WORKING GROUP ON THE BIOLOGY AND ASSESSMENT OF DEEP-SEA FISHERIES RESOURCES (WGDEEP)

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Contents

i Executive summary

The ICES working group on biology and assessment of deep-sea fisheries resources (WGDEEP) provides scientific advice on 29 assessment units including stocks of deep-water species and those on shelf areas and in deep waters.

Advice is provided every other year for each stock, except for stocks from ICES Division 5.a (Iceland) with annual advice.

First draft of advice was prepared for 13 stocks. Due to the Covid 19 disruption, the meeting was conducted entirely by web-based correspondence. Available time-series for international landings and discards, fishing effort, survey indices and biological information were updated for all stocks and are presented in Sections 4–15 of the report.

Due to covid19 complications in 2020 there was no survey in Azores ICES division 10a which affected the assessment of blackspot seabream. Also, there was not a full spatial coverage in the Norwegian slope survey and this to some extend affected the assessment of greater silver smelt in ICES areas 1, 2, 3a and 4.

Atlantic Wolffish was introduced as a potential species to be included in WGDEEP. A benchmark is being requested for 2022. The main fishing grounds for Atlantic wolffish are in the west and northwest part of the Icelandic shelf. The catches are mainly taken in waters 0-180 m. Since 2001 the Gadget model has been used for analytical assessment of Atlantic wolffish in Icelandic waters.

Main conclusions regarding each stock with advice 2021 were:

Greater silver smelt in 1, 2, 3a and 4 was benchmarked in 2020. New precautionary approach was applied for the trend-based advise. While direct fisheries in 2 have decreased in later years the bycatch in are 4 has increased substantially.

Greater silver smelt in 5a and 14 was benchmarked in 2020. The assessment framework has been upgraded from category 3 to category 1. The spawning stock biomass has slightly decreased from last year´s historical high level. Recruitment shows an increasing trend since 2006.

Greater silver smelt in 5b and 6a was benchmarked in 2020. The assessment framework has been upgraded from category 3 to category 1 age based assessment (SAM) with reference points. The fishing mortality is below F_{MSY} and the spawning biomass is above MSY $B_{trigger}$. The recruitment is very constant. When the MSY approach is applied the advice of catch increases substantially from previous precautionary trend-based advice.

Greater silver smelt in 6b, 7, 8, 9, 10 and 12 has not been benchmarked. The fisheries from this area is very minor and there are no directed fisheries. For previous years, the discards have been very high compared to the landings, while for this year the landings accounted for around 40 percent of the total catches. Although the present catches are minor, it is important to monitor and follow if new fisheries emerge, as catches have been considerable in the past.

The recruitment of blue ling in 5a and 14 has been low since 2010. Biomass indices have decreased in recent years, resulting in lower advice for the next fishing years. An exploratory Gadget model was presented.

The biomass index for ling in subareas 1 and 2 based on Norwegian longliners increased steadily from 2000 to 2017, and then decreased until 2020. Because of this decrease and because the precautionary buffer was applied the advice for 2022 and 2023 was lowered.

Ling in subareas in subareas 6–9, 12, and 14, and in divisions 3.a and 4.a. The main fisheries are in Subarea 6 and Division 4.a, where the biomass index increased from 2000 to 2011 but then levelled off. In subareas 7 and 8, survey data show a declining abundance, which suggest that the assessment unit may encompass more than one biological stock.

Recent biomass levels of ling in 5a show a downward revision, causing an upward revision in harvest rate and lower advice for the next fishing year.

Ling in Division 5b was benchmarked in 2021. The assessment framework has been upgraded from category 3 to category 1 age-based assessment (SAM) with reference points. The spawning biomass is well above MSY $B_{trigger}$. The fishing mortality is above F_{MSY} but below F_{pa} and F_{lim}. $F_{6\text{-}10}$ has generally been around 0.4; but F decreased to F_{MSY} in 2017 and 2018, and has since increased again to 0.3 in 2020. The increase in SSB and decrease in F is explained by good recruitments.

Blackspot seabream in subarea 10. There was no new information regarding samples from the fishery and survey (2020) in area 10. Survey abundance indices are high for 20172019. The standardized commercial CPUE has been variable but shows no overall trend, it has not been updated for the recent years (20172020). Current landings are low and below advice, and there are severe management regulations in place.

The biomass index for tusk in subareas 1 and 2 based on Norwegian longliners increased steadily from 2004 to 2017 then decreased until 2020. Because of this decrease and because the precautionary buffer was applied the advice for 2022 and 2023 was lowered.

The landings of tusk in subareas 4 and 7–9, and in divisions 3.a, 5.b, 6.a, and 12.b has decreased since 2000. The biomass index (20002020) based on Norwegian longliners increased from 2003 to 2012, since then it has been relatively stable. For the 20222023 advice the precautionary buffer was applied, and the advice is slightly lower than the previous advice.

Tusk in 5a and 14. There has been a downward correction of the whole times series of biomass levels for tusk in 5a as well as a large downward revision of biomass trends estimated over the last decade. Total biomass is shown to be decreasing, and spawning-stock biomass has been stable only slightly above B_{pa} since 2005. Errors in the survey index used for the model tuning and possibly insufficient criteria for model optimization are the likely reasons for these downward revisions not detected until last year.

ii Expert group information

Expert group name	Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chairs	Elvar H. Hallfredsson, Norway
	Ivone Figueiredo, Portugal
Meeting venue and dates	22-28 April 2021, online (31 participants)

1 Ecosystem productivity and ecosystem approach in WGDEEP stocks

1.1 Ecosystem productivity and ecosystem approach for deep-water stocks

Most deep-water stocks present a lower biological productivity than continental shelf and coastal stocks: natural mortality (M) is lower for deep-water stocks, age-at-maturity higher and growth rate lower. The lower productivity of deep-water ecosystems, which is well documented and was subject to a recent review for the west of the British Isles (Vieira *et al*, 2019), is *de facto* accounted for in population dynamics models of these stocks.

For ICES category 1 stocks this is conveyed in the assessment, forecast and advice by using the stock specific life history traits. For the numerous Category 3 stock assessed by WGDEEP, a population indicator (usually a biomass index from a scientific survey) is used to estimating the stock trend in recent years. By its very nature such indicator is expected to change with both the exploitation rate and the biological productivity of the stock as these factors are confounded in the indicator. In none of the WGDEEP Category 3 stocks these two factors can be quantitatively disentangled. However, for some stocks some ecosystems factors have been identified or hypothesised to influencing observed trends.

Note that decreasing productivity and increasing exploitation would have the same effect of decreasing a biomass indicator. For more information see Annex 6, *WGDEEP 2021 productivity changes survey.*

1.2 Ecosystem considerations for selected WGDEEP stocks

Ecosystem considerations are presented for those WGDEEP stocks where appropriate and relevant knowledge is available.

1.2.1 Blackspot sea bream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

The strait of Gibraltar has been the main area where this stock has been fished since the 1980s. Based on a biomass indicator in the Strait of Gibraltar, the stock biomass decreased in the last decade as a consequence of increasing exploitation. The EU TAC covers Subarea 9 but the Strait of Gibraltar is the path between the Atlantic ocean and the Mediterranean sea and it is also cut at 36°N by limit between the CECAF and the ICES area. Blackspot seabream migrates across the three areas, where management regimes differ, in particular with the TAC only applying to the ICES area.

In ICES Division 9, in addition to catches from the targeted fishery in the Strait of Gibraltar, there are catches from coastal areas of Northern Spain (Galicia) and Portugal. The stock structure is unclear and the level of mixing of population from Gulf of Cadiz with those at the occidental Iberian coast is unknown. The overexploited status of the stock is derived from data from the Spanish fishery in the Strait of Gibraltar where in addition the high fishing mortality resulting from the high valued of the species and the absence of catch limits in the Mediterranean and CECAF areas, natural mortality may have increased as a consequence of the predation from the recovering blue fin tuna stocks. The Spanish project VORATUN (CTM2017-8b2808-R: Study of blackspot seabream-bluefin tuna interactions in the food web of the Strait of Gibraltar with analysis of stomach contents and stable isotopes: Impact on fisheries) is on-going to analyse this question.

Sanz-Fernández *et al*. (2019) suggests that the main factor responsible for the decline in the abundance of blackspot seabream in the Strait of Gibraltar is fishery overexploitation and that environmental conditions (such as water temperature anomaly, salinity anomaly and the NAO index) had a one-off effect which, depending on the year, favoured or harmed the recovery of the stock.

1.2.2 Blackspot seabream (*Pagellus bogaraveo*) in subareas 6, 7, and 8 (Celtic Seas and the English Channel, Bay of Biscay)

This stock collapsed in the 1980s and is remains at a low level compared to historical level. The stock annex reports that environment has changed in the Bay of Biscay, in particular with a documented warming of the upper layer of water. This warming was considered unlikely to be unfavourable to blackspot seabream, as other stocks of the species are distributed in warmer areas in the Gulf of Cadiz and the Mediterranean Sea.

1.2.3 Blackspot sea bream (Pagellus bogaraveo) in Subarea 10 (Atlantic Iberian waters)

The stock reported in this section is from the Azores EEZ (ICES 10.a2). It is distributed along the coastal areas of the islands and seamounts until 700m. Recruitment occurs on the coastal areas and juveniles migrate later to offshore seamounts. The assessment of the stock is based on the survey trends and currently it is considered intensively exploited. Survey relative abundance indices trends presents high inter annual variability. Causes for this variability may be related with catch dynamics between fish and gear (competition, gear saturation, forage behaviour, etc.) or with environmental effects. Both factors seem to affect catchability. Further studies are necessary to better understand both effects on the abundance estimates.

1.2.4 Blue ling (*Molva dypterygia*) in Subarea 14 and Division 5.a (East Greenland and Iceland grounds)

In 2019, the expert group considered to include further ecological consideration in the assessment used for this stock. Since 2012, the advice of blue ling in 5.a and 14.b has been based on F_{proxy}. In 2018, the biomass indicator was at high level and the application of the F_{proxy} implies an increase of the catch advice for 2020 with respect to 2019. However, as the index of small fishes, indicated that the recruitment over the past 7 years has been very low, an increase of adult stock catches seemed inappropriate. The driving factor for the low recruitment might be environmental as the adult biomass continues to be high. In terms of environmental changes, warming of sea temperature and expansion of distribution area of warm-water species such as anglerfish has been observed in Icelandic waters (see stock annex). The effect of these on blue ling recruitment is unknown. Nevertheless, the low recruitment was taken into account in the assessment and advice for the stock

1.2.5 Roundnose grenadier (*Coryphaenoides rupestris*) in Division 3.a (Skagerrak and Kattegat)

The stock was depleted by a directed fishery that lasted from 2000–05. This stock, compared to other deep-water stock, is distributed in a restricted area. Recruitment was observed to be intermittent (Bergstad *et al*., 2014). Recovery from the depleted status is unlikely to occur until a new strong recruitment event, which is unpredictable. The previous one dates back from the early 1990s.

1.2.6 Ling (*Molva molva*) in Subareas 6-9, 12, and 14, and Divisions 3.a and 4.a (Northeast Atlantic and Arctic Ocean)

CPUE indices from areas where the main fisheries occur are used to assess the stock. These show an increasing trend since the early 2000s. The application of the ICES Category 3 rule leads to an advice catch for 2020-2021 slightly higher than the previous advice. However, the Spanish survey on the Porcupine bank (SPPGFS-WIBTS-Q3) covering ICES divisions 7c,k shows a strong declining trend on abundance and on biomass. The advice was not changed because 90% of the catch from this stock come from Subareas 4 and 6. However, it was considered likely that there are different trends by area. Landings in Subarea 7 have decreased since the late 1980s where they were comparable to landings in each of subareas 4 and 6. WGDEEP considered likely that environmental changes have made Subarea 7 less suitable to ling.

1.2.7 Black scabbardfish (*Aphanopus carbo*) in the Northeast Atlantic and Artic Ocean

The stock structure in the whole Northeast Atlantic is still uncertain. Although available information does not unequivocally support the assumption of a single stock, most available evidences support it. Juveniles are mesopelagic and adults are benthopelagic. The species does not complete its life cycle in one area and either small- or large-scale migrations occur. So far, the known spawning grounds occur in CECAF areas (Madeiran and Canary Islands waters). Juveniles recruit in Northern areas. These particularities are taken into consideration by ICES model adopted to monitor the stock dynamics.

After 2012, both the annual biomass and annual abundance indices are at higher levels, indicating that the population at the Northern component has been increasing. However in recent years, the Icelandic abundance index, the French LPUE index from the west of Scotland show a decreasing trend while both the Icelandic and the Scottish survey biomass indices have been increasing. The analysis of these trends suggests that the level of recruitment have been decreasing. This effect is unlikely to result from an increasing fishing pressure because (1) the TAC set for black scabbardfish have been stable for several years and (2) in EU waters the ban of trawling in areas deeper than 800 m has strongly reduced the fraction of the species habitat which can be exploited as the depth range of the species extends down to 2000 m. Therefore, the observed decrease might be due to ecosystem effect**s**. Acting ecosystem factors may be:

- Changes in the abundance of prey species. In particular the black scabbardfish preys upon blue whiting, which SSB increased in 2011-2016 and have decreased in more recent year (ICES, 2019);
- Changes in abundance of predators. After the heavy exploitation in the 1990s and early 2000, TACs for deep-water species were introduced in 2003 and gradually decreased thereafter. The black scabbardfish fish is one of the most productive deep-water species, with a faster growth than its potential predators particularly deep-water sharks. Target

fishing from deep-water sharks have been strongly restricted since 2006 with the ban of deep-water nets and was further restricted in 2012 after the introduction of a 0 TAC for deep-water sharks that applies for all gears. The latter might have been an incentive to diverge fishing to locations where sharks were a small proportion of commercial catches. Lastly the ban, in 2016, of trawling deeper than 800 m in EU waters might have resulted in reduction of deepwater-sharks bycatch to low levels in trawl fisheries. Although no reliable indicator of deep-water shark abundance is available, population might be increasing in recent years and thus increasing the predation on black scabbardfish.

1.2.8 2.6 Greater forkbeard (Phycis blennoides) in all ecoregions

ICES currently considers greater forkbeard as a single-stock for the entire NE Atlantic, although the stock structure be more complex. Further studies would be required to justify change to the current assumption. Fishing is a major disturbance factor of the continental shelf communities of the regions. As the fishery of greater forkbeard is mainly a bycatch of trawler fishery in all ecoregions the main ecosystem effects are the impact on the sediment compound.

1.3 References

Bergstad, O. A., H. O. Hansen, and T. Jorgensen. 2014. Intermittent recruitment and exploitation pulse underlying temporal variability in a demersal deep-water fish population. ICES Journal of Marine Science 71:2088-2100.

Sanz-Fernández, V., J.C. Gutiérrez-Estrada, I. Pulido-Calvo, J. Gil-Herrera, S. Benchoucha, S. el Arraf. 2019. Environment or catches? Assessment of the decline in blackspot seabream (*Pagellus bogaraveo*) abundance in the Strait of Gibraltar. Journal of Marine Systems, 190: 15-24 (https://doi.org/10.1016/j.jmarsys.2018.08.005).

Vieira RP, Trueman CN, Readdy L, Kenny A, Pinnegar JK. Deep-water fisheries along the British Isles continental slopes: status, ecosystem effects and future perspectives. J Fish Biol. 2019;1–12. https://doi.org/10.1111/jfb.13927

1.4 The percentage of the total catch that has been taken in the NEAFC regulatory areas by year in the last year

Generic ToR c-iii asks for the percentage of the total catch that has been taken in the NEAFC regulatory area by year in the last year. WGDEEP stocks are distributed broadly across the NEAFC Convention Area, with catches of some stocks occurring within the NEAFC Regulatory Area (RA). In the table 1.1 in the WGDEEP 2020 report the WG presented the most likely landings from these RA areas in 2019 based on the official reports and discussions within the WG. For relevant stocks of the 13 with advice this year the estimated percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2020 is reported in the advice sheets. List of participants

2 Stocks and Fisheries of the Oceanic Northeast Atlantic

2.1 Area overviews

Stocks and fisheries of the Oceanic Northeast Atlantic (Mid-Atlantic Ridge and oceanic seamounts and the Azores archipelago). The Mid-Atlantic Ridge (MAR) is the spreading zone between the Eurasian and American plate. The ridge is continually being formed as the two plates spread at a rate of about two cm/year. In the ICES area it extends over 1500 nm from the Iceland to the Azores, crossing the Azores archipelago between the western and central islands groups. The subareas with hard substrata are characterized by a rough bottom topography comprising summits and upper slopes of seamounts and seamount complexes, the central rift valley slopes, and several fracture zones with steep slopes. However, the MAR is mainly sediment-covered and has generally gentle sloping bathymetry, and only about 5% of the lower bathyal area is hard substratum (Niedzielski *et al.* 2013).

The oceanic Northeast Atlantic also has off-ridge seamounts and seamount complexes with summits reaching into fishable depths, e.g. the Altair and Antialtair, and the Josephine Seamount.

The Azorean archipelago of nine islands and many seamounts is a major geomorphological feature spanning the MAR in the southern end of the ICES area.

2.2 Fisheries overview

Two different types of deep-water fisheries occur in the area, i.e. 1) oceanic fisheries with large midwater and bottom trawlers and longliners fishing in the central region and northern parts of the MAR, and 2) longline and handline fisheries inside the Azorean EEZ where trawling is prohibited. The latter fishery is targeted at stocks which may extend south of the ICES area.

This section deals with fisheries on the MAR and in the Azores.

2.2.1 Azores EEZ

The Azores deep-water fishery is a multispecies and multigear fishery. The dynamics of the fishery appears primarily determined by the main target species *Pagellus bogaraveo*. However, others commercially important species are also caught and the target species change seasonally according abundance, species availability, and market demand.

The fishery is relatively small scale in which the small vessels (<12 m; 90% of the total fleet) predominate, using mainly traditional bottom longline and several types of handlines. The ecosystem is a seamount and island slope type with fishing operations occurring in all available areas, from the islands coasts to the multiple seamounts within the Azorean EEZ. The fishery takes place at depths up to 1000 m, catching species from different assemblages, with a mode in the 200–600 m strata which is the intermediate strata where the most commercially important species occur.

2.2.2 Mid-Atlantic Ridge

The Northern MAR is a very extensive area located between Iceland and Azores, and comprises features such as the comparatively shallow Reykjanes Ridge extending from southern Iceland to the Charlie-Gibbs Fracture Zone, as well as prominent seamount complexes such as the Faraday Seamounts just south of that fracture zone. Trawl fisheries started on the MAR in 1973, and more than 40 seamounts have subsequently been explored, fished for shorter or longer periods, and regarded as commercially important in Soviet/Russian assessments (Table 2.7.1). Figure 2.7.1 illustrates subareas of the area beyond national jurisdiction (where the Northeast Atlantic Fisheries Commission regulates fisheries) with depths shallower than 2000 m. These are the subareas within the approximate maximum depth of deep-water fisheries in the ICES area (in reality few fisheries extend deeper than 1500 m).

The basis of the pioneer Soviet deep-water fishery was the discovery of concentrations of roundnose grenadier (*Coryphaenoides rupestris)* on multiple hills along the MAR. Later aggregations of alfonsino *(Beryx splendens)*, orange roughy *(Hoplostethus atlanticus)*, cardinal fish *(Epigonus telescopus)*, tusk (*Brosme brosme*), 'giant' redfish (*Sebastes marinus)* and blue ling (*Molva dypterigia)* were found during multi-nation exploratory and commercial operations in the 1970s–1990s. Trawl and longline fisheries were conducted in Subareas 10, 12, 14 and 5 (Figure 2.7.2) by Russian, Icelandic, Faroese, Polish, Latvian, Spanish and Norwegian vessels. However, few of these (often subsidized) efforts led to lasting regular fisheries. It has also been suspected that IUU fishing occurred by vessels from other areas, but the scale of such activity is unknown.

The fishing activity has declined substantially during the last decade and in recent years (i.e. after 2010) the fisheries on the MAR comprised primarily a minor Faroese fishery targeting orange roughy on a few seamounts, and a recently developed Spanish trawl fishery (with benthopelagic trawls) targeting grenadiers (*Macrouridae*). Both fisheries fished in very limited areas compared with historical operations.

The major fishery in waters on and adjacent to the MAR is, however, currently the midwater trawl fishery along the western slope of the Reykjanes Ridge and in the Irminger Sea targeting *Sebastes mentella.* Annual landings in international waters ranged between 23 and 41 thousand tonnes in 2012–2014 (ICES, 2015).

2.3 Details on the history and trends in fisheries

2.3.1 Azores EEZ

Since the mid-1990s the landings of deep-water species show a decreasing tendency (Figure 2.7.3 and Table 2.7.2), reflecting the change in the fleet behaviour towards targeting blackspot sea bream.

Since 2000, the use of bottom longlines in the coastal areas has been significantly reduced as a result of the interdiction by the local authorities of the use of longlines in the coastal areas on a range of 6 miles from the islands coast. Large vessels (>24 m) are restricted to seamount areas outside 30 miles from the islands. As a consequence, the smaller boats that operate in the islands coast area have changed their gears to several types of handlines, which may have increased the pressure on some species. The deep-water bottom longline is at present only a seamount fishery. An expansion on the fishing area has been observed for this fleet class during the last decade.

Also in one other fleet component, the medium size boats, ranging from 12–16 meters, a change from bottom longline to handlines has been observed during the last decade. All these changes in the fishing pattern of the fleet may explain the changes in the landings of some species that were more vulnerable to the use of bottom longlines or target on specific handlines.

2.3.2 Mid-Atlantic Ridge

Grenadier (Macrouridae) fisheries: The greatest annual catch of roundnose grenadier (almost 30 000 t) on the MAR was taken by the Soviet Union in 1975, fluctuating in subsequent years between 2800 and 22 800 t. The fishery for grenadier declined after the dissolution of the Soviet Union in 1992. In the last 19 years, there has only been a sporadic fishery (Figure 2.7.2) by vessels from Russia (annual catch estimated at 200–3200 t), Poland (500–6700 t), Latvia (700–4300 t) and Lithuania (catch data are not available). During the entire fishing period to 2009, the catch of roundnose grenadier from the northern MAR amounted to more than 236 000 t, mostly from ICES Subarea 12.

Spain carried out five limited exploratory trawl surveys to seamounts on the MAR between 1997–2000 and a longline survey in 2004, but except for sporadic fisheries in the northern area (Division 14.b) there has been a decline in interest.

A new Spanish fishery for grenadiers has developed in Division 14.b since 2010. Official Spanish landings of roundnose grenadier have ranged between 242 and 2075 t. In the same period annual catches of 4–2687 tonnes of roughhead grenadier as well as 3–448 tonnes of roughsnout grenadier were reported to the working group. Spain have reported regularly landings of roundnose grenadier from subdivision 14.b1 and 12a.1 In 2020 the official Spanish landings were reported 131t from 12.a1.

Blue ling fisheries: The deep-water fisheries off Iceland tend to be on the continental slopes although in 1979 a short-lived fishery on spawning blue ling (*Molva dypterygia*) was initiated on a "small steep hill" at the base of the slope near the Westman Islands. The fishery peaked at 8000 t in 1980 and subsequently declined rapidly. Later, in 1993, French trawlers found a small seamount in southerly areas of the Reykjanes Ridge at the border of the Icelandic EEZ and were fishing for blue ling there with 390 t of catch. The maximum Icelandic catch in that area was more 3000 t also in 1993. Catches declined sharply to 300 and 117 t for next two years and no fishery was reported later (Figure 2.7.2). A fishery on the seamount was resumed by Spanish trawlers in the 2000s with biggest catch about 1000 t, but this has ceased. During 2020 Spain reported a landing of 0.272t from 12.a1.

Orange roughy fisheries: In 1992 the Faroe Islands began a series of exploratory cruises for orange roughy beginning in their own waters and later extending into international waters. Exploitable concentrations were found in late 1994 and early 1995. Several vessels began a commercial fishery but only one vessel managed to maintain a viable fishery. Most of the fishery took place on five banks. In the northern area (ICES Subarea 12) catches peaked in 1995–1998 (570–802 t), and since then have generally been less than 300 t (Figure 2.7.2). Catches from 6 to 470 t per annum were also made in ICES Subarea 10 in 1996–1998, 2000–2001, 2004–2011, 2012, 2014, 2015 and 2016. The black scabbardfish was the main bycatch species and for the most recent years' (2009–2014) catches were 45–313 t for both Subareas. There are no landings reported since 2016.

Longline fisheries for redfish: In 1996 a small fleet of Norwegian longliners began a fishery for 'giant' redfish and tusk on the Reykjanes Ridge. The fishery was mainly conducted close to the summits of seamounts and vertical longlines were used in the fishery in rugged terrain. The fishery continued in 1997, but experienced an 84% decrease in cpue. Norway carried out two exploratory longline surveys in 1996 and 1997. A Russian longline fishery was conducted in the same area in 2005–2007 and 2009.

Alfonsino fisheries: The first commercial catches of alfonsino in this area were taken by pelagic trawling on the Spectre seamount in 1977 and this and other seamounts were exploited in 1978 and 1979. No commercial fishing took place during the 1980s but nine exploratory and research cruises yielded about 1000 t of mixed deep-water species, mostly alfonsino, but also commercial catches of cardinal fish, orange roughy, black scabbardfish and silver roughy (*Hoplostethus mediterrraneus)*. A joint Norwegian-Russian survey in 1993 used a bottom trawl to survey three seamounts and a catch of 280 t, mainly alfonsino and cardinal fish, was taken from two of them. Orange roughy, black scabbard fish and wreckfish *(Polyprion americanus)* were also of potential commercial significance. Commercial fishing yielded more than 2800 t over the next seven years (Figure 2.7.2). In recent years there have been no indications of a target fishery for alfonsino. Since the discovery of the seamounts in the North Azores area Soviet and Russian, vessels have taken about 6000 t, mainly of alfonsino. Vessels from the Faroe Islands and the UK have also taken small catches of the species in the area. Faroe Islands reported landings of 141 t of alfonsinos and 82 t of orange roughy from area 10 (and 1.7 t from area 12) during 2015. During 2016 Faroes reported landings, from area 10, of 48 t of alfonsinos, 86 t of orange roughy (and 7 t from area 12) and 50 t of black scabbardfish (and 0.2 t from area 12). During 2019 Faroe report landings of 5 t from area 10.

Current status*:* Deep-water fisheries in the MAR have declined to very low levels in the recent years in Subareas 10 and 12, due to many reasons, including the economic reason and the implementation of a range of management measures.

2.4 Technical interactions

2.4.1 Azores EEZs

The fishery is multispecies and so technological interactions are observed. In the past the bycatch of this fishery was considered insignificant, according to a pilot study conducted in 2004 (ICES, 2006). However, reported discards from observers in the longline fishery from 2004–2010 shows that for some species, like deep-water sharks, the discards may be important. Actually, commercial value species like red blackspot sea bream and alfonsinos among others, are also discarded. These changes may be due to the management measures introduced, particularly the TAC/quotas, minimum size and fishing area restrictions that changed the fleet behaviour on targeting, 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 be exploiting the same stocks as considered here.

2.4.2 Mid-Atlantic Ridge

Seamount aggregating species such alfonsinos and orange roughy are sensitive to sequential local depletion. However, no data were available to assess such effects in these areas. Little is understood about the stock structure of these species and it is not known whether the trawler fleets that fished in international waters of the MAR fish the same stocks that are exploited inside the EEZ by the Azorean fishery.

2.5 Ecosystem considerations

2.5.1 Azores EEZ

The Azores is considered a “seamount ecosystem area” because of its high seamount density. The Azores, as for most of the volcanic islands, do not have a coastal platform and are surrounded by extended areas of great depths, punctuated by some seamounts where fisheries occur. The average depth in the Azores EEZ is 3000 m, and only 0.8% (7715 km^2) has depths <600 m while 6.8% is between 600 and 1500 m. The deep-water fishery in the Azores is mostly a seamount fishery where only bottom longlines and handlines are used.

2.5.2 Mid-Atlantic Ridge

Most of Divisions 12.a, 12.c, 10.b, 14.b1 and 5.a are abyssal plain habitats with an average depth of around 4000 m which remains unexploited. The major topographic feature is the northern part of the MAR, located between Iceland and the Azores. The geomorphological characteristics of seamounts and ridges and the hydrographic conditions associated with them form the basis for densely populated filter-feeding epifaunal communities comprising sponges, bivalves, brittlestars, sea lilies and a variety of corals (gorgonians, scleractinians a.o.), including the cold-water coral *Lophelia pertusa* and *Solenosmilia* (Mortensen *et al*., 2008). This benthic habitat, probably also benefitting from impinging biomass of mesopelagic organisms (fish, zooplankton) (Sutton *et al.*, 2008), supports elevated levels of biomass in the form of aggregations of fish such as roundnose grenadier, orange roughy, alfonsinos, etc. The sessile benthic communities on hard substrata (i.e. regarded as ‘vulnerable marine ecosystems’ *sensu* FAO (2009) are highly susceptible to damage by bottom fishing gear, and the fish stocks can be rapidly depleted due to the life-history traits and behaviour of the species. The demersal fish fauna of the MAR has been well described based on data from exploratory fishing and scientific investigations (e.g. Hareide and Garnes, 2001; Bergstad *et al*., 2008; Fossen *et al*., 2008). Several of the seamount fish have long lifespans, low production rates and form easily targeted aggregations.

The MAR is isolated from the continental slope except for the relatively continuous shallower connections via the Greenland and Scotland ridges, and some seamount chains, e.g. the New England seamounts provide other linkages to the continents. There is a substantial literature on biogeography of seamounts and the MAR, and also some recent studies of population genetics. Demersal fish assemblages on the MAR resemble those on adjacent slope areas on either side (Bergstad *et al*., 2012), and for some important commercial species, e.g. roundnose grenadier, genetic studies suggest homogeneity across wide areas across the ocean basin (Knutsen *et al*., 2012).

2.6 Management of fisheries

2.6.1 Azores EEZ

In the Azorean EEZ fisheries management is based on regulations issued by the European Community, by the Portuguese government, and by the Azores regional government. Under the EC Common Fisheries Policy (CFP), TACs were introduced for some species, e.g. blackspot sea bream, black scabbardfish, and deep-water sharks, in 2003 (EC. Reg. 2340/2002) and revised/maintained thereafter. Specific access requirements and conditions applicable to fishing for deep-water stocks were also established (EC. Reg. 2347/2002). Fishing with trawl gears is forbidden in the Azores region. A box of 100 miles limiting the deep-water fishing to vessels registered in the Azores was created in 2003 under the management of fishing effort of the CFP for deep-water species (EC Reg. 1954/2003). Some technical measures were also introduced by the Azores regional government since 1998 (including fishing restrictions by area, vessel type and gear, fishing licences based on landing thresholds, minimum lengths, marine protected areas and closed seasons) and updated thereafter. Some target fisheries are managed based on quarter TACs by islands and vessel.

2.6.2 Mid-Atlantic Ridge

There is a NEAFC regulation of fishing effort in the fisheries for deep-sea species (species on the NEAFC Annex 1b) list of regulated resources). This generalized measure is intended to prevent expansion in fisheries, including by third parties. The use of gillnets is prohibited beyond 200 m depth.

Specific measures including the TAC were introduced for grenadiers, orange roughy, blue ling and deep-water sharks (http://neafc.org/managing_fisheries/measures/current). In 2015, the fishery for orange roughy was closed, and directed fishery for deep-water sharks has been prohibited.

Current NEAFC measures also include regulations on bottom fishing aimed to protect VMEs. Regular fishing with bottom-touching fishing gear is only allowed in restricted subareas of the NEAFC Regulatory Area designated as 'existing fishing areas' (Figure 2.7.4). Other areas are either closed to bottom fishing or considered subareas only open to pre-assessed exploratory fisheries evaluated and accepted by the commission. In the event a possible VME is encountered in 'existing fishing areas' or during exploratory fishing, move-on rules apply and temporary closures established until it has been determined that a VME exists or not.

European Union TACs for deep-sea species apply to licensed EU vessels fishing on the MAR.

2.7 References

Bergstad, O.A., G. Menezes and Å.S. Høines. 2008. Demersal fish on a mid-ocean ridge: Distribution patterns and structuring factors. Deep Sea Research II. **55,** 185–202.

Bergstad, O.A., G M M Menezes, AS Høines, JDM Gordon and JK Galbraith. 2012. Patterns of distribution of deepwater demersal fish of the North Atlantic mid-ocean ridge, continental slopes, islands and seamounts. Deep-Sea Research I 61: 74–83.

FAO. 2009. The FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas. http://www.fao.org/fishery/topic/166308/en.

Fossen, I., C.F. Cotton, O.A. Bergstad and J.E. Dyb. 2008. Species composition and distribution patterns of fish captured by longlines on the Mid-Atlantic Ridge. Deep Sea Research II. **55,** 203–217.

Hareide, N.-R. and G. Garnes. 2001. The distribution and catch rates of deep water fish along the Mid-Atlantic Ridge from 43 to 618N. Fisheries Research **51**, 297–310.

Knutsen, H., PE Jorde, OA Bergstad, M Skogen. 2012. Population genetic structure in a deepwater fish *Coryphaenoides rupestris*: patterns and processes. Mar Ecol Prog Ser 460: 233–246.

Mortensen, P.B., L. Buhl-Mortensen, A.V. Gebruk and E.M. Krylova. 2008. Occurrence of deep-water corals on the Mid-Atlantic Ridge based on MAR-ECO data. Deep Sea Research II. **55,** 142–152.

Niedzielski, T., Å. Høines, M.A. Shields, T.D. Linley and I. G. Priede. 2013. A multi-scale investigation into seafloor topography of the northern Mid-Atlantic Ridge based on geographic information system analysis. Deep-Sea Res. II (2013), http://dx.doi.org/10.1016/j.dsr2.2013.10.006i.

Sutton, T.T, F.M. Porteiro, M. Heino, I. Byrkjedal, G. Langhelle, C.I.H. Anderson, J. Horne, H. Søiland, T. Falkenhaug, O.R. Godø and O.A. Bergstad. 2008. Vertical structure, biomass and topographic association of deep-pelagic fish in relation to a mid-ocean ridge system. Deep Sea Research II**. 55,** 161–184.

2.8 Tables

Table 2.7.2. Overview of landings in Subareas 10 (a.1, a.2, b),12I (c, a.1) (does not include information from 12.b, Western Hatton Bank) and 14. b1).

	ALFONSINOS (*Beryx* spp.)	ARGENTINES (*Argentina silus*)	BLUE LING (*Molva dypterigia*)	BLACK SCABBARDFISH (*Aphanopus carbo*)	BLUEMOUTH (*Helicolenus dactylopterus*)	DEEP WATER CARDINAL FISH (*Epigonus telescopus*)	GREATER FORKBEARD (*Phycis blennoides*)	LING (*Molva molva*)	MORIDAE	ORANGE ROUGHY (*Hoplostethus atlanticus*)	RABBITFISHES (Chimaerids)	RAGIDAE	ROUGHHEAD GRENADIER (*Macrourus berglax*)	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	RED (=BLACKSPOT) SEABREAM *Pagellus bogaraveo*)	BEAKED REDFISH (*Sebastes mentela*)	SHARKS, VARIOUS	SILVER SCABBARDFISH (*Lepidopus caudatus*)	SMOOTHHEADS (Alepocephalidae)	Trachipterus sp	TUSK (Brosme brosme)	WRECKFISH (*Polyprion americanus*)	TOTAL
1995	731		602	304	589		75	50		676				644	1115		1385	789			18	244	7222
1996	1510	1	814	455	483		47	2		1289				1739	1052		1264	826	230		158	243	10113
1997	384		438	203	410		32	9		814	32			8622	1012		891	1115	3692		30	177	17861
1998	229		451	253	381		39	2		806	42			11979	1119		1051	1187	4643		1	140	22323
1999	725	2	1363	224	340		41	2		441	115		3	9696	1222		50	86	6549		1	133	20993
2000	484		607	357	452	3	100	7	1	447	48		7	8602	947		1069	28	4146		5	268	17578
2001	199		675	134	301		91	59	88	839	79		10	7926	1034		1208	14	3592		52	232	16533
2002	243		1270	1062	280	14	63	8	113	28	98		7	11 468	1193		35	10	12538		27	283	17272
2003	172		1069	502	338	16	56	19	140	201	81		2	10 805	1068		25	25	6883		83	270	10950
2004	139	4	644	384	282	21	46		91	711	128		28	10 748	1075		6	29	4368		16	189	8161
2005	161		35	198	190	4	22	2	69	324	193		8	513	1383		14	31	6872		66	279	10364
2006	192		65	73	209	10	134		127	104			8	86	958		104	35			64	497	2666
2007	211		1		275	7	201		86	20				2	1070		63	55			19	664	2674
2008	252			80	281	7	18		53	108				13	1089		12	63				513	2489
2009	312			162	267	7	26	1	68	26	22		6	5	1042		1	64			2	382	2393
2010	245		72	240	213	5	14		54	74	0		0	1691	687		7	68			107	238	3715
2011	232		0	163	231	5	11		55	112			0	3366	624		5	148			0	266	5218
2012	222		16	16	190	4	6	0		139	2		2726	2724	613		31	282	160	54	29	226	7441
2013	168		9	206	235	4	8	0			6		868	1907	692		70	0	17			209	4398
2014	131			85	200	2	9			47			448	2075	663			713				121	4493
2015	292		0	7	256	4	10	1		84				862	701			429			1	116	2764
2016	156			86	306		10			93				660	515			87				101	2014
2017	149	0	0	63	333	5	15	0	169	<1	0	70	0	84	499	2277	75	101	0	0	0	128	3967
2018	157	0	28	17	283	4	75	0		0	0	60	0	27	474	2873	0	65	0	0	506	80	4649
2019	143	0	1	21	187	9	13	0			0	43	0	215	481	2403	0	65	0	0	0	80	3662
2020*	139	0	0	11	130	5	9	0		0	0	5	0	131	491	2205	1	88	0	0	0	81	3297

***- provisional data**

Table 2.7.1. Summary data on seamount fisheries on the MAR.

Main species	Discovery		No. of commercial seamounts	Maximum catch/yr ('000 t)
	Year	Country		
Coryphaenoides rupestris	1973	USSR	34	29.9
Beryx splendens	1977	USSR	4	1.1
Hoplostethus atlanticus	1979	USSR	5	0.8
Molva dypterigia	1979	Iceland	1	8.0
Epigonus telescopus	1981	USSR	1	0.1
Aphanopus carbo	1981	USSR	2	1.1
Brosme brosme	1984	USSR	15	0.3
Sebastes marinus	1996	Norway	10	1..0

2.9 Figures

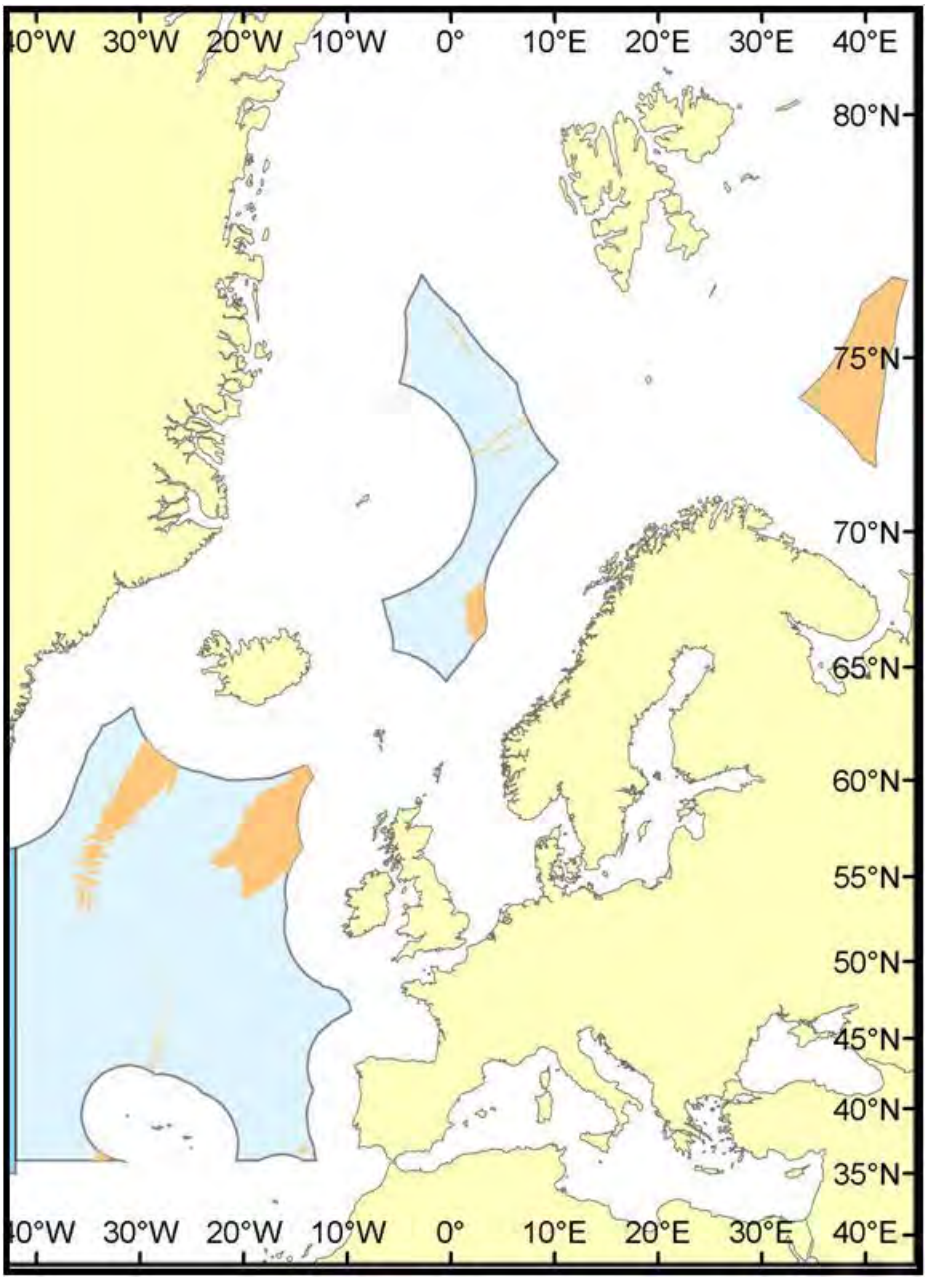


Figure 2.7.1. The NEAFC Regulatory Area (area beyond national jurisdiction) in the Northeast Atlantic (light blue polygons) with superimposed subareas shallower than 2000 m (light brown patches). Note that the NEAFC RA in the Barents Sea is entirely shallower than 2000 m, and that a high Arctic NEAFC RA (beyond 80◦N) is not shown on the map.

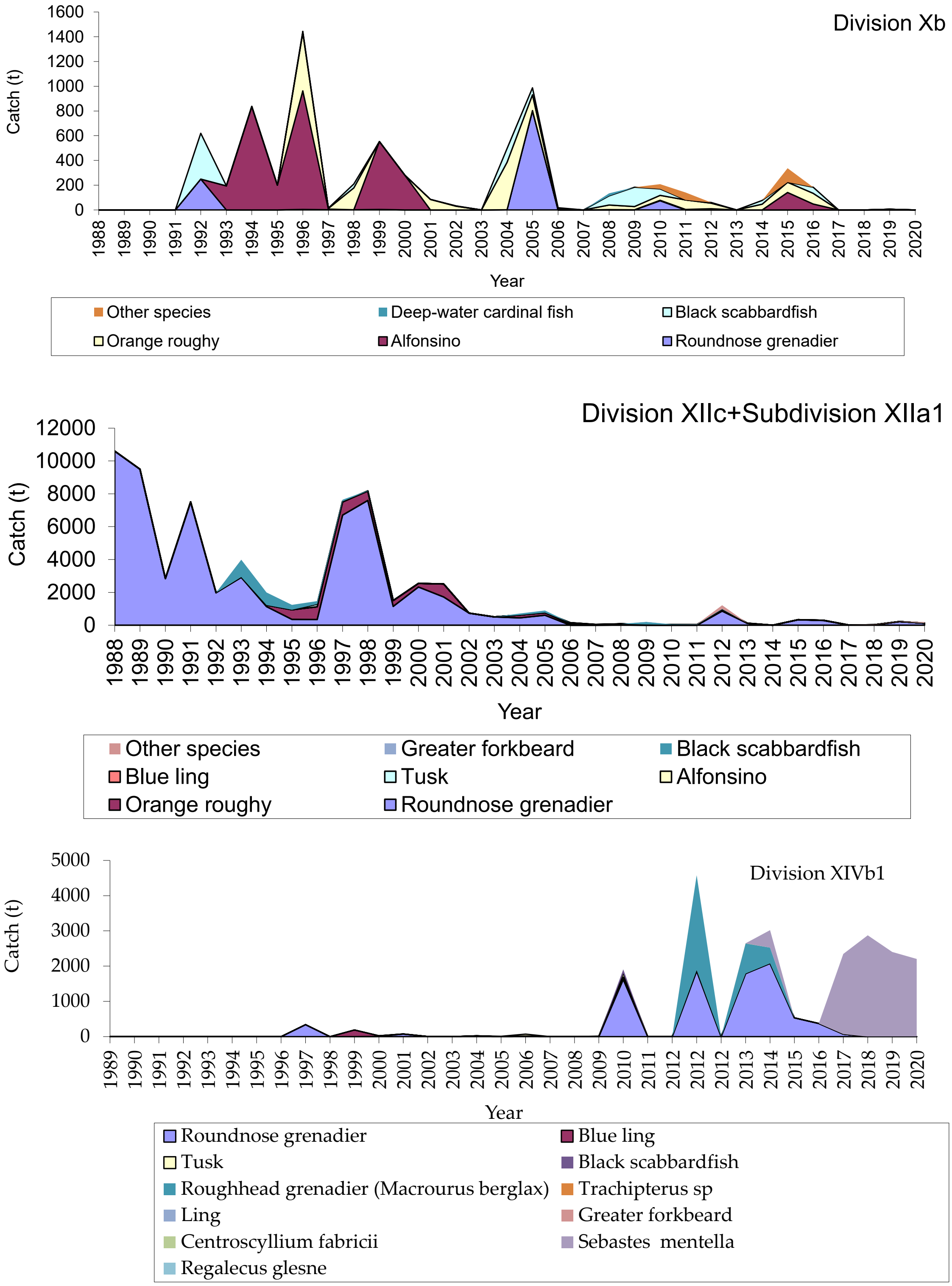


Figure 2.7.2. Annual catch of major deep-water species on MAR in 1988–2020.

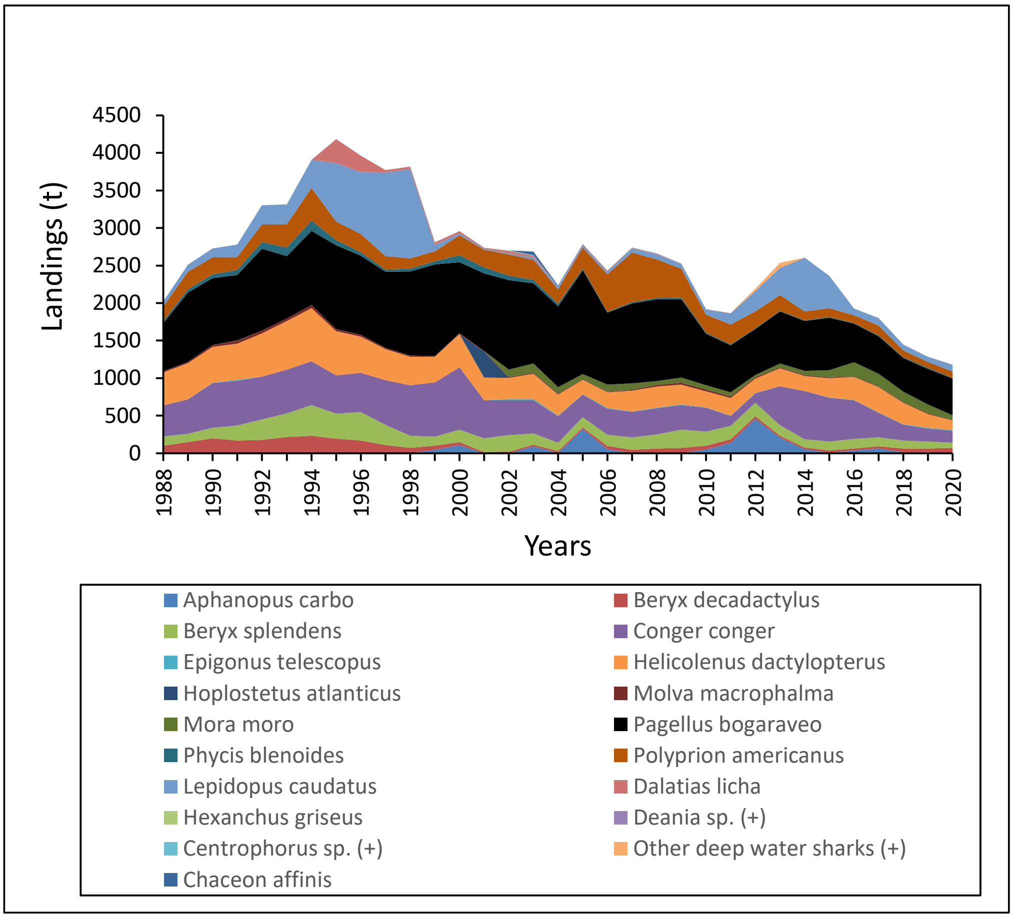


Figure 2.7.3. Annual landings of major deep-water species in Azores from hook and line fishery (1988–2020).

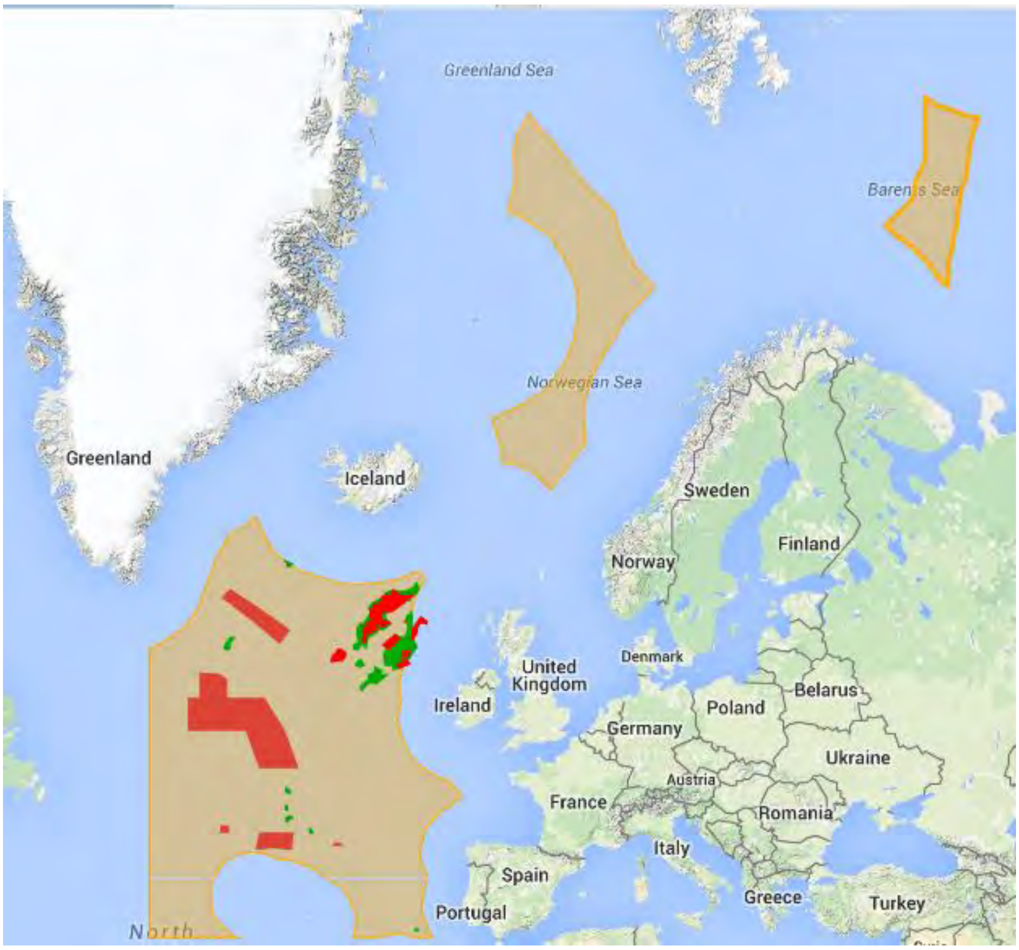


Figure 2.7.4. The regulatory area of NEAFC (light brown) and subareas of the Mid-Atlantic Ridge, seamounts and the Rockall-Hatton areas designated as bottom fishing closures (red), and 'existing fishing areas (green). Areas outside closures and 'existing fishing areas' are only open to pre-assessed exploratory bottom fishing. Source: www.neafc.org .

3 Ling (*Molva Molva*)

3.1 Stock description and management units

WGDEEP 2006 indicated: 'There is currently no evidence of genetically distinct populations within the ICES area. However, ling at widely separated fishing grounds may still be sufficiently isolated to be considered management units, i.e. stocks, between which exchange of individuals is limited and has little effect on the structure and dynamics of each unit. It was suggested that Iceland (Division 5.a), the Norwegian Coast (Subarea 2), and the Faroes and Faroe Bank (Division 5.b) have separate stocks, but that the existence of distinguishable stocks along the continental shelf west and north of the British Isles and the northern North Sea (Subareas 4, 6, 7 and 8) is less probable. Ling is one of the species included in a recently initiated Norwegian population structure study using molecular genetics, and new data may thus be expected in the future'.

WGDEEP 2007 examined available evidence on stock discrimination and concluded that available information is not sufficient to suggest changes to current ICES interpretation of stock structure.

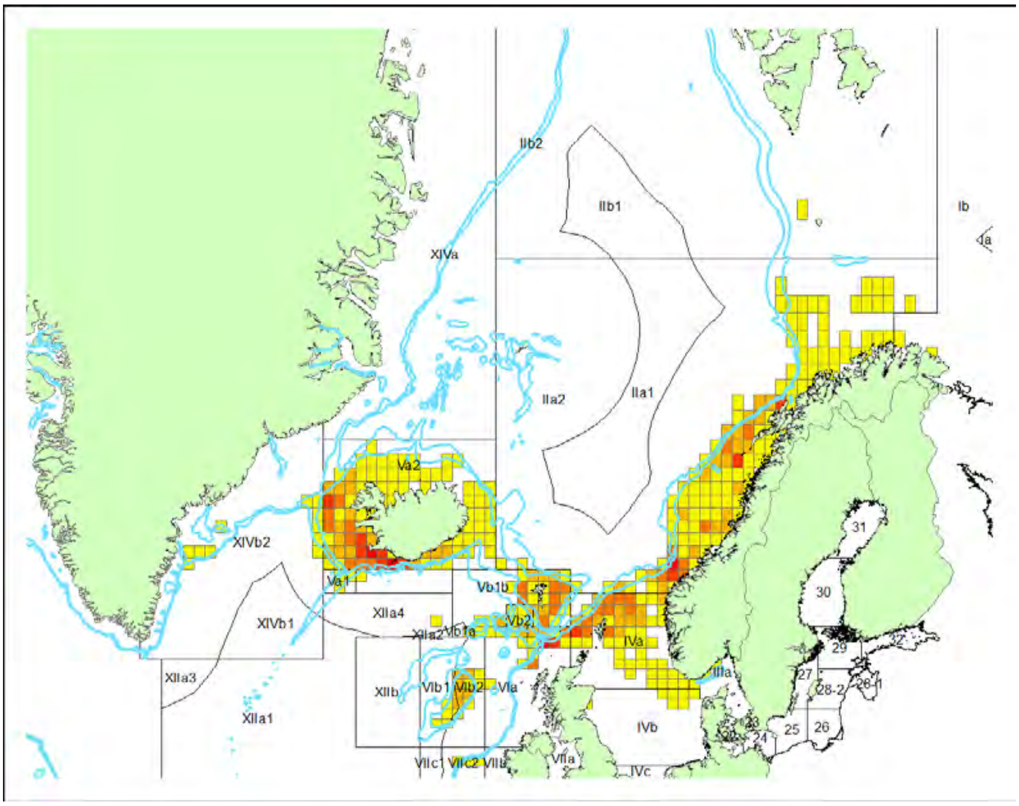


Figure 3.1. Map of fishery distribution (catches) in 2013 (data from Iceland, Faroes and Norway).

A study on population genetic structure of ling in the Northeast Atlantic rejected the hypothesis of a single ling stock in the Northeast Atlantic, and rather suggest the existence of two or more groups, with the main grouping represented by a western (Rockall and Iceland) and an eastern group (Faroe Bank, Norway) (Gonzales *et al*., 2015). Significant genetic differences coincide with an expanse of deep water that probably limits connectivity facilitated by migration. Retention in gyres and directional oceanic circulation may also prevent drift and admixture during planktonic life stages. On the other hand, the apparent absence of genetic differentiation within the eastern part of the distribution range indicates gene flow, perhaps by larval drift and migration, over considerable distances.

A small-scale exchange of 50 ling otolith images was done in 2013 (WKAMDEEP, 2013). The results of this exchange showed that the mean CV of all the 9 age readers of ling was 10.3% and the conclusion was that the precision is probably high enough to support age-structured analytical assessments (WGDEEP, 2013). The results from the annotations of this exchange highlighted that the problem (in most cases) was to do with edge growth. It is necessary to train an age reader and inform them when to count the first translucent zone (first year) (WKAMDEEP, 2013). Also earlier ling otolith exchanges concluded that there was some inconsistencies between age readers but the differences were not very substantial and could easily be adjusted (Bergstad *et al*., 1998; Øverbø Hansen, 2012). An analysis of edge growth of ling otoliths is recommended to help on this problem with edge growth.

3.1.1 References

Blanco Gonzalez, E., Knutsen, H., Jorde, P. E., Glover, K. A., and Bergstad, O. A. Genetic analyses of ling (*Molva molva*) in the Northeast Atlantic reveal patterns relevant to stock assessments and management advice. – ICES Journal of Marine Science, 72: 635–641.

3.2 Ling (*Molva Molva*) in Division 5.b

3.2.1 The fishery

General description of the fishery in Faroese waters is presented in the stock annex. In 2020, the longliners and trawlers who catch ling as bycatch in saithe fishery were mainly fishing on the slope on the Faroe Plateau and somewhat to the South East on the Faroe Bank and Wyville-Thomson Ridge (Figure 3.2.1). Recent years, foreign catches were mainly by the Norwegian longliners.

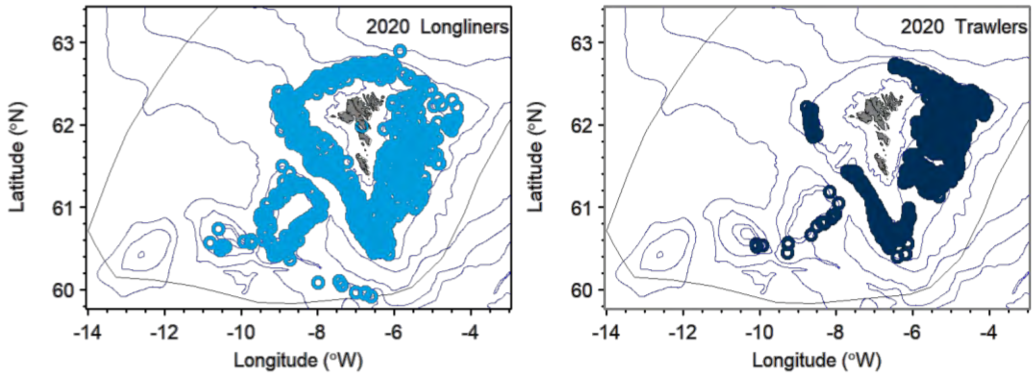


Figure 3.2.1. Ling in 5.b. Spatial distribution in 2020 of the Faroese longliner fishery (left) and pair trawler fishery (bycatch in saithe fishery, right).

3.2.2 Landings trends

Landing statistics for ling by nation for the period 1988–2020 are given in Tables 3.2.1–3.2.3 and total landings data from 1904 onwards are available and shown in Figure 3.2.2. The historic landing trends are described in the stock annex.

Total landings in Division 5.b have in general been very stable since the 1970s varying between around 4000 and 7000 tonnes. In the period from 1990–2005 around 20% of the catch was fished in area 5.b2, and in the period 2006–2020 this has decreased to around 10%. The preliminary landings of ling increased in 2020 to 9427 tons (the highest catch in the whole time series), of which the Faroes caught 67%. The reason for the low foreign catches in 2011–2013 was because of no bilateral agreement on fishing rights between the Faroes, Norway and EU.

Around 50–70% of the ling in 5.b was caught by longliners and the rest mainly by trawlers (30–40%). Only a minor part of the landings was by other gear (Table 3.2.4).

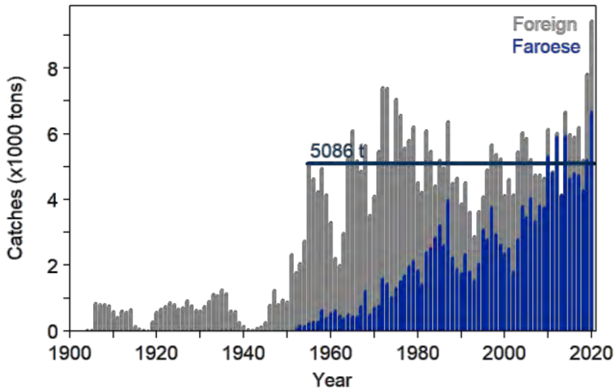


Figure 3.2.2. Ling in 5.b. Total international catches since 1904. The mean catches from 1955-present were around 5000 tons.

3.2.3 ICES Advice

ICES advices that when the precautionary approach is applied, catches should be no more than 4157 tonnes in each of the years 2020 and 2021. All catches are assumed to be landed. ICES is not in a position to advice on the corresponding level of fishing effort.

3.2.4 Management

For the Faroese fleets, there is no species-specific management of ling in 5.b although there is a licensing scheme and effort limitations. The main fleets targeting ling are each year allocated a total allowable number of fishing days to be used in the demersal fishery in the area. Other nations fishing ling in Division 5.b are regulated by TACs. The recommended minimum landing size for ling is 60 cm (total length) which is not enforced due to the discard ban. Regulation is set for juvenile catch and a maximum of 25% of the ling catch (per settings/hauls) can be juveniles e.g. smaller than 75 cm.

Since 1977 there has been a bilateral agreed quota between Norway and Faroe Islands except for 2011–2013. In 2021, Norway can catch 2500 tons ling/blue ling, 2000 tons tusk and 800 tons other species as by-catch in bottom fishery in Faroese waters (fiskiveiðiavtala-millum-føroyar-og-noreg-fyri-2021.pdf).

In 2021, the Faroese Party will allow five Russian fishing vessels to undertake experimental fishing in the Faroese Fishing Zone at depths deeper than 700 meters provided that a Russian scientific observer is onboard. No more than three of these vessels can be operating simultaneously. Two of these vessels can undertake experimental fishery in deep waters around Outer Bailey and Bill Baileys Banks at depth between 500 and 700 meters provided that catches in this area do not exceed 500 tonnes of deep-sea species (fiskiveiðiavtala-millum-føroyar-og-russland-fyri-2021.pdf).

There are no agreements about a TAC between EU and Faroe Islands at the time of this year's assessment.

3.2.5 Data available

Data on length, gutted weight and age are available for ling from the Faroese landings and Table 3.2.5 give an overview of the level of sampling since 1996.

There are also catch and effort data from logbooks for the Faroese longliners and trawlers. In addition, there are also data available on catch, effort and some mean lengths from Norwegian longliners fishing in Faroese waters.

From the two annual Faroese groundfish surveys on the Faroe Plateau targeting cod, haddock and saithe, biological data (mainly length and round weight, Table 3.2.6) as well as catch and effort data are available. Data of ling larvae from the annual 0-group survey on the Faroe Plateau has also been investigated.

3.2.5.1 Landings and discards

Landing data is available for all relevant fleets. No estimates of discards of ling are available. But since the Faroese fleets are not regulated by TACs and there is a ban on discarding in Faroese EEZ, incentives for illegal discarding are believed to be low. The landings statistics are therefore regarded as being adequate for assessment purposes.

3.2.5.2 Length compositions

Length composition data is available from the Faroese commercial longliners, the trawler fleet that captures ling as bycatch in saithe fishery and from the two groundfish surveys (Figures 3.2.3–3.2.5).

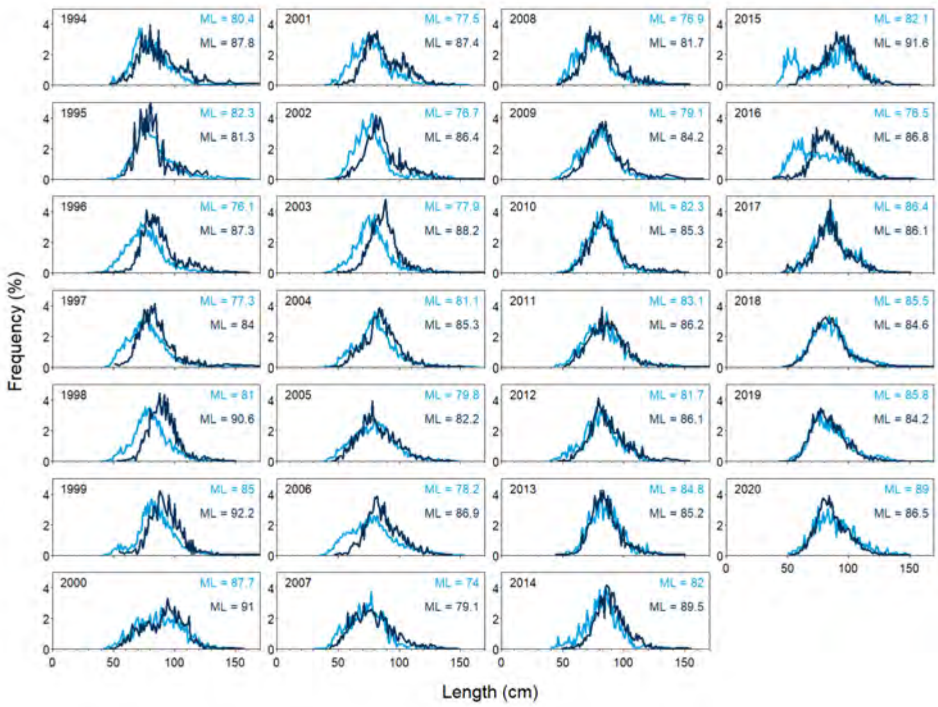


Figure 3.2.3. Ling in 5.b. Length frequencies from the landings of ling from Faroese longliners (>110 GRT, turquoise line) and Faroese trawlers (>1000 HP, dark blue line) from 1994-present. ML- mean length.

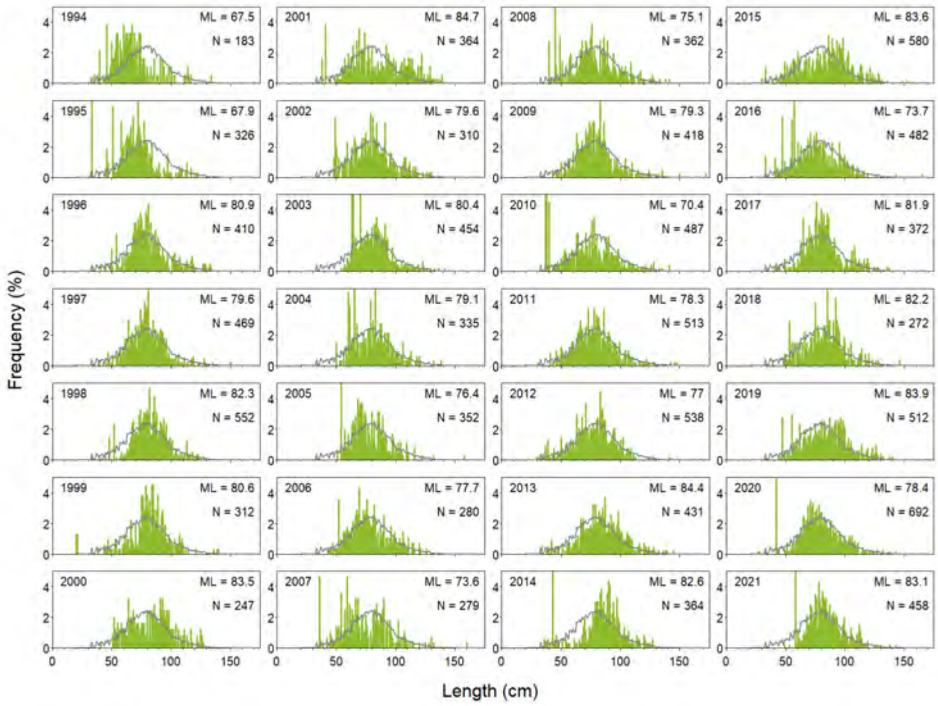


Figure 3.2.4. Ling in 5.b. Length frequencies from the groundfish spring survey. ML- mean length, N–number of calculated length measures, grey line- mean of all years. The small ling are often sampled from a subsample of the total catch, so the values are multiplied to total catch.

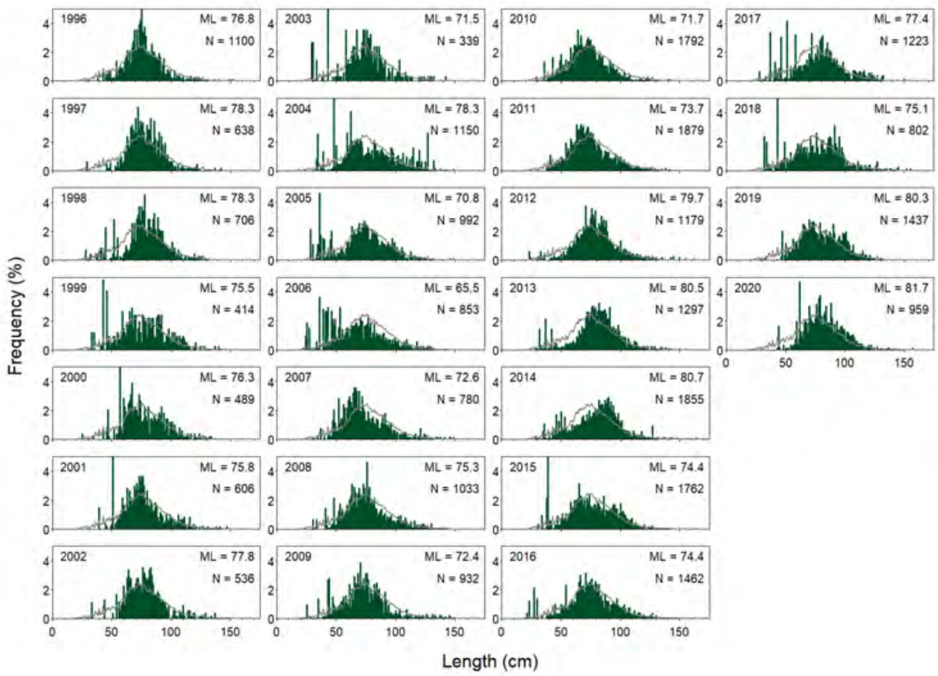


Figure 3.2.5. Ling in 5.b. Length frequencies from the groundfish summer survey. ML- mean length, N–number of calculated length measures, grey line- mean of all years. The small ling are often sampled from a subsample of the total catch, so the values are multiplied to total catch.

3.2.5.3 Catch-at-age

Catch-at-age data were provided for the Faroese fishery in 5.b for the period 1996 - present. In 2020, a new ALK- program was used to calculate the catch number at age from 1996 - present (see ICES, 2021, Stock annex). The most common ages in the landings are from five to nine years and the mean age is around 7–8 years (Figure 3.2.6 and Table 3.2.7). Consistency plot of the catch at age data is shown in Figure 3.2.7.

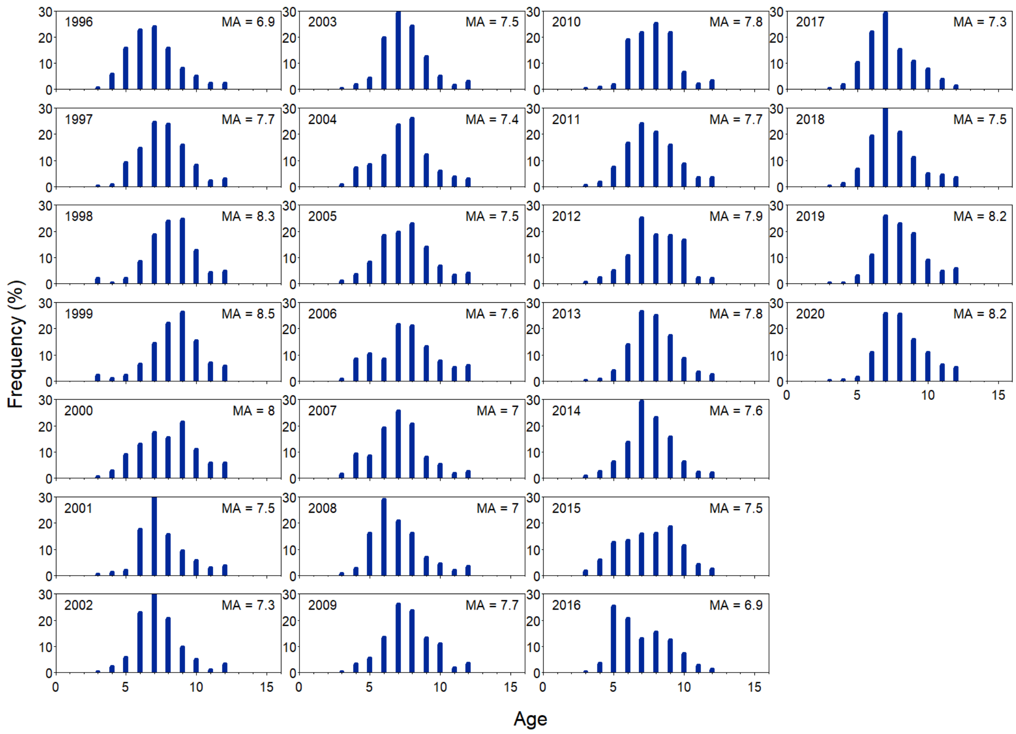


Figure 3.2.6. Ling 5.b. Catch-at-age from the commercial fleets in the assessment. MA- mean age.

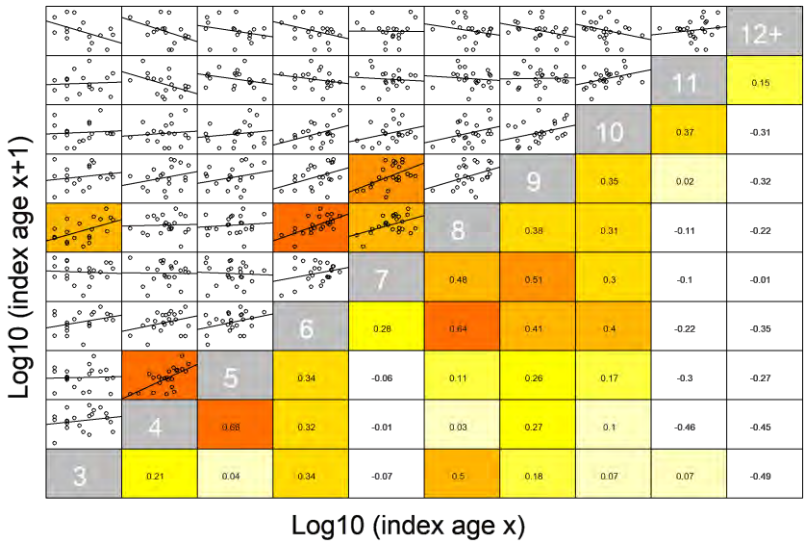


Figure 3.2.7. Ling 5.b. Consistency plot of catch-at-age used in the assessment.

3.2.5.4 Weight-at-age

Mean weight-at-age data from the landings in 5.b is modelled using the Faroese ALK-program (Stock annex, ICES, 2021). There are no particular trends in the mean weights over the period (Figure 3.2.8 and Table 3.2.8).

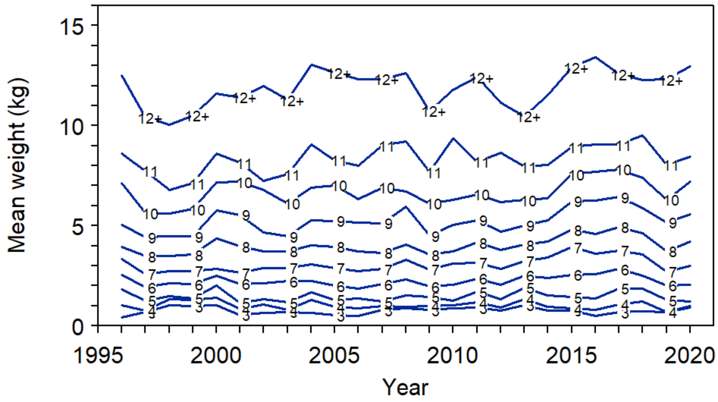


Figure 3.2.8. Ling in 5.b. Mean weight-at-age in the catches from 1996-present.

3.2.5.5 Maturity and natural mortality

The proportion mature at age used in the assessment is presented in the table below. The same maturity-at-age calculated from all data (2000-2019) for sexes combined was used for all years in the assessment. Maturity ogives of ling are presented in stock annex.

Age	3	4	5	6	7	8	9	10	11	12+
Proportion mature	0.00	0.04	0.19	0.50	0.79	0.93	0.98	1.00	1.00	1.00

No information is available on natural mortality of ling in 5.b. Natural mortality of 0.15 was assumed for all ages in the assessment. That is the same as used for ling in Division 5.a.

3.2.5.6 Catch, effort and research vessel data

Commercial cpue series

There are catch per unit of effort (cpue) data available from three commercial series; the Faroese longliners, the Faroese pair trawlers (bycatch in saithe fishery) and Norwegian longliners fishing in Division 5.b. Information on abundance trends can be derived from the CPUE data from these fleets. Even though there were no striking problems detected with the commercial tuning series (in terms of series trends or problems arising from aggregating fish or fishery targeting), the WKBARFAR benchmark decided not to use the commercial series in the tuning of the assessment model (ICES, 2021). The cpue series for Faroese fishery are described in stock annex for ling in 5b whilst the standardized cpue data from Norwegian longliners fishing in Division 5.b are described in the stock annex for ling in 2.a (Section ling in 1 and 2).

Fisheries-independent cpue series

Survey biomass index (kg/h) for ling are available from two annual groundfish trawl surveys on the Faroe Plateau targeting cod, haddock and saithe. The annual survey on the Faroe Plateau covers the main fishing areas and a large part of the spatial distribution. Information on the surveys and standardization of the data are described in the stock annex. WKBARFAR benchmark decided to use these two survey series in the tuning of the assessment model (ICES, 2021).

A potential recruitment index for ling less than 40 cm has been calculated from the groundfish surveys. In addition, an index has been calculated from the annual 0-group survey on the Faroe Plateau.

3.2.6 Data analyses

Mean length in the length composition from commercial catches from Faroese longliners and trawlers showed an increase in mean length from 74–79 cm in 2007 to around 83–86 cm after 2010 (Figure 3.2.3). The mean length in 2003–2009 from the Norwegian longliners fishing in Faroese waters were around 87 cm. The Faroese trawlers and longliners have almost identical length compositions, only a few years where longliners have a lower mean length compared with the trawlers.

Length composition from the two groundfish surveys on the Faroe Plateau showed high interannual variation in mean length, from 65 to 85 cm which may partly be explained by occasional high abundance of individuals smaller than 60 cm (Figures 3.2.4–3.2.5).

3.2.6.1 Fluctuations in abundance

The Faroese longline CPUE series and the Faroese trawl bycatch CPUE series show an increasing trend since around 2001 (Figure 3.2.9). The Norwegian longline series show an increase after 2004, except in 2018 (Figure 3.2.9). It has to be noted that there are less than 100 fishing days from Norwegian longliners in Faroese waters in 2009–2014.

The two survey abundance series indicate a stable situation from the late 1990s and an increase to a higher level since 2010 (Figure 3.2.10).

A potential recruitment index was calculated from the two surveys with the number of ling smaller than 40 cm (Figure 3.2.13). The index indicates high recruitment in the period 2013-2018. There has been a decrease since 2019. In addition, a potential recruitment index was calculated of ling (2–3 cm in length) from the annual 0-group survey on the Faroe Plateau from 1983 - present. This also showed indications of high recruitment in some years (Figure 3.2.12). Together these recruitment indices support an indication of high recruitment in distinct years.

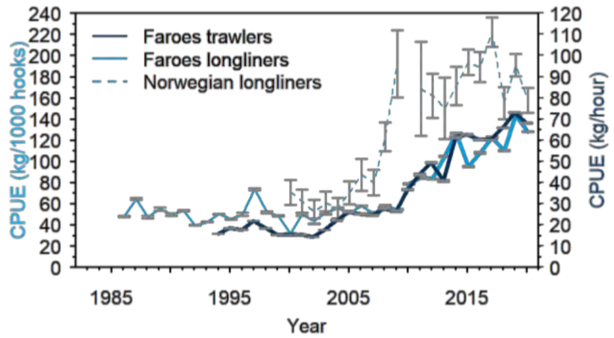


Figure 3.2.9. Ling in 5.b. Standardized CPUE from Faroese pair trawlers (bycatch, dark blue line), Faroese longliners (turquoise line) and Norwegian longliners (turquoise stippled line) fishing in Faroese waters. Data from Faroese trawlers are from hauls where ling was caught and saithe >60% of the total catch. Data from Faroese longliners (>110 GRT) are from

sets where ling >30% of the total catch. The error bars are SE. The bars denote the 95% confidence intervals in the Norwegian data (Helle and Pennington, WD 2021).

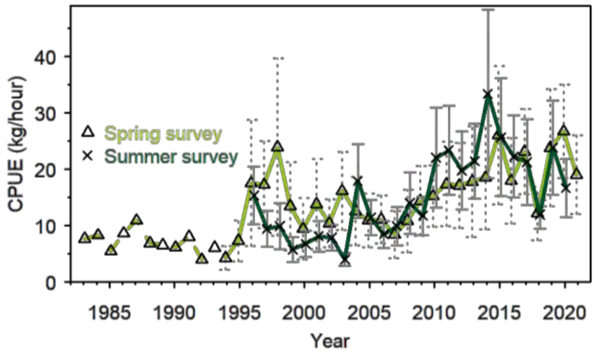


Figure 3.2.10. Ling in 5.b. Standardized CPUE (kg/hour) from the two annual Faroese groundfish surveys on the Faroe Plateau with standard errors. The data for 1983–1993 were not standardized.

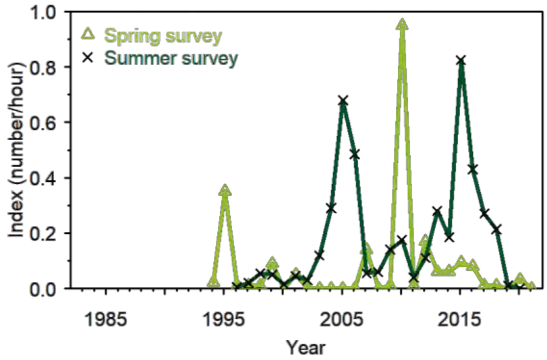


Figure 3.2.11. Ling in 5.b. Index (number/hour) of ling smaller than 40 cm from the spring- and summer survey on the Faroe Plateau.

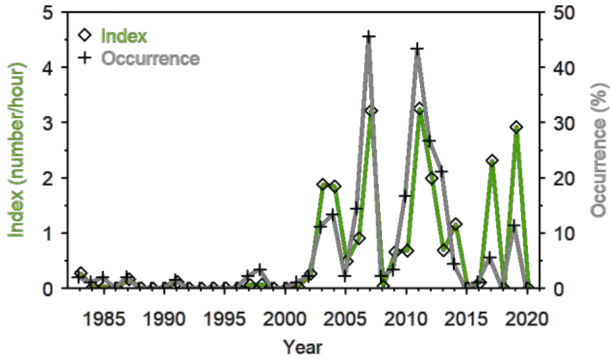


Figure 3.2.12. Ling in 5.b. Index (number/hour) and occurrence (%) of ling (2–3 cm in length) caught in the annual 0-group survey on the Faroe Plateau.

3.2.6.2 Stock assessment

Prior to the WKBARFAR benchmark in February 2021 this stock was under ICES 3.2 rule, where the advice was based on a survey trend-based assessment (ICES, 2019) using a survey biomass index (kg/h) from the Faroese summer groundfish survey. However, an exploratory age based assessment using SAM has been presented in the WGDEEP report since 2017 (ICES, 2020). At the WKBARFAR benchmark 2021 a Category 1 approach was adopted using the SAM model (ICES, 2021 and stock annex).

Analytical assessment using SAM

The input for the SAM model was catch at age for ages 3 to 12+ and for years back to 1996. Catch at age was derived from the Faroese sampling, and thereafter raised to the total catches. Maturity at age was from the Faroese survey data and used as time-invariant variable. Natural mortality was set to 0.15 for all ages and years. The age-disaggregated tuning series were the Faroese summer survey, ages 3 to 11 years (1996-2020) and the Faroese spring survey, ages 4 to 11 years (1998-2020). SAM model settings are described in detail in the stock annex.

The catches at age for the spring- and summer survey tuning series are presented in Table 3.2.9 and 3.2.10. They show periods of good year classes. An indication of good year classes was also seen in the 0-group survey (Figure 3.2.12). Stratified mean catch of ling in kg per hour shows an increased level since around 2010 in both surveys (Figure 3.2.10). The summer survey consistency plot shows good consistency between the cohorts (Figure 3.2.13), but in the spring survey the consistency in the cohorts is not as good (Figure 3.2.14). The fish seems to be fully recruited to the survey gear at around age 5.

The results and diagnostics of the final assessment **Ling5b_wgdeep2021** (stockassessment.org) are presented in Tables 3.2.11-3.2.14 and Figures 3.2.15-3.2.19.

The results from SAM shows that the spawning stock biomass (SSB) currently is at the highest level for the whole assessment period (since 1996) (Figure 3.2.15, Tables 3.2.11, 3.2.13). The fishing mortality ($F_{6\text{-}10}$) has generally been around 0.4; but F decreased to F_{MSY} in 2017 and 2018, and has since increased again to 0.3 in 2020 (Figure 3.2.15, Tables 3.2.11, 3.2.12). The increase in SSB and decrease in F is explained by good recruitments (Figure 3.2.15, Table 3.2.11).

The SAM results for 2020 showed that the spawning stock biomass was well above MSY $B_{trigger}$ and the fishing mortality above F_{MSY} but below F_{pa} and F_{lim}.

The diagnostics from SAM is shown as model fits to the data (Figure 3.2.16), residuals (Figure 3.2.17), leave-one-out analysis (Figure 3.2.18), retrospective analysis (Figure 3.2.19) and parameter estimates (Table 3.2.14). Overall, it seems that the model fits the data quite well. The residuals are randomly distributed. The leave one out analysis shows that the model is robust, only for recruitment it seems to give a bit different results. The retrospective pattern shows that F is overestimated and SSB subsequently underestimated. All the retrospective runs falls within the confidence intervals of the final assessment. Mohn's rho parameters are estimated at -12%, 27% and 1% for the spawning stock biomass, F and recruitment, respectively.

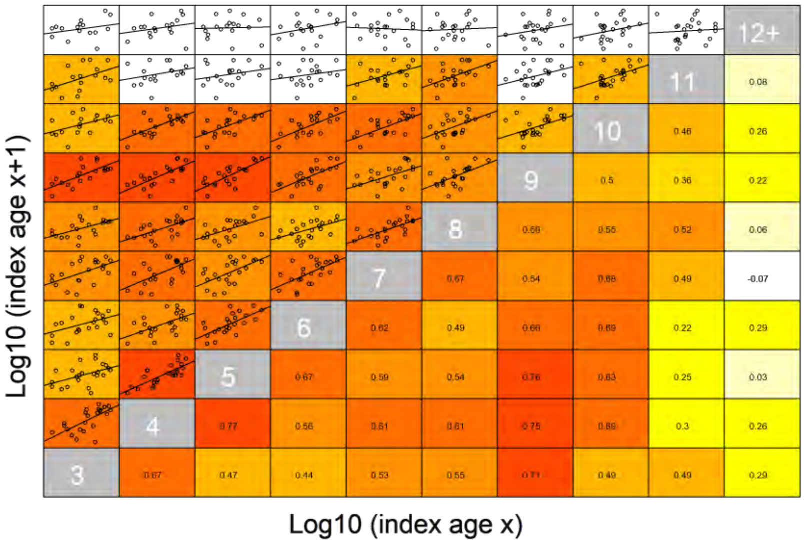


Figure 3.2.13. Ling in 5.b. Consistency plot of catch-at-age in the summer survey tuning series in the assessment.

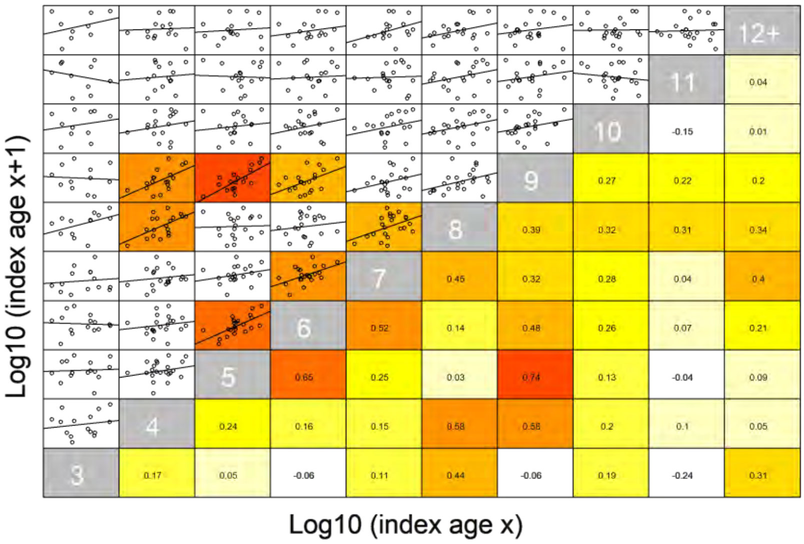


Figure 3.2.14. Ling in 5.b. Consistency plot of catch-at-age in the spring survey tuning series in the assessment.

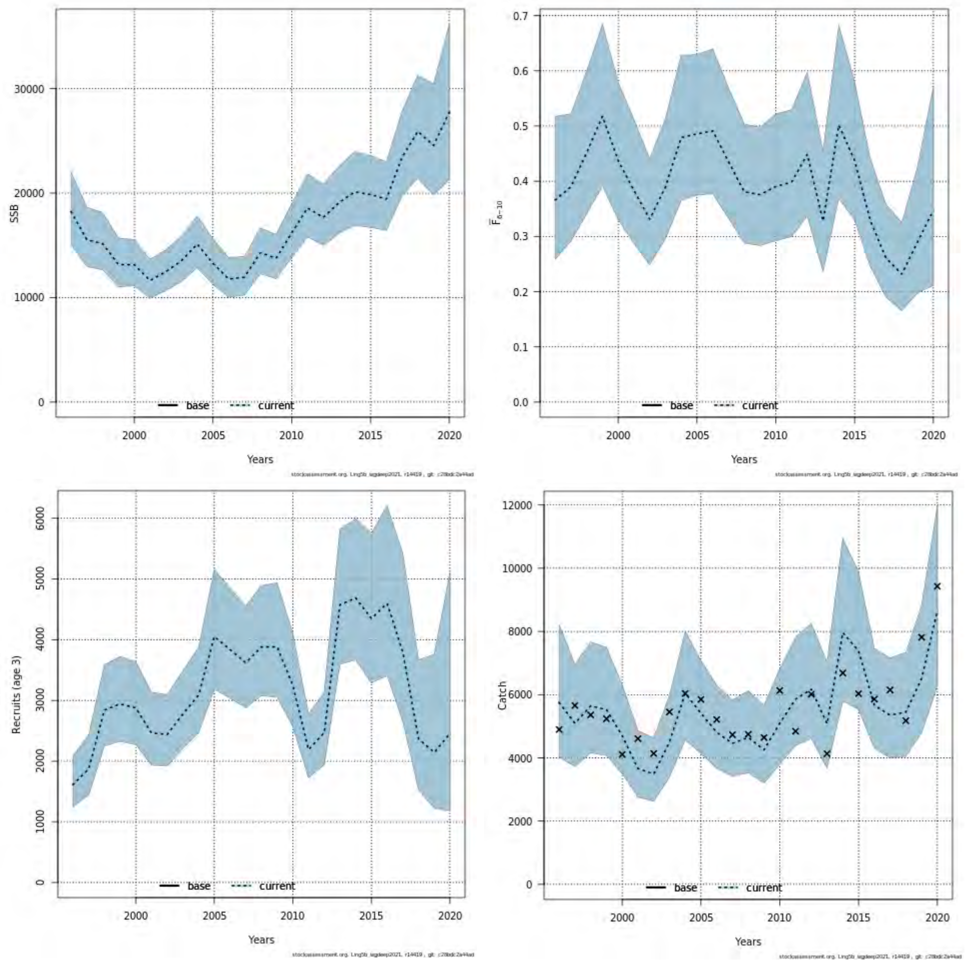


Figure 3.2.15. Ling in 5.b. Output from SAM. Results per year for spawning stock biomass (tonnes, upper left), fishing mortality ($F_{6\text{-}10}$, upper right), recruitment (age 3, thousands, lower left) and catch (tonnes, lower right). Stippled line is median, shaded area is 95% CI and x- is actual catch.

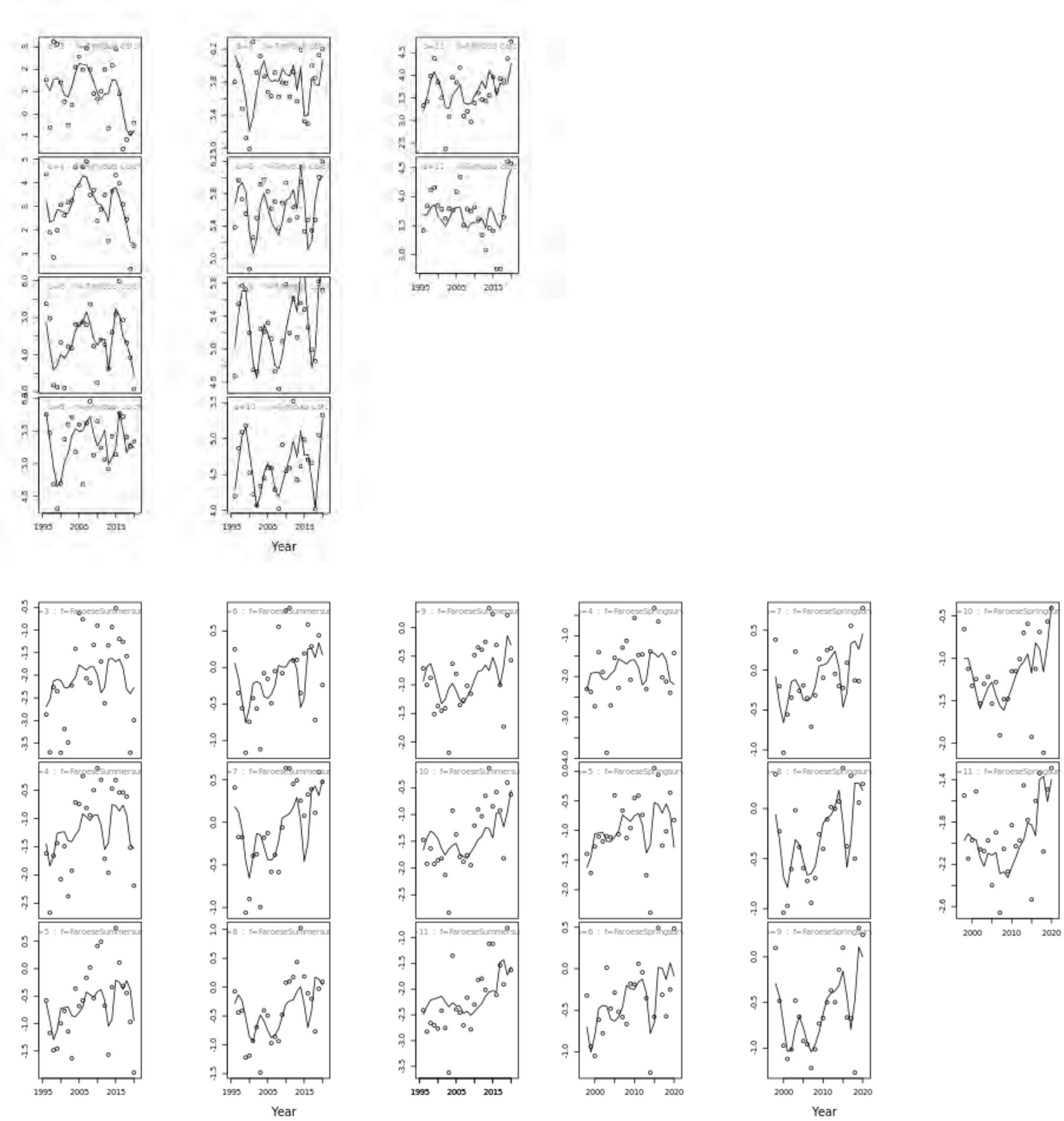


Figure 3.2.16. Ling in 5.b. Output from SAM. Model fit of data; catch (upper left), summer survey (lower left) and spring survey (lower right).

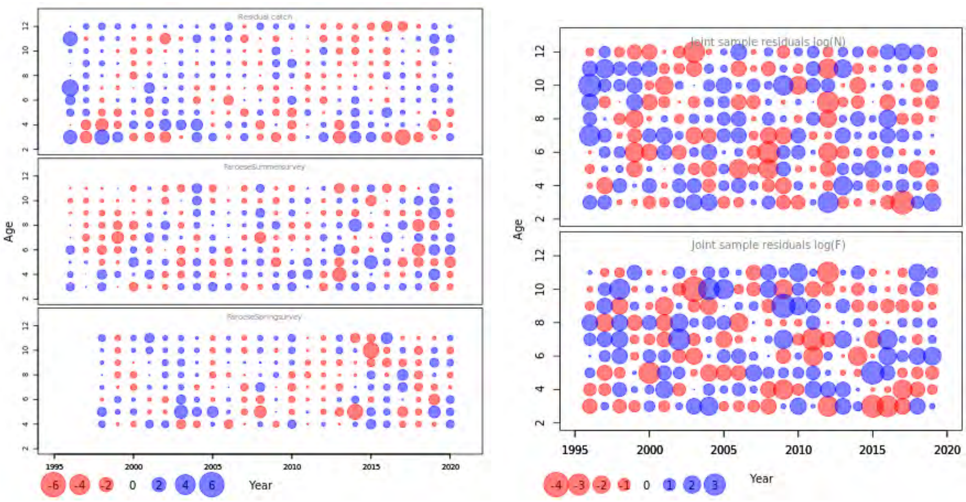


Figure 3.2.17. Ling in 5.b. Output from SAM. Estimated correlations and residuals.

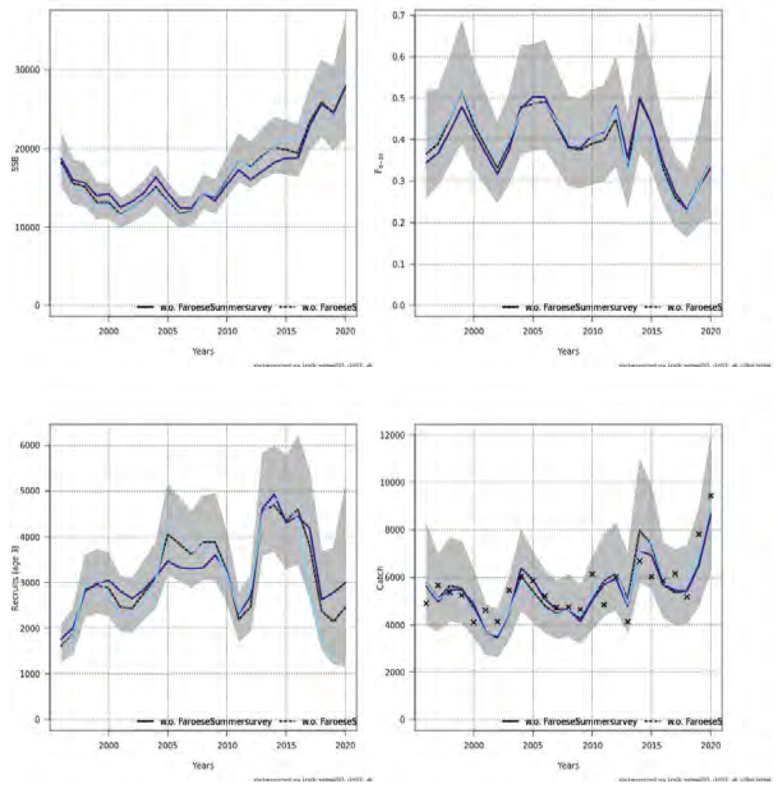


Figure 3.2.18. Ling in 5.b. Output from SAM. Leave-one-out analysis of SSB (upper left), fishing mortality (upper right), recruitment (lower left) and catch (lower right).

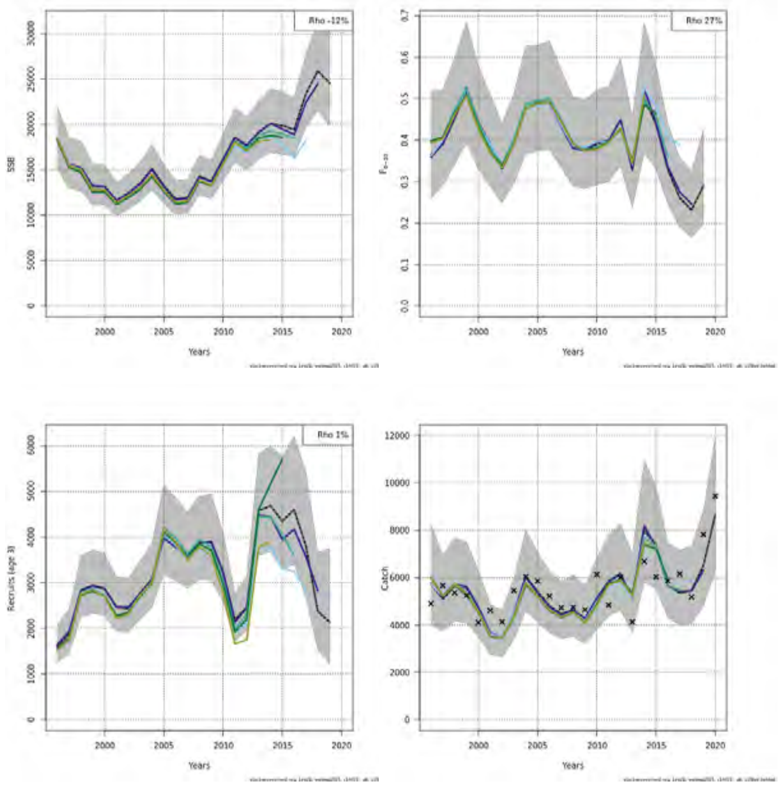


Figure 3.2.19. Ling in 5.b. Output from SAM. Retrospective analysis of SSB (upper left), fishing mortality (upper right), recruitment (lower left) and catch (lower right).

3.2.6.3 Quality of the assessment

Ling 5.b was benchmarked in 2021 (ICES, 2021), where the assessment was transformed from a trend-based assessment derived from the Faroese summer survey to a SAM state-space assessment using catch at age information and the Faroese spring- and summer surveys as tuning series. An exploratory assessment for ling in 5.b has been done for several years (with only summer survey as tuning series), and a comparison between the assessments of WGDEEP 2021 and the exploratory assessment WGDEEP 2020 indicates that the model results are comparable, although recruitment and F are estimated a bit higher at WGDEEP 2020 than in the 2021 assessment and SSB and TSB lower. Though, these values are still well inside the 95% CI.

3.2.7 Short term prediction

At the benchmark 2021 suggested settings for the short term prediction was approved (ICES, 2021), was performed in the final assessment **Ling5b_wgdeep2021** (stockassessment.org). The description of the model settings is found in the stock annex.

3.2.7.1 Input data

The assumptions made for the interim year and in the forecast are presented in the table below.

Variable	Value	Notes
$F_{ages\ 6–10}$ (2021)	0.357	$F_{sq} = F_{2020}$
SSB (2022)	25 070	Short-term forecast fishing at F_{sq}; Tonnes.
$R_{age\ 3}$ (2021/2022)	2 942	Median recruitment, resampled from the years 1996–2019; Thousands.
Total catch (2021)	8 744	Short-term forecast using F_{sq}; Tonnes.

3.2.7.2 Results

Results of short term forecast using F=F_{MSY} including confidence intervals (low and high columns) is presented in the Table below. According to the short term forecast with the F_{MSY} advised (F_{MSY} = 0.23), catches are projected to 5 636 tonnes in 2022, resulting in an SSB in 2022 of 25 070 tonnes, when assuming a recruitment of 2 942 thousands in 2021 and 2022. Under these conditions, SSB will be at the same level in 2023 as in 2022, at 25 018 tonnes.

Catch options for scenarios with F_{MSY}, F_{pa}, F_{lim}, F_{sq} and F = 0 is presented in Table 3.2.15.

Year	**$F_{6\text{-}10}$**			**Recruitment (thousands)**			**SSB (tonnes)**			**Catch (tonnes)**			**TSB (tonnes)**		
	Median	Low	High	Median	Low	High	Median	Low	High	Median	Low	High	Median	Low	High
2021	0.357	0.222	0.572	2497	1182	5323	27949	21684	36598	8754	6347	11883	38581	29763	50605
2021	0.357	0.222	0.572	2942	1611	4687	27756	19317	38145	8744	6965	11072	37830	27217	51272
2022	**0.23**	0.143	0.368	**2942**	1611	4687	**25070**	15592	37169	**5636**	4388	7439	35165	24098	49968
2023	**0.23**	0.143	0.368	**2942**	1611	4687	**25018**	14821	39170	5660	4071	7686	35807	24113	51326

3.2.8 Reference points

The reference points for ling in 5.b are shown in the Table below. Description of the reference points calculation is given in the stock annex and in ICES, 2021.

$MSY_{Btrigger}$	**$5thPerc\_SSB_{msy}$**	**B_{pa}**	**B_{lim}**	**F_{pa}**	**F_{lim}**	**F_{p05}**	**$F_{msy\_unconstr}$**	**F_{MSY}**
11627	21707	11627	9340	0.62	0.85	0.6	0.23	0.23

3.2.9 Comments on assessment

All signals from the commercial catches and also surveys indicate that ling stock in Division 5.b at present is in good condition, and this is also confirmed in the assessment.

3.2.10 Management consideration

Stability in landings and abundance indices do suggest that ling stock in Division 5.b has been stable since middle of the 1980s, with an increasing trend in biomass in the last decade. The available data series does not cover the entire period of the fishery (back to the early 1900s; see Figure 3.2.3) and no information is available on stock levels prior to 1986. There is evidence of increased recruitments in last decade compared to earlier (Figure 3.2.15).

The only species-specific management in effect for Faroese fisheries of ling in Division 5.b is the recommended minimum landing size (60 cm). But this seems not to be enforced because of the general discard ban. Up to 25% of ling catches (per settings/hauls) can be juveniles e.g. smaller than 75 cm.

The exploitation of ling is influenced by regulations aimed at other groundfish species, e.g. cod, haddock, and saithe; such as closed areas. Fisheries by other nations are regulated by TACs.

The Faroese effort management system introduced in 1996 is in force for the demersal fleets operating on the Faroe Plateau. A preliminary management plan using a harvest control rule was adopted by the Faroese fisheries authorities in 2020, and applied for the first time for the calendar year 2021. The number of fishing days was decided according to the stock status of cod, haddock and saithe. Although the management plan opens up for the development of special bycatch rules, this has not yet been integrated. The management plan has not been evaluated by ICES, but will likely be sent to review in 2021.

3.2.11 Ecosystem considerations

Since on average 67% of the catches are taken by longlines, the remaining by trawls, the effects of the ling fishery on the bottom fauna and benthic ecosystem is moderate (Table 3.2.4).

3.2.12 Future research and data requirements

The aim is to collect a sufficient number of individual age and maturity samples to cover both the Faroese spring- and summer surveys, especially from the smallest and largest individuals.

3.2.13 References

ICES. 2017. ICES fisheries management reference points for category 1 and 2 stocks. ICES Advice Technical Guidelines. DOI:10.17895/ices.pub.3036

ICES. 2021. Benchmark Workshop for Barents Sea and Faroese Stocks (WKBARFAR 2021). ICES Scientific Reports. 3:21. 205 pp. https://doi.org/10.17895/ices.pub.7920

Pedersen, M. W., and Berg, C. W. 2017. A stochastic surplus production model in continuous time. Fish and Fisheries, 18: 226–243. doi: 10.1111/faf.12174.

Nielsen A. and Berg C.W. Estimation of time-varying selectivity in stock assessments using state-space models. https://www.stockassessment.org/docs/selpap-postprint.pdf 2014.

3.2.14 Tables

Table 3.2.1. Ling in 5.b1. Nominal landings (1988–present).

Year	Denmark(2)	Faroes	France	Germany	Norway	E&W(1)	Scotland (1)	Russia	Total
1988	42	1383	53	4	884	1	5		2372
1989		1498	44	2	1415		3		2962
1990		1575	36	1	1441		9		3062
1991		1828	37	2	1594		4		3465
1992		1218	3		1153	15	11		2400
1993		1242	5	1	921	62	11		2242
1994		1541	6	13	1047	30	20		2657
1995		2789	4	13	446	2	32		3286
1996		2672			1284	12	28		3996
1997		3224	7		1428	34	40		4733
1998		2422	6		1452	4	145		4029
1999		2446	17	3	2034	0	71		4571
2000		2103	7	1	1305	2	61		3479
2001		2069	14	3	1496	5	99		3686
2002		1638	6	2	1640	3	239		3528
2003		2139	12	2	1526	3	215		3897
2004		2733	15	1	1799	3	178	2	4731
2005		2886	3		1553	3	175		4620
2006	3	3563	6		850		136		4558
2007	2	3004	9		1071		6		4092
2008		3354	4		740	32	25	11	4166
2009	13	3471	2		419		270		4174
2010	28	4906	2		442		121		5500
2011	49	4270	2		0		0		4321
2012	117	5452	7		0		0		5576
2013	3	3734	7		0		0		3744
2014		5653	10		308		0	13	5983

Year	Denmark[(2)]	Faroes	France	Germany	Norway	E&W[(1)]	Scotland [(1)]	Russia	Total
2015		4375	16		993	1	0	6	5391
2016		4214	8		855	0	103		5180
2017		4371	4		864		54		5294
2018		3836	2		793		42		4673
2019		4862	25		1983		27		6895
2020*		5642	16		2537		83		8277

***Preliminary.**

(1) Includes 5.b2.

(2) Greenland 2006–2013.

Table 3.2.2. Ling in 5.b2. Nominal landings (1988–present).

Year	Faroes	France	Norway	Scotland	Total
1988	832		1284		2116
1989	362		1328		1690
1990	162		633		795
1991	492		555		1047
1992	577		637		1214
1993	282		332		614
1994	479		486		965
1995	281		503		784
1996	102		798		900
1997	526		398		924
1998	511		819		1330
1999	164	4	498		666
2000	229	1	399		629
2001	420	6	497		923
2002	150	4	457		611
2003	624	4	927		1555
2004	1058	3	247		1308
2005	575	7	647		1229
2006	472	6	177		655

2007	327	4	309		640
2008	458	3	120		580
2009	270	1	198		469
2010	393	1	236		630
2011	522	0	0		522
2012	434	1	0		435
2013	387	1	0		388
2014	276		389	7	672
2015	244	1	337	3	585
2016	569	4	126	11	710
2017	359		542		901
2018	428		78	6	512
2019	338		580	2	920
2020*	1015		128	6	1149

***Preliminary.**

Table 3.2.3. Ling in 5.b. Nominal landings (1988–present).

Year	5.b1	5.b2	5.b
1988	2372	2116	4488
1989	2962	1690	4652
1990	3062	795	3857
1991	3465	1047	4512
1992	2400	1214	3614
1993	2242	614	2856
1994	2657	965	3622
1995	3286	784	4070
1996	3996	900	4896
1997	4733	924	5657
1998	4029	1330	5359
1999	4571	666	5238
2000	3479	629	4109
2001	3686	923	4609

Year	5.b1	5.b2	5.b
2002	3528	611	4139
2003	3897	1555	5453
2004	4731	1308	6039
2005	4620	1229	5849
2006	4558	655	5213
2007	4092	640	4731
2008	4166	580	4747
2009	4174	469	4643
2010	5500	630	6129
2011	4321	522	4843
2012	5576	435	6011
2013	3744	388	4132
2014	5983	672	6655
2015	5391	585	5976
2016	5180	710	5890
2017	5294	901	6195
2018	4673	512	5185
2019	6895	920	7816
2020*	8277	1149	9427

***Preliminary.**

Table 3.2.4. Ling in 5.b. Catch distribution by fleet and total catch in 1996 to 2020. * preliminary catch.

Year	Trawl (%)	Longline (%)	Other (%)	Total catch (tonnes)
1996	31	68	1	4896
1997	37	62	1	5657
1998	39	61	0	5359
1999	37	62	1	5238
2000	42	57	1	4109
2001	37	61	1	4609
2002	41	57	1	4139

Year	Trawl (%)	Longline (%)	Other (%)	Total catch (tonnes)
2003	33	65	2	5453
2004	25	73	1	6039
2005	27	72	1	5849
2006	24	75	1	5213
2007	33	66	1	4731
2008	24	75	1	4747
2009	27	72	1	4643
2010	23	76	1	6129
2011	29	71	1	4843
2012	30	70	0	6011
2013	29	70	0	4132
2014	28	72	0	6684
2015	42	58	0	6031
2016	37	62	1	5857
2017	31	69	0	6148
2018	34	66	0	5185
2019	39	61	0	7816
2020	31	69	0	9427*
Average	32	67	1	5558

Table 3.2.5. Ling in 5.b. Overview of the sampling from commercial landings since 1996.

	Lengths			Gutted weights			Ages		
Year	Long-liners	Trawl-ers	Other	Long-liners	Trawl-ers	Other	Long-liners	Trawl-ers	Other
1996	5003	1426	48	290	120	0	709	375	0
1997	6493	1407	0	361	180	0	1195	331	0
1998	4163	1651	193	180	358	0	723	358	0
1999	3024	1067	445	180	120	60	240	180	60
2000	1719	1793	0	120	240	0	120	240	0
2001	2243	1562	0	180	240	0	180	240	0

2002	1845	2454	0	60	120	0	120	180	0
2003	4533	2052	0	120	240	0	421	240	0
2004	4350	2477	0	990	179	0	480	179	0
2005	4995	2172	0	3097	120	0	420	120	0
2006	4936	1291	0	3576	1082	0	157	119	0
2007	2077	1662	172	1034	447	172	60	60	0
2008	1432	1087	0	1215	730	0	60	0	0
2009	2127	2246	0	2102	2246	0	112	120	0
2010	1421	2502	422	1421	2436	422	60	120	0
2011	1438	1765	202	1438	1188	202	0	0	0
2012	1413	1397	0	1283	1164	0	50	0	0
2013	1040	1437	0	1040	1036	0	0	0	0
2014	827	1953	205	827	1242	205	0	20	0
2015	820	1724	0	820	1351	0	40	170	0
2016	1432	1329	0	1432	928	0	180	180	0
2017	1201	1776	0	1201	1225	0	239	241	0
2018	2717	4726	0	2717	4726	0	659	1013	0
2019	2890	3576	0	2890	3576	0	300	592	0
2020	1276	2698	0	705	1911	0	360	569	60

Table 3.2.6. Ling in 5.b. Overview of the sampling from spring-, summer and other surveys since 1996. * Have gender but not maturity.

	Lengths			**Round weights**			**Ages**			**Gender and maturity**		
Year	Spring	Summer	Other	Spring	Summer	Other	Spring	Summer	Other	Spring	Summer	Other
1996	398	1013	235	129	216	26	0	0	11	0	0	15
1997	460	631	274	0	247	79	0	0	0	0	0	0
1998	514	648	280	190	462	173	0	0	0	230*	20	5
1999	300	372	84	252	355	62	0	0	0	248*	3	7

	Lengths			Round weights			Ages			Gender and maturity		
2000	245	433	498	244	360	313	0	0	0	14	1	0
2001	347	553	600	265	503	472	0	0	0	28	0	2
2002	285	510	542	222	477	389	0	0	0	0	0	0
2003	389	284	660	345	284	582	0	0	0	0	0	0
2004	284	857	418	284	802	345	0	0	0	0	0	0
2005	321	821	172	264	719	161	0	0	0	0	0	0
2006	271	647	220	264	612	214	0	0	0	0	1	0
2007	268	729	99	247	662	99	0	0	0	0	0	0
2008	309	973	66	208	779	65	0	0	0	0	10	0
2009	413	859	152	371	608	152	0	0	0	0	0	0
2010	395	1637	125	281	1021	125	0	0	0	0	0	0
2011	507	1826	167	411	1400	165	0	0	0	3	0	0
2012	518	1160	145	518	1109	144	0	0	0	0	0	0
2013	427	1232	120	427	1105	120	100	78	96	100	78	114
2014	336	1725	674	330	1280	658	161	195	200	177	195	206
2015	562	1440	1077	496	1043	962	92	92	234	100	91	235
2016	409	1366	550	409	1265	550	131	191	110	131	193	110
2017	372	1004	306	308	914	247	124	201	112	126	203	115
2018	265	712	682	265	687	682	228	221	343	227	222	345
2019	490	1318	465	435	1089	465	144	147	155	144	147	162

	Lengths			Round weights			Ages			Gender and maturity		
2020	665	900	249	594	884	249	181	140	99	186	140	99

Table 3.2.7. Ling in 5.b. Catch numbers at age (*1000) used in the assessment.

Year/Age	3	4	5	6	7	8	9	10	11	12+
1996	4.61	78.35	217.21	315.07	331.78	218.24	107.42	66.60	28.09	30.47
1997	0.55	6.75	146.07	238.84	402.52	390.43	257.69	129.96	30.65	46.49
1998	25.65	2.33	24.05	108.31	240.07	309.48	320.41	162.44	53.70	61.29
1999	22.75	7.35	22.63	74.23	167.75	257.56	306.70	178.02	79.40	63.87
2000	4.08	21.44	75.97	109.44	146.73	130.44	181.12	92.52	46.92	47.02
2001	1.72	13.75	22.35	215.75	540.89	193.18	116.06	68.42	33.26	44.27
2002	0.61	23.90	68.27	271.06	371.53	244.48	113.10	58.66	10.70	37.57
2003	1.52	25.89	64.96	302.49	453.02	371.62	189.99	76.46	21.85	44.53
2004	8.17	105.61	123.96	177.67	354.74	394.72	183.83	85.85	52.06	43.07
2005	13.02	48.96	121.94	271.20	293.16	340.27	204.43	98.64	46.65	59.31
2006	7.26	106.18	132.44	107.98	279.51	275.68	168.54	98.24	64.85	76.51
2007	18.96	134.46	122.59	276.73	372.36	299.89	113.57	72.91	22.21	33.42
2008	7.34	32.64	214.41	386.01	276.34	215.38	91.76	55.91	24.63	43.71
2009	2.49	40.18	69.00	168.71	328.79	295.46	164.51	136.75	19.61	42.54
2010	1.96	10.95	25.69	285.53	325.54	378.05	326.26	94.46	29.59	45.48
2011	2.76	17.90	82.28	189.47	276.87	238.35	180.57	98.56	36.85	37.23
2012	7.33	32.67	71.90	158.38	374.58	280.16	274.01	249.81	31.86	28.24
2013	0.53	4.75	37.42	137.06	261.82	246.96	171.52	83.66	31.18	21.83
2014	8.82	37.92	101.19	225.79	486.84	382.35	259.59	101.01	35.07	31.81
2015	18.28	75.68	161.86	170.67	205.68	207.57	240.45	146.60	52.78	30.18
2016	2.46	53.49	395.66	320.91	199.76	238.59	193.40	110.50	39.20	15.73
2017	0.21	22.12	139.53	305.36	403.18	210.10	147.90	105.84	50.66	15.70
2018	0.32	11.62	75.56	222.94	347.56	239.32	128.53	55.74	48.96	38.21
2019	0.43	1.43	50.59	193.19	458.31	405.07	337.82	155.72	79.56	100.16
2020	0.63	3.51	20.19	193.48	460.41	458.05	282.34	191.36	107.11	89.74

Table 3.2.8. Ling in 5.b. Weighted mean weights at age used in the assessment.

Year/Age	3	4	5	6	7	8	9	10	11	12+
1996	0.437	1.033	1.815	2.549	3.356	3.949	5.054	7.143	8.600	12.509
1997	0.689	0.772	1.271	1.932	2.602	3.487	4.427	5.643	7.740	10.415
1998	1.038	1.345	1.469	2.112	2.728	3.500	4.486	5.599	6.786	10.064
1999	0.987	1.299	1.377	2.092	2.739	3.552	4.462	5.843	7.122	10.506
2000	1.037	1.402	2.005	2.517	2.855	4.374	5.775	7.157	8.622	11.587
2001	0.549	0.858	1.154	2.093	2.651	3.983	5.555	7.207	8.136	11.429
2002	0.660	1.081	1.351	2.146	2.888	3.728	4.665	6.798	7.239	11.995
2003	0.701	0.818	1.181	2.225	2.890	3.732	4.463	6.123	7.585	11.290
2004	0.654	1.292	1.674	2.251	3.093	4.042	5.271	6.923	9.080	13.031
2005	0.528	0.964	1.300	2.006	2.890	3.950	5.241	7.034	8.270	12.661
2006	0.495	0.876	1.378	1.867	2.719	3.710	5.145	6.323	7.987	12.332
2007	0.788	1.010	1.216	2.092	2.841	3.651	5.138	6.915	9.019	12.339
2008	0.872	0.942	1.534	2.317	3.295	4.070	5.944	6.713	9.197	12.625
2009	0.796	1.006	1.462	1.965	2.830	3.556	4.514	6.124	7.682	10.750
2010	0.897	1.049	1.248	2.072	3.133	3.730	5.066	6.311	9.372	11.798
2011	0.901	1.173	1.705	2.358	3.165	4.159	5.277	6.564	8.211	12.429
2012	0.770	0.929	1.342	2.043	2.845	3.804	4.716	6.169	8.646	11.149
2013	1.036	1.352	1.912	2.519	3.238	4.048	5.013	6.282	7.947	10.466
2014	0.765	0.963	1.540	2.400	3.424	4.225	5.275	6.356	8.056	11.528
2015	0.775	0.864	1.438	2.565	3.940	4.812	6.233	7.580	8.947	12.918
2016	0.500	0.805	1.364	2.585	3.610	4.575	6.269	7.711	9.064	13.436
2017	0.672	1.085	1.867	2.846	3.763	4.952	6.445	7.821	9.049	12.586
2018	0.735	1.231	1.878	2.516	3.578	4.632	5.886	7.411	9.537	12.299
2019	0.702	0.707	1.294	2.030	2.703	3.738	5.176	6.298	8.056	12.321
2020	0.930	0.995	1.205	2.062	3.013	4.206	5.585	7.200	8.462	12.949

Table 3.2.9. Ling in 5.b. Spring survey input to the tuning series in the assessment.

Year	Effort/Age	4	5	6	7	8	9	10	11
1998	99	9.89	24.55	71.72	145.22	139.42	109.23	51.43	21.05
1999	100	9.32	17.96	39.25	81.76	79.70	61.73	32.54	11.70
2000	100	6.56	28.07	35.01	35.48	35.38	37.82	26.64	13.93
2001	100	24.58	33.24	54.15	57.28	37.88	32.66	28.81	22.10
2002	100	15.14	30.60	45.98	70.90	54.61	36.26	21.67	12.77
2003	100	2.10	33.42	101.31	126.24	98.29	61.98	27.26	12.56
2004	100	6.69	32.83	61.94	77.23	68.05	51.93	29.60	13.89
2005	100	21.42	66.62	75.03	82.55	55.15	39.79	21.59	9.09
2006	100	10.26	34.55	59.54	70.37	48.54	38.40	27.83	14.98
2007	100	27.50	51.54	55.93	49.14	39.00	29.58	14.88	7.01
2008	99	32.19	32.12	50.88	72.16	49.44	35.93	22.52	12.70
2009	100	12.53	38.37	83.48	115.08	77.42	48.14	22.83	10.35
2010	100	56.82	63.62	82.75	90.90	66.86	51.17	31.64	16.06
2011	102	23.41	67.54	108.40	131.17	91.45	62.01	32.31	13.43
2012	100	23.31	47.92	95.85	131.63	101.62	69.24	36.49	13.89
2013	100	9.97	17.30	70.18	95.52	99.77	60.88	49.70	23.41
2014	99	24.90	9.11	28.35	81.17	106.26	86.14	54.74	16.70
2015	96	69.48	101.31	53.80	76.77	143.87	106.13	14.00	7.62
2016	100	52.22	94.11	163.49	109.75	68.63	51.51	32.53	20.20
2017	90	11.96	25.69	65.83	157.08	124.76	45.87	45.23	23.65
2018	99	11.88	35.88	55.86	87.03	60.08	27.86	11.99	12.39
2019	100	9.12	69.58	77.89	87.17	106.18	137.35	56.81	22.55
2020	91	21.93	39.91	147.74	198.27	116.33	115.87	60.55	25.11

Table 3.2.10. Ling in 5.b. Summer survey input to tuning series in the assessment.

Year	Effort/Age	3	4	5	6	7	8	9	10	11
1996	200	11.38	39.70	111.95	256.77	300.86	185.77	98.00	45.83	17.95
1997	200	4.94	13.89	61.94	140.89	168.21	128.83	73.46	29.36	11.85
1998	201	20.92	38.21	45.48	114.95	168.79	133.77	83.41	39.23	14.09
1999	199	18.93	47.30	46.45	61.87	68.93	58.80	43.86	29.08	13.34
2000	200	4.89	25.12	73.80	95.02	81.32	61.06	50.79	31.30	12.60
2001	200	8.27	45.07	92.59	131.29	135.02	78.89	46.75	32.41	17.82
2002	199	6.10	18.48	63.43	113.29	136.87	99.41	48.59	23.73	12.67
2003	200	21.61	29.24	39.10	65.24	73.98	45.50	22.43	11.78	5.36
2004	200	48.54	97.79	139.48	184.82	167.07	133.66	106.36	79.13	51.71
2005	200	106.85	95.08	101.27	171.28	176.16	122.33	89.16	50.75	18.26
2006	200	93.25	155.98	111.89	122.50	111.92	75.77	51.65	33.39	17.12
2007	199	25.15	88.26	168.60	189.28	135.89	84.28	56.02	30.35	13.32
2008	200	22.87	78.03	204.72	349.54	111.51	78.49	72.37	34.51	22.90
2009	200	52.94	121.59	117.20	184.95	188.36	124.15	63.02	28.61	12.40
2010	200	81.20	179.96	302.53	436.20	378.24	216.37	123.76	59.79	20.05
2011	200	36.65	146.14	327.38	451.03	376.30	221.33	141.50	81.09	32.33
2012	202	14.74	36.49	102.95	221.93	316.95	240.56	137.37	71.99	33.48
2013	202	52.95	28.43	42.21	224.36	330.64	312.16	157.45	105.37	26.94
2014	200	78.55	125.02	142.89	140.83	258.05	557.88	281.63	175.20	65.24
2015	200	119.36	145.39	420.17	242.21	215.94	240.78	253.17	85.59	65.09
2016	199	60.14	116.01	222.53	358.31	275.61	178.93	147.10	111.26	24.05
2017	203	57.55	118.45	148.43	271.06	299.32	165.99	74.49	80.68	43.59
2018	202	41.65	109.80	129.74	98.40	226.02	93.65	35.76	32.80	29.95
2019	200	4.90	43.91	75.89	310.24	360.70	194.83	249.01	133.51	88.56
2020	199	9.98	22.31	29.98	156.65	320.24	218.20	112.55	106.64	39.00

Table 3.2.11. Ling in 5.b. Estimated recruitment, spawning stock biomass (SSB), and average fishing mortality.

Year	$R_{(age\ 3)}$	Low	High	SSB	Low	High	$Fbar_{(6-10)}$	Low	High	TSB	Low	High
1996	1609	1244	2081	18210	15068	22006	0.366	0.259	0.517	29077	24628	34330
1997	1870	1438	2431	15533	12952	18629	0.391	0.292	0.522	22734	19410	26627
1998	2837	2246	3584	15148	12668	18113	0.452	0.341	0.599	24196	20888	28029
1999	2939	2323	3719	13144	11013	15687	0.517	0.391	0.684	22580	19577	26045
2000	2872	2272	3631	13141	11124	15524	0.437	0.331	0.579	25131	21891	28850
2001	2459	1931	3131	11627	9913	13638	0.384	0.288	0.512	19554	17026	22457
2002	2436	1919	3091	12451	10649	14557	0.332	0.249	0.442	21536	18756	24727
2003	2772	2206	3483	13519	11519	15865	0.390	0.297	0.513	21971	19101	25271
2004	3086	2462	3868	15101	12828	17776	0.479	0.365	0.628	25448	22164	29220
2005	4049	3182	5151	13244	11247	15595	0.486	0.375	0.629	22337	19485	25607
2006	3833	3033	4846	11762	10021	13806	0.491	0.377	0.639	21336	18638	24426
2007	3616	2875	4547	11941	10229	13939	0.435	0.333	0.569	23562	20604	26945
2008	3874	3072	4885	14288	12263	16647	0.381	0.288	0.504	27599	24102	31604
2009	3873	3045	4924	13745	11785	16030	0.376	0.284	0.498	26473	23096	30343
2010	3239	2562	4095	16170	13807	18938	0.391	0.293	0.522	28970	25198	33306
2011	2183	1721	2769	18554	15780	21815	0.398	0.300	0.529	32022	27751	36952
2012	2462	1937	3128	17640	14963	20797	0.448	0.337	0.596	27754	23990	32110
2013	4557	3581	5799	19061	16126	22530	0.329	0.238	0.456	33037	28577	38195
2014	4664	3648	5962	20065	16849	23895	0.501	0.369	0.681	32716	28222	37926
2015	4324	3266	5724	19820	16680	23551	0.438	0.331	0.581	33727	29059	39144
2016	4567	3382	6167	19364	16363	22916	0.330	0.246	0.441	33003	28257	38548
2017	3770	2637	5392	23319	19623	27711	0.262	0.191	0.360	40377	34048	47882
2018	2353	1519	3647	25740	21307	31095	0.234	0.167	0.328	41814	34476	50714
2019	2124	1209	3732	24360	19632	30227	0.290	0.197	0.428	34812	27949	43361
2020	2424	1165	5045	27531	21094	35933	0.329	0.201	0.540	37741	28751	49543

Table 3.2.12. Ling in 5.b. Estimated fishing mortality at age.

Year /Age	3	4	5	6	7	8	9	10	11	12
1996	0.003	0.014	0.060	0.158	0.304	0.367	0.453	0.546	0.441	0.441
1997	0.002	0.008	0.041	0.127	0.289	0.391	0.517	0.629	0.511	0.511
1998	0.002	0.007	0.033	0.116	0.302	0.449	0.627	0.766	0.629	0.629
1999	0.002	0.008	0.032	0.117	0.334	0.529	0.736	0.871	0.715	0.715
2000	0.001	0.007	0.029	0.104	0.284	0.454	0.636	0.708	0.584	0.584
2001	0.001	0.007	0.026	0.100	0.266	0.389	0.543	0.620	0.490	0.490
2002	0.001	0.008	0.030	0.111	0.273	0.359	0.434	0.483	0.379	0.379
2003	0.001	0.012	0.042	0.147	0.347	0.445	0.499	0.513	0.412	0.412
2004	0.002	0.020	0.064	0.193	0.437	0.545	0.594	0.625	0.495	0.495
2005	0.003	0.022	0.067	0.192	0.421	0.536	0.604	0.674	0.570	0.570
2006	0.003	0.023	0.066	0.183	0.403	0.518	0.610	0.742	0.637	0.637
2007	0.003	0.023	0.067	0.186	0.391	0.462	0.523	0.614	0.516	0.516
2008	0.002	0.016	0.051	0.153	0.331	0.388	0.457	0.576	0.479	0.479
2009	0.001	0.010	0.035	0.121	0.297	0.374	0.475	0.614	0.518	0.518
2010	0.001	0.007	0.027	0.102	0.272	0.392	0.533	0.656	0.573	0.573
2011	0.001	0.008	0.031	0.103	0.260	0.381	0.565	0.683	0.594	0.594
2012	0.001	0.010	0.037	0.115	0.276	0.412	0.657	0.782	0.651	0.651
2013	0.001	0.006	0.026	0.080	0.186	0.292	0.515	0.573	0.508	0.508
2014	0.001	0.011	0.052	0.147	0.306	0.440	0.831	0.782	0.655	0.655
2015	0.001	0.012	0.059	0.149	0.278	0.399	0.684	0.680	0.569	0.569
2016	0.001	0.009	0.051	0.133	0.232	0.326	0.493	0.464	0.406	0.406
2017	0.000	0.005	0.033	0.101	0.198	0.277	0.390	0.345	0.313	0.313
2018	0.000	0.003	0.023	0.082	0.177	0.260	0.350	0.299	0.290	0.290
2019	0.000	0.002	0.019	0.077	0.192	0.331	0.455	0.397	0.395	0.395
2020	0.000	0.002	0.020	0.080	0.204	0.364	0.531	0.467	0.475	0.475

Table 3.2.13. Ling in 5.b. Estimated stock numbers at age.

Year /Age	3	4	5	6	7	8	9	10	11	12
1996	1609	2033	2368	2375	1868	1005	445	183	74	119
1997	1870	1367	1717	1903	1738	1188	602	244	91	107
1998	2837	1621	1185	1372	1422	1119	692	308	113	103
1999	2939	2436	1415	1015	1013	886	615	317	123	100
2000	2872	2486	2091	1238	794	601	443	256	114	94
2001	2459	2500	2118	1716	1002	531	322	198	110	100
2002	2436	2126	2146	1781	1329	675	319	159	90	111
2003	2772	2111	1848	1778	1387	868	407	182	84	119
2004	3086	2388	1849	1541	1291	846	477	212	97	116
2005	4049	2627	2002	1503	1099	715	424	228	97	112
2006	3833	3488	2206	1575	1073	620	362	198	101	103
2007	3616	3292	2902	1781	1119	622	319	171	80	93
2008	3874	3075	2729	2293	1269	657	341	160	81	89
2009	3873	3359	2576	2187	1627	808	392	185	77	91
2010	3239	3384	2835	2155	1636	1008	485	212	86	86
2011	2183	2824	2946	2354	1668	1059	578	247	95	84
2012	2462	1834	2438	2447	1809	1099	626	282	107	84
2013	4557	2043	1506	2053	1904	1160	620	282	110	85
2014	4664	4049	1736	1278	1593	1418	712	326	134	100
2015	4324	3978	3564	1457	962	1011	804	254	129	103
2016	4567	3598	3420	2824	1146	638	582	344	111	111
2017	3770	3982	2948	2764	2089	819	393	311	185	127
2018	2353	3343	3438	2400	2146	1451	532	234	189	196
2019	2124	1991	2903	2933	1944	1470	981	329	153	249
2020	2424	1838	1647	2503	2375	1386	902	533	193	233

Table 3.2.14. Ling 5.b. Output from SAM. Model parameters.

Parameter name	par	Sd(par)	Exp(par)	Low	High
logFpar_0	-9.964	0.187	0	0	0
logFpar_1	-8.944	0.127	0	0	0
logFpar_2	-8.236	0.113	0	0	0
logFpar_3	-7.483	0.113	0.001	0	0.001
logFpar_4	-7.009	0.113	0.001	0.001	0.001
logFpar_5	-6.806	0.116	0.001	0.001	0.001
logFpar_6	-6.585	0.12	0.001	0.001	0.002
logFpar_7	-6.353	0.127	0.002	0.001	0.002
logFpar_8	-9.68	0.168	0	0	0
logFpar_9	-8.657	0.089	0	0	0
logFpar_10	-7.862	0.087	0	0	0
logFpar_11	-7.231	0.087	0.001	0.001	0.001
logFpar_12	-6.929	0.088	0.001	0.001	0.001
logFpar_13	-6.638	0.091	0.001	0.001	0.002
logFpar_14	-6.505	0.098	0.001	0.001	0.002
logSdLogFsta_0	-1.047	0.201	0.351	0.235	0.525
logSdLogN_0	-1.352	0.191	0.259	0.177	0.379
logSdLogN_1	-2.876	0.479	0.056	0.022	0.147
logSdLogObs_0	-0.68	0.073	0.507	0.438	0.587
logSdLogObs_1	-0.139	0.138	0.87	0.66	1.146
logSdLogObs_2	-0.579	0.137	0.561	0.426	0.737
logSdLogObs_3	-0.7	0.111	0.496	0.398	0.62
logSdLogObs_4	-0.291	0.143	0.748	0.562	0.994
logSdLogObs_5	-1.102	0.085	0.332	0.28	0.394
transfIRARdist_0	-1.439	0.248	0.237	0.145	0.389
transfIRARdist_1	-0.463	0.212	0.629	0.412	0.961
itrans_rho_0	1.305	0.266	3.686	2.164	6.28

Table 3.2.15. Ling 5.b. Forecast of recruitment (thousands), SSB (tonnes), catch (tonnes) and TSB (tonnes) when $F=F_{sq}$ in 2020 and 2021 and different scenarios such as $F=F_{MSY}$, F=0, $F=F_{pa}$, $F=F_{lim}$, $F=F_{sq}$. Median values showed.

	Year	F_{6-10}	Recruitment	SSB	Catch	TSB
$F=F_{sq}$, then F_{MSY}	2020	0.357	2497	27949	8754	38581
	2021	0.357	2942	27756	8744	37830
	2022	0.23	2942	25070	5636	35165
	2023	0.23	2942	25018	5660	35807
$F=F_{sq}$, then 0	2020	0.357	2497	27949	8754	38581
	2021	0.357	2942	27756	8744	37830
	2022	0	2942	25070	0	35165
	2023	0	2942	31436	0	42315
$F=F_{sq}$, then $F_{pa}=F_{p0.5}$	2020	0.357	2497	27949	8754	38581
	2021	0.357	2942	27756	8744	37830
	2022	0.6	2942	25070	11838	35165
	2023	0.6	2942	17951	8212	28485
$F=F_{sq}$, then F_{lim}	2020	0.357	2497	27949	8754	38581
	2021	0.357	2942	27756	8744	37830
	2022	0.85	2942	25070	14816	35165
	2023	0.85	2942	14728	8263	25166
$F=F_{sq}$	2020	0.357	2497	27949	8754	38581
	2021	0.357	2942	27756	8744	37830
	2022	0.357	2942	25070	8083	35165
	2023	0.357	2942	22279	7101	32822

3.3 Ling (*Molva Molva*) in Subareas 1 and 2

3.3.1 The fishery

Ling has been fished in Subareas 1 and 2 for centuries, and the historical development is described in Bergstad and Hareide (1996). In particular, the post-World War II increase in catch caused by a series of technical advances, are well documented. Currently the major fisheries in Subareas 1 and 2 are the Norwegian longline and gillnet fisheries, and bycatches of ling are taken by other gears, such as trawls and handlines. Historically around 50% of the Norwegian landings were taken by longlines and 45% by gillnets, partly in directed ling fisheries and as bycatch in other fisheries. This distribution between the gear types seem to be changing and in 2020 the gillnet fishery was landing 59 % and longliners 37 % of the total catches. Other nations catch ling as bycatch in their trawl fisheries. Figure 3.3.1 shows the spatial distributions of the total catches for the Norwegian longline fishery in 2020. There was no fishery in the NEAFC regulatory area in 2020.

The Norwegian longline fleet (vessels larger than 21 m) increased from 36 in 1977 to a peak of 72 in 2000, and afterwards the number stabilized at 27 but increased to 30 in 2020. The number of vessels declined mainly because of changes in the law concerning the quotas for cod. The average number of days that the longliners operated in ICES Subareas 1 and 2 has declined since its peak in 2011.. During the period 2000 to 2014 the main technological change in Subareas 1 and 2 was that the average number of hooks per day increased from 31 000 hooks to 35 000 hooks. During the period 1974 to 2014 the total number of hooks per year has varied considerably, but with a downward trend since 2002.(for more information see Helle and Pennington, WD 2021).

The cod stock in the Barents Sea has been very abundant for years, but now there is a downward trend in the cod stock which has resulted in lower quotas. Most likely the of lower quotas for cod has resulted in the observed increase in fishing pressure on ling.

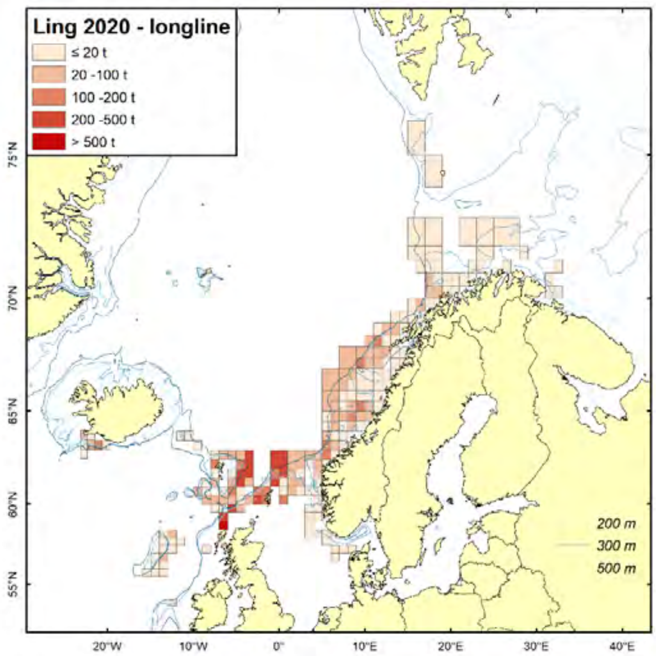


Figure 3.3.1. Distribution of the total catch of ling in Subareas 1 and 2 taken by the Norwegian longline fishery in 2020.

3.3.2 Landings trends

Landing statistics by nation in the period 1988–2020 are in Tables 3.3.1a–d. During 2000–2005, the landings varied between 5000 and 7000 t, which was slightly lower than the landings in the preceding decade. In 2007, 2008 and 2010 the landings increased to over 10 000 t. After this the landings declined to 8000 tons in 2017 followed by two years with high landings, above 11 000 tons. The preliminary landings for 2020 are 9 500 t, a significant decrease compared to the previous years. This decrease may be caused by lower fishing activities due to Covid 19. Total international landings in Areas 1 and 2 are given in Figure 3.3.2.

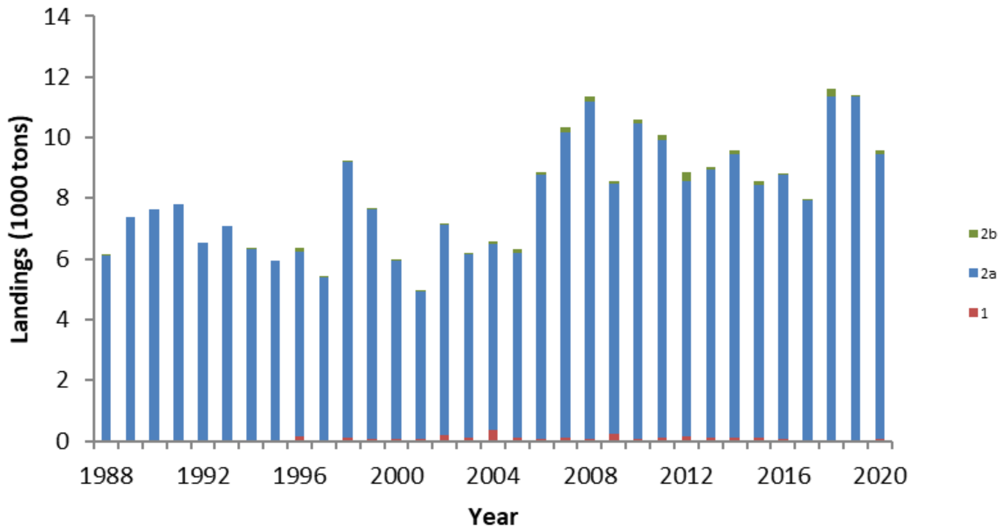


Figure 3.3.2. Total international landings of ling in Subareas 1 and 2.

