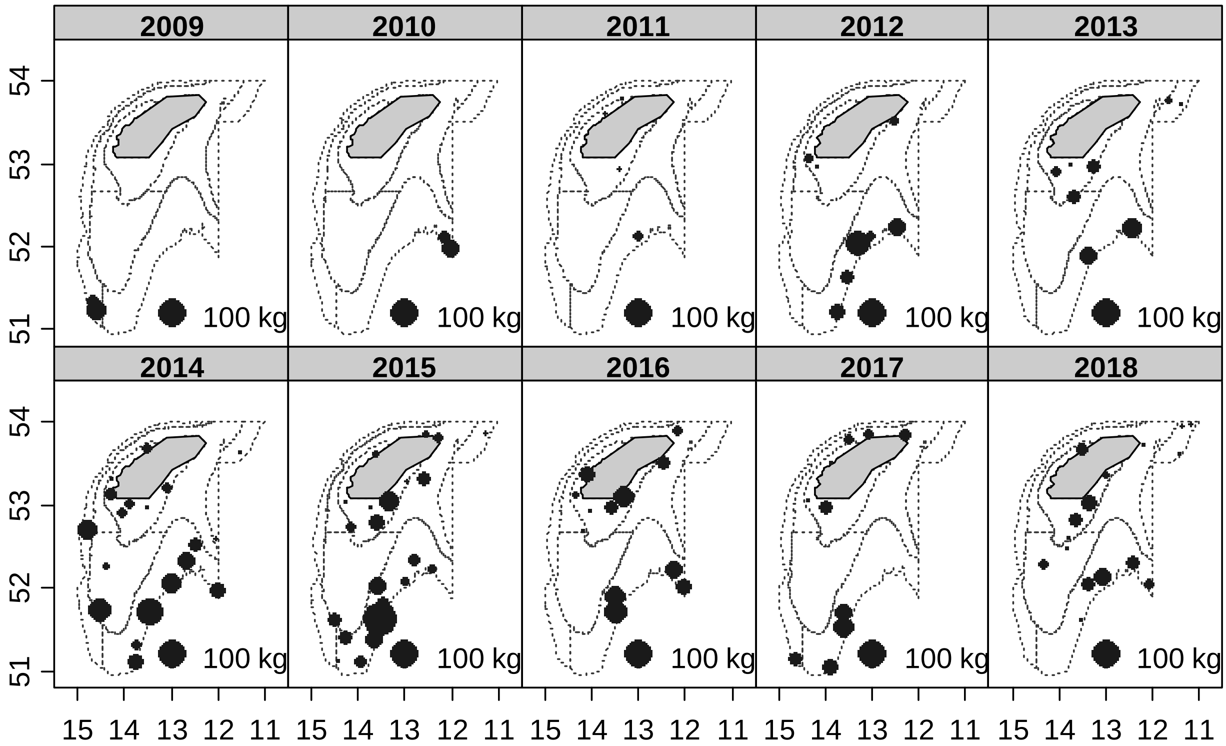


Figure 43 Geographic distribution of *Dipturus* spp. catches (Kg· haul^{-1}) in Porcupine surveys (2009-2018)

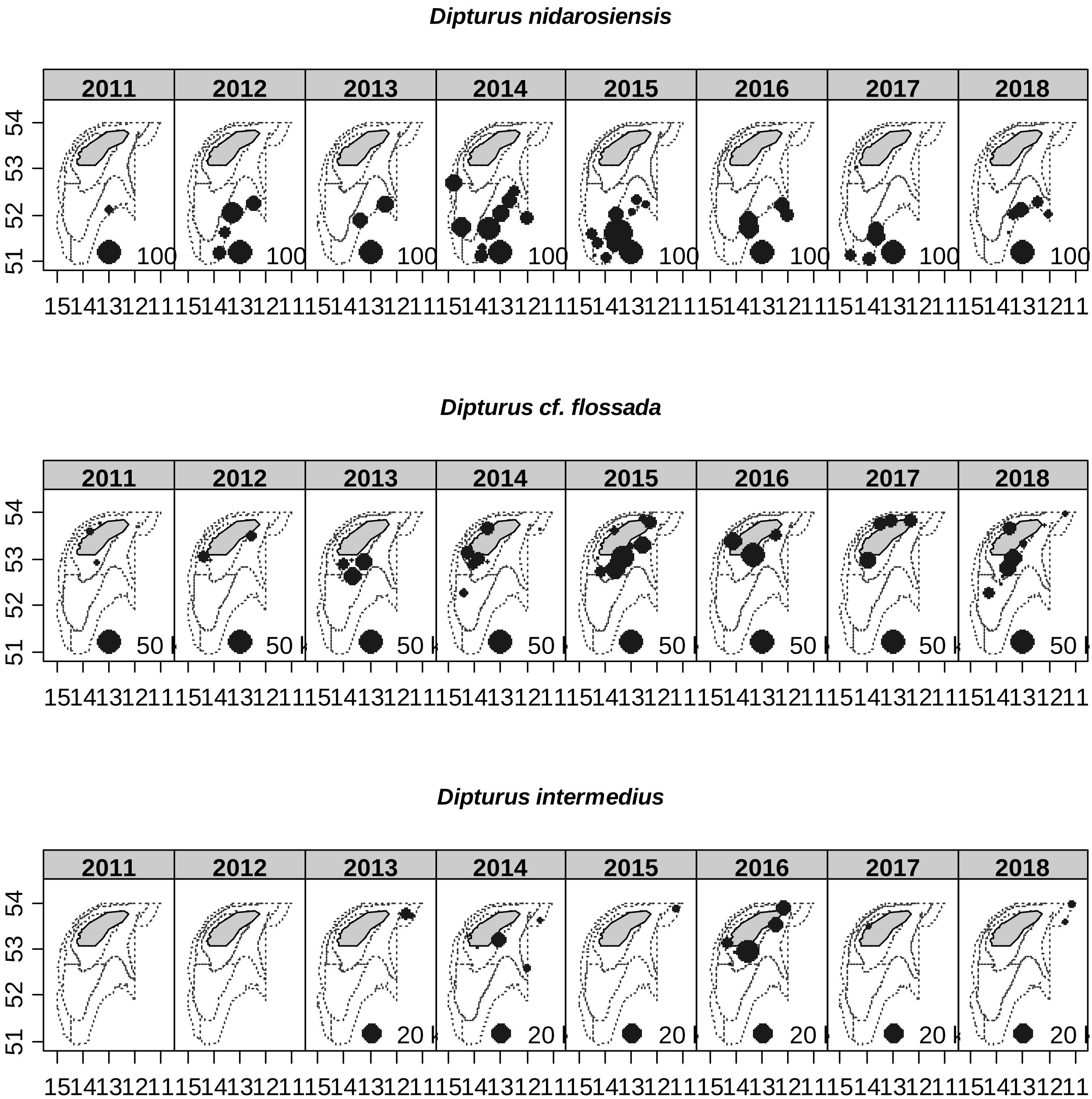


Figure 44 Geographic distribution of *Dipturus nidarosiensis*, *Dipturus cf. flossada* and *Dipturus cf. intermedia* catches (Kg· haul^{-1}) in Porcupine surveys (2011-2018)

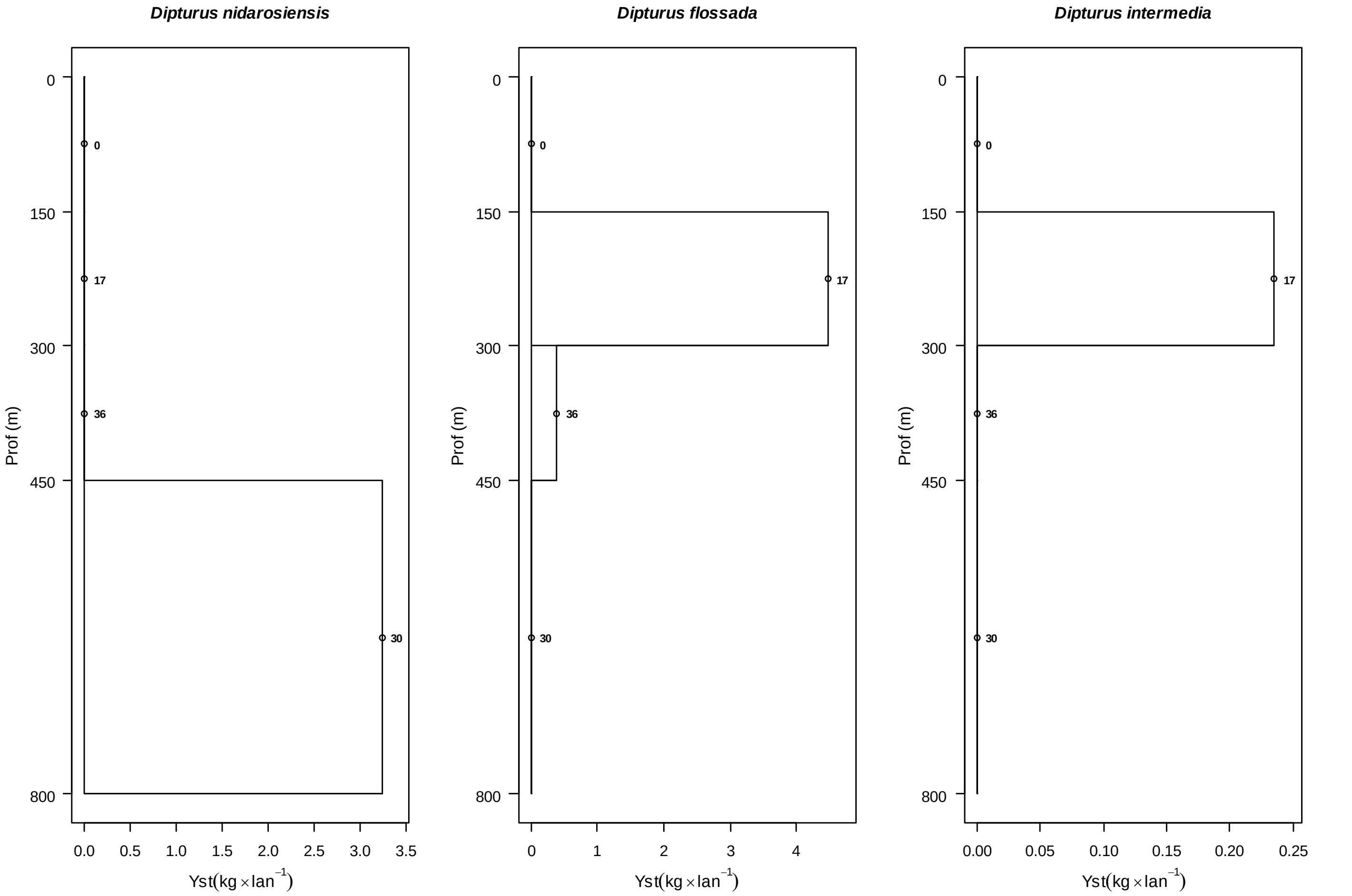


Figure 45 Depth distribution of *Dipturus nidarosiensis*, *Dipturus cf. flossada* and *Dipturus cf. intermedia* catches (kg/30 min haul) in Porcupine surveys 2018. Numbers mark total hauls

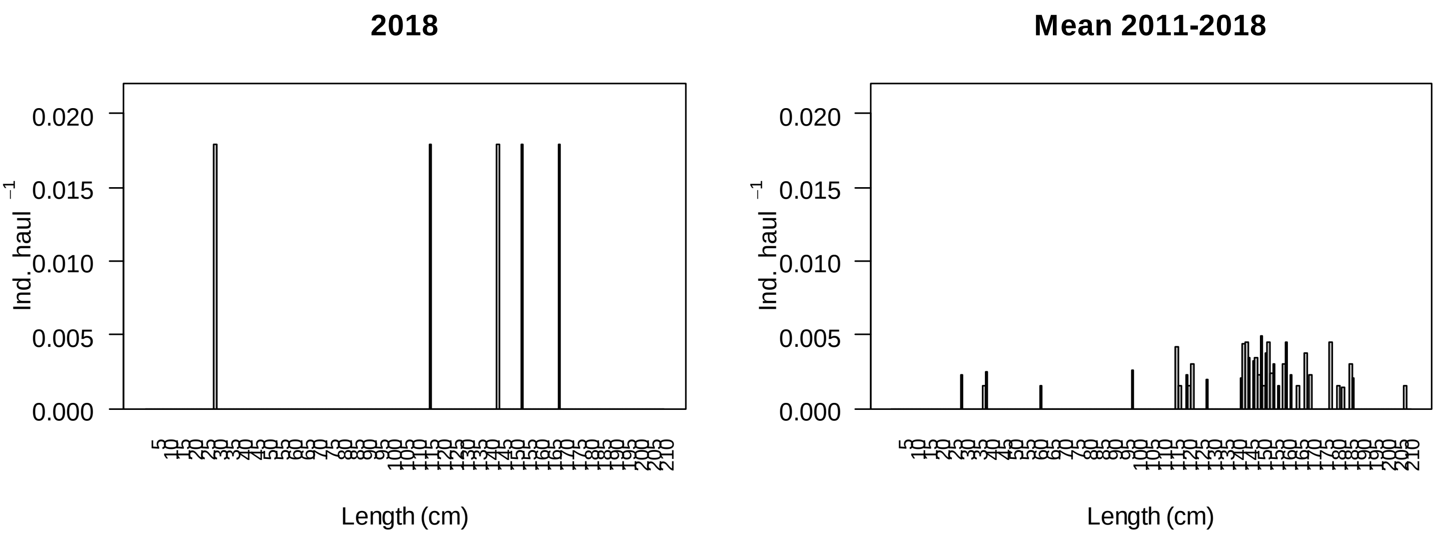


Figure 46 Stratified length distribution of *Dipturus nidarosiensis* in 2018 Porcupine survey, and mean values in Porcupine surveys (2011-2018)

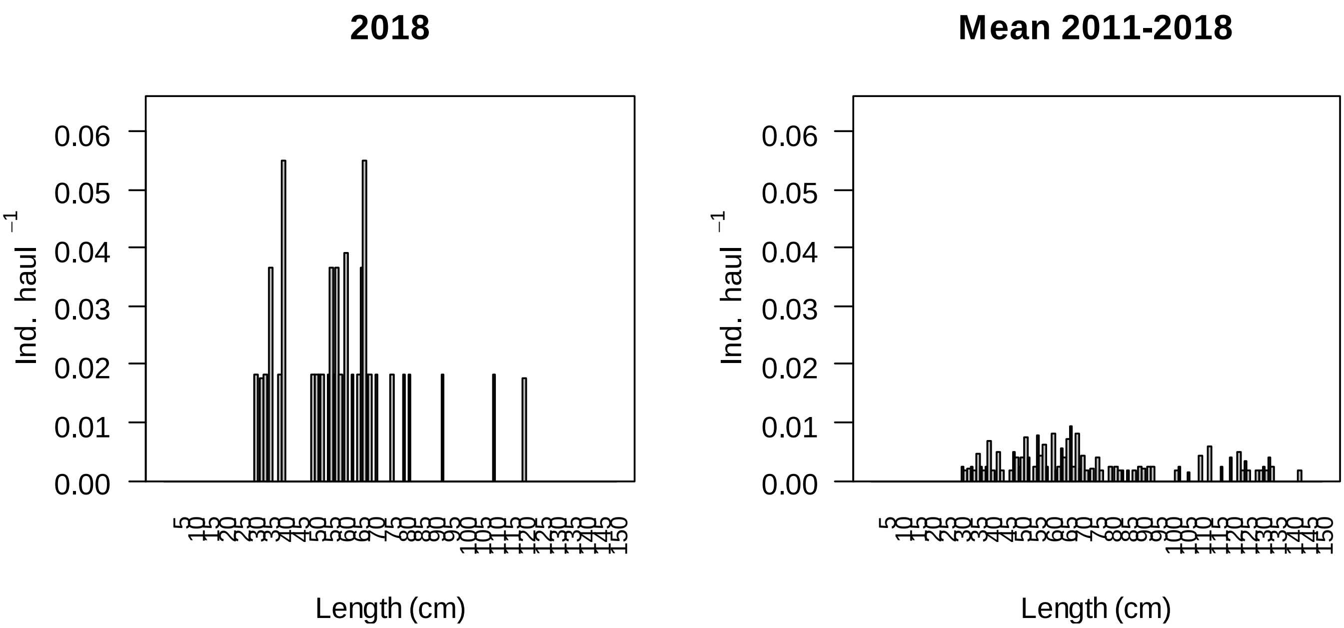


Figure 47 Stratified length distribution of *Dipturus cf. flossada* in 2018 Porcupine survey, and mean values in Porcupine surveys (2011-2018)

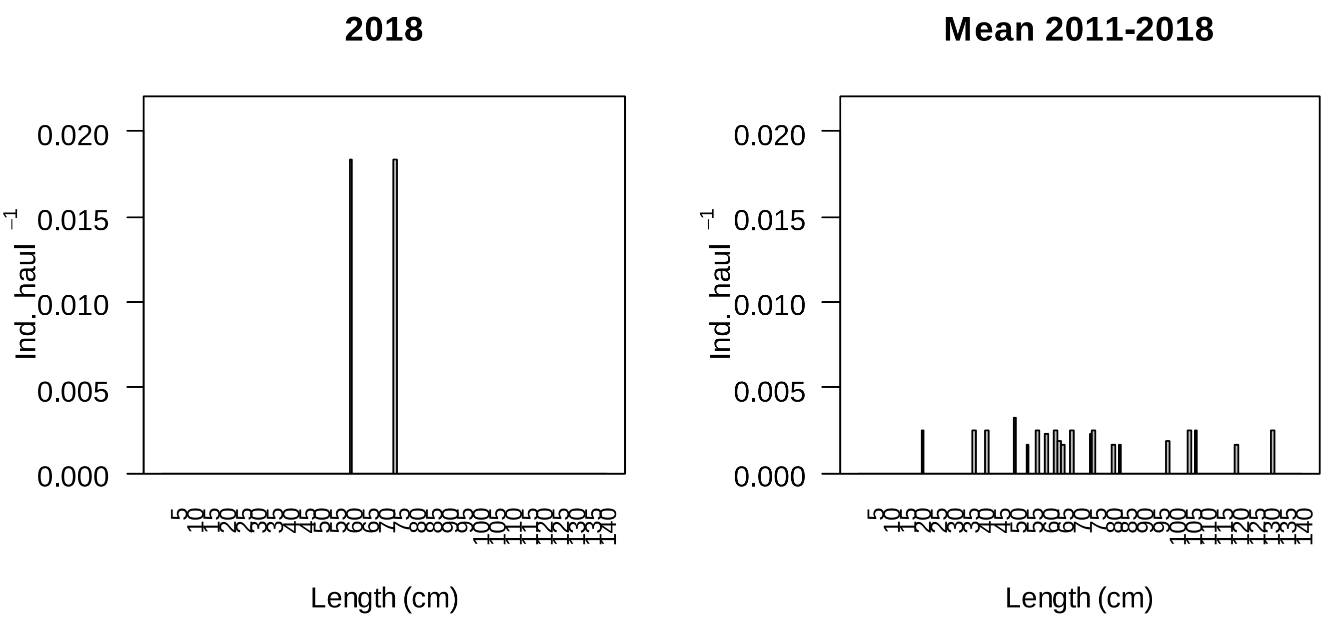


Figure 48 Stratified length distribution of *Dipturus intermedius* in 2018 Porcupine survey, and mean values in Porcupine surveys (2011-2018)

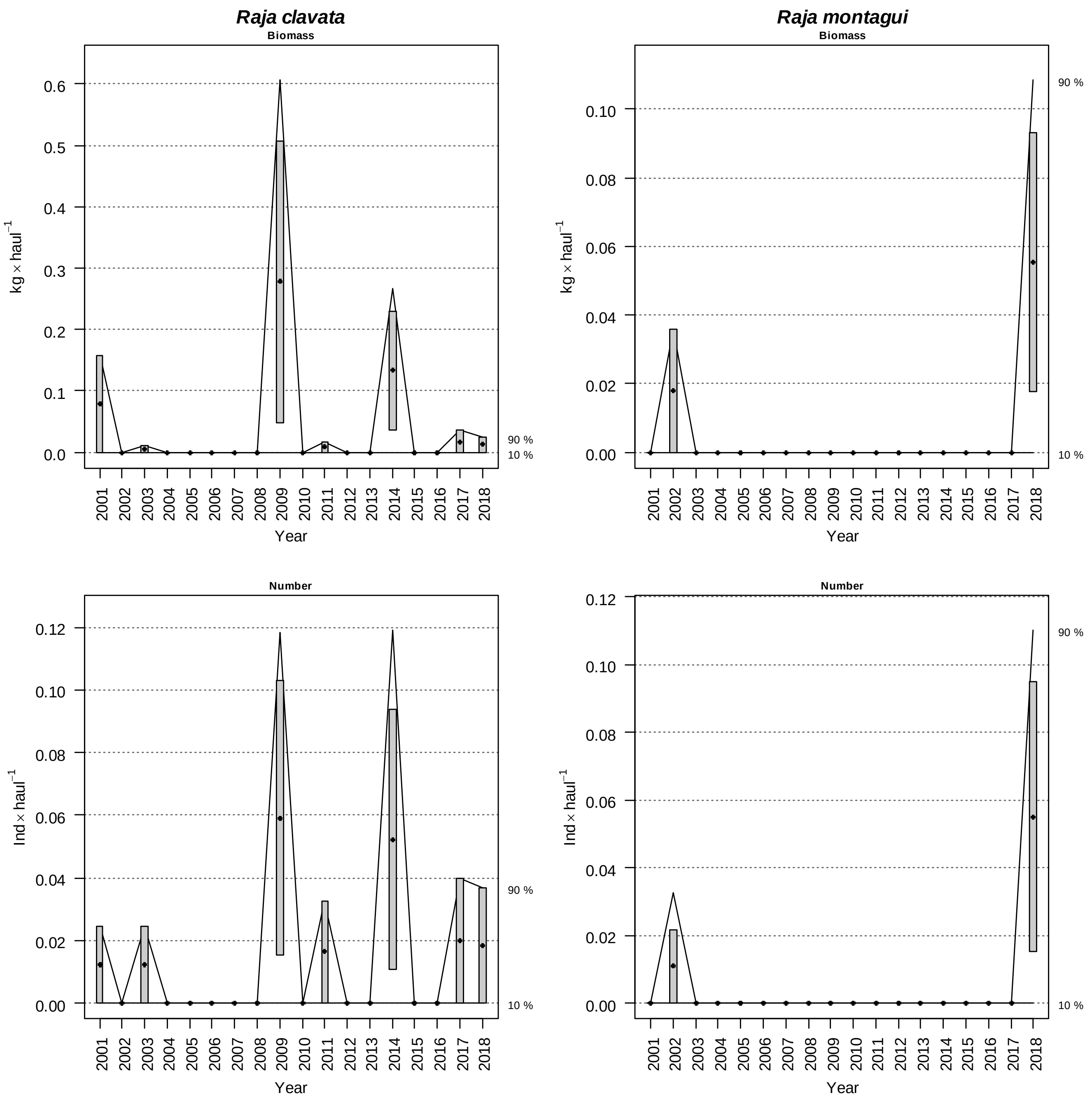
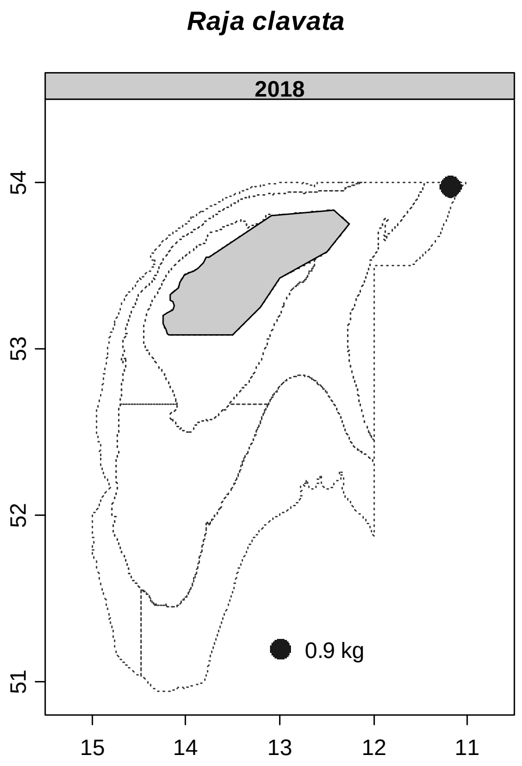


Figure 49 Evolution of *Raja clavata* and *Raja montagui* biomass and abundance indices from 2001 and 2018 Porcupine surveys. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000)



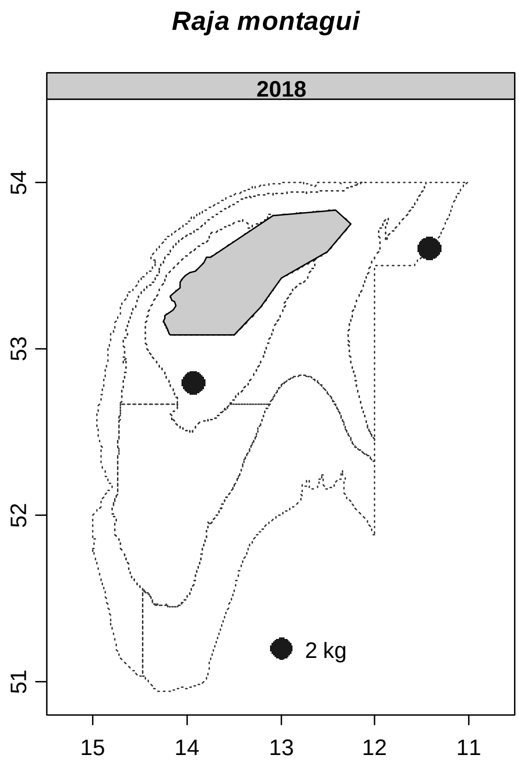


Figure 50 Geographic distribution of *Raja clavata* and *Raja montagui* catches (Kg· haul^{-1}) in Porcupine surveys 2018

Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 18–27 2019: [Rev 1.]

Updated life-history parameters for starry smooth-hound *Mustelus asterias* in the North-east Atlantic

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Abstract: Updated life-history parameters (length-weight relationship; maturity stages by length; maturity ogive; fecundity-at-length; preliminary growth parameters) are provided for starry smooth-hound *Mustelus asterias* in the waters around the British Isles. In total, 4 951 specimens (2 334 females, 23–130 cm total length and 2 617 males, 22–102 cm total length) captured during fishery-independent trawl surveys were examined. Length at 50% maturity was estimated to be 85.4 cm for females and 73.5 cm for males. Uterine fecundity ranged from 2–20 with a mean value of 8.5.

Introduction

Starry smooth-hound *Mustelus asterias* Cloquet, 1819, is a medium-sized triakid shark (attaining a maximum length of 124–140 cm total length, L_T), that occurs on the continental shelf of the Northeast Atlantic from the North Sea south to Mauritania), including the Mediterranean (Branstetter, 1984; Compagno, 1984; Farrell *et al.*, 2015) and Black Seas (Eryilmaz *et al.*, 2011). It is seasonally common species in coastal waters off the south-eastern coasts of the British Isles and may be present off south-western coasts for longer periods of the year. It is now considered likely to be the only member of the genus around the British Isles (Farrell *et al.*, 2009).

In earlier years, *M. asterias* was often discarded by the English fleet, but an increased proportion is now retained (Silva *et al.*, 2019). The increased proportion landed by the English fleets may be due to a combination of factors (e.g. larger catches, improved knowledge on processing, and greater market demand). The main nations exploiting *M. asterias* are France and England, with the English Channel and southern North Sea both important fishing grounds.

Mustelus asterias is an aplacentally viviparous species, with *in utero* pups absorbing nutrients from a yolk-sac that is depleted during development (Capapé 1983; Compagno, 1984). Various aspects of the reproductive biology of *M. asterias* have been reported for populations in the Mediterranean Sea (Capapé, 1983) and around the British Isles (Farrell *et al*., 2010a, 2013; McCully Phillips & Ellis, 2015), including length-at-maturity, ovarian and uterine fecundities. The reproductive cycle is thought to be either annual (12-month gestation) or biennial (12-month gestation period and a resting period).

Although some triakid sharks, including *Mustelus* spp., are often considered relatively productive sharks, in comparison to other elasmobranch groups (Frisk *et al*., 2001; Conrath & Musick, 2002), the age-at-maturity and longevity of *M. asterias* (6 and 18 years, respectively: Farrell *et al*., 2010b) and reproductive behaviour of this species means that this stock and expanding fishery should be quantitatively assessed and managed appropriately if overfishing, such as occurred with *S. acanthias,* is to be avoided.

Since the quantitative studies of the reproductive biology were undertaken by McCully Phillips & Ellis (2015), CEFAS trawl surveys have collected further biological data on this species, which are presented below.

Methods

Updated biological parameters: Samples *of M. asterias* were obtained from fishery-independent trawl surveys performed by CEFAS during the period 2009–2019. Specimens were sexed and total length (L_T, in cm) and total weight (M_T, in g) were recorded. In males, maturity was assigned following gross external examination of the claspers. For females, maturity was assigned following internal examination of the ovary and follicles, and the development of the nidamental gland and uteri (for details on the maturity scale used, see Table 1). The number of uterine eggs or pups present in gravid females (stages D–E) was also recorded. If specimens were in good condition and were tagged (e.g. for studies on their movements), females were assigned a maturity stage 'U' (undetermined).

The length-frequency distributions for both females and males were constructed and tested for significative differences by the Kolmogorov-Smirnov test. The relationship between L_T and M_T was estimated for each sex. Length at 50% maturity (L_{50}) was calculated using a GLM model where the error distribution and link function were binomial (Crawley, 2007; see McCully *et al*. (2012) for further details). The numbers of mature and immature fish at length were used to model the proportion of mature fish using a logistic model as a function of length.

Given the limited number of observations on gravid females available, data on uterine fecundity (F_U) sampled during the present study were collated along with data from previously published studies (Henderson *et al*., 2003; Farrell *et al*., 2010a; McCully Phillips & Ellis, 2015) and used in the construction of the fecundity-at-length relationship (Table 2).

Age and growth parameters: During the extensive biological sampling conducted for McCully Phillips & Ellis (2015) and some additional sampling during CEFAS trawl surveys, vertebrae were collected for further studies on age and growth. The methodology for collection and treatment of vertebrae followed the procedure outlined by Farrell *et al.* (2010b). In terms of ageing, a first batch (n = 50) was read by seven Cefas staff, with expert quality control and assurance (QC/QA) provided by Edward Farrell (n = 39). The two readers with the best agreement with the expert aged the vertebrae of the remaining fish (n = 554). The first batch were annotated and read through photos to enable a better QC and comparison between readers. The remaining 554 were read via microscope, as per Farrell *et al.* (2010b).

Tagging: CEFAS have tagged-and-released specimens of *M. asterias* from fishery-independent trawl surveys since 2003 (Burt *et al.*, 2013). These surveys are carried out annually around much of the British Isles and deploy either a 4 m beam trawl or otter trawl (usually either the 'Grande ouverture vertical' (GOV) trawl, Portuguese high headline trawl (PHHT) or monkfish trawl). Standard groundfish survey tows are of a relatively short duration (30 min), which can allow captured fish to be in a suitable condition for mark-recapture studies, although the weight and contents of the catch may affect the suitability of individual fish to be tagged and released. There have also been opportunities to tag specimens of starry smooth-hound during other research projects using fishery-dependent surveys (e.g. Ellis *et al*., 2008, 2010).

After fish were caught, those that were considered to be in good condition and suitable for tagging were either tagged and released immediately or, if a longer period was required between capture and release, they were kept in tanks with running seawater. Fish were tagged using numbered Petersen discs, that comprised two plastic discs, one of which had a unique identification number, which were secured to the first dorsal fin using a stainless steel wire. The L_T was recorded, as well as additional biological information including sex, weight and (where possible) maturity, and a note was also made of the fish's condition ('lively' or 'sluggish'). Fish were released as soon as possible with the position noted (typically the haul location).

Tagged fish returns have generally been from commercial fishing vessels. There is on-going work on tagging starry smooth-hounds with electronic tags (n = 113 releases) in order to better understand their behaviour, movement and discard survivability.

Results and discussion

Life-history parameters: In total, 4 951 *M. asterias* were examined, comprising 2 334 females (23–130 cm L_T) and 2 617 males (22–102 cm L_T; Fig. 1). Sexual dimorphism in size was pronounced (KS, D = 0.22115, *p-value* <0.05), with the largest male and female measuring 102 cm and 130 cm[1] L_T, respectively. The heaviest mature male (M_T = 5 120 g) was slightly less than half the mass of the heaviest female (M_T = 9 580 g). The relationship between L_T and M_T was examined by sex (Fig. 2). Both the coefficients of determination were similar (females, r^2 = 0.992; males, r^2 = 0.991) with females attaining higher body mass values but also higher total lengths.

The smallest mature female observed was 75 cm L_T, and the largest immature was 91 cm L_T. The L_{50} for females was estimated at 85.4 cm L_T, with 100% maturity attained at approximately 92 cm L_T (Fig. 3). These values varied slightly from previous studies in North Atlantic waters; McCully Phillips & Ellis (2015) estimated a L_{50} of 81.9 cm L_T and Farrell *et al*. (2010a) of 87 cm L_T. Developing females were found between 40–91 cm L_T (Fig. 4), which indicates a long time period for this stage.

The smallest mature male was 64 cm L_T, and the largest immature male was 99 cm L_T. The L_{50} for males was estimated at 73.5 cm L_T, with 100% maturity attained at approximately 90 cm L_T (Fig. 3). Similar to females, estimates of L_{50} for males also showed slight differences from previous studies; McCully Phillips & Ellis (2015) estimated a L_{50} of 70.4 cm L_T and Farrell *et al.* (2010a) of 78 cm L_T. Developing males were found between 55–99[2] cm L_T (Fig. 4), which further indicates a variable period for maturation.

In total, 74 gravid females (stages D–F) were analysed in the present study (Fig. 5), with the smallest gravid female at 80 cm L_T. Of all the gravid females, the uterine fecundity ranged from 2–20 (mean = 8.5) which is similar to the initial studies of subsets of this combined dataset (4–20: McCully Phillips & Ellis (2015); 6–18: Farrell *et al.* (2010)). It is important to note that female elasmobranchs may abort their pups during capture, due to stress, and so some of the uterine fecundities reported here may have been underestimates. Whilst an apparent proportional linear relationship was observed between F_U and L_T, further data would be desirable to provide a more robust estimate.

[1] The largest size *M. asterias* authenticated by the authors remains 124 cm (McCully Phillips & Ellis, 2015), and the validity of the 130 cm specimen reported here is uncertain, as specimens of tope *Galeorhinus galeus* may sometimes be confounded with starry smooth-hound.
[2] The validity of a 99 cm developing male is questionable, and may be an input error. The next largest developing (stage B) male was 95 cm.

Ageing and growth parameters: Preliminary estimates of age and growth curves for *M. asterias* for females and males were calculated. These results should be viewed as exploratory, as further work is required to validate the ageing and produce a more robust growth curve and associated von Bertalanffy life-history parameters.

A total of 604 fish vertebrae were aged (estimate), with agreement reached between reader 2 and reader 3 for 53% of the vertebrae (data from reader 1 are not shown as only a subset of data were QC'd to date). Preliminary results on the agreed estimated aged fish (Female: N = 163, L_T = 28–124 cm, ages: 0–17 and male: N = 159, L_T = 24–100 cm, ages 0–14), provided a L_∞ = 130.1 cm and L_∞ = 94.6 cm for females and males, respectively (Fig. 6). Previously, Farrell *et al.* (2010) estimated that L_∞ was 123.5 cm (females) and 103.7 cm (males), although it should be noted that the present study had more fish at age 0. Future studies could also benefit from greater sample sizes for larger specimens (L_T > 100 cm). Further work is required to further and evaluate the current estimated ages and, in terms of stock assessment modelling, the results of Farrell *et al.* (2010b) should still be used at the present time.

Tagging: From 2003–2019, a total of 1 613 *M. asterias* (744 females and 868 males, one unsexed specimen) were tagged and released, of which 40 (2.48%) have been recaptured and details returned (Table 3). Most tagged specimens were released in the southern North Sea (ICES Divisions 4.c; 39.7% of releases), western Channel (7.e; 22.8%), Irish Sea (7.a; 14.6%) and Bristol Channel (7.f; 10.5%) (Table 4, Fig. 7). Tagged males ranged from 39[3]–109 cm L_T, and tagged females ranged from 31–130[4] cm L_T (Fig. 8).

Whilst 40 recaptures were reported to Cefas, only 23 records had complete recapture details and, therefore, were considered in the following analysis. Tagged specimens were recaptured between 18–1385 days after their release, with a mean time at liberty of 330 days. Recaptures occurred at distances (minimum distances, measured as straight lines between release and recapture locations) of <600 km (mean of 188 km).

Females, on average, travelled *ca.* 223 km during *ca.* 433 days at liberty. The female recaptured after the longest time at liberty was tagged in the area of the Outer Thames (Division 4.c) and was recaptured 1385 days later in Liverpool Bay (Irish Sea, Division 7.a) (Fig. 9). Males travelled *ca.* 150 km during *ca.* 225 days, on average. The male displaying the longest time at liberty was also tagged in the Outer Thames (Division 4.c) and recaptured 286 days after in the Lyme Bay area (western Channel, Division 7.e) (Fig. 9). An apparent increase in the distance travelled with increasing time at liberty was observed (Fig. 10), although it is

[3] Current tagging studies of *M. asterias* focused on specimens >50 cm, although a limited number of specimens smaller than this have been tagged.
[4] See footnote 1.

important to note that the distances estimated are minimum straight-line distances, and this was based on a relatively small sample size.

The majority of the female recaptures in the southern North Sea (Division 4.c) took place in the second and third quarters of the year (summer months) while those from the English Channel, Celtic Sea, Irish Sea and Bay of Biscay occurred mainly in quarters one and four (winter months) (Fig. 9). Previous work has suggested that this species tends to inhabit waters from the Bay of Biscay to the English Channel during the winter, and moving to the southern North Sea (e.g. Dutch Delta and Outer Thames) and eastern English Channel waters during the summer months for parturition when water temperatures are warmer (Brevé *et al.*, 2016).

In North-east Atlantic waters, the species is known to pup during summer months (McCully Phillips & Ellis, 2015) in shallow embayments around the British Isles (Ellis *et al.*, 2005; Farrell *et al.*, 2010). The same pattern was found for males with all the recaptures in quarters two and three occurring in the southern North Sea and recaptures from the winter months occurring mainly in the English Channel and Celtic Sea (except for one male tagged in the North Sea and recaptured 18 days later in the same region). The present tagging results suggest that the species is wide ranging in northern European seas and displays seasonal migrations which are likely related to its reproductive cycle.

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Table 1: Maturity staging key used for *Mustelus asterias* (McCully Phillips & Ellis, 2015).

Maturity stage	Males	Females
A	**Immature**: Claspers undeveloped, shorter than extreme tips of posterior margin of pelvic fin. Testes small and thread-shaped, sperm ducts straight	**Immature**: Ovaries small, gelatinous or granulated, but no differentiated oocytes visible. Oviducts small and thread-shaped, width of shell gland not much greater than the width of the oviduct.
B	**Developing**: Claspers longer than posterior margin of pelvic fin, their tips more structured, but the claspers are soft and flexible and the cartilaginous elements are not hardened. Testes enlarged, sperm ducts beginning to meander.	**Developing**: Ovaries enlarged and with more transparent walls. Oocytes differentiated in various small sizes (usually <5mm) and pale in colour. Oviducts small and thread-shaped, width of the shell gland greater than the 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.	**Mature**: Ovaries large with very large, yolk-filled oocytes, (often 10–30 mm in diameter). Shell gland fully formed and hard. Uteri fully developed but without yolky matter (Stage D) or embryos (Stages E–F) and not dilated (Stage G)
D	**Active**: Clasper reddish and swollen, sperm present in clasper groove, or flows if pressure exerted on cloaca.	**Early gravid**: Uteri filled with yolky matter, which may appear unsegmented, or if segmented, without visible embryos.
E	-	**Mid-term gravid**: Uteri filled with yolk sacs and small developing embryos that can be counted.
F	-	**Late gravid**: Uteri filled with well-developed term pups, and the yolk sac has been absorbed (or is very small).
G	-	**Post-partum**: Similar to stage C, but with a greater number of degenerating follicles and uteri dilated.
X	Abnormal reproductive system	Abnormal reproductive system
U	-	Maturity stage undetermined, internal organs not examined

Table 2: Fecundity-at-length data for *Mustelus asterias* in the North-east Atlantic.