3.3.3 ICES Advice

Advice for 2020 and 2021: ICES advises that when the precautionary approach is applied, catches should be no more than 15 593 tons in each of the years 2020 and 2021. All catches are assumed to be landed

3.3.4 Management

There is no quota for the Norwegian fishery for ling, but the vessels participating in the directed fishery for ling and tusk in Subareas 1 and 2 are required to have a specific license. There is no minimum landing size for the Norwegian EEZ.

There are ongoing negotiations between EU, UK and Norway and The TACs are therefore not available.

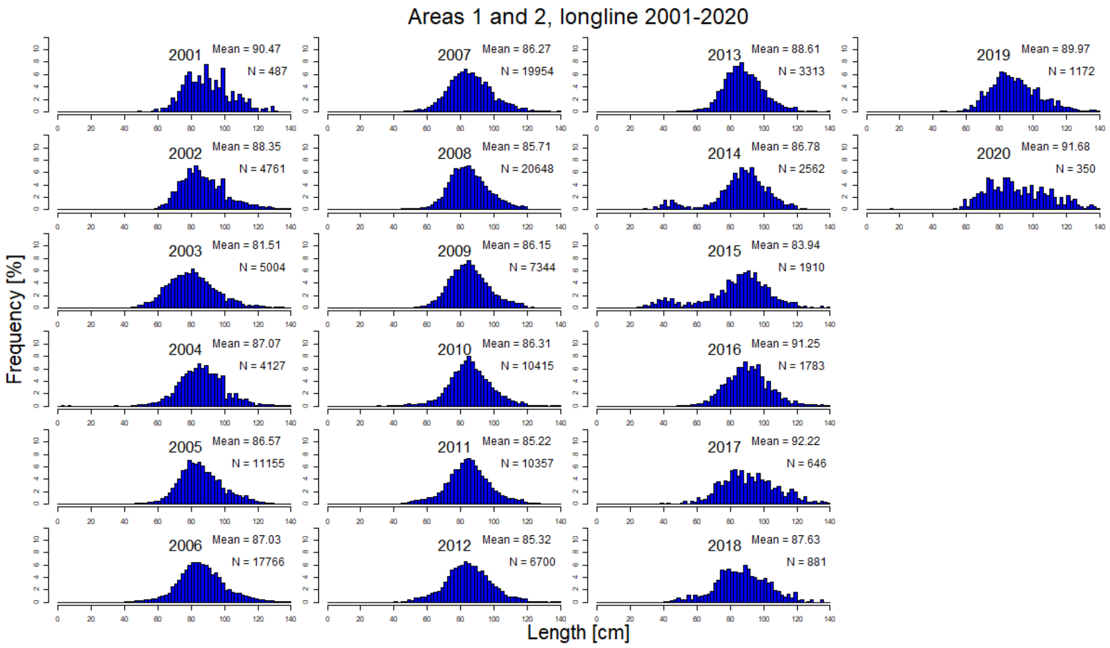
3.3.5 Data available

3.3.5.1 Landings and discards

Amounts landed were available for all relevant fleets. No discards were reported in 2020. But since the Norwegian fleets are not regulated by TACs, and there is a ban on discarding, the incentive for illegal discarding is believed to be low. The landings statistics are therefore regarded as being adequate for assessment purposes.

3.3.5.2 Length compositions

Length composition data are available for the longliners and gillnetters from the Norwegian Reference fleet. Figures 3.3.3 and 3.3.4 show the length distribution of ling in Areas 1 and 2 for the period 2001 to 2020. The mean length in Area 1 has varied slightly, while the mean length in Area 2a has been very stable. The weight–length graphs are in Figure 3.3.5.



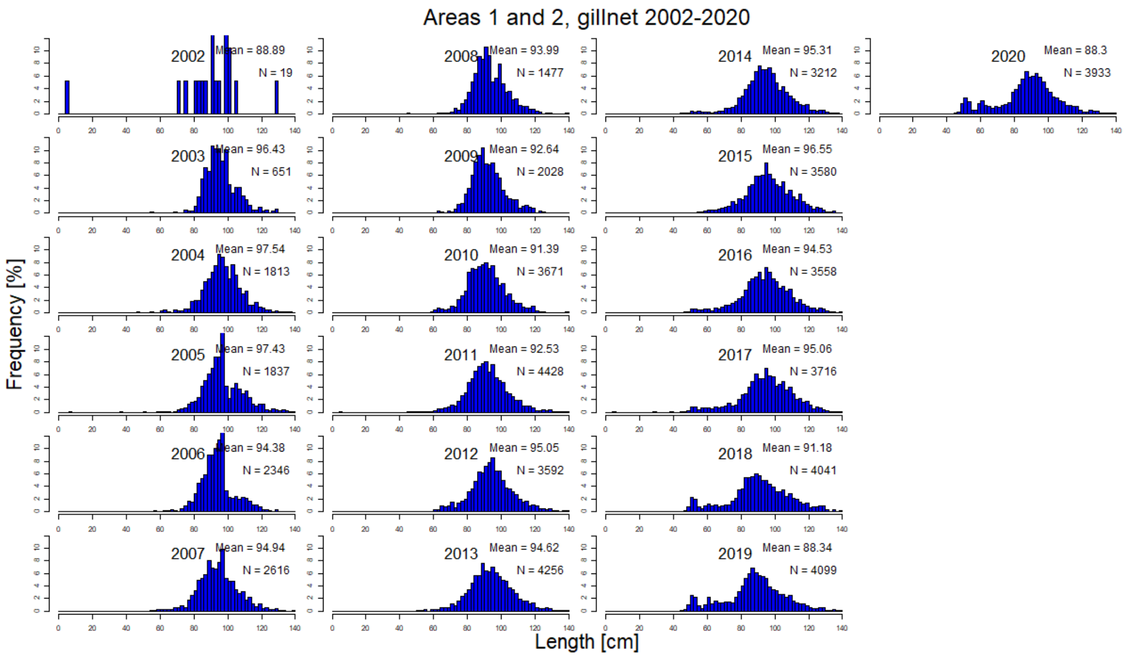


Figure 3.3.3. Plots of the length distributions of ling in Subareas 1 and 2 combined for the period 2001 to 2020 from the Norwegian Reference fleet.

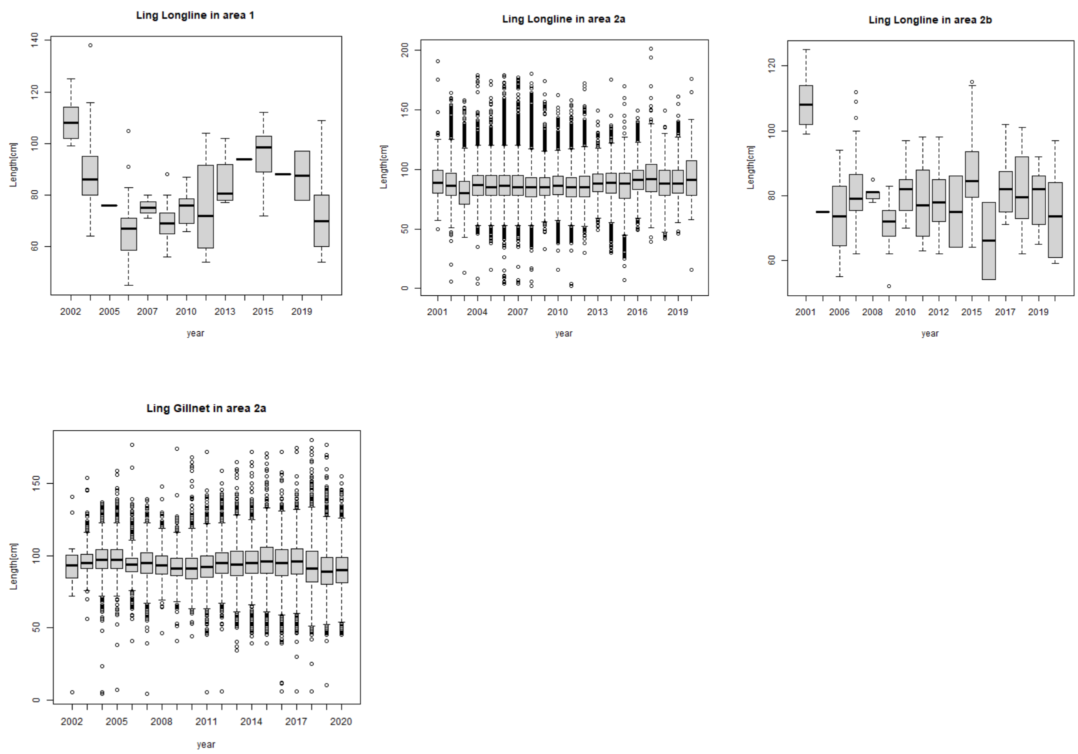


Figure 3.3.4. Box and whiskers plots for the length of ling in Areas 1, 2a and 2b for the period 2001 to 2020 from the Norwegian Reference fleet.

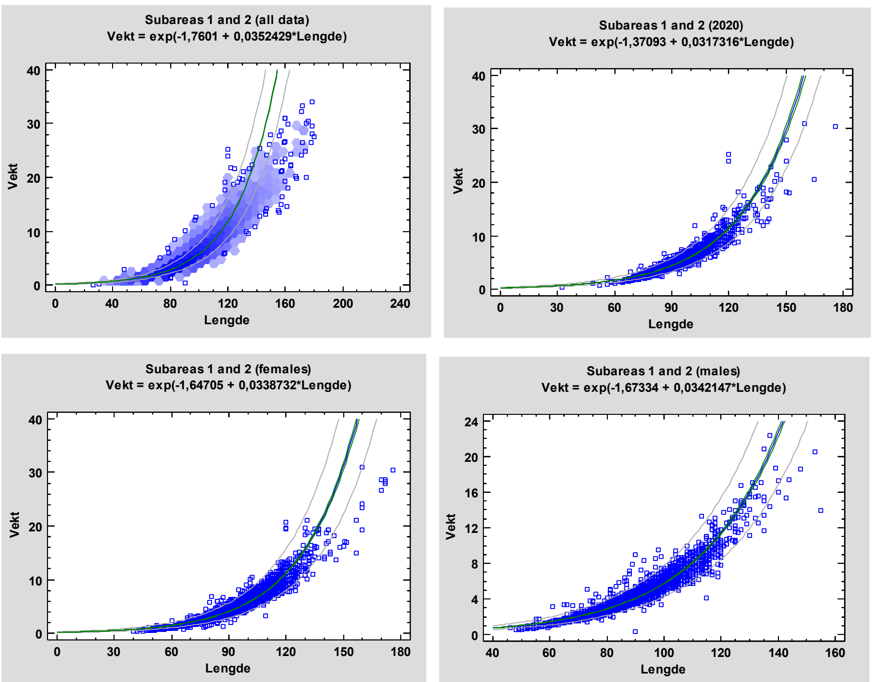


Figure 3.3.5. Weight–length relationship for the period 2008–2020, and only for 2020 (upper panel) and for females and for males, separately (lower panel). Data were collected by the Norwegian Reference Fleet.

3.3.5.3 Age compositions

The Catch-at-age composition for the longline fishery and for the gillnet fishery for 2010–2020 (Figure 3.3.6), and box and whiskers plots for the estimated age distribution of catch for each area are in Figure 3.3.7.

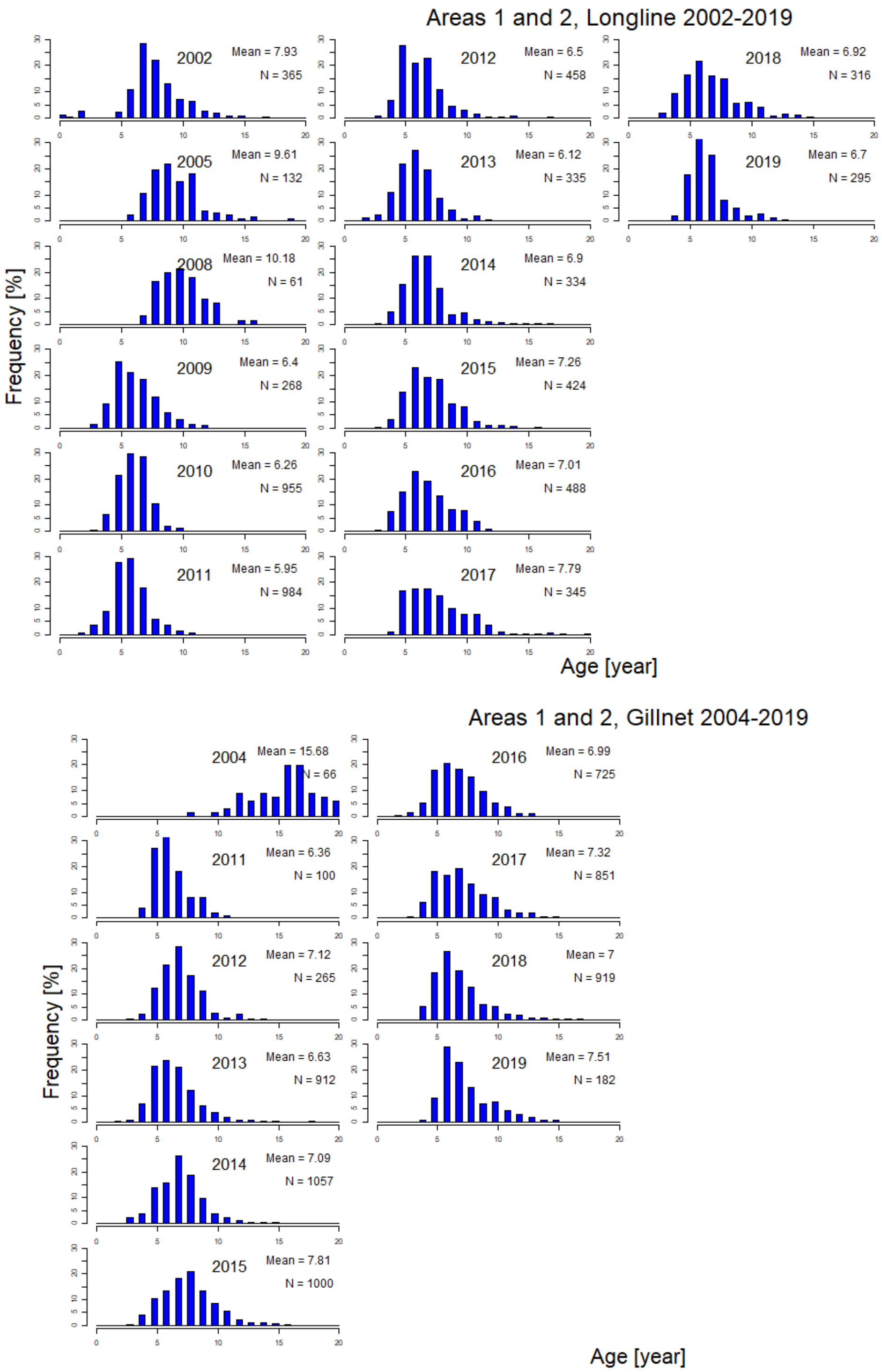


Figure 3.3.6. Ling in Areas 1 and 2, Catch-at-age compositions based on data from the Reference fleet, longliners and gillnetters...

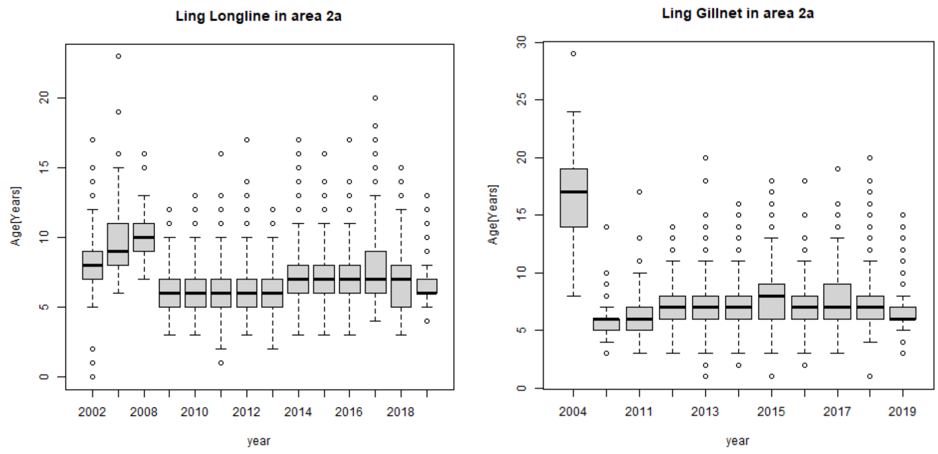


Figure 3.3.7. Age composition of the fish caught by longliners and gillnetters during the period 2002–2019.

3.3.5.4 Length and weight -at-age

Figure 3.3.8 shows the average mean length at age and mean weight at age for the years 2009–2020.

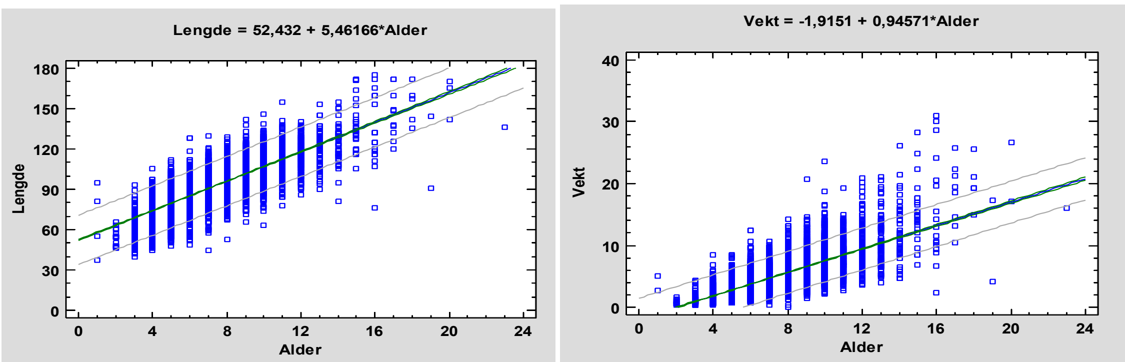


Figure. 3.3.8. Average mean length and mean weight versus age for the period 2010–2020.

3.3.5.5 Maturity and natural mortality

Maturity ogives for ling are in Figure 3.3.9 and in the following table. The results fit well with previous observations that ling reach maturity between ages 5–7 (60–75 cm) in most areas, while males reach maturity at a slightly younger age than females (Magnusson *et al.*, 1997).

Maturity parameters:

Stock	L50	N	A50	N	Source
Lin-arct	73.0	1540	7.0	769	Norwegian long liners (Reference fleet) and survey data

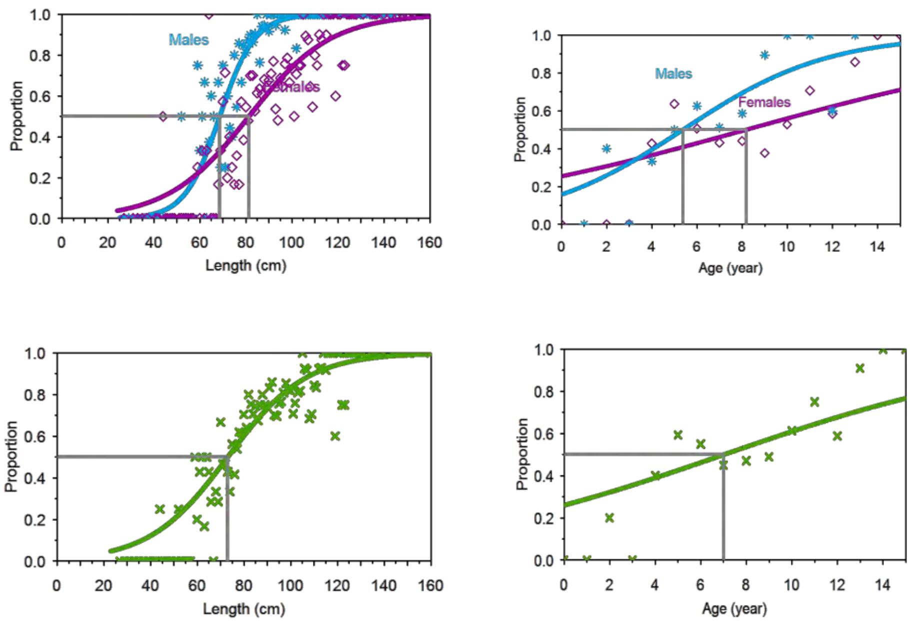


Figure 3.3.9. Maturity ogives for ling in Areas 1 and 2: males and females (upper panel) and for males and females combined (lower panel).

3.3.5.6 Catch and effort data

Two standardized cpue series for 2000–2020 for Norwegian longliners are in Figure 3.3.10. One series was based on all the catch data, and the other cpue series used only catches of ling that made up more than 30% of the total catch by weight, that is it is assumed that these were targeted catches. No research vessel data are available.

3.3.6 Data analyses

Length distribution

In Figures 3.3.3 and 3.3.4 are plots of the length distributions in Area 1 and 2 for 2001 to 2020. It appears that the mean length in Area 1 has varied slightly, while the mean length in Areas 2a and 2b has been very stable. The average length is slightly higher in the gillnet fishery than in the longline fishery.

Age distribution

In Figures 3.3.6 and 3.3.7 are plots of the age distributions in Area 1 and 2 for 2001 to 2020. It appears that the mean age in Area 2a has been very stable. The average age is slightly higher in the gillnet fishery than in the longline fishery.

Cpue

Graphs of two standardized GLM-based cpue series estimated based on all the data and based on data for which ling made up more than 30% of the catch are shown in Figure 3.3.10. Both cpue series indicate an upward trend for the period until 2017, after 2017 there was a declining trend. The method is described in Helle *et al*., 2015.

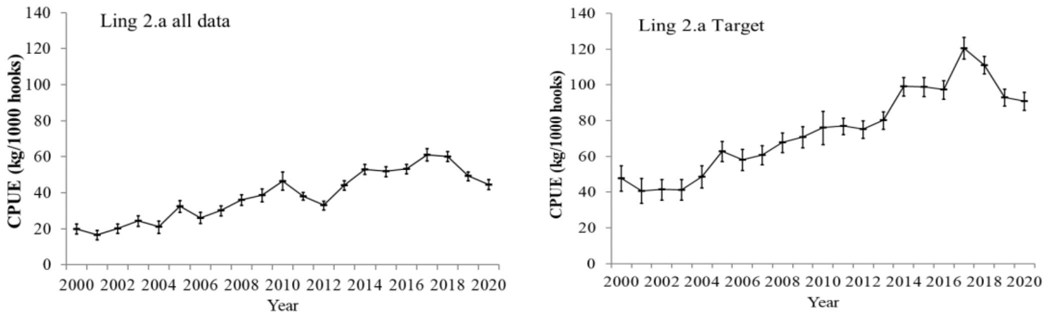


Figure 3.3.10. Estimate of cpue (kg/1000 hooks) for ling in Area 2a based; on all available data, and on catches when ling was considered the target species for 2000–2020. The bars denote the 95% confidence intervals. The data are from skipper's logbooks.

3.3.7 Comments on the assessment data analyses

The two cpue series, based on all data and when ling were targeted, show a stable and positive trend until the last three years.

3.3.8 Management considerations

The annual catch of ling since 2006 do not appear to have had a detrimental effect on the stock given that cpue continued to increase steadily, and even with the recent decline the current catch levels are considered appropriate.

However, the cod stock in the Barents Sea has been very abundant for several years but now there is a downward trend in the cod stock which results in lower quotas. There has also been an increase in the number longliners. Because of lower quotas for cod and the increased number of vessels, the fishing pressure on ling appear to have increased.

As always, it should be emphasized that commercial catch data are typically observational data; that is, there were no scientific controls on how or from where the data were collected. Therefore, it is not known with certainty if the ling cpue series tracks the population and/or how accurate the measures of uncertainty associated with the series are (see, for example, Rosenbaum, 2002). Consequently, one must usually hope that a cpue series, which is based only on commercial catch data, truly tracks abundance.

An infamous example of a misleading cpue series based on commercial data was a cpue series for Newfoundland cod that incorrectly indicated that the abundance of the cod stock was increasing greatly. Advice based on this cpue series ultimately caused the collapse of the stock (see, e.g., Pennington and Strømme, 1998).

In general, any assessment method based only on commercial catch data needs to be applied with caution. The reason that assessments using only commercial data are problematic is because the relation between the commercial catch and the actual population is normally unknown and probably varies from year to year.

3.3.9 Application of MSY proxy reference points

The Length-based indicator method (LBI) were applied for ling in Areas 1 and 2.

Length-based indicator method (LBI)
The input parameters and the length distributions of the catches for the period 2001–2020 are in Table 3.3.2 and Figure 3.3.11. The length data used in the LBI model are from the Norwegian gill netter and longline fleet.

Table 3.3.2. Ling in arctic waters (1, 2.a, 2.b). Input parameters for LBI.

Data type	Years/Value	Source	Notes
Length–frequency distribution	2001–2020	Norwegian gill netters (Reference fleet) fishing in divisions 1,2a,2b	
Length–weight relation	$0.0055 * \text{length}^{3.0175}$	Norwegian Reference fleet and survey data	
L_{MAT}	73 cm	Norwegian Reference fleet and survey data	Sexes combined
L_{inf}	172 cm (L_{max})	Norwegian Reference fleet and survey data	

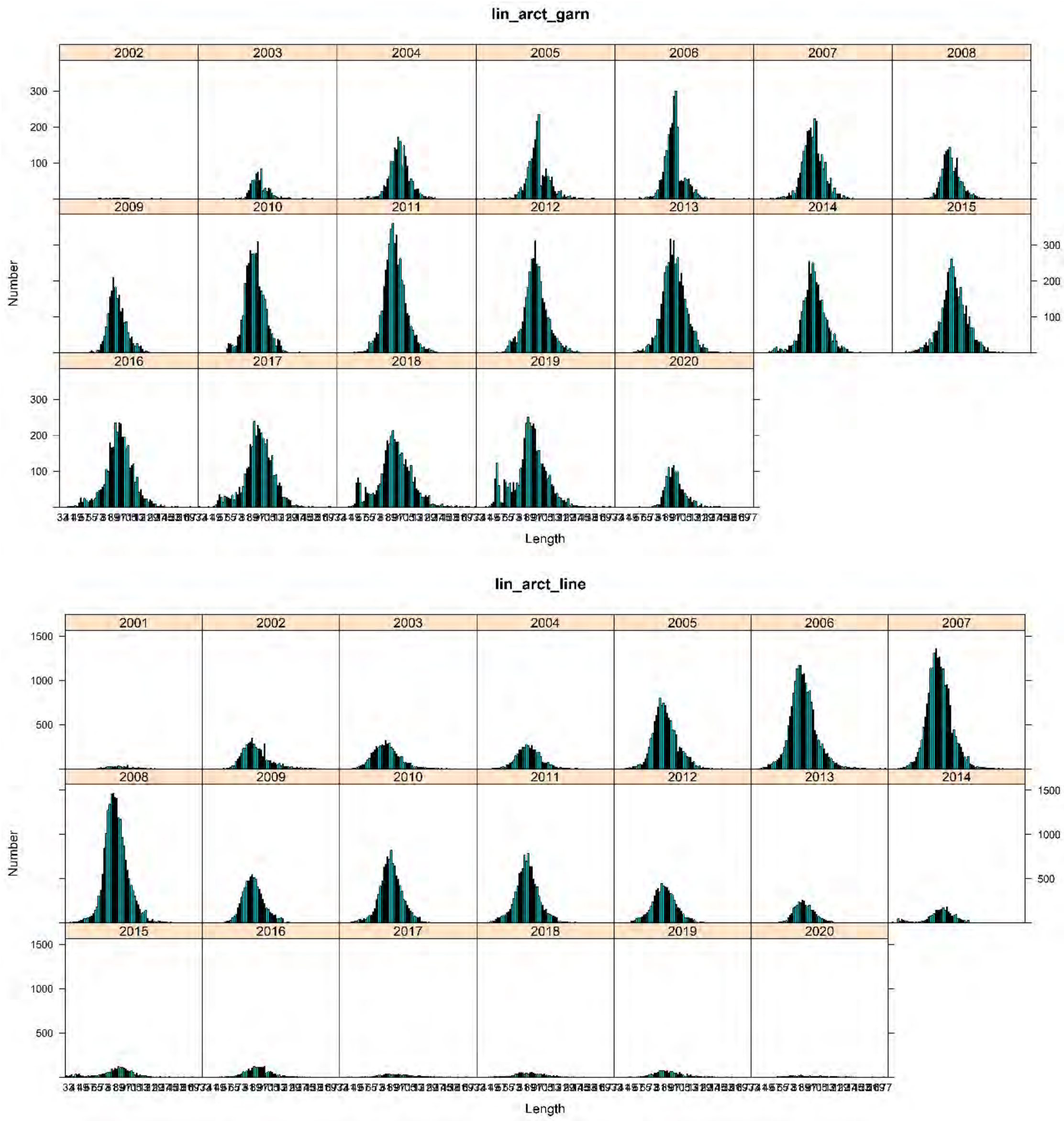


Figure 3.3.11. Ling in arctic waters (1, 2.a, 2.b), upper panel are length data from gillnetters, lower are from longliners. Catch length distributions, 2 cm length classes, for the period 2001–2020 (sex combined).

Outputs from the screening of length indicator ratios for combined sexes under three scenarios: (a) Conservation; (b) Optimal yield; and (c) maximum sustainable yield, for ling from the gillnet and longline fishery are in Figures 3.3.12a and b.

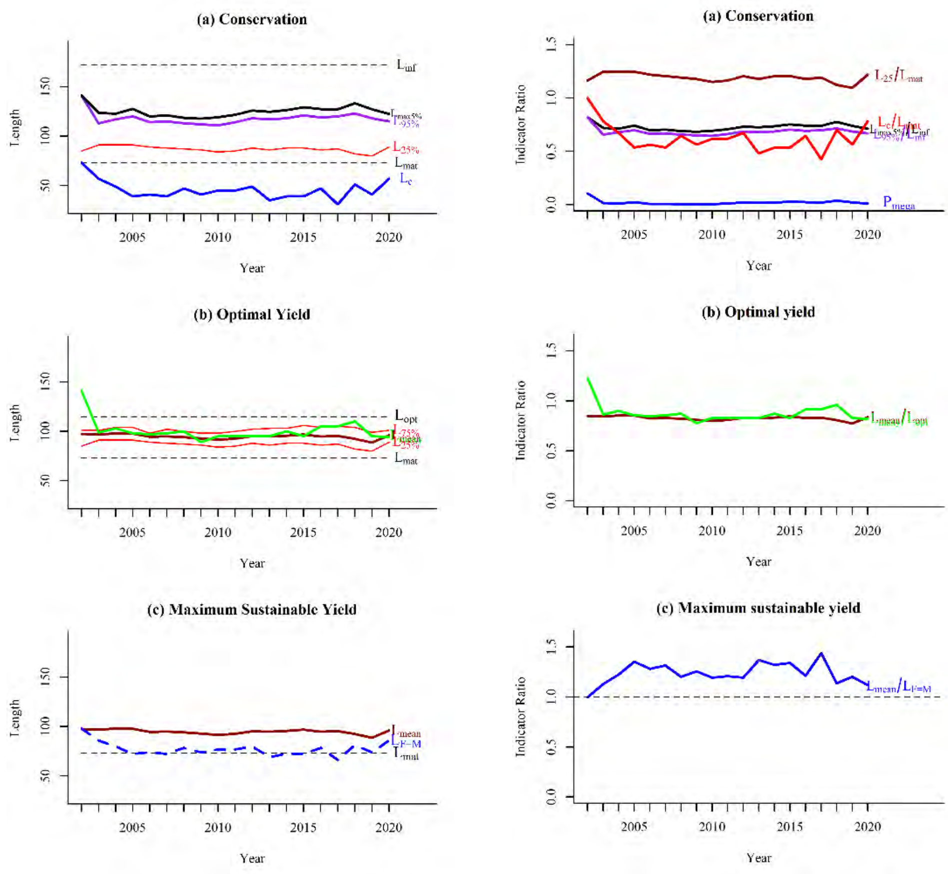


Figure 3.3.12a. Ling from gillnetters in arctic waters (1, 2.a, 2.b). Screening of the length indicator ratios for sex combined under three scenarios: (a) Conservation; (b) Optimal yield; and (c) maximum sustainable yield.

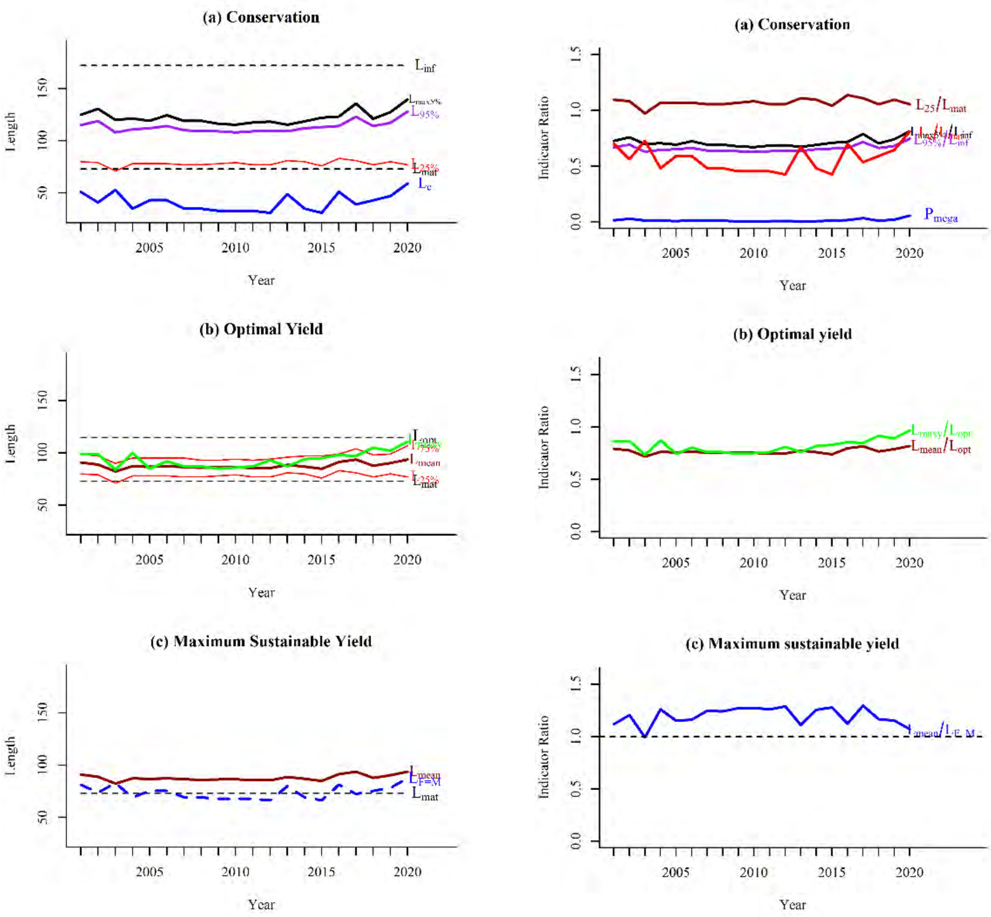


Figure 3.3.12b. Ling from longliners in arctic waters (1, 2.a, 2.b). Screening of the length indicator ratios for sex combined under three scenarios: (a) Conservation; (b) Optimal yield; and (c) maximum sustainable yield.

Analysis of results

The results using length data from gillnet and longline fishery showed the same trend. The model for the conservation of immature ling shows that L_c/L_{mat} is usually less than one, but $L_{25\%}/L_{mat}$ is usually greater than 1 (Figure 3.3.12). In 2016–2020, $L_{25\%}/L_{mat}$ was also greater than 1 (Table 3.3.3), therefore there is no indication that immature ling are being overfished.

For the status for large ling, the model shows that the indicator ratio of $L_{max5\%}/L_{inf}$ is around 0.7 for the whole period (Figure 3.3.12) and between 0.74 and 0.78 in 2018–2020 (Table 3.3.3), which is less than the limit of 0.8 suggesting that there is a lack of mega-spawners in the catch, which indicates that there is a truncation point in the length distribution. The mean length of ling in the catch is lower than the mean length for optimizing yield.

The MSY indicator ($L_{mean}/L_{F=M}$) is greater than 1 for almost the whole period (Figure 3.3.12), which indicates that ling in arctic waters are fished sustainably. Regarding model sensitivity, the MSY value was always greater than 0.90.

Table 3.3.5. gives the outcomes of all estimates from the LBI, based on data from the gillnet and the longline fishery provided by the Norwegian reference fleet

Conclusion: The overall perception of the stock during the period 2018–2020 is that ling in arctic waters seems to be fished sustainably (Table 3.3.3a and b). However, the results are very sensitive to the assumed values of L_{mat} and L_{inf}.

Table 3.3.3a. Ling (gillnetters)in arctic waters (1, 2.a, 2.b). The results from the LBI method.

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2018	0,70	1,12	0,78	4 %	0,81	1,14
2019	0,56	1,10	0,74	2 %	0,77	1,20
2020	0,78	1,22	0,71	1 %	0,84	1,12

Table 3.3.3b. Ling (longliners) in arctic waters (1, 2.a, 2.b). The results from the LBI method.

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2018	0,59	1,05	0,70	1 %	0,77	1,17
2019	0,64	1,10	0,74	2 %	0,79	1,15
2020	0,81	1,05	0,81	5 %	0,82	1,07

Table 3.3.4 Ling in arctic waters (1, 2.a, 2.b). Stock status inferred from LBI for MSY. Green tick marks for MSY are provided because the $L_{mean}/L_{F=M}$ > 1 in each year. Stock size is unknown as this method only provides exploitation status.

	Fishing pressure			
	2018	2019	2020	
MSY (F/F$_{MSY}$)	✓	✓	✓	Fished sustainably

	Stock size			
	2018	2019	2020	
MSY B$_{trigger}$.(B/B$_{MSY}$)	?	?	?	Unknown

Table 3.3.5. Outcomes from the LBI, based on data from the gillnet and the longline fishery provided by the Norwegian reference fleet.

	Gillnet			Longline		
Year	2018	2019	2020	2018	2019	2020
L75	104	99	101	98	99	107
L25	82	80	89	77	80	77
Lmed	92	89	94	88	88	90
L90	115	110	110	107	111	122
L95	123	118	115	114	117	128
Lmean	92.45	88.61	95.88	87.75	90.23	93.58
Lc	51	41	57	43	47	59
LFeM	81.25	73.75	85.75	75.25	78.25	87.25
Lmaxy	110	95	94	105	102	111
Lmat	73	73	73	73	73	73
Lopt	114.67	114.67	114.67	114.67	114.67	114.67
Linf	172	172	172	172	172	172
Lmax5%	133.35	127.20	122.40	120.96	127.37	139.60
Lmean/LFeM	1.14	1.20	1.12	1.17	1.15	1.07
Lc/Lmat	0.70	0.56	0.78	0.59	0.64	0.81
L25/Lmat	1.12	1.10	1.22	1.05	1.10	1.05
Lmean/Lmat	1.27	1.21	1.31	1.20	1.24	1.28
Lmean/Lopt	0.81	0.77	0.84	0.77	0.79	0.82
L95/Linf	0.72	0.69	0.67	0.66	0.68	0.74
Lmaxy/Lopt	0.96	0.83	0.82	0.92	0.89	0.97
Lmax5%/Linf	0.78	0.74	0.71	0.70	0.74	0.81
Pmega	0.04	0.02	0.01	0.01	0.02	0.05
Pmegaref	0.3	0.3	0.3	0.3	0.3	0.3

3.3.10 References

Bergstad, O.A. and N.R. Hareide, 1996. Ling, blue ling and tusk of the northeast Atlantic. Fisken og Havet (Institute of Marine Research, Bergen) 15. 126 p.

Helle, K., M. Pennington, N-R. Hareide and I. Fossen. 2015. Selecting a subset of the commercial catch data for estimating catch per unit of effort series for Ling (*Molva molva* L.). Fisheries Research 165: 115–120.

Helle, K. and Pennington, M. 2021. The development of the Norwegian longline fleet's fishery for ling and tusk during the period 2000-2020. Working Document to the ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).21 pp.

Magnússon JV, Bergstad OA, Hareide NR, Magnússon J, Reinert J (1997) Ling, Blue Ling and Tusk of the Northeast Atlantic. In: Nordic project report, p. 58.

Pennington, M., and Strømme, T. (1998). Surveys as a research tool for managing dynamic stocks. Fisheries Research 37, 97–106.Rosenbaum, P.R.2002. Observational Studies (second ed.), Springer-Verlag, New York, NY (2002) (377 pp.)

Rosenbaum, P.R.2002. Observational Studies (second ed.), Springer-Verlag, New York, NY (2002) (377 pp.)

3.3.11 Tables

Table 3.3.1a. Ling 1.a and b. WG estimates of landings.

Year	Norway	Iceland	Scotland	Faroes	France	Total
1996	136					136
1997	31					31
1998	123					123
1999	64					64
2000	68	1				69
2001	65	1				66
2002	182		24			206
2003	89					89
2004	323			22		345
2005	107					107
2006	58					58
2007	96					96
2008	55					55
2009	236					236
2010	57					57
2011	129					129
2012	158					158
2013	126					126
2014	122				1	123
2015	93					93
2016	65					65
2017	43					43
2018	34					34
2019	37					37
2020*	73					73

Preliminary. Table 3.3.1b. Ling 2a. WG estimates of landings.

Year	Fa-roes	France	Ger-many	Nor-way	E & W	Scot-land	Rus-sia	Ire-land	Iceland	Spain	Greenland	Poland	Total
1988	3	29	10	6070	4	3							6119
1989	2	19	11	7326	10	-							7368
1990	14	20	17	7549	25	3							7628
1991	17	12	5	7755	4	+							7793
1992	3	9	6	6495	8	+							6521
1993	-	9	13	7032	39	-							7093
1994	101	n/a	9	6169	30	-							6309
1995	14	6	8	5921	3	2							5954
1996	0	2	17	6059	2	3							6083
1997	0	15	7	5343	6	2							5373
1998		13	6	9049	3	1							9072
1999		12	7	7557	2	4							7581
2000		9	39	5836	5	2							5891
2001	6	9	34	4805	1	3							4858
2002	1	4	21	6886	1	4							6917
2003	7	3	43	6001		8							6062
2004	15	0	3	6114		1	5						6138
2005	6	5	6	6085	2		2						6106
2006	9	8	6	8685	6	1	11						8726
2007	18	6	7	9970	1	0	55	1					10 058
2008	22	4	7	11 040	1	1	29	0					11 104
2009	1	2	7	8189	0	19	17						8244
2010	10	0	18	10 318	0	2	47						10 395
2011	4	6	6	9763			19						9798
2012	21	6	9	8334		7	45		3				8425
2013	7	9	7	8677		1	114		4				8819

Year	Fa-roes	France	Ger-many	Nor-way	E & W	Scot-land	Rus-sia	Ire-land	Ice-land	Spain	Green land	Po-land	Total
2014	3	13	3	9245			73						9337
2015	10	5	4	8220		3	115		5				8362
2016	18	6	11	8523	2	3	112		8	2	9	6	8700
2017	17	13	8	7684		3	150		15		4	6	7900
2018	13	9	16	11155			129		4		1	5	11332
2019	5	24	9	11216			60		1			1	11316
2020*	8	13	5	9323	1	1	42		2				9395

*** *Preliminary. Table 3.3.1c. Ling 2b. WG estimates of landings.**

Year	Norway	E & W	Faroes	France	Total
1988		7			7
1989		-			
1990		-			
1991		-			
1992		-			
1993		-			
1994		13			13
1995		-			
1996	127	-			127
1997	5	-			5
1998	5	+			5
1999	6				6
2000	4	-			4
2001	33	0			33
2002	9	0			9
2003	6	0			6
2004	77				77
2005	93				93
2006	64				64

Year	Norway	E & W	Faroes	France	Total
2007	180		0		180
2008	162	0	0		162
2009	84				84
2010	128				128
2011	164			7	171
2012	266				266
2013	76				76
2014	85	52			137
2015	95				95
2016	53				1
2017	28				28
2018	238				238
2019	55				55
2020	96				96

***Preliminary.**

Table 3.3.1d. Ling 1 and 2. Total landings by subarea or division.

Year	1	2.a	2.b	All areas
1988		6119	7	6126
1989		7368		7368
1990		7628		7628
1991		7793		7793
1992		6521		6521
1993		7093		7093
1994		6309	13	6322
1995		5954		5954
1996	136	6083	127	6346
1997	31	5373	5	5409
1998	123	9072	5	9200
1999	64	7581	6	7651

Year	1	2.a	2.b	All areas
2000	69	5891	4	5964
2001	66	4858	33	4957
2002	206	6917	9	7132
2003	89	6062	6	6157
2004	345	6138	77	6560
2005	107	6106	93	6306
2006	58	8726	64	8848
2007	96	10 058	180	10 334
2008	80	11 104	161	11 346
2009	236	8244	84	8564
2010	57	10395	128	10580
2011	129	9798	171	10098
2012	158	8425	266	8849
2013	126	8819	76	9021
2014	123	9337	137	9606
2015	93	8362	95	8550
2016	65	8700	54	8819
2017	43	7900	28	7971
2018	34	11332	238	11604
2019	37	11321	55	11413
2020*	73	9395	96	9564

***Preliminary.**

3.4 Ling in 5.a (*Molva molva*)

3.4.1 The fishery

The fishery for ling in Icelandic waters has not changed substantially in recent years. Around 130-160 longliners annually report catches of ling, around 20-50 gillnetters and around 60 trawlers. Most of ling is caught on longlines (Figure 3.4.1 and Table 3.4.1) which has increased since 2000 to around 67% in 2020. At the same time the proportion caught by gillnets has decreased from 20–30% in 2000–2007 to around 2% in 2020. Catches in trawls have varied less and have been at around 20% of Icelandic catches. (Figure 3.4.1, Table 3.4.1). Most of the ling caught by Icelandic longliners is caught at depths less than 300 m, and by trawlers at less than 400 m (Figure 3.4.2). The main fishing grounds for ling as observed from logbooks are in the south, southwestern and western part of the Icelandic shelf (Figure 3.4.3 and Figure 3.4.4). The main trend in the spatial distribution of catches according to logbook entries is the decreased proportion of catches caught in the southeast and increased catches on the western part of the shelf two decades ago. Around 40% of ling catches are caught on the southwestern part of the shelf (Figure 3.4.3). In recent years, the main fishing pressure has shifted towards shallower waters (Figure 3.4.2).

Table 3.4.1: Ling in 5.a and 14. Number of Icelandic boats and catches by fleet segment participating in the ling fishery from logbooks.

Year	Bottom trawl	Gill nets	Longlines	Bottom trawl	Gill nets	Longlines	Other	Total catch
2000	125	184	289	726	704	1540	244	3214
2001	108	232	254	493	1061	1101	225	2880
2002	100	203	235	664	648	1283	250	2845
2003	96	172	244	583	454	2215	337	3589
2004	97	165	234	656	545	2017	508	3726
2005	99	127	260	989	501	2046	779	4315
2006	91	99	259	1246	629	3734	676	6285
2007	91	86	251	1395	633	4042	529	6599
2008	82	68	209	1509	477	5007	748	7741
2009	77	78	208	1540	723	6232	1121	9616
2010	75	69	197	1538	363	6532	1436	9869
2011	67	61	201	1676	222	5595	1297	8790
2012	68	62	206	1396	245	7479	1575	10695
2013	71	62	209	1610	345	6836	1465	10256
2014	64	57	220	1707	673	10624	1242	14246
2015	64	55	207	1911	650	9249	1225	13035
2016	65	55	186	1825	681	6545	834	9885

2017	67	48	171	1527	556	5975	708	8766
2018	63	47	151	1606	387	5366	702	8061
2019	61	32	149	1667	115	5964	523	8269
2020	68	36	124	1985	138	4765	162	7061

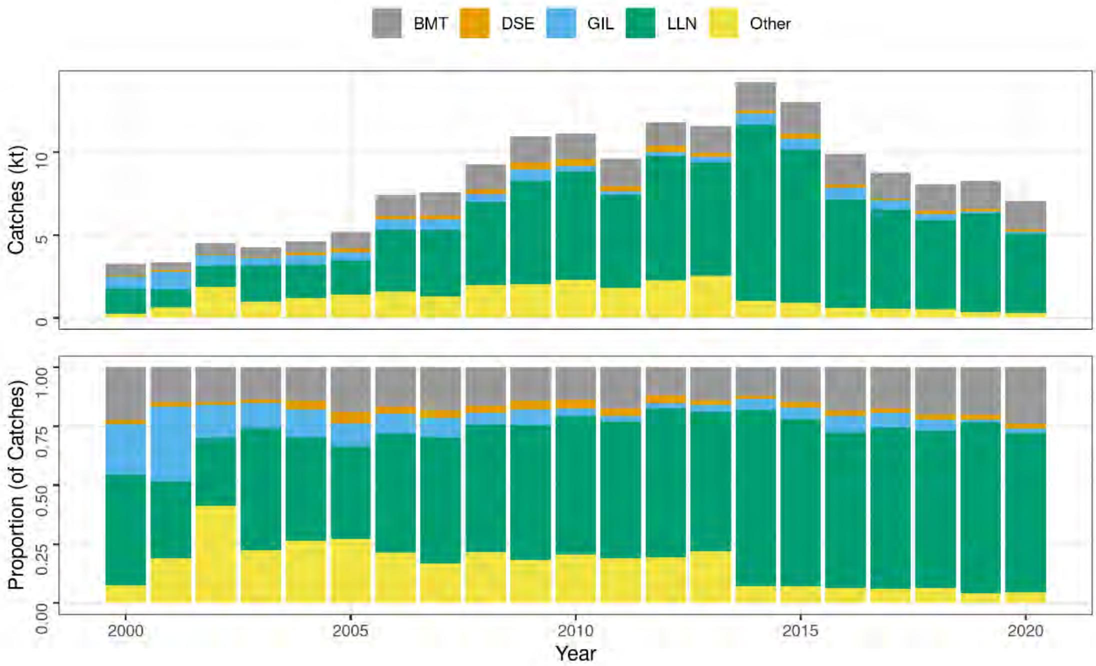


Figure 3.4.1: Ling in 5.a and 14. Commercial catches by gear as registered in Icelandic logbooks.

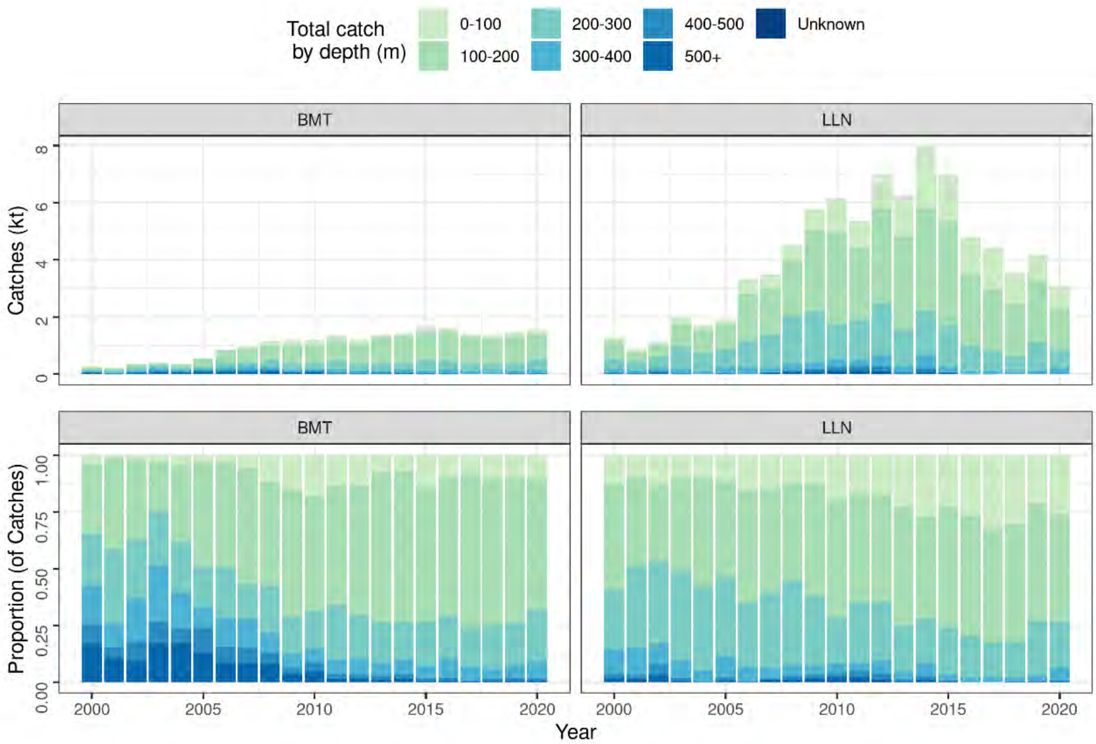


Figure 3.4.2: Ling in 5.a and 14. Depth distribution of catches in 5.a according to logbooks. All gears combined.

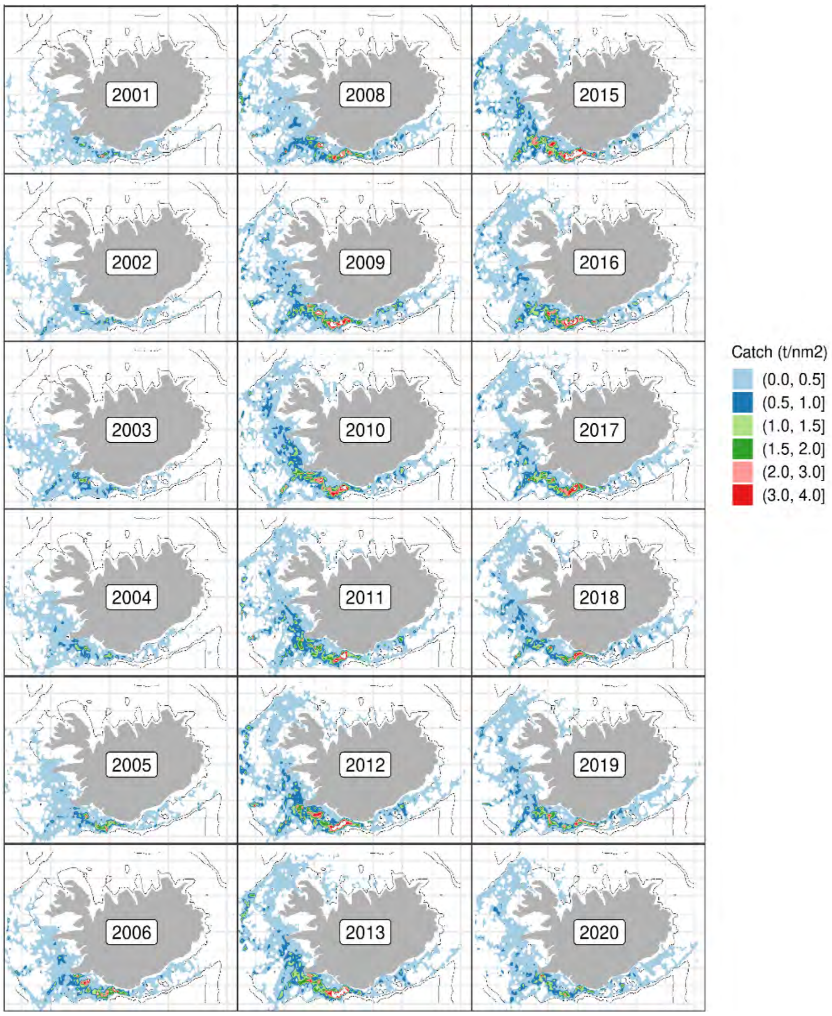


Figure 3.4.3: Ling in 5.a and 14. Spatial distribution of the Icelandic fishery catches as reported in logbooks. All gears combined.

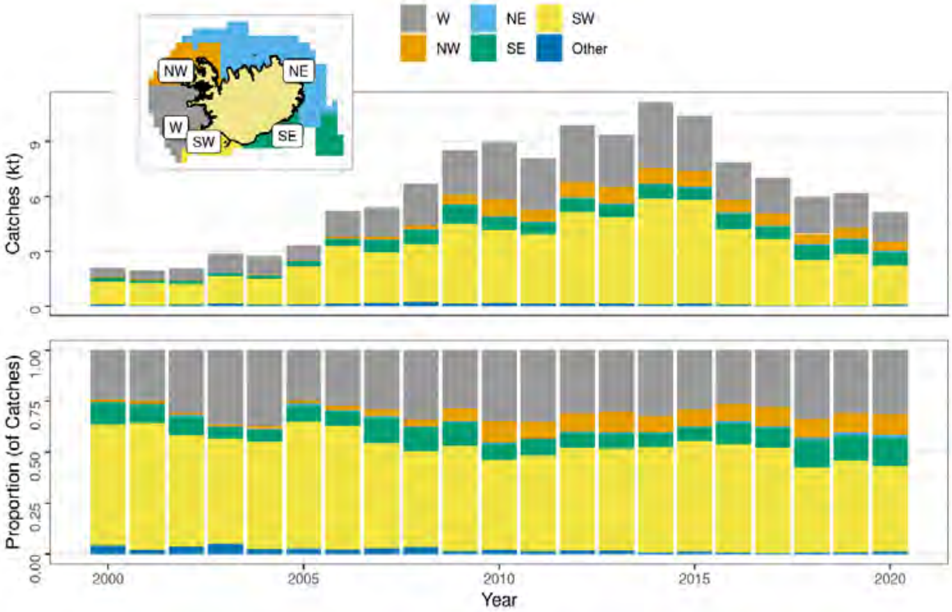


Figure 3.4.4: Ling in 5.a and 14. Changes in spatial distribution of the Icelandic fishery as reported in logbooks. All gears combined.

3.4.2 Landing trends

In 1950 to 1971, landings of ling in Icelandic waters ranged between 7000 to more than 15000 tonnes. Landings decreased between 1972 and 2000 to as little as 3000 tonnes as a result of most foreign vessels being excluded from the Icelandic EEZ. In 2001-2010, catches increased constantly and reached 11000 tonnes in 2010 and remained at that level for the most part until 2014, when the catches increased to 14000 tonnes. Since 2014, ling catches have reduced and were around 7061 tonnes in 2020 (Table 3.4.2 and Figure 3.4.5).

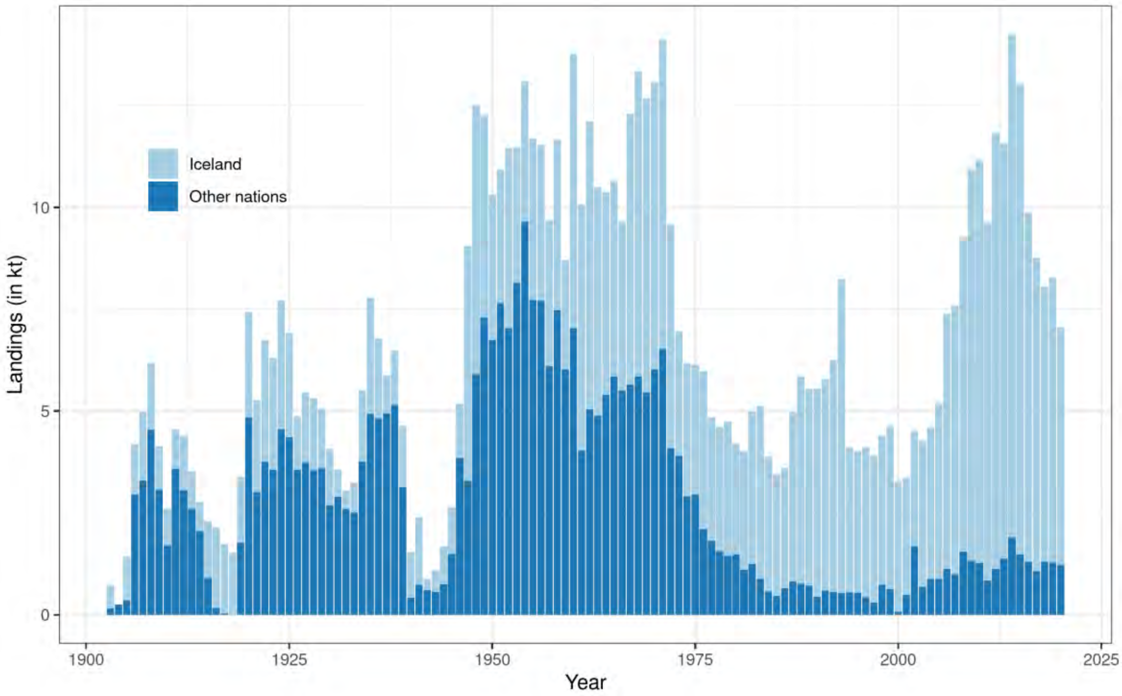


Figure 3.4.5: Ling in 5.a and 14. Landings in 5.a

Table 3.4.2: Ling in 5.a and 14. Percentage of landed catch by gear as reported from logbooks in 5.a.

Year	Bottom trawl	Gill nets	Longlines	Other	Total
1992	24	13	57	7	1158
1993	27	39	25	10	3525
1994	24	36	27	13	3563
1995	25	23	38	14	3552
1996	26	20	39	14	3747
1997	25	17	46	12	3607
1998	23	19	47	11	3695
1999	20	17	54	9	4003
2000	23	22	48	8	3214
2001	17	37	38	8	2881
2002	23	23	45	9	2845

Year	Bottom trawl	Gill nets	Longlines	Other	Total
2003	16	13	62	9	3590
2004	18	15	54	14	3727
2005	23	12	47	18	4315
2006	20	10	59	11	6285
2007	21	10	61	8	6599
2008	19	6	65	10	7741
2009	16	8	65	12	9616
2010	16	4	66	15	9868
2011	19	3	64	15	8789
2012	13	2	70	15	10695
2013	16	3	67	14	10257
2014	12	5	75	9	14246
2015	15	5	71	9	13035
2016	18	7	66	8	9884
2017	17	6	68	8	8766
2018	20	5	67	9	8062
2019	20	1	72	6	8269
2020	24	2	67	8	7061

3.4.3 Data available

In general sampling is considered good from commercial catches from the main gears (longlines and trawls). Sampling does seem to cover the spatial distribution of catches for longlines and trawls but less so for gillnets. Similarly, sampling does seem to follow the temporal distribution of catches (Figure 3.4.6, ICES (2012)).

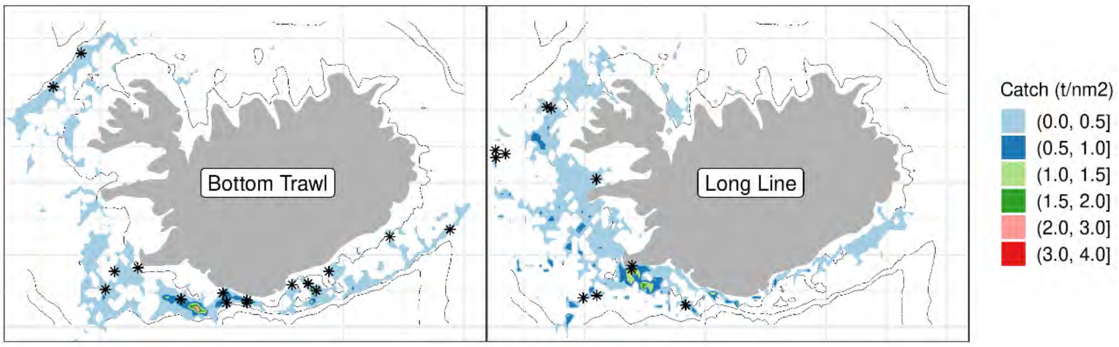


Figure 3.4.6: Ling in 5.a and 14. Fishing grounds in 2020 as reported by catch in logbooks (tiles) and positions of samples taken from landings (asterisks) by longliners and trawlers.

3.4.4 Landings and discards

Landings by Icelandic vessels are given by the Icelandic Directorate of Fisheries. Landings of Norwegian and Faroese vessels are given by the Icelandic Coast Guard. Discarding is banned by law in the Icelandic demersal fishery. Based on limited data, discard rates in the Icelandic long-line fishery for ling are estimated very low (<1% in either numbers or weight) (ICES (2011) :WD02). Measures in the management system such as converting quota share from one species to another are used by the fleet to a large extent and this is thought to discourage discarding in mixed fisheries. A description of the management system is given in the stock annex and Iceland fisheries overview (ICES (2017b) and ICES (2019) .

3.4.5 Length composition

An overview of available length measurements is given in Table 3.4.3. Most of the measurements are from longlines. The number of available length measurements has been increasing in recent years in line with increased landings. Length distributions from the Icelandic longline and trawl-ing fleet are presented in Figure 3.4.7. Sampling from commercial catches of ling is considered good; both in terms of spatial and temporal distribution of samples (Figure 3.4.6). Mean length as observed in length samples from catches decreased from 2005-2008 from around 86 to 80 cm (Figure 3.4.7). This may be the result of increased recruitment in recent years rather than in-creased fishing effort. Mean length has gradually increased since 2015 and the mean length in 2020 is the highest recorded. It is premature to draw conclusions from the limited age-structured data. It can only be stated that most of the ling caught in the Icelandic spring survey is between age 5 and 10; but from longlines the age is between 6 to 11.

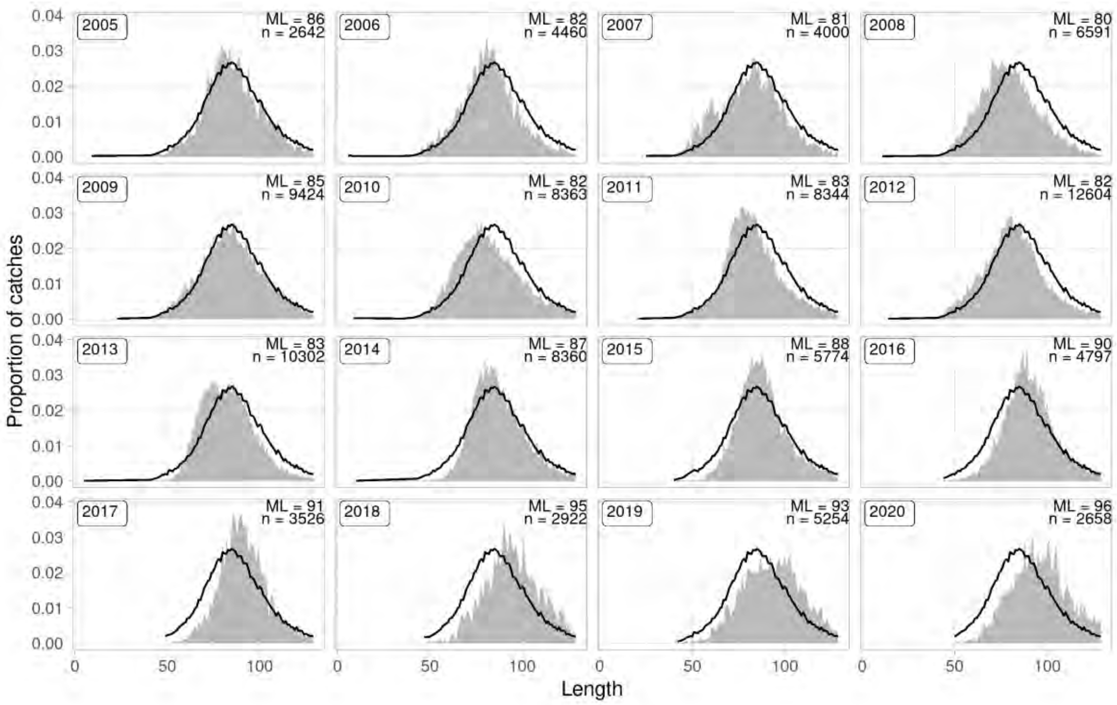


Figure 3.4.7: Ling in 5.a and 14. Length distribution from the Icelandic fleet (grey area) from 2005-2020. Black line is the average mean of the period.

Table 3.4.3: Ling in 5.a and 14. Number of available length and age measurements from Icelandic commercial catches.

Year	Length measurements					Age measurements					
	BMT	DSE	GLN	LLN	Other	LLN	GIL	DSE	BMT	Other	Total
2000	377	0	566	1624	6	650	200	0	150	0	1000
2001	37	0	493	1661	0	550	193	0	37	0	780
2002	221	0	366	1504	0	519	166	0	150	0	835
2003	137	0	300	2404	143	900	100	0	100	50	1150
2004	141	46	198	2640	150	750	50	46	100	50	996
2005	349	101	1	2323	180	750	0	0	181	50	981
2006	1157	0	641	3354	405	1138	289	0	450	100	1977
2007	400	76	0	3661	0	1300	0	50	100	0	1450
2008	819	15	357	5847	150	1950	150	0	315	50	2465
2009	516	0	410	9014	450	2550	150	0	250	150	3100
2010	1146	0	56	7322	1200	2498	50	0	450	400	3398
2011	1245	150	0	7248	750	2546	0	50	450	250	3296
2012	1411	150	85	11356	1337	3526	50	50	541	400	4567

Year	Length measurements					Age measurements					
2013	993	122	267	9405	1344	2590	100	50	350	450	3540
2014	2089	120	1286	6448	2964	665	225	20	399	514	1823
2015	2615	0	1563	3315	3052	595	300	0	484	520	1899
2016	2460	0	2039	2483	1212	440	345	0	460	220	1465
2017	1963	0	485	1637	1226	310	85	0	370	225	990
2018	1603	0	559	1424	712	245	100	0	310	120	775
2019	1830	0	0	3598	819	385	0	0	340	140	865
2020	1718	0	4	1099	0	225	40	0	355	0	620

3.4.6 Age composition

A limited number of otoliths collected in 2010 were aged and a considerable difference in growth rates was observed between the older data and the 2010 data (ICES (2011) :WD07). Substantial progress has been made since 2010. Now aged otoliths are available from the 2000 onwards (Table 3.4.3). Most of the ling caught in the Icelandic spring survey is between age 5 and 8 but from longlines the age is between 6 and 9.

3.4.7 Catch, effort and research vessel data

3.4.7.1 CPUE and effort

The CPUE estimates of ling in Icelandic waters have not been considered representative of stock abundance.

3.4.7.2 Survey data

Indices: The Icelandic spring groundfish survey, which has been conducted annually in March since 1985, covers the most important distribution area of the ling fishery. In addition, the autumn survey was commenced in 1996 and expanded in 2000 however a full autumn survey was not conducted in 2011 and therefore the results for 2011 are not presented. A detailed description of the Icelandic spring and autumn groundfish surveys is given in the stock annex. Figure 3.4.8 shows both a recruitment index and the trends in biomass from both surveys. Length distributions from the spring survey are shown in Figure 3.4.9 (abundance) and changes in spatial distribution in the spring survey are presented in Figure 3.4.10.

Ling in both in the spring and autumn surveys are mainly found in the deeper waters south and west off Iceland. Both the total biomass index and the index of the fishable biomass (>40 cm) in the March survey gradually decreased until 1995 (Figure 3.4.8). In the years 1995 to 2003 these indices were half of the mean from 1985–1989. In 2003 to 2007, the indices gradually increased until 2017. Since then, indices have decreased. The index of the large ling (80 cm and larger) shows similar trend as the total biomass index (Figure 3.4.8). The recruitment index of ling, defined here as ling smaller than 40 cm, also showed a similar increase in 2003 to 2007 and but then decreased by around 25% and remained at that level until 2010. Then the juvenile index fell to a very low level in 2014 and has fluctuated at a low level since. (Figure 3.4.8). However, the juvenile index is very uncertain as it is simply some variation in the length distribution of the survey but not a distinct peak (Figure 3.4.8).

The shorter autumn survey shows that biomass indices were low from 1996 to 2000 but have increased since then (Figure 3.4.8). There is a consistency between the two survey series; the autumn survey biomass indices are however derived from substantially fewer ling caught. Also, there is an inconsistency in the recruitment indices (<40 cm), where the autumn survey shows much lower recruitment, in absolute terms compared with the spring survey (Figure 3.4.8). This discrepancy is likely a result of much lower catchability of small ling (due to different gears) in the autumn survey, where ling less than 40 cm has rarely been caught.

Changes in spatial distribution as observed in surveys: According to the spring survey, most of the increase since 2010 in ling abundance is in the western area, but an increase can be seen in most areas. However, most of the index in terms of biomass comes from the southwestern area, or around 40% compared to around 30% between 2003 and 2011. A similar pattern is observed in the autumn survey.

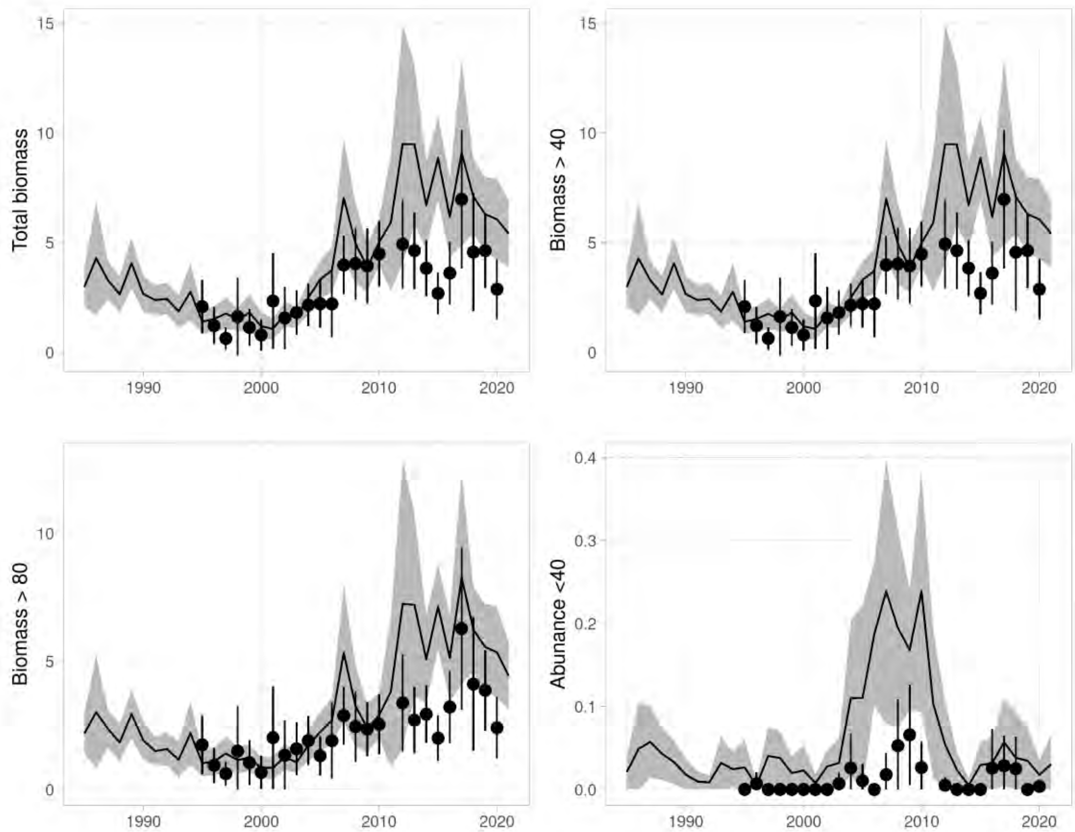


Figure 3.4.8: Ling in 5.a. and 14. Total biomass indices, biomass indices larger than 40 cm, biomass indices larger than 80 cm and abundance indices <40 cm. The lines with shaded area show the spring survey index from 1985 and the points with the vertical lines show the autumn survey from 1997. The shaded areas and vertical lines indicate +/- standard error.

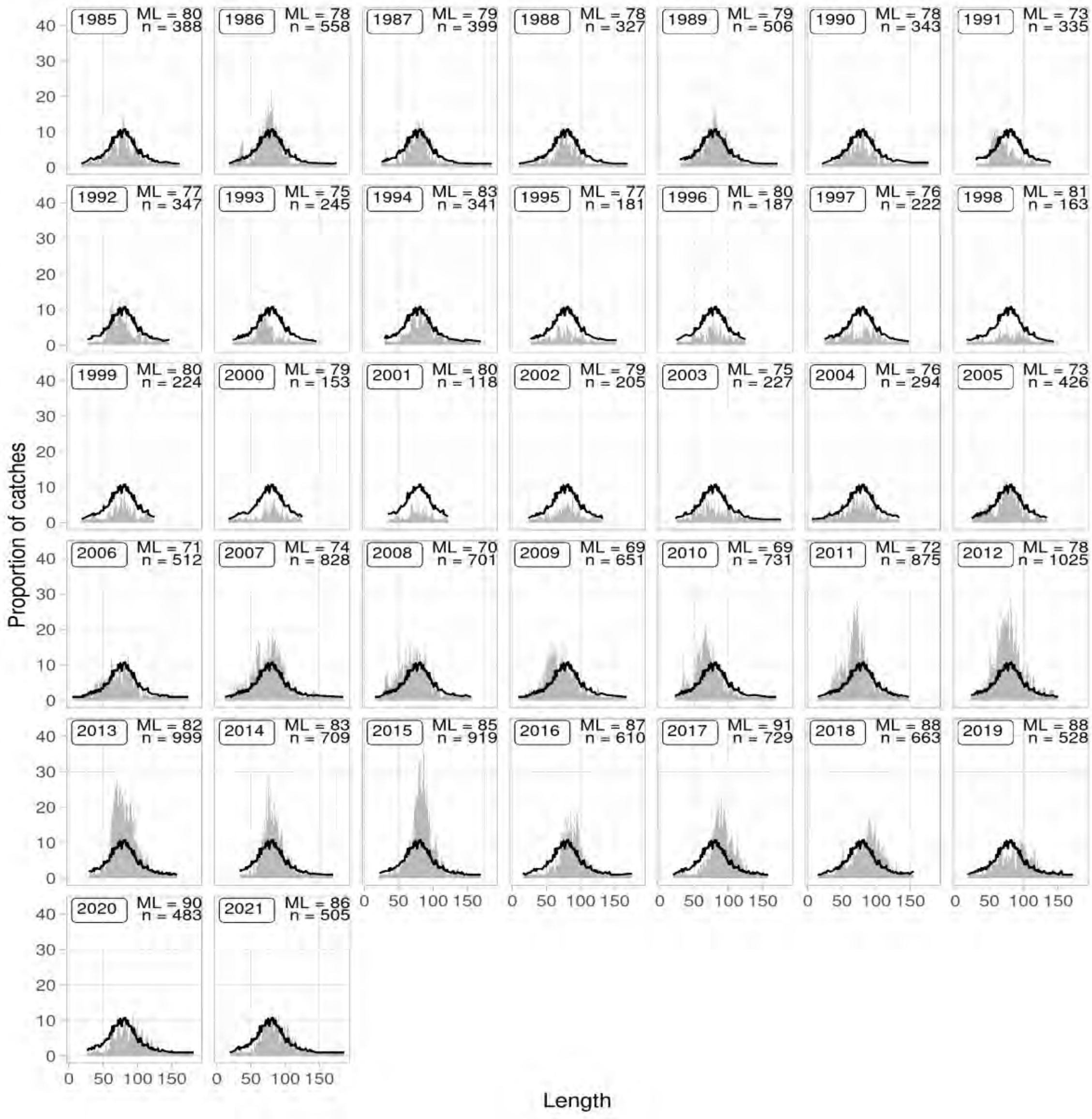


Figure 3.4.9: Ling in 5.a. and 14. Length distribution (grey area) from the spring survey. Black lines are the average mean of the period.

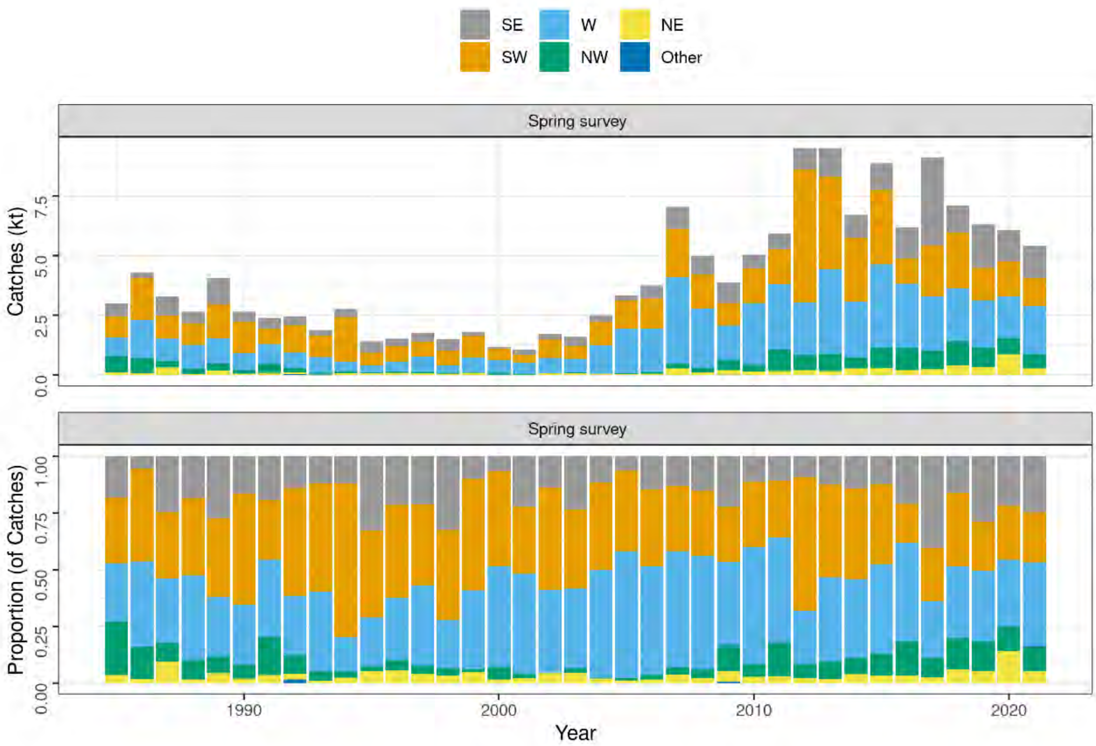


Figure 3.4.10: Ling in 5.a and 14. Estimated survey biomass in the spring survey by year from different parts of the continental shelf (upper figure) and as proportions of the total (lower figure).

3.4.8 Data analyses

3.4.8.1 Analytical assessment using Gadget

In 2014 a model of Ling in Icelandic waters developed in the Gadget framework (see http://www.hafro.is/gadget for further details) and was benchmarked for the use in assessment. As part of a Harvest Control Evaluation requested by Iceland this stock was benchmarked in 2017 (ICES (2017a)). Several changes were made to the model setup and settings which are described in the Stock Annex.

3.4.8.2 Data used and model settings

Data used for tuning are given in the stock annex. Model settings used in the Gadget model are described in more detail in the stock annex.

3.4.9 Diagnostics

3.4.9.1 Observed and predicted proportions by fleet

Overall fit to the predicted proportional length and age–length distributions was close to the observed distributions. (Figure 3.4.11, Figure 3.4.12 Figure 3.4.13, Figure 3.4.14). In the initial years of the spring the observed length proportions appear to have greater noise, however as the number of samples caught increases, the noise level decreases. Similarly, for gears where only a small portion of the ling catch is caught, such as the gillnet, the overall noise is greater than for those gears with greater numbers of samples.

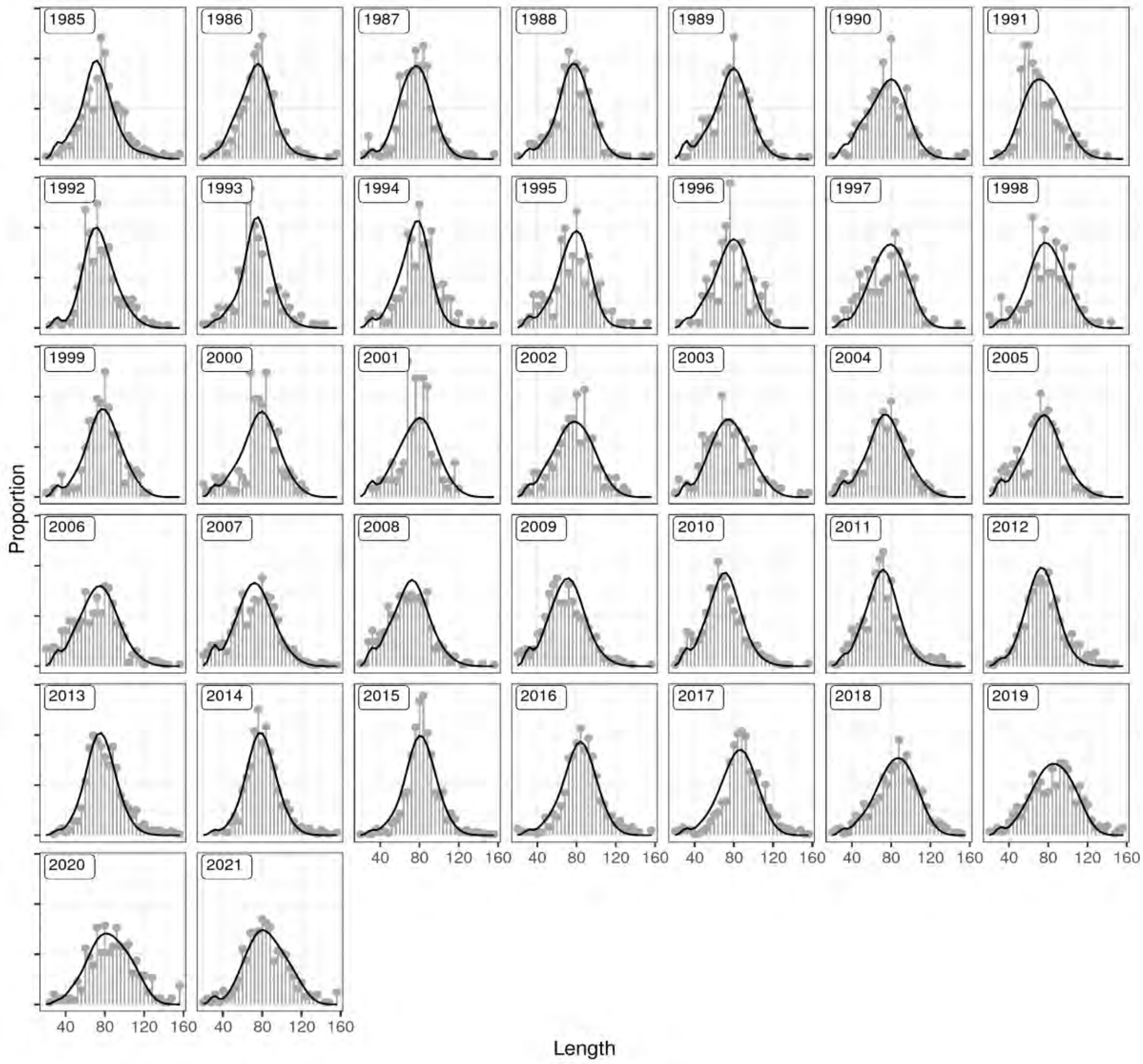


Figure 3.4.11: Ling in 5.a and 14. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the spring survey (grey lines and points)

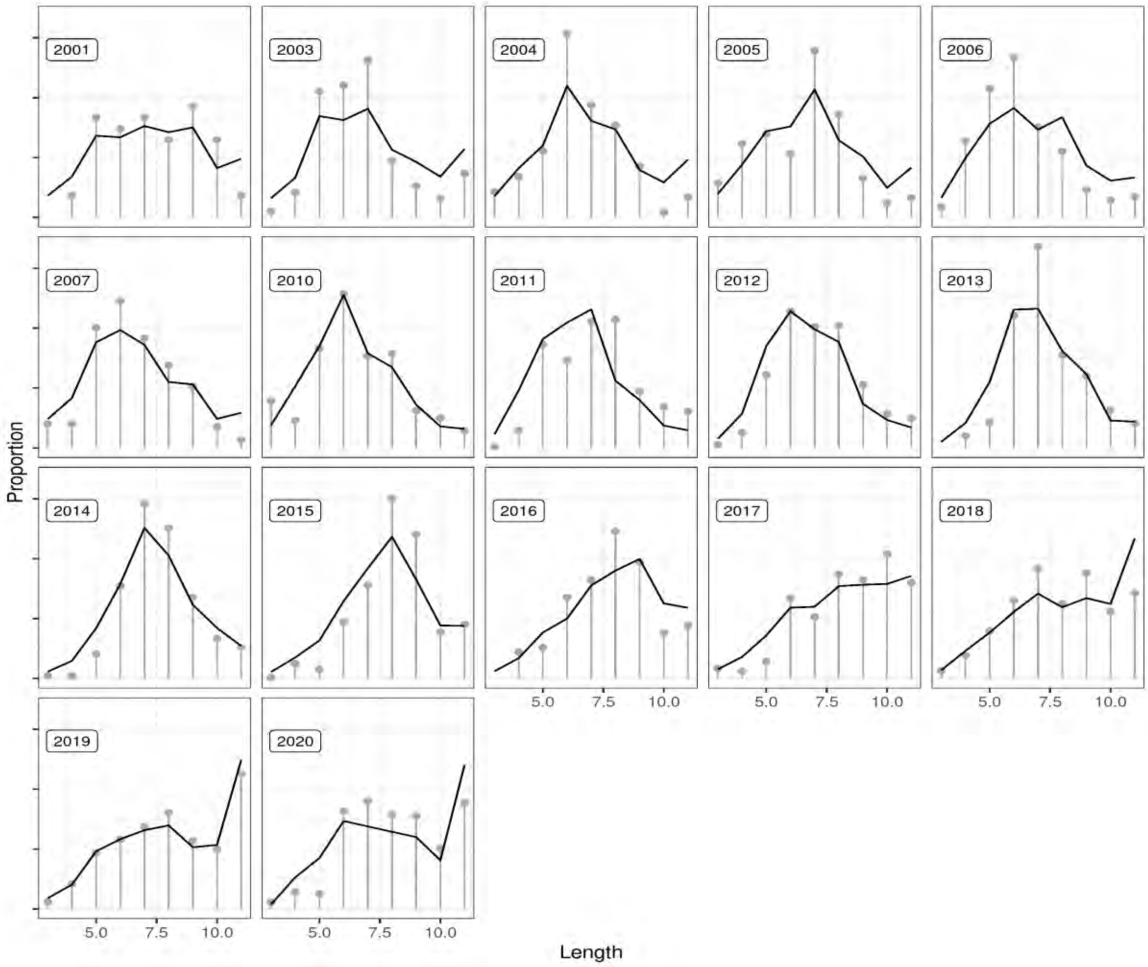


Figure 3.4.12: Ling in 5.a and 14. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the spring survey catches (grey lines and points).

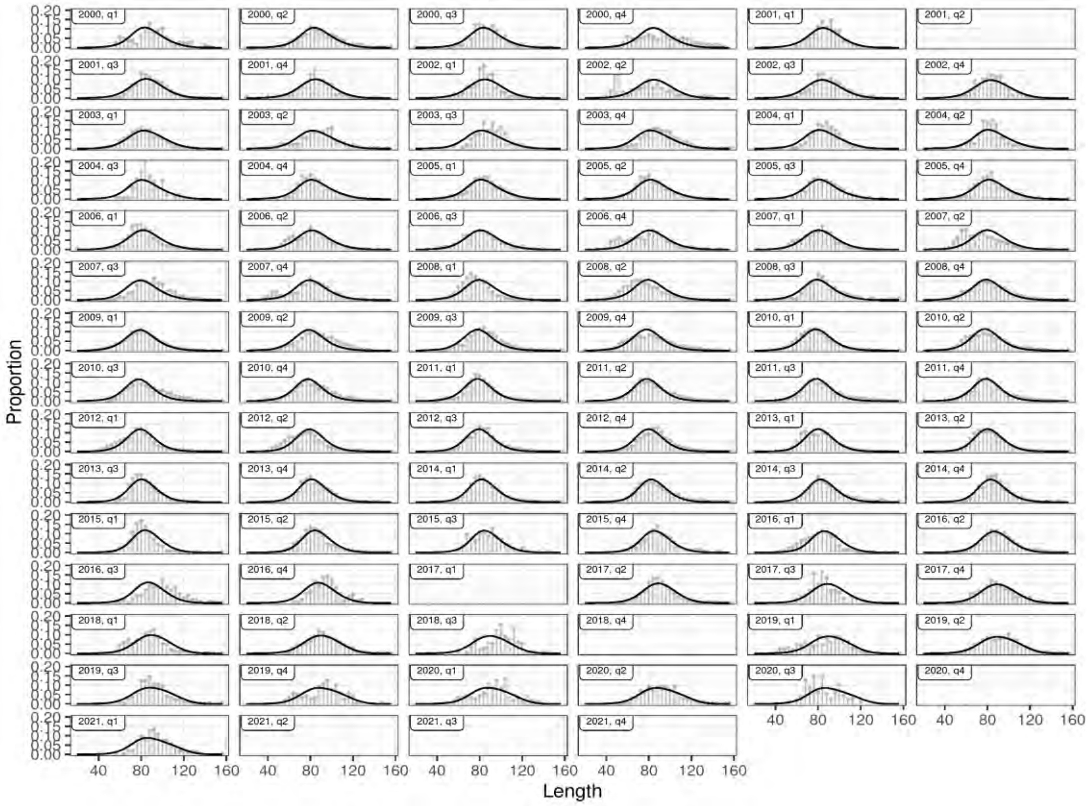


Figure 3.4.13: Ling in 5.a and 14. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from longline catches (grey lines and points).

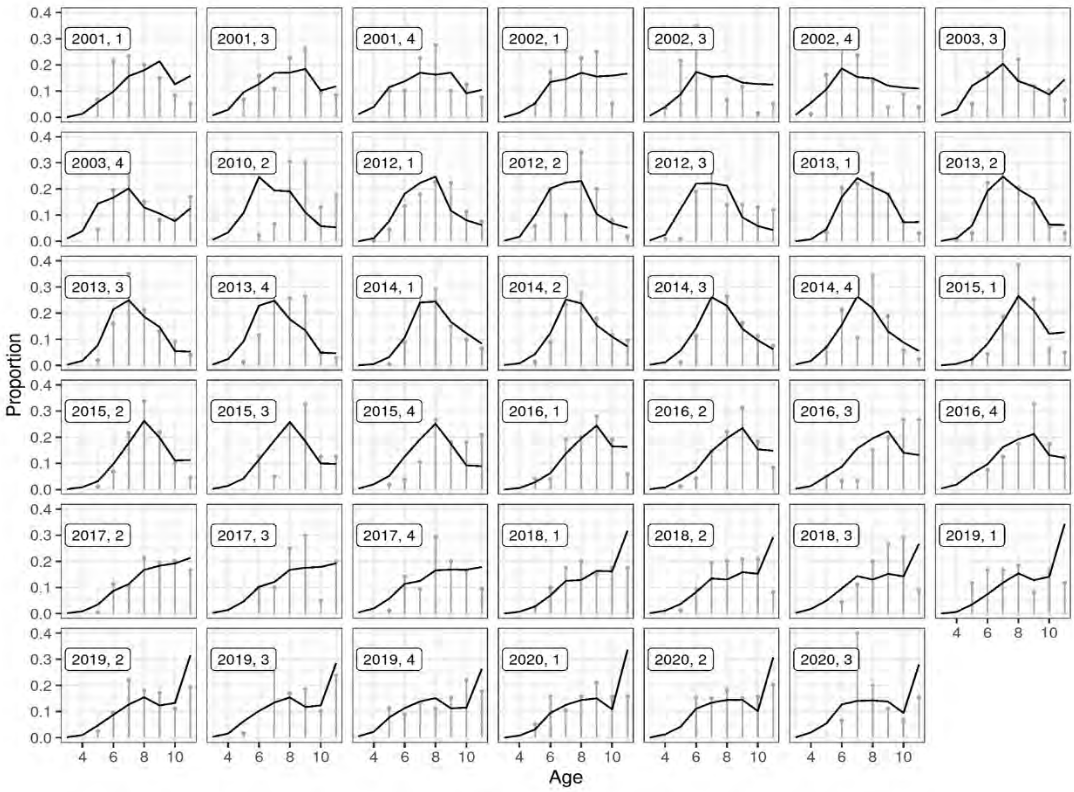


Figure 3.4.14: Ling in 5.a and 14. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in longline catches (grey lines and points).

3.4.9.2 Model fit

Figure 3.4.15 shows the overall fit to the survey indices described in the stock annex. In general, the model appears to follow the stock trends historically. Furthermore, the terminal estimate is not seen to deviate substantially from the observed value for most length groups, with model overestimating the abundance in the two largest length group. Summed up over survey biomass the model overestimates the biomass in the terminal years.

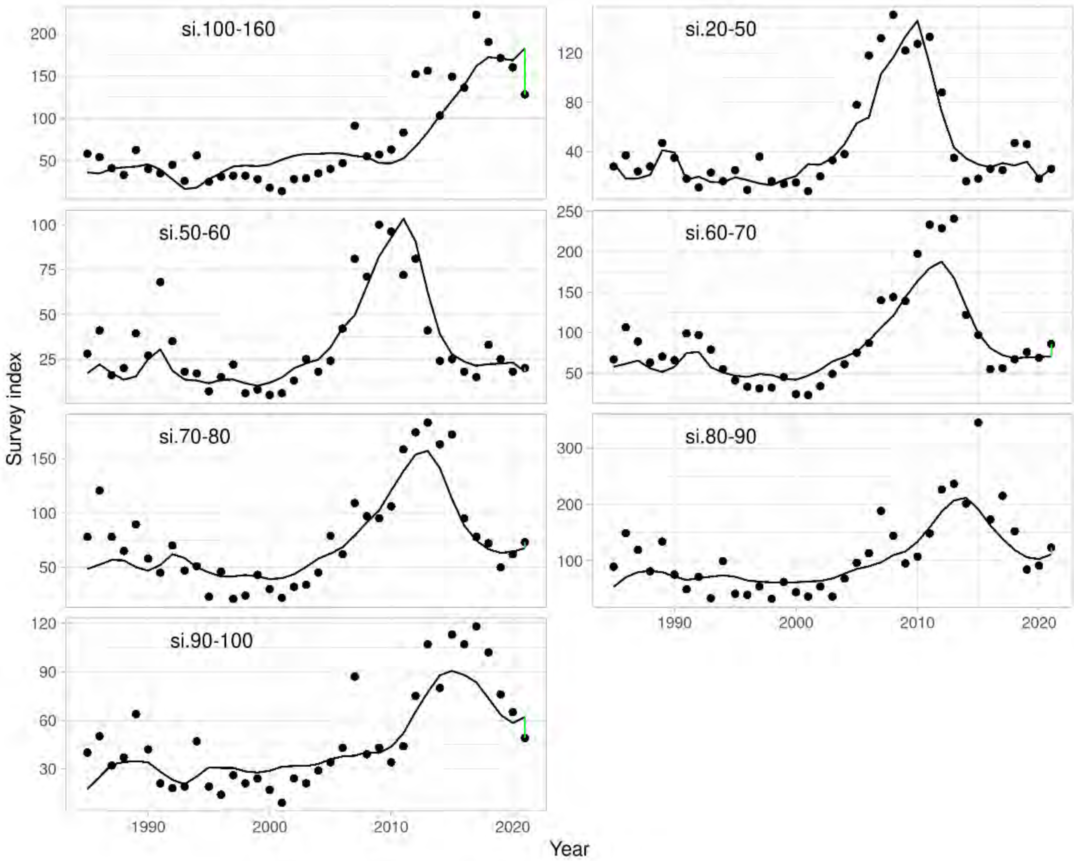


Figure 3.4.15: Ling in 5.a and 14. Fitted spring survey index by length group from the Gadget model (black line) and the observed number of ling caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

3.4.10 Results

The results are presented in Table 3.4.6 and Figure 3.4.16. The results are presented in Table 6 and Figure 16. Recruitment peaked in 2007 to 2010 but has decreased and is estimated in 2013 to 2015 to be at a level similar to that observed before the peak. The 2021 recruitment estimate is high compared to last year. Spawning–stock biomass has increased since 2000 and was estimated to be at its highest during 2014–2019 but has decreased this year and is expected to continue to decrease. Similarly, harvestable biomass was estimated at its highest level in 2015 but shows a slow and steady decrease. Fishing mortality for fully selected ling (age 14–19) has decreased from 0.66 in 2009 to 0.29 in 2020.

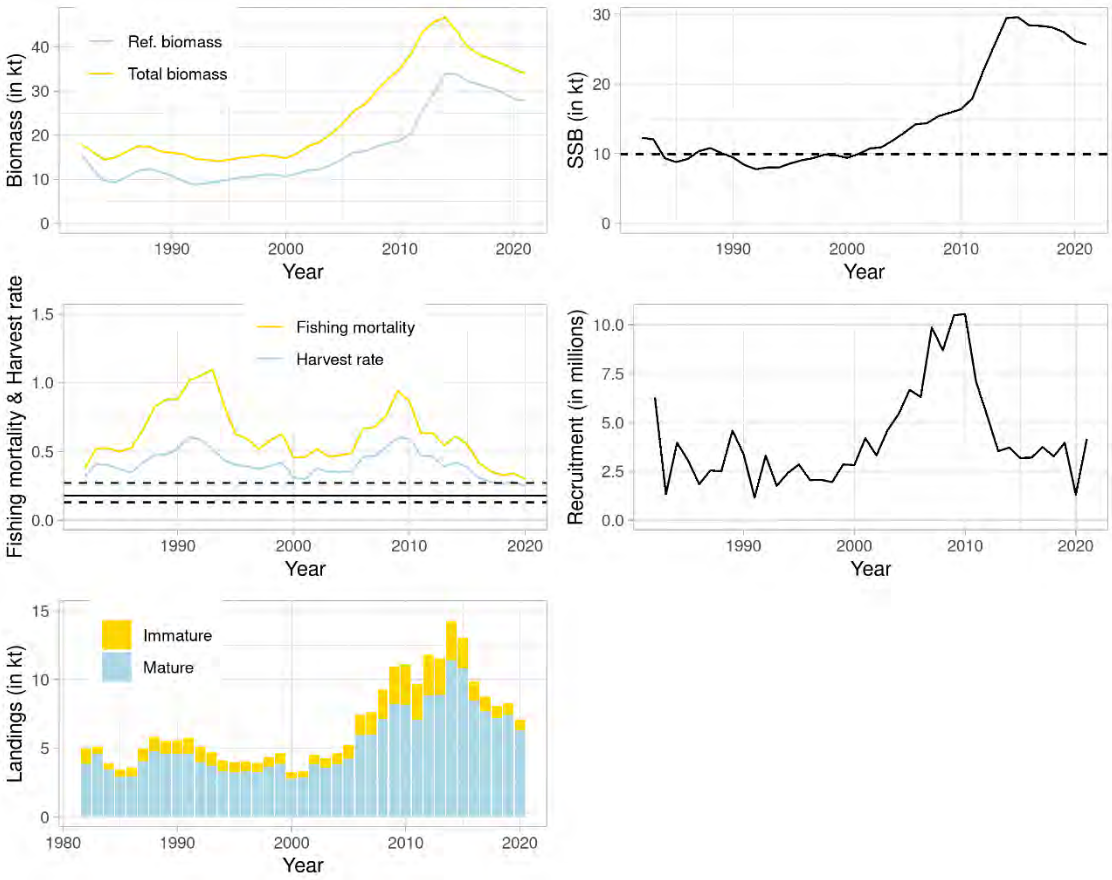


Figure 3.4.16: Ling in 5.a and 14. Estimated total biomass and reference biomass (>70+ cm), spawning stock biomass (SSB), fishing mortality for fully selected fishes and harvest rate, recruitment, and total catches. The dashed line in the SSB plot represents Bpa. The solid line in the harvest rate plot indicates the target harvest rate used in the harvest control rule, whereas the dashed lines indicate the bounds of the realized harvest rates resulting from the harvest control rule given the uncertainty in the assessment.

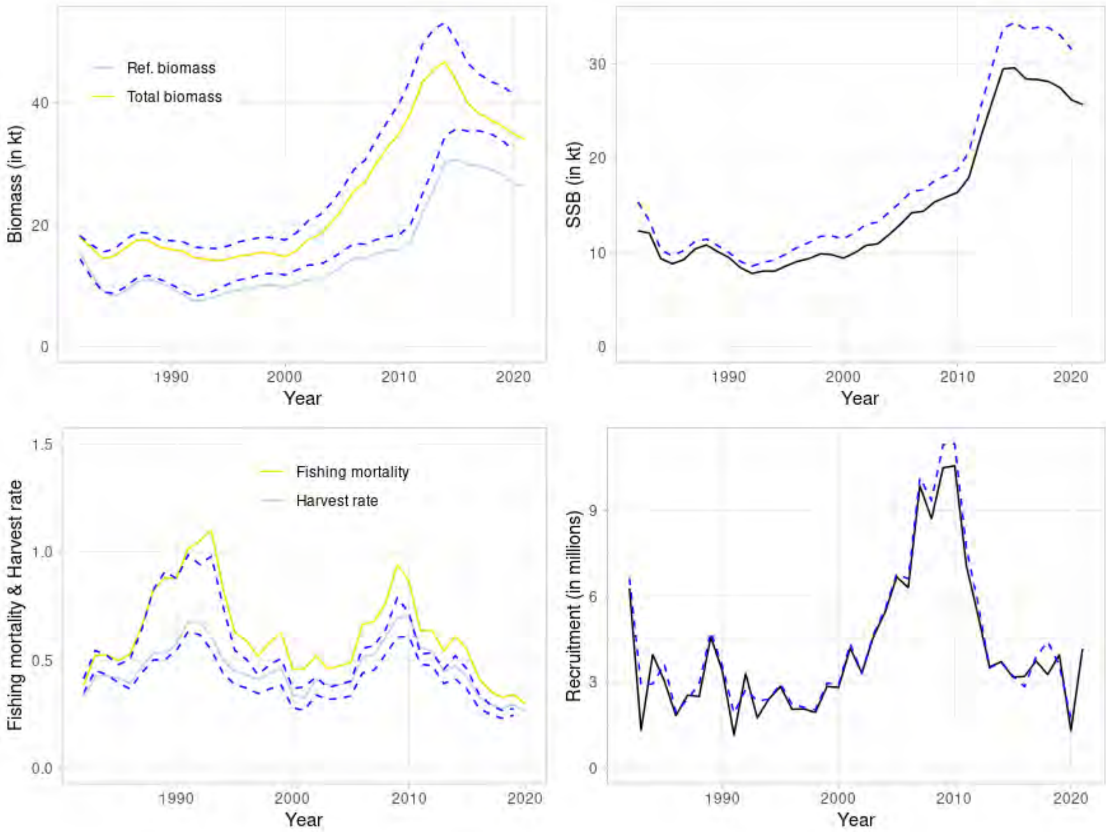


Figure 3.4.17: Ling in 5.a and 14. This year's assessment (blue and yellow lines) compared with the previous year's assessment (dashed lines). Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes and harvest rate and recruitment.

3.4.10.1 Retrospective analysis

The results of an analytical retrospective analysis are presented. The analysis indicates that there was an upward revision of biomass from the 5th to the 4th peel, followed by a downward revision of biomass that was more stably estimated over the last 3 years. As a result, there was a downward then upward revision of F. Estimates of recruitment are decently stable except for the apparent peak in 2017 - 2018. As explained in reference to the survey indices, this is likely the influence of highly variable survey indices that, for the smallest sizes in the most recent years, have no repeated observations at larger sizes with which this influence can be tempered. Therefore, it is expected that these recruitment peaks may simply be the result of uncertainty in survey indices and are likely to disappear in the coming assessment years. In addition, the downward revision observed between peels 4 and 3 is the result of the population reaching its peak in biomass and now decreasing. As the steep decrease in age 3 recruitment observed in 2010 - 2013 is expected to now be observed as decreased spawning stock size, it is likely that more downward revisions will be observed over the next 3 - 5 annual assessment cycles.

Mohn's rho was estimated to be 0.0778 for SSB, 0.306 for F, and 0.134 for recruitment.

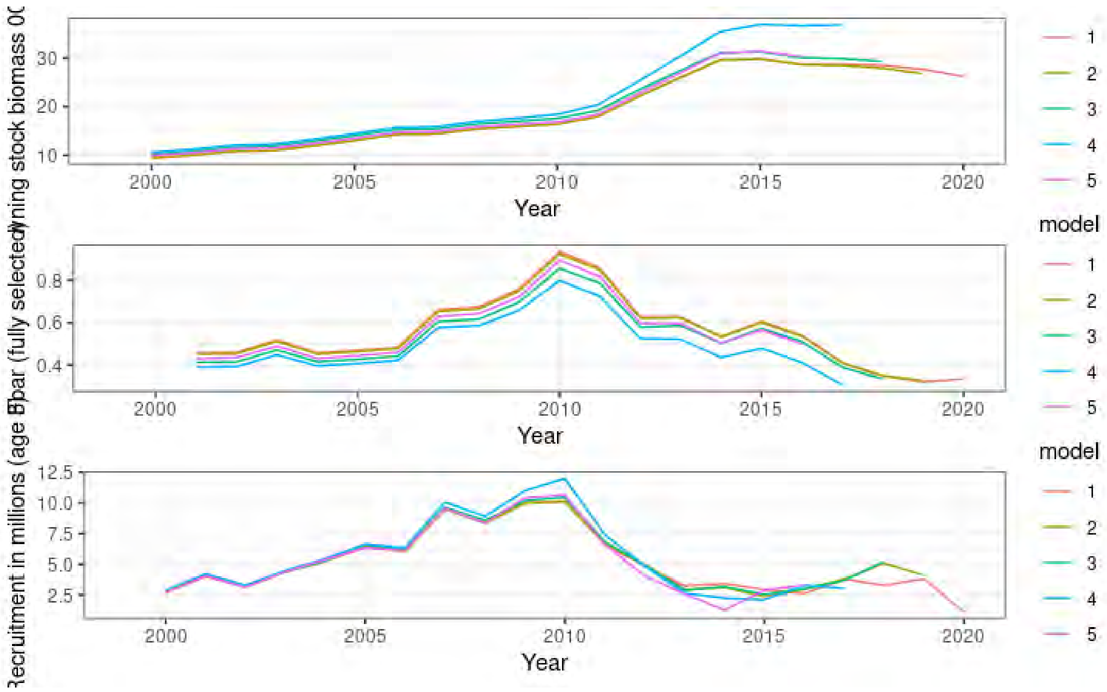


Figure 3.4.18: Ling in 5.a and 14. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 3) are shown.

3.4.11 ICES advice

In 2021, ICES advised that when the Iceland management plan was applied, catches in the fishing year 2021/2022 should be no more than 4 735 tonnes.

3.4.12 Management

The Icelandic Ministry of Industries and Innovation is responsible for management of the Icelandic fisheries and implementation of legislation. The Ministry issues regulations for commercial fishing for each fishing year (1 September–31 August), including an allocation of the TAC for each stock subject to such limitations. Ling in 5.a has been managed by TAC since the 2001/2002 fishing year.

Landings have exceeded both the advice given by MFRI and the set TAC from 2002/2003 to 2013/2014 but amounted to less than two thirds in 2015/2016 (Table 3.4.4). Overshoot in landings in relation to advice/TAC has been decreasing steadily since the 2009/2010 fishing year, with an overshoot of 53% to 35% in 2010/2011, 24% in 2011/2012 and 4% in 2012/2013. The reasons for the implementation errors are transfers of quota share between fishing years, conversion of TAC from one species to another (Figure 3.4.19) and additional catches by Norway and the Faroe Islands, taken in accordance with bilateral agreement. The level of those catches is known in advance but has until recently not been taken into consideration by the Ministry when allocating TAC to Icelandic vessels. There is no minimum landing size for ling.

There are agreements between Iceland, Norway and the Faroe Islands relating to a fishery of vessels in restricted areas within the Icelandic EEZ. Faroese vessels are allowed to fish 5600 t of demersal fish species in Icelandic waters which includes maximum 1200 tonnes of cod and 40 t of Atlantic halibut. The rest of the Faroese demersal fishery in Icelandic waters is mainly directed at tusk, ling and blue ling. Further description of the Icelandic management system can be found in the stock annex (ICES (2017b)).

Table 3.4.4: Ling in 5.a and 14. TAC recommended for ling in 5.a by the Marine and Fisheries Research Institute, national TAC and total landings.

Fishing Year	MFRI Advice	National TAC	Landings
1999/00			3 961
2000/01			3 451
2001/02	3 000	3 000	2 968
2002/03	3 000	3 000	3 715
2003/04	3 000	3 000	4 608
2004/05	4 000	4 000	5 238
2005/06	4 500	5 000	6 961
2006/07	5 000	5 000	7 617
2007/08	6 000	7 000	8 560
2008/09	6 000	7 000	10 489
2009/10	6 000	7 000	10 713
2010/11	7 500	7 500	10 095
2011/12	8 800	9 000	11 133
2012/13	12 000	11 500	12 445
2013/14	14 000	13 500	14 983
2014/15	14 300	13 800	13 166
2015/16	16 200	15 000	11 229
2016/17	9 343	8 143	8 426
2017/18	8 598	7 598	8 573
2018/19	6 255	5 200	6 927
2019/20	6 599	5299	7155
2020/21	5700		

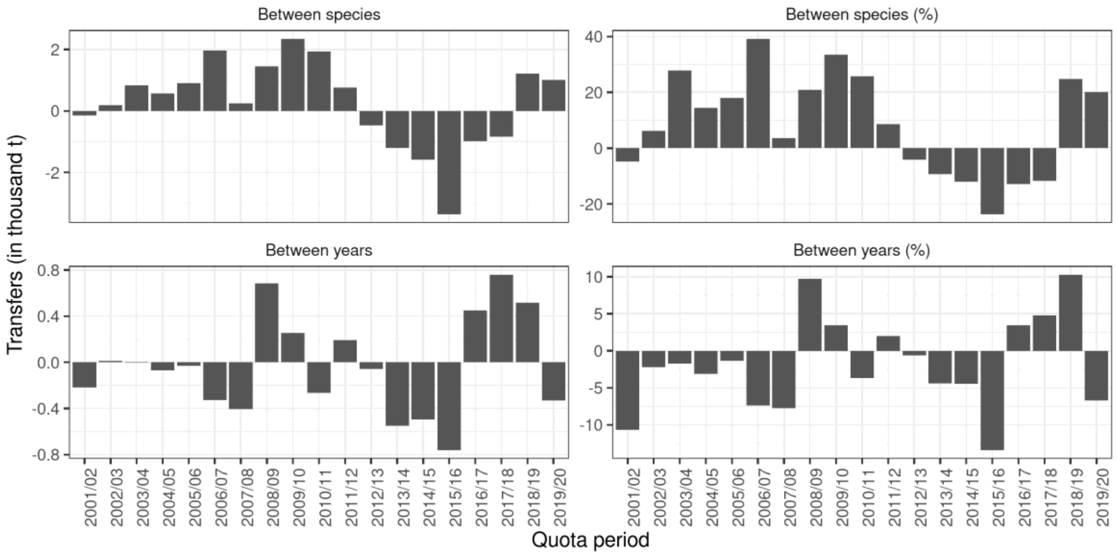


Figure 3.4.19: Ling in 5.a and 14. Net transfer of quota in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to ling, but negative values indicate a transfer of ling quota to other species. Between years (lower): Net transfer of quota for a given fishing year (may include unused quota).

3.4.13 Current management plan

As part of the WKICESMSE 2017 HCR evaluations (ICES 2017a), the following reference points were defined for the stock:

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	9.93 kt	B_{pa}
	H_{msy}	0.24	The harvest rate that maximises the median long-term catch in stochastic simulations with recruitment drawn from a block bootstrap of historical recruitment scaled according to a hockey stick recruitment function with B_{loss} as defined below.
	F_{msy}	0.284	The median fishing mortality when an harvest rate of H_{msy} is applied.
Precautionary approach	B_{lim}	7.09 kt	$B_{pa}/e^{1.645\sigma}$ where $\sigma = 0.2$
	B_{pa}	9.93 kt	SSB(1992), corresponding to B_{loss}
	H_{lim}	0.56	H corresponding to 50% long-term probability of SSB $> B_{lim}$
	F_{lim}	0.70	F corresponding to H_{lim}
	F_{pa}	0.41	$F_{lim}/e^{1.645\sigma}$ where $\sigma = 0.33$
	H_{pa}	0.35	H corresponding to F_{pa}
Management plan	H_{mp}	0.18	H such that $P(SSB < B_{pa}$|for any given year$) < 0.05$.

Figure 3.4.20: Ling in 5.a and 14. Reference points

The management plan accepted was: The spawning–stock biomass trigger (MGT Btrigger) is defined as 9.93 kilotonnes, the reference biomass is defined as the biomass of ling 70+ cm and the target harvest rate (HRMGT) is set to 0.18. In the assessment year (Y) the TAC for the next fishing year (September 1 of year Y to August 31 of year Y+1) is calculated as follows: When SSBY is equal or above MGT Btrigger: TACY/y+1 = HRMGT*BRef,y When SSBY is below MGT Btrigger: TACY/y+1 = HRMGT* (SSBy/MGT Btrigger) * Bref,y WKICEMSE 2017 concluded that the HCR was precautionary and in conformity with the ICES MSY approach.

3.4.14 Management considerations

All the signs from commercial catch data and surveys indicate that ling is at present in a good state, even though the survey indices show downward trend in most recent years. This is confirmed in the Gadget assessment. However, the drop in recruitment since 2010 will result in decrease in sustainable catches in the near future. Currently the longline and trawl fishery represent 95% of the total fishery, while the remainder is assigned to gillnets. Should those proportions change dramatically, so will the total catches as the selectivity of the gillnet fleet is substantially different from other fleets.

Table 3.4.5: Ling in 5.a and 14. Landings (tonnes) by country in 5.a.

Year	Faroe Islands	Germany	Iceland	Norway	UK
2002	1631	0	2843	45	0
2003	570	2	3585	108	5
2004	739	1	3727	139	0
2005	682	3	4313	180	20
2006	962	1	6283	158	0
2007	807	0	6599	185	0
2008	1366	0	7738	179	0
2009	1157	0	9616	172	0
2010	1095	1	9868	168	0
2011	588	0	8789	249	0
2012	875	0	10695	248	0
2013	1030	0	10198	294	0
2014	1738	0	12350	158	0
2015	1233	0	11552	250	0
2016	1072	0	8583	230	0
2017	829	0	7692	244	0
2018	1103	0	6756	203	0
2019	1093	0	6992	184	0
2020	989	0	5836	237	0

Table 3.4.6. Tusk in 5.a and 14. Estimates of biomass, biomass 75+ cm, spawning–stock biomass (SSB) in thousands of tonnes and recruitment at age 1 (millions), harvest rate (HR) and fishing mortality from Gadget.

Year	Biomass	B40+	SSB	Rec3	Catch	HR	F
1982	18025	15374	12272	6274	4990	0.3245661	0.3847664
1983	16300	12068	12033	1325	5123	0.4245079	0.5220458
1984	14468	9084	9334	3959	3880	0.4270757	0.5229999
1985	14860	8270	8782	3047	3450	0.4171414	0.4981307
1986	16227	9204	9215	1833	3596	0.3907509	0.5264808
1987	17475	10605	10346	2541	4974	0.4690014	0.6563439
1988	17435	11061	10787	2499	5846	0.5285165	0.8249893
1989	16314	10495	10061	4578	5547	0.5284825	0.8793505
1990	15966	9684	9419	3384	5562	0.5743323	0.8793992
1991	15682	8560	8354	1157	5786	0.6758984	1.0158334
1992	14604	7507	7756	3296	5089	0.6779047	1.0520722
1993	14368	7733	8007	1755	4713	0.6094853	1.0978429
1994	14097	8274	7999	2411	4114	0.4972561	0.8319725
1995	14375	8884	8568	2848	3973	0.4471917	0.6280615
1996	14890	9384	9035	2050	4068	0.4334756	0.5904247
1997	15132	9584	9334	2064	3913	0.4082190	0.5177041
1998	15475	9988	9842	1943	4354	0.4359269	0.5794658
1999	15207	10033	9755	2848	4623	0.4607841	0.6271320
2000	14751	9644	9380	2814	3279	0.3400225	0.4581415
2001	15826	10340	9937	4191	3355	0.3244067	0.4577054
2002	17542	11071	10739	3309	4527	0.4089269	0.5202638
2003	18423	11096	10890	4592	4281	0.3858220	0.4602551
2004	20263	11966	11867	5429	4628	0.3867674	0.4721237
2005	22626	13220	12964	6666	5219	0.3947768	0.4878131
2006	25546	14516	14190	6301	7431	0.5119168	0.6649649
2007	27064	14457	14348	9850	7619	0.5270253	0.6778604
2008	30174	15273	15341	8700	9279	0.6075612	0.7640860
2009	32786	15773	15851	10480	10948	0.6940933	0.9412426

Year	Biomass	B40+	SSB	Rec3	Catch	HR	F
2010	35094	15861	16356	10546	11150	0.7030059	0.8658254
2011	38425	17389	17911	7064	9651	0.5549826	0.6341439
2012	43390	21808	22043	5336	11828	0.5423801	0.6349251
2013	45626	25731	25793	3525	11536	0.4483119	0.5414505
2014	46729	30233	29449	3713	14246	0.4712265	0.6117677
2015	43565	30785	29566	3176	13036	0.4234666	0.5472376
2016	39931	29849	28384	3196	9884	0.3311291	0.4180847
2017	38273	29615	28318	3737	8766	0.2959844	0.3561808
2018	37179	29051	28109	3264	8062	0.2775206	0.3275949
2019	36233	28226	27453	3950	8269	0.2929494	0.3399325
2020	34926	26730	26157	1306	7061	0.2641664	0.2983928
2021	34400	26304	25667	4165	3127	0.1188742	0.1332668

3.4.15 Ecosystem considerations

In 2010 to 2013, the distribution of ling expanded to the north and recruitment peaked (Figure 3.4.3 and Figure 3.4.8). These suggest favourable environmental conditions during this time; however, recruitment has returned to previous levels and therefore biomass levels are naturally expected to follow. In addition, there have been no obvious changes in maturity patterns or growth through time. Demographic patterns of ling should be monitored as other Icelandic demersal species have exhibited recent changes (e.g., haddock). Multispecies interactions are not currently considered to be a concern for the assessment.

3.4.16 References

ICES. 2011. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (Wgdeep), 2 March–8 March, 2011, Copenhagen, Denmark. ICES Cm 2011/Acom:17." International Council for the Exploration of the Seas; ICES publishing.

2012. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (Wgdeep), 28 March–5 April, 2012, Copenhagen, Denmark. ICES Cm 2012/Acom:17." International Council for the Exploration of the Seas; ICES publishing.

2017a. "Report of the Workshop on Evaluation of the Adopted Harvest Control Rules for Icelandic Summer Spawning Herring, Ling and Tusk (WKICEMSE), 21–25 April 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:45." International Council for the Exploration of the Seas; ICES publishing.

2017b. "Stock Annex: Ling (Molva molva) in Division 5.a (Iceland grounds)." International Council for the Exploration of the Seas; ICES publishing.

2019. "11.2 Icelandic Waters ecoregion – Fisheries overview." International Council for the Exploration of the Seas; ICES publishing. https://doi.org/10.17895/ices.advice.5706.

3.5 Ling (*Molva molva*) in subareas 3,4, 6–9, 12, and 14 (Northeast Atlantic and Arctic Ocean)

3.5.1 The fishery

Significant fisheries for ling are conducted in Subareas 3 and 4 at least since the 1870s pioneered by Swedish longliners. Since the mid-1900s, the major ling targeted fishery in Area 4.a. There Norwegian longliners fished around Shetland and in the Norwegian Deep. There is little activity in ICES Division 3.a. The Norwegian total landings in 2019 in Subareas 3 and 4 were: 83% taken by longlines, 9% by gillnets, and the remainder by trawls. The bulk of the landings from other countries were taken by trawls as bycatches, and the landings from the UK (Scotland) are the most substantial. The comparatively low landings from central and southern North Sea (4.b,c) are bycatches from various other fisheries.

The major directed ling fishery in subarea 6 is the Norwegian longline fishery. Catches of ling by trawl fisheries from the UK (Scotland) and from France are primarily bycatches.

When subareas 3–4 and 6–14 are summed over 1988–2019, 42% of the total landings were in Subarea 4, 30% in Subarea 6, and 24% in Subarea 7.

In Subarea 7, divisions b, c, and g–k provide most of the landings of ling. Norwegian landings, and some Irish and Spanish landings are from targeted longline fisheries, whereas other landings are primarily bycatches in trawl fisheries. Data split by gear type were not available for all countries, but the bulk of the total landings (at least 60–70%) were taken by trawls in these areas.

In Subareas 8 and 9, 12 and 14 all landings are bycatches from various fisheries.

The Norwegian fishery

The Norwegian longline fleet increased from 36 in 1977 to a peak of 72 in 2000, and afterwards the number of vessels decreased and then stabilized at -26 in 2015 to 2018 but increased to 30 in 2020. The number of vessels declined mainly because of changes in the law concerning the quotas for cod. The average number of days that each Norwegian longliner operated in an ICES division was highly variable for 4.a, stable for 6.b and declining for 6.a. The average number of hooks has remained relatively stable in Divisions 4.a and 6.a. During the period 1974 to 2020 the total number of hooks per year has varied considerably, but with a downward trend since 2000. This is also reflected in the number of fishing days (Figure 3.5.1).

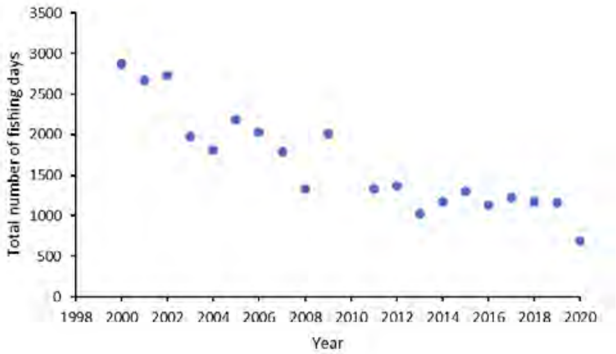


Figure 3.5.1. Total fishing days by the Norwegian longliners (20002020).

The French fishery

French fleets operating in 6, 7b-k are mainly otter trawlers, gillnetters and longliners.

The number of otter trawlers operating in the region has decreased from around 70 in the beginning of 2000 to 28 in 2018. Gillnetters have varied from 24 vessels in 2005 to 5 in 2016. In 2018 the number of vessels increased to 14. The number of longliners has increased from 1 in 2000 to 16 in 2019 (Table 3.5.3).

Since 2000, otter trawlers effort has decreased by a factor of 2. Gillnetters had a peak effort in mid-2000 followed by a steep decrease by a factor of 5 since 2010 as increase in 2017 and 2018. The recorded fishing efforts by longliners were imprecise due to lack of information in the first part of the 2000s. The activity seems to have peaked in 2007 followed by a sharp decrease to 2009. Since 2009, the effort has been steadily increasing (Figure 3.5.13).

Landings of ling by otter trawlers increased from 2004 to 2014, and since declined. For gillnetters and longliners, landings are closely related to changes in efforts.

The Spanish fishery

The Spanish catches of ling in ICES Subarea 7, are mostly in Divisions b, c and g–k, and are mainly taken by longliners. However, there are also important bycatches of ling by trawlers operating in the Subarea 7. Porcupine Bank is an important fishing area for the Spanish trawlers, therefore the data from the Porcupine Bank Spanish ground fish survey could be useful as an indicator of abundance and status of ling in the area.

3.5.2 Landings trends

Landing statistics for ling by nation in the period 1988–2019 are in Tables 3.5.1 and 3.5.2 and in Figures 3.5.2 and 3.5.3. For the early time-series, from 1988 to 2000, only international landings by area are presented (table 3.5.2), see stock annex for details of landings by country and area before 200. Detailled landings by area and country are presented for the time-series 2001-2021 only (Table 3.5.1).

There was a decline in landings from 1988 to 2003, and since lannded has been stable and slightly increasing. Areas 3–14 are pooled, the total landings averaged around 32 000 t in the period 1988–1998 and afterwards the average catch varied between 16 000 and 20 000 tons per year. The preliminary landings for 2020 is 15 257 t.

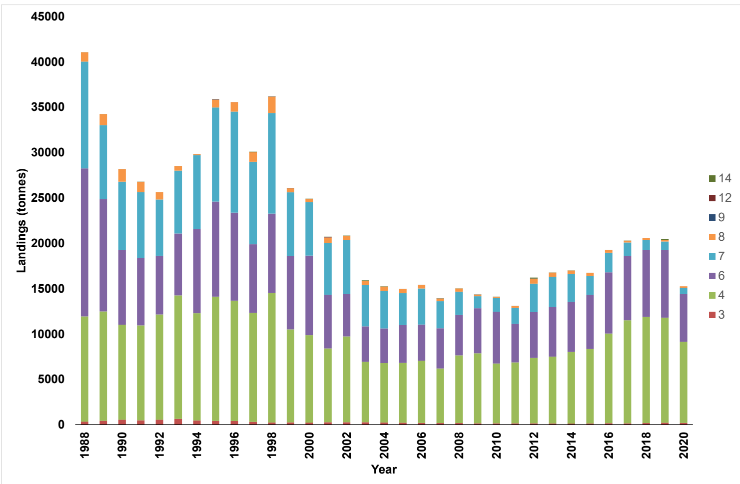


Figure 3.5.2. International landings of ling in subareas 3,4, 6–9, 12, and 14 .

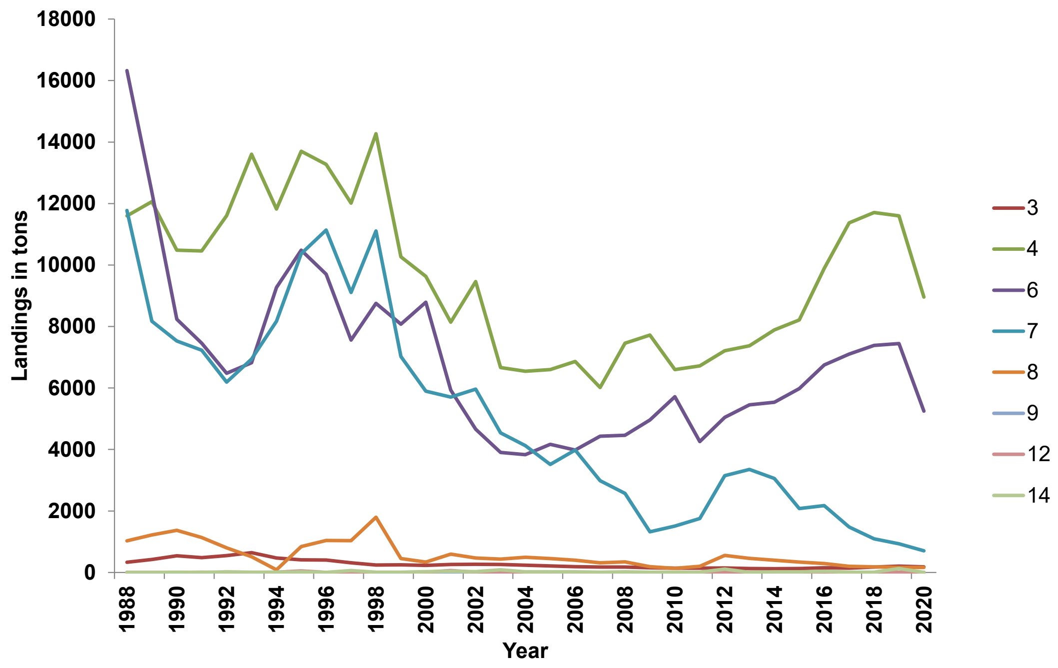


Figure 3.5.3. International landings of ling in subareas 3,4, 6–9, 12, and 14 .

3.5.3 ICES Advice

Advice for 2020 to 2021: "ICES advises that when the precautionary approach is applied, catches should be no more than 18 516 tons in each of the years 2020 and 2021".

3.5.4 Management

Norway has a licensing scheme in EU waters, and in 2020 the Norwegian quota in EU waters is 8000 t. The Faroe Islands has a quota of 200 t in Divisions 6.a and 6.b. The quota for the EU in the Norwegian zone (Subarea 4) is set at 1 350 t. For 2021, provisional TACs have been set from 01.01.2021 to 31.07.2021

EU TACs in EU and international waters in the stock area and EU quota in Norwegian waters 2016–2021

	2016	2017	2018	2019	2020	2021(1)
Division 3a	87 t	87	87	170	179	68
Subarea 4 (EU waters)	2912 t	3494	3843	4035	4237	370
Subarea 4 (Norwegian waters)	950	1350	1350	1350	1350	900
Subarea 6, 7,8, 9, 10,12,14 (EU and international waters)	16 997 t.	20 396	20 396	20 396	20 396	5357

(1) provisional TACs set from 01.01.2021 to 31.07.2021

3.5.5 Data available

3.5.5.1 Landings and discards

Landings are available for all relevant fleets. Within the Norwegian EEZ and for Norwegian vessels fishing elsewhere, discarding is prohibited and therefore are no information about discards. Discards by countries are given In Table 3.5.4. for the years 2012 to 2020, In all years discards are <5%, so are considered negligible for assessment. The bulk of the discard is from UK (Scotland).

Table 3.5.4. Total discards of ling by country for the years 2012 to 2020.

	Denmark	Spain	Ireland	France	Sweden	UK (Scotland)	UK (England)	Total discard	Total catches	%discard
2012		46	176					222	16435	1.35
2013		101	160	29				290	17063	1.70
2014		54	435	15				504	17518	2.88
2015		0	0	131	4	704		839	17596	4.77
2016		1	220	72		1302	22	1598	20881	7.74
2017	1	10	105	71	2	959		1147	21443	5.35
2018	1		43	89		876	3	1012	21566	4.69
2019	3	8	70	13		993	9	1096	21837	4.85
2020	4	37	19	1	0	346	0	407		

3.5.5.2 Length composition

Data from the Norwegian reference fleet

Average fish length, weight–length relationships and the length distribution for the Norwegian longline and gillnet fishery in Divisions 4a, 6a, 6b for ling are shown in Figure 3.5.4–3.5.6, respectively. Data are from the Norwegian longline reference fleet. The length-weight relationship from sex combined is $W=0.0055*TL^{3.0120}$.

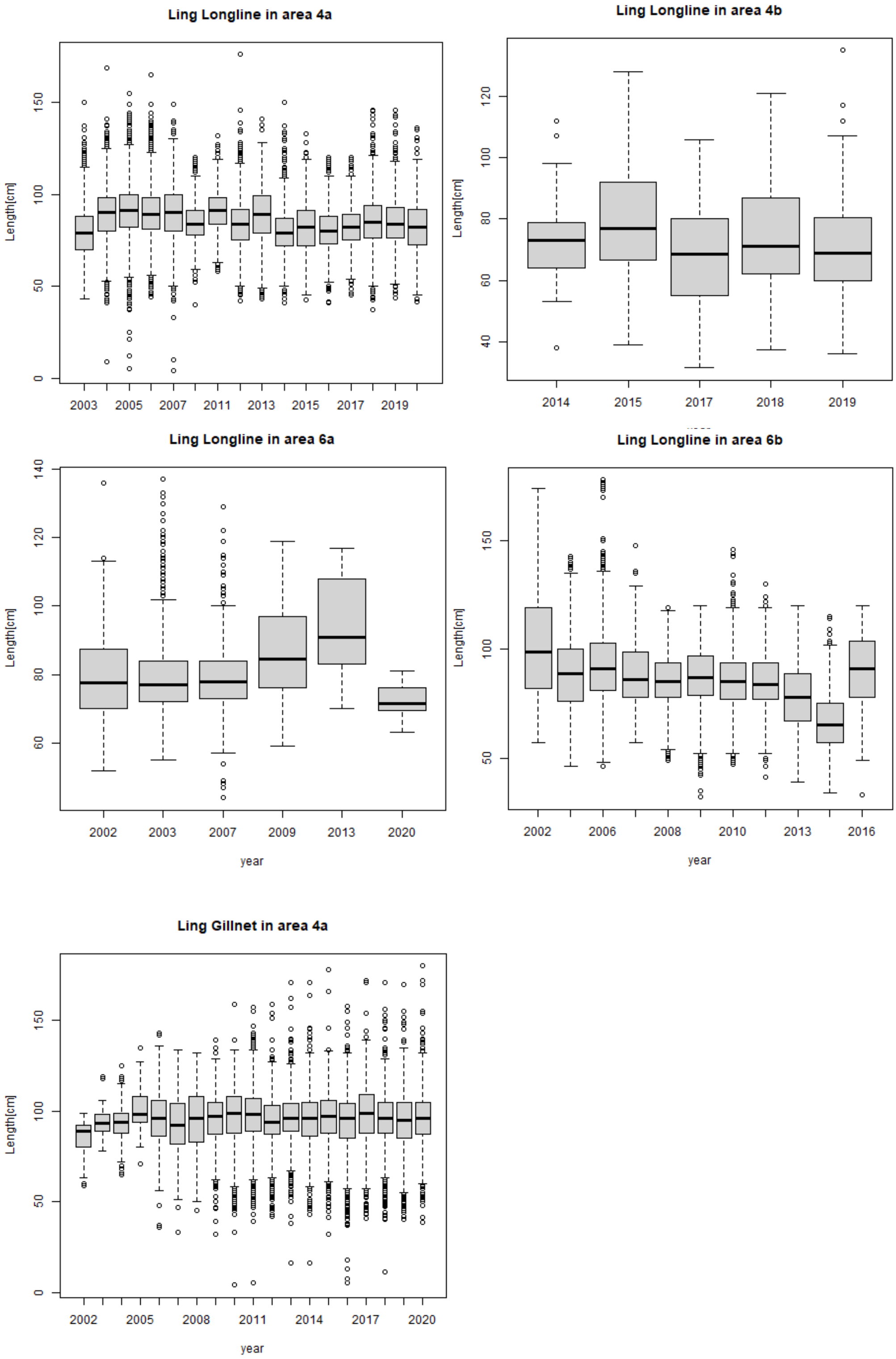


Figure 3.5.4. Time-series of mean length of ling caught by the Norwegian longline reference fleet in divisions 4.a, 4.b, 6.a and 6.b (note that some years are missing in some divisions).

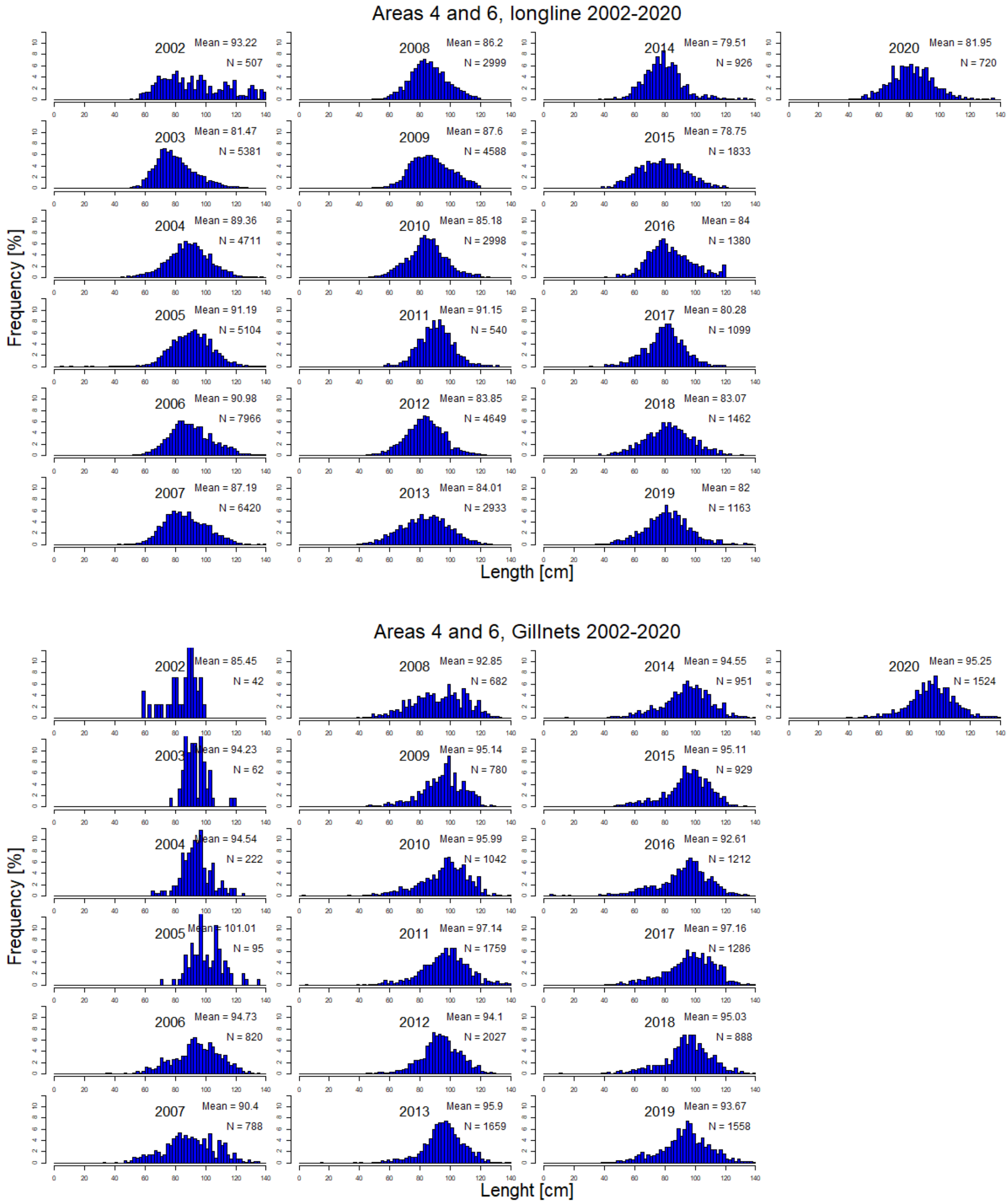


Figure 3.5.5. Length distributions of ling in Areas 3a, 4.a, 6.a and 6.b based on data from the Norwegian reference fleet.

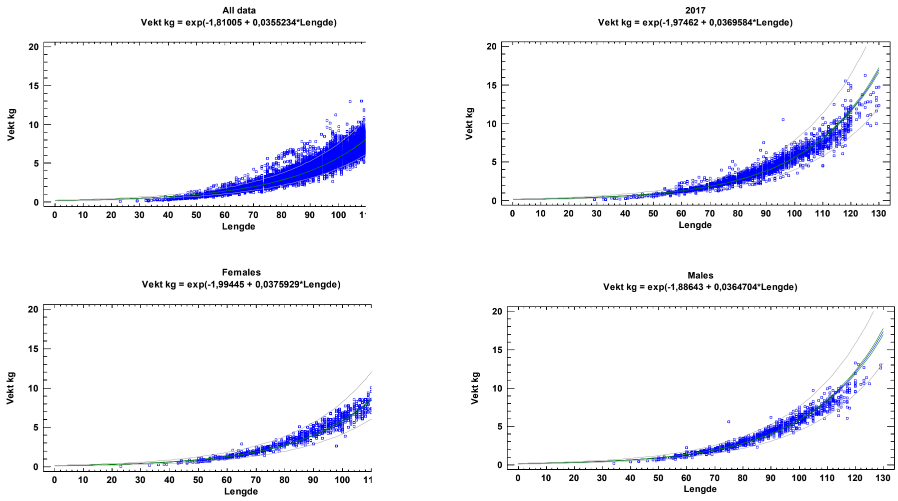


Figure 3.5.6. Weight as a function of length for ling based on all available Norwegian data.

Estimated Length distributions based on the Spanish Porcupine Bank (NE Atlantic) surveys

The length distribution of catches of ling in the Spanish Porcupine survey, reflect first the declining of number caught in this survey (3.5.7). Further individual remaining in the two last year are small for more information see Ruiz-Pico *et al*. (WD 2020).

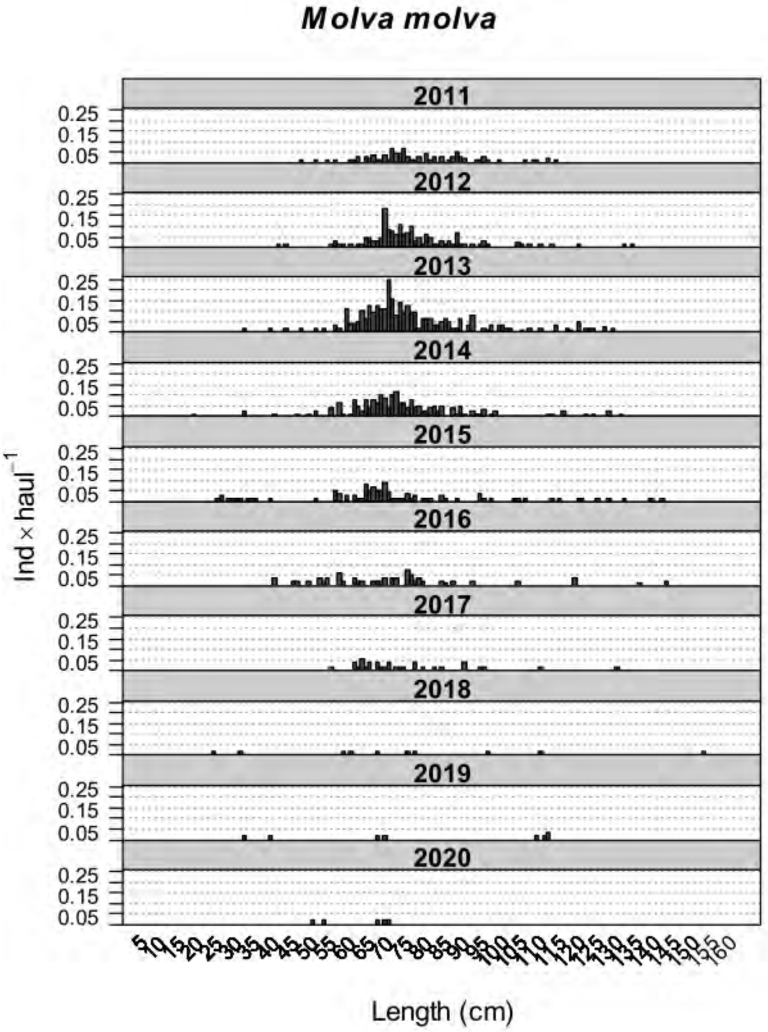


Figure 3.57. Estimated length distributions of ling (*M. molva*) based on the Porcupine Bank Spanish survey in the period 2011–2020.

3.5.5.3 Age compositions

Estimated age distributions for the years 2009–2019 based on data from the Norwegian Reference fleet for all areas combined (Figures 3.5.8) and box and whisker plots for the age composition of the fish taken by longliners and gillnetters in Area 4.a (Figure 3.5.9).

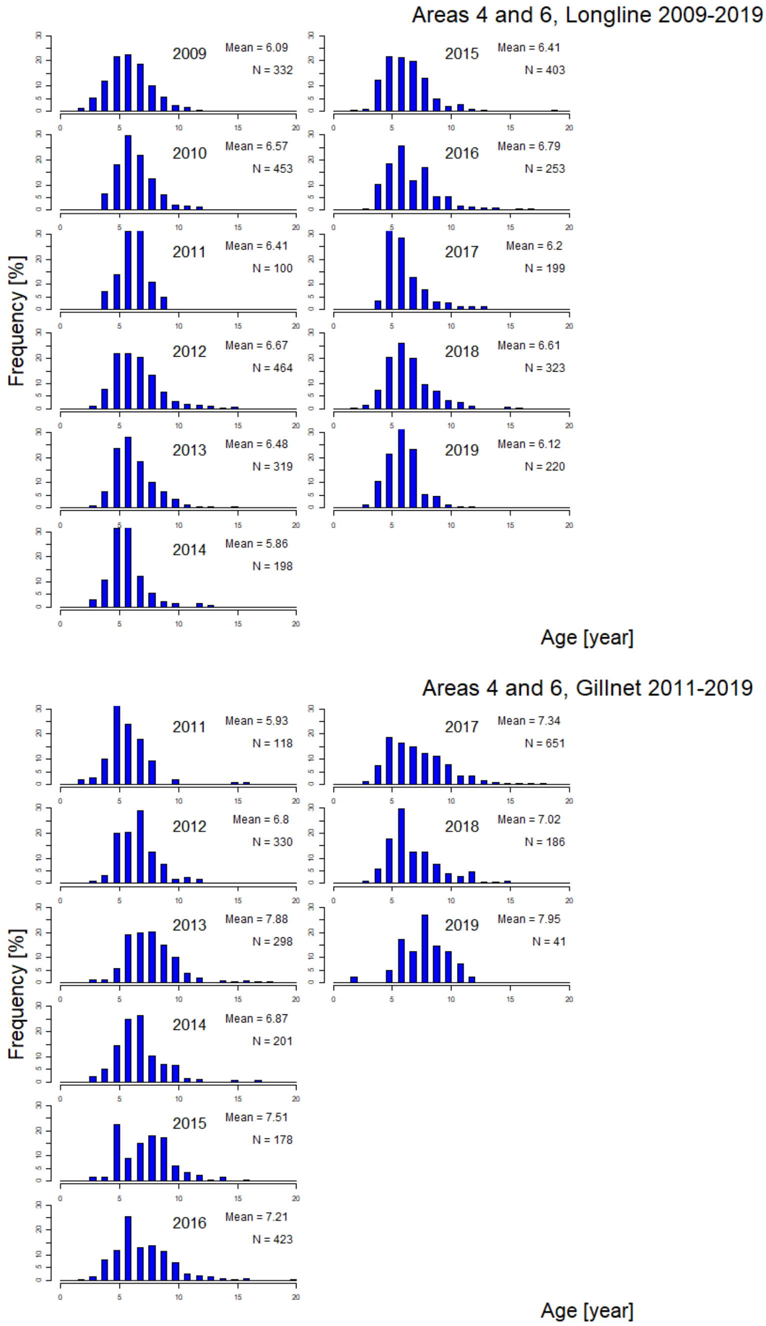


Figure 3.5.8. Age distributions for ling areas combined for all catches taken by longliners and by gillnetters.

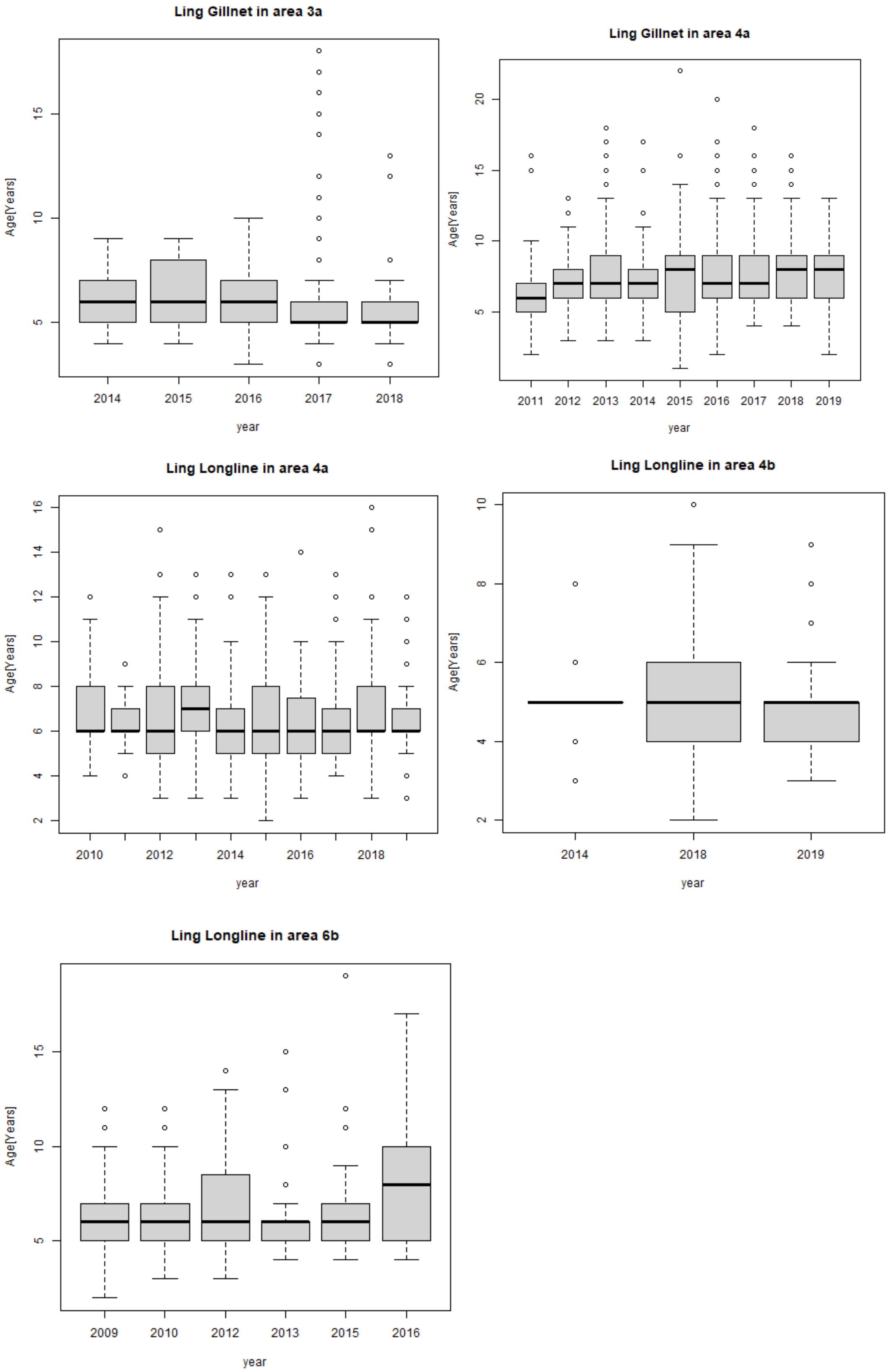


Figure 3.5.9. Average age of ling catches by longliners and gillnetters by area.

3.5.5.4 Weight-at-age

Weight and length at age for all age readings of ling from divisions 4.a and 6.a from 2009 to 2017 sampled from the longliners in the Norwegian reference fleet show quite linear relationships (Figure 3.5.10).

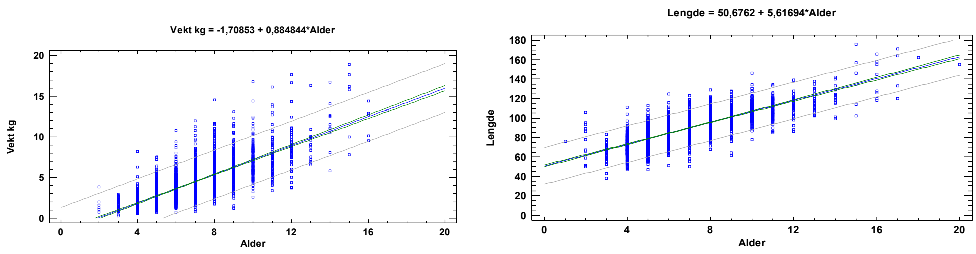


Figure 3.5.10. Weight versus age and length versus age for ling (combined data from 2009 to 2017) for divisions 4.a and 6.a based on the Norwegian longliner reference fleet.

3.5.5.5 Maturity and natural mortality

The maturity parameters used for the stock are:

Stock	L_{50}	N	A_{50}	N	Source
Lin-lin.27.3.a4.a6-91214	63.6	1472	4.8	336	Norwegian long liners (Reference fleet) and survey data

Similar estimates have been found in other area, e.g. Age at fist maturity around 5–7 years (60–75 cm lengths) with males maturing at a slightly younger age than females (Magnusson *et al.*, 1997).

There was no new data in 2021.

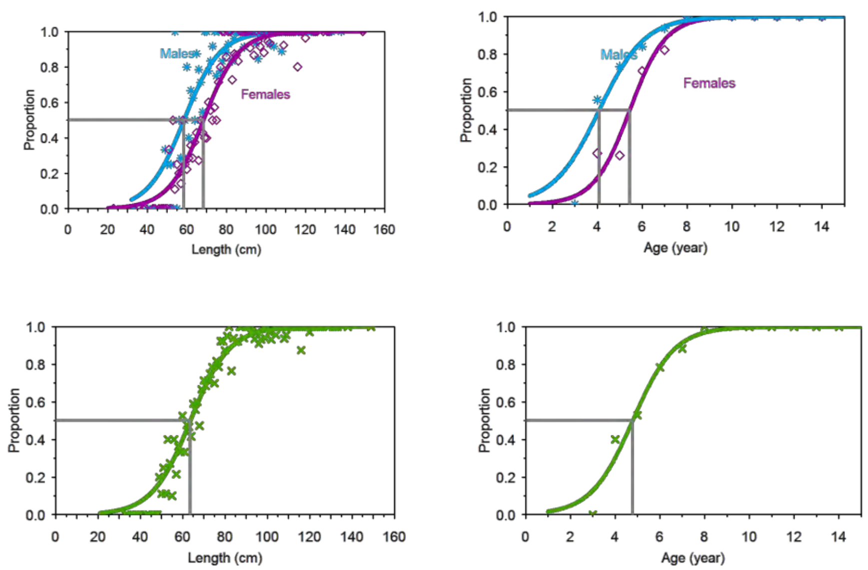


Figure 3.5.10. Ling (lin.27.3a4a6-91214), maturity ogives for age and length for males and females (top panel) and sexes combined (lower panel).

3.5.5.6 Growth

Preliminary new estimates of growth of ling were presented for the Celtic Sea, an area with no previous growth estimates for the species (Vieira and Visconti, 2021). Despite that growth parameters are necessary for length-based indicators (LBIs), they remain limited for ling (Table 3.5.7). Estimates from various studies in and out of the stock area differ.

Table 3.5.7. Growth estimated of ling

L∞	K	t_0	Sex	Area	Data from the stock area	Reference
119	0.136			Faroe Bank	No	Magnussen 2007
189	0.08			Northern North Sea	Yes	Bergstad & Hareide 1996
183	0.118		Female	Faeroe Islands	No	Joenoes 1961
166	0.103			West of Scotland	Yes	Bergstad & Hareide 1996
158	0.087			Rockall	Yes	Bergstad & Hareide 1996
141	0.143			Norwegian Sea		Bergstad & Hareide 1996
170	0.132		Male	Faeroe Islands	No	Joenoes 1961
124	0.163			Faeroe Islands	No	Bergstad & Hareide 1996
148	0.11	-2.19		Celtic Sea	Yes	Vieira and Visconti, 2021

3.5.5.7 Natural mortality

Natural mortality is also poorly known. For the adjacent stocks in the Faroese and Icelandic ecoregions (lin.27.5a and lin.27.5b) a natural mortality of 0.15 is assumed, the same is used here.

3.5.5.8 Catch, effort and research vessel data

Spanish Porcupine Bottom Trawl Survey

Spanish Porcupine Bottom Trawl Survey (SP-PORC) in ICES divisions 7.c and 7.k has been carried out annually since 2001 to study the distribution, relative abundance and biological parameters of commercial fish in these areas (ICES, 2010a; 2010b). The survey provides estimates of biomass and abundance indices. The stratification and location of station is shown in Figure 3.5.11.

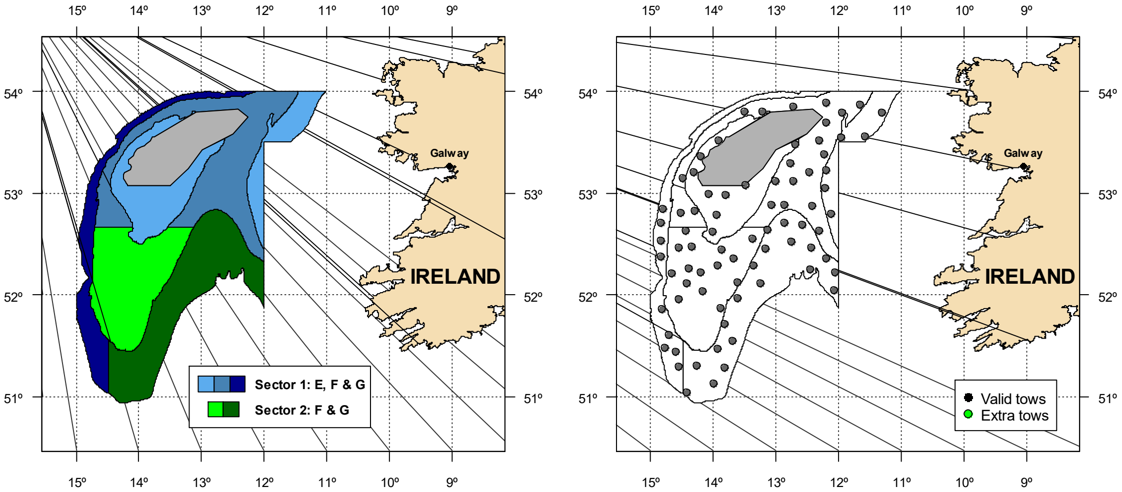


Figure 3.5.11. Left: Stratification design used in the Porcupine surveys starting in 2003: Previous years were re-stratified. Depth strata are: E) shallower than 300 m, F) 301 – 450 m and G) 451 – 800 m. Grey area in the middle of Porcupine bank denotes a large non-trawl able area. Right: distribution of hauls in 2020.

French Southern Atlantic Bottom trawl survey (EVHOE)

Ling are caught in small numbers in the French Southern Atlantic Bottom trawl survey (EVHOE). Population indices (based on swept area for biomass, mean length, etc.) for the Bay and Biscay and Celtic Sea (ICES divisions 7g-k and 8a,b,d) combined were provided for years 1997–2020 (Figure 3.5.15). The survey covers depths from 30 to 600 m and is stratified by depth and latitude. The percentiles are based on a very small number of ling per year and that is the reason for the small error bar in the percentile graph.

Commercial cpues

French lpue

A crude lpue based on landings and effort, measured in hours at sea have been presented in previous years and was not updated in 2020 considering that a properly standardised lpue might be informative of abundance trends.

Norwegian longline cpue

Norway started in 2003 to collect and enter data from official logbooks into an electronic database and data are now available for the period 2000–2020. Selected vessels were those with a total landed catch of ling, tusk and blue ling of more than 8 t per year. The logbooks contain records of the daily catch, date, position, and number of hooks used per day. The quality of the Norwegian logbook data is poor for 2010 due to changes from paper to electronic logbooks. Since 2011 data quality has improved considerably and data from the entire fleet were available.

Standardised cpue series are calculated for the Norwegian fleet using data from official logbooks starting from 2000 (Helle *et al.* 2015). Two standardized time-series of cpue are calculted using all catch data, and a subset where ling make up more than 30% of the total catch. This subset is considered to represent targeted fishing.

3.5.6 Data analyses

Length data analysis

Mean length of the commercial catches by the Norwegian longlining reference fleet fluctuate around 90 cm in Divisions 4a abd 6.a, in Division 6b there may have been a decline in mean length up to 2015 then larger fish were landed in 2016. More recent data are missing. In division 4b, catches are slightly smaller than in 4.a. (Figure 3.5.3). When all data for these areas are combined for longline and for gill netters the average length is about 10 cm higher for gill netters than for longliners (Figure 3.5.4)

The estimated length distributions of ling caught in SP-PORC survey suggest a disappearance of large fish. Ling smaller than 50 cm are not caught in significant number in Surveys (Figure 3.5.14). For more information, see Ruiz-Pico *et al.*, WD 2020.

Ling are caught in small numbers (average of 14 individuals per year since 1997) in EVHOE therefore, populations indices from this survey are not considered representative of stock trends and not used for advice purposes. They are however presented (Figure 3.5.12) and their overall trend suggest a decline of ling in the survey area.

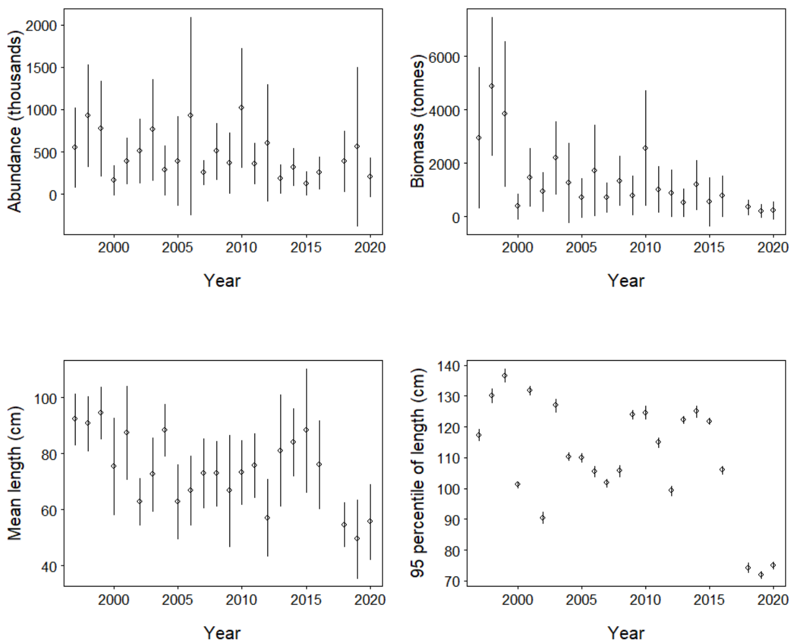


Figure 3.5.12. Population indices (swept area raised abundance and biomass, mean length and 95 percentile of the length distribution) of ling in the Bay and Biscay and Celtic Sea (ICES divisions 7.g,hjk and 8a,b,d) from the French EVHOE survey (W-IBTS-Q4), 1997–2020 (except 2017).

Spanish Porcupine Bank survey

Estimated biomass and abundance indices based on data from the Porcupine Survey for the years 2001–2020 are in Figure 3.5.13. The abundance indices for ling based on the survey were quite stable from 2001–2012. After the peak in 2013 there has been a large decline to a very low level.

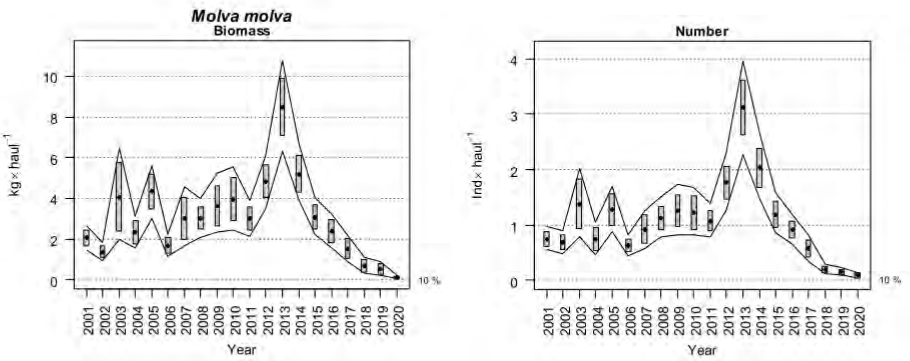


Figure 3.5.13. Estimated biomass and abundance indices based on the Porcupine Survey for the years 2001–2020. Boxes mark the parametric, based standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

Cpue series based on the Norwegian longline fleet

Figure 3.5.14 shows the Norwegian CPUE series from 2000 to 2020. In Division 4a there was a steady increase in CPUE from 2002 until 2016 then a stabilization. This trend can be seen both when all data was used and when ling was targeted. In Divisions 6a and 6b there was also an increasing trend from 2002 to 2016 followed by a stabilization in 6.a and a decrease in 6.b.

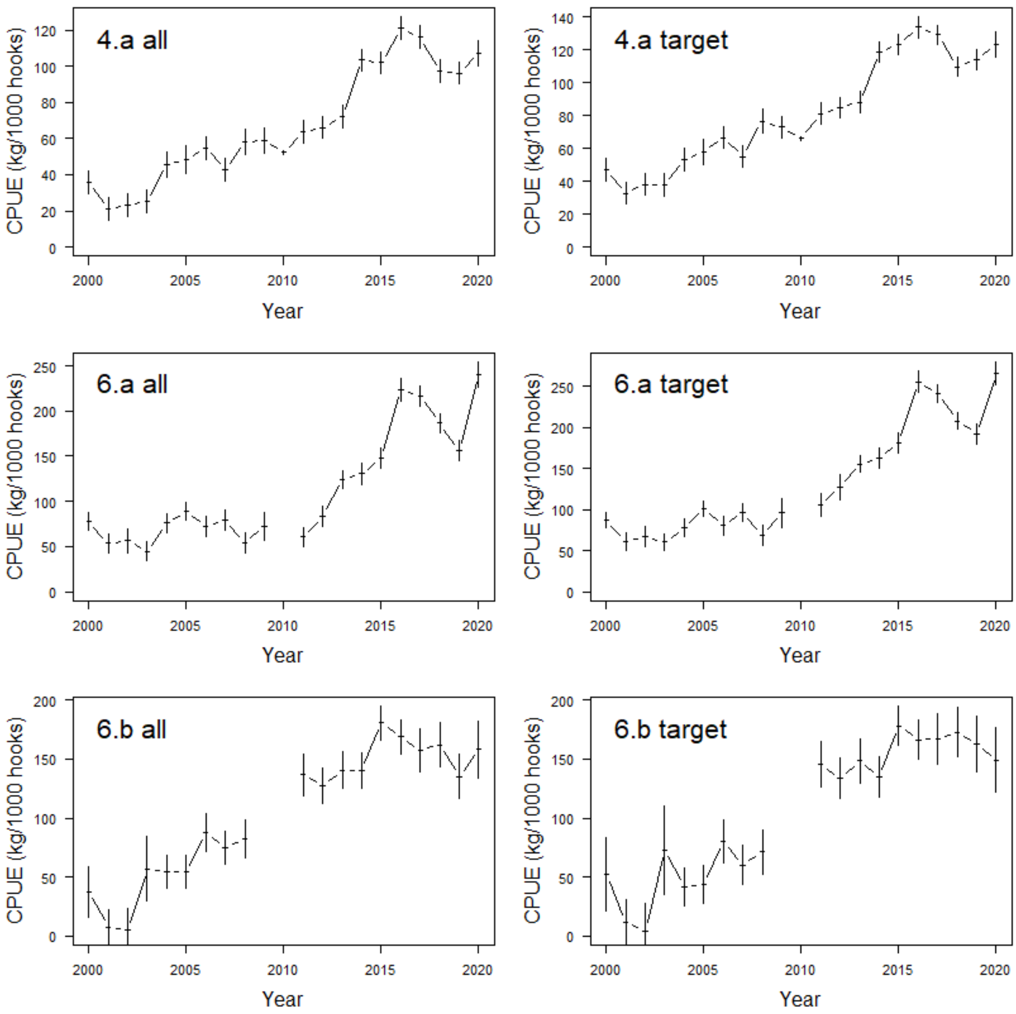


Figure 3.5.14. Cpue series for ling for the period 2000–2020 based on all available data and when ling was targeted. The bars denote the 95% confidence intervals.

The index used for advice on the stock is the combination of all data for the 3 areas, the index used since 2015 is the cpue when ling was targeted (Figure 3.5.16 right). Nevertheless, the time-series is similar when targeted fishing and all fishing for ling are considered (Figure 3.5.15).

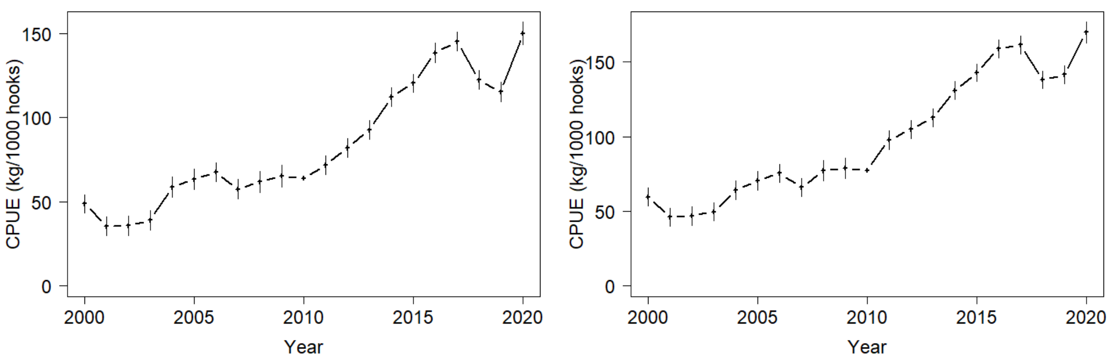


Figure 3.5.15. Cpue series for ling, areas 4a, 4b, 6a and 6b combined, for the period 2000–2020 for all data available (left) and for target fishing (right). The bars depict the 95% confidence intervals.

3.5.7 Biological reference points: length-based indicators

In 2020, Length based indicator (LBIs) were recalculated, using recent data and update parameters to investigate further the application of MSY proxy reference points. SPiCT was not run.

The length data used in the LBI model are data from the Norwegian longline fleet. The length data are not weighted and therefore do not represent the length distribution of the entire catch. For calculating the LBIs, the assumption M=0.15 was used with the length at first maturity (Lmat= 64 cm) and the length-weight relationship from Norwegian data. Three pairs of L_∞ and k, from the same model fit were trialled. These are estimates from sampling fish caught by the Norwegian fleet (L_∞ = 183 cm and k=0.118) and the extreme pairs of all available estimates (L_∞ = 189 cm, k=0.08 and L_∞ = 124 cm, k=0.163). The length- weight relationship w=0.0055*Lt^3.0120 estimated on samples from the Norwegian longline fleet.

Table 3.5.6 Ling in other areas (3.a, 4.a, 4.b, 6.a, 6.b, 7). Input parameters for LBI.

	Parameter				
set	M	L_{mat}	L_∞	k	M/k
Set1	0.15	0.64	183	0.118	1.27
Set 2	0.15	0.64	189	0.08	1.88
Set 3	0.15	0.64	124	0.163	0.92

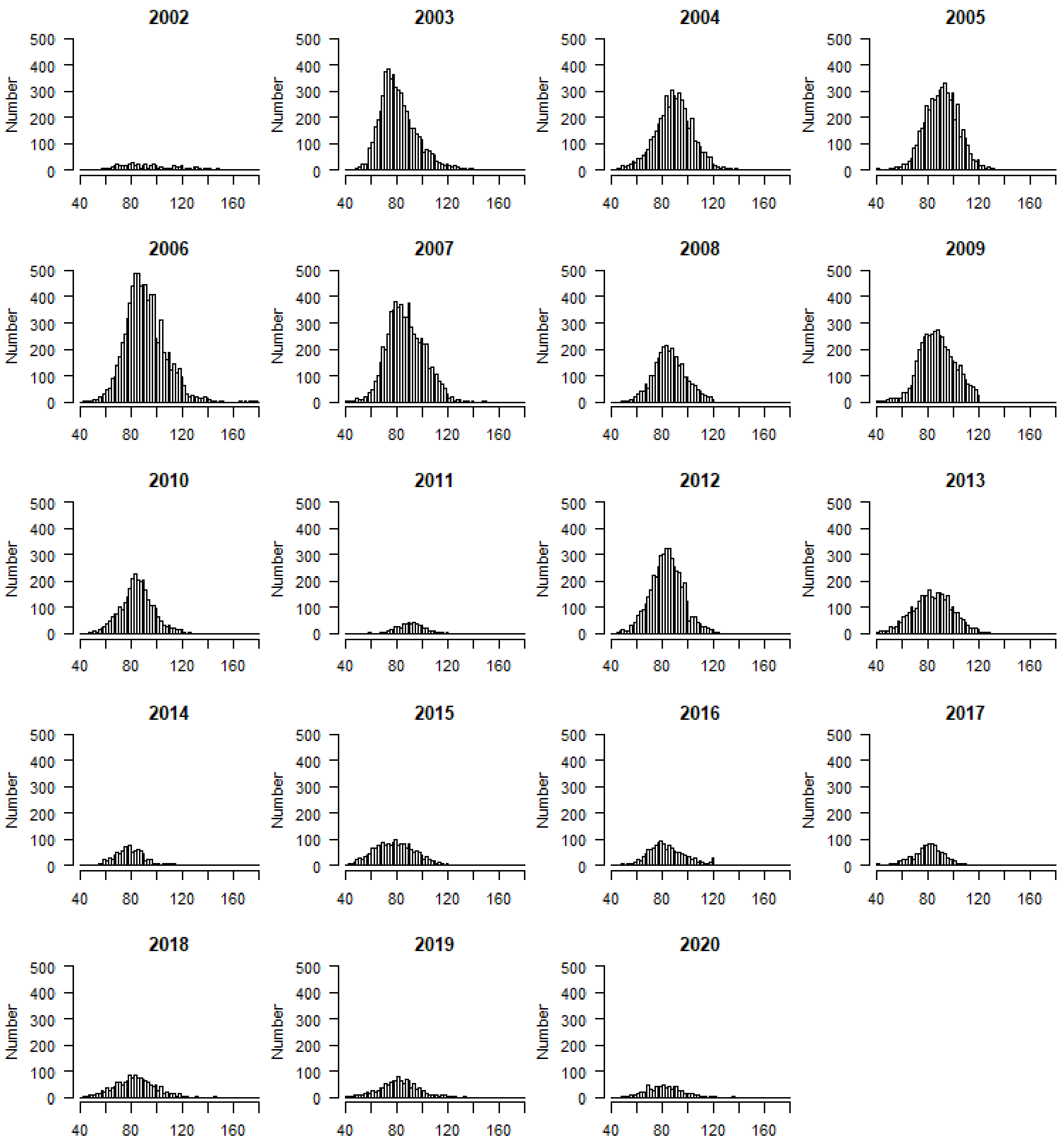


Figure 3.5.16 Ling in other areas (3.a, 4.a, 4.b, 6.a, 6.b, 7). Length composition of the catch from the Norwegian longliner fleet, for the period 2002–2020 by 2 cm length classes (sex combined).

<u>Outputs</u>

The stock status for the most recent three years is given in Figure 3.5.17 for the three sets of input parameters. In all case the conservation of immature (Lc/Lmat and $L_{25\%}$/Lmat) is achieved, which is consistent with the empirical knowledge that small ling are generally not caught in significant numbers by commercial fisheries. In contrast, the conservation of adults is not achieved, suggesting that the proportion of large ling in the stock is small compared to an unexploited stock. large ling. The optimal yield is only achieve with the parameter set 3, which combines the smaller L_{∞} *with* the larger *k* and the MSY criterion is mostly not achieved. Overall it can be considered that biological parameters of the stock are too uncertain (in particular M for which assumed value were borrowed from other stocks) to rely on LBIs, which however suggest that the stock is likely overexploited.

Parameters Set 1

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	$L_{max\ 5}$ / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2018	1.08	1.14	0.65	0	0.69	0.87
2019	1.17	1.14	0.65	0	0.70	0.85
2020	1.08	1.14	0.63	0	0.67	0.85

Parameters Set 2

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	$L_{max\ 5}$ / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2018	1.08	1.14	0.63	0.01	0.76	0.94
2019	1.17	1.14	0.63	0.01	0.77	0.90
2020	1.08	1.14	0.61	0.01	0.74	0.92

Parameters Set 3

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	$L_{max\ 5}$ / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2018	1.08	1.14	0.96	0.10	0.93	1.00
2019	1.17	1.14	0.96	0.08	0.94	0.97
2020	1.08	1.14	0.93	0.07	0.91	0.98

Figure 3.5.17. Ling in other areas (3.a, 4.a, 4.b, 6.a, 6.b, 7). Screening of length indicators ratios for sex combined under three scenarios: (a) Conservation, (b) Optimal yield, and (c) maximum sustainable yield.

3.5.8 Comments on the assessment

Data in Divisions 4.a, 6.a and 6.b were combined to make an index for the entire area. These series show the same positive trend until 2016 and after 2016 was a declining trend. This trend is also reflected in the French LPUE series based on the otter trawlers. The Norwegian data do not include area 7. The Spanish survey on the Porcupine bank showed a stable biomass from 2001- 2012, a peak in 2013 and a sharp downward trend to a record low in 2019 (Figure 3.5.14.) In area 7, the landings have decreased from around 11 000 tons in the end of the 1990ies to under 1000 tons in 2019. For other areas, the landings have been stable or increasing. It is not clear what has caused the decline in biomass and catches in this area.

However, the length-based indicator, derived from the Norwegian longline fishery data, indicates that ling are fished sustainably.

3.5.9 Management considerations

LBI estimated this year suggest that the stock is exploited beyond MSY limits. These estimates are however uncertain as a consequence of the insufficience of growth and natural mortality estimates.The CPUE series, based on commercial data, indicates an increasing trend until 2016 then a stable or slightly declining trend. During 2000-2016, there was an increasing trend, and at the end of the series, there are signs that may be declining, which has to be followed closely.

As always, it should be emphasized that commercial catch data are typically observational data; that is, there were no scientific controls on how or from where the data were collected. Therefore, it is not known with certainty if the ling CPUE series tracks the population and/or how accurate the measures of uncertainty associated with the series are (see, for example, Rosenbaum, 2002).

An notorious example of a misleading CPUE series based on commercial data was a CPUE series for Newfoundland cod that incorrectly indicated that the abundance of the cod stock was increasing greatly. Advice based on this CPUE series ultimately caused the collapse of the stock (see, e.g. Pennington and Strømme, 1998).

In general, any assessment method based only on commercial catch data needs to be applied with caution. The reason that assessments using only commercial data are problematic is because the relation between the commercial catch and the actual population is normally unknown and probably varies from year to year.

3.5.10 Recommendations

Although based on small numbers caught survey in subareas 6 and 7 suggest different abundance trends than the commercial cpue in subareas 4 and 6. Although the CPUE may not track fully stock trends, as underlined in the previous section, it would be hardly plausible to obtain an increasing CPUE with actual stock trends similar to those reflected by surveys in subareas 6 and 7. Therefore, further investigation in the stock structure within the assessment unit is necessary.

WGDEEP recommends that stock identity of ling is explore in more detail.

3.5.11 References

Bergstad, O. A. and Hareide, N.-R. (1996). Ling, blue ling and tusk of the north-east atlantic. His, Storebo, Matredal, Institute of Marine research**:** 125.

Helle, K., Pennington, M., Hareide, N.-R. and Fossen, I. (2015). "Selecting a subset of the commercial catch data for estimating catch per unit effort series for ling (molva molva l.)." Fisheries Research **165**: 115-120. '10.1016/j.fishres.2014.12.015': 10.1016/j.fishres.2014.12.015

Joenoes, G., 1961. Über die Biologie und fischereiliche Bedeutung der Lengfische (*Molva molva* L., Molva byrkelange Wal) und des Lumb (*Brosmius brosme* Asc.). Ber. dt. Wiss. Kommn. Merres. 16(2):129-160.

Magnussen, E. (2007). "Interpopulation comparison of growth patterns of 14 fish species on faroe bank: Are all fishes on the bank fast-growing?" Journal of Fish Biology **71**(2): 453-475.

Vieira RP, Visconti V., 2021. Preliminary data on age and growth of Ling (*Molva molva*) in ICES divisions 7.d–j. Working document to WGDEEP.

3.5.12 Tables

Table 3.5.1. Ling in subareas 3,4, 6–9, 12, and 14 . WG estimates of landings.

Ling 3

Year	Belgium	Denmark	Germany	Norway	Sweden	E & W	France	Total
2001		125	+	102	35			262
2002		157	1	68	37			263
2003		156		73	32			261
2004		130	1	70	31			232
2005		106	1	72	31			210
2006		95	2	62	29			188
2007		82	3	68	21			174
2008		59	1	88	20			168
2009		65	1	62	21			149
2010		58		64	20			142
2011		65		57	18			140
2012		66	<1	61	17			144
2013		56	1	62	11			130
2014		51	1	54	14			120
2015		58	1	50	16			125
2016		77	1	57	17			152
2017		58	1	57	22			138
2018		95	1	57	25			177
2019		139		38	27		0	205
2020*		127	0	35	17		4	183

***Preliminary.**

Table 3.5.1. (continued).

Ling 4.a

***Preliminary.**

(1) Includes 4b 1988–1993.

Year	Belgium	Denmark	Faroes	France	Germany	Neth.	Norway	Sweden[1)]	E&W	N.I.	Scot.	Total
2001		702		128	54		3613	6	61		3290	7854
2002	6	578	24	117			4509		59		3779	9072
2003	4	779	6	121	62		3122	5	23		2311	6433
2004		575	11	64	34		3753	2	15		1852	6306
2005		698	18	47	55		4078	4	12		1537	6449
Year	**Belgium**	**Denmark**	**Faroes**	**France**	**Germany**	**Neth.**	**Norway**	**Sweden[1)]**	**E&W**	**N.I.**	**Scot.**	**Total**
2006		637	2	73	51		4443	3	55		1455	6719
2007		412	-	100	60		4109	3	31		1143	5858
2008		446	1	182	52		4726	12	20		1820	7259
2009		427	7	90	27		4613	7	19		2218	7408
2010		433		62	40		3914		28		1921	6398
2011		541		90	62		3790	8	18		1999	6508
2012		419		105	47		4591	6	28		1822	7018
2013		548		104	83		4273	5	15		2169	7197
2014		404		182	53		5038	3	23		2046	7749
2015		424		127	53		5369	6	90		2018	8069
2016		797		304	71		6021	5	65		2477	9740
2017		1036		308	111		6925	11	78		2761	**11230**
2018		980		842	114	2	6326	14			3270	**11548**
2019	0	1022		926	130	5	6062	16	74		3208	**11443**
2020*	0	673		653	93	15	4494	31	34	0	2855	**8848**

Table 3.5.1. (continued).

Ling 4.bc.

Year	Belgium	Denmark	France	Sweden	Norway	E & W	Scotland	Germany	Netherlands	Total
2001	46	81	1	3	23	62	60	6	2	284
2002	38	91		4	61	58	43	12	2	309
2003	28	0		3	83	40	65	14	1	234
2004	48	71		1	54	23	24	19	1	241
2005	28	56		5	20	17	10	13		149
2006	26	53		8	16	20	8	13		144
2007	28	42	1	5	48	20	5	10		159
2008	15	40	2	5	87	25	15	11		200
2009	19	38	2	13	58	29	137	17	1	314
2010	23	55	1	13	56	26	10	17		201
2011	15	59	0		85	24	11	17		211
2012	12	45	1	10	84	25	7	8		192
2013	15	47	1	5	71	0	21	12	4	176
2014	16	46	0	6	34	7	14	15	3	141
2015	11	36		6	54	10	16	14		147
2016	14	42		6	50	7	9	21	1	150
2017	9	36		9	74	4	9		2	143
2018	9	38		8	62		8	36	1	**162**
2019	13	41		12	55	2	6	26	3	**158**
2020*	16	37	0	8	31	4	0	14	0	**110**

***Preliminary.**

Table 3.5.1. (continued).

Ling 6.a.

Year	Belgium	Denmark	Faroes	France	Germany	Ireland	Norway	Spain)	E&W	IOM	N.I.	Scot.	Total
2001				774	3	70	1869	142	106			2179	5143
2002				402	1	44	973	190	65			2452	4127
2003				315	1	88	1477	0	108			1257	3246
2004				252	1	96	791	2	8			1619	2769
2005			18	423		89	1389	0	1			1108	3028
2006			5	499	2	121	998	0	137			811	2573
2007			88	626	2	45	1544	0	33			782	3120
2008			21	1004	2	49	1265	0	1			608	2950
2009			30	418		85	828	116	1			846	2324
2010			23	475		164	989	3	0			1377	3031
2011			102	428		95	683	8				1683	2999
2012			30	585		47	542	862				1589	3655
2013			50	718		54	1429	899	10			1500	4660
2014			0	937		39	1006	1005	6			1768	4761
2015				891		65	1214	961	4			1629	4764
2016			92	1005		156	1313	1109	9			1975	5659
2017			5	870		156	1530	1500	3			2244	**6308**
2018				831		156	2185	1560				1922	**6654**
2019				927		142	1616	1689	1			2168	**6543**
2020*			0	823		200	1084	913	3		0	1518	**4563**

***Preliminary. .**

Table 3.5.1. (continued).

Ling 6.b.

Year	Faroes	France[)]	Germany	Ireland	Norway	Spain	E & W	N.I.	Scotland	Russia	Total
2001	+	16	3	18	328		116		307		788
2002		2	2	2	289		65		173		533
2003		2	3	25	485		34		111		660
2004	+	9	3	6	717		6		141	182	1064
2005		31	4	17	628		9		97	356	1142
2006	30	4	3	48	1171		19		130	6	1411
2007	4	10	35	54	971		7		183	50	1314
2008*	69	6	20	47	1021		1		135	214	1513
2009	249	5	6	39	1859		3		439	35	2635
2010	215	2		34	2042		0		394		2687
2011	12	5		16	957		1		268		1259
2012	60	7		13	1089	3			218		1390
2013		19		8	532	6			229	1	795
2014	60	7		10	435	2			258	2	774
2015	5	10	1	16	952	11	6		211	3	1215
2016	56			35	821	2	4		170		1088
2017	5		2	59	498	7	2		219	1	**793**
2018			2	59	408	6			255		**730**
2019		5	1	102	459	9	1		326	1	**904**
2020*		1		106	247	3	0	0	330		**687**

***Preliminary..**

Table 3.5.1. (continued).

Ling 7.a.

Year	Belgium	France	Ireland	E & W	IOM	N.I.	Scotland	Total
2001	6	3	33	20			31	87
2002	7	6	91	15			7	119
2003	4	4	75	18			11	112
2004	3	2	47	11			34	97
2005	4	2	28	12			15	61
2006	2	1	50	8			27	88
2007	2	0	32	1			8	43
2008	1	0	13	1			0	15
2009	1	36	9	2			0	48
2010		28	15	1			0	44
2011	1	2	23	1			1	28
2012	2		11	1			0	14
2013	1		6				23	30
2014	2	0	11				16	29
2015	1		8				10	19
2016	1		10				13	24
2017			9				15	24
2018		1	9				8	18
2019	2		3				7	12
2020*	1	0	0	0	0	4	0	5

***Preliminary.**

Table 3.5.1. (continued).

Ling 7.b, c.

Year	France	Germany	Ireland	Norway	Spain	E & W	Scotland	Total
2001	80	2	413	515		94	122	1226
2002	132	0	315	207		151	159	964
2003	128	0	270			74	52	524
2004	133	12	255	163		27	50	640
2005	145	11	208			17	48	429
2006	173	1	311	147		13	23	668
2007	173	5	62	27		71	20	358
2008	122	16	44	0		14	63	259
2009	42		71	0		17	1	131
2010	34		82	0		6	131	253
2011	29		58			28	93	208
2012	126	1	39	230	370	1	246	1013
2013	267	2	46		379	136	180	1010
2014	118		57		279	19	59	532
2015	101		53		184	144	78	560
2016	93		46	6	172	46	207	570
2017	90		32		133	34	26	315
2018	57		39		138	32		**266**
2019	53		0		238	14	8	**313**
2020*	47		25	0	67	11	4	**154**

***Preliminary. .**

Table 3.5.1. (continued).

Ling 7.d, e.

Year	Belgium	Denmark	France	Ireland	E & W	Scotland	Ch. Islands	Nether-lands	Spain	Total
2000	5		454	1	372		14			846
2001	6		402		399					807
2002	7		498		386	0				891
2003	5		531	1	250	0				787
2004	13		573	1	214					801
2005	11		539		236					786
2006	9		470		208					687
2007	15		428	0	267					710
2008*	5		348		214	2				569
2009	6		186		170			1		363
2010	4		144		138				8	294
2011	5		238		176				6	425
2012	7		255	1	164	2			7	436
2013	5		259		218					482
2014	4		338	1	262					605
2015	5		204		137			1		347
2016	3		141		149					293
2017	4		104		94					**202**
2018	3		85		32			**1**		**121**
2019	2		54		59			2		**118**
2020*	2		48	0	35	0	0	0	0	**85**

***Preliminary.**

Table 3.5.1. (continued).

Ling 7.f.

Year	Belgium	France	Ireland	E & W	Scotland	Total
2001	14	114	-	92		**220**
2002	16	139	3	295		**453**
2003	15	79	1	81		**176**
2004	18	73	5	65		**161**
2005	36	59	7	82		**184**
2006	10	42	14	64		**130**
2007	16	52	2	55		**125**
2008	32	88	4	63		**187**
2009	10	69	1	26		**106**
2010	10	42	0	17	0	**69**
2011	20	39	2	94		**155**
2012	28	80	<1	59	<1	**167**
2013	22	68	1	93	40	**224**
2014	61	182	0	91		**334**
2015	15	54	2	17		**88**
2016	25	51	1	34	3	**114**
2017	7	20	1	19		**47**
2018	5	18	1	19		**43**
2019	4	11		11		**26**
2020*	6	14	0	13	0	**33**

***Preliminary.**

Table 3.5.1. (continued).

Ling 7.g–k.

Year	Belgium	Denmark	France	Germany	Ireland	Norway	Spain [1]	E&W	IOM	Scot.	Total
2001	16		1154	4	727	24	559	591		285	3360
2002	16		1025	2	951		568	862		102	3526
2003	12		1240	5	808		455	382		38	2940
2004	14		982		686		405	335		5	2427
2005	15		771	12	539		399	313		4	2053
2006	10		676		935		504	264		18	2407
2007	11		661	1	430		423	217		6	1749
2008	11		622	8	352		391	130		27	1541
2009	7		183	6	270		51	142		14	673
2010	10		108	1	279		301	135		14	848
2011	15		260		465		16	157		23	936
2012	23		584	2	516		201	138		56	1520
2013	24		622		495		190	74		203	1608
2014	13		535		445		177	185		202	1557
2015	11		391		366		153	131		13	1065
2016	10		383		549		107	114		9	1172
2017	10		298		392		85	91		12	**888**
2018	6		170		333		76	62			**647**
2019	7		143		212		57	43		3	**465**
2020*	8	0	117	0	205	51	44	0		2	**427**

***Preliminary. [1] Includes 7.b c until 2011**

Table 3.5.1. (continued).

Ling 8.

Year	Belgium	France	Germany	Spain	E & W	Scot.	Ireland	Total
2001		245		341	6	2		594
2002		316		141	10	0		467
2003		333		67	36			436
2004		385		54	53			492
2005		339		92	19			450
2006		324		29	45			398
2007		282		20	10			312
2008		294		36	15	3		345
2009		150		29	7			186
2010		92		31	11			134
2011		148		47	6			201
2012		349		201	2			552
2013		281		139	35	4		459
2014		280		110	4	1		395
2015*		269		63	5			337
2016		207		77	3			**287**
2017		156		43	2			**201**
2018		145		34	4			**183**
2019		139		23			1	**163**
2020*		147	15	0	0	0	0	**162**

Ling 9.

Year	Spain	Total
2001	0	0
2002	0	0
2003	0	0
2004		
2005		

Year	Spain	Total
2006		
2007	1	1

Table 3.5.1. (continued).

Ling 12.

Year	Faroes	France	Norway	E & W	Scotland	Germany	Ireland	Total
2001		0	29	2	24		4	59
2002		0	4	4	0			8
2003			17	2	0			19
2004								
2005				1				1
2006	1							1
2007								0
2008								0
2009		0	1					1
2010								0
2011		1						1
2012	3						1	4
2013								0
2014								0
2015								0
2016								0
2017								0
2018								0
2019								0
2020*								

Table 3.5.1. (continued).

Ling 14.

Year	Faroes	Germany	Iceland	Norway	E & W	Scotland	Russia	GREEN-LAND	Total
2001	1			35				1	37
2002	3			20				0	23
2003				83				0	83
2004				10				9	19
2005								18	18
2006								19	19
2007				5				2	7
2008					1		1	19	20
2009	+	3						5	8
2010		3						3	6
2011	2			1				5	8
2012	1		105					5	111
2013								2	2
2014	1	1	6	1	1			8	17
2015								21	21
2016	9	1		10			1	15	35
2017	1			1			2	5	7
2018								5	5
2019				128					128
2020*									

***Preliminary.**

Table 3.5.2 Ling. Total landings by subarea or division.

Year	3	4.a	4.bc	6.a	6.b	7	7.a	7.bc	7.de	7.f	7.g–k	8	9	12	14	All areas
1988	331	11 223	379	14 556	1765	5057	211	865	779	444	4415	1028		0	3	41 056
1989	422	11 677	387	8631	3743	5261	311	577	700	310	1012	1221		0	1	34 253
1990	543	10 027	455	6730	1505	4575	169	678	799	233	1077	1372		3	9	28 175
1991	484	9969	490	4795	2662	3977	125	749	680	302	1394	1139		10	1	26 777
1992	549	10 763	842	4588	1891	2552	105	1286	519	137	1593	802		0	17	25 644
1993	642	12 810	797	5301	1522	2294	219	1434	436	223	2334	510		0	9	28 531
1994	469	11 496	323	6730	2540	2185	284	1595	451	400	3254	85		5	6	29 823
1995	412	13 041	659	8847	1638		305	1944	1389	602	6131	845		50	17	35 880
1996	402	12 705	569	8577	1124		210	2201	1477	399	6850	1041		2	0	35 557
1997	311	11 315	699	6746	814		264	1780	1472	547	5045	1034	0	9	61	30 097
1998	214	13 631	627	7362	1394		198	1034	1500	561	7814	1797	2	2	6	36 142
1999	216	9810	446	6899	1175		84	1366	1060	312	4189	452	1	2	9	26 013
2000	228	9247	384	6909	1879		73	1182	846	218	3578	339	1	7	26	24 916
2001	262	7857	284	5143	788		94	1226	807	220	3360	594	0	59	37	20 720
2002	263	9152	309	4127	533		126	964	891	453	3526	467	0	8	23	20 756
2003	261	6433	234	3246	660		112	524	788	176	2940	436		19	83	15 912
2004	236	6306	241	2769	1064		97	640	801	161	2427	492		0	19	15 240
2005	210	6449	149	3028	1142		61	429	786	184	2053	450		1	18	14960

Year	3	4.a	4.bc	6.a	6.b	7	7.a	7.bc	7.de	7.f	7.g–k	8	9	12	14	All areas
2006	188	6719	144	2573	1411		88	668	687	130	2407	398		1	19	15433
2007	174	5858	159	3120	1314		43	358	710	125	1749	312		0	7	13929
2008	175	7259	200	2950	1513		15	259	569	187	1541	345		0	20	15033
2009	149	7408	314	2324	2635		48	131	363	106	673	186		1	8	14346
2010	142	6398	201	3031	2687		44	253	294	69	848	134		0	6	14107
2011	140	6508	211	2999	1259		28	208	425	155	936	201		1	8	13079
2012	145	7018	192	3655	1390		14	1013	436	167	1520	552	1	4	111	16218
2013	130	7197	176	4660	795		30	1010	482	224	1608	459		0	2	16773
2014	120	7749	141	4761	774		29	532	605	334	1557	395		0	17	17014
2015	125	8069	147	4764	1215		19	560	347	88	1065	337		0	21	16757
2016	152	9740	150	5659	1088		24	570	293	114	1172	287			35	19284
2017	138	11230	143	6308	793		24	315	202	47	888	201		0	7	20296
2018	177	11548	162	6654	730		18	266	121	43	647	183		0	5	20554
2019	205	11443	158	6543	904		12	313	115	26	465	163		0	130	20480
2020	182	8848	110	4563	687		5	154	85	33	427	162				15257

***Preliminary.**

Table 3.5.3. Number of French fishing vessels (otter trawlers, gillnetters and longliners) during the period 2000–2019.

NUMBERS OF SHIPS	OTTER TRAWLERS	GILLNETTERS	LONGLINERS
2000	65	12	1
2001	77	13	2
2002	66	15	3
2003	61	19	2
2004	52	22	0
2005	46	24	1
2006	44	20	6
2007	42	20	7
2008	37	20	7
2009	38	20	6
2010	29	21	2
2011	32	18	3
2012	36	15	4
2013	33	14	8
2014	33	13	9
2015	31	9	11
2016	28	5	12
2017	32	11	17
2018	28	14	17
2019	32	17	16

4 Blue Ling (*Molva dypterygia*) in the Northeast Atlantic

4.1 Stock description and management units

Biological investigations in the early 1980s suggested that at least two adult stock components were found within the area, a northern stock in Subarea 14 and Division 5.a with a small component in 5.b, and a southern stock in Subarea 6 and adjacent waters in Division 5.b. This was supported by differences in length and age structures between areas as well as in growth and maturity. Egg and larvae data from early studies also suggested the existence of many spawning grounds in each of areas of the northern and southern stocks and this was considered as indications of stock separation. However, in most areas small blue ling below 60 cm do not occur and fish appear in survey and commercial catch at 60–80 cm suggesting large spatial migrations and therefore limited population structuring. The conclusion is that stock structure of blue ling in the ICES area is uncertain.

As in previous years, in addition to one stock in Division 5.b and subareas 6 and 7 and one in Division 5.a and Subarea 14. All remaining areas (subareas 1, 2, 8, 9 and 12 and divisions 4.a and 3.a) are grouped as in a single stock unit, labelled "Northeast Atlantic" for advice purposes". Historical landing in subareas 1 and 2 and Division 4.a and 3.a have been significant. Whilst landings reported in 8 and 9, where the species does not occur, are now ascribed to the related Spanish ling (*Molva macrophtalma*).

The situation in Subarea 12 is different as this subarea includes part of the Mid-Atlantic Ridge (ICES Divisions 12.a1, 12.a2, 12.a4 and 12.c) and the western slope of the Hatton Bank (ICES Division 12.b). Since 2012, none of these areas presented major landings. However, based upon the continuity of bathymetric features and lesser abundance, blue ling from the western Hatton Bank is likely to be related to those from the northern Hatton Bank (ICES Division 6.b) and blue ling from other divisions of Subarea 12 is likely to be related to those from Icelandic and east Greenland waters. At least this revised stocks units would be more consistent that the current stocks units where the "Northeast Atlantic" unit comprises two blocks separated by the two main stock units combines Subarea 12 . Because of the much lesser landings from Subarea 12, compared to landings from the main stock unit areas, the assessment of the two main stocks would not be significantly impacted.

Historical total international landings show that blue ling have been exploited for long. Before the start of the time-series considered by WGDEEP, Norway landed 1000–2000t per year in the 1950s and 1960s. These landings might have been mainly from subareas1 and 2. German landings starting in the 1950s were mainly reported in Statlant from ICES Division 5.a and 5.b. Since 1966, the main fishing countries have been the Faroe Islands, France, Germany, Iceland and Norway (Figure 4.1.1). Except in a few recent years where large amount where caught in Division 5.a, the stock unit of Division 5.b and subareas 6 and 7 have had the main contribution to total landings (Figure 4.1.2).

Blue ling forms spawning aggregations, i.e., blue ling is an aggregating species at spawning time. From 1970 to 1990, the bulk of the fisheries for blue ling were seasonal and targeted those aggregations which were thus subject to sequential depletion. Known spawning areas are shown in Figure 4.1.3. In Iceland, the depletion of one spawning aggregation in a few years was documented (Magnússon, 1995). To prevent depletion of adult populations temporal closures have been set in the Icelandic and EU EEZs as well as in the NEAFC RA.

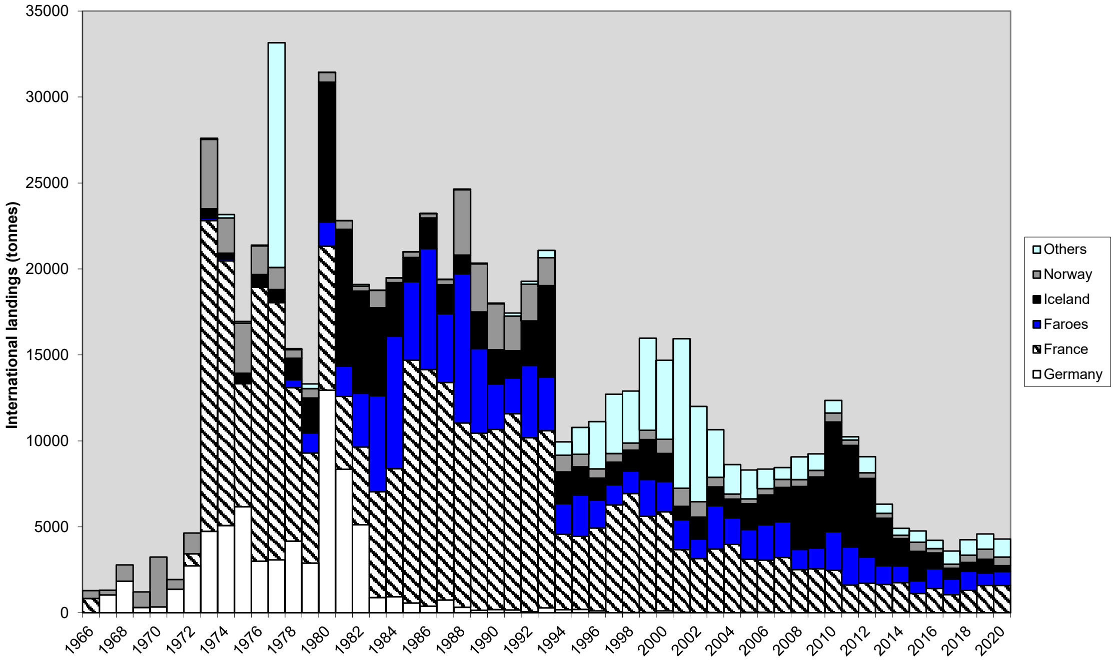


Figure 4.1.1. Total international landings of blue ling in the Northeast Atlantic, by country, 1966–2020.

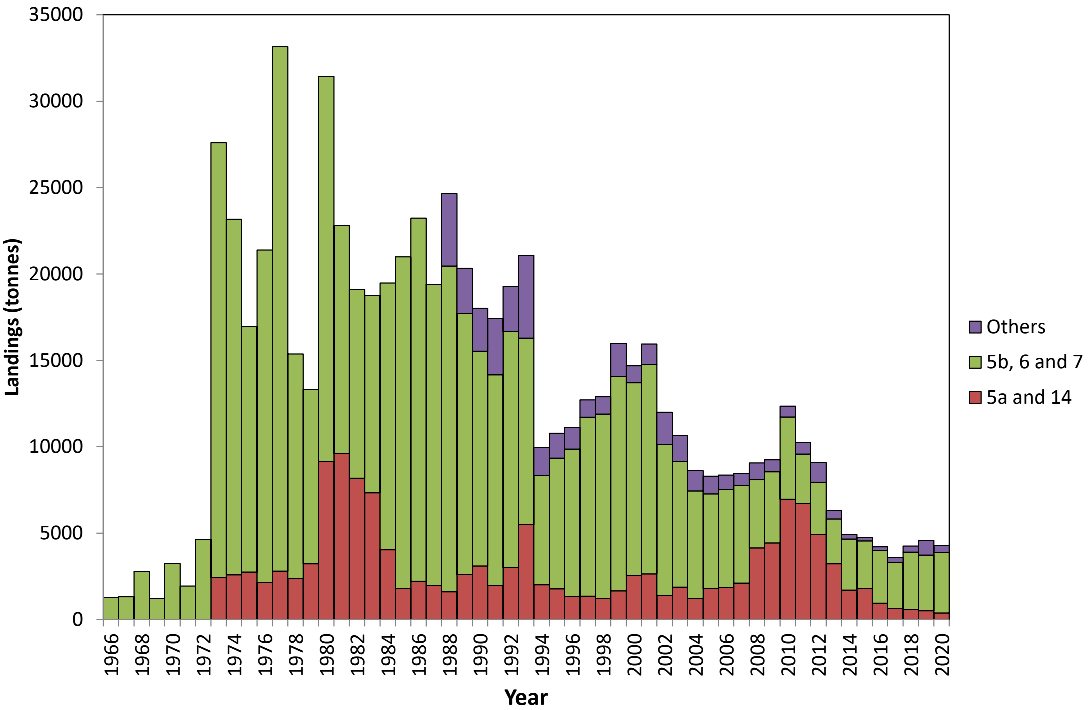


Figure 4.1.2. Total international landings of blue ling in the Northeast Atlantic, by stock unit, 1966–2020.

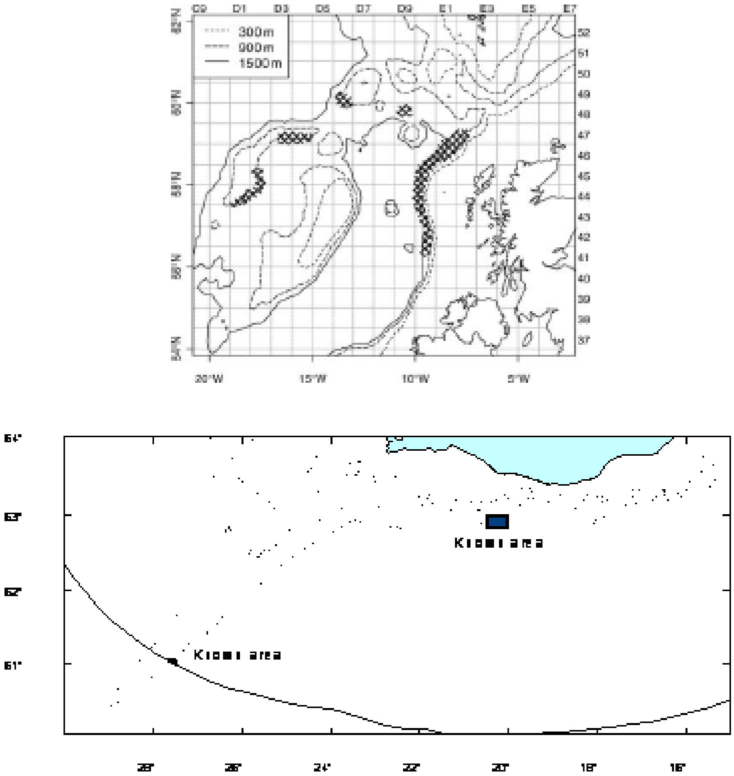


Figure 4.1.3. Known spawning areas of blue ling in Icelandic water (lower panel) and to the West of Scotland (upper panel, from Large *et al.*, 2010).

4.2 Blue ling (*Molva dypterygia*) in 5a and 14

4.2.1 Fishery

The geographical distribution of the Icelandic blue ling fisheries from 2000 to 2020 (Figure 4.2.1 and Figure 4.2.2), indicates an expansion of the fishery of blue ling to north-western waters. This increase may partly be the result of increased availability of blue ling in the north-western area.

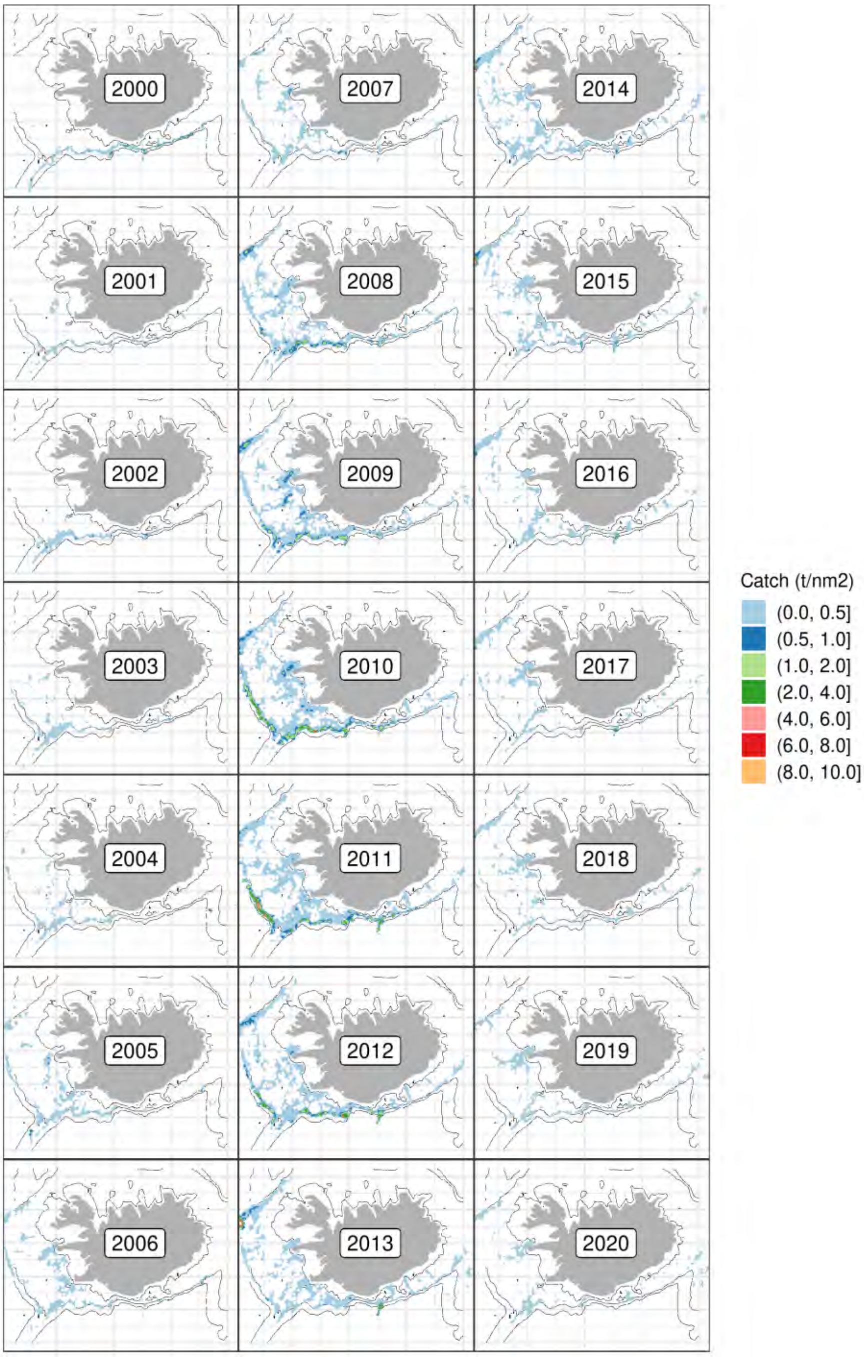


Figure 4.2.1. Blue ling in 5.a and 14. Geographical distribution of the Icelandic blue line fishery since 2000 as reported in logbooks. All gear types combined.

Before 2008, most blue ling catches were by trawlers, as bycatch in fisheries targeting Greenland halibut, redfish, cod and other demersal species (Table 4.2.1). Most of the catches by trawlers are taken in waters shallower than 700 m and by longliners until 2008 mostly at depths shallower than 600 m.

After 2008 there was a substantial change in the fishery for blue ling (Table 4.2.1 and Figure 4.2.3). The proportion of catches taken by longliners increased from 7–20% in 2001–2007 to around 70% in 2011 as longliners started targeting blue ling.

In 2015–2020, the trend has reversed; the proportion of longline catches decreased to 20–30% and longliners started fishing in shallower waters. From 2008-2014, longline catches were mostly taken at depths greater than 500 Now, the depth distribution resembles the one observed before 2008, or at depths less than 400 m., (Figure 4.2.4).

Historically the fisheries in Subarea 14 have been relatively small but highly variable.

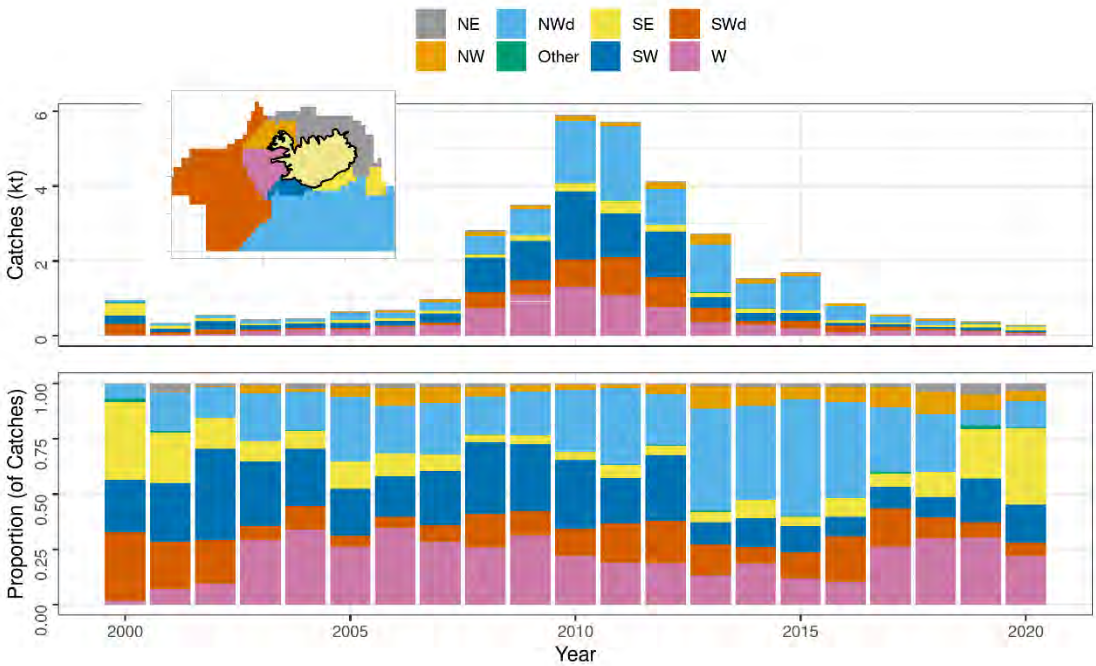


Figure 4.2.2: Blue ling in 5.a and 14. Catch distribution and proportions by area according to logbooks. All gears combined.

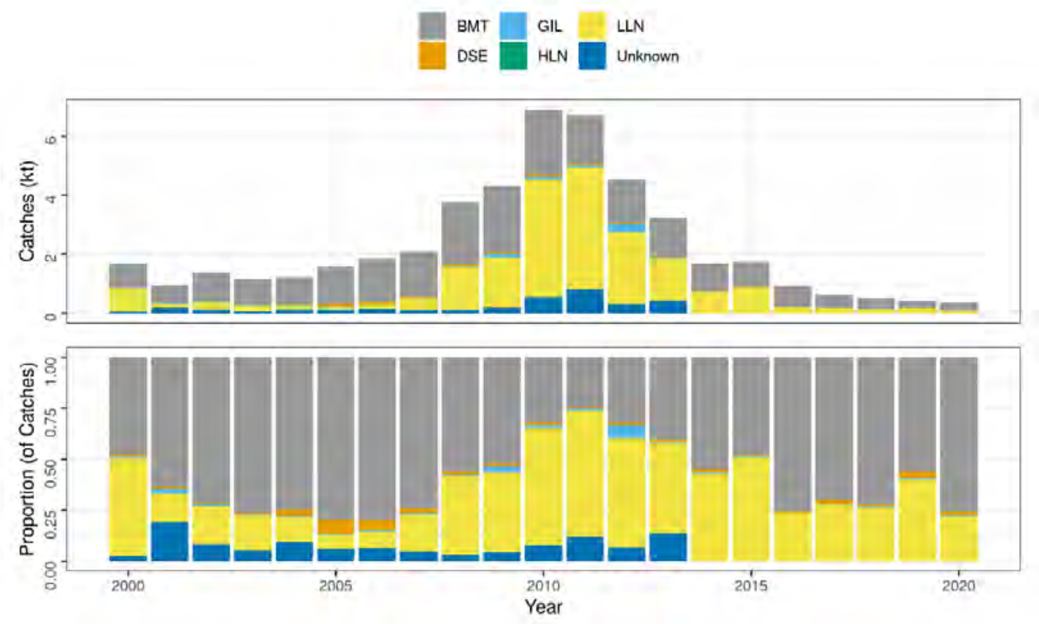


Figure 4.2.3: Blue ling in 5.a and 14. Total catch (landings) and proportion by fishing gear since 2000. according to logbooks.

In 2020, the total landings of the Icelandic fleet were 349 t (Table 4.2.1). Between 2006 and 2010, the catches of blue ling increased by more than 370%; the main part of this increases can be attributed to increased targeting of blue ling by the longline fleet. Since then, catches decreased substantially due to increased management procedures. Now, blue ling is mainly caught as by-catch in the redfish and Greenland halibut fisheries (Table 4.2.1).

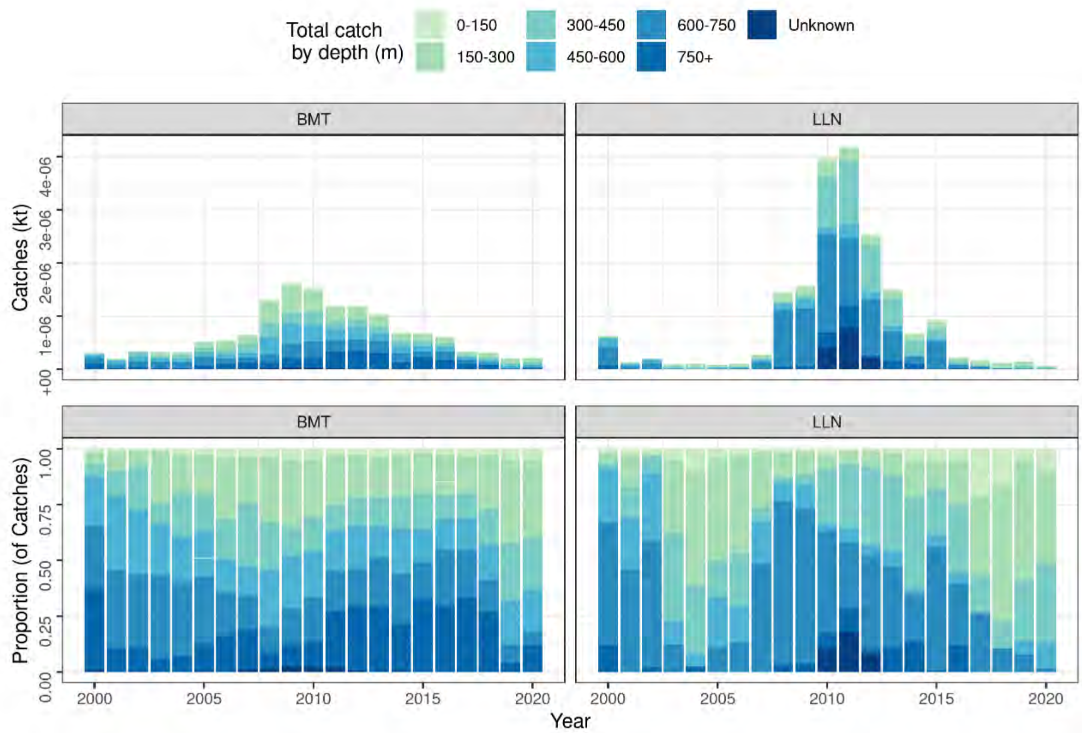


Figure 4.2.4: Blue ling in 5.a and 14. Depth distribution and proportion of longlines (LLN) (right) and trawls (BMT) (left) catches according to logbook entries.

4.2.2 Landings trend

In 2020, the preliminary total landings in ICES Division 5.a were 349 t of which the Icelandic fleet caught 343 t. (Table 4.2.2 and Figure 4.2.5). Catches of blue ling in ICES Division 5.a increased by more than 370% between 2006 and 2010, the main part of this increases can be attributed to increased targeting of blue ling by the longline fleet. Since then, catches in ICES Division 5.a decreased compared substantially due to increased management procedures (Table 4.2.1).

Total international landings from Subarea 14 (Table 4.2.2) have been highly variable over the years, ranging from a few tonnes in some years to around 3700 t in 1993 and 950 t in 2003. Most of the landings in 2003 were taken by Spanish trawlers (390 t). Since then, no further information is available on this fishery. The high landing values in Subarea are very occasional, and in most years, total international landings have been between 50 and 200 t. Preliminary landings in 2020 were 27 t.

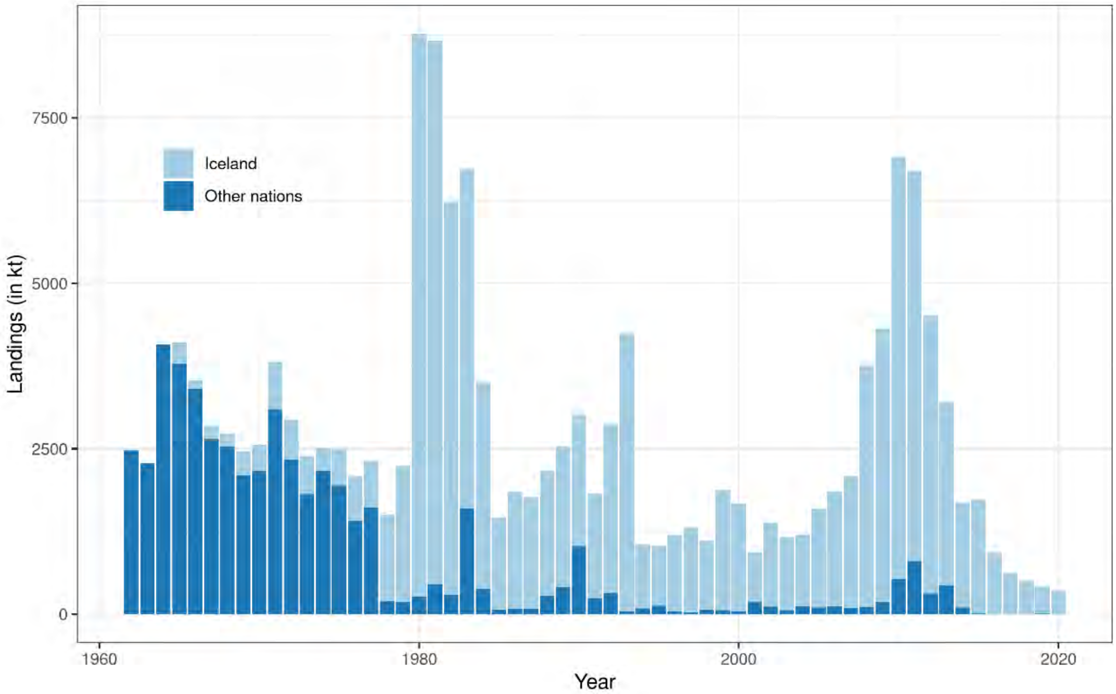


Figure 4.2.5: Blue ling in 5.a and 14. Nominal landings

4.2.3 ICES advice

The assessment presented above is based on the ICES DLS approach for category 3 stocks. The Icelandic autumn trawl survey (IS-SMH) was used as the index for the stock development. The advice is based on the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B) multiplied by the last years advice. The index/ratio is estimated to have decreased by less than 20% and thus the uncertainty cap was not applied. The stock status relative to candidate reference points is unknown and the precautionary buffer was applied. The result is advice for 2021/2022 set at 349 t ((840.6/976.7)*406), which is a 14% decrease from last year's advice. The basis for the advice 20122020 was the following: The ICES framework for category 3.3 stocks was applied (ICES, 2012). The Icelandic autumn trawl survey was used together with the catch to calculate a harvest rate index. Based on this an F_{proxy} has been chosen from a reference period, 2002–2009, when the fishing pressure was relatively constant and the SSB increased steadily, which implies that the harvest was considered sustainable. The advice was based first on a comparison of the latest index value (index A) with the preceding value (index B), combined with the Fproxy target (catch/survey biomass). When the index was estimated to have changed by more than 20% the uncertainty cap was applied. However, following the close of the WGDEEP working group meeting in 2019 and during the preparation of the draft advice for 2020, there were discussions about the appropriateness of using the Fproxy in deriving the advice. It was concluded that the recruitment estimates of recent years were much lower than those observed during the period used for the calculation of the Fproxy and that the Fproxy is likely no longer appropriate. Consequently, the ICES framework for category 3 stocks using survey trends was applied instead.

4.2.4 Management

Before the 2013/2014 fishing year the Icelandic fishery was not regulated by a national TAC or ITQs. The only restrictions on the Icelandic fleet regarding the blue ling fishery were the introduction of closed areas in 2003 to protect known spawning locations of blue ling, which are in effect. As of the 2013/2014 fishing year, blue ling is regulated by the ITQ system (regulation 662/2013) used for many other Icelandic stocks such as cod, haddock, tusk and ling.

The TAC for the 2018/2019 fishing year was set at 1520t based on the recommendations of MFRI using the same advisory procedure as for ICES category 3 stocks. The difference between national TAC and landed catch in Icelandic waters can be attributed to species transformation which for blue ling is only from blue ling to other species and not vice versa as for other species in the ITQ system (Figure 4.2.6).

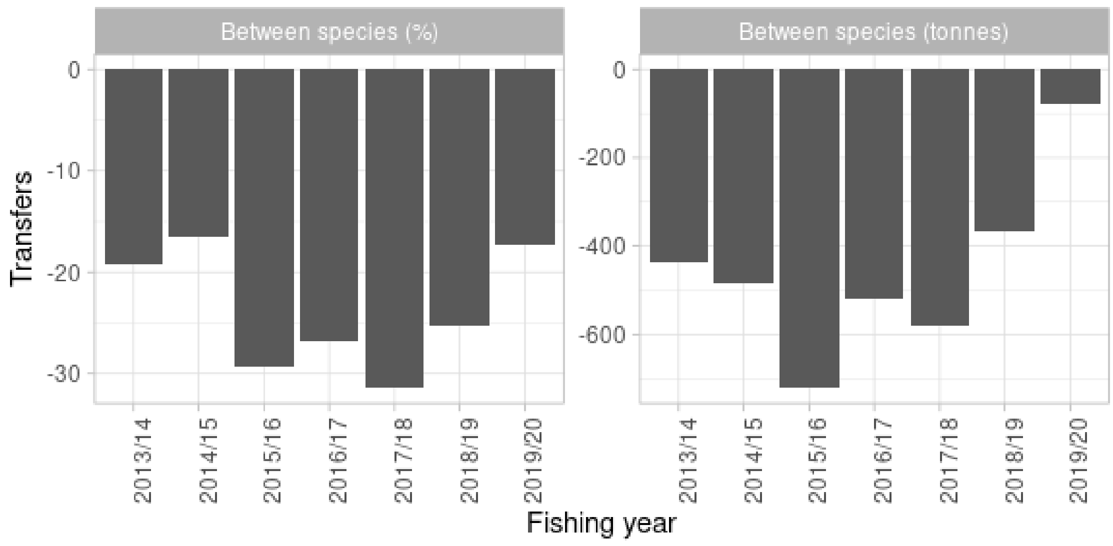


Figure 4.2.6: Blue ling in 5.a and 14. Net transfer of quota, from blue ling to other species, in the Icelandic ITQ system by fishing year.

4.2.5 Data available

In general sampling is considered adequate from commercial catches from the main gears (longlines and trawls). The sampling does seem to cover the spatial distribution of catches for longlines and trawls. Similarly, sampling does seem to follow the temporal distribution of catches (WGDEEP 2012).

4.2.5.1 Landings and discards

Landings data are given in Table 4.2.4 and Table 4.2.2. Discarding is banned in the Icelandic fishery. There is no available information on discarding of blue ling. Being a relatively valuable species and not being subjected to TAC constraints prior to 2013/2014 fishing year nor minimum landing size there should be little incentive to discard blue ling.

4.2.5.2 Length composition

Length distributions from the Icelandic trawl and longline catches for the period 2005– 2020 are shown in Figure 4.2.8. No length measures were called for from commercial catches in 2017. In 2020, only three sample were collected from commercial catch; one from long line and two from bottom trawls and does therefore not cover the spatial distribution of catches (Figure 4.2.7, Table 4.2.5).

Mean length from catches increased from 86 cm in 2005 to 103 cm in 2018. On average mean length from longlines is higher than from trawls.

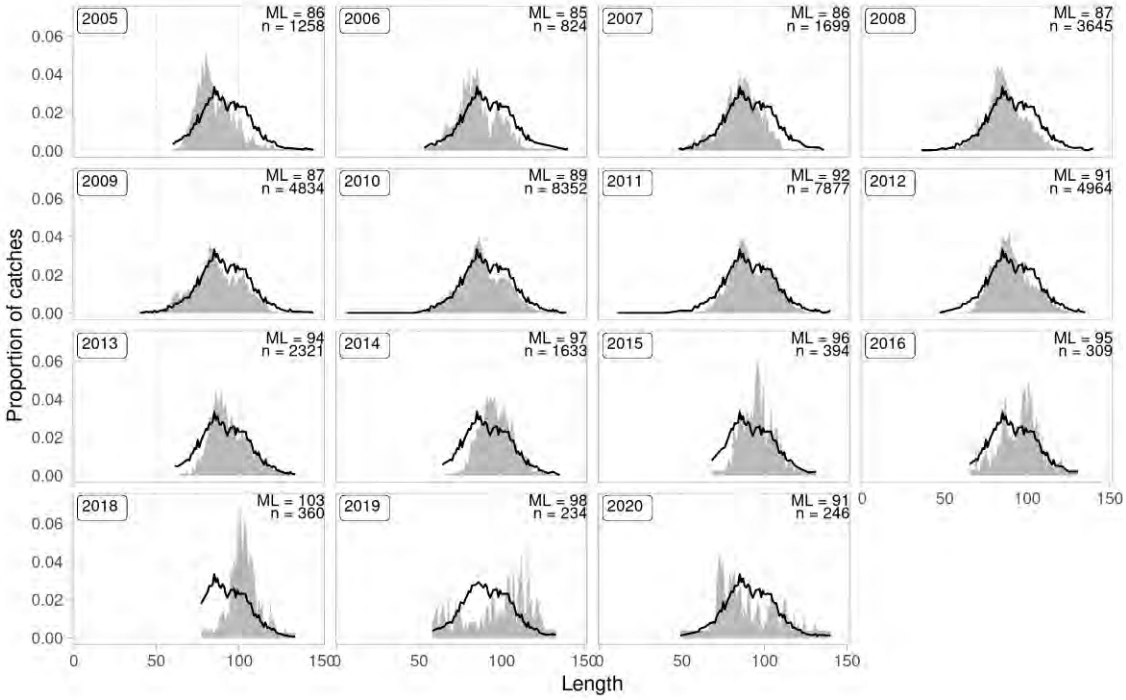


Figure 4.2.7: Blue ling in 5a. Length distribution of blue ling from trawls (grey area) and longlines (red lines) of the Icelandic fleet since 2004. No data available in 2017.

4.2.5.3 Age composition

No new data were available. Existing data are not presented due to the difficulties in the ageing of this species.

4.2.5.4 Weight-at-age

No new data were available. Existing data are not presented because of difficulty in ageing.

4.2.5.5 Maturity and natural mortality

Length at 50% maturity is estimated at roughly 77 cm and the range for 10–90% maturity is 65–90 cm. No information is available on natural mortality (M)

4.2.5.6 Catch, effort and survey data

Effort and nominal CPUE data from the Icelandic trawl and longline fleet are given in Figure 4.1.9. Due to changes in the fishery (expansion into new areas, fleet behaviour, etc.) and technical innovations CPUE is not considered a reliable index of biomass abundance of blue ling and therefore no attempt has been made to standardize the series.

However, looking at fluctuations in CPUE may be informative regarding the development of the fishery. CPUE from longlines was high from 2008 to 2013 but has decreased markedly since then. CPUE from trawls has been gradually decreasing in the period.

Effort from longlines peaked in 2009 but has since then decreased sharply. Effort from trawls peaked in 2011 but has remained relatively stable since. Non-standardised estimates of CPUE (left) and fishing effort (right) from longlines and trawls, based on logbook data where blue ling was recorded in catches.

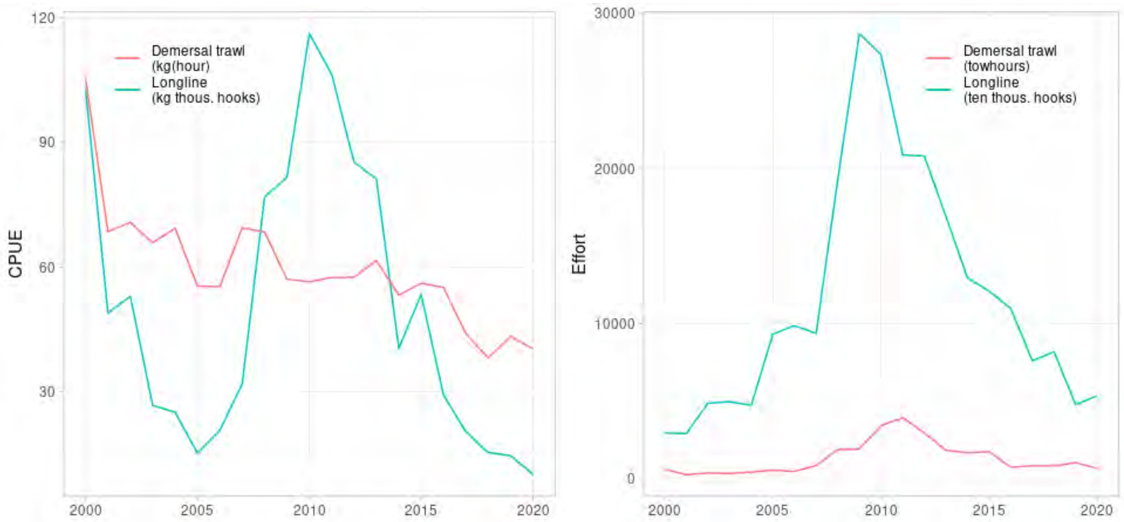


Figure 4.2.8: Blue ling in 5.a and 14. Nominal CPUE and effort from longlines (blue line) and trawls (red line) in 5.a based on logbook data where blue ling was either recorded in catches or above certain level.

Time-series stratified abundance and biomass indices from the spring (G3239) and autumn (G4493) trawl surveys are shown in Figure 4.2.9.

The length distributions from the autumn survey and its spatial distribution are presented in Figure 4.2.10 and Figure 4.2.11. Due to industrial action in 2011 the autumn survey was cancelled after about one week of survey time. Therefore, no estimates are presented for 2011.

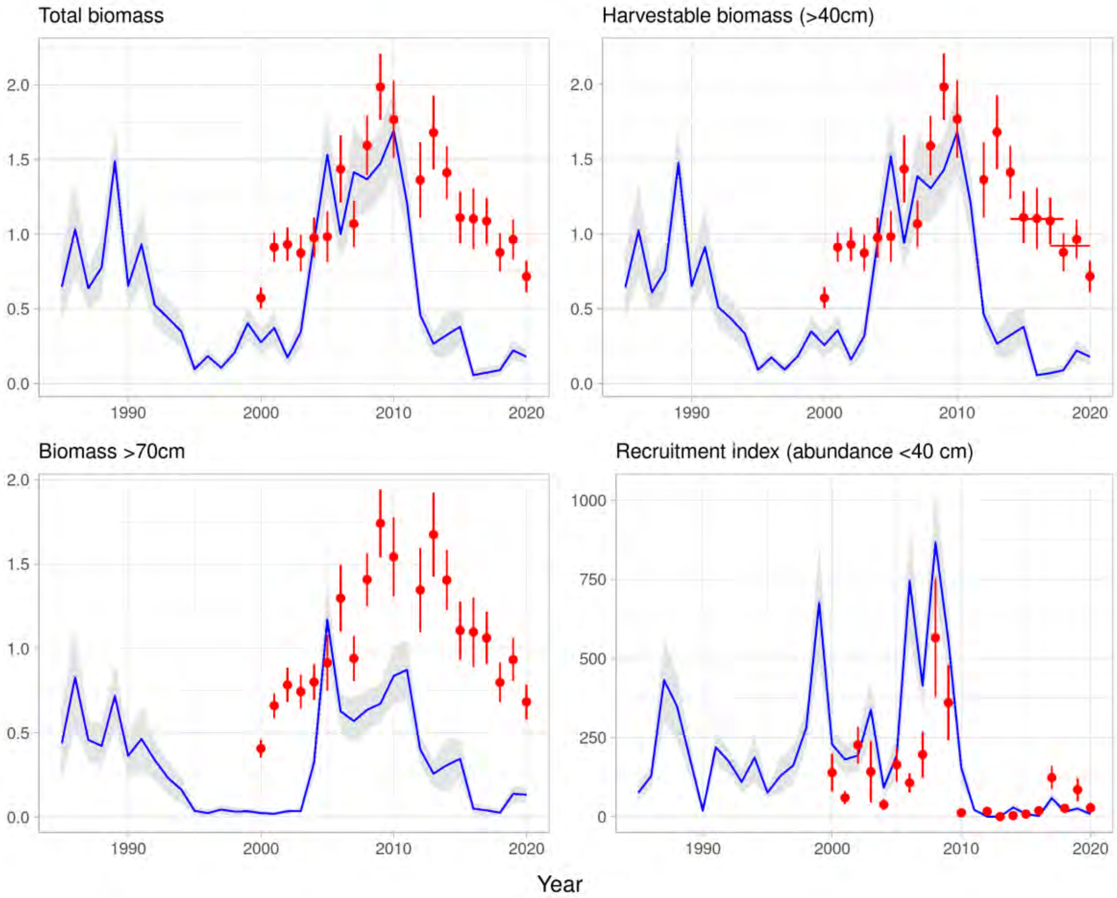


Figure 4.2.9: Blue ling in 5.a and 14. Abundance indices for blue ling in the Icelandic autumn survey since 2000 (red points and vertical lines) and the spring survey since 1985 (faded lines and shaded area). Total biomass index (top-left), biomass of 40 cm and larger (top-right), biomass of 70 cm and larger (bottom-left) and abundance - standard error of the estimate.

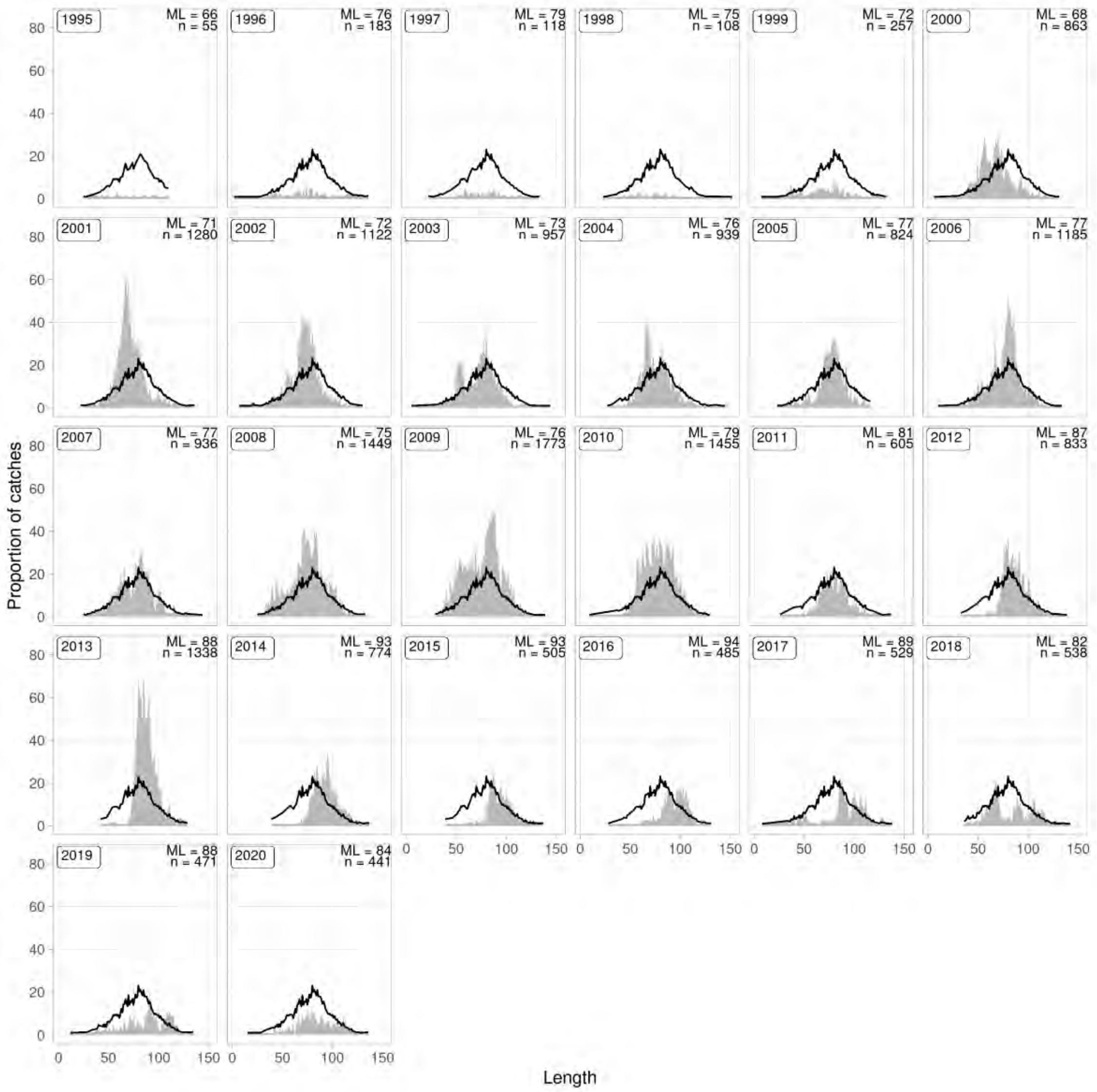


Figure 4.2.10: Blue ling in 5.a and 14. Length distribution from the Icelandic autumn survey since 1995. Black line is the average by length over the displayed period.

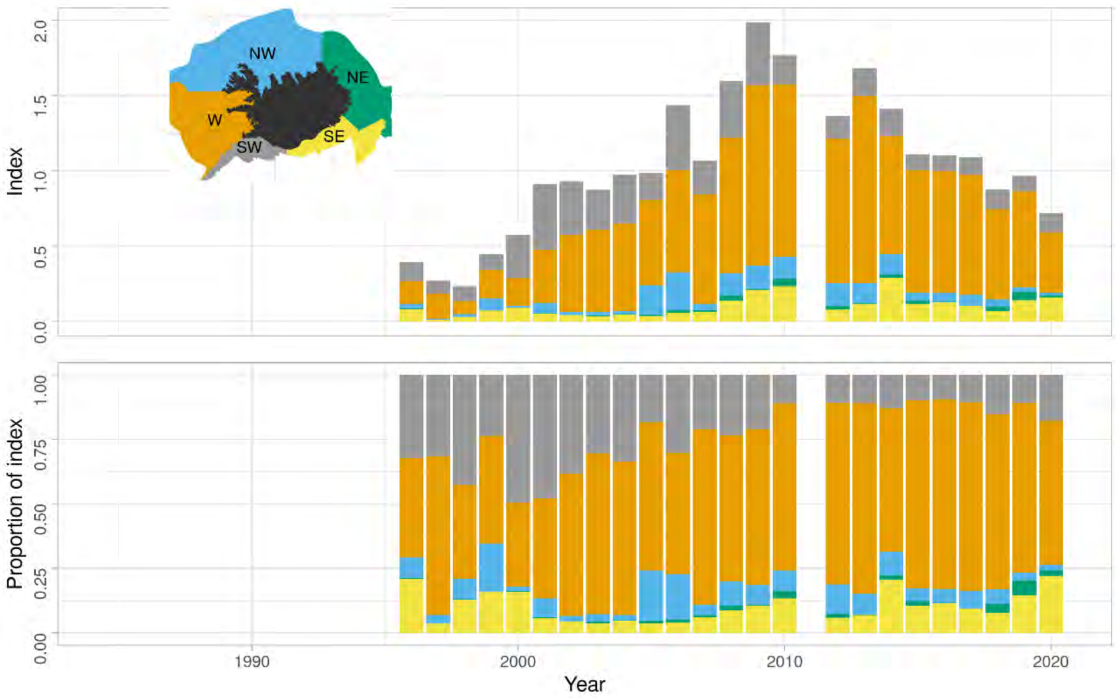


Figure 4.2.11: Blue ling in 5.a and 14. Spatial distribution of biomass index from the Icelandic autumn survey in 1996-2020.

4.2.6 Data analysis

Landings and sampling

Catches from the Icelandic longline fleet increased rapidly from 2007–2010 resulting in a rapid expansion of the fishing area and change in the selectivity of the fishery although there are now strong indications since 2012 that this may have reversed (Table 4.2.1).

In 2005 longliners caught 102 tonnes of blue ling when trawlers caught 1260 tonnes or 83% of the total catches (1505 tonnes). In 2011 trawlers caught 1618 tonnes, out of 5900 tonnes or 23%, but longliners 4138 tonnes or 70%. Since then, the proportion taken by longliners has decreased and in 2020 longliners caught 70 or 20.5% of the catches, trawls 264 or 77% and other gear 8, or 2.5%. As longliners take on average larger specimens of blue ling, this will have resulted in an overall change in the selection pattern in 2006–2015.

Total catches by the Icelandic fleet decreased between 2010 and 2013 and this decrease is mainly the result of decrease in trawls fishing activity in 2011 and longlines in 2012 and 2013. The expansion of the longline fleet to deeper waters (Figure 4.2.4) may be the result of decreased catch rates in shallower areas.

CPUE and effort: CPUE indices from commercial catches are not considered a reliable index of stock abundance. The rapid CPUE increase from longlines should not be viewed as an increase in stock biomass but rather as the result of increased interest by the longline fleet and its expansion into deeper waters (Figure 4.2.8). In 2011 to 2012 there was a slight decrease in CPUE from longline but the CPUE increased again in 2013 to its highest value in the time-series. CPUE from trawling has remained at low levels while effort increased until about 2009 after which it has decreased (Figure 4.2.8).

Surveys The spring survey covers only the shallower part of the depth distributional range of blue ling and shows high interannual variance (Figure 4.2.11). It is thus unknown to what extent the spring indices reflect actual changes in total blue ling biomass, given that it does not cover the depths were largest abundance of blue ling occur. It is however not driven by isolated large catches at a few survey stations. The shorter autumn survey, which goes to greater depths and is therefore more likely to reflect the true biomass dynamics, does indicate that there was an increase in blue ling biomass 2007-2009 (Figure 4.2.11). Since 2010 the biomass index has decreased to similar levels as observed in 2002–2005. A large increase of more than 200% in the recruitment index was observed in 2008 but in the 2010 it had decreased again to its lowest observed value and has not increased again for nine years, with the exception of 2017, when an increase was observed (Figure 4.2.10 and Figure 4.2.11). As a result, mean length measured in the autumn survey has been higher after 2009 than it was before. Due to industrial action, only part of the autumn survey was conducted in 2011.

Fproxy Relative fishing mortality (Fproxy = Yield/Survey biomass index) derived from the autumn survey (+40 cm) and the combined catches from Iceland and Greenland, indicates that fishing mortality may have increased by more than 150% between 2006–2010 (Figure 4.2.13 and Table 4.1.6). Since then, there are indications that it has decreased by similar percentage between 2012 and 2014, to the same levels as observed in 2002 and 2009 but has decreased even further in 2015-2017.

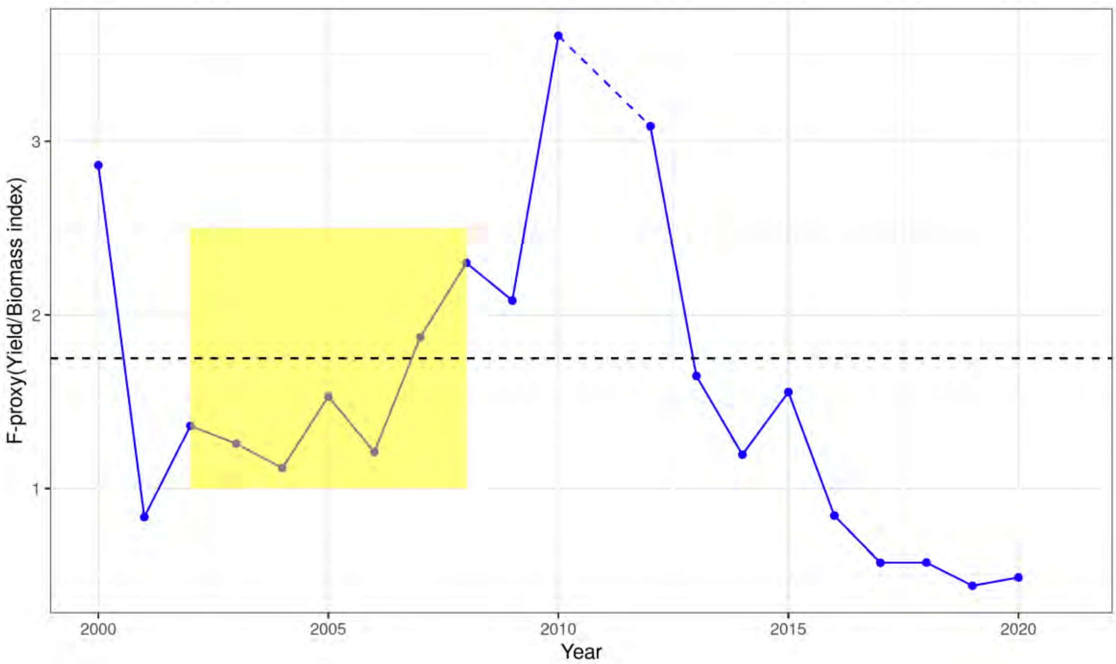


Figure 4.1.12: Blue ling in 5.a and 14. Changes in relative fishing mortality (Yield/Survey biomass >39 cm). The yellow box highlights the reference period used as basis for the advice in 2012-2020, and the horizontal dotted line used to be the target Fproxy.

Analytical assessment ***Exploratory stock assessment on blue ling using gadget***

An exploratory stock assessment of blue ling using the Gadget model was presented at WGDEEP 2012. Updated results of the model were not presented at WGDEEP 2021.

4.2.6.1 Comments on the assessment and advice

The assessment of this stock is based on the ICES DLS approach for category 3 stocks. The Icelandic autumn trawl survey (IS-SMH) was used as the index for the stock development. The advice is based on the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B) multiplied by last year's advice. The index/ratio is estimated to have decreased by 20% and thus the uncertainty cap was not applied.

The result is advice for 2021/2022 set at 349 t ((840.6/976.7)*406), which is a 14% decrease from last year's advice. The Icelandic autumn trawl survey was used together with the catch to calculate a harvest rate index. Based on this an Fproxy has been chosen from a reference period, 2002–2009, when the fishing pressure was relatively constant and the SSB increased steadily, which implies that the harvest was considered sustainable. However, following 2019 WGDEEP there were discussions about the appropriateness of using the Fproxy in deriving the advice. It was concluded that the recruitment estimates of recent years were much lower than those observed during the period used for the calculation of the Fproxy and that the Fproxy is likely no longer appropriate.

4.2.7 Management considerations

Landings have decreased considerably in the last year and as blue ling is now part of the ITQ system such a rapid increase in landings as observed between 2006 and 2011 is unlikely. Blue ling is caught in mixed fisheries by the trawler fleet, mainly targeting redfish and Greenland halibut. After the inclusion of blue ling in the ITQ system the longliners have shifted from a directed fishery to a more mixed fishery for the species. Because of the restrictions of the TAC the implications of low blue ling TAC for the trawlers can be considerable, although the species is a low percentage in their catches. Recruitment index from the autumn survey indicates very little recruitment to the stock since 2010, resulting in a truncated length distribution from both the survey and commercial catches. Closure of known spawning areas should be maintained and expanded where appropriate.

Table 4.2.1: Blue ling in 5.a and 14. Number of Icelandic boats with blue ling landings and their total landings in 5a.

Year	Bottom trawl	Gill nets	Longlines	Other	Bottom trawl	Gill nets	Longlines	Total catch
2000	797	13	808	17	102	18	44	1635
2001	573	24	131	35	94	27	39	763
2002	961	15	256	33	88	14	41	1265
2003	869	6	197	26	88	14	47	1098
2004	869	5	145	65	98	19	53	1084
2005	1242	8	108	138	94	16	60	1496
2006	1441	13	151	129	93	16	69	1734
2007	1483	22	374	116	88	24	90	1995
2008	2082	28	1454	90	82	25	92	3654
2009	2076	136	1677	241	77	30	87	4130
2010	1904	91	3978	405	73	30	96	6378
2011	1381	76	4140	307	67	24	96	5904
2012	1306	274	2425	201	67	22	78	4206
2013	1113	14	1420	220	64	20	71	2767

Year	Bottom trawl	Gill nets	Longlines	Other	Bottom trawl	Gill nets	Longlines	Total catch
2014	763	11	622	192	60	15	73	1588
2015	736	9	868	99	59	18	76	1712
2016	641	3	213	68	62	11	53	925
2017	381	1	169	67	56	8	52	618
2018	338	2	132	30	63	6	59	502
2019	238		161	25	57	8	53	416
2020	264	1	70	7	58	9	46	343

Table 4.2.2: Blue ling in 5.a and 14 and 14.b.Landing in ICES Division 14. Source: STATLANT database and WD02 (Annex 2).

YEAR	FAROE	GERMANY	GREENLAND	ICELAND	NORWAY	RUSSIA	SPAIN	UK	DENMARK	TOTAL
1983	0	621	0	0	0	0	0	0	0	621
1984	0	537	0	0	0	0	0	0	0	537
1985	0	315	0	0	0	0	0	0	0	315
1986	214	149	0	0	0	0	0	0	0	363
1987	0	199	0	0	0	0	0	0	0	199
1988	21	218	3	0	0	0	0	0	0	242
1989	13	58	0	0	0	0	0	0	0	71
1990	0	64	5	0	0	0	0	10	0	79
1991	0	105	5	0	0	0	0	45	0	155
1992	0	27	2	0	50	0	0	32	0	111
1993	0	16	0	3124	103	0	0	22	0	3265
1994	1	15	0	300	11	0	0	57	0	384
1995	0	5	0	117	0	0	0	19	0	141
1996	0	12	0	0	0	0	0	2	0	14
1997	1	1	0	0	0	0	0	2	0	4
1998	48	1	0	0	1	0	0	6	0	56
1999	0	0	0	0	1	0	66	7	0	74
2000	0	1	2	4	0	0	889	2	0	898
2001	1	0	1	11	61	0	1631	6	0	1711

YEAR	FAROE	GERMANY	GREENLAND	ICELAND	NORWAY	RUSSIA	SPAIN	UK	DENMARK	TOTAL
2002	0	0	0	11	1	0	0	0	0	12
2003	0	0	3	0	36	0	670	5	0	714
2004	0	0	7	0	1	0	0	7	0	15
2005	2	0	6	0	1	0	176	8	0	193
2006	0	0	6	0	3	1	0	0	0	10
2007	19	0	1	0	1	0	0	0	0	21
2008	1	0	5	0	2	0	381	0	1	390
2009	1	0	5	0	3	0	111	4	0	124
2010	1	0	8	0	9	0	34	0	3	55
2011	0	0	8	0	2	0	0	1	6	17
2012	0	0	13	367	9	0	0	0	3	392
2013	0	0	16	0	0	0	0	3	9	28
2014	0	0	14	0	3	0	0	0	0	17
2015	0	0	66	0	1	0	0	0	5	72
2016	0	0	9	0	0	0	0	0	7	16
2017	0	0	12	0	4	0	0	0	3	19
2018	0	0	34	0	12	0	0	0	5	51
2019	0	7	20	0	36	0	0	0	0	62
2020	0	7	18	0	2	0	0	0	0	27

Table 4.2.3: Blue ling in 5.a and 14. Advised TAC, national TAC and total landings since the quota year 2013/2014.

Fishing Year	MFRI Advice	National TAC	Iceland	Others	Landings
2013/14	2400	2400	1653	101	1754
2014/15	3100	3100	1898	41	1939
2015/16	2550	2550	1734	90	1828
2016/17	2032	2032	932	23	955
2017/18	1956	1956	554	79	592
2018/19	1520	1520	424	62	424
2019/20	483	483	371	5	376

Fishing Year	MFRI Advice	National TAC	Iceland	Others	Landings
2020/21	406	406			
2021/22	349				

Table 4.2.4: Blue ling in 5.a and 14.: Landings from Icelandic fishing grounds (5a)

Year	Faroe	Germany	Iceland	Norway	UK
2002	28	4	1264	74	10
2003	16	16	1098	6	24
2004	38	9	1083	49	27
2005	24	31	1496	20	26
2006	63	22	1734	27	11
2007	78		1995	4	13
2008	88		3653	21	
2009	178		4129	5	
2010	515		6378	13	
2011	797		5904	2	
2012	312		4207	2	
2013	435		2769	2	
2014	70		1588	30	
2015	12		1712	4	
2016	6		925		
2017	4		619		
2018	28		502		
2019	28		415	4	
2020	6		343	0.1	

Table 4.2.5: Blue ling in 5.a and 14. Catches along with survey biomass index (larger than 40 cm) from the Icelandic Autumn survey and the calculated Fproxy (Catches in Iceland and Greenland)/Index)

Year	Iceland	Greenland	Index	Fproxy
2000	1635.876	896	566.3	4.4709094
2001	761.809	1710	911.9	2.7106141
2002	1264.674	12	929.4	1.3736540
2003	1098.029	711	872.7	2.0729105
2004	1089.908	8	975.0	1.1260595
2005	1502.326	187	982.0	1.7202912
2006	1736.037	4	1435.0	1.2125693
2007	1998.092	20	1067.3	1.8908386
2008	3653.183	385	1588.8	2.5416560
2009	4129.245	119	1982.5	2.1428726
2010	6377.866	47	1767.7	3.6345907
2012	4206.665	379	1362.6	3.3653787
2013	2769.869	28	1680.4	1.6650018
2014	1687.642	17	1412.1	1.2071680
2015	1727.363	72	1110.7	1.6200261
2016	930.790	16	1103.2	0.8582215
2017	622.257	19	1087.0	0.5899328
2018	502.955	17	877.1	0.5928115
2019	423.983	62	963.9	0.53215
2020	349.307	27	716.4	0.5252750

4.3 Blue Ling (*Molva dypterygia*) in Division 5.b and subareas 6 and 7

4.3.1 The fishery

In the last decade, the main fisheries have been from French, Faroese and Scottish trawlers. Faroese vessels have been fishing almost exclusively in ICES Division 5.b, French and Scottish vessels have been mostly fishing in in ICES Division 6.a, with a smaller catch in in ICES Division 5.b from French trawlers. Scottish vessels have been catching an increasing proportion of annual international landings. The two other countries, which contribute notably to the total catch are Norway and Spain. Total international landings from Subarea 7 are small and are mostly bycatches in other fisheries. There used to be more fishing in divisions 7.bc, but these have declined to very small bycatch in recent years.

Landings by Faroese trawlers are mostly taken in the spawning season. Historically, this was also the case for French trawlers fishing in in ICES Division 5.b and 6.a. However, since the 2000s blue ling has been taken round the year together with roundnose grenadier and black scabbardfish, as well as deep-water sharks until 2009. Since 2016 trawling is banned deeper than 800 m, whist blue ling is abundant down to at least 12000 m.

In 2019, 94.2 % of the landings were from bottom trawlers and 5.8% from longliners. In 2020, the contribution of longliners increased to 9%. As in previous years, all Norwegian catch were from longliners. The Spanish fleet as a component of longliners, which represented one quarter of Spanish catches in 2019.

4.3.2 Landings trends

See the stock annex for the time-series of landings from 1966 to 1999.Total international landings from Division 5.b (Tables 4.3.1a–f, Figure 4.3.1 and stock annex) peaked in the late 1970s at around 21 000 t and then declined until 2010. Thereafter landings have oscillated between 1000 and 1700 tonnes per year.

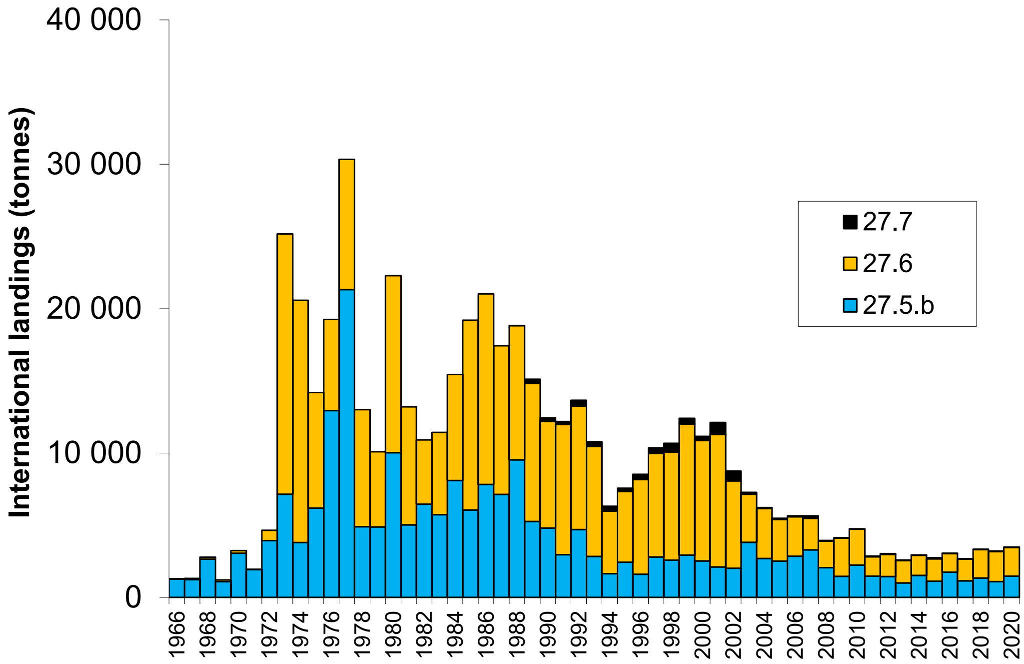


Figure 4.3.1. International landings for bli.27.5b67 in ICES subareas 6 and 7 and Division 5b.

The landings from Subarea 27.6 peaked at about 18 000 t in 1973 and fluctuated throughout the 1980s within the range of 5000–10 000 t and have since gradually declined. In the 2000s reducing EU TACs have been the main driver of the catch level. In the 2010s, the landings declined to an historical low level of less than 1300 tonnes in 2016 but have increased since to more than 2000 tonnes in 2019. Although significant in the past, landings in Division 6b were minor in the last 10 years.

Landings from Subarea 7 are comparatively small, mostly less than 500 t per year in the whole time-series and less than 50 t during the last ten years, except in 2015 when 78 t were landed.

Landings in the two last years are the highest since 2010. This recent increase was spread across all fishing countries and all areas. This increase was therefore not the consequence of an emerging fishery but that of higher catch in all fisheries. Nevertheless, landings remain well below the TAC and maximum catch level recommended in the ICES advice. Some EU fleets, in particular the French fleet of large trawlers, appear to be in a situation of under capacity. Although fishing opportunities for blue ling have increased from 2015, vessels kept fishing mostly for saithe. This under capacity is the result of the reduction of the number of French trawlers >=30 m, based in harbours where deep-water species are landed, from 35 in 2005 to 16 in 2016 (Common Fleet Register data). Further the EU regulation limiting fishing at spawning time no longer allows for large targeted catch during the spawning season as in the 1980s and 1990s.

Like in recent years, landings data by country and ICES Division were extracted from InterCatch for all countries, expect for the Faroe Islands for which official Faroese landings were provided. Preliminary landings for 2018 were updated with final figures.

4.3.3 ICES Advice

The ICES advice for 221 and 2022 is "when the MSY approach is applied, catches should be no more than 11522 tonnes in 2021 and no more than 10859 tonnes in 202."

4.3.4 Management

This stock is classified as Category 4 in the NEAFC categorization of deep-sea species/stocks which implies that fisheries are primarily restricted to Coastal State exclusive economic zones (EEZs) and therefore management measures are not taken by NEAFC unless complementary to coastal state conservation and management measures.

Prior to 2009, EU deep-water TACs were set on a biennial basis; however from 2009 onwards, annual TACs were applied for the components of this stock in EU waters of in ICES Division 5.b, and Subareas 6 and 7. TACs are fixed according to bilateral agreements between EU and Faroe Islands and EU and Norway. The EU TAC includes quotas for Norway and the Faroe Islands and the EU has a quota for ling and blue ling in Faroese waters (1885 t in 2019 and 2020). This EU quota in Faroese waters is divided in national quotas between Germany, France and UK.

The table below provides the EU TAC the quota allocated to EU vessel in Faroese waters and the ICES estimate of international landings in recent years.

				QUOTA INCLUDED IN EU TAC			EU QUOTA IN FAROESE WATERS OF 5.b(1)	INTERNATIONAL
Year	**Area**	**ICES advice**	**EU TAC**	**EU**	**Norway**	**Faroe**		**landings**
2006	67	Biennial		3037	200	400	3065	5650
2007	67	No direct fisheries		2510	160	200	3065	5648
2008	67	Biennial		2009	150	200	3065	3940
2009	5b67	No direct fisheries	2309	2009	150	150	3065	4121
2010	5b67	Biennial	2032	1732	150	150	2700	4759
2011	5b67	No direct fisheries	2032	1717	150	0	0	2861
2012	5b67	Same as 2011	2031	1882	150	0	0	3031
2013	5b67	3900	2540	23905	150	0	0	2588
2014	5b67	3900	2540	2210	150(2)	150(3)	1500	2949
2015	5b67	5046	5046	4746	150(2)	150(3)	1500	2793
2016	5b67	5046	5046	4746	150(2)	150(3)	2100	3059
2017	5b67	11314	11314	11014	150(2)	150(3)	2000	2669
2018	5b67	10763	10763	11463	150(2)	150(3)	2000	3322
2019	5b67	11778	11778	11378	250(2)	150(3)	1885	3218
2020	5b67	11150	11150	10750	250(2)	150(3)	1885	
2021	5b67	11522	5425(4)	5425	0	0	(5)	

Year	Area	ICES advice	EU TAC	QUOTA INCLUDED IN EU TAC EU	Norway	Faroe	EU QUOTA IN FAROESE WATERS OF 5.b(1)	INTERNATIONAL landings
2022	5b67	10859						

(1) TAC for ling and blue ling, against which a bycatch roundnose grenadier and black scabbard fish may be counted, up to a limit of 665 t in 2018.

(2) To be fished in Union waters of 27.2.a and 27.4-7 (BLI/*24X7C).

(3) Including bycatch of roundnose grenadier and black scabbardfish.

(4) preliminary TAC from 01.012021 to 07.31.2021, according to agreement between EU and UK

(5) status of this quota unknown

In Faroese waters, Faroese vessels are encouraged to land all fish, which is thought to be done for blue ling, owing to the species value and the absence of fish of unmarketable size. Faroese vessels in Faroese waters are regulated by licences and fishing days but no quota.

From 2015 to 2020, the EU TAC in EU and international waters was set to the level of the ICES catch advice. As a significant fraction of the catch comes from Faroese waters, setting the EU TAC at the level of the ICES advice implied that the ICES advice could have been overrun without any illegal catch, so creating a risk of exploiting the stock beyond the recommended level.

In 2009, the EU introduced protection areas of spawning aggregations of blue ling on the edge of the Scottish continental shelf (6.a) and at the edge of Rosemary Bank (6.a). Fishing for blue ling is restricted in known spawning areas during 3 months corresponding to the spawning season. Entry/exit regulations apply and vessels cannot retain >6 t of blue ling from these areas per trip. On retaining 6 t vessels must exit and cannot re-enter these areas before landing. This regulation and the coordinate of the prohibited area are included in regulation 2019/1241 of the European parliament and of the Council. Since 2021 and the Brexit, these spawning areas are no longer in EU but in UK waters. In 2013, NEAFC introduced a protection of the spawning area located near the southwest boundary of the Icelandic EEZ, this area is banned to bottom fishing gears from 15 February to 15 April (rec 7:2017, https://www.neafc.org/managing_fisheries/measures/current).

In ICES Division 27.6.b, areas closed to bottom fishing gears have been extended and these include some of the spawning areas identified by Large *et al*. (2009), see Figure 4.1.3b.

Blue ling has been subject to a minimum conservation reference (MCRS) of 70 cm in EU North-Western and South-Western waters (EU regulation 2019/124). This regulation also apply to the NEAFC RA. The impact of this MCRS regulation is minor as the proportion of blue ling smaller than 70 cm has always been minor.

4.3.5 Data availability

4.3.5.1 Landings and discards

The time-series of landings was updated (Tables 4.3.1a-f).

As in previous years, landings from the Faroe Islands in 2020 were not uploaded to InterCatch but provided to the expert group. From all countries, except the Faroe Islands, landings estimates submitted to InterCatch were used. In InterCatch, official landings where available for a subset of fleets only, in these case official landings and estimates were similar. For the Faroe Islands, official landings from Statland were used.

Data submitted to InterCatch showed that international discards in 2018-20 were less than 1% of landings for country reporting through InterCatch. Faroese vessels are considered making no discards. This low discarding proportion comes from the absence of catch of small blue ling on most of the fishing grounds. Overall, discarding is well below the maximum level of 5% for considering it negligible in ICES advice.

4.3.5.2 No catch in international waters were reported in 2020.Length compositions

Length composition times-series previously used were all updated (see below section 5.3.6 data analyses). The length composition of the landings used for the stock assessment was taken from InterCatch.

4.3.5.3 Age compositions

Age estimations have been carried out by France since 2009, using a consistent protocol (see stock annex) .so even that ageing are not validated for this species, comparable data are now available for 11 years. The MYCC model uses not only the age composition but also the variability of age-at-length, so that in addition to the catch in number at age, the age-length key is necessary to this model. The age length ley from France is applied to the international length distribution of the landings.

4.3.5.4 Weight-at-age

Blue ling is landed gutted in France, the only EU country where age estimation of this species is carried out. Weight-at-age is calculated using the length-at-age and length–weight relationship. Since the stock was benchmarked in 2014, the length–weight relationship used comes from the Faroese surveys, which cover a wide range of size (see stock annex).

4.3.5.5 Maturity and natural mortality

No new data.

4.3.5.6 Catch, effort and RV data

Catch data were updated, discards data reported to InterCatch were negligible (less than 5% of total catch). Effort data are not used for modelling the dynamics of the stock.

Abundance and biomass indices from surveys were all available. Blue ling is sampled in three Faroese surveys and one Scottish survey. The commercial CPUE series from the Norwegian longliner fleet was updated (Table 4.3.3).

4.3.6 Data analyses

4.3.6.1 Length compositions

Possible recruitment inputs are visible in length compositions of Faroese commercial catches in some years, e.g. 2007–2009 and again in 2018 (Figure 4.3.2).

In the sampling of Faroese landings, large numbers of fish have been measured in the last five years, making this data set useful to appraise change in the stock. On the contrary, in years 2000 to 2014, the number of fish measured seemed low. Despite the good data quality in recent years, these length distributions were not included in the assessment because quarterly length distribution was not available.

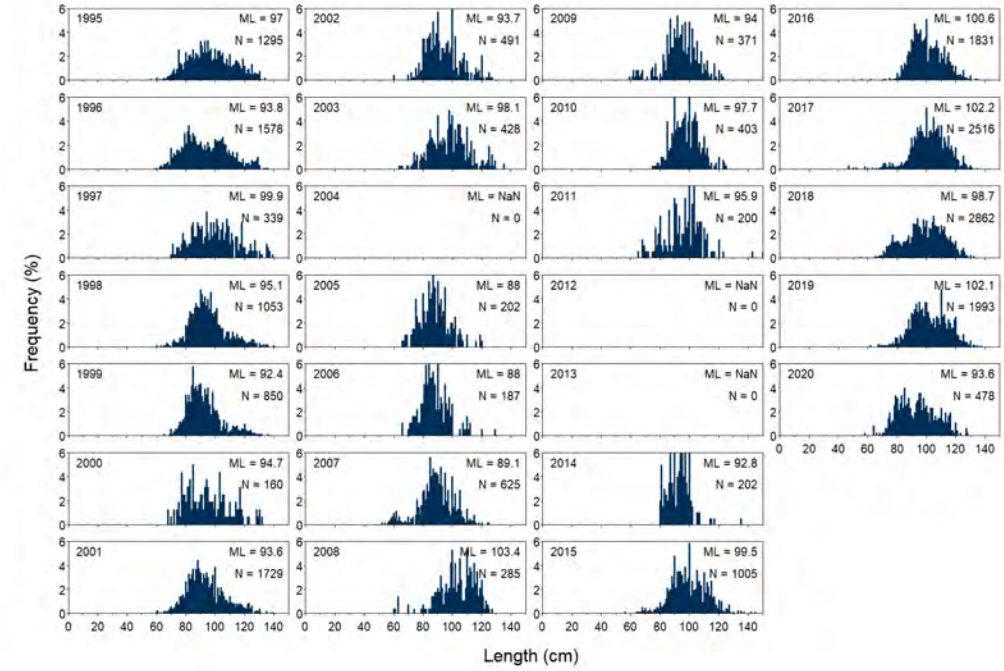


Figure 4.3.2. Length composition of blue ling landings from Faroese otter-board trawlers >1000 HP in Division 5.b from 1195 to 2020.

Small blue ling (between 40 and 60 cm total length) were caught in higher number during both surveys in the three last years than during most of the time series (Figures 4.3.3 and 4.3.4). The length distribution of the Faroese deep-water survey initiated in 2014 is shifted to the right compared to the other survey, which is expected as blue ling move to deeper areas with age. Nevertheless, in 2019 the deep-water survey also shows a higher proportion of smaller (60-80 cm) individuals (Figure 4.3.5).

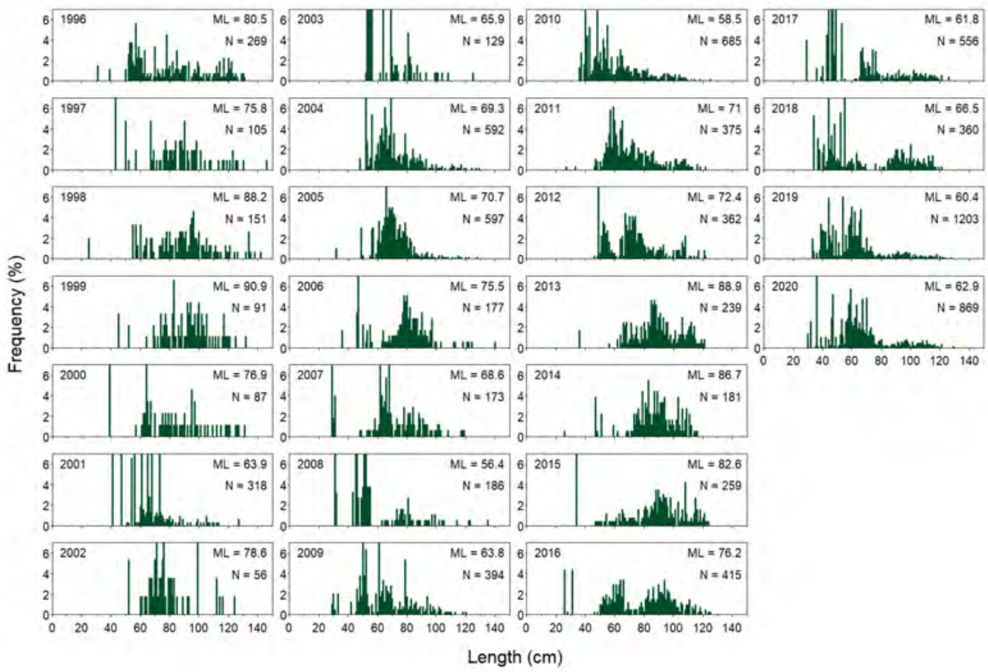


Figure 4.3.3. Length composition of blue ling in the Faroese summer groundfish survey on the Faroe Plateau (1996-2020).

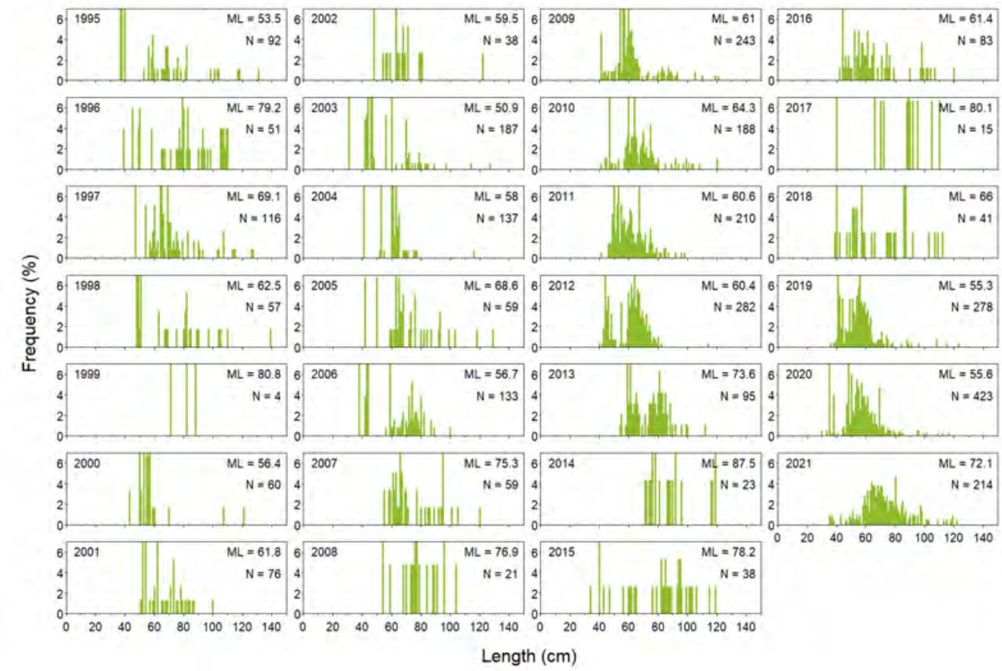


Figure 4.3.4. Length composition of blue ling in the Faroese spring groundfish survey on the Faroe Plateau (1995-2021).

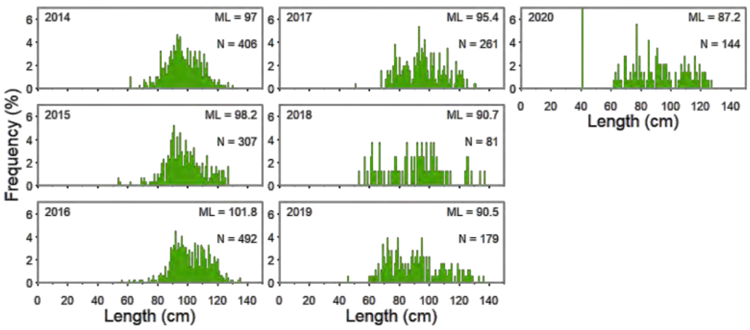


Figure 4.3.5. Length composition of blue ling in the Faroese deep-water survey in Faroese waters (2014-2020).

The length composition in French commercial data show an increasing proportion of larger fish over the past decade with an increasing proportion of fish on size larger than 1 m in the catch compared to the late 1990s to 2010 (Figure 4.3.6). The mean length was lower in years 1995-2006 and increased to a peak in 2014, then decreased further. This decreasing reflects a large income of small fish (recruitment) as in 2014-2018 the stock biomass increased and the fishing mortality was low. On the contrary, the large increase in mean length in 2019 probably reflects a lesser recruitment (Figure 4.3.7).

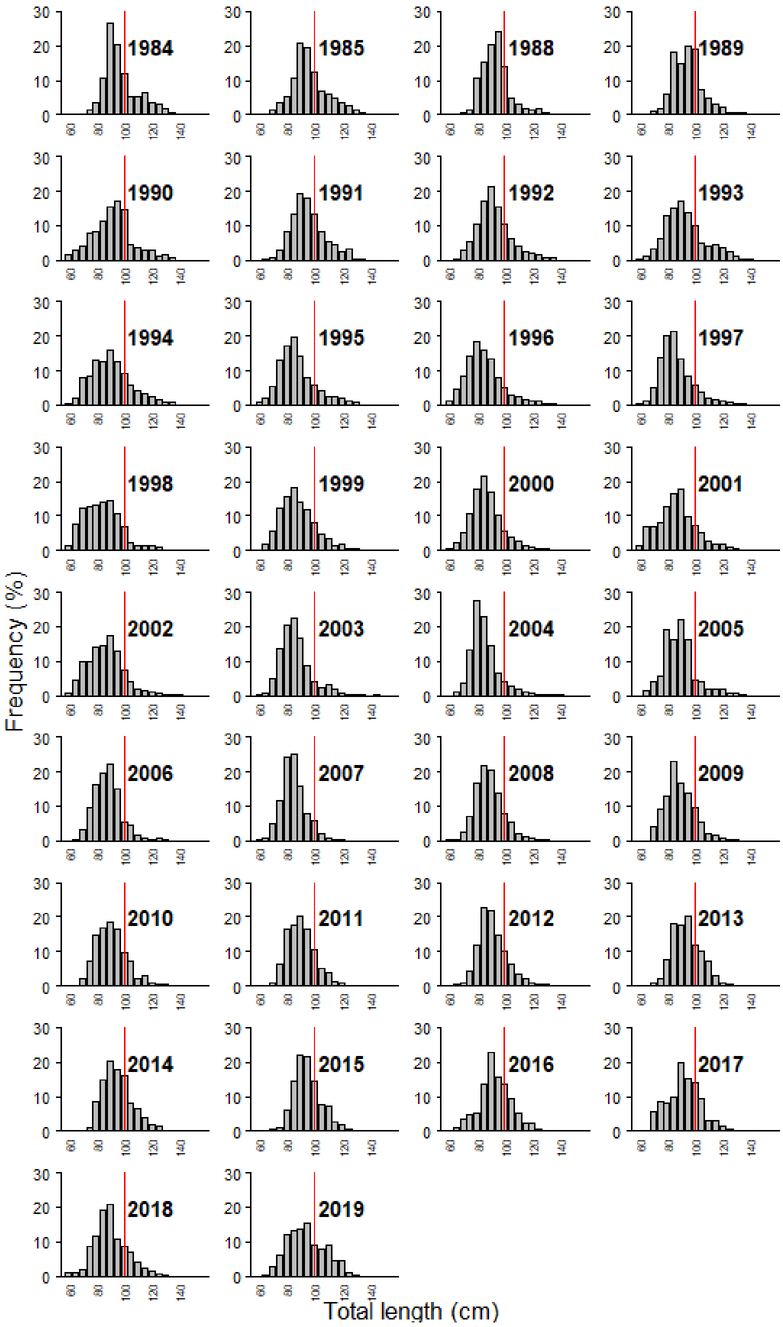


Figure 4.3.6. Length distribution of French landings from 1984 to 2019 (no data in 1986-87) by 5 cm intervals. The red line represent the 100 cm size class.

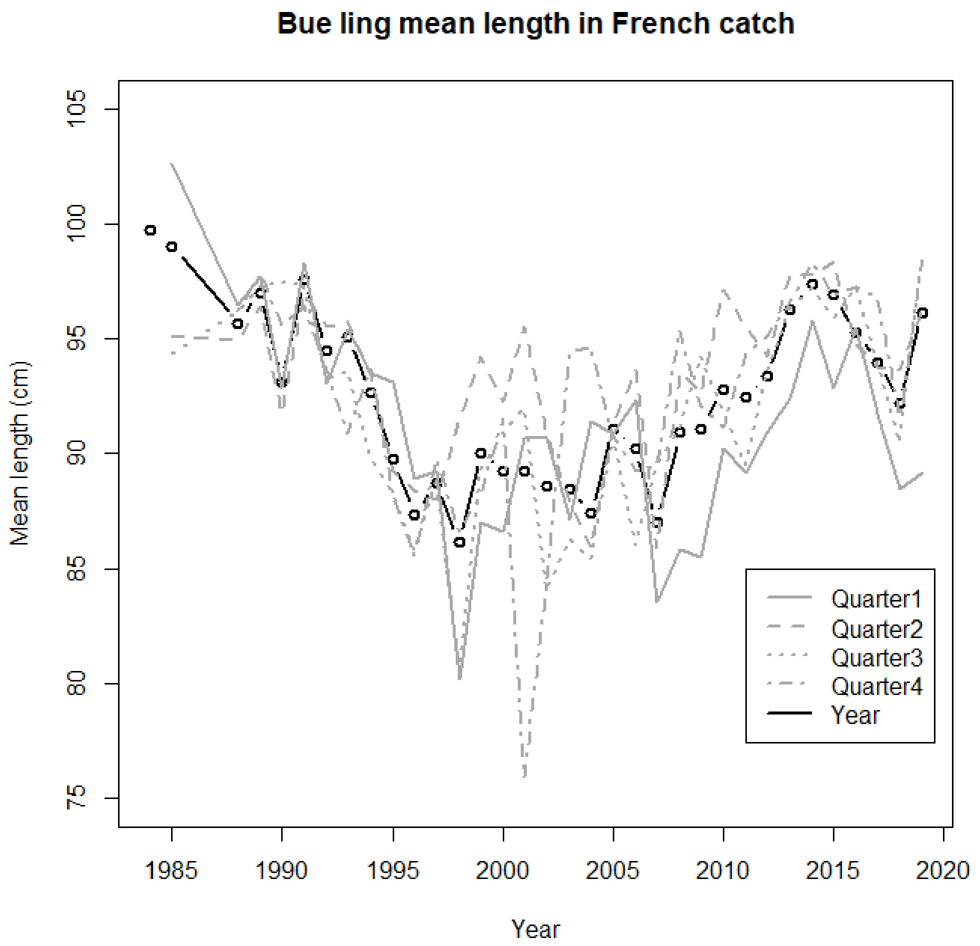


Figure 4.3.7. Quarterly mean length in French trawlers landings, 1984–2019 (no data in 1986-87).