Total length (cm)	Uterine fecundity	Maturity	Source
87	10	D	Henderson et al. (2003)
89	2	D	Henderson et al. (2003)
109	10	D	Henderson et al. (2003)
83	6		Farrell et al. (2010)
90	8		Farrell et al. (2010)
91	7		Farrell et al. (2010)
92	4		Farrell et al. (2010)
94	7		Farrell et al. (2010)
97	6		Farrell et al. (2010)
97	9		Farrell et al. (2010)
100	9		Farrell et al. (2010)
103	14		Farrell et al. (2010)
104	7		Farrell et al. (2010)
106	7		Farrell et al. (2010)
106	11		Farrell et al. (2010)
108	10		Farrell et al. (2010)
111	18		Farrell et al. (2010)
112	9		Farrell et al. (2010)
80	4	D	McCully Phillips & Ellis (2015)
83	7	D	McCully Phillips & Ellis (2015)
86	10	E	McCully Phillips & Ellis (2015)
88	9	D	McCully Phillips & Ellis (2015)
90	7	D	McCully Phillips & Ellis (2015)
91	6	F	McCully Phillips & Ellis (2015)
92	6	D	McCully Phillips & Ellis (2015)
93	4	F	McCully Phillips & Ellis (2015)
96	14	F	McCully Phillips & Ellis (2015)
97	9	F	McCully Phillips & Ellis (2015)
97	5	E	McCully Phillips & Ellis (2015)
97	11	D	McCully Phillips & Ellis (2015)
98	10	F	McCully Phillips & Ellis (2015)
98	10	D	McCully Phillips & Ellis (2015)
101	7	F	McCully Phillips & Ellis (2015)
101	11	E	McCully Phillips & Ellis (2015)
101	10	F	McCully Phillips & Ellis (2015)
101	12	D	McCully Phillips & Ellis (2015)
102	11	F	McCully Phillips & Ellis (2015)
103	12	F	McCully Phillips & Ellis (2015)
104	13	F	McCully Phillips & Ellis (2015)
105	17	F	McCully Phillips & Ellis (2015)
105	8	F	McCully Phillips & Ellis (2015)
106	11	F	McCully Phillips & Ellis (2015)

Table 2 (continued): Fecundity-at-length data for *Mustelus asterias* in the North-east Atlantic.

Total length (cm)	Uterine fecundity	Maturity	Source
110	17	F	McCully Phillips & Ellis (2015)
115	12	F	McCully Phillips & Ellis (2015)
116	20	F	McCully Phillips & Ellis (2015)
116	15	E	McCully Phillips & Ellis (2015)
124	13	F	McCully Phillips & Ellis (2015)
101	5	F	Cefas (unpublished[5])
88	4	D	Cefas (Ciro 2/02)
92	2	D	Cefas (Ciro 2/02)
93	2	D	Cefas (Ciro 2/02)
101	9	F	Cefas (Ciro 2/02)
111	14	F	Cefas (Ciro 2/02)
93	4	F	Cefas (CEND 2/13)
97	10	E	Cefas (CEND 2/13)
81	3	F	Cefas (CEND 04/18)
85	5	F	Cefas (CEND 04/18)
87	4	F	Cefas (CEND 04/18)
88	4	F	Cefas (CEND 04/18)
89	5	F	Cefas (CEND 04/18)
89	5	F	Cefas (CEND 04/18)
90	4	F	Cefas (CEND 04/18)
90	6	F	Cefas (CEND 04/18)
91	7	E	Cefas (CEND 04/18)
93	8	F	Cefas (CEND 04/18)
97	10	F	Cefas (CEND 04/18)
99	9	F	Cefas (CEND 04/18)
100	12	F	Cefas (CEND 04/18)
101	4	F	Cefas (CEND 04/18)
82	6	F	Cefas (CEND 3/19)
99	10	F	Cefas (CEND 3/19)
100	12	F	Cefas (CEND 3/19)
100	9	E	Cefas (CEND 3/19)
108	2	D	Cefas (CEND 3/19)

[5] April 2019, 101 cm, 3671 g total weight.

Table 3: Number of *Mustelus asterias* released (by year) and recaptured.

	Released	Recaptured	
Year	No.	No.	%
2003	10		0.00
2004	54	2	3.70
2005	47		0.00
2006	50		0.00
2007	179	5	2.79
2008	74	1	1.35
2009	65		0.00
2010	73	1	1.37
2011	109	3	2.75
2012	36	1	2.78
2013	258	9	3.49
2014	73		0.00
2015	58		0.00
2016	48	1	2.08
2017	99	4	4.04
2018	281	13	4.63
2019	99		0.00
Total	1613	40	2.48

Table 4: Number of *Mustelus asterias* released (by ICES Division) and recaptured

	Released	Recaptured	
ICES Division	No.	No.	%
Div 4.b	14		0.00
Div 4.c	641	21	3.28
Div 7.a	235	1	0.43
Div 7.d	92	10	10.87
Div 7.e	367	3	0.82
Div 7.f	170	1	0.59
Div 7.g	49	3	6.12
Div 7.h	44	1	2.27
Div 7.j	1		0.00
Total	1613	40	2.48

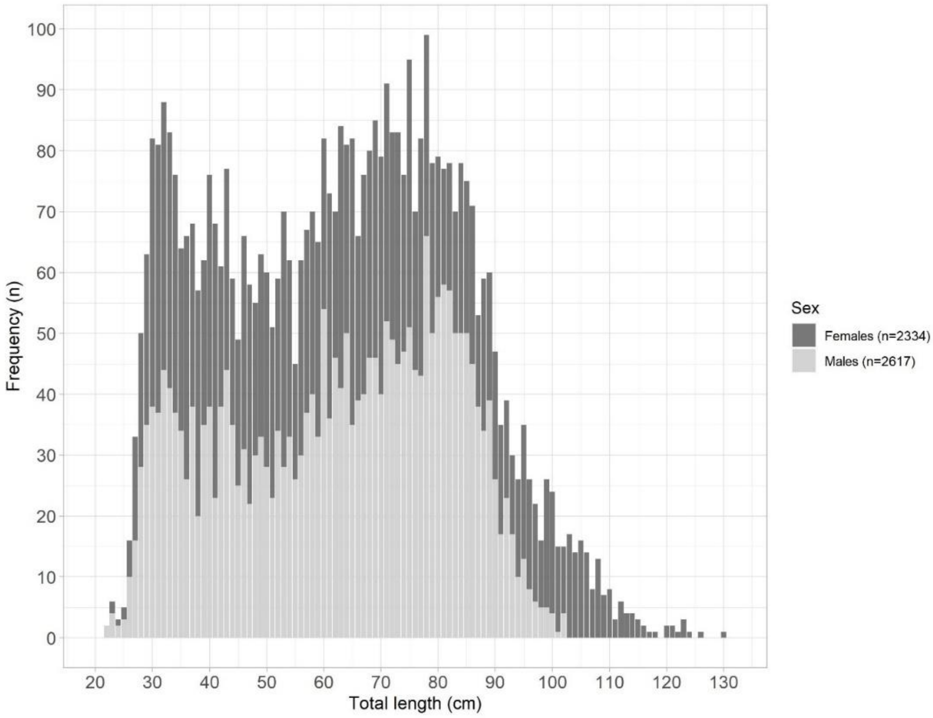

Figure 1: Length frequency distribution for female and male *Mustelus asterias.*

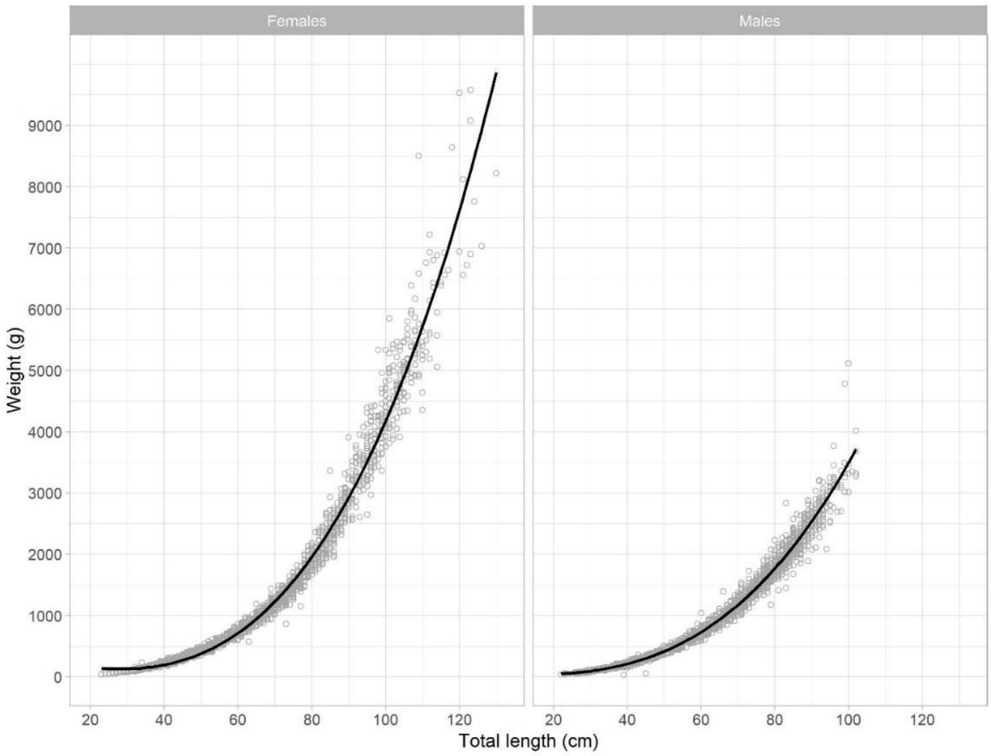

Figure 2: Total length and body mass relationship for female and male *Mustelus asterias*. The relationships were described by the equations: females, $M_T = 0.002\ T_L^{3.1}$ (r2 = 0.992, n = 2323); males, $M_T = 0.003\ T_L^{3.0}$ (r2 = 0.991, n = 2471).

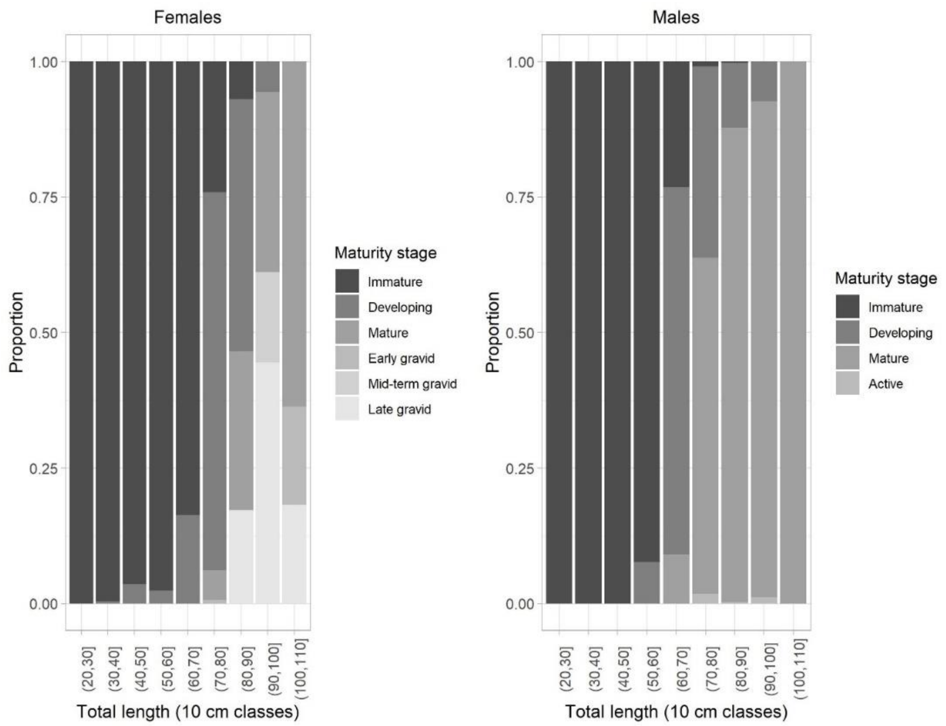

Figure 3: Proportion of each maturity stage by length class for female (n = 1 149) and male (n = 2 154) *Mustelus asterias*.

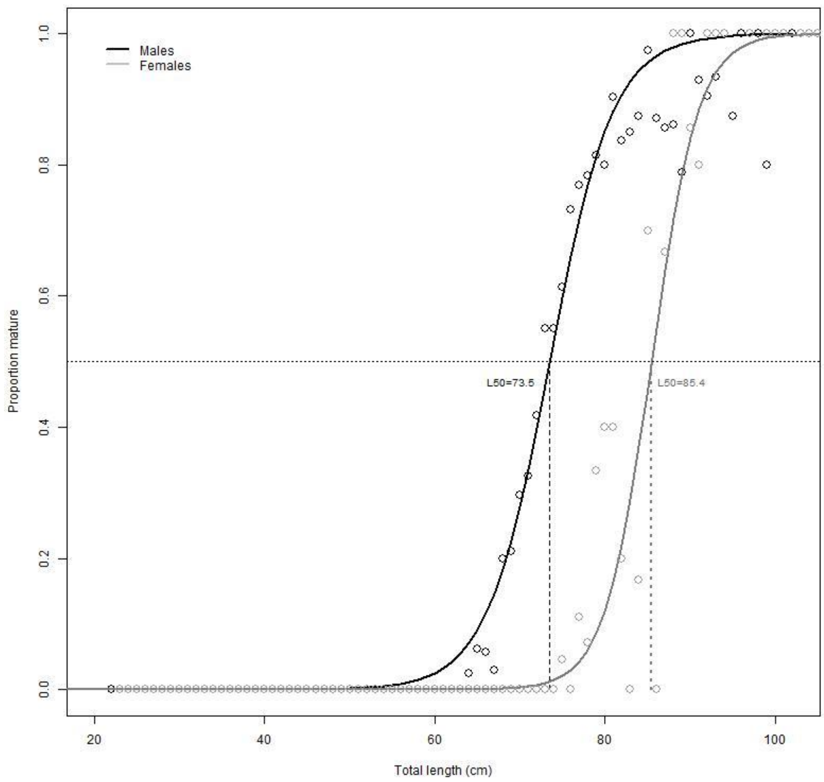

Figure 4: Maturity ogives for female (n=1 158) and male (n=2 154) *Mustelus asterias*.

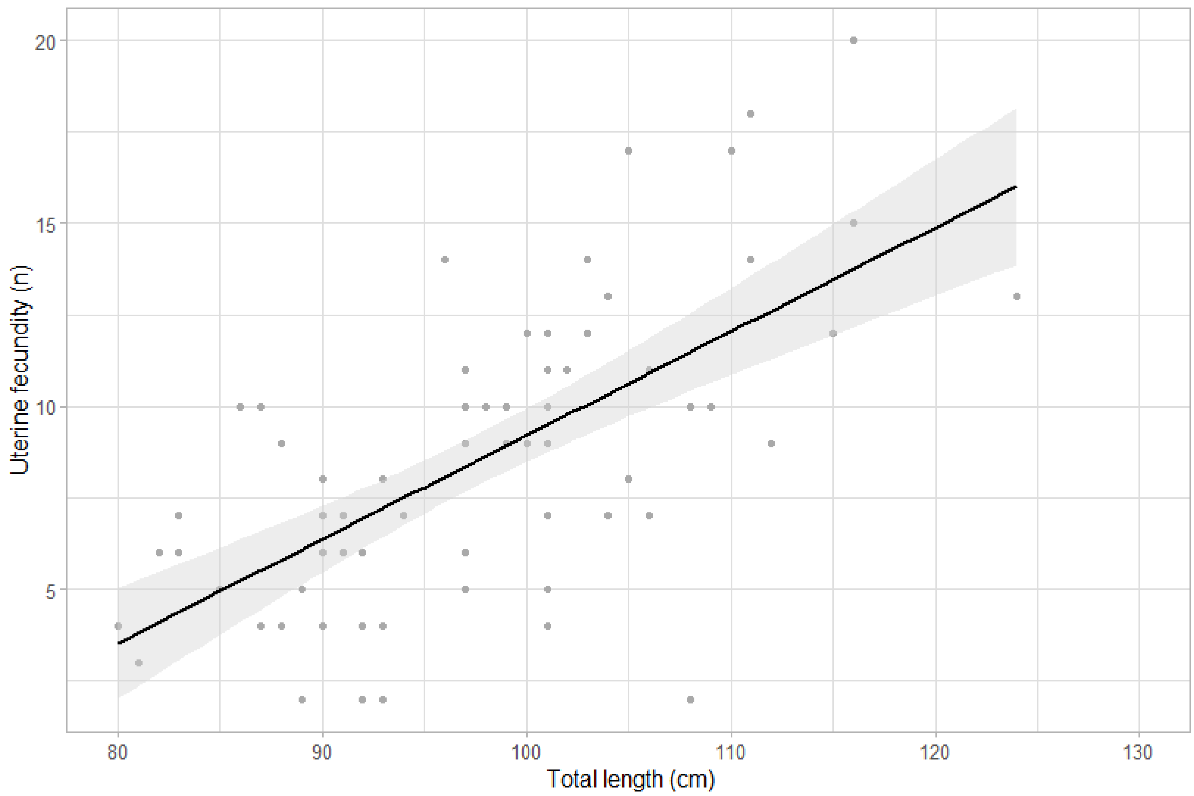

Figure 5: Fecundity-at-length relationship for female *Mustelus asterias*, $F_U = 0.28390\ L_T - 19.18583$ ($r^2 = 0.4295$, n = 74). Grey shade represents the 95% c.i.

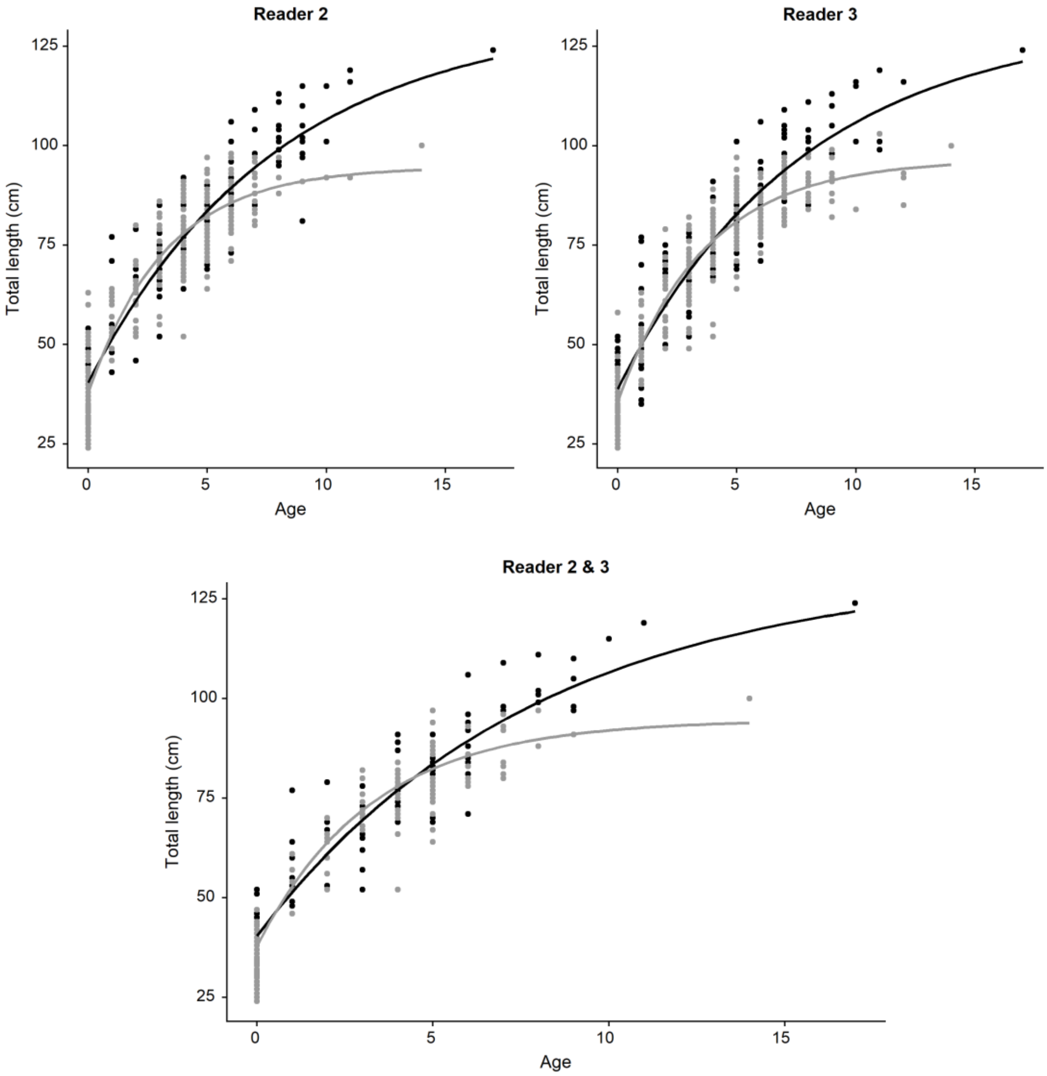

Figure 6: Preliminary estimated ages and growth curves for *Mustelus asterias* for females (black) and males (grey) for each reader (top panel) and for combined ages for fish where agreement was reached (bottom panel). Reader 1 not shown at this stage as only a subset of ages QC'd.

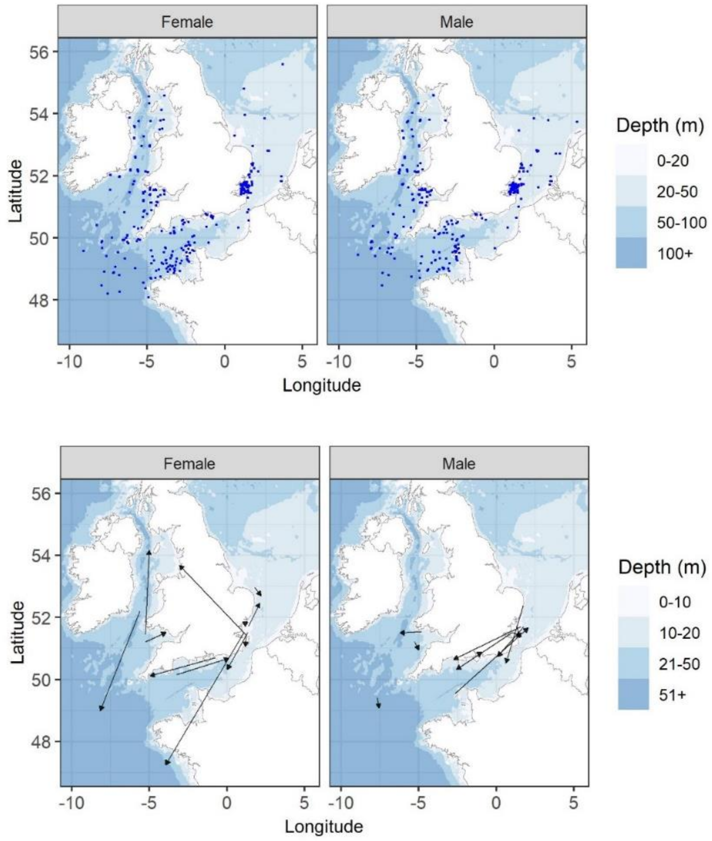

Figure 7: Tagging locations (on top) and displacement vectors (on bottom) of female and male *Mustelus asterias*.

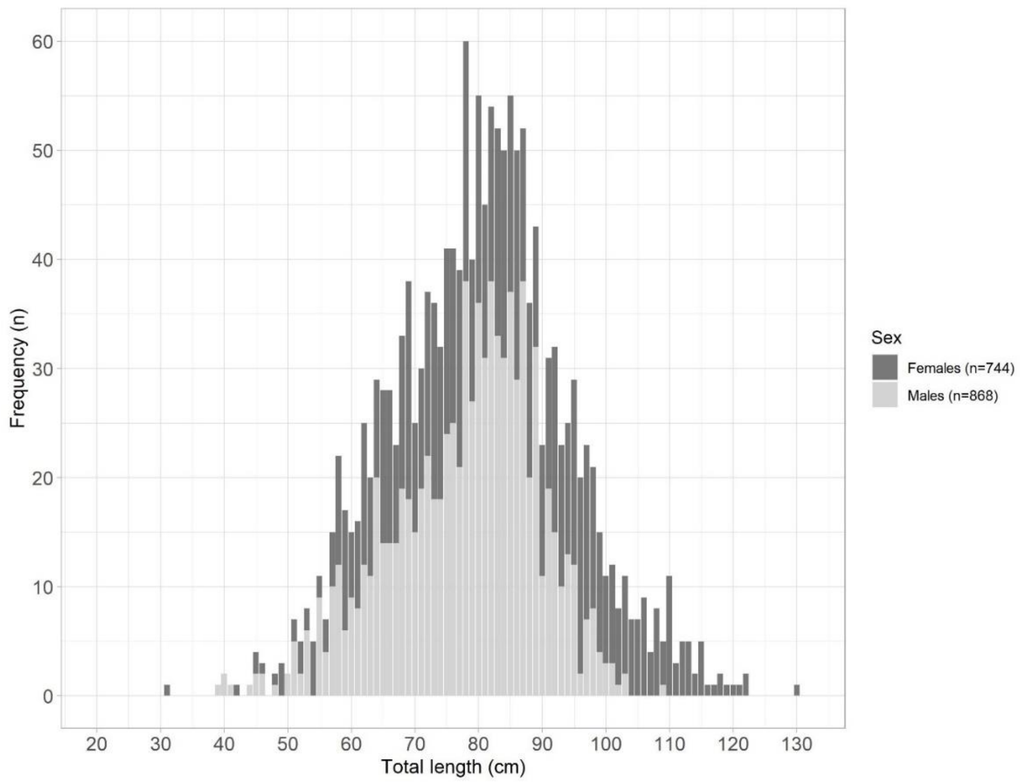

Figure 8: Length frequency distribution for tagged female and male *Mustelus asterias.*

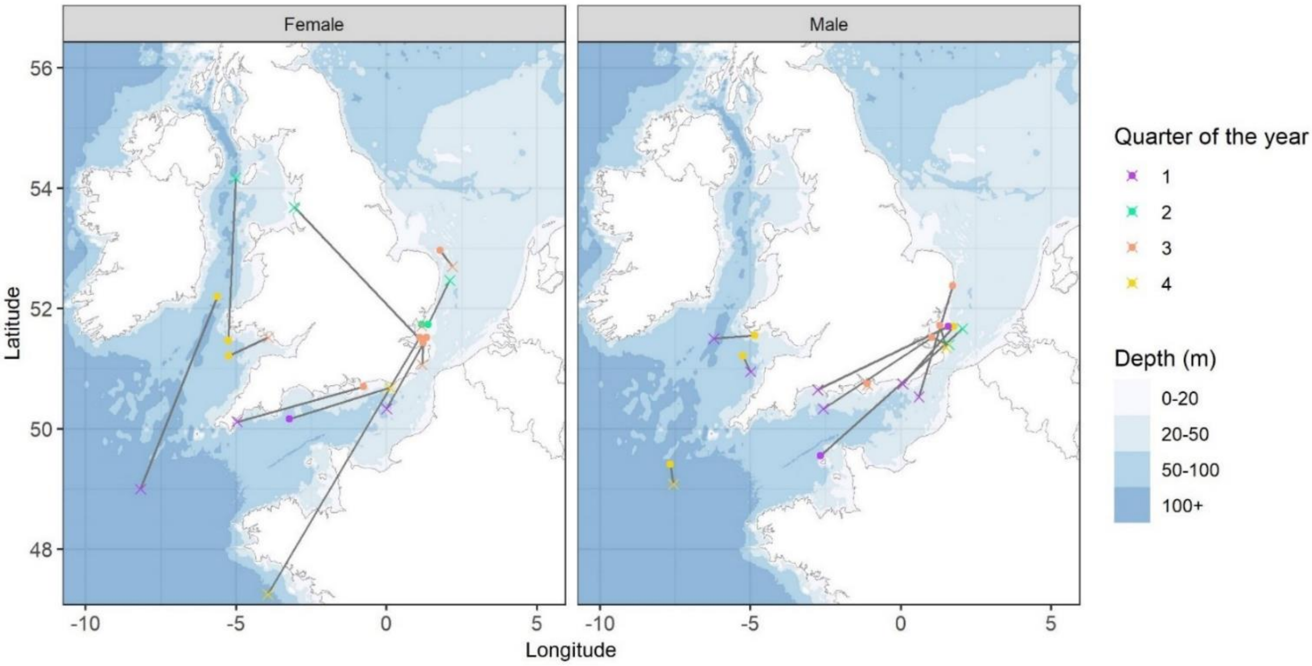

Figure 9: Displacement vectors (on bottom) of female and male *Mustelus asterias* with indication of the quarter of the year. Dots indicate release location and crosses indicate recapture location.

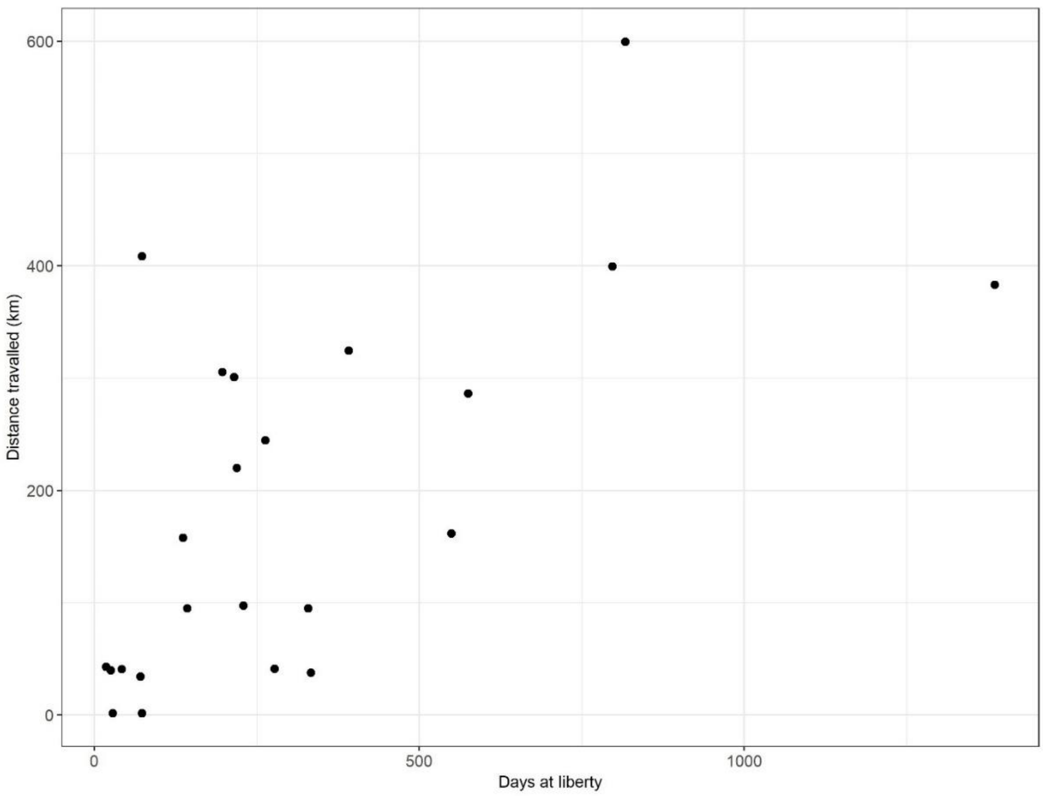

Figure 10: Relationship between the minimum distance travelled (km) and the number of days at liberty of recaptured *Mustelus asterias*.

<u>**Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 18–27 2019**</u>

Tope *Galeorhinus galeus*: A preliminary bibliography of scientific studies

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Abstract: There is increasing interest in tope (or school shark) *Galeorhinus galeus*, which is listed as Vulnerable by the IUCN. A range of biological studies have been undertaken from across the species' range, including the NE Atlantic, SW Atlantic, eastern Pacific, Australia, New Zealand and South Africa. Earlier literature may refer to junior synonyms of *G. galeus*, including *G. australis, G. vitaminicus* and *G. zyopterus.* Given the broad geographical range of the species, the range of common names in use (e.g. tope, school shark, soupfin shark, cazón), and range of scientific names attributed to the species over the longer-term, the scientific literature for this species has largely been uncollated. A preliminary bibliography of scientific papers relevant to the fisheries biology of tope was collated, in order to provide a source of relevant information.

A preliminary bibliography of scientific studies on the tope *Galeorhinus galeus*

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New updated survey index for catsharks (*Scyliorhinus* spp.) and starry smooth-hound *Mustelus asterias* in the Q3 UK beam trawl survey of the Irish Sea and Bristol Channel (ICES Divisions 7.a.f)

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Abstract: The present document refers to an update of data provided by UK (England & Wales) to the ICES WGEF 2017 on *Scyliorhinus canicula* and *S. stellaris* in the Q3 UK beam trawl survey in the Irish Sea and Bristol Channel (ICES Divisions 7.a.f.) (Ellis, 2017). Average catch rates of starry smooth-hound *Mustelus asterias*, lesser-spotted dogfish *Scyliorhinus canicula* and greater-spotted dogfish *Scyliorhinus stellaris* increased over the time series. Although, the abundance mean catch rates (2017–2018) have decreased slightly compared to the preceding five-year period (2012–2016) for both *Scyliorhinus* spp. contrary occurring for starry smooth-hound *Mustelus asterias*, which shows an increase in mean catch rate for 2017–2018.

Introduction

The annual beam trawl survey conducted in the Irish Sea and Bristol Channel (Divisions 7.a.f) samples two of the three species of catshark that occur in that area: lesser-spotted dogfish *Scyliorhinus canicula* and greater-spotted dogfish *Scyliorhinus stellaris*. Black-mouth dogfish *Galeus melastomus* has been recorded from the deeper parts of the north-western Irish Sea (Ellis *et al.*, 2002), but these grounds are not usually sampled. This beam trawl survey also capture starry smooth-hound *Mustelus asterias*, although the majority of specimens are smaller-bodied individuals.

Methods

The UK beam trawl survey in ICES Divisions 7.a.f. has been conducted since 1989, although only with a standardized survey grid 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). Therefore, the index here presented has only been calculated from 1993 onwards using the Cefas Fishing Survey System (FSS) and R software (2017).

The survey of the Irish Sea and Bristol Channel is conducted each September (although surveys in any one year may extend into late August or early October), and 97 fixed stations have been fished consistently over the time period (during at least 23 years of the 26-year study period). 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. From these primes, only data from successfully fished stations are considered in the survey index calculation. Data from other stations were excluded from the present analysis of temporal trends, in order to ensure that data were as standardised as possible.

Data for common smooth-hound *Mustelus mustelus* and starry smooth-hound *M. asterias* were aggregated and considered to relate to the latter starry smooth-hound.

Catch rates for this survey are based on abundance (mean ind.h^{-1}) for all three species in this study, and on biomass (mean kg.h^{-1}) for only *M. asterias* and *S. canicula*. Numbers at length were raised to biomass using the length-weight relationships in Silva *et al.* (2013), with parameters for *M. asterias as* a = 0.0030 and b = 3.039 and, for *S. canicula* as a = 0.0022 and b = 3.1194. Data for all fish are included in these calculations.

Whilst *S. canicula* is caught in abundance over the entire length range, fewer *S. stellaris* are caught and these may range in size from newly-hatched specimens to large mature individuals. Consequently, an index based on biomass may lead to more variable indices for this species, and so *S. stellaris* is examined in terms of numbers.

Numbers at length and biomass were aggregated across sex and length class per station and raised to one-hour tow duration. These results were then divided by the number of successfully fished prime stations in a given year (including zero catch stations) in order to provide the final survey index as the mean catch rate by abundance (mean ind.h^{-1}) and biomass (mean kg.h^{-1}). All analyses were done in R (R Core Team, 2017).

Results and discussion

<u>Lesser-spotted dogfish</u>

Scyliorhinus canicula occurs over a range of bathymetric and sedimentary environments and is distributed widely across the survey area. Average catch rates of *S. canicula* in the beam trawl survey of the Irish Sea and Bristol Channel have shown a longer-term increase over the entire time series (Figure 1; Table 1).

There were contrasting signals in relation to the mean annual cpue for 2017–2018 when compared to the preceding 5-year period, with a small decrease in terms of abundance (0.97) but a slight increase in biomass (1.04). Overall, the data suggest an increase in the most recent year, similar to the peak catch rates observed in 2011–2013.

Greater-spotted dogfish

S. stellaris is taken frequently in the beam trawl survey of the Irish Sea and Bristol Channel, mainly in Welsh waters. Whilst catch rates are low, it should be noted that this species inhabits inshore, rocky areas and so only occurs in certain parts of the survey grid. Whilst the mean catch for the most recent two-years (2017–2018) has declined (0.79) from the preceding five-year period (2012–2016), there has been a longer-term increase in the catch rates of this species (Figure 1; Table 1).

Starry smooth-hound

Mustelus asterias occurs over a range of habitats, with beam trawl surveys sampling primarily juveniles, with proportionally fewer mature fish captured by this gear.

Average catch rates have increased over the overall time series in the Irish Sea and Bristol Channel (Figure 1; Table 1). However, data suggest a recent decrease in 2018. The mean annual cpue for 2017–2018 (compared to the preceding 5-year period) has shown a recent increase of 1.05 (abundance) and 1.37 (biomass).

Data quality

It should be noted that the survey indices for both species differ very slightly in some years from the previous indices provided to WGEF in 2017. This is the result of on-going quality assurance procedures for information held in the Cefas database (FSS)[1]. However, the differences are very minor (Figure 2), the overall trend has not changed, and it is not considered to have an impact on the advice for these species.

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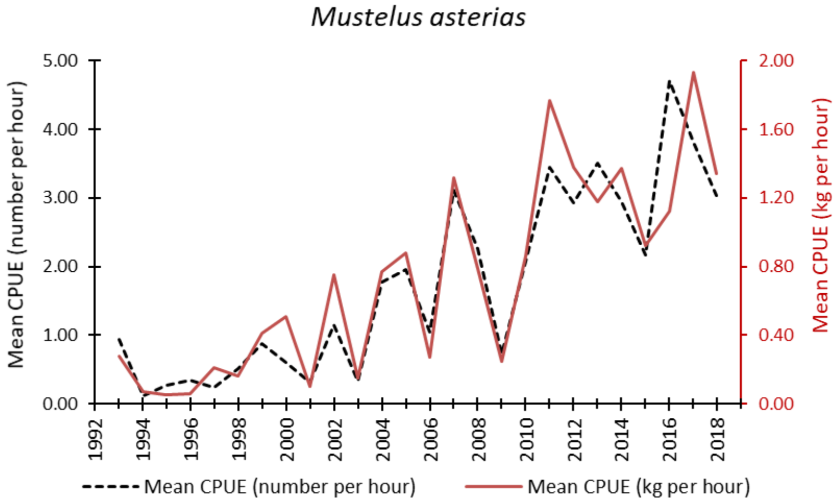
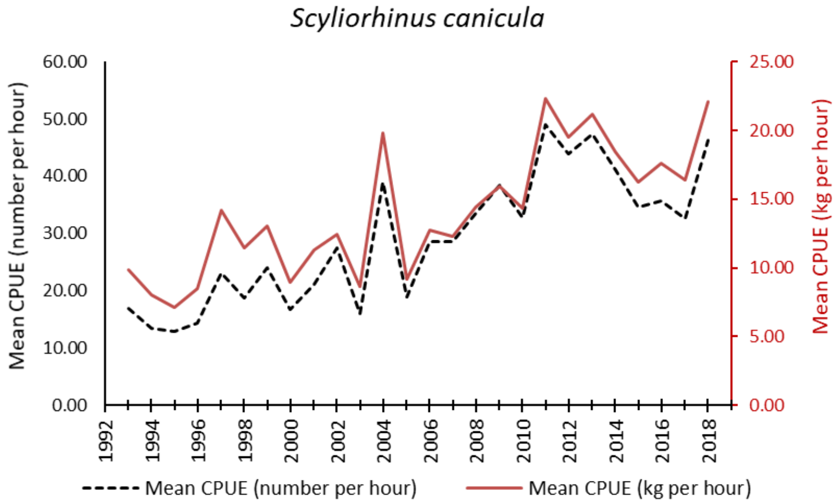
Table 1: Annual mean CPUE (n.h^{-1} and kg.h^{-1}) of *Scyliorhinus canicula*, annual mean CPUE (n.h^{-1}) of *Scyliorhinus stellaris* and the number of successfully fished prime stations per year in the 7.a and 7.f beam trawl survey (1993–2018). *new and updated estimate for catch rate (with different data provided to WGEF 2017).

Year	N prime stations fished	*Mustelus asterias*		*Scyliorhinus canicula*		*Scyliorhinus stellaris*
		Mean catch rate (ind.h^{-1})	Mean catch rate (kg.h^{-1})	Mean catch rate (ind.h^{-1})	Mean catch rate (kg.h^{-1})	Mean catch rate (ind.h^{-1})
1993	92	0.93	0.28	16.94	9.84	0.07
1994	97	0.12	0.07	13.38	8.04	0.09
1995	95	0.27	0.05	12.80	7.11	0.06
1996	95	0.34	0.06	14.40	8.52	0.08
1997	96	0.24	0.21	23.04*	14.20*	0.19
1998	95	0.51	0.16	18.67	11.47	0.17
1999	97	0.88	0.41	24.06	13.02	0.45
2000	93	0.60*	0.51*	16.71*	8.97*	0.30
2001	97	0.31	0.10	21.03*	11.32*	0.21
2002	97	1.15	0.75	27.53	12.40	0.27
2003	97	0.33	0.15	16.00	8.65	0.33
2004	96	1.77	0.77	38.90	19.84	0.36
2005	96	1.96	0.88	18.99	9.15	0.42
2006	97	1.05	0.27	28.60	12.77	0.27
2007	97	3.11	1.32	28.63	12.25	0.27
2008	93	2.26	0.79	33.49	14.38	0.21
2009	97	0.72*	0.25*	38.34*	15.91*	0.21
2010	97	2.08	0.86	32.76*	14.35*	0.41*
2011	96	3.45	1.77	48.96	22.29	0.81
2012	97	2.93	1.38	43.80	19.53	0.56
2013	97	3.51	1.18	47.37	21.19	0.36
2014	97	2.95	1.37	41.11	18.45	0.47
2015	97	2.17	0.92	34.52	16.20	0.41
2016	96	4.70	1.12	35.68	17.60	0.36
2017	97	3.81	1.93	32.56	16.42	0.27
2018	97	3.03	1.34	46.33	22.12	0.41
Index A (2017-2018)		3.42	1.64	39.45	19.27	0.34
Index B (2012-2016)		3.25	1.19	40.50	18.59	0.43
Index A / Index B		1.05	1.37	0.97	1.04	0.79

Figure 1: Temporal trends in the CPUE (n.h^{-1} and kg.h^{-1}) of *Mustelus asterias*, *Scyliorhinus canicula* and *Scyliorhinus stellaris* in the 7.a.f. beam trawl survey (1993–2018).





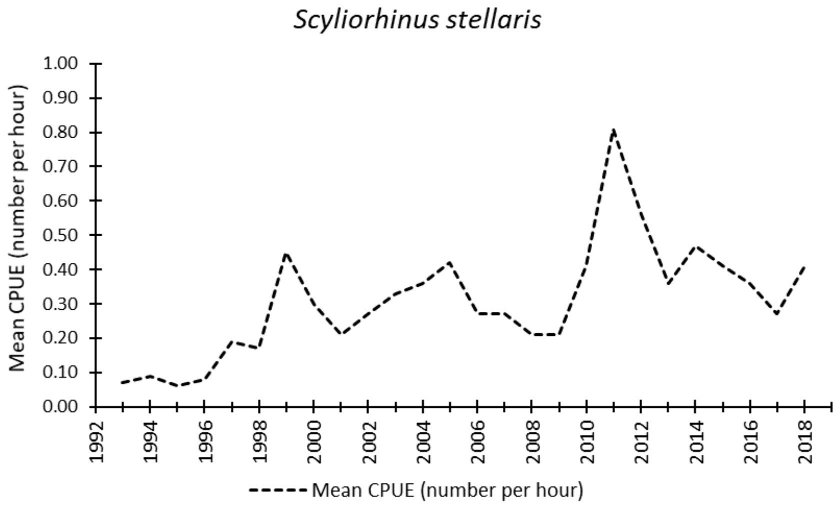
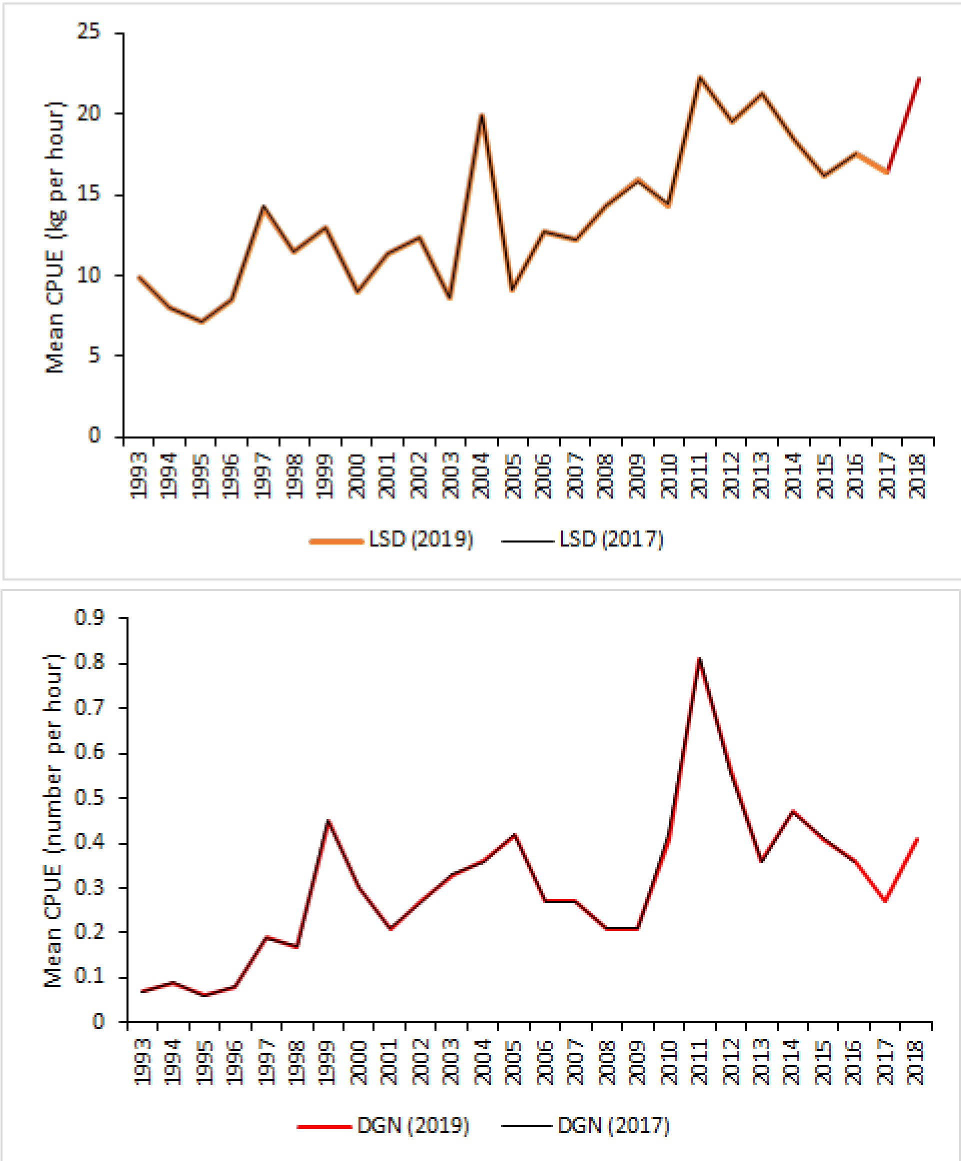


Figure 2: Differences in the indices for *Scyliorhinus canicula* (LSD; biomass index; top) and *Scyliorhinus stellaris* (DGN; abundance index; bottom) in the 7.a.f. beam trawl survey (1993–2018). The corrected data are not discernible from the previous index.



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 (PTGFS-WIBTS-Q4), 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 1990-2018. Increasing trends was observed for R. clavata, while R. montagui showed a stable trend between 2014 and 2017 and no catch in 2018 (to note that for that year a different vessel performed part of the survey). Captures of L. naevus in 2016 and 2017 were limited to take conclusions on biomass and abundance trends, while in 2018 were above the average of the time series.*

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 (PTGFS-WIBTS-Q4), 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 PTGFS-WIBTS-Q4 surveys from 1990 to 2017 (except for RJM that was from 2005 to 2017), while that for *L. naevus* (RJN) was obtained from PT-CTS surveys from 1997 to 2017, conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) onboard the RV "Noruega" (Dimensions= 47.52m 10.32m, Ton= 693 ton).
To note that for RJC the surveys from 1996, 1999, 2003 and 2004 conducted onboard the RV "Capricrnio" and from which the captures were not comparable to the remaining series, were not considered in the analysis. No PTGFS-WIBTS-Q4 survey was conducted in 2012, and no PT-CTS survey was conducted in 2004, 2010 and 2012.
Also to highlight, that in 2018, due to mechanical problems in RV "Noruega", part of the demersal survey was conducted onboard the commercial trawler "Calypso" (Dimensions= 24.8m 7.8m, Ton= 215 ton), which covered the Alentejo coast (strata LIS, SIN, MIL and ARR).

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 3.6.0 (www.r-project.org) and the level of significance was $\alpha < 0.05$.

3. Results/Discussion

3.1. Raja clavata (thornback ray, RJC)

Raja clavata (13-110 cm LT) is found along the coast, from 23 to 675 m deep, but more common south off Cabo Carvoeiro and shallower than 200 m deep (Fig. 1).

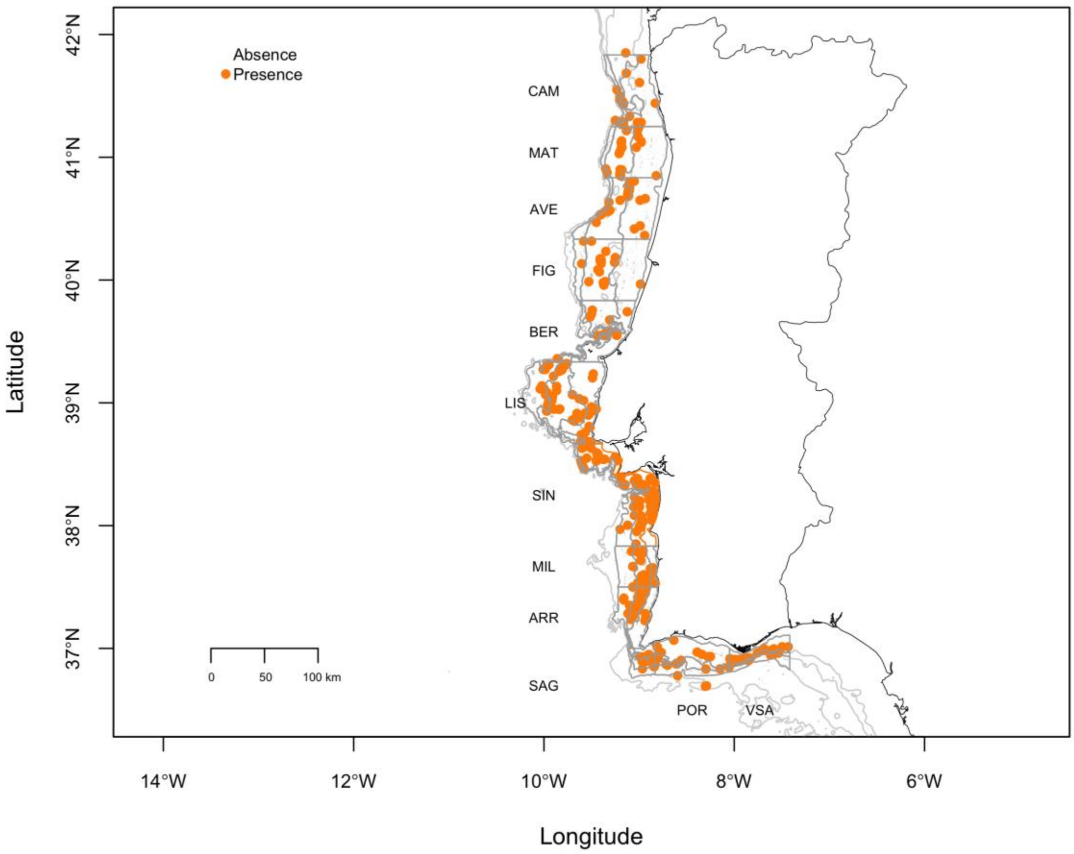

Figure 1. *Raja clavata* distribution from 1981 to 2018 (PTGFS-WIBTS-Q4 surveys).

A summary of the number of stations conducted and those with the species is presented in Table 1. The percentage of stations with the species was higher in the last two years comparing to the overall series. If the stations from "Calypso" are removed from 2018, the percentage of occurence of the species is 19%.

Table 1. Summary of the number of stations by year (n), number (n.spp) and percentage (%.spp) of stations with the species *Raja clavata* (non-zeros).

	n	n.spp	%.spp
1990	123	23	0.19
1991	93	9	0.10
1992	59	10	0.17
1993	65	9	0.14
1994	88	11	0.12
1995	88	8	0.09
1996	70	20	0.29
1997	58	12	0.21
1998	74	7	0.09
1999	79	14	0.18

2000	78	11	0.14
2001	58	8	0.14
2002	66	6	0.09
2003	80	25	0.31
2004	79	28	0.35
2005	89	14	0.16
2006	88	6	0.07
2007	96	17	0.18
2008	87	9	0.10
2009	93	13	0.14
2010	87	11	0.13
2011	86	15	0.17
2013	93	17	0.18
2014	81	12	0.15
2015	92	20	0.22
2016	85	15	0.18
2017	89	22	0.25
2018	65	19	0.29

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 2 and Fig. 2). Considering all the station conducted in 2018, the mean annual biomass index for 2017-2018 (0.74 kg.h^{-1}) was 93% greater than observed in the preceding five years (2012-2016; 0.38 kg.h^{-1}). While, mean annual abundance index for 2016-2017 (4.33 num.h^{-1}) was 434% greater than observed in the preceding five years (2012-2016; 0.77 num.h^{-1}).

Due to possible differences in the catchability of *Raja clavata* between RV "Noruega" and "Calypso" the indexes were also computed without the stations from the later. For that series, the mean annual biomass index for 2017-2018 (0.60 kg.h^{-1}) was 56% greater than observed in the preceding five years (2012-2016; 0.39 kg.h^{-1}), while, the mean annual abundance index for 2016-2017 (1.68 num.h^{-1}) was 103% greater than observed in the preceding five years (2012-2016; 0.83 num.h^{-1}) (Table 3 and Fig. 3). Due to the differences observed in the catch levels onboard "Calypso" when compared to the data series onboard "Noruega" (specially that for station #61; Fig. 4), and since no calibration was performed between vessels, is to WGEF group to decide what is the dataset and model to be considered to provide the indices for 2018.

Table 2. *Raja clavata* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PTGFS-WIBTS-Q4 from 1990 to 2018. Standard error (s.e.) is also presented for each index.

YEAR	Biomass	s.e.	Abundance	s.e.
1990	0.3090	0.09402	0.4565	0.1832
1991	0.2462	0.08792	0.3521	0.1624
1992	0.3525	0.13667	0.7048	0.3289
1993	0.3578	0.13483	0.5489	0.2703
1994	0.1774	0.07369	0.3179	0.1579

YEAR	Biomass	s.e.	Abundance	s.e.
1995	0.1863	0.07362	0.4191	0.1873
1997	0.4469	0.15430	0.5924	0.2796
1998	0.1469	0.07321	0.3378	0.1823
2000	0.3214	0.11485	0.8330	0.3349
2001	0.2399	0.09844	0.3670	0.1901
2002	0.1427	0.06504	0.1912	0.1122
2005	0.3341	0.10607	0.6759	0.2598
2006	0.1342	0.05831	0.2631	0.1314
2007	0.3381	0.10654	0.7961	0.2942
2008	0.2314	0.08408	0.4673	0.2009
2009	0.3802	0.11739	0.8628	0.3175
2010	0.3495	0.10982	0.4789	0.2001
2011	0.3887	0.12075	0.6616	0.2607
2013	0.3325	0.10672	0.5284	0.2198
2014	0.3333	0.11145	0.5091	0.2200
2015	0.4284	0.12586	1.0009	0.3564
2016	0.4404	0.12841	1.0530	0.3690
2017	0.5996	0.16968	1.4844	0.5153
2018	0.8792	0.27126	6.7700	2.0676

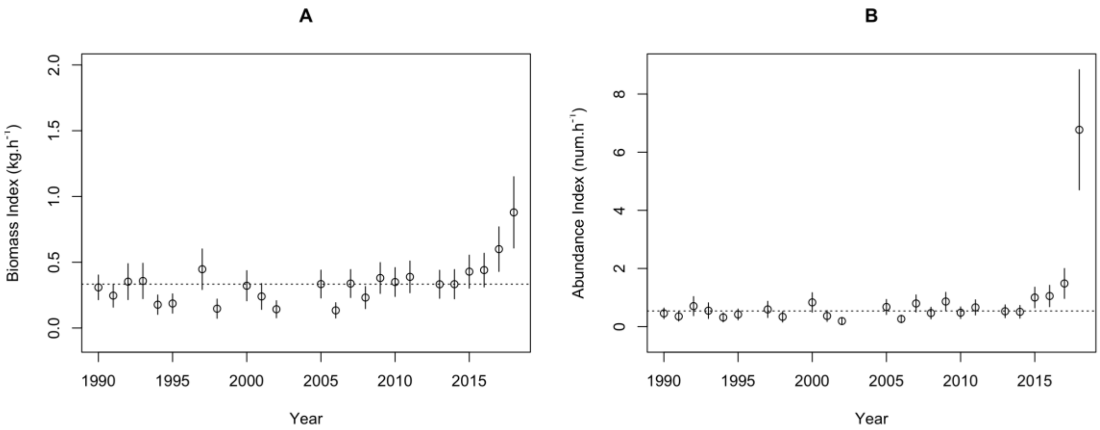

Figure 2. *Raja clavata* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PTGFS-WIBTS-Q4 from 1990 to 2018. Dashed line represents the mean annual abundance for the considered period.

Table 3.*Raja clavata* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PTGFS-WIBTS-Q4 from 1990 to 2018, removing stations conducted onboard Calypso. Standard error (s.e.) is also presented for each index.

YEAR	Biomass	s.e.	Abundance	s.e.
1990	0.3113	0.09450	0.4779	0.1837
1991	0.2485	0.08849	0.3810	0.1686
1992	0.3534	0.13682	0.7395	0.3310
1993	0.3601	0.13531	0.5710	0.2696
1994	0.1794	0.07430	0.3479	0.1657

1995	0.1884	0.07423	0.4748	0.2012
1997	0.4507	0.15518	0.6384	0.2870
1998	0.1484	0.07382	0.3791	0.1950
2000	0.3239	0.11541	0.9387	0.3565
2001	0.2428	0.09935	0.4002	0.1980
2002	0.1435	0.06535	0.2061	0.1174
2005	0.3371	0.10677	0.7322	0.2671
2006	0.1356	0.05882	0.2936	0.1397
2007	0.3413	0.10719	0.8606	0.3020
2008	0.2336	0.08468	0.4968	0.2042
2009	0.3840	0.11819	0.9342	0.3257
2010	0.3527	0.11045	0.5102	0.2036
2011	0.3918	0.12141	0.6936	0.2611
2013	0.3348	0.10714	0.5565	0.2210
2014	0.3348	0.11171	0.5356	0.2224
2015	0.4315	0.12633	1.0606	0.3585
2016	0.4448	0.12923	1.1550	0.3821
2017	0.6036	0.17012	1.5525	0.5097
2018	0.6051	0.24994	1.8064	0.8068

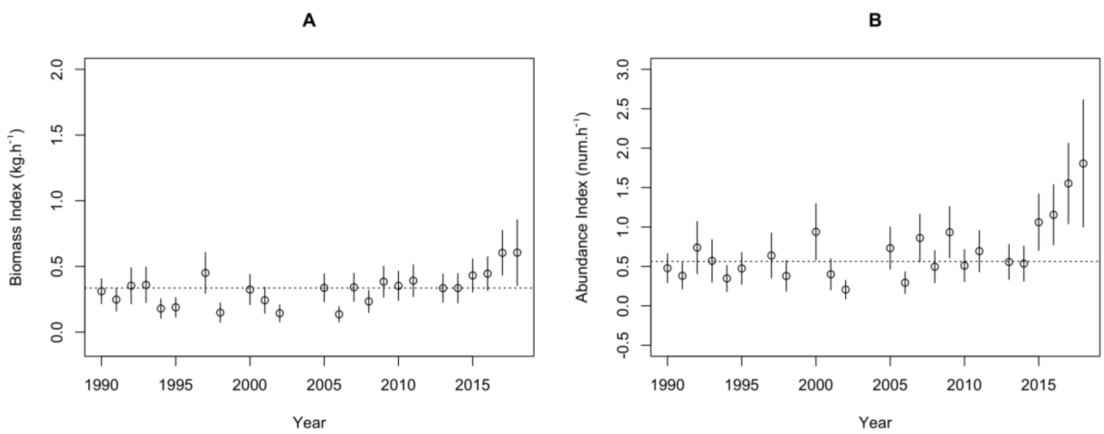

Figure 3. *Raja clavata* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PTGFS-WIBTS-Q4 from 1990 to 2018, removing stations conducted onboard Calypso. Dashed line represents the mean annual abundance for the considered period.

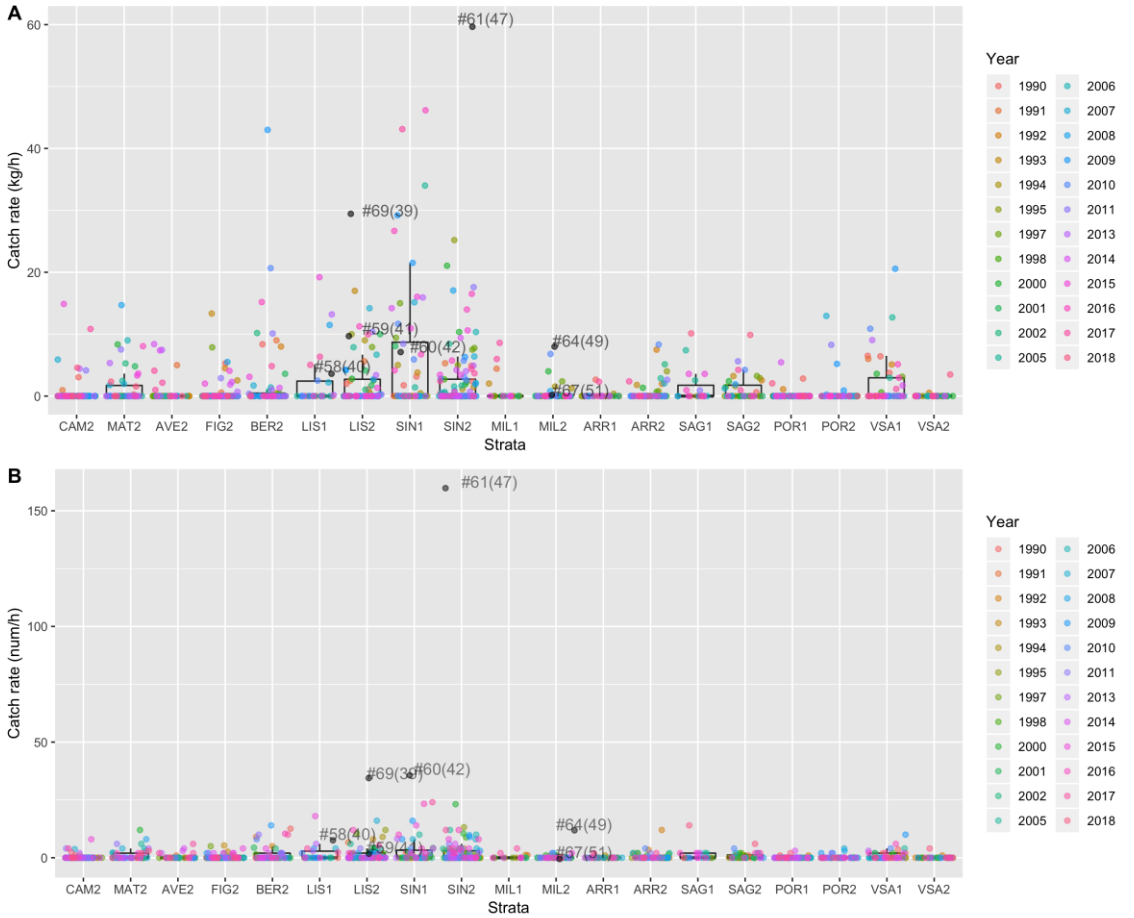

Figure 4. Distribution of the catch rate (A) of *Raja clavata* in weight and in number) by strata. Points are coloured by year. The grey points correspond to the stations conducted onboard Calypso with indication of the number of stations and code of stations between brackets.

The length distribution was relatively stable along the time-series, with the mean length above the average in 2017 and 2018 (Fig. 5).

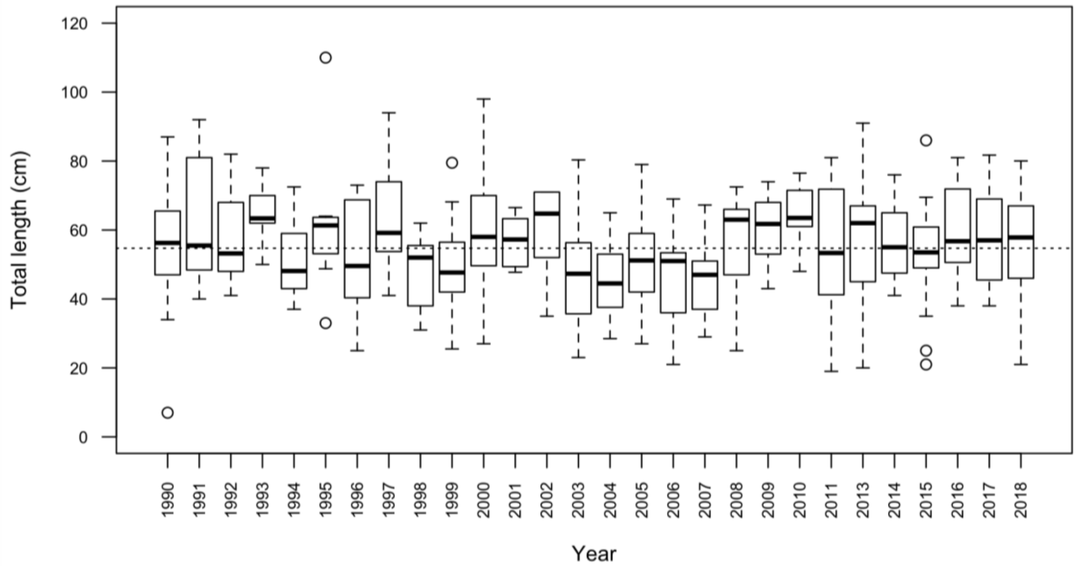

Figure 5. Total length variation of *Raja clavata*, by year on PTGFS-WIBTS-Q4 (dashed line represents the mean annual length for 1990-2017).

3.2. Raja montagui (spotted ray, RJM)

Raja montagui (21-71 cm LT) is found along the coast, from 21 to 455 m deep, but more common in the southwest coast of Portugal, between 40 and 150 m deep (Fig. 6).

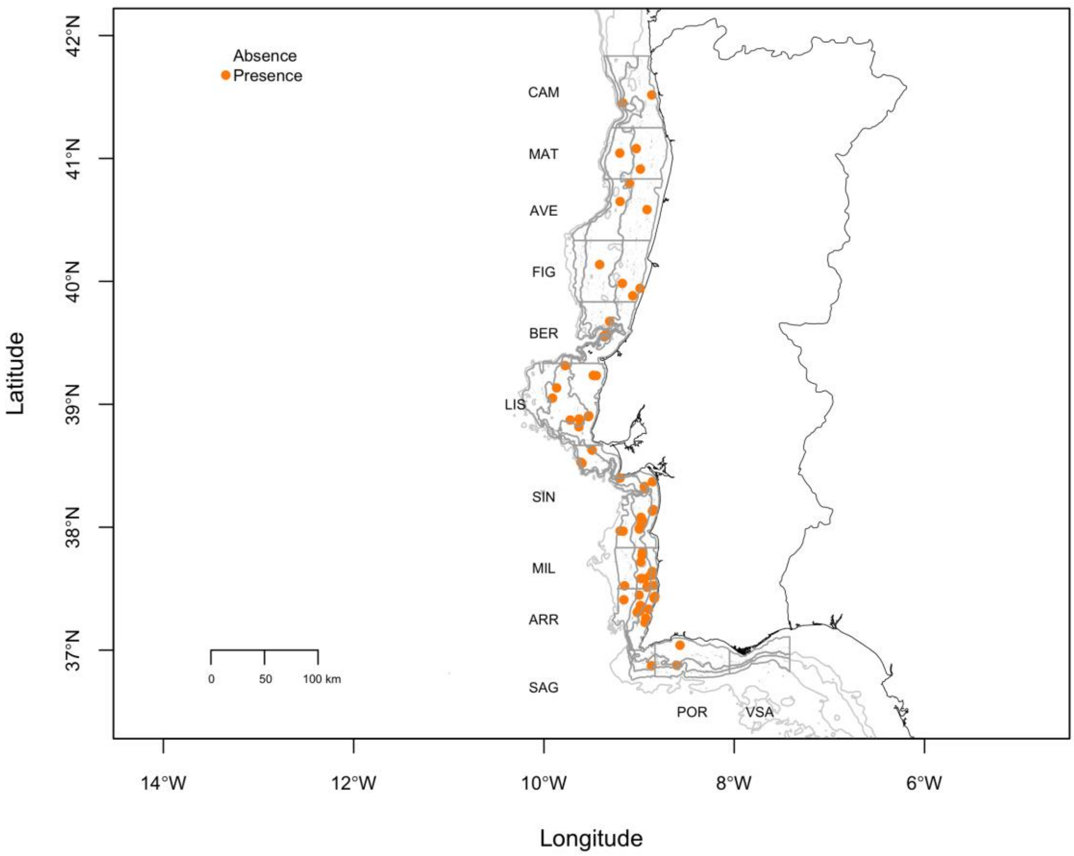

Figure 6. *Raja montagui* distribution from 1981 to 2018 (PTGFS-WIBTS-Q4 surveys).

A summary of the number of stations conducted and those with the species is presented in Table 4. The percentage of stations with the species was stable in the last five years, between 6 and 10%. However, if the stations from "Calypso" are removed from 2018, the percentage of occurence of the species is 0%.

Table 4. Summary of the number of stations by year (n), number (n.spp) and percentage (%.spp) of stations with the species *Raja montagui* (non-zeros).

Year	n	n.spp	%.spp
1990	123	23	0.19
1991	93	9	0.10
1992	59	10	0.17
1993	65	9	0.14
1994	88	11	0.12
1995	88	8	0.09
1996	70	20	0.29
1997	58	12	0.21
1998	74	7	0.09
1999	79	14	0.18
2000	78	11	0.14
2001	58	8	0.14
2002	66	6	0.09
2003	80	25	0.31
2004	79	28	0.35
2005	89	14	0.16
2006	88	6	0.07
2007	96	17	0.18
2008	87	9	0.10
2009	93	13	0.14
2010	87	11	0.13
2011	86	15	0.17
2013	93	17	0.18
2014	81	12	0.15
2015	92	20	0.22
2016	85	15	0.18
2017	89	22	0.25
2018	65	19	0.29

The biomass and abundance Indexes have been relatively stable since 2014 and above the average values for the time-series (Table 5 and Fig. 7). Considering all the station conducted in 2018, the mean annual biomass index for 2017-2018 (0.22 kg.h^{-1}) was 30% greater than observed in the preceding five years (2012-2016; 0.17 kg.h^{-1}). While, mean annual abundance index for 2016-2017 (2.39 num.h^{-1}) was 594% greater than observed in the preceding five years (2012-2016; 0.34 num.h^{-1}).

Due to possible differences in the catchability of *Raja montagui* between RV "Noruega" and "Calypso" the indexes were also computed without the stations from the later. Yet to note, that in 2018, all the catches of the species were made onboard "Calypso", and therefore absent from the catch on the remaining stations (i.e. onboard RV "Noruega" the catch of *Raja montagui* was 0 kg/0 individuals) For that series, the mean annual biomass index for 2017-2018 (0.09 kg.h^{-1}) was 52% smaller than observed in the preceding five years (2012-2016; 0.18 kg.h^{-1}), while, the mean annual abundance index for 2016-2017 (0.60 num.h^{-1}) was 40% smaller than observed in the preceding five years (2012-2016; 0.41 num.h^{-1}) (Table 6 and Fig. 8). Due to the differences observed in the catch levels onboard "Calypso" when compared to the data series onboard "Noruega" (specially that for station #61; Fig. 9), and since no calibration was performed between vessels, is to WGEF group to decide what is the dataset and model to be considered to provide the indices for 2018.

Table 5.*Raja montagui* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PTGFS-WIBTS-Q4 from 2005 to 2018. Standard error (s.e.) is also presented for each index.

YEAR	Biomass	s.e.	Abundance	s.e.
2005	0.06	0.04	0.11	0.08
2006	0.06	0.04	0.11	0.08
2007	0.02	0.02	0.08	0.06
2008	0.10	0.06	0.28	0.18
2009	0.09	0.06	0.14	0.10
2010	0.07	0.05	0.11	0.09
2011	0.05	0.04	0.13	0.10
2013	0.07	0.05	0.08	0.07
2014	0.20	0.10	0.34	0.21
2015	0.23	0.11	0.53	0.29
2016	0.19	0.09	0.42	0.24
2017	0.17	0.09	0.45	0.26
2018	0.28	0.17	4.33	2.04

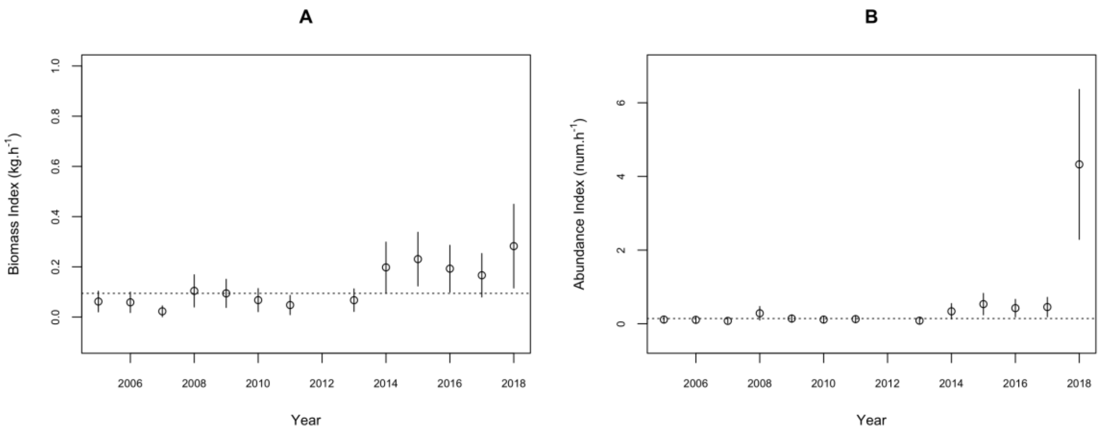

Figure 7. *Raja montagui* A) biomass index (kg.hour^{-1}) and B) abundance (num.hour^{-1}) on PTGFS-WIBTS-Q4 from 2005 to 2018. Dashed line represents the mean annual abundance for the considered period.

Table 6. *Raja montagui* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PTGFS-WIBTS-Q4 from 2005 to 2018,removing stations conducted onboard Calypso. Standard error (s.e.) is also presented for each index.

YEAR	Biomass	s.e.	Abundance	s.e.
2005	0.07	0.04	0.16	0.10
2006	0.06	0.04	0.11	0.08
2007	0.02	0.02	0.09	0.07
2008	0.11	0.07	0.40	0.21
2009	0.10	0.06	0.18	0.11
2010	0.07	0.05	0.14	0.09
2011	0.05	0.04	0.16	0.11
2013	0.07	0.05	0.10	0.08
2014	0.20	0.10	0.39	0.20
2015	0.24	0.11	0.62	0.27
2016	0.20	0.09	0.53	0.24
2017	0.17	0.09	0.49	0.24
2018	0.00	0.00	0.00	0.00

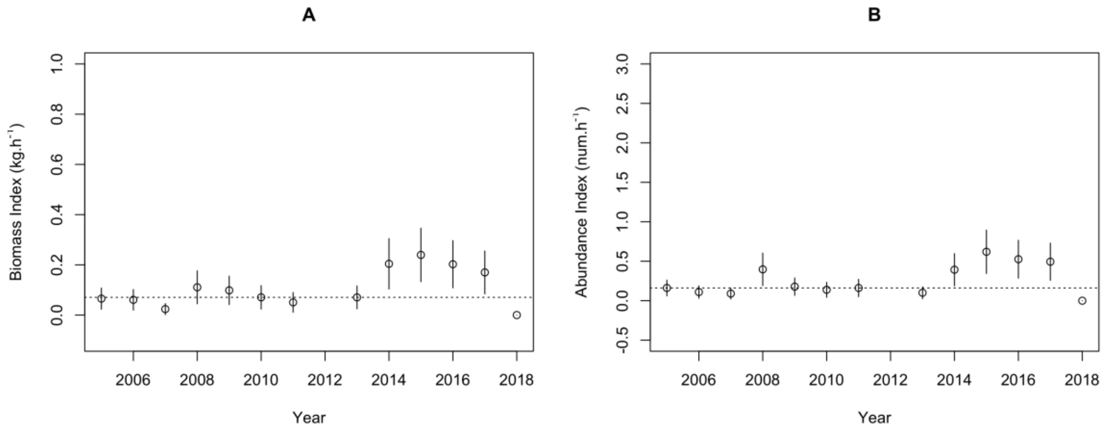

Figure 8. *Raja montagui* A) biomass index (kg.hour^{-1}) and B) abundance (num.hour^{-1}) on PTGFS-WIBTS-Q4 from 2005 to 2018,removing stations conducted onboard Calypso. Dashed line represents the mean annual abundance for the considered period.