4.3.6.2 Abundance and biomass indices

The previously used indicators of abundance and occurrence of blue ling smaller than 80 cm, also reflect this higher abundance of juveniles in Faroese surveys (Figure 4.3.6). The numbers per hour and occurrence of blue ling smaller than 80 cm caught in the last survey of both series (summer 2019 and spring 2020) are the highest since the start of these time-series.

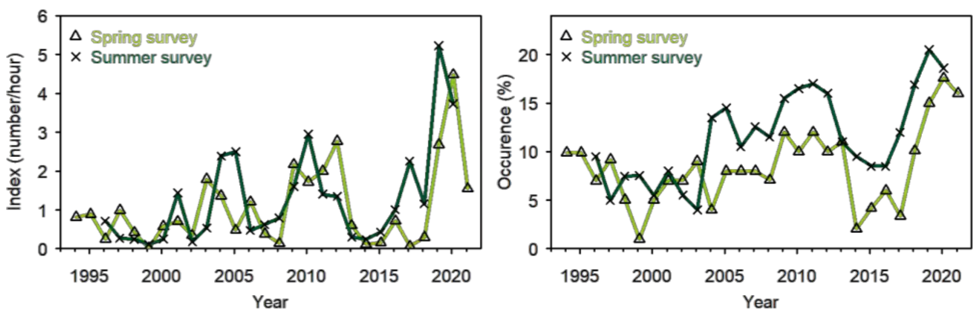


Figure 4.3.6. Juvenile (<80 cm) blue ling caught in groundfish surveys on the Faroe Plateau (left) number per hour and (right) occurrence.

The indices of total biomass from Faroese are uncertain with high values in 2004, 2005 and since 2009 for the summer survey. The spring summer shows a sharp increase since a low level in 2017. The two last points of the two surveys are amongst the highest from the whole time-series (Figure 4.3.7, Table 4.3.2). Over the last decade the indices from the two surveys did not track each other. The depth range (mostly <500 m) of these surveys do not extend down to the core depth distribution of blue ling. The indices include all hauls and are calculated using a design-based stratification.

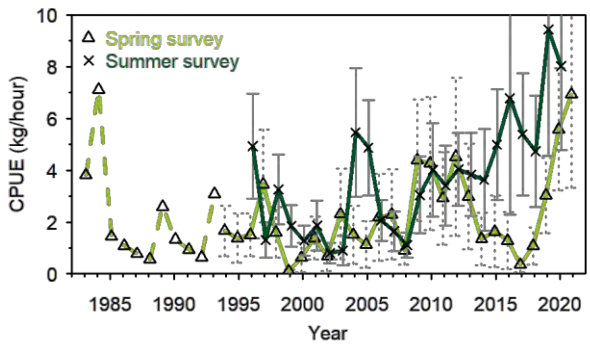


Figure 4.3.7. Biomass indices (kg.hour^{-1}) of blue ling in Faroese surveys.

Indices from the Marine Scotland trawl deepwater survey carried out on the fisheries research survey SCOTIA are uncertain (Figure 4.3.8, Table 4.3.4) probably owing to the small number of hauls per year and the aggregating distribution of blue ling. The indices are averaged numbers and weights caught per haul carried out in the depth range 400 to 1600 m (n = 377 hauls for the whole time-series), which is the core range of the species along the Scottish slope. Only hauls from the Scottish slope are included, excluding data from Rockall and seamounts. The survey was performed biennially since 2013 and annually before (with no surveys in 1999, 2001, 2003 and 2010). There was no survey in 2020.

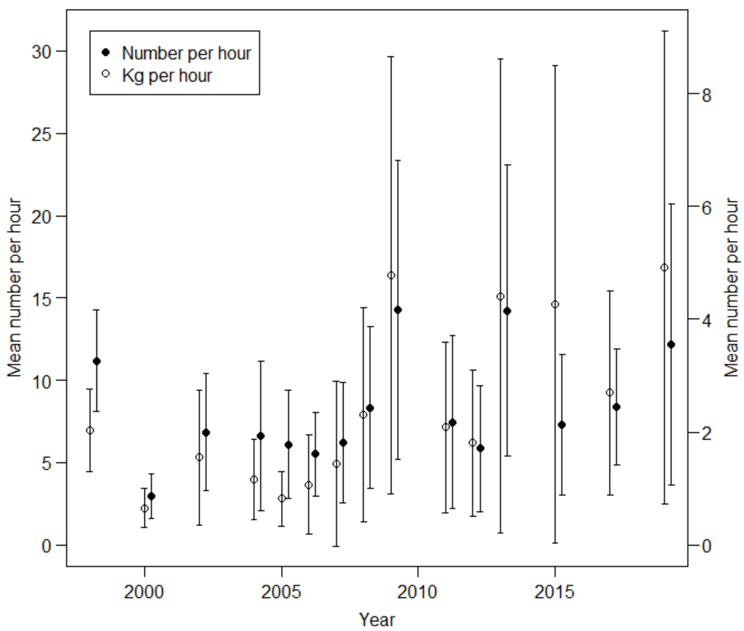


Figure 4. 3.8. Biomass and abundance indices of blue ling from the Marin Scotland deep-water survey.

Multiyear catch curve (MYCC) model

No stock assessment was made in 2021.Stock Reduction Analysis (SRA) using FL_{aspm}.

The model was not fitted in 2021.

Reference points

Reference points the stock were defined as F_{MSY}=0.12, MSY F_{lower}=0.08 and MSY F_{upper}=0.17. MSY $B_{trigger}$ was set as B_{pa}=1.4*B_{lim} (table below), because the variability of the stock dynamics was not fully captured by the analysis (ICES 2016). This is because the only input available, at the time was the Stock reduction analysis (SRA) as the MYCC did not cover a sufficient time-series to estimate a stock–recruitment relationship. SRA does not allow for significant variability of recruitment. In these circumstances a MSY $B_{trigger}$ based on 5% of B_{MSY} is not meaningful and was not recommended. B_{lim} was set as B_{loss}, the lowest biomass estimate in the time-series (here the time-series of biomass from the SRA estimated in 2014).

Reference points for bli-5b67 estimated by WKMSYref4.

MSY F_{lower}	F_{MSY}	MSY Fupper with AR	MSY $B_{trigger}$ (tonnes)	MSY Fupper with no AR
0.08	0.12	0.17	75 000	0.14

Further, F_{lim} was estimated to 0.17 based on simulated fishing mortality to B_{lim} and F_{pa} was estimated to 0.12 as F_{lim}*exp(-1.645*0.2). Therefore, F_{pa} is estimated to be equal to F_{MSY} and F_{lim} to MSY F_{upper}. This comes from setting B_{lim} at B_{loss}≈20% of the unexploited biomass, which is in all circumstances much more than 5% B_{MSY}, again, a level not used here because the long-term mean of B_{MSY} could not be projected in a projection taking account of recruitment variability.

4.3.7 Comments on assessment

No assessment in 2021.

4.3.7.1 Management considerations

International landings have been well below the ICES advice for several years. This is the consequence of several factors including:

- in Faroese waters, fleet have other resources available and do not target particularly blue ling,
- in EU waters the major fishing country has been France since the 1970s, the French fleets of large trawlers has reduced and the remaining vessels fish primarily for saithe and hake,
- historically most of the landings were caught in quarter 2 during the spawning season, the fishing for spawning blue ling in now restricted in particular in Division 6a (EU regulation 2019/1241),
- the ban of trawling deeper than 800 m for EU fleets, reduced the access to the stock which depth distribution extends deeper.

4.3.8 References

ICES. 2016. Report of the Workshop to consider F_{MSY} ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 2015/ACOM:58. 187 pp.

Large, P. A., G. Diez, J. Drewery, M. Laurans, G. M. Pilling, D. G. Reid, J. Reinert, A. B. South, and V. I. Vinnichenko. 2010. Spatial and temporal distribution of spawning aggregations of blue ling (*Molva dypterygia*) west and northwest of the British Isles. ICES Journal of Marine Science 67:494–501.

4.3.9 Tables

Table 4.3.1a. Landings of blue ling in Subdivision 5.b.1 (see stock annex for years before 2000).

YEAR	FAROES	FRANCE(1)	GERMANY(1)	NORWAY	UK (E & W) (1)	UK (Scot.)	IRELAND	RUSSIA(1)	TOTAL
2000	1677	575	1	163	33			1	2450
2001	1193	430	4	130	11		2		1770
2002	685	578		274	8				1545
2003	1079	1133		12	1				2225
2004	751	1132		20				13	1916
2005	1028	781		15	1				1825
2006	1276	839		21	1			16	2153
2007	1220	1166		212	8			36	2642
2008	642	865		35				110	1652
2009	523	325						0	848
2010	840	464		49			0	0	1353
2011	838	312		0			0	0	1150
2012	799	424		8			0	5	1236
2013	440	423		0			0	3	866
2014	730	609		29					1368
2015	621	142	0	140	0		0	0	9503
2016	1100	555	0	74	0		0	0	1730
2017	766	267	0	21	0	3	0	0	1057
2018	818	222	0	150	0	0	0	0	1190
2019	573	379		29					981
2020	697	580	0	0	87	0	0	5	1369

(1) Includes 5.b.2.

Table 4.3.1b. Landings of Blue ling in Subdivision 5.b.2 (see stock annex for years before 2000).

YEAR	FAROES	NORWAY	SCOTLAND	France	TOTAL
2000	0	37	37		74
2001	212	69	63		344
2002	318	21	140		479
2003	1386	84	120		1590
2004	710	6	68		784
2005	609	14	68		691
2006	647	34	16		697
2007	632	6	16		654
2008	317	0	91		408
2009	444	8	161		613
2010	656	10	225		891
2011	319	0	0		319
2012	211	0			211
2013	133	0	2		135
2014	150	6	2		158
2015	82	97		46	225
2016	13	0	7		20
2017	88	9	0	0	97
2018	150				150
2018	151	0	0	0	151
2019	64	56	0	0	120
2020	102	0	4	0	106

Table 4.3.1c. Landings of blue ling in Division 6.a (see stock annex for years before 2000).

YEAR	FAROES	FRANCE	GERMANY	IRELAND	NORWAY	SPAIN(1)	E & W	SCOTLAND	LITHUANIA	TOTAL
2000		4544	94	9	102	108	24	1300		6181
2001		2877	6	179	117	797	116	2136	16	6244
2002		2172		125	61	285	16	2027	28	4714
2003	7	2010		2	106	3	3	428	29	2588

YEAR	FAROES	FRANCE	GERMANY	IRELAND	NORWAY	SPAIN(1)	E & W	SCOTLAND	LITHUANIA	TOTAL
2004	10	2264		1	24	4	1	482	38	2824
2005	17	2019		2	33	88		390	1	2550
2006	13	1794		1	49	87	3	433	2	2382
2007	13	1814			31	47		113	1	2019
2008	14	1579			73	10		112	2	1790
2009	11	2202			74	165		178		2630
2010	43	1937			86	223		134		2423
2011	10	1136			93	10		74		1323
2012	5	1178			86	6		47		1322
2013	2	1168			132	11		203		1516
2014		1094			18			278		1390
2015	0	920	0	0	127	83	8	371	0	1509
2016	0	831			37	125	0	273	0	1266
2017	0	772	0	0	29	44	0	641	0	1486
2018		1128			87	72		735		2022
2019		1192			67	92		718		2069
2020		985				28	244		719	1976

Table 4.3.1d. Landings of blue ling in Division 6.b (see stock annex for years before 2000).

YEAR	POLAND	RUSSIA	FAROES	FRANCE	GERMANY	NORWAY	E & W	SCOTLAND	ICELAND	IRELAND	ESTONIA	SPAIN	TOTAL
2000				514		184	500	966		7			2171
2001			238	210	1	256	337	1803		4	85		2934
2002		3	79	345		273	141	497		1			1339
2003	4	2		510		102	14	113			5		750
2004	1	5	4	514		2	10	96			3		635
2005		15	1	235		1	9	80					341
2006			3	313		2	4	29					351
2007		1	15	112		4	7	30					169
2008		12	2	29		2	2	9		0			56
2009		1		10		1		7		0			19
2010		0	0	39		15		1		0			55
2011		0	0	9		11		0					20
2012				3		3						1	217(1)
2013				5				0				3	39(1)
2014								3					4(1)
2015	0	0	0	0	0	2	0	0	0	0	0	31	33
2016	0	0	0	0	0	0	0	0	0	0	0	18	18

YEAR	POLAND	RUSSIA	FAROES	FRANCE	GERMANY	NORWAY	E & W	SCOTLAND	ICELAND	IRELAND	ESTONIA	SPAIN	TOTAL
2017	0			0	0	1						21	22
2018				0				1				6	7
2019						3		1				5	9
2020	0		0	0	0	0	2	0	0	6	0	3	11

[1] Includes unallocated catch.

Table 4.3.1e. Landings of blue ling in Subarea 7 (see stock annex for years before 2000).

YEAR	FRANCE	GERMANY	SPAIN	NORWAY	E & W	SCOTLAND	IRELAND	TOTAL
2000	91	2	65	5	31	17	73	284
2001	84	2	64	5	29	17	634	835
2002	45	4	42	0	77	55	453	676
2003	27	1	42	0	8	16	28	122
2004	23	1	15	0	4	1	19	63
2005	37	0	25	0	1	0	11	74
2006	30	0	31	0	2	0	4	67
2007	121	0	38	0	2	1	2	164
2008	28	0	6	0	0	0	0	34
2009	10	0	1	0	0	0	0	11
2010	13	0	24	0	0	0	0	37
2011	23	0	26	0	0	0	0	49
2012	19	0	21	5	0	0	0	45
2013	32	0	0	0	0	0	0	32
2014	24				3	2		29
2015	11	0	63	0	3	1	0	78
2016	23	0	0	0	0	1	1	25
2017	5	1	0	0	1	0	0	7
2018	4	0	58	0	0	1	0	63
2019	3	0	35	0	0	0	0	38
2020	4	0	0	0	24	0	0	28

Table 4.3.1f. Blue ling landings in Division 5.b and subareas 6 and 7 (see stock annex for years before 2000).

YEAR	5.b	6	7	TOTAL
2000	2524	8352	284	11 160
2001	2114	9178	835	12 127
2002	2024	6053	676	8753
2003	3815	3338	122	7275
2004	2700	3459	63	6222
2005	2516	2891	74	5481
2006	2850	2733	67	5650
2007	3296	2188	164	5648
2008	2060	1846	34	3940
2009	1461	2649	11	4121
2010	2244	2478	37	4759
2011	1469	1343	49	2861
2012	1447	1539	45	3031
2013	1001	1555	32	2588
2014	1526	1394	29	2949
2015	1128	1542	78	2748
2016	1750	1284	25	3059
2017	1154	1508	7	2669
2018	1338	2029	63	3431
2019	1102	2078	38	3,218
2020	1475	1987	28	3 490

Table 4.3.2. Standardized biomass indices (kg/h) of blue ling in the annual demersal trawl spring and summer survey on the Faroe Plateau.

YEAR	SPRING SURVEY		SUMMER SURVEY	
	Index	SE	Index	SE
1994	1.66	0.98		
1995	1.38	0.95		
1996	1.39	0.78	4.93	2.03
1997	3.46	2.10	1.31	0.67
1998	1.60	0.97	3.26	1.34
1999	0.10	0.06	1.85	0.81
2000	0.63	0.58	1.28	0.57
2001	1.38	0.83	1.87	0.96
2002	0.68	0.58	0.80	0.40
2003	2.31	1.76	0.90	0.57
2004	1.51	1.12	5.46	2.47
2005	1.13	0.90	4.87	1.84
2006	2.18	1.68	2.06	0.80
2007	2.30	1.74	1.64	0.76
2008	0.90	0.55	1.11	0.48
2009	4.39	2.35	3.04	1.48
2010	4.27	2.58	4.01	1.80
2011	2.92	1.79	3.41	1.55
2012	4.52	3.05	4.04	1.41
2013	2.99	2.04	3.84	1.61
2014	1.36	1.01	3.63	1.97
2015	1.63	1.38	5.00	2.14
2016	1.28	1.1	6.78	4.50
2017	0.35	0.3	5.38	2.36
2018	1.08	0.72	4.73	2.14
2019	3.03	1.47	9.44	4.88
2020	5.59	2.36	8.02	3.23

YEAR	SPRING SURVEY		SUMMER SURVEY	
	Index	SE	Index	SE
	6.93	3.60		

Table 4.3.3. Standardized cpue index (kg/1000 hooks) from the Norwegian longliners in ICES Division 6.a.

YEAR	LOWER LIMIT	MEAN INDEX	UPPER LIMIT
2000	8.07787	11.5548	15.0318
2001	4.60621	8.82401	13.0418
2002	8.40796	13.3235	18.2389
2003	4.54772	7.89182	11.2359
2004	1.55956	5.33972	9.11989
2005	5.68665	8.7668	11.847
2006	10.7495	13.8033	16.8571
2007	7.18068	10.7865	14.3923
2008	14.6099	18.4694	22.3289
2009	11.7957	16.2868	20.778
2010			
2011	14.141	16.7851	19.4292
2012	16.9459	19.8301	22.7144
2013	19.1724	21.7229	24.2733
2014	8.23313	11.3728	14.5126
2015	21.8908	24.7353	27.5797
2016	8.60406	11.761	14.918
2017	8.91193	11.9361	14.9602
2018	12.3624	15.0228	17.6833
2019	12.2703	15.1831	18.096

Table 4.3.4. Abundance (nb.hour^{-1}) and biomass (kg.h^{-1}) indices from the Scottish deep-water survey in ICES Division 6.a. Lower in upper bounds of 95% confidence intervals of the mean are estimated assuming a normal distribution.

	Number per hour			Weight per hour (kg)			
Year	**Lower bound**	**Mean**	**Upper bound**	**Lower bound**	**Mean**	**Upper bound**	**Number of hauls**
1998	2.366	3.263	4.160	4.47	7.0	9.48	19
1999							
2000	0.462	0.857	0.648	1.04	2.2	3.45	35
2001							
2002	0.964	2.000	0.188	1.22	5.3	9.39	27
2003							
2004	0.599	1.929	0.225	1.55	4.0	6.43	28
2005	0.820	1.778	0.202	1.16	2.8	4.48	18
2006	0.864	1.607	-0.092	0.65	3.7	6.67	28
2007	0.739	1.810	-1.153	-0.08	4.9	9.94	21
2008	0.994	2.429	-0.016	1.42	7.9	14.39	28
2009	1.524	4.167	0.428	3.07	16.4	29.64	24
2010							
2011	0.641	2.172	0.433	1.96	7.1	12.32	20
2012	0.596	1.711	0.629	1.74	6.2	10.63	27
2013	1.571	4.154	-1.882	0.70	15.1	29.51	23
2014							
2015	0.875	2.130	-1.138	0.12	14.6	29.14	24
2016							
2017	1.423	2.447	2.019	3.04	9.2	15.46	29
2018							
2019	1.058	3.554	-0.028	2.47	16.9	31.23	18

4.4 Blue ling (*Molva dypterygia*) in 1, 2, 3.a, 4, and 12

4.4.1 The fishery

The directed fisheries on spawning aggregations for blue ling on Hatton Bank (ICES Division 12.b) and ICEs Division 2.a (Storegga) are no longer conducted. Blue ling is now only taken as bycatch of other fisheries taking place in these areas.

In Hatton Bank (Division 12.b) blue ling has represented a significant bycatch of trawl fisheries for mixed deep-water species; especially from Spanish freezer trawlers. In Division 2.a there is a bycatch from the longline and gillnet fisheries on ling, tusk and saithe.

In other ICES subareas blue ling is taken in minor quantities. Small reported landings in Subareas 8 and 9 are now ascribed to the closely related Spanish ling (*Molva macropthalma*) since the species is not known to occur in any significant numbers in these subareas.

4.4.2 Landing trends

Landing data are presented in Tables 4.4.0a–f. There are also historical landings from the Norwegian fishery, mainly from Division 2.a, back from 1896 (Figure 4.4.1). During the whole time-series, around 90% or more of the total landings were taken in Subareas 2, 4 and 12 combined. Landings from Subarea 12 which primarily are from the western slope of Hatton Bank (ICES Division 12.b) are now very low. Landings are now reported mostly from ICES Divisions 2a and 4a. In 2020, 96% of the landings came from Subarea 2 and 4 and this was mainly Norwegian landings. In 2019 and from Subarea 1, Iceland has landed 45% of total landings from the whole stock area but there are some uncertainties about this number. In 2020, Iceland had no landings from this area.

For all areas, a continuous decline on landings has been observed after the higher landing levels in the 1988–1993 period and total landings are now 13% of that level. However, the total landings have increased since 2015 which was the lowest level recorded since 1988. As a result of the Icelandic landings from Subarea 1, the total landings from 2018-2019 more than doubled (348-862 tons). For 2020, the total landings are at recent levels.

4.4.3 ICES Advice

The ICES advice for 2020 to 2023 is:

"*ICES advise that when precautionary approach is applied, there should be zero catches in each of the years 2020 to 2023. Closed areas to protect spawning should be maintained*."

4.4.4 Management

A 2020 precautionary TAC for EU vessels in international waters of ICES Subarea 12 was set to 34 tonnes and only applicable to bycatches; no directed fishery for blue ling was allowed in this area. TACs for vessels in EU waters and international waters of ICES Division 5.b, and Subareas 6 and 7 were set to 2790 tons; of this a quota for Norwegian, Faroese and UK vessels was set to 618 tonnes (63, 38 and 517 respectively), each to be fished in Union waters of ICES Divisions 2.a, 4, 5.b, and Subareas 6 and 7. In European Union and international waters of Subareas 2 and 4, a precautionary TAC for EU vessels was set to 10 tonnes. In European Union and international waters of ICES Division 3.a, a precautionary TAC for EU vessels was set to 2 tonnes.

4.4.5 Data availability

4.4.5.1 Landings and discards

Landings and discards data are presented in Table 4.4.0a–f and 4.4.1 respectively. The discards data from Scotland were revised in 2021 and the Scottish discards were updated in the table for 2015-2020 (Table 4.4.1).

4.4.5.2 Length compositions

Length compositions from the Norwegian longline and gill net fishery from 2002-2020 are available (Figure 4.4.2). Length compositions from the Spanish fishery from 2017 in Stock Annex.

4.4.5.3 Age compositions

No age data are available.

4.4.5.4 Weight-at-age

No weight-at-age data are available.

4.4.5.5 Maturity and natural mortality

No data were available.

4.4.5.6 Catch, effort and research vessel data

For the Norwegian catches there was presented a CPUE from Subareas 1, 2 and 4 and ICES Division 3.a combined (Figure 4.4.3). The CPUE series was calculated for the time period 2000–2020 and is based on longline data from the Norwegian fishery.

4.4.6 Data analyses

The assessment for this stock is based on landing trends (Figures 4.4.4-4.4.6). This is followed by some uncertainties because the trends in landings can be a consequence of changes in effort rather than changes in the stock. However, it is regarded that the situation for the stock is reflected by the landings and it is also thought that discards are minimal since the fishery is exclusively done on larger individuals.

The landings have declined for all areas and the mean landings are now only 13% of the mean landings from the years 1988–1993 (the period with stable landings). There has been however, some fluctuations in landings for some areas.

Landings from Subarea 1 has always been low (less than 5 t for the whole time series). However, for 2019 Iceland landed 389 tons (45% of total landings for the whole stock area) which were assigned to in Subarea 1. For 2020 and for Subarea 1, there were no Icelandic landings and the total landings are back on recent levels.

The historical Norwegian landings, mainly in ICES Division 2.a reached almost 6000 tonnes in 1980. Since then, landings have decreased. In 2010, there was an increase in landings from Subarea 2 as a result of an increase in Faroese landings. From 2013 onwards, landings are at the same low levels as seen in the early 2000s. Landings in 2015 were lowest on record but have increased since then.

The increase of landings in Division 3a in 2005 (2.5 times increase from 2004–2005) is likely to be associated to the increase of the Danish roundnose grenadier fishery. This fishery stopped in 2006 and the landings of blue ling have since been insignificant.

The landings in Subarea 4 increased from 2019-2020. This increase came from Norwegian and French landings. Norwegian landings increased from 66 to 138 tons in this area.

An increase on French and Norwegian landings was also registered in 2010-2012. The landings then decreased to less than 100 tons and the landings have been stable around this level since 2015. The 2020 level of landings are back to the increased level in 2010-12. An analyse of the Norwegian 2020 landing data by gear type revealed that 28% of the blue ling was taken with gillnet that year compared with 23% for 2019.

In Subarea 12 and after relative high levels for the period 2001–2005 landings have declined. There have been reductions in Spanish fishing activity in this area which for now is the only country reporting landings from this area. The reported landings from this Subarea have always been from Division 12b; however, from 2019-20 there was also some landings from Division 12a.

Denmark and Scotland report discards from Division 4a. A revision of the Scottish discard data for 2015-2020 was done. The revised values for Scottish discards increased, especially in 2019.

The Norwegian length compositions from the longline and gill net fishery from 2002-2020 show some years inclusions of smaller fish. It is also possible to follow a dominant group of ages from year to year in some periods (from 2009-2014 and 2015-2020). The mean length varies from 77-100 cm.

The length compositions from Spanish landings from 2017 show lengths from 69-129 cm (See Stock Annex). This is in the same range as seen in length compositions from Faroese catches from areas 5.b, 6 and 7.

The Norwegian CPUE series shows a low level and varies without any trend for the years 2000–2020. Although there is no directed fishery from this area there seems to be no recovery for this part of the stock.

4.4.6.1 Biological reference points

There are not yet suggested methods to estimate biological reference points for category 5 and 6 stocks.

4.4.7 Comments on assessment

Assessment is based on landing trends. Landings have declined since the 90's (Figure 4.4.7) and are thought to represent stock status. However, there is some concern about the last year increase in Norwegian landings in Subarea 4. In this subarea, blue ling is bycatch in ling and tusk fishery and these bycatch landings may come from a shift to larger proportion of gill nett landings in the fishery for ling.

4.4.8 Management considerations

Trends in landings suggest serious depletion in Subarea 2 and perhaps also for the other Subareas. Landings have also declined strongly in Subarea 12 from 2002 onwards. Landings in other subareas and divisions are minor but there is some evidence of a persistent decline.

The advice given in 2019 remains appropriate.

Blue ling specimens caught in Division 12.b probably belong to the same stock that is exploited in Subarea 6. Management of Division 12.b should be consistent with the Advice for ICES Division 5.b and for Subareas 6 and 7.

The bulk of current bycatches of blue ling from subareas and divisions treated in this section are taken within EE (Table 4.4.2).

4.4.9 Tables

Table 4.4.0a. Blue ling (*Molva dypterygia*). Working group estimates of landings (tonnes) in Subarea 1. (* preliminary).

Year	Iceland	Norway	France	Faroes	Greenland	Total
1988		10				10
1989		8				8
1990		4				4
1991		3				3
1992		5				5
1993		1				1
1994		3				3
1995		5				5
1996		2				2
1997		1				1
1998		1				1
1999		1				1
2000		3				3
2001		1				1
2002		1				1
2003						0
2004		1				1
2005		1				1
2006						0
2007						0
2008						0
2009		1				1
2010		1				1
2011			3			3
2012			1			1
2013						0
2014				4		4

Year	Iceland	Norway	France	Faroes	Greenland	Total
2015						0
2016		1				1
2017						0
2018	6				16	22
2019	389					389
2020*		1				1

Table 4.4.0b. Blue ling (*Molva dypterygia*). Working group estimates of landings (tonnes) in Divisions 2.a, b. (* preliminary).

Year	Faroes	France	Germany	Greenland	Norway	E & W	Scotland	Sweden	Russia	Total
1988	77	37	5		3416	2				3537
1989	126	42	5		1883	2				2058
1990	228	48	4		1128	4				1412
1991	47	23	1		1408					1479
1992	28	19		3	987	2				1039
1993		12	2	3	1003					1020
1994		9	2		399	9				419
1995	0	12	2	2	342	1				359
1996	0	8	1		254	2	2			267
1997	0	10	1		280					291
1998	0	3			272		3			278
1999	0	1	1		287		2			291
2000		2	4		240	1	2			249
2001	8	7			190	1	2			208
2002	1	1			129	1	17			149
2003	30				115		1	1		147
2004	28	1			144				1	174
2005	47	3			144	1			2	197
2006	49	4			149					202
2007	102	3			154		3			262
2008	105	9			208		11			333

Year	Faroes	France	Germany	Greenland	Norway	E & W	Scotland	Sweden	Russia	Total
2009	56	1			219		9			285
2010	183	1			234		4			422
2011	312	7			167					486
2012	188	7			142		1			338
2013	79	16			107					202
2014	29	16			73		9			127
2015	16	6			91					113
2016	22	7	0.059		57		1			87
2017	57	5			112		3			177
2018	112	4			124	0,105	0,69			241
2019	48	7			321					376
2020*		2			237					239

Table 4.4.0c. Blue ling (*Molva dypterygia*). Working group estimates of landings (tonnes) in Subarea 3. (* preliminary).

Year	Denmark	Norway	Sweden	FRANCE	Total
1988	10	11	1		22
1989	7	15	1		23
1990	8	12	1		21
1991	9	9	3		21
1992	29	8	1		38
1993	16	6	1		23
1994	14	4			18
1995	16	4			20
1996	9	3			12
1997	14	5	2		21
1998	4	2			6
1999	5	1			6
2000	13	1			14
2001	20	4			24
2002	8	1			9

Year	Denmark	Norway	Sweden	FRANCE	Total
2003	18	1			19
2004	18	1			19
2005	48	1			49
2006	42				42
2007					0
2008		2			2
2009		+			0
2010		+			0
2011					0
2012					0
2013		1			1
2014		+	+		0
2015	+	+			0
2016	0.154	0.64	0.005	0.307	1
2017		0,775			1
2018	0,286	0,97	0,085		1
2019	0,885	0,63	0,047		2
2020*	0,775	0,948	0,070		2

Table 4.4.0d. Blue ling (*Molva dypterygia*). Working group estimates of landings (tonnes) in Division 4.a. (* preliminary).

Year	Denmark	Faroes	France (4ab)	Germany	Norway	E & W	Scotland	Ireland	Total
1988	1	13	223	6	116	2	2		363
1989	1		244	4	196	12			457
1990			321	8	162	4			495
1991	1	31	369	7	178	2	32		620
1992	1		236	9	263	8	36		553
1993	2	101	76	2	186	1	44		412
1994			144	3	241	14	19		421
1995		2	73		201	8	193		477
1996		0	52	4	67	4	52		179

Year	Denmark	Faroes	France (4ab)	Germany	Norway	E & W	Scotland	Ireland	Total
1997		0	36		61	0	172		269
1998		1	31		55	2	191		280
1999	2		21		94	25	120	2	264
2000	2		15	1	53	10	46	2	129
2001	7		9		75	7	145	9	252
2002	6		11		58	4	292	5	376
2003	8		8		49	2	25		92
2004	7		17		45		14		83
2005	6		7		51		2		66
2006	6		6		82				94
2007	5		2		55				62
2008	2		9		63		+		74
2009	1		12		69		7		89
2010	1		24		109		21		155
2011			129		46		1		176
2012			96		70				166
2013			5		38				43
2014			4		34		12		50
2015	+		6		74	+	3		83
2016	0,48		6	0,041	74		6		87
2017	0,499		3		65	0,012	5		73
2018	3,209		3	0,018	50	0,025	3		60
2019	2,521		12		66	0,027	4		85
2020*	6,823		21	0,004	138		10		176

Table 4.4.0e. Blue ling (*Molva dypterygia*). Working group estimates of landings (tonnes) in Subarea 12. (* preliminary).

Year	Faroes	France	Germany	Spain	E & W	Scotland	Norway	Iceland	Poland	Lithuania	Russia	unallocated	Total
1988		263											263
1989		70											70
1990		5					547						552
1991		1147											1147
1992		971											971
1993	654	2591	90			1							3336
1994	382	345	25										752
1995	514	47			12								573
1996	445	60		264		19							788
1997	1	1		411	4								417
1998	36	26		375	1								438
1999	156	17		943	8	43		186					1353
2000	89	23		406	18	23	21	14					594
2001	6	26		415	32	91	103	2					675
2002	19			1234	8	48	9						1318
2003		7		1096			40		12	37			1192
2004		27		861		10					7		905
2005		10		657		35				8			710
2006		61		436							4		501
2007	1			353									354
2008				564									564
2009		+		312							+		312
2010				50									50
2011				55									55
2012				205								427	632
2013				178								76	254
2014				80									80
2015				12									12

Year	Faroes	France	Germany	Spain	E & W	Scotland	Norway	Iceland	Poland	Lithuania	Russia	unallocated	Total
2016				29									29
2017				28									28
2018				24									24
2019				10									10
2020*				13									13

Table 4.4.0f. Blue ling (*Molva dypterygia*). Total landings by Subarea (past reported landings from subareas 8 and 9 are ascribed to *Molva macropthalma* and not included). (* preliminary data).

Year	1	2	3	4	12	Total
1988	10	3537	22	363	263	4195
1989	8	2058	23	457	70	2616
1990	4	1412	21	495	552	2484
1991	3	1479	21	620	1147	3270
1992	5	1039	38	553	971	2606
1993	1	1020	23	412	3336	4792
1994	3	419	18	421	752	1613
1995	5	359	20	477	573	1434
1996	2	267	12	179	788	1248
1997	1	291	21	269	417	999
1998	1	278	6	280	438	1003
1999	1	291	6	264	1353	1915
2000	3	249	14	129	594	989
2001	1	208	24	252	675	1160
2002	1	149	9	376	1318	1853
2003	0	147	19	92	1192	1450
2004	1	174	19	83	905	1182
2005	1	197	49	66	710	1023
2006	0	202	42	94	501	839
2007	0	262	0	62	354	678
2008	0	333	2	74	564	973

Year	1	2	3	4	12	Total
2009	1	285	0	89	312	687
2010	1	422	0	155	50	628
2011	3	486	0	176	55	720
2012	1	338	0	166	632	1137
2013	0	202	1	43	254	500
2014	4	127	0	50	80	261
2015	0	113	0	83	12	208
2016	1	87	1	87	29	205
2017	0	177	1	73	28	279
2018	22	241	1	60	24	348
2019	389	376	2	85	10	862
2020*	1	239	2	176	13	431

Table 4.4.1 Blue ling in Subarea 27.nea. Discards from 2015-2020. Discards from Denmark are taken from InterCatch. Discards from Scotland are estimated in 2021.

Year	Denmark	Scotland	Total discards	Scotland old[1]
2015		0		
2016		0		
2017	0.808	2.403	3.211	0.117
2018	0.300	0.774	1.074	0.002
2019	0.750	14.110	14.860	0,023
2020*	1.448	0	1.448	0

[1] The old InterCatch values for discards from Scotland; revised in 2021. The new values are estimated from 2015-2020.

Table 4.4.2 Blue ling in Subarea 27.nea. Landings inside and outside the NEAFC Regulatory Area (RA). Landings inside NEAFC area are from 12a and 12b. Weights are in tonnes.

Year	Inside the NEAFC RA	Outside the NEAFC RA	Total landings
2014	80	181	261
2015	12	196	208
2016	29	176	205
2017	28	251	279
2018	24	324	348

Year	Inside the NEAFC RA	Outside the NEAFC RA	Total landings
2019	10	852	862
2020*	13	418	431

4.4.10 Figures

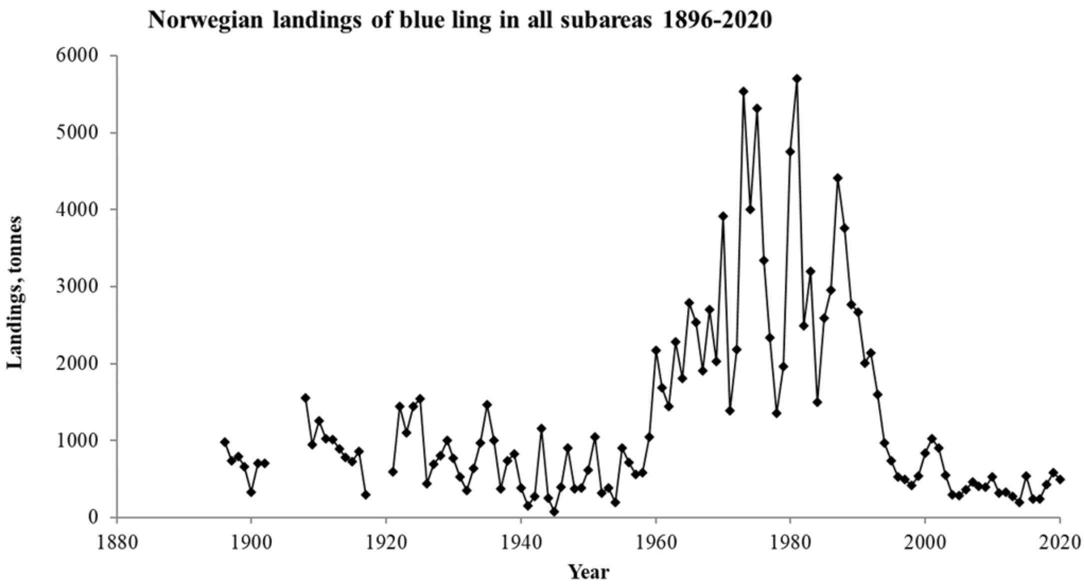


Figure 4.4.1. Reported Norwegian landings on blue ling from 1896–2020.

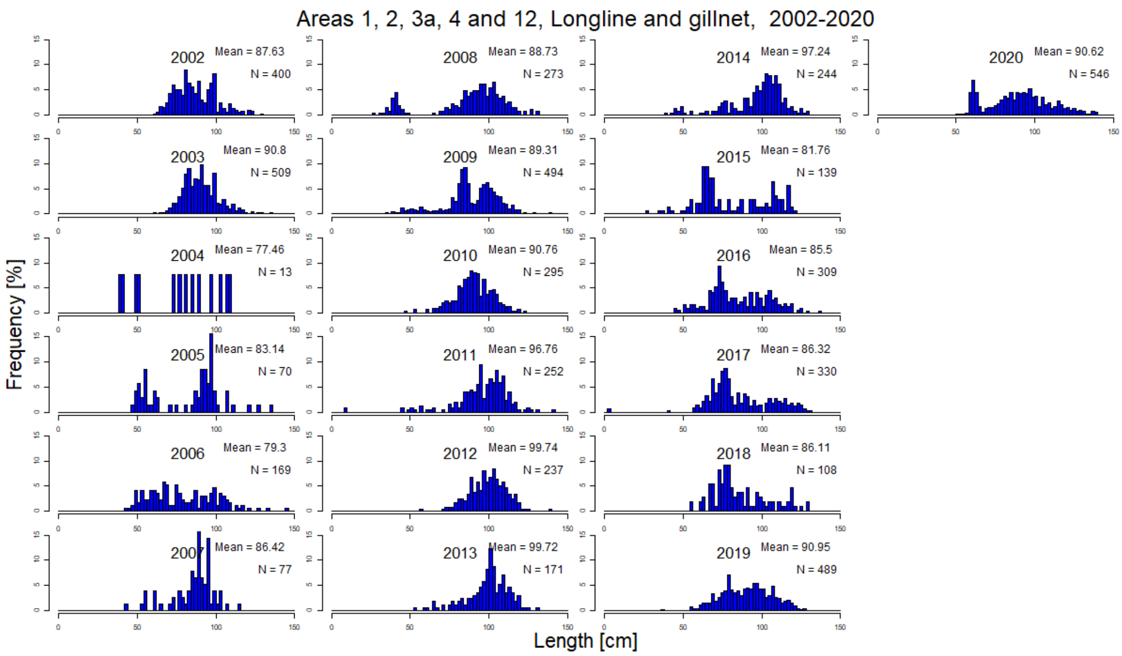


Figure 4.4.2. Length compositions from Norwegian longline and gill net fishery from 2002-2020.

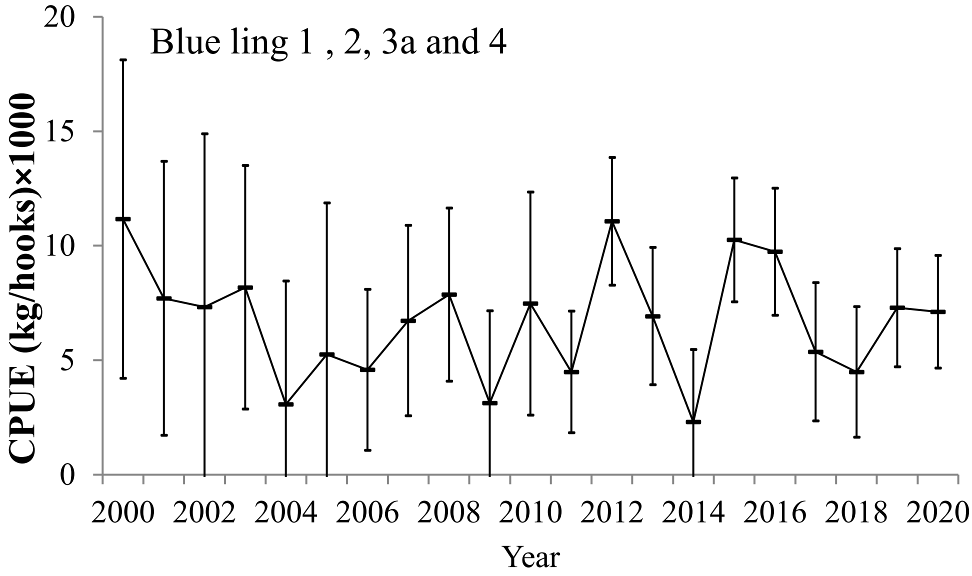


Figure 4.4.3. Norwegian cpue (kg/1000 hooks) from longlines catches in areas 1, 2, 3.a and 4 from 2000–2020.

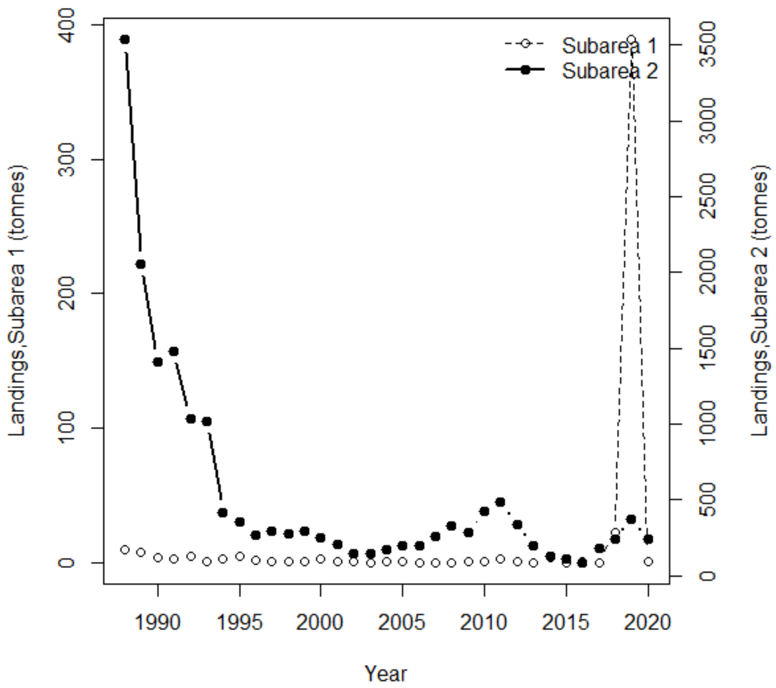


Figure 4.4.4. Landings of blue ling in Subareas 1 and 2. Subarea 1: open circles, left axis. Subarea 2: filled circles, right axis.

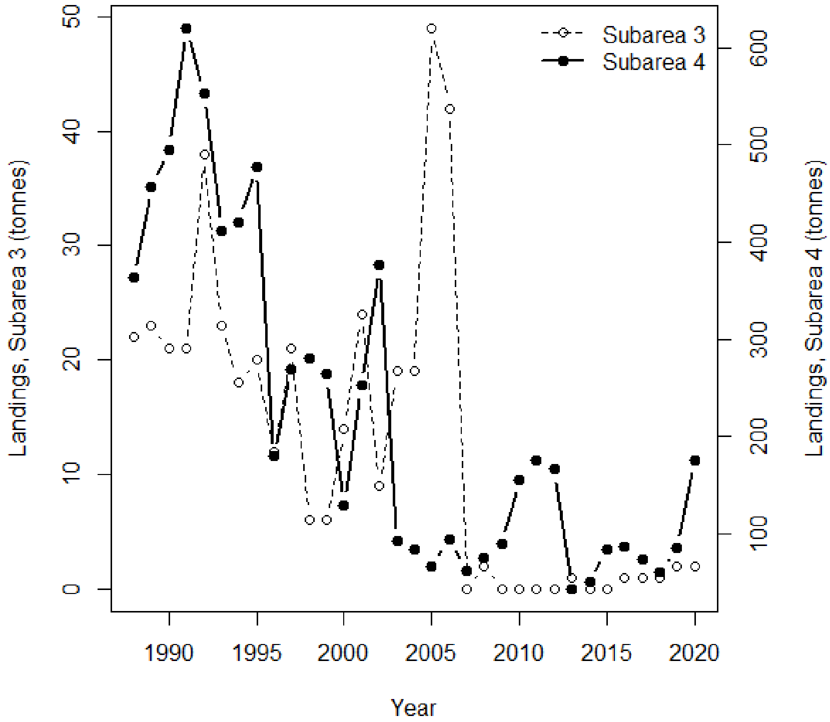


Figure 4.4.5. Landings of blue ling in Subareas 3 and 4. Subarea 3: open circles, left axis. Subarea 4: filled circles, right axis.

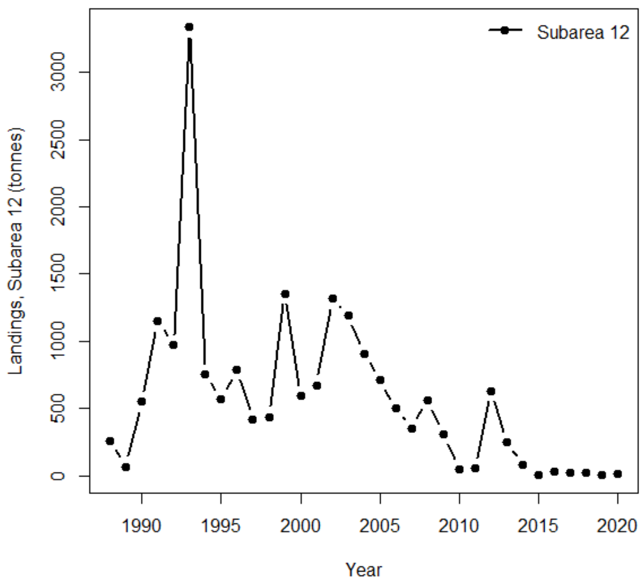


Figure 4.4.6. Landings of blue ling in Subarea 12.

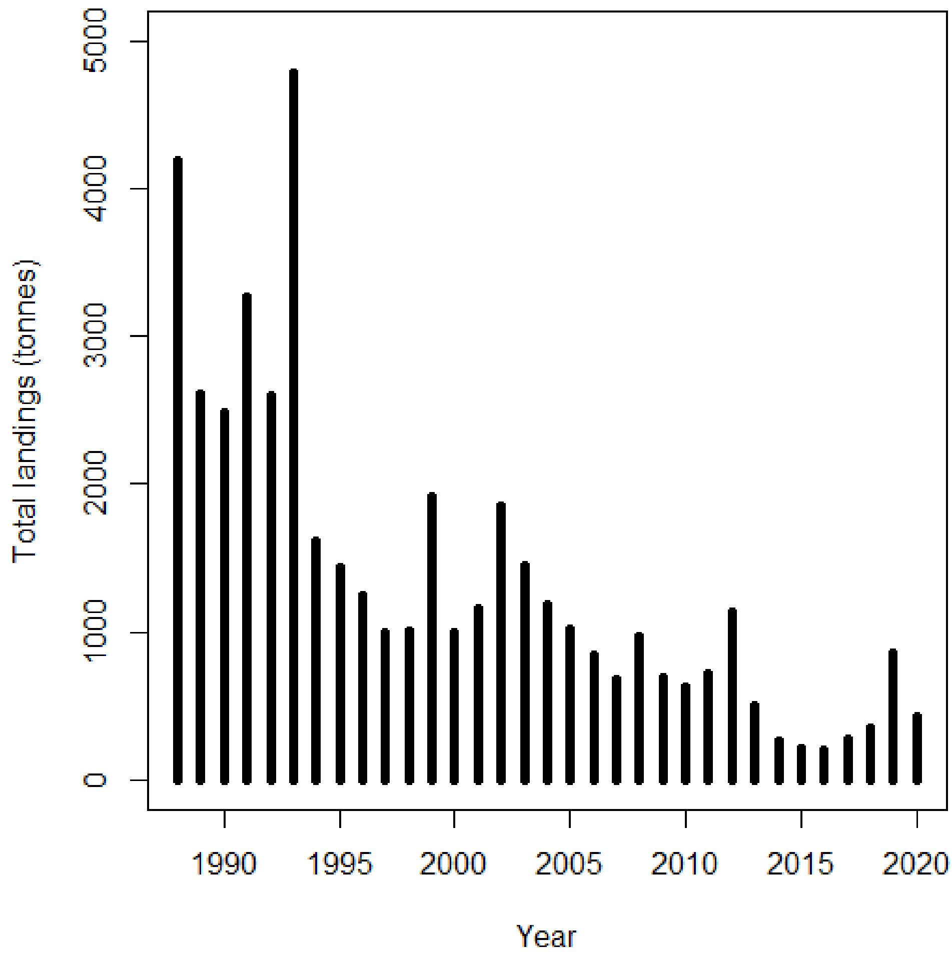


Figure 4.4.7. Total landings of blue ling from stock area 1,2,3a,4 and 12 from 1988-2020.

5 Tusk (*Brosme brosme*).

5.1 Stock description and management units

In 2007, WGDEEP examined the available evidence for separate tusk stocks in the ICES region. Based on genetic investigations, the group suggested the following stock units for tusk:

- Area 5.a and 14;
- Mid-Atlantic Ridge;
- Rockall (6.b);
- Areas 1, 2.

All other areas (4.a,5.b, 6.a, 7,…) should be assessed as one stock unit until further evidence of multiple stocks become available.

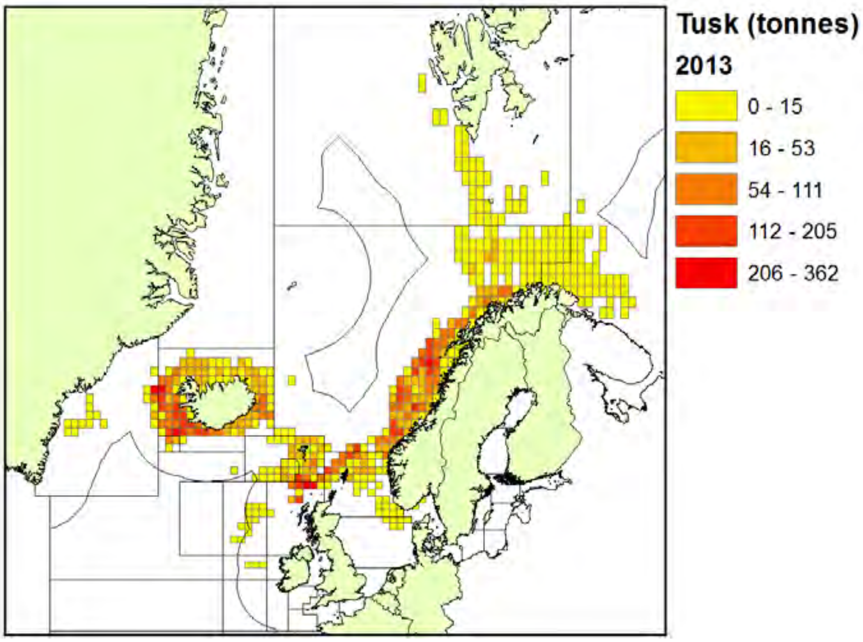


Figure 5.1. Reported landings of tusk in the ICES area by statistical rectangle in 2013. Data are from Norway, Faroes, Iceland, France, UK (England and Wales) and Spain. Landings shown in account for 99% of all reported landings in the ICES area.

5.1 Tusk in 5.a and 14 (*Brosme brosme*)

5.1.1 The fishery

Tusk in 5.a is caught in a mixed longline fishery, conducted in order of importance by Icelandic, Faroese and Norwegian boats. Between 150 and 240 Icelandic longliners report catches of tusk, but ~100 more vessels have small amounts of bycatch landings (Table 5.1.1). Far fewer gillnetters and trawlers participate in the fishery. The number of longliners reporting tusk catches have been continually decreasing in the past few years (Table 5.1.1). Most of tusk in 5.a, around 97% of catches in tonnes, is caught by longlines, and this proportion has been relatively stable since 1992 (Table 5.1.2).

Table 5.1.1. Tusk in 5.a. Number of Icelandic boats with tusk landings and their total landings

	Number of Boats			Catch (Tonnes)				
Year	Bottom trawl	Gill nets	Longlines	Bottom trawl	Gill nets	Longlines	Other	Total catch
2000	106	175	370	93	44	4564	37	4738
2001	83	224	350	73	63	3248	38	3422
2002	80	174	304	75	93	3722	30	3920
2003	78	148	305	56	41	3941	21	4059
2004	74	130	303	85	28	3007	15	3135
2005	77	101	324	108	19	3398	14	3539
2006	72	82	338	91	40	4912	16	5059
2007	64	65	308	95	38	5834	20	5987
2008	63	59	255	114	42	6762	19	6937
2009	66	65	239	107	72	6757	16	6952
2010	59	62	228	92	52	6761	14	6919
2011	51	54	221	69	24	5742	12	5847
2012	53	68	228	60	13	6255	16	6344
2013	53	43	233	74	15	4911	17	5017
2014	52	43	249	86	18	6045	14	6163
2015	47	32	228	69	7	4745	14	4835
2016	54	32	206	61	6	3420	8	3495
2017	50	31	180	48	5	2481	6	2540
2018	55	27	158	83	8	2841	8	2940
2019	48	22	155	102	7	3326	9	3444
2020	52	23	126	107	31	3270	12	3420

Most of the tusk caught in 5.a by Icelandic longliners is caught at depths less than 300 meters Figure 5.1.1). The main fishing grounds for tusk in 5.a as observed from logbooks are on the southeast, southwestern and western part of the Icelandic shelf (Figure 5.1.2 and Figure 5.1.3). The spatial distribution of catches in 5.a according to logbook entries shows a decreasing trend in the southeast until 2015, but this proportion has been increasing in the last 5 years (Figure 5.1.2 and Figure 5.1.3). The proportional catch in the northwest has also increased over the years. Around 50–60% of tusk is caught on the southern and western parts of the shelf (Figure 5.1.3).

Tusk in 14 is caught mainly as a bycatch by longliners and trawlers. The main area where tusk is caught in 14 is 63°–66°N and 32°–40°W, well away from the Icelandic EEZ.

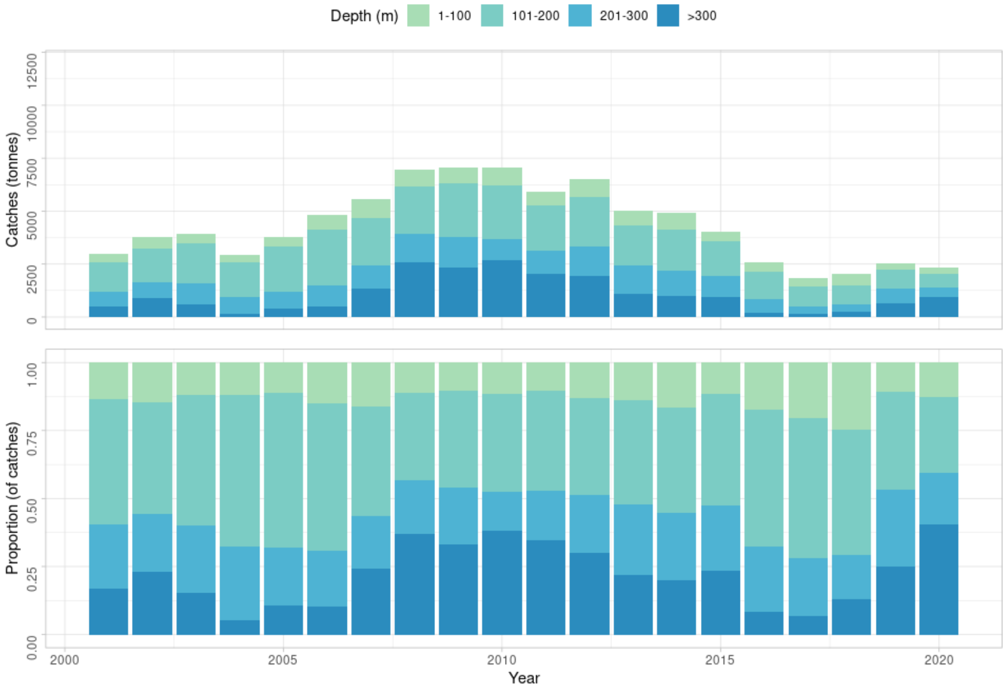


Figure 5.1.1: Tusk in 5.a and 14. Depth distribution of catches in 5.a according to logbooks. All gears combined.

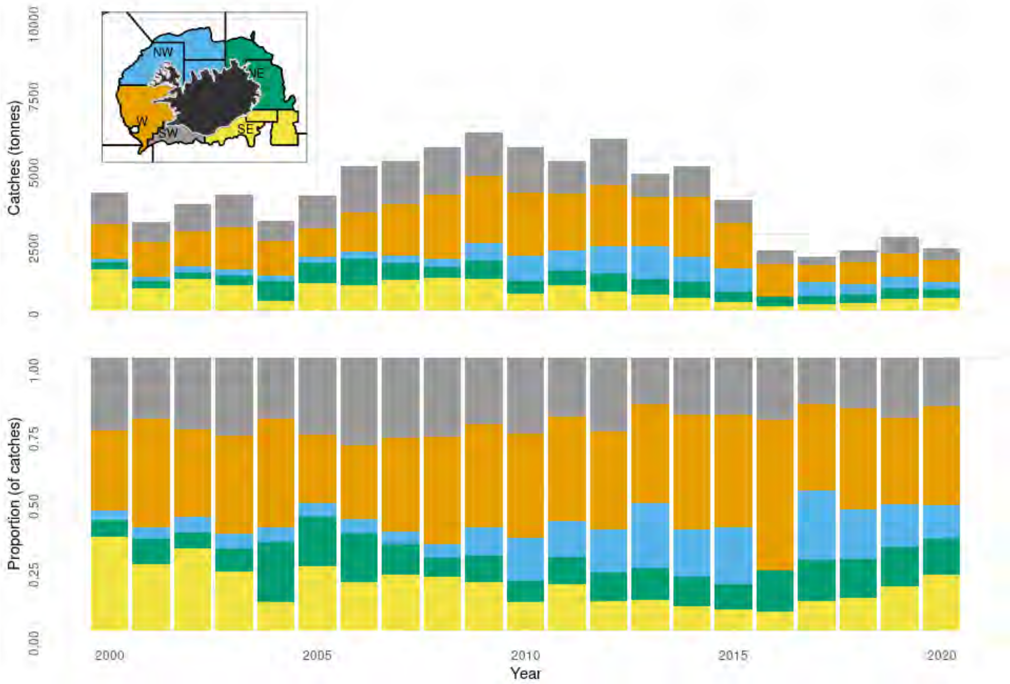


Figure 5.1.2: Tusk in 5.a and 14. Catch distribution and proportions by area according to logbooks. All gears combined.

Figure 5.1.3: Tusk in 5.a and 14. Geographical distribution (tonnes) of the Icelandic longline fishery since 2000, as reported in logbooks by the Icelandic fleet.

5.1.2 Landing trends

The total annual landings from ICES Division 5.a were around 3420 tonnes in 2020 (Table 5.1.1), signifying a continuous decrease in landings from 2010. This is contrary to the trend in landings from 2000 in which the annual landings gradually increased in 5.a to around 9000 tonnes in 2010 (Figure 5.1.4).

The foreign catch (mostly from the Faroe Islands, but also from Norway) of tusk in Icelandic waters has always been considerable. Until 1990, between 40–70% of the total annual catch from ICES Division 5.a was caught by foreign vessels, mainly vessels from the Faroe Islands. This proportion reduced to 15–25% until the most recent years in which it increased to closer to 50% due to a reduction in Icelandic catches (Table 5.1.2).

Landings in 14.b have always been low compared to 5.a, rarely exceeding 100 t. However, around 900 tonnes were caught in 2015, after which catches have been consistently substantial. Catch data from section 14 reported by the Greenland Institute of Natural Resources (WD02, Annex to WGDEEP 2019) also reflect this trend. Around 566 tonnes in 2019 were caught in the 14.b mainly by Faroese and Greenlandic vessels (Table 5.1.3). This has however decreased in 2020 to about 233 tonnes constituting 7% of the annual catch.

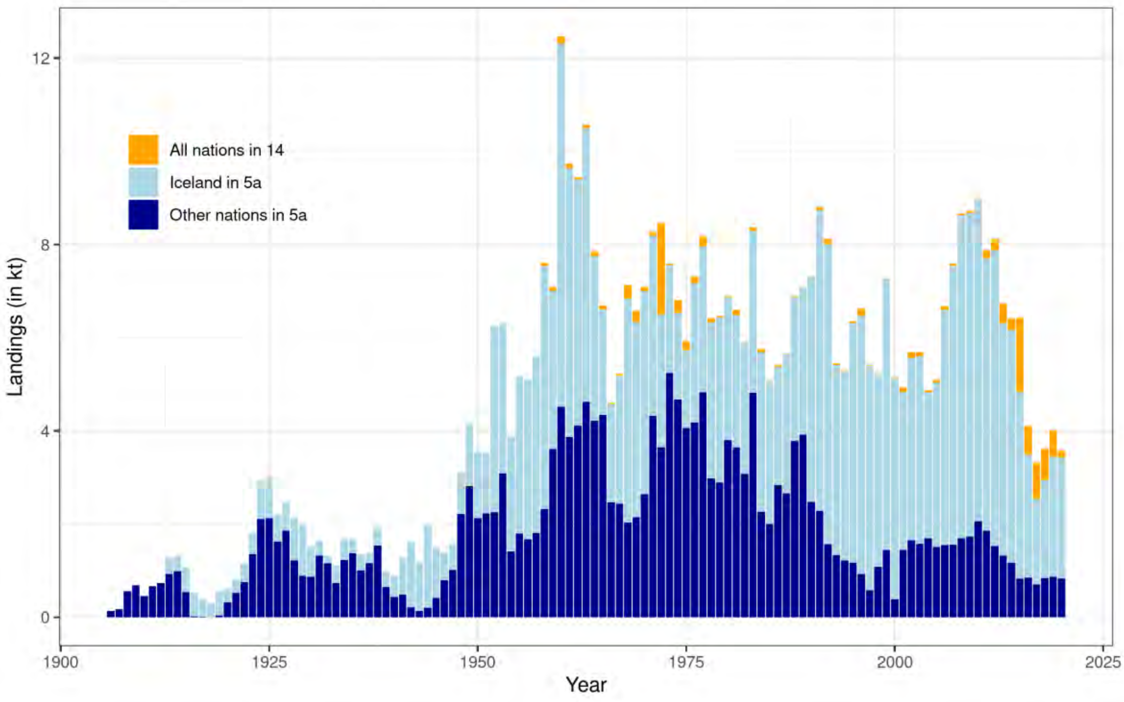


Figure 5.1.4: Tusk in 5.a and 14.Nominal landings within Icelandic waters by Icelandic vessels (light blue) or foreign vessels (dark blue), or within Greenlandic waters (orange). (source for 14: STATLANT).

Table 5.1.2. Tusk in 5.a and 14. Nominal landings by nations in 5.a.

YEAR	FAROE	DENMARK	GERMANY	ICELAND	NORWAY	UK	TOTAL
1980	2873	0	0	3089	928	0	6890
1981	2624	0	0	2827	1025	0	6476
1982	2410	0	0	2804	666	0	5880
1983	4046	0	0	3469	772	0	8287
1984	2008	0	0	3430	254	0	5692
1985	1885	0	0	3068	111	0	5064
1986	2811	0	0	2549	21	0	5381
1987	2638	0	0	2984	19	0	5641
1988	3757	0	0	3078	20	0	6855
1989	3908	0	0	3131	10	0	7049
1990	2475	0	0	4813	0	0	7288
1991	2286	0	0	6439	0	0	8725
1992	1567	0	0	6437	0	0	8004
1993	1329	0	0	4746	0	0	6075
1994	1212	0	0	4612	0	0	5824

YEAR	FAROE	DENMARK	GERMANY	ICELAND	NORWAY	UK	TOTAL
1995	979	0	1	5245	0	0	6225
1996	872	0	1	5226	3	0	6102
1997	575	0	0	4819	0	0	5394
1998	1052	0	1	4118	0	0	5171
1999	1035	0	2	5794	391	2	7224
2000	1154	0	0	4714	374	2	6244
2001	1125	0	1	3392	285	5	4808
2002	1269	0	0	3840	372	2	5483
2003	1163	0	1	4028	373	2	5567
2004	1478	0	1	3126	214	2	4821
2005	1157	0	3	3539	303	41	5043
2006	1239	0	2	5054	299	2	6596
2007	1250	0	0	5984	300	1	7535
2008	959	0	0	6932	284	0	8175
2009	997	0	0	6955	300	0	8252
2010	1794	0	0	6919	263	0	8976
2011	1347	0	0	5845	198	0	7390
2012	1203	0	0	6341	217	0	7761
2013	1092	0.12	0	4973	192	0	6257
2014	728	0	0	4995	306	0	6029
2015	625	0	0	4000	198	0	4823
2016	543	0	0	2649	302	0	3494
2017	492	0	0	1833	216	0	2540
2018	517	0	0	2097	326	0	2940
2019	549	0	0	2579	316	0	3444
2020	558	0	0	2590	272	0	3420

Table 5.1.3. Tusk in 5.a and 14. Nominal landings by nations in 14.

YEAR	FAROE	DEN-MARK	GREEN-LAND	GER-MANY	ICE-LAND	NOR-WAY	RUSSIA	SPAIN	UK	TOTAL
1980	0	0	0	13	0	0	0	0	0	13
1981	110	0	0	10	0	0	0	0	0	120
1982	0	0	0	10	0	0	0	0	0	10
1983	74	0	0	11	0	0	0	0	0	85
1984	0	0	0	5	0	58	0	0	0	63
1985	0	0	0	4	0	0	0	0	0	4
1986	33	0	0	2	0	0	0	0	0	35
1987	13	0	0	2	0	0	0	0	0	15
1988	19	0	0	2	0	0	0	0	0	21
1989	13	0	0	1	0	0	0	0	0	14
1990	0	0	0	2	0	7	0	0	0	9
1991	0	0	0	2	0	68	0	0	1	71
1992	0	0	0	0	3	120	0	0	0	123
1993	0	0	0	0	1	39	0	0	0	40
1994	0	0	0	0	0	16	0	0	0	16
1995	0	0	0	0	0	30	0	0	0	30
1996	0	0	0	0	0	157	0	0	0	157
1997	0	0	0	0	10	9	0	0	0	19
1998	0	0	0	0	0	12	0	0	0	12
1999	0	0	0	0	0	8	0	0	0	8
2000	0	0	0	0	11	11	0	3	0	25
2001	3	0	0	0	20	69	0	0	0	92
2002	4	0	0	0	86	30	0	0	0	120
2003	0	0	0	0	2	88	0	0	0	90
2004	0	0	0	0	0	40	0	0	0	40
2005	7	0	0	0	0	41	8	0	0	56
2006	3	0	0	0	0	19	51	0	0	73
2007	0	0	0	0	0	40	6	0	0	46

YEAR	FAROE	DEN-MARK	GREEN-LAND	GER-MANY	ICE-LAND	NOR-WAY	RUSSIA	SPAIN	UK	TOTAL
2008	0	0	33	0	0	7	0	0	0	40
2009	12	0	15	0	0	5	11	0	0	43
2010	7	0	0	0	0	5	0	0	0	12
2011	20	0	0	0	131	24	0	0	0	175
2012	33	0	0	0	174	46	0	0	0	253
2013	1.9	0.3	0	0	0	23.8	0	0	0	26
2014	2	0	0	0	0	26	0	0	0	28
2015	670	0.1	166	0	0	62	0	0	0	898
2016	111	0	182	0	0	178	0	0	0	471
2017	83	0.38	335	0	0	141	0	0	0	559
2018	345	0	108	0	0	228	0	0	0	681
2019	41	0	66	1	0	458	0	0	0	566
2020	0	0	233	2	0	114	0	0	0	349

5.1.2.1 ICES advice

ICES advises that when the Iceland management plan is applied, catches in the fishing year 2020/2021 should be no more than 2 171 tonnes.

5.1.2.2 Management

The Icelandic Ministry of Industries and Innovation (MII) is responsible for management of the Icelandic fisheries and implementation of legislation. Tusk was included in the ITQ system in the 2001/2002 quota year and as such subjected to TAC limitations. At the beginning, the TAC was set as recommended by MFRI but thereafter had often been set higher than the advice. One reason is that no formal harvest advisory rule existed for this stock. Up until the fishing year 2011/2012, the landings, by quota year had always exceeded the advised and set TAC by 30-40%. However, since then the overshoot in landings has decreased substantially, apart from 2014/2015 when the overshoot was 34%. In recent years the TAC has not been filled Table 5.1.4.

The reasons for the large difference between annual landings and both advised and set TACs are threefold: 1) It is possible to transfer unfished quota between fishing years; 2) It is possible to convert quota shares in one species to another; 3) The national TAC is only allocated to Icelandic vessels. All foreign catches are therefore outside the quota system. [However, in recent years managers have to some extent taken into account the foreign catches when setting the national TAC (see below)].

There are bilateral agreements between Iceland, Norway and the Faroe Islands related to fishing activity of foreign vessels in restricted areas within the Icelandic EEZ. Faroese vessels are allowed to fish 5600 t of demersal fish species in Icelandic waters which includes a maximum 1200 tonnes of cod and 40 t of Atlantic halibut. The rest of the Faroese demersal fishery in Icelandic waters is mainly directed at tusk, ling, and blue ling. The tusk advice given by MFRI and ICES for each quota year is, however, for all catches, including foreign catches. Further description of the Icelandic management system can be found in the stock annex.

Figure 5.1.5 shows the net transfers in the Icelandic ITQ-system. During the 2005/2006–2010/2011 fishing years there was a net transfer of other species quota being converted to tusk quota, this however reversed during the following three fishing years. In the 2015/2016 and 2016/2017 fishing years there was again a small net transfer of other species being changed to tusk quota. In the last four fishing years, 2017/2018-2019/2020, net transfers have been negative again with tusk quota being converted to other species.

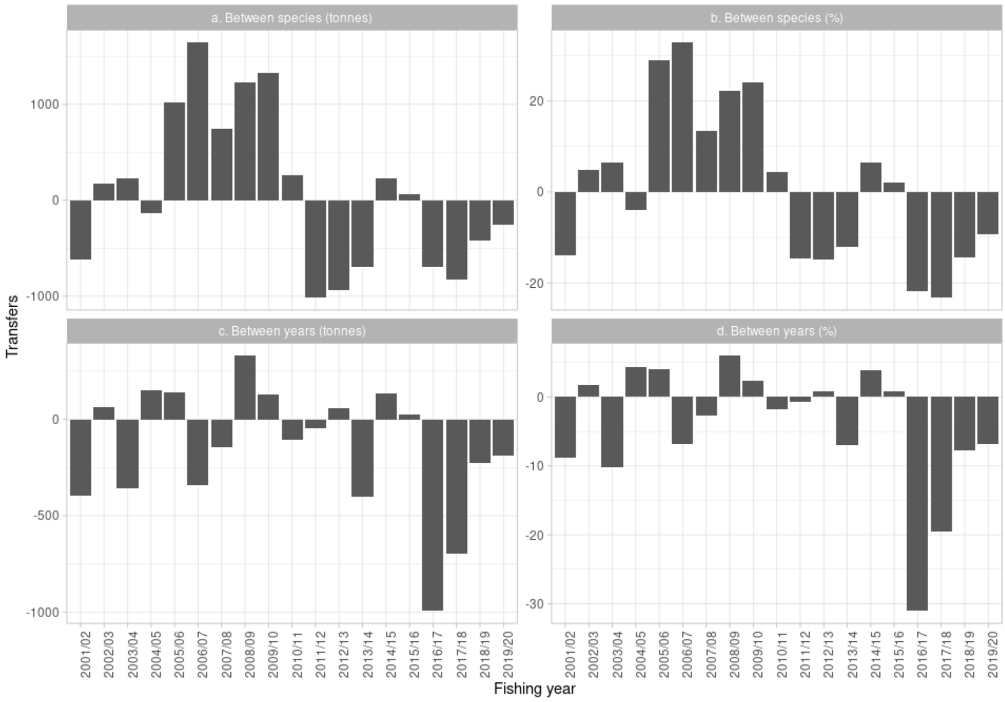


Figure 5.1.5: Tusk in 5.a and 14. Net transfer of quota in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to tusk, but negative values indicate a transfer of tusk quota to other species. Between years (lower): Net transfer of quota for a given fishing year (may include unused quota).

Table 5.1.4. Tusk in 5.a and 14. TAC recommended for tusk in 5.a by the Marine Research Institute, national TAC and total landings from the quota year 2001/2002.

Fishing Year	MFRI Advice	National TAC	Landings
2001/02		4 500	4 876
2002/03	3 500	3 500	5 046
2003/04	3 500	3 500	4 958
2004/05	3 500	3 500	4 901
2005/06	3 500	3 500	5 928
2006/07	5 000	5 000	7 942
2007/08	5 000	5 500	7 279
2008/09	5 000	5 500	8 162
2009/10	5 000	5 500	8 382

Fishing Year	MFRI Advice	National TAC	Landings
2010/11	6 000	6 000	7 777
2011/12	6 900	7 000	7 401
2012/13	6 700	6 400	6 833
2013/14	6 300	5 900	5 881
2014/15	4 000	3 700	4 958
2015/16	3 440	3 000	3 494
2016/17	3 780	3 380	2 407
2017/18	4 370	4 370	3 139
2018/19	3 776	3 100	2 454
2019/20	3 856	3 856	3 445
2020/21	2 289	2 289	
2021/22	2 171	2 171	

5.1.3 Data available

In general sampling is considered appropriate from commercial catches from the main gear (longlines), although the quantity of samples has decreased substantially in recent years. The sampling does seem to cover the spatial distribution of catches for longlines and trawls. Similarly, sampling does seem to follow the temporal distribution of catches (ICES (2012)). The sampling coverage by gear in 2020 is shown in Figure 5.1.6.

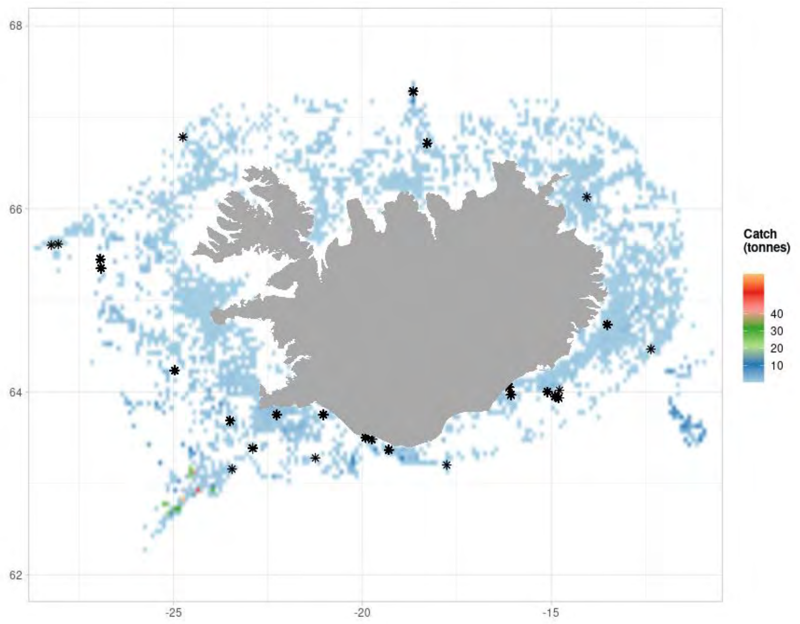


Figure 5.1.6: Tusk in 5.a and 14. Fishing grounds in 2019 as reported by catch in logbooks (tiles) and positions of samples taken from landings (asterisks) by longliners.

5.1.3.1 Landings and discards

Landings by Icelandic vessels are given by the Icelandic Directorate of Fisheries. Landings of Norwegian and Faroese vessels are given by the Icelandic Coast Guard. Discarding is banned by law in the Icelandic demersal fishery, as well as in Norway. Based on limited data, discard rates in the Icelandic longline fishery for tusk are estimated very low (<1% in either numbers or weight) (ICES (2011) :WD02). Measures in the Icelandic management system such as converting quota share from one species to another are used by the Icelandic fleet to a large extent, and this is thought to discourage discards in mixed fisheries. A description of the management system is given in the stock annex and Iceland fisheries overview (ICES (2017b) and ICES (2019)). Landings for tusk in Greenlandic waters are obtained from the STATLANT database. Figures reported by the Greenland Institute of Natural Resources (ICES (2014):WD06) are in agreement. No information is available on discards in Greenlandic waters.

5.1.3.2 Length compositions

An overview of available length measurements from 5.a is given in Table 5.1.6. Most of the measurements are from longlines; number of available length measurements increased in 2007 from around 2500 to around 4000 and were close to that until 2016 when they decreased to around 1700 and have remained roughly at that level. Length distributions from the spring survey data and longline fishery are shown in Figures 5.1.7 and 5.1.8 respectively. In the figures, numbers-at-length are multiplied by the expected proportion mature at that length to split catch numbers into mature and immature components.

No length composition data from commercial catches in Greenlandic waters are available.

Table 5.1.5. Tusk in 5.a and 14. Number of available length measurements from Icelandic (5.a) commercial catches.

Year	Bottom trawl	Demersal seine	Gill net	Long lines	Other
2000	0	0	0	2995	0
2001	0	0	0	3097	151
2002	0	0	0	2843	0
2003	0	0	0	8444	0
2004	150	0	0	3809	0
2005	21	0	0	5820	0
2006	472	0	0	4861	0
2007	150	0	167	11936	0
2008	0	0	0	20963	0
2009	0	0	0	21451	0
2010	0	0	0	9084	0
2011	0	0	0	8158	0
2012	150	0	0	11867	0
2013	0	150	0	6469	0
2014	0	0	0	11748	0

Year	Bottom trawl	Demersal seine	Gill net	Long lines	Other
2015	0	0	0	4821	0
2016	0	0	0	4844	0
2017	0	0	0	1710	0
2018	0	0	0	2781	0
2019	0	0	0	2952	0
2020	1	0	0	2336	0

Figure 5.1.7: Tusk in 5.a and 14. Length distributions (4 cm grouping) from the spring survey since 1985. Red areas are immature tusk and green represent mature tusk. Small numbers to the right refer to mean length (ML).

Figure 5.1.8: Tusk in 5.a and 14. Length distributions from Icelandic commercial longline catches.

5.1.3.3 Age compositions

Table 5.1.6 gives an overview of otolith sampling intensity by gear types from 2000 to 2020 in 5.a. Since 2010, considerable effort has been put into ageing tusk otoliths, so now aged otoliths are available from 1984, 1995, 2008–2018. The age data are used as input for the Gadget assessment. It is expected that the effort in ageing of tusk will continue. Age distributions are shown from the spring survey and commercial longline samples in Figure 5.1.9 and Figure 5.1.10 respectively. No data are available from 14.

Table 5.1.6. Tusk in 5.a and 14. Number of available otoliths from Icelandic (5.a) commercial catches and the Icelandic Spring survey and the number of aged otoliths.

Year	No. samples (catch)	No. otoliths (catch)	No.samples (survey)	No.aged (survey)
2008	14	600	282	475
2009	24	1090	277	434
2010	29	1373	241	363
2011	28	1306	270	728
2012	33	1112	285	750
2012	1	48	285	750
2013	1	20	275	536
2013	22	490	275	536
2014	28	587	241	560
2015	26	505	260	573

Year	No. samples (catch)	No. otoliths (catch)	No.samples (survey)	No.aged (survey)
2016	14	290	259	676
2017	8	152	245	571
2018	9	179	247	549
2019	15	321	251	704
2020	12	236	250	647

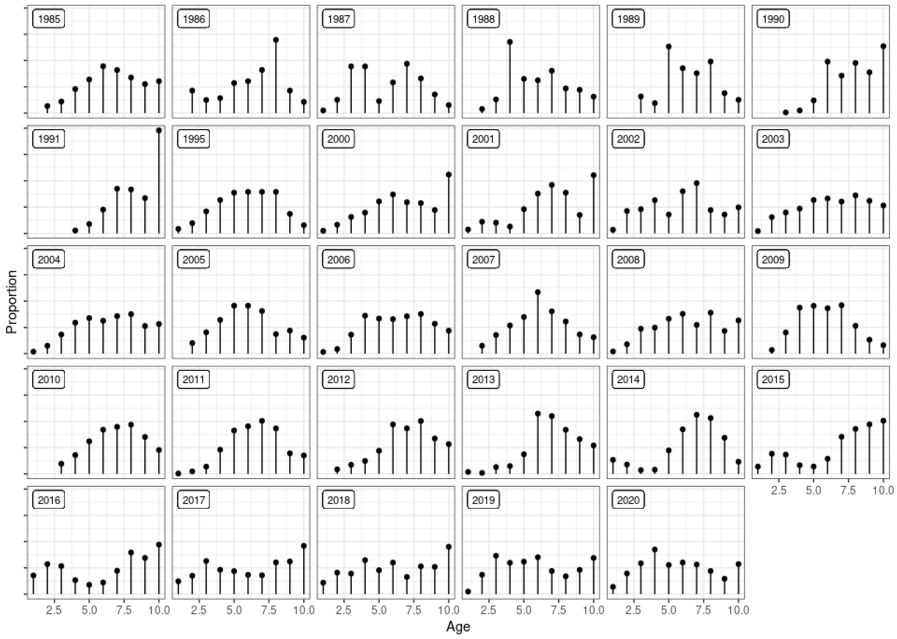


Figure 5.1.9: Tusk in 5.a and 14. Age distributions in proportions in 5.a from the Iceland spring survey.

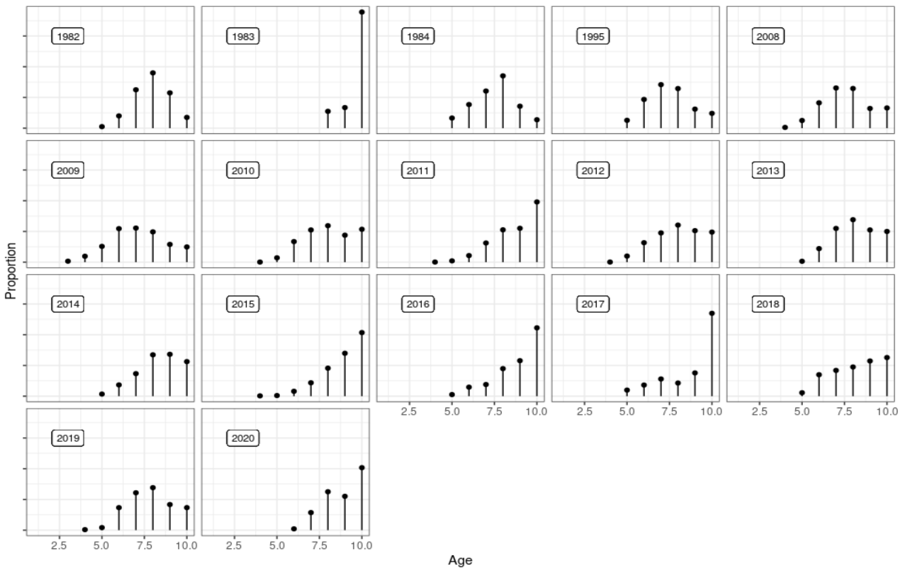


Figure 5.1.10: Tusk in 5.a and 14. Age distributions in proportions in 5.a (from longlines). Samples for 2019 are only from January – March.

5.1.3.4 Weight at age

Weight-at-age data from 5.a are limited to 2008–2021. No data are available from 14.

5.1.3.5 Maturity at age

At 54 cm around 25% of tusk in 5.a is mature, at 62 cm 50% of tusk is mature and at 70 cm 75% of tusk is mature based on the spring survey data.

No data are available for 14.

5.1.3.6 Natural mortality

No information is available on natural mortality of tusk in 5.a or 14. For assessment and advisory purpose the natural mortality is set to 0.1 for all age groups.

5.1.3.7 Catch, effort and research vessel data

Catch per unit of effort and effort data from commercial fisheries

The CPUE estimates of tusk in 5.a are not considered representative of stock abundance.

CPUE estimations have not been attempted on available data from 14.

Icelandic survey data (ICES division 27.5.a)

Information on abundance and biological parameters from tusk in Icelandic waters is available from two surveys, the Icelandic groundfish survey in the spring and the Icelandic autumn survey. The Icelandic spring groundfish survey, which has been conducted annually in March since 1985, covers the most important distribution area of the tusk fishery. In 2011 the 'Faroe Ridge' survey area was included into the estimation of survey indices. In addition, the autumn survey was commenced in 1996 and expanded in 2000; however, a full autumn survey was not conducted in 2011 due to labour strikes and therefore the results for 2011 are not presented. A detailed description of the Icelandic spring and autumn groundfish surveys is given in the Stock Annex (ICES (2017b)). Figure 5.1.11 shows recruitment index and the trends in various biomass indices. No substantial changes in spatial distribution are seen in general although there are spatial gradients in size distribution Figure 5.1.12.

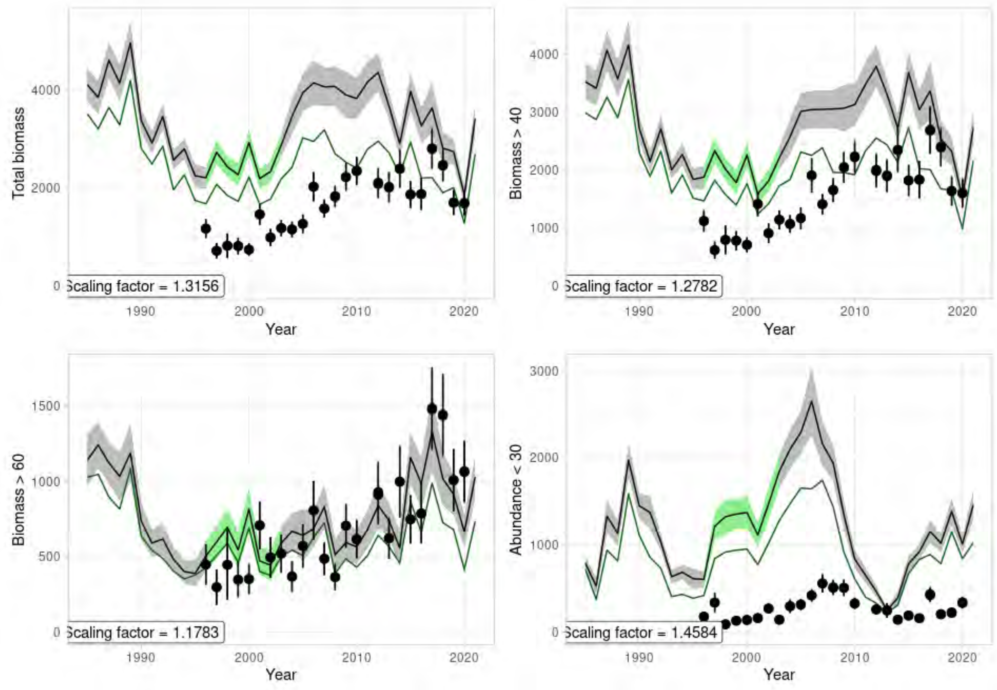


Figure 5.1.11: Tusk in 5.a and 14. Aa) Total biomass indices, b) biomass indices larger than and including 40 cm, c) biomass indices larger than and including 60 cm and d) abundance indices smaller than and including 30 cm. The lines with shaded areas show the spring survey index from 1985 and the points with the vertical lines show the autumn survey from 1997. The shaded area and vertical lines indicate +/- standard error. Green line is the index excluding the Iceland-Faroe Ridge.

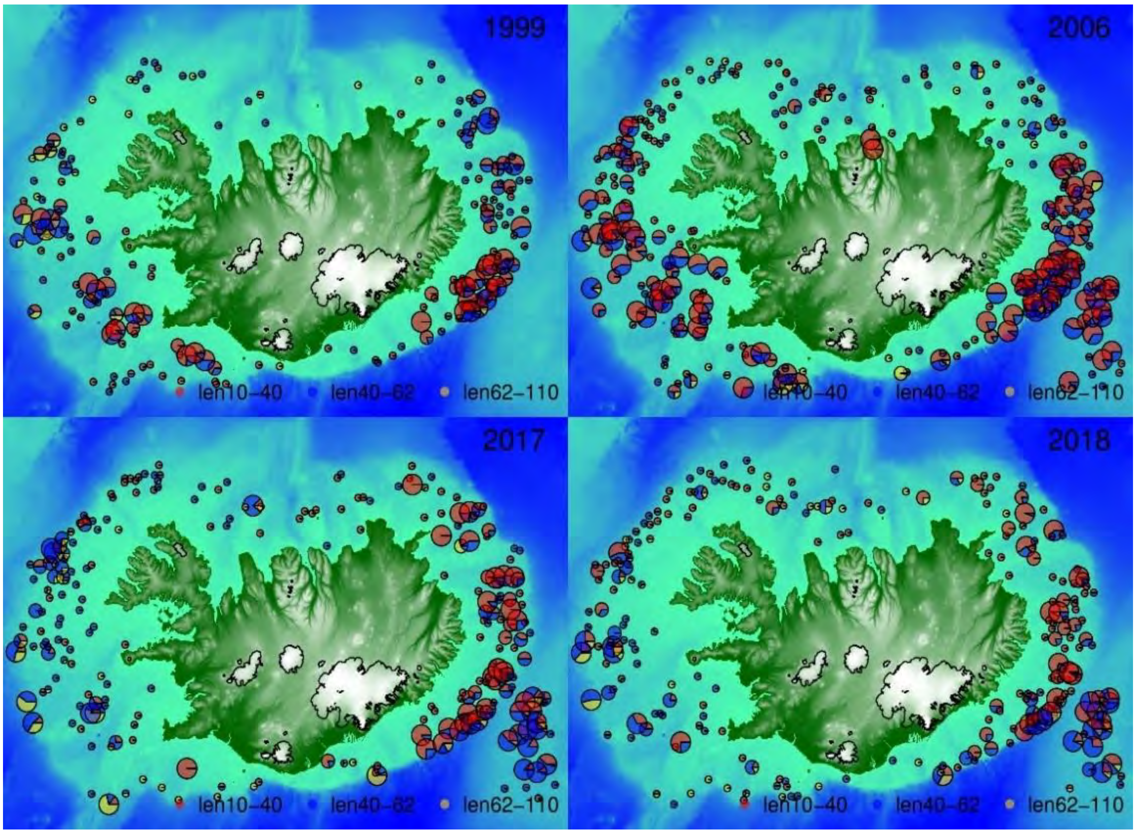


Figure 5.1.12: Tusk in 5.a and 14. Changes in spatial distribution divided by size. Size of pie is indicative of numbers of specimens caught at the tow-station.

German survey data (ICES Subarea 27.14)

The German groundfish survey was started in 1982 and is conducted in autumn. It is primarily designed for cod but covers the entire groundfish fauna down to 400 m. The survey is designed as a stratified random survey; the hauls are allocated to strata off West and East Greenland both according to the area and the mean historical cod abundance at equal weights. Towing time was 30 minutes at 4.5 kn. (Ratz, 1999). Data from the German survey in 14 were available at the meeting up to 2015. The trend in the German survey catches is similar to those observed in surveys in 5.a. It should, however, be noted that the data presented in Figure 5.1.13 is based on total number caught each year so it can't be used directly as an index from East Greenland. Length distributions from the survey in recent years are shown in Figure 5.1.14.

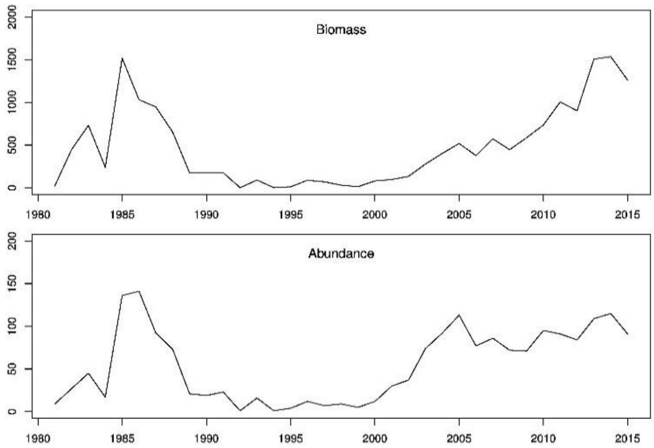


Figure 5.1.13: Biomass and abundance estimates from the Walter Herwig survey in 14. The data are just the total number caught and then converted to weight.

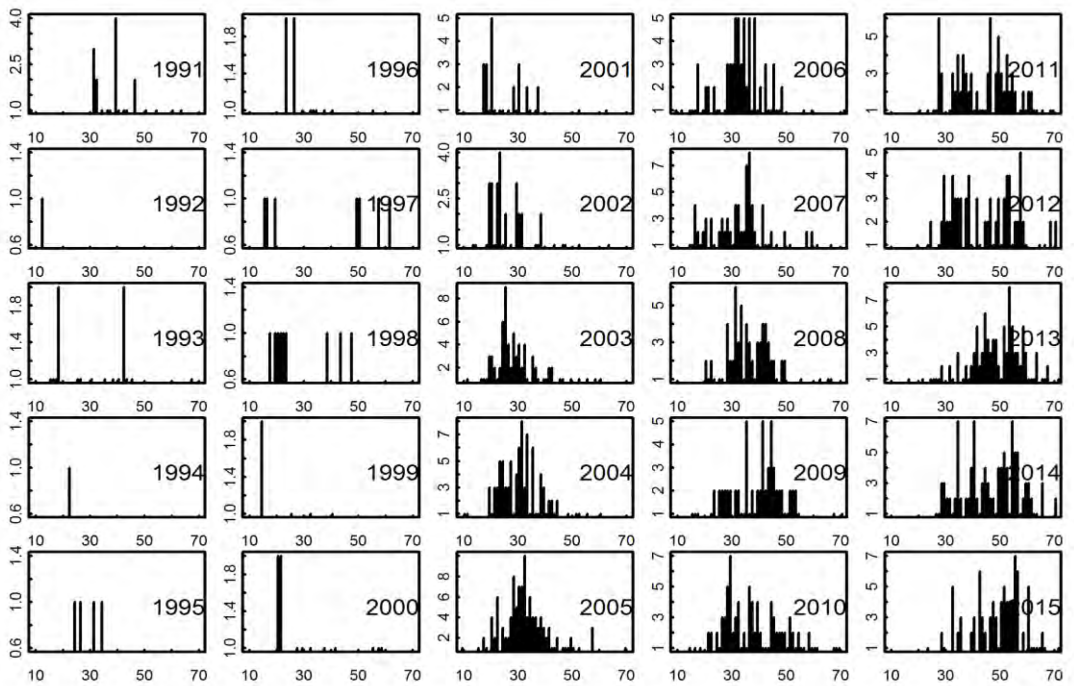


Figure 5.1.14: Length distributions from the Walter Herwig survey in 14.

Greenland survey data (ICES Subarea 27.14)

The Greenland Institute of Natural Resources conducted a stratified bottom trawl survey in East Greenland (ICES 14b) from 1998 to 2016 at depths between 400 to 1500 m (ICES (2019) :WD05). Survey results for tusk show a highly variable but increasing trend over recent years, so results from this survey will be monitored after it resumes in the future as a potential biomass index to be included in the tusk assessment.

5.1.4 Data analyses

There have been no marked changes in the number of boats nor the composition of the fleet participating in the tusk fishery in 5.a. Catches decreased from around 9000 tonnes in 2010 to 3445 tonnes in 2019. This decrease is mainly because of reductions in landings by the Icelandic longline fleet and to a lesser extent Faroese and Norwegian landings (Table 5.1.2 and Table 5.1.3).

This has resulted in less overshoot of landings relative to set TAC (Table 5.1.4). Species conversions in the ITQ system show that other species were converted to tusk last year rather than vice versa.

There are no marked changes in the length compositions since 2004, mean length in the catches ranges between 52.7 and 54.1 (Figure 5.1.7 and Figure 5.1.8). According to the available length distributions and information on maturity only around 29% of catches in abundance and 44% in biomass are mature. There does seem to be a gradual increase in mean age of the age distribution from commercial catches from roughly 7 to 9 (Figure 5.1.10). The reason for this is unknown but given the lack of distinctive cohort structure in the data the first explanation might be a lack of consistency in ageing. Also, tusk have experienced a reduction in fishing mortality over the latter half of this range. Reasons such as difference in sampling, temporal or spatial are highly unlikely.

At WGDEEP 2011 the Faroe-Iceland Ridge was included in the survey index when presenting the results from the Icelandic spring survey for tusk in 5.a. The total biomass index and the biomass index for tusk larger than 40 cm (reference biomass) has decreased substantially over the past 3 years (Figure 5.1.11). The same holds for the index of tusk larger than 60 cm (spawning–stock biomass index). The index of juvenile abundance (<30 cm) decreased by a factor of six between the 2005 survey when it peaked and the 2013 survey when it was at its lowest observed value. Since 2013 juvenile index has increased year on year in the 2014–2017 surveys. The index excluding the Faroe-Iceland Ridge shows similar trends as described above. The result from the shorter autumn survey are by and large similar to those observed from the spring survey except for the juvenile abundance index that is more or less at a constant level compared to the spring survey juvenile index. Due to labour strikes in the fishing industry, the autumn survey did not take place in 2011.

When looking at the spatial distribution from the spring survey around half of the index is from the SE area. However only around 20 to 25% of the catches are caught in this area (Figure 5.1.2 and Figure 5.1.3). The change in juvenile abundance between 2006 and recent years can be clearly seen in Figure 5.1.11 and Figure 5.1.12 where in 2006 juveniles (<40 cm) were all over the southern part of the shelf but can hardly be seen in recent years.

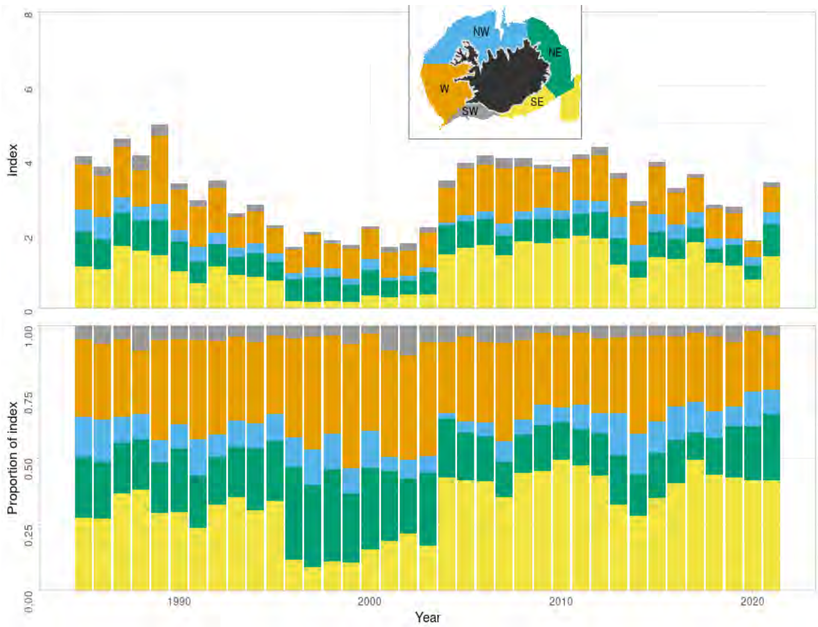


Figure 5.1.15: Tusk in 5.a and 14. Estimated survey biomass in the spring survey by year from different parts of the continental shelf (upper figure) and as proportions of the total (lower figure).

5.1.4.1 Stock assessment on Tusk in 5.a using Gadget

Since 2010 the Gadget model (Globally applicable Area Disaggregated General Ecosystem Toolbox, see www.hafro.is/gadget) has been used for the assessment of tusk in 5.a (See stock annex for details). As part of a Harvest Control Evaluation requested by Iceland this stock was benchmarked in 2017 (ICES (2017a)). Several changes were made to the model setup and settings which are described in the stock annex (ICES (2017b)).

5.1.4.2 Data used by the assessment and model settings

Data used for tuning are given in the stock annex. Model settings used in the Gadget model for tusk in 5.a are described in more detail in the stock annex.

5.1.4.3 Diagnostics

Overall, the fit of the predicted proportional catch length distributions is close to the observed distributions (Figure 5.1.16 and Figure 5.1.17). In general, for the commercial catch distributions the fit is better at the end of the time-series (Figure 5.1.16). The reason for this is there are few data at the beginning of the time-series and the model may be constrained by the initial values. In contrast, the fit of the survey data is not as good toward the end of the time series, mainly due to an absence of fish in the middle size ranges 2015-2018 (5.1.17). The survey age distributions are relatively well-fit (Figure 5.1.18), however, commercial age distributions show some misfits especially toward the end of the time series (Figure 5.1.19).

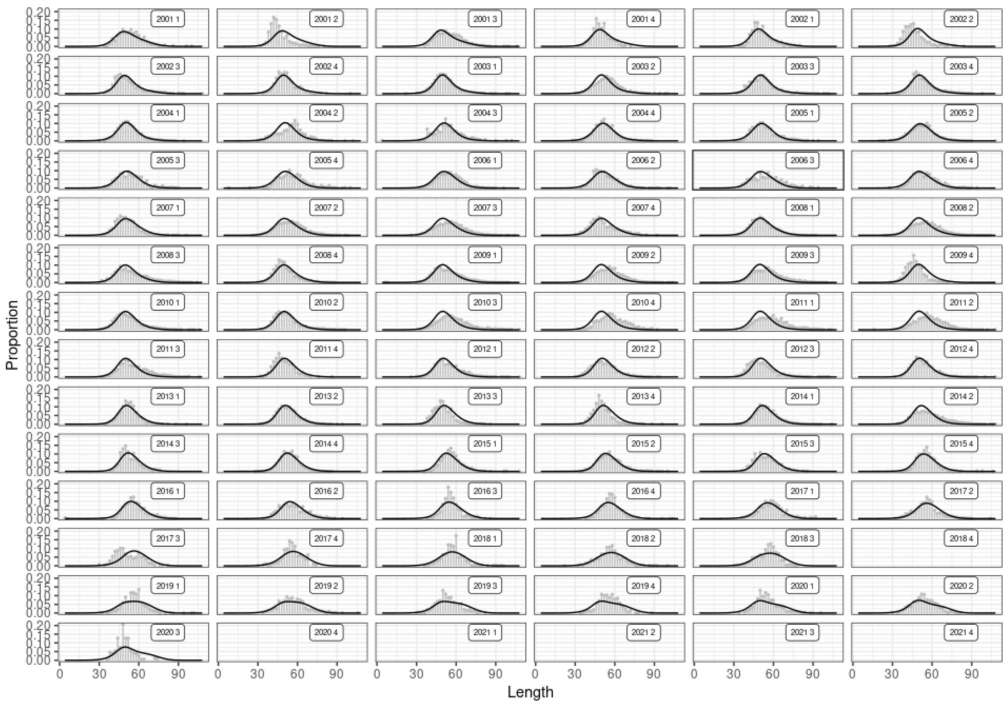


Figure 5.1.16: Tusk in 5.a and 14. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from longline catches (grey lines and dots).

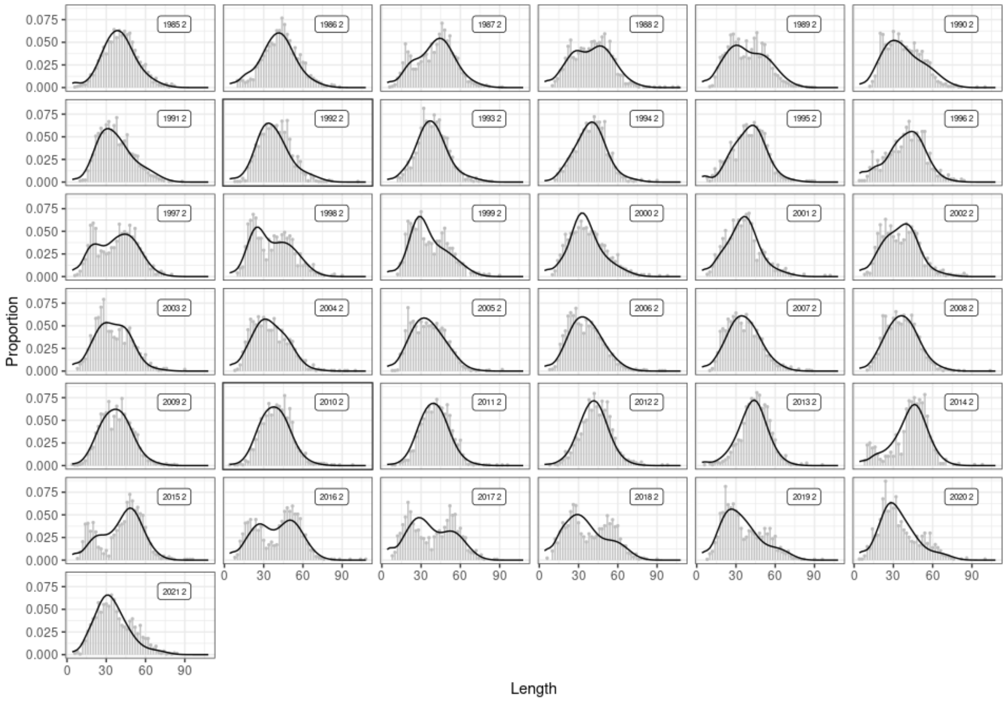


Figure 5.1.17: Tusk in 5.a and 14. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from spring survey catches (grey lines and dots).

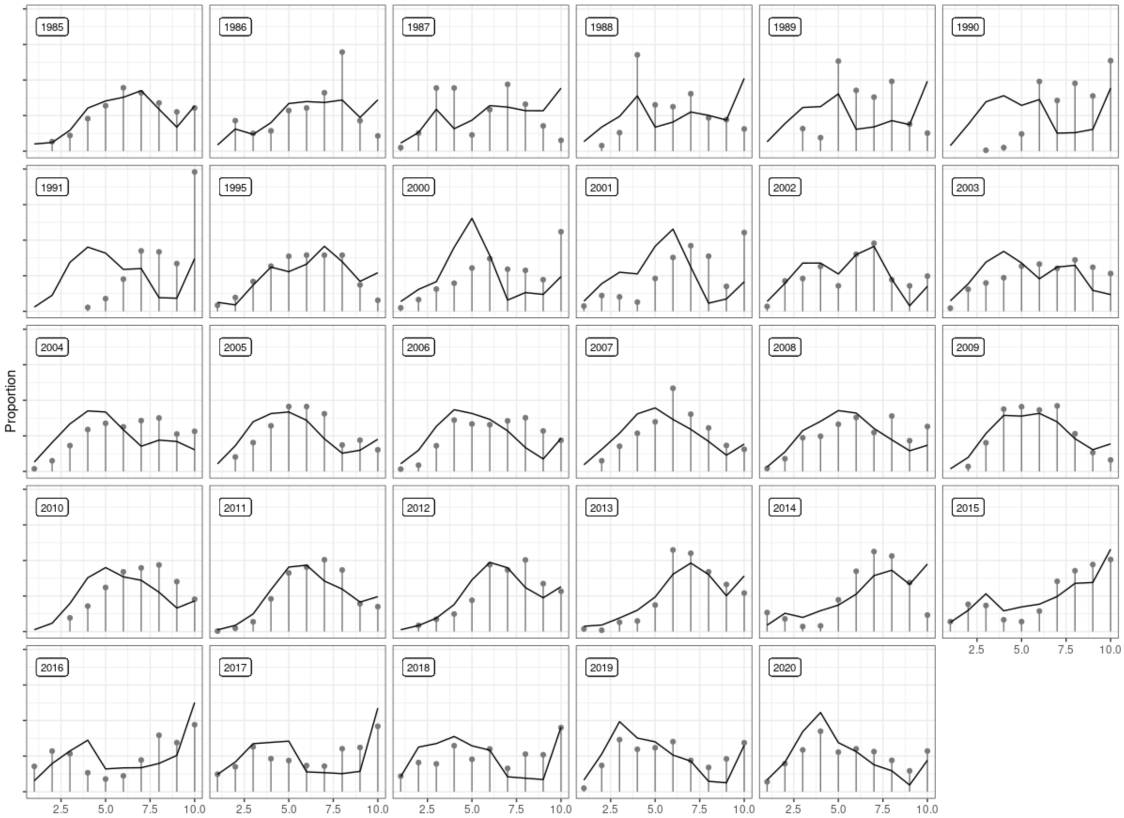


Figure 5.1.18: Tusk in 5.a and 14. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions from the spring survey catches (grey lines and dots).

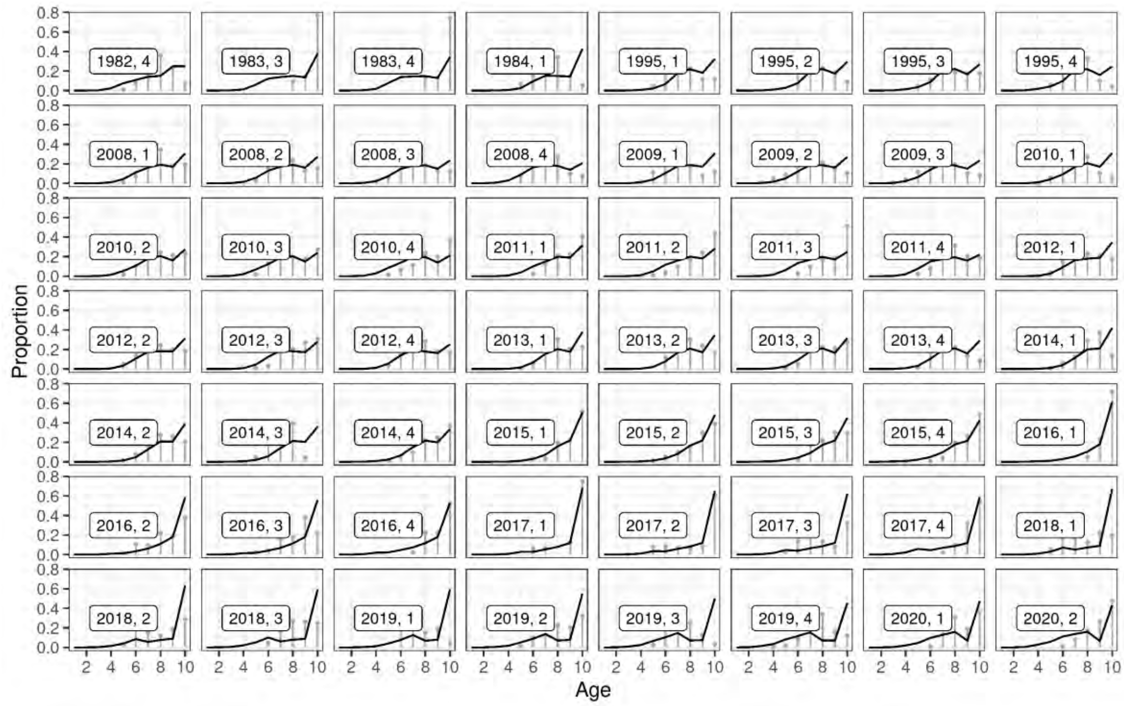


Figure 5.1.19: Tusk in 5.a and 14. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions from longline catches (grey lines and dots).

In Figure 5.1.20 the length disaggregated indices are plotted against the predicted numbers in the stock as a time-series. The correlation between observed and predicted is good for the first five length groups (10–19, 20–29, 30–39, 40–49, 50–59 and 60–69), of which the first three to four are the main length groups of tusk caught in the spring survey. In the two larger length groups the fit gets progressively worse.

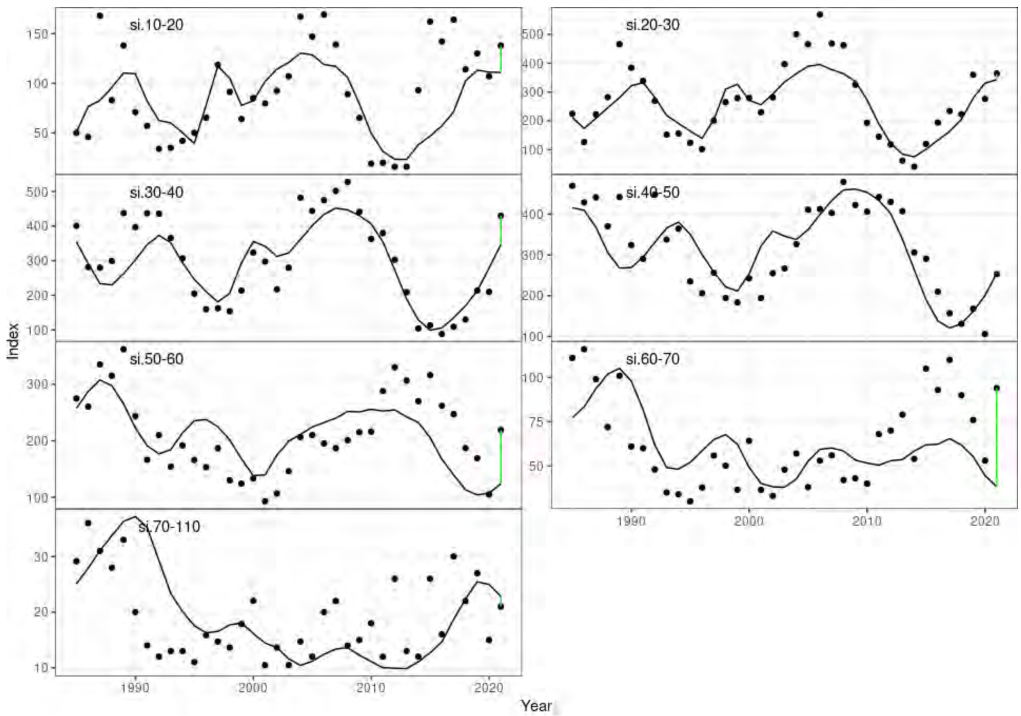


Figure 5.1.20: Tusk in 5.a and 14. Gadget fit to indices from disaggregated abundance by length indices from the spring survey.

5.1.4.4 Model results

The results are presented in Table 5.1.7 and Figure 5.1.21. Total biomass is shown to be decreasing with a slight increase in 2021, and spawning–stock biomass has been stable but only slightly above Bpa since 2005 with a slight decrease observed in the last 2 years.

A large downward revision was observed last year following correction of survey indices used for model tuning and revision of model optimization criteria. The main cause of this revision, in comparison to previous assessments, is that the model is increasingly relying on the three survey indices reflecting the smallest sized tusk, and therefore do not follow the recent peaks in large-sized fish indices (especially since 2010 in indices for 50-60 and 60-70 cm tusk, Figure 5.120. and retrospective plots, next section). It is also possible that errors detected in the survey indices and optimization prevented the detection of smaller incremental downward revisions in previous years.

The same trend can also be seen in length distribution data from surveys beginning 2016 (Figure 5.1.17). Many years prior to 2018 appear bimodal, whereas each year since then has shown a large decrease in the right lobe of the length distribution. Previous years have shown a better fit in the bimodal length distributions observed 2015 - 2018. However, this year, a distinct trough between the two modes of the length distribution can be tracked from 2015 but cannot be fitted by the model. This trough appears to have reached roughly 40 cm this year, thereby presenting a distinct decrease in reference and spawning stock biomass values in a more catchable length range. This suggests that the best model fit to the data this year includes a rather large underestimation of the right lobe of this distribution during the years 2017 - 2020 in order to reconcile these data with the patterns found in 2015 - 2016 and 2020.

There are a few possible explanations for the change in the view of biomass levels. The first is that the underestimation of 40+ tusk in 2017 - 2020 is due to unusually high true catchability during this period. Conversely, unusually low catchability could be currently experienced by the largest sized tusk. However, a shift in catchability by the survey has not been observed in other species, and assuming this is the case could lead to overestimation of the reference biomass and advice. Similarly, time-variable changes in selectivity from the current assumed logistic shape to a dome-shaped curve could potentially cause such a discrepancy. However, further investigations of model fits including time-invariant dome-shaped selectivity did not improve the model fit in these last years, while implementing dome-shaped selectivity for only the last few years could also introduce overestimation of biomass with little grounds for suspecting such a selectivity shift. Finally, unaccounted for changes in past mortality, such as higher natural or discard mortality, or outmigration in the size range of the trough could explain this discrepancy.

In any case, the management strategy evaluation that informed the management plan for this stock was completed with high assessment uncertainty and autocorrelation (CV = 0.3, rho = 0.8, WKICESMSE 2017), so it is unlikely that this downward correction has an effect on reference point calculation or the derived management plan.

Recruitment peaked in 2005 to 2006 but has decreased and is estimated in 2013 to have been the lowest observed. Recruitment in 2014–2020 is estimated to be considerably higher than in 2013. Harvest rate has decreased from 0.29 in 2008 to 0.12 in 2016 and remains close to the target 0.13. Estimates of reference biomass (B40+) have also been stable for the last several years.

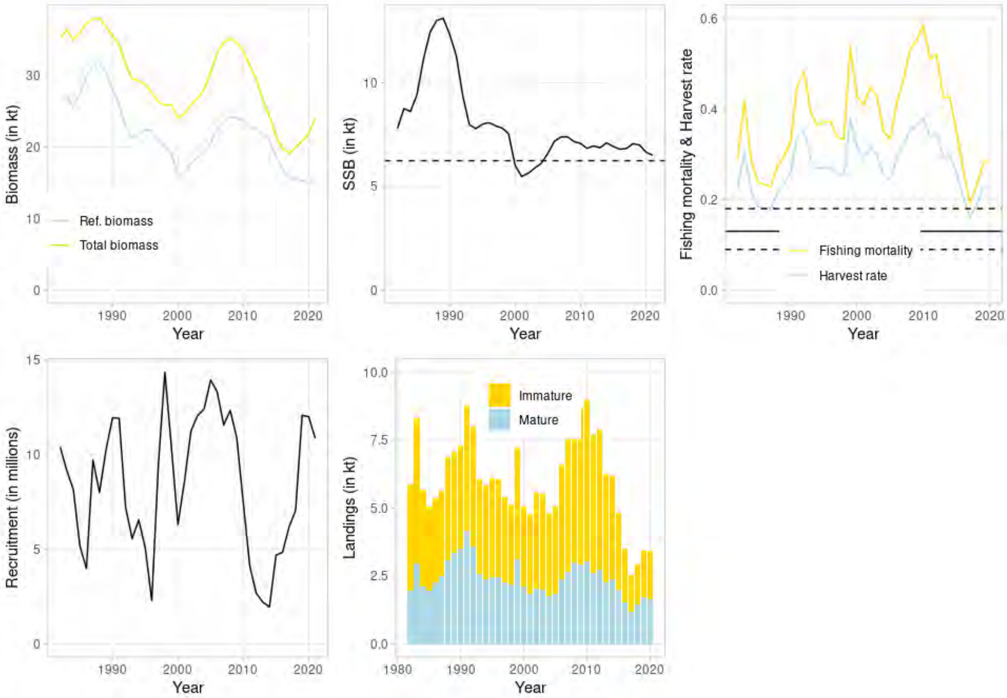


Figure 5.1.21: Tusk in 5.a and 14. Estimates of recruitment, biomass, harvestable biomass and fishing mortality for tusk for the age groups most important in the fishery i.e. ages 7 to 10 (solid line).

5.1.4.5 Retrospective analysis

The results of an analytical retrospective analysis are presented (Figure 5.1.22). Additional plots are provided due to the large downward revision detected last year. The analysis indicates that with each subsequent peel going backwards in time, an upward revision in reference biomass and spawning stock biomass is observed except the fourth and fifth peel giving similar estimates. Consequently, a downward revision of *F* is observed. Estimates of recruitment shows in increase in the recent two peels leading to a strong retrospective pattern.

Recruitment indices generally tend to be uncertain as there are few repeated observations at larger sizes with which this influence can be tempered. However, the good fit to survey indices in the age 3 recruitment length range (20 - 30 cm, (Figure 5.1.23), suggest that at least recruitment estimates from this peak are reliable. In addition, a peak in these sizes of tusk followed by a sharp decline in 2020 are reflected in length distribution data as a rather large but steep peak in proportions of fish that have begun to shift right (to larger sizes) with no obvious new peaks of small sizes taking its place (Figure 5.1.24). Therefore, it is likely that reference biomass may increase once the current recruitment peak reaches 40+ cm sizes.

The changes in estimation of later peels can also be observed in these plots as progressively worse fits to survey indices of larger sized tusk, as well as underestimation of the right peak of the bimodal length distributions observed in the last 5 years (Figure 5.1.24). It is possible that these misfits reflect an underestimation of the current true spawning stock biomass levels. However, this is difficult to conclude as these misfits generally represent an inconsistency between the model being able to reconcile length distribution and survey data collected after 2018 with the relatively good fits to these data observed in the earliest assessment periods. Trends in catchability estimates across peels indicate that changes to the catchability of the largest two indices, to which the fit of the model has changed, are likely to cause the overall shifts in biomass levels (5.1.25).

Mohn's rho was estimated to be 0.143 for SSB, -0.102 for F, and 0.358 for recruitment.

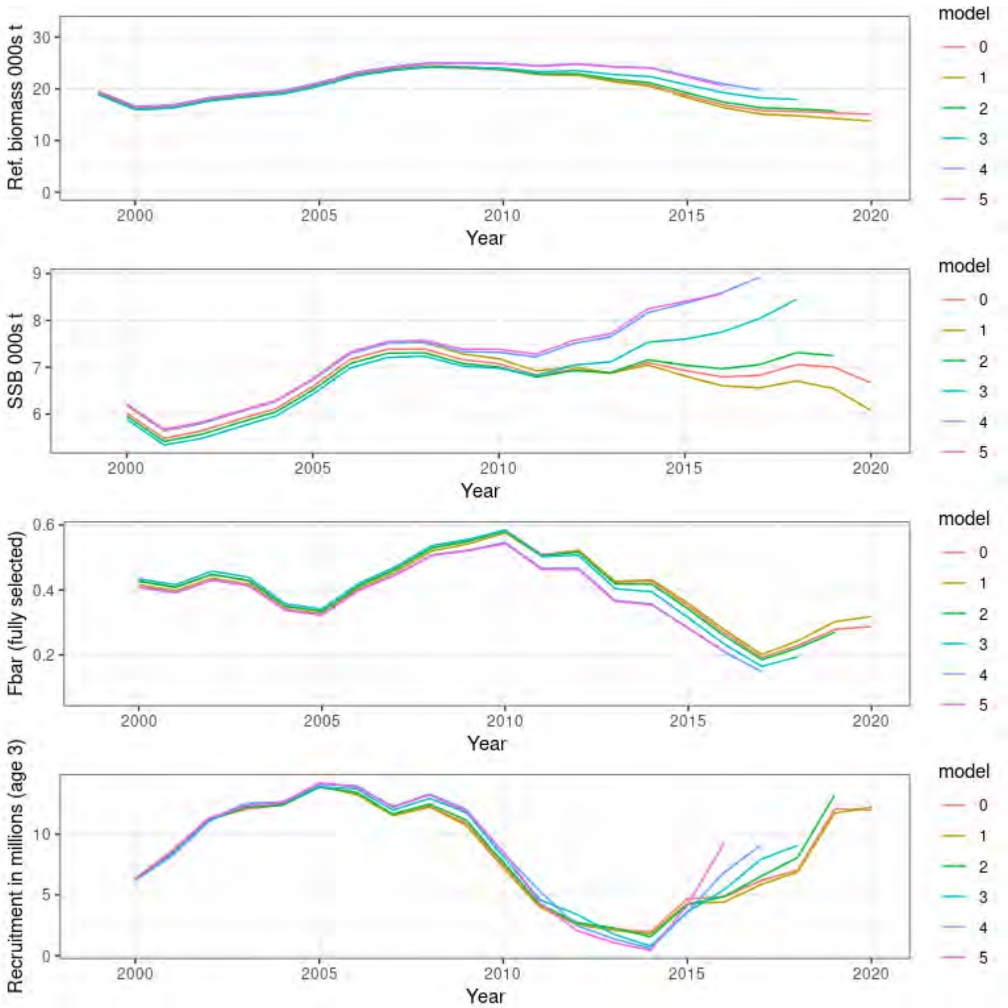


Figure 5.1.22: Tusk in 5.a and 14. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 3) are shown.

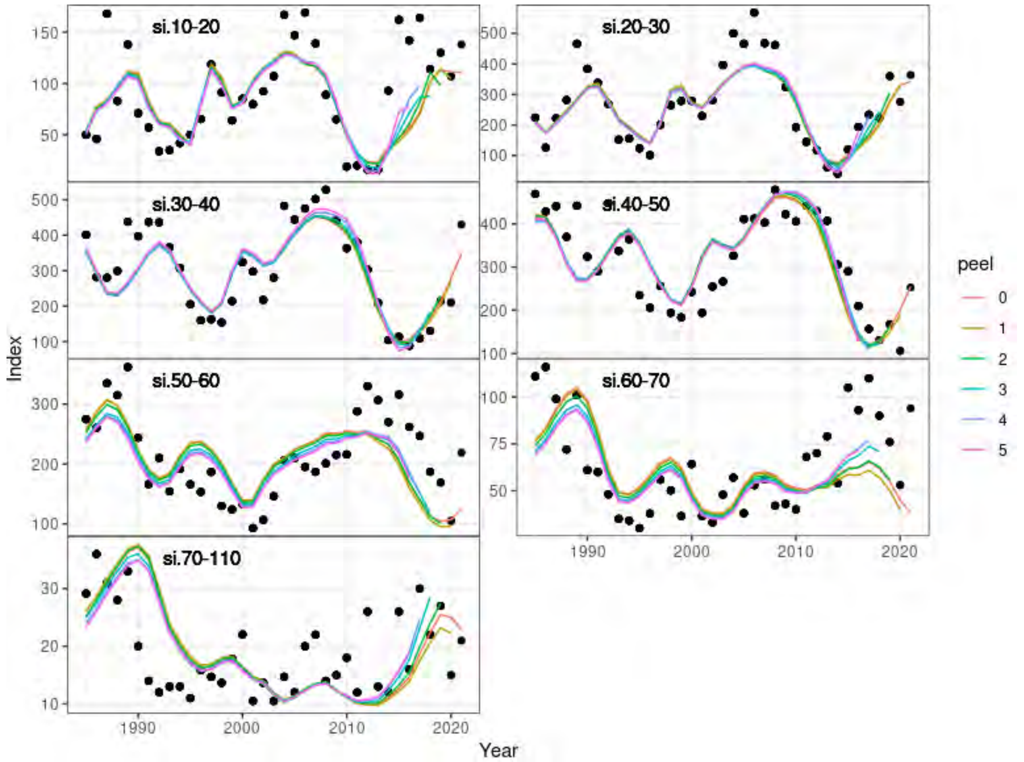


Figure 5.1.23: Tusk in 5.a and 14. Retrospective plots illustrating stability in model fits to survey indices over a 5-year 'peel' in data.

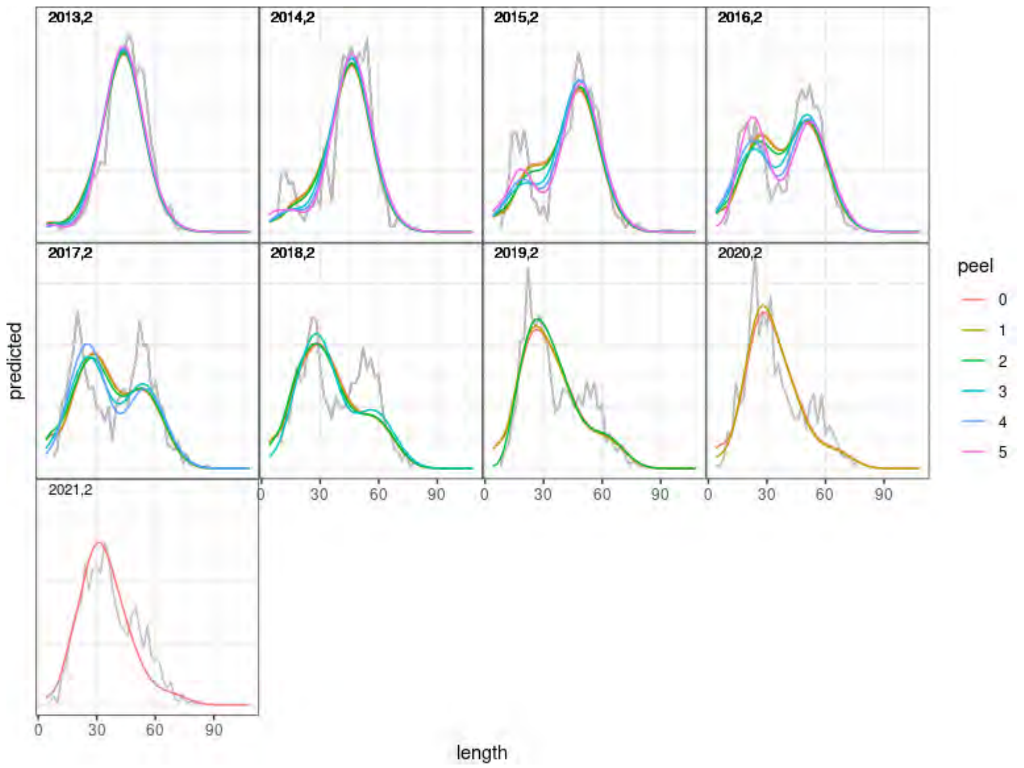


Figure 5.1.24: Tusk in 5.a and 14. Retrospective plots illustrating stability in fit length distribution data from the spring survey over a 5-year 'peel' in data.

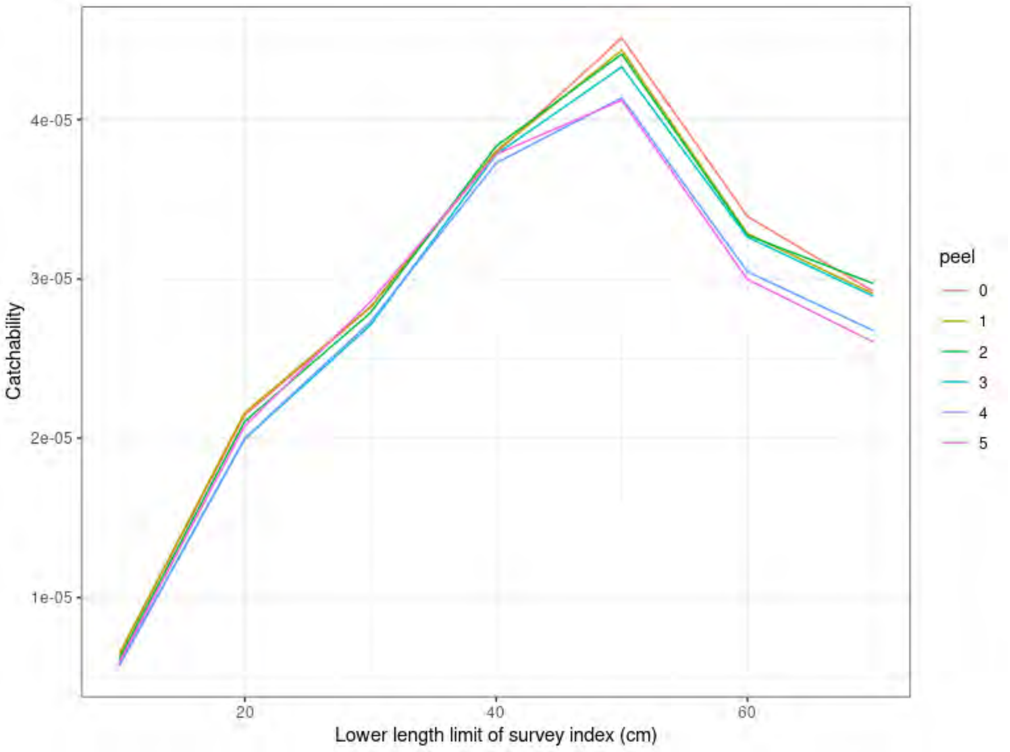


Figure 5.1.25: Tusk in 5.a and 14. Retrospective plots illustrating stability in catchability estimates over a 5-year 'peel' in data.

5.1.5 Current management plan

As part of the WKICEMSE 2017 HCR evaluations (ICES (2017a)), the following reference points were defined for the stock.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	6.24 kt	B_{pa}
	H_{msy}	0.17	The harvest rate that maximises the median long-term catch in stochastic simulations with recruitment drawn from a block bootstrap of historical recruitment scaled according to a hockey stick recruitment function with B_{lim} as defined below.
	F_{msy}	0.226	The median fishing mortality when an harvest rate of H_{msy} is applied.
	$H_{p.05}$	0.371	The harvest rate that has an annual probability of 5% of SSB < B_lim.
	$F_{p.05}$	0.356	The median fishing mortality when an harvest rate of $H_{p.05}$ is applied.
Precautionary approach	B_{lim}	4.46 kt	$B_{pa}/e^{1.645\sigma}$ where $\sigma = 0.2$
	B_{pa}	6.24 kt	SSB(2001), corresponding to B_{loss}
	H_{lim}	0.27	H corresponding to 50% long-term probability of SSB > B_{lim}
	F_{lim}	0.41	F corresponding to H_{lim}
	F_{pa}	0.27	$F_{lim}/e^{1.645\sigma}$ where $\sigma = 0.25$
	H_{pa}	0.20	H corresponding to F_{pa}
Management plan	H_{mp}	0.13	

The management plan accepted was: The spawning–stock biomass trigger (MGT Btrigger) is defined as 6.24 kt, the reference biomass is defined as the biomass of tusk 40+ cm and the target harvest rate (HRmgt) is set to 0.13. In the assessment year (Y) the TAC for the next fishing year (September 1 of year Y to August 31 of year Y+1) is calculated as follows:

When SSBy is equal or above MGT Btrigger:

TACy/y+1 = HRmgt*BRef,y

When SSBY is below MGT Btrigger:

TACy/y+1 = HRmgt* (SSBy/MGT Btrigger) * Bref,y

WKICEMSE 2017 concluded that the HCR was precautionary and in conformity with the ICES MSY approach.

5.1.6 Management considerations

Increased catches in 14.b from less than 100 tonnes in previous years to 900 tonnes in 2015, and about 566 tonnes in 2019 are of concern. However, the signs from commercial catch data and surveys indicate that the total biomass of tusk in 5.a is stable. This is confirmed in the Gadget assessment. Recruitment in 5.a is on the increase again after a low in 2013. A reduction in fishing mortality has also led to harvestable biomass and SSB that seem to be either stable or slowly increasing. Due to the selectivity of the longline fleet catching tusk in 5.a and the species relatively slow maturation rate, a large proportion of the catches is immature (60% in biomass, 70% in abundance). The spatial distribution of the fishery in relation to the spatial distribution of tusk in 5.a as observed in the Icelandic spring survey may result in decreased catch rates and local depletions of tusk in the main fishing areas. Tusk is a slow growing late maturing species, therefore closures of known spawning areas should be maintained and expanded if needed. Similarly, closed areas to longline fishing where there is high juvenile abundance should also be maintained and expanded if needed.

5.1.6.1 Ecosystem considerations

Tusk has recently exhibited spatial changes in length distributions (Figure 5.1.12), however, there have been no obvious changes in maturity patterns or growth through time. Demographic patterns of tusk should be monitored as other Icelandic demersal species have exhibited recent changes (e.g., haddock). Tusk biomass levels have recently decreased, possibly as a result of increased natural mortality and environmental factors. However, the causes for this, such as multispecies interactions, are unknown and not currently considered in the assessment.

Table 5.1.7. Tusk in 5.a and 14. Estimates of biomass, biomass 40+ cm, spawning–stock biomass (SSB) in thousands of tonnes and recruitment (millions), harvest rate (HR) and fishing mortality from Gadget.

YEAR	BIOMASS	B40+	SSB	REC3	CATCH	HR	F
1982	36494	28927	11176	10297	5877	0.20	0.28
1983	37690	28796	10850	9135	8286	0.29	0.40
1984	36302	28217	10203	8396	5692	0.20	0.28
1985	37177	30120	11043	5232	5061	0.17	0.23
1986	38415	32196	12209	3765	5381	0.17	0.23
1987	38990	33580	13191	8858	5644	0.17	0.22
1988	39095	33108	13476	7591	6864	0.21	0.27

YEAR	BIOMASS	B40+	SSB	REC3	CATCH	HR	F
1989	37900	31778	13449	10590	7076	0.22	0.29
1990	36635	29620	12679	11867	7296	0.25	0.32
1991	35291	27171	11349	12348	8762	0.32	0.44
1992	32503	24606	9514	7202	7999	0.33	0.47
1993	30390	23498	8300	5883	6074	0.26	0.38
1994	29996	24279	8256	6294	5828	0.24	0.36
1995	29451	24317	8306	5518	6225	0.26	0.37
1996	28146	23536	8259	1819	6101	0.26	0.37
1997	26871	22652	8235	8688	5399	0.24	0.33
1998	26454	21406	8069	14892	5171	0.24	0.33
1999	26471	19444	7341	11071	7225	0.37	0.53
2000	24628	17708	6094	6290	5087	0.29	0.42
2001	25208	18100	5473	8284	4809	0.27	0.41
2002	26435	19921	5841	11127	5551	0.28	0.45
2003	27296	20243	5984	12517	5571	0.28	0.43
2004	28545	20645	6140	12566	4822	0.23	0.35
2005	31029	22598	6697	13958	5041	0.22	0.34
2006	33744	24451	7150	13739	6598	0.27	0.42
2007	35230	25714	7377	11887	7540	0.29	0.47
2008	35908	26647	7493	12729	8626	0.32	0.53
2009	35365	26074	7153	11405	8680	0.33	0.55
2010	34293	25864	7128	7822	8978	0.35	0.58
2011	32191	25187	7026	4365	7702	0.31	0.51
2012	30482	24911	7203	2799	7873	0.32	0.51
2013	27615	23317	7122	2415	6265	0.27	0.41
2014	25489	22147	7391	1548	6163	0.28	0.41
2015	22804	20295	7433	4245	4836	0.24	0.33
2016	21069	18206	7266	4853	3494	0.19	0.25
2017	20591	17778	7633	6097	2541	0.14	0.18

YEAR	BIOMASS	B40+	SSB	REC3	CATCH	HR	F
2018	21410	17316	7712	7202	2940	0.17	0.21
2019	22441	17575	7868	12385	3445	0.20	0.25
2020	23715	17609	7546	13748	3420	0.21	0.29

5.1.7 References

ICES. 2011. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (Wgdeep), 2 March–8 March, 2011, Copenhagen, Denmark. ICES Cm 2011/Acom:17." International Council for the Exploration of the Seas; ICES publishing.

2012. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (Wgdeep), 28 March–5 April, 2012, Copenhagen, Denmark. ICES Cm 2012/Acom:17." International Council for the Exploration of the Seas; ICES publishing.

2014. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (Wgdeep). ICES Scientific Reports. 1:21., Copenhagen, Denmark. ICES Cm 2014/Acom:17." International Council for the Exploration of the Seas; ICES publishing. https://doi.org/10.17895/ices.pub.5262.

2017a. "Report of the Workshop on Evaluation of the Adopted Harvest Control Rules for Icelandic Summer Spawning Herring, Ling and Tusk (WKICEMSE), 21–25 April 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:45." International Council for the Exploration of the Seas; ICES publishing.

2017b. "Tusk in ICES Subarea 14 and Division 5.a." International Council for the Exploration of the Seas; ICES publishing.

2019. "11.2 Icelandic Waters ecoregion – Fisheries overview." International Council for the Exploration of the Seas; ICES publishing. https://doi.org/10.17895/ices.advice.5706.

5.3 Tusk (*Brosme brosme*) on the Mid-Atlantic Ridge (Sub-divisions 12.a1 and 14.b1)

5.3.1 The fishery

Tusk is bycatch in the gillnet and longline fisheries in Subdivisions 12.a1 and 14.b1. During 1996 and 1997 Norway also had a fishery in this area.

5.3.2 Landings trends

Landing statistics by nation in the years 1988 to 2020 are shown in Table 5.3.1.

The reported landings are generally very low in these areas. Russia reported some landings of tusk in 2005, 2006, 2007 and 2009 and no landings were reported by the Russians for 2010 and 2011. In 2012 Norway reported 17 tonnes in Area 14.b1 and the Faroe Islands, 1 ton. No landings have been reported in 2013, 2014, 2016 to 2020, while in 2015 Greenland reported 2 tons.

5.3.3 ICES Advice

Advice for **2020 to 2024:** ICES advises that when the precautionary approach is applied, there should be zero catches in each of the years from 2020 to 2024.

5.3.3.1 Management

In 2014 NEAFC (Rec 03 2014) recommends the effort in areas beyond national jurisdiction shall not exceed 65 percent of the highest effort level for deep-water fishing in the past.

5.3.4 Data available

5.3.4.1 Landings and discards

Landings were available for all the relevant fleets. No discard data were available.

5.3.4.2 Length compositions

No length compositions were available.

5.3.4.3 Age compositions

No age compositions were available.

5.3.4.4 Weight-at-age

No data were available.

5.3.4.5 Maturity and natural mortality

No data were available.

5.3.4.6 Catch, effort and research vessel data

No data were available.

5.3.5 Data analyses

There are insufficient data to assess this stock.

5.3.5.1 Biological reference points

WKLIFE has not yet suggested methods to estimate biological reference points for stocks which have only landings data or are bycatch species in other fisheries. Therefore, no attempt was made to propose reference points for this stock.

5.3.6 Comments on the assessment

No assessment was carried out this year.

5.3.7 Management considerations

Tusk is a bycatch in all fisheries. Advice should consider the advice for the targeted species. Life-history traits for tusk do not suggest it is particularly vulnerable.

5.3.8 Tables

Table 5.3.1. Tusk 12. WG estimate of landings.