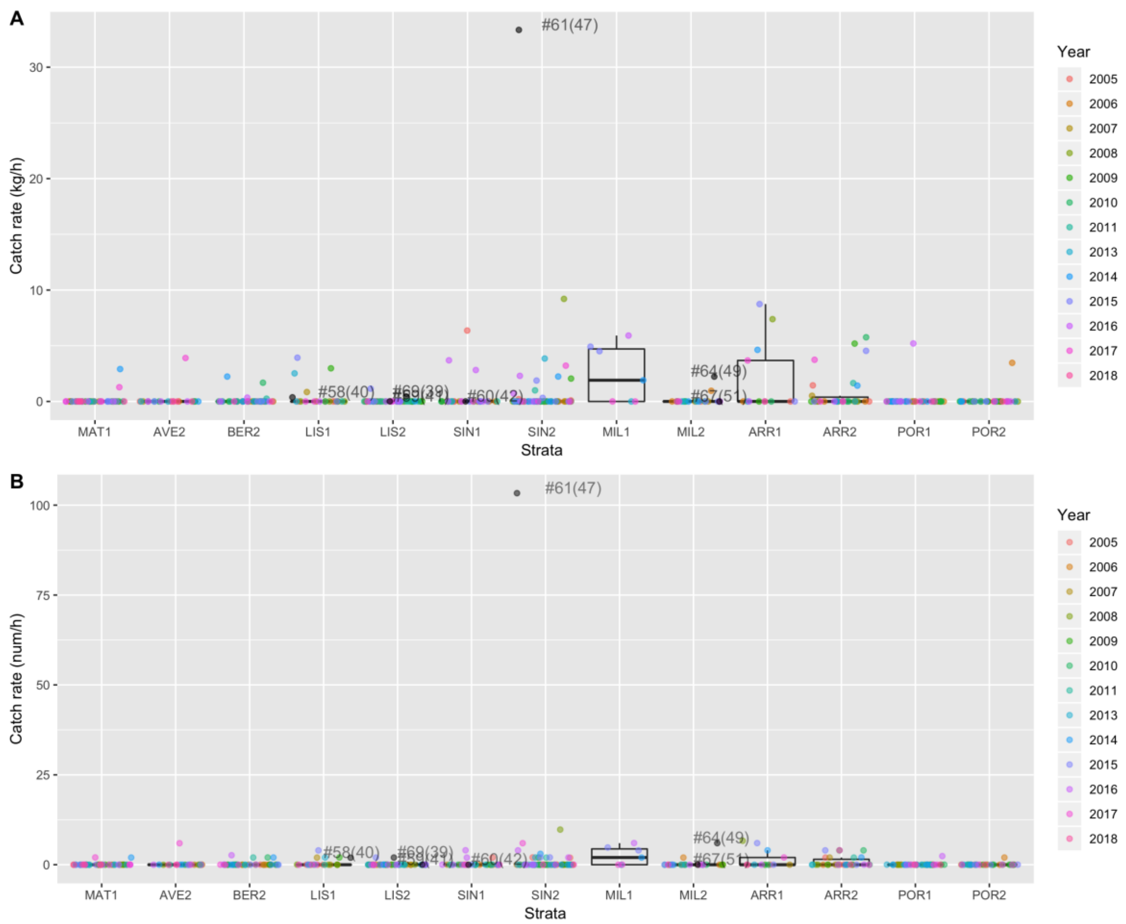

Figure 9. Distribution of the catch rate (A) of *Raja montagui* in weight and in number) by strata. Points are coloured by year. The grey points correspond to the stations conducted onboard Calypso with indication of the number of stations and code of stations between brackets.

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. 10). As onboard "Calypso" no measurements were recorded, and the species only occur on the stations conducted there, there are no estimates of the mean total length in 2018.

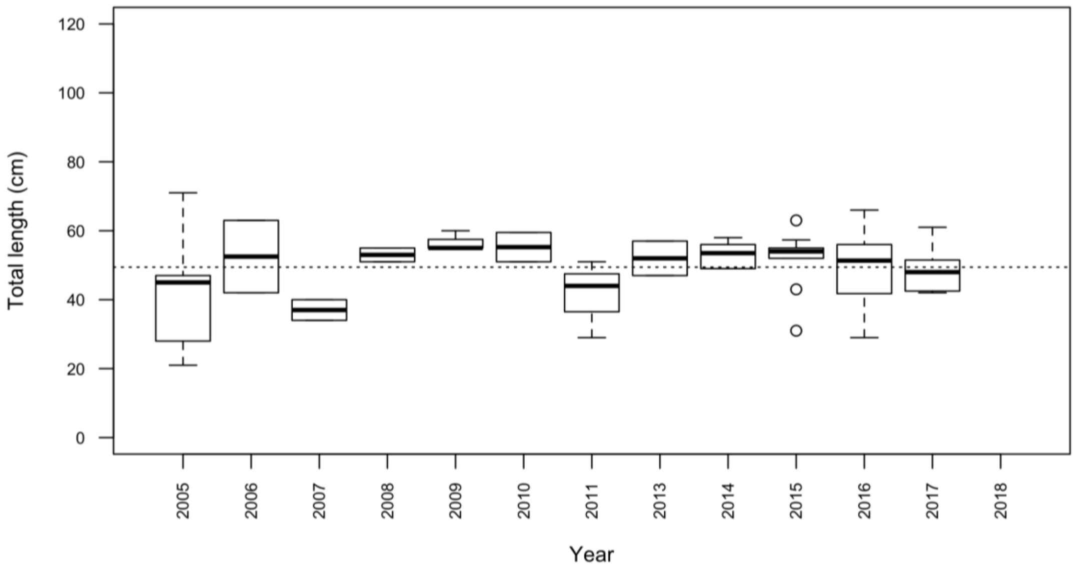

Figure 10. Total length variation of *Raja montagui*, by year on PTGFS-WIBTS-Q4 (dashed line represents the mean annual length for 2005-2018).

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. 11).

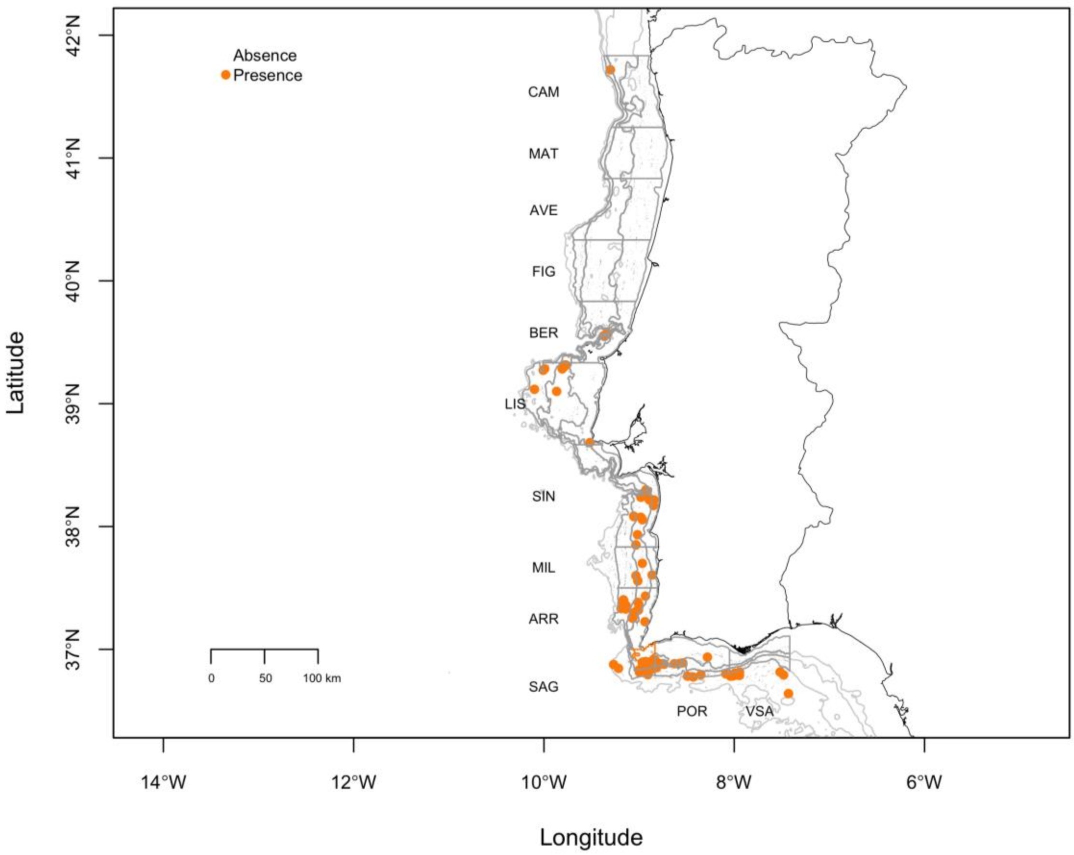

Figure 11. *Leucoraja naevus* distribution from 1981 to 2017 (all surveys combined).

In 2016 there were no catches of *Leucoraja naevus* in the PT-CTS. In 2017, the catch of *Leucoraja naevus* attained the lowest levels of the PT-CTS series (Fig. 12). The same occured with other demersal species (e.g. anglerfishes), but until this meeting no justification was found for that occurence. To note, that by mistake, in previous WGEF meetings the zero catch in 2009 and 2016 were referred as NA, but corrected in the present working document. The WGEF 2019 report should be updated accordingly.

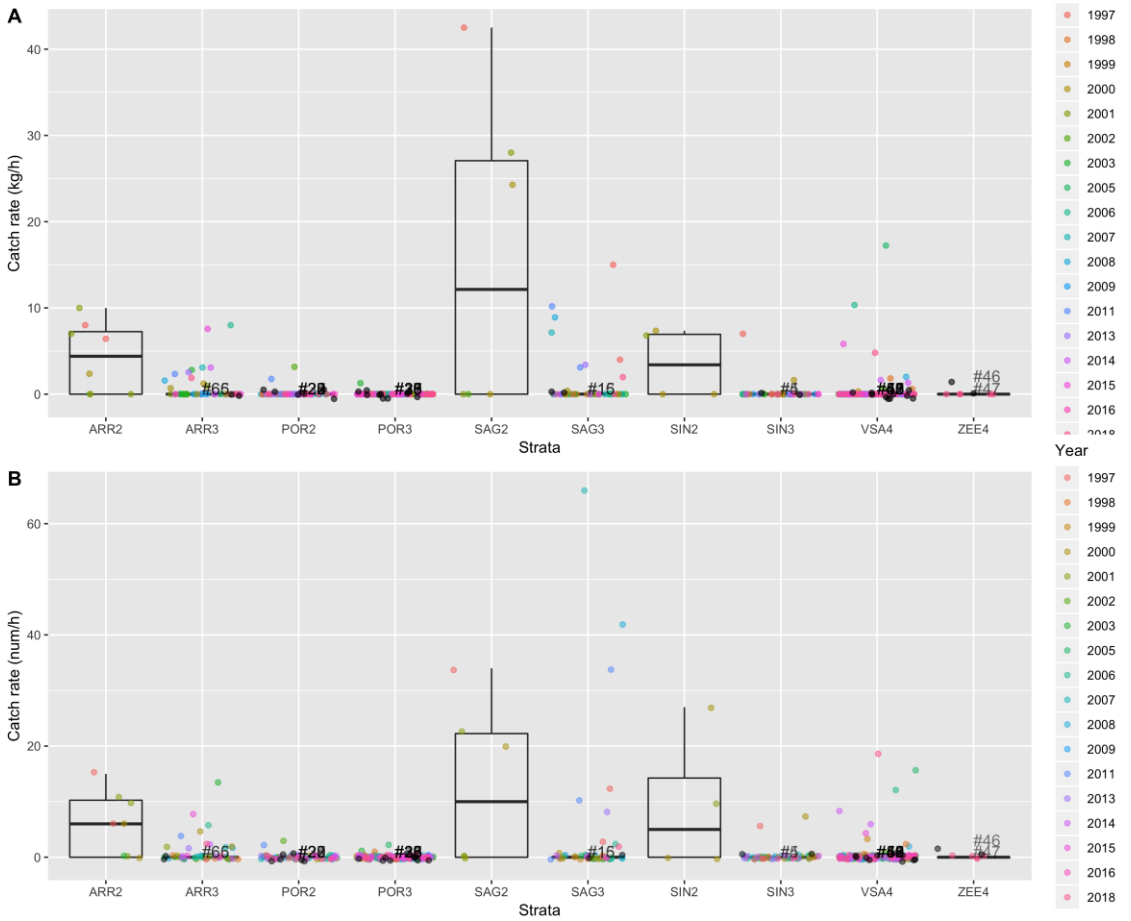

Figure 12. Distribution of the catch rate (A) of *Leucoraja naevus* in weight and in number) by strata. Points are coloured by year. The grey points correspond to the stations conducted in 2017 with indication of the number of stations and code of stations between brackets.

The biomass and abundance indexes have been variable in the last eight years, with increasing trend in 2018 and within the average values for the time-series (Table 7 and Fig. 13). Mean annual biomass index for 2017-2018 (0.08 kg.h-1) was 12% smaller than observed in the preceding five years (2012-2016; 0.09 kg.h-1). While, mean annual abundance index for 2017-2018 (0.44 num.h^{-1}) was 46% higher than observed in the preceding five years (2012-2016; 0.30 num.h^{-1}).

Table 7.*Leucoraja naevus* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PT-CTS from 1997 to 2018. Standard error (s.e.) is also presented for each index.

YEAR	Biomass	s.e.	Abundance	s.e.
1997	0.27	0.19	0.68	0.60
1998	0.06	0.06	0.17	0.20
1999	0.02	0.04	0.20	0.31
2000	0.10	0.08	0.40	0.34
2001	0.11	0.08	0.28	0.25
2002	0.06	0.06	0.10	0.12
2003	0.07	0.06	0.31	0.30
2005	0.10	0.08	0.66	0.57
2006	0.14	0.10	0.53	0.48
2007	0.07	0.07	0.84	0.71
2008	0.11	0.09	0.60	0.53
2009	0.00	0.00	0.00	0.00
2011	0.21	0.16	0.99	0.88
2013	0.06	0.06	0.16	0.18
2014	0.11	0.10	0.59	0.56
2015	0.17	0.14	0.44	0.46
2016	0.00	0.00	0.00	0.00
2017	0.03	0.03	0.07	0.10
2018	0.12	0.10	0.80	0.69

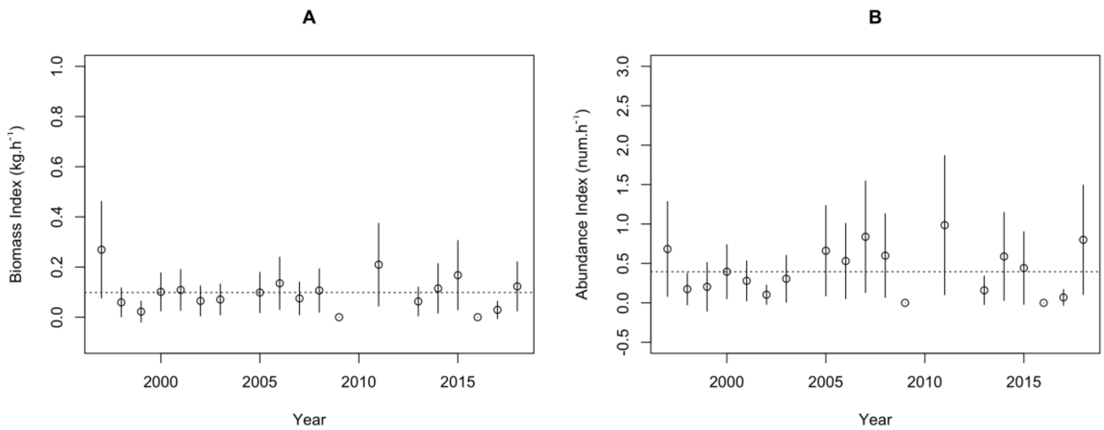

Figure 13. *Leucoraja naevus* biomass index (kg.hour^{-1}) and abundance (num.hour^{-1}) on PT-CTS from 1997 to 2017. Dashed line represents the mean annual abundance for the considered period.

The length distribution has been relatively variable along the time-series, mainly due to higher catches of juveniles in certain years (Fig. 14). The mean length the above the average since 2015.

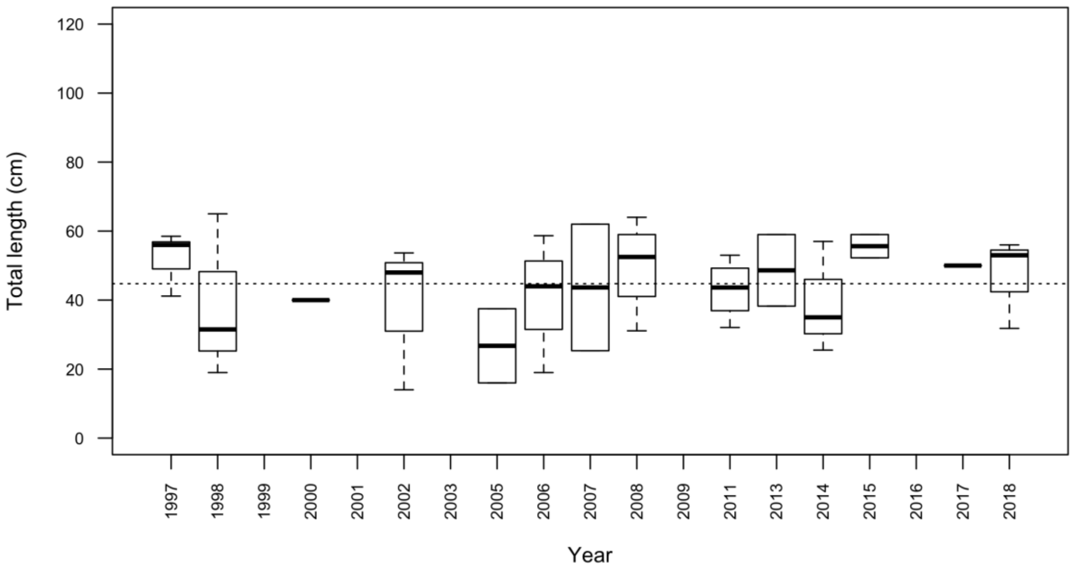

Figure 14. Total length variation of *Leucoraja naevus*, by year on PT-CTS (dashed line represents the mean annual length for 1997-2017).

4. Acknowledgements

We would like to thank the crew and scientific teams onboard the RV "Noruega" crew from IPMA (IPIMAR) that made possible the PTGFS-WIBTS-Q4 and PT-CTS surveys.

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Scientific evidences on discard survival of skates and rays (Rajidae) in Portuguese mainland waters (ICES division 27.9.a)

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INDEX

Abstract:

The current working document summarizes the available information on survival studies of skates and rays in Portuguese mainland waters (ICES Division 27.9.a), including evidences of survival of skates in net and trawl fisheries. Experiments were conducted on categorical vitality assessment (R. clavata, *L. naevus*, *R. montagui, R. brachyura* and *R. undulata* in net fisheries and *R. clavata in trawl survey), mark-recapture (R. undulata in net fisheries) and short-term survival (preliminary captive experiments on R. clavata in trawl survey). The experiments conducted by IPMA followed the procedures described in previous studies on the survival of this group of species and the recommendations made by the STECF and the ICES Working Group on Methods to Estimate Discard Survival. The scientific results obtained so far during the different projects conducted by IPMA (DCF pilot study on skates and the UNDULATA project) support the fishermen perspective of high survivability of skates and rays to fishing. In particular, the vitality status after capture of R. clavata, L. naevus, R. montagui, R. brachyura and R. undulata caught by net fisheries is generally high, as the percentage of skates in Excellent and Good vitality status always represented more than 75% of the fish sampled, independently of the species, mesh size or soak time. The mark-recapture study (UNDULATA project) of R. undulata caught by trammel net obtained a return rate of 11% and the mean observed time-at-liberty was of 54 days and maximum of 313 days. These results are a good indication that the species has a potential high long-term survival. Vitality results Raja clavata caught by otter-trawl in IPMA's surveys indicate that in overall most of the specimens are found in Excellent or Good conditions (60-72%), with an at-vessel-mortality of 6-7%. The preliminary estimated survival of R. clavata caught by otter-trawl in the Demersal survey was 64%.*

1 Introduction

1.1 Management of skates and rays

In Europe skates and rays (Rajidae) exploited by commercial fleets are important marine resources. Since 2009 fisheries of skates and rays are managed through a generic Total Allowable Catch (TAC) for all species. In 2019, the TAC for the Biscay and Iberian ecoregion (ICES subareas 27.8 and 27.9) was 4759 tonnes with a corresponding quota of 1463 ton for Portugal. Till 2016, this generic TAC was not applicable for the undulate ray *Raja undulata* which was under a *moratorium*, but after 2017 started to be managed by a specific quota. In Portuguese continental waters undulate ray is regionally regulated under a specific legislative framework (Portaria no. 96/2016; Portaria no. 27/2017; Portaria no. 15-D/2018). Other Portuguese regional management measures are adopted for skates and rays such as the seasonal fishing closure in May and June during which the catch, the maintenance on board and the landing of any Rajiformes species are prohibited to all fishing trips, except bycatch of less than 5% in weight, along the whole continental Portuguese EEZ (Portaria no 315/2011, Portaria no 47/2016, Portaria no. 96/2016). The seasonal closure established for *R. undulata* is extended to the month of July. Portugal adopted a minimum landing size (MLS) of 52 cm total length (T_L) for all Rajiformes (Portaria no 170/2014), except *R. undulata*, for which both a minimum landing size of 78 cm T_L and a maximum landing size of 97 cm T_L are applied (Portaria no. 96/2016).

1.2 Portuguese fisheries capturing skates and rays

From the 1990s to 2010, the Portuguese mean annual landed weight of skates and rays were around 1200 tonnes.y^{-1}. Annual landings decreased in later years (1138 tonnes in 2017), in line with reductions in the TAC and the national legislation adopted to reduce fishing effort (ICES, 2018). In Portuguese mainland waters (ICES Division 27.9.a), skates and rays are caught as by-catches by the trawl and polyvalent fleets. In 2017, the fishing fleet landing skates and rays was composed of 57 vessels of the trawl fleet and 1024 vessels of the polyvalent. In 2017, landings from the polyvalent fleet represented around 83% of the total landed weight of skates and rays (Table 1).

In the particular case of *R. undulata,* after the moratorium, Portugal implemented a closed monitoring plan, under which 50 fishing permits are given each year to allow landing the species to a maximum of 30 kg per trip (Portaria no. 96/2016; Portaria no. 27/2017; Portaria no. 15-D/2018). The remaining vessels are allowed to land only one specimen per trip, and in 2017 were identified a total of 246 vessels with landings of *R. undulata*.

Table 1. Estimated landed weight by species of skates and rays in Portugal mainland waters (ICES Division 27.9.a) by the polyvalent and trawl segments (period 2010-2017).

						Trawl fleet					
Year	JAI	RJC	RJE	RJH	RJI	RJM	RJN	RJO	RJU	SKA	TOTAL
2010	4	159	7	44	2	59	26	9	21	28	358
2011	1	229	0	18	0	29	29	29	12	13	360
2012	2	203	0	16	0	31	18	3	9	11	293
2013	0	173	0	21	0	31	10	22	6	6	268
2014	1	161	4	17	0	9	10	9	1	1	212
2015	0	150	0	14	0	9	9	12	1	1	197
2016	0	149	6	20	0	18	15	0	0	0	209
2017	0	122	1	26	0	23	16	1	2	0	192
						Polyvalent fleet					
Year	JAI	RJC	RJE	RJH	RJI	RJM	RJN	RJO	RJU	SKA	TOTAL
2010	2	452	36	177	10	216	29	11	0	183	1116
2011	4	582	29	143	1	91	27	39	0	157	1075
2012	3	367	36	149	0	77	21	21	0	161	836
2013	1	470	40	159	0	80	17	40	0	31	838
2014	1	424	42	156	0	82	24	24	0	49	802
2015	0	427	31	222	0	58	10	62	0	3	813
2016	1	410	58	200	2	50	42	25	23	0	811
2017	0	497	67	209	1	71	23	40	33	0	941

(JAI *Raja miraletus,* RJC *Raja clavata*, RJE *Raja microocellata*, RJH *Raja brachyura*, RJI *Leucoraja circularis*, RJM *Raja montagui*, RJN *Leucoraja naevus*, RJO *Dipturus oxyrinchus*, RJU *Raja undulata*, SKA, Rajidae)

In 2017, both in polyvalent and trawl fishing segments, the thornback ray *Raja clavata* is the most landed species (620 tonnes) and it represents around 55% of the total landed weight of skates and rays (Table 1). Landings of *R. clavata* represent 53% of Rajiformes landings from polyvalent vessels, and 64% from trawlers. The second most landed species is blonde ray *Raja brachyura* (235 tonnes in 2017), accounting for 21% of the total landed weight of skates and rays, followed by the spotted ray *Raja montagui* (94 tonnes in 2017) with 8% of the landings, both mostly landed by the polyvalent segment (89% and 76% of the landed weight, respectively). The cuckoo ray *Leucoraja naevus* represented only 2% of the landings (39 tonnes in 2017), 59% from polyvalent vessels and 41% from trawlers.

To help prioritizing the studies on the survival of skate and ray species in Portuguese mainland waters, the relative importance (in weight) of the estimated landings for 2017 by species from the two segments in relation to the total overall is represented in Figure 1.

The Portuguese polyvalent segment includes vessels with an overall length (LOA) ranging from 5 to 27 m and that can own several fishing licenses that enable them to use one or more type of fishing gears by trip (including gill-nets, trammel nets, traps, longline, etc.). Most of the landings of skates and rays by the polyvalent segment are from trammel nets, but other fishing gears (e.g. longlines and gillnets) are also used (Maia et al., 2013; ICES, 2018). This fleet operates mainly in the continental shelf off Portuguese mainland waters (ICES Div. 27.9.a). The species targeted by this fleet varies seasonally and geographically (e.g. sole, John Dory, anglerfishes), and skates and rays are captured as by-catch species.

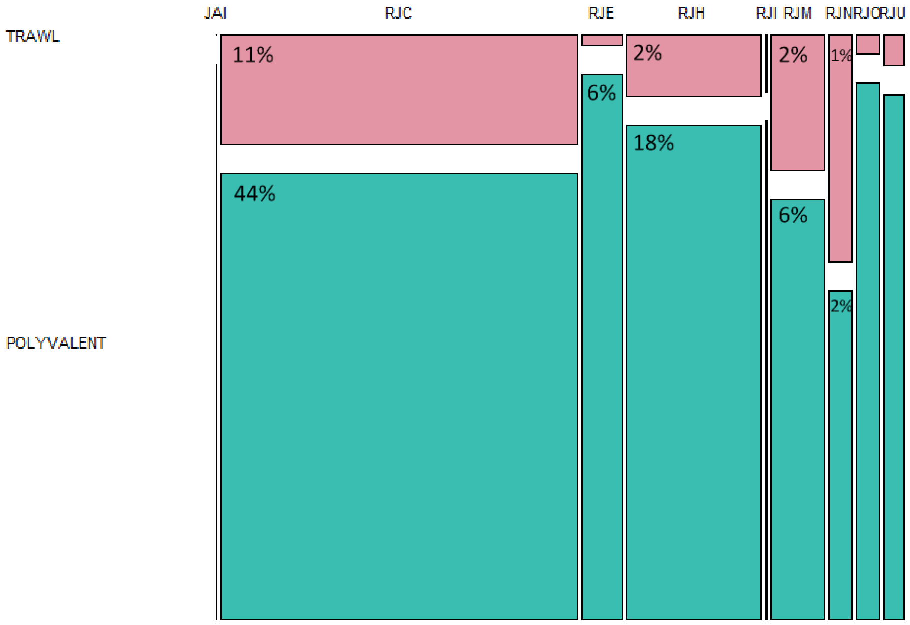

Figure 1. Relative importance (in weight) of the landings, in 2017, by of skate and ray species and segment (Trawl and Polyvalent) in Portuguese mainland waters (ICES Div. 27.9.a). (JAI *Raja miraletus,* RJC *Raja clavata*, RJE *Raja microocellata*, RJH *Raja brachyura*, RJI *Leucoraja circularis*, RJM *Raja montagui*, RJN *Leucoraja naevus*, RJO *Dipturus oxyrinchus*, RJU *Raja undulata*)

1.3 Common Fisheries Policy and landing obligation

The Common Fisheries Policy (CFP) aims to ensure that fishing activities conducted by European fleets contribute to long-term environmental, economic and social sustainability of marine resources. One of the measures implemented to reduce unwanted by-catches and reduce the impact of commercial fishing is the landing obligation of all discards of species subject to catch limits (TAC and quotas) caught during fishing activities (EU Regulation 1380/2013 article 15). The implementation of such regulation has been a gradual process since 2015, with full implementation in 2019. During this period, the Scientific, Technical, and Economic Committee for Fisheries (STECF) reviewed the Joint Recommendations from Member States regional groups (STECF, 2013, 2014a-c, 2015a-b, 2016, 2018), which include: *definitions of fisheries and species; de minimis and high survivability exemptions; fixation of minimum conservation references sizes; additional technical measures to implement the landing obligation; and the documentation of catches.* The STECF recommendations serve as a basis to build the Delegated Regulations that have been establishing the discard plans for each regional group since 2015 (e.g. for the South-Western waters: Commission Delegated Regulation (EU) 2015/2439; Commission Delegated Regulation (EU) 2016/2374; Commission Delegated Regulation (EU) 2017/2167; Commission Delegated Regulation (EU) 2018/2033).

A new survivability exemption for all skate and ray species was requested as a Joint Recommendation by Belgium, Spain, France, the Netherlands and Portugal in 2018 (STECF, 2018). Although the scientific studies presented provided solid scientific evidences on the high survivability rates of certain species and gears, those did not cover all Fleet X Area combinations. Therefore, as to gather more detailed information by fleet and area the fisheries would need to continue, the European Commission granted the exemption to all skate species caught by all gears in South-Western waters for the period 2019-2021 (Commission Delegated Regulation (EU) 2018/2033). This exemption implies, that during that period, all Member States have to present before 31th May each year: a) *a roadmap developed in order to increase survivability and to fill in the data gaps identified by STECF, to be annually assessed by STECF, (b) annual reports on the progress and any modifications or adjustments made to the survivability programmes.*

As for the cuckoo ray *Leucoraja naevus* the survival rates presented to STECF were lower than for the other species, the exemption is only applicable for one year, being the extension dependent on the presentation of new studies and development of improved survivability measures, before 31 May 2019, to be further evaluated by STECF.

The present report summarizes the available information on survival studies of skates and rays in Portuguese mainland waters (ICES Division 27.9.a), including evidences of survival of skates in net and trawl fisheries.

2 Survival of skates in net fisheries

2.1 Methods

Categorical vitality assessment (CVA) studies focused on skate and ray species caught by the trammel net fleet of the polyvalent segment were conducted under two scientific projects developed by IPMA: DCF Pilot Study on Skates (2011-2013) and UNDULATA project (2014-2015). The sampling covered all year long and the fishing areas were located in the north, central and southwest Portugal mainland waters, where the main Rajiformes landings are registered (Maia et al., 2013; Serra-Pereira et al., 2018). The experiments were conducted onboard commercial polyvalent vessels operating with trammel nets. Two major groups of mesh size were considered: i) <180 mm (100-110 mm) and ii) >180 mm (200-280 mm). The technical characteristics of the net gear within the sampled vessels include three panels made of polyethylene, with 2.5 to 4 m stretched height and around 40 m long. Trammel net sets were composed of a variable number of panels, depending on the vessel and/or haul (in average 230 panels). Each net set was anchored at each end on the sea bottom.

As the nets were retrieved onboard the vessel, specimens were untangled from the net by fishermen and sorted as retained or discarded. Then, for each skate and ray specimen caught, the species was identified, measured the total length (T_L; in cm), sexed and the vitality status assessed using a three-stages scale adapted from Enever et al. (2009) (Table 2).

Table 2. Description of the criteria used to assess vitality status of skates and rays after capture.

Vitality status		Criteria
1	Excellent	Vigorous wing/body movement and rapid spiracle movement
2	Good	Limp wing/body and spiracle movement.
3	Poor/Dead	Dead or nearly dead, no body movement, slight spiracle movement

Also, under the UNDULATA project (2014-2015) a tagging programme was implemented. Specimens of *R. undulata* captured by polyvalent vessels operating with trammel nets were tagged using Petersen discs applied in the middle of the disc (Fig. 2). The tagging was both performed by scientific observers and by fishermen collaborating with the project.

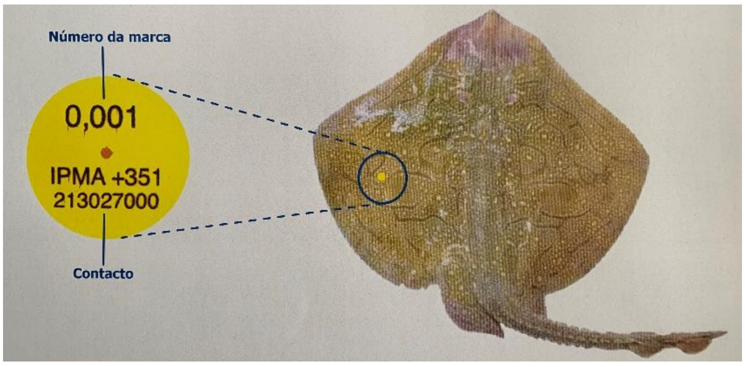

Figure 2. Tagging of *Raja undulata* using Petersen discs, under the UNDULATA project.

2.2 Results

2.2.1 Sampling

Under the Portuguese DCF Pilot Study on Skates, a total of 36 hauls using set nets were sampled. The skate and ray specimens were caught in 21 trips onboard 4 different vessels (9-20 m LOA, 8-88 ton, 70-184 HP). Under the UNDULATA project a total of 48 hauls were sampled. The specimens of *R. undulata* were derived from 32 trips onboard 13 different vessels (9-13 m LOA, 3-16 ton, 41-137 HP). The geographic locations of the fishing hauls are mapped in Figure 3. The mean bottom depth of the fishing hauls sampled under the DCF Pilot Study on Skates was 54 m (standard deviation of 29 m), while that from UNDULATA was shallower (7 ± 6 m deep).

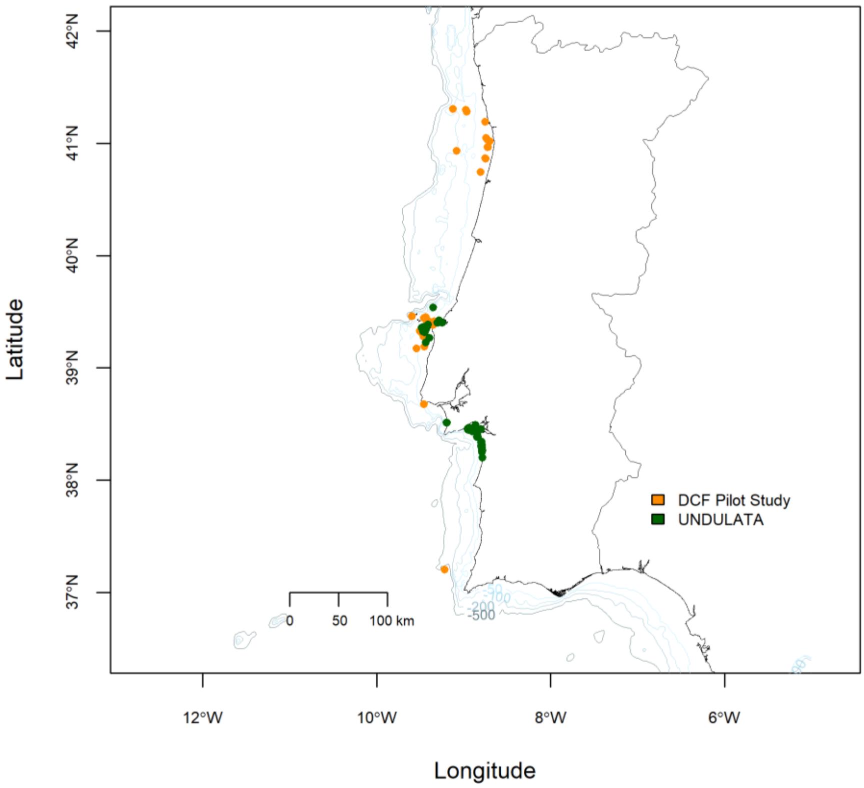

Figure 3. Sampling locations with vitality assessment of skates from net fisheries in DCF Pilot Study on Skates (n=36) and UNDULATA project (n=48).

The soaking time in the sampled hauls was similar to that of the normal commercial time. To analyse the data, two groups of soaking time were considered: less than 24h and more than 24h. The median soaking time for nets with mesh size < 180 mm was around 24h, while that with mesh size > 180 mm was around 27h (Fig. 4).

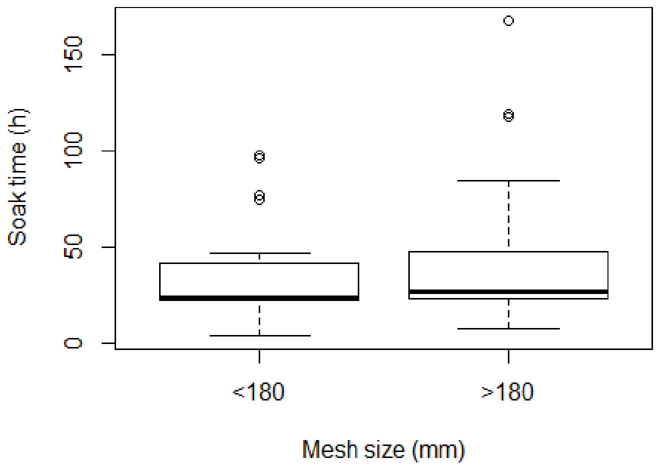

Figure 4. Soaking time (h) by group of mesh size (mm) in the sampled hauls using set nets. (n=84)

Under the DCF Pilot Study on Skates, the skate and ray species from which information was collected were: *R. clavata*, *L. naevus*, *R. montagui, R. brachyura* and *R. undulata*. The length frequency distribution was determined for each species separately for the retained and discarded fractions sampled and is presented in Figure 5 for *R.*

clavata, R. brachyura, R. montagui and *L. naevus*. Although the sampling period was prior to the implementation of the minimum landing size of 52 cm T_L for all Rajiformes (Portaria no 170/2014), it was included in graphs as a reference.

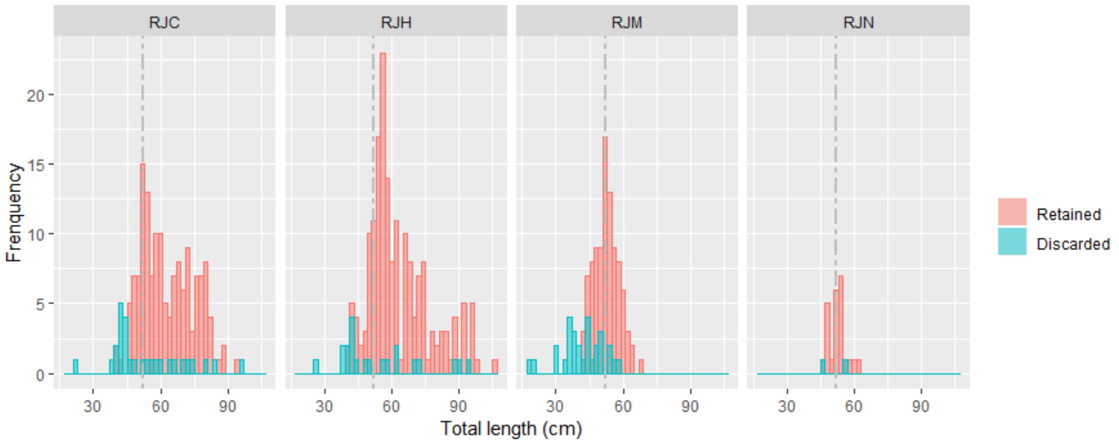

Figure 5. Length distribution (cm) by species for the retained and discarded fraction in the sampled hauls using set nets under the DCF Pilot Study on Skates. The dashed grey line indicates the minimum landing size of 52 cm T_L implemented for all Rajiformes in Portuguese mainland waters. (RJC, *Raja clavata*; RJH, *Raja brachyura*; RJM, *Raja montagui*; RJN, *Leucoraja naevus*)

In the UNDULATA project only information on *R. undulata* was collected. The length frequency distribution of *Raja undulata* sampled in the two sampling projects is presented in Figure 6.

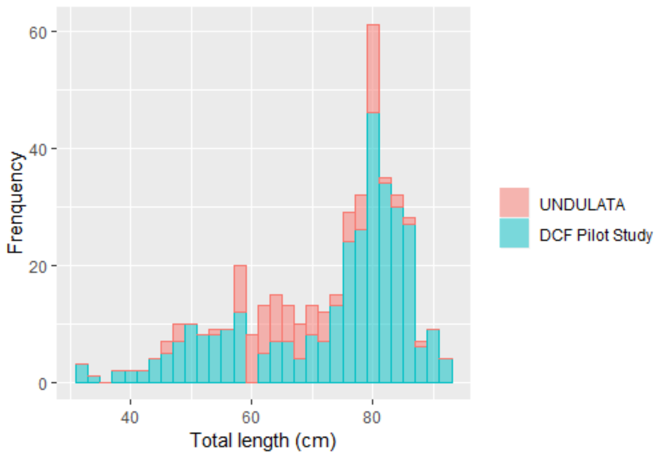

Figure 6. Length distribution (cm) of *Raja undulata* in the sampled hauls using set nets from the DCF Pilot Study on Skates and UNDULATA project.

2.2.2 Categorical vitality assessment

For each Rajiform species studied, the categorical vitality assessment results indicate that the vitality after capture is generally high (in Excellent or Good vitality status). There were evidences that both mesh size and soaking time affected survivorship (Table 3). As the scale used to assess the vitality status does not discriminate species in poor status from dead specimens, it was not possible to estimate the percentage of at-vessel mortality for the trammel net fleet. Summarizing the results by species:

- *R. clavata* - specimens caught in both mesh size groups with soak time < 24h were mainly found in Excellent conditions (100% and 92%, respectively), while those from hauls with > 24h, although most specimens were caught in Excellent conditions (72% and 52%), the percentage of Poor/Dead vitality status was comparatively higher (16% and 24%, respectively for each mesh size);

- *R. brachyura* - most specimens were caught in Excellent conditions, representing 67% of the observations from mesh size < 180 mm and soaking time < 24 h, 92% for the same mesh and soaking time > 24h, 57% and 70% for mesh size > 180 mm for each soaking time period, respectively. The highest percentage of specimens in Poor/Dead status for that species was observed for mesh size > 180 mm and soaking time < 24 h (24%);

- *R. montagui* - specimens caught with mesh size < 180 mm and in Excellent vitality represented 100% and 67% depending on the soaking time; specimens caught with mesh size > 180 mm and in in Excellent vitality represented 40% and 37%. The percentage of specimens in Poor/Dead conditions was higher for the larger mesh size group (30%) than for the smaller one (0% and 12%);

- *L. naevus* - representative data was only obtained for mesh size > 180 mm and soaking time > 24h. Under this situation 58% was the percentage of specimens in Excellent condition while 21% and 21% corresponded to specimens in Good and 21% Poor/Dead condition respectively;

- *R. undulata* - the percentage of specimens in Excellent conditions was higher than 79% for all mesh sizes and soak times; with highest values were observed for mesh size > 180 mm and soaking time > 24h (96%). The percentage of specimens in Poor/Dead conditions was 2% and 5% for mesh size < 180 mm and 3% and 14% for mesh size > 180 mm, respectively for each of the two soaking times considered.

Table 3. Percentage of individuals by vitality status (1 = Excellent; 2 = Good; 3 = Poor/Dead) by skate and ray species in relation to mesh size and soak time in the Portuguese polyvalent fleet operating with trammel nets. The total length range is also given. (adapted from ICES, 2018).

			Vitality status				
Species	Mesh size (mm)	Soak time (h)	1	2	3	n	TL range (cm)
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 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
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
Leucoraja naevus	< 180	< 24	1	-	-	1	53

	> 180	< 24	1	-	-	1	61
		> 24	58%	21%	21%	24	46-62
Raja undulata	< 180	< 24	82%	16%	2%	44	40-89
		> 24	90%	5%	5%	58	43-92
	> 180	< 24	79%	7%	14%	71	32-92
		> 24	96%	1%	3%	174	44-92

Table 4. Percentage of individuals from each skate and ray species by vitality status (1 = Excellent; 2 = Good; 3 = Poor/Dead) in relation to length class. The values are presented for retained and for discarded specimens separately. For n ≤5, observed numbers by vitality are shown instead of percentages

		Retained				Discarded			
		Vitality status				Vitality status			
Species	Length class	1	2	3	n	1	2	3	n
Raja clavata	<52 cm	68%	18%	14%	22	83%	0%	17%	12
	>52 cm	70%	19%	10%	125	0%	0%	100%	12
Raja brachyura	<52 cm	69%	15%	15%	26	83%	8%	8%	12
	>52 cm	75%	20%	5%	150	0%	0%	100%	9
Raja montagui	<52 cm	61%	28%	11%	36	76%	4%	20%	25
	>52 cm	51%	32%	18%	57	-	-	4	4
Leucoraja naevus	<52 cm	57%	14%	29%	7	1	-	-	1
	>52 cm	65%	24%	12%	17	-	-	1	1
Raja undulata	<52 cm	-	-	-	-	78%	16%	5%	37
	>52 cm	-	-	-	-	91%	3%	6%	318

The results obtained suggest that the vitality after capture of a specimen is not related to its size (Table 4). For all the species, and regardless of specimens' size (T_L < 52 cm and > 52 cm) or being retained or discarded, the majority was found in Excellent vitality conditions (60-92%). The vitality status of small and large fish differs in the discarded fraction. Small individuals seem to be mostly in Excellent conditions (50-85%) while all large fish discarded were all in Poor/Dead conditions, except for *R. undulata* which was under moratorium. This indicate than in general, large fish were generally not in good conditions for selling.

Generalized linear model (GLM) were adjusted to retained and discarded data (binomial response variable, 0=retained, 1=discarded) and the effect of factors length, vitality status, mesh size and soak time evaluated. A binominal error distribution and a logit link function were adopted in the GLM models. Note that although the threshold used for the length classes was 52 cm, the MLS was not established at the time of the sampling.

GLM results summarized in Table 5 indicate that:

- The levels large size specimen (T_L>52 cm) and Poor/Dead vitality status were significant;
- In *R. clavata, R. brachyura* and *R. montagui* discards were less frequent for larger individuals (T_L>52 cm) than for the smallest ones. In these species discards was significantly more frequent for Poor/Dead vitality than for Excellent vitality;
- For *R. brachyura* the effect of mesh size and soaking time were significant, with less occurrence of discards in mesh size > 180 mm and soak time > 24h;

- For *R. montagui* the occurrence of discards from Good vitality was significantly lower than those in Excellent vitality;
- For *L. naevus* no significant effects were found.

Table 5. Results from the GLM model on the factors affecting the fraction of discarded specimens by skate species. The parameter estimates, the standard error (s.e.) and statistical significance of the effect of the parameter are presented.

Species	Parameter	Estimate	s.e.	*p*
Raja clavata	(Intercept)	-1.02	0.69	0.14
	T_L>52 cm	-2.34	0.75	<0.01
	Poor/Dead vitality	3.05	0.74	<0.01
Raja brachyura	(Intercept)	0.37	0.65	0.57
	T_L>52 cm	-2.05	0.68	0.00
	Poor/Dead vitality	3.15	0.73	<0.01
	Mesh size >180 mm	-1.31	0.73	0.07
	Soak time >24h	-1.29	0.63	0.04
Raja montagui	(Intercept)	-0.69	0.52	0.18
	T_L>52 cm	-2.59	0.69	<0.01
	Good vitality	-2.19	1.10	0.05
	Poor/Dead vitality	1.47	0.73	0.04

2.2.3 Mark-recapture data

Under the project UNDULATA a total of 353 specimens of *R. undulata* were tagged. From those, 40 were recaptured, which corresponds to a return rate of 11%. The time at liberty ranged from 1 to 313 days, with an average of 54 days.

3 Evidences of survival of skates in trawl fisheries

3.1 Methods

Categorical vitality assessment studies focused on skate and ray species caught by otter trawl were conducted onboard the 2018 IPMA's scientific surveys: summer survey focused on crustacean species (PT-CTS (UWTV (FU 28–29)) and autumn survey focus on demersal species (PTGFS-WIBTS-Q4). Both surveys were carried with the Portuguese RV "Noruega", which is a stern trawler of 47.5 m length, 1500 horse power and 495 GRT. For the first survey the fishing gear used was a shrimp trawl net (type FGAV020), with synthetic wrapped wire core and chain, 20 mm cod-end mesh size (herein OTB_CRU) and for the second a Norwegian Campelen Trawl gear with rollers in the groundrope, and 20 mm codend mesh size (herein OTB_DEM) (ICES, 2015, 2017). For both surveys, fishing hauls are carried during daylight at a mean speed of 3.0 knots with duration of 30 min. The experiments onboard the Crustaceans survey carried out in the south coast of mainland Portugal and those onboard PTGFS-WIBTS-Q4 were conducted in the north.

In each fishing haul, as the catch was being separated by boxes and sorted on deck, the species of each skate and ray specimen was identified and immediately placed in a box filled with sea water and with aeration. Each specimen was also measured the total length (in cm), sexed and the vitality status assessed. The deck time (in minutes) was recorded for each assessment, to evaluate the effect of the sorting process in the vitality status of skates and rays. From the experience gain in previous projects on trammel net fisheries, it was decided to separate poor from dead specimens, so a four-stages scale (Table 6) was used in this experiment and will be applied in future studies to be conducted by IPMA, following Catchpole et al. (2017).

Table 6. Description of the criteria used to assess vitality status of skates and rays after capture.

Vitality status		Criteria
1	Excellent	Vigorous wing/body movement and rapid spiracle movement
2	Good	Limp wing/body and spiracle movement.
3	Poor	No body movement, slight spiracle movement
4	Dead	No body or spiracle movement. No response to stimuli.

Additionally, captive observations were conducted onboard to assess the short-term survival of skate and ray species. Fish were maintained in tanks (255 l, 355 and 650 l) with continuous circulating sea water and aeration (Fig. 7). Temperature, salinity and pH of the water in tanks were routinely monitored. A water cooling system was attached to the 650 l tank to maintain water temperature at 15-17 ºC.

Figure 7. Tanks used onboard the RV “Noruega”: 255 l, 355 and 650 l (from left to right).

For each specimen at the moment of the selection, a set of Reflex Action Mortality Predictor (RAMP) reflexes (Table 7) and body lesions were assessed. For specimens selected to maintain in captivity RAMP was assessed every 6h during for a maximum of 4 days (97h). Body lesions were recorded by body section, i.e., head, disc and tail, according to a four-stage scale: 0 - without lesions, 1 - lesions covering less than 10% of the region, 2 – lesions covering between 10 and 50% of the region and 3 – lesions covering more than 50% of the region. For specimens with a healthy behaviour inside the tank, only tail grab and spiracles RAMP reflexes were tested, as the remaining would imply removing the skate out of the water and cause extra stress to the animal.

Observed data were fitted to non-parametric Kaplan-Meier survival models using R package survival (Therneau, 2019).

Table 7. List of reflex actions scored as Reflex Action Mortality Predictor

Reflex		Procedure	Reaction
i	Tail grab	Grab the tail of the skate, while inside the water	Burst swims away
ii	Spiracles	Observe the spiracles movement	Spiracles actively open and close
iii	Body flex	Place the skate on a flat surface	Vigorous movement of body and tail

3.2 Results

3.2.1 Sampling

In 2018 IPMA Crustaceans and Demersal surveys a total of 35 and 24 hauls, respectively, were sampled for survival data (Table 8). *R. clavata* was caught in 9 fishing hauls at the Crustaceans survey (n=66 specimens) and 5 hauls at the Demersal survey (n=37 specimens). *Leucoraja naevus* was only caught in 1 fishing haul at the Crustaceans survey (n=5 specimens).

Table 8. Summary of the number of hauls, depth range (m), number of sampled specimens and size range (T_L in cm) of sampled specimens from 2018 IPMA's Crustaceans and Demersal surveys. Data are presented for sampled hauls and for hauls with *Raja clavata* and *Leucoraja naevus.*

Survey	Hauls	Number of hauls	Depth range (m)	Sampled specimens	T_L range (cm)
Crustaceans	Sampled	35	106-770	-	-
	With *R. clavata*	9	106-770	66	21-73
	With *L. naevus*	1	675	5	21-46
Demersal	Sampled	24	36-320	-	-
	With *R. clavata*	5	76-152	37	38-100
	With *L. naevus*	0	-	0	-

The geographical location of the stations sampled with *R. clavata* onboard the Crustaceans survey were located in the south off Portugal mainland, between Portimão and Vila Real de Santo António, at depths of 106 to 770 m, while those in the Demersal survey were located in the north between Caminha and Aveiro, at depths of 36 to 320 m (Fig. 8).

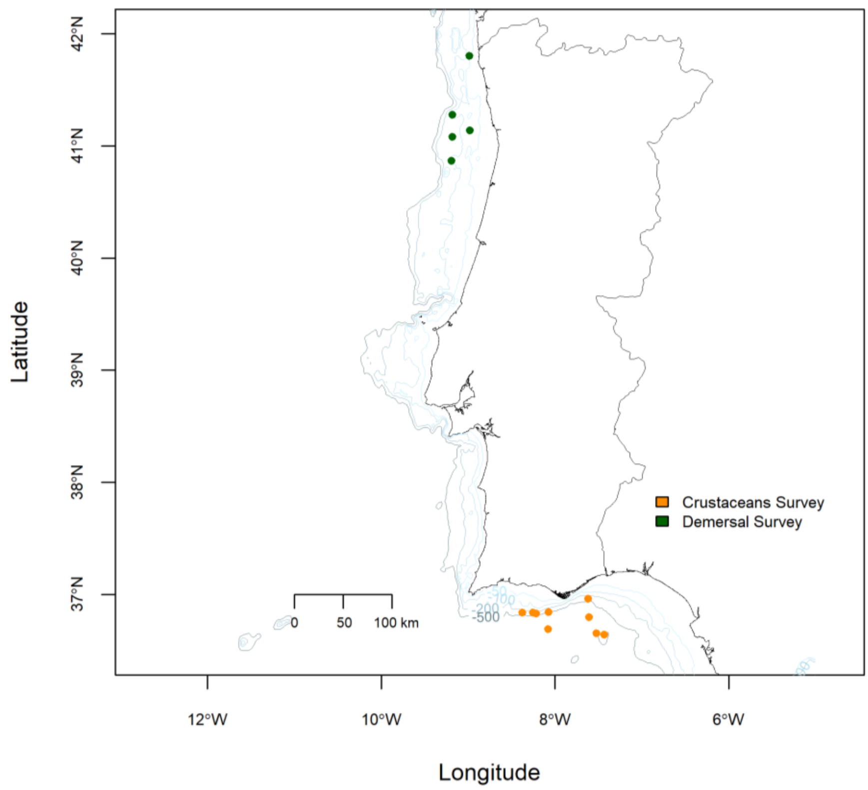

Figure 8. Sampling locations with *Raja clavata* caught in IPMA's Crustaceand and Demersal surveys conducted in 2018 (n=14).

R. clavata length frequency distribution based on specimens caught at the sampled fishing hauls differ between surveys (Fig. 9), although the cod-end mesh size was the same in both nets. Smaller specimens were caught in the Crustacens survey, where total length of *R. clavata* ranged from 21 to 73 cm T_L (mean around 40 cm), while that in the demersal survey ranged from 38 to 100 cm T_L (mean around 77 cm).

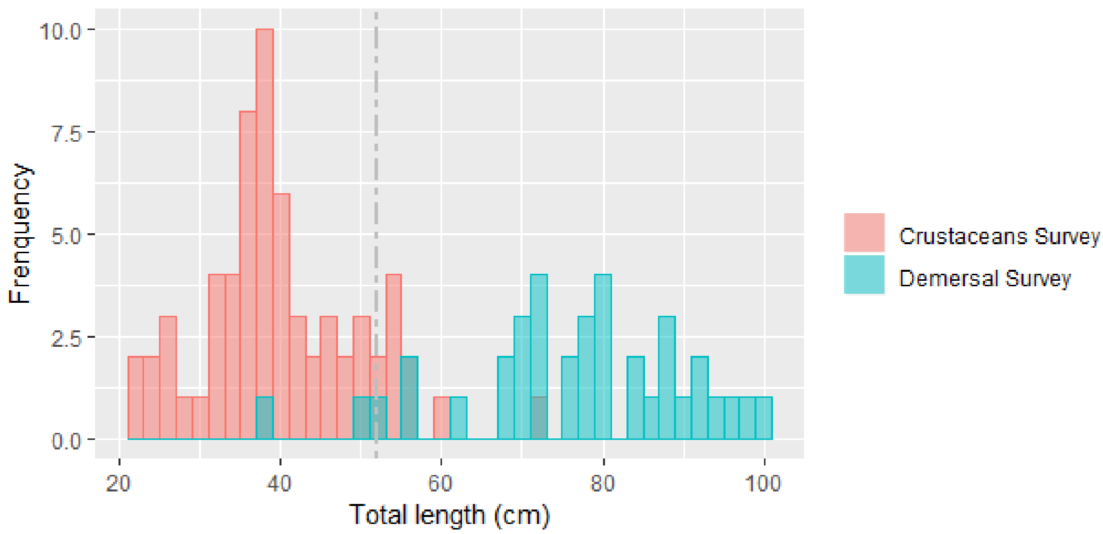

Figure 9. Length distribution (cm) of *Raja clavata* sampled in the two IPMA surveys conducted in 2018. The dashed grey line indicates the minimum landing size of 52 cm T_L implemented for all Rajiformes in Portuguese mainland waters.

3.2.2 Categorical vitality assessment

A total of 66 specimens of *Raja clavata* from the Crustacean Survey and 37 from the Demersal survey were subsampled to evaluate the vitality status after capture (Table 9). In the Crustacean survey 5 specimens of *L. naevus* were also evaluated.

Table 9. Number of specimens of *Raja clavata* subsampled for each experiment, by vitality status, in each survey.

Survey	Vitality status	Vitality assessment	RAMP and lesions	Survival
Crustaceans	1=Excellent	18	17	-
	2=Good	5	5	-
	3=Poor	12	12	-
	4=Dead	31	1	-
	All	*66*	*35*	-
Demersal	1=Excellent	9	9	3
	2=Good	16	16	6
	3=Poor	9	9	2
	4=Dead	3	3	-
	All	*37*	*37*	*11*

A GLM was fitted to the proportion of dead specimens of *R. clavata* by deck time (in minutes). The deck time at which 50% of the specimens are expected to be dead was estimated to be 108 min. Since the deck time had influence on the proportion of dead animals, and consequently on the vitality status of the species after capture, this threshold was used to estimate the percentages by vitality status by size class in each sampled survey.

For *Raja clavata, v*itality results indicate that in overall, when the deck time is less than 108 minutes, most of the specimens are found in Excellent or Good conditions (Table 10). In the Crustaceans survey, using OTB_CRU, 60% were found in Excellent or Good conditions, 33% were in Poor conditions and 7% were dead. In the Demersal survey 72% were found in Excellent or Good conditions, 23% were in Poor Conditions and 6% were dead. In the Crustaceans survey, specimens assessed with more than 108 minutes of deck time were all found dead, with exception of one specimen with T_L> 52 cm found in Good conditions.

For *L. naevus* only 5 specimens were observed and most were found dead (n=4) (Table 8). Nevertheless, conclusions should not be taken for the overall vitality of this species caught by OTB_CRU, as the sample was not considered representative.

Table 10. Percentage of individuals by vitality status (1 = Excellent; 2 = Good; 3 = Poor; 4= Dead) of each species assessed onboard IPMA's otter trawl surveys, for different deck times. For n ≤5, observed numbers by vitality are shown instead of percentages.

Species	Survey	Deck time	Length class	1	2	3	4	n	TL range (cm)
Raja clavata	Crustaceans	< 108 min	< 52 cm	47%	13%	33%	7%	30	

		< 108 min	> 52 cm	4	-	1	-	5	
		> 108 min	< 52 cm	0%	0%	0%	100%	25	
		> 108 min	> 52 cm	-	1	-	3	4	
	Demersal	< 108 min	< 52 cm			1	1	2	
		< 108 min	> 52 cm	26%	46%	23%	6%	35	
Leucoraja naevus	Crustaceans		All			1	4	5	21-46

3.2.3 Short-term survival (captive experiments)

In both surveys, the RAMP and body lesions of *R. clavata* were assessed at the moment of specimens' selection for captive experiments. A subsample of 35 specimens from the Crustacean survey and all captured specimens (n=37) from the demersal survey were evaluated (Table 9). From those, 49% and 24% were in Excellent vitality status, 14% and 43% in Good, 34% and 24% in Poor and 3% and 8% were dead, respectively for each survey.

All specimens in Excellent vitality status showed all reflexes. All specimens in all vitality status presented a positive spiracle reflex. The percentage of body flex and tail grab reflexes decreased with vitality status, 71% to 29% and 48% to 29%, respectively.

The observed proportion of coverage of each body lesion presented differences between surveys (Fig. 10).

- Crustacean survey and for every vitality status, the percentage of specimens without any lesion was higher than in the Demersal survey. In that survey the lesions in the disc were the most frequent and with larger coverage.

- Demersal survey, all specimens in Excellent vitality status showed some extent of lesion in the tail. Disc lesions was also the one presenting a larger coverage (most with 0.10-0.50 coverage in Good and Poor vitality status). A proportion of 0.38 of the specimens in Poor conditions showed extensive tail lesions (>50% coverage).

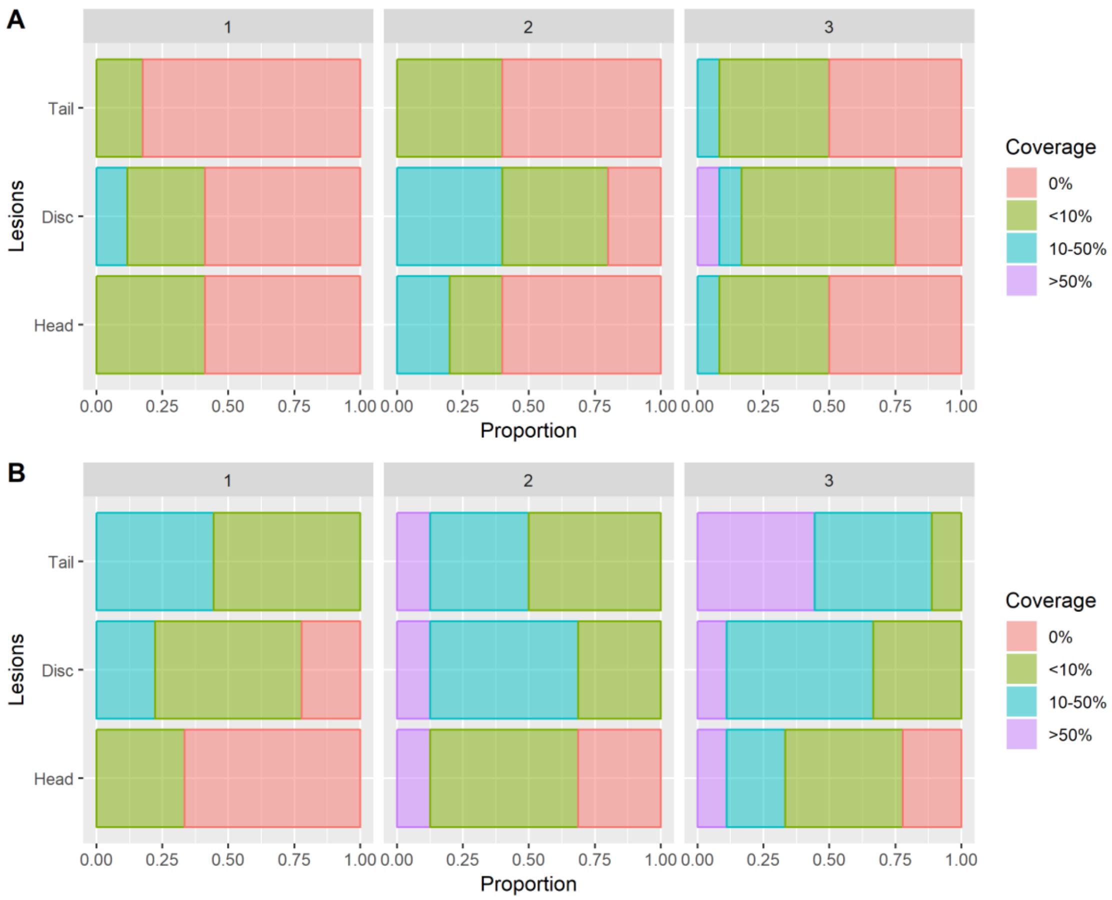

Figure 10. Proportion of coverage of each body lesions by vitality status (1 = Excellent; 2 = Good; 3 = Poor; 4= Dead) assessed in *Raja clavata* onboard each survey (A-Crustaceans survey, B-Demersal survey).

Captive observations conducted onboard the Crustaceans survey were considered a trial to obtain technical experience for the subsequent studies. Therefore, only results obtained onboard the Demersal survey are presented.

Onboard the Demersal survey 11 specimens were selected to be monitored for a maximum 4-days period (97 hours). From those 11 specimens, 3 specimens were selected with Excellent vitality status, 6 with Good vitality status and 2 in Poor (Table 9). Specimens measured from 38 to 80 cm T_L (average of 65 cm T_L).

The water temperature in the tanks was maintained stable at 15-20 ºC, the salinity ranged from 35 to 38 and pH ranged from 7.8 to 8.1. During the sampled trips the mean sea surface temperature was around 16ºC (13-18ºC) and the salinity 36. Bottom sea temperature and salinity were 13ºC (13-14ºC) and 35, respectively.

Observed survivorship data were fitted to the non-parametric Kaplan-Meier survival models, and no significant differences were found between vitality status (p=0.84), so the survival model selected was fitted for all vitality status combined (Fig.11 and Table 11). The model estimated survival for *R. clavata* caught by otter-trawl in the Demersal survey was 64%. To note, that this results should be considered preliminary as the number of specimens used in the experiment was low (n=11), and the uncertainty of the estimated values was relatively high as expressed by the wide range of the 95% confidence intervals observed in Figure 11.

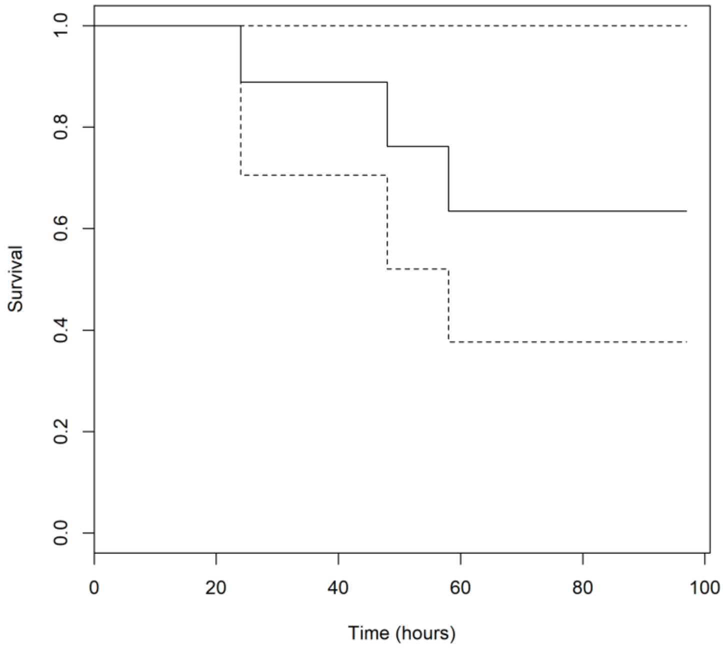

Figure 11. Kaplan-Meier curve fitted to survival data for *Raja clavata* at the Demersal survey. Dashed lines represent 95% confidence intervals.

Table 11. Kaplan-Meier survival model output for *Raja clavata* at the Demersal survey.

time	n.risk	n.event	survival	s.e.	lower 95% CI	upper 95% CI
24	9	1	0.89	0.11	0.71	1.00
48	7	1	0.76	0.15	0.52	1.00
58	6	1	0.64	0.17	0.38	1.00

3.3 Discussion and conclusion

The experiments conducted by IPMA on survival of skate species followed the procedures described in previous studies on the survival of this group of species (e.g. Enever et al., 2009; Catchpole et al., 2017; Valeiras and Álvarez-Blazquez, 2018) and the recommendations made by the STECF (STECF, 2013) and the ICES Working Group on Methods to Estimate Discard Survival (WGMEDS; ICES, in press).

The fishing sector has been actively collaborating with IPMA in all the projects focused on skates and rays (DCF pilot study on skates and the UNDULATA project), under which several meetings were conducted. This collaboration has provided a good inter-change of knowledge and facility to go onboard the commercial vessels to conduct scientific experiments, including those to collect survivability data. Based on Portuguese fishermen´s knowledge, the majority of skate and ray specimens caught by the different fisheries arrive onboard alive and lasting in that condition for some time. According to fishermen, those caught by polyvalent gears, like trammel nets and longline, tend to arrive on deck in better conditions (more lively) than those from trawlers. They also state that the great majority of specimens released to the sea immediately take an active behaviour by swimming away from the vessels and to the bottom, so that **local fishing associations (e.g. Cooperativa dos Armadores de**

Pesca Artesanal, CAPA, in Peniche) encourages their fishermen to promptly release the specimens that are selected to be discarded to improve their survivability. To highlight that, due to their concern on the state of the stocks of skates and rays, the Peniche local artisanal fishery association (CAPA) was actively involved on the proposal of the two national legislations implemented (i.e. seasonal closure and MLS for all Rajiform species) to manage the captures of skates and rays in mainland Portugal. Since the application of such measures, the fishermen have the perception of increasing abundance of most of the skate and ray species which is corroborated by the last scientific advice conducted by the ICES Working Group on Elasmobranch Fishes (WGEF) for all Iberian stocks (ICES Division 27.9.a) (ICES, 2018).

The scientific results obtained so far during the different projects conducted by IPMA on the survivability of skates and rays caught by trammel nets and otter trawl in Portugal mainland (ICES Division 27.9.a) support the fishermen perspective of high survivability of skates and rays to fishing. These results are also in accordance to the scientific evidences presented to STECF to other fisheries and areas (e.g. STECF, 2017), that led to the exemption of the landing obligation. In summary:

- **From the results obtained under the DCF pilot study on skates and the UNDULATA project, it is concluded that the vitality status after capture of *R. clavata*, *L. naevus*, *R. montagui, R. brachyura* and *R. undulata* caught by net fisheries is generally high.** And although variables, as mesh size and soak time may affect the vitality status after capture and therefore the skates' survival capacity after being released to the sea, the percentage of skates in **Excellent and Good vitality status always represented more than 75%** of the fish sampled, independently of the species, mesh size or soak time. The results obtained for the Portuguese fishery are within that obtained for the trammel net fishery in the North Sea and English Channel (Ellis et al., 2018), with the former with relatively higher percentages of specimens in Excellent and Good vitality status (98% for *R. clavata*) and the latter with lower values for some species (68% for *R. montagui* and 60% for *R. clavata*).

- **The categorical vitality assessment study in the net fishery also showed that there are no differences on the vitality after capture between sizes**. Similar results were also observed in several fisheries in the North Sea (Ellis et al., 2018).

- **Long-term post-release survival of *R. undulata* caught by trammel net may be indirectly inferred from the mark-recapture study.** The species presented a return rate of 11%, compatible to the type of tags used and within the results obtained in studies conducted in other areas, such as Bay of Biscay (6%; Delamare et al., 2013) and English Channel (7-21%; Ellis et al., 2011). The high return rates observed for the species is in part related to a potentially high long-term survivability and to the patchy distribution characteristic of the species (ICES, 2018). Also, a good indication that the species has a potential high long-term survival is the mean observed time-at-liberty of 54 days and maximum of 313 days.

- **For *Raja clavata* caught by otter-trawl in IPMA's surveys, vitality results indicate that in overall, when the deck time is less than 108 minutes, most of the specimens are found in Excellent or Good conditions (60-72%).** Although the study here presented was not undertaken in a commercial vessel, the percentage of specimens in Excellent and Good vitality status was similar to that in the commercial fleet operating in the North Sea (87%; Ellis et al., 2018), but significantly higher than that published for the Spanish commercial fleet (31%; Valeiras and Álvarez-Blazquez, 2018).

- **The at-vessel-mortality observed in the surveys operating with otter-trawls was 6-7%**. This result is similar to that presented by the DESCARSEL project on the Spanish otter bottom trawl targeting demersal species (7%; Valeiras and Álvarez-Blazquez, 2018), but higher than that described for the North Sea (1%; Ellis et al., 2018).

- **The Kaplan-Meier model estimated that the survival for *R. clavata* caught by otter-trawl in the Demersal survey is 64%.** To highlight, that these results should be considered preliminary due to the reduced number of specimens used in the study. Nevertheless, although the fishing operation used in the Surveys differ from the commercial otter trawl fleets operating with OTB_CRU (codend mesh size ≥ 55 mm) and OTB_DEF (codend mesh size between 65 and 69 mm), including codend mesh size and soak time, the results shown here should be indicative of a potential high survival for the species in those fisheries. In fact, the estimated survival rate was within the values obtained from captivity studies for the trawl fleet operating in the Bristol Channel (54-87%; Catchpole et al., 2017), in which was also shown that the tow duration has no effect on the survival rate of *R. clavata*.

The relevant results to be evaluated by STECF for the high survivability exemption for skate and ray species caught by Portuguese fisheries (nets and otter trawl) in ICES Division 27.9.a are summarized in Table 12. The sampling levels, in particular the frequency of occurrence of each species in the discards of sampled hauls under the DCF onboard sampling programme in each métier was added to the STCEF template. Regarding the net fishery estimates of total discards are not available for Portugal mainland. Therefore, in net fisheries (n=76 hauls sampled in the period 2014-2016), the mean and standard deviation (s.d) of the number of discarded specimens per species was added to the column "Estimated discards", and the mean percentage (and s.d.) of discarded specimens (in number) in relation to the captured specimens (in number) was added to the column "Discard rate".

From the data presented in this report, future studies on the survivability of skates and rays on each relevant Portuguese fishery (ICES Division 27.9a) should continue to be conducted. Yet, at the present date there are no dedicated projects on this subject, so that data will be collected under other projects. At the current moment, the programmed studies that could contribute with the collection of new information on the survival of skates and rays in 2020 are summarized in Table 13. Priority will be given to the most abundant species and main gears, and to *L. naevus* in face of EU request.

Table 12. Summary of high survivability results for Rajiformes caught in ICES Division 27.9.a by Portuguese fleets. Landings and fleet dimension was based on data from 2016-2017. Discard levels based on DCF onboard sampling trips from 2014-2016.

Country	Exemption applied for (species, area, gear, type)	Species as bycatch or target	Number of vessels subject to the LO [(1)]	Landings (tonnes)	Frequency of occurrence of discards (in sampled hauls)	Estimated discards (mean number of observed discarded specimens)	Estimated catch	Discard rate (mean discard rate in observed hauls)	Estimated discard survival proxies from provided studies
PRT	OTB	*Raja clavata* (by-catch)	57	136 tonnes (64-72% of skates landed in OTB)	OTB_CRU= 0% OTB_DEF= 11%	- Below 30% occurrence in sampled trips	Approx. 122	Approx. 0%	Estimated survival=64% %Excellent/Good vitality =60-72% At-vessel mortality =6-7%
PRT	Polyvalent vessels: GTR, GNS	*Raja clavata* (by-catch)	1024 [(2)]	454 tonnes [(2)] (53% of all skates landed by polyvalent)	22%	- (1.4±4.1 specimens discarded per haul)	NA	- (11±26% in number of specimens)	% Excellent/Good (soaking time <24h)=96-100% % Excellent/Good (soaking time >24h)=75-84%
PRT	Polyvalent vessels: GTR, GNS	*Raja brachyura* (by-catch)	1024 [(2)]	205 tonnes [(2)] (22% of all skates landed by polyvalent)	7%	- (0.1±0.5 specimens discarded per haul)	NA	- (3±15% in number of specimens)	% Excellent/Good (soaking time <24h)=76-89% % Excellent/Good (soaking time >24h)=90-96%
PRT	Polyvalent vessels: GTR, GNS	*Raja montagui* (by-catch)	1024 [(2)]	61 tonnes [(2)] (8% of all skates landed by polyvalent)	11%	- (1.4±4.1 specimens discarded per haul)	NA	- (7±24% in number of specimens)	% Excellent/Good (soaking time <24h)=70-100% % Excellent/Good (soaking time >24h)=70-88%
PRT	Polyvalent vessels: GTR, GNS	*Leucoraja naevus* (by-catch)	1024 [(2)]	33 tonnes [(2)] (2% of all skates landed by polyvalent)	7%	- (0.1±0.6 specimens discarded per haul)	NA	- (5±20% in number of specimens)	% Excellent/Good vitality (soak time >24h)=79%
PRT	Polyvalent vessels: GTR, GNS	*Raja undulata* (by-catch)	50 (246) [(3)]	28 tonnes (4% of all skates landed by polyvalent)	3%	- (0.0±0.4 specimens discarded per haul)	NA	- (2±12% in number of specimens)	% Excellent/Good (soaking time <24h)=86-98% % Excellent/Good (soaking time >24h)=95-97%

(1) The number of vessels is given considering all skate species combined, except *Raja undulata*.
(2) Considering all polyvalent vessels landing skates and rays, and that most of the landings are from trammel nets.
(3) 50 vessels with specific fishing licence to capture *R. undulata*. In 2017, a total of 246 vessels landed the species, limited to one specimen per trip to those vessels without specific fishing licence (Portaria nº 15-D/2018)

Table 13. Future Portuguese studies to be conducted in Portuguese mainland waters (ICES Div. 9a) that could contribute with the collection of new information on the survival of skates and rays in 2020.

Study	Species	Fleet	Information to be collected	Possible choke species
DCF onboard programme (2019-2021)	*Raja clavata* *Raja brachyura* *Raja montagui* *Leucoraja naevus*	Nets	Vitality assessment	Yes
DCF onboard programme (2019-2021)	*Raja clavata* *Raja brachyura* *Raja montagui* *Leucoraja naevus*	Trawl	Vitality assessment	Yes
PhD thesis (predicted for 2020, under Project PP-centro)	*Leucoraja naevus*	Trawl	Vitality assessment Short-term survival	Yes
MsC thesis (predicted for 2020, under Project PP-centro)	*Raja clavata* *Leucoraja naevus*	Nets	Vitality assessment Short-term survival	Yes

3.4 References

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Effects of the *Raja undulata* fisheries ban on its abundance[1]

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Abstract

Since 1999, fisheries bans have been put in place to support the recovery of vulnerable elasmobranch species. However, the effectiveness of fisheries bans are rarely evaluated. Here, we assess the effect of the 2009 *Raja undulata* (undulate ray) fisheries ban, by exploring abundance and length General Additive Mixed Models derivative changes. Potential knock-on responses on partially sympatric species *Raja clavata* (thornback ray) are equally explored. To undertake this analysis fisheries dependent (2003 to 2018) and independent data (1995 to 2018) were used.