Tusk 12

Year	Faroes	France	Iceland	Norway	Scotland	Russia	Total
1988		1					1
1989		1					1
1990		0					0
1991							0
1992							0
1993	29	1	+				30
1994	27	1	+				28
1995	12	-	10				18
1996	7	-	9	142			158
1997	11	-	+	19			30
1998				-			1
1999				+	1		1
2000				5	+		5
2001		1		51	+		52
2002				27			27
2003				83			83
2004		2		7		5	14
2005	2	1					3

Year	Faroes	France	Iceland	Norway	Scotland	Russia	Total
2006						64	64
2007						19	19
2008						0	0
2009						2	2
2010							0
2011							0
2012	1						1
2013							0
2014							0
2015							0
2016							0
2017							0
2018							0
2019							0
2020*							0

*Preliminary.

Tusk 14.b1

Year	Faroes	Iceland	Norway	E & W	Russia	GREENLAND	Total
2012			17				17
2013							0
2014							0
2015						2	2
2016							0
2017							0
2018							0
2019							0
2020							0

Table 5.3.1. (Continued). Tusk, total landings by subareas or division.

Year	12	14.b1	All areas
1988	1		1
1989	1		1
1990	0		0
1991	0		0
1992	0		0
1993	30		30
1994	28		28
1995	18		18
1996	158		158
1997	30		30
1998	1		1
1999	1		1
2000	5		5
2001	52		52
2002	27		27
2003	83		83
2004	14		14
2005	3		3
2006	64		64
2007	19		19
2008	0		0
2009	2		2
2010	0		0
2011	0		0
2012	1	17	18
2013	0		0
2014	0		0
2015	0	2	2
2016	0		0

Year	12	14.b1	All areas
2017			0
2018			0
2019			0
2020			0

*Preliminary.

5.4 Tusk (*Brosme brosme*) in 6.b

5.4.1 The fishery

Tusk are only caught as bycatch and not targeted in the trawl, gillnet and longline fisheries in Subarea 6.b. Norway has traditionally landed the largest catch of tusk in area 6.b. In particular, during the period 1988–2020 Norwegian vessels have reported 70-80% of the total landings. Small bycatches of tusk were also taken in 6.b by trawlers in the haddock fishery. Since January 2007 parts of the Rockall Bank have been closed to fishing which were the traditional areas fished by the Norwegian longline fleet.

The Norwegian longline fishery

The Norwegian longline fleet increased from 36 in 1977 to a peak of 72 in 2000, and afterwards the number decreased and then stabilized around 25-27 since 2014. The number of vessels declined mainly because of changes in the law concerning the quotas for cod. The total number of days the fleet has been fishing in area 6.b per year was a maximun of 464 fishing days in 2002 to 60 days in 2020 (Figure 5.4.1)..

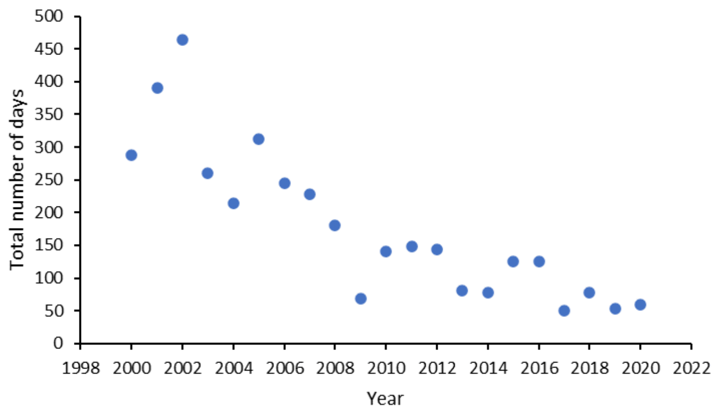


Figure 5.4.1. Estimated total number of days the Norwegian longline fleet fished for tusk (bycatch) during the period 2000 to 2020 based on logbooks.

5.4.2 Landings trends

Landing statistics by nation in the period 1988–2020 are in Table 5.4.1.

Landings varied considerably between 1988 and 2000; peaked at 2344 t in 2000, and since 2000 were low with a declining trend. In 2014 the catch was 38 tons, an all-time low during this period, while in 2015 the total catch increased to 226 tons, in 2020 the landings decreased to 91 tons (Figure 5.4.1).

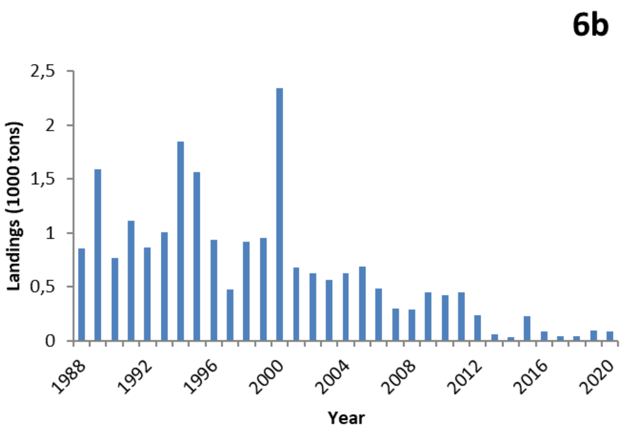


Figure 5.4.1. The international total landings of tusk from Subarea 6.b.

5.4.3 ICES Advice

Advice for 2021 to 2022: ICES advises that when the precautionary approach is applied, catches should be no more than 280 tonnes in each of the years 2021 and 2022

5.4.4 Management

Apart from the closed areas, there are no management measures that apply exclusively to 6.b.

Norway, which also has a licensing scheme, had a catch allocation in EU waters (Subareas 5, 6 and 8 There are ongoing negotiations between EU, UK and Norway and The TACs for 2021 are, therefore, not available. NEAFC recommended in 2009 that the effort in the NEAFC regulatory area shall not exceed 65 percent of the highest effort level of the deep fishing levels in previous years.

5.4.5 Data available

5.4.5.1 Landings and discards

Landings were available for all relevant countries. An overview over landings and discards are shown in Table 5.4.2.

Table 5.4.2. Landings, discards, total catch and percentage discards of the total catch of tusk in 6.b.

Year	Landings	Discards	Total catches	% discards
2016	90	7	97	7
2017	47	14	61	23
2018	47	21	68	31
2019	100	12	112	11
2020	91	24	116	21

5.4.5.2 Length compositions

The length distributions of tusk based on data provided by the Norwegian reference fleet for the period 2002–2017 are in Figures 5.4.3 and 5.4.4. The average length during this period fluctuated without any obvious trends (no data are available for 2004, 2011, 2014, 2017 to 2020).

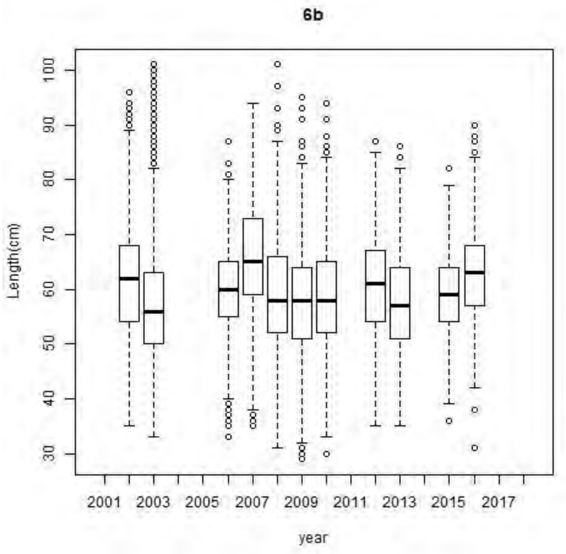


Figure 5.4.3. The length distribution of tusk based on data provided by the Norwegian reference fleet for 2002–2016 (no data are available for 2004, 2011, 2014 and 2017–2020).

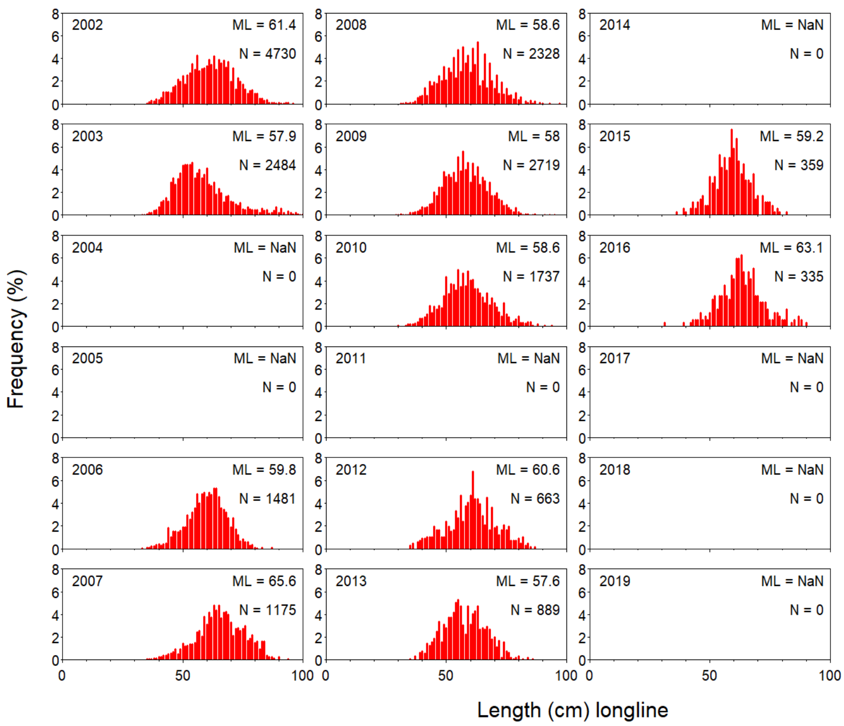


Figure 5.4.4. The length distribution of tusk based on data provided by the Norwegian reference fleet for 2002–2016 (no data are available for 2004, 2005, 2011, 2014, 2017–2020).

5.4.5.3 Age compositions

No new age composition data were available.

5.4.5.4 Weight-at-age

No new data were presented.

5.4.5.5 Maturity and natural mortality

No new data were presented.

5.4.5.6 Catch, effort and research vessel data

Norway began in 2003 collecting and entering data from official logbooks into an electronic database, and data are now available for 2000–2020. Vessels were selected that had a total landed catch of ling, tusk and blue ling exceeding 8 t in each year. The logbooks contain records of the daily catch, date, position, and number of hooks used per day.

5.4.6 Data analyses

No analytical assessments were carried out.

Norwegian longline cpue

The CPUE series based on the Norwegian longliners show a decrease from 2000 to 2007. After this the CPUE had been at a low but stable level. (Figure 5.4.5).

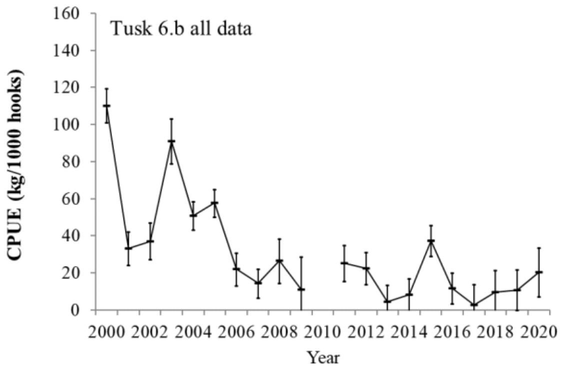


Figure 5.4.5. Estimated cpue (kg/1000 hooks) series for tusk in Subarea 6.b based on skipper's logbooks (during the period 2000–2020). The bars denote the 95% confidence intervals.

5.4.6.1 Biological reference points

No new data were presented.

5.4.7 Comments on the assessment

There are no assessments for tusk in this area.

5.4.8 Management considerations

The landings since 2001 have been low with a decreasing trend. With the exception of 2015, the landings have been very low since 2013. The decreasing size of the fleet was caused by several factors including; closed areas, increasing fuel costs and larger quotas of Arcto Norwegian cod.

The total number of days the fleet were fishing in area 6.b per year has decreased from a maximun of 464 fishing days in 2002 to 60 days in 2020 (Figure 5.4.1). When all available data are combined, the cpue series also shows a decreasing trend until 2007 after this it has been at a stable but low level.

The main fishing grounds traditionally exploited by the Norwegian fleet in 6.b were closed to bottom contacting gears in 2007 and this may be the reason for the low estimates of cpue.

As always, it should be emphasized that commercial catch data are typically observational data; that is, there were no scientific controls on how or from where the data were collected. Therefore, it is not known with certainty if the tusk cpue series tracks the population and/or how accurate the measures of uncertainty associated with the series are (see, for example, Rosenbaum, 2002). Consequently, one must usually hope and pray that a cpue series, which is based only on commercial catch data, truly tracks abundance.

In general, any assessment method based only on commercial catch data needs to be applied with caution. The reason that assessments using only commercial data are problematic is because the relation between the commercial catch and the actual population is normally unknown and probably varies from year to year.

5.4.9 Application of MSY proxy reference points

Length-based indicator method (LBI)

There is not enough length data or other biological data to apply this indicator LBI. Background data for L_{mat} are not available for the Rockall area and have been earlier “borrowed” parameters based on the Faroese data. The tusk on Rockall are genetically different from the tusk in neighbouring areas (Knutsen *et al*. 2009), and it is very likely that values like L_{mat} also are different from other areas. Until these values have been established for area 6.b, the method and results must be evaluated accordingly. No new length data or other biological data are available for 2020.

5.4.10 References

Helle, K., M. Pennington, N-R. Hareide and I. Fossen. 2015. Selecting a subset of the commercial catch data for estimating catch per unit of effort series for Ling (*Molva molva* L.). Fisheries Research 165: 115–120.

Helle, K. and Pennington, M. 2021. The development of the Norwegian longline fleet’s fishery for ling and tusk during the period 2000-2020. Working Document to the ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).21 pp.

Knutsen, H., Jorde, P. E., Sannæs, H., Hoelzel, A. R., Bergstad, O. A., Stefanni, S., Johansen, T., et al. 2009. Bathymetric barriers promoting genetic structure in the deepwater demersal fish tusk Brosme brosme. Molecular Ecology, 18: 3151 –3162.

Pennington, M., and Strømme, T. (1998). Surveys as a research tool for managing dynamic stocks. Fisheries Research 37, 97–106.Rosenbaum, P.R.2002. Observational Studies (second ed.), Springer-Verlag, New York, NY (2002) (377 pp.)

Rosenbaum, P.R. 2002. Observational Studies (second ed.), Springer-Verlag, New York, NY (2002) (377 pp.)

Table 5.4.1. Tusk 6.b. WG estimate of landings.

Year	Faroes	France	Germany	Ireland	Iceland	Norway	E & W	N.I.	Scot.	Russia	Total
1988	217		-	-		601	8	-	34		860
1989	41	1	-	-		1537	2	-	12		1593
1990	6	3	-	-		738	2	+	19		768
1991	-	7	+	5		1068	3	-	25		1108
1992	63	2	+	5		763	3	1	30		867
1993	12	3	+	32		899	3	+	54		1003
1994	70	1	+	30		1673	6	-	66		1846
1995	79	1	+	33		1415	1		35		1564
1996	0	1		30		836	3		69		939
1997	1	1		23		359	2		90		476
1998		1		24	18	630	9		233		915
1999				26	-	591	5		331		953
2000		2		22		1933	14		372	1	2344
2001	1	1		31		476	10		157	6	681
2002		8		3		515	8		88		622
2003		7		18		452	11		72	1	561
2004		9		1		508	4		45	60	627
2005		5		9		503	5		33	137	692
2006	10	1		16		431	2		25	2	487
2007	4	0		8		231	1		30	25	299
2008	41	0		2		190	0		16	44	293
2009	70			4		358			17	3	452
2010	57			1		348			13		419
2011	3					433			14		450
2012	15					209			9		233
2013		1				46			11		57
2014	6					26			6		38
2015	1					218	7		7		226
2016				1		80			9		90

Year	Faroes	France	Germany	Ireland	Iceland	Norway	E & W	N.I.	Scot.	Russia	Total
2017				2		37			8		47
2018				2		35			10		47
2019				9		70			21		100
2020*				9		51			31		91

*Preliminary.

Table 5.4.1. (Continued).

Tusk, total landings in Subarea 6.b.

Year	6.b	All areas
1988	860	860
1989	1593	1593
1990	768	768
1991	1108	1108
1992	867	867
1993	1003	1003
1994	1846	1846
1995	1564	1564
1996	939	939
1997	476	476
1998	915	915
1999	953	953
2000	2344	2344
2001	681	681
2002	622	622
2003	561	561
2004	627	627
2005	692	692
2006	487	487
2007	299	299
2008	293	293

Year	6.b	All areas
2009	452	469
2010	419	419
2011	450	450
2012	233	233
2013	57	57
2014	38	38
2015	226	226
2016	90	90
2017	47	47
2018	47	47
2019	100	100
2020	91	91

***Preliminary.**

5.5 Tusk (*Brosme brosme*) in Subareas 1 and 2

5.5.1 The fishery

Tusk are primarily bycatch in the ling and cod fisheries in Subareas 1 and 2. Currently the major fisheries in Subareas 1 and 2 are the Norwegian longline and gillnet fisheries, but there are also bycatches by other gears, e.g. trawls and handlines. The total Norwegian landings are usually around 85% from longlines, 10% from gillnets and the remainder by other gears. For other nations, tusk is bycatch in trawl and longline fisheries.

Figure 5.5.1 shows the spatial distribution of the total catch by the Norwegian longline fishery from 2013 to 2020. The Norwegian longline fleet (vessels larger than 21 m) increased from 36 in 1977 to a peak of 72 in 2000, and afterwards the number decreased to 26 in 2018. However, the number of vessels have increased to 30 in 2020. The number of vessels declined mainly because of changes in the law concerning the quotas for cod.

The average number of days that the longliners operated in ICES Subareas 1 and 2 has declined since the peak in 2011. During the period 1974 to 2018 the total number of hooks per year has varied considerably, but with a downward trend since 2002 (For more information see Helle and Pennington, WD 2021).

Since the total number of hooks per year takes into account the number of vessels, the number of hooks per day, and the number of days each vessel participated in the fishery, it follows that it may be a suitable measure of changes in applied effort. Based on this gauge, it appears that the average effort for the years 2011–2020 is 40% less than the average effort during the years 2000–2003. It should be noted that the annual fishery covers the entire distribution of tusk in Subareas 1 and 2 (see Figure 5.5.1), so that the catch produced by the applied effort is likely proportional to the actual population.

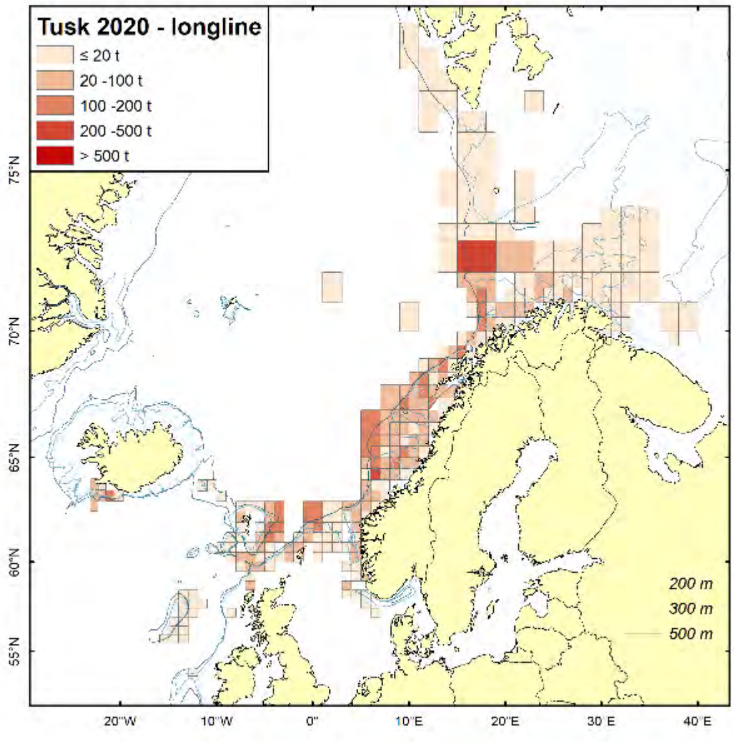


Figure 5. 5.1. Distribution of catches for the Norwegian longline fishery in Subareas 1 and 2 in 2013 to 2020.

5.5.2 Landings trends

Landing statistics by nation from 1988 to 2020 are given in Table 5.5.1a–d. Landings declined from 1989 to 2005, afterwards the landings increased and varied around 10.000 t. (Figures 5.5.2 and 5.5.3). The preliminary landings for 2020 are 9 122t.

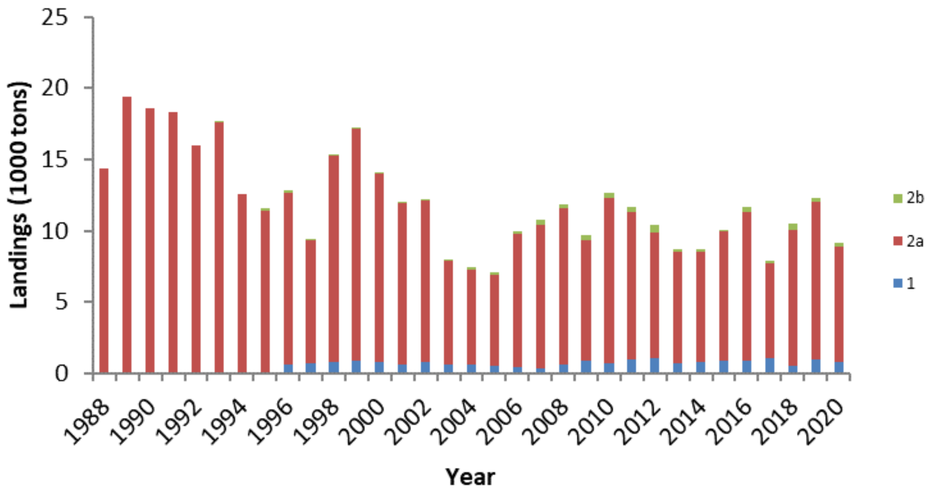


Figure 5.5.2. Total yearly landings of tusk in Areas 1 and 2 for 1988–2020.

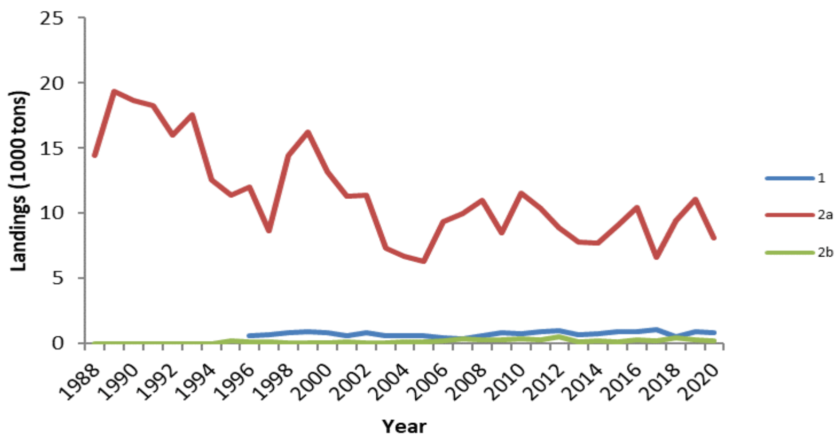


Figure 5.5.3. Total yearly landings of tusk in Areas 1 and 2 for 1988–2020.

5.5.3 ICES Advice

ICES advises that when the precautionary approach is applied, catches should be no more than 11 077 tonnes in each of the years 2020 and 2021. All catches are assumed to be landed.

5.5.4 Management

There is no quota for the Norwegian fishery for tusk, but the vessels participating in the directed fishery for ling and tusk in Subareas 1 and 2 are required to have a licence for tusk. There is no minimum landing length in the Norwegian EEZ.

There are ongoing negotiations between EU, UK and Norway and the TACs are therefore not available.

5.5.5 Data available

5.5.5.1 Landings and discards

The amount landed is available for all the relevant fleets. The Norwegian fleets are not regulated by TACs, and there is a ban on discarding. The incentive for illegal discarding is believed to be small. No discards were reported in 2020. The landings statistics are regarded as being adequate for assessment purposes.

5.5.5.2 Length compositions

Figures 5.5.4 and 5.5.5 show the length distributions and Figure 5.5.6 shows the length–weight relationship for tusk based on data provided by the Norwegian reference fleet for the period 2001–2020.

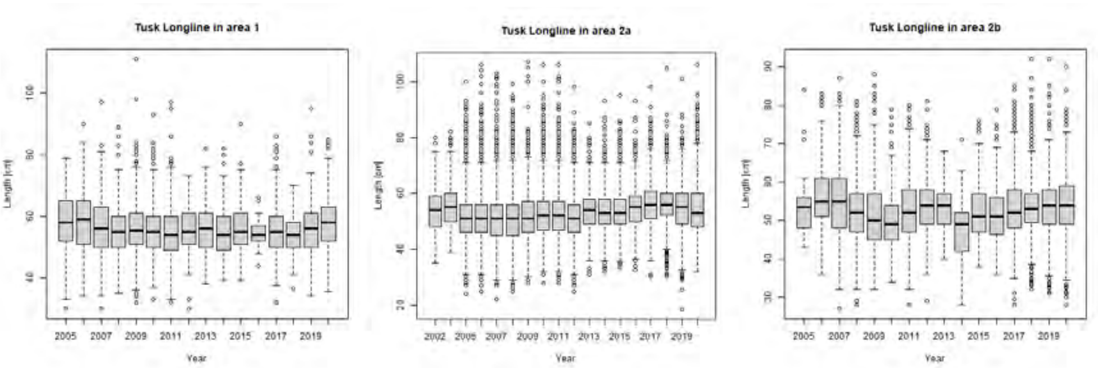
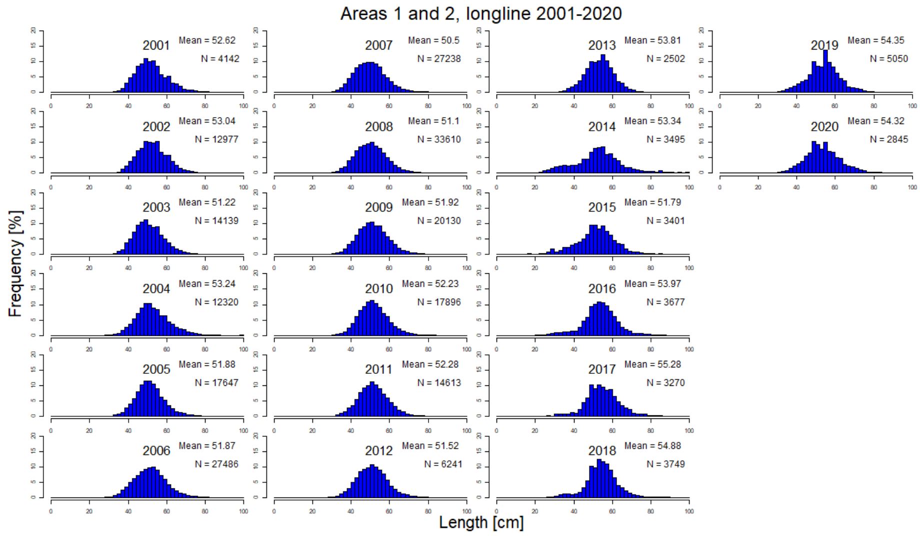


Figure 5.5.4. Box and whisker plots showing the length distribution of tusk. The data were provided by the Norwegian reference fleet for the period 2001–2020.



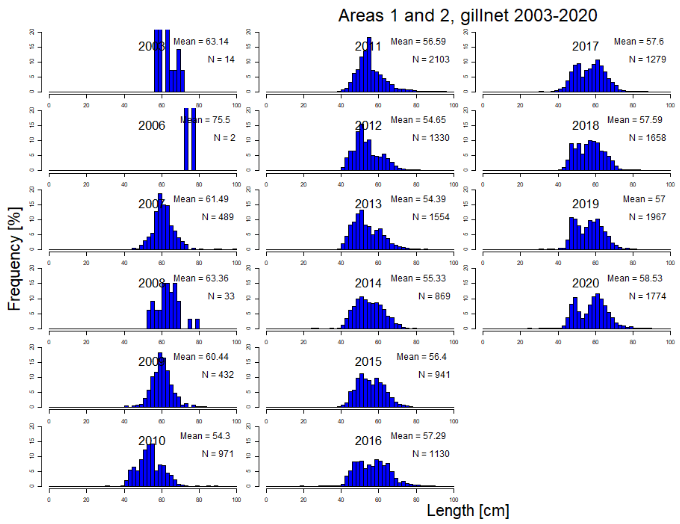


Figure 5.5.5. The estimated length distributions of the catch of tusk by Norwegian longliners and gillnetters combined for the Areas 1, 2.a and 2.b.

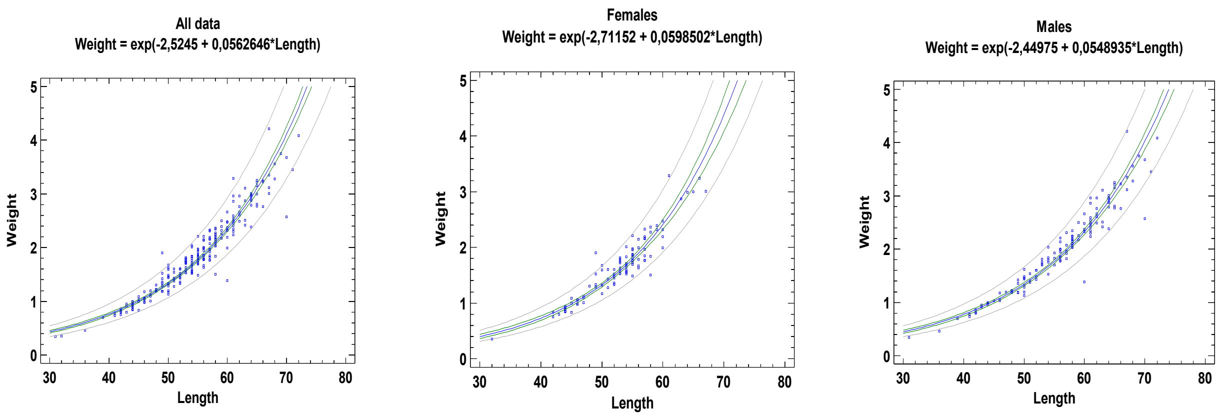


Figure 5.5.6. Length–weight relationship for tusk.

5.5.5.3 Age compositions

No new data are available.

5.5.5.4 Maturity and natural mortality

Maturity ogives for tusk are in Figure 5.5.9 and in the Table below. There were insufficient age data to determine A_{50}.

Maturity parameters:

Stock	L_{50}	N	A_{50}	N	Source
Usk-arct	56.3	2616			Norwegian long liners (Reference fleet) and survey data

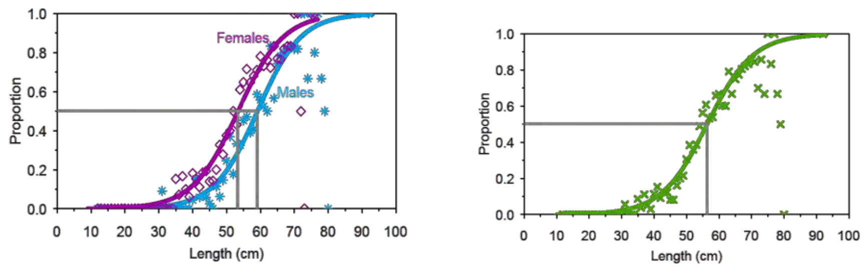


Figure 5.5.7. Tusk Area 1 and 2, Maturity ogive on length for males and females, and all data combined.

5.5.5.5 Catch, effort and research vessel data

Norway began in 2003 to collect and enter data from official logbooks into an electronic database, and these data are now available for the period 2000–2020. Vessels were selected that had a total landed catch of ling, tusk and blue ling exceeding 8 t each year. The logbooks contain records of the daily catch, date, position, and number of hooks used per day.

The method for estimating cpue for tusk is given in Helle *et al*., 2015. An analysis based on these data is in the WD Helle and Pennington, 2021. Two cpue series, one based on all data and one when tusk was targeted were presented (Figure 5.5.8). No research vessel data are available.

5.5.6 Data analyses

Length distribution

In Figures 5.5.4 and 5.5.5 are plots of the length distributions in Area 1 and 2 for 2001 to 2020. It appears that the mean length in Area 1 has varied slightly, while the mean length in Areas 2a and 2b has been very stable. The average length is slightly higher in the gillnet fishery than in the longline fishery. In 2020 the average length was 54.3 cm in the longline fishery and 58.5 cm in the gillnet fishery

Assessment

No analytical assessments were possible due to lack of age-structured data and/or tuning series.

CPUE

Two standardized GLM-based cpue series using all the data and based only when tusk made up more than 30% of the catches are in Figure 5.5.9. Both cpue series have been relative stable since 2011, but with a declining trend the last three years for the targeted fishery (Figure 5.5.8).

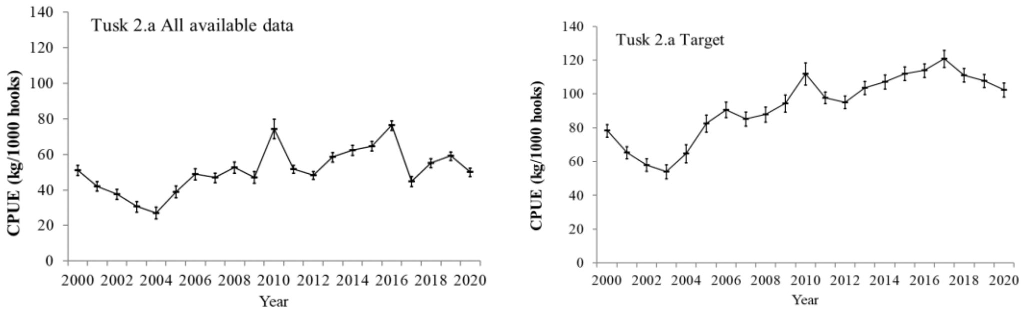


Figure 5.5.8. Estimates of cpue (kg/1000 hooks) of tusk based on skipper's logbook data for 2000–2020. The bars denote the 95% confidence interval.

Biological reference points

No traditional biological reference points are established for tusk. Life history parameters are in Table 5.5.2.

5.5.7 Comments on the assessment

It appears more likely that the cpue series for tusk based only on data from the targeted fishery reflects the population trends than does the series based on all the catch data.

5.5.8 Management considerations

The fishing pressure on tusk has decreased considerably. The number of longline vessels fishing for tusk has decreased by about 65 percent from 2000 to 2018, but with a sharp increase in 2019.

The cod stock in the Barents Sea was very abundant for many years, but now there is a downward trend resulting in lower quotas. Because of lower quotas for cod the fishing pressure on tusk has increased considerably.

As always, it should be emphasized that commercial catch data are observational data; that is, there were no scientific controls on how or from where the data were collected. Therefore, it is not known with certainty if the tusk cpue series tracks the population and/or how accurate the measures of uncertainty associated with the series are (see, for example, Rosenbaum, 2002). Consequently, one must usually hope and pray that a cpue series, which is based only on commercial catch data, truly tracks abundance.

An infamous example of a misleading cpue series based on commercial data was a cpue series for Newfoundland cod that incorrectly indicated that the abundance of the cod stock was increasing greatly. Advice based on this cpue series ultimately caused the collapse of the stock (see, e.g. Pennington and Strømme, 1998).

In general, any assessment method based only on commercial catch data needs to be applied with caution. The reason that assessments using only commercial data are problematic is because the relation between the commercial catch and the actual population is normally unknown and probably varies from year to year.

5.5.9 Application of MSY proxy reference points

Summary of SPiCT from benchmark meeting; for tusk in Subareas 1 and 2

It was not possible for the group to recommend or approve a SPiCT assessment for this stock. The reason for this was primarily the construction of the CPUE index; the CPUE index itself was not disregarded but it was not regarded suitable for the SPiCT model. Two points were pointed out as problematic; the targeting effect and technological creep. Especially handling the targeting effect; the spatial-time interactions must be solved before data can be used by SPiCT.

The recommendations from the benchmark were to enhance the standardization of the CPUE and either try an integrated model or try SPiCT again with the new CPUE. The stock should continue to be assessed as category 3 stock.

Input data for tusk arctic was the landings time series with historical landings back to 1908-2020. The abundance index was the CPUE index from the longline fishery from 2000-2020. Two variants of the CPUE index were used; one with all catches and one with only catches with more than 30% tusk.

The model was run with priors on initial depletion level and on the shape of the production curve.

The catch series is almost stable at the end of the series; this together with the very steep increase in the 30% CPUE made the CPUE to drive the model. The increase in all catches CPUE is not as pronounced as the targeted CPUE and that is probably why the model fits better to this scenario.

The very steep increase in CPUE over the short time period is problematic as the model estimate the stock to be 2–4 times BMSY and to have F below FMSY. The very high r (0,3–1,0) seems to be unrealistic as the expected value for r should be 0.12 for tusk (SPMpriors from Fish-Life). The very long catch time series (with low and high catches) and the short CPUE time series by the end of the catch time series period probably entails alternative states that are hidden to current SPiCT runs.

Stock status assessed by SPiCT indicated that B was above BMSY and F below FMSY. Other models were tried that came to contradictory conclusions. The development on B and F from SPiCT were to the assessors not totally unrealistic as the result plots to some extent resembled the history of the fishery and the believed present stock status for tusk in this area. The problem is that F probably was higher in the 1970–1980s than the model estimate. Together with the increase in CPUE this probably makes the results from the SPiCT model to be too optimistic.

The assessments on SPiCT could not be approved according to the uncertainty in the CPUE index and due to the observed inconsistencies described above. Link to the benchmark report: https://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=37488

Results for the LBI, WGDEEP 2021

Information and data

The input parameters and the catch's length distribution for the period 2001-2020 are in the following tables and figures. The length data used in the LBI model are from the Norwegian longliner fleet. The length data are not raised to total catch.

Table 5.5.2 Tusk in arctic waters (1, 2.a, 2.b). Input parameters for LBI.

Data type	Years/Value	Source	Notes
Length frequency distribution	2001-2020	Norwegian long-liners (Reference fleet)	
Length-weight relationship	0.0106* length $^{3.0168}$	Norwegian long-liners (Reference fleet) and survey data.	combined sex
L_{MAT}	56 cm	Norwegian long-liners (Reference fleet) and survey data.	
L_{inf}	119 cm (L_{max})	Norwegian long-liners (Reference fleet) and survey data.	

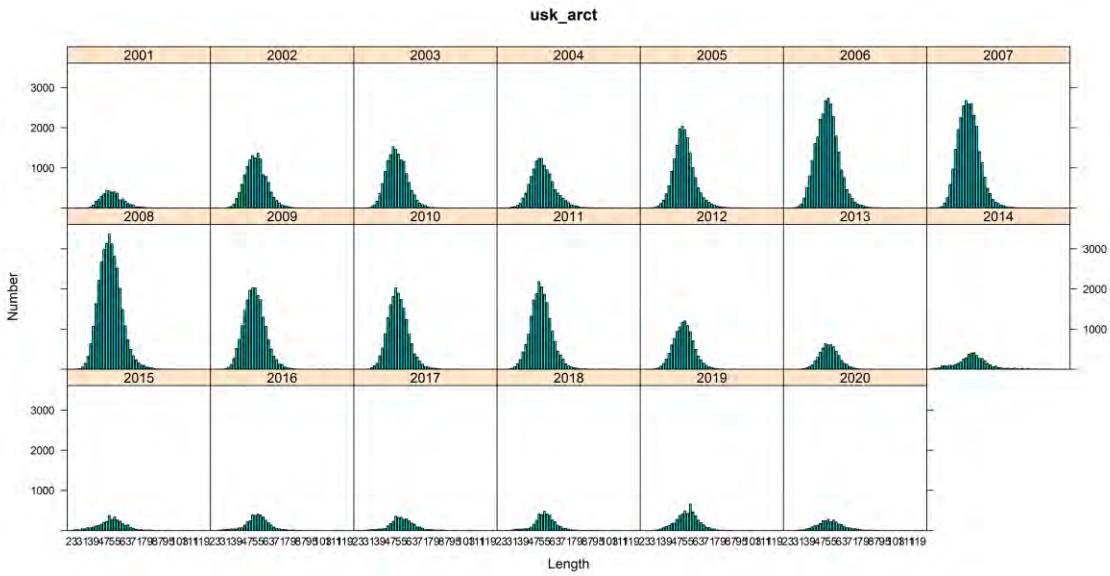


Figure 5.5.9 Tusk in arctic waters (1, 2a, 2b). The length distribution (2 cm length bins) based on data from the Norwegian longline fleet for the period 2001–2020 (sex combined).

Outputs

The length indicator ratios for combined sexes were examined for three scenarios: (a) Conservation, (b) Optimal yield, and (c) maximum sustainable yield are presented in the following figures.

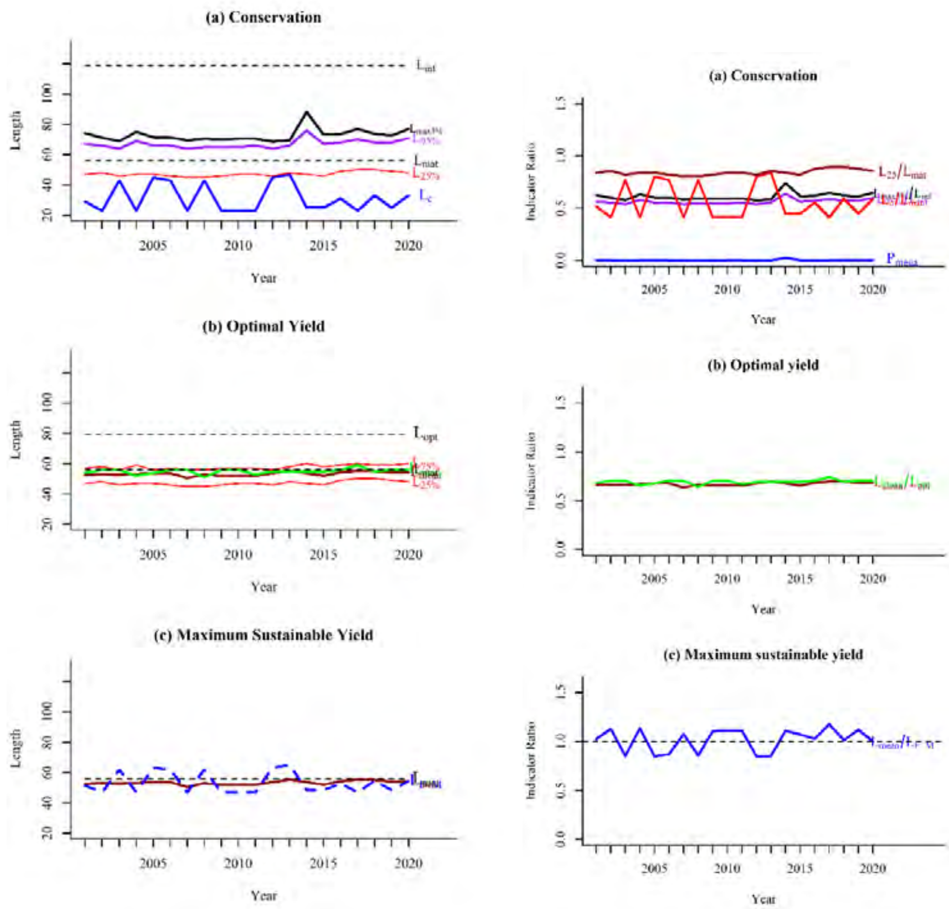


Figure 5.5.10 Tusk in arctic waters (1, 2.a, 2.b). Using length indicators ratios for sex combined to examine three scenarios: (a) Conservation, (b) Optimal yield, and (c) maximum sustainable yield.

<u>Analysis of results</u>

The conservation model for immature tusk shows that both L_c/L_{mat} and $L_{25\%}/L_{mat}$ are less than one, but $L_{25\%}/L_{mat}$ is still usually greater than 0.8 (Figure 6.510, Table 6.5.3). Regarding the sensitivity of L_{mat}, there appears to be little or no overfishing of immature individuals.

The conservation model for large individuals estimates that the indicator ratio, $L_{max5\%}/L_{inf}$ is between 0.61 and 0.65 in 2018-2020 (Table 6.5.10), which is less than the cut-off point.0.8. Since the VBF results gave an unusual low L_{inf}, the value used in the model was L_{max}. This could be the reason that the indicator ratio is less than 0.8. If we had used a smaller L_{inf} - the indicator ratio would be higher. Since tusk is a slow growing, deep-water species, the P_{mega} and L_{mean}/L_{opt} values are unreliably.

The MSY indicator ($L_{mean}/L_{F=M}$) is greater than 1 for almost the whole period (Figure 4.3.10), which indicates that tusk in arctic waters are fished sustainably. Regarding model sensitivity, the MSY value was always greater than 0.90.

Conclusion: The overall perception of the stock during the period 2018–2020 is that tusk in arctic waters seems to be fished sustainably (Table 6.5.3). However, the results are very sensitive to the assumed values of L_{mat} and L_{inf}.

Table 5.5.3 Tusk in arctic waters (1, 2.a, 2.b). The results from the LBI method

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/$L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2018	0,59	0,89	0,62	0 %	0,70	1,01
2019	0,45	0,88	0,61	0 %	0,68	1,12
2020	0,59	0,86	0,65	0 %	0,69	1,00

Table 5.5.4 Tusk in arctic waters (1, 2.a, 2.b). Stock status inferred from LBI for MSY. Green tick marks for MSY are provided because the $L_{mean}/L_{F=M}$ > 1 in each year. Stock size is unknown as this method only provides exploitation status.

Fishing pressure				
	2017	2018	2019	
MSY (F/F_{MSY})	✓	✓	✓	Fished sustainably
Stock size				
	2016	2017	2018	
MSY $B_{trigger}$.(B/B_{MSY})	?	?	?	Unknown

5.5.10 References

Helle, K., M. Pennington, N-R. Hareide and I. Fossen. 2015. Selecting a subset of the commercial catch data for estimating catch per unit of effort series for Ling (*Molva molva* L.). Fisheries Research 165: 115–120.

Helle, K. and Pennington, M. 2021. The development of the Norwegian longline fleet's fishery for ling and tusk during the period 2000-2020. Working Document to the ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).21 pp

Pennington, M., and Strømme, T. (1998). Surveys as a research tool for managing dynamic stocks. Fisheries Research 37, 97–106.Rosenbaum, P.R.2002. Observational Studies (second ed.), Springer-Verlag, New York, NY (2002) (377 pp.)

Rosenbaum, P.R. 2002. Observational Studies (second ed.), Springer-Verlag, New York, NY (2002) (377 pp.)

https://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=37488

5.5.11 Tables

Table 5.5.1 a. Tusk in subarea 1. Official landings.

Year	Norway	Russia	Faroes	Iceland	Ireland	France	Total
1996	587						587
1997	665						665
1998	805						805
1999	907						907
2000	738	43	1	16			798
2001	595	6		13			614
2002	791	8	n/a	0			799
2003	571	5			5		581
2004	620	2			1		623
2005	562						562
2006	442	4					446
2007	355	2					357
2008	627	7					634
2009	869	1					870
2010	725	1				1	727
2011	941						941
2012	1024						1024
2013	692						692
2014	766	5					771
2015	904						904
2016	890	2					892
2017	1036	1					1037
2018	555	2					557
2019	944	1		1			946
2020*	813	4					817

*Preliminary.

Table 5.5.1 b. Tusk in Division 2.a. Official landings.

Year	Faroes	France	Germany	Greenland	Nor-way	E & W	Scotland	Russia	Ireland	Iceland	Total
1988	115	32	13	-	14 241	2	-				14 403
1989	75	55	10	-	19 206	4	-				19 350
1990	153	63	13	-	18 387	12	+				18 628
1991	38	32	6	-	18 227	3	+				18 306
1992	33	21	2	-	15 908	10	-				15 974
1993	-	23	2	11	17 545	3	+				17 584
1994	281	14	2	-	12 266	3	-				12 566
1995	77	16	3	20	11 271	1					11 388
1996	0	12	5		12 029	1					12 047
1997	1	21	1		8642	2	+				8667
1998		9	1		14 463	1	1	-			14 475
1999		7	+		16 213		2	28			16 250
2000		8	1		13 120	3	2	58			13 192
2001	11	15	+		11 200	1	3	66	5		11 301
2002		3			11 303	1	4	39	5		11 355
2003	6	2			7284		3	21			7316
2004	12	2			6607		1	61	1		6684
2005	29	6			6249			37	3		6324
2006	33	9			9246	1		51	11		9351
2007	54	7			9856	0	5	85	12		10 019
2008	52	6			10 848	1	3	56	0		10 966
2009	59	3			8354		1	82			8499
2010	39	6			11 445		1	49			11 540
2011	59	5			10 290		1	41			10 405
2012	54	7	1		8764	2		48		1	8877
2013	24	13	3		7729		7	52		2	7830
2014	10	9	1		7682		7	38			7743
2015	19	5			8906	1		90			9021

Year	Faroes	France	Germany	Greenland	Nor-way	E & W	Scotland	Russia	Ireland	Iceland	Total
2016	61	2	1	2	10332		1	57		3	10459
2017	14	4	2	3	6521		2	106		3	6655
2018	12	2	5	1	8651		1	63		731	9466
2019	13	3	3		10980			70		1	11070
2020*	18	1	1	1	7964			92		2	8079

***Preliminary.**

(1) Includes 2.b.

Table 5.5.1 c. Tusk in Division 2.b. Official landings.

Year	Norway	E & W	Russia	Ireland	France	Total
1988		-				0
1989		-				0
1990		-				0
1991		-				0
1992		-				0
1993		1				1
1994		-				0
1995	229	-				229
1996	161					161
1997	92	2				94
1998	73	+	-			73
1999	26		4			26
2000	15	-	3			18
2001	141	-	5			146
2002	30	-	7			37
2003	43					43
2004	114		5			119
2005	148		16			164
2006	168		23			191
2007	350		17	1		368

Year	Norway	E & W	Russia	Ireland	France	Total
2008	271		11	0		282
2009	249		39			288
2010	334		57			391
2011	299		20		5	324
2012	453		40			493
2013	121	3	16			140
2014	185		41			226
2015	97		69			166
2016	165		144			309
2017	153		81			234
2018	427		37			464
2019	241		53			294
2020*	200		26			226

Table 5.5.1 d. Tusk in subareas 1 and 2. Official landings by Subarea and divisions.

Year	1	2a	2b	All areas
1988		14 403	0	14 403
1989		19 350	0	19 350
1990		18 628	0	18 628
1991		18 306	0	18 306
1992		15 974	0	15 974
1993		17 584	1	17 585
1994		12 566	0	12 566
1995		11 388	229	11 617
1996	587	12 047	161	12 795
1997	665	8667	94	9426
1998	805	14 475	73	15 353
1999	907	16 250	26	17 183
2000	798	13 192	18	14 008
2001	614	11 301	146	12 061

Year	1	2a	2b	All areas
2002	799	11 355	37	12 191
2003	581	7316	43	7940
2004	623	6684	119	7426
2005	562	6324	164	7050
2006	446	9351	191	9988
2007	357	10 019	368	10 744
2008	634	10 966	282	11 882
2009	870	8499	288	9657
2010	727	11 540	391	12 658
2011	941	10 386	319	11 646
2012	1024	8862	493	10 394
2013	692	7830	140	8662
2014	771	7745	226	8742
2015	904	9021	166	10 091
2016	892	10459	309	11660
2017	1037	6655	234	7926
2018	557	9466	464	10487
2019	946	11070	294	12310
2020*	817	8079	226	9122

***Preliminary.**

5.6 Tusk (*Brosme brosme*) in areas 3.a, 4, 5.b, 6.a, 7, 8, 9 and other areas of 12

5.6.1 The fishery

Tusk is bycatch in the trawl, gillnet and longline fisheries in areas 3.a, 4, 5.b, 6.a, 7, 8, 9 and 12. Norway has traditionally landed the major proportion of the landings. Around 90% of the Norwegian and Faroese landings are taken by longliners.

When landings from Areas 3–4 and 6.a–12 are pooled over the period 1988–2020, 35% of the landings have been in Area 4, 47% in Division 5.b, and 16% in Area 6.a.

In Division 5.b, tusk was mainly fished by longliners (about 90% of the catch), and the rest of the catch of tusk was taken by large trawlers. The main fishing ground for tusk are on the slope around the Faroes Plateau and on the Faroe Bank in areas deeper than approximately 200 m. The Norwegian longline fishery decreased from an average 15 days per vessel in 2019 to 11 days per vessel in 2020.

5.6.2 Landings trends

Landing statistics by nation in 1988–2020 are in Table 5.6.1 and are shown by year in Figure 5.6.1.

Figure 5.6.1. Landings of tusk per year for 1988–2020.

For all subareas/divisions, the catches were relatively stable from 2002 to 2012, afterwards the total catch declined and stabilized at about 4 500 tons. The total catch was 4 065 tons in 2020 (Figures 5.6.1 and 5.6.2).

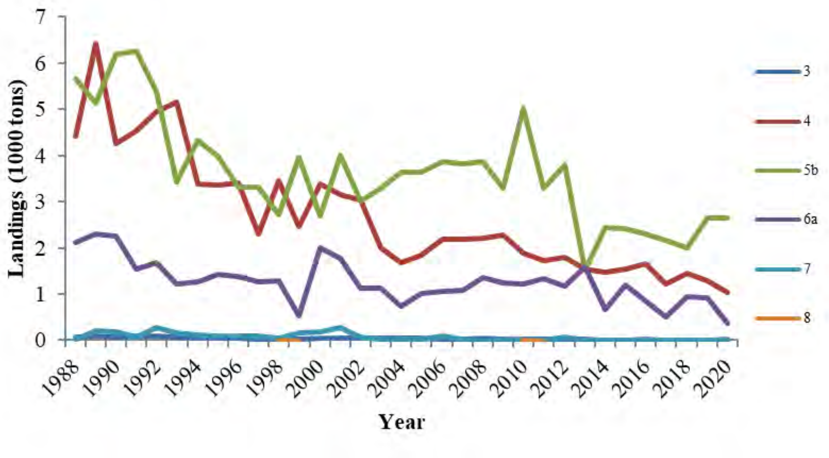


Figure 5.6.2. Landings of tusk by area for 1988–2020.

5.6.3 ICES Advice

Advice for 2020 and 2021: ICES advises that when the precautionary approach is applied, catches should be no more than 8627 tonnes in each of the years 2020 and 2021.

5.6.4 Management

There are a licensing scheme and effort limitation in Division 5.b. The minimum landing length for tusk in Division 5.b is 40 cm. Norway has a bilateral quota with Faroe Islands in 5.b, which is 2 000 t tusk for 2021.

In 2021, the Faroese Government will allow five Russian vessels to undertake experimental fishing in the Faroese Fishing Zone at depths deeper than 700 meters, provided that a Russian scientific observer is onboard. No more than three vessels can simultaneously be operating. Two of these vessels can undertake experimental fishery in deep waters around Outer Bailey and Bill Baileys Banks, at depth between 500 and 700 meters, provided that catches in this area do not exceed 500 tonnes of deep-sea species.

The quota for the EU in the Norwegian zone (Subarea 4) is set at 75 t, but only three vessels can be operating simultaneously.

EU TACs for 2015-2020 are given in table 5.6.2. *There are ongoing negotiations between EU, UK and Norway and The TACs for 2021 are, therefore, not available.

Table 5.6.2. TACs tusk in subareas 4 and 7–9, and in divisions 3.a, 5.b, 6.a. All weights are in tonnes.

Year	TAC EU Subarea 3	TAC EU Subarea 4 (EU waters)	TAC EU Subarea 4 (Norwegian waters)	TAC EU, Subareas 5,6, 7	TAC Norway2.a and 5.b,4, 6 and 7
2015	29	235	170	937	2923
2016	29	235	170	937	2923
2017	29	235	170	937	2923
2018	31	251	170	1207	2923

Year	TAC EU Subarea 3	TAC EU Subarea 4 (EU waters)	TAC EU Subarea 4 (Norwegian waters)	TAC EU, Subareas 5,6, 7	TAC Norway2.a and 5.b,4, 6 and 7
2019	31	251	170	1207	2923
2020	31	251	170	1207	2923
2021					

NEAFC recommended that in 2009 the effort in areas beyond national jurisdictions should not exceed 65% of the highest level of effort for deep-water fishing used in the past.

5.6.5 Data available

5.6.5.1 Landings and discards

The total landings and discards of tusk were available for all the relevant fleets. The Norwegian and Faroese fleet are not allowed to discard tusk, and incentives for illegal discarding are believed to be low. The landing statistics and logbooks are therefore regarded as being adequate for assessment purposes.

Discards by countries for the years 2013–2020 (Table 5.6.3), and by area and country for 2020 (Table 5.6.4).

Table 5.6.3 Total discards of tusk by country for 2013 to 2020.

	Spain	Ireland	France	UK (Scotland)	Denmark	Germany	Total landings	Total discards	Total catches	% discards
2013	40	12					4673	52	4725	1.1
2014	0	0					4585	0	4585	0.0
2015			6	12			5155	18	5173	0.3
2016			1	152			4820	153	4973	3.1
2017			8	130	5		3916	143	4059	3.5
2018	1	6	4	80		6	4411	96	4507	2.1
2019			5	63		5	4862	73	4931	1.5
2020		2		67			4065	69	4134	1.7

Table 5.6.4. Discards of tusk in 2020 by area on country.

Area	Country	Discards
27.4	UK(Scotland)	61
27.5.b.1.b	UK(Scotland)	1
27.6.a	Ireland	2

Area	Country	Discards
27.6.a	UK(Scotland)	5
Total		69

5.6.5.2 Length compositions

Norwegian reference fleet data

Figure 5.6.3a and b shows the estimated length distributions of tusk in divisions 4.b, 5.b and 6.a based on data provided by the Norwegian reference fleet for 2001–2020, and Figure 5.6.4 shows the estimated length distributions of the catch of tusk by Norwegian longliners, combined, for divisions 4.a, 5.b and 6.a.

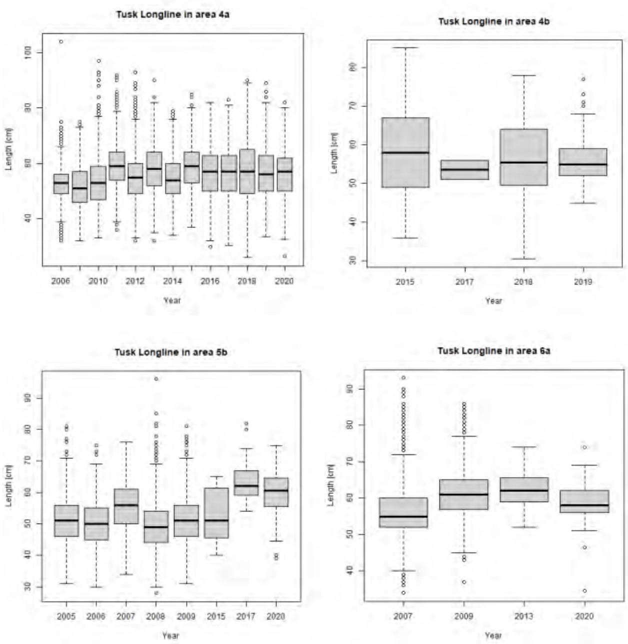


Figure 5.6.3a. Length distributions of tusk in Areas 4.a, 4.b, 5.b and 6.a for 2001–2020, based on longline data from the Norwegian reference fleet.

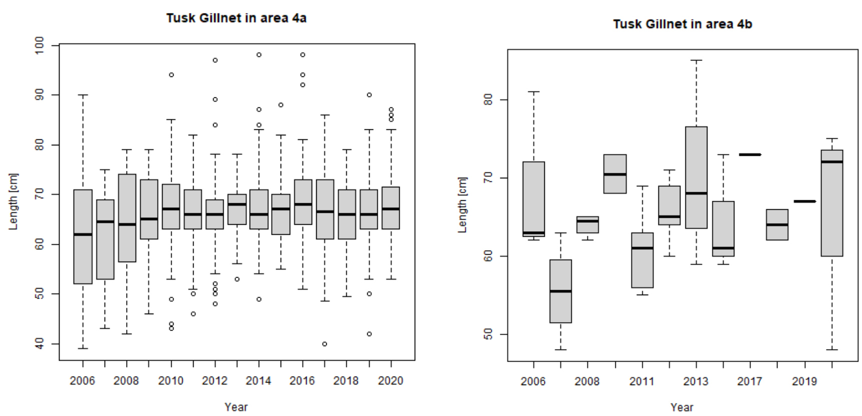


Figure 5.6.3b. Length distributions of tusk in Areas 4.a, 4.b, 5.b and 6.a for 2001–2020, based on gillnet data from the Norwegian reference fleet.

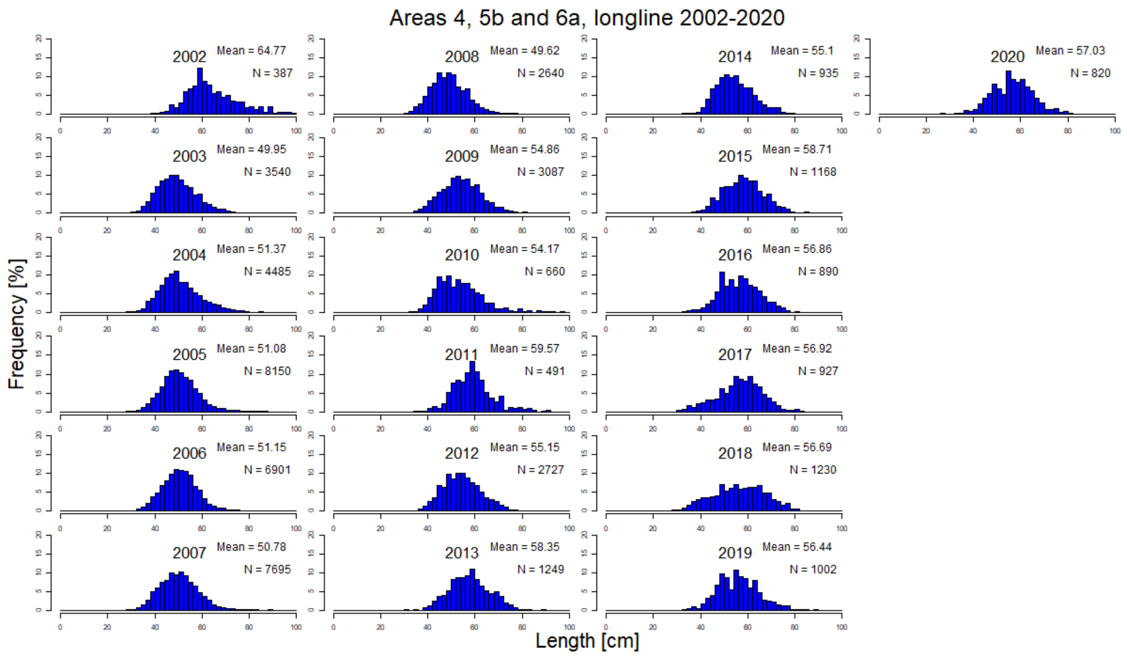


Figure 5.6.4. The estimated length distributions of the catch of tusk by Norwegian longliners, combined, for Areas 4.a, 5.b and 6.a.

Faroese length data

In Division 5.b is the length distributions of tusk based on the commercial catches by Faroese longliners since 1994 are in Figure 5.6.5.

The length data are from the annual spring- and summer groundfish surveys conducted on the Faroe Plateau are presented in Figures 5.6.6 and 5.6.7. In WGDEEP Report 2020 length distributions of tusk caught in other surveys in Division 5.b such as deep water survey (2014- present), Greenland halibut survey (1995- present), redfish trawl survey (2003-2011) and blue ling trawl survey (2000-2003) was presented.

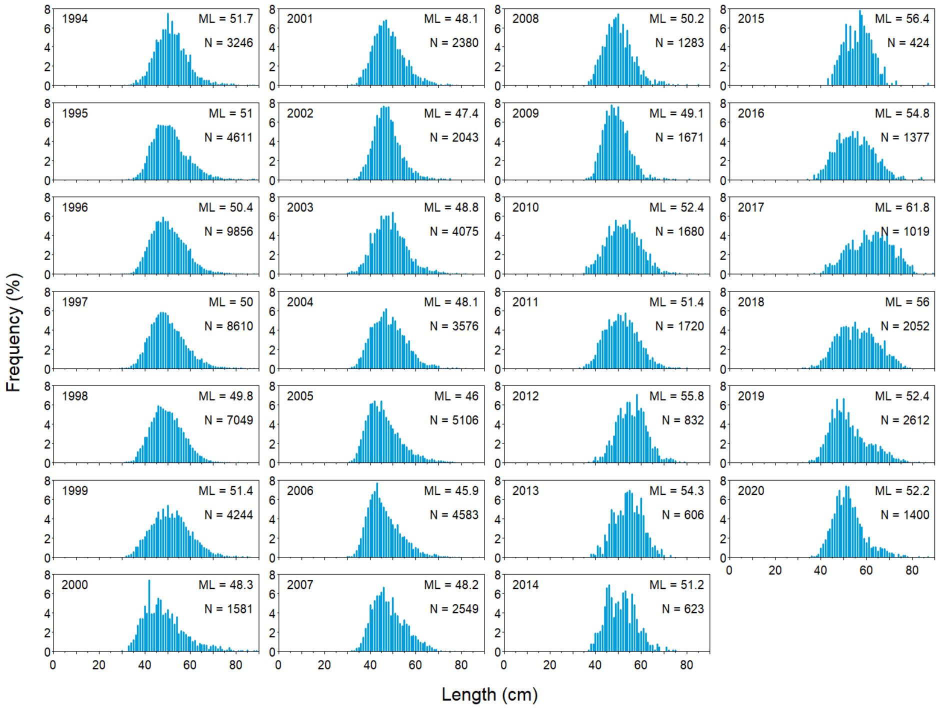


Figure 5.6.5. Length distributions of the catch of tusk by Faroese longliners (>100 BRT) in Division 5.b.

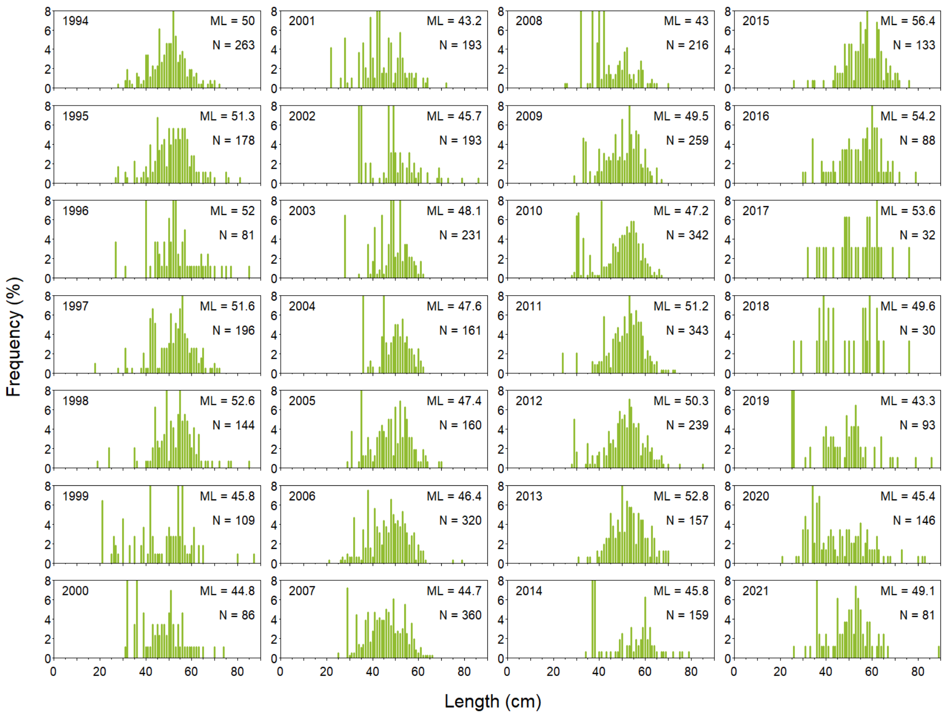


Figure 5.6.6. Length distributions of tusk in Division 5.b based on data from the Faroese spring groundfish surveys. ML-mean length, N- number of calculated length measures. Small tusk are often sampled from a subsample of the total catch, so the values are multiplied to total catch.

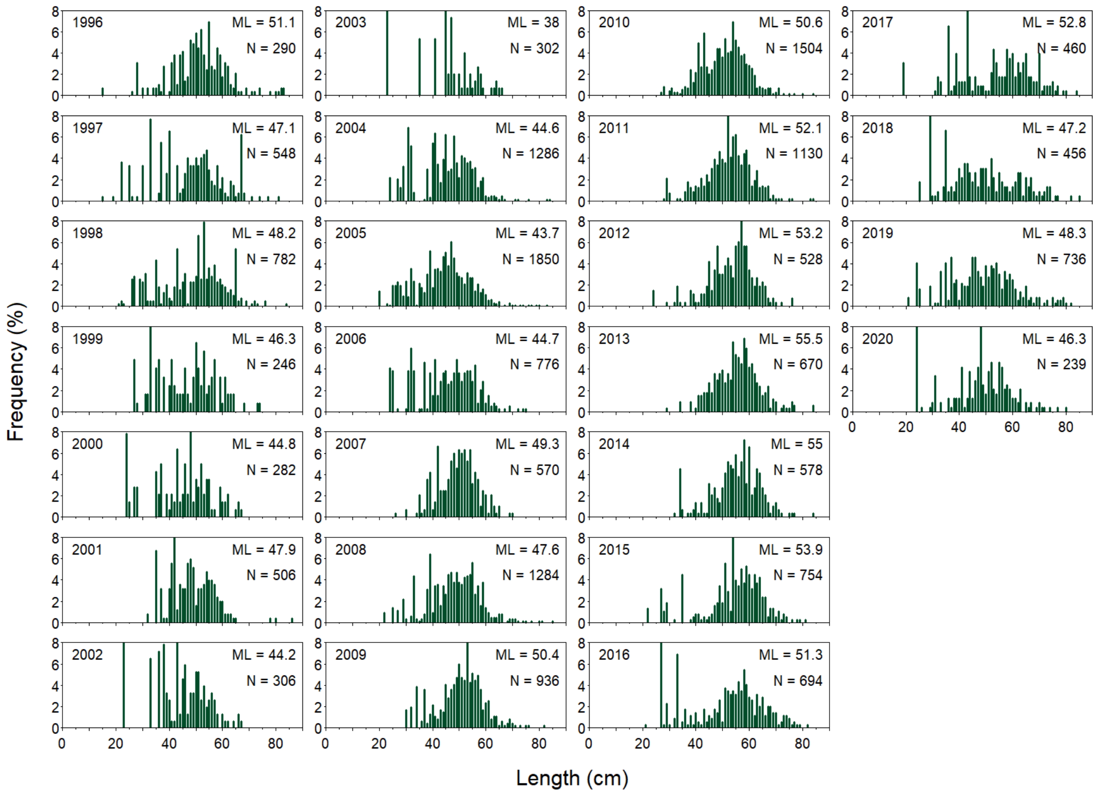


Figure 5.6.7. Length distributions of tusk in Division 5.b based on data from the Faroese summer groundfish surveys. ML-mean length, N- number of calculated length measures. Small tusk are often sampled from a subsample of the total catch, so the values are multiplied to total catch.

5.6.5.3 Age and growth compositions

No new data are available (See stock annex for current estimates).

5.6.5.4 Weight-at-age

No new data are available.

5.6.5.5 Maturity and natural mortality

No new data are available (See stock annex for current estimates).

5.6.5.6 Catch, effort and research vessel data

Commercial cpue series

Norway started in 2003 to collect and enter data from official logbooks into an electronic database, and data are now available for 2000–2020. Vessels were selected that had a total landed catch of ling, tusk and blue ling exceeding 8 t in every year. The logbooks contain records of the daily catch, date, position, and number of hooks used per day. The quality of the Norwegian logbook data is poor in 2010 due to the switch from paper to electronic logbooks. Since 2011, data quality has improved considerably and data from the entire fleet were available.

The cpue data for tusk from Norwegian longliners fishing in Division 5.b are described in the stock annex for tusk in 2.a (Section tusk in 1 and 2) and in Helle *et al.*, 2015. The cpue series was based on sets where tusk was greater than 30% of the total catch.

Fisheries independent cpue series

Estimates of the cpue series (kg/hour) for tusk are available from two annual Faroese groundfish trawl surveys on the Faroe Plateau that were designed for cod, haddock and saithe. The annual survey on the Faroe Plateau covers the main fishing areas and mainly the larger part of the spatial distributional area (Ofstad, WD WGDEEP 2017). Information on the surveys and standardization of the data are described in the stock annex.

5.6.6 Data analyses

Length distributions

Norwegian length distributions, based on data provided by the longline reference fleet from divisions 4.a, 5.b and 6.a, have varied slightly with no obvious trends (Figures 5.6.3 and 5.6.4). The average length of tusk caught by Norwegian longliners in the combined Areas 4.a, 5.b and 6.a was 56.4 cm in 2019 and 57 cm in 2020.

Faroese length distributions, based on data from Faroese longliners fishing in Division 5.b, varied mainly between 48 and 56 cm (average 51 cm), and there was no downward trend. In 2020, the mean length was 52.2 cm, the maximum was 88 cm and most of the landings were between 40 and 60 cm (Figure 5.6.5).

The mean length of tusk sampled in the Faroese spring and summer groundfish surveys varied between 43 and 55 cm (Figures 5.6.6 and 5.6.7). The length distributions are noisy, and the reason is that small tusk are often sampled in a subsample of the total catch, so the values are multiplied to total catch. Few tusks smaller than 30 cm are reported to be caught in these surveys.

Cpue trends

4.a

Two cpue series for tusk in Division 4.a based: Norwegian longline data were on all the catches and data when tusk appeared to be the target species. The series based on all the catches indicates at first a stable cpue and then a slightly decreasing trend for the last four years. The series based on the targeted fishery shows a clear and positive upward trend from 2002 until 2013, after 2013 there was a declining trend, this trend is especially clear for the targeted fishery (Figure 5.6.8).

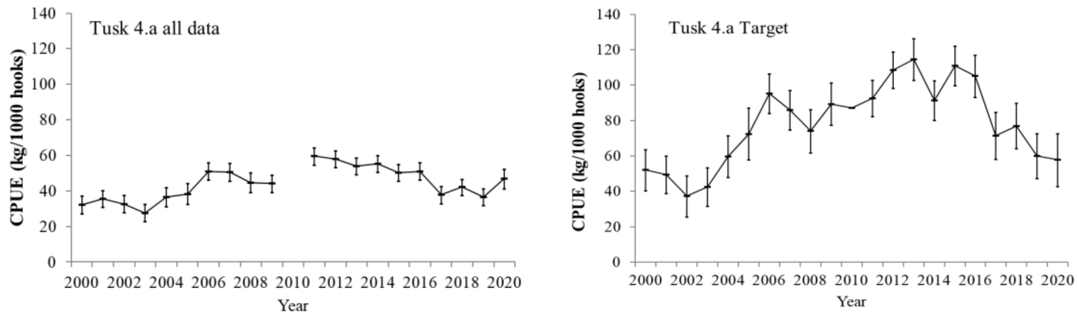


Figure 5.6.8. Tusk cpue series in 4.a for 2000–2020 based on all available data and when tusk appeared to be targeted. The bars denote the 95% confidence intervals.

5.b

The standardized cpue from the annual Faroese groundfish surveys in spring (1994-present) and summer (1996-present) are in Figure 5.6.9. In addition, a CPUE series for the spring survey, 1983-

1993, based on non-stratified data, are in Figure 5.6.9. The cpue series for the annual groundfish surveys show a downward trend during the last years. These surveys are only conducted in waters less than 530 m, so these estimates are not covering the whole distribution area of tusk.

Abundance indices for tusk < 40 cm, generated by the Faroese groundfish survey on the Plateau, are around mean level in the last years (Figure 5.6.10).

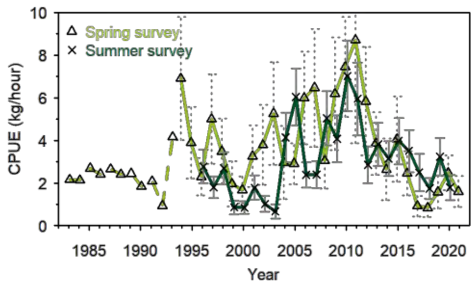


Figure 5.6.9. Tusk 5.b. Standardized cpue from the annual trawl groundfish surveys. The spring survey data from 1983–1993 are not stratified.

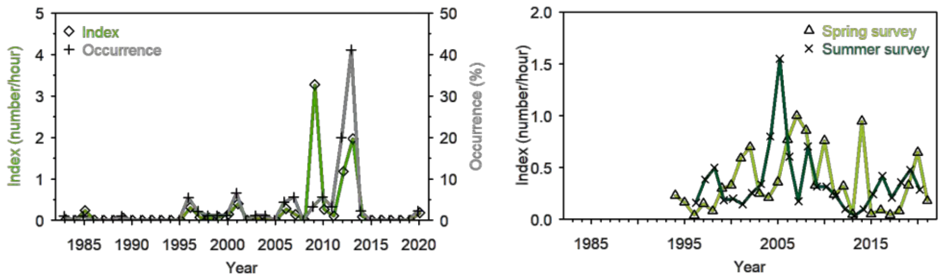


Figure 5.6.10. Tusk 5.b. Abundance index for tusk (2–3 cm in length in number/hour) on the Faroe Plateau based on the 0-group survey (left figure) and abundance index for tusk <40 cm from the annual spring and summer trawl survey on the Faroe Plateau (right figure).

The cpue series based on the Norwegian longline data shows a stable trend from 2000 to 2008, increased until 2012, decreased until 2017, a relatively large increase in 2018 and then decreased in 2019 and 2020 (Figure 5.6.11).

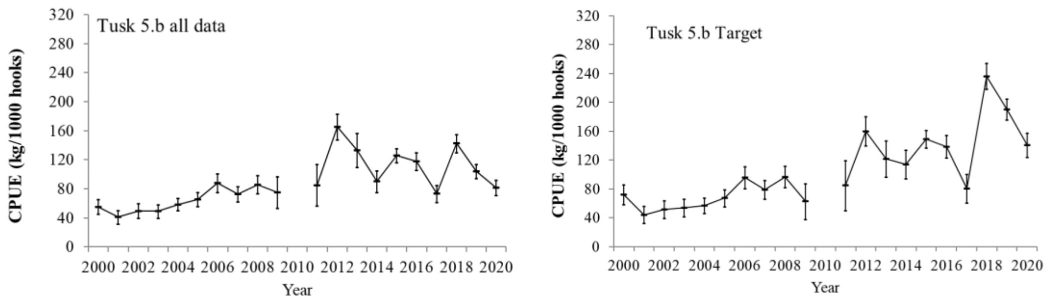


Figure 5.6.11. Tusk cpue series in 5.b for 2000–2020 based on all available data and when tusk appeared to be targeted. The bars denote the 95% confidence intervals.

6.a

In Division 6.a, a cpue series based on the Norwegian longline data shows an increase in cpue from 2004 to 2008, afterwards it has remained at a high, but slightly increasing level when all data are used (Figure 5.6.12).

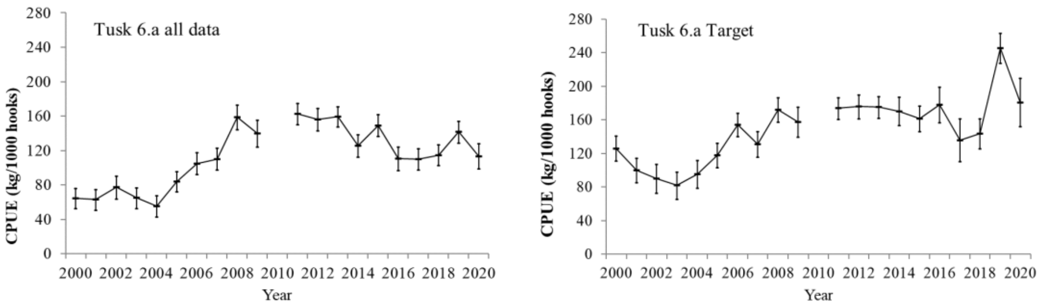


Figure 5.6.12. Two cpue series for tusk in area 6.a from 2000–2020 based on all available data and when tusk appeared to be targeted. The bars denote the 95% confidence intervals.

Combined cpue series for "Tusk areas 4, 5b and 6a"

A cpue series for merging all areas, data from the Norwegian longline fleet was combined with divisions 4.a, 4.b, 5.b and 6.a.

Two cpue series were estimated: based on using all available data and when tusk was targeted (daily catches when tusk made up more than 30% of the total catch, Figure 5.6.13).

The combined Norwegian longline cpue series shows an increasing trend from 2000 to 2010, after 2010 cpue was at a high and stable level (Figure 5.6.13).

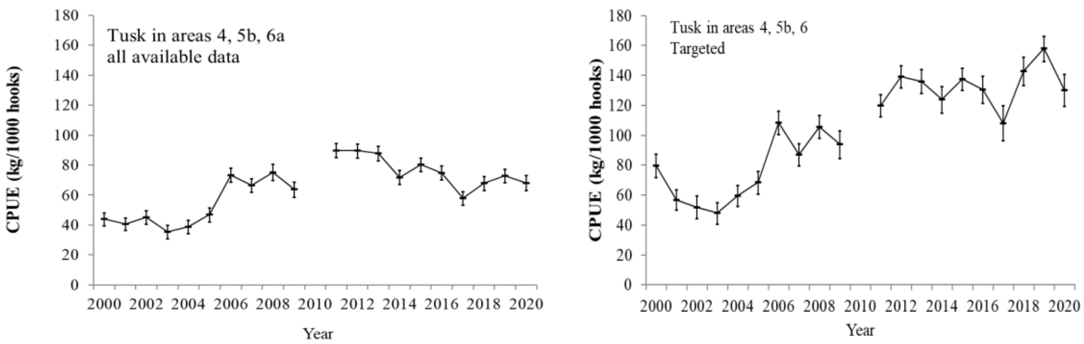


Figure 5.6.13. A combined cpue series for all "other tusk" areas for 2000–2019 based on data from the Norwegian longline fleet when tusk was targeted (>30% of total catch). The bars denote the 95% confidence intervals.

5.6.6.1 Biological reference points

See Section 5.6.9.

5.6.7 Comments on the assessment

The tusk stocks in Areas 3.a, 4, 5b, 6a, 7, 8, 9, 10, 12, 14 were best covered by the Norwegian longline fleet. WGDEEP decided that a combined cpue series should be made to give advice for the entire area, and that the data from the targeted fishery should be used.

5.6.8 Management considerations

Tusk landings from all subareas have been relatively stable since 2013. A cpue series, based on the Norwegian longline fishery when all areas are combined, shows a stable or positive trend since 2003. The combined Norwegian longline cpue series shows an increasing trend from 2000 to 2010, after 2010 the cpue series based on targeted catches shows a high and stable level. The two CPUE series show very different trends, and the series will be recalculated. For more information, see section 5.6.9.

As always, it should be emphasized that commercial catch data are typically observational data; that is, there were no scientific controls on how or from where the data were collected. Therefore, it is not known with certainty if the tusk cpue series tracks the actual population and/or how accurate the measures of uncertainty associated with the series are (see, for example, Rosenbaum, 2002). Consequently, one must usually hope that a cpue series, which is based only on commercial catch data, truly tracks abundance.

An infamous example of a misleading cpue series based on commercial data was a cpue series for Newfoundland cod that incorrectly indicated that the abundance of the cod stock was increasing greatly. Advice based on this cpue series ultimately caused the collapse of the stock (see, e.g. Pennington and Strømme, 1998).

In general, any assessment method based only on commercial catch data needs to be applied with caution. The reason that assessments using only commercial data are problematic is because the relation between the commercial catch and the actual population is normally unknown and probably varies from year to year.

5.6.9 Application of MSY proxy reference points

Summary of SPiCT from benchmark meeting; tusk in Areas 3.a, 4, 5b, 6a, 7, 8, 9, 10, 12, 14

It was not possible for the group to recommend or approve a SPiCT assessment for this stock. The reason for this was primarily the construction of the CPUE index; the CPUE index itself was not disregarded but it was not regarded suitable for the SPiCT model. Two points were pointed out as problematic; the targeting effect and technological creep. Especially handling the targeting effect; the spatial-time interactions must be solved before data can be used by SPiCT.

The recommendations from the benchmark was to enhance the standardization of the CPUE and either try an integrated model or try SPiCT again with the new CPUE. The stock should continue to be assessed as category 3 stock.

Input data for tusk arctic was the landings time series with historical landings back to 1950-2020. The abundance index was the CPUE index from the longline fishery from 2000-2020. Two variants of the CPUE index were used; one with all catches and one with only catches with more than 30% tusk.

The model was run with priors on initial depletion level and on the shape of the production curve.

The catch series is almost stable at the end of the series; this together with the very steep increase in the 30% CPUE made the CPUE to drive the model. The increase in all catches CPUE is not as pronounced as the targeted CPUE and that is probably why the model fits better to this scenario.

The very steep increase in CPUE over the short time period is problematic as the model estimate the stock to be 2–4 times BMSY and to have F below FMSY. The very high r (0.3–1.0) seems to be unrealistic as the expected value for r should be 0.12 for tusk (SPMpriors from Fish-Life). The very long catch time series (with low and high catches) and the short CPUE time series by the end of the catch time series period probably entails alternative states that are hidden to current SPiCT runs.

Stock status assessed by SPiCT indicated that B was above BMSY and F below FMSY. Other models were tried that came to contradictory conclusions. The development on B and F from

SPiCT were to the assessors not totally unrealistic as the result plots to some extent resembled the history of the fishery and the believed present stock status for tusk in this area. The problem is that F probably was higher in the 1970–1980s than the model estimate. Together with the increase in CPUE this probably makes the results from the SPiCT model to be too optimistic.

The assessments on SPiCT could not be approved according to the uncertainty in the CPUE index and due to the observed inconsistencies described above. Link to the benchmark report: https://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=37488

Results for the LBI, WGDEEP 2021

Information and data

The input parameters and the catch length composition for the period 2002-2020 are presented in the following tables and figures. The length data used in the LBI model are data from the Faroese- and Norwegian longliners. The length data are not raised to total catch.

Table 5.6.5. Tusk in other areas (3.a, 4.a, 5.b, 6.a, 7, 8, 9, 12). Input parameters for LBI.

Data type	Years/Value	Source	Notes
Length frequency distribution	2002–2018	Faroese long-liners fishing in Division 5.b	Data combined from both sources
	2002-2020	Norwegian long-liners fishing in divisions 4.a, 4.b, 5.b, 6.a	Lengths grouped into 2 cm bins
Length-weight relationship	0.0161* length $^{2.9101}$	Norwegian long-liners (Reference fleet) and survey data.	combined sexes
L_{MAT}	51 cm	Faroese survey data	
L_{inf}	125 cm (L_{max})	Norwegian long-liners (Reference fleet)	

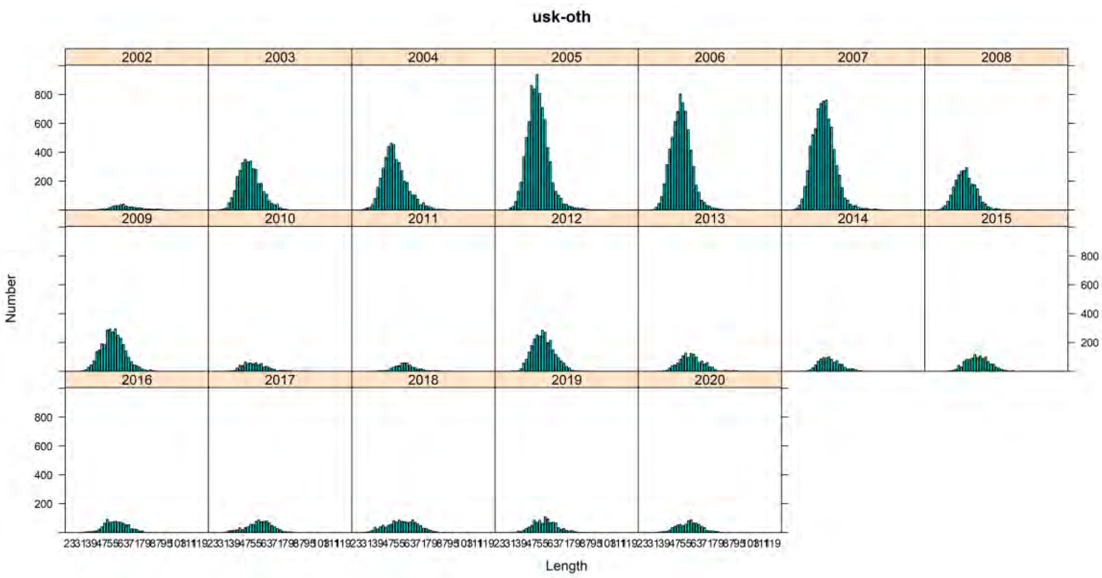


Figure 5.6.14. Tusk in other areas (3.a, 4.a, 5.b, 6.a, 7, 8, 9, 12). Catch length distributions (2 cm bins) have not been raised to total catch for the period 2002–2020 (combined sexes).

Outputs

The length indicator ratios for combined sexes were examined for three scenarios: (a) Conservation, (b) Optimal yield, and (c) maximum sustainable yield are presented in the following Figure 5.6.15.

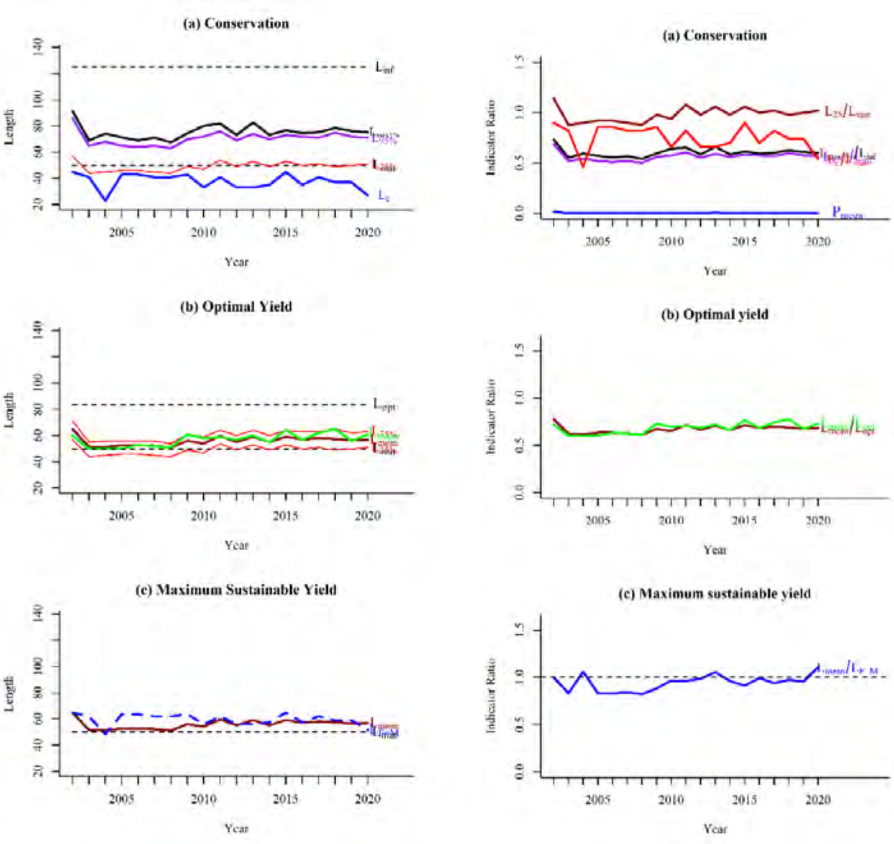


Figure 5.6.15 Tusk in other areas (3.a, 4.a, 5.b, 6.a, 7, 8, 9, 12). Screening of length indicators ratios for sexes combined under three scenarios: (a) Conservation, (b) Optimal yield, and (c) maximum sustainable yield.

Analysis of results

The conservation model for immature tusk shows that both L_c/L_{mat} and $L_{25\%}/L_{mat}$ is around or above 1 (Figure 5.6.19). In 2019-2020, the ratios were between 0.98 and 1,20 (Table 5.6.6). Regarding the sensitivity of L_{mat}, there appears to be little or no overfishing of immature individuals. The estimate of L_{mat} is based on data from Division 5.b, so L_{mat} may differ in the other areas.

The conservation model for large individuals shows that the indicator ratio of $L_{max5\%}/L_{inf}$ was around 0.6 for the whole period (Figure 5.6.20), and between 0.6 and 0.63 during the period 2019-2020 (Table 5.6.20), which is less than the baseline, 0.8. The reason that the VBF results gave unusually low values of L_{inf}, was because the value used in the model was L_{max}. If we had used a smaller value of L_{inf}, then the indicator ratio would be higher. Since tusk is a deep-water and slow-growing species, the P_{mega} and L_{mean}/L_{opt} values used were probably incorrect.

The MSY indicator, $L_{mean}/L_{F=M}$, was less than 1 for the entire period except for the last year (Figure 5.6.19), which indicates that tusk in other areas were fished unsustainably but has in 2020 been fished sustainably. It should be noted that if L_{inf} were set equal to L_{max}, then MSY would always have been greater than 0.8.

Table 5.6.6. Tusk in other areas (3.a, 4.a, 5.b, 6.a, 7, 8, 9, 12). The results based on the LBI method.

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0,8**	**>30%**	**~1 (>0,9)**	**≥1**
2018	0,74	0,98	0,63	0 %	0,69	0,97
2019	0,74	1,00	0,61	0 %	0,68	0,96
2020	0,54	1,20	0,60	0 %	0,68	1,11

Conclusions

The overall perception of the tusk stock in these areas during the period 2018–2020, based on the LBI results, is that tusk seems to be overexploited in the beginning, but that the stock had been fished sustainably during the last year (Table 5.6.7.). However, the results are very sensitive to the assumed values of L_{mat} and L_{inf}.

Table 5.6.7. Tusk in other areas (3.a, 4.a, 5.b, 6.a, 7, 8, 9, 12). Stock status inferred from LBI for MSY. Red tick marks for MSY are provided because the $L_{mean}/L_{F=M}$ < 1 in each year. The MSY ($L_{mean}/L_{F=M}$). Stock size is unknown as this method only provides the exploitation status.

	Fishing pressure			
	2018	2019	2020	
MSY (F/F$_{MSY}$)				Fished sustainably

	Stock size			
	2018	2019	2020	
MSY B$_{trigger}$.(B/B$_{MSY}$)				Unknown

5.6.10 References

Helle, K., M. Pennington, N-R. Hareide and I. Fossen. 2015. Selecting a subset of the commercial catch data for estimating catch per unit of effort series for Ling (*Molva molva* L.). Fisheries Research 165: 115–120.

Helle, K. and Pennington, M. 2021. The development of the Norwegian longline fleet's fishery for ling and tusk during the period 2000-2020. Working Document to the ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).21 pp.

Ofstad, L. 2017. Tusk in Faroese waters (Division 5.b). Working Document to the ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).14 pp.

Pennington, M., and Strømme, T. (1998). Surveys as a research tool for managing dynamic stocks. Fisheries Research 37, 97–106.Rosenbaum, P.R.2002. Observational Studies (second ed.), Springer-Verlag, New York, NY (2002) (377 pp.)

Rosenbaum, P.R. 2002. Observational Studies (second ed.), Springer-Verlag, New York, NY (2002) (377 pp.)

https://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=37488

5.6.11 Tables

Table 5.6.1. Tusk 3.a, 4, 5.b, 6, 7, 8, 9. WG estimates of amount landed.

Tusk 3.a

Year	Denmark	Norway	Sweden	Total
1988	8	51	2	61
1989	18	71	4	93
1990	9	45	6	60
1991	14	43	27	84
1992	24	46	15	85
1993	19	48	12	79
1994	6	33	12	51
1995	4	33	5	42
1996	6	32	6	44
1997	3	25	3	31
1998	2	19		21
1999	4	25		29
2000	8	23	5	36
2001	10	41	6	57
2002	17	29	4	50
2003	15	32	4	51
2004	18	21	6	45
2005	9	30	5	44
2006	4	21	4	29
2007	1	19	1	21
2008	0	43	3	46
2009	1	17	1	19
2010	1	17	3	21
2011	1	14	3	17
2012	1	17	2	20
2013	1	20	1	22

Year	Denmark	Norway	Sweden	Total
2014	1	7	1	9
2015	1	7	1	9
2016	1	12	1	14
2017	1	8	1	10
2018	2	5	1	8
2019	1	7	0	8
2020*	1	12	0	13

*Preliminary.

Tusk 4.a

Year	Denmark	Faroes	France	Germany	Norway	Sweden(1)	E & W	N.I.	Scotland	Ireland	Total
1988	83	1	201	62	3998	-	12	-	72		4429
1989	86	1	148	53	6050	+	18	+	62		6418
1990	136	1	144	48	3838	1	29	-	57		4254
1991	142	12	212	47	4008	1	26	-	89		4537
1992	169	-	119	42	4435	2	34	-	131		4932
1993	102	4	82	29	4768	+	9	-	147		5141
1994	82	4	86	27	3001	+	24	-	151		3375
1995	81	6	68	24	2988		10		171		3348
1996	120	8	49	47	2970		11		164		3369
1997	189	0	47	19	1763	+	16		238	-	2272
1998	114	3	38	12	2943		11		266	-	3387
1999	165	7	44	10	1983		12		213	1	2435
2000	208	+	32	10	2651	2	12		343	1	3259
2001	258		30	8	2443	1	11		343	1	3095
2002	199		21		2438	1	8		294		2961
2003	217		19	6	1560		4		191		1997
2004	137	+	14	3	1370	+	2		140		1666
2005	123	17	11	4	1561	1	2		107		1826
2006	155	8	14	3	1854		5		120		2159
2007	95	0	22	4	1975	1	6		74	3	2180

Year	Denmark	Faroes	France	Germany	Norway	Sweden[1]	E & W	N.I.	Scotland	Ireland	Total
2008	57	0	16	2	1975		3		85	1	2139
2009	48		8	1	2108	7	3		93		2268
2010	36		10	2	1734		8		71		1861
2011	52		24		1482	1	6		72		1636
2012	28		14	1	1635	1	3		67		1749
2013	42		11	3	1375		3		76		1510
2014	21		13	3	1365		3		58		1463
2015	24		6	2	1448	1	5		44		1530
2016	33		5	3	1565	1	4		39		1650
2017	37		5	2	1121				41		1206
2018	37		6	1	1341	1			53		1439
2019	46		9	2	1139	1	4		46		1247
2020*	46		8		898	5	2		65		1024

(1) Includes 4.b 1988–1993.

***Preliminary.**

Table 5.6.1. (Continued).

Tusk 4.b

Year	Denmark	France	Norway	Germany	E & W	Scotland	Ireland	Sweden	Total
1988		n.a.		-	-				
1989		3		-	1				4
1990		5		-	-				5
1991		2		-	-				2
1992	10	1		-	1				12
1993	13	1		-	-				14
1994	4	1		-	2				7
1995	4	-	5	1	3	2			15
1996	4	-	21	4	3	1			33
1997	6	1	24	2	2	3			38
1998	4	0	55	1	3	3			66
1999	8	-	21	1	1	3			34

Year	Denmark	France	Norway	Germany	E & W	Scotland	Ireland	Sweden	Total
2000	8		106	+	-	2			116
2001	6		45(1)	1	1	3			56
2002	6		61	1	1	2			71
2003	2		5	1					8
2004	2		19	1		1			23
2005	2		4	1					7
2006	2		30						32
2007	1		6				8		15
2008	0		69			0	2		71
2009	1		3			0	0	13	17
2010	1		13						15
2011	1		95						96
2012	2		43					2	47
2013	3		28						31
2014	2		9						11
2015	3		14	1					18
2016	2		5		2				9
2017	1		16					1	18
2018	1		15	1					17
2019	1		31	1					33
2020*	1		8						9

(1) Includes 4.c.

***Preliminary.**

Tusk 5.b1

Year	Denmark	Faroes[4]	France	Germany	Norway	E & W	Scotland [1]	Russia	Total
1988	+	2827	81	8	1143	-			4059
1989	-	1828	64	2	1828	-			3722
1990	-	3065	66	26	2045	-			5202
1991	-	3829	19	1	1321	-			5170
1992	-	2796	11	2	1590	-			4399
1993	-	1647	9	2	1202	2			2862
1994	-	2649	8	1 [2]	747	2			3407
1995		3059	16	1 [2]	270	1			3347
1996		1636	8	1	1083				2728
1997		1849	11	+	869		13		2742
1998		1272	20	-	753	1	27		2073
1999		1956	27	1	1522		11[3]		3517
2000		1150	12	1	1191	1	11[3]		2367
2001		1916	16	1	1572	1	20		3526
2002		1033	10		1642	1	36		2722
2003		1200	11		1504	1	17		2733
2004		1705	13		1798	1	19		3536
2005		1838	12		1398		24		3272
2006		2736	21		778		24	1	3559
2007		2291	28		1108	2	2	37	3431
2008		2824	18		816	18	13	109	3689
2009		2553	14		499	4	31	34	3135
2010		3949	16		866		58		4889
2011		3288	3		1		1		3293
2012		3668	23		102				3793
2013		1464	36		0				1500
2014		1764	32		511		3		2310
2015		1338	26		717				2081
2016		1494	17		747		3		2261

Year	Denmark	Faroes[(4)]	France	Germany	Norway	E & W	Scotland [(1)]	Russia	Total
2017		1472	18		544		1		2035
2018		1119	14		849		1		1983
2019		1110	13		835		2		1960
2020		1302	18		1139		3		2462

[1)] Included in 5.b2 until 1996.

[(2)] Includes 5.b2.

[(3)] Reported as 5.b.

[(4)] 2000–2003 5.b1 and 5.b2 combined.

*** Preliminary.**

Table 5.6.1. (Continued).

Tusk 5.b2

Year	Faroe	Norway	E & W	Scotland [(1)]	France	Total
1988	545	1061	-	+		1606
1989	163	1237	-	+		1400
1990	128	851	-	+		979
1991	375	721	-	+		1096
1992	541	450	-	1		992
1993	292	285	-	+		577
1994	445	462	+	2		909
1995	225	404	-2	2		631
1996	46	536				582
1997	157	420				577
1998	107	530				637
1999	132	315				447
2000		333				333
2001		469				469
2002		281				281
2003		559				559
2004		107				107
2005		360				360
2006		317				317

Year	Faroe	Norway	E & W	Scotland [1]	France	Total
2007		344				344
2008		61				61
2009		164				164
2010		127				127
2011		0				0
2012		0				0
2013					12	12
2014		123			6	129
2015		323			1	324
2016		42				42
2017		135				135
2018		21				21
2019	71	611			2	684
2020*	161	30				191

(1)Includes 5.b1.

(2)See 5.b1.

(3)Included in 5.b1.

***Preliminary.**

Table 5.6.1. (Continued).

Tusk 6a

Year	Denmark	Faroes	France [1]	Germany	Ireland	Norway	E & W	N.I.	Scot.	Spain	Netherlands	Total
1988	-	-	766	1	-	1310	30	-	13			2120
1989	+	6	694	3	2	1583	3	-	6			2297
1990	-	9	723	+	-	1506	7	+	11			2256
1991	-	5	514	+	-	998	9	+	17			1543
1992	-	-	532	+	-	1124	5	-	21			1682
1993	-	-	400	4	3	783	2	+	31			1223
1994	+		345	6	1	865	5	-	40			1262
1995		0	332	+	33	990	1		79			1435
1996		0	368	1	5	890	1		126			1391
1997		0	359	+	3	750	1		137	11		1261
1998			395	+		715	-		163	8		1281
1999			193	+	3	113	1		182	47		539
2000			267	+	20	1327	8		231	158		2011
2001			211	+	31	1201	8		279	37		1767
2002			137		8	636	5		274	64		1124
2003			112		4	905	3		104	0		1128

Year	Denmark	Faroes	France [1]	Germany	Ireland	Norway	E & W	N.I.	Scot.	Spain	Netherlands	Total
2004		1	140		22	470			93	0		726
2005		10	204		7	702			96	0		1019
2006		5	239		10	674	16		115	0		1059
2007		39	261		3	703	9		70	0		1085
2008		30	307		1	964	0		44	0		1346
2009		33	217		4	898	0		88	2		1242
2010		41	183		5	939			48			1216
2011		87	173		1	1060			25			1337
2012		106	166		1	860			41			1174
2013		46	191		1	1204			66	86		1594
2014		0	193			393			60	16		662
2015			200			866	1		63	62	1	1193
2016		41	178		1	499			42	82	1	844
2017		5	136			274			59	37		511
2018			144		0	658			81	57		940
2019			130		7	669			71	50		927
2020*		6	110		17	114			54	58		359

Not allocated by divisions before 1993.

*** Preliminary.**

Tusk 7.a

Year	France	E & W	Scotland	Total
1988	n.a.	-	+	+
1989	2	-	+	2
1990	4	+	+	4
1991	1	-	1	2
1992	1	+	2	3
1993	-	+	+	+
1994	-	-	+	+
1995	-	-	1	1
1996	-	-		
1997	-	-	1	1
1998	-	-	1	1
1999	-	-	+	+
2000		-	+	+
2001		-	1	1
2002	n/a	-	-	-
2003		-	-	-
2004				
2005				
2006				
2007				
2008				
2009				
2010				
2011				
2012				
2013				
2014				
2015				

Year	France	E & W	Scotland	Total
2016				
2017				0
2018				
2019				
2020*				

*Preliminary.

Tusk 7.b,c

Year	France	Ireland	Norway	E & W	N.I.	Scotland	Total
1988	n.a.	-	12	5	-	+	17
1989	17	-	91	-	-	-	108
1990	11	3	138	1	-	2	155
1991	11	7	30	2	1	1	52
1992	6	8	167	33	1	3	218
1993	6	15	70	17	+	12	120
1994	5	9	63	9	-	8	94
1995	3	20	18	6		1	48
1996	4	11	38	4		1	58
1997	4	8	61	1		1	75
1998	3		28	-		2	33
1999	-	16	130	-		1	147
2000	3	58	88	12		3	164
2001	4	54	177	4		25	263
2002	1	31	30	1		3	66
2003	1	19		1			21
2004	2	19					21
2005	4	18				1	23
2006	4	23	63			0	90
2007	2	4	7				13
2008	2	2	0				4

Year	France	Ireland	Norway	E & W	N.I.	Scotland	Total
2009	0	4	0				4
2010		5					5
2011		1					1
2012			63				63
2013	3	1					4
2014		1					1
2015							0
2016							0
2017						1	1
2018						3	3
2019	2	1					3
2020*	1						4

*Preliminary.

Table 5.6.1. (Continued).

Tusk 7.g–k

Year	France	Germany	Ireland	Norway	E & W	Scotland	Spain	Total
1988	n.a.		-	-	5	-		5
1989	3		-	82	1	-		86
1990	6		-	27	0	+		33
1991	4		-	-	8	2		14
1992	9		-	-	38	-		47
1993	5		17	-	7	3		32
1994	4		12	-	12	3		31
1995	3		8	-	18	8		37
1996	3		20	-	3	3		29
1997	4	4	11	-		+	0	19
1998	2	3	4	-		1	0	10
1999	2	1	-	-		+	6	8
2000	2		5	-	-	+	6	13

Year	France	Germany	Ireland	Norway	E & W	Scotland	Spain	Total
2001	3		-	9	-	+	2	14
2002	1				1		3	5
2003	1		1				1	3
2004	1						0	1
2005	1						1	2
2006	1		1				1	3
2007	1						1	1
2008	0						0	0
2009	0		0		0	0	0	0
2010	0							0
2011	0							0
2012	0					2		2
2013	0							0
2014								0
2015								0
2016								0
2017								0
2018								0
2019								0
2020*	1							1

***Preliminary.**

Tusk 8.a

Year	E & W	France	Spain	Total
1988	1	n.a.		1
1989	-	-		-
1990	-	-		-
1991	-	-		-
1992	-	-		-
1993	-	-		-
1994	-	-		-
1995	-	-		-
1996	-	-		-
1997	+	+		+
1998	-	1		1
1999	-	-		0
2000	-			-
2001	-			-
2002	-	+		+
2003	-	-		-
2004		1		
2005				
2006				
2007				
2008				
2009				
2010		4		4
2011		0		0
2012				0
2013				0
2014				0
2015				0
2016				0

Year	E & W	France	Spain	Total
2017				0
2018				0
2019*			1	01

*Preliminary.

Table 5.6.1. (Continued).

Tusk, total landings by subareas or division.

Year	3	4.a	4.b	5.b1	5.b2	6.a	7.a	7.b,c	7.g-k	8.a	All areas
1988	61	4429		4059	1606	2120		17	5	1	12 298
1989	93	6418	4	3722	1400	2297	2	108	86		14 130
1990	60	4254	5	5202	979	2256	4	155	33		12 948
1991	84	4537	2	5170	1096	1543	2	52	14		12 500
1992	85	4932	12	4399	992	1682	3	218	47		12 370
1993	79	5141	14	2862	577	1223		120	32		10 048
1994	51	3375	7	3407	909	1262		94	31		9136
1995	42	3348	15	3347	631	1435	1	48	37		8904
1996	44	3369	33	2728	582	1391		58	29		8234
1997	31	2272	38	2742	577	1261	1	75	19		7016
1998	21	3387	66	2073	637	1281	1	33	10	1	7510
1999	29	2435	34	3517	447	539		147	8	0	7156
2000	36	3260	116	2367	333	2011		164	13		8300
2001	57	3095	56	3526	469	1767	1	263	14		9248
2002	50	2961	71	2722	281	1124		66	5		7280
2003	51	1997	8	2733	559	1128		21	3		6500
2004	45	1666	23	3536	107	726		21	1		6125
2005	44	1826	7	3272	360	1019		23	2		6553
2006	29	2159	32	3560	317	1059		90	3		7249
2007	21	2180	15	3468	344	1077		13	1		7119
2008	46	2139	71	3798	61	1347		4	0		7466
2009	19	2268	17	3135	164	1242		4	0		6849

Year	3	4.a	4.b	5.b1	5.b2	6.a	7.a	7.b,c	7.g-k	8.a	All areas
2010	21	1861	15	4889	127	1216		3	0	4	8136
2011	17	1623	96	3287	0	1337		5	0	0	6361
2012	20	1749	47	3793	0	1174		63	2		6848
2013	22	1510	31	1500	12	1594		4	0		4673
2014	9	1463	11	2310	129	662		1			4585
2015	9	1530	18	2081	324	1193		0			5155
2016	14	1650	9	2261	42	844		0			4820
2017	10	1206	18	2035	135	511		1			3916
2018	8	1439	17	1983	21	940		3			4411
2019	8	1247	33	1960	684	927		3			4862
2020*	13	1024	9	2462	191	359		5	1	1	4065

***Preliminary.**

6 Greater silver smelt (*Argentina silus*)

6.1 Stock description and management units

At the WGDEEP 2014 it was suggested that unit arg-oth should be further split into advisory units as fishing grounds are sufficiently isolated (WD10, WGDEEP2014, Figure 6.1.1). This change was implemented at the WGDEEP meeting in 2015. Greater silver smelt is now divided into four management units by ICES areas;

- aru.27.123a4 in ICES areas 1, 2, 3a and 4;
- aru.27.5a14 in ICES areas 5a and 14;
- aru.27.5b6a in ICES areas 5b and 6a;
- aru.27.6b7–1012 in ICES areas 6b, 7-10 and 12.

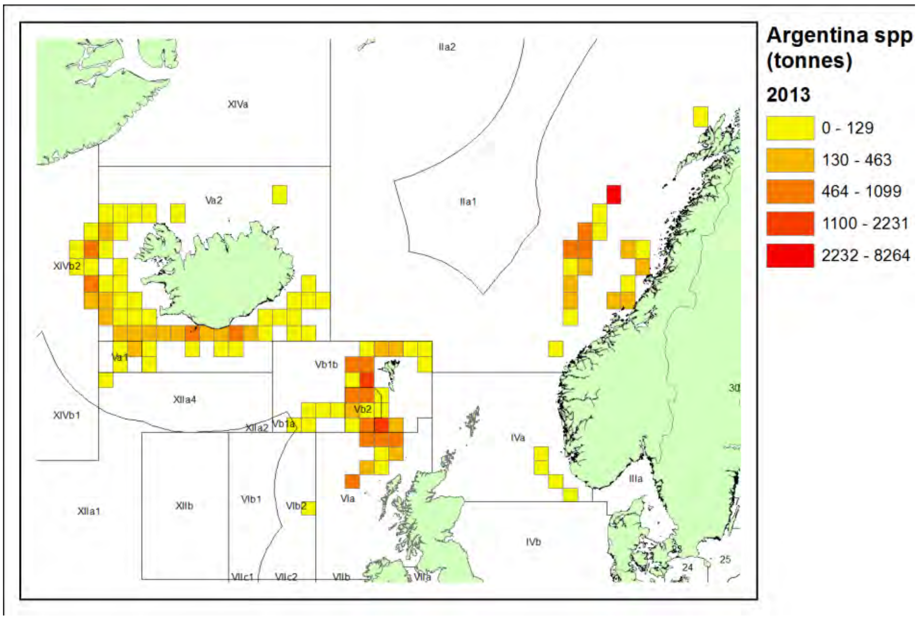


Figure 6.1.1. Catches of greater silver smelt by Iceland, Norway, Faroes and the Netherlands in 2013. Some catches of *A. sphyraena* and *Argentina* unidentified may be included in the Norwegian and Dutch landings.

Stock structure was a subject at the WKGSS 2020 benchmark for greater silver smelt (ICES 2021), where three of these stock units were benchmarked for the first time. The stock in ICES areas 6b, 7-10 and 12 (aru.27.6b7–1012) has not been benchmarked.

6.2 Greater silver smelt (*Argentina silus*) in 1, 2, 3.a and 4

6.2.1 The fishery

The targeted fishery is primarily conducted by Norwegian midwater and bottom trawlers in Division 2.a, and the fishery was initiated in the early 1980s. From the 1970s until the mid-1990s a smaller target fishery existed in Division 3.a (Skagerrak), but landings from that area have since been only minor bycatch.

In addition to the target fisheries in 2.a, trawl fisheries for other species along the Norwegian Deep in Division 4.a (northern North Sea) result in variable but sometimes significant landed bycatch of greater silver smelt. These landings can also contain, presumably minor, quantities of the lesser silver smelt (*Argentina sphyraena*) which has a more southern and shallower distribution then greater silver smelt. Since 2012 the landings increased from 351 t to reaching the highest landings so far in 2018 with 8071 t, and then a slight reduction to become 7215 t in 2020.

6.2.2 Landing trends

International landings are summarised in Tables 6.2.1–6.2.4, and Figures 6.2.1 and 6.2.2. The variation through the time-series prior to 2014 primarily reflects the developments in the Norwegian target fisheries in Subarea 2. The landings from Division 4.a were estimated based on sampling of mixed-species catches at the fishmeal factories, and the quality of the process may have varied somewhat through the time-series. Since 2014 the bycatch in the North Sea (Subarea 4) has been increasing gradually to substantial levels, now amounting close to half of the total catch.

From peak levels of 10000 t to 11000 t in the 1980s when the targeted fishery developed, the landings (primarily by Norway) from Subareas 1 and 2 declined in the 1990s. Except for 2001, when landings were 14369 t, the landings remained relatively stable at 6–8000 t until 2003. In 2004 to 2006 landings increased sharply to reach 21685 t in 2006. The monitoring of abundance was not satisfactory in that period, but the increase in landings did probably not reflect increased abundance. Since the fishery was not restricted by a TAC, it is thought that temporal variation in landings primarily reflected variation in the market demand. In 2007–2017 the Norwegian catches in targeted fisheries were around 12000 t per year in accordance with annual TAC regulations reintroduced in 2007. In 2018 the landings increased to 15832 t, while in 2019 the landings were 12501 t. In 2020 these catches are reduced to 8705 t.

Since 2014 a marked increase is observed in catches in subareas 3 and 4, and these have risen in 2018, 2019 and 2020 to substantial 8067 t, 7210 t and 7215 t, respectively. Mostly they are bycatch taken at the southern slope of Norwegian trench, and the bulk of them are reported as lesser silver smelt. There are uncertainties on how well these landings are estimated and about species identification, and this should be addressed with better sampling in cooperation with the industry. In the end of 2018, 267 samples of Argentines from the industry were identified to either *Argentina silus* or *Argentina sphyraena* using different criteria given in the identification key of Argentines; number of muscle segments, number of pectoral fin rays, number of gill rakes on the lower part of the first gill bow and the size of the eye diameter compared to the snout length (ICES WGDEEP 2019 WD7). Preliminary results show that up to 10% of the individuals sampled might be *A. sphyraena*. In this report, all registered landings are assumed to be greater silver smelt.

In 2020 total landings were 15820 t (Table 6.2.1–6.2.3). Landings from subareas 1 and 2 were 8705 t and the remainder were reported from Subarea 4 and Division 3.a. The total landings were substantially higher than the ICES advice for 2019, primarily due to by-catch landings in the North Sea.

6.2.3 ICES Advice

In 2019 ICES advised that, when the precautionary approach is applied, catches should be no more than 10 270 tonnes in each of the years 2020 and 2021. Discarding is known to take place but is negligible.

6.2.4 Management

For a period after 1983 a Norwegian precautionary unilateral annual TAC was applied in Division 2.a which was always the main fishing area. The landings never exceeded the quota and this regulation was abandoned in 1992. As landings increased substantially in the mid-2000s, a 12000 t unilateral Norwegian TAC was introduced in 2007 and this TAC was maintained until 2015 when for 2016 it was increased to 13047 t, which also was the TAC for 2017. In 2018 and 2019 the TAC was 13770 t. The TAC in the direct fisheries for 2020 and 2021 is 9033 t. The Norwegian target fishery is further regulated by a licensing system that limits the number of trawlers that can take part and specifies gear restrictions, bycatch restrictions, and an area and time restriction. Usually around 25 trawlers are active in the fishery.

In 2016, RTC-regime (Real Time Closures) was implemented to the direct fisheries in Subarea 2, aimed to limit bycatch of redfish, saithe and haddock. Closing criteria was sat to 1000 kg in combined weight of redfish, saithe and haddock in single catches.

In 2017 a minimum landing size (MLS) in the direct fisheries of 27 cm was implemented in the direct fisheries, with access to 20% mixture of greater silver smelt in numbers under the MLS in single catches. Also, ban on landing greater silver smelt to be processed to fishmeal was repealed in 2017.

In Norway vessels that are not licensed to greater silver smelt fisheries can have up to 10% in weight bycatch of greater silver smelt in single catches and landings. This also applies to vessels that are licenced, but those must subtract the bycatch from their quota.

If the total TAC in the direct fishery is not fished during the year, up to 10% of the total TAC can be transferred to the following year.

There is no Norwegian TAC for fisheries in divisions 4.a and 3.a where targeted fisheries are prohibited, but bycatch restrictions apply. The EU introduced TAC management in 2003 applying to EU vessels fishing in the EU EEZ and international waters. For 2020 the EU TAC for subareas 1+2 was 90 t, and for subareas 4 + 3 the TAC was 1234 t. TAC for 2021 is not agreed yet between EU and UK.

This management unit is not distributed in international waters, hence the 2020 TACs described above totalling 9033 t (Norway) and 90 (EU; subareas 1 and 2) + 1234 t (EU; subareas 3 and 4) apply to Norwegian and EU waters, respectively.

6.2.5 Data available

6.2.5.1 Landings and discards

Landings data are presented by ICES Subareas and Divisions and countries (Tables 6.2.1–6.2.4, Figure 6.2.1–6.2.3). Data from 2014–2020 were obtained from national official statistics (Norway) and InterCatch. From earlier years data are WG estimates based on national submissions to ICES which are not fully included in InterCatch.

Discarding is banned in Norway and all catches are assumed to be landed. There is information in InterCatch on very minor discards from non-Norwegian fisheries on this management unit, but bycatches are assumed generally to be landed.

6.2.5.2 Length compositions

Length distributions are presented for target fishery catches from Division 2.a for the period 2009–2020 and for bycatches by Norwegian vessels in Division 4.a for the years 2011, 2013, 2014 and 2016-2020 (Figure 6.2.5 and 6.2.6). For each year these distributions are derived by pooling multiple samples from landing sites and samples provided by commercial vessels (Hallfredsson *et al.* 2016, WGDEEP 2016, WD).

Length information is available from the Norwegian slope March/April survey in Division 2.a conducted in 2009 and 2012, and biennially since then (Figure 6.2.7) (Heggebakken *et al.* 2020, WKGSS WD18).

Length information is available from the annual Norwegian shrimp survey in divisions 3.a and 4.a, 1984–2020 (Figure 6.2.8).

Some length distributions from landings and discards from fisheries by Scotland, Sweden and Netherlands are available in InterCatch, but are still to be analysed.

6.2.5.3 Age compositions

Age compositions from Norwegian catches 2013-2020 are presented in Figure 6.2.9. Age distributions from the Norwegian slope survey and the shrimp survey in North Sea/Skagerrak are shown in Figure 6.2.10.

6.2.5.4 Weight-at-age

No new data on weight-at-age were presented to the meeting. Length at age and length-weight relations were scrutinized at the WKGSS 2020 benchmark workshop on greater silver smelt (ICES 2021).

6.2.5.5 Maturity and natural mortality

No new data on maturity and natural mortality were presented to the meeting, but these were scrutinized at the 2020 benchmark workshop.

6.2.5.6 Catch, effort and research vessel data

A trawl acoustic survey has been conducted in 2009, 2012 and biennially since then, along the continental slope in Norwegian EEZ from 62–74°N (subareas 1 and 2). Additionally, trawl surveys were conducted in Division 2.a in 2003–2005. Acoustic index from this survey is used in the SPiCT assessment.

Surveys were conducted in early 1990-ties in the Norwegian Sea and south–east slope with acoustics, pelagic and bottom trawl (Monstad and Johannessen, 2003), the ones in spring 1990-1992 are used in the SPiCT assessment.

For Subarea 4 and Division 3.a information is available from the Norwegian shrimp survey in years 1984–2020. Stations are in the depth range of 80-660 meters, with around 25% of the stations deeper than 300 meters. The survey has been conducted in different seasons, and this may affect the index for greater silver smelt. The index did not perform well with SPiCT (ICES 2021).

6.2.6 Data analyses

Length and age distributions

In Division 2.a size and age distributions from target fisheries (Figures 6.2.5 and 6.2.9) continue to consist of rather smaller and younger fish than catches in the 1980s during the initial years of the target fisheries (Bergstad, 1993; Monstad and Johannessen, 2003; Johannessen and Monstad, 2003). There are, however, no major changes in the shape of size composition in the recent nine years when the target fishery has been regulated with TACs and other measures.

Age distributions in the Norwegian slope survey are rather even through the years with a mode around age six to eight, while the 2020 age distribution in the North Sea/Skagerrak survey is bimodal with more juveniles of age one to three as well (Figure 6.2.10). The fishery is mainly conducted shallower than 400 m.

The shape of the length distributions in both numbers and biomass in the Norwegian slope survey have varied through the years, but low numbers and biomass are apparent in the 2018 survey while 2020 survey shows upward trend (Figure 6.2.7).

In Division 3.a the length distributions throughout the 1984–2020 shrimp survey time-series are bimodal since 2014, as the age distribution in 2020, with marked appearance of larger fish around 30 cm (Figure 6.2.8).

In Division 4.a size distributions from the bycatch (Figure 6.2.6) are bimodal in later years and suggest that the catches comprise rather variable but smaller fish than those in the target fishery landings in Division 2.a. This probably reflects that the slope of the Norwegian Deep in Division 4.a is comparatively shallow and is mainly a juvenile area and feeding area for dispersed large fish out with the winter-spring aggregatory phase (Bergstad, 1993).

Commercial CPUE and survey series

In Subarea 2 biomass estimates based on the acoustic observations show a decreasing trend from 2014-2018, while the 2020 estimate is higher (strata 1A and 2A in Figure 6.2.11). Greater silver smelt spatial distribution shows highest concentrations in approximately 62-70°N (Figure 6.2.12), which agrees to where the direct fisheries are mostly conducted. The index was recalculated using the StoX software at the 2020 benchmark. The 2020 survey was affected by complications related to covid19 restrictions and bad weather conditions. As a result, the area North of 67°N was not covered, being an area with lowest biomass of greater silver smelt in the survey (stratum 3 in Figure 6.2.11) and it is suggested to exclude that area from the index that is used in SPiCT (ICES 2021).

Swept area biomass indices and swept area abundance indices for greater silver smelt from the annual Norwegian shrimp survey in Division 3.a and south-eastern parts of Division 4.a are shown in Figure 6.2.13. The indices are calculated using StoX, which is now the recommended program for calculating survey estimates from acoustic and swept area surveys at IMR (Johnsen *et al.* 2019) (Heggebakken *et al.* 2020, WKGSS WD18). Seasonality of the survey has varied through the years and this may affect the index for greater silver smelt. It was conducted in October 1984-2002, in May 2004-2005, in February 2006-2007 and in January since then.

The indices in terms of numbers and weight from the survey in divisions 3.a and 4.a suggest pronounced variation and trends (Figure 6.2.13). The survey catches rates first declined steadily and then rather abruptly to unprecedented low levels in 2006. After 2010, indices showed an abrupt increase until around 2015 and have been at a relatively high level since then.

A preliminary catch CPUE based on electronic logbook data from the direct fisheries in Division 2.a is shown in Figure 6.2.14. For the pelagic trawls CPUE, year 2013 is the one with highest value, followed by a declining trend until 2016 and a slight increase after that (Heggebakken *et* *al.* 2020, WKGSS WD18). For the bottom trawls CPUE, the trend is increasing, apart from year 2015 which showed the lowest CPUE for all years. The CPUE series was examined at the 2020 benchmark and considered not applicable to the assessment at present stage. It is foreseeably a labour-intensive task to get the old logbooks digitalized, and a cost-benefit consideration is needed based on further analysis of the electronical logbook data and experience with CPUE series from other areas.

6.2.7 Assessment

LBI was run with updated data. The results show that $L_{mean}/L_{F=M}$ = 1.05 (Figure 6.2.15), which indicates that the exploitation status is within precautionary levels.

SPiCT results are shown in Figure 6.2.16-6.2.20. The average of the relative biomass index from SPiCT (Figure 6.2.21) for the last two years was 1.16235, and 1.6223 for the three years before that. Thus, the ratio to be used in the ICES two-over-three rule for advice is 1.16235/ 1.6223 = 1.0001. The precautionary buffer was last used in 2019 and is thus not applied in the 2021 assessment.

6.2.8 Comments on the assessment

The assessment is in accordance to the WKGSS 2020 benchmark workshop (ICES 2021).

Due to covid19 complications the 2020 Norwegian slope survey in subareas 1 and 2 did not cover the northernmost survey area (stratum 3). The biomass estimates for this stratum has been minor compared to stratum 1A and 2A (Figure 6.2.11). Thus, the SPiCT analysis was run with summed biomass estimates for stratum 1A and 2A, leaving out stratum 3.

Existing abundance, length and age data series for this stock are rather short compared to potential life span of the species (approx. 30 years). However, if the time-series are maintained they may support more analytical assessment in a near future. CPUE from the fisheries is the only known source of data that potentially can give information on historical development of the stock back in time to around 2009. Electronic logbooks were introduced in the Norwegian fisheries in 2011 but are not available digitally for earlier years. Before 2011 the fishing vessels were obliged to keep logbooks, and have them available in case of inspection, but not to deliver them to the government. Thus, it is foreseeably a labour-intensive task to get the old logbooks digitalized, and a cost-benefit consideration is needed based on further analysis of the electronic logbook data and experience with CPUE series from other areas. It is currently unknown if the CPUE reliably will reflect the dynamics in the population.

6.2.9 Management considerations

Advice is given every second year for this stock and the 2021 advice applies for 2022 and 2023.

The bycatch in Subarea 4 (North Sea) has increased rapidly since 2012 and total catch in this area reached levels of around 7 to 8 thousand tonnes. In 2020 the catches in Subarea 4 were 7115 t, reaching levels not far from to the catches in the direct fisheries in subareas 1 and 2 (8705 t). This is an alarming level as the bycatches are not well regulated. There are uncertainties in how this bycatch is estimated in this fishery, as it is an industry fishery for reduction. Additionally, most of these catches are registered as lesser silver smelt, but there are strong reasons to assume that for the most part they are greater silver smelt catches (Hallfredsson and Heggebakken 2019, ICES WGDEEP 2019 WD7).

6.2.10 References

Bergstad, O.A., 1993. Distribution, population structure, growth, and reproduction of the greater silver smelt, *Argentina silus* (Pisces, Argentinidae), of the Skagerrak and the north-eastern North Sea. ICES J. Mar. Sci., 50(2): 129-143.

Hallfredsson, E.H., Bergstad, O.A., Heggebakken, L., and Hansen, H.Ø. Greater silver smelt in ICES areas I,II,IIIa and IV. ICES WGDEEP 2016 WD.

Hallfredsson, E.H. and Heggebakken, L., 2019. On mixed greater silver smelt (*Argentina silus*) and lesser silver smelt (*Argentina sphyraena*) bycatches in industry fisheries in the North-Sea. ICES WGDEEP 2019 WD7.

Heggebakken, L., Hallfredsson, E.H., Harbitz, A., Tranang, C.A and Vihtakari, M. 2020. Greater silver smelt in ICES areas 1, 2, 3a and 4 – survey indices and CPUE. ICES WKGSS 2020, WD18.

ICES. 2014. Revision of ICES assessment units for greater silver smelt based on the distribution of fishing grounds. WGDEEP, WD10.

ICES. 2021. Benchmark Workshop of Greater silver smelt (WKGSS). ICES Scientific Reports. 3:5. 482 pp. https://doi.org/10.17895/ices.pub.5986

Johannessen, A. and Monstad, T., 2003. Distribution, growth and exploitation of greater silver smelt (*Argentina silus* (Ascanius, 1775)) in Norwegian waters 1980-83. Symposium on deep-sea fisheries: NAFO/ICES/CSIRO Symposium 12-14 September 2001. pp. 319-332. [J. Northwest Atl. Fish. Sci.]. Vol. 31.

Johnsen, E., Totland, A., Skålevik, Å., Holmin, A. J., Dingsør, G. E., Fuglebakk, E., & Handegard, N. O. 2019. StoX: An open source software for marine survey analyses. Methods in Ecology and Evolution. 10 :1523 –1528.

Monstad, T. and Johannessen, A., 2003. Acoustic recordings of greater silver smelt (*Argentina silus*) in Norwegian waters and west of the British Isles, 1989-94. J. Northw. Atl. Fish. Sci., 31: 339-351.

6.2.11 Tables

Table 6.2.1. Greater Silver Smelt in 1, 2, 3.a and 4 by countries. WG estimates of landings in tonnes. ICES official statistics. Landings from 1966-2018 are shown in Stock Annex. * Preliminary landings.

year	Denmark	Sweden	Ireland	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Lithua-nia	Iceland	SUM
1988	1062	0	0	1	0	13014	5	14	0	0	0	0	0	14096
1989	1322	0	0	0	335	10495	0	23	1	0	0	0	0	12176
1990	737	0	0	13	5	10686	0	0	0	0	0	0	0	11441
1991	1421	0	0	0	3	8864	0	0	6	1	0	0	0	10295
1992	3564	0	0	1	70	8932	0	0	101	0	0	0	0	12668
1993	2353	0	0	0	298	8481	0	0	56	0	0	0	0	11188
1994	1118	0	0	0	0	6221	0	0	614	0	0	0	0	7953
1995	1061	0	0	357	0	6419	0	0	20	0	0	0	0	7857
1996	1446	0	0	0	0	6817	0	0	0	0	0	0	0	8263
1997	1455	542	0	1	0	5167	0	0	0	0	0	0	0	7165
1998	748	428	0	169	277	8655	0	0	0	0	0	0	0	10277
1999	1420	0	0	0	7	7151	0	0	18	0	0	0	0	8596
2000	1039	273	10	0	3	6107	0	195	18	9	0	0	0	7654
2001	907	1011	3	0	0	14360	0	7	233	28	0	0	0	16549
2002	614	484	4	0	0	7406	0	0	164	0	0	0	0	8672

year	Denmark	Sweden	Ireland	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Lithua-nia	Iceland	SUM
2003	918	42	0	4	617	8351	0	7	22	4	4	0	0	9969
2004	910	0	36	4	4277	11574	0	4	12	0	0	0	0	16817
2005	470	0	0	1	28	17066	0	16	0	0	14	0	0	17595
2006	335	0	0	6	0	25149	0	4	2	0	0	0	0	25496
2007	0	0	0	0	0	16373	0	1	0	0	0	0	0	16374
2008	0	0	0	0	0	13424	0	0	0	0	0	0	0	13424
2009	0	0	0	0	0	13495	0	0	0	0	0	0	0	13495
2010	0	0	0	0	0	12865	0	0	33	0	0	0	0	12898
2011	0	0	0	0	0	12060	0	0	0.4	4	0	0	0	12064
2012	0	0	0	0	0	12352	0	0	0	1.2	114	0	18	12485
2013	0	0	0	0	0	13227	0	0	0	2.3	0	0	0	13229
2014	40	1	0	204	345	14471	0	0	0	1	0	0	0	15062
2015	0	1	0	0	0	15235	0	0	0	0	0	0	0	15236
2016	0	1	0	38	11	18835	0	7	0	1.4	0	0	0	18893
2017	0	1	0	0	10	17788	0	35	0	0	0	0	0	17835
2018	18	4	0	67	152	23609	0	9	0	0	0	0	0	23859
2019	0	0	0	143	349	19172	0	8	0	0	0	0	0	19672
2020*	0	0	0	0	222	15534	21	8	0	0	0	35	0	15820

Table 6.2.2. Greater Silver Smelt in 1 and 2. WG estimates of landings in tonnes. *Preliminary landings.

Year	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Iceland	TOTAL
1988			11332	5	14					11351
1989			8367		23					8390
1990		5	9115							9120
1991			7741							7741
1992			8234							8234
1993			7913							7913
1994			6217			590				6807
1995	357		6418							6775
1996			6604							6604
1997			4463							4463
1998	40		8221							8261
1999			7145			18				7163
2000		3	6075		195	18	2			6293
2001			14357		7	5				14369
2002			7405			2				7407
2003		575	8345		7	2	4	4		8937
2004		4235	11557		4					15796
2005			17063		16			14		17093

Year	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Iceland	TOTAL
2006			21681		4					21685
2007			13272		1					13273
2008			11876							11876
2009			11929							11929
2010			11831			23				11854
2011			11476			0.4				11476
2012			12002				0.2	114	18	12134
2013			11978				0.3			11979
2014			11752							11752
2015			12049							12049
2016			13115		7		0.4			13122
2017		10	12277		35					12322
2018	0.2	0.4	15823		8.5					15832
2019			12493		8					12501
2020*			8697		8					8705

Table 6.2.3. Greater Silver Smelt in 3. WG estimates of landings in tonnes. Figures in parentheses are discards as recorded in InterCatch. Landings from 1966-2018 are shown in Stock Annex. *Preliminary landings.

Year	Denmark	Germany	Norway	Sweden	TOTAL
1988	1062		27		1089
1989	938		236		1174
1990	732		1150		1882
1991	1421		800		2221
1992	3564		634		4198
1993	2343		487		2830
1994	1108				1108
1995	1061				1061
1996	1389		159		1548
1997	1455		703	542	2700
1998	748		413	428	1589
1999	1420		2		1422
2000	1039		4	273	1316
2001	907			1011	1918
2002	614			484	1098
2003	918			42	960
2004	910		1		911

Year	Denmark	Germany	Norway	Sweden	TOTAL
2005	470				470
2006	324				324
2007					0
2008					0
2009					0
2010					0
2011					0
2012					0
2013					0
2014			2	1	3
2015			22	1	23
2016			101	1	102
2017			3	(1)	3(1)
2018				(3.6)	(3.6)
2019				(66)	(66)
2020*					0

Table 6.2.4. Greater Silver Smelt in 4. WG estimates of landings in tonnes. Figures in parentheses are discards as recorded in InterCatch. Landings from 1970-2018 are shown in Stock Annex. *Preliminary landings.

Year	Denmark	France	Germany	Netherlands	Norway	Scotland	Ireland	Russia	Lithuania	Poland	TOTAL
1988			1		1655						1656
1989	384			335	1892	1					2612
1990	5		13		421						439
1991		1		3	323	6					333
1992			1	70	64	101					236
1993	10			298	81	56					445
1994	10				4	24					38
1995					1	20					21
1996	57				54						111
1997			1		1						2
1998			129	277	21						427
1999				7	4						11
2000		7			28		10				45
2001		28			3	228	3				262
2002					1	162	4				167
2003			4	42	6	20					72
2004			4	42	16	12	36				110

Year	Denmark	France	Germany	Netherlands	Norway	Scotland	Ireland	Russia	Lithuania	Poland	TOTAL
2005			1	28	3						32
2006	11		6		3468	2					3487
2007					3101						3101
2008					1548						1548
2009					1566						1566
2010					1034	10					1044
2011		4			584						588
2012		1			350						351
2013		2			1249						1251
2014	40 (7)	1	204	345	2717						3307(7)
2015					3164						3164
2016		1	38	11	5619						5669
2017					5508	(388)					5508(388)
2018	17(1)		67	152	7786	(38)		6			8028(39)
2019			143	349	6679	(39)					7171(39)
2020*				222	6837	(100)			35	21	7115(100)

6.2.12 Figures

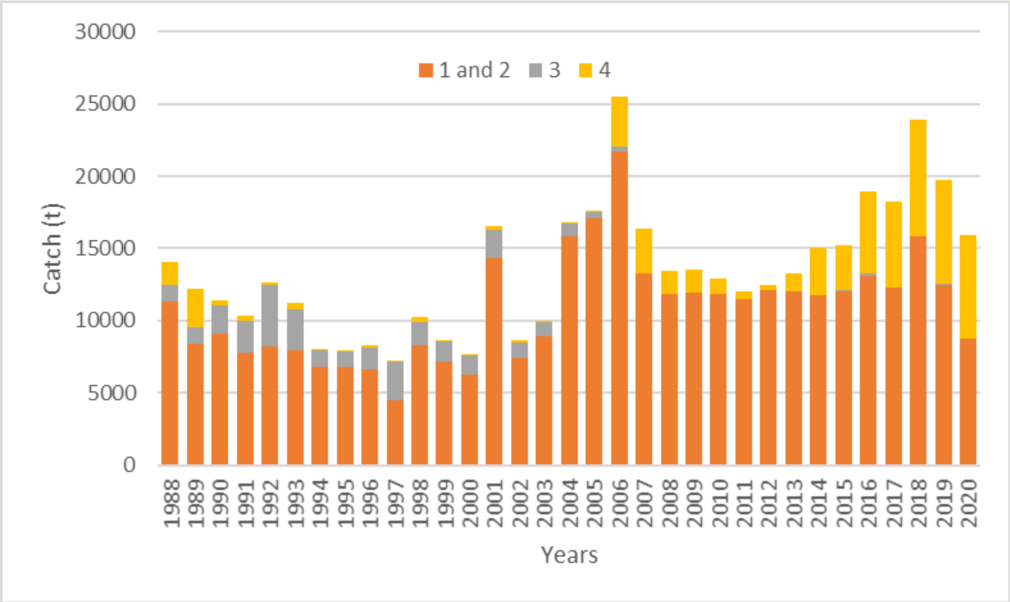


Figure 6.2.1. Total catch of greater silver smelt in subareas 1, 2, 3 and 4.

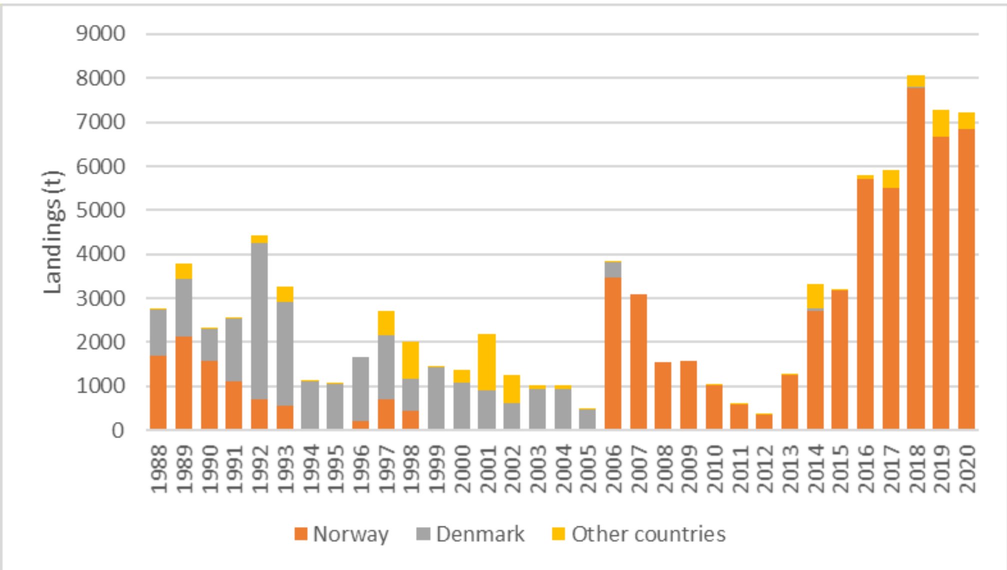


Figure 6.2.2. Total catch of greater silver smelt in subareas 3 and 4, by countries.

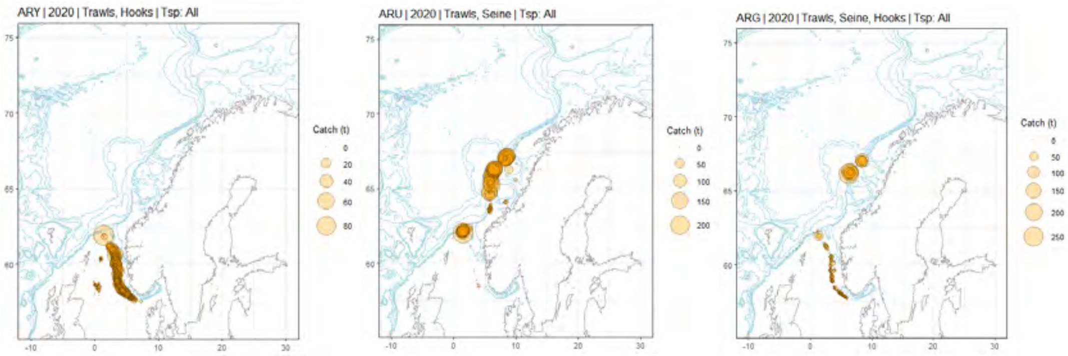


Figure 6.2.3. Norwegian catches in 2020 based on logbooks, including bycatch. Left, middle and right panels show catches registered as lesser silver smelt, greater silver smelt and mix of both species, respectively. Bubble sizes reflect sizes of single catches. NB: Catch representing max bubble size varies between panels.

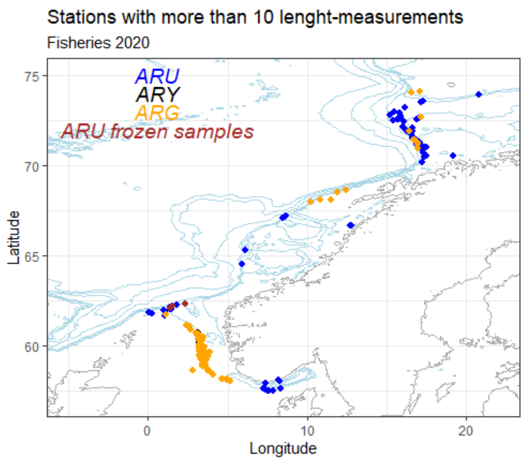


Figure 6.2.4. Positions from the fisheries for 2020 with length measurement landed as GSS, LSS, GSS/LSS and frozen samples.