An increase in mean abundance and length was observed in both species following the ban. Although the ban was appeared to be the primary reason for the increased abundance, warmer seawater temperature also positively influenced the abundance of these shallow water species. A population dynamic model confirmed that discard survival supported population recovery during the ban.

Fisheries bans not only have positive effects on the species in question but also on species with a niche overlap. However, due to ongoing demersal fishing for other species, their full potential can be mitigated. Insufficient time passed for long lasting responses of the fisheries ban to be detected.

1. Introduction

Within this study, we use long term fisheries dependent (2003 to 2018) and independent (1995 to 2018) data on skate abundance, and analysed significant Generalised Additive Mixed Model (GAMM) derivative changes according to the implementation of a fisheries ban. We used the *Raja undulata*, Undulate ray fisheries ban, set up in 2009 (EC 43/2009; Ellis et al. 2012) to protect this IUCN red list 'Endangered species' as a case study (IUCN, 2019). The *R. undulata* fisheries ban imposed was, however, controversial with certain fishers due to high capture rates observed (ICES, 2018a & b). Consequently, *R. undulata* was removed from the

[1] This working document is a shortened version of a manuscript which intends to be submitted to a journal.

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prohibition list in 2015, and a small but annually increasing Total Allowable Catch (TAC) was permitted in the English Channel (112 to 180 tonnes) and the Bay of Biscay (25 to 30 tonnes) (EC 2015/960; ICES 2018a & b).

Due to missing control data on this species, partially sympatric *Raja clavata*, the thornback ray (classified as 'Near threatened') (IUCN, 2019) abundance variations were also studied. To understand whether changes in skate abundance were as a result of the fisheries ban and not climate change, abundance variations in accordance to seawater temperature were analysed.

1. Method

1.1. Study area and survey data

Fisheries independent Channel Ground Fish Survey (CGFS) data and French fisheries dependent observer (ObsMer) data were analysed from North-Eastern Atlantic waters. ObsMer data provide targeted and bycatch, landed and discarded data from fishing vessels throughout the year. The ObsMer programme begun in 2003, however, data were standardised as of 2009. To reduce zero inflation, spatial and temporal bias, and presence over estimations, a skate catch of more than one percent, and only gear types with an even spatial-temporal coverage were used for analysis. For both skates, these included trammel nets (GTR), otter beam and otter twin trawls (OTB and OTT).

1.2. Skate abundance variations over time

All statistical modelling and mapping was undertaken within R CRAN free software. Potential outliers were identified with boxplots and mapping aberrant values. Negative binomial GAMM were implemented to observe non-linear trends over time. Mean skate abundance per trawl were modelled against time to reduce the stochasticity of population trends. Negative binomial distributions was implemented to account for over dispersion. The mean abundance was square root transformed to reduce right skewness and improve the model fit. To account for gear and area (International Council for the Exploration of the Sea (ICES) divisions) effects on skate abundance from the ObsMer data, both variables were incorporated into the model as random effects.

1.3. Climate change effects

To explore whether climate change effects were responsible for the increase in skate abundance, monthly mean sea surface temperature data were downloaded from Copernicus (1995 to 2016) and PATHFINDER (2003 to 2018) websites.

1.4. Age-structured population dynamic model

To understand the abundance changes observed in *R. undulata* according to the different management plans introduced, an age-structured population dynamic model was created under two scenarios:

1) A fished population, where fishing was constant, until a hypothetical ban was introduced (2009);

2) A fished population with increased juvenile (Age-0-2) survival rate from discards, until a hypothetical ban was introduced (2009).

To model these scenarios, *R. undulata* length at age was calculated from the ObsMer dataset using the von Bertalanffy growth function (VBGF).

2. Results

2.1. Skate abundance variations

Using both datasets, a significant increase in abundances of both *R. undulata* and *R. clavata* were observed during the *R. undulata* fisheries ban, which tailed off when the TAC quotes for *R. undulata* was reintroduced in 2015 (Fig. 1). From the CGFS data, the significant increase in *R. undulata* abundance was observed from 2010 (Fig. 1.a.i), whereas the increase in *R. clavata* mean abundance was observed from 2008 (Fig. 1.b.i). Using the ObsMer dataset, for both species, a decline in mean abundance was observed between 2003 and 2004 (Fig. 1.ii). *R. undulata* mean abundance increases as of 2008 (Fig. 1.a.ii). Whereas *R. clavata* mean abundance increased between 2005 and 2007 and again as of 2011(Fig. 1.b.ii).

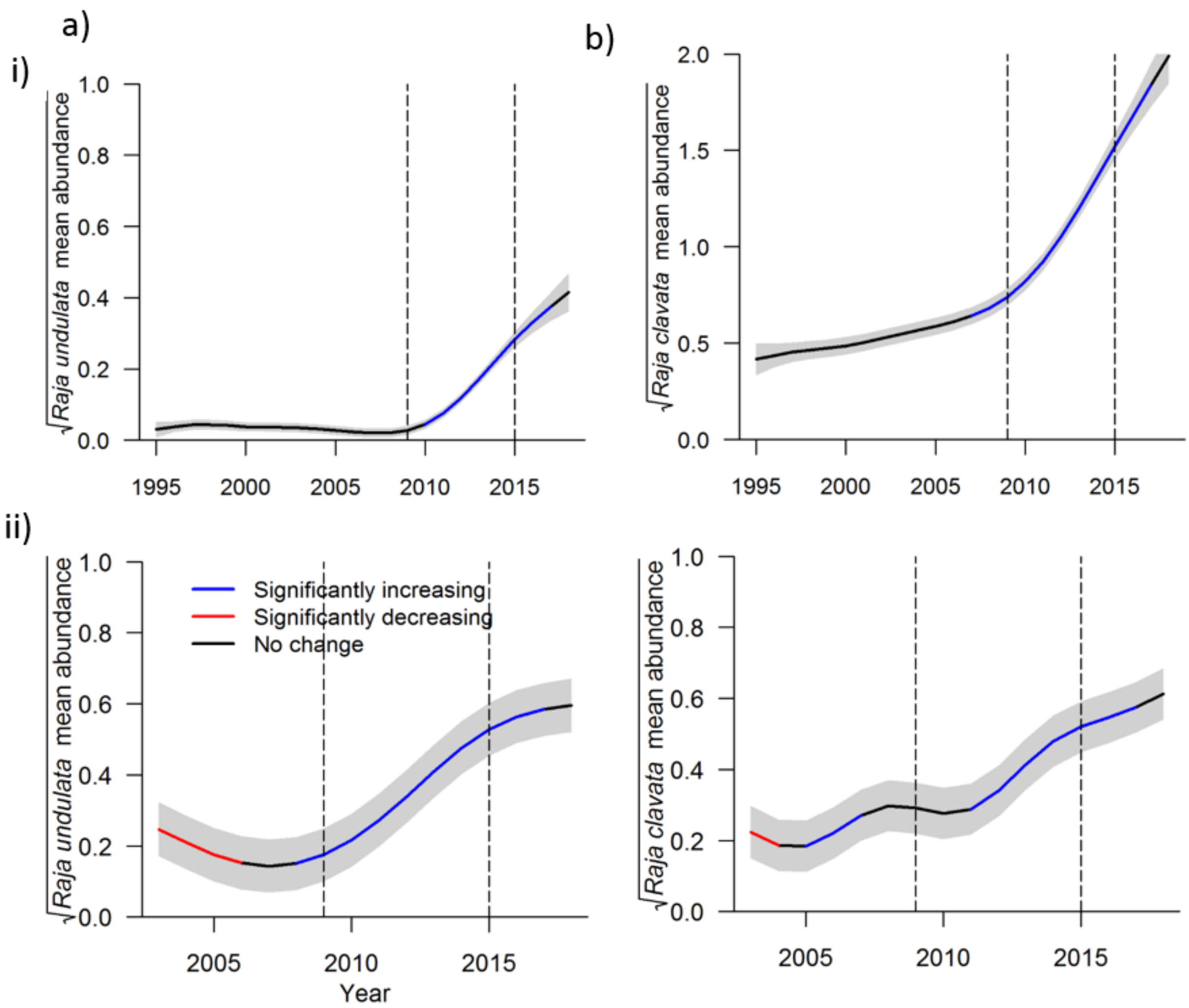

Fig. 1 a) *Raja undulata* b) *Raja clavata* mean square root abundance trends from i) 1995 to 2018 using Channel Ground Fish Survey data and ii) 2003 to 2018, using ObsMer data. Each response variable is fitted with a general additive mixed-effect model versus year. The fitted line is black, and 95% confidence intervals are shaded in grey. The vertical dashed black line indicates the 2009 *R. undulata* ban and the 2015 relax in prohibition.

2.2. Climate change effects

For both species the model of best fit was that of an interaction between temperature and time. *R. undulata* had a non-linear preference for warmer water (Fig. 2.a), whereas *R. clavata* had a preference for cooler waters than *R. undulata* (Fig. 2.b). When comparing predictor variables independently, year was the stronger predictor variable for both *R. undulata* and *R. clavata*.

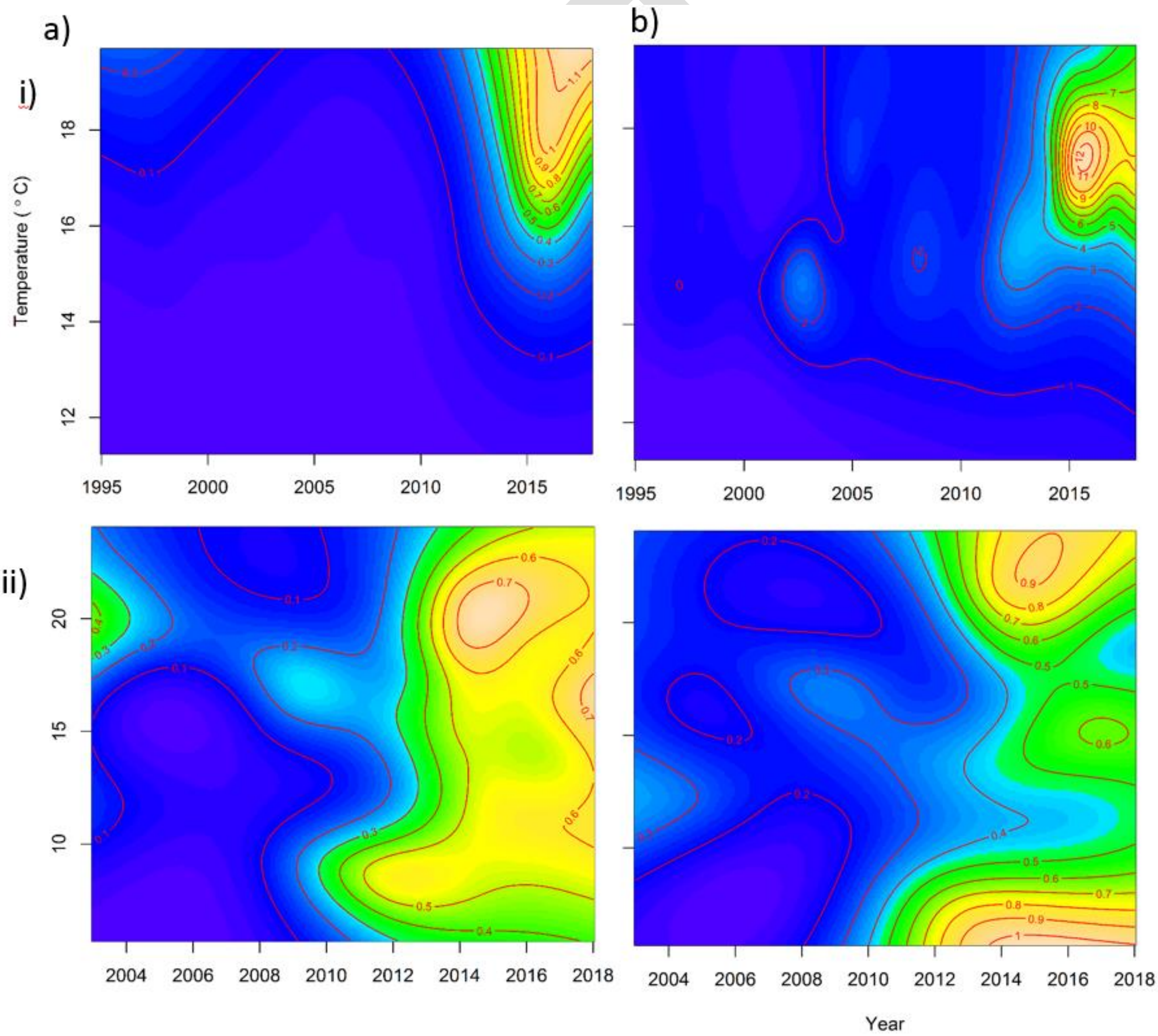

Fig. 2. Vis.gam plot of the effect of temperature and time on the mean abundance of i) *R. undulata* and ii) *R. clavata* using a) Channel Ground Fish Survey data and b) ObsMer data. Contours highlight relative abundance, Lighter colours represent higher abundances and darker colours represent lower abundances.

2.3. Age-structure population dynamic model

Within a fished environmnent *R. undulata* modeled abundance declined until the ban was introdued, where the abundance leveled off (Fig. 3a). However, when the population dynamic model was modified to allow for increased discards survival, a strong increase in abundance was observed following the ban (Fig. 3b), similar to that observed within Figure 1.

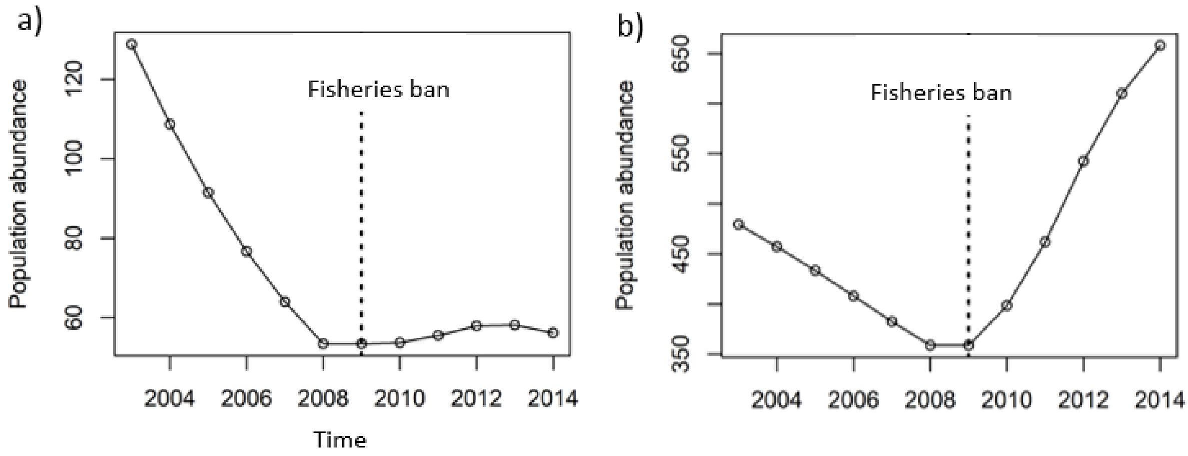

Fig. 3. *Raja undulata* age-structured population dynamic model under a) fished environment before 2009 and the ban there after and b) under a fished environment before 2009 where discarded juveniles survive and the ban introduction after 2009. The dashed vertical line indicates the 2009 fisheries ban introduction.

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Distribution and ontogenetic shift models indicate vulnerability in skates[1]

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Abstract

Here, three supposedly sympatric skates occupying north-eastern Atlantic waters, which are subjected to similar environmental pressures, were studied. These skates have differing conservation status, indicating varying ecological traits. Fisheries dependent data on skate bycatch and a series of environmental variables were used to model spatio-temporal differences in habitat use between the three species in order to understand their contrasting conservation status.

Raja undulata, the undulate ray (IUCN red listed as 'Endangered') was observed to have an isolated coastal distribution. *Raja clavata,* the thornback ray ('Near threatened'), had a broader distribution with higher presence in the eastern English Channel. *Raja montagui*, the spotted ray's distribution ('Least concerned'), was greatest off the coast of southern Ireland. Seasonal and ontogenetic distribution differences were also observed.

From the fisheries dependent data, wider spatio-temporal skate distributions than previously studied, were modelled, indicating that these species may not be fully sympatric. This study contributes to a greater understanding of skate habitat during their key life history stages, and indicates reasons for *R. undulata's* increased vulnerability than *R. clavata* and *R. montagui*. Information from the distribution models could be used for specific spatio-temporal management measures. Better understanding of the distribution of species may also avoid protected species such as *R. undulata* from becoming choking factor in a fishery due to high bycatch rate.

1. Introduction

Several supposedly sympatric species of skate are found to occur within north-eastern Atlantic waters. Here, three species were studied because of their sympatric geographical coverage (Ellis et al., 2004; Serra-Pereira et al., 2014), and because of their contrasting conservation status, indicating potential ecological trait differences. These skates include *Raja undulata* the undulate ray which is globally classified as 'Endangered' under the IUCN red list, *Raja clavata* the thornback ray, classified as 'Near threatened', and *Raja montagui* the spotted ray,

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classified as ‘Least concerned’ (IUCN, 2019). *R. undulata* was also listed as a ‘prohibited species’ by the European Commission from 2009 to 2015/2016, depending on the area (EC 43/2009). All three species are caught as bycatch by a number of different gear types.

Here, fisheries dependent data on skate bycatch and a variety of oceanographic variables which affect the habitat these demersal skates occupy, were used to model their spatio-temporal distribution within north-eastern Atlantic waters. Since fisheries dependent data is collected throughout the year, seasonal variation in habitat use was possible to model. Ontogenetic differences were also explored.

2. Methods

On board French fisheries observer data (ObsMer) were analysed from north-eastern Atlantic waters. ObsMer data provides targeted and bycatch information from fishing vessels throughout the year. All statistical modelling and mapping was undertaken within R CRAN free software. Binomial generalised linear mixed models with a logit or a complementary log-log link function were employed. Since the skates studied were not frequently present in catches (> 70 % zero), and to avoid zero inflation, the study area was downscaled and divided into a regular grid. For each grid cell, the central point was assigned a value of one if it contained an individual and a value of zero in the absence of an individual.

Variations in the distribution of skate according to the different time of year were explored to identify possible migratory behaviour. The model of best fit was identified by testing the accuracy, the mean deviance explained and the lowest Akaike Information Criterion (AIC) of the prediction by a bootstrap cross-validation. For cross-validation, a random subset of 75% of the dataset was used for parameter estimation and the remaining 25% of observations were used for validation. This procedure was then replicated 1000 times. The potential for aggregated skate distributions was inspected by cluster. Ontogenetic habitat variation was explored by modelling the explanatory variables according to length using a general linear mixed model.

3. Results

3.1. Skate presence absence distribution models

Over 100,000 fishing operations were analysed from 2009 to 2017. Between the different sized grids (10 km^2, 20 km^2 and 30 km^2), higher prediction accuracy (improved AUC) and a more even gear spatio-temporal coverage for all three species was observed with a grid of 10 km^2.

The three species of skate were observed to have very different distributions. *R. undulata* had a patchy coastal distribution (visualised through the cluster analysis at a distance of 0.15 of a decimal degree), with highest presence in the east of Brittany (ICES division 7.e). *R. clavata’s* distribution was mainly concentrated to the east of the English Channel (ICES division 7.d). *R. montagui*’s distribution was highest within ICES division 7.g (south of Ireland; Fig 1). *R. undulata* and *R. clavata* had a reduced presence in winter, whereas *R. montagui’s* distribution was the broadest in winter and extended down to ICES division 7.h (Fig 1). All models exceeded the evaluation criteria ($P < 0.01$, AUC and a confusion matrix score of >0.7) (Hosmer, 2013).

Predictor variables influencing the habitat of the three species were mainly reflected by that of their spatial (X, Y and Z) distribution. *R. undulata* was observed in shallower waters than *R. clavata*. *R. montagui* was observed in deeper waters than the other two species. For all three species, a higher presence was observed over coarse-grain. The latter was particularly prominent for *R. montagui*, where no individuals were observed over a mud flat off the coast of southern Ireland.

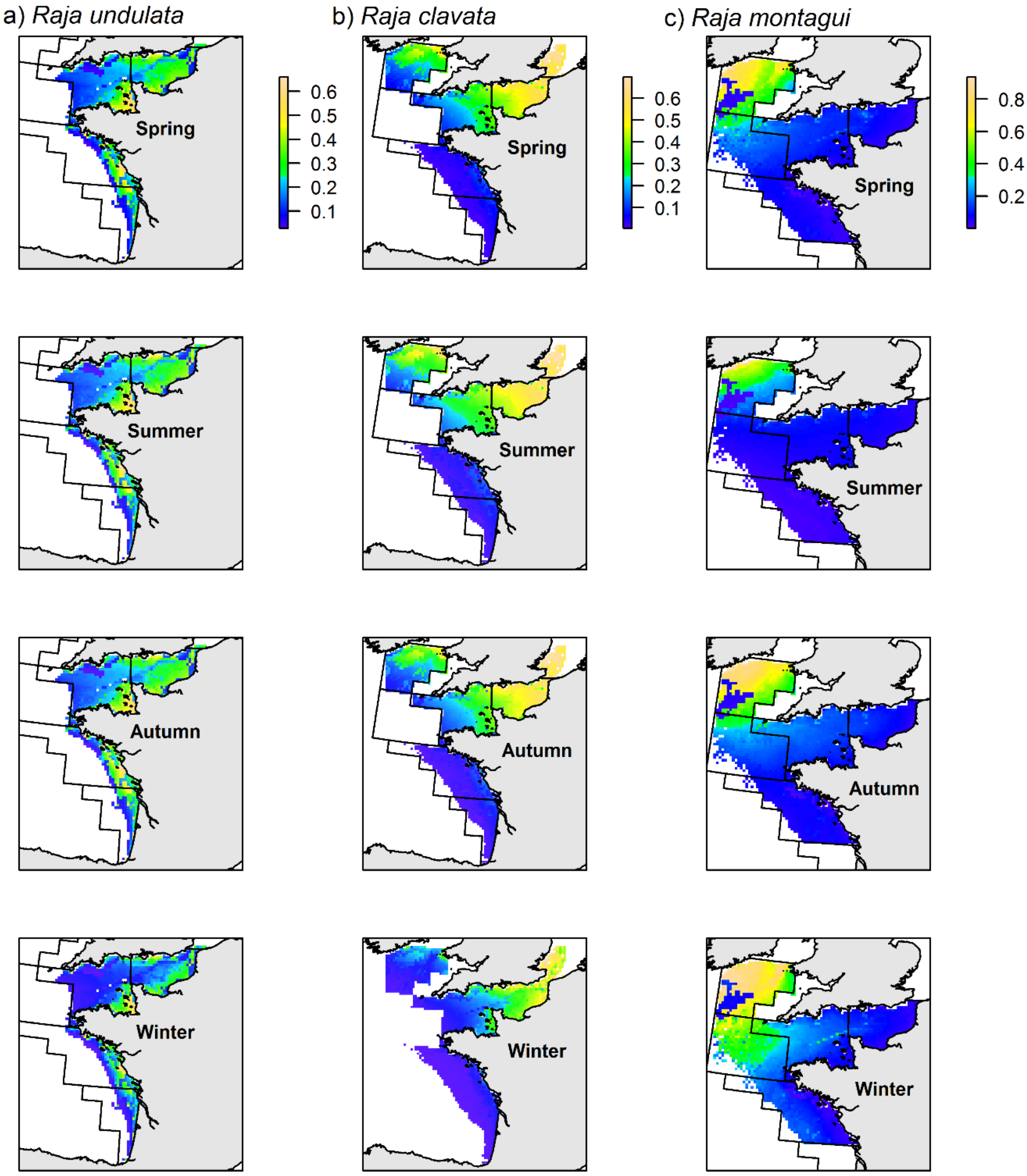

Fig. 1. a) *Raja undulata* b) *Raja clavata* and c) *Raja montagui* prediction maps (10 km^2 cells) per season (three month period).

3.2. *Skate Ontogenetic differences*

For all three species, larger individuals were observed in deeper or more saline waters, and over more rugose sediments than smaller individuals (Table 1). For *R. montagui,* an increase in depth with length was not observed.

Table 1. Summary of the predictor variables effect for the length models for each species. R = rock, Cg = course grain, S = sand, M = mud. A = autumn, Sp = spring, Su = summer, W = winter, ↑ = increase, ↓ = decrease.

Species	Predictor variable	Effect	P value
R. undulata	Depth: Season	↑ Au & Sp > Su & W	0.0001
	Salinity: Season	↑	0.0001
	Sediment type	R > Cg > S & M	0.0001
R. clavata	Depth: Season	↑ ~same between season	0.0001
	Salinity	↑	0.0001
	Chlorophyll a	↓	0.0001
	Turbidity	↓	0.001
	Sediment type	Cg & R > S & M	0.001
R. montagui	Salinity: Season	↑ Sp > A & W > Su	0.0001
	Turbidity	↓	0.0001
	Sediment type	Cg > S	0.0001

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This study was funded by the French marine fisheries and aquaculture administration (DPMA). We are grateful to DPMA and all those who were involved in collecting and compiling on-board fisheries observer data (OBSMER).

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Working Document for the ICES Working Group on Elasmobranch Fishes

Lisbon, 18th – 27th June 2019

Onboard sampling information for deep-water sharks in Portuguese mainland waters (2009-2018)

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ABSTRACT

Information collected under Data Collection Framework (PNAB/DCF) for the deep-water sharks *Centroscymnus coelolepis*, *Centrophorus squamosus* and *Deania calcea* is presented. Data was collected onboard vessels belonging to the deep-water longline fishery targeting the black scabbardfish, from 2009 to 2018. The sampling effort achieved, by year, is considered insufficient to provide information on the abundance or biomass on deep-water shark species.

INTRODUCTION

The black scabbardfish *Aphanopus carbo* (Lowe, 1839) is one of the main species landed in Portugal mainland. There is a deep-water longline fishery targeting this species which started in 1983 at fishing grounds around Sesimbra (Bordalo-Machado and Figueiredo, 2009). In the 1990´s, the fishery was composed by a fleet of nearly 22 vessels. Nowadays the longline fishery operates in the north and centre (down to Sesimbra) of the Portuguese continental slope, from 1000 to 1400 m deep (Moura et al., 2013). It is composed by 15 artisanal vessels, that operate at specific fishing grounds. Despite the expansion of the fishing area, Sesimbra (at the south of Lisbon) continues to be the most important landing port for this fishery.

Before the EU management measures adopted for deep-water sharks, particularly in 2010, the by-catch of the leafscale gulper shark, *Centrophorus squamosus* (Bonnaterre, 1788), and of the Portuguese dogfish, *Centroscymnus coelolepis* Barbosa du Bocage and de Brito Capello, 1864 constituted an important added value for the fishermen involved in black scabbardfish fishery. These species were included in the EU list of deep-water sharks (EU, 2013) which also includes the following taxa: *Apristurus* spp., *Chlamydoselachus anguineus*, *Centrophorus* spp., *Centroscymnus crepidater*, *Centroscyllium fabricii*, *Deania calcea*, *Dalatias licha*, *Etmopterus princeps*, *Etmopterus spinax*, *Galeus murinus*, *Hexanchus griseus*, *Oxynotus paradoxus*, *Scymnodon ringens*, and *Somniosus microcephalus*. From these, ICES has information and provides advice for three species: the Portuguese dogfish (*C. coelolepis*), the leafscale gulper shark (*C. squamosus*), and the kitefin shark (*D. licha*).

In the last 12 years, and due to the EU restriction measures, registered catches of deep-sea sharks in the NE Atlantic have greatly declined. At the present, although discarding is known to occur in existing deep-water fisheries, these have not been fully quantified. Preliminary ICES estimates are considered uncertain (ICES, 2015).

Information available for this fleet is collected by the Portuguese Institute for the Sea and Atmosphere (IPMA) which is the responsible for the Portuguese onboard sampling programs conducted under the National Biological Sampling Programme (PNAB/EU DCF). Sampling follows a quasi-random sampling design focusing the fleet composed by cooperative commercial vessels with length overall (LOA) between 12 and 40 m (Prista *et al*., 2014 WD). The sampling program started in late 2003´s and, at the beginning, the design and sampling effort allocation were focused on the estimation of European hake discards. Later, the program was extended to include more fishing *métiers* and fleets, amongst other, bottom otter trawl, deep-water set longlines (LLS-DWS métier), gill and trammel nets (of various mesh sizes), beam trawl and purse seines.

The sampling effort initially assigned to LLD-DWS *métier* was determined following the Neyman criterion. According to this, the optimum number of trips to be performed per vessel at Sesimbra landing port was estimated as 3 trips per month (margin of error of 1 with 95% probability). However, throughout the whole time period, several factors have conditioned the attainment of that sampling effort and, therefore, a median of 2 hauls per month was achieved and not all months of the year were sampled.

The present study provides information on the deep-water sharks caught in fishing trips with onboard sampling and conducted in vessels belonging to the deep-water longline fishery targeting the black scabbardfish. The analysis is based on the data collected by IPMA from 2009 to 2018.

MATERIAL AND METHODS

Data presented was collected under PNAB/DCF from 2009 to 2018. The sampling was highly condition by on-board conditions, namely the vessels capacity to accommodate observers. Data collected included, among others, the position and depth of the hauls and the number of individuals caught by species.

Based on the deep-water shark species occurrence data and on their economic relevance, the analysis of these data will focus on three main species: *C. squamosus*; *C. coelolepis* and *D. calcea*.

RESULTS

IPMA on-board sampling program - deep-water longline fishery

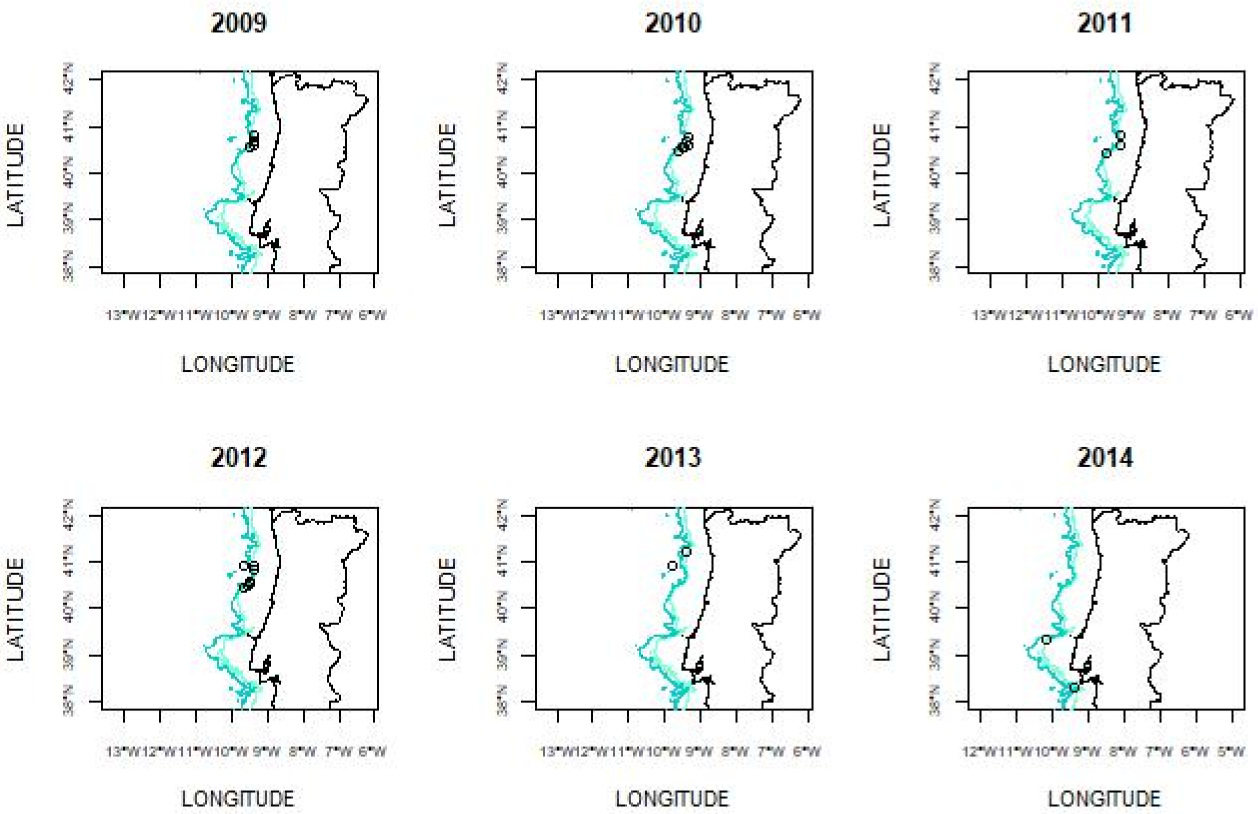
The on-board sampling of the LLS-DWS *métier* took place at nine different vessels. The number of sampled hauls, by vessel, differed among years. Only three vessels were sampled along the whole time period whereas the remaining were sampled either at its beginning or at its end.

Table 1 presents the number of fishing hauls where elasmobranch species occurred by year, for the period 2009 – 2018. *Deania calcea*, *C. squamosus* and *C. coelolepis* are among the most frequently caught species.

Table 1 - Number of fishing hauls in which the species occur, by year (2009-2018).

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	T_hauls
Deania calcea	3	3	3	3	2	2	4	2	16	13	51
Centrophorus squamosus	3	3	3	3	2	1	4	2	13	12	46
Etmopterus pusillus				3	2		3	1	15	12	36
Centroscymnus coelolepis	3	3	1	2	1	2	3	1	9	4	29
Scymnodon ringens	2	2	1	2		1	4	2	5	8	27
Centroscymnus crepidater	3	2	1	1	2		1	1	4	7	22
Galeus melastomus	1	2	3	2	2	1	3	1	1	4	20
Etmopterus spp	3	3	3	1	1				2	3	16
Centrophorus granulosus	1	1			1		1			3	7
Deania profundorum				1			1	1	2	2	7
Etmopterus spinax						2	1			3	6
Dalatias licha		1							1	3	5
Galeus atlanticus									1	2	3
Selachii		2	1								3
Chlamydoselachus anguineus		1								1	2
Galeus spp								1		1	2
Somniosus rostratus									2		2
Etmopterus princeps									1		1
Heptranchias perlo							1				1
Hexanchus griseus								1			1

Figure 1 presents, for each year, the geographic locations of the sampled fishing hauls for the whole set of on-board fishing trips. The analysis of the figures shows that, before 2014, sampled fishing hauls were mainly located northwards; after this year, the fishing hauls locations were more disperse, covering a more southern area. It should be noted that these differences do not reflect any change on fleet dynamics but are rather related to the opportunistic feature of the sampling.


2009
2010
2011
2012
2013
2014
LATITUDE
LONGITUDE

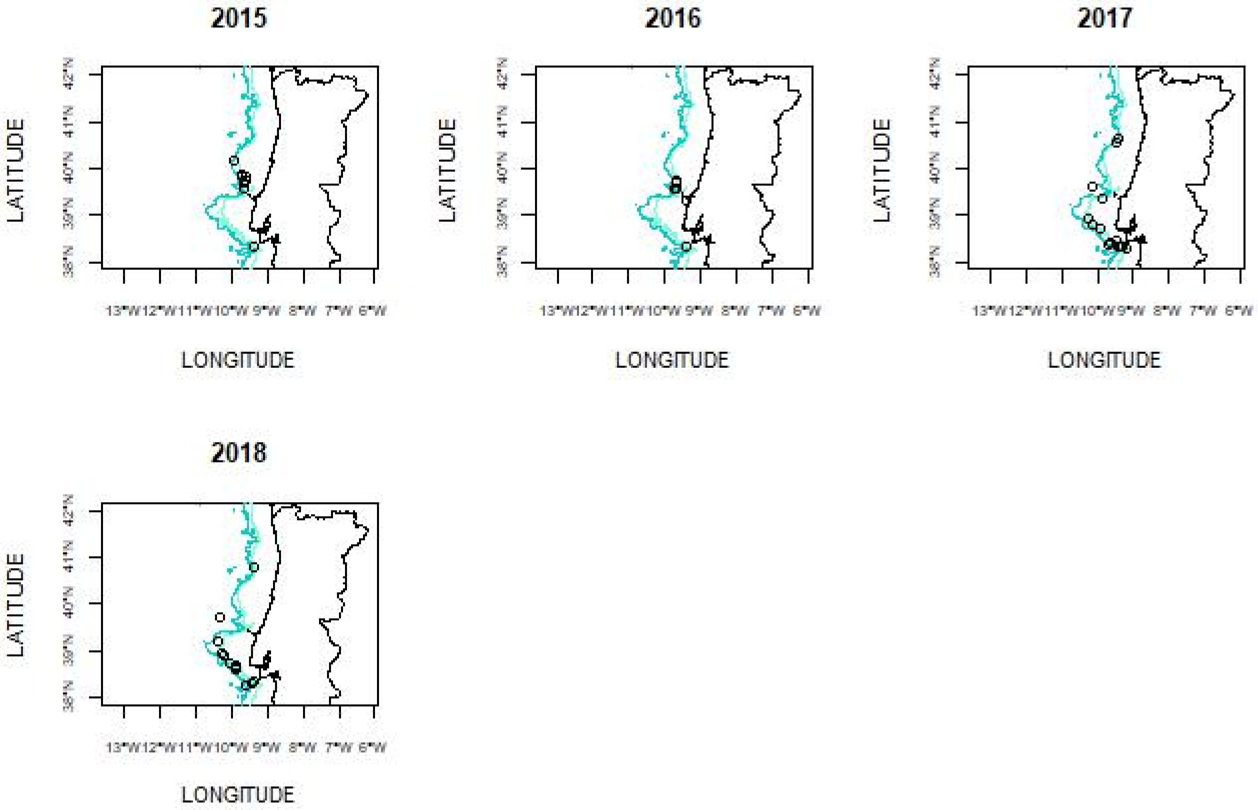


Figure 1 – Geographic locations of the LLS-DWS fishing hauls sampled from 2009 to 2018

Centrophorus squamosus

Centrophorus squamosus was caught in all sampled vessels and its relative occurrence at the sampled fishing hauls varied between 17 and 100%. Also, the number of specimens caught varied not only among years but also among vessels (Table 2).

Table 2 - *Centrophorus squamosus* Maximum (max_no) and minimum (min_no) number of specimens by haul, number of hauls(n_hauls) with the species and total number of hauls (T_n_hauls) sampled per year and per vessel

VESSEL_CODE	YEAR	min_no	max_no	n_hauls	T_n_hauls
V1	2009	26	27	1	2
V1	2010	3	8	1	3
V1	2011	16	16	1	1
V1	2012	8	8	1	2
V1	2013	5	5	1	1
V1	2017	21	30	1	2
V1	2018	1	1	1	1
V2	2009	4	5	1	2
V2	2010	8	13	1	2
V2	2015	14	14	1	1
V2	2017	16	16	1	1
V2	2018	1	7	1	4
V3	2015	1	11	1	6
V3	2017	9	9	1	1
V4	2014	25	25	1	1
V4	2015	44	44	1	1
V4	2016	2	8	1	2
V4	2017	5	8	1	4
V4	2018	8	15	1	3
V5	2009	5	7	1	2
V5	2010	2	21	1	4
V5	2011	21	21	1	1
V5	2012	6	52	1	4
V5	2015	2	5	1	2
V5	2016	6	15	1	6
V5	2017	2	8	1	4
V5	2018	2	2	1	2
V6	2011	3	38	1	4
V6	2012	3	30	1	3
V6	2013	15	15	1	1
V7	2017	1	2	1	2
V8	2017	4	4	1	2
V8	2018	1	1	1	2
V9	2017	10	10	1	1
V9	2018	5	5	1	2

The number of specimens caught by fishing haul versus depth does not suggest any clear trend (Figure 2).

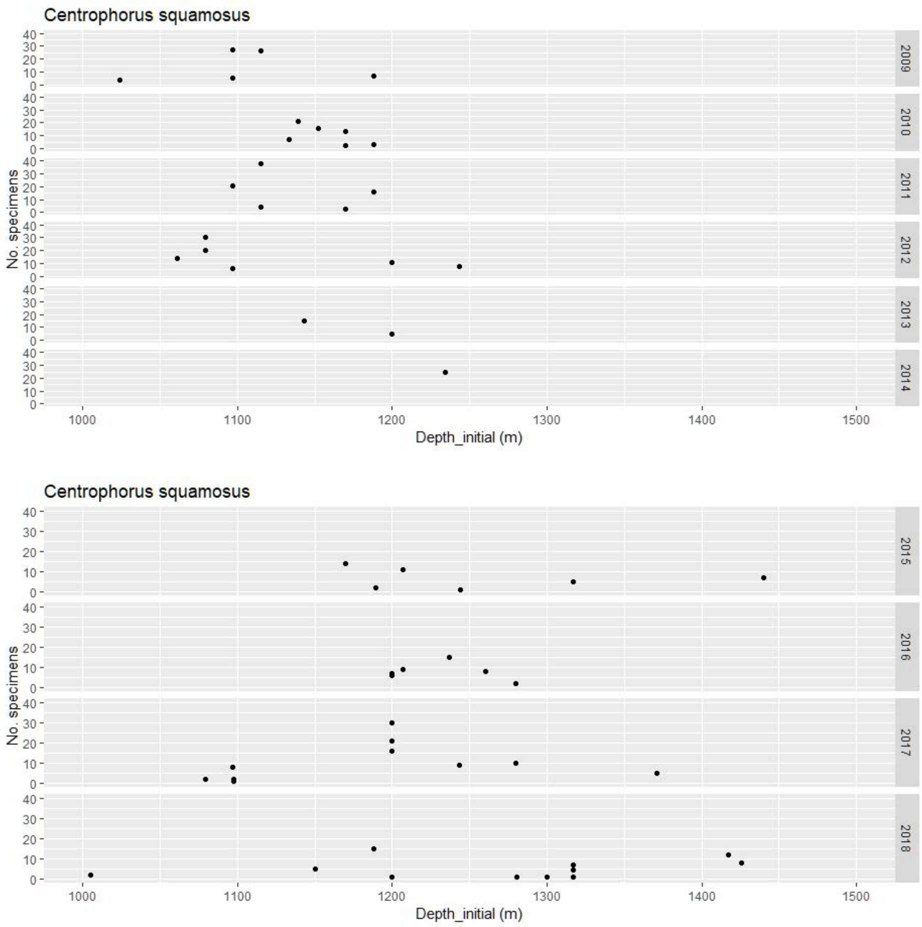
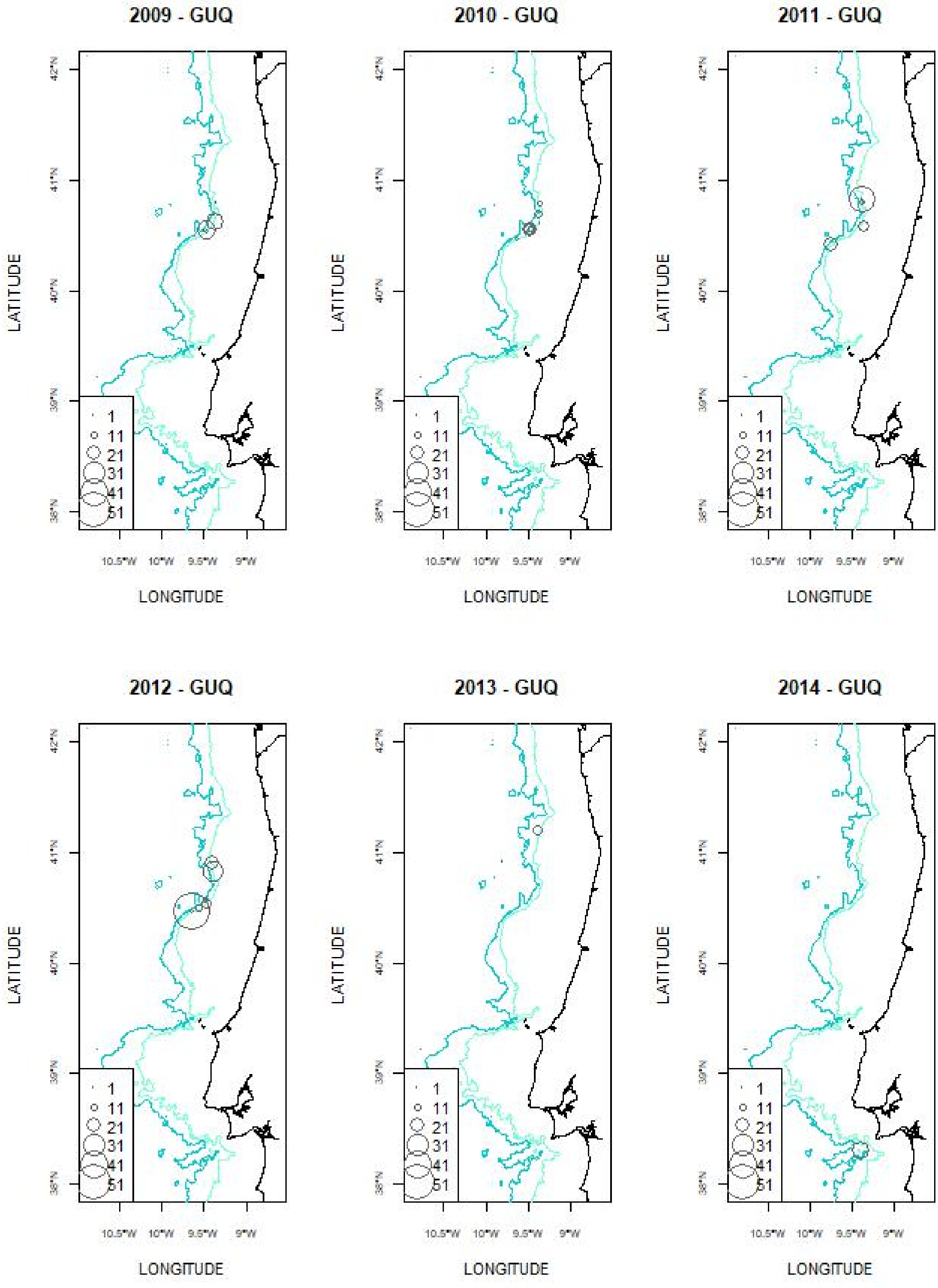


Figure 2 –Number of specimens of *C. squamosus* caught by fishing haul *versus* depth (in m) for the period 2009 to 2018.

The geographic location of the number of the specimens caught does not put in evidence any temporal trend, which can be also associated with the spatial changes of the sampled fishing hauls as previously mentioned. Until 2014 there was a predominance of fishing hauls located northwards while afterwards fishing hauls were located southward (Figure 3).


2009 - GUQ
2010 - GUQ
2011 - GUQ
2012 - GUQ
2013 - GUQ
2014 - GUQ
LATITUDE
LONGITUDE
1
11
21
31
41
51
10.5°W 10°W 9.5°W 9°W
38°N 39°N 40°N 41°N 42°N

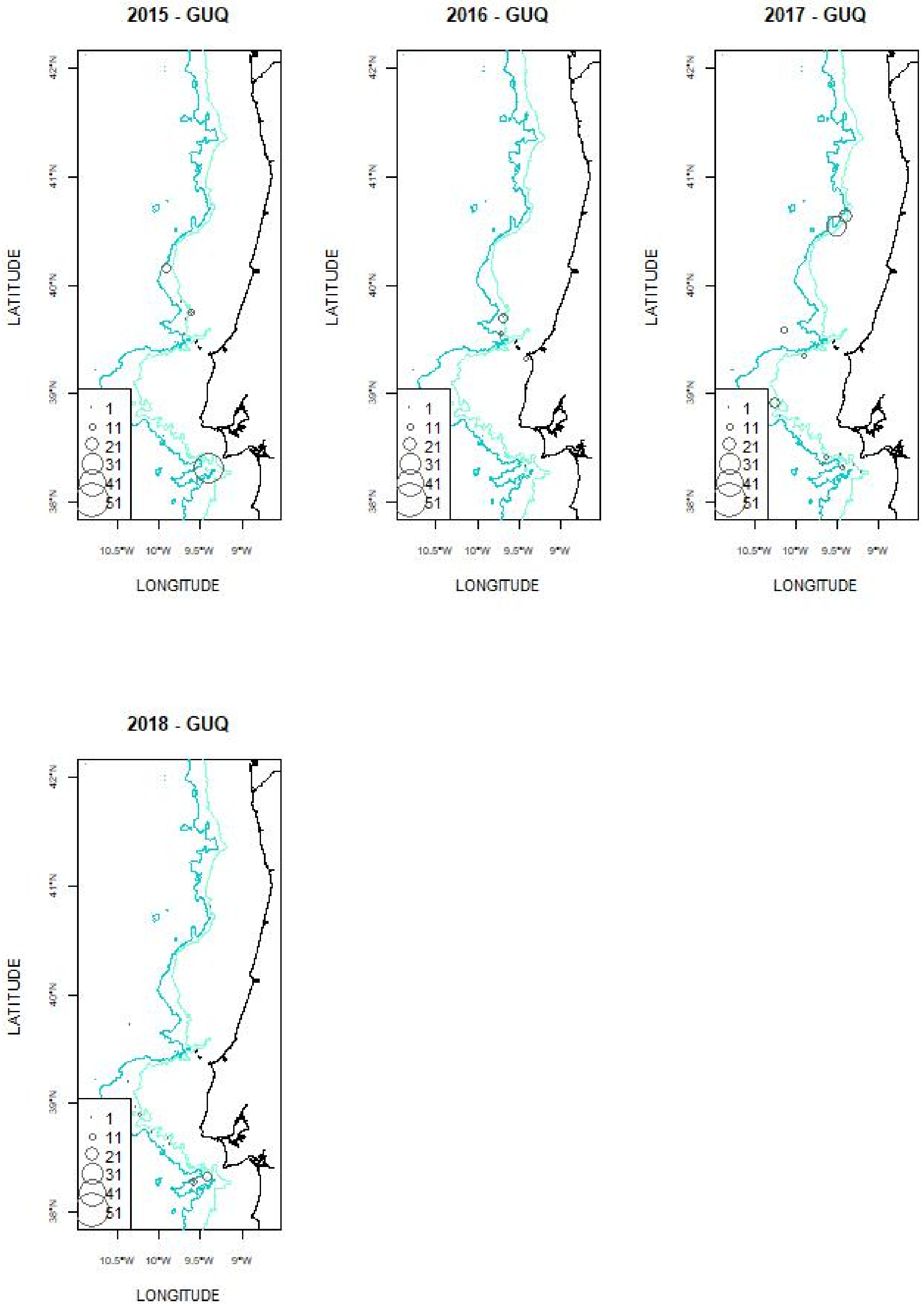


Figure 3 – Geographic location and number of specimens of *C. squamosus* caught by fishing haul for the period 2009 to 2018.

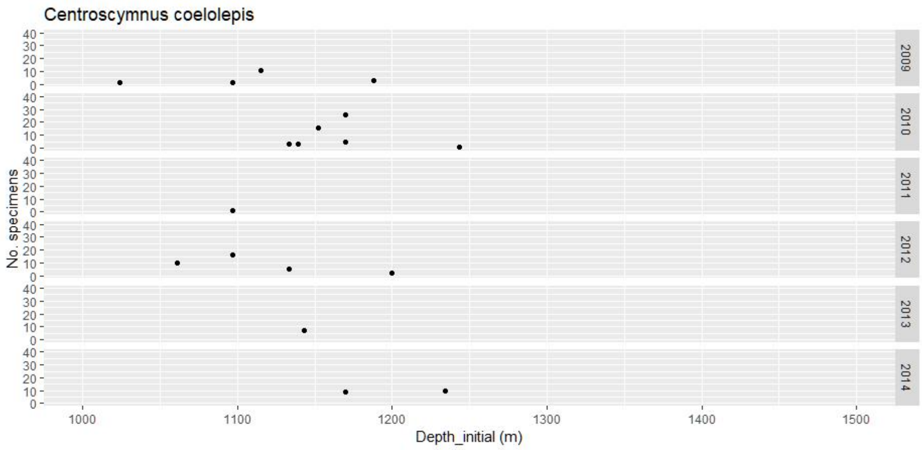
Centroscymnus coelolepis

Centroscymnus coelolepis was caught in all sampled vessels and its relative occurrence at the sampled fishing hauls varied between 33 and 100%. The number of specimens caught per fishing haul varied, not only among years, but also among vessels (Table 3).

Table 3 - *Centroscymnus coelolepis Maximum* (max_no) and minimum (min_no) number of specimens per haul, number of hauls(n_hauls) with the species and total number of hauls (T_n_hauls) sampled per year and per vessel

VESSEL_CODE	YEAR	min_no	max_no	n_hauls	T_n_hauls
V1	2009	1	11	2	2
V1	2010	1	1	1	3
V2	2009	1	17	2	2
V2	2010	5	5	1	2
V2	2017	1	1	1	1
V2	2018	1	12	2	4
V3	2015	3	5	2	6
V4	2014	10	10	1	1
V4	2015	3	3	1	1
V4	2017	1	19	3	4
V4	2018	1	1	1	3
V5	2009	3	3	1	2
V5	2010	3	26	4	4
V5	2011	1	1	1	1
V5	2012	2	16	4	4
V5	2014	9	9	1	1
V5	2015	1	6	2	2
V5	2016	1	2	4	6
V5	2017	1	1	2	4
V6	2012	1	1	1	3
V6	2013	7	7	1	1
V7	2017	2	4	2	2
V8	2017	33	33	1	2
V9	2018	4	4	1	2

The number of specimens caught by fishing haul *versus* depth presented in Figure 4 does not suggest any clear trend.



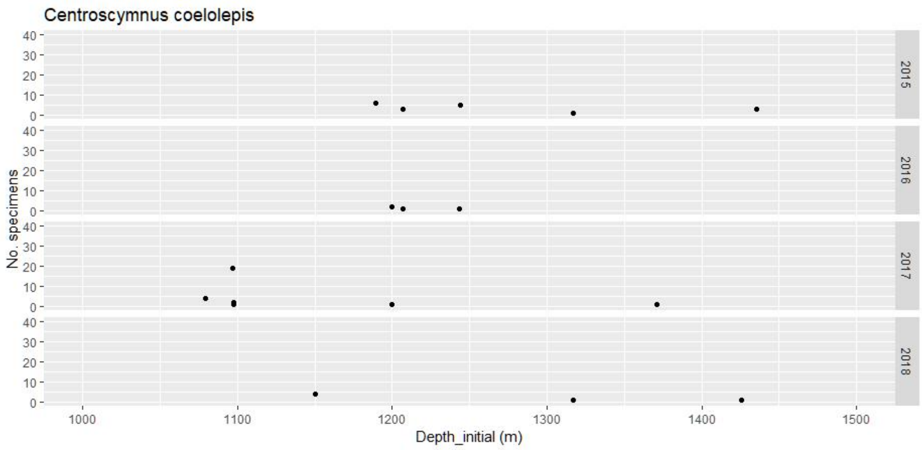
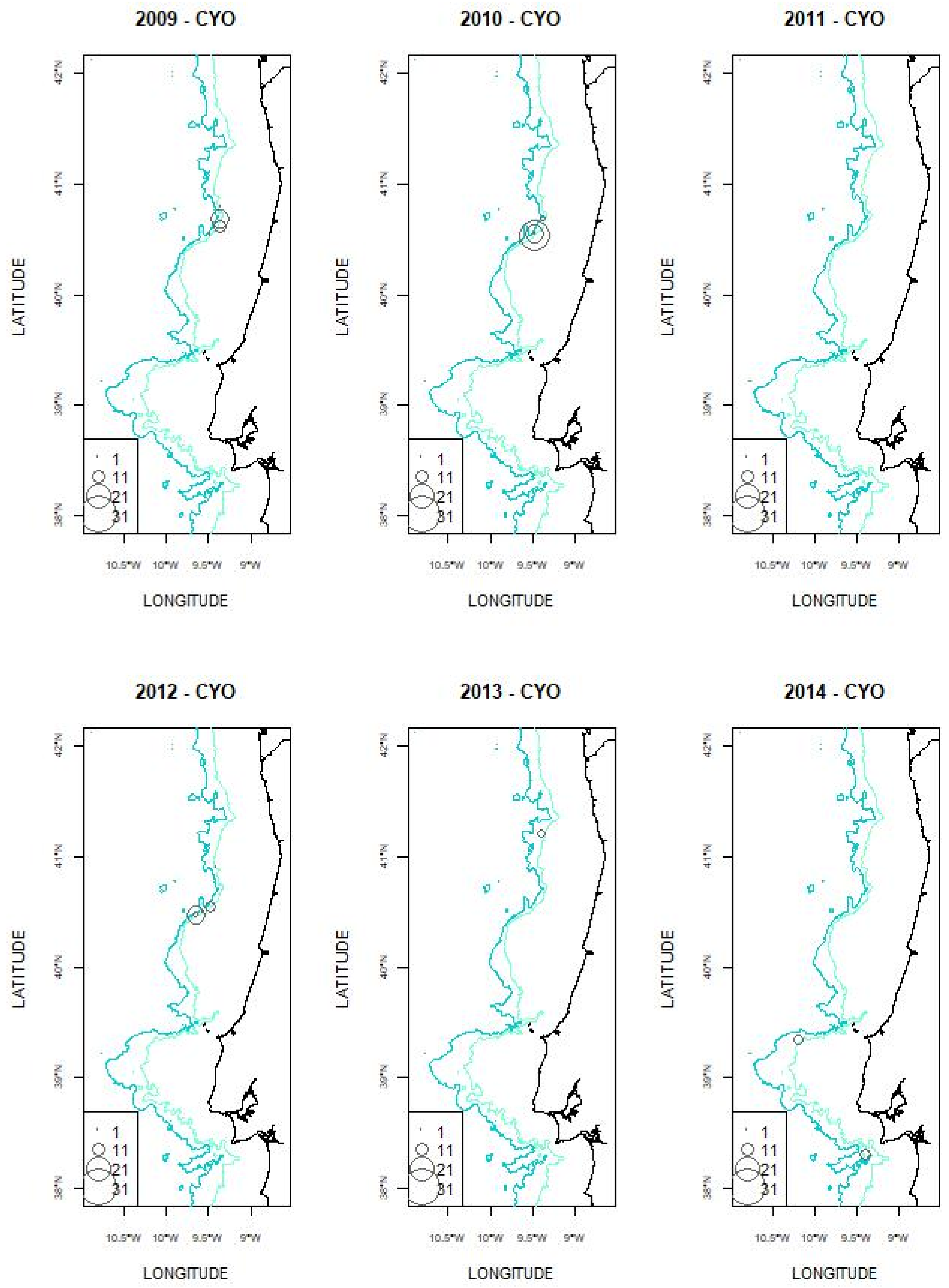


Figure 4 –Number of specimens of *C. coelolepis* caught by fishing haul *versus* depth (in m) for the period 2009 to 2018.

The geographic information on number of specimens caught per fishing haul suggests a patchy distribution of the species; high number of specimens were consistently caught in some places (Figure 5).


2009 - CYO
2010 - CYO
2011 - CYO
2012 - CYO
2013 - CYO
2014 - CYO
LATITUDE
LONGITUDE
42°N
41°N
40°N
39°N
38°N
10.5°W
10°W
9.5°W
9°W
1
11
21
31

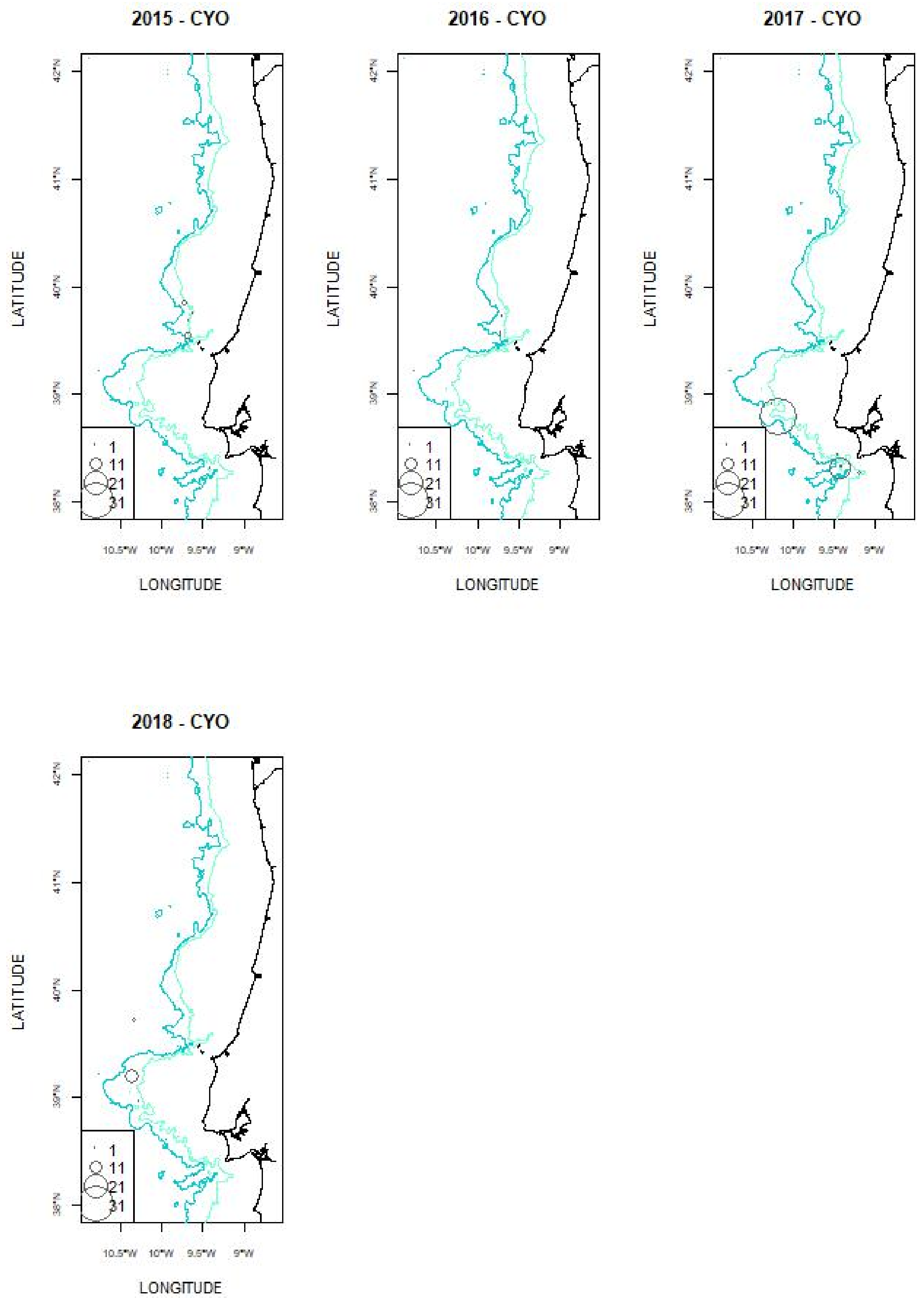


Figure 5 – Geographic location and number of specimens of *C. coelolepis* caught per fishing haul for the period 2009 to 2018.

Deania calcea

Deania calcea was frequently caught by all sampled vessels (Table 4). Its relative occurrence at the sampled fishing hauls varied between 75 and 100%. The number of specimens caught was commonly higher than those of the two previous species, but also varied not only between years but also between vessels (Table 4).

Table 4 - *Deania calcea* Maximum (max_no) and minimum (min_no) number of specimens per haul, number of hauls(n_hauls) with the species and total number of hauls (T_n_hauls) sampled per year and per vessel

VESSEL_CODE	YEAR	min_no	max_no	n_hauls	T_n_hauls
V1	2009	2	13	2	2
V1	2010	6	8	3	3
V1	2011	2	2	1	1
V1	2012	5	33	2	2
V1	2013	7	7	1	1
V1	2017	19	38	2	2
V1	2018	21	21	1	1
V2	2009	12	14	2	2
V2	2010	11	11	2	2
V2	2015	6	6	1	1
V2	2017	7	7	1	1
V2	2018	10	20	3	4
V3	2015	3	34	6	6
V4	2014	11	11	1	1
V4	2015	12	12	1	1
V4	2016	10	26	2	2
V4	2017	3	11	4	4
V4	2018	11	17	3	3
V5	2009	4	9	2	2
V5	2010	7	28	4	4
V5	2011	3	3	1	1
V5	2012	13	27	4	4
V5	2014	13	13	1	1
V5	2015	7	7	2	2
V5	2016	3	16	5	6
V5	2017	1	8	4	4
V5	2018	2	7	2	2
V6	2011	5	37	4	4
V6	2012	3	11	3	3
V6	2013	31	31	1	1
V7	2017	6	16	2	2
V8	2017	5	15	2	2
V8	2018	2	7	2	2
V9	2017	6	6	1	1
V9	2018	1	4	2	2

For each year the number of specimens caught in each haul is plotted *versus* depth is presented in Figure 6.

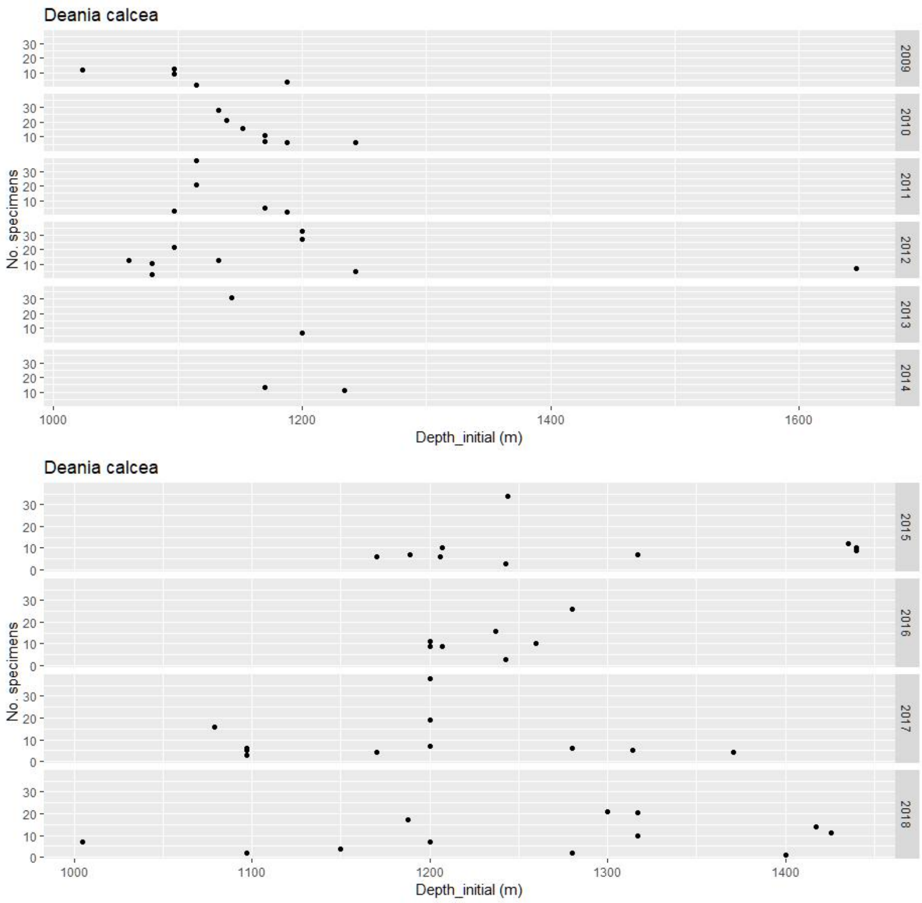
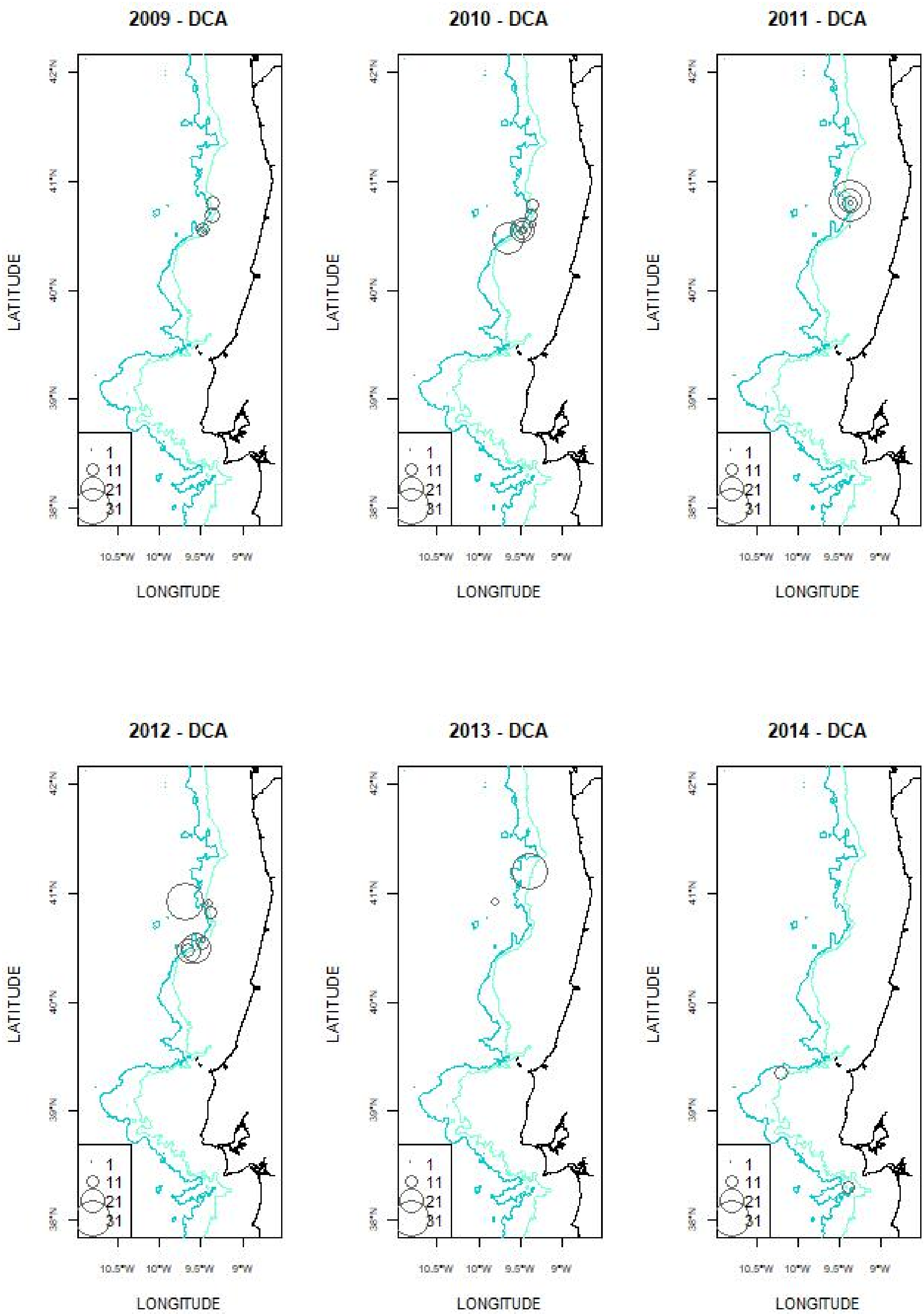


Figure 6 – Number of specimens of *D. calcea* caught by fishing haul *versus* depth (in m) for the period 2009 to 2018.

In most of the years and irrespective of the fishing area high catches of *D. calcea* were found in some fishing hauls (Figure 7).


2009 - DCA
2010 - DCA
2011 - DCA
2012 - DCA
2013 - DCA
2014 - DCA
LATITUDE
LONGITUDE
42°N
41°N
40°N
39°N
38°N
10.5°W
10°W
9.5°W
9°W
1
11
21
31

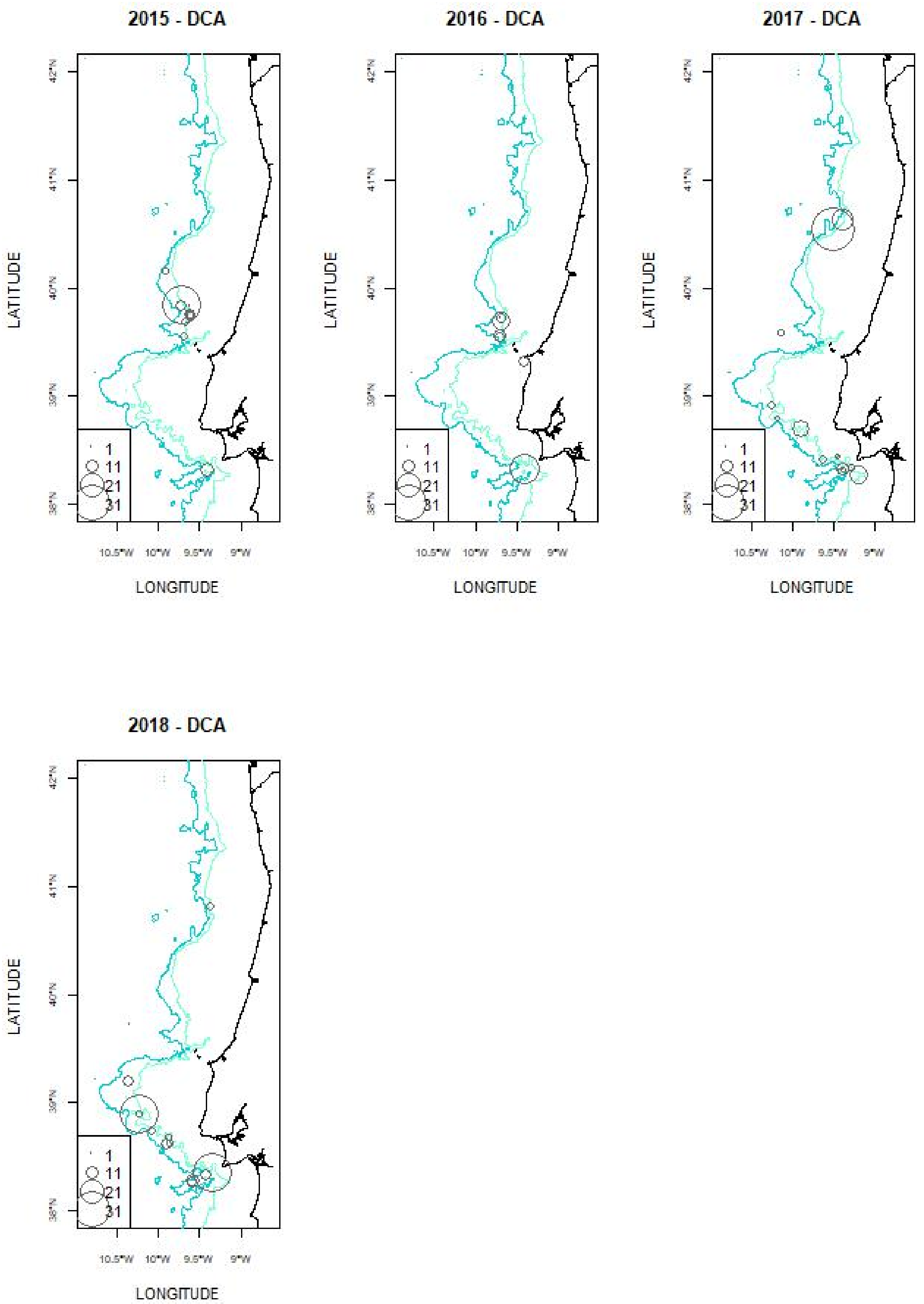


Figure 7 – Geographic location and number of specimens of *D. calcea* caught per fishing haul for the period 2009 to 2018.

Conclusions

The initial idea beyond this study was to estimate the level of by-catch of the main deep-water sharks by year and by area, from 2009 to 2018 and, in addition to evaluate any potential trend during this time period, to compare with catch levels prior to 2007 (when the TAC started to restrict landings). However, the sampling effort achieved, by year, is considered insufficient to provide reliable information on the abundance or biomass trend of deep-water shark species. The spatial locations of the fishing hauls are heterogeneously dispersed along time and the vessels sampled also changed. It should be noted that given the vessel site fidelity, there is a confounding effect between the fishing vessel and the fishing grounds, difficult to disentangle.

As a reaction of the restrictive EU management measures adopted for deep-water sharks, fishing vessels also tend to avoid fishing grounds where, as fishermen noted, the deep-water sharks tend to be more frequent. Efforts to assess the degree of spatial overlap between the distributions of the black scabbardfish and the two deep-water sharks Portuguese dogfish and of the leafscale gulper shark, proved that the two latter distribute deeper than the black scabbardfish in the Portuguese continental slope (Veiga et al., 2013; Veiga, 2015 WD; Veiga et al., 2015 WD). However, although not adversely impacted by this fishery, no survival is expected when returned to the sea. The only successful notice of survivorship of deep-water sharks was observed for leafscale gulper sharks caught during a tagging scientific survey. The survey used deep-water longlines which were laid at depths ranging from 900 to 1100 m (Rodríguez-Cabello and Sánchez, 2014). In that study, the soaking time was restricted to 2–3 hours and the lines were hauled back at a slow speed (0.4–0.5 m.s–1). It is important to note that these fishing practices are different from those used by commercial vessels. It should be noted that the only fishery impacting these deep-water sharks in particular is the black scabbardfish deep-water longline fishery.

Despite distributing deeper and in a broader area than the one impacted by the black scabbardfish fishery, *C. squamosus* and *D. calcea*, have a higher overlap with the black scabbardfish fishery, given their depth distribution range. Also, it is assumed that both species have a widespread distribution and undertake migrations associated to reproduction (despite those from the *D. calcea* being less understood). In the particular case of *C. coelolepis*, results showed that the species is not uniformly distributed, which gives support to previous findings that the black scabbardfish fishery may operate at locations of lower abundance of *C. coelolepis* (Veiga et al., 2015 WD). This species is thought to be able to complete its life cycle in the same geographical area (although sampling data on newborns is still scarce) (Moura et al., 2014).

Information on deep-water shark's abundance and distribution is still scarce. WGEF recognizes that data derived from discards sampling is not adequate to estimate the quantities caught (ICES, 2018). Major scientific investment is required to gain a full understanding of the spatial and temporal population dynamics of deep-water sharks to enable estimates of sustainable exploitation levels (Figueiredo and Moura, 2016 WD). Several strategies to be adopted to monitor species abundance and evaluate fishing impact on their populations by the different deep-water fisheries have been discussed in previous meetings: i) increase of close monitoring of deep water shark populations; ii) development of specific studies to assess the distribution patterns of species and estimate the spatial overlap with fisheries; iii) evaluation of the effect on the by catch of deep water sharks of modifications in deep water fishing operations (Figueiredo and Moura, 2016 WD).

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Investigating the added value of Belgian Beam Trawl Survey (BTS) data for the use in elasmobranch stock assessments

Date: June 2019

Member State: Belgium

Submitter: Research Institute for Agriculture, Fisheries and Food, Animal sciences Unit – Fisheries and Aquatic production, Ankerstraat 1, 8400 Oostende (Belgium)

Contact: Loes Vandecasteele (loes.vandecasteele@ilvo.vlaanderen.be), Lies Vansteenbrugge (lies.vansteenbrugge@ilvo.vlaanderen.be)

1. Introduction and objective

Elasmobranch stocks are often classified as data limited stocks, resulting in category 3 or 5 stock assessments. Given the increasing importance for a proper management of these stocks, this working document investigates to what extent data from the Belgian Beam Trawl Survey contributes to filling these data gaps.