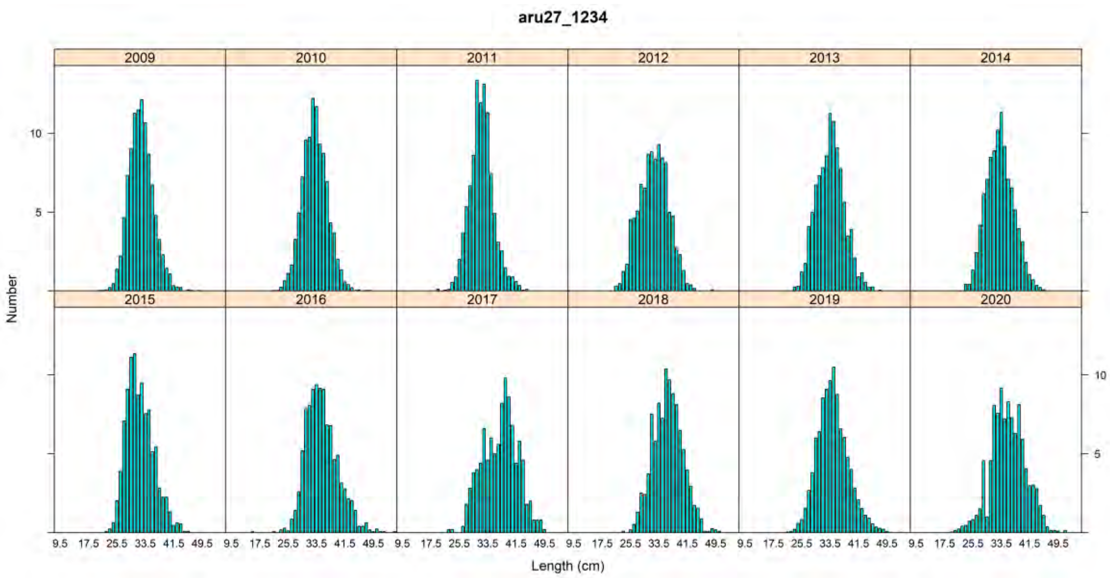


Figure 6.2.5. Greater silver smelt in subareas 1, 2, and 4 and Division 3.a. Length distributions (% numbers) from the target fisheries in 2009–2020 north of 62°N (approximately subareas 1 and 2).

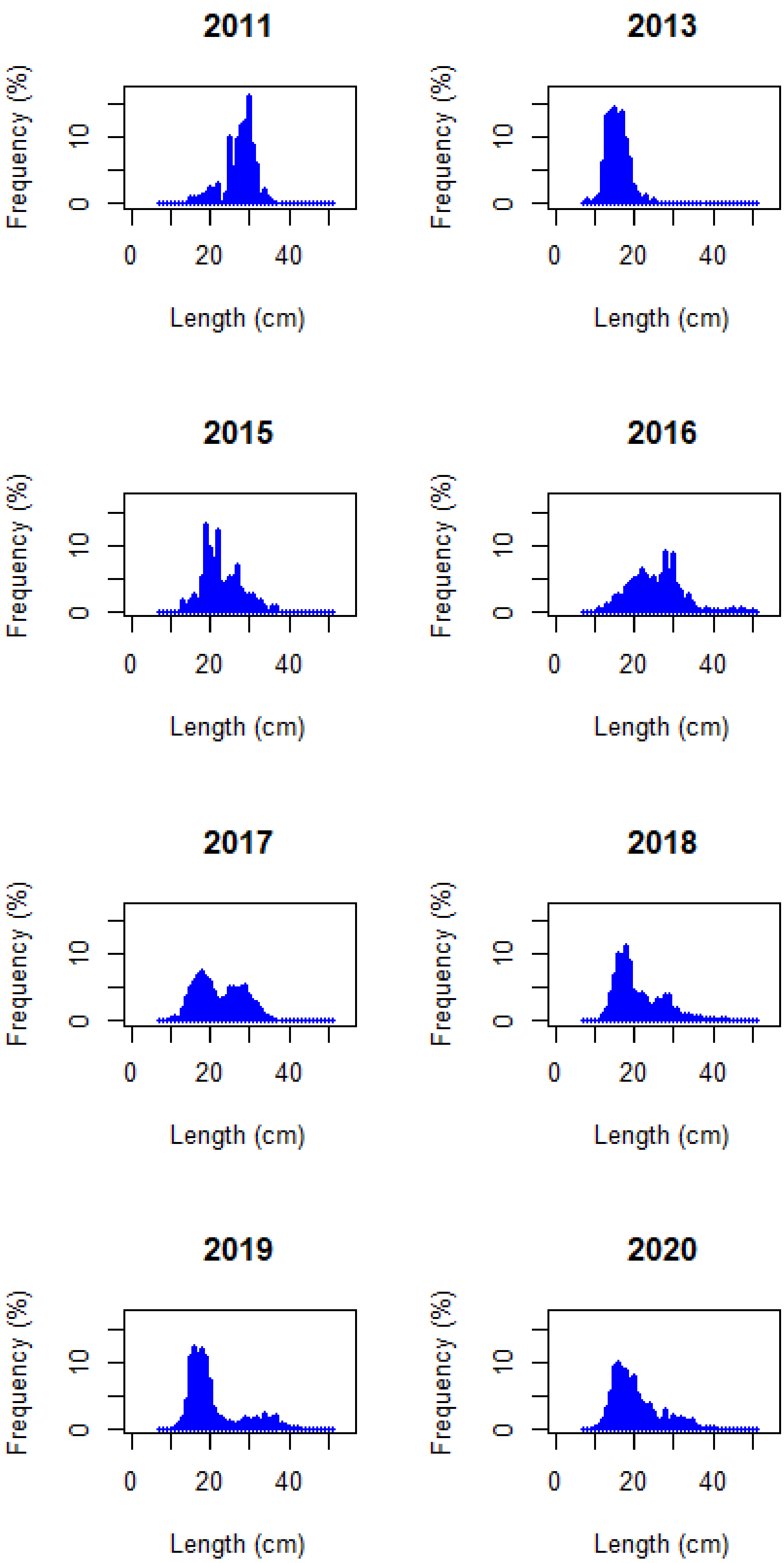


Figure 6.2.6. Greater silver smelt in 1, 2, 3.a and 4. Length distributions in annual samples from Norwegian bycatches south of 62°N (approximately subareas 3 and 4).

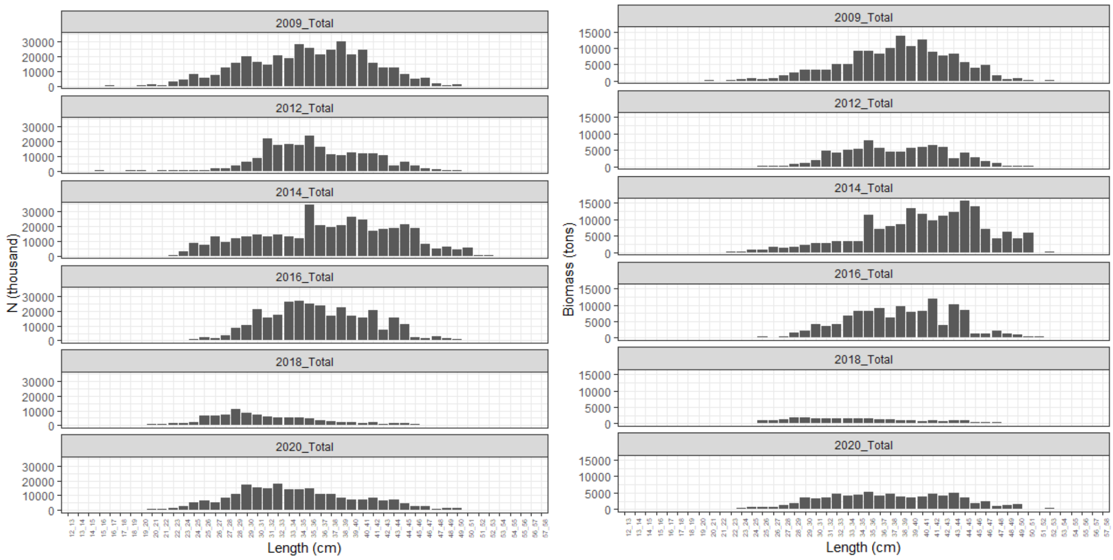


Figure 6.2.7. Length distributions in numbers (left panels) and biomass (tons) (right panels) for greater silver smelt in the Norwegian Sea south-east slope survey in 2009, 2012, 2014, 2016, 2018 and 2020. Swept area estimates from StoX.

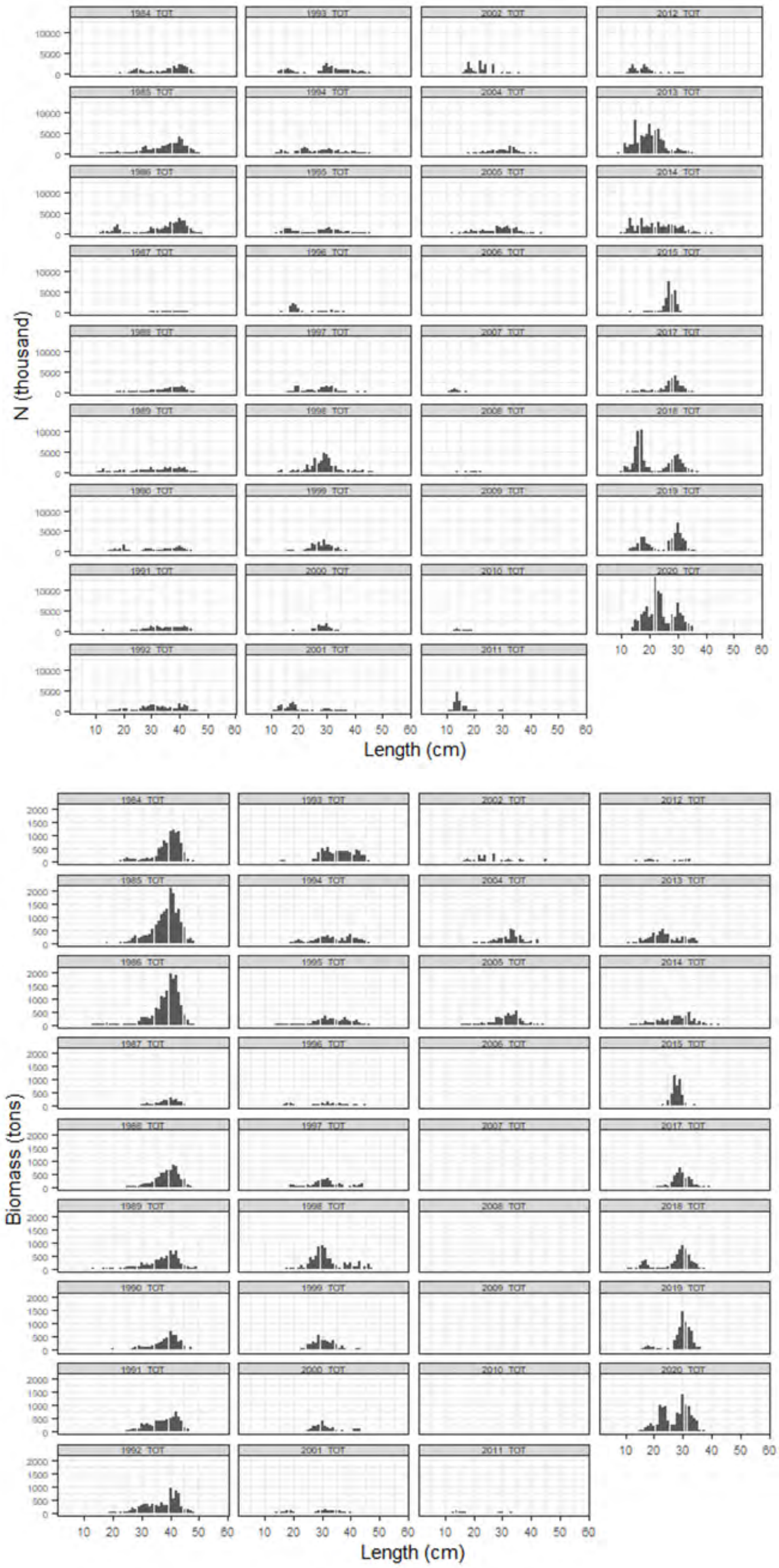


Figure 6.2.8. Length distributions in numbers (upper panels) and biomass (lower panels) for greater silver smelt in the North Sea/Skagerrak survey.

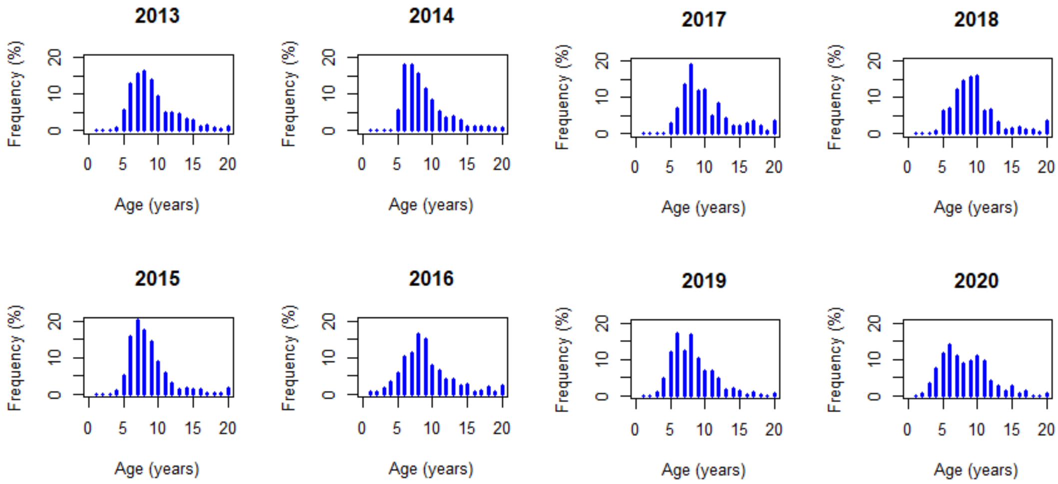


Figure 6.2.9. Greater silver smelt in 1, 2, 3, and 4. Age composition of Norwegian landings samples, 2013-2020.

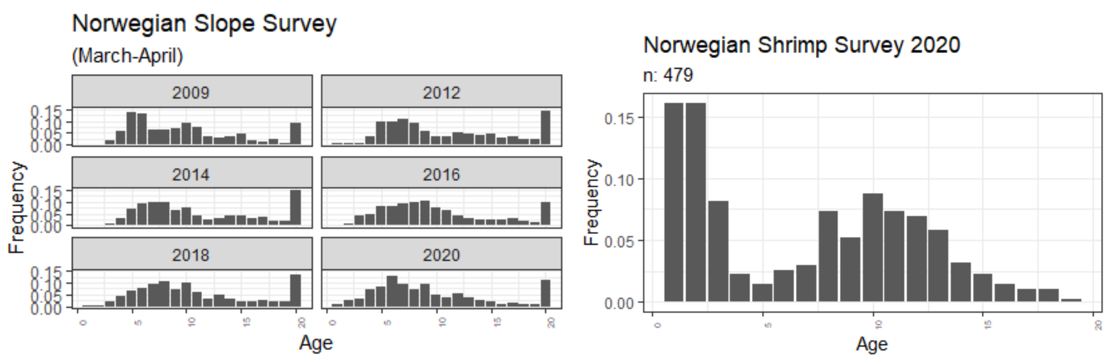


Figure 6.2.10. Age distributions of greater silver smelt from the Norwegian slope survey 2009-2020 (left panels) and the Norwegian Shrimp survey in North Sea/Skagerrak 2020 (right panel). Age 20 is a plus group.

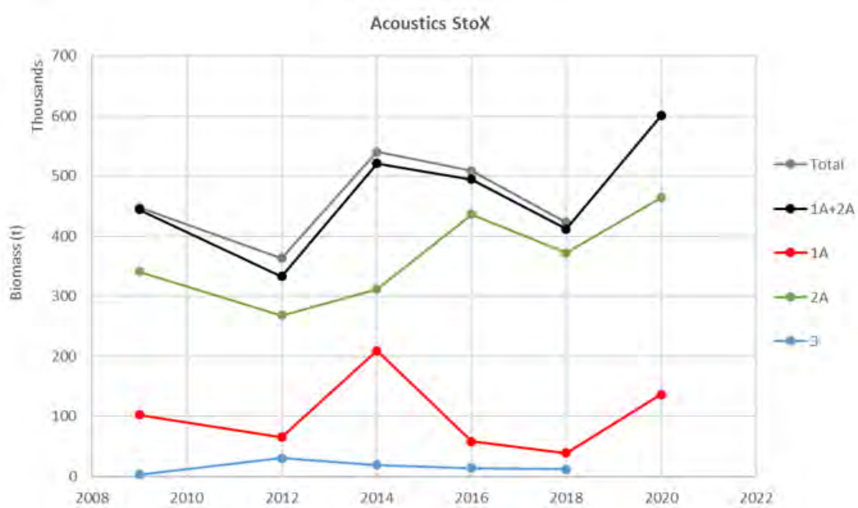


Figure 6.2.11. Acoustic index from the Norwegian Slope survey in subareas 1 and 2. Biomass estimates for different strata (1A, 2A and 3) in the survey are shown, as well as summed estimates for 1A and 2A and total for all strata. Stratum 3 was not covered in 2020 due to covid19 complications in the conduct of the survey.

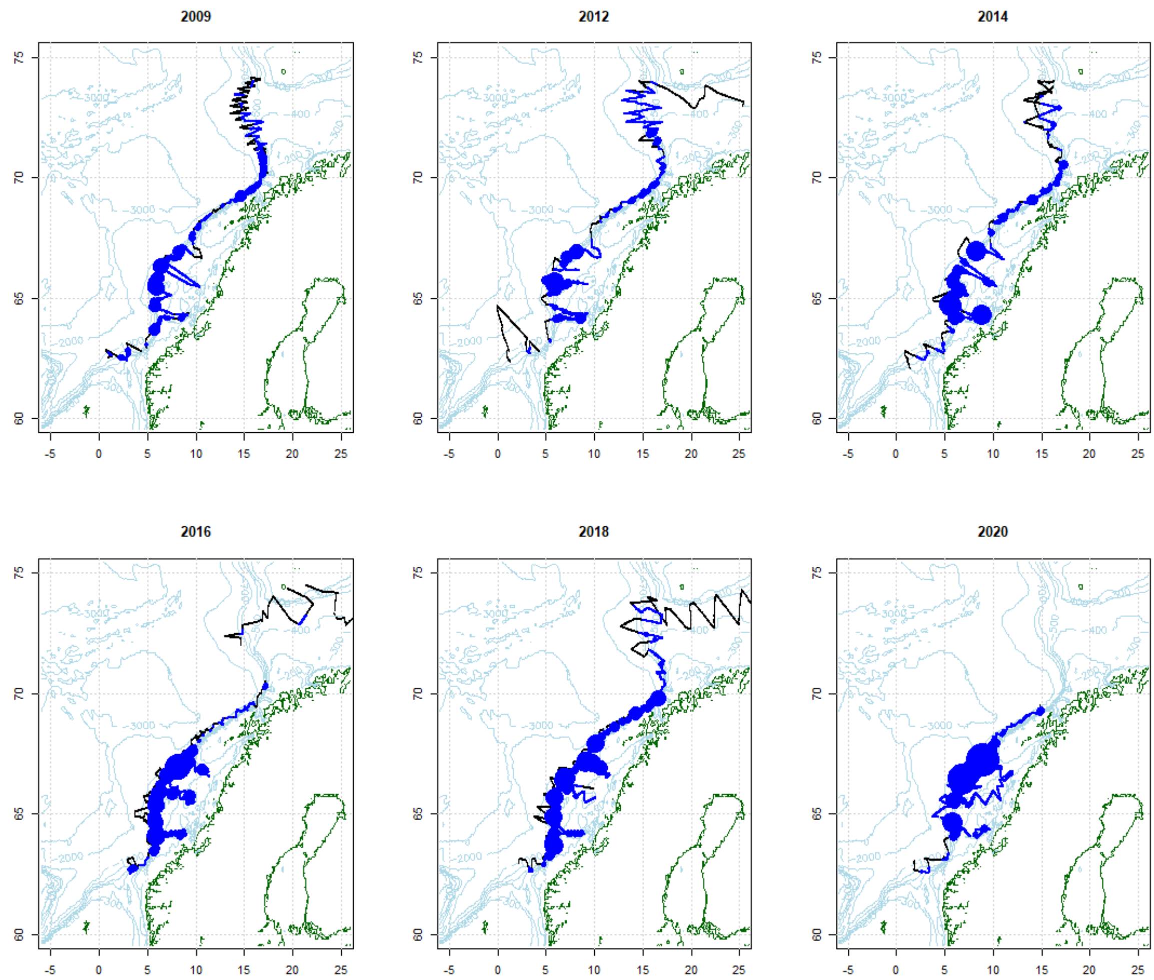


Figure 6.2.12. Greater silver smelt in Division 2.a. Acoustic backscattering strength estimates (SA-values) in Norwegian continental shelf and slope surveys March–April 2009, 2012, 2014, 2016, 2018 and 2020.

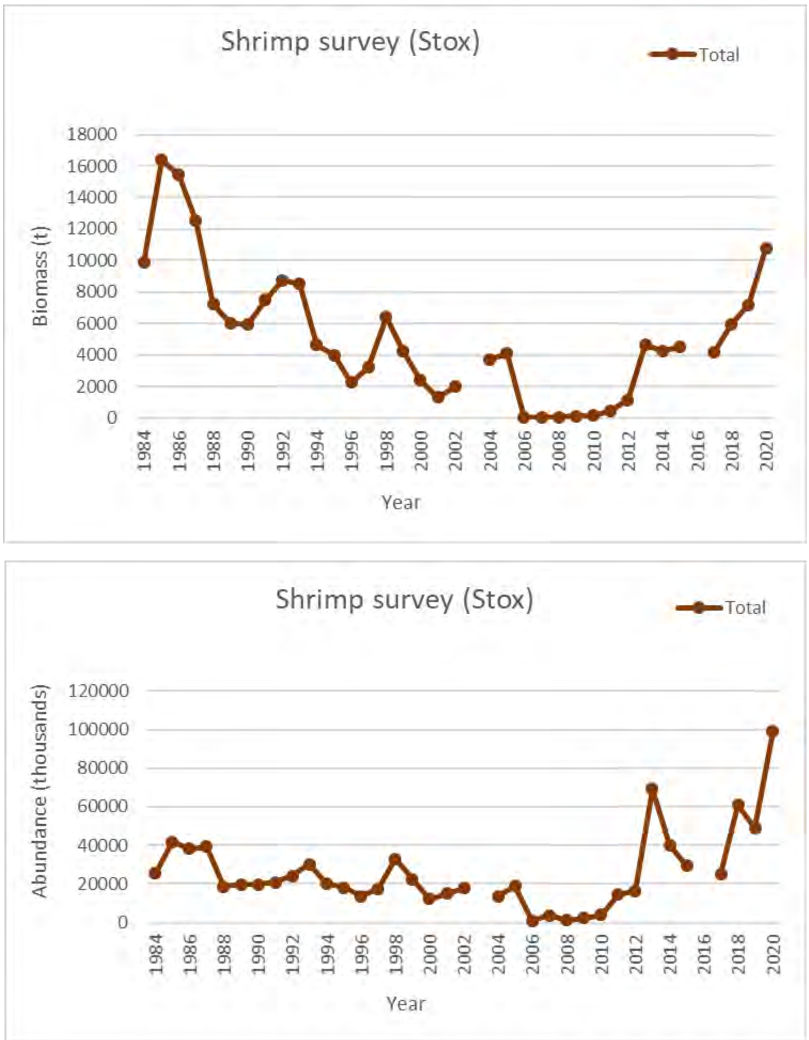


Figure 6.2.13. Swept area total biomass index (upper panel) and swept area total abundance index (lower panel) for greater silver smelt in the shrimp survey in North Sea/Skagerrak. Seasonality of the survey has varied through the years. It was conducted in October 1984-2002, May 2004-2005, February 2006-2007 and in January since then.

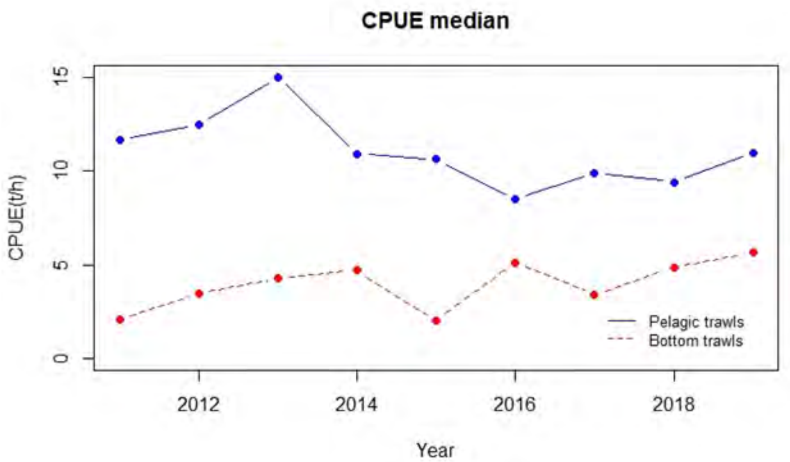
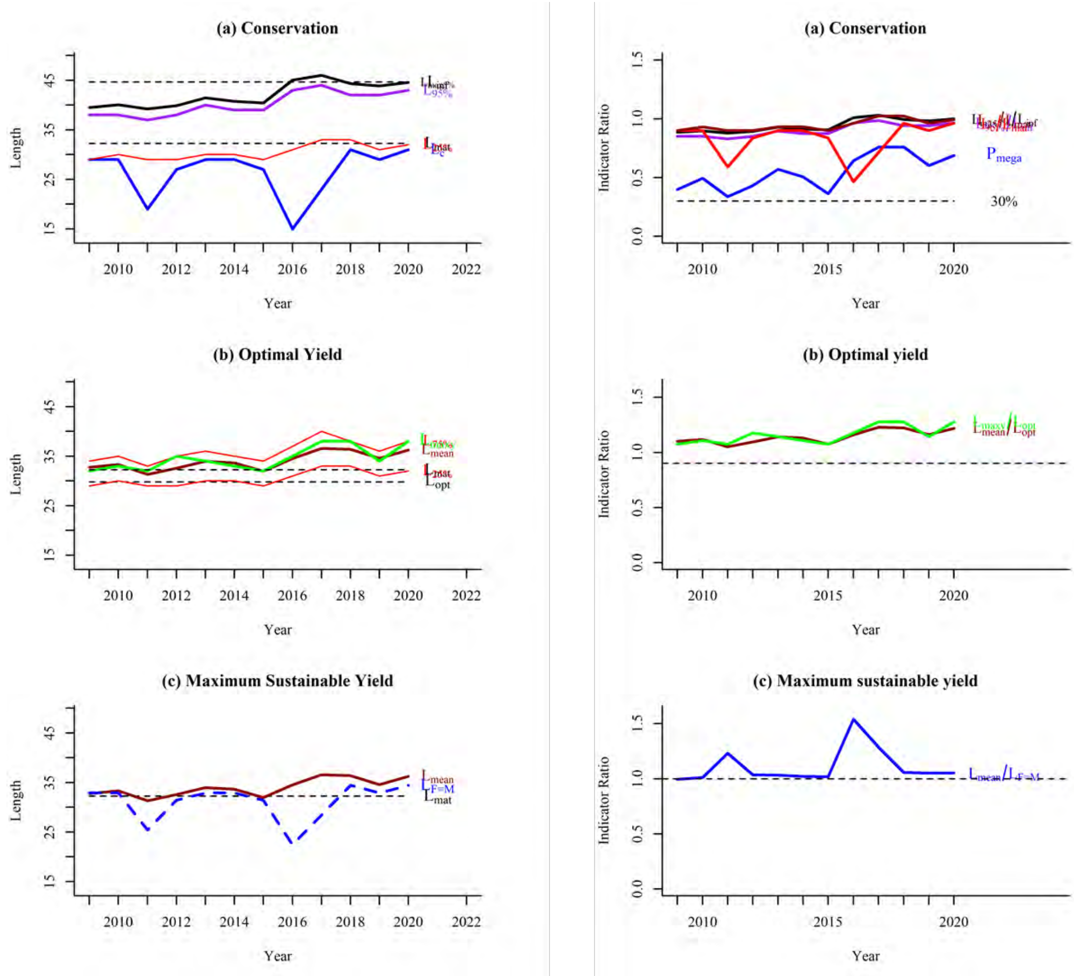


Figure 6.2.14. CPUE from the Norwegian direct fisheries on greater silver smelt in Division 2.a, based on electronic log-books 2011-2019.



Traffic light indicators

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/$L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2018	0.96	1.02	0.99	0.76	1.22	1.06
2019	0.90	0.96	0.98	0.60	1.16	1.05
2020	0.96	0.99	1.00	0.69	1.22	1.05

Figure 6.2.15. Results from the length-based indicator method (LBI) used for the evaluation of the exploitation status in subareas 1 and 2. The exploitation status is below $F_{MSYproxy}$ when the index ratio $L_{mean}/L_{F=M}$ value for the maximum sustainable yield (c) is higher than 1.

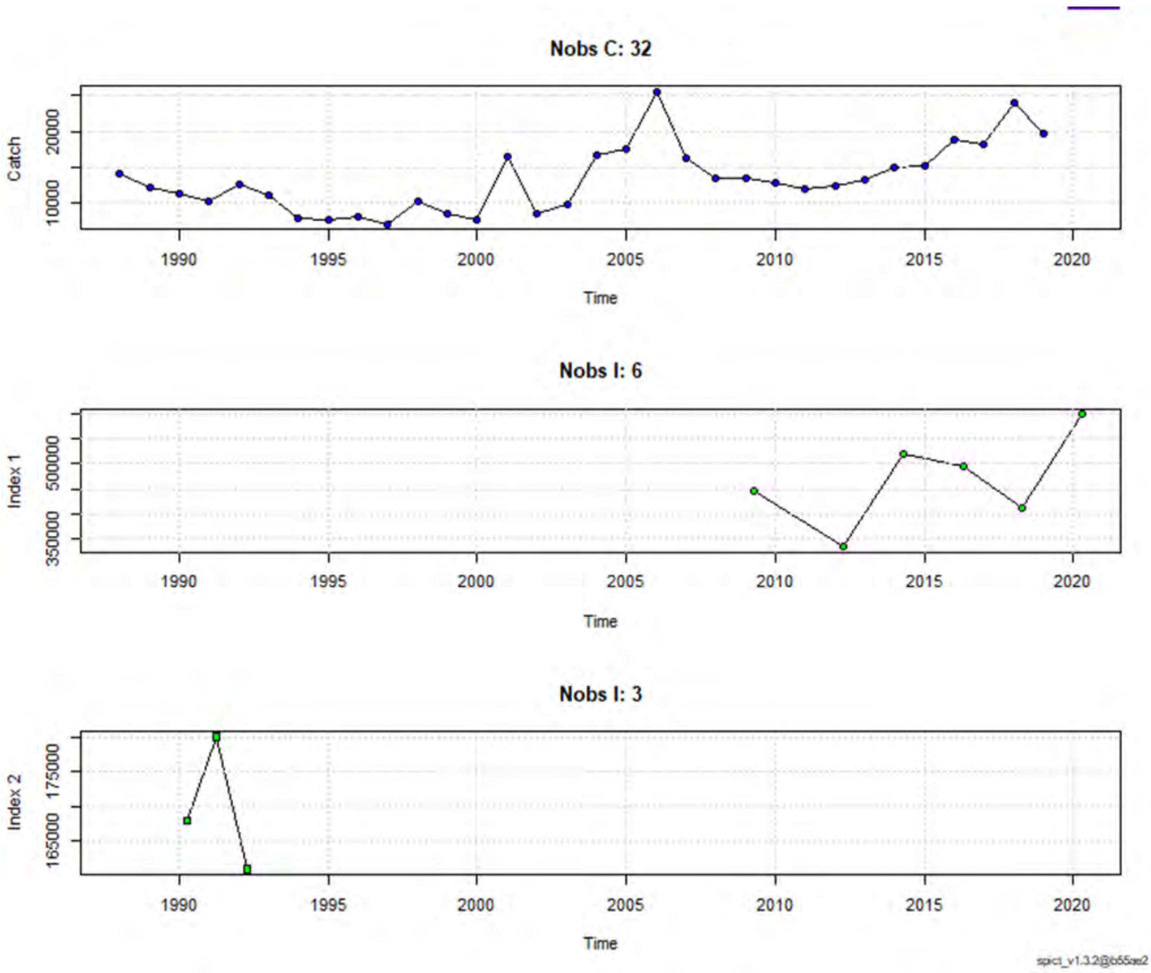


Figure 6.2.16. Input data to the SPiCT analysis. Uppermost panel is catch in tonnes, midpanel is acoustic index from the Norwegian slope survey and lowest panel is acoustic index from surveys at the slope in the 1990s.

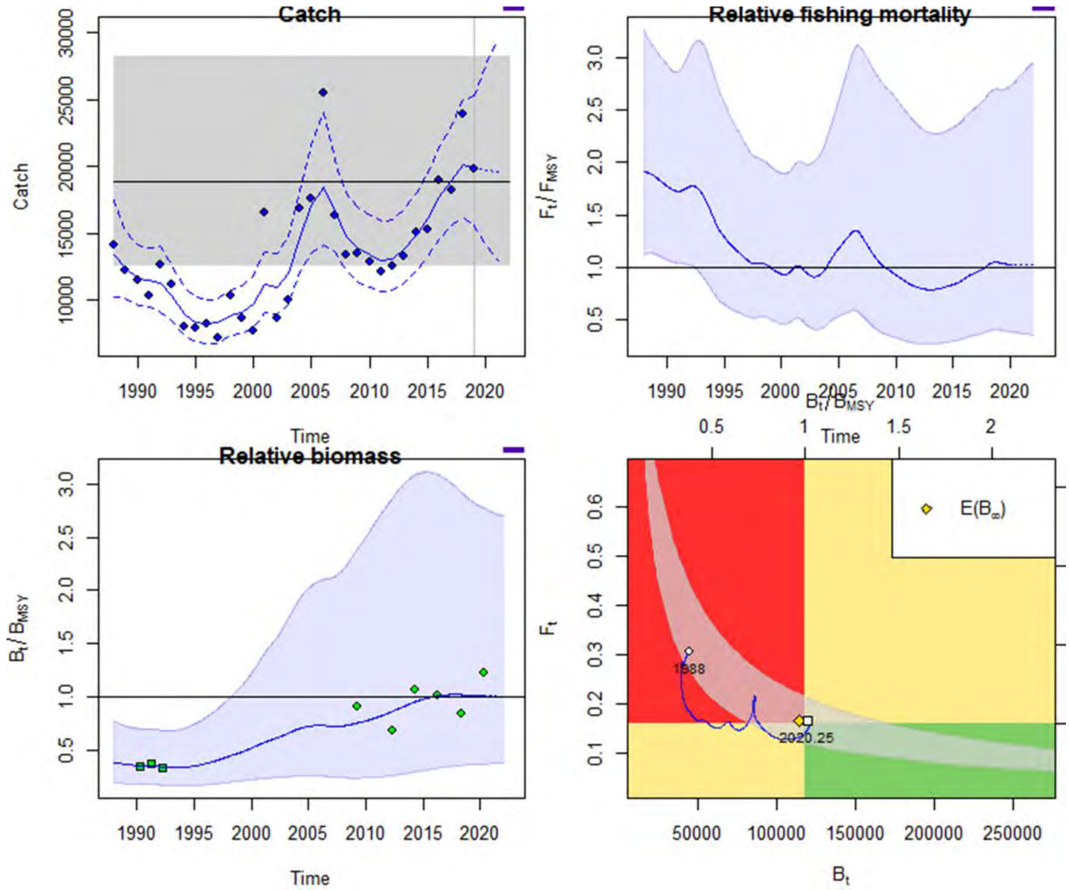


Figure 6.2.17. Results from the SPiCT analysis

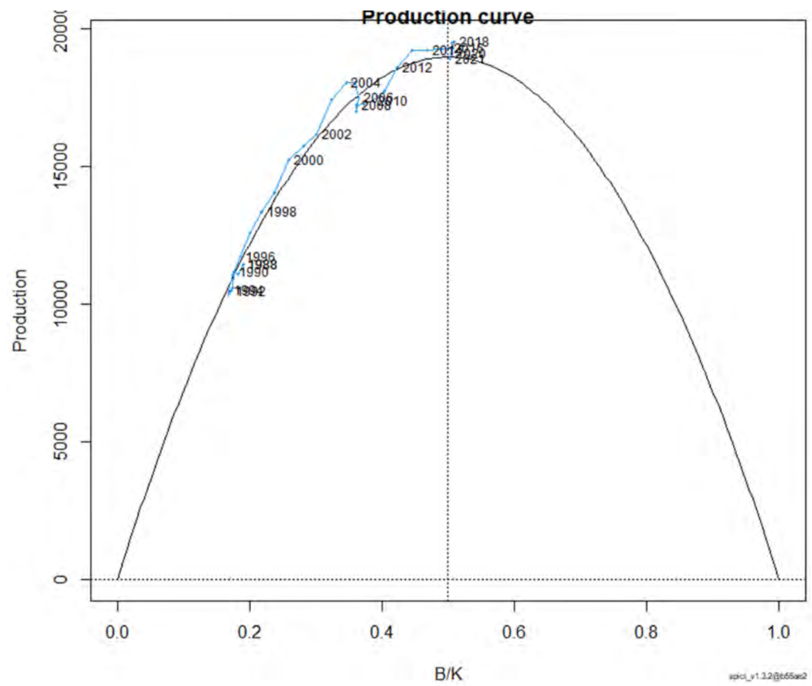


Figure 6.2.18 Production curve from the SPiCT analysis.

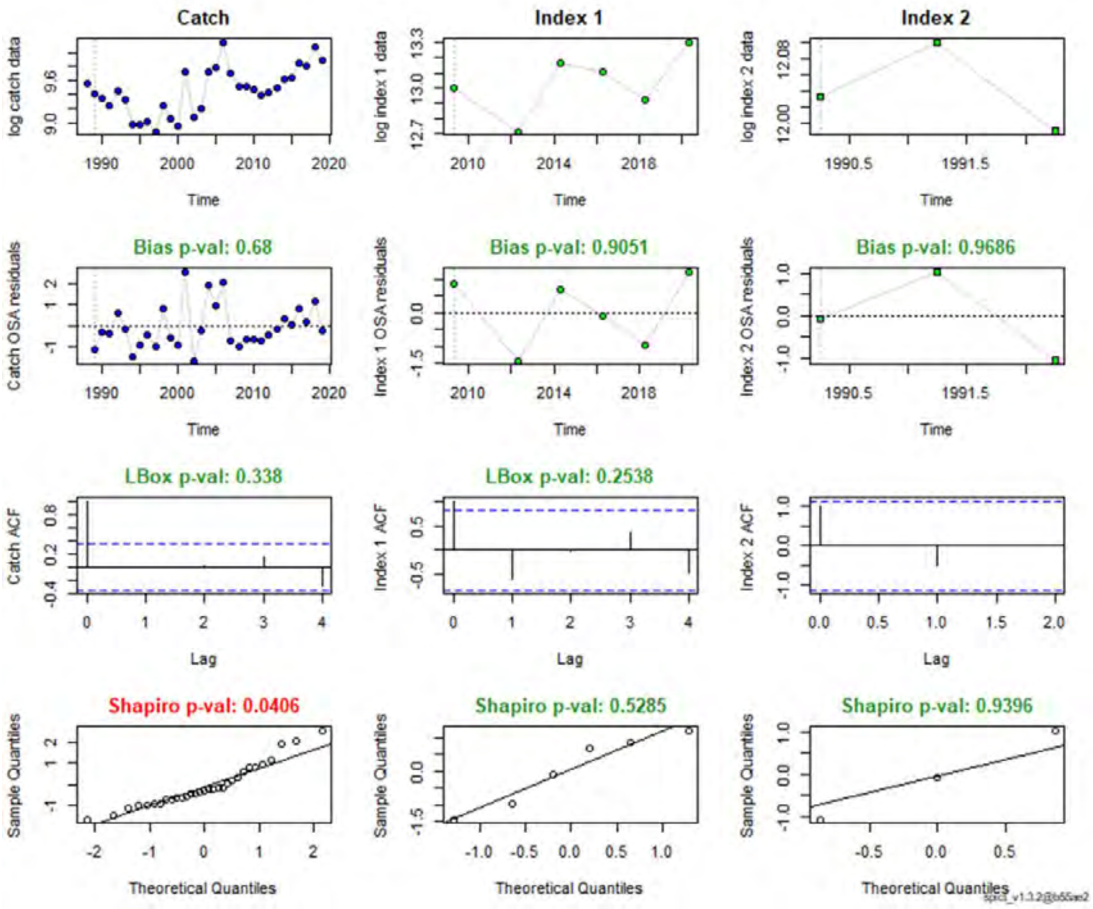


Figure 6.2.19. Diagnostics from the SPiCT analysis.

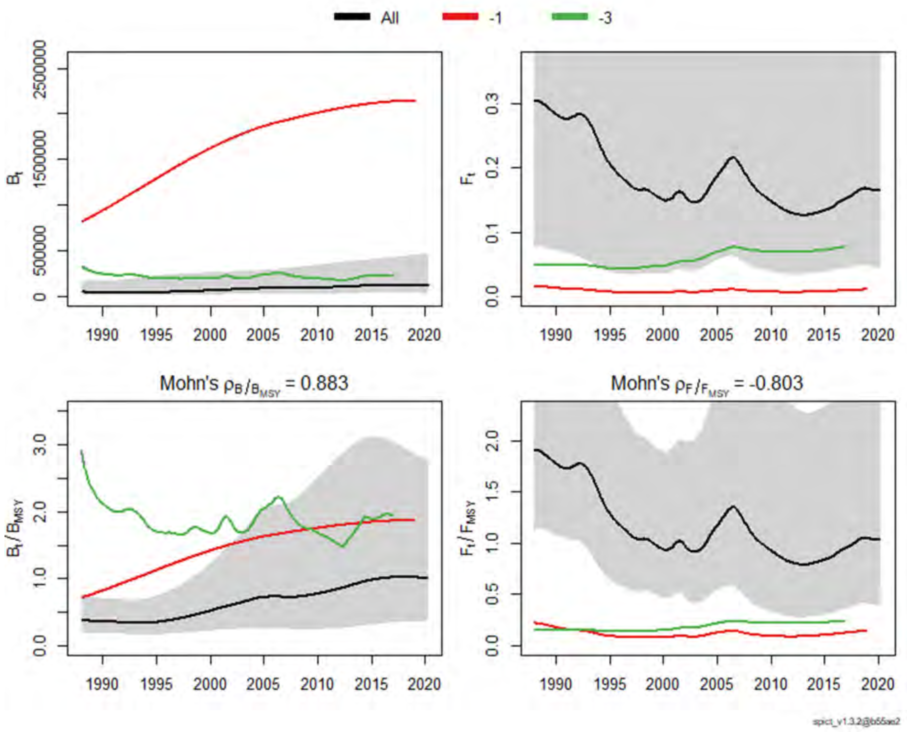


Figure 6.2.20. Retrospective analysis from the SPiCT analysis.

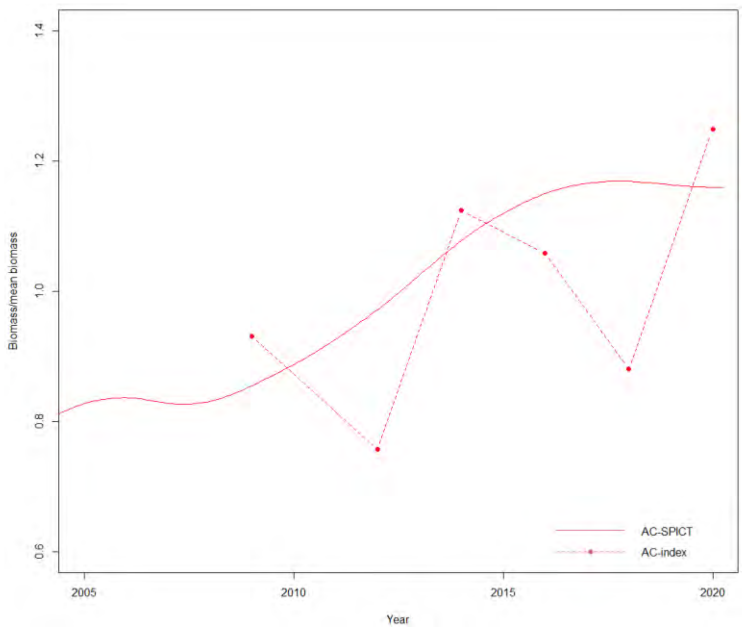


Figure 6.2.21. Relative biomass (estimated biomass/mean) from the SPiCT analysis with the acoustic index from the Norwegian slope survey.

6.3 Greater silver smelt (*Argentina silus*) in 5.a and 14

6.3.1 The fishery

Greater silver smelt is mostly fished along the south and southwest coast of Iceland, at depths between 500 and 800 m, as targeted fishing is only allowed at depths greater than 400 m (Figure 6.3.1). Greater silver smelt has been caught in bottom trawls for years as a bycatch in the redfish fishery. Only small amounts were reported prior to 1996 as most of the greater silver smelt was discarded. However, discarding is not considered significant because of the relatively large mesh size used in the redfish fishery. Since 1997, a directed fishery for greater silver smelt has been ongoing and the landings have increased significantly in the past (Table 6.3.1).

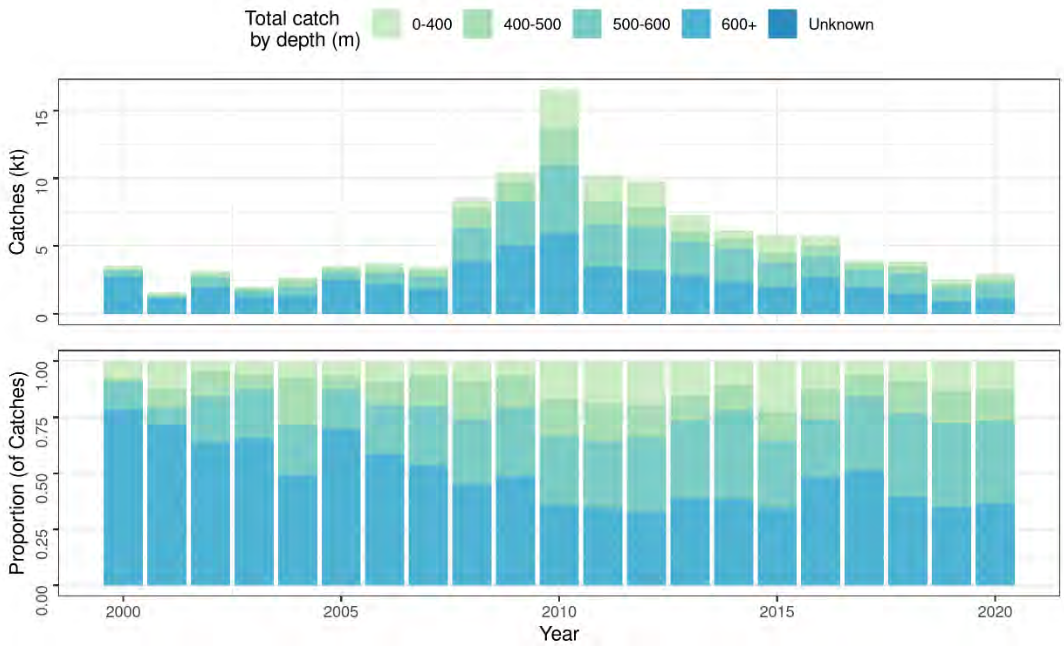


Figure 6.3.1: Greater silver smelt in 5.a and 14. Depth distribution of catches in 5.a according to Icelandic logbooks. All gear combined.

Table. 6.3.1. Greater silver smelt in 5.a and 14. Landings (tonnes) records from the Icelandic directorate of Fisheries and Greenland (WD05, annexed to this report).

Year	Inside the NEAFC RA	Outside the NEAFC RA		Landings (tonnes)
		Section 5.a	Section 14.b	
1988				206
1989				8
1990				112
1991				247
1992				657
1993				1255

Year	Inside the NEAFC RA	Outside the NEAFC RA		Landings (tonnes)
1994				613
1995				492
1996				808
1997				3367
1998				13387
1999				6704
2000				5657
2001				3043
2002				4960
2003				2686
2004				3637
2005				4481
2006				4775
2007				4226
2008				8778
2009				10829
2010				16428
2011				10515
2012				9290
2013	0	7154		7154
2014	0	7241	4	7245
2015	0	6056	12	6068
2016	0	5646	16	5662
2017	0	3946	666	4612
2018	0	4035	425	4460
2019	0	3208	0.5	3209
2020	0	3775	22	3797

6.3.2 Fleets

Since 1996 between 20 and 39 trawlers have annually reported catches of greater silver smelt in 5.a (WGDEEP 2019, Table 6.3.2). The trawlers participating in the greater silver smelt fishery also target redfish (*Sebastes marinus* and *S. mentella*) and to a lesser extent Greenland halibut and blue ling. The number of hauls peaked in 2010, but the number of hauls have decreased since then in line with lower total catches. In most years, over 50% of the greater silver smelt catches were taken in hauls where the species composed more than 50% of the catch (Table 6.3.2).

Table 6.3.2: Greater silver smelt in 5.a. Information on the fleet reporting catches of greater silver smelt.

Year	Number of trawlers	Number of hauls	Reported catch (kg)	No. hauls which GSS > 50% of catch	Proportion of reported catch in hauls where GSS > 50%
1987	1	14	4740	3	0.6751055
1988	2	146	224700	50	0.5718736
1990	1	24	46350	10	0.6256742
1991	13	114	74210	7	0.2641153
1992	23	275	230782	16	0.2032221
1993	25	317	772031	98	0.7282091
1994	16	151	304550	52	0.7832868
1995	24	200	180736	21	0.4039040
1996	22	307	259660	29	0.4039898
1997	26	874	2281654	355	0.8216162
1998	40	2683	11388707	1991	0.9465763
1999	25	1509	4563652	810	0.8485031
2000	23	1301	3549812	608	0.7971971
2001	26	794	1606420	245	0.6920637
2002	32	1160	3158313	468	0.7440289
2003	30	1176	2005477	213	0.4732091
2004	27	1052	2732879	292	0.6527805
2005	30	1388	3557625	335	0.7069759
2006	31	1554	3735916	355	0.6897529
2007	27	1275	3469927	416	0.7179114
2008	31	3256	8568592	848	0.6478629
2009	34	3555	10425146	1010	0.6804055
2010	36	4846	16499826	1821	0.7271470
2011	34	3309	10237373	961	0.7151100
2012	31	3395	9775676	988	0.7103783
2013	31	2743	7246715	609	0.6418890

Year	Number of trawlers	Number of hauls	Reported catch (kg)	No. hauls which GSS > 50% of catch	Proportion of reported catch in hauls where GSS > 50%
2014	24	2363	6195337	487	0.6076312
2015	24	2195	5835439	356	0.5735490
2016	26	2096	5718623	385	0.5926304
2017	21	1363	3894310	236	0.5844221
2018	20	1440	3892702	215	0.4785869
2019	28	1169	2569762	143	0.5063064
2020	25	1170	2968000	174	0.4750000

6.3.3 Targeting and mixed fisheries issues in the Greater Silver Smelt fishery in 5.a

6.3.3.1 Mixed fisheries issues: species composition in the fishery

Redfish spp. (*Sebastus marinus* and *S. mentella*) are the main bycatch species in the mixed fishery encompassing greater silver smelt. Other species of lesser importance are Greenland halibut, blue ling and ling. Other species than these rarely exceed 10% of the bycatch in the greater silver smelt fishery in 5.a (ICES 2014).

6.3.3.2 Spatial distribution of catches through time

Spatial distribution of catches (5.a and 14) in 2000– 2020 is presented in Figure 6.3.2 and Figure 6.3.3. Most of the catches have been from the southern edge of the Icelandic shelf. However, since 1993, there has been a gradual increase in the proportion caught in the western area and even in the northwestern area. The likely reason for this is that the fleet focusing on redfish and Greenland halibut in more northern regions also takes a few hauls of greater silver smelt in the area (Figure 6.3.2).

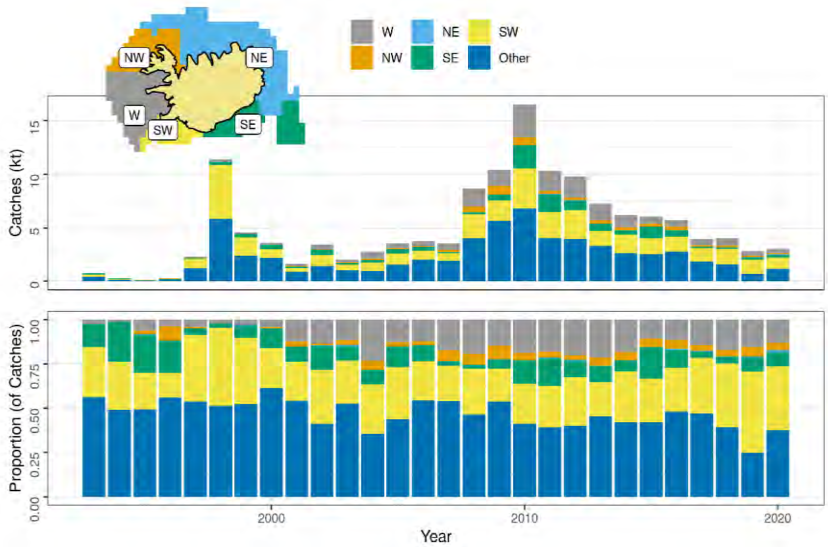


Figure 6.3.2: Greater silver smelt in 5.a and 14. Spatial distribution of catches defined by regions deeper than 400 m by year (See stock annex for details). Above are the catches on absolute scale and below in proportions. All gears combined.

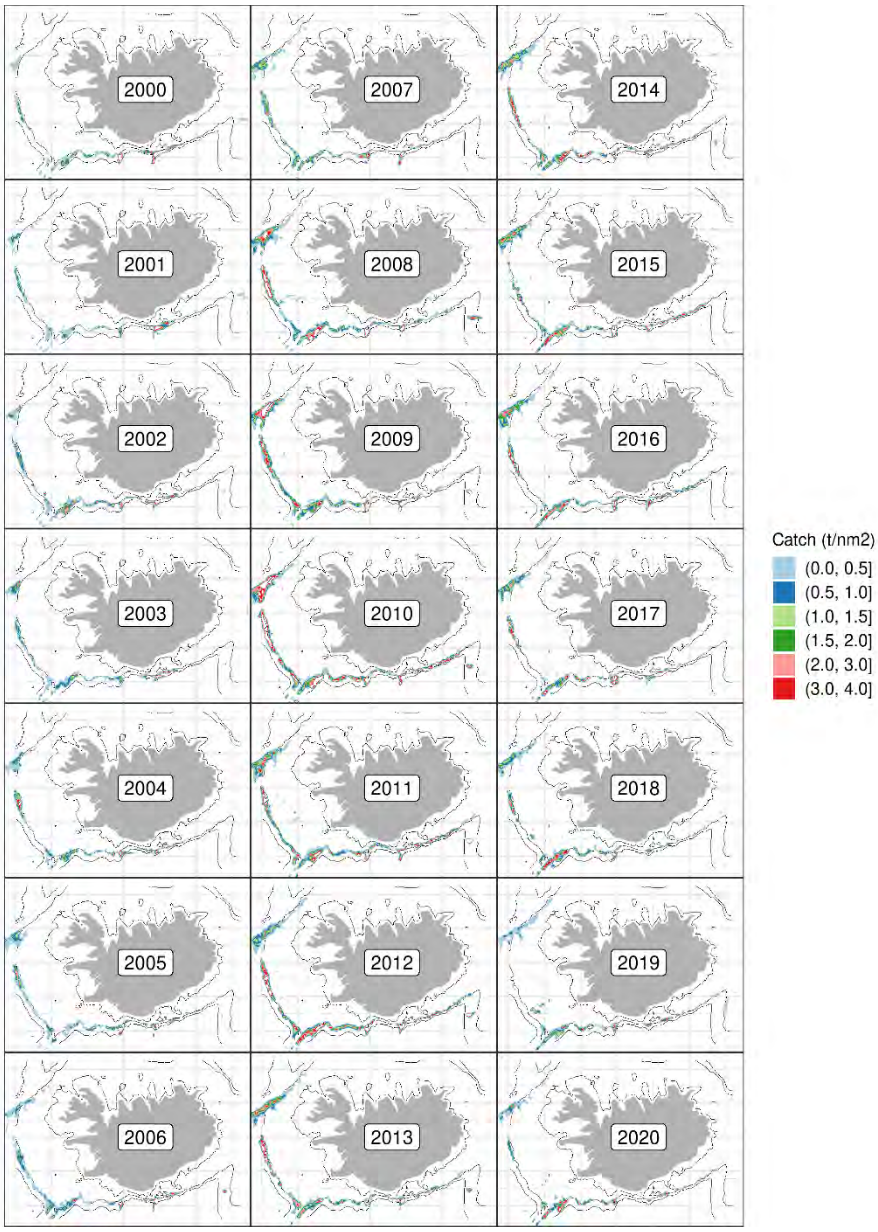


Figure 6.3.3: Greater silver smelt in 5.a and 14. Spatial distribution of the Icelandic fishery catches as reported in logbooks. All gears combined.

6.3.4 Landing trends

Landings of Greater Silver Smelt are presented in Table 6.3.1 and Figure 6.3.4. Since directed fishery started in 1997–1998, the landings increased from 800 t in 1996 to 13 000 t in 1998. Between 1999 and 2007 catches varied between 2 600 to 6 700 t. Since 2008 landings have increased substantially, from 4 200 t in 2007 to almost 16 500 t in 2010. In 2011 landings started to decrease due to increased management actions, and landings in 2020 amounted to approximately 3797 tonnes in 14 and 5.a. Substantial landings were reported in Greenlandic waters in 2017 and 2018; however, these exploratory directed fisheries appear to have ceased in 2019 but should be monitored for reappearance.

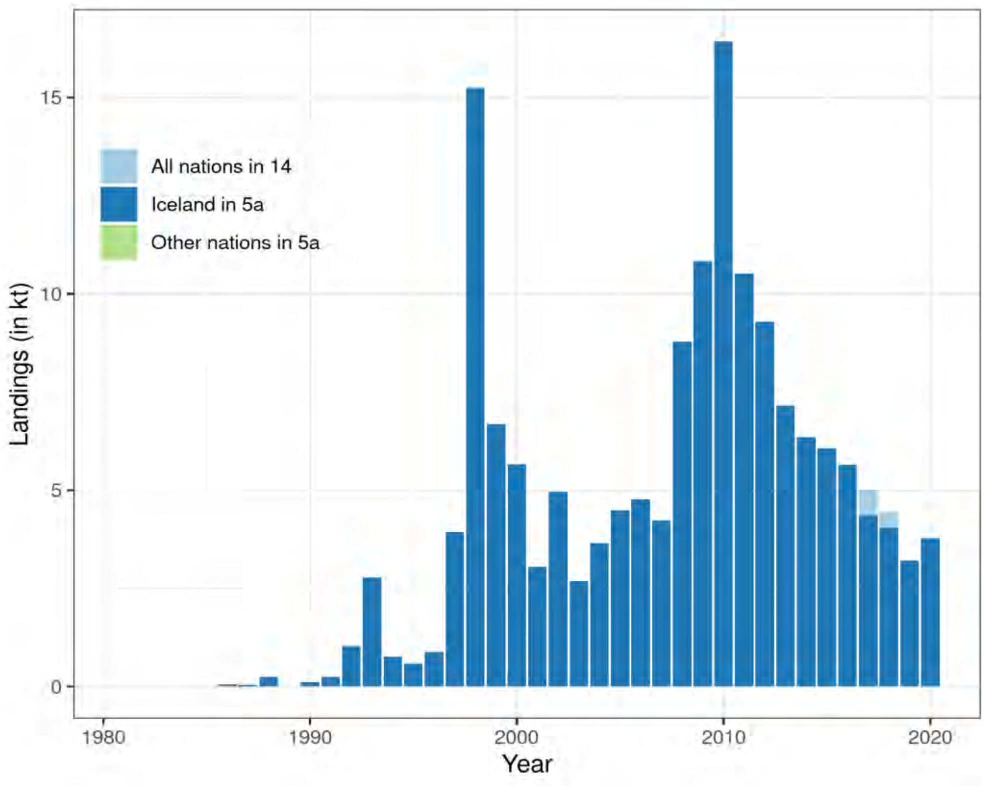


Figure 6.3.4: Greater silver smelt in 5.a and 14. Nominal landings. 23 tonnes were landed by foreign vessels (England and Wales) in 1999, which is the only year of catches reported by foreign vessels.

6.3.5 Data available

In general sampling is considered representative from commercial catches, as one of the requirements of owning a fishing license for greater silver smelt is the retention of scientific samples (Table 6.3.3). Samples were only obtained from bottom trawls. The sampling does seem to cover the spatial and temporal distribution of catches. The sampling coverage in 2020 is shown in Figure 6.3.5. However, recent years have experienced a large decline in sampling. No age data were collected in 2019.

Table 6.3.3: Greater silver smelt in 5.a. Summary of sampling intensity and overview of available data.

Year	No. length samples	No. length measurements	No. otolith samples	No. otoliths	No. otoliths aged
1997	48	4991	31	1447	1059
1998	148	15557	114	6966	889
1999	58	4163	44	2180	82
2000	27	2967	18	1011	113
2001	10	489	6	245	17
2002	21	2270	10	360	127
2003	63	5095	13	425	
2004	34	996	7	225	84
2005	49	3708	14	772	

Year	No. length samples	No. length measurements	No. otolith samples	No. otoliths	No. otoliths aged
2006	29	4186	13	616	525
2007	14	2158	8	285	272
2008	44	3726	39	1768	1387
2009	53	5701	36	1746	1574
2010	134	16351	68	3370	3120
2011	63	6866	40	1953	1774
2012	43	4440	31	1492	603
2013	47	4925	34	710	704
2014	39	4709	16	350	340
2015	11	1275	8	221	217
2016	45	5879	13	285	283
2017	29	3466	21	430	416
2018	12	1437	9	185	181
2019	8	1010	0	0	0
2020	8	1566	2	50	25

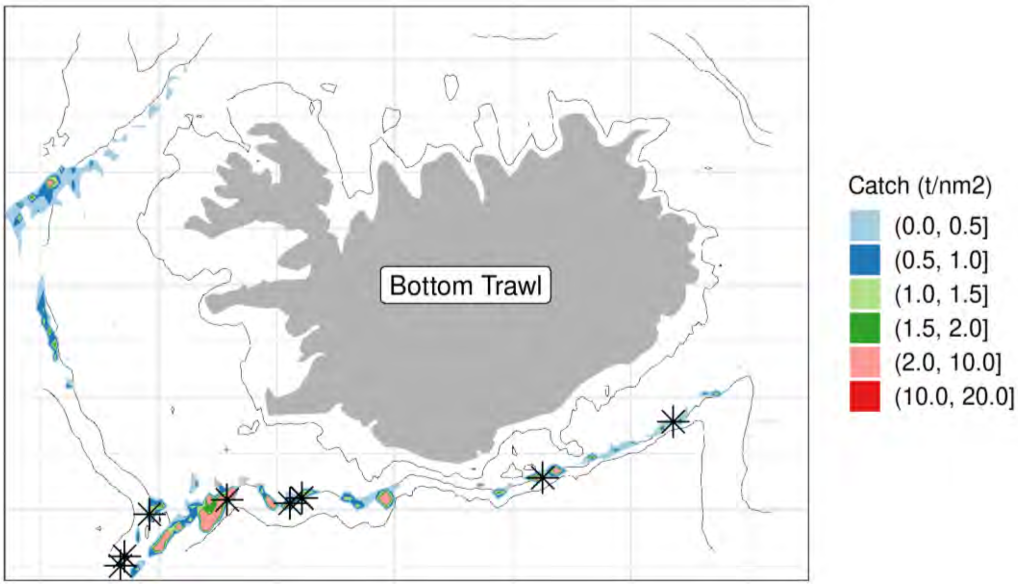


Figure 6.3.5: Greater silver smelt in 5.a and 14. Fishing grounds in 2020 as catches reported in logbooks (tiles) and positions of samples taken from landings (asterisks).

6.3.6 Landings and discards

Landings by Icelandic vessels are given by the Icelandic Directorate of Fisheries. Discarding is banned in Icelandic waters, and currently there is no available information on greater silver smelt discards. It is however likely that unknown quantities of greater silver smelt were discarded prior to 1996.

6.3.7 Catch, effort and research vessel data

6.3.7.1 Catch per unit of effort and effort data from commercial fisheries

At WKDEEP 2010 a glm cpue series was presented (WKDEEP 2010, GSS-05), however because of strong residual patterns the group concluded that the glm-cpue series was not suitable to use as an indicator of stock trends. The cpue is not considered to represent changes in stock abundance as the fishery is mostly controlled by market factors, oil prices and quota status in other species, mainly redfish.

6.3.7.2 Icelandic survey data

The Icelandic spring groundfish survey, which has been conducted annually in March since 1985, gives trends on fishable biomass of many exploited stocks on the Icelandic fishing grounds. In total, about 550 stations are taken annually at depths down to 500 m. The survey area does not cover the most important distribution area of the greater silver smelt fishery in 5.a and is therefore not considered representative of stock biomass. The survey may be indicative of recruitment; however, the data have not been explored in sufficient detail to be used for this purpose. In addition, the autumn survey was commenced in 1996 and expanded in 2000. A detailed description of the autumn groundfish survey is given in the stock annex for greater silver smelt in 5.a. The survey is considered representative of stock biomass of greater silver smelt since it was expanded in 2000. Figure 6.3.6 gives trends in biomass density and juvenile density (numbers) for the spring survey in 1985 to 2021 and for the autumn survey in 2000 to 2020. Due to industrial action in 2011 the autumn survey was cancelled after about one week of survey time. Greater Silver Smelt is among the most difficult demersal fish stocks to get reliable information on from bottom-trawl surveys. This is in large part because most of the greater silver smelt caught in the survey is taken in few but relatively large hauls. This can result in very high indices with large variances particularly if the tow-station in question happens to be in a large stratum with relatively few tow-stations. No substantial changes in proportional catch by area is seen in general (Figure 6.3.7).

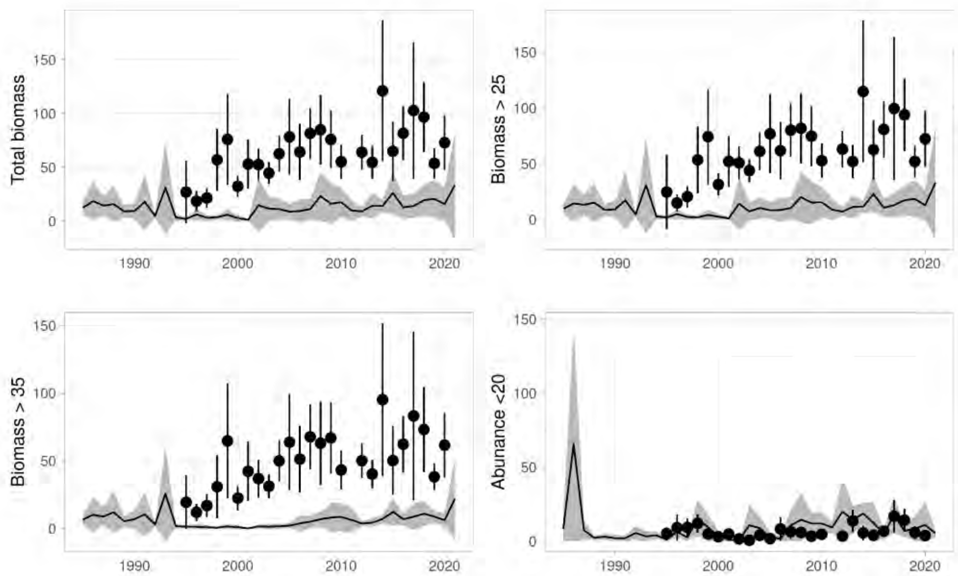


Figure 6.3.6. Greater silver smelt in 5.a and 14. Indices calculated from the Icelandic spring survey (black lines and shaded area) and from the autumn survey (dots and vertical lines). Vertical lines and shaded area represent +/- 1 standard error.

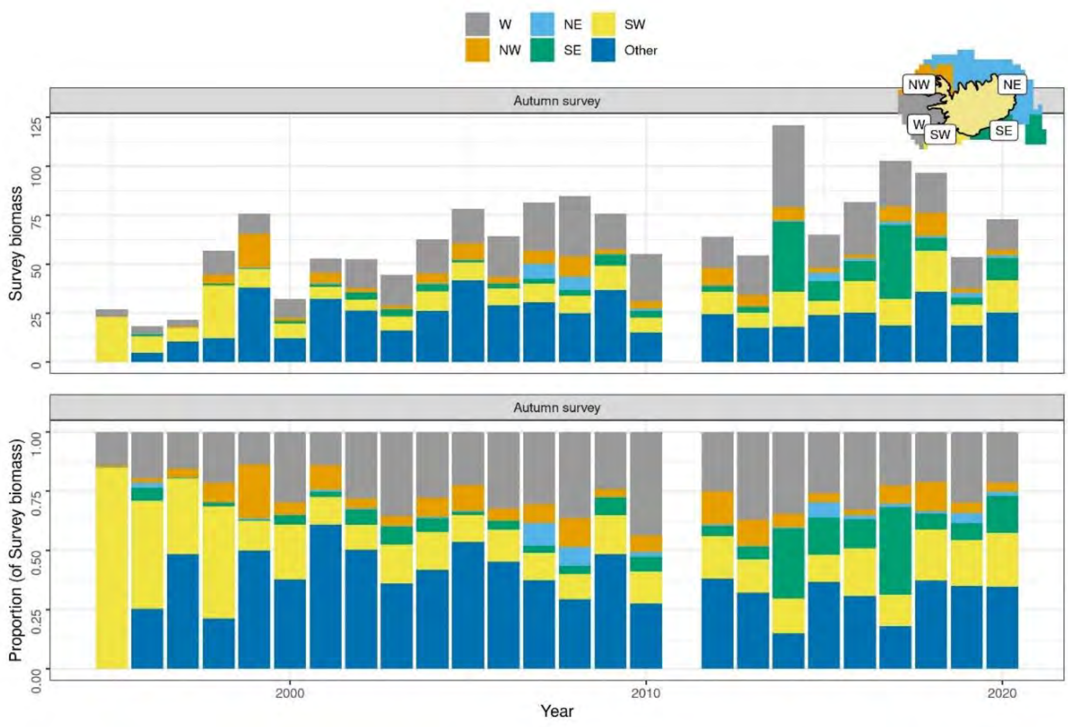


Figure 6.3.7: Greater silver smelt in 5.a and 14. Estimated survey biomass in the autumn survey by year from different parts of the continental shelf (upper panel) and as a proportion of the total (lower panel)

6.3.7.3 Length compositions

Table 6.3.2 gives the number of samples and measurements available for calculations of catch in numbers of Greater Silver Smelt in 5.a. Length distributions from autumn survey and commercial samples are presented in Figure 6.3.8 and Figure 6.3.9 respectively. Length distribution from the autumn survey are rather stable, with 202 being close to the long-term average (Figure 6.3.8).

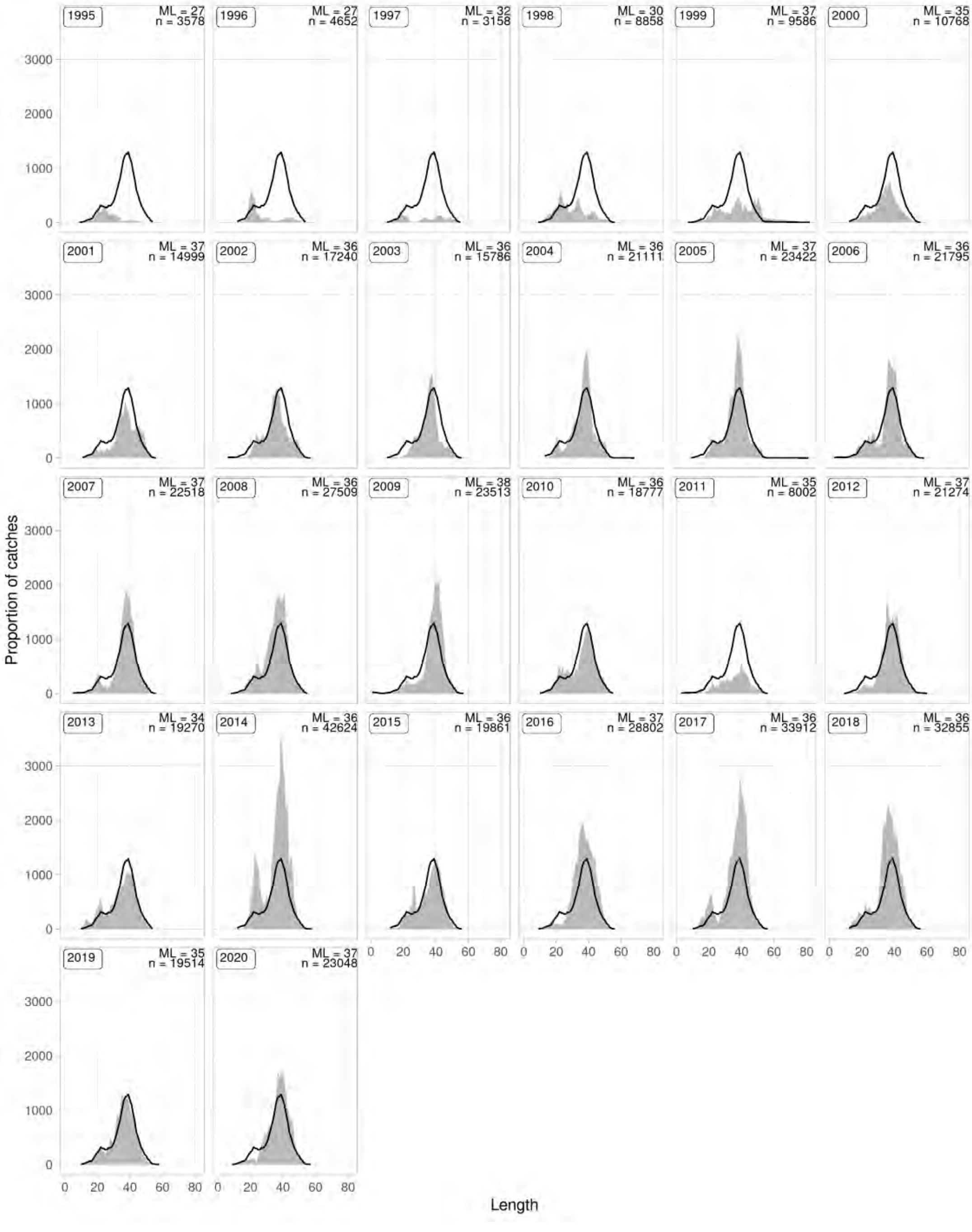


Figure 6.3.8: Greater silver smelt in 5.a and 14. Length distribution from the autumn survey. The black line shows the mean for all years.

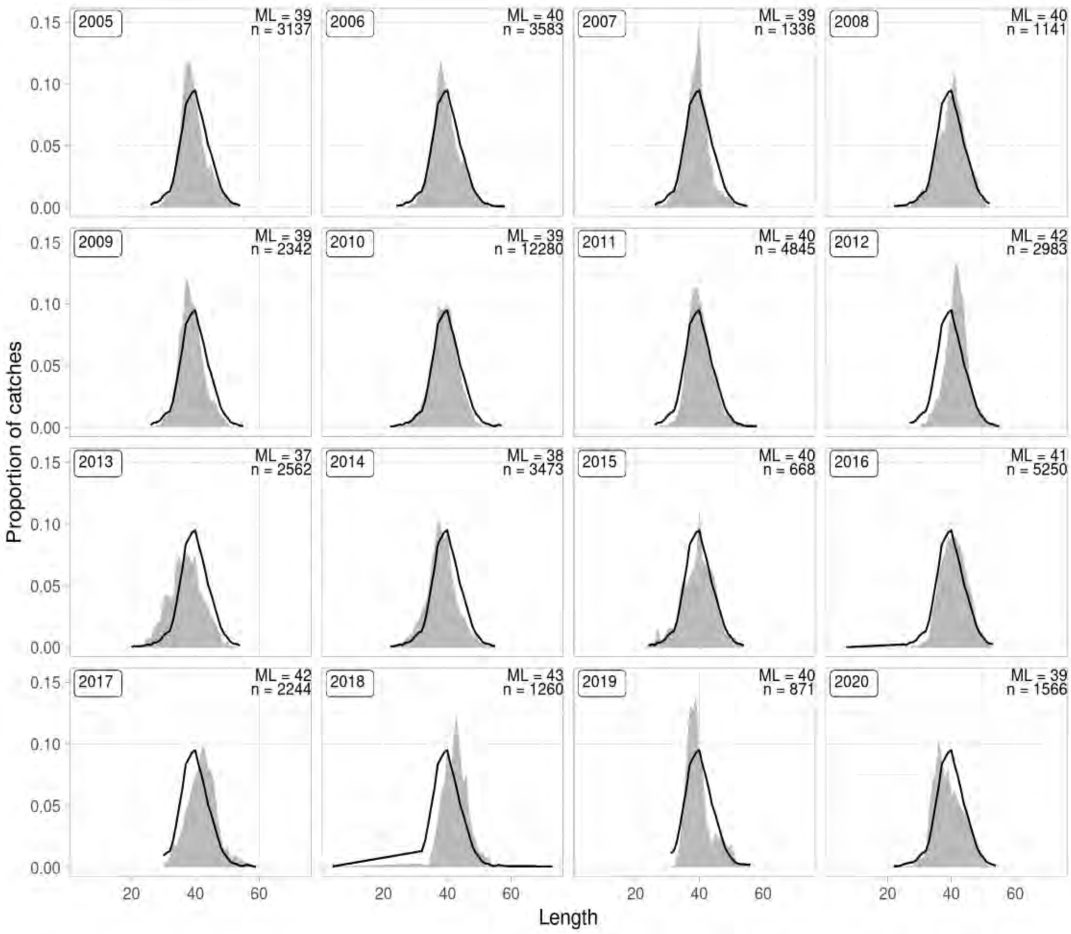


Figure 6.3.9: Greater silver smelt in 5.a and 14. Length distributions from commercial catches.

6.3.7.4 Age compositions

Table 6.3.2 gives the number of samples and measurements available for calculations of catch in numbers of greater silver smelt in 5.a. Age distributions estimated as catch in numbers are given in Figure 6.3.10 & 6.3.11.

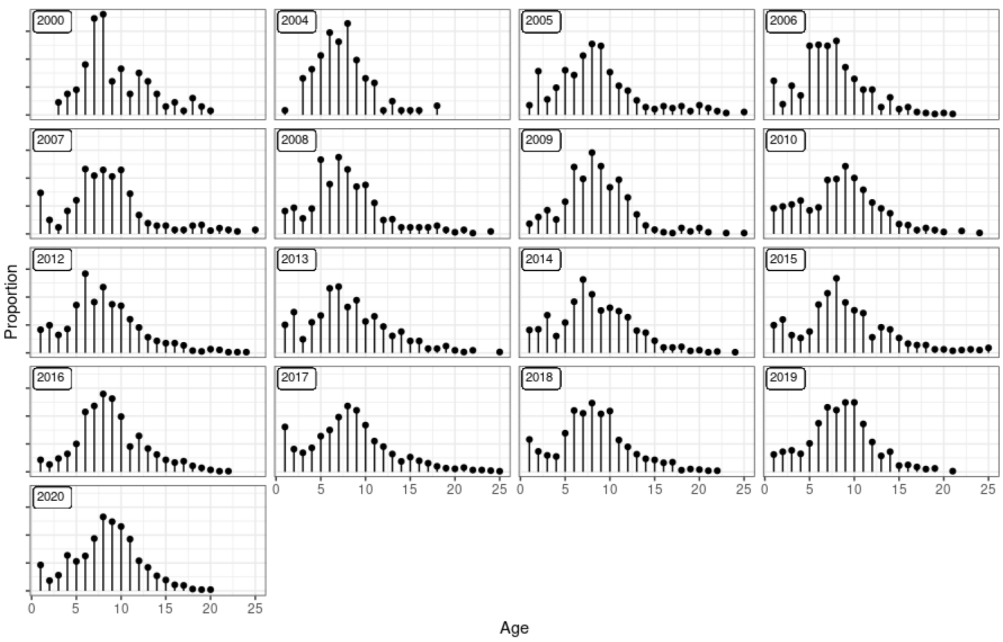


Figure 6.3.10: Greater silver smelt in 5.a and 14. Age distributions in proportions in 5.a from the Icelandic autumn survey.

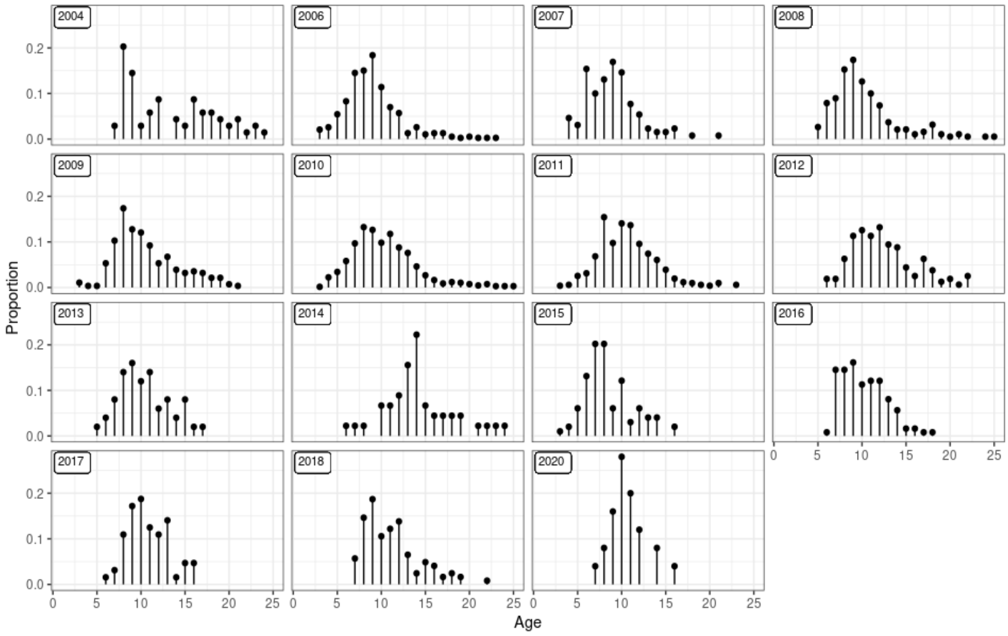


Figure 6.3.11: Greater silver smelt in 5.a and 14. Catch in numbers at age. Estimates for 2002 are based on limited number of aged otoliths. No age data are available for 2019.

6.3.7.5 Weight at age

Biological data from spring, fall, and commercial data were combined to analyse growth. Von Bertalanffy growth curves were fitted and plotted within a series of time periods, including 2016–2019, 2011–2015, 2006–2010, 2001–2005, 1994–2000, and prior to 1994 to increase sample sizes for estimating each curve. The exponential length–weight relationship is extremely consistent across periods. In general, there is very little variation between periods, although females can be seen to grow to larger sizes than males. Maturity at age and natural mortality

Estimates of maturity ogives of greater silver smelt in 5.a were presented at the WKGSS 2020 meeting for both age and length (WKGSS 2020) using data collected in the Icelandic autumn survey (See stock annex for details). Males tend on average to mature at a slightly higher age or at 6.5 compared to 5.6 for females but at a similar length as females 35.3 cm. Most of the greater silver smelt caught in commercial catches in 5.a are mature.

No information exists on natural mortality of greater silver smelt in 5.a.

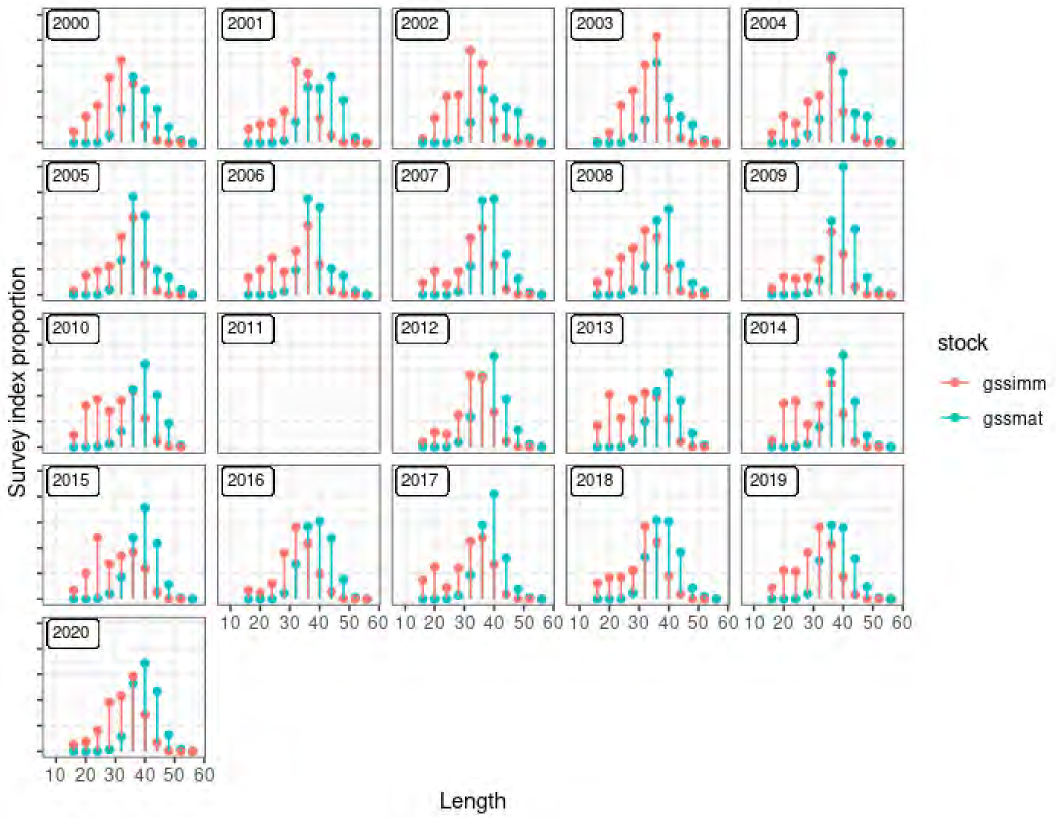


Figure 6.3.12: Greater silver smelt in 5.a and 14. Length distributions from the autumn survey since 2000. Red areas are immature greater silver smelt and green represent mature greater silver smelt.

6.3.8 Data analyses

6.3.8.1 Landings and sampling

Spatial distribution of catches in 5.a did not change markedly between 2015 and 2016 and fishing for greater silver smelt in the NW area seems to have stopped (Figure 6.3.2 and Figure 6.3.3). Landings of greater silver smelt increased rapidly from 2007 to 2010 when they peaked at around 16 000 tonnes, since then they have decreased to around 3209 tonnes in 2020 (Figure 6.3.4 and Table 6.3.1). The decrease in catches is the result of increased vigilance by the managers to constrain catches to those advised and also lesser interest by the fleet in the stock. At the same time mean length in catches decreased from around 44 cm in 1998 to 38–40 in 2008 to 2011. However, there is a slight increase in mean length in 2012 which can also be seen in recent years (Figure 6.3.9). A similar continuous downward trend in mean age in the commercial catches is also observed. Mean age in the fishery has decreased since the late nineties from around 16 to around 10 in 2006 to 2011. However, as is the case for mean length, mean age in catches in 2012 increased, and is estimated closer to 11 years in the most recent years (Figure 6.3.11). The reason for this change is not known as there is no marked difference in the spatial distribution of the fishery; however, reduced fishing pressure may be a factor.

6.3.9 Surveys

As mentioned above, greater silver smelt is a difficult species to survey in trawl surveys and the indices derived from the both the spring and autumn surveys have high CVs. Occasional spikes in the indices without any clear trend characterize the spring survey biomass indices (without stratification). The only thing that can be derived from the spring survey is that the biomass indices (total and >25 cm), in 1985–1993 and again from 2002 to 2020 are at a higher level than in 1994–2001. The juvenile index (spring survey) has a very high peak in 1986 but then hardly any juveniles are detected in the survey in 1987 to 1995. Since 1998 there have been several small spikes in the recruitment index (Figure 6.3.6).

The observed trends in the biomass indices from the autumn survey have a considerably different trend than those observed in the spring survey (Figure 6.3.6). According to the autumn survey, biomass increased more or less year on year from 2000 to 2008 but then decreased in 2009 and 2010. The total biomass index in the autumn survey showed slight variations until 2014 when the index increased to the highest value observed, and thereafter has been relatively stable but with high variability.

There is a clear gradient in mean length of greater silver smelt with depth, larger fish being in deeper water, and therefore no abundance index is presented for the spring survey. Fishing for greater silver smelt in 5.a is banned at depths less than 400 meters. The autumn survey index for depth greater than 400 meters is therefore considered the best indicator of available biomass to the fishery and is used in the advice procedure.

6.3.9.1 Analytical assessment using Gadget

In 2020 a model of greater silver smelt in Icelandic and Greenlandic waters developed in the Gadget framework (see http://www.hafro.is/gadget for further details) was benchmarked for the use in assessment (WKGSS 2020).

6.3.9.2 Data used and model settings

Data used for tuning and model settings used in the Gadget model are described in more detail in the stock annex (ICES 2020).

6.3.9.3 Diagnostics

6.3.9.4 Observed and predicted proportions by fleet

Overall fit to the predicted proportional length and age–length distributions is close to the observed distributions, with the exception of a small peak of small-sized fish (Figure 6.3.13, Figure 6.3.14 Figure 6.3.15, Figure 6.3.16). This peak does not shift from year to year and therefore is considered to exist because of high catchability in aggregations of small fish rather than cohorts in recruitment peaks. These peaks are likely absent from commercial data due to the requirement of fishing at > 400 m depth.

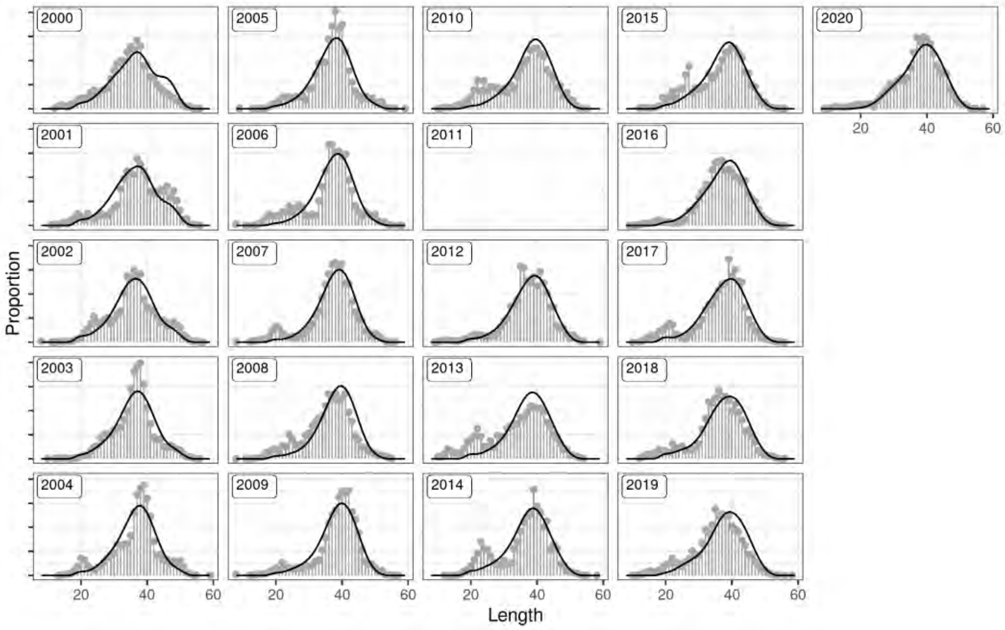


Figure 6.3.13: Greater silver smelt in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the autumn survey (green lines and points)

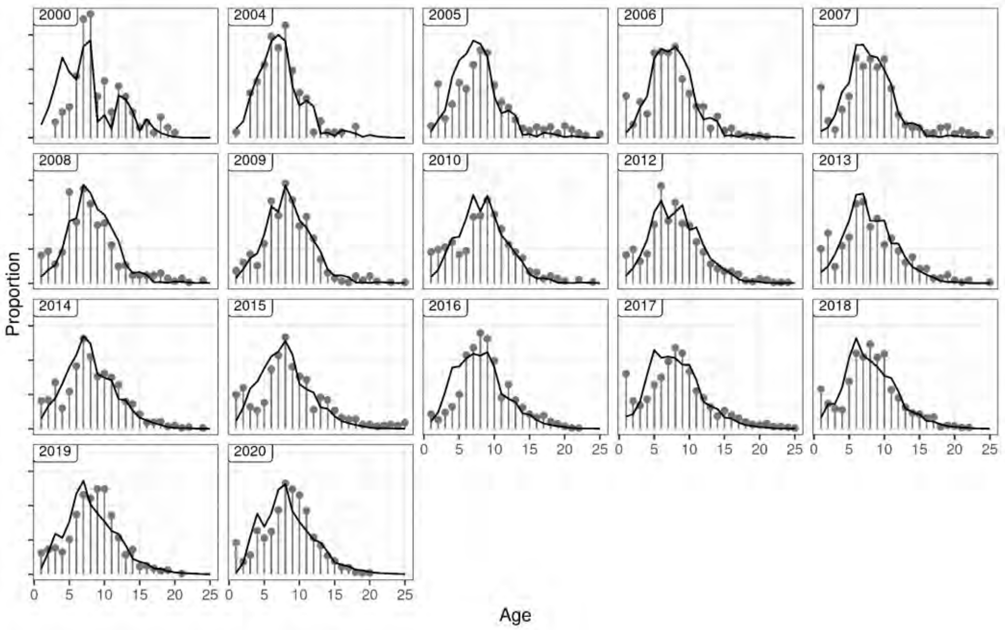


Figure 6.3.14: Greater silver smelt in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the autumn survey catches (grey lines and points).

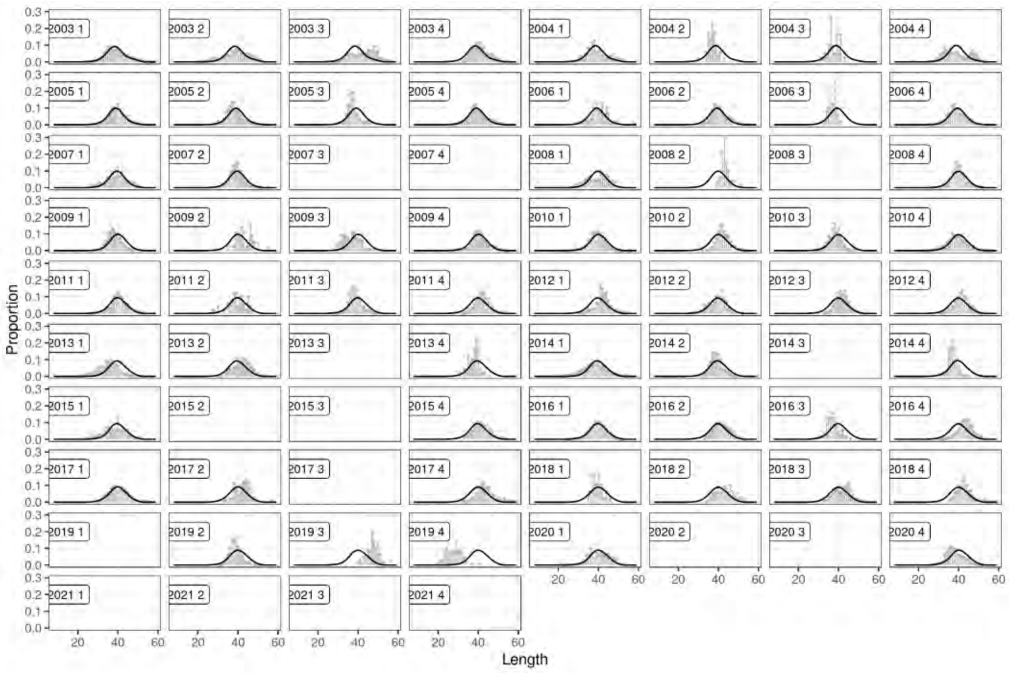


Figure 6.3.15: Greater silver smelt in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from commercial catches (grey lines and points).

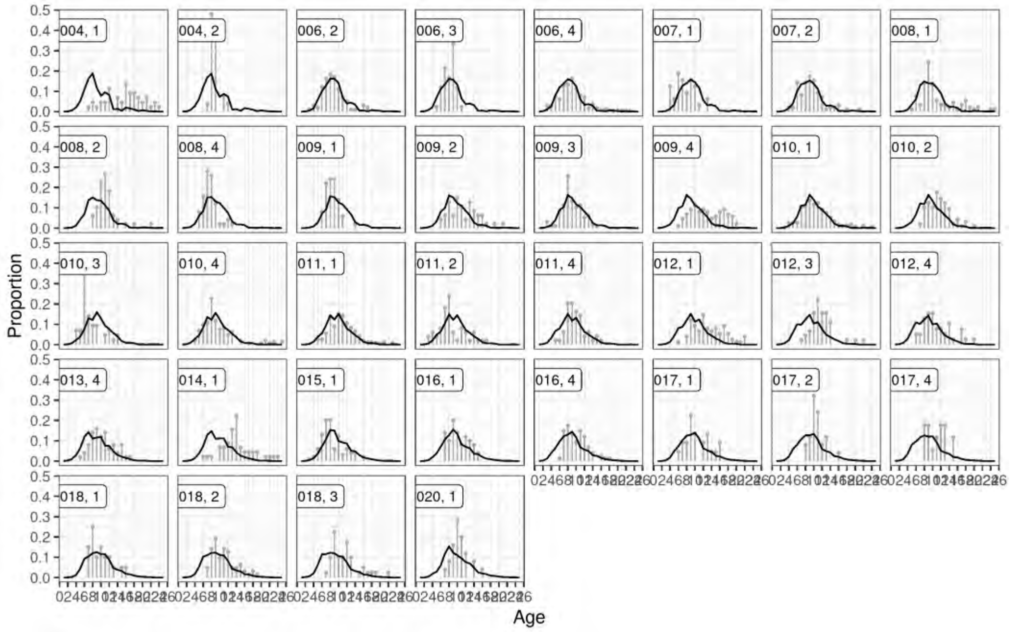


Figure 6.3.16: Greater silver smelt in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in commercial catches (grey lines and points).

6.3.9.5 Model fit

Figure 6.3.17 shows the overall fit to the survey indices described in the stock annex. In general, the model appears to follow the stock trends historically. In previous category 3 assessments of this stock, the autumn survey was winsorized due to high variability in the survey index, which can also be seen here, as survey indices are not winsorized or standardized before being used. The peak observed in the two smallest size classes (10-25 and 25-30) are likely due to selectivity and aggregation and not cohort dynamics. The terminal estimate has a large overestimation indicating the potential for overestimation of biomass this year and downward revisions in coming years, if this trend continues.

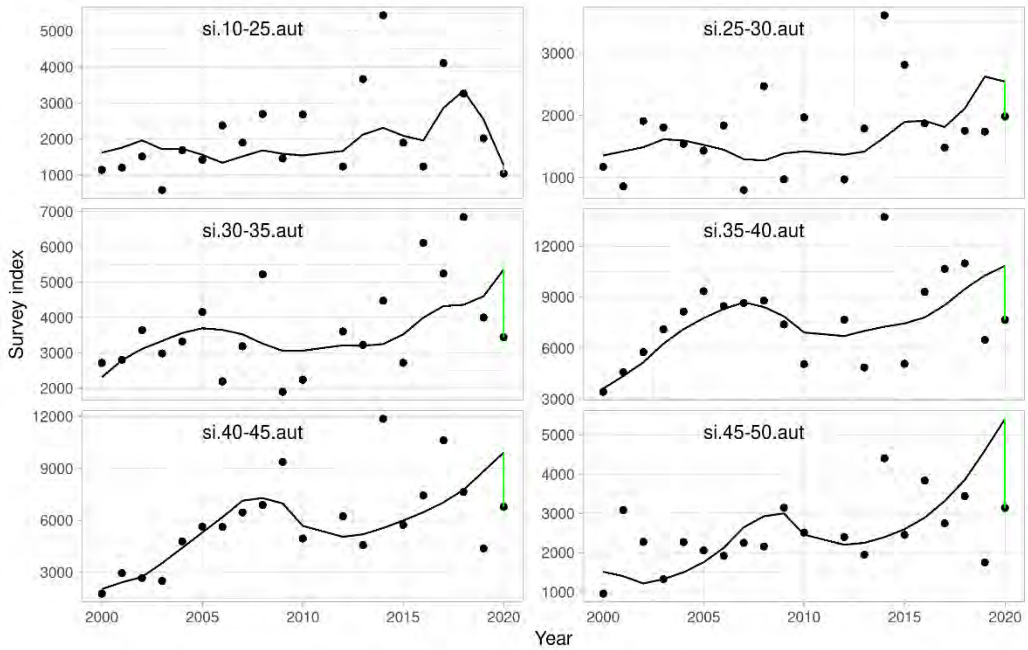


Figure 6.3.17: Greater silver smelt in 5.a. Fitted autumn survey index by length group from the Gadget model (black line) and the observed number of greater silver smelt caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

6.3.10 Results

The results are presented in Table 6.3.4 and Figure 6.3.18. Recruitment has been increasing over the past decade, but the most recent very high estimates of age 1 recruitment in 2017 - 2019 may be the result of recent high variability in survey indices, and are therefore likely to be revised downwards in the next few years. Spawning–stock biomass has increased since 2012 and reached the highest SSB estimate in 2019 with a slight decrease in 2020. Fishing mortality for greater silver smelt (age 6–14) has decreased from around 0.2 in 2010 to 0.05 over the past several years, due to greater regulation of the fishery as well as reduced commercial interest.

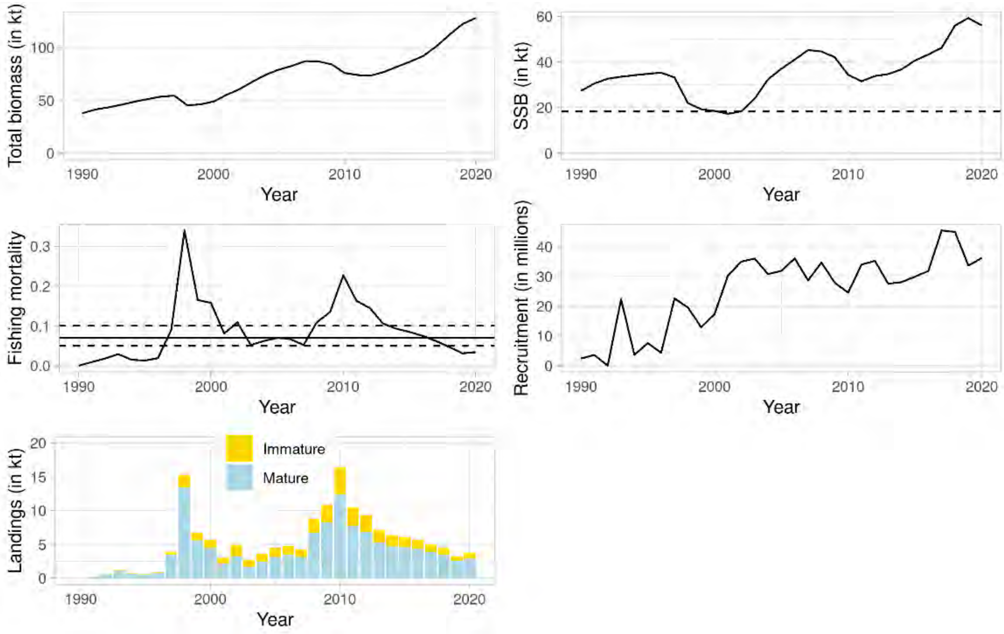


Figure 6.3.18: Greater silver smelt in 5.a and 14. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes, recruitment and total catches. The dashed line in the SSB plot represents Bpa. The solid line in the fishing mortality plot indicates the fishing mortality used in the ICES MSY advice rule, whereas the dashed lines indicate the bounds of the realized fishing mortality resulting from the advice rule given the uncertainty in the assessment.

Table 6.3.4: Greater silver smelt in 5.a. Gadget assessment model results including input catch values (tonnes), estimated spawning stock biomass (SSB, tonnes), recruitment (Rec., age 5 in millions), and fishing mortality (age 5). Projections are given in the last year.

Year	Total Biomass	Catch	SSB	Rec.	F
2000	46249.11	5.657	19298.27	17.38056	0.158
2001	48895.48	3.043	18545.38	30.28578	0.081
2002	55261.09	4.961	17296.34	35.00796	0.109
2003	60763.54	2.680	18419.44	36.02414	0.052
2004	67871.64	3.645	23931.51	30.80830	0.062
2005	74388.48	4.482	32418.07	31.87912	0.070
2006	79222.95	4.769	37040.10	36.07259	0.067
2007	82814.22	4.227	41196.46	28.70044	0.052
2008	87171.57	8.778	45386.04	34.69130	0.109
2009	86918.64	10.828	44726.62	27.92182	0.135
2010	84134.24	16.428	42206.14	24.57031	0.227
2011	75966.08	10.516	34539.26	33.97954	0.163
2012	73956.18	9.289	31698.93	35.25951	0.145
2013	73520.22	7.155	33986.69	27.56153	0.106
2014	76981.45	6.348	34801.72	28.07747	0.093

Year	Total Biomass	Catch	SSB	Rec.	F
2015	81911.83	6.070	36913.52	29.94022	0.085
2016	86801.96	5.662	40824.24	31.84774	0.075
2017	92113.52	5.011	43405.92	45.46419	0.062
2018	101318.33	4.460	46453.89	44.98915	0.047
2019	112322.33	3.209	56170.72	33.67367	0.031
2020	122340.89	3.775	59500.52	36.19197	0.034
2021	128040.96	9.824	56362.38	81.86833	0.085
2022	129260.89	8.838	49051.34	85.78528	0.067

6.3.10.1 Retrospective analysis

An analytical retrospective analysis is presented. The analysis indicates that there was an upward revision of biomass from the first to the second year of the peel followed by a downward revision of biomass (SSB) over the last 3 years. The F shows a downward revision over the years. Estimates of recruitment show an increase in the first two years of the peel, followed by a downward revision with an apparent peak in 2017-2018. As explained in reference to the survey indices, this is likely the influence of highly variable survey indices that, for the smallest sizes in the most recent years, have no repeated observations at larger sizes. Therefore, it is expected that these recruitment peaks may simply be the result of uncertainty in survey indices and are likely to disappear in the coming assessment years.

Mohn's rho was estimated to be 0.293 for SSB, -0.188 for F, and 0.245 for recruitment.

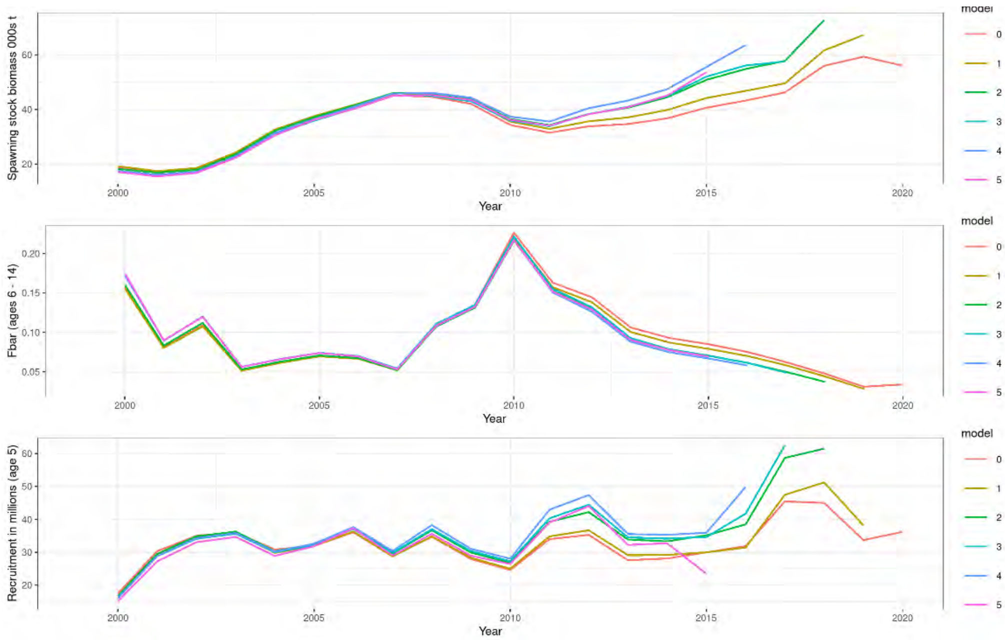


Figure 6.3.19: Greater silver smelt in 5.a and 14. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 5) are shown.

6.3.11 ICES advice

No advice from ICES wad requested by Iceland in 2020 due to the Covid 19 disruption.

In 2020 this stock was benchmarked (WKGSS 2020) and a length- and age-based assessment was accepted as a category 1 assessment method. The ICES MSY advice rule is applied for this stock in 2021/2022 advice. The decision which allocates catches to the fleets requires 1) an expected quantity of catch to be removed that will complete total catch removals for the current fishing season, 2) a 1-year projection to determine the amount of biomass available to fish, and 3) application of projected fishing effort according to F_{MSY} to determine the expected catch from fishing at this level. Advised catch is set to this value while SSBy>$B_{trigger}$, scaled by (SSBy)/$B_{trigger}$ while Blim≤SSBy<$B_{trigger}$, and set to 0 while SSBy≤B_{lim}.

6.3.12 Management

The Icelandic Ministry of Industries and Innovation is responsible for management of the Icelandic fisheries and implementation of legislation. The Ministry issues regulations for commercial fishing for each fishing year (1 September–31 August), including an allocation of the TAC for each stock subject to such limitations. Before the 2013/2014 fishing year the Icelandic fishery was managed as an exploratory fishery subject to licensing since 1997. A detailed description of regulations on the fishery of greater silver smelt in 5.a is given in the stock annex (ICES 2016).

The TAC for the 2013/2014 fishing year was set at 8 000 based on the recommendations of MRI using a preliminary Gadget model and the 2014/2015 fishing year the recommendation was to maintain the catches at 8 000 t. For the fishing year 2015/2016 it was also maintained at 8 000 t, but was 7 885 t for 2016/2017, 9 310 t for 2017/2018, 7 603 t for 2018/2019, 9 142 t for 2019/20 and 8 729 for 2020/21(Table 6.3.5).

Table 6.3.5: Greater silver smelt in 5.a. TAC recommended for greater silver smelt in 5.a by the Marine and Fisheries Research Institute, national TAC and total landings.

Fishing Year	MFRI Advice	National TAC	Landings
2010/11	8 000		12 091
2011/12	8 000		8 497
2012/13	8 000		11 217
2013/14	8 000	8 000	7 242
2014/15	8 000	8 000	6 848
2015/16	8 000	8 000	5 991
2016/17	7 885	7 885	3 570
2017/18	9 310	9 310	5 159
2018/19	7 603	7 603	2 818
2019/20	9 124	9124	3775
2020/21	8729	8729	2395
2021/22	8717		

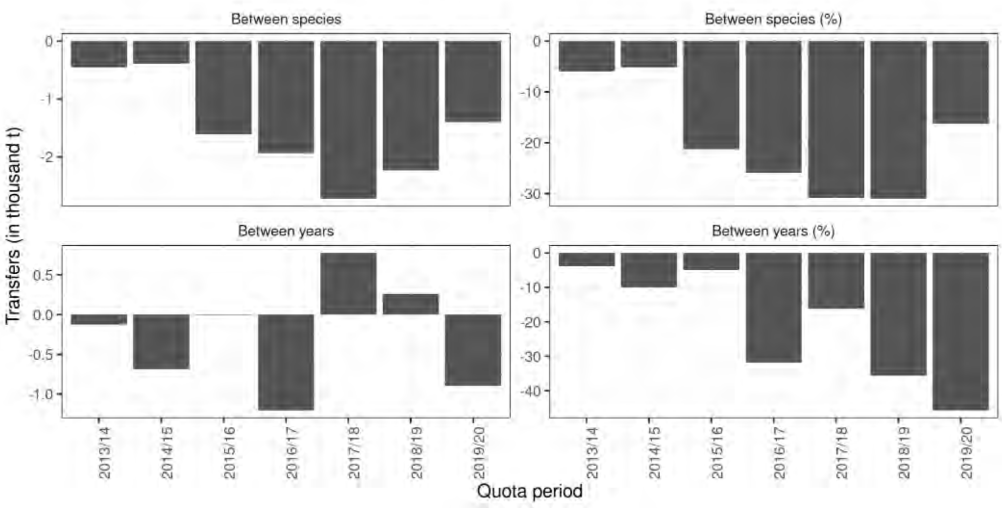


Figure 6.3.20: Greater silver smelt in 5.a and 14. An overview of the net transfers of quota between years and species transformations in the fishery in 5.a.

6.3.13 Current advisory framework

As a part of the WKGSS 2020 benchmark proceedings (WKGSS 2020), the following reference points were defined for the stock:

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	25.44 kt	B_{pa}
-	F_{msy}	0.14	Median F that maximises the median long-term catch in stochastic simulations with 7-year block-bootstrapped recruitment, scaled according to a hockey stick recruitment function with the breakpoint set to B_{lim}.
-	$F_{p.05}$	0.07	The fishing mortality that has an annual 5% probability of of SSB < B_{lim}.
Precautionary approach	B_{lim}	18.3 kt	SSB(2003), corresponding to B_{loss} as the fishing level in relation to F_{msy} is unclear and model uncertainty high
-	B_{pa}	25.44 kt	$B_{lim} * e^{1.645*\sigma}$ where $\sigma = 0.2$
-	F_{lim}	0.24	F corresponding to 50% long-term probability of SSB > B_{lim}
-	F_{pa}	0.16	$F_{lim}/e^{1.645*\sigma}$ where $\sigma = 0.25$
MSY advice rule	F_{msy}	0.07	F such that $F \leq F_{msy}$, $F \leq F_{pa}$, and $F \leq F_{0.05}$, long-term yield is consistent with MSY while leading to high stock biomass
-	MSY $B_{trigger}$	25.44	Set as B_{pa}

Figure 6.3.22: Greater silver smelt in 5.a and 14. Reference points.

Information on how these reference points were generated and the model setting for short-term projections can be found in WKGSS 2020 report (WKGSS 2020).

The current intermediate year assumption regarding catch is set equal to the TAC during the fishing season (last quarter of year y and quarters 1 – 3 in year y + 1) and projections for the following year run at a selected harvest rate. However, the recommended TAC in recent years has been much higher than recorded landings. Therefore, for sensitivity analysis, projections were also run using intermediate year catch assumptions which are more indicative of recorded landings than TAC. Based on a crude assumption of fishing year landings being approximately half of the recommended TAC for 2020/2021, the TAC for the fishing year 2021/2022 was estimated to be 9200 tonnes instead of 8717 tonnes. A reduction in total catch removals will lead to a higher estimated TAC.

Age 1 recruitment estimates are highly uncertain from the most recent three years. Therefore, in forecasts, it is proposed to use the geometric mean of the three years previous to these values (e.g. for 2020, this would be the geometric mean of age 1 recruitment estimates from years 2014–2016). The projected recruitment reported from the model output is for age 5 because recruitment estimated for ages 1-4 are highly uncertain.

6.3.14 Management considerations

Exploitation of greater silver smelt has been reduced in recent years, coming down from relatively high levels in 1998 and 2010, to levels lower than the average exploitation rate in the reference period.

6.3.14.1 Ecosystem considerations for management

Shorter periods of reduced biomass due to high fishing rates are observed in the history of greater silver smelt fishing in Iceland. However, there has been a general trend since the mid 1990s of a decrease in biomass levels from the mid 1980s to the mid 1990s, during which catch records are unreliable so the general reduction cannot directly be attributed to fishing, followed by a general increase in biomass in the past two decades. It is likely that a combination of lower fishing rates and favourable environmental conditions have led to high recruitment levels over the past decade.

6.3.15 References

ICES. 2014. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (Wgdeep). ICES Scientific Reports. 1:21., Copenhagen, Denmark. ICES Cm 2014/Acom:17." International Council for the Exploration of the Seas; ICES publishing. https://doi.org/10.17895/ices.pub.5262.

2016. "Stock Annex: Greater silver smelt (Argentina silus) in Subarea 14 and Division 5.a (East Greenland and Iceland grounds)." International Council for the Exploration of the Seas; ICES publishing.

ICES. 2021. Benchmark Workshop of Greater silver smelt (WKGSS; Outputs from 2020 meeting). ICES Scientific Reports. 3:5. 485 pp. https://doi.org/10.17895/ices.pub.5986

6.4 Greater silver smelt (*Argentina silus*) in 5.b and 6.a

6.4.1 The fishery

The target fisheries on greater silver smelt in Divisions 5.b and 6.a are mainly conducted by Faroese and European trawlers. In 2020, the catches in 5.b were mainly taken by three pairs of Faroese pair trawlers deploying bentho-pelagic trawls (99%) while the catches in 6.a were mostly taken by European trawlers (58%) and the remainder mainly by previously mentioned Faroese trawlers (42%, inside the Faroese EEZ) (Table 6.4.1 and Figure 6.4.1).

Historically, greater silver smelt were only taken as bycatch in the shelf-edge deep-water fisheries and either discarded or landed in small quantities. Targeted fisheries for greater silver smelt in Faroese waters in 5.b did not develop until the mid-1990s and for 6.a in the early 1990s.

From the mid-1990s to 2007 the greater silver smelt fishing grounds in Faroese waters were located north and west on the Faroe Plateau and around the banks southwest of Faroe Plateau mainly at depths between 300 and 700 meters. Since 2008 the Faroese fishery has extended the fishing grounds to include the area on the Wyville-Thomson Ridge south of the Faroe Plateau. Since 2012 around 50% of the Faroese catches were caught on the Wyville-Thomson Ridge (in Divisions 5.b and 6.a, inside the Faroese EEZ).

The European fisheries on silver smelt mostly takes place on the shelf edge within Divisions 6a, 5.b and 4.a. New information from the self-sampling program carried out by the European fisheries (Pelagic Freezer-trawler Association, PFA) was presented to the Working Group in 2018 and been updated in (Pastoors, WD 2021). The self-sampling program consists of historical information derived from skipper's notes (2002 - present) and new information collected as part of the research program within the PFA. An overview of catch rates of silver smelt (*Argentina spp.*) from both the Faroese and European fisheries is shown in Figure 6.4.2.

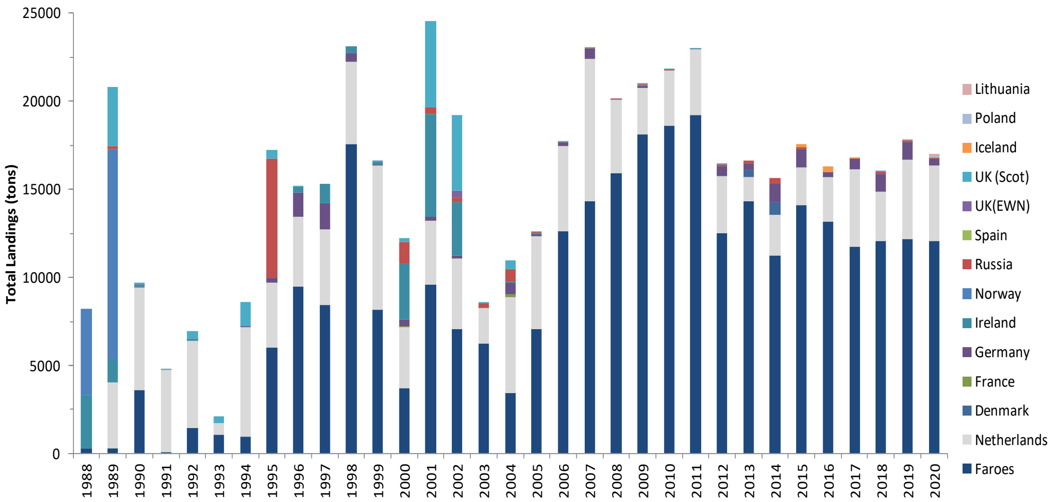


Figure 6.4.1. Greater silver smelt in 5.b and 6.a. Total landings per year of greater silver smelt in 5.b and 6.a by countries from 1988-present.

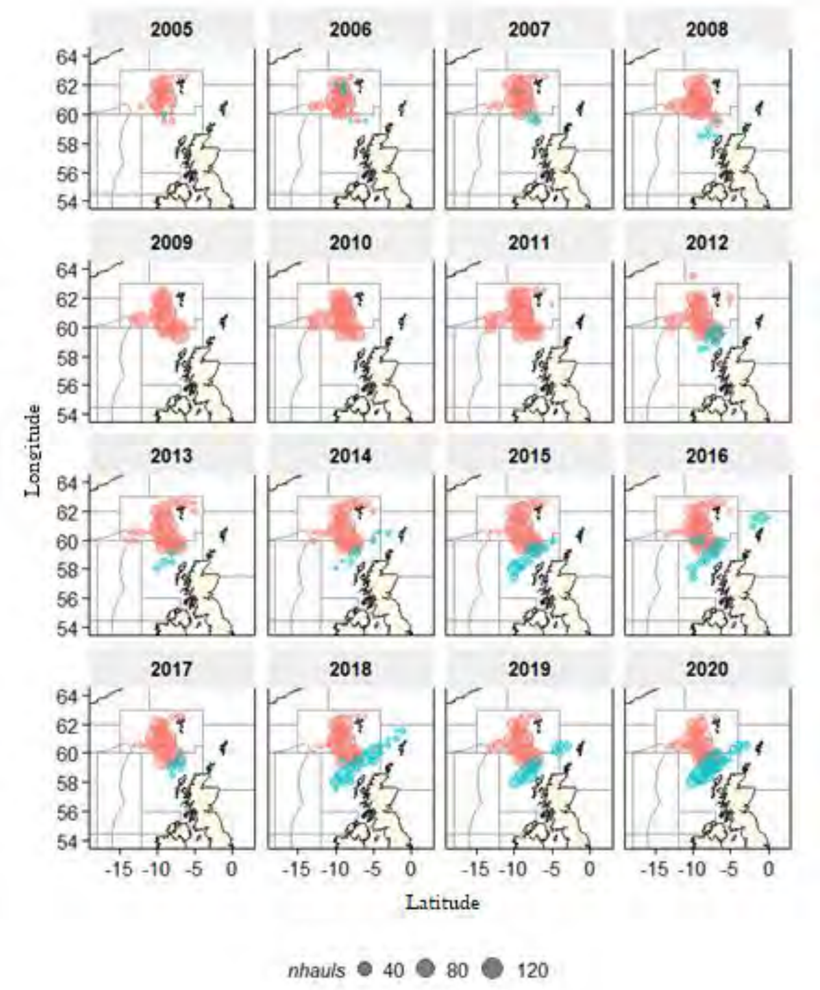


Figure 6.4.2. Greater silver smelt in 5.b and 6.a. Number of hauls of commercial fisheries available for standardized CPUE calculation in Faroese fishery (red circles) and PFA fishery (blue circles) from 2005-present (WGDEEP 2021, WD02).

6.4.1.1 Landing trends

Landings in Division 5.b increased rapidly from 2004 (5300 tonnes) to 2006 (12 500 tonnes) and further increased in 2011 to 15 600 tonnes (Table 6.4.2). Since then landings have been around 10 000 – 13 000 tonnes. The reduction in greater silver smelt catches in 5.b in 2012 was probably a combination of the introduction of quotas for greater silver smelt in Faroese waters, the effect that the fishery was targeting mackerel rather than greater silver smelt and also a shift in fishing area moving into Division 6.a within the Faroese EEZ towards the Wyville-Thomson Ridge.

Landings in Division 6.a have been fairly stable at around six to eight thousand tonnes since the fishery started excluding two peaks in 1989 and in 2001 with landings comprising of 20581 and 14 466 respectively. Since 2004 landings varied between 5000 and 7500 tonnes.

In 2020 the preliminary catch is 8438 tonnes in Division 5.b and 8576 tonnes in Division 6.a.

6.4.2 ICES Advice

ICES advises that when the precautionary approach is applied, landings should be no more than 7703 tonnes in each of the years 2020 and 2021. ICES cannot quantify the corresponding catches.

6.4.3 Management

The EU introduced total allowable catch (TAC) management for greater silver smelt in 2003 and has since then set a TAC quota for the EU fishery in Subareas 5, 6 and 7 (separate EU TACs exist for greater silver smelt in areas 1 and 2, and in areas 3a and 4). TAC quotas for the EU fishery in Subareas 5, 6 and 7 for the period 2014 - present are presented in the Table 6.4.3.

In the period from 2010 to 2013, the Faroese greater silver smelt fishery was managed by an agreement between the Faroese fleet with licences to conduct direct greater silver smelt fishery and the Faroese authorities. This management was guided by the stock assessment and scientific advice of Faroe Marine Research Institute (FAMRI). With this agreement, total annual landings should not exceed 18 000 tonnes in the Faroese EEZ. There was no advice from ICES that was specific for the Faroese greater silver smelt component. Regulation was through a general regulation of fishing days for the trawler group. There were also limitations in e.g. minimum size, bycatch, mesh size and fishing area restrictions.

In 2014, the Faroese authorities introduced species-specific TAC quota for greater silver smelt applicable for Faroese trawlers fishing inside the Faroese EEZ. Six trawlers had licences to target greater silver smelt at this point in time and the technical measures continued to apply. The Faroese TAC quotas are also presented in the Table 6.4.3. A decrease in the biomass index as estimated by the age-based exploratory assessment of greater silver smelt in Faroese waters has resulted in the decreasing TAC from 2014 to 2017.

ICES advice for greater silver smelt and the TACs that have been set by the Faroese authorities and the European Union are also summarised in Table 6.4.3.

6.4.4 Data available

Commercial data on length, round weight and age were available for greater silver smelt from samples taken from Faroese and European landings. There were also catch and effort data from logbooks for the Faroese trawlers and from the PFA fisheries in the Northeast Atlantic (WGDEEP 2021, WD02).

From the annual ground fish summer survey on the Faroe Plateau, biological data (mainly length and round weight) as well as catch and effort data are available for greater silver smelt from 1995 - present. This survey is targeting cod, haddock and saithe, but entire catch is examined and quantified. In addition, a Faroese deepwater survey has been conducted since 2014 which covers the greater silver smelt fishery areas in inside the Faroese EEZ.

The Scottish deepwater survey is also included in the SAM assessment as a biomass index. This survey covers the European fisheries in 6a (Campell 2020, WD01 WKGSS). This survey includes catch and effort data.

6.4.4.1 Landings and discards

The landings statistics are regarded as being adequate for assessment purposes. Landings data is presented by area and countries in Tables 6.4.1 and 6.4.2, Figure 6.4.1 and are available for all relevant fleets.

Discard is banned inside the Faroese EEZ and all catches are assumed to be landed. In the European Union, the landing obligation for pelagic fisheries was implemented in 2015. Catches of all species caught during pelagic fisheries are to be landed, except for protected species which need to be immediately released after capture. In 2019 the EU landing obligation was applied to demersal fisheries.

For this stock unit, information on discards from non-Faroese fisheries is reported to ICES (Table 6.4.4). It is assumed that bycatch is landed.

In Subareas 6 and 7 greater silver smelt can represent a significant discard of the trawl fisheries on the continental slope particularly at depths of 300 to 700 m (e.g. Girard and Biseau, WD 2004). New calculation of the estimates for 2012 and 2013 reduced strongly the discards reported by Spain. In 2014–2015 there appears to have been no Spanish discards of this species in Subarea 6 (only in 7).

Based upon on-board observations from EU data collection framework (DCF) sampling, the catch composition of the French mixed trawl fisheries in 5.b, 6 and 7 include 5.3% of greater silver smelt based upon data for year 2011 (Dubé *et al*., 2012). This species was discarded in that fishery; representing 25.3% of the discards. The discards in 2015 - present were mainly in Division 6.a reported from the French and Scottish deep-water fisheries (data from ICES) (Table 6.4.4). Discard data reported to ICES from 2014 - present comprise 3.4% of the total catches.

6.4.4.2 Length compositions

Length frequency distributions of commercial catches are from Faroese commercial trawl catches in 5.b and 6.a (Figure 6.4.3) and from PFA fisheries in Divisions 4a, 5b and 6a (Pastoors, WD06 2020) (Figure 6.4.4).

Length distributions from the Faroese summer ground fish survey on the Faroe Plateau in Division 5.b are presented in Figures 6.4.5. Length distributions from the Faroese deep water survey are presented in Figure 6.4.6.

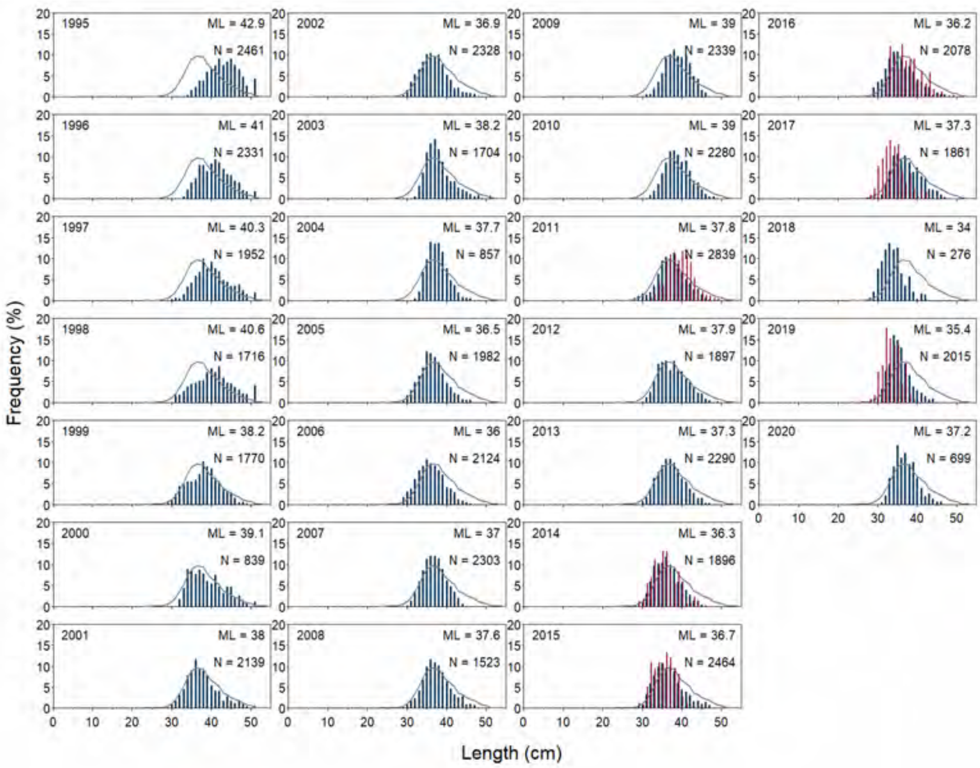


Figure 6.4.3. Greater silver smelt in 5.b. Length frequencies of greater silver smelt in the Faroese catches from 1995-present. Blue bars are catches within area 5b and red bars are catches within area 6a. Curves are the average over whole time frame. ML= mean length (cm) and N= number of length measurements.

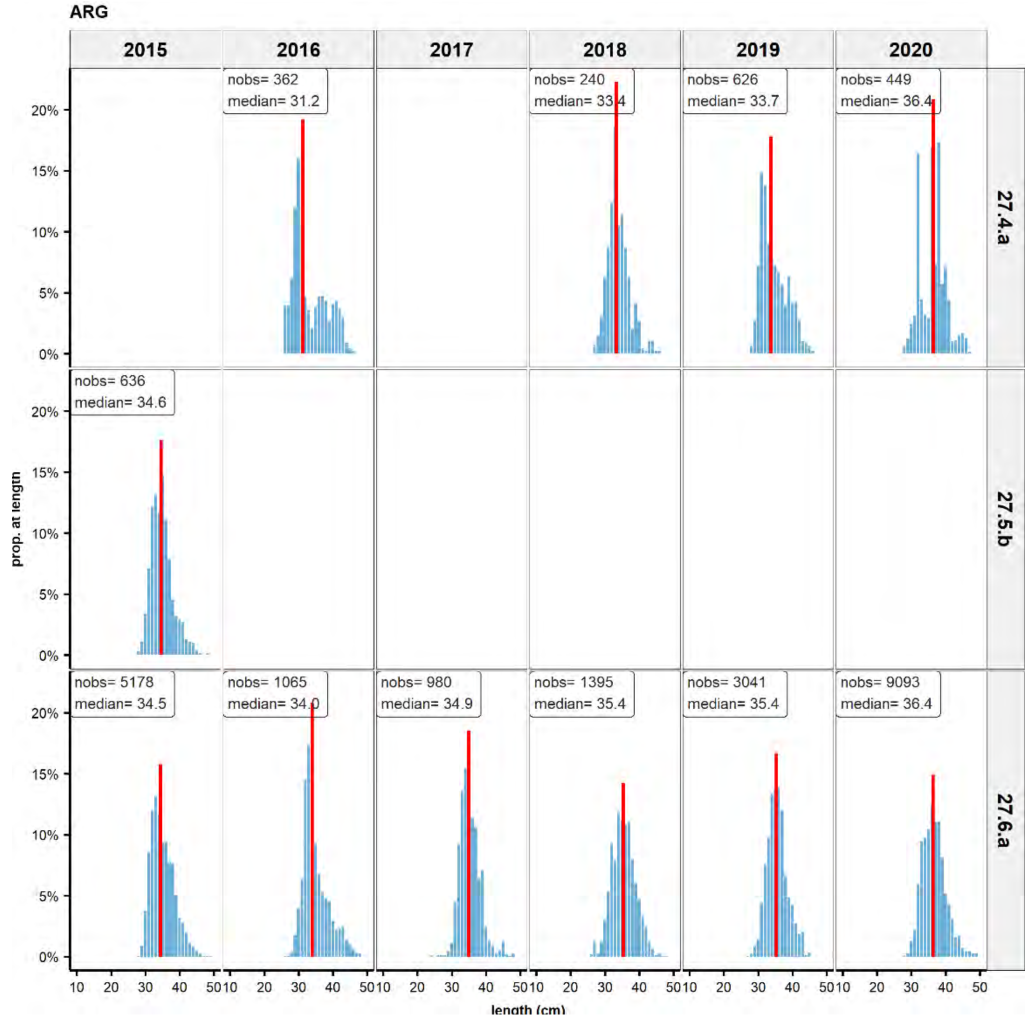


Figure 6.4.4. Silver smelt (*Argentine spp.)* in 5.b and 6.a. Relative length frequencies in PFA self-sampled fisheries in division 4a, 5b and 6a. Median length in red. Number of length measurement in top left (WGDEEP 2021, WD02).

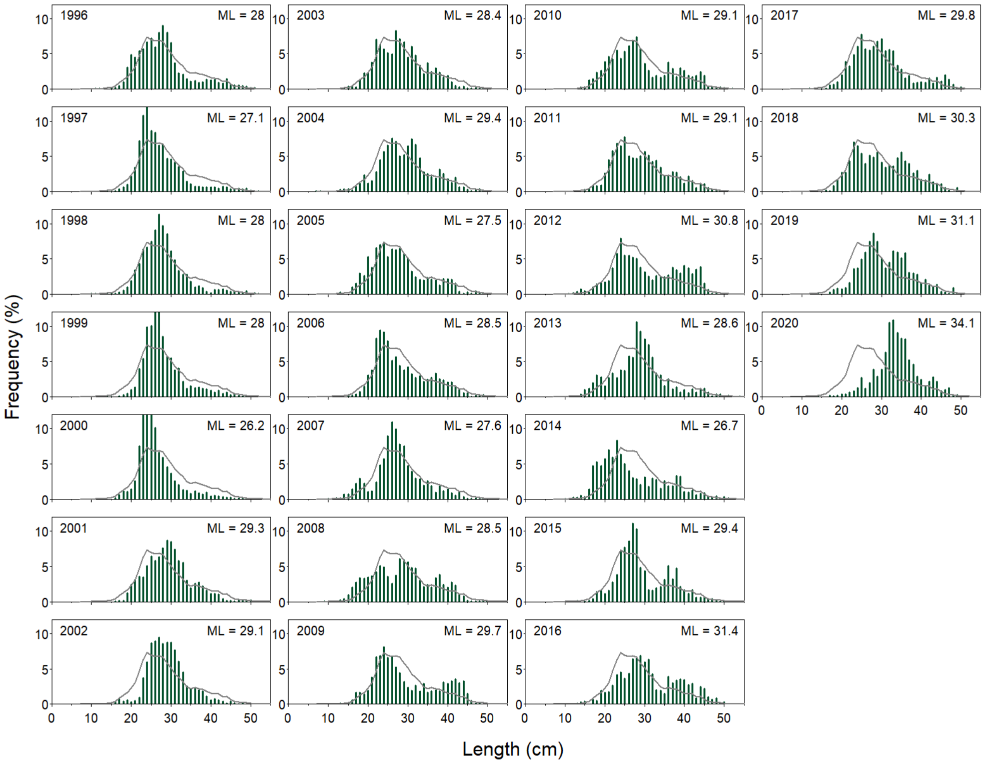


Figure 6.4.5. Greater silver smelt in 5.b. Length frequencies from Faroese ground fish summer survey from 1996-present. Greater silver smelt is sub sampled of the total catch i.e. the values of greater silver smelt are scaled to reflect total catch. ML= mean length.

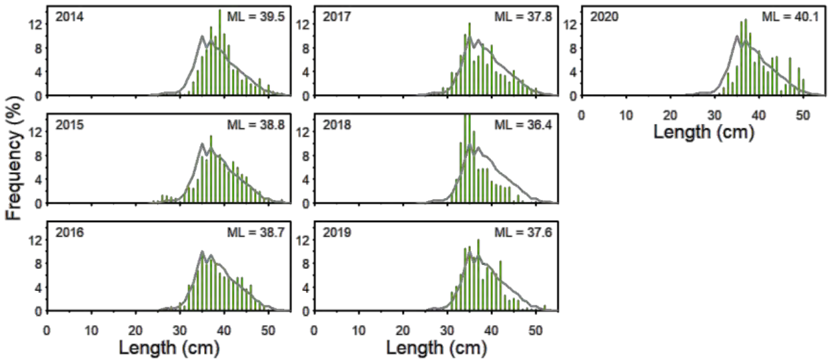


Figure 6.4.6. Greater silver smelt in 5.b. Length frequencies from the Faroese deep water survey from 2014 r. ML = mean length.

6.4.4.3 Catch at age (CAA)

Age frequency distributions from the combined catch at age (CAA) matrix compiled in Inter-Catch are presented in Figure 6.4.7 and Table 6.4.5. These data are used in the age based SAM assessment. In addition, for some years age data are available from Netherland and Scottish fishery in Division 6.a. The calculation of catch at age is described in detail in stock annex.

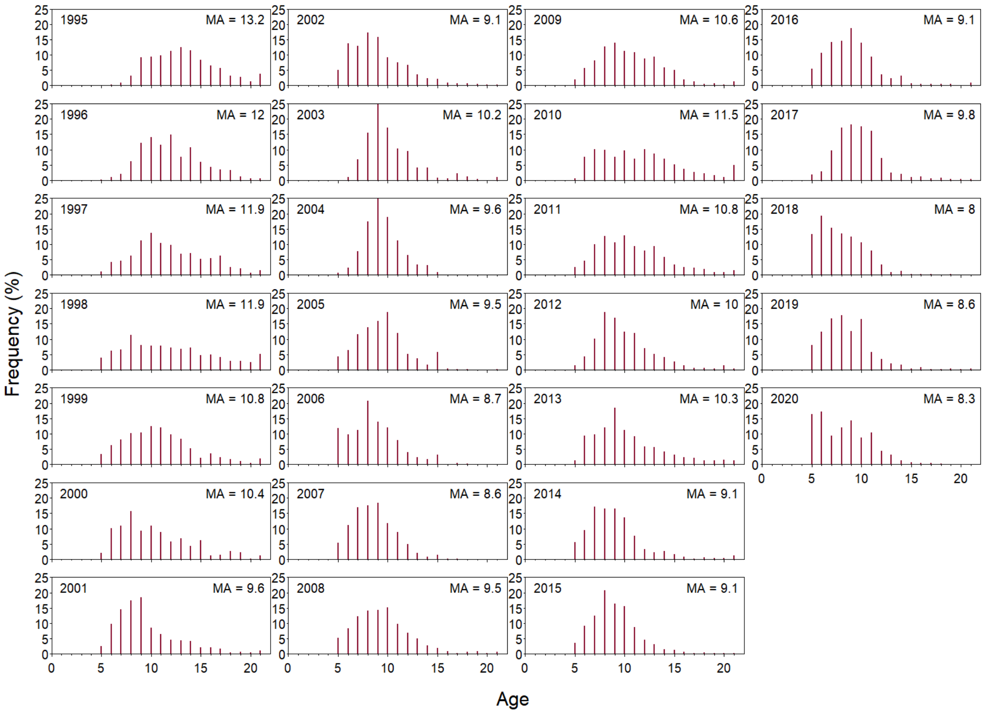


Figure 6.4.7. Greater silver smelt in 5.b and 6.a. Catch at Age (CAA) used in the SAM assessment in 1995-present. Prior to 2005 only CAA from the Faroese data has been used. From 2005 to present the combined CAA from Faroese and EU data have been used (compiled in InterCatch). MA= mean age.

6.4.4.4 Weight-at-age

Catch weight at age data used in the assessment is compiled in InterCatch (Figure 6.4.8 and Table 6.4.6). Data from 1995 to 2005 is only available from Faroese fishery in Division 5.b. Stock weights at age are set to the same values as catch weight at age (1995 - present, ages 5 to 21+). The low values of greater silver smelt older than 15 years in 2019 are potentially due to the low age sample size of old fish (Figure 6.4.8).

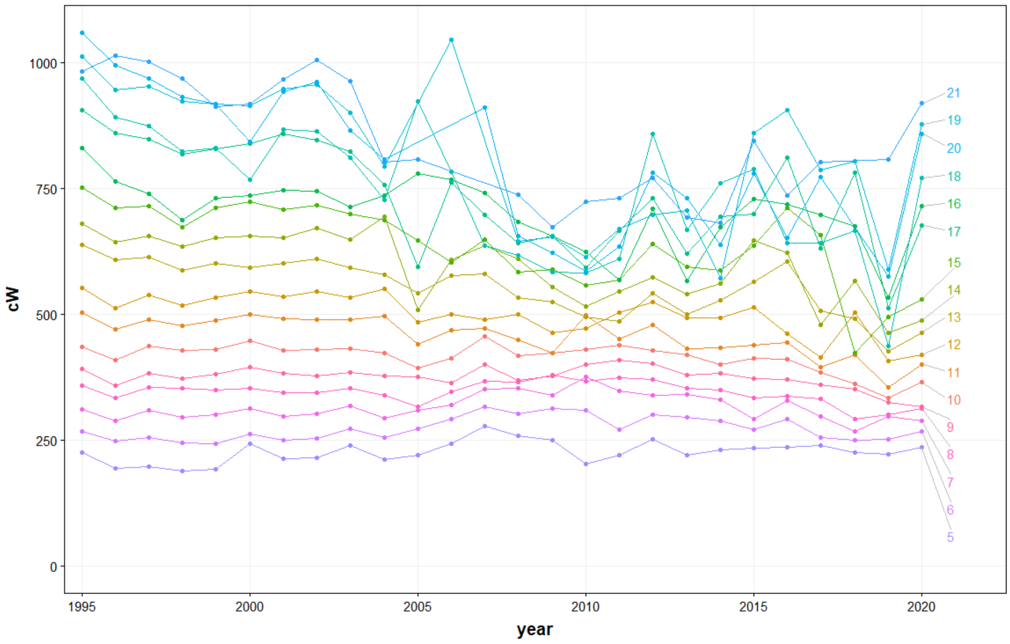


Figure 6.4.8. Greater silver smelt 5.b and 6a. Mean weight-at-age of greater silver smelt in the commercial catch within 5.b and 6.a.