2. Survey description

Annually, a quarter 3 Beam Trawl Survey (BTS) is carried out by Belgium in the south-western part of the North Sea (Fig. 1), primarily targeting sole (*Solea solea*) and plaice (*Pleuronectes platessa*). Starting in 1992, the RV Belgica samples 62 fixed sampling stations by towing a 4 m beam trawl equipped with a chain mat from the stern. The net has a 40 mm cod end (stretched) mesh size. At each station, the net is trawled for approximately 30 minutes at a towing speed of 4 knots.

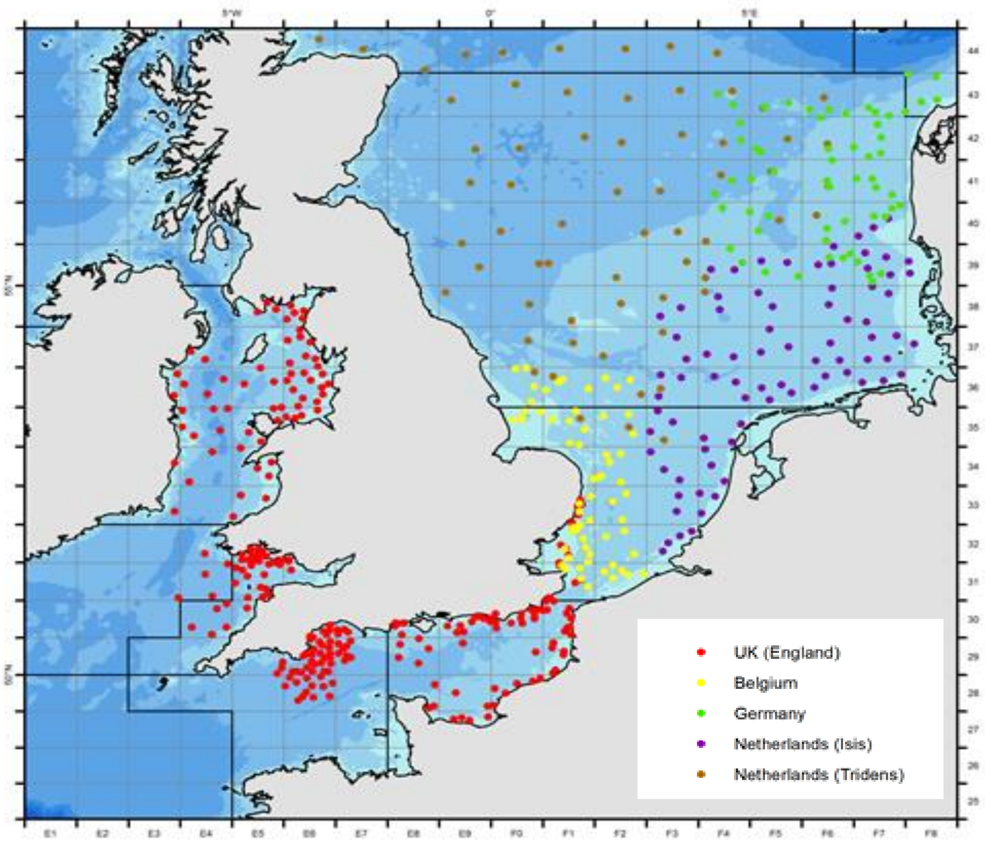

Fig. 1: BTS stations in the North East Atlantic. Belgian BTS stations are shown in yellow.

During the survey, fish are measured and weighed. For all elasmobranchs, catch weight, length and sex[1] data are available. For a selection of fish (*e.g*. sole), also individual weight and sex are determined, and otoliths are cut for age determination.

Belgium (ILVO) has been actively participating in the ICES Working Group on Beam Trawl Surveys (WGBEAM) since it was founded, where inshore and offshore beam trawl surveys are planned and coordinated. The Belgian BTS is one of the nine offshore surveys included. The WGBEAM aims to further standardise survey sampling, which is enhanced by e.g. staff exchange. Belgium has been actively involved in this.

3. Data availability and quality

The Belgian BTS data are currently available in the ICES Datras database from 2010-2018. Historical data (prior to 2010) are being prepared for uploading to Datras.

In 2015 and 2016, the RV Belgica could not be used to carry out the survey due to severe technical problems. To avoid interruption of the Belgian BTS time series, a commercial vessel was chartered (Z.279 Ramblers). The commercial vessel trawled for the same duration (30 min) and at the same speed (4 knots) and was equipped with the same gear (4m beam trawl with chain mat + 40 mm cod end net). However, the gear was town from starboard side instead of from the stern (cfr. RV Belgica). Nevertheless, WGBEAM discussed that despite the potential risk of including differences in catchability, the use of a commercial vessel for the Belgian BTS will not have major effects on indices calculated from the survey.

Quality checks of the Belgian BTS data occur on three levels: 1) data quality checks on the software and database level, 2) data exploration quality checks in Power-bi and 3) additional quality checks in R.

All BTS data are stored in the **ILVO Smartfish database**, which is accessed through the Smartfish application (data registration **software**). The Smartfish app is a client-server application for registration of commercial and survey sampling data, which manages trip, haul and sample data. Sampling data consist of length data and/or other biological parameters (weight, sex, maturity). The Smartfish application contains extensive validation both on the clientside and serverside. Clientside validation involves the completion of required fields and is applied with every 'save' command. Serverside validation is applied when the trip status is changed from 'raw' (when entering the data) to 'validated' (when approving the data after checking with 2 people). An overview is listed in Annex 1.

When the trip is validated, **data are explored using Power-Bi**. The BTS data stored in the ILVO Smartfish database are directly available (read-only) in Power-Bi through an ODBC connection (open database connector). This business analytics solution allows visualisation of data by querying the database directly. Data checks entail verifying the haul positions and haul validity (>15 min and < 40 min), but also checking whether length ranges are realistic for each species, whether the entire catch is sampled and making length-weight and age-length key plots to identify outliers. A detailed overview is given in Annex 2.

The BTS data stored in the ILVO Smartfish database are directly available (read-only) in **R** through an ODBC connection. In R (using R Studio), the raw BTS data are transformed and converted in the Datras HH, HL and CA datasets. Several additional checks are done to ensure that the fields are in the correct

[1] Sex data are only available from 2018 onwards.

format, all mandatory fields are completed, but also for example whether realistic ranges and units are used for the Year class and IndWgt columns. A detailed overview is presented in Annex 3.

When no irregularities are left, the trip status in Smartfish is set to 'consolidated' and data are submitted to Datras (ICES data platform).

4. Elasmobranchs in the survey area

The most abundant elasmobranch species caught in the Belgian BTS are small spotted catshark (*Scyliorhinus canicula*), thornback ray (*Raja clavata*) and spotted ray (*Raja montagui*). For all three species the observed numbers have increased over the last 15 years (Fig. 2). Blonde ray (*Raja brachyura*) and smooth-hound (*Mustelus sp.*) are also caught, but in smaller amounts (Fig. 2) and probably less relevant for use in assessments. Other elasmobranch species such as starry skate (*Amblyraja radiata*), cuckoo ray (*Leucoraja naevus*), undulate ray (*Raja undulata*), smalleyed ray (*Raja microocellata*), spurdog (*Squalus acanthias*), greater spotted dogfish (*Scyliorhinus stellaris*) and tope (*Galeorhinus galeus*) may be observed, but these occasions are rather rare.

Note that most of the smooth-hounds records are likely to be starry smooth-hound (*Mustelus asterias*). However it is known that this species can be easily confused with common smooth-hound (*Mustelus mustelus*) which may also occur in the North Sea. Therefore numbers of starry smooth-hound, common smooth-hound and individuals that were recorded under the genus level of *Mustelus* were aggregated into one group of *Mustelus sp*.

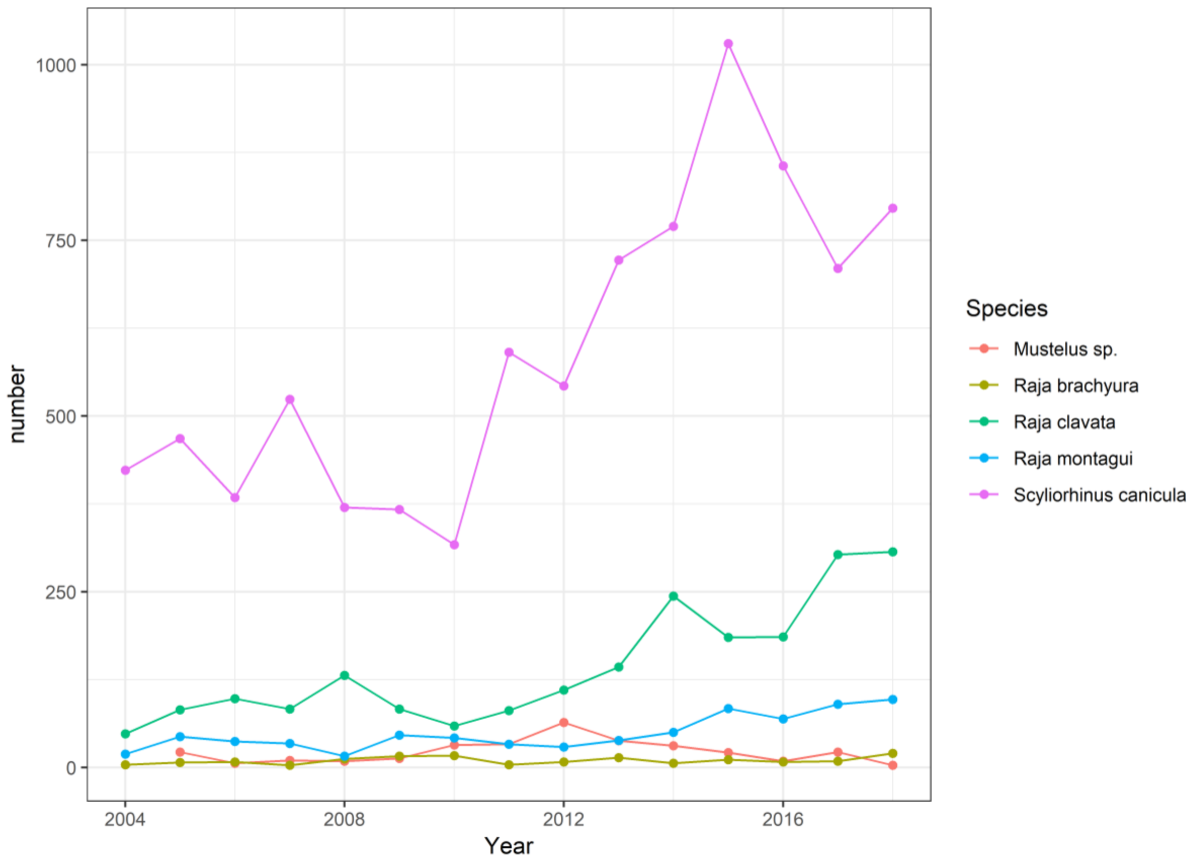

Fig 2. Elasmobranch numbers caught in Belgian BTS from 2004-2018. These are actual observed numbers, no standardization for fishing time has been done.

Abundance data from all the BTS surveys in the central and southern part of the North Sea (ICES areas 27.4.b and 27.4.c) from the last 15 years were analyzed for the two most important skate species (thornback and spotted ray) and one shark species (small spotted catshark). Belgian data from 2004-2009 is not available in Datras yet, but was obtained from the national (Smartfish) database at ILVO.

CPUEs were calculated based on the numbers that were caught in each station and standardized to the swept area[2] of each tow (numbers/km²). Then these numbers were averaged over the stations in each of the ICES statistical rectangles.

Temporal analysis:

For each of the three species (Fig. 3, 4 and 5) a survey index was calculated by summing the average CPUEs over all ICES statistical rectangles in the whole survey area. Without taking the German data into account (due to small numbers) an increase in the 15 year period was found for all three species in both the Belgian and Dutch survey.

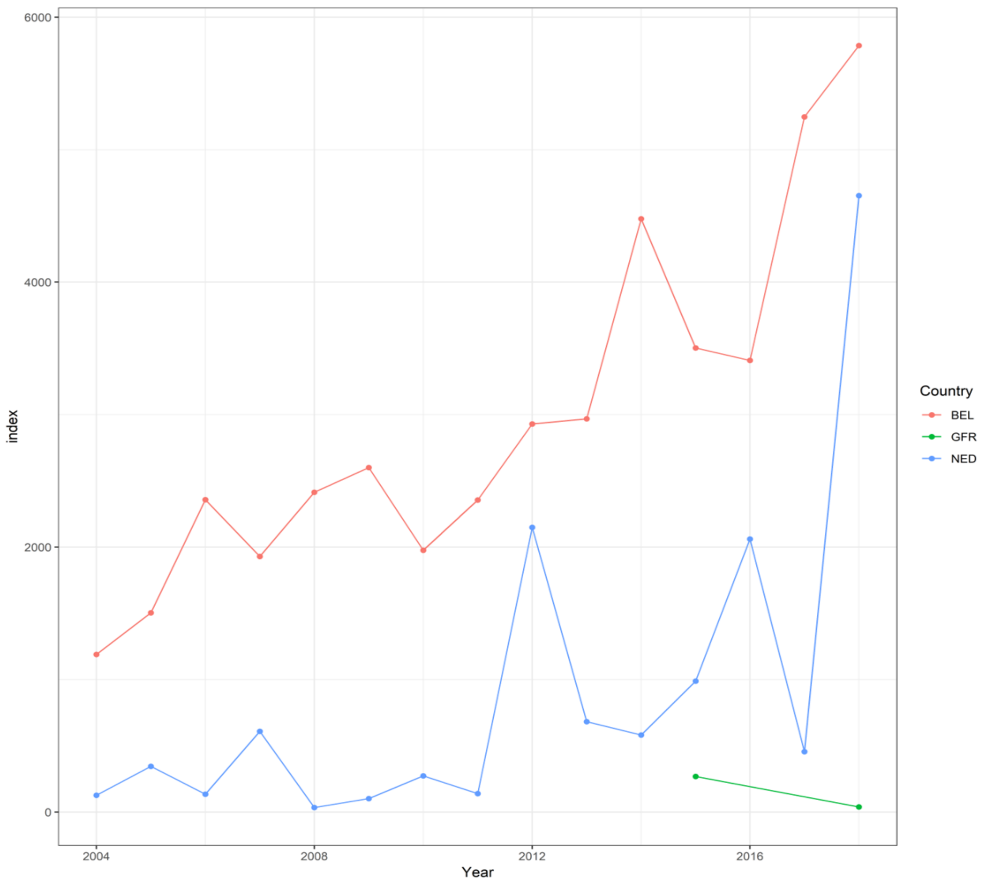

Fig 3: Thornback ray abundance index (split by country) for the whole survey area.

[2] Swept area is calculated based on beam width, fishing speed and fishing duration.

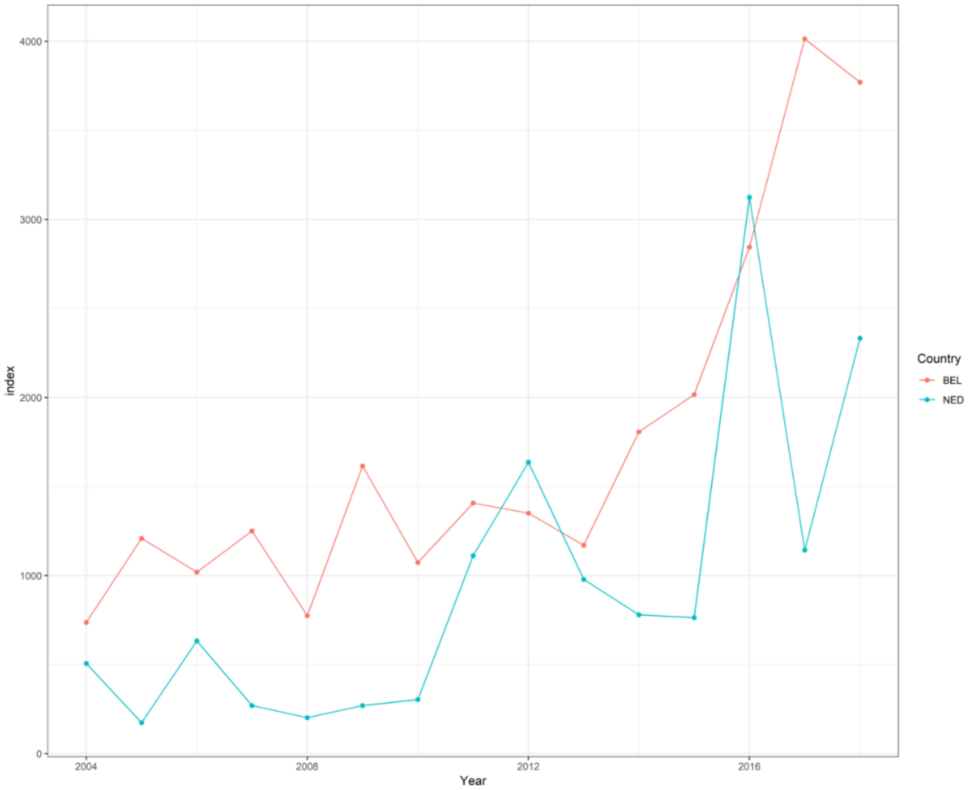

Fig 4: Spotted ray abundance index (split by country) for the whole survey area.

Fig 5: Small spotted catshark abundance index (split by country) for the whole survey area.

Spatial analysis:

Distribution maps allow to identify the spatial distribution of these three species. In Fig. 6, 7 and 8, average CPUEs (numbers/km²) per statistical rectangle were averaged over the whole time period (2004-2018).

Results show that the distribution of thornback ray is concentrated in the southern part of survey area (Fig. 6). The species also occurs along the eastern part of the North Sea, but in much lower numbers (and these observations in the eastern part were only from the most recent years).

Spotted ray is caught less frequently than thornback ray, but there is a large overlap in the distribution area, although spotted ray seems to be more confined to the western part of the southern North Sea (Fig. 7).

Small spotted catshark (Fig. 8) shows a wider distribution range, but the highest abundances are also found in the south-western part of the North Sea (Greater Thames estuary and the Wash).

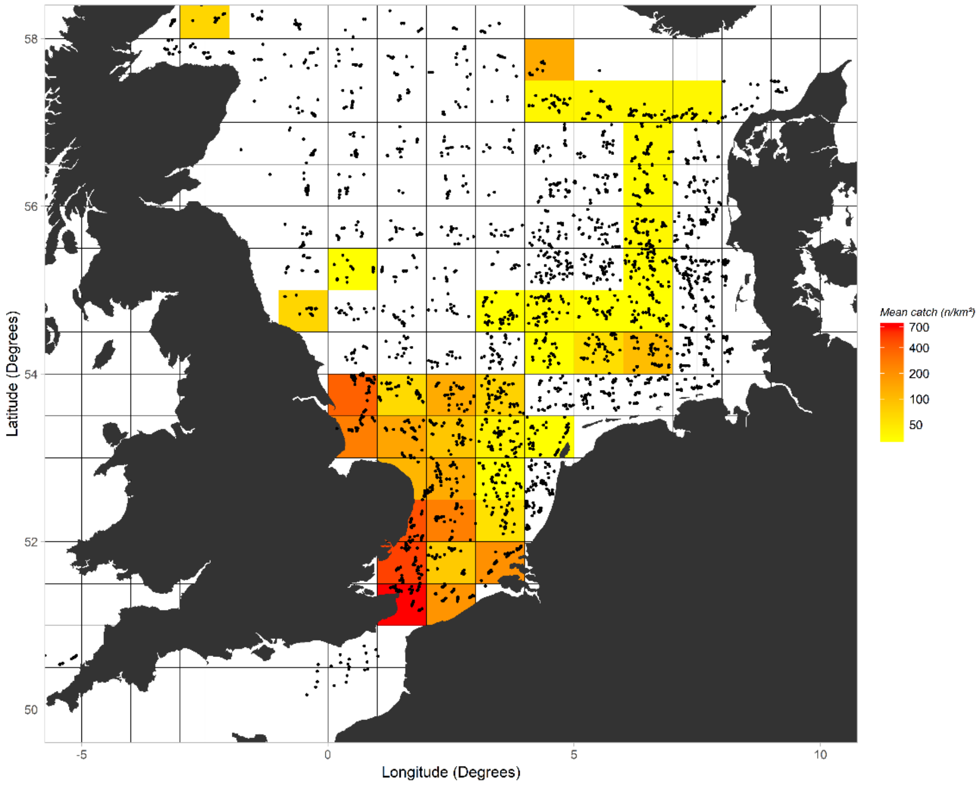

Fig 6. Average thornback ray catches (numbers per km²) from all BTS surveys (German, Dutch and Belgian) in the southern North Sea for the period 2004-2018. Black dots show the different shooting positions from the survey hauls over the entire period.

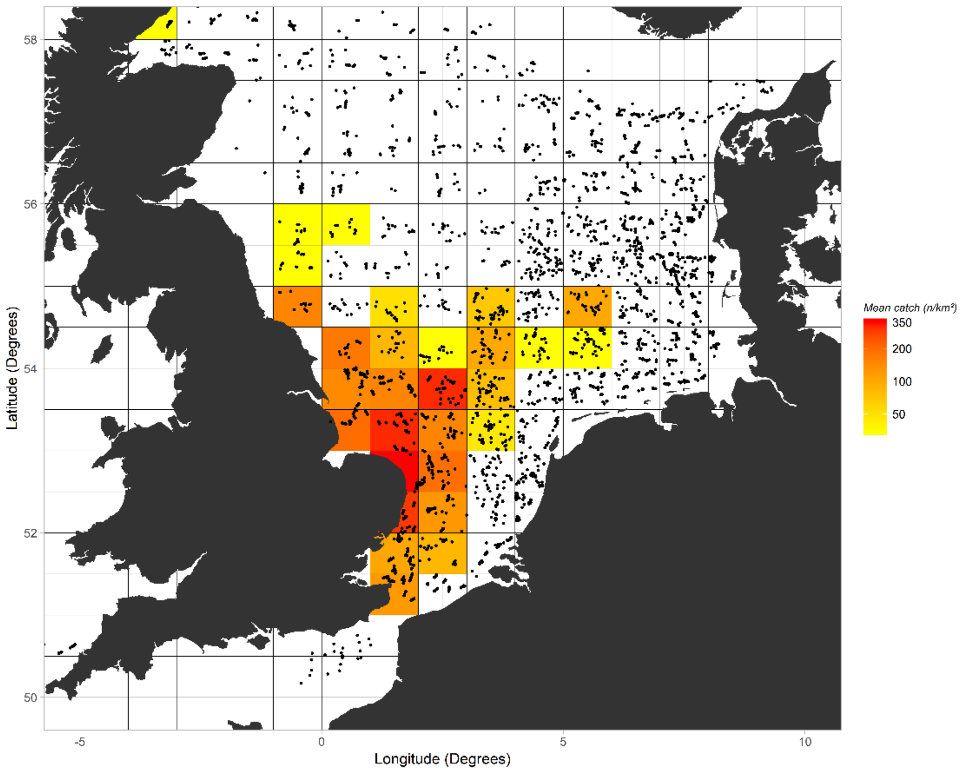

Fig 7. Average spotted ray catches (numbers per km²) from all BTS surveys (German, Dutch and Belgian) in the southern North Sea for the period 2004-2018. Black dots show the different shooting positions from the survey hauls over the entire period.

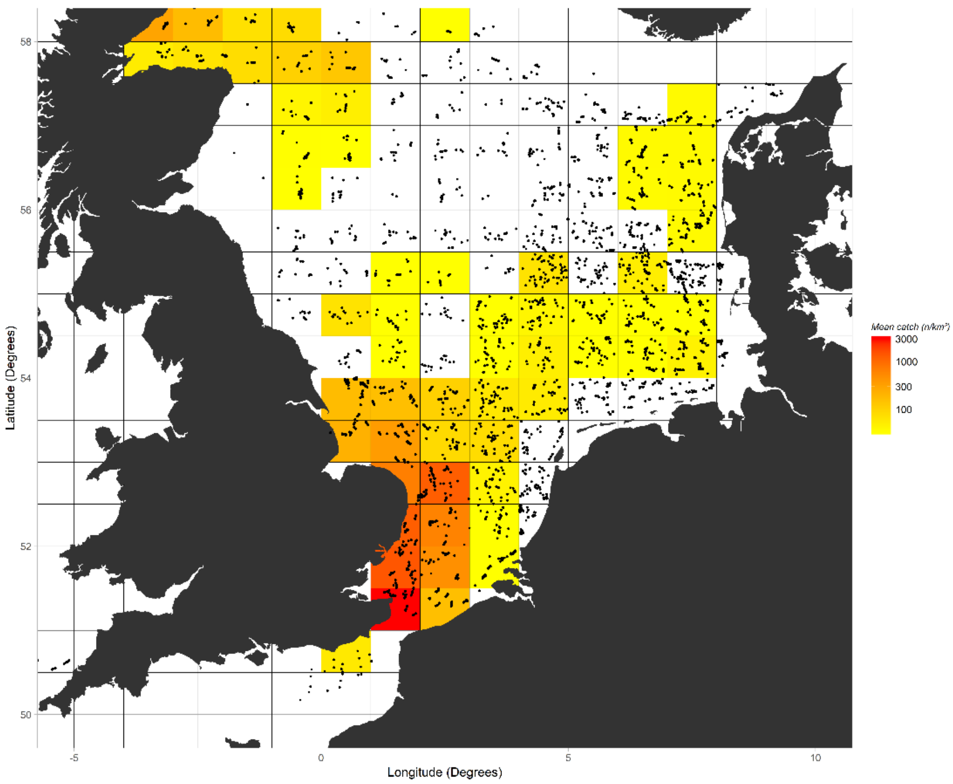

Fig 8. Average small spotted catshark catches (numbers per km²) from all BTS surveys (German, Dutch and Belgian) in the southern North Sea for the period 2004-2018. Black dots show the different shooting positions from the survey hauls over the entire period.

Analysis of length data:

Finally, the length structure of the three species was analyzed (only for Belgian BTS). For thornback ray (Fig. 9) 88% of the individuals caught in the period of 2004-2018 was under 65 cm. B~~b~~efore 2012 mostly small individuals under 50 cm ~~under 50 cm~~ were caught and fr~~. Fr~~om 2012 onwards also larger individuals have been observed in the survey. ~~and~~ N~~n~~umbers have increased for both ~~-~~small and larger individuals in the recent years~~. -~~. For spotted ray (Fig. 10) predominately smaller individuals (96 % is under 60 cm) are observed over the entire time series. Comparing to thornback ray with maximum lengths of one meter, spotted ray seems to grow less big with an observed maximum of 68 cm ~~in the survey~~. For small spotted catshark (Fig. 11) also predominantly small individuals (85% are under 55 cm) have been observed in the survey. ~~The predominance of small (immature) individuals may indicate the presence of nursery grounds in the Belgian BTS area for these three species.~~

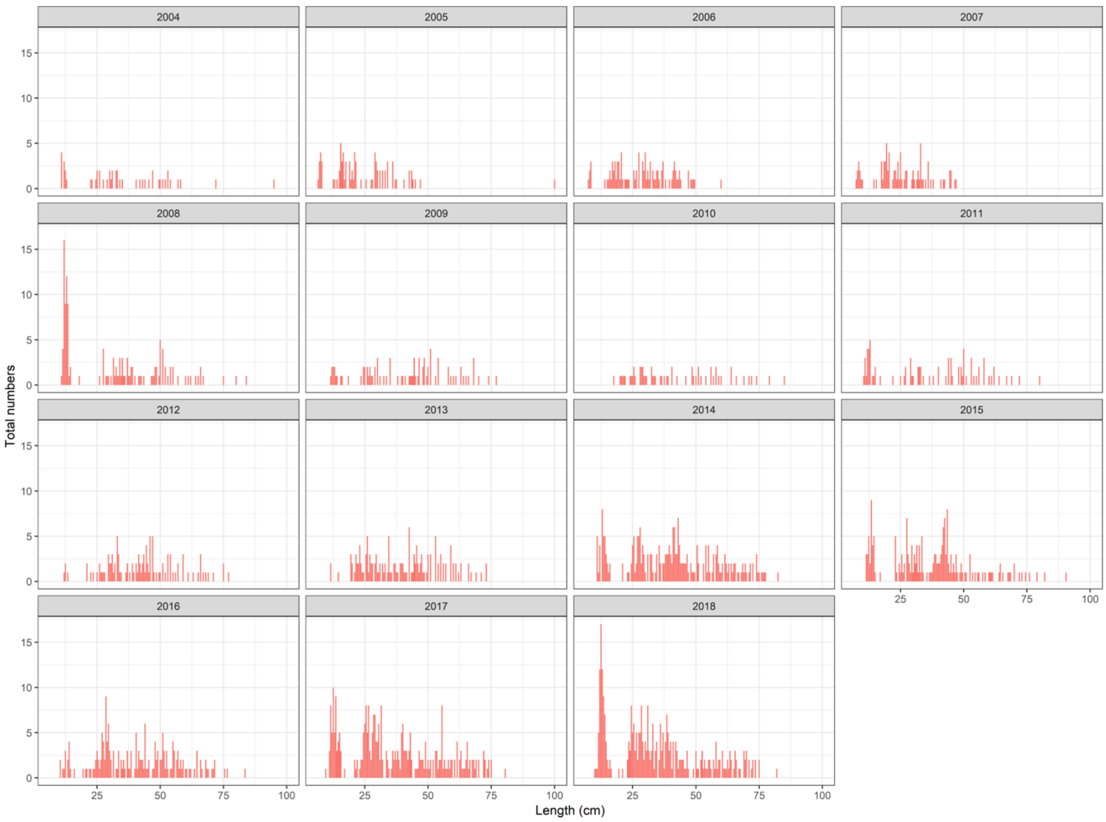

Fig. 9: Length distributions of Belgian BTS thornback ray catches from 2004-2018. Lengths range from 6.5 cm – 100 cm.

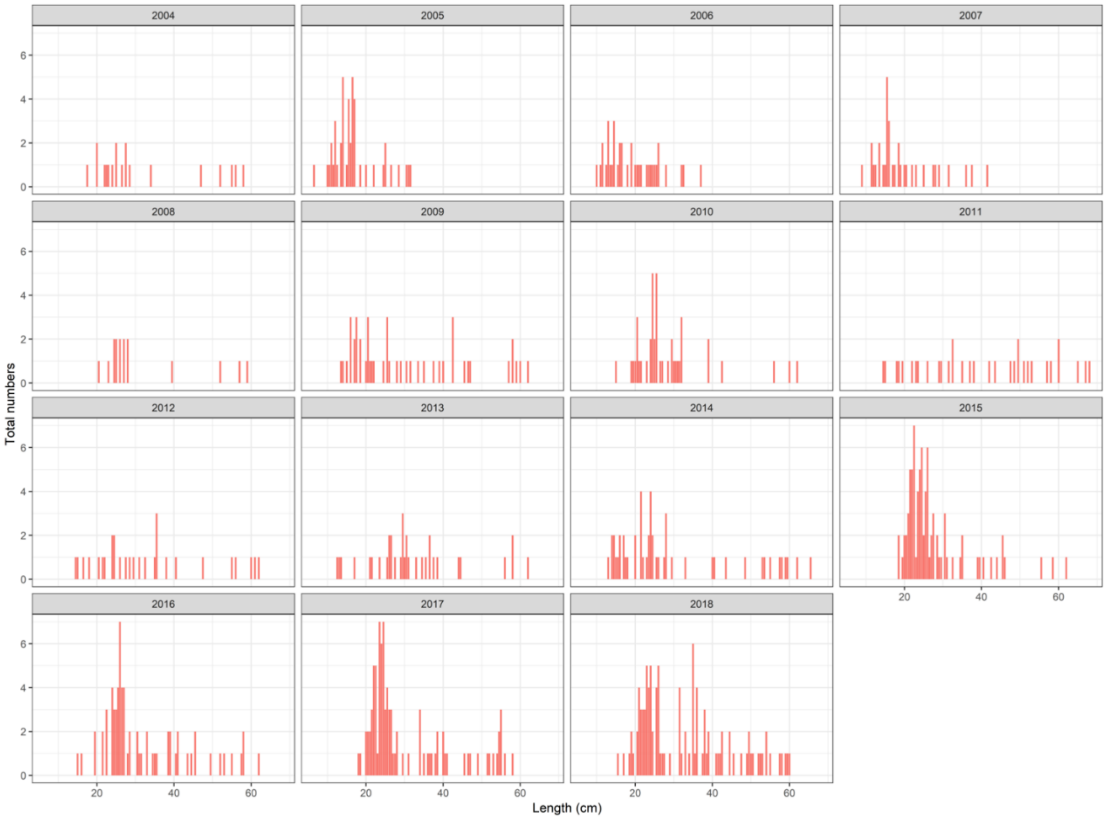

Fig. 10: Length distributions of Belgian BTS spotted ray catches from 2004-2018. Lengths range from 6.5 cm – 68 cm

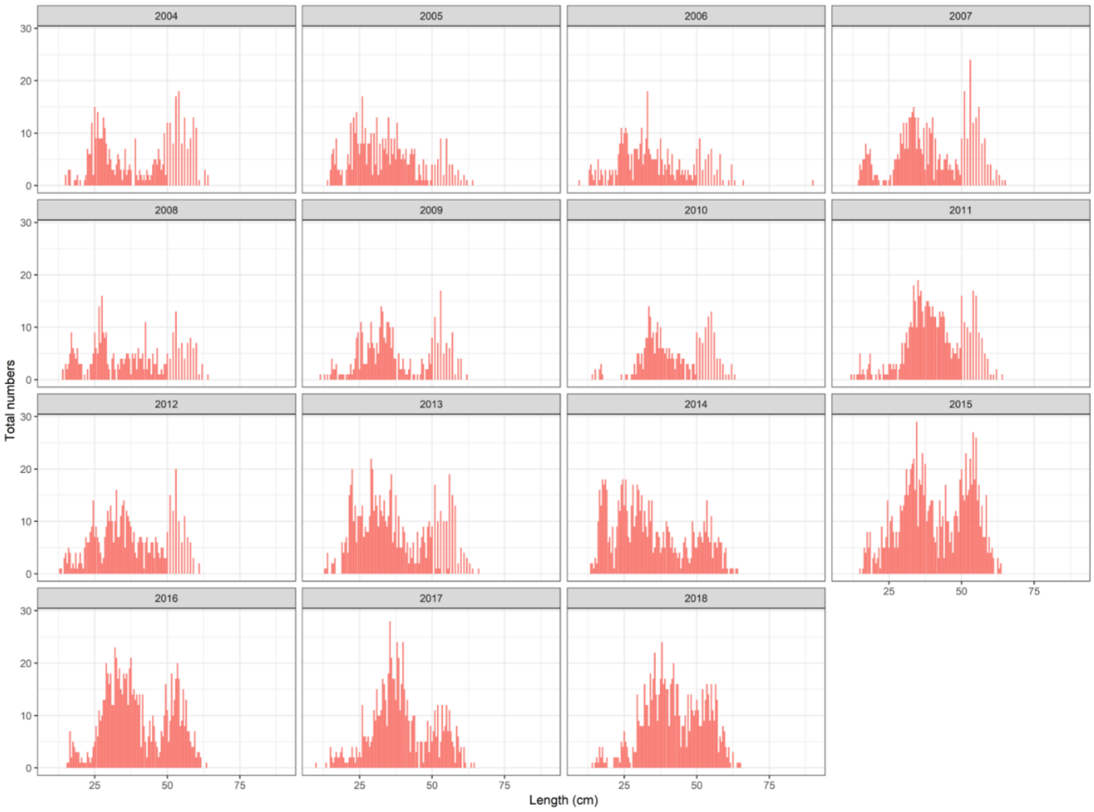

Fig. 11: Length distributions of Belgian BTS small spotted catshark catches from 2004-2018. Lengths range from 9.5 cm – 90 cm

5. Discussion and conclusion

Given the location of the Belgian BTS in this south-western part of the North Sea (Fig. 1), the analysis shows that this particular survey contributes substantially to overall distribution estimates of thornback ray, spotted ray and small spotted catshark.

Especially the Greater Thames estuary and Wash show to be important areas for these species. For thornback ray, these findings are in line with an analysis on the International Bottom Trawl Surveys data (iBTS), which showed that the area has been of great importance over the past 40 years (Walker & Heessen, 1996; ICES, 2017a).

Furthermore, abundances of thornback ray, spotted ray and small spotted catshark have gradually increased in recent years. The predominance of small (immature) individuals may indicate the presence of nursery grounds in the Belgian BTS area for these three species. Information collected during the Belgian BTS (e.g. length) could potentially give indications of population dynamics and help explain the recent trends in abundances, which all together enhances the understanding of the stock dynamics and improve the perception of these stocks.

6. References

ICES. 2017a. Report of the Working Group on Elasmobranch Fishes (WGEF), 31 May–7 June 2017, Lisbon, Portugal. ICES CM 2017/ACOM:16. 1018 pp.

Walker, P. A., & Heessen, H. J. L. (1996). Long-term changes in ray populations in the North Sea. *ICES Journal of Marine Science, 53(*6), 1085-1093.

7. Annexes

Annex 1: Data quality checks on the Smartfish software and database

Record Type	**Checks**
Trip	• DepartureDate: required AND not in the future • ReturnDate: required AND not in the future AND after DepartureDate • DeparturePort: required • ReturnPort: required • Vessel: required • SortingType: required
Gear	• Metier: required • VesselSide: required
Haul	• Number: required • Shoot DateTime: required AND between trip DepartureDate and ReturnDate AND before Haul DateTime • Haul DateTime: required AND between trip DepartureDate and ReturnDate • Shoot Latitude: required • Shoot Longitude: required • Haul Latitude: required • Haul Longitude: required • IcesDivision: required • IcesStatisticalRectangle: required

	• Additionally, all haul Numbers must be in sequence, and haul durations are not allowed to overlap.
Sample	• Species: required • VesselSide: required • Presentation: required • Sample Weight: 0 > x < 999999.99 • Total Weight: 0 > x < 999999.99 • Sample Count: cannot exceed Total Count • When at least one length measurement or count exists, Sample Weight must be greater than zero.
Otolith	• ContainerType: required • ContainerNumber: 0 > x < 1000 • ContainerPosition: 0 > x < 1000

Annex 2: Data exploration quality checks in Power-bi

Record Type	**Checks**
Cruise	• Correct quarter • Realistic number of hauls
Haul	• Positions between correct ranges
Haul details	• If HaulDuration <15 or >40 invalid haul (HaulVal = I) • Realistic ranges for Depth, WindSpeed, WindDir, SurTemp, BotTemp, SurSal and BotSal • Correlation between depth and warplength ±7 times
Sample weight	• Entire catch is sampled
Sample length	• Number of lengths for top 10 species
Sample length scatter	• Realistic length ranges per species
CPUE	• Realistic CPUE per ICES division and species
Sample BIO	• Sufficient biological data for mandatory species collected in each stratum.
Sample BIO length	• Realistic length ranges for the biological samples
Sample BIO length-weight	• LWK outlier plots
Sample BIO Age- length	• ALK outlier plots
Sample benthos	• Realistic numbers of top 10 benthos species

Annex 3: Additional quality checks in R

DATRAS Record Type	**Checks**
HH	• All fields in correct format • Depth field completed

	• Data Type = R • Realistic ranges for haul distance
HL	• All mandatory fields completed • Correct for NAs • Units of SubWgt in grams, CatCatchWgt in grams, LngtClass units according to selected LngtCode • Realistic ranges for TotalNo, NoMeas, SubWgt, CatCatchWgt, LngtClass and HLNoAtLngt
CA	• Sex determined for all individuals • Realistic ranges and units for Year class & IndWgt