6.4.4.5 Maturity and natural mortality

Most of the greater silver smelt caught in commercial catches in Division 5.b is mature (ICES, 2021).

Proportion mature is time invariant. The background data are from different Faroese surveys in the period 2000-2019, see Table 6.4.7. There is no maturity data available from the Scottish deep-water survey.

The natural mortality was set to 0.15 (ICES, 2021).

6.4.4.6 Catch, effort and research vessel data

Catch and effort data by haul for the commercial Faroese (1995 - present) and PFA fishery (2005-2008, 2012 - present) are available from Faroese logbooks and the PFA self sampling program. The catch from the Faroese trawlers logbook data accounts for more than 80% of the Faroese landings from 2005 and onwards. Therefore this period was chosen for calculating CPUE index. The PFA self-sampling logbooks account for varying percentages of the total registered catch by Germany and Netherland in Division 5.b and 6.a.

At the benchmark meeting in 2020, a standardized, combined CPUE series for the Faroese and European (PFA) fisheries was presented using a GLM model that incorporates year, week and depth category as explanatory variables (WKGSS 2020, WD03, WGDEEP 2021, WD01). A single fleet analysis is also routinely carried out to assess the year trends in CPUE for the data by Faroese and PFA fisheries separately. This indicates that the variability is substantially higher in the PFA series compared to the Faroese series (See stock annex). Parameter estimates for explanatory variables are routinely checked and described in WD01, WGDEEP 2021.

Commercial CPUE may be influenced by changes greater silver smelt quotas and fishing season/marked factors, but these influences were regarded as minor in comparison to variations in stock biomass.

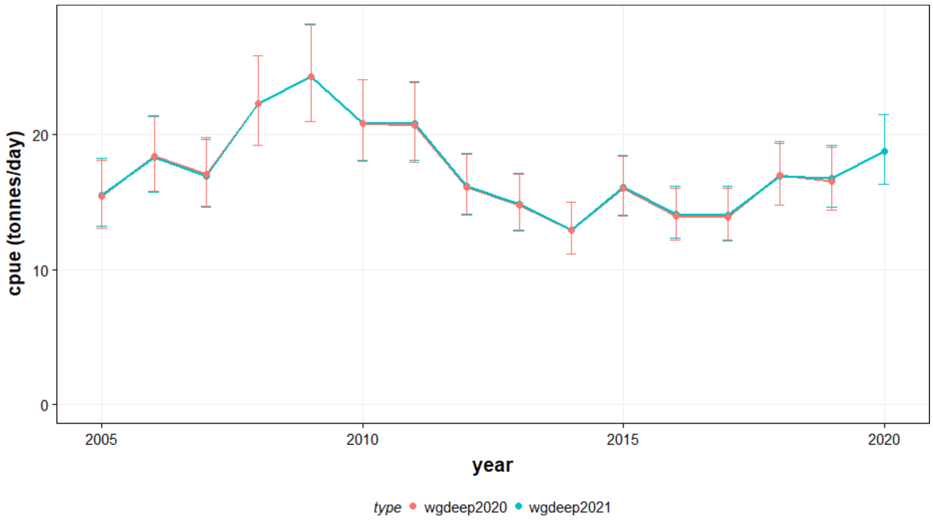


Figure 6.4.9. Greater silver smelt in 5b and 6a. Combined standardized CPUE with confidence intervals from Faroese and EU fisheries from 2005 to last data year (blue line) compared to last year's assessment (red line) (Pastoors *et al*. 2021, WD01).

Standardised catch index from the Faroese summer groundfish survey, conducted in August since 1996, is used to tune the assessment of greater silver smelt in 5.b and 6.a (Figure 6.4.10, ICES, 2021, stock annex). It has to be noted that the survey have very few stations deeper than 500 m and are therefore likely to only cover the juveniles adequately. The adult part of the population is not fully covered by these surveys and they may not necessarily reflect correctly the temporal variation of the biomass of the stock that is better covered by the deep water survey. The spring survey series, conducted in February/March since 1994, needs closer investigation before it can be used as a tuning series for greater silver smelt, because of large variation.

A Faroese deep-water trawl survey has been conducted in September since 2014, covering the slope and banks including the fishing area for greater silver smelt in the Faroese EEZ (5.b and 6.a)(ICES, 2021, Stock annex). The standardized index is presented in Figure 6.4.10. The Faroese surveys are conducted by R/V Magnus Heinason.

No Scottish deep water survey was conducted in 2020. The Scottish deepwater trawl survey (6.a) was explored at the benchmark in 2020 (ICES, 2021). A regular trawl survey of the fish community in the deep waters to the northwest of Scotland has been undertaken irregularly since 1998, using the MRV Scotia and showed that greater silver smelt are found at depths between 400m and 750m (Campbell, WD Nov. 2019). The CPUE was standardized (Figure 6.4.10) and the number of hauls per year where greater silver smelt is encountered is generally around 10 (ICES, 2021, stock annex).

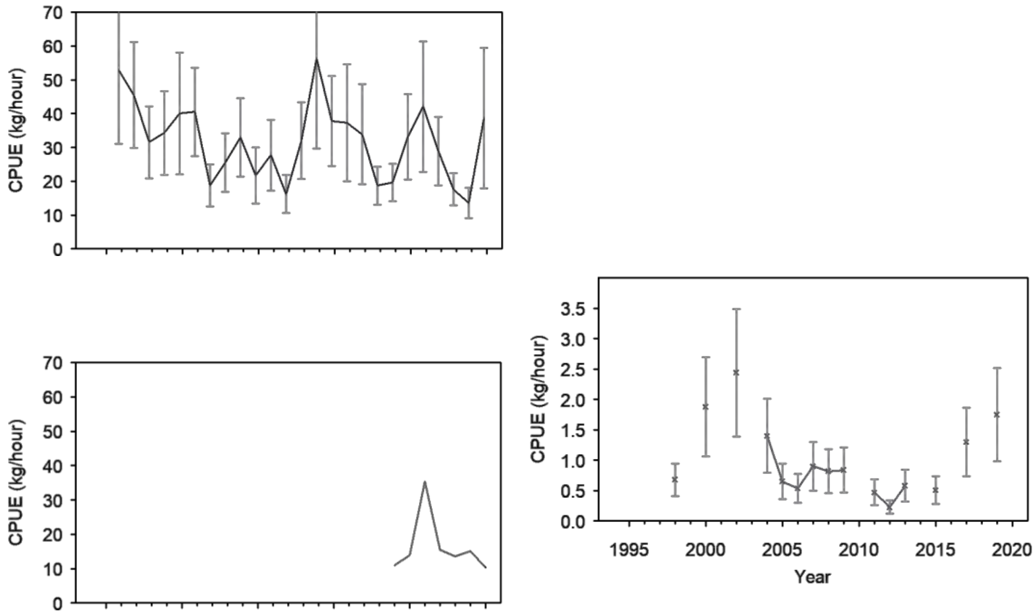


Figure 6.4.10. Survey indices (kg/hour) with confidence intervals from the Faroese summer survey (1995-present) top, Faroese deepwater survey (2014-present) centre and Scottish deepwater survey (1998-2019, irregularly) bottom.

6.4.5 Data analyses

6.4.5.1 Length and age distributions

In Division 5.b the mean length and age in the Faroese landings decreased from 1994 to 2000 and have been stable since then (Figures 6.4.3, 6.4.11). This trend probably reflects a gradual change during and following the first years of exploitation of a virgin stock (Ofstad, WD WKDEEP 2010). The variation in mean length during the latest years could be due to different depths sampled in the various areas as the size of greater silver smelt is known to increase with increasing depth as reported in WKGSS 2020. Generally, the Faroese bottom surveys catch individuals with length less than 30 cm at depths shallower than 350 m whereas larger individuals (35–40 cm) are found deeper.

For the whole period 1995 - present, mean lengths in landings from Netherland were mainly between 34 to 38 cm (Figure 6.4.11).

After 2003, the mean length of greater silver smelt from Faroese and Netherland trawlers landings was very similar, around 36–39 cm (Figure 6.4.11). The low mean lengths observed in the Netherlands fishery (1996, 1999, 2002) could be due to the catch being a mixture of Argentina silus and A. spyraena or due to the Netherland trawlers fished in shallower waters these particular years compared to other years. Another probability is that the data are from discard not landings.

The mean length in the catch from the fisheries in the Faroes, PFA and Netherland as well as from the Faroese deepwater survey are comparable allowing the use of Faroese age-length data in the age-based assessment. The Faroese summer survey on the other hand has a lower mean length which is due to the shallow waters covered in the summer survey (Figure 6.4.11). However, this survey covers distribution of juveniles which the other indices do not.

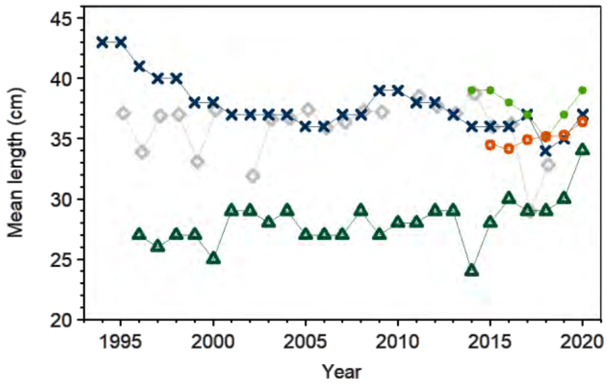


Figure 6.4.11. Greater silver smelt in 5.b and 6.a. Comparison of median lengths at year from Faroese (Blue crosses), PFA (open orange circles) and Netherland (grey diamonds) catches and from the Faroese summer (dark green triangles) and deepwater surveys (green filled circles).

6.4.5.2 Stock assessment

In the benchmark workshop on greater silver smelts (ICES, 2021), a Category 1 approach has been agreed for the stock in divisions 5b and 6a. The SAM model is used with catch at age from ages 5 to 21+ and years starting in 1995 (Table 6.4.5). Catch at age data for 1995 to 2004 is derived from the Faroese sampling raised to the international catches. Catch at age data for 2005 until present is derived from InterCatch whereby the age-based data is only contributed by Faroe Islands and the Netherlands. Only catch at age data from age 5 and upwards is used in the assessment, while in InterCatch, also information is available on (small) catches at ages 2-4.

Maturity at age is based on Faroese survey data and used as time-invariant variable.

Natural mortality was set to 0.15 for all ages and years (ICES, 2021)

The age-disaggregated tuning series were the Faroese summer survey, ages 5 to 12 years (1997-present, Table 6.4.8) and the Faroese deepwater survey, ages 5 to 14 years (2014-present, Table 6.4.9).

The Scottish deepwater survey (1998-2019, irregular, Table 6.4.10) and the combined commercial Faroese and EU trawlers catch per unit effort (2005-present, Table 6.4.10) were used as biomass indices in the tuning of the assessment.

The model configuration has a correlated error structure for the age-based survey information (Faroese summer survey, Faroese deepwater survey). The model configuration required 23 estimated parameters (Table 6.4.11).

Other details regarding the age based SAM stock assessment can be found in the Stock annex.

Diagnostics and results of the SAM model ARU _27.5b6a_WGDEEP2021 @ stockassessment.org are shown in the Figures and Tables below:

- Model fits to the data (Figures 6.4.12-6.4.15)
- Standardized one-step-ahead residuals (Figure 6.4.16)
- Leave-one-out analysis (Figure 6.4.17)
- Retrospective analysis (Figure 6.4.18)
- Estimated correlations between age groups for each fleet (Figure 6.4.19)
- SSB, Fbar, Recruitment and Catch (Figure 6.4.20 and Table 6.4.13)
- Parameter estimates (Table 6.4.12, Figure 6.4.21)

A closer look to the leave one out analysis showed that the model is very sensitive to exclusion of the Faroese summer survey from the model fit (Figure 6.4.17), especially for the estimation of recruitment.

In order to minimize systematic year effects, the final SAM model included correlated errors across ages (Figure 6.4.19). Residuals were more randomly distributed after the correlated errors were taken into account.

The retrospective pattern shows that recruitment has been underestimated. All the retrospective runs falls within the confidence intervals of the final assessment. Mohn's rho parameters are estimated at 0%, -13% and -13% for the spawning stock biomass, F and recruitment, respectively.

The results from SAM shows that the spawning stock biomass (SSB) currently around 86 000 tonnes (Figure 6.4.20, Tables 6.4.13, 6.4.15), which is above B_{pa}. The fishing mortality (F_{6-14}) has varied but has been below F_{MSY} since 2018 (Figure 6.4.20, Tables 6.4.13, 6.4.14). The model-estimated catch in the years since 2014 has been lower than the observed catch.

Parameter estimates of the model are in the Table 6.4.5 and compared with the WGDEEP 2020 assessment in the Figure 6.4.21. Overall, parameter estimates are comparable between years, although some differences are observed in the observation variance of the Faroese Deepwater survey (LogSdLogObs - 2) and the correlation in observations of the Faroese Deepwater survey (transflRAR_dist - 1).

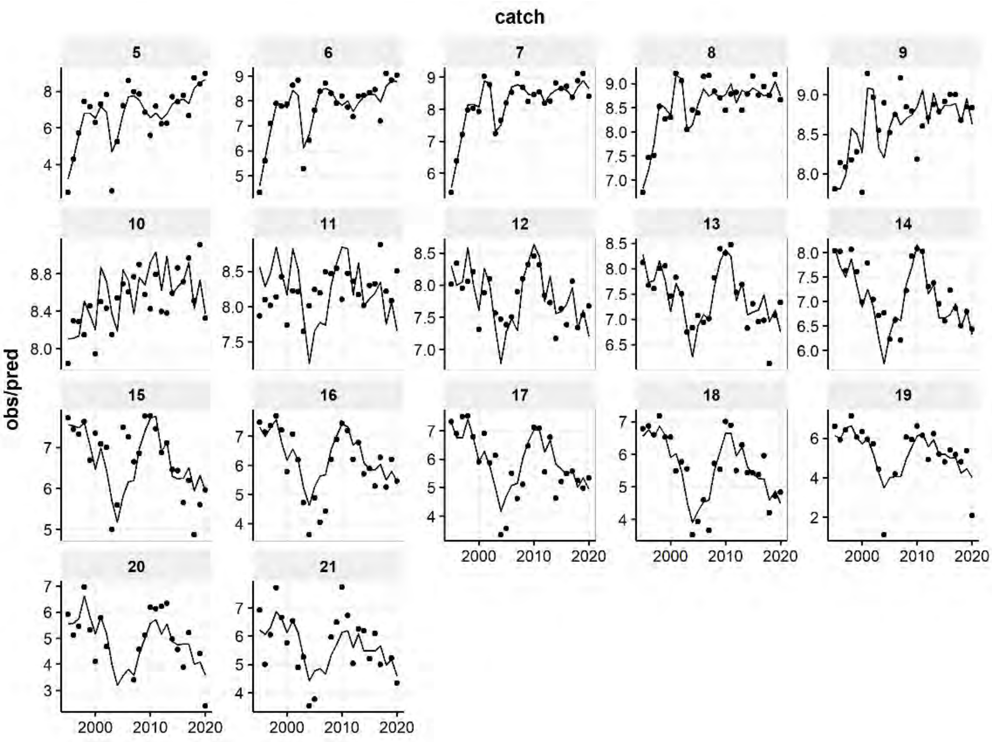


Figure 6.4.12. Greater silver smelt in 5.b and 6.a. Fit of the assessment model to the catches at age.

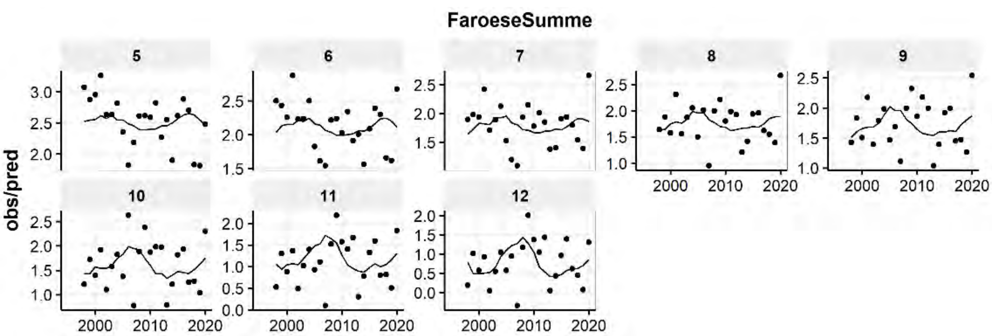


Figure 6.4.13. Greater silver smelt in 5.b and 6.a. Fit of the assessment model to the Faroese summer survey.

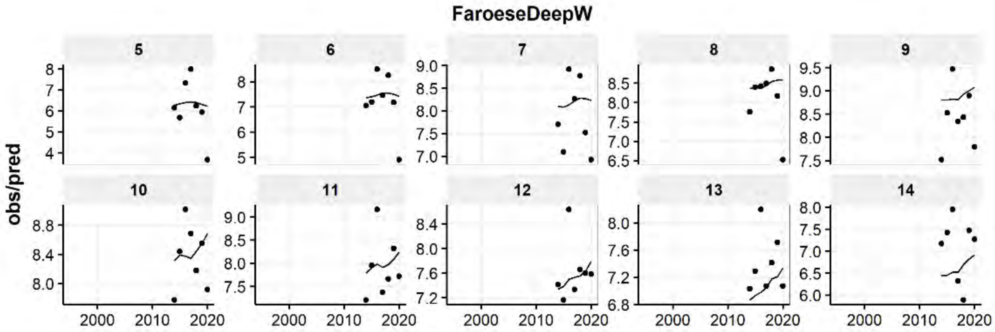


Figure 6.4.14. Greater silver smelt in 5.b and 6.a. Greater silver smelt in 5b and 6a. Fit of the assessment model to the Faroese deepwater survey

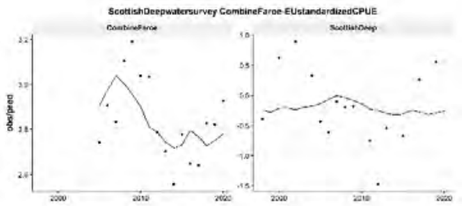


Figure 6.4.15. Greater silver smelt in 5b and 6a. Fit of the assessment model to the combined Faroese/EU CPUE (left) and the Scottish deepwater survey (right).

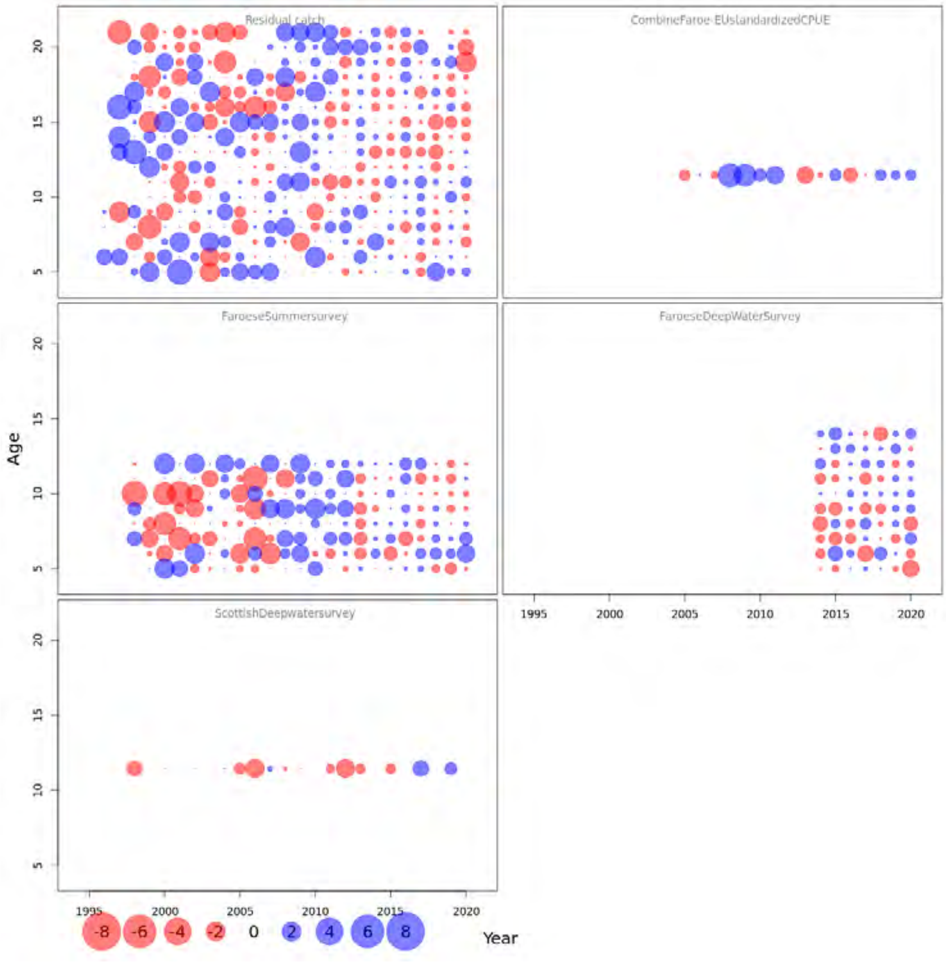


Figure 6.4.16. Greater silver smelt in 5b and 6a. Standardized one-step-ahead residuals from the SAM model.

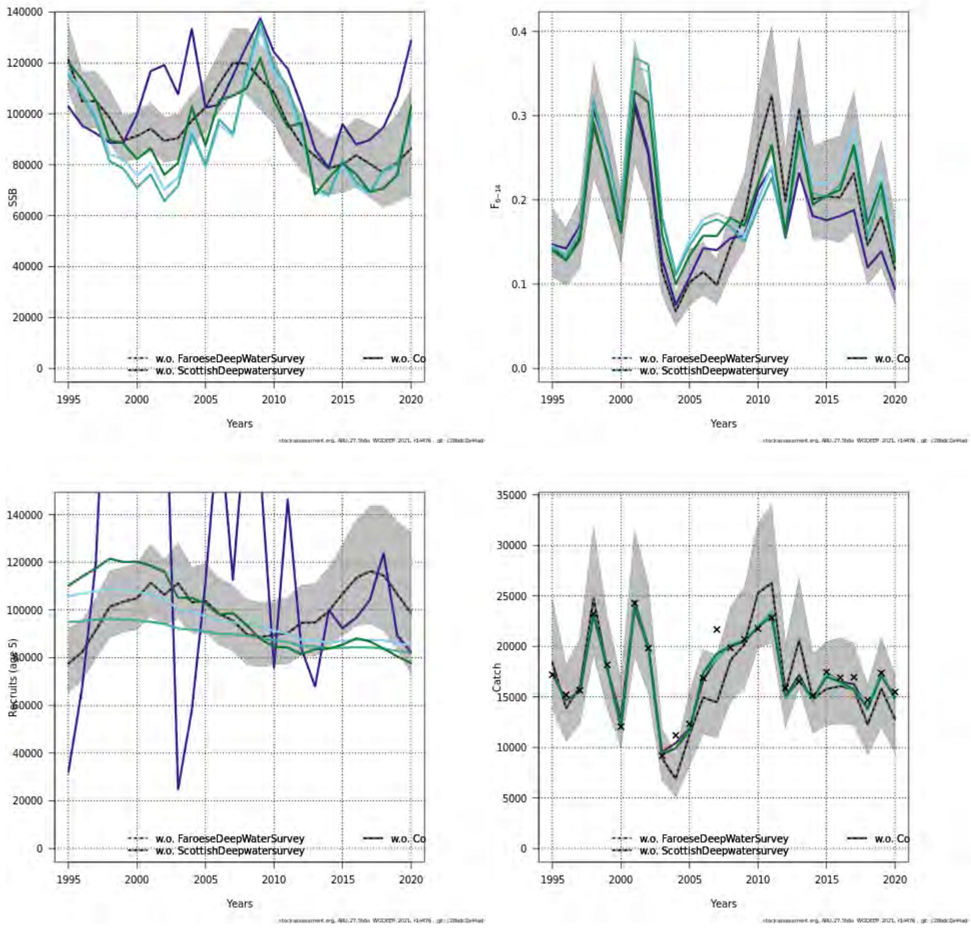
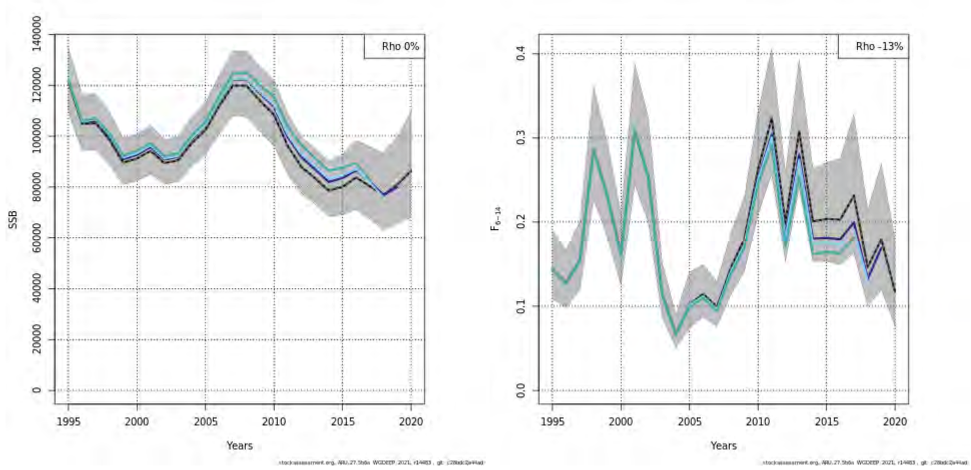


Figure 6.4.17. Greater silver smelt in 5b and 6a. Leave-one-out analysis of SSB (upper left), fishing mortality (upper right), recruitment (lower left) and catch (lower right).



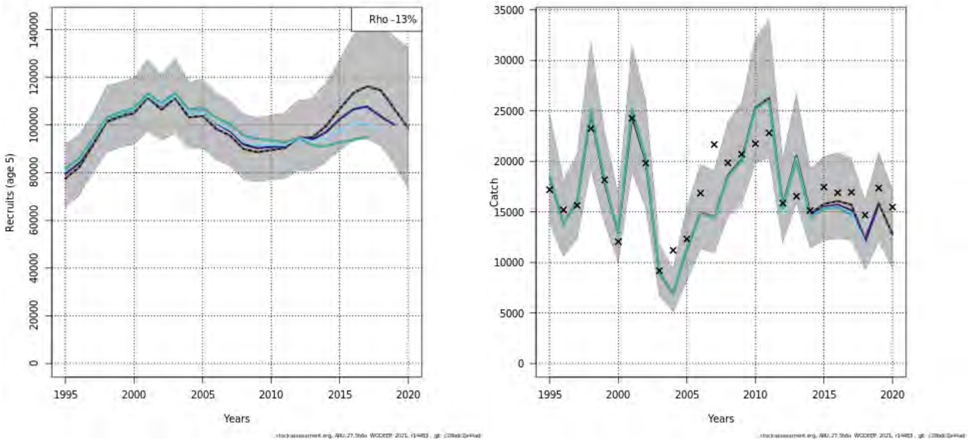


Figure 6.4.18. Greater silver smelt in 5b and 6a. Retrospective analysis with 3 peels in SSB (upper left), fishing mortality (upper right), recruitment (lower left) and catch (lower right).

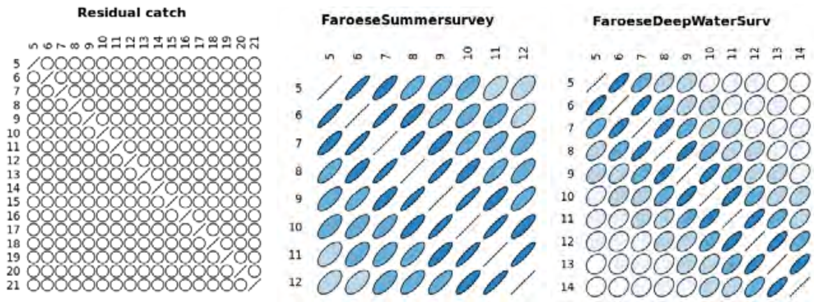


Figure 6.4.19. Greater silver smelt in 5b and 6a. Estimated correlations between age groups for each fleet.

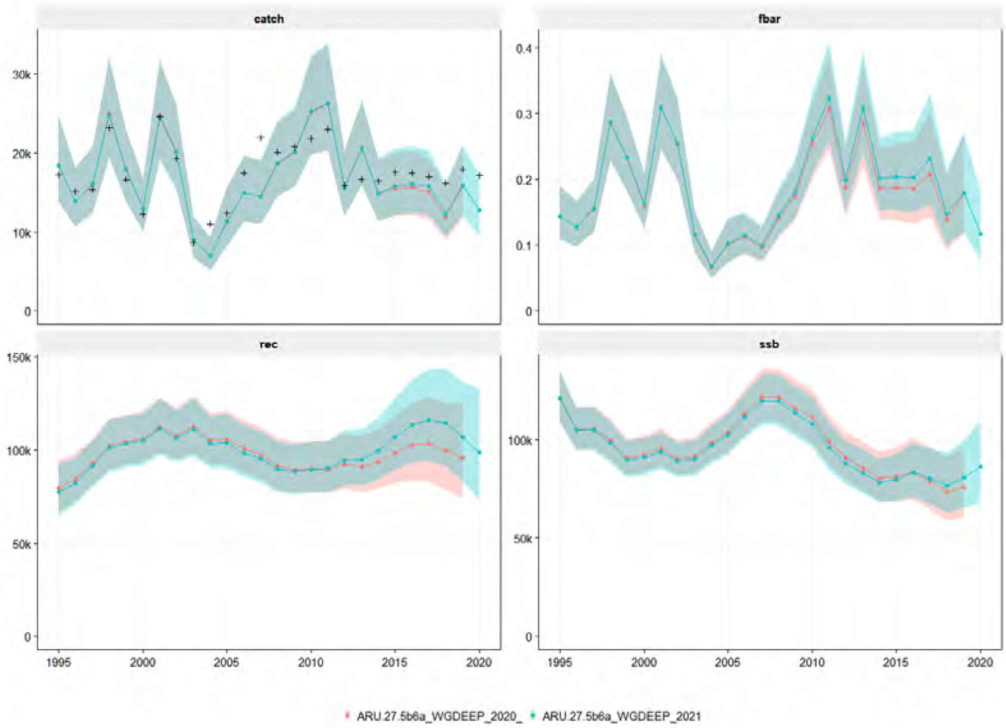


Figure 6.4.20. Greater silver smelt in 5.b and 6.a. Results from the SAM assessment. Catch, tonnes (upper left), fishing mortality (upper right), recruitment (lower left) and SSB (lower right).

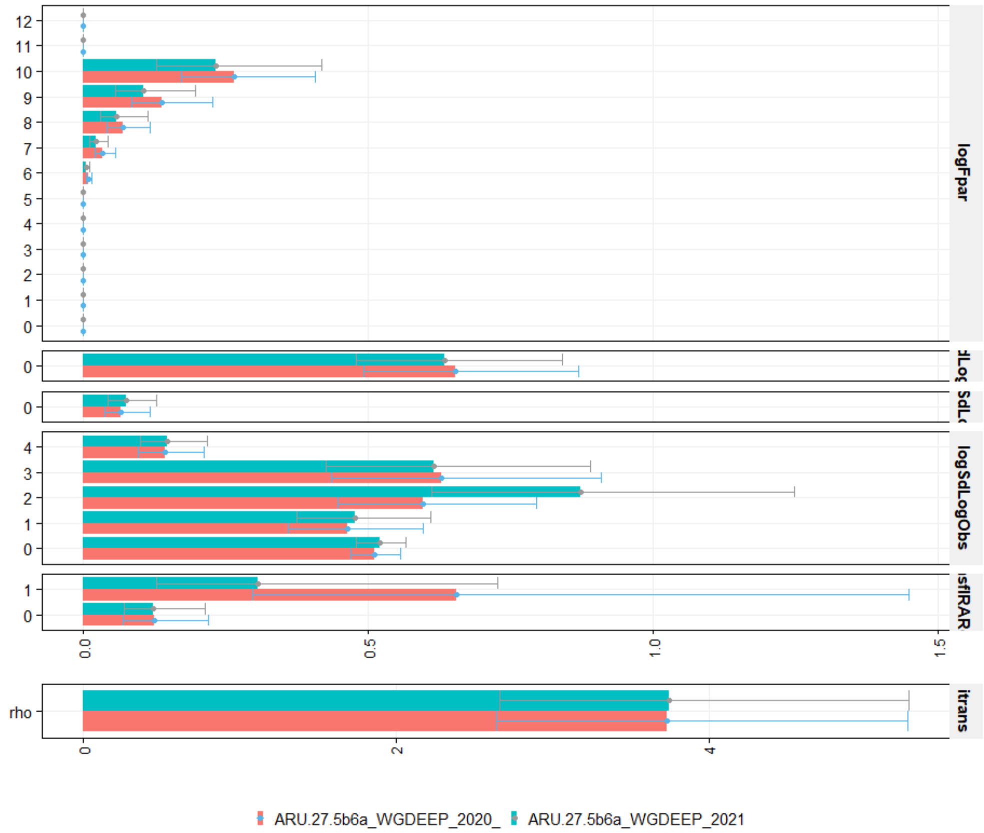


Figure 6.4.21. Greater silver smelt in 5.b and 6.a. Comparison of parameter estimates of WGDEEP 2020 (red) and WGDEEP 2021 (green).

6.4.6 Quality of the assessment

The assessment of greater silver smelt was benchmarked in 2020 (ICES, 2021), where the assessment was moved from a trend-based assessment derived from the Faroese summer survey to a SAM state-space assessment using catch at age information and four indices. A comparison between the assessments of WGDEEP 2020 and WGDEEP 2021 indicates that the model results are largely comparable, although both F and recruitment are estimated somewhat higher than in the 2021 assessment (Figure 6.4.20).

Catch at age information from the period 1995-2004 is derived from the Faroese catch at age sampling raised to the total catch, while the catch at age 2005 to present is derived from InterCatch raising based on Faroese and Netherland catch at age data.

During the 2021 assessment of this stock, we noticed that there was a substantial discrepancy between the calculated catch in tonnes from InterCatch and the SAM estimated catch in tonnes. The discrepancy mostly occurred in the period 2015 to present. Part of the discrepancy derives from the truncation of the age-range used in the assessment model, where only age 5 and up have been used whereas in InterCatch catch at age information is available from age 2 onwards. A comparison of the catch in tonnes that is and that is not included in the assessment is shown in Figure 6.4.22 (both in tonnes and in proportion). This explains part of the discrepancy between observed catch and modelled catch, but still a noticeable discrepancy remains. This could potentially be due to a mis-match between the catch at age information from InterCatch and the SAM model configuration which should be further explored before next WGDEEP.

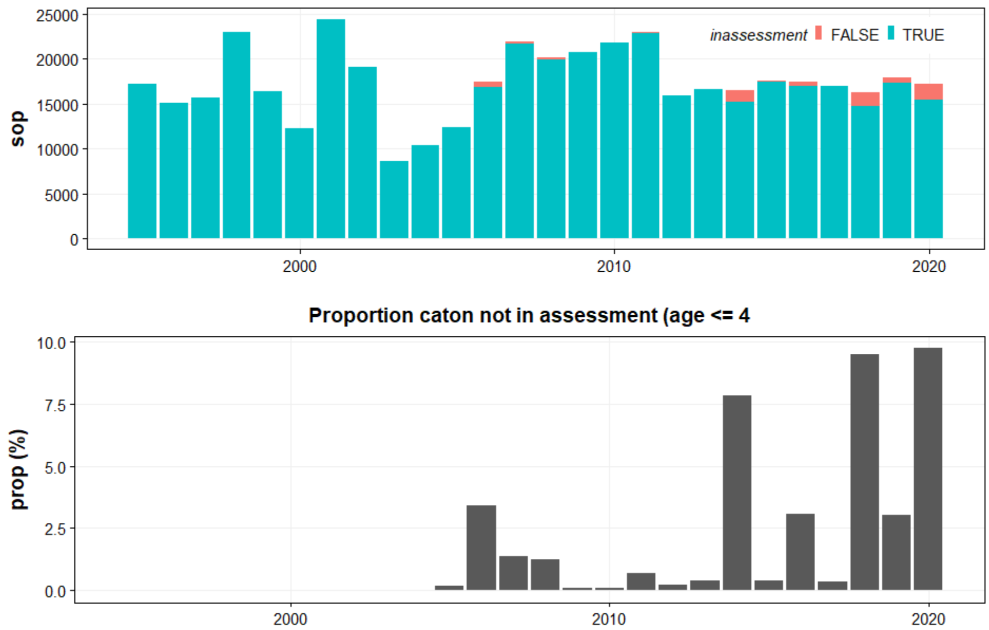


Figure 6.4.22. Greater silver smelt in 5.b and 6.a. Proportion of catch in tonnes available in InterCatch (ages 2-4) that is not included in the assessment.

During the benchmark of greater silver smelt, the method for deriving the survey index at age in the Faroese deepwater survey was based on a GLM approach that involves re-estimating all values for all years every time that the GLM is being run. In the meantime, a new ALK program has been developed and tested by the Faroe Marine Research Institute that allows for annual estimates of abundance at age, without the need to re-estimate all previous years. A comparison between the abundance at age from the GLM and the ALK approach has been carried out during WGDEEP 2021 (Figure 6.4.23, stockassessment.org: ARU.27.5b6a_WGDEEP_2021 and ARU.27.5b6a_WGDEEP_2021_DWalk) and found that there was no discernible difference. Therefore, the WGDEEP 2021 approved that the ALK method will be used to generate catch number at age from the Faroese deepwater survey from WGDEEP 2022 onwards, and the stock annex will be updated correspondingly.

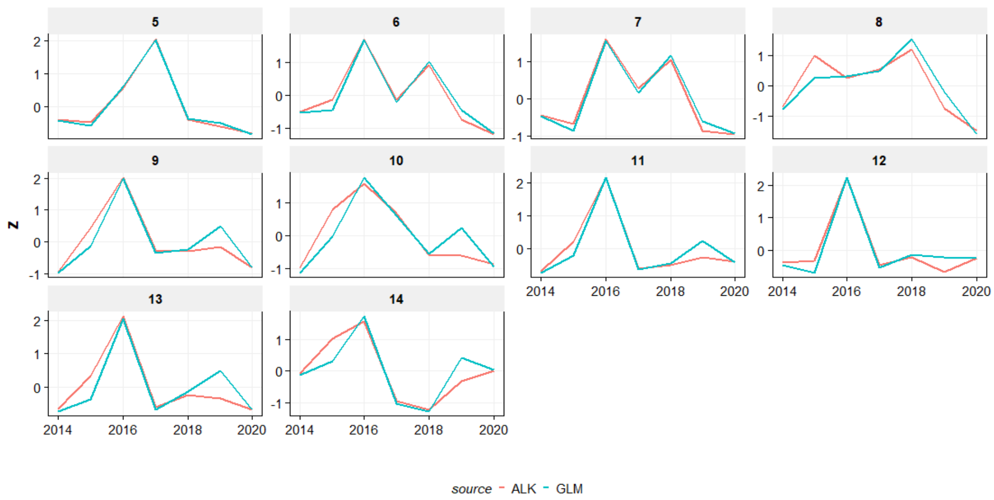


Figure 6.4.23. Greater silver smelt in 5.b and 6.a. Comparison between the estimated catch number of age from the Faroese deepwater survey. Red line- numbers from ALK-program and blue line- numbers when using GLM.

6.4.7 Short term forecast

A short term forecast was carried out using the forecast options on stockassessment.org. Recruitment was based on a 10 year geometric mean recruitment (2010-2019) and mean weights was based on 5 year averages. Stock numbers and selectivity were taken from the final year.

A particular challenge in the forecast of this stock, is the way to deal with the discrepancy between the SAM estimates of catch and the InterCatch estimated catch. Ideally, this discrepancy would have been resolved prior to the provision of advice, but because this is not feasible in a very short time, the WG decided to put forward two different short term forecasts, based on either:

- A status quo fishing mortality at F = 0.117, which results in a catch of 13 337 tonnes in 2021 (as agreed on WKGSS, ICES, 2021).
- A catch constraint of 17 141 tonnes in 2021, which results in a F = 0.16.

Both options are presented on the final run on Stockassessment.org (SAO) (ARU.27.5b6a_WGDEEP_2021) and in Tables 6.4.16, 6.4.17.

6.4.8 Reference points

Reference points for this stock were estimated at the benchmark meeting WKGSS 2020 (ICES, 2021). Two types of reference points are referred to when giving advice for Category 1 stocks: precautionary approach (PA) reference points and maximum sustainable yield (MSY) reference points.

With the updated technical guidelines on reference points (ICES (2021). 16.4.3.1. ICES fisheries management reference points for category 1 and 2 stocks. ICES Advice Technical Guidelines.), the procedure for estimating fishing mortality reference points have changed. F_{pa} is now set at $F_{p0.5}$ = 0.33. The previously estimated F_{lim} (=0.29) is no longer considered relevant, as it is lower than the new F_{pa}. F_{MSY} is maintained at F=0.20 (Table 6.4.18).

6.4.9 Management considerations

In Faroese waters, the greater silver smelt fishery is managed by Faroese authorities. The quota of greater silver smelt in the Faroese EEZ has been reduced from 16 000 tonnes (for 2014) to 11 700 in 2018 and 2019 (Table 6.4.3). The reason for this was the decrease in the spawning–stock biomass index from the exploratory assessment in 2018.

The TACs by the European Union for areas 5, 6 and 7 are set for the European fisheries only. This TAC mostly applies to the fishery in Divisions 5.b and 6.a where the bulk of the catches are taken. After the entering into effect of the EU-UK separation agreement ("Brexit"), no agreement has been reached so far (April 2021) between EU and UK on the 2021 quota for shared stocks, including the greater silver smelt stock.

There has never been an agreement between the Faroe Islands and EU on the setting of an overall TAC for greater silver smelt in 5.b and 6.a. The sum of the quotas of the Faroe Islands and EU has exceeded the scientific ICES advice from 2016 onwards (Table 6.4.3).

6.4.10 Future research and data requirements

The WG recommends that work be done to further explore the assessment and forecast issues that have been identified for this stock. Pending the outcome of these analyses, an Interbenchmark could be carried out for this stock to implement potentially identified solutions after a thorough discussion during WGDEEP 2022 but prior to final advice in 2022. The most pressing issues are:

- Revisit the whole time series of catch at age and weight at age in order to resolve the discrepancy between modelled catch and observed catch. Special attention should be devoted to the allocation criteria for assigning catch at age proportions to unsampled strata. Furthermore, the catch weight at age estimates need attention as the lack of samples of fish older than 15 years, in some years, highlights the need to combine catch at age and weight at age samples in the allocation process that is currently handled separately in Division 5b and 6a.
- Review the short-term forecast assumptions and method in the light of the discrepancy between the SAM estimates of catch and the InterCatch estimated catch and revisiting the catch at age and weight at age matrices.
- Revisit, if needed, the biological reference points in the light of the new guidelines from ACOM.

6.4.11 Tables

Table 6.4.1. Greater Silver Smelt 5.b and 6.a. WG estimates of landings in tonnes.

Division 5.b														TOTAL
Year	**Den-mark**	**Faroes**	**France**	**Germany**	**Greenland**	**Iceland**	**Ireland**	**Netherlands**	**Norway**	**Poland**	**UK(E&W)**	**UK (Scot)**	**Russia**	
1988		287												287
1989		111											116	227
1990		2885											3	2888
1991		59										1		60
1992		1439											4	1443
1993		1063												1063
1994		960												960
1995		5534											6752	12286
1996		9495										3		9498
1997		8433												8433
1998		17570												17570
1999		8186	5								23	15		8229
2000		3713	64									247	1185	5209
2001		9572					1					94	414	10081
2002		7058						5				144	264	7471
2003		6261						51				1	245	6558
2004		3441						1125				42	702	5310

Division 5.b Year	Den-mark	Faroes	France	Germany	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	UK(E&W)	UK (Scot)	Russia	TOTAL
2005		6939						15					59	7013
2006		12554											35	12589
2007		14085						441	32				8	14566
2008		14930							3				19	14952
2009		14200											28	14228
2010		15567										40	2	15609
2011		15578											8	15586
2012		9744											110	9854
2013		11109											114	11223
2014		9747		110									339	10196
2015		13025	0	40		132							115	13312
2016		11129		38		345		31				0	13	11557
2017		9424		1		63		2					6	9496
2018		10114	0							1			150	10265
2019	0	9194		2		6				4			87	9292
2020	0	8416								0			22	8438

***preliminary data**

Table 6.4.1 (Continued).

Division 6.a Year	Den-mark	Faroes	France	Germany	Ireland	Lithuania	Netherlands	Norway	Poland	UK (E&W)	UK (Scot)	Russia	Spain	Total
1988					3040			4884						7924
1989		188			1325		3715	11984			3369			20581
1990		689		14	110		5870				112			6795
1991			7				4709				10			4726
1992			1		100		4964				466			5531
1993							663				406			1069
1994				43			6217				1375			7635

Division 6.a Year	Den-mark	Faroes	France	Germany	Ireland	Lithuania	Netherlands	Norway	Poland	UK (E&W)	UK (Scot)	Russia	Spain	Total
1995		483		284			3706				465			4938
1996				1384	295		3953							5632
1997				1496	1089		4309							6894
1998				464	405		4696							5565
1999				24	168		8188			5				8385
2000			19	403	3178		3436							7036
2001			7	189	5838		3654				4777			14465
2002			1	150	3035		4009			424	4136			11755
2003				26	1		1958				80			2065
2004			147	652	46		4335				507			5687
2005		103	10	125	18		5276				61			5593
2006		52		213			4841				3		1	5110
2007		254		589			7621	3					2	8469
2008		991		10			4186	3						5190
2009		3923		115			2616	83			6	36		6779
2010		3060					3139	7			20	11		6237
2011		3655					3724			2	2			7383
2012		2781		538			3248			5	5	1		6578
2013	388	3197		417	0		1380					13		5395
2014	711	1495		908			2332					21		5467
2015		1055		1027			2154	0						4236
2016		2050	0	228			2495							4773
2017		2304		599			4405	2						7310
2018		1974	8	1001			2763	5				18		5769
2019		2980	4	953	6		4540		29			28	0	8538
2020		3629	8	384	0	114	4330		111				0	8576

***preliminary data**

Table 6.4.2. Greater silver smelt (*Argentina silus*) (5.b and 6.a).

Year	5.b	6.a	Total Landings	Discard 5.b	Discard 6.a	Total catches
1988	287	7924	8211			8211
1989	227	20581	20808			20808
1990	2888	6795	9683			9683
1991	60	4726	4786			4786
1992	1443	5531	6974			6974
1993	1063	1069	2132			2132
1994	960	7635	8595			8595
1995	12286	4938	17224			17224
1996	9498	5632	15130			15130
1997	8433	7269	15702			15327
1998	17570	5556	23126			23135
1999	8229	8223	16452			16614
2000	5209	6989	12198			12245
2001	10081	14466	24547			24546
2002	7471	11766	19237			19226
2003	6558	2039	8597			8623
2004	5310	5059	10369			10997
2005	7013	5634	12647			12606
2006	12559	4897	17456			17699
2007	14126	7817	21943			23035
2008	14952	5160	20112			20142
2009	14228	6651	20879			21007
2010	15609	6237	21846			21846
2011	15586	6709	22295			22969
2012	9854	5115	14969			16432
2013	11223	5445	16668			16618
2014	10196	5467	15663	28	1553	17244
2015	13312	4236	17548		270	17818
2016	11547	4773	16320	12	1651	17993

Year	5.b	6.a	Total Landings	Discard 5.b	Discard 6.a	Total catches
2017	9496	7310	16806	31	239	17076
2018	10265	5769	16033	2	185	16220
2019	9287	8626	17913		86	17916
2020*	8438	8576	17014	0	127	17141

Table 6.4.3. Greater silver smelt in 5.b and 6.a. Overview of ICES advice and TACs set by the Faroese authorities and the European Union for greater silver smelt in area 5.b and 6.a.

Year/Area	ICES advise (5.b and 6.a)	Faroe Islands Quota (5.b and 6.a)	EU Quota ^ (5, 6, 7)	UK Quota (5, 6, 7)	TACs Summed
2014	-	16000	4316	-	20316
2015	-	14400	4316	-	18716
2016	10030	13000	4316	-	17316
2017	10030	11500	3884	-	15384
2018	12036	11700	4661	-	16361
2019	12036	11700	4661	-	16361
2020	7703	11700	3729	-	15429
2021	7703	11700	*	*	

^ The EU TAC applies to all of areas 5, 6 and 7. However, only minor catches have been taken outside of divisions 5.b and 6.a.

*** No current agreement on quotas available between EU and UK (April2021).**

Table 6.4.4. Greater silver smelt in 5.b and 6.a. Discards of greater silver smelt in tons per country per area from 2014 to last data year along with discard percentage of combined annual catch.

Year	Area 5.b				Area 6.a					Areas combined 5.b and 6.a	
	France	Germany	Netherlands	UK(Scotland)	France	Germany	Netherlands	Spain	UK(Scotland)	Total	% of catches
2014		28			808	92			653	1581	9.2
2015					161				109	270	1.5
2016	12				200				1451	1663	9.2
2017	31		0		217		9		14	270	1.6
2018	2				118				67	187	1.2
2019					13			9	64	86	0.5
2020				0				2	124	127	0.7

Table 6.4.5. Greater silver smelt in 5.b and 6.a. Catch numbers at age (*1000) used in the assessment (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
1995	12	76	222	851	2459	2534	2610	3036	3361	3086	2264	1765	1502	880	728	370	1005
1996	73	267	593	1747	3435	3999	3278	4201	2145	3055	1708	1258	986	952	373	167	148
1997	306	1205	1358	1828	3246	3969	3023	2843	2010	2058	1524	1569	1803	725	603	233	423
1998	1696	2688	2911	5015	3542	3443	3418	3155	2996	3174	2065	2212	1853	1303	1251	1053	2228
1999	1282	2416	3070	3891	3932	4710	4551	3674	3144	2021	802	1351	883	681	425	203	772
2000	544	2603	2780	4026	2355	2819	2293	1499	1736	1086	1562	324	368	679	557	61	317
2001	1472	5606	8333	9983	10595	4920	3714	2646	2498	2420	1196	1178	1001	241	383	323	692
2002	2468	6843	6436	8571	7810	4590	3682	3302	1802	1144	1102	487	355	318	299	107	132
2003	13	195	1397	3127	5149	3458	2093	1924	849	822	148	112	458	255	83	-1	193
2004	189	614	2097	4678	7288	5109	3016	1750	925	869	268	37	28	34	3	-1	34
2005	1369	2042	3643	4388	5007	5959	3795	1608	1180	506	1795	131	35	51	-1	-1	43
2006	5299	4377	5040	9345	6286	5454	3613	1819	1030	747	1425	57	244	99	66	-1	-1
2007	2896	6064	9147	9561	10031	6435	4865	2695	1110	495	771	84	100	39	-1	30	-1
2008	2571	4011	5955	6882	6928	7314	4738	3294	2475	1370	951	493	166	302	427	97	387
2009	948	2722	3810	6031	6586	5334	5115	4101	4409	2767	2345	974	642	254	375	168	657
2010	272	3599	4722	4665	3586	4561	3293	4695	4037	3234	2375	1719	1235	1095	752	484	2275
2011	1328	2319	5104	6500	5439	6604	4779	4092	4776	3041	1740	1328	1196	972	461	458	836

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2012	503	1576	3595	6732	6044	4432	4266	2547	1862	1491	962	492	255	242	138	504	154
2013	526	3631	3846	4651	7141	4342	3533	2263	2174	1610	1227	884	876	532	501	563	517
2014	2225	3731	6778	6517	6540	5390	3023	1298	919	1046	637	301	101	229	180	143	487
2015	1666	4151	5676	9401	7438	7057	4023	2064	1483	736	624	362	182	227	121	96	181
2016	2360	4656	6133	6351	8134	6084	4118	1609	1042	1376	286	198	243	215	220	49	441
2017	781	1331	4326	7605	8074	7851	7174	3177	1070	955	491	528	263	382	175	184	148
2018	6161	8981	7209	6314	5866	4968	3709	1540	457	667	130	190	189	67	122	-1	-1
2019	4470	6850	9164	9783	6932	9077	3233	1881	1189	894	270	492	145	112	212	82	186
2020	7904	8313	4481	5775	6887	4119	4942	2146	1524	624	389	235	208	125	8	11	77

Table 6.4.6. Greater silver smelt in 5.b and 6.a. Mean weight at age used in the assessment (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
1995	0.225	0.268	0.312	0.358	0.392	0.435	0.503	0.553	0.638	0.681	0.751	0.830	0.906	0.968	1.013	1.060	0.982
1996	0.194	0.249	0.289	0.334	0.359	0.409	0.470	0.512	0.608	0.643	0.711	0.764	0.860	0.891	0.946	0.994	1.015
1997	0.198	0.256	0.309	0.355	0.383	0.438	0.489	0.538	0.614	0.656	0.715	0.739	0.848	0.875	0.952	0.969	1.003
1998	0.189	0.245	0.295	0.354	0.373	0.428	0.477	0.517	0.588	0.634	0.674	0.687	0.818	0.824	0.923	0.932	0.968
1999	0.192	0.244	0.301	0.350	0.382	0.431	0.488	0.533	0.601	0.652	0.712	0.730	0.829	0.830	0.917	0.917	0.912
2000	0.243	0.262	0.313	0.353	0.395	0.448	0.501	0.546	0.592	0.655	0.724	0.736	0.839	0.767	0.915	0.843	0.918
2001	0.214	0.250	0.298	0.345	0.383	0.429	0.492	0.535	0.602	0.653	0.709	0.746	0.858	0.867	0.948	0.943	0.966

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2002	0.215	0.254	0.303	0.344	0.378	0.431	0.490	0.545	0.610	0.672	0.717	0.744	0.847	0.863	0.957	0.962	1.007
2003	0.239	0.273	0.318	0.353	0.384	0.432	0.490	0.533	0.592	0.649	0.700	0.713	0.823	0.812	0.900	0.866	0.963
2004	0.212	0.255	0.294	0.339	0.378	0.423	0.496	0.550	0.579	0.694	0.687	0.736	0.757	0.728	0.793	0.807	0.802
2005	0.221	0.273	0.309	0.316	0.376	0.394	0.440	0.484	0.542	0.509	0.647	0.780	0.595	0.923	-1	-1	0.808
2006	0.244	0.293	0.321	0.346	0.364	0.412	0.469	0.500	0.577	0.609	0.604	0.768	0.762	0.784	1.046	-1	-1
2007	0.279	0.317	0.351	0.367	0.400	0.457	0.473	0.489	0.581	0.637	0.648	0.741	0.698	0.636	-1	0.910	-1
2008	0.259	0.303	0.353	0.365	0.370	0.418	0.449	0.500	0.533	0.611	0.584	0.683	0.642	0.617	0.646	0.655	0.738
2009	0.251	0.314	0.339	0.379	0.378	0.423	0.423	0.464	0.524	0.555	0.589	0.656	0.656	0.584	0.654	0.622	0.674
2010	0.203	0.309	0.377	0.368	0.401	0.430	0.499	0.473	0.495	0.516	0.558	0.624	0.592	0.582	0.613	0.586	0.724
2011	0.220	0.272	0.348	0.375	0.410	0.439	0.452	0.503	0.486	0.546	0.568	0.569	0.667	0.610	0.670	0.634	0.730
2012	0.252	0.301	0.339	0.371	0.402	0.428	0.480	0.524	0.542	0.574	0.640	0.710	0.731	0.859	0.697	0.781	0.771
2013	0.221	0.296	0.342	0.354	0.380	0.420	0.432	0.493	0.500	0.541	0.595	0.567	0.620	0.668	0.706	0.731	0.693
2014	0.231	0.289	0.330	0.350	0.383	0.400	0.434	0.493	0.528	0.562	0.588	0.673	0.694	0.761	0.571	0.639	0.682
2015	0.235	0.271	0.293	0.335	0.373	0.413	0.439	0.515	0.565	0.647	0.636	0.729	0.700	0.788	0.861	0.779	0.845
2016	0.236	0.293	0.329	0.338	0.371	0.411	0.445	0.461	0.605	0.622	0.711	0.719	0.811	0.642	0.905	0.652	0.736
2017	0.239	0.256	0.298	0.333	0.361	0.385	0.396	0.415	0.507	0.479	0.657	0.697	0.632	0.641	0.787	0.773	0.802
2018	0.226	0.250	0.267	0.292	0.352	0.363	0.420	0.503	0.492	0.566	0.424	0.675	0.781	0.666	0.804	-1	-1
2019	0.222	0.252	0.297	0.301	0.326	0.335	0.355	0.407	0.427	0.464	0.495	0.534	0.512	0.438	0.589	0.576	0.808

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2020	0.237	0.267	0.288	0.314	0.317	0.366	0.401	0.420	0.463	0.488	0.530	0.715	0.677	0.771	0.877	0.859	0.919

Table 6.4.7. Greater silver smelt 5.b and 6a. Maturity proportion by age used in the assessment for greater silver smelt .

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
Prop mature	0.13	0.29	0.52	0.75	0.89	0.96	0.98	0.99	1	1	1	1	1	1	1	1	1

Table 6.4.8. Greater silver smelt in 5.b and 6.a. Summer survey input to tuning series in the assessment (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year	Effort/Age	5	6	7	8	9	10	11	12
1998	0.2	4.317	2.435	1.336	1.033	0.832	0.672	0.339	0.242
1999	0.2	3.556	2.281	1.446	1.310	1.250	1.120	0.735	0.551
2000	0.2	3.828	1.909	1.393	0.969	0.902	0.805	0.483	0.354
2001	0.2	5.236	3.559	2.256	2.024	1.758	1.367	0.782	0.504
2002	0.2	2.778	1.863	1.107	0.951	0.806	0.603	0.325	0.209
2003	0.2	2.795	1.875	1.323	1.303	1.192	0.970	0.555	0.346
2004	0.2	3.352	2.446	1.680	1.556	1.453	1.234	0.806	0.569
2005	0.2	2.103	1.245	0.919	0.894	0.866	0.786	0.507	0.354
2006	0.2	1.234	1.002	0.664	1.500	1.080	2.775	0.607	0.515
2007	0.2	1.779	0.933	0.595	0.516	0.607	0.433	0.220	0.142
2008	0.2	2.713	1.834	1.378	1.475	1.469	1.318	0.914	0.645
2009	0.2	2.727	1.869	1.717	1.838	2.040	2.160	1.783	1.495

Year	Effort/Age	5	6	7	8	9	10	11	12
2010	0.2	2.662	1.521	1.183	1.216	1.288	1.298	0.965	0.789
2011	0.2	3.370	2.084	1.492	1.451	1.777	1.455	0.811	0.570
2012	0.2	1.927	1.355	1.269	1.370	1.469	1.437	1.064	0.843
2013	0.2	2.559	1.489	0.795	0.669	0.564	0.440	0.271	0.209
2014	0.2	1.336	0.952	0.816	0.821	0.806	0.671	0.436	0.310
2015	0.2	2.727	1.614	1.353	1.387	1.370	1.228	0.752	0.524
2016	0.2	3.571	2.184	1.387	1.416	1.470	1.379	0.983	0.805
2017	0.2	2.990	2.001	1.207	1.010	0.853	0.699	0.446	0.372
2018	0.2	1.245	1.046	0.934	0.943	0.870	0.717	0.452	0.314
2019	0.2	1.220	1.007	0.805	0.803	0.708	0.566	0.332	0.215
2020	0.2	2.380	2.910	2.870	2.909	2.548	1.996	1.246	0.738

Table 6.4.9. Greater silver smelt in 5.b and 6.a. Deepwater survey input to tuning series in the assessment (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year	Effort/Age	5	6	7	8	9	10	11	12	13	14
2014	0.110	50.90	128.50	243.10	258.50	202.40	260.80	148.10	181.50	124.40	142.80
2015	0.078	22.80	103.70	94.00	346.00	391.90	360.40	222.20	100.40	114.20	131.00
2016	0.073	110.80	358.00	547.20	332.90	943.60	601.80	697.30	412.30	265.50	208.10
2017	0.073	216.40	126.80	282.50	357.20	307.40	430.80	116.80	111.80	85.70	40.70
2018	0.038	19.40	144.70	245.80	268.50	174.70	135.10	80.50	80.60	63.10	13.70

Year	Effort/Age	5	6	7	8	9	10	11	12	13	14
2019	0.052	19.70	68.20	96.10	182.70	380.20	268.10	213.20	103.90	116.60	91.40
2020	0.031	1.20	4.20	31.40	21.10	75.20	84.90	69.90	60.70	36.40	44.50

Table 6.4.10. Greater silver smelt in 5.b and 6.a. Index from the Scottish deepwater survey and CPUE from the combined Faroe- EU standardized CPUE used as input to tuning series in the assessment (ARU _27.5b6a_WGDEEP2021 @ stock-assessment.org).

Year	Scottish deepwater survey	Combined Faroe-EU CPUE
1998	0.68	
1999	-1	
2000	1.88	
2001	-1	
2002	2.44	
2003	-1	
2004	1.4	
2005	0.65	15.5
2006	0.54	18.3
2007	0.9	17
2008	0.82	22.3
2009	0.84	24.3
2010	-1	20.9
2011	0.47	20.8
2012	0.23	16.2
2013	0.58	14.9
2014	-1	12.9
2015	0.51	16.1
2016	-1	14.1
2017	1.3	14
2018	-1	16.9
2019	1.75	16.8
2020	-1	18.7

Table 6.4.11. Greater silver smelt in 5.b and 6.a. Model configuration with 23 parameters.

$minAge	5
$maxAge	21
$maxAgePlusGroup	1 0 0 0 0
$keyLogFsta	
catch	0 1 2 3 4 6 5 5 5 5 5 5 5 5 5 5 5
Faroese summer surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Scottish deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag	2
$keyLogFpar	
catch	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese summer surv	0 1 2 3 4 5 5 5 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	6 7 8 9 10 10 10 10 10 10 -1 -1 -1 -1 -1 -1 -1
Scottish deepw surv	11 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	12 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyQpow	All -1
$keyVarF	
catch	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Faroese summer surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Scottish deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarLogN	0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
$keyVarObs	
catch	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Faroese summer surv	1 1 1 1 1 1 1 1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	2 2 2 2 2 2 2 2 2 2 -1 -1 -1 -1 -1 -1 -1
Scottish deepw surv	3 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	4 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$obsCorStruct	"ID" "AR" "AR" "ID" "ID"
$keyCorObs	
catch	NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
Faroese summer surv	0 0 0 0 0 0 0 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	1 1 1 1 1 1 1 1 1 -1 -1 -1 -1 -1 -1 -1
Scottish deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$stockRecruitmentModelCode	0
$noScaledYears	0
$keyScaledYears	
$keyParScaledYA	
$fbarRange	6-14
$keyBiomassTreat	-1 -1 -1 5 5
$obsLikelihoodFlag	"LN" "LN" "LN" "LN" "LN"
$fixVarToWeight	0
$fracMixF	0
$fracMixN	0
$fracMixObs	0 0 0 0 0
$constRecBreaks	

Table 6.4.12. Greater silver smelt in 5.b and 6.a. Model parameter estimates (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-8.901	0.111	0	0	0
logFpar_1	-9.116	0.11	0	0	0
logFpar_2	-9.221	0.11	0	0	0
logFpar_3	-8.968	0.11	0	0	0
logFpar_4	-8.693	0.111	0	0	0
logFpar_5	-8.419	0.112	0	0	0

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_6	-5.117	0.34	0.006	0.003	0.012
logFpar_7	-3.788	0.333	0.023	0.012	0.044
logFpar_8	-2.829	0.324	0.059	0.031	0.113
logFpar_9	-2.25	0.31	0.105	0.057	0.196
logFpar_10	-1.458	0.294	0.233	0.129	0.419
logFpar_11	-12.115	0.165	0	0	0
logFpar_12	-9.076	0.069	0	0	0
logSdLogFsta_0	-0.455	0.14	0.635	0.479	0.84
logSdLogN_0	-2.59	0.273	0.075	0.043	0.129
logSdLogObs_0	-0.652	0.042	0.521	0.48	0.567
logSdLogObs_1	-0.74	0.122	0.477	0.374	0.609
logSdLogObs_2	-0.135	0.178	0.873	0.612	1.247
logSdLogObs_3	-0.485	0.184	0.615	0.426	0.889
logSdLogObs_4	-1.912	0.194	0.148	0.1	0.218
transfIRARdist_0	-2.093	0.277	0.123	0.071	0.214
transfIRARdist_1	-1.181	0.432	0.307	0.13	0.728
itrans_rho_0	1.322	0.171	3.75	2.663	5.28

Table 6.4.13. Greater silver smelt in 5.b and 6.a. Assessment summary. Weights are in tonnes, recruitment in thousands (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year	$R_{(age\ 5)}$	Low	High	SSB	Low	High	$Fbar_{(6\text{-}14)}$	Low	High	TSB	Low	High
1995	77583	65291	92189	121184	109013	134715	0.144	0.109	0.19	159874	145163	176076
1996	82306	70641	95897	104863	94417	116466	0.128	0.098	0.167	142610	129506	157039
1997	91525	79870	104880	105074	94561	116755	0.155	0.12	0.201	147965	134315	163003
1998	101307	88310	116216	98523	88671	109471	0.287	0.227	0.361	143650	130508	158115
1999	103466	90680	118054	89603	80943	99191	0.232	0.182	0.296	137673	125262	151313
2000	104892	92011	119575	91237	82452	100957	0.162	0.126	0.21	147604	134243	162294
2001	111408	97320	127535	94185	85094	104247	0.309	0.245	0.389	148969	135441	163849
2002	106435	93456	121217	89408	81111	98554	0.254	0.2	0.324	144337	131336	158625
2003	111213	96565	128083	90504	82080	99794	0.115	0.087	0.152	150554	136575	165965
2004	103186	90245	117983	97360	88205	107465	0.068	0.051	0.09	152946	138775	168564
2005	103800	90278	119349	102479	92689	113304	0.102	0.074	0.141	159922	144852	176559
2006	98387	85440	113297	111861	100962	123937	0.115	0.088	0.15	171446	155111	189501
2007	95527	82717	110321	119958	107872	133399	0.099	0.076	0.129	182548	164655	202385
2008	89926	77329	104574	119777	107547	133398	0.145	0.113	0.186	176489	158916	196005
2009	88597	76125	103113	113796	101691	127343	0.18	0.142	0.23	168098	150635	187585
2010	89528	77006	104087	108392	96262	122049	0.263	0.209	0.331	159293	141912	178802
2011	90303	77528	105182	96152	84993	108776	0.324	0.257	0.407	145706	129252	164254

Year	$R_{(age\ 5)}$	Low	High	SSB	Low	High	$Fbar_{(6-14)}$	Low	High	TSB	Low	High
2012	94593	81003	110463	87900	77538	99647	0.199	0.153	0.258	142020	125625	160555
2013	94749	80790	111121	83431	73136	95177	0.308	0.241	0.394	135851	119481	154464
2014	99501	84285	117464	78567	68406	90238	0.201	0.153	0.263	132324	115571	151505
2015	106770	89461	127429	80111	69002	93009	0.204	0.153	0.271	134039	116052	154813
2016	113376	93405	137617	83731	71190	98481	0.203	0.149	0.276	143218	122580	167332
2017	116219	94177	143419	80323	67281	95893	0.232	0.163	0.329	139124	117509	164715
2018	114505	91295	143616	76855	63169	93507	0.147	0.1	0.214	133613	111100	160689
2019	106631	83169	136713	80955	65611	99887	0.18	0.12	0.269	136950	112283	167036
2020	98685	73419	132645	86361	68001	109679	0.117	0.077	0.18	140914	112800	176036

Table 6.4.14. Greater silver smelt in 5.b and 6.a. Estimated fishing mortality at age (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
1995	0.000	0.002	0.006	0.025	0.073	0.133	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263
1996	0.001	0.005	0.013	0.039	0.083	0.127	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
1997	0.003	0.014	0.027	0.062	0.105	0.150	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259
1998	0.010	0.036	0.063	0.128	0.186	0.246	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480
1999	0.009	0.034	0.059	0.114	0.158	0.211	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379
2000	0.007	0.028	0.050	0.089	0.119	0.159	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254
2001	0.013	0.056	0.111	0.193	0.257	0.312	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2002	0.010	0.043	0.104	0.185	0.251	0.270	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359
2003	0.001	0.005	0.021	0.060	0.116	0.182	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
2004	0.002	0.009	0.026	0.058	0.089	0.132	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074
2005	0.009	0.025	0.050	0.090	0.115	0.231	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102
2006	0.024	0.057	0.090	0.123	0.146	0.176	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
2007	0.027	0.066	0.101	0.122	0.125	0.130	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087
2008	0.022	0.061	0.102	0.138	0.157	0.196	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
2009	0.013	0.043	0.083	0.133	0.175	0.215	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
2010	0.009	0.036	0.082	0.145	0.213	0.309	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395
2011	0.011	0.043	0.100	0.191	0.276	0.403	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475
2012	0.007	0.028	0.065	0.128	0.189	0.272	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277
2013	0.010	0.038	0.083	0.162	0.275	0.421	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448
2014	0.016	0.049	0.092	0.150	0.206	0.272	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260
2015	0.018	0.052	0.099	0.164	0.225	0.271	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256
2016	0.019	0.046	0.088	0.153	0.220	0.293	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256
2017	0.014	0.032	0.066	0.133	0.229	0.360	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316
2018	0.034	0.060	0.084	0.124	0.161	0.209	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
2019	0.050	0.079	0.104	0.154	0.202	0.251	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2020	0.063	0.083	0.084	0.114	0.138	0.157	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120

Table 6.4.15. Greater silver smelt in 5.b and 6.a. Estimated stock numbers at age (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
1995	77583	56980	44508	39597	37333	28411	24284	18629	18294	15184	8840	7001	6925	3251	2140	1191	2303
1996	82306	66754	48951	38072	33224	29860	21402	16064	12323	12101	10044	5848	4631	4581	2150	1416	2312
1997	91525	70770	57179	41606	31506	26307	22628	14758	11076	8497	8344	6926	4032	3193	3159	1483	2570
1998	101307	78519	60089	47906	33652	24405	19481	15027	9800	7356	5643	5541	4599	2678	2121	2098	2692
1999	103466	86363	65215	48551	36271	24053	16427	10375	8003	5219	3917	3005	2951	2449	1426	1129	2550
2000	104892	88218	71844	52900	37297	26661	16770	9682	6115	4717	3076	2309	1771	1739	1444	840	2169
2001	111408	89635	73823	58849	41663	28496	19570	11194	6463	4082	3148	2053	1541	1182	1161	964	2009
2002	106435	94675	72938	56853	41782	27729	17953	10613	6071	3505	2214	1707	1114	836	641	630	1612
2003	111213	90723	78041	56551	40689	27969	18211	10795	6381	3650	2107	1331	1027	670	503	385	1348
2004	103186	95621	77667	65800	45834	31196	20077	13306	7887	4662	2667	1540	972	750	489	367	1266
2005	103800	88604	81581	65152	53442	36083	23528	16052	10638	6306	3728	2132	1231	777	600	391	1306
2006	98387	88530	74362	66760	51231	41008	24650	18290	12478	8270	4902	2898	1657	957	604	466	1319
2007	95527	82644	72012	58472	50789	38086	29606	19011	14105	9623	6378	3780	2235	1278	738	466	1377
2008	89926	80062	66581	56003	44534	38596	28776	23365	15003	11132	7595	5033	2983	1764	1009	582	1455
2009	88597	75702	64811	51746	41982	32775	27308	21034	17079	10967	8137	5551	3679	2181	1289	737	1489

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2010	89528	75301	62395	51333	38985	30333	22761	18426	14193	11524	7400	5490	3746	2482	1471	870	1502
2011	90303	76402	62492	49468	38209	27127	19161	13201	10687	8231	6683	4292	3184	2172	1440	853	1376
2012	94593	76876	63007	48668	35158	24965	15597	10256	7066	5720	4406	3577	2297	1704	1163	771	1193
2013	94749	80825	64352	50830	36869	25052	16366	10176	6691	4610	3732	2875	2334	1499	1112	759	1281
2014	99501	80737	67006	50971	37194	24099	14160	8996	5593	3678	2534	2051	1580	1283	824	611	1121
2015	106770	84280	66180	52623	37775	26066	15796	9395	5969	3711	2440	1681	1361	1048	851	547	1150
2016	113376	90237	68898	51598	38458	25968	17101	10524	6260	3977	2473	1626	1120	907	699	567	1130
2017	116219	95777	74140	54300	38104	26568	16667	11389	7009	4169	2649	1647	1083	746	604	465	1130
2018	114505	98604	79825	59749	40917	26093	15946	10458	7146	4398	2616	1662	1033	679	468	379	1001
2019	106631	95275	79923	63163	45429	29975	18228	11576	7592	5188	3193	1899	1207	750	493	340	1002
2020	98685	87317	75788	62000	46629	31957	20065	12756	8101	5313	3630	2234	1329	844	525	345	939

Table 6.4.16. Greater silver smelt in 5.b and 6.a. Short term forecast with F_{sq} constraint in 2021 (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Intermediate year assumptions				
		Value	low	high
TAC	2021	13337		
Advice	2021	7703		
F_{bar}	2021	0.117	0.077	0.178
Catch	2021	13337	10132	16921
Recruitment	2021-2023	106631	89528	116219
SSB	2021	93047	72522	119450
SSB	2022	95864	73681	123191

Forecast options						
Scenario	**Catch**	**Fbar**	**SSB**	**%SSB change**	**% TAC change**	**%Advice change**
	2022	**2022**	**2023**			
F_{MSY}	22224	0.2	90010	-6	67	189
F=0	0	0	109016	14	-100	-100
F_{sq}	13581	0.117	97503	2	2	76
F_{lim}	30874	0.29	82978	-13	131	301
$F_{p0.5}$	34461	0.33	80007	-17	158	347
F=0.16	18146	0.16	93497	-2	36	136
F=0.241	26288	0.241	86780	-9	97	241

Table 6.4.17. Greater silver smelt in 5.b and 6.a. Short term forecast with catch constraint in (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Intermediate year assumptions				
		Value	low	high
TAC	2021	17141		
Advice	2021	7703		
F_{bar}	2021	0.16	0.105	0.242
Catch	2021	17141	13263	21415
Recruitment	2021-2023	106631	89528	116219
SSB	2021	89337	68527	115597
SSB	2022	88854	66383	116356

Forecast options						
Scenario	**Catch**	**Fbar**	**SSB**	**%SSB change**	**% TAC change**	**%Advice change**
	2022	**2022**	**2023**			
F_{MSY}	20811	0.2	84323	-5	21	170
F=0	0	0	101816	15	-100	-100
F_{sq}	12725	0.117	91012	2	-26	65
F_{lim}	28866	0.29	77692	-13	68	275
$F_{p0.5}$	32262	0.33	75000	-16	88	319
F=0.16	16997	0.16	87456	-2	-1	121
F=0.241	24585	0.241	81323	-8	43	219

Table 6.4.18. Greater silver smelt in 5.b and 6.a. Reference points, values, their technical basis and source.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	82 999	B_{pa}; in tonnes	(ICES, 2021a)
	F_{MSY}	0.2	Stochastic simulations (EqSim) with segmented regression fixed at B_{lim}	(ICES, 2021a)
Precautionary approach	B_{lim}	59 730	B_{lim}=B_{pa}⁄(exp(σ×SSB×1.645),σ=0.2); in tonnes	(ICES, 2021a)
	B_{pa}	82 999	B_{loss}, lowest observed SSB (2014) from 2020 benchmark; in tonnes	(ICES, 2021a)
	F_{lim}	Not defined	F_{lim} was set to 0.29 at WKGSS which is below new F_{pa} based on F_{p05}. F_{pa} in WKGSS was set to 0.2.	
	F_{pa}	0.33	The F that provides a 95% probability for SSB to be above B_{lim} (F_{P05}).	(ICES, 2021a)

6.5 Greater silver smelt (*Argentina silus*) in 6.b, 7, 8, 9,10 and 12

6.5.1 The fishery

The fisheries from this area is very minor and there are no directed fisheries.

6.5.2 Landing trends

Landings from this area are reported from 1966–2020. Landings increased until 2002 to 4662 tons then declined again to low levels of less than a ton in 2016. Landings from 2006 until 2019 have been less than 50 tons. However, the landings of 76 t in 2020 was the highest since 2005. The main landings have been from Subareas 6b and 7 where Ireland were fishing for some years between 2000 and 2003.

Landings in Division 6.b and subareas 7–10 and 12 are small. Considerable discarding is known to occur in some fisheries in the Porcupine Bank outer shelf and upper slope fisheries for demersal and deep-water fish. These fisheries do not land greater silver smelt. Targeted fisheries for greater silver smelt that existed prior to 2006 have not operated significantly in these areas since then. It is considered more likely that variations in landings over time reflect market opportunities rather than fish abundance.

6.5.3 ICES Advice

Advice is given every other year. The 2019 advice for area 6b, 7, 8, 9, 10 and 12, stated "ICES advises that catches should be no more than 193 tonnes in each of the years 2020 and 2021. The precautionary approach is not applied for the advice given in 2019. ICES previously gave advice on landings for this stock. Because discard data are now available, the present advice is provided for catch.

6.5.4 Management

The EU introduced TAC management in 2003. For 2020 and 2021 the EU TAC in Subareas 5, 6 and 7 are 3521 t and 881 t, respectively. Catches of blue whiting may include unavoidable by-catches of greater silver smelt in the area.

6.5.5 Data available

6.5.5.1 Landings and discards

Landings data are presented by area and countries (Tables 6.5.1–6.5.5, Figure 6.5.1). Discards data from the six last years are presented in Table 6.5.6. Discards from 2015 to 2019 are mainly from the Spanish fishery and from Subarea 7, while for 2020 the discards were around 50 t from both the Spanish fishery and the Scottish fishery. For previous years, the discards were very high compared to the landings. In 2020 this has shifted, with Dutch landings of 62 t from Subarea 7.

Argentina silus can be a very significant discard of the trawl fisheries of the continental slope of Subareas 6 and 7 particularly at depths 300–700 m (e.g. Girard and Biseau, WD 2004) (Table 6.5.7). Information have been available on discards in 2009 and 2012 in Basque country and Spanish fisheries in Subareas 6–7, and Divisions 5.3.abcd and northern 9.a. These estimates have been in the range 1000–4000 t since 2003. In 2010 and 2011 they were around 2000 t. New calculation of the estimates for 2012 and 2013 reduce strongly the discards reported by Spain. Same applies for discards registered by the Netherlands. Based upon on-board observations from DCF sampling, the catch composition of the French mixed trawl fisheries in 5.b, 6 and 7 include 5.3% of greater silver smelt, based upon data for year 2011 (Dubé *et al*., 2012). This species is discarded in that fishery; it represents 25.3% of the discards. Raised to the total landings from that fishery an estimated 280 t of discarded greater silver smelt was estimated for 2011. It should be noted that after redefinition of stock structure in 2015 area 6.a is not included in this stock.

ICES considers that the high landings of silver smelt seen in the early 2000s (Table 6.5.1 and 6.5.2, and Figure 6.5.1.) may have resulted from misreporting of fish species other than silver smelt. There is currently no directed fishery, and bycatches of greater silver smelt are discarded in fisheries for other species (primarily hake, monkfish, and megrim).

6.5.5.2 Length compositions

The size compositions of *Argentinas* spp. from Porcupine survey since 2009 is presented in Figure 6.5.2.

Length distribution from discards are available in InterCatch for 2015 (Scotland), 2016 (Spain), 2017 (Spain and Scotland), 2018 (Spain and Scotland), 2019 (Spain) and 2020 (Scotland and Spain). For landings, length distributions are available from 2020 (Netherland). These length distributions have, for the time being, not been analysed.

6.5.5.3 Age compositions

No new data on age composition were presented.

6.5.5.4 Weight-at-age

No new data on weight-at-age were presented.

6.5.5.5 Maturity and natural mortality

No new data on maturity and natural mortality were presented.

6.5.5.6 Catch, effort and research vessel data

Spanish bottom-trawl surveys have been carried out in Subarea 7 (Porcupine) since 2001. Recent investigations have revealed that survey catches from the Spanish Porcupine survey contain both *A. Silus* and *A. Sphyraena* (Table 6.5.8 and Figures 6.5.2 - 6.5.6). Abundance and biomass indices from survey catches of mixed *A. silus* and *A. sphyraena* is presented in Figure 6.5.4. The Spanish survey only covers depths to 400 m and is unlikely to fully cover the depth range of greater silver smelt.

6.5.6 Data analyses

Length and age distributions

In previous years, the size compositions from Porcupine Bank in Subarea 7 have not shown any obvious trend towards smaller fish, but these data may be disturbed by the relative species composition of *A.silus* and *A.sphyreana* (Figure 6.5.2 and 6.5.5). In 2019, however, despite the low abundance per size of *A.silus* from the last survey, small specimens (around 17 cm) were found. For *A.silus* this shows the highest amount of small specimens in the last ten years. A second small mode was found around 28 cm. For 2020, the length composition from the survey for *A.silus* shows that the mode around 22 cm increased greatly. However, *A.sphyraena* showed a single mode around 22 cm (Figure 6.5.2).

Commercial and survey cpue series

For Subarea 7, abundances and biomass indices from the Spanish porcupine survey have been showing a decreasing trend from 2002 until 2011 but have been rising since then until 2016 (Figure 6.5.4). The index has decreased for *A.silus* the last three years compared to 2016. However, the survey is unlikely to cover all the exploitable biomass of the stock as it only covers depth down to 400 meters. In 2019, the biomass of both species of *Argentina* continued decreasing, whereas the abundance increased slightly (Table 6.5.8 and Figure 6.5.4). *A.silus*, the most contributing species in the overall percentage of silver smelt, followed the downward trend of the previous years, whereas *A.sphyraena* increased abruptly both regarding biomass and abundance (Table 6.5.8 and Figure 6.5.3). However, the index from the survey conducted in 2020 shows that both the biomass and he number of *A.silus* increased considerably, breaking the downward trend of recent years and staying in the medium-high values of historical series. *A.sphyraena*, by contrast, decreased sharply, getting medium-low values of the time series.

Exploratory assessment

No exploratory assessment was presented.

Biological reference points

SPiCT was run on the landings dataseries (1973–2016) and the biomass index series from Porcupine bank (2001–2016) at WGDEEP 2017, but it did not converge.

6.5.7 Assessment

The ICES framework for category 3 stocks was applied (ICES, 2012). The Spanish Porcupine bank survey greater silver smelt index (Table 6.5.8 and Figure 6.5.3) was used for the stock development. The advice is based on a comparison of the two latest index values (index A) with the three preceding values (index B), multiplied by recent advice and divided by the retention rate (1 – discard rate). The index is estimated to have decreased by 66% and thus the uncertainty cap was applied. The stock status relative to candidate reference points is unknown.

6.5.8 Comments on the assessment

Advice is given every second year for this stock and last advice applies for 2022 and 2023.

It should be noted that lesser silver smelt (*Argentina sphyraena*) may in some southerly areas have been included in the landing figures. According to research on the Spanish Porcupine survey where both species appear, lesser silver smelt are smaller and occupies shallower areas than greater silver smelt (Figures 6.5.2, and 6.5.6). The proportion of lesser silver smelt in the fisheries is not believed to be large but further investigations should be undertaken.

The biomass index is only from the Porcupine bank and is therefore not covering the total stock area.

6.5.9 Management considerations

The trends for Porcupine bank survey biomass indices for *Argentina* species have increased in 2015 and 2016, declined in 2017, 2018 and 2019 before increasing again in 2020.

6.5.10 References

Dubé, B., J. Dimeet, M.-J. Rochet, A. Tétard, O. Gaudou, C. Messannot, L. Fauconnet, Y. Morizur, A. Biseau, and M. Salaun. 2012. Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2011.

Girard, Marine & Alain Biseau. 2004. Preliminary results concerning spatial variability of the catch in the ICES Subarea VI: Composition and importance of the discard fraction. 8 p. WD WGDEEP 2004

6.5.11 Tables

Table 6.5.1. Greater Silver Smelt in 6.b. WG estimates of landings in tonnes. *landings in 2020 are preliminary.

Year	Faroes	Germany	Ireland	Netherlands	Scotland	Russia	Spain	TOTAL
1979								
1980		13						13
1981		525						525
1982								
1983		4						4
1984								
1985								
1986								
1987								
1988								
1989								
1990			300					300
1991				5				5
1992			220		1			221
1993					3			3
1994					20			20
1995	1114							1114
1996								
1997								
1998								
1999			178					178
2000			1355			29		1384

Year	Faroes	Germany	Ireland	Netherlands	Scotland	Russia	Spain	TOTAL
2001					62	68		130
2002					1	29		30
2003					6	120		126
2004				11		12		23
2005						4		4
2006								
2007								
2008						1	8	9
2009								
2010								
2011								
2012								
2013								
2014						20.5		20.5
2015								0
2016								0
2017								0
2018								0
2019						1		1
2020*						11		11

Table 6.5.2. Greater Silver Smelt in 7. WG estimates of landings in tonnes. *landings in 2020 are preliminary.

Year	France	Germany	Ireland	Netherlands	Scotland	Norway	Poland	Spain	UK E/W	TOTAL
1972										
1973	40									103
1974							63			
1975										
1976										
1977			1							1
1978		404					5			409

Year	France	Germany	Ireland	Netherlands	Scotland	Norway	Poland	Spain	UK E/W	TOTAL
1979		103								103
1980										
1981										
1982						666				666
1983						595				595
1984						163				163
1985										
1986						258				258
1987						50				50
1988						100				100
1989						200				200
1990		23		1						24
1991				9						9
1992				254						254
1993				505						505
1994				39						39
1995		73	6	431						510
1996		10								10
1997				12						12
1998										
1999			50							50
2000		79	166	244				34		523
2001	5		1592	2	2782			34		4415
2002			4433		2			2		4437
2003			95	19				5		119
2004				13	19			15		47
2005		26	1		14			17		58
2006								40		40
2007								35		35

Year	France	Germany	Ireland	Netherlands	Scotland	Norway	Poland	Spain	UK E/W	TOTAL
2008										
2009	13		1					6		20
2010	10			8				2	3	23
2011		4			8					12
2012		2			1					3
2013				1						1
2014				1						1
2015				5						5
2016	0			0				0		0
2017				8						8
2018				31				1		32
2019			0	5						5
2020*			1	62						63

Table 6.5.3. Greater Silver Smelt in 8. WG estimates of landings in tonnes. *landings in 2020 are preliminary.

Year	Netherlands	Spain	Ireland	TOTAL
2002	195			194.61
2003	43			42.525
2004	23			22.722
2005	202			202.29
2006				0
2007				0
2008		10		10
2009				0
2010				0
2011	1			1
2012				0
2013				0
2014	1.1			1.1
2015				0

Year	Netherlands	Spain	Ireland	TOTAL
2016		0		0
2017		0		0
2018		3.9		3.9
2019		1.6	0.5	2.1
2020*		1.6		1.6

Table 6.5.4. Greater Silver Smelt 9. WG estimates of landings in tonnes. *landings in 2020 are preliminary.

Year	Netherlands	Spain	Portugal	TOTAL
2006				0
2007	1			1
2008			0.5	0.5
2009			1.9	1.9
2010			1.9	1.9
2011			0.9	0.9
2012			1.9	1.9
2013				0
2014				0
2015				0
2016				0
2017				0
2018		0.1		0.1
2019				0
2020*				0

Table 6.5.5. Greater Silver Smelt 12. WG estimates of landings in tonnes. *landings in 2020 are preliminary.

Year	Faroes	Iceland	Russia	Netherlands	TOTAL
1988					0
1989					0
1990					0
1991					0
1992					0
1993	6				6
1994					0
1995					0
1996	1				1
1997					0
1998					0
1999					0
2000		2			2
2001					0
2002					0
2003					0
2004			4	625	629
2005				362	362
2006					0
2007					0
2008					0
2009					0
2010					0
2011					0
2012		31			31
2013					0
2014					0
2015					0
2016					0

Year	Faroes	Iceland	Russia	Netherlands	TOTAL
2017					0
2018					0
2019					0
2020*					0

Table 6.5.6. Discard data from 2015-2020 from Subarea 6b, 7-1012. *discards in 2020 are preliminary

Year	Spain				UK (Scotland)	TOTAL
	6b	7	8	9	6b	
2015	0.7	28			0.5	29.2
2016		237	2	1		240
2017	1.82	148.8			0.3	151
2018	2.9	97.9	1.8	0.8	10.3	114
2019	5	146	0.2	0.1	0.29	152
2020*	2	44.6	7.4	2.9	50	107

Table 6.5.7. Discards by Spain and Netherlands from before the redefinition of the stock area (Subarea 6,7 and 8) from 2003–2014.

Year	Spain	Denmark	Germany	Sweden	Netherland	Total
2003	2807				1247	4053
2004	3075				300	3375
2005	2438				0	2438
2006	1250				149	1399
2007	2038				45	2083
2008	3060				58	3118
2009	4109				74	4183
2010	2006				23	2029
2011	2050				6	2056
2012	177				26	203
2013	91			21	20	133
2014	160	6	120	1	111	398

Table 6.5.8. Greater silver smelt in subareas 7–10 and 12, and in Division 6.b. Assessment summary. Biomass index from the Spanish Porcupine Bank survey for both greater and lesser silver smelt. Also given is the biomass index for A.silus only and the proportion between the two species. High and low refer to standard errors.

Year	*Argentina sp.*			*Argentina silus*			Proportion of *A. silus*/*A. sphyrena* in the survey
	kg haul^{-1}	Low	High	kg haul^{-1}	Low	High	
2001	133.17	72.76	193.57				
2002	143.72	62.36	225.08				
2003	141.33	82.19	200.47				
2004	142.76	68.42	217.09				
2005	111.15	59.60	162.69				
2006	98.05	36.29	159.81				
2007	79.03	43.71	114.35				
2008	82.16	32.93	131.40				
2009	79.74	43.65	115.83	72.95	37.69	108.21	0.91
2010	97.39	41.19	153.59	89.97	34.02	145.91	0.92
2011	57.57	32.38	82.75	50.32	25.85	74.78	0.87
2012	93.52	51.51	135.53	83.02	42.52	123.53	0.89
2013	135.63	76.35	194.91	121.50	66.25	176.75	0.90
2014	75.59	48.41	102.77	59.57	35.53	83.61	0.79
2015	92.80	53.82	131.79	72.56	41.95	103.18	0.78
2016	199.00	109.49	288.51	172.94	92.32	253.55	0.87
2017	159.31	89.22	229.41	129.63	73.41	185.86	0.81
2018	112.36	38.57	186.16	98.72	25.44	172.00	0.88
2019	92.59	70.69	114.49	67.60	48.07	87.13	0.73
2020	125.34	87.95	162.72	109.81	75.28	144.34	0.88

6.5.12 Figures

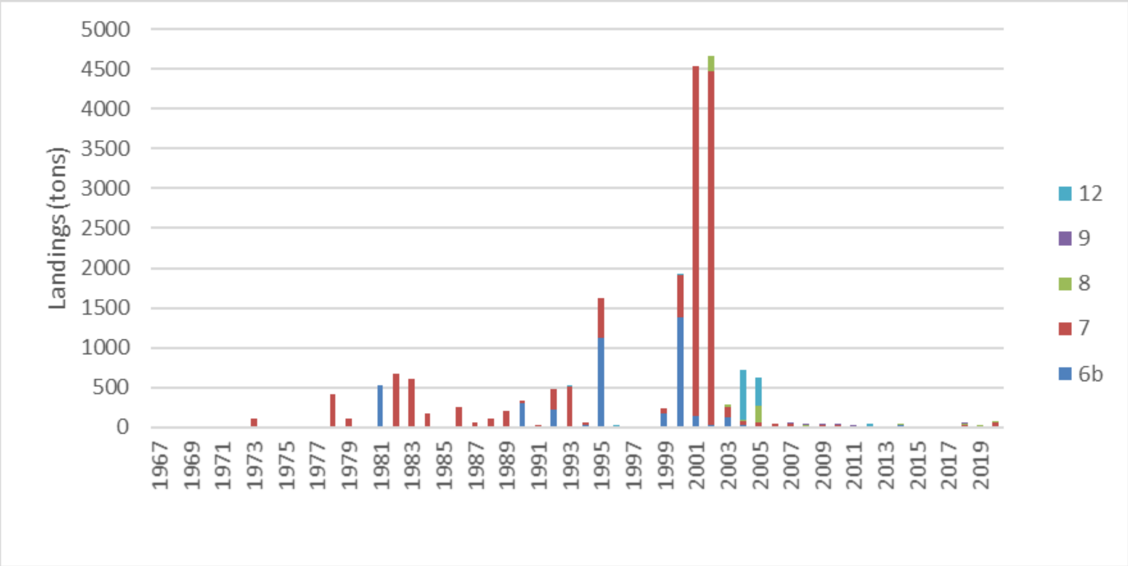


Figure 6.5.1. Total landings from 1966–2020 of greater silver smelt in 6.b, 7, 8, 9, 10 and 12.

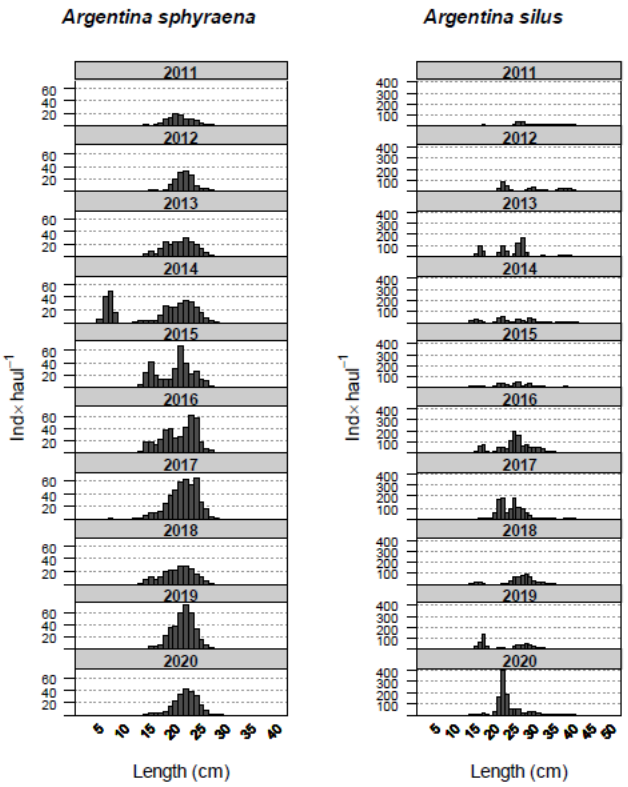


Figure 6.5.2. Mean stratified length distributions of *Argentina* spp. in Spanish Porcupine surveys from 2009–2020. Note different range in the y-axis values between species.

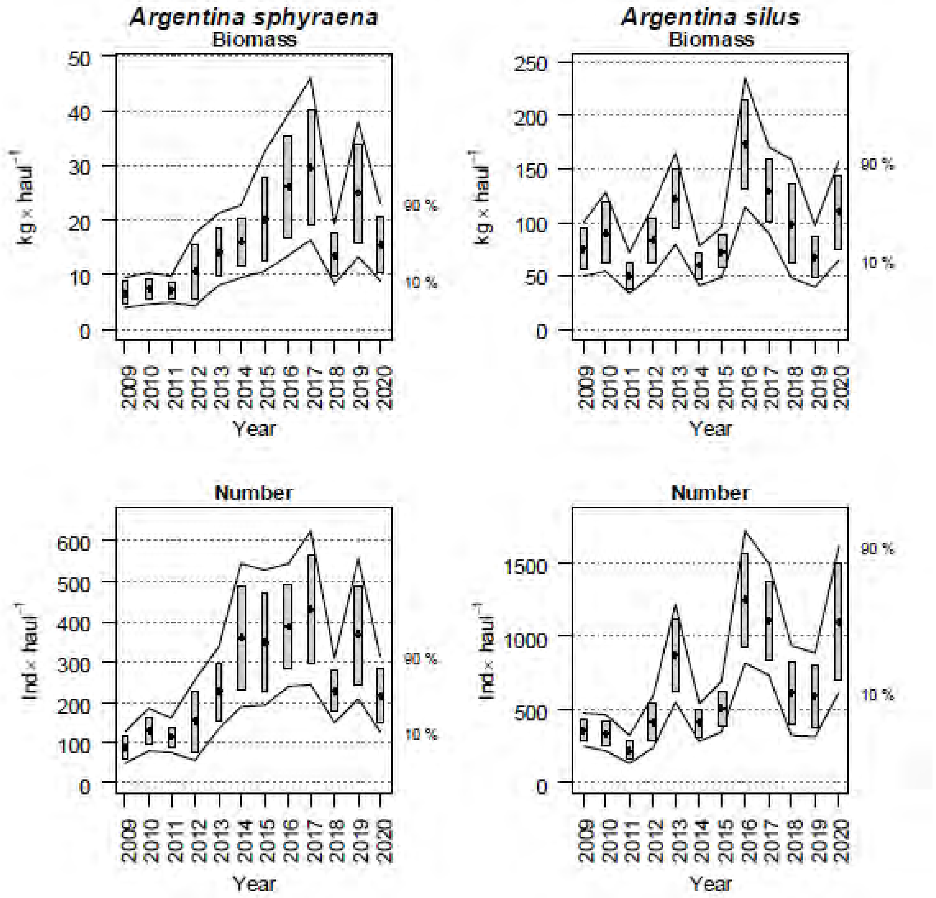


Figure 6.5.3. Evolution of *Argentina sphyraena* and *Argentina silus* biomass and abundance indices in Porcupine surveys (2009–2020). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a=0.80, bootstrap iterations=1000).

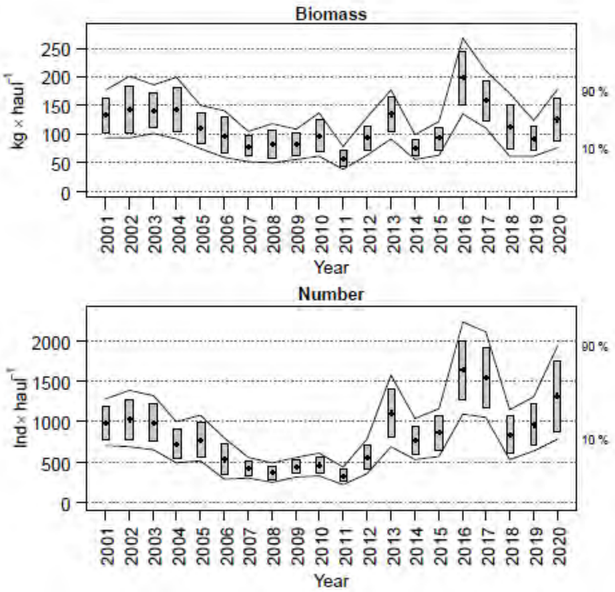


Figure 6.5.4. Evolution of *Argentina* spp. (mainly *Argentina silus*) biomass and abundance indices in Porcupine surveys (2001-2020). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000)

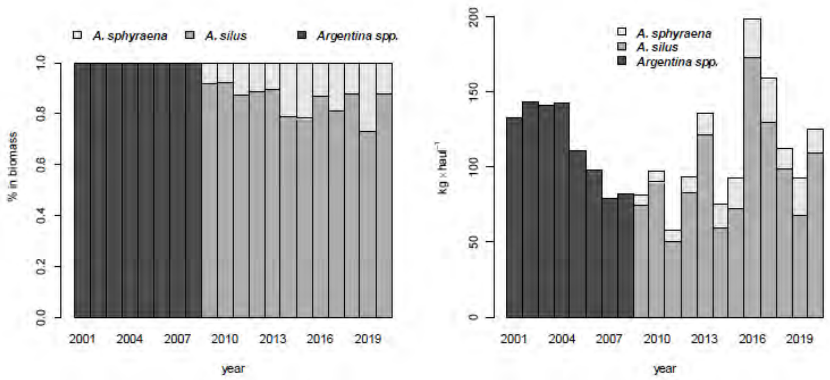


Figure 6.5.5. Share and abundance of *Argentine* species in Porcupine Bank surveys (2001–2020).

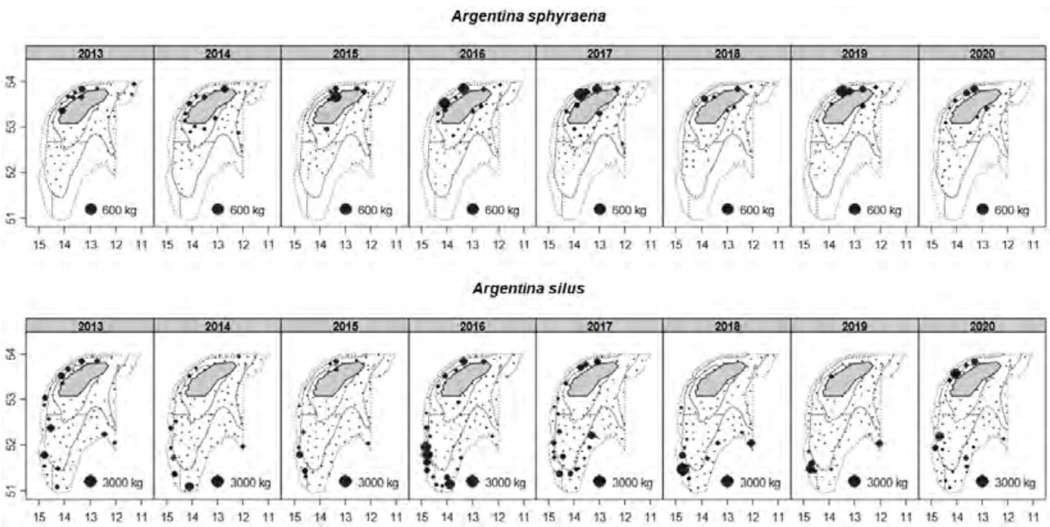


Figure 6.5.6. Geographic distribution of *Argentina sphyraena* and *Argentina silus* catches (kg/30 min haul) in Porcupine surveys (2013 - 2020)

7 Orange roughy (*Hoplostethus atlanticus*) in the Northeast Atlantic

7.1 Stock description and management units

The stock structure of this species but the information available is insufficient to admit the existence of separate populations of orange roughy in the North Atlantic.

For assessment purposes, ICES considers three assessment units along ICES area:

- Subarea 6;
- Subarea 7;
- Orange roughy in all other areas.

Given the scarcity of spatial fisheries data, biological and genetics data, WGDEEP have not altered these assessment units.

Orange roughy is an aggregating species and the spatial scale of current management units would not prevent sequential depletion of local aggregations. Such local aggregations may not represent different biological populations, i.e. a biological population may comprise several local aggregations. However the sequential depletion of local aggregations could lead to depletion at stock level. Therefore, ICES has recommended that where the small-scale distribution is known, this be used to define smaller and more meaningful management units. ? In other words, where aggregation are known, their biomass should be estimated to derive small-scale catch levels that can be sustained at aggregation level. Nevertheless, the methodology to do that is hardly available.

7.2 Orange roughy (*Hoplostethus Atlanticus*) in Subarea 6

7.2.1 The fishery

There was a French target fishery, centred on spawning aggregations around the Hebrides Terrace Seamountin the early 1990s. Irish vessels exploited aggregations further south in divisions 7c and 7k In the early 20000, but directed fisheries had ceased by 2006. No fishing and no catch was reported for years 2017-2020. From 2017, following the ban of trawling deeper than 800 m in EU waters and for EU vessels in International waters (EU regulation 2016/2336 of 14 December 2016), catch by EU vessels are expected negligible or null.

7.2.2 Landings trends

Table 7.2.1 and Figure 7.2.1 show the landings (ICES estimates) data for orange roughy for ICES Subarea 6 as reported to ICES or as reported to the WGDEEP ?. In recent years, only a small landing, 700 kg rounded to 1 tonne (Table 7.2.1) was landed by the Faroe Islands in 2016. The cumulative landings in Subarea 6 since 1988 were 7188 tonnes. There were no landings in 2017-2020.

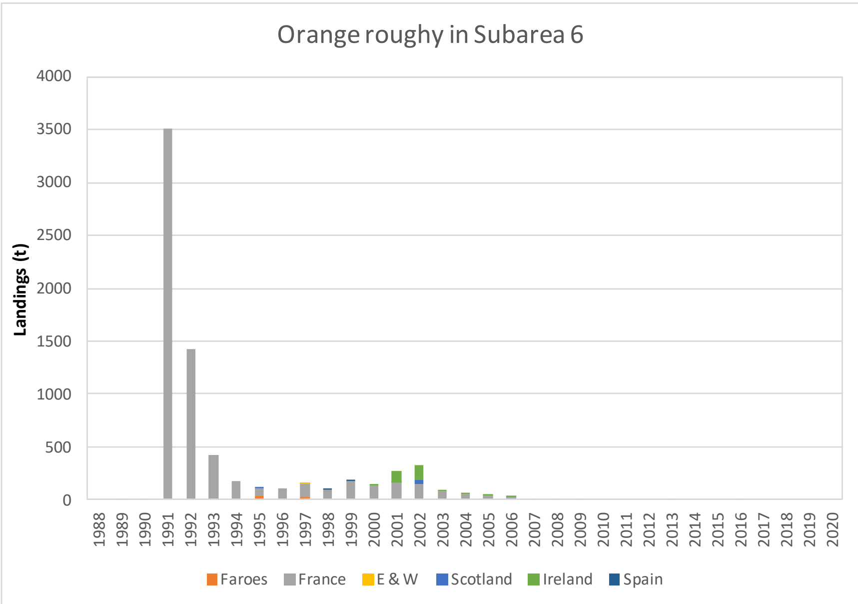


Figure 7.2.1. Time-series of orange roughy landings by country in ICES Subarea 6.

7.2.3 ICES Advice

The ICES advice was published in 2020 for 2021–2024. It applies to orange roughy in the Northeast Atlantic and states that when the precautionary approach is applied, there should be zero catches in each of the years 2021–2024.

7.2.4 Management

In 2003 a TAC was introduced for orange roughy in Subarea 6, this TAC remained at 88 tonnes until 2006. In order to align the TAC with landings, the TAC for EU vessels in Area 6 was reduced annually between 2007 and 2009. Zero TACs have been set for orange roughy in all EU waters since 2010. In recent years, the species is prohibited in all EU waters.

Landings in relation to TAC are displayed in Table 7.2.2.

Table 7.2.2. EU TACs and landings in EU and international waters of 6.

		Landing (t)	
Year	TAC (t)	EU vessels	Total
2003	88	81	81
2004	88	56	56
2005	88	45	45
2006	88	33	33
2007	51	12	12
2008	34	5	5
2009	17	2	2
2010	0	0	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0	0	0
2015	0	0	0
2016	0	0	1
2017	0	0	0
2018	0	0	0
2019	0	0	0
2020	0	0	0

7.2.5 Data available

7.2.5.1 Landings and discards

Landings are in Table 7.2.1.

Raised discard weights were not available for 2014 and 2015. For 2016 and 2017, discards were estimated to 0 (zero). In 2018-2020 there was no reported landings nor discards to ICES.

7.2.5.2 Length compositions

Length distributions are available from historical observer programmes and current deep-water surveys. Available information can be found in the stock annex.

7.2.5.3 Age compositions

No new information. Available information can be found in the stock annex.

7.2.5.4 Weight-at-age

No information.

7.2.5.5 Maturity and natural mortality

No new information. Available information can be found in the stock annex.

7.2.5.6 Catch, effort and research vessel data

No new information. Available information can be found in the stock annex.

7.2.6 Data analyses

No new analysis was performed in 2021.

7.2.7 Management considerations

A zero TAC without allowing a bycatch can potentially lead to discarding if existing fisheries overlap with the distribution of orange roughy. However since the ban of trawling deeper than 800 m the overlap between existing fisheries and the distribution of orange roughy might be minimal in EU waters of Subarea 6.

Due to the closure of the fishery in subareas 6 and 7 and trawling ban deeper than 800 m there are no fishery-dependent data to evaluate the status of the stocks.

PSA assessment of the susceptibility of orange roughy populations in Subareas 6 and 7 to current and deep-water trawl fisheries (see WGDEEP 2014, Section 7.3) has shown a strong reduction in risk over time when fisheries directed targeting practices stopped and continued with mixed deep-water trawl fisheries. Before the ban of trawling deeper than 800 m, some spatial overlap between the species and fisheries remained, such as on the ”flat” fishing grounds in Subarea 6 on the continental slope to the northwest of Ireland extending to the west of Scotland. Following the application of the ban of bottom trawling deeper than 800 m (EU regulation 2016/2336) this bycatch might be minor in EU fisheries because the fraction of orange rough biomass occurring shallower than 800 m is minor or inexistent.

Table 7.2.1. Orange roughy catch in Subarea 6.

Year	Faroes	France	E & W	Scotland	Ireland	Spain	Total
1988	-	-	-	-	-	-	0
1989	-	5	-	-	-	-	5
1990	-	15	-	-	-	-	15
1991	-	3,502	-	-	-	-	3502
1992	-	1,422	-	-	-	-	1422
1993	-	429	-	-	-	-	429
1994	-	179	-	-	-	-	179
1995	40	74	-	2	-	-	116
1996	0	116	-	0	-	-	116

Year	Faroes	France	E & W	Scotland	Ireland	Spain	Total
1997	29	116	1	-	-	-	146
1998	-	100	-	-	-	2	102
1999	-	175	-	-	0	1	176
2000	-	136	-	-	2	-	138
2001	-	159	-	11	110	-	280
2002	n/a	152	-	41	130	-	323
2003	-	79	-	-	2	-	81
2004	-	54	-	-	2	-	56
2005	-	41	-	-	6	-	47
2006		32			1		33
2007		12					12
2008		5					5
2009		3					3
2010		0					0
2011		0					0
2012		0					0
2013		1(1)					3**
2014		0					0
2015							0
2016	1						1
2017							0
2018							0
2019							0
2020							0

7.3 Orange roughy (*Hoplostethus Atlanticus*) in Subarea 7

7.3.1 The fishery

After the first few years (1991-93) of the fishery in Subarea 6, the main fishery for orange roughy in the northern hemisphere was in Subarea 7. This fishery peaked in 2002 and rapidly declined thereafter. Some targeted fishing from a few or even one single 20–24 m trawlers was carried out until 2008 while the remaining catches were a bycatch from the mixed deep-water trawl fishery operating on the slopes.

7.3.2 Landings trends

Table 7.3.1 and Figure 7.3.1 show the landings data for orange roughy as reported to ICES or as reported to the Working Group.

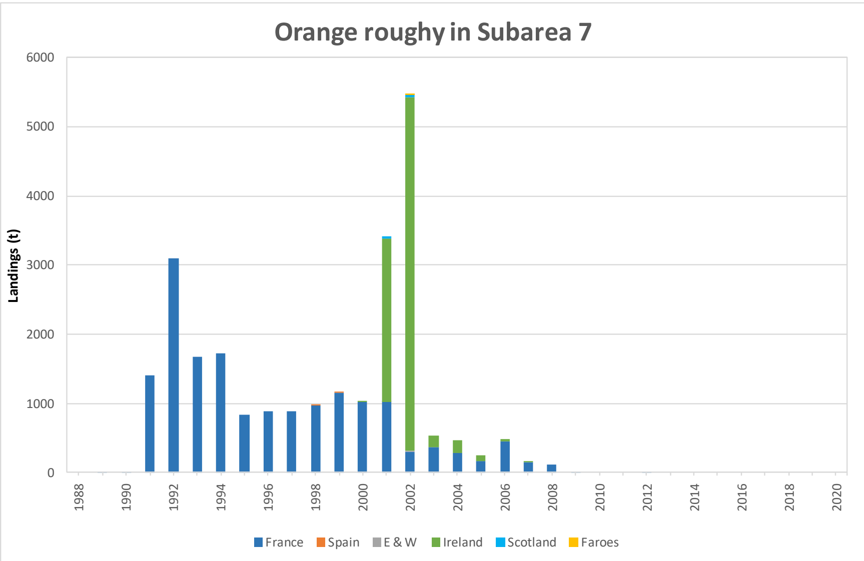


Figure 7.3.1. Time-series of orange roughy landings by country in ICES Subarea 7.

7.3.3 ICES Advice

The ICES advice was published in 2020 for 2021–2024. It applies to orange roughy in the Northeast Atlantic and states that when the precautionary approach is applied, there should be zero catch in each of the years 2021–2024.

7.3.4 Management

A TAC for orange roughy in Subarea 7 was first introduced in 2003. Landings in relation to TAC are displayed in the table below:

Table 7.3.2. EU TACs and landings in EU and international waters of Subarea 7.

		Landing (t)	
Year	TAC (t)	EU vessels	Total
2003	1349	541	541
2004	1349	467	467
2005	1149	255	255
2006	1149	489	489
2007	193	172	172
2008	130	118	118
2009	65	15	15
2010	0	0	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0	0	0
2015	0	0	0
2016	0	0	0
2017	0	0	0
2018	0	0	0
2019	0	0	0
2020	0	0	0

The TAC for orange roughy in Subarea 7 was set to 0 t for 2016 and 2017. No catch was reported.

7.3.5 Data available

7.3.5.1 Landings and discards

Landings are shown are in Table 7.3.1.

There were no landings since 2010. Discards of orange roughy from the French mixed deep-water fishery in Subareas 6 and 7 were estimated from observer data. In recent years, discards estimated at fleet level have been calculated for total discards and by species. In 2012, the estimated discards of orange roughy was 400 kg.

7.3.5.2 Length compositions

No new information available. Historic information can be found in the stock annex.

7.3.5.3 Age compositions

No new information available. Historic information can be found in the stock annex.

7.3.5.4 Weight-at-age

No data.

7.3.5.5 Maturity and natural mortality

No new information available. Historic information can be found in the stock annex.

7.3.5.6 Catch, effort and research vessel data

No new information. Available information can be found in the stock annex.

7.3.6 Management considerations

See section 6.1.1. Management considerations.

Table 7.3.1. Working Group estimates of landings of orange roughy, *Hoplostethus atlanticus,* by country in Subarea 7. Reported landings after 2012 have been 0 and the table was not expanded for these years.

Year	France	Spain	E & W	Ireland	Scotland	Faroes	Total
1988	-	-	-	-	-	-	0
1989	3	-	-	-	-	-	3
1990	2	-	-	-	-	-	2
1991	1406	-	-	-	-	-	1406
1992	3101	-	-	-	-	-	3101
1993	1668	-	-	-	-	-	1668
1994	1722	-	-	-	-	-	1722
1995	831	-	-	-	-	-	831
1996	879	-	-	-	-	-	879
1997	893	-	-	-	-	-	893
1998	963	6	-	-	-	-	969
1999	1157	4	-	-	-	-	1161
2000	1019	-	-	1		-	1020
2001	1022	-	1	2367	22	-	3412
2002	300		14	5114	33	4	5465
2003	369			172			541
2004	279			188			467

Year	France	Spain	E & W	Ireland	Scotland	Faroes	Total
2005	165			90			255
2006	451			37			489
2007	145			28			164
2008	118						118
2009	15						15
2010							0
2011							0
2012	2						2

7.4 Orange Roughy (*Hoplostethus atlanticus*) In subareas 1, 2, 4, 5, 8, 9, 10, 12 and 14 and Division 3.a

7.4.1 The fishery

Fisheries have been conducted in Divisions 5.a–b and Subareas 8, 10 and 12. Most started in the early 1990s, the exception being Subarea 10 which started in 1996. Since 2010, fisheries are mainly occurring in subareas 10 and 12, with sporadic catches in 5.a, 5.b and 9. In recent years, one Faroese trawler operated a small directed fishery in ICES Subareas 10 and 12. Information on this fishery is presented in WD01 Ofstad, 2020.

7.4.2 Landing trends

Table 7.4.0 and Figure 7.4.1 show ICES estimates of landings of orange roughy from ICES subareas 1, 2, 4, 5, 8, 9, 10, 12 and 14 and Division 3.aLandings from the single trawler fishing in subareas 10 and 12 have been between 50 and 150 tonnes per year since 2014. They amounted to 150 tonnes in 2017. During the two last years, these landings were from subarea 10 only. In 2018, 20.65 tonnes was caught in Subarea 10 and 8.75 tonnes in Subarea 12. In 2019, 31.07 tonnes was caught in Subarea 10 and 28.96 tonnes in Subarea 12. There were no catch of orange roughy in 2020.

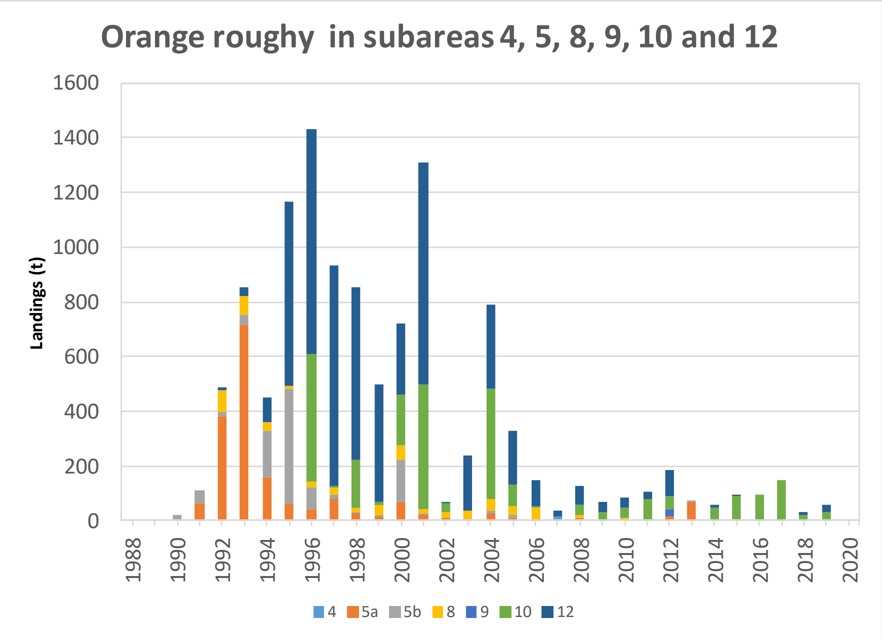


Figure 7.4.1. Time-series of orange roughy landings by subarea in all ICES areas (except subareas 6 and 7).

7.4.3 ICES Advice

The ICES advice was published in 2020 for 2021–2024. It applies to orange roughy in the Northeast Atlantic and states that when the precautionary approach is applied, there should be zero catch in each of the years 2021–2024.

7.4.4 Management measures

The EU TAC is set to for 0. The TAC applies to Community waters and EC vessels in international waters. Landings in relation to EU TAC are shown in Table 7.4.1.

In the NEAFC Regulatory Area, targeted fisheries for orange roughy are not permitted to vessels of the contracting parties, which must take measures to decrease bycatch (Recommendation 6: 2016).

In addition there are a number of management measures that are currently in place in the NEAFC regulatory area in relation to bottom trawling in known VMEs and outside existing fishing areas.

Table 7.4.1. EU TACs and landings in Community waters and waters not under the sovereignty or jurisdiction of third countries of 1, 2, 3, 4, 5, 8, 9, 10, 11, 12 and 14.

		Landing (t)	
Year	EU TAC (t)	EU vessels	Total
2005	102	71	278
2006	102	58	149
2007	44	16	36
2008	30	8	112
2009	15	5	62
2010	0	<1	83
2011	0	4	124
2012	0	28	167
2013	0	0	57
2014	0	0	58
2015	0	0	84
2016	0	0	0
2017	0	0	0
2018	0	0	0
2019	0	0	0
2020	0	0	0

7.4.5 Data available

7.4.5.1 Landings and discards

Landings are in Table 7.4.0. In recent years, Faroe Islands continued the fishery for orange roughy. The Faroese catches were 93 and 150 tonnes in Subarea 10, respectively in 2016 and 2017. In 2016 and 2017, small discards were reported by Spain in divisions 8.c and 9.a, 500 and 225 kg respectively in 2016 and 2017. In 2018 reported discards were 120 kg by Spain from Division 8.c. The Faroese catches were 21 tons in Subarea 10 and 9 tons in Subarea 12 in 2018 and 31 tons in area 10 and 29 tons in Subarea 12 in 2019. There were no catch of orange roughy in 2020.

7.4.5.2 Length composition

Sampling of lengths, weight and gender of orange roughy was carried out by trained crew members on board the single Faroese fishing vessel operating in this fishery. Samples were taken randomly from the catch. The length distribution of the catch is between 50–70 cm total length (Figure 7.4.1), which is the same as in the Faroese experimental fishery in the nineties (Thomsen, 1998). The average length and weight of orange roughy females and males were around the same in 2011–2018 compared with the results from the experimental fishery in 1992–1998 (Thomsen, 1998) (Table 7.4.2). In 2019, only length measurements were taken, no sex or weight measurements were available.

Table 7.4.2. Mean length and weight by sex and combined (comb.). From sampling by trained crew members on board the single Faroese fishing vessel targeting orange roughy. [a] Thomsen, 1998.

Year	Area	Month	Average length (cm)			Average weight (kg)	
			Female	Male	Comb.	Female	Male
1992-1998[a]	Faroe Islands		61.4	58.6		4.4	3.7
1992-1998[a]	Hatton Bank		64.6	62.8		4.9	4.3
1992-1998[a]	Reykjanes ridge		58.9	56.4		3.6	3.0
1992-1998[a]	North of Azores		60.6	59.7		3.9	3.7
2011	27.10b	Feb., Mar.	61.4	60.5	60.9	3.5	3.2
2012	27.10b	Feb.	61.4	60.8	61.0	3.5	3.2
2013	27.10b	Jan.	60.9	57.7	59.6	4.3	3.8
2014	27.10b	Jun., Jul.	62.1	58.4	60.5	4.2	3.7
2015	27.10b	Jul., Aug.	59.0	58.3	58.6	3.7	3.5
2016	27.10b	Jun., Oct., Nov.	61.4	58.7	60.1	4.3	3.7
2017	27.10b	Nov.	60.6	57.5	58.7	3.9	3.4
2018	27.10b, 27.12c	Feb.	63.4	60.1	61.5	4.2	3.8
2019	27.10b, 27.12cd	Feb., Mar.			61.4		

7.4.5.3 Age composition

No data.

7.4.5.4 Weight-at-age

No data.

7.4.5.5 Maturity and natural mortality

No data.

7.4.5.6 Catch, effort and research vessel data

Catch and effort data were collected on a haul-by-haul basis in the Faroese fishery.

Orange roughy is caught occasionally in the stratified bottom trawl survey in East Greenland (Division 14.b) (Nielsen et. al., 2019). The species was only caught in 2008, 2013, 2014 and 2015 (Figure 7.4.2). In 2014 and 2015, estimated biomass was 1.7 t and 1.1 t, respectively, and all other years it was zero or very close to. No length distributions are calculated because of too few specimens (N<20) has been caught.

There was no information available of orange roughy in ICES division 14.b in the period 1999-2019 (Nilsen, 2020).

7.4.6 Data analysis

No data analysis was carried out in 2021.

7.4.7 Management considerations

Due to its very low productivity, orange roughy can only sustain very low rates of exploitation. Currently, it is not possible to manage a sustainable fishery for this species. ICES recommends no directed fisheries for this species. Bycatches in mixed fisheries should be as low as possible.

The zero EU TAC implies that no EU fishing for the species is allowed. The application of the EU regulation 2016/2336, establishing specific conditions for fishing for deep-sea stocks in the north-east Atlantic implies that bycatch in EU trawl fisheries might be minor as a consequence of the ban of fishing deeper than 800 m with trawls in this regulation. Possible bycatch should be minor because the fraction of orange rough biomass occurring shallower than 800 m is minor or inexistent. With the exception of the black scabbardfish fishery in Subarea 9.a, where bycatch of orange roughy are not known to occur, there are no EU longline fisheries at depth where orange roughy occurs.

Concerns were raised at the WGDEEP 2020 about potential sequential depletion of orange roughy at seamounts. It was recommended to perform an analysis of available VMS-data and investigate the fishing grounds exploited by this fishery.

In 2015–2019 all landings from the stock were caught in the NEAFC RA.

7.4.8 References

ICES. 2014. Report of the Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 4–11 April 2014, Copenhagen, Denmark. ICES CM 2014/ACOM:17. 862 pp.

Nilsen, J., Nogueira, A., and Christensen, H.T. 2019. Survey results of roughhead grenadier, roundnose grenadier, greater silver smelt, blue ling, tusk, black scabbardfish, ling, and orange roughy in ICES subdivision 14.b.2 in the period 1998-2016. WD05 WGDEEP 2019.

Nilsen, J. 2019. Commercial catches of roundnose grenadier, roughhead grenadier, greater silver smelt, blue ling, tusk, black scabbard fish, ling and orange roughy in ICES division 14b in the period 1999-2019. WD02 WGDEEP 2020.

Ofstad, L.H. 2020. Faroese fishery of orange roughy in ICES areas 10 and 12. WD01 WGDEEP 2020.

Thomsen, B. 1998. Faroese quest of orange roughy in the North Atlantic. Copenhagen (Denmark), ICES.

7.4.9 Tables and Figures

Table 7.4.0a. Working Group estimates of landings in tonnes of orange roughy, *Hoplostethus atlanticus*, in Division 5.a.

Year	Iceland	Total
1988	-	0
1989	-	0
1990	-	0
1991	65	65
1992	382	382
1993	717	717
1994	158	158
1995	64	64
1996	40	40
1997	79	79
1998	28	28
1999	14	14
2000	68	68
2001	19	19
2002	10	10
2003	0	0
2004	28	28
2005	9	9
2006	2	2
2007	0	0
2008	4	4
2009	<1	<1
2010	<1	<1
2011	4	4

Year	Iceland	Total
2012	16	16
2013	54	54
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020	0	0

Table 7.4.0b. Working Group estimates of landings in tonnes of orange roughy, *Hoplostethus atlanticus*, in Division 5.b.

Year	Faroes	France	Total
1988	-	-	0
1989	-	-	0
1990	-	22	22
1991	-	48	48
1992	1	12	13
1993	36	1	37
1994	170	+	170
1995	419	1	420
1996	77	2	79
1997	17	1	18
1998	-	3	3
1999	4	1	5
2000	155	0	155
2001	1	4	5
2002	1	0	1
2003	2	3	5
2004		7	7
2005	3	10	13

Year	Faroes	France	Total
2006	0	0	0
2007	0	1	1
2008	0	<1	<1
2009	<1	2	2
2010	<1	<1	<1
2011	0	0	0
2012	0	0	0
2013	1		1
2014	0		0
2015	0		0
2016	0	0	0
2017	0	0	0
2018	0	0	0
2019	0	0	0
2020	0	0	0

Table 7.4.0c. Working Group estimates of landings in tonnes of orange roughy, *Hoplostethus atlanticus*, in Subarea 8.

Year	France	Spain	E & W	Total
1988	-	-	-	0
1989	0	-	-	0
1990	0	-	-	0
1991	0	-	-	0
1992	83	-	-	83
1993	68	-	-	68
1994	31	-	-	31
1995	7	-	-	7
1996	22	-	-	22
1997	1	22	-	23
1998	4	10	-	14
1999	33	6	-	39

Year	France	Spain	E & W	Total
2000	47	-	5	52
2001	20	-	-	20
2002	20	-	-	20
2003	31			31
2004	43			43
2005	29			29
2006	43			43
2007	1			1
2008	8			8
2009	13			13
2010	8			8
2011	0			0
2012	0			0
2013	0			0
2014				0
2015	6			6
2016	0			0
2017	0	0	0	0
2018	0	0	0	0
2019	0	0	0	0
2020	0	0	0	0

Table 7.4.0d. Working Group estimates of landings in tonnes of orange roughy, *Hoplostethus atlanticus*, in Subarea 9.

Year	Portugal	Spain(1)	Total
1990	0	-	0
1991	0	-	0
1992	0	-	0
1993	0	-	0
1994	0	-	0
1995	0	-	0

Year	Portugal	Spain(1)	Total
1996	0	-	0
1997	0	1	1
1998	0	1	1
1999	0	1	1
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0
2010	0	0	0
2011	4	0	4
2012	28		28
2013	0		0
2014			0
2015			0
2016			0
2017			0
2018			0
2019	0	0	0
2020			0

Included in landings from Subarea 9 until 2002

Table 7.4.0e. Working Group estimates of landings in tonnes of orange roughy, *Hoplostethus atlanticus*, in Subarea 10.

Year	Faroes	France	Norway	E & W	Portugal	Ireland	Total
1989	-	-	-	-	-		0

Year	Faroes	France	Norway	E & W	Portugal	Ireland	Total
1990	-	-	-	-	-		0
1991	-	-	-	-	-		0
1992	-	-	-	-	-		0
1993	-	-	1	-	-		1
1994	-	-	-	-	-		0
1995	-	-	-	-	-		0
1996	470	1	-	-	-		471
1997	6	-	-	-	-		6
1998	177	-	-	-	-		177
1999	-	10	-	-	-		10
2000	-	3	-	28	157		188
2001	84	-	-	28	343		455
2002	30	-	-	-	-		30
2003		1					1
2004	384					19	403
2005	128	2					130
2006	8						8
2007	0						0
2008	37						37
2009	26						26
2010	39						39
2011	77						77
2012	45						45
2013	0						0
2014	47 (1)						47
2015	83 (1)						83
2016	93 (1)						93
2017	150 (1)						150
2018	21 (1)						21

Year	Faroes	France	Norway	E & W	Portugal	Ireland	Total
2019	31 (1)						31
2020	0						0

(1) Landings 2014–2019 were from Division 10.b

Table 7.4.0f. Working Group estimates of landings in tonnes of orange roughy, *Hoplostethus atlanticus*, in Subarea 12.

Year	Faroes	France	Iceland	Spain	E & W	Ireland	New Zealand	Russia	Total
1989	-	0	-	-	-			-	0
1990	-	0	-	-	-			-	0
1991	-	0	-	-	-			-	0
1992	-	8	-	-	-			-	8
1993	24	8	-	-	-			-	32
1994	89	4	-	-	-			-	93
1995	580	96	-	-	-			-	676
1996	779	36	3	-	-			-	818
1997	802	6	-	-	-			-	808
1998	570	59	-	-	-			-	629
1999	345	43	-	43	-			-	431
2000	224	21	-	-	2			12	259
2001	345	14	-	-	2		450	-	811
2002	+	6	-	-	-		0	-	6
2003		64				136	0	-	200
2004	176	131					0		307
2005	158	36					0		193
2006	81	15							96
2007	20								20
2008	71								71
2009	34								34
2010	35								35
2011	27								27
2012	94								94

Year	Faroes	France	Iceland	Spain	E & W	Ireland	New Zealand	Russia	Total
2013	2								2
2014	11								11
2015	1								1
2016	0								0
2017	0								0
2018	9								9
2019	29								29
2020	0								0

Table 7.4.0g. Orange roughy total international landings in tonnes in the ICES area, excluding Subareas 6 and 7.

Year	4	5.a	5.b	8	9	10	12	All areas
1988		0	0	0	0	0	0	0
1989		0	0	0	0	0	0	0
1990		0	22	0	0	0	0	22
1991		65	48	0	0	0	0	113
1992		382	13	83	0	0	8	486
1993		717	37	68	0	1	32	855
1994		158	170	31	0	0	93	452
1995		64	420	7	0	0	676	1167
1996		40	79	22	0	471	818	1430
1997		79	18	23	1	6	808	935
1998		28	3	14	1	177	629	852
1999		14	5	39	1	10	431	500
2000		68	155	52	0	188	259	722
2001		19	5	20	0	455	811	1310
2002		10	1	20	0	30	6	67
2003		+	5	31	0	1	200	237
2004		28	7	43	0	403	307	788
2005		9	13	29	0	83	193	327
2006		2	0	43	0	8	96	149

Year	4	5.a	5.b	8	9	10	12	All areas
2007	14		1	1	0	0	20	36
2008	7	4	<1	8	0	37	71	127
2009	0	1	2	3	0	26	34	66
2010	0	<1	<1	8	0	39	35	82
2011	0	4	0	0	<1	77	27	108
2012		16	0	0	28	45	94	183
2013		54	1	0	0	0	2	57
2014						47	11	58
2015				6		83	1	90
2016						93		93
2017						150		150
2018						21	9	30
2019						31	29	60
2020						0	0	0

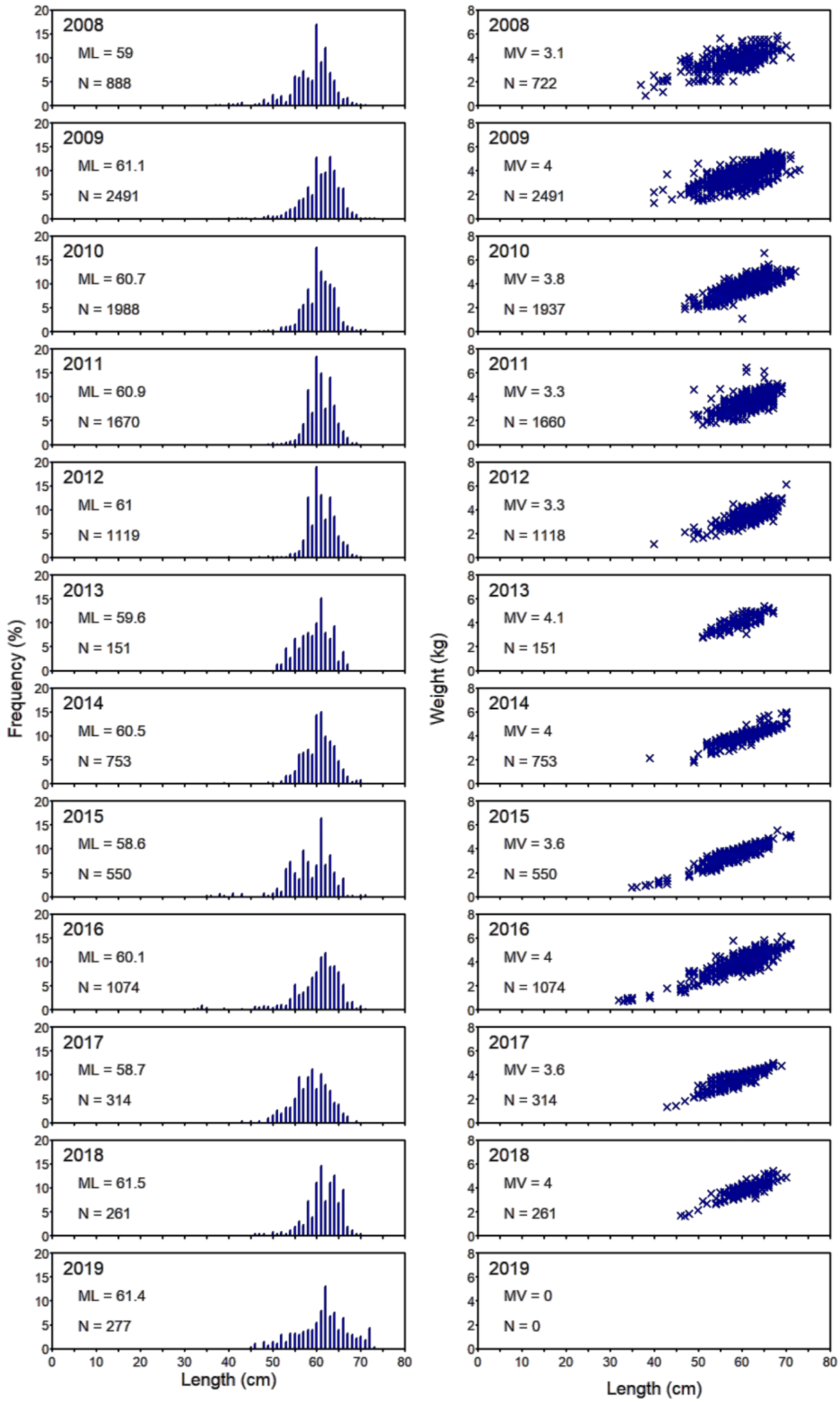


Figure 7.4.1. Length composition and length–weight relation of orange roughy in Faroese catches 2008–2019. There were no weight measurements of orange roughy in 2019.

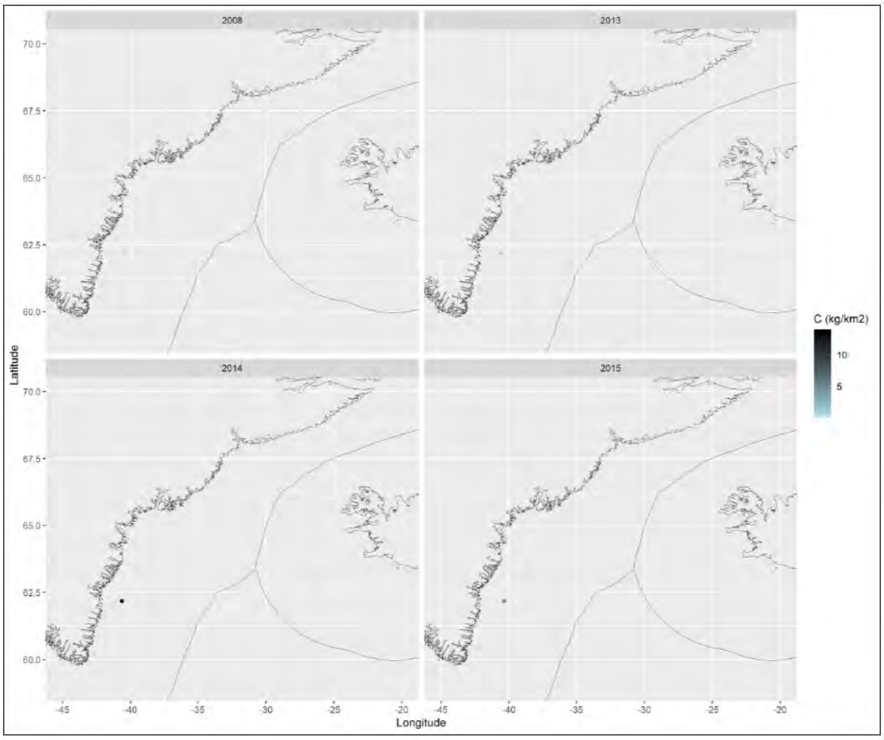


Figure 7.4.2. Distribution of survey catches of orange roughy at East Greenland in 1998–2016. No survey in 2001, 2017

8 Roundnose grenadier (Coryphaenoides rupestris)

8.1 Stock description and management units

ICES WGDEEP has in the past proposed four assessment units of roundnose grenadier in the NE Atlantic:

- Skagerrak (Division 3.a);
- The Faroe-Hatton area, Celtic sea (Divisions 5.b and 12.b, Subareas 5, 7);
- the Mid-Atlantic Ridge 'MAR' (Divisions 5.b, 12.c, Subdivisions 5.a1, 12.a.1, 14.b.1);
- All other areas (Subareas 1, 2, 4, 8, 9, Division 14.a, Subdivisions 5.a.2, 14.b.2).

This current perception is based on what are believed to be natural restrictions to the dispersal of all life stages. The Wyville-Thomson Ridge may separate populations further south on the banks and slopes off the British Isles and Europe from those distributed to the north along Norway and in the Skagerrak. Considering the general water circulation in the North Atlantic, populations from the Icelandic slope may be separated from those distributed to the west of the British Isles. It has been postulated that a single population occurs in all the areas south of the Faroese slopes, including also the slopes around the Rockall Trough and the Rockall and Hatton Banks but the biological basis for this remains hypothetical.

In 2007, WGDEEP examined the available evidence of stock discrimination in this species but, on the available evidence, was not able to make further progress in discriminating stocks. On this basis WGDEEP concluded there was no basis on which to change current practice.

In the 2010s, genetic analyses have brought forward information regarding the stock discrimination in the roundnose grenadier. White *et al*. (2010), investigating a limited geographic area in the central and eastern North Atlantic, found evidence of population substructure and local adaptation to depth. Knutsen *et al*. (2012) covered a larger geographic range including East and West Atlantic as well as Artic areas and found significant genetic structure. Parts of this structure, notably in peripheral (Canada) and bathymetrically isolated basins (Skaggerak and Trondheimsleia (off Norway)), was found to represent distinct biological populations with limited present connectivity with central Atlantic and West European slope. Off the British Isles (Irish slope, Rockall, and Rosemary Bank), the magnitude of genetic structure was found weak. This lack of definition could reflect that samples from this area represent a single, widespread population. On the other hand, a study of coastal Atlantic cod (Knutsen *et al*., 2011) reported highly restricted connectivity (less than 0.5% adult fish exchanged per year) among two populations that were only weakly differentiated at microsatellite loci. This level is similar to that found between Greenland, Mid-Atlantic Ridge, Rockall, and Rosemary Bank for grenadier. These sites may therefore represent distinct demographical populations, where there is a sufficient gene flow to maintain genetic similarity in terms of allele frequency but the demography is driven by local/regional recruitment and growth with a minor contribution of large scale migrations of juveniles and adults or transport of larvae. .

The current stock units are consistent with the study from Knutsen *et al*. (2012) except that the unit covering subareas 1, 2, 4, 8, and 9, Division 14.a, and subdivisions 14.b.2 and 5.a.2, should not be considered as a demographic stock or a genetic population because it includes Artic and Atlantic areas in which roundnose grenadier was found to be genetically different. This unit might be only considered as an aggregations of areas where roundnose grenadier occurs at low to moderate density and is not subject to significant continuous exploitation.

8.2 Roundnose grenadier (*Coryphaenoides rupestris*) in Division 3.a

8.2.1 The fishery

From the late 1980s until 2006 a Danish directed fishery for roundnose grenadier was conducted in the deeper part of Division 3.a. Until 2003 landings increased gradually, from around 1000 t to 4000 t with fluctuations. In 2004 and 2005 exceptionally high catches were reported; reaching almost 12 000 tonnes in 2005. This directed fishery stopped in 2006 due to implementation of new agreed regulations between EU and Norway.

At present, there are no directed fisheries for roundnose grenadier in Division 3.a.

8.2.2 Landing trends

The total landings by all countries from 1988–2020 are shown in Table 8.3.0 and Figure 8.3.0.

The landings from the directed Danish fishery ceased in 2007 and the total landings have since been minor (<2 tonnes). The landings are now by-catches from other fisheries.

8.2.3 ICES Advice

The 2021 and 2022 advice for rng.3a was: "ICES advices that when the precautionary approach is applied, there should be zero catch in each of the years 2021 and 2022".

8.2.4 Management

The directed fishery for roundnose grenadier was stopped in April 2006 based on agreements between Norway and the EU. The directed fishery has then been prohibited since 2006. Norway and the EU has introduced a mandatory use of sorting grids in shrimp fisheries in order to minimize the bycatch of fish.

In Council Regulation (EU) No 2021/91 of 28 January 2021, fixing for 2021 and 2022 the fishing opportunities for EU vessels for fish stocks of certain deep-sea fish species, a precautionary TAC was set to 5 tons for each years, for EU vessels in EU waters and international waters of Subarea 3. Since there is no area outside national jurisdiction (international waters) in 3.a, this regulation applies to EU waters unless other agreements are negotiated with Norway. There is no TAC for Norwegian vessels in Norwegian waters but the agreed regulation between EU and Norway apply for this area.

8.2.5 Data available

8.2.5.1 Landings and discards

Landings data from 1988-2020 are presented in Table 8.3.0. Discards have been reported from both the Swedish and Danish fishery since 2014 (Table 8.3.2).

8.2.5.2 Length compositions

Since the Danish directed fishery has stopped there is no new information on size compositions from commercial catches other than the data given for the period 1996–2006 (see stock annex for further details).

Updated information on size distribution from the Norwegian shrimp survey is provided in Figure 8.3.1.

8.2.5.3 Age composition

Age data are available from a deep sea species survey in 1987 and from the Norwegian shrimp survey in 2007-2019 (Table 8.3.3).

These age data are presented in Bergstad *et al*., 2014.

8.2.5.4 Bycatch effort and cpue

Data from the Norwegian reference fleet have been analysed from 2013-2019 to estimate the catch of roundnose grenadier in the shrimp fishery (Table 8.3.5).

Earlier, there has been estimated bycatch of roundnose grenadier in Norwegian shrimp fishery in ICES Division 4.a and 3.a (see Stock Annex). These bycatch estimates were not obtained by sampling of the commercial catches but derived using the mean annual Norwegian shrimp trawl survey catches of grenadier at depths <400 m and annual effort in the shrimp trawl fishery. The shrimp fishery in this area is mainly conducted shallower than the primary depth range of roundnose grenadier. It should be noted that commercial vessels fishing in the relevant areas use sorting grids to reduce bycatch, a device not used in the survey, hence survey-based estimates of bycatches are likely to be overestimates.

8.2.5.5 Survey indices

The Norwegian annual shrimp survey conducted since 1984 samples deeper parts of the Skagerrak and north-eastern North Sea (3.a and 4.a), including the depth range where the roundnose grenadier occurs (mainly 300–600 m) (Bergstad, 1990b). The minor area >600 m is an ammunition and warship dumping ground with warning against fishing. The survey is considered to adequately sample the main distribution area of roundnose grenadier, and the sample sizes by year (no. of tows at depths >300 m and >400 m) are presented in Table 8.3.1. The survey indices from the shrimp survey where updated with new information (Table 8.3.4 and Figure 8.3.2). The indices are given as biomass (kg/h) and abundance (number/h).

8.2.6 Data analyses

An earlier study analysed the time-series of abundance of roundose grenadier through the time-series (Bergstad *et al*., 2014). Catch rates in terms of biomass (kg/h) and abundance (nos/h) were calculated for stations 300 m and deeper (Figure 8.3.2). Stations with zero catches were included, and the catches at non-zero stations were standardized by tow duration. The published analysis also includes a time-series of small grenadier, i.e. <5 cm PAL, illustrating variation in recruitment.

8.2.6.1 Trends in landings, effort and estimated bycatches

Collated information on landings and estimates of bycatch from the Norwegian Reference fleet suggest that the removals of roundnose grenadier are now at low levels in Division 4.a and 3.a. For 2020, there were no discards and all catches were landings. Although the discards from the fishery in this area from recent years was reported to be at the same level as the landings, the level on reported total catch was still low and in the range of what it has been since 2007.

There is no longer a directed fishery for grenadier in this area and data on effort and CPUE is therefore not available from the commercial catches. The earlier evaluation of the Danish CPUE data were presented in ICES (2007) but these CPUE data do not provide any clear indications of stock status nor stock development for the time of the directed fishery, which ceased in mid–2006.

Landings and discards are now insignificant and have been represented as bycatches from other fisheries. Data from the Norwegian reference fleet show that catches of roundnose grenadier in the Norwegian shrimp fishery is low (Table 8.3.5). Discards from Danish and Swedish fishery is zero for 2020.

8.2.6.2 Size compositions

The recent length distributions from the Norwegian shrimp survey data contrasts with the 1991–2004 distributions by not having a distinct mode of small fish as seen in the early 1990s (Bergstad *et al*., 2014). The pulse of juveniles appearing in the early 1990s appears to have represented the only major recruitment event through the time-series 1984–present. Recently some small juveniles appear every year in the survey, but there is no indication of a pronounced recruitment pulse as observed in the early 1990s.

The Danish and Norwegian length distributions, sampled from commercial landings and survey catches, respectively, agree well for those years covered by samples from both countries (1987 and 2004–2006) (See stock annex for information on the Danish length distributions from the directed fishery). Note that both in 1987 and 2004 there appear to be two clearly distinguishable components in the Danish length compositions. In the Norwegian data, several years show two modes and it is possible to follow the more abundant occurrence of juveniles<5 cm (PAL) through several years.

8.2.6.3 Biomass and abundances indices from survey

The survey catch rates in terms of biomass (kg/h) and abundance (nos/h) varied strongly through the time-series, but elevated levels were observed from 1998 to 2005. The indices have declined since 2004 with both biomass and abundance being lowest on record in 2017. The index for 2021 show a small increase since the lowest record in 2017. Since the directed fishery is stopped and the bycatches from other fisheries are expected to be low, it is uncertain why the survey catches still are very low compared to the levels before 2000.

8.2.6.4 Age data

The age frequency distributions from recent years contrast with distributions from the 1980s (Bergstad, 1990b) in terms of proportions of old fish (e.g. >20 years) (Table 8.3.3). After the exploitation pulse in 2003–2005, the proportion of old fish has declined to very low levels (Bergstad *et al*., 2014). In recent years, i.e. after 2006 the mean age in the catches has increased somewhat, but the proportion of fish >20 years remains low.

Analyses of size distributions and the time-series of survey abundance of small juveniles by Bergstad *et al*. (2014) suggested that only a single very abundant recruitment event occurred during the period 1984–2020, perhaps only a single major year class. This event rejuvenated the stock and enhanced abundance in subsequent years.

8.2.7 Comments on assessment

In 2018, the working group decided to upgrade this stock to a 3.2 category using the biomass index from the Norwegian shrimp survey, derived from the relevant depth range of the species in this area.

8.2.8 Management considerations

The decline in abundance after 2005–2006 suggested by the Norwegian shrimp survey catch rates probably reflect the combined effect of the enhanced targeted exploitation in 2003–2005 and low recruitment in the years following the single recruitment pulse in the early 1990s. The percentage of fish >15 cm is at a lower level as in the late 1980s and early 1990s, and there is no suggestion of a new recruitment pulse as seen in the 1990s. Recent age distributions almost lack the >20 years old component which was prominent in the 1980s.

Since the targeted fishery has stopped and the bycatch in the shrimp fishery seems low, the potential for recovery of the roundnose grenadier in Skagerrak may be good. Abundance levels has declined since 2004 and in 2017 it was the lowest recorded during the survey period 1984–2021. However, there has been a small increase in the index since 2017 but still at very low levels. Rejuvenation and growth of the population would at present seem unlikely due to low recruitment during the recent decade.

8.2.9 References

Bergstad, O.A. 1990b. Distribution, population structure, growth and reproduction of the roundnose grenadier *Coryphaenoides rupestris* (Pisces:Macrouridae) in the deep waters of the Skagerrak. *Marine Biology* 107: 25–39.

Bergstad, O.A., H.Ø. Hansen and T. Jørgensen. 2014. Intermittent recruitment and exploitation pulse underlying temporal variability in a demersal deep-water fish population. ICES Journal of Marine Science, 71: 2088–2100.

8.2.10 Tables and Figures

Table 8.3.0. Roundnose grenadier in Division 3.a. WG estimates of landings.

Year	Denmark	Norway	Sweden	TOTAL
1988	612		5	617
1989	884		1	885
1990	785	280	2	1067
1991	1214	304	10	1528
1992	1362	211	755	2328
1993	1455	55		1510
1994	1591		42	1633
1995	2080		1	2081
1996	2213			2213
1997	1356	124	42	1522
1998	1490	329		1819
1999	3113	13		3126
2000	2400	4		2404
2001	3067	35		3102
2002	4196	24		4220
2003	4302			4302
2004	9874	16		9890
2005	11 922			11 922
2006	2261	4		2265
2007	+	1		1
2008	+	+		+
2009	2	+	+	2
2010	1	+	+	1
2011		0		0
2012	1	0		1
2013	1	0		1
2014	0,6	0	0,4	1

Year	Denmark	Norway	Sweden	TOTAL
2015	0,6	+	+	0.6
2016	1,1	0,3	0,01	1,4
2017	0,7	0,03	0,03	0,76
2018	0,3	0,06		0,36
2019	0,9	0,09	+	1
2020*	0.4	0.8	+	1.2

*** Preliminary data.**

Table 8.3.1. Summary of data on bottom-trawl survey series from the Norwegian shrimp survey, 1984-2021. Rg-rock-hopper groundgear. 'Strapping'maximum width of trawl constrained by rope connecting warps in front of otter doors. MS-RV Michael Sars, HM-RV Håkon Mosby. Data from 2019 survey are included. All trawls were fitted with a 6mm mesh codend liner.

YEAR	Survey month	Vessel	IMR Gear code	Additional gear info.	No. trawls >300m	No. trawls >400m	No. trawls survey
1984	OCT	MS	3230	Shrimp trawl (see text)	10	1	67
1985	OCT	MS	3230	"	21	5	107
1986	OCT/NOV	MS	3230	"	24	9	74
1987	OCT/NOV	MS	3230	"	35	14	120
1988	OCT/NOV	MS	3230	"	31	11	122
1989	OCT	MS	3236	Campelen 1800 35mm/40, Rg	31	7	106
1990	OCT	MS	3236	"	26	5	89
1991	OCT	MS	3236	"	28	9	123
1992	OCT	MS	3236	"	27	10	101
1993	OCT	MS	3236	"	30	10	125
1994	OCT/NOV	MS	3236	"	27	10	109
1995	OCT	MS	3236	"	29	12	103
1996	OCT	MS	3236	"	27	11	105
1997	OCT	MS	3236	"	25	6	97
1998	OCT	MS	3270	Campelen 1800 20mm/40, Rg	23	6	97
1999	OCT	MS	3270	"	27	8	99

YEAR	Survey month	Vessel	IMR Gear code	Additional gear info.	No. trawls >300m	No. trawls >400m	No. trawls survey
2000	OCT	MS	3270	"	25	10	109
2001	OCT	MS	3270	"	18	4	87
2002	OCT	MS	3270	"	24	6	82
2003	OCT/NOV	HM	3230	Shrimp trawl (as in 1984–1988)	13	0	68
2004	MAY	HM	3270	Campelen 1800 20mm/40, Rg	17	6	65
2005	MAY	HM	3270	"	23	8	98
2006	FEB	HM	3270	"	10	0	45
2007	FEB	HM	3270	"	11	1	66
2008	FEB	HM	3271	Campelen 1800 20mm/40, Rg and strapping*	18	5	73
2009	JAN/FEB	HM	3271	"	25	7	91
2010	JAN	HM	3271	"	24	7	98
2011	JAN	HM	3271	"	22	7	93
2012	JAN	HM	3271	"	20	5	65
2013	JAN	HM	3271	"	28	8	101
2014	JAN	HM	3271	"	16	7	69
2015	JAN	HM	3271	"	28	9	92
2016	JAN	HM	3271	"	28	9	108
2017	JAN	KB	3271	"	30	9	128
2018	JAN	KB	3271	Campelen 1800 20mm/40, Rg and strapping**	27	8	111
2019	JAN	KB	3296	Campelen 1800 20mm/40, Rg and strapping***	27	8	119
2020	JAN	KB	3296	""	26	7	106
2021	JAN	KB	3296	""	27	8	113

*** Path width of the tow constrained by a 10 m rope connecting the warps, 200 m in front of otter boards. ** Path width of the tow constrained to a 15 m rope connecting the warps, 100 m in front of the otter boards. *** Same trawl and strapping but from 2019 there are inserted several floaters on the trawl to lighten the trawl (Nordsjørigging).**

Table 8.3.2. Discards (tons) reported for roundnose grenadier in 3a from 2014-2020.

Year	Denmark	Sweden	Norway	TOTAL
2014		0.4		0.4
2015	1			1
2016	0.1	0.9		1
2017		1.6		1.6
2018	2.9	0.01		2.9
2019	0,5	0,08		0,6
2020	0	0		0

Table 8.3.3. Cumulative percentages (%) for selected ages from the deep-sea species survey in1987 and from the Norwegian shrimp survey in 2007-2019

	Age				
Year	5	10	20	30	50
1987	9	21	45	75	96
2007	10	23	83	94	96
2008	22	40	92	99	100
2009	14	30	88	93	100
2010	12	29	71	96	99
2011	6	23	65	94	99
2012	10	28	48	96	100
2013	14	28	56	92	99
2014					
2015	7	17	48	95	100
2016					
2017	14	52	81	94	99
2018	23	50	77	99	100
2019	8	37	64	92	100

Table 8.3.4. Mean biomass index and mean abundance index from the Norwegian shrimp survey 1984-2021. Missing data are from surveys that are not representable according to roundnose grenadier catches (less stations > 300 m). Data from 2016 are considered unreliable according to gear inconsistencies.

Mean biomass (kg/h), Mean abundance (n/h), Number (n) and Standard error (2SE)					
Year	**n**	**(kg/h)**	**SE(kg/h)**	**(n/h)**	**SE(n/h)**
1984	10				
1985	21	108.12	38.32	149.95	49.43
1986	24	83.75	32.16	117.83	46.99
1987	35	76.15	13.56	125.80	24.60
1988	31	72.14	13.92	105.19	21.22
1989	31	122.69	43.48	195.94	73.07
1990	26	49.81	18.20	72.66	27.55
1991	28	107.14	22.27	176.86	38.75
1992	27	188.54	67.53	698.52	337.67
1993	30	58.59	19.42	190.33	74.15
1994	27	87.19	21.21	372.96	143.56
1995	29	118.30	32.36	440.62	144.41
1996	27	99.63	31.68	268.01	116.92
1997	25	113.86	66.47	362.72	222.08
1998	23	255.54	87.80	812.82	336.85
1999	27	149.30	42.85	388.83	122.54
2000	25	129.27	30.39	389.06	107.71
2001	18	105.33	51.84	272.99	151.99
2002	24	174.77	66.27	371.70	129.97
2003	13				
2004	17	324.38	125.48	1143.35	487.33
2005	23	193.65	93.81	550.42	260.94
2006	10				
2007	11				
2008	18	95.58	65.81	259.10	208.53
2009	25	72.72	39.81	207.41	121.84
2010	24	33.24	21.47	77.21	54.81

Mean biomass (kg/h), Mean abundance (n/h), Number (n) and Standard error (2SE)					
Year	**n**	**(kg/h)**	**SE(kg/h)**	**(n/h)**	**SE(n/h)**
2011	22	26.84	12.61	54.76	27.05
2012	20	16.69	11.97	34.40	23.83
2013	28	11.48	4.92	35.06	16.90
2014	16	25.62	15.76	49.56	28.69
2015	28	7.28	4.59	21.19	12.14
2016	28				
2017	30	6.64	2.41	15.74	6.73
2018	27	12.88	6.60	41.91	26.13
2019	27	14.59	5.77	40.09	18.05
2020	26	18.72	11.48	63.02	38.07
2021	27	9.59	5.03	26.14	14.19

Table 8.3.5. Proportion of tows with shrimp trawl that caught roundnose grenadier. Data from Norwegian Reference fleet

Year	Total number of shrimp trawl	Number of trawl hauls that caught roundnose grenadier	Catch of roundnose gren-adier (kg)	% of the total catch
2013	243	0		0
2014	288	2		0,69
2015	1489	14		0.94
2016	4811	23		0,48
2017	3798	20	29	0,53
2018	2849	19		0,67
2019	1233	4	80	0,32

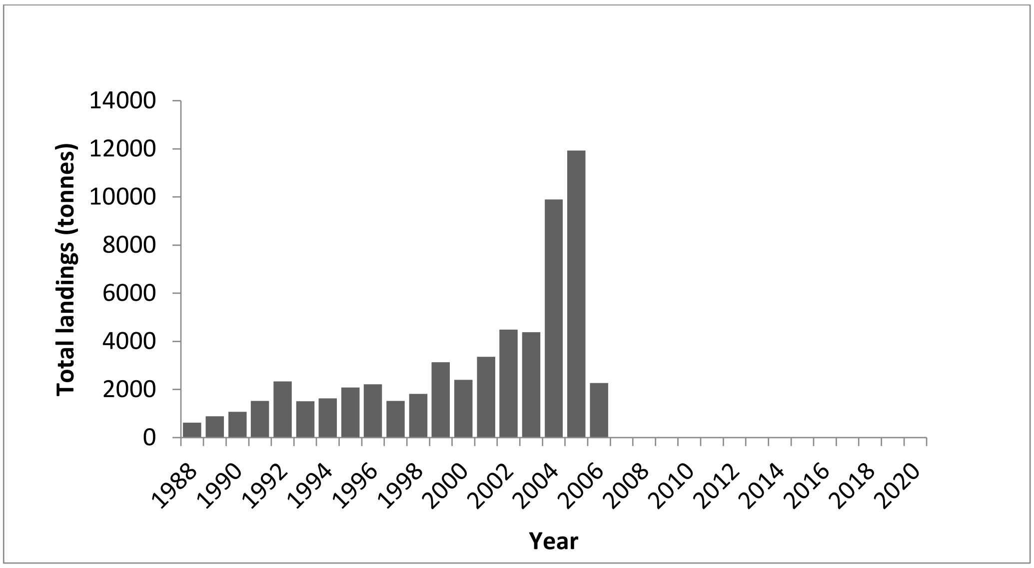


Figure 8.3.0. Landings of roundnose grenadier from Division 3.a. Landings from 2007–2020 are insignificant.

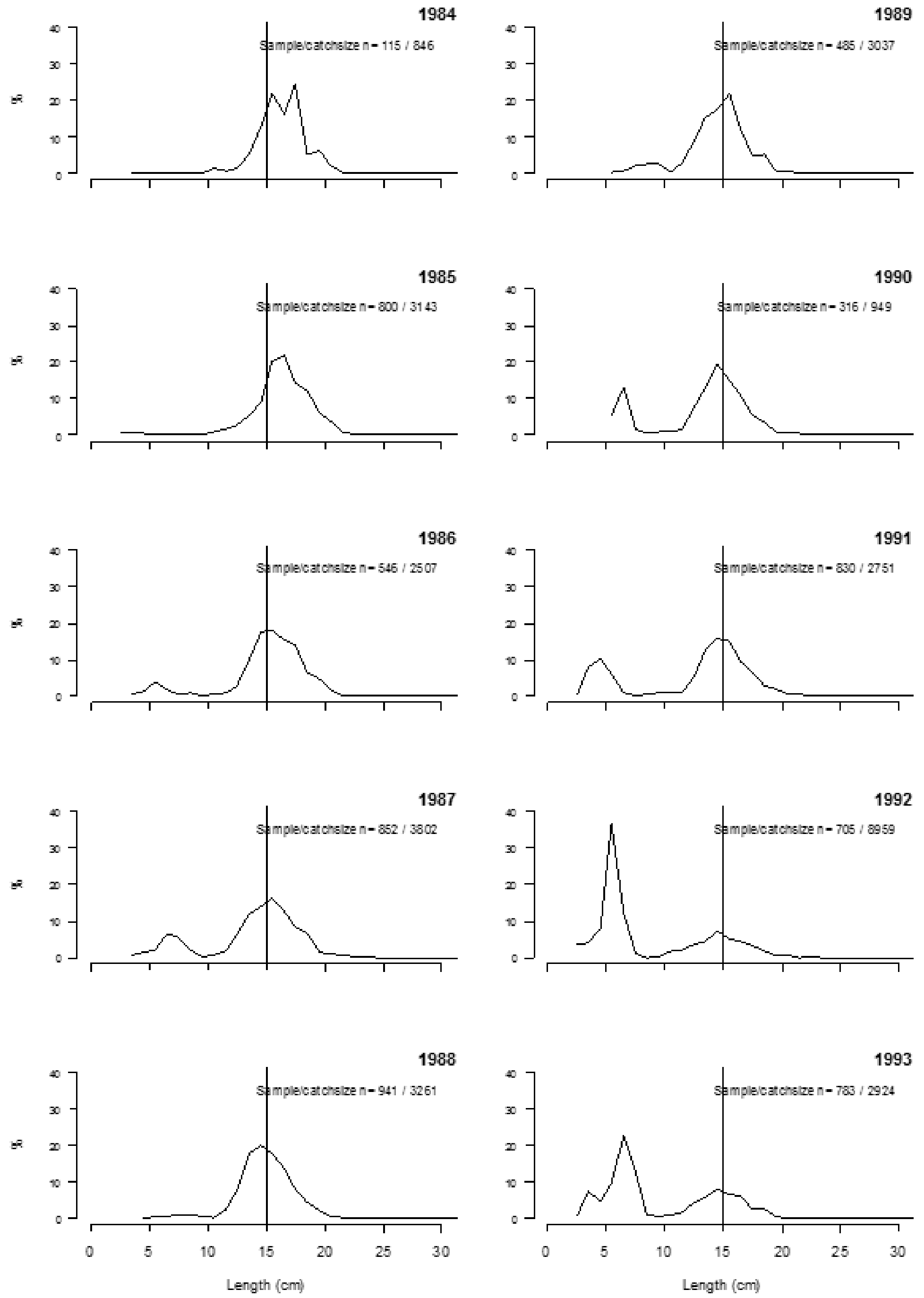


Figure 8.3.1. Length–frequency distributions for roundnose grenadier, 1984–2021. Data from Norwegian shrimp survey, all catches deeper than 300 m. Length is measured as pre-anal length in cm. The distributions are calculated as percent-number of fish in each cm length interval standardized to total catch number and trawling distance for each station each year.

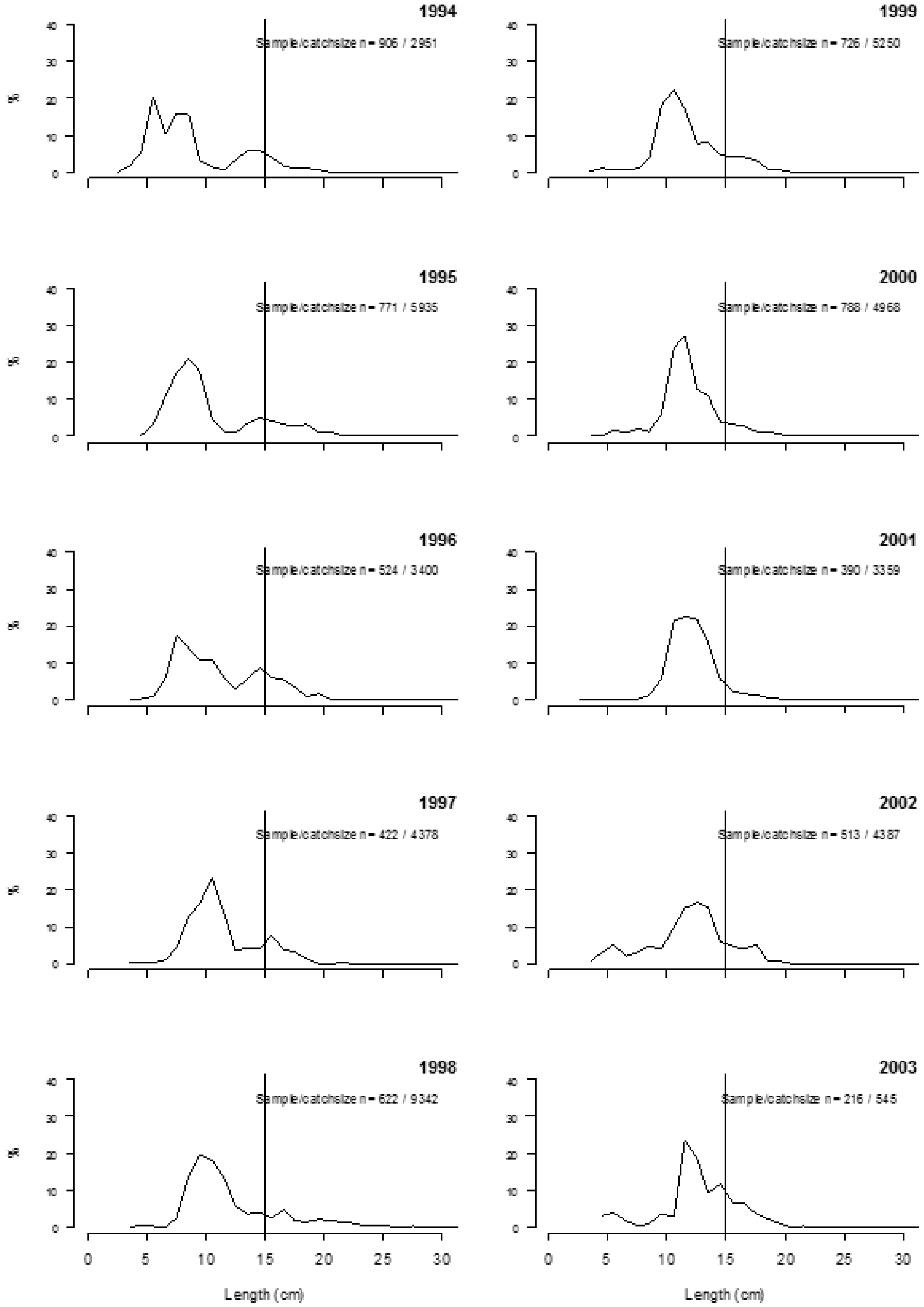


Figure 8.3.1. (Con't).

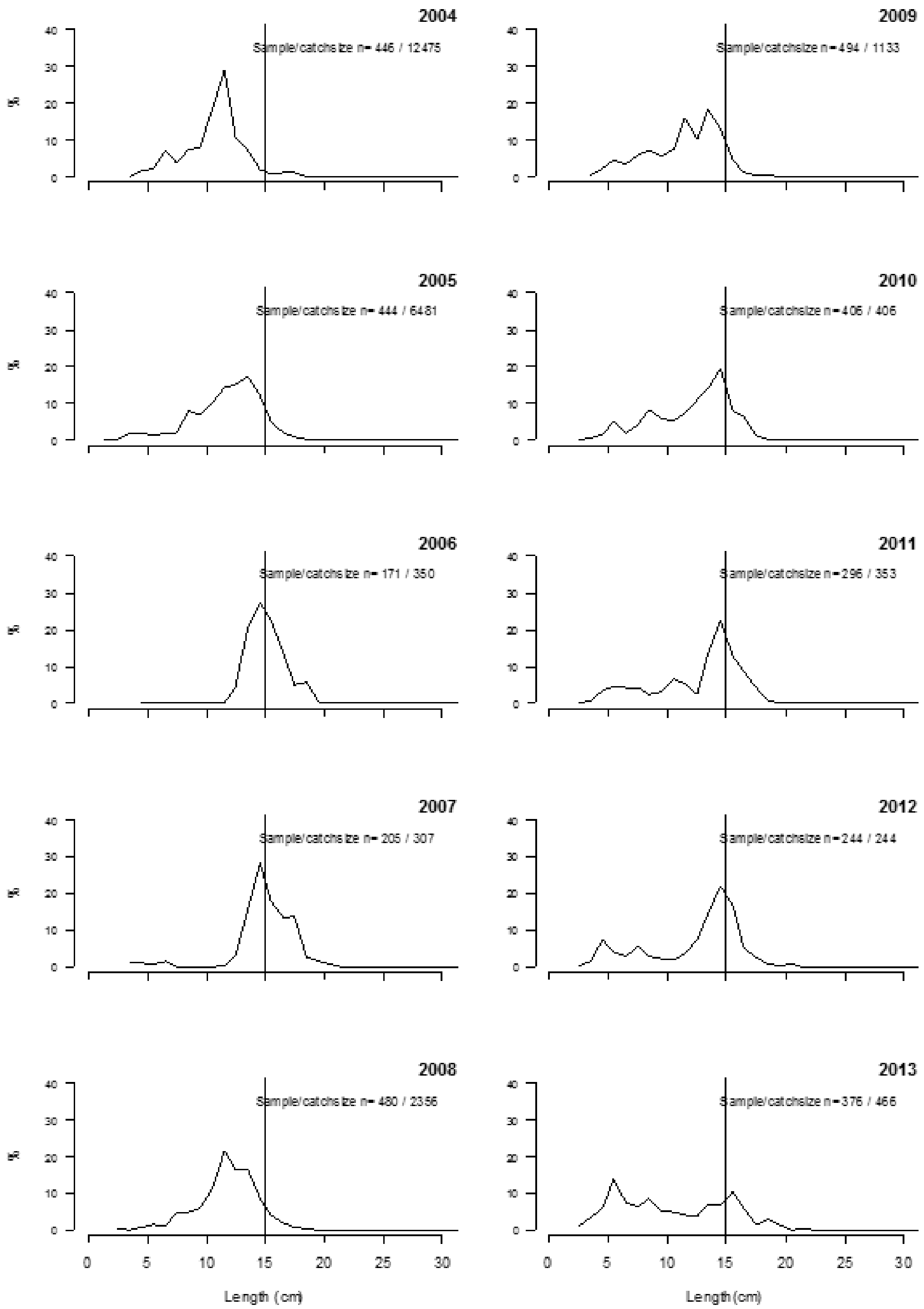


Figure 8.3.1. (Con't).

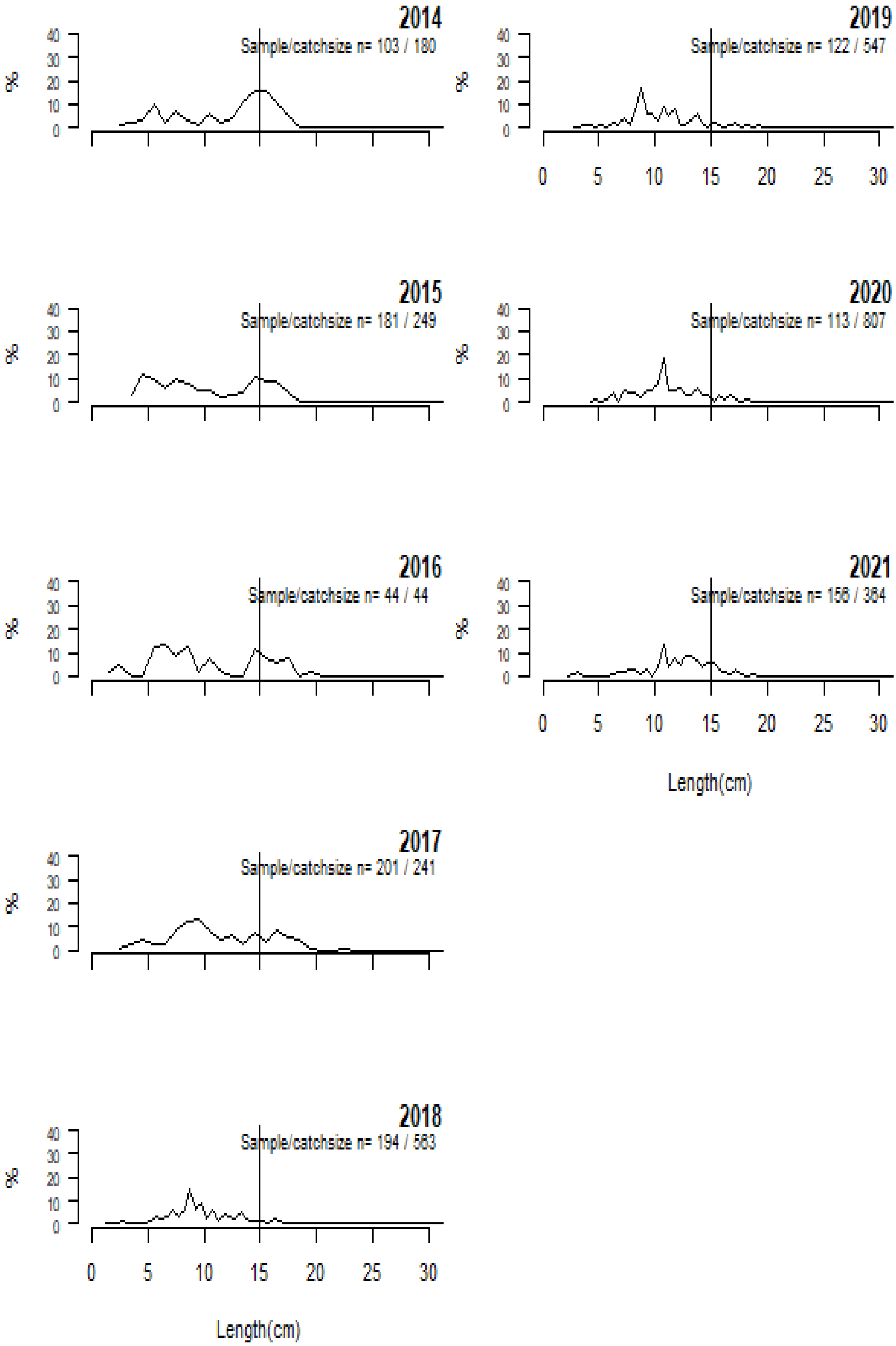


Figure 8.3.1. (Con't).

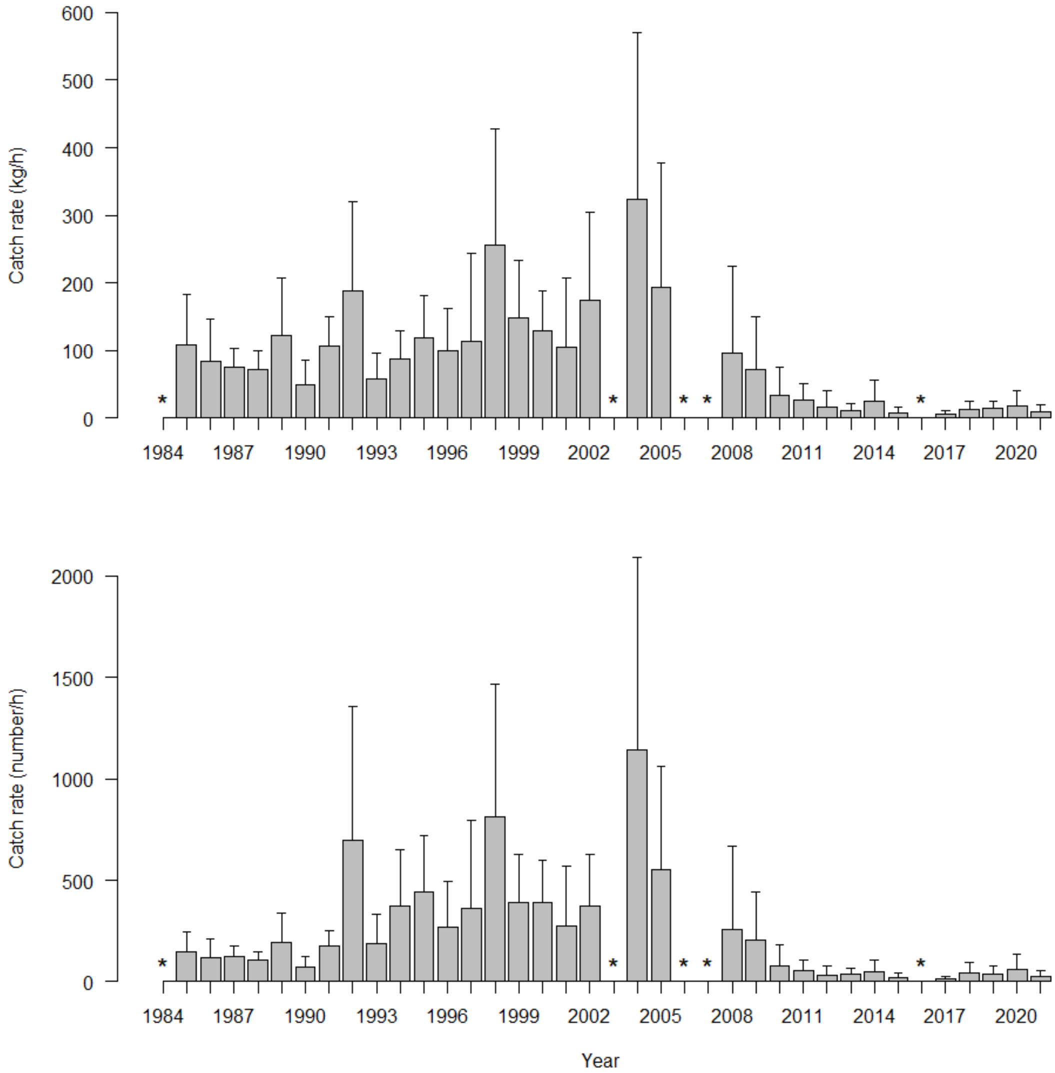


Figure 8.3.2. Survey catch rates in biomass (kg/h) and abundance (nos/h) of grenadier 1984–2021 in the Norwegian shrimp survey. Note: in 1984, 2003, 2006, and 2007 only a single or no trawls were made deeper than 400 m, thus the primary grenadier habitat was not sampled for those years. For 2016 data from the shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded. For the other years the survey is thought to cover the distribution area of roundnose grenadier Lines indicate estimates of 2SE (Updated from Bergstad *et al.*, 2014).

9 Black scabbardfish (*Aphanopus carbo*) in the Northeast Atlantic

9.1 Stock description and management units

The species is distributed on both sides of the North Atlantic and on seamounts and ridges, from the Strait of Denmark, southwards to about 30°N (Nakamura & Parin, 1993). Juveniles are mesopelagic and adults benthopelagic. The life cycle of the species is not completed in just one area and large-scale migrations occur seasonally.

All available evidences suggest one single stock doing a clockwise migration between Northern European waters (ICES subareas 5, 6 and 7 and Division 27.12.b) and southern European waters (subareas 8 and 9) down to Madeira in the CECAF area, where spawning occurs (Farias *et al.*, 2013). The connexions between the Northern and Southern components and other areas, in particular Azorean waters and the mid-Atlantic Ridge is less clear. However, ICES considers one single assessment unit in the Northeast Atlantic.

Two different species, the black scabbardfish (*Aphanopus carbo*) and the intermediate scabbardfish (*A. intermedius)*, coexist in Azorean waters (Subarea 10), Madeira, and the Canaries (Stefanni & Knutsen, 2007; Stefanni *et al.*, 2009; Biscoito *et al.*, 2011; Besugo *et al.*, 2014 WD). This latter species is not subject to assessment by ICES.

Because of the different characteristics of fisheries and life stage occurring in each area, the report is organised in four sections treating fisheries in northern, southern, other areas, and CECAF. WGDEEP does not assess fisheries in Madeira (Eastern Central Atlantic area, CECAF) or in other areas outside the ICES area.

Section 9.2 "Black scabbardfish (*Aphanopus carbo*) in subareas 27.5, 27.6 and 27.7 and Division 27.12.b" presents data and analyses on fisheries and catches in the Northern component of the ICES areas. In these areas the bulk of the catch is by trawlers.

Section 9.3 "Black scabbardfish (*Aphanopus carbo*) in subareas 27.8 and 27.9" presents data and analyses where the main fishery is from deep-water longliners in Division 27.9.a, which represents the Southern component of the ICES areas, as well as results of the model for the overall stock. The modelling relies on a state-space dynamic population model benchmarked at WKDEEP 2014 (ICES, 2015).

Section 9.4 " Black scabbardfish (*Aphanopus carbo*) in other areas" presents data and analyses for other areas, namely Division 27.3.a and subareas 27.1, 27.2, 27.4, 27.10, and 27.14. Data are mostly about longline fisheries. Since, 2010 the overall landings from those areas were globally much lower than at the other two management units.

Section 9.5 " Black scabbardfish (*Aphanopus carbo*) in CECAF area" presents data and analysis of fisheries and landings in CECAF area 34.1.2, where a directed bottom longline fishery operates. Although ICES does not asses this fishery, it is admitted that the incorporation of reliable CECAF data could provide a wider perception of the stock dynamics.

9.2 Black scabbardfish (*Aphanopus carbo*) in subareas 27.5, 27.6 and 27.7 and Division 27.12.b

In this section, fisheries, landings trends, and applicable management are presented for divisions 27.5.a, 27.5.b, and 27.12.b and subareas 27.6 and 27.7, but the stock assessment data analyses and management considerations apply to these areas and ICES subareas 27.8 and divisions 27.9.a.

ICES Division 27.5.a, initially included in “Other areas”, has been included in the Northern Component since 2016, both for stock assessment analyses and for management considerations.

9.2.1 The fishery

The fishing effort from EU vessels in the Northern Component area has been greatly reduced due to the EU Regulation 2016/2336 of 14 December 2016 (EU, 2016) that bans fishing with bottom trawls at a depth below 800 metres, with impacts on the French bottom deep-water fishery that catches the black scabbardfish.

In Division 27.5.b, black scabbardfish was initially fished by large trawlers that operated on the slope around the Faroe Bank and on the Wyville-Thomsen ridge close to the southernmost Faroese EEZ boarder. In Faroese waters, the black scabbardfish fishery is managed through a fishing licencing scheme and since 2013, only one trawler has had licence to fish black scabbardfish as a targeted species.

Faroese commercial trawlers use a star trawl with 486 meshes, 160 mm with a net mesh size of 80 mm. Black scabbardfish is usually fished at depths from 600 to 1000 m and the haul duration varies from 6 to 8h, but may last less in case of large catch (Ofstad, 2019 WD).

9.2.2 Landings trends

The historic landing trends on this assessment unit are described in the stock annex.

Total landings from the ICES Division 27.12.b and subareas 27.5, 27.6, and 27.7 show a markedly increasing trend from 1999 to 2002 followed by a decreasing until 2005 (Figure 9.2.1). The peak in landings was registered in 2002 and came mainly from landings in ICES subareas 27.6 and 27.7. The 2002 peak appears to be mainly driven as a response to the EU TAC management (Figure 9.2.1). From 2009 until 2016, landings have been stable, fluctuating around about 3000 tonnes per year. Since 2017, there was a slight decrease.

Since 2010, Icelandic landings in ICES Division 27.5.a have increased, remaining stable around 300 t between 2012 and 2017, and decreasing in more recent years.

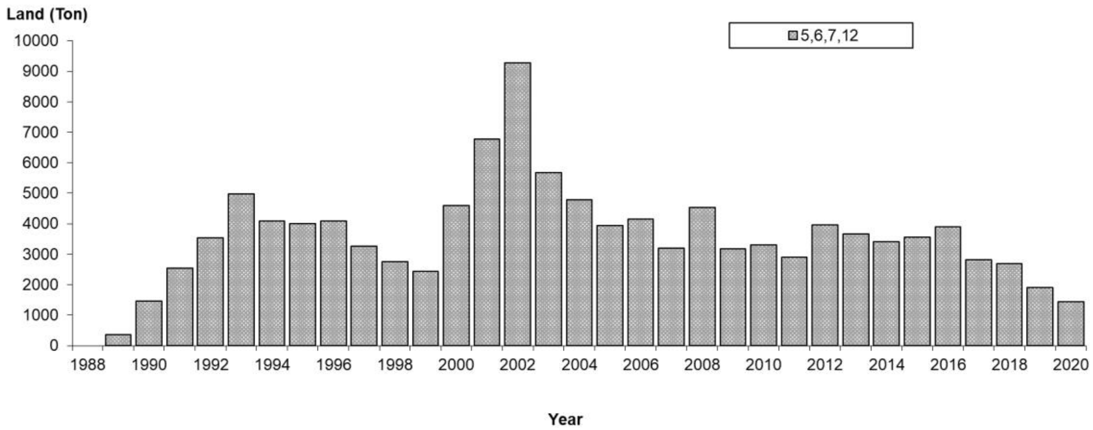


Figure 9.2.1. bsf.27.nea Northern component annual landings time-series for ICES subareas 27.5, 27.6, 27.7, and 27.12.

In early years, French landings represented more than 75% of the Northern component total landings, but in 2002 and 2006 they just represented about 50%. The relative importance of French landings, particularly at ICES Subarea 27.6, augmented from 2009 to 2012, decreased until 2015 and increased until 2017 to decrease again from 2017 to 2020. From 2013 to 2018, Spanish landings of black scabbardfish showed a slight increased, also decreasing in 2019, whereas Faroese landings increased from 2017 to 2020, which resulted on a rise in their relative contribution (Figure 9.2.2).

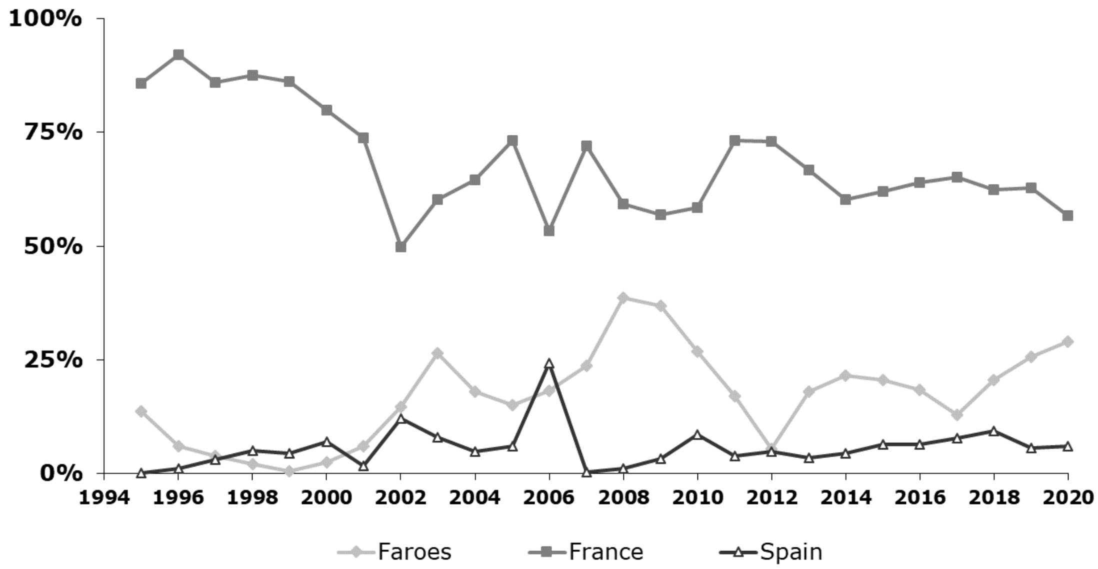


Figure 9.2.2 bsf.27.nea Northern component French, Spanish and Faroese relative contribution to the annual landings for the Northern component.

9.2.3 ICES Advice

The latest ICES advice, in 2020, was: "*ICES advises that when the precautionary approach is applied, catches should be no more than 4506 tonnes in each of the years 2021 and 2022.*

Distributed by area, this corresponds to annual catches of no more than 2143 tonnes in subareas 6 and 7 and divisions 5.b and 12.b, annual catches of no more than 2084 tonnes in Subarea 8 and Division 9.a, and annual catches of no more than 280 tonnes in subareas 1, 2, 4, and 10 and divisions 3.a and 5.a."

9.2.4 Management

Since 2003, the management of black scabbardfish, adopted for EU vessels fishing in EU and international waters, includes a combination of TAC and licensing system. TACs and total landings of EU vessels in subareas 27.5, 27.6, 27.7, and 27.12, from 2006 to 2020, are presented in Table 9.2.1. The difference between the TAC and landings may not necessarily be regarded as TAC overshoot as some catches occur in waters under the jurisdiction of third countries and are therefore not covered by the EU TAC.

Given the EU Regulation 2016/2336 of the European Parliament and of the Council of 14 December 2016 (EU, 2016), "No fishing authorisation shall be issued for the purpose of fishing with bottom trawls at a depth below 800 metres", black scabbardfish catches from trawl fishing grounds deeper than 800 meters are null for EU vessels since 2017.

Table 9.2.1. Black scabbardfish TACs and total landings of EU vessels in ICES subareas 27.5, 27.6, 27.7, and 27.12 from 2006 to 2021.

Year	EU TAC 27.5, 27.6, 27.7 & 27.12	Landings 27.5, 27.6, 27.7 and 27.12
2006	3042	4150
2007	3042	3194
2008	3042	4533
2009	2738	3159
2010	2547	3421
2011	2356	2900
2012	2179	2399
2013	3051	3229
2014	3966	3408
2015	3649	3546
2016	3357	3882
2017	2954	2821
2018	2600	2686
2019	2470	1903
2020	2470	1450
2021	583	

9.2.5 Data available

9.2.5.1 Landings and discards

In 2021, updated landing data were made available for the major fishing countries operating in ICES subareas 27.5, 27.6, 27.7, and 27.12 (Table 9.2.4).

Updated discard data were also provided for major fishing countries operating at the Northern component area. Based on the discard data available for this component, it is concluded that discards of black scabbardfish are negligible.

9.2.5.2 Research vessel data

Since September 2014, a Faroese deep-water survey has been conducted to investigate bottom fishes at deep waters and other areas than those the annual Faroese groundfish surveys covers (Ofstad, 2019 WD). The main species studied are tusk, blue ling, greater silver smelt, black scabbardfish, roundnose grenadier, deep-water redfish and Greenland halibut.

Faroese deep-water surveys are held onboard the research vessel "Magnus Heinason". The trawl gear used is a star trawl with 40 mm mesh size in the cod-end. Rockhopper ground gear, 120 m bridles and Thyborøn-trawl doors. Fishing hauls have a mean duration of one hour, but the fishing haul duration (i.e. the time interval between the time when the gear reaches the bottom till it is hauled up from the bottom) may vary. The adopted sampling procedure is the same as those adopted for Faroese annual groundfish surveys. After each fishing haul the total catch is sorted by species and total weight is determined for each species. Further samples are also collected with the aim of obtaining data on specimens´ length and weight. For the main species, subsamples are also collected to determination of sex, maturity and age.

In Faroese waters, black scabbardfish is mainly distributed on the slope north of the Faroe Bank and on the Wyville-Thomsen ridge (Figure 9.2.3), which correspond to the main Faroese fishing areas. A closer look shows that the black scabbardfish is only caught in the area north-west of the Faroes and never caught on the Faroe Plateau (Figure 9.2.4). In 2020, only 31 out of the 75 hauls planned for the survey were performed due to the weather conditions and problems with the vessel.

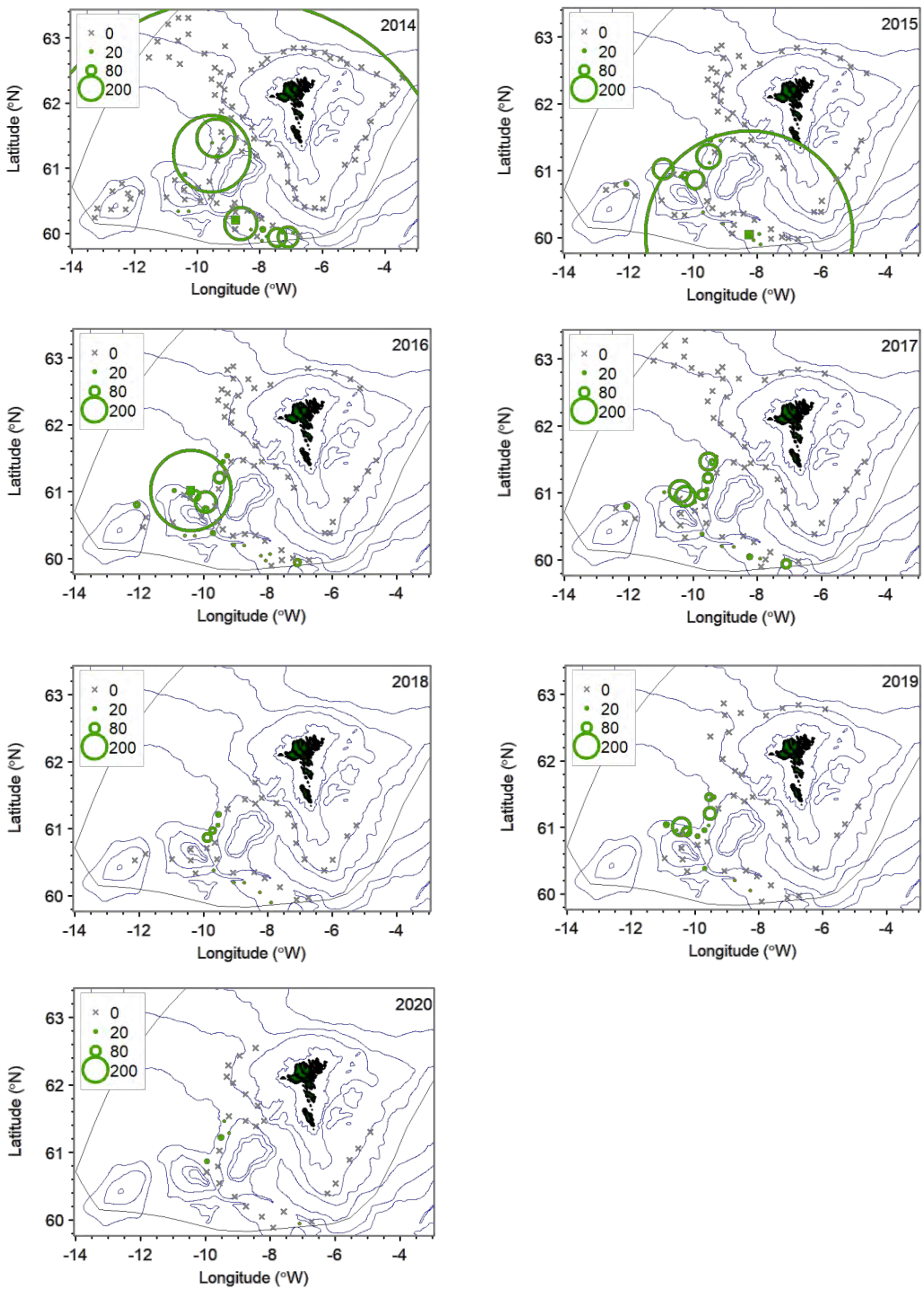


Figure 9.2.3. bsf.27.nea Northern component. Spatial distribution of CPUE (kg/h) from the deep-water surveys in 2014-2020. The green squares show the position of the largest catch. (Source: Ofstad, 2019, WD; Ofstad, L., 2020, 2021, pers. comm.).

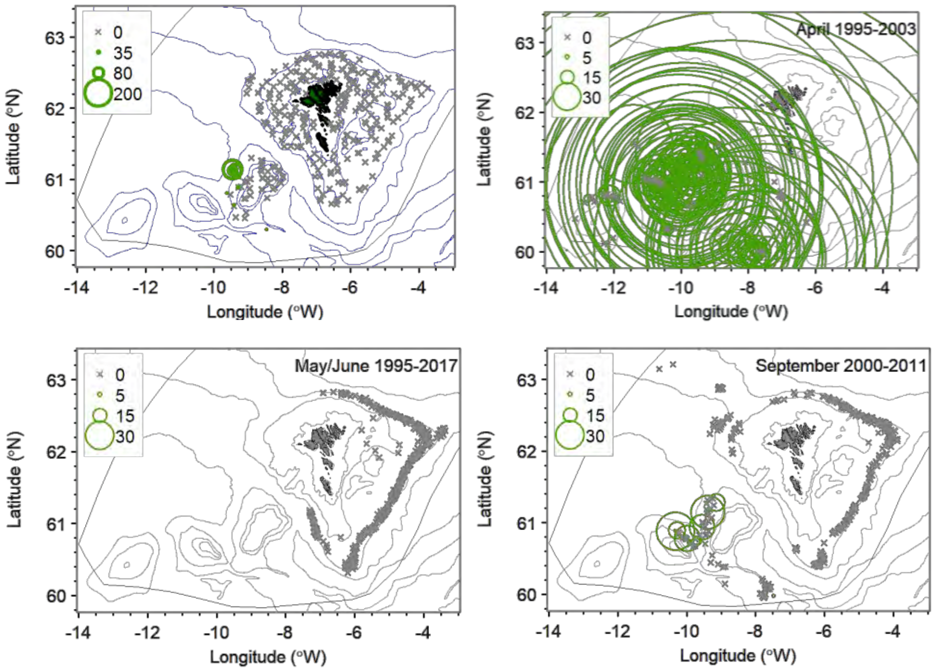


Figure 9.2.4. bsf.27.nea Northern component. Spatial distribution, CPUE (kg/h), from different surveys. Annual ground-fish surveys, August 1996-2017 (upper left), Blue ling surveys, April 1995-2003 (upper right), Greenland halibut surveys, May/June 1995–2017 (lower left) and Redfish surveys, September 2000-2011 (lower right). (Source: Ofstad, 2019, WD)

Oceanographic data collected in Faroese surveys indicate that the species occurs at depths below 500 m, in waters with temperature higher than 6°C (Figure 9.2.5). These two conditions are registered at the oceanic Faroese waters (Figure 9.2.6).

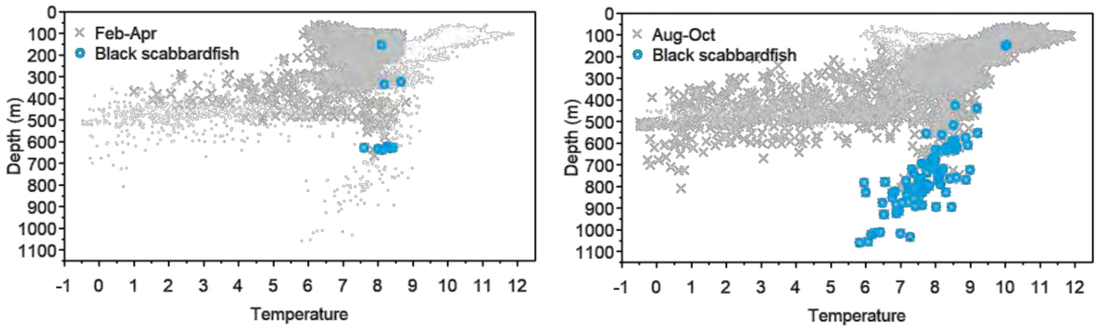


Figure 9.2.5. bsf.27.nea Northern component. Temperature and depth distribution of black scabbardfish (blue dots) and catch with no black scabbardfish (grey crosses) in February-April (left) and August-October (right). (Source: Ofstad, 2019, WD)

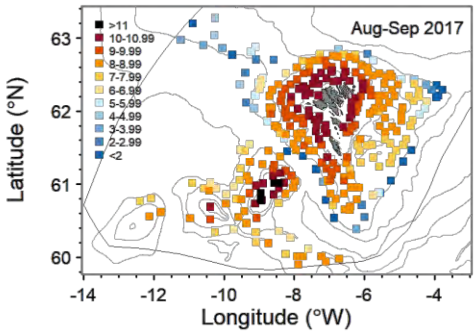


Figure 9.2.6. Temperature and depth distribution in Faroese waters August-September 2017. (Source: Ofstad, 2019, WD)

9.2.5.3 Length compositions

The annual length frequency distributions, based on French on-board observer data, for the period 2004-2020 are presented in Figure 9.2.7. The length frequency distribution is similar between years and reflects a predominance of immature individuals, i.e. specimens with less than 103 cm total length.

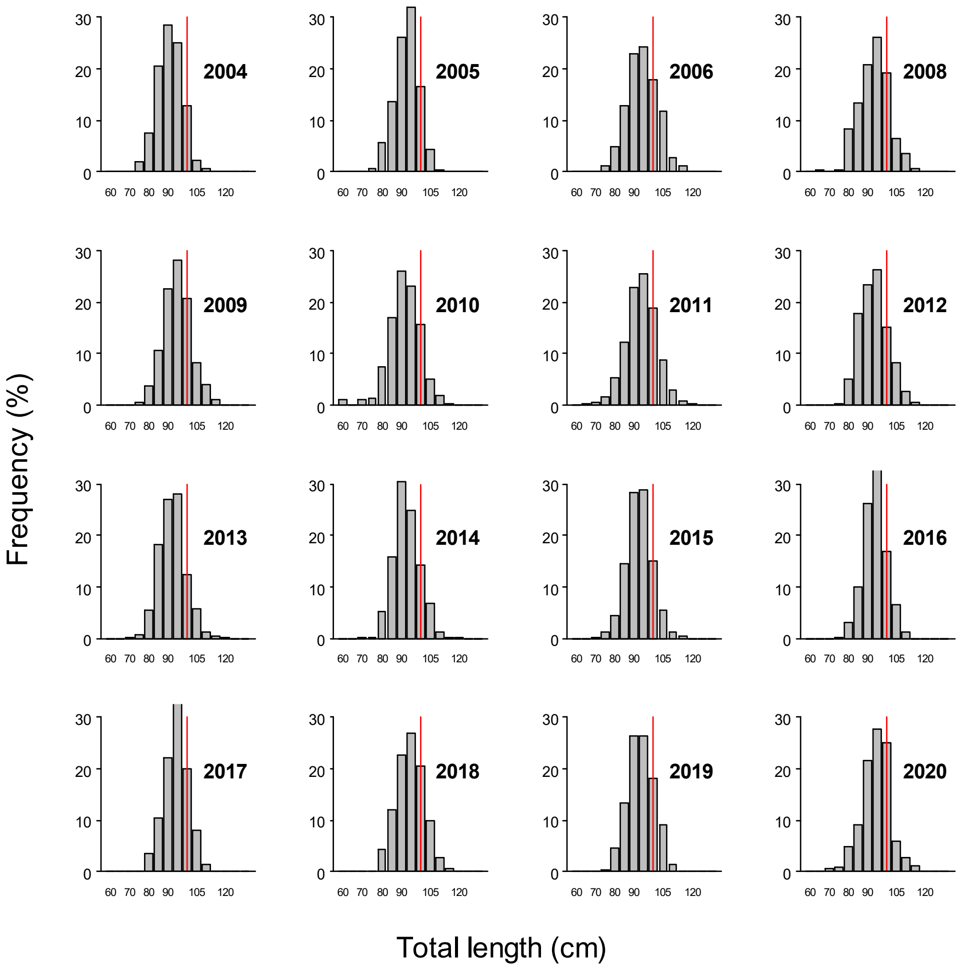


Figure 9.2.7. bsf.27.nea Northern component. Annual frequency length distribution of black scabbardfish based on French observer data collected on-board commercial vessels (2004–2020). The red vertical line indicates the length of 1st maturity of the species.

For the period 2004–2020, the temporal evolution of the mean length shows no trend (Figure 9.2.8), reflecting a stability on the length structure of the exploited population. In quarter 4, the lower mean length values were registered in 2010 and 2020, which may be associated with a high recruitment signal.

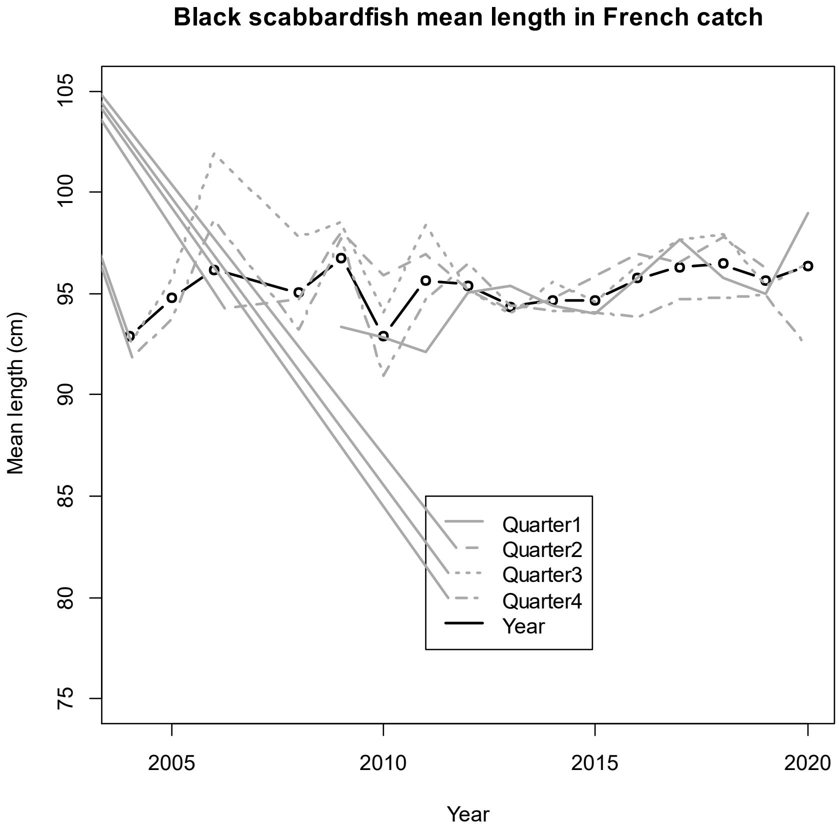


Figure 9.2.8. bsf.27.nea Northern component. Mean length estimates of black scabbardfish by quarter for the period 2004-2019. Data were collected under the French on-board observer program.

For the period 2014–2020, the annual length-frequency distributions based on samples collected at Faroese landings and Faroese deep-water surveys are presented in Figure 9.2.9. The mean length of the exploited population is around 90-92 cm, which is about the same mean length registered at the deep-water survey. In 2020, the Faroese survey length distribution includes specimens with length between 20 and 40 cm which were not registered before. Also, in 2020, the upper limit of the length range is lower than those from the previous years. The length frequency distribution for 2020 is not considered representative as it is based on 91 specimens and in the survey only 31 out of the 75 hauls planned were performed, due to the weather conditions and problems with the vessel.

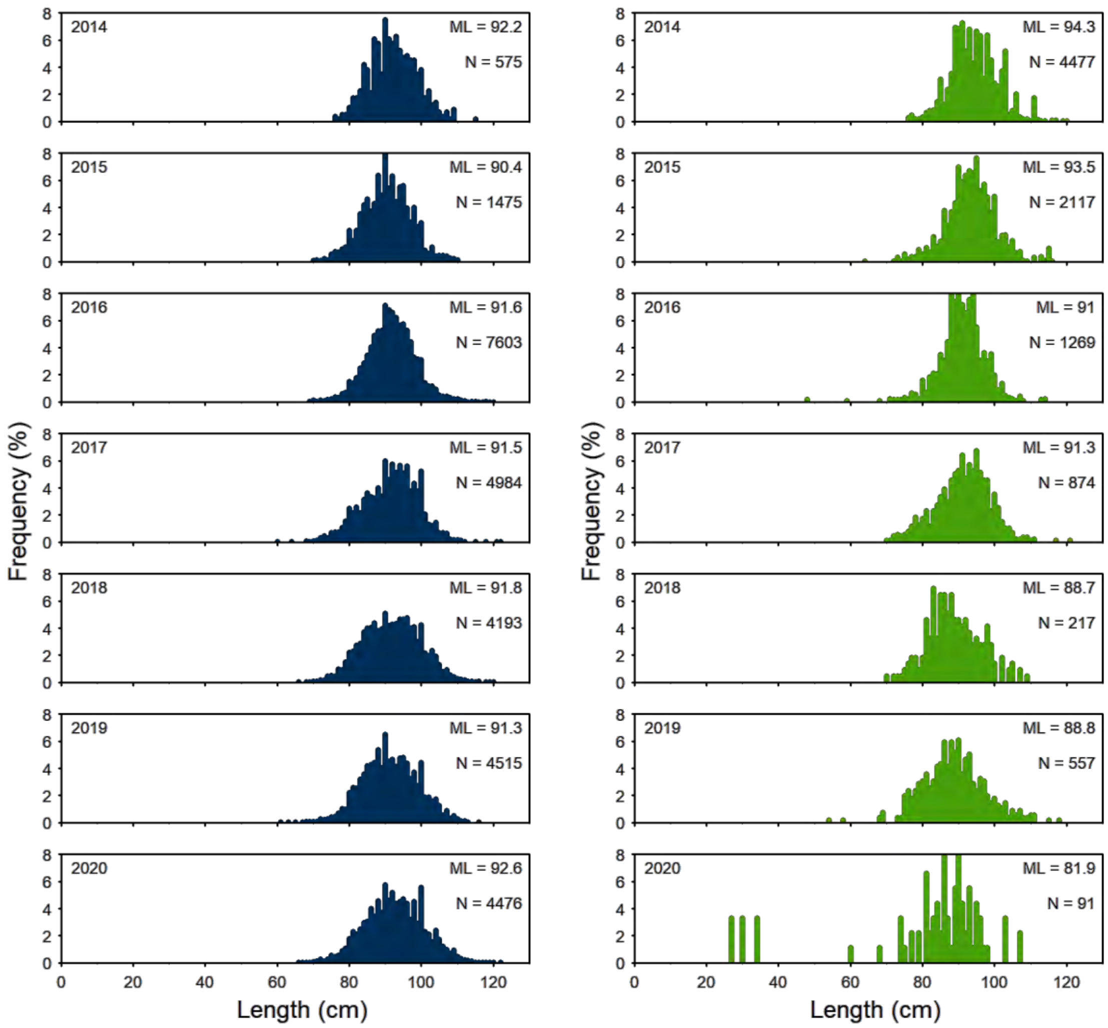


Figure 9.2.9. bsf.27.nea Northern component. Length-frequency distribution from the landings (left) and the deep-water survey (right) in 2014-2020. (Source: Ofstad, 2019 WD; Ofstad, L., 2020, 2021, pers. comm.)

In 2020, no new length information was provided by Spain for ICES Division 27.6.b and ICES Subarea 27.12. For 2014 and 2015, the annual length frequency distributions for ICES Division 27.6.b and ICES Subarea 27.12 were constructed based on the length data collected under Spanish on-board observer program (Figure 9.2.10).

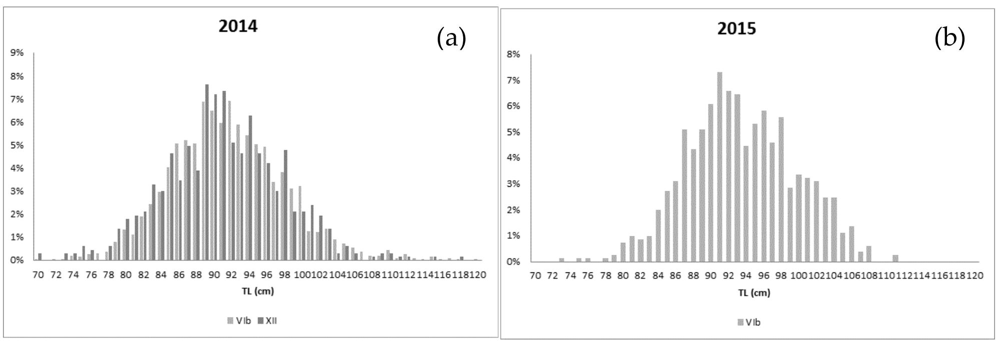


Figure 9.2.10. bsf.27.nea Northern component. Length frequency distribution based on Spanish on-board observations in 2014 (a) and in 2015 (b) in Division 6.b and Subarea 12.

Length frequency distributions for ICES Division 27.5.a based on the Icelandic Autumn surveys for the period 2000–2020 are presented in Figure 9.2.11.

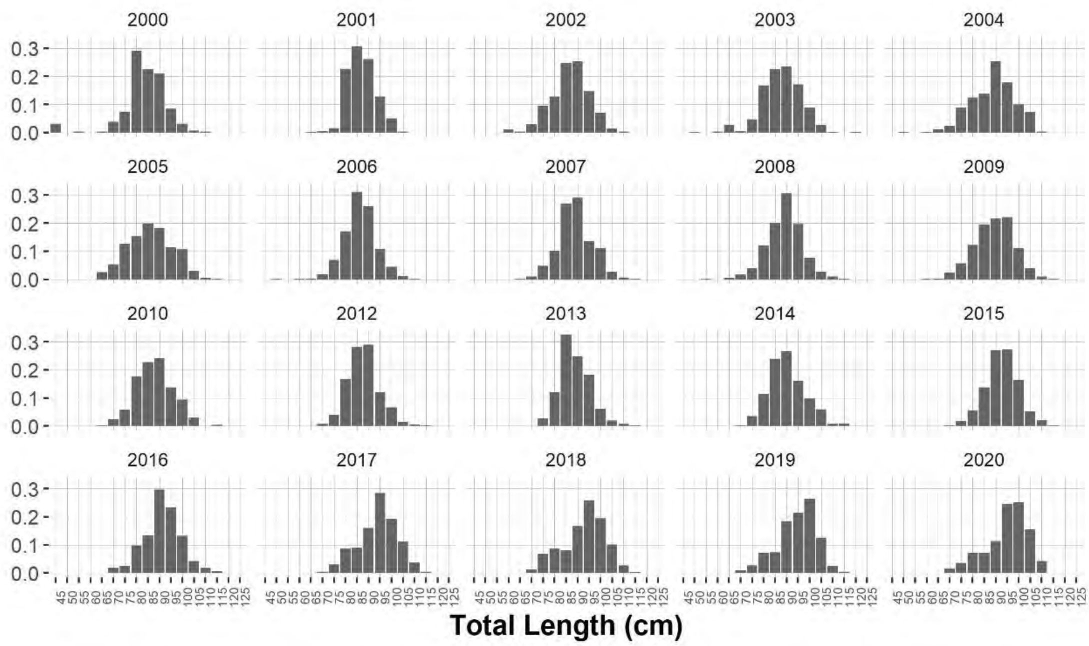


Figure 9.2.11. bsf.27.nea Northern component. Black scabbardfish in Division 27.5.a: length distribution from the Icelandic Autumn survey, from 2000 to 2019.

The length data available for the Northern component suggests a similar length structure of the exploited population between the different fishing fleets and specimens with total length smaller than 103 cm predominate.

The longest length data time series is from France and because of that French data is used to calculate the total catches, in number, grouped by the two length classes considered in the assessment model (the two length classes are: C2, which includes specimens from 70 to 103 cm TL (total length), and C3, which are specimens larger than 103 cm TL).

The total catch in weight (ton) and in number by length class, C2 and C3, for the period 1999-2019 used in the last advice in 2020 is presented in Table 9.2.2. A six-month time period is adopted as the time unit in the model and defined as: SEM1 = months 3-8 of the year; SEM2 = month 9–12 of the year plus months 1 and 2 of the following year.

Table 9.2.2. bsf.27.nea Northern component. Total catch estimates (in ton) and total catch estimates (in number) in length group C2 and C3 by SEM1 (3-8 of the year) and SEM 2 (month 9-12 of the year plus months 1 and 2 of the following year) for the years 1999–2019.

	Catch (in ton)		Catch (in number) C2		Catch (in number) C3	
Year	Sem 1	Sem 2	Sem 1	Sem 2	Sem 1	Sem 2
1999		1553		1264092		197321
2000	2044	3053	1555358	2485582	242786	387991
2001	2759	3758	2098661	3059087	327594	477514
2002	3720	4362	2830256	3550670	441794	554248
2003	2442	2775	1857504	2258718	289950	352578
2004	2143	2119	1740128	1928011	153435	95913
2005	1860	2040	1406337	1582422	182697	161474
2006	2801	1919	2152433	1512990	243934	172945
2007	1682	1930	1164611	1527070	209447	174555
2008	1874	2616	1160752	2069458	301462	236553
2009	2202	1740	1357278	1159152	352502	263009
2010	1843	1569	1327905	1166053	186787	167764
2011	1671	1653	965970	1135256	287668	167927
2012	1475	1283	985407	631463	189141	155895
2013	1879	1651	1382488	1056923	174340	138409
2014	2134	1726	1454066	1181859	233393	147308
2015	2048	1549	1455544	1222845	193143	127742
2016	2267	1462	1530274	1117978	291048	131779
2017	1601	1301	1046235	977682	229587	116252
2018	1574	961	992597	703734	232860	96849
2019*	1097		792651		124663	

* incomplete SEM 2 since January and February 2020 were not available

9.2.5.4 Age compositions

The exploited population is not structured by age because the assessment approach followed to assess the stock is a stage-based model, with stages defined according to length.

9.2.5.5 Weight-at-age

No data on weight-at-age are available.

9.2.5.6 Maturity and natural mortality

The information available for ICES Subareas 27.5.b, 27.6, 27.7, and 27.12 consistently points out to the predominance of small and immature specimens.

9.2.5.7 Catch, effort and research vessel data

The standardised French CPUE series covering the period 1998–2020 is presented in Figure 9.2.12. Estimates were made for one vessel in each ICES rectangle, for the mean fishing depth by rectangle, and determined by averaging over rectangles by area. CPUE was estimated by six-month time periods as: SEM1= months 3–8 of the year; SEM 2=month 9–12 of the year, plus months 1 and 2 of the next year. The use of an index by semester instead of a yearly index was driven by a clear seasonal pattern in CPUE with higher catch rates in autumn-winter.

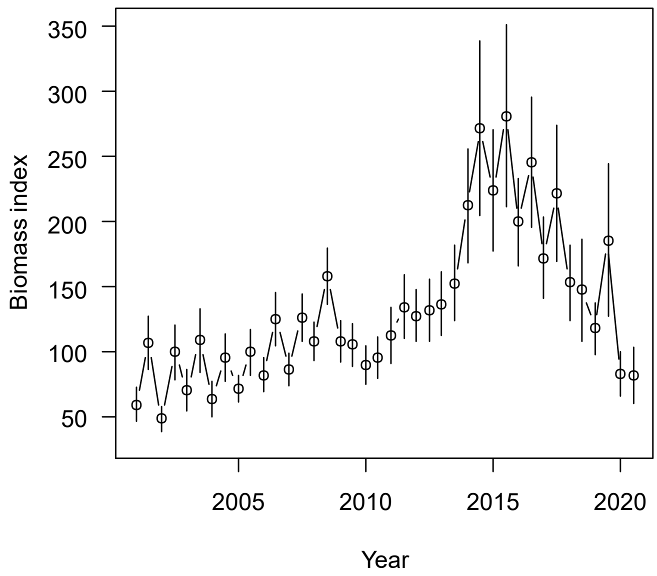


Figure 9.2.12. bsf.27.nea Northern component. CPUE by new semesters, i.e., SEM1= months 3-8 of the year and SEM2=month 9-12 of the year, plus months 1 and 2 of the next year.

For the period from 2006 to 2020, the monotonic trend in the standardised fishing effort time series for the Northern component was tested using the Kendall rank correlation test. The time series plot with LOWESS smooth indicates a downward trend (Figure 9.2.13) and the autocorrelation in this data is not significant (Fig 10.2.14). The Mann-Kendall trend test (tau = -0.717; 2-sided p-value =3.1601e-07) confirms the downward trend in fishing effort for the Northern component.

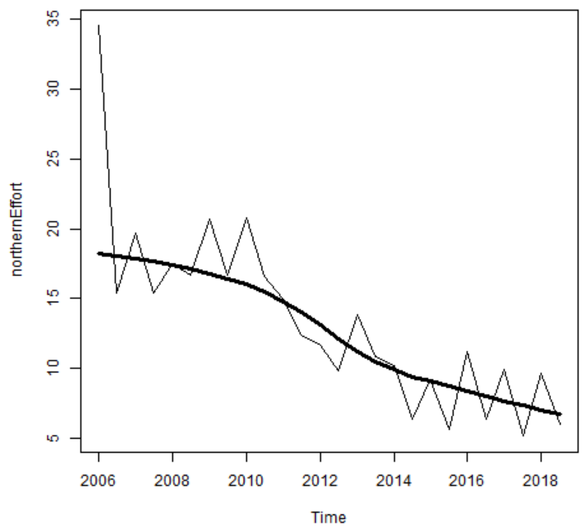


Figure 9.2.13. bsf.27.nea Northern component. Standardised effort by new semesters, i.e., SEM1= months 3-8 of the year and SEM2=month 9-12 of the year, plus months 1 and 2 of the next year.

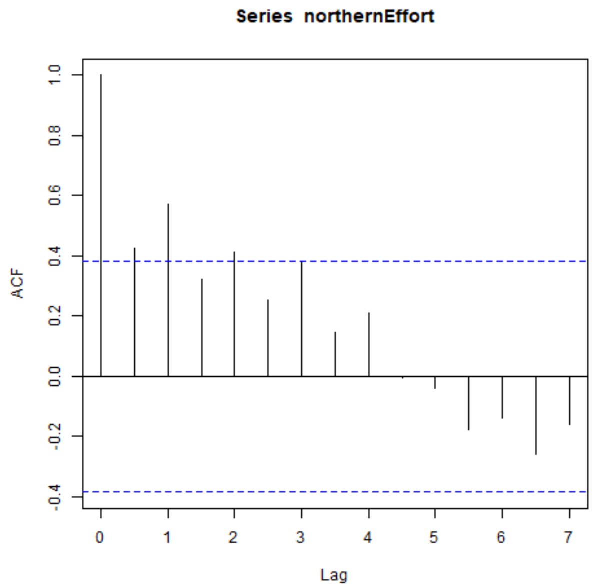


Figure 9.2.14. bsf.27.nea Northern component. Standardised fishing effort time series autocorrelation.

Scottish research survey data have been provided to WGDEEP. The survey takes place every two years. The annual biomass and abundance index estimates (kg per hour and mean numbers per hour of trawling for each haul with 95 % confidence intervals) obtained for hauls deeper than 500 and shallower than 1600 m are presented in Figure 9.2.15 (Campbell, 2020, pers. comm.). After 2012, both the annual biomass and annual abundance indices are at higher levels, indicating that the population at the Northern component has been increasing.

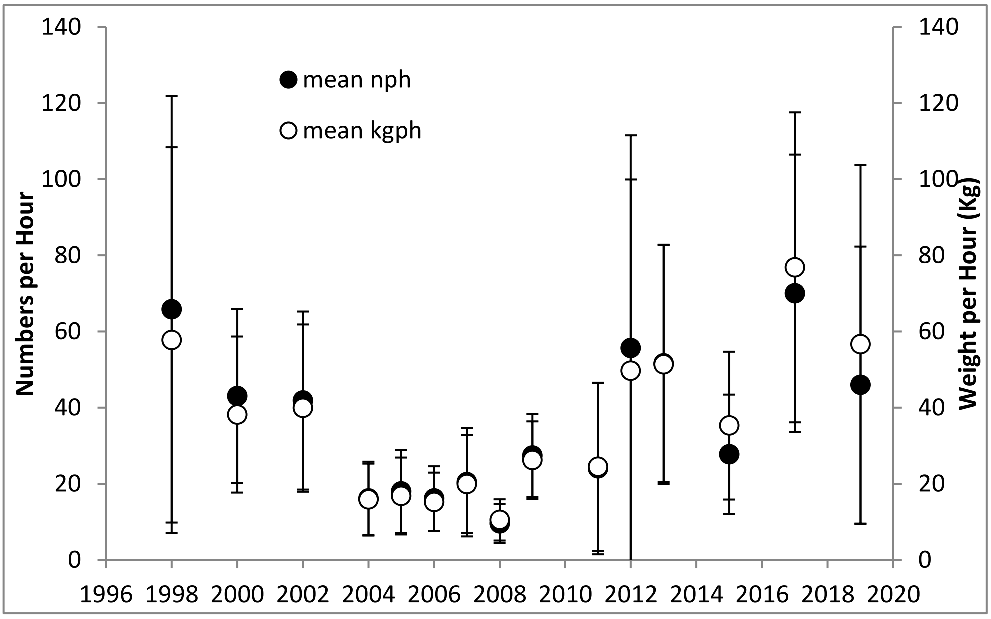


Figure 9.2.15. bsf.27.nea Northern component. Annual biomass and abundance indices of black scabbardfish estimated for depths deeper than 500 m and shallower than 1600 m, from 1998 to 2019. Seamounts/Rockall not included. (Source: Campbell, N., 2020, pers. comm.)

In ICES Division 27.5.a, the Icelandic Autumn survey biomass index series for all sizes (Total biomass) and specimens larger than 90 cm are at the higher level of the whole series are presented for the period between 2000 and 2019 (Figure 9.2.16). Black scabbardfish abundance index from

Icelandic Autumn survey shows an overall decreasing trend since 2013 however it is at higher levels than those registered at the beginning of the series (Figure 9.2.17).

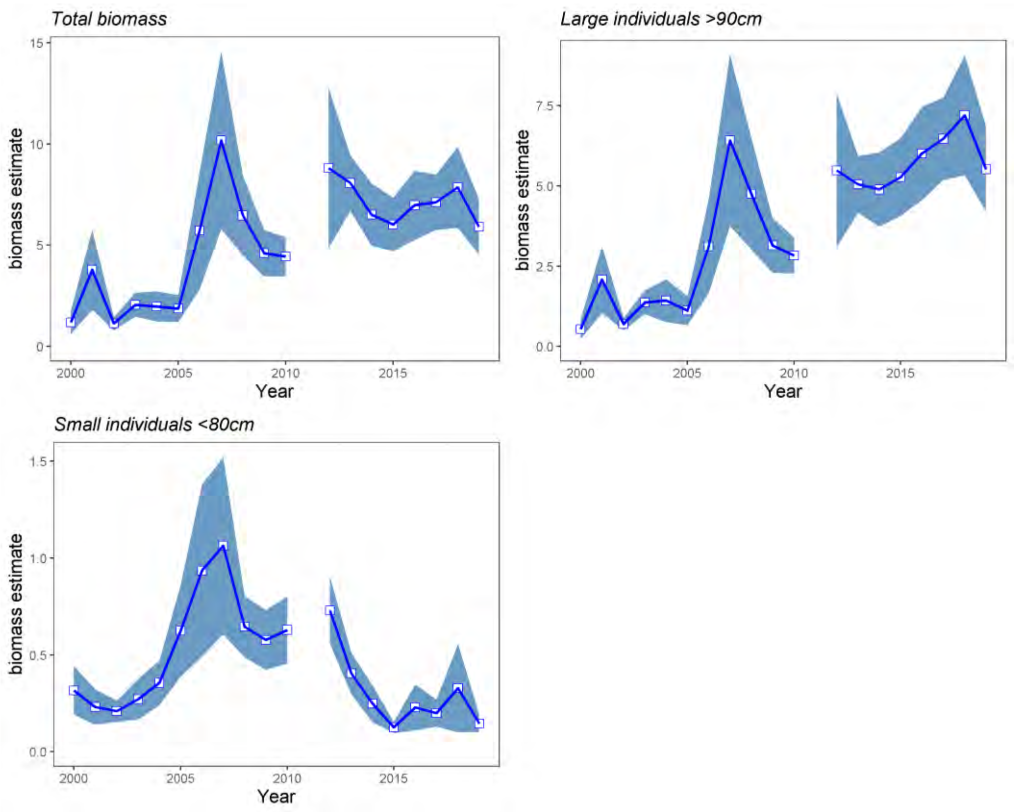


Figure 9.2.16. bsf.27.nea Northern component. Black scabbardfish biomass index with 95% confidence interval from the Icelandic Autumn survey from 2000 to 2019 for all sizes (Total biomass, upper left); specimens larger than 90 cm (Large individuals >90 cm, upper right); specimens smaller than 80 cm (Small individuals <80 cm, lower left).

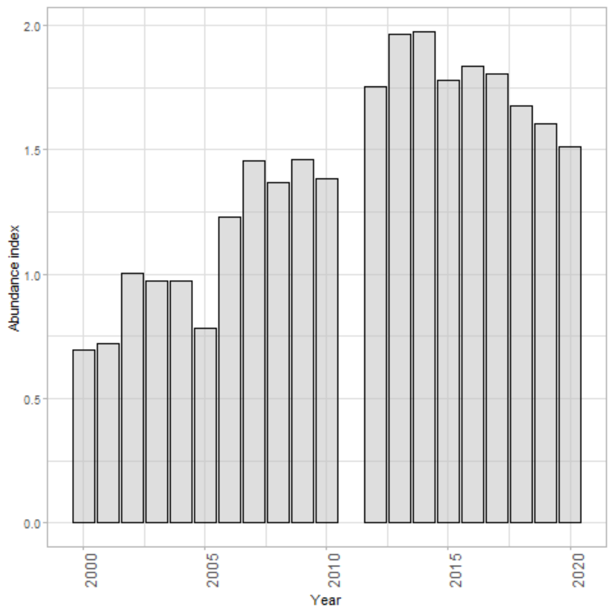


Figure 9.2.17. bsf.27.nea Northern component. Abundance of black scabbardfish from Icelandic Autumn survey from 2000 to 2020.

Regarding the Scottish survey data, the recent abundance and biomass indices are at similar levels when comparing with the beginning of the time-series (1998) and higher than in the mid-2000's, whereas for the Icelandic survey the abundance and biomass indices are at higher levels than at the beginning of the time-series (2000).

The trends in the abundance or biomass in recent years for the French fleet are different from both the Scottish and the Icelandic surveys. The lower French CPUE values in recent years reflect the spatial displacement of fishing effort to lower depths as a consequence of the bottom trawl ban for waters deeper than 800 m. In fact, based on Scottish surveys, black scabbardfish in Northern areas appear to be more frequent at depths between 800 and 1000 m.

Faroese commercial CPUE, between 2000 and 2020, calculated using fishery data from large Faroese trawlers and restricted to fishing hauls where black scabbardfish represents more than 30% of the total catch and for fishing haul with a duration larger than 2 hours is presented in Figure 9.2.18. The mean CPUE for the whole period was 250 kg/h and from 2013 to 2015 the CPUE was twice the overall mean value, about 508 kg/hour. Since 2016, the CPUE has been slightly decreasing probably related with an increased targeting of the fishery for blue ling.

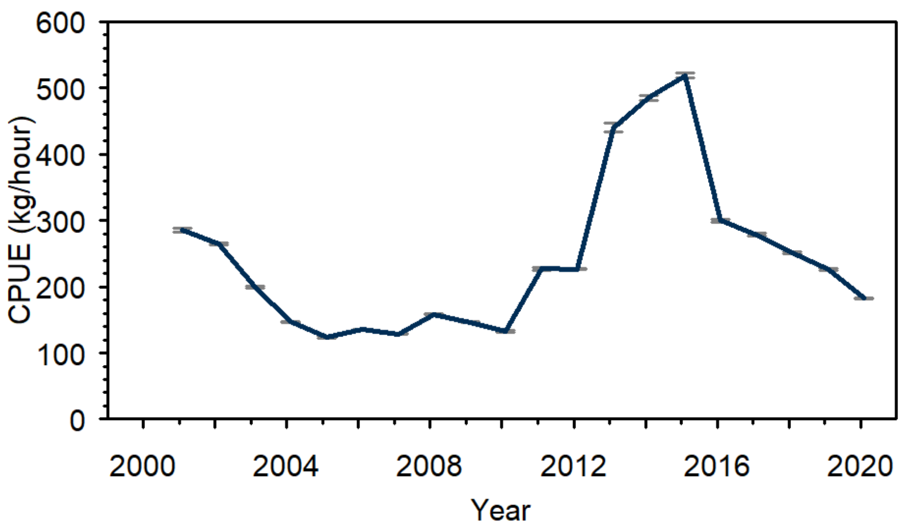


Figure 9.2.18. bsf.27.nea Northern component. Standardised CPUE (kg/hour) from Faroese commercial trawlers (> 1000 HK). Criteria: black scabbardfish >30% of total catch and effort > 2 hours per haul. (Source: Ofstad, L., 2021, pers. comm.).

9.2.6 Data analyses

For the major fishing countries exploiting the northern and southern stock components in the ICES area, the landing data are considered reliable and discards are minor. For stock assessment purposes the catches in weight are converted into numbers and aggregated by six-month time periods defined as: SEM1= months 3-8 of the year; SEM 2=month 9-12 of the year plus months 1 and 2 of the next year. Worth to remark that the adopted assessment model includes a parameter that accommodates for the uncertainty on the input catch data.

In the model, the standardised French CPUE series is adopted for the Northern component and the standardised Portuguese CPUE series is used for the Southern component.

The CPUE series and the catch weights from each component are used to derive the standardised fishing effort. Standardised fishing effort for the Northern and Southern components are calculated for each time periods, i.e., SEM1 and SEM2. These estimates are obtained by dividing the catch weight data by the corresponding standardised CPUE. Within the assessment model a full recruitment model with log-normal error linking the fishing effort estimate by SEM with the catchability coefficient is used to define the prior distribution of the parameter - survivorship to fishing.

Furthermore, the distribution of the parameter related to emigration to the Northern component (recruitment) is unknown since survey data available is insufficient to derive a prior distribution for this parameter. The Scottish survey is held every two years and at a time period out of the migration season. So, the information available does not allow inferring the index of C2 elements entering in the Northern area in SEM2 each year. Due to the lack of a reliable recruitment index, a non-informative prior distribution is adopted in the model.

As 2020 is not an assessment year for this stock, the model subsequent analyses were not performed.

MSY proxy reference points

Length-based indicators (LBIs) proposed by ICES for stocks in categories 3 and 6 were applied to the exploited population in the whole ICES area, that corresponds to the combined overall length frequency distribution of black scabbardfish from French length sampling in the Northern component (divisions 27.5.b, 27.6.a, and 27.6.b.1) and Portuguese length sampling in the Southern component (Division 27.9.a) for the period between 2014 and 2020. The length frequency distributions of 1 cm interval class were used. The life history parameters used for calculating the reference points, were L_{mat} = 103 cm (Figueiredo et al, 2003) and L_{inf} = 159 cm (Vieira et al., 2009).

The following traffic light table presents the final results from the combined length distribution of black scabbardfish in the Northern and Southern components for the period from 2014 to 2020 (Table 9.2.3).

Table 9.2.3. bsf.27.nea Northern and Southern components. LBI screening method ratios between 2014 and 2020.

	Conservation						Optimizing Yield	MSY
	L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{95\%}/L_{inf}$	L_{maxy}/L_{opt}	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref.	**> 1**	**> 1**	**> 0.8**	≈ 1	**> 0.8**	**>30%**	≈ 1 (>0.9)	≥ 1
2014	0.62	0.89	0.73	0.99	0.75	4%	0.94	1.14
2015	0.65	0.91	0.72	0.92	0.75	4%	0.94	1.12
2016	0.75	0.92	0.72	0.96	0.74	3%	0.95	1.03
2017	0.61	0.92	0.71	0.96	0.73	2%	0.95	1.16
2018	0.67	0.91	0.72	1.02	0.74	3%	0.95	1.10
2019	0.73	0.94	0.73	1.01	0.75	4%	0.97	1.07
2020	0.64	0.99	0.74	1.03	0.76	6%	1.00	1.19

The length at first catch was smaller than the length at first maturity in all years.

The MSY indicator ($L_{mean}/L_{F=M}$) was above 1 in all years, and the optimizing yield indicator (L_{mean}/L_{opt}) is close to 1 in all analysed years.

Analysis of results

LBI results show that the stock is at an adequate status as the exploitation levels are above the length-based indicator of MSY.

Most indicators of conservation state of the stock are below the desirable levels because they are based on length frequency analysis, which is shunt to lower lengths in the Northern component. These indicators are considered less informative given the available knowledge on species length-structure which are closely related to the tail of the frequency distribution. For this species, it should be possible to provide stock status by expert judgement, using indicators based on scientific knowledge on the species and the fishery.

9.2.7 Management considerations

Available information does not unequivocally support the assumption of a single stock for the whole NE Atlantic area, however most available evidences support it. In face of these evidences, catches from ICES Division 27.5.a were included in the Northern component in the assessment of the stock.

The analysis of the annual relative fishing effort by depth strata (Figure 9.2.19, in relation to total fishing effort) indicates changes on the fishing depth by the French trawlers. This change might have an impact on catchability and a deeper scrutiny on depth of the French fishing grounds by year is required to incorporate those changes in the assessment model. In recent years the fishing effort on black scabbardfish indicates that the fishing operations are mainly performed at depth strata shallower than 800m, possible as a response to the EU Regulation trawl ban (EU, 2016).

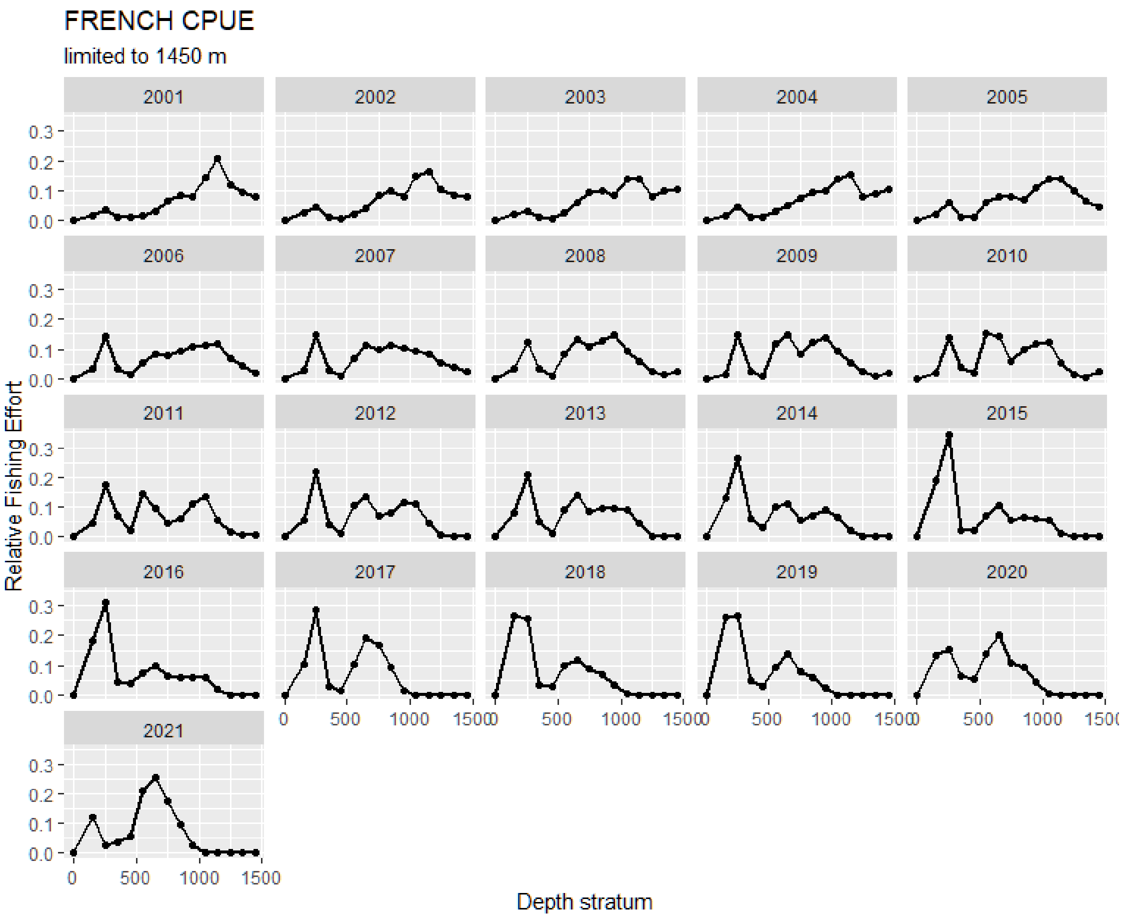


Figure 9.2.19. bsf.27.nea Northern component. French fleet annual relative fishing effort by depth strata, in relation to total fishing effort).

9.2.8 Tables

Table 9.2.4a. Landings of black scabbardfish from Division 27.5.b. Working Group estimates. E&W&NI is England, Wales and Northern Ireland.

Year	Faroes			France	Germany*		Scotland	E&W&NI	Russia**	Total
	27.5.b.1	27.5.b.2	27.5.b	27.5.b	27.5.b.1	27.5.b	27.5.b			
1988					.	.	-			
1989	-	-		170	.	.	-			**170**
1990	2	10		415	.	.	-			**427**
1991	-	1		134	-	-	-			**135**
1992	1	3		101	-	-	-			**105**
1993	202	-		75	9	-	-			**286**
1994	114	-		45		1	-			**160**
1995	164	85		175			-			**424**
1996	56	1		129			-			**186**
1997	15	3		50			-			**68**
1998	36	-		144			-			**180**
1999	13	-		135			6			**154**
2000			116	186			9			**311**
2001	122	281		457			20			**880**
2002	222	1138		304			80			**1744**
2003	222	1230		172			11			**1635**
2004	80	625		94			70			**869**
2005	65	363		106			20			**553**
2006	54	637		93						**784**
2007	78	596		116						**790**
2008	94	787	828	159						**1868**
2009	117	852		96			1			**1067**
2010	102	715		142			31			**990**
2011	67	371		115						**553**
2012	84	43		115						**242**
2013	38	379	159	160						**735**

Year	Faroes			France	Germany*		Scotland	E&W&NI	Russia**	Total
	27.5.b.1	**27.5.b.2**	**27.5.b**	**27.5.b**	**27.5.b.1**	**27.5.b**	**27.5.b**			
2014	400	181	143	0	0	0	0	0	1	**725**
2015	549	181	0	211			1			**941**
2016			712	52						**765**
2017	285	14		112			0			**412**
2018	324	229		41			-			**594**
2019	395	93		52						**540**
2020	317	102		21			0			**440**

***STATLAND data from 1988 to 2011.**

****STATLAND data.**

Table 9.2.4b. Landings of black scabbardfish from Division 27.12. Working Group estimates. E&W&NI is England, Wales and Northern Ireland.

Year	Faroes	France	Scotland	Spain	Germany*	E&W&NI	Ireland	Total
1988					.			**0**
1989		0			.			**0**
1990		0			.			**0**
1991		2			-			**2**
1992		7			-			**7**
1993	1051	24			93			**1168**
1994	779	9			45			**833**
1995	301	8						**309**
1996	187	7		41				**235**
1997	102	1		98				**201**
1998	20	324		134				**478**
1999		1	0	109				**109**
2000	1	5		237				**243**
2001		3		115				**118**
2002		0	1	1117		0		**1119**
2003		7		444			1	**452**
2004	95	10	1	230				**337**
2005	127	14		239			0	**380**

Year	Faroes	France	Scotland	Spain	Germany*	E&W&NI	Ireland	Total
2006	8	0		1009				**1017**
2007	0		0	9			0	**9**
2008	1		0	53			0	**54**
2009	156			103		0	0	**259**
2010	27	1		180		0	0	**208**
2011	24	1		113				**138**
2012				47				**47**
2013	1			50				**51**
2014				149				**149**
2015				51				**51**
2016				82				**82**
2017	0			68				**68**
2018				125				**125**
2019	0			46				**46**
2020				25				**25**

***STATLAND data from 1988 to 2011.**

Table 9.2.4b. Continued.

Year	Iceland*	Poland*	Russia**	Lithuania*	Estonia	Unallocated	Total
1988		-	.	.	.		**0**
1989		-	.	.	.		**0**
1990		-	.	.	.		**0**
1991		-	.	.	-		**0**
1992		-	.	-	-		**0**
1993		-	.	-	-		**0**
1994		-	.	-	-		**0**
1995		-	.	-			**0**
1996	0	-	.				**0**
1997							**0**
1998							**0**
1999							**0**

Year	Iceland*	Poland*	Russia**	Lithuania*	Estonia	Unallocated	Total
2000							**0**
2001							**0**
2002							**0**
2003		1		1			**2**
2004				1			**1**
2005					1		**1**
2006					2		**2**
2007					7		**7**
2008			4				**4**
2009							**0**
2010							**0**
2011							**0**
2012						907	**907**
2013						289	**289**
2014							**0**
2015							**0**
2016							**0**
2017							**0**
2018							**0**
2019							**0**
2020							**0**

***STATLAND data from 1988 to 2011.**

****STATLAND data.**

Table 9.2.4c. Landings of black scabbardfish from Subarea 27.6. Working group estimates.

Year	France			Faroes		Ireland	Scotland		Spain		Total
	27.6	27.6.a	27.6.b	27.6.a	27	27.6.a	27.6.a	27.6.b	27.6.a	27.6.b	
1988											**0**
1989		138	0	46			-	-			**184**
1990		971	53				-	-			**1023**
1991		2244	62				-	-			**2307**

Year	France			Faroes		Ireland	Scotland		Spain		Total
	27.6	27.6.a	27.6.b	27.6.a	27	27.6.a	27.6.a	27.6.b	27.6.a	27.6.b	
1992		2998	113	3			-	-			**3113**
1993		2857	87		62		-	-			**3006**
1994		2331	55				2	-			**2403**
1995		2598	15				14	4			**2634**
1996		2980	1				36	<0.5			**3019**
1997		2278	16		3		147	88			**2533**
1998		1553	7				142	6			**1708**
1999		1610	8				133	58			**1809**
2000		2971	27				333	41			**3371**
2001		3791	29		3		486	145			**4454**
2002		3833	156	2			603	300			**4894**
2003		2934	67	45			78	9			**3132**
2004		2637	99	59			100	24			**2919**
2005	3	2533	59	38			18	62			**2714**
2006	-	1713	36	59		1	63	0			**1872**
2007	-	1991	4	44	37	0	53	0			**2129**
2008	-	2348	0	37	0	0	26	0			**2412**
2009	15	1609	1	39	0	0	80	0			**1744**
2010	-	1778	1	72		0	73	0			**1923**
2011	5	1791	3	31			1	0			**1830**
2012	-	1509	0	3			34	0			**1546**
2013		1799	9	6			57				**1871**
2014	0	1902	0	4	2		110				**2018**
2015		1870		1			124		10	172	**2176**
2016		2336					96		9	163	**2604**
2017		1714		64			101		3	153	**2035**
2018		1601		-	-		65	0	0	124	**1791**
2019		1124					45		1	52	**1222**
2020	0	769	0	0	0	0	20	0	0	57	**846**

Table 9.2.4c. Continued.

Year	Germany*		Netherlands **			Lithuania**	Estonia**	Poland**	Russia**	Unallocated	Total
	27.6.a	27.6.b	27.6.a	27.6.b	27.6	27.6.a	27.6.b	27.6.b	27.6.b		
1988	.	.	-	-		.	.		.		**0**
1989	.	.	-	-		.	.	-	.		**0**
1990	.	.	-	-		.	.	-	.		**0**
1991	-	-	-	-		.	-	-	-		**0**
1992	-	-	-	-		-	-	-	-		**0**
1993	48	-	-	-		-	-	-	-		**48**
1994	30	15	-	-		-	-	-	-		**30**
1995	-	3	-	-		-	-	-	-		**0**
1996	-	2	-	-		-	-	-	-		**0**
1997			-	-		-	-	-	-		**0**
1998			-	-		-	-	-	-		**0**
1999			11	-		-	-	-	-		**11**
2000			7	-		-	-	-	-		**7**
2001			-	-		3	225	-	226		**454**
2002			21	2		9		2			**34**
2003				2		12	7	2	7		**30**
2004						85	5		5		**95**
2005						5	11		11		**27**
2006						1	3		3		**7**
2007											**0**
2008			14						1		**15**
2009											**0**
2010											**0**
2011											**0**
2012										690	**690**
2013										189	**189**
2014	0		3	0		0	0	0	0	0	**3**
2015					5						**5**

Year	Germany*		Netherlands **			Lithuania**	Estonia**	Poland**	Russia**	Unallocated	Total
	27.6.a	27.6.b	27.6.a	27.6.b	27.6	27.6.a	27.6.b	27.6.b	27.6.b		
2016					1						**1**
2017					0						**0**
2018											**0**
2019											**0**
2020											**0**

***STATLAND data from 1988 to 2011.**

****STATLAND data.**

Table 9.2.4d. Landings of black scabbardfish from Division 27.7. Working group estimates. E&W&NI is England, Wales and Northern Ireland.

Year	France								Ireland			Scotland	E&W&NI	Spain	Total
	7	7.a	7.b	7.c	7.d-g	7.h	7.j	7.k	7.b,j	7.c	7.k	7.b,c,j,e,k	7.j,k	7	
1988															
1989		0	-	-	-		-	-				-			**0**
1990		0	2	8	0		0	-				-			**10**
1991		0	14	17	7		7	49				-			**94**
1992		0	9	69	11		49	183				-			**322**
1993		0	24	149	16		170	109				-			**468**
1994		0	32	165	8		120	336				-			**662**
1995		0	52	121	9		74	385				-			**641**
1996		0	104	130	2		60	360				-			**658**
1997		0	24	200	1		33	202				-		1	**462**
1998		0	15	104	6		52	211				-		2	**390**
1999	-	-	7	97	0	2	70	177				-		0	**355**
2000	-	-	25	173	1	4	100	253				3		0	**559**
2001	-	-	40	237	0	3	180	267				41		0	**768**
2002	-	0	33	105	2	7	138	49				53			**386**
2003	-	-	15	29	1	3	159	36				1			**245**
2004	-	-	31	28	8	9	115	63				0			**253**
2005	0	5	6	11	1	17	105	23				-			**169**
2006	-	-	3	10	1	24	315	20	1	32	37	0	2		**445**

Year	France								Ireland			Scotland	E&W&NI	Spain	Total
	7	7.a	7.b	7.c	7.d-g	7.h	7.j	7.k	7.b,j	7.c	7.k	7.b,c,j,e,k	7.j,k	7	
2007	-	-	2	7	0	4	168	7	0	52	17	-	-		**257**
2008	-	-	2	19	0	6	148	4	-	-	-	0	-		**179**
2009	-	-	-	29	1	2	53	4	-	-	-	-	-		**90**
2010	-	-	2	40	0	2	36	-	-	-	-	-	-		**81**
2011	-	-	0	81	0	2	129	-	-	-	-	-	-		**212**
2012	-	-	13	36	2	9	63	6	-	-	-	-	-	31	**160**
2013		0	21	86	1	12	67	1	-	-	-	-	-	9	**196**
2014		0	14	79	0	9	50	0	-	-	-	.	.		**153**
2015			26	39	1	3	48		-	-	-			1	**118**
2016			6	0	52	3	30	0	-	-	-			1	**92**
2017			1	0	4	1	9	0	-	-	-	0		0	**15**
2018			0	0	0	6	29	0		0				0	**35**
2019			0	0	0	6	15	0		0				10	**30**
2020			1	0	0	16	15	0		0				5	**37**

Table 9.2.4e. Landings of black scabbardfish from Divisions 27.6 and 27.7. Working Group estimates. **E&W&NI is England, Wales and Northern Ireland.**

Year	Ireland	E&W&NI	Total
1988			
1989			**0**
1990			**0**
1991			**0**
1992			**0**
1993	8		**8**
1994	3		**3**
1995			**0**
1996		1	**1**
1997	0	2	**2**
1998	0	1	**1**
1999	1	1	**2**

Year	Ireland	E&W&NI	Total
2000	59	40	**99**
2001	68	37	**105**
2002	1050	43	**1093**
2003	159	5	**164**
2004	293	2	**295**
2005	79	-	**79**
2006	-	-	**0**
2007	-	-	**0**
2008	-	-	**0**
2009	-	-	**0**
2010	-	-	**0**
2011	-	-	**0**
2012	-	-	**0**
2013	-	-	**0**
2014	-	-	**0**
2015	-	-	**0**
2016	-	-	**0**
2017	-	-	**0**
2018		0	**0**
2019			**0**
2020	0	0	**0**

Table 9.2.4f. Landings of black scabbardfish from Subarea 27.5.a. Working group estimates of landings.

Year	Iceland	Faroes	Total
1988	-		**0**
1989	-		**0**
1990	-		**0**
1991	-		**0**
1992	-		**0**
1993	0		**0**

Year	Iceland	Faroes	Total
1994	0		**0**
1995	0		**0**
1996	0		**0**
1997	1		**1**
1998	0		**0**
1999	6		**6**
2000	10		**10**
2001	5		**5**
2002	13		**13**
2003	14		**14**
2004	19		**19**
2005	19		**19**
2006	23		**23**
2007	1		**1**
2008	0		**0**
2009	15		**15**
2010	109		**109**
2011	172		**172**
2012	365		**365**
2013	325	0	**325**
2014	360	-	**360**
2015	265	0	**265**
2016	346		**346**
2017	294		**294**
2018	142		**142**
2019	65		**65**
2020	102		**102**

9.3 Black scabbardfish (*Aphanopus carbo*) in subareas 27.8 and 27.9

9.3.1 The fishery

The main fishery taking place in these subareas is derived from Portuguese longliners. This fishery was described in 2007 WGDEEP report (Bordalo-Machado and Figueiredo, 2007 WD) and updated later by Bordalo-Machado and Figueiredo (2009).

The French bottom trawlers operating mainly in Subareas 6 and 7 have a small marginal fishing activity in Subarea 27.8. In 2014 and 2015, Spain has also reported catches of black scabbardfish in Subareas 27.8 and 27.9 but these are also relatively low.

9.3.2 Landings trends

Landings in subareas 27.8 and 27.9 are mostly from the Portuguese longline fishery that takes place in Division 27.9.a, which represents more than 96% of the total landings (Figure 9.3.1).

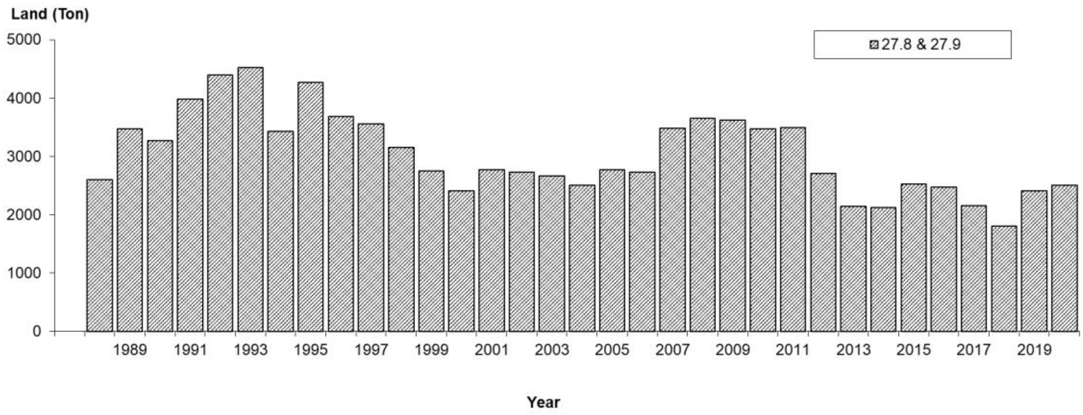


Figure 9.3.1. bsf.27.nea Southern component. Annual landings for ICES Subarea 27.8 and Division 27.9.a.

9.3.3 ICES Advice

The latest ICES advice, in 2020, was: "*ICES advises that when the precautionary approach is applied, catches should be no more than 4506 tonnes in each of the years 2021 and 2022.*

Distributed by area, this corresponds to annual catches of no more than 2143 tonnes in subareas 6 and 7 and divisions 5.b and 12.b, annual catches of no more than 2084 tonnes in Subarea 8 and Division 9.a, and annual catches of no more than 280 tonnes in subareas 1, 2, 4, and 10 and divisions 3.a and 5.a."

9.3.4 Management

Since 2003, management of black scabbardfish by EU vessels fishing in EU and international waters includes a combination of TAC and licensing system. The TAC adopted from 2006 until 2020, as well as the total landings in subareas 27.8, 27.9, and 27.10 are presented in Table 9.3.1.

Table 9.3.1. Black scabbardfish TACs and total landings of EU vessels in subareas 27.8, 27.9, and 27.10 from 2006 to 2020.

Year	EU TAC 27.8,27.9,27.10	EU Landings in 27.8 and 27.9	EU Landings in 27.10*
2006	3042	2726	65
2007	4000	3481	0
2008	4000	3647	75
2009	3600	3620	162
2010	3348	3470	102
2011	3348	3494	164
2012	3348	2711	462
2013	3700	2140	206
2014	3700	2118	30
2015	3700	2532	240
2016	3700	2476	86
2017	3330	2151	70
2018	2997	1801	14
2019	2832	2409	0
2020	2832	2509	0
2021	2266		

*** The proportion of *A. intermedius* in the catches is considered high but is not quantified.**

9.3.5 Data available

9.3.5.1 Landings and discards

New information on the discards of deep-water species produced by the Portuguese on-board sampling programme (EU DCR/NP) was presented (Fernandes, 2021, WD).

Discards of most species carried out by Portuguese vessels operating deep-water set longlines (targeting black scabbardfish) within the Portuguese part of ICES Division 27.9.a were not quantified at fleet level. The black scabbardfish discards are mainly due to shark and cetacean predation on hooked specimens and are relatively low when compared to catches.

The low frequency of occurrence of discarding and the low number of discarded specimens registered in the sampled hauls and sets lead to assume that discards in the Southern component are negligible.

9.3.5.2 Length compositions

Length–frequency distributions of the black scabbardfish landed at the main landing port for the species in ICES Division 27.9.a (Sesimbra port) by the Portuguese longline fleet derived from the DCF/EU landing sampling program from 2014 to 2020 are presented in Figure 9.3.2.

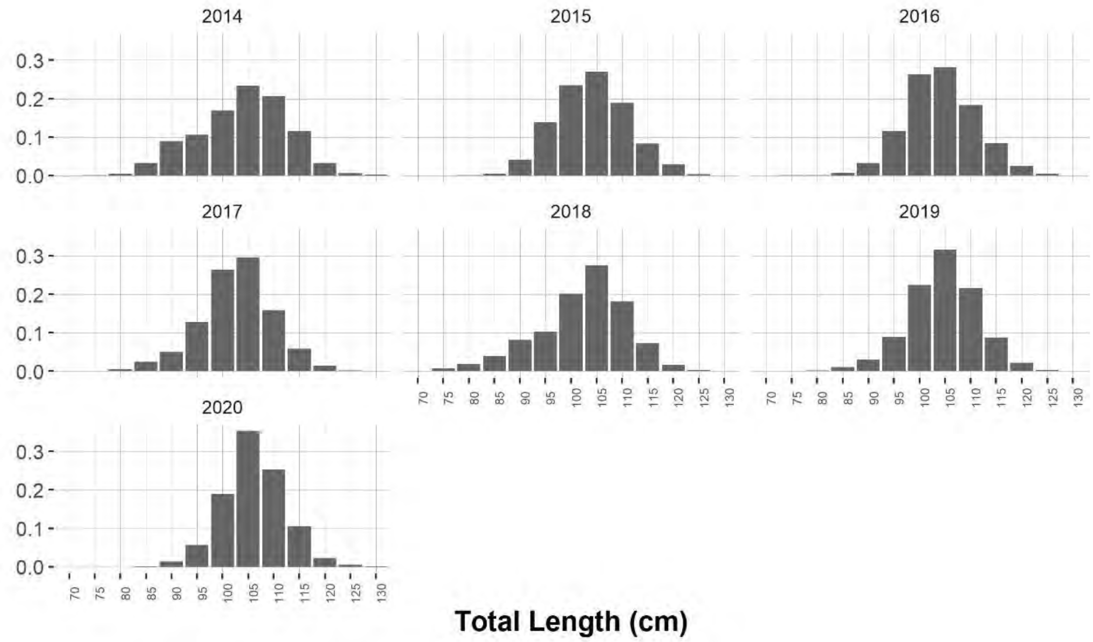


Figure 9.3.2. bsf.27.nea Southern component. Length–frequency distribution of black scabbardfish exploited by the deep-water longline fishery for ICES Division 27.9.a, from 2014 to 2020.

In the last assessment, in 2020, length–frequency distributions of the black scabbardfish from 2001 to 2019 were used, to separate the Southern component into the two length groups (TL (total length): 70 cm < C2 < 103 cm; C3: TL > 103 cm) defined by the assessment approach adopted by WKDEEP 2014.

Table 9.3.1. bsf.27.nea Southern component. Total catch estimates (in ton), and total catch estimates (in number) in length groups C2 and C3 by six-month time period (Sem 1 and Sem 2) for the years 2001 to 2019.

	Catch (in ton)		Catch (in number) C2		Catch (in number) C3	
Year	Sem 1	Sem 2	Sem 1	Sem 2	Sem 1	Sem 2
2001	1025	1162	166255	224512	454294	494926
2002	994	1205	242627	281845	394790	486076
2003	1001	1038	246200	326925	391912	369658
2004	939	1087	319954	289114	326133	421767
2005	1001	1068	173811	191031	441320	470265
2006	970	1229	154077	200083	447828	561937
2007	1162	1713	258842	348131	512897	808791
2008	1392	1335	252886	248574	617378	582175
2009	1390	1346	225098	183532	633817	627814
2010	1464	1287	126636	353994	720474	501186
2011	1257	1808	299508	395972	520973	768757
2012	1188	1245	273648	374823	470397	454947
2013	1011	1079	266160	307426	393448	402958
2014	1233	970	184774	170893	566277	434309
2015	1188	1408	269689	234314	498482	716949
2016	1265	1219	276593	184425	557797	347314
2017	1067	1027	260837	291527	461092	420569
2018	797	1056	170683	185786	361261	514079
2019*	1163		222580		635079	

* incomplete SEM 2 since January and February 2020 were not available

9.3.5.3 Age compositions

The black scabbardfish population is not structured by ages because the approach followed to assess the stock is a stage-based model. The age growth parameters are used to construct the prior distribution for the probability a specimen transits from C2 to C3 length group during one semester taking into account the length structure of the population inhabiting the Southern area (for further details see the Stock Annex).

9.3.5.4 Weight-at-age

No new information on age was presented.

9.3.5.5 Maturity and natural mortality

In ICES Division 27.9.a, only immature and early developing specimens have been observed (Figueiredo, 2009, WGDEEP WD; Neves *et al.*, 2009). Mature individuals have only been reported in Madeira (Figueiredo *et al.*, 2003), Canary Islands (Pajuelo *et al.*, 2008), and the Northwestern coast of Africa (Perera, 2008). In those areas, spawners of two congener species (*Aphanopus carbo* and *A. intermedius*) coexist (Stefanni and Knutsen, 2007; Biscoito *et al.*, 2011; Besugo *et al.*, 2014, WD).

Black scabbardfish has a determinate fecundity strategy; the relative fecundity estimates ranged from 73 to 373 oocytes/female weight (g). Skipped spawning was also considered to occur; the percentages of non-reproductive females between 21% and 37% (Neves *et al.*, 2009).

9.3.5.6 Catch, effort and research vessel data

Standardised Portuguese CPUE series covering the period 1998-2019 are presented by a six-month time period, as: SEM1=months 3-8 of the year; SEM2=month 9-12 of the year plus months 1 and 2 of the following year (Figure 9.3.3). Estimates of CPUE were obtained through the adjustment of a GLM model, in which monthly CPUE is the response variable and Year, Month, and Vessel are the factors. The monthly CPUE was calculated for each vessel as the ratio of the total landed weight (Kg) and the number of fishing trips. Only vessels having total annual landings ≥ 1000 Kg and more than one year of landings were considered.

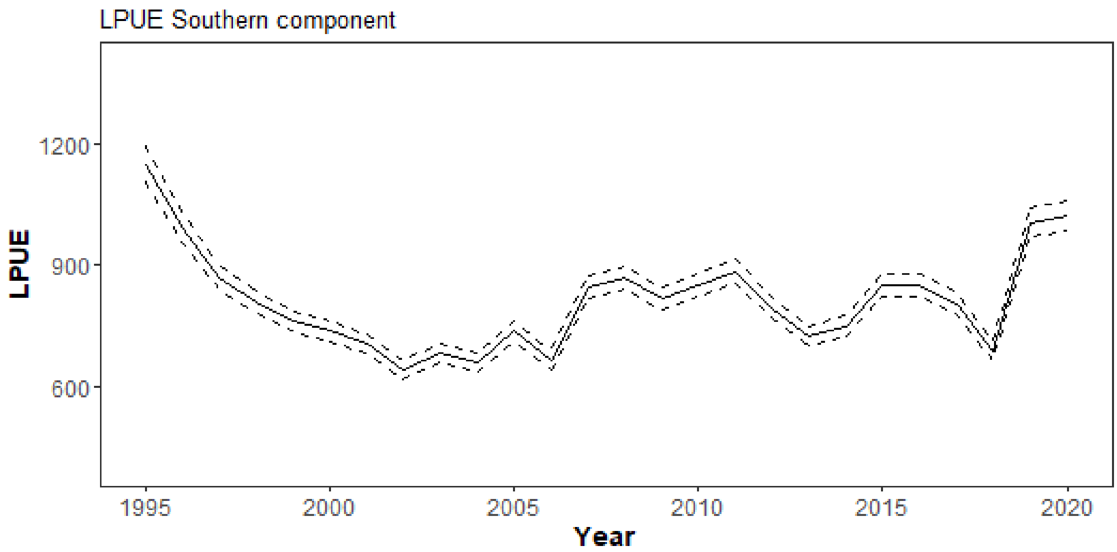


Figure 9.3.3. bsf.27.nea Southern component. Standardised Portuguese CPUE.

For the period 2006 to 2019, the monotonic trend in the standardised fishing effort time series for the Southern component was tested using the Kendall rank correlation. The time series plot with LOWESS smooth indicates a downward trend (Figure 9.3.4) and the autocorrelation in this data is not significant (Figure 9.3.5). The Mann-Kendall trend test (tau = -0.391; 2-sided p-value = 0.0054823) confirms the downward trend in fishing effort for the Southern component.

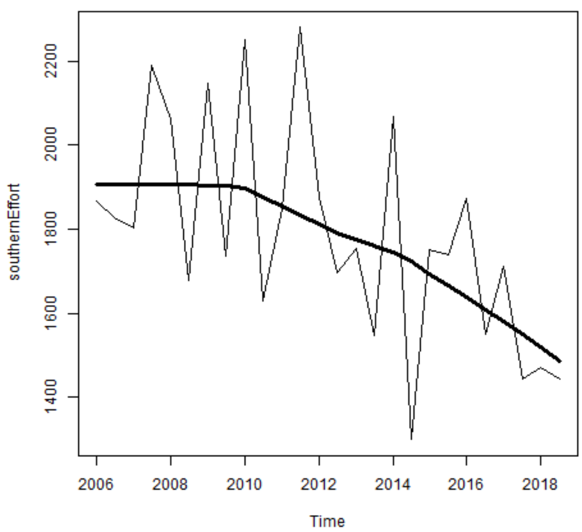


Figure 9.3.4. bsf.27.nea Southern component. Standardised effort by new semesters, i.e., SEM1= months 3-8 of the year and SEM2=month 9-12 of the year, plus months 1 and 2 of the next year.

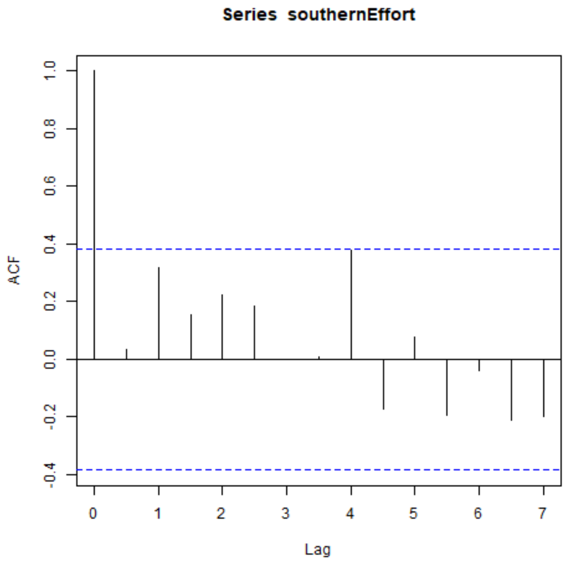


Figure 9.3.5. bsf.27.nea Southern component. Standardised fishing effort time series autocorrelation.

9.3.6 Data analyses

Data analyses are described in section 9.2.5. One single assessment is admitted for the stock, which combines data from the two fisheries areas: subareas 27.5, 27.6 and 27.7 and Division 27.12.b; and divisions 27.8 and 27.9 on the other hand.

9.3.7 Management considerations

Management considerations are described in section 9.2.6.

9.3.8 Tables

Table 9.3.2a. Black scabbardfish from Subarea 27.9. Working Group estimates of landings.

Year	Portugal	France	Spain	Total
1988	2602			**2602**
1989	3473			**3473**
1990	3274			**3274**
1991	3978			**3978**
1992	4389			**4389**
1993	4513			**4513**
1994	3429			**3429**
1995	4272			**4272**
1996	3686			**3686**
1997	3553		0	**3553**

Year	Portugal	France	Spain	Total
1998	3147		0	**3147**
1999	2741		0	**2741**
2000	2371		0	**2371**
2001	2744		0	**2744**
2002	2692			**2692**
2003	2630	0		**2630**
2004	2463			**2463**
2005	2746			**2746**
2006	2674			**2674**
2007	3453			**3453**
2008	3602			**3602**
2009	3601			**3601**
2010	3453		0	**3453**
2011	3476			**3476**
2012	2668		12	**2680**
2013	2130			**2130**
2014	2109			**2109**
2015	2527		0	**2527**
2016	2456		0	**2456**
2017	2117		0	**2117**
2018	1727		0	**1727**
2019	2302			**2302**
2020	2369	0	0	**2370**

Table 9.3.2b. Black scabbardfish from Subarea 27.8. Working group estimates of landings.

Year	France						Spain					Total
	8	8.a	8.b	8.c	8.d	8.e	8.a	8.b	8.c	8.d.2	8	
1988												**0**
1989												**0**
1990					0							**0**

Year	France						Spain					Total
	8	8.a	8.b	8.c	8.d	8.e	8.a	8.b	8.c	8.d.2	8	
1991		1			0							**1**
1992		4			4							**9**
1993		5			7							**11**
1994		3			2							**5**
1995		0										**0**
1996		0			0						3	**3**
1997		1			0						1	**2**
1998		2			0						3	**6**
1999		7			4						0	**12**
2000		15	0		20	0					1	**36**
2001		16	0		12	0					1	**29**
2002		17	2		16						1	**36**
2003		25			8						1	**34**
2004	0	25	0		14						1	**40**
2005		19	0		6						1	**26**
2006		30	2	0	19						0	**52**
2007		14	1		13						1	**29**
2008		10	0		35						1	**45**
2009		15	1	0	3						1	**19**
2010	0	13	1	0	3							**17**
2011		4	0	0	14							**18**
2012		10	0		3						18	**32**
2013		5	0	0	2						3	**10**
2014		7	0	0	3							**9**
2015		5	0								0	**5**
2016		2	0		1						16	**19**
2017		2	0		0						32	**35**
2018		4	2	0	4		34	12	1	18		**74**

Year	France						Spain					Total
	8	**8.a**	**8.b**	**8.c**	**8.d**	**8.e**	**8.a**	**8.b**	**8.c**	**8.d.2**	**8**	
2019		12	5		8		45	15	0	22		**108**
2020		19	5	0	14	0	55	23	1	20	0	**139**

9.4 Black scabbardfish (*Aphanopus carbo*) in other areas (27.1, 27.2, 27.3.a, 27.4, 27.10, and 27.14)

9.4.1 The fishery

This assessment unit is made up of diverse areas. In some of these areas, fisheries have occurred sporadically or at extremely low levels, such as in subareas 27.1–4. Those levels may just indicate that the species has a low occurrence in those areas. On the contrary, landings from other areas, particularly in Subarea 27.10, indicate that the level of abundance of the species appears to be significant.

To guarantee the consistency of the underlying assumption of a unique stock in NE Atlantic and since there are no evidences against this assumption, WGDEEP 2016 agreed to include ICES Division 27.5.a in the Northern component (ICES, 2016). Consequently, landings information from ICES Division 27.5.a, which was formerly included in the present section, has been moved to section 9.2 of this Report.

No further information is available on the Faroese exploratory trawl fishery that was taking place in the Mid-Atlantic Ridge area, starting from 2008.

9.4.2 Landings trends

In ICES Subarea 27.10 landings have been variable but in for the period 2012-2016 landings increased, decreasing to less than 100 kg in 2020. The 111 tonnes reported in 2010 in ICES Subarea 27.14 are considered as misreporting.

9.4.3 ICES Advice

The latest ICES advice, in 2020, was: "*ICES advises that when the precautionary approach is applied, catches should be no more than 4506 tonnes in each of the years 2021 and 2022.*

Distributed by area, this corresponds to annual catches of no more than 2143 tonnes in subareas 6 and 7 and divisions 5.b and 12.b, annual catches of no more than 2084 tonnes in Subarea 8 and Division 9.a, and annual catches of no more than 280 tonnes in subareas 1, 2, 4, and 10 and divisions 3.a and 5.a."

9.4.4 Management

Since 2003, management of black scabbardfish by EU vessels fishing in EU and international waters includes a combination of TAC and licensing system. The TAC adopted from 2007 to 2020 by subarea are presented in Table 9.4.1.

In 2010, between 2012 and 2014, and in 2016, the TACs have been exceeded, particularly in 2010. More information is needed to track the situation.

Table 9.4.1. Black scabbardfish TACs in subareas 27.1, 27.2, 27.3, and 27.4 and total landings of EU vessels in subareas 27.2, 27.3, 27.4, and 27.14 and Division 27.5a, from 2007 to 2020.

YEAR	EU TAC 27.1, 27.2, 27.3, and 27.4	EU Landings 27.2, 27.3, 27.4, and 27.14
2007	15	1
2008	15	0
2009	12	5
2010	12	127
2011	12	1
2012	9	39
2013	9	51
2014	9	10
2015	9	2
2016	9	10
2017	9	0
2018	9	1
2019	-	1
2020	-	4

*** TACs and landings for subarea 27.10 are included in Table 9.3.1.**

9.4.5 Data available

9.4.5.1 Landings and discards

Landings are given in Tables 9.4.2a–e and in Figure 9.4.1. In subareas 27.2, 27.4, and 27.14 reported landings are considered to be misreported, although it is not known to what extent.

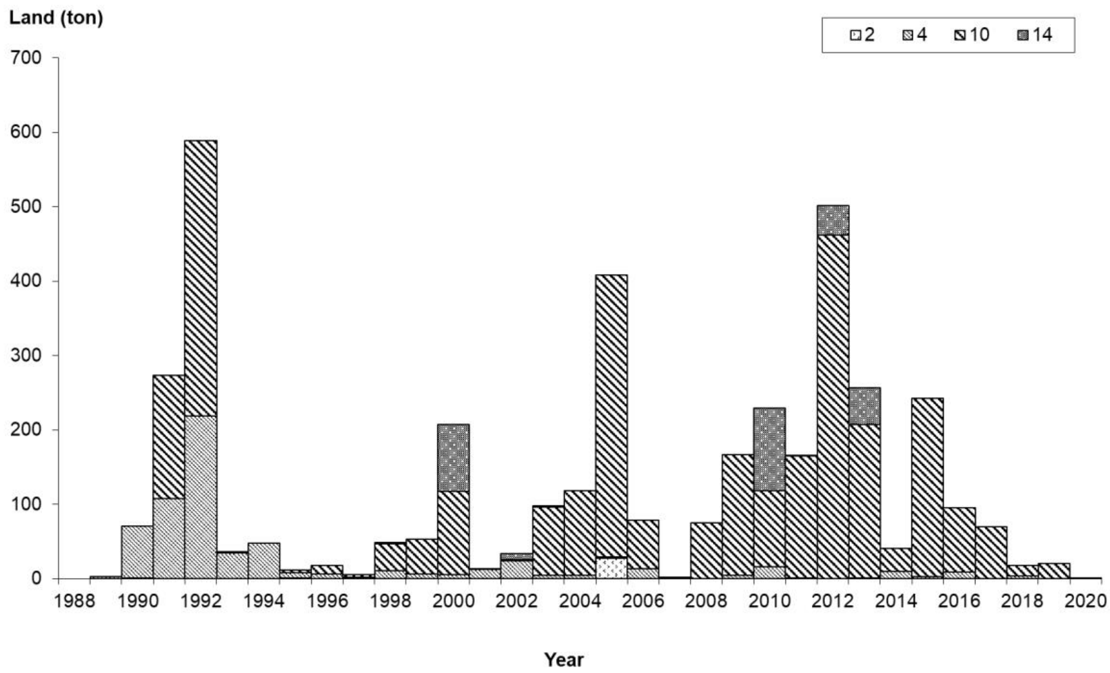


Figure 9.4.1. Annual landings for black scabbardfish in ICES subareas 27.2, 27.4, 27.10, and 27.14, between 1988 and 2020.

Greenland catches of black scabbardfish have been null in years between 1998 and 2020 except 2010 and 2011 (Nielsen, 2020 WD). For these two later years, 100 and 300 kg were reported from trawl bycatch, both in September (Figure 9.4.2).

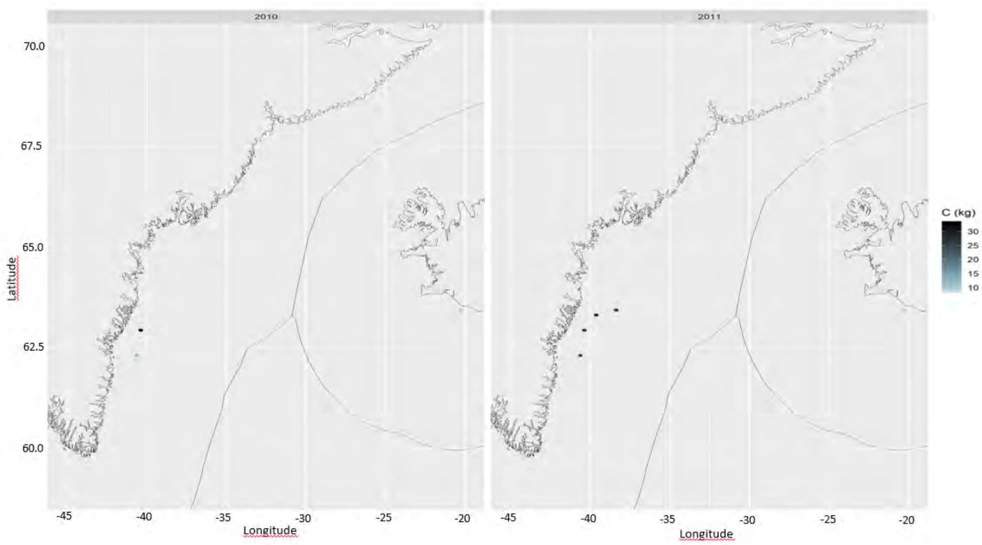


Figure 9.4.2. bsf.27.nea Black scabbardfish in 14. Distribution of commercial catches of black scabbard fish (in Kg) in East Greenland from 2010 and 2011. (Source: Nielsen *et al.*, 2019b WD)

9.4.5.2 Length compositions

No new information has been reported, except for ICES Division 27.5.a, which was included in the Northern component Section 9.2.4.3.

9.4.5.3 Age compositions

No data were available.

9.4.5.4 Weight-at-age

No data were available.

9.4.5.5 Maturity and natural mortality

No new data were available.

9.4.5.6 Catch, effort and research vessel data

In ICES Division 27.14.b, catches of black scabbard fish have been zero all years except 2010 and 2011 when 100 and 300 kg were reported from trawl bycatch from the fishery for Greenland halibut (*Reinhardtius hippoglossoides*) (Nielsen, 2021 WD).

From 1998 to 2016, the Greenland Institute of Natural Resources conducted stratified bottom trawl surveys in East Greenland (ICES Subarea 27.14.b). The survey is held onboard R/V Pâmiut. The depth of surveyed area ranged from 400 to 1500 m (Nielsen *et al.*, 2019a WD).

Until 2008, the survey took place in June but for almost all years it was affected by the ice covering the east coast of Greenland during early summer. From 2008 onwards, surveys have been held in August/September and the ice problems were eliminated. The 2008 survey was combined with a new shrimp/fish survey that uses a different trawl gear and operates at more shallow waters than the Greenland halibut survey. The combination of the two surveys led to a change in trawling hours so that most of the stations since 2008 were taken during night-time. Details on the survey namely information on survey design, vessel and trawling gear and handling of the catch see NWWG working document for Greenland halibut (Christensen & Hedeholm, 2016).

Black scabbardfish was rarely caught in the survey; the species did not occur in 1998, 1999, 2000, 2002, 2003, 2006, and 2016 surveys. In 2013 and 2015, the species was caught in one station out of an average number of 78 stations, whereas it was found in 4-6 stations in 2011, 2012 and 2014. For these years, catches ranged from 0.7 kg to 21.7 kg. In 2015, the species was only registered in Q5 at depths between 801-1200 m, where most of the biomass has also been observed in previous years (Figure 9.4.3)

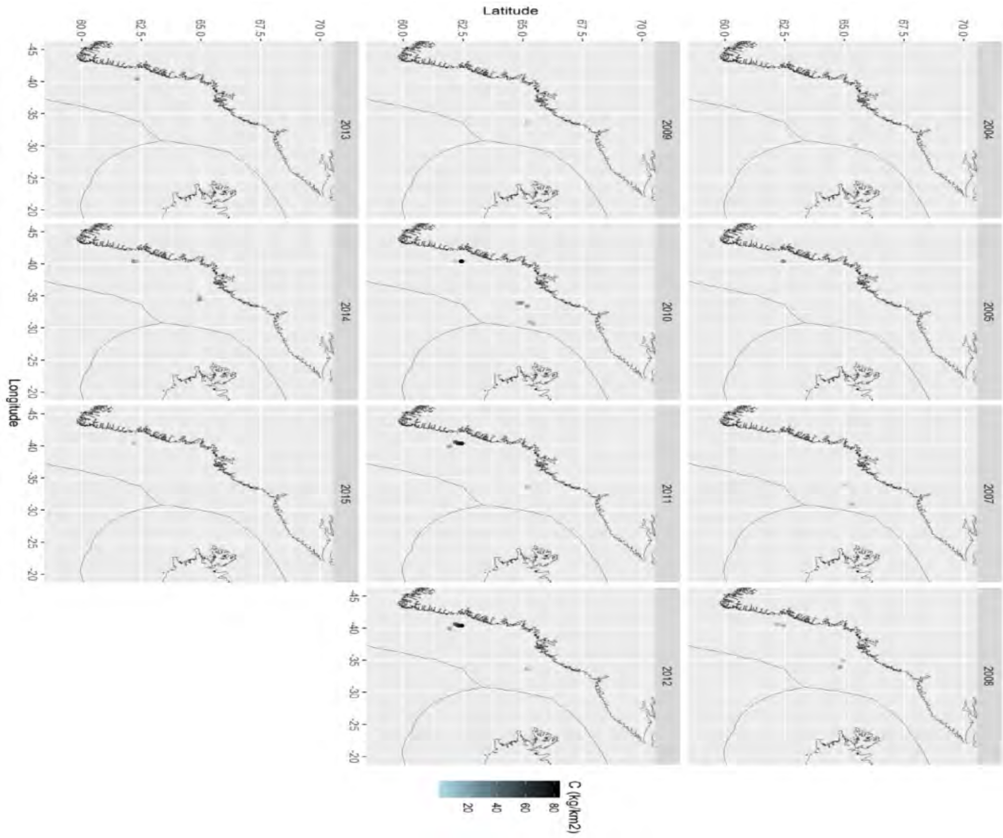


Figure 9.4.3. bsf.27.nea Black scabbardfish in Subarea 27.14. Distribution of survey catches of black scabbard fish at East Greenland (ICES Division 27.14.b) in 1998-2016. No survey in 2001, 2017, and 2018. (Source: Nielsen *et al.*, 2019a WD)

In 2008 and 2010-2012, the estimated biomass varied between 32.8 t and 56.4 t, whereas in all the other years the biomass was less than 7.9 t. This is most likely because black scabbardfish is benthopelagic and deep living, hence it is not fully fished by the fishing gear (bottom trawl). Hence the biomass estimates are considered not to reflect the actual biomasses in the surveyed area. The length frequency distributions based on 2011 and 2012 surveys show a wide mode between 70 cm and 110 cm (Figure 9.4.4).

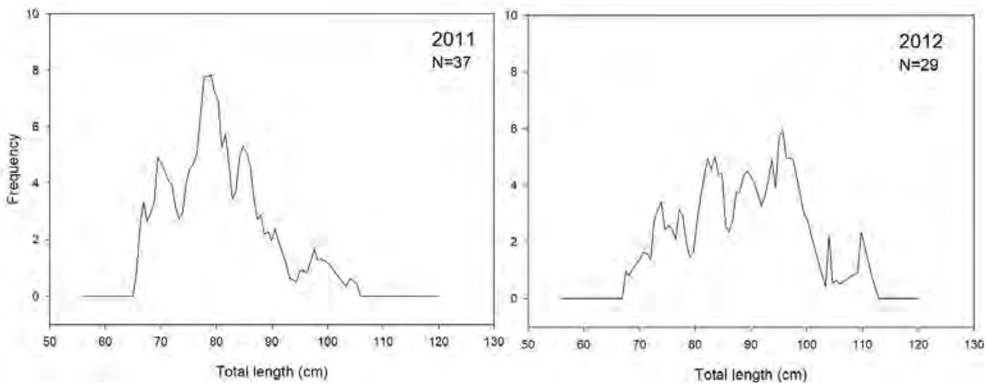


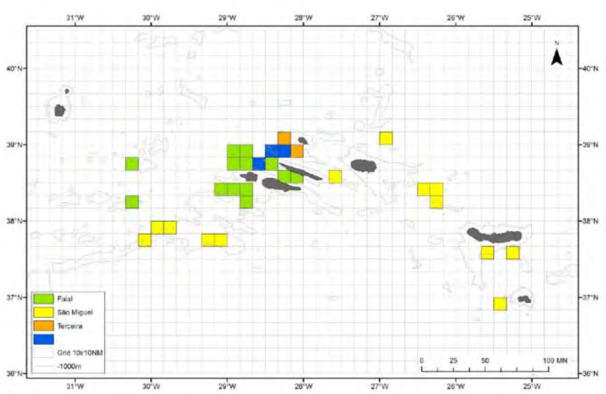
Figure 9.4.4 bsf.27.nea Black scabbardfish in Subarea 27.14. Length distribution of black scabbardfish at East Greenland (ICES Division 27.14.b) for 2011 and 2012. Survey years with n<20 are not shown. No survey in 2001, 2017 and 2018. (Source: Nielsen *et al.*, 2019a WD)

9.4.6 Data analyses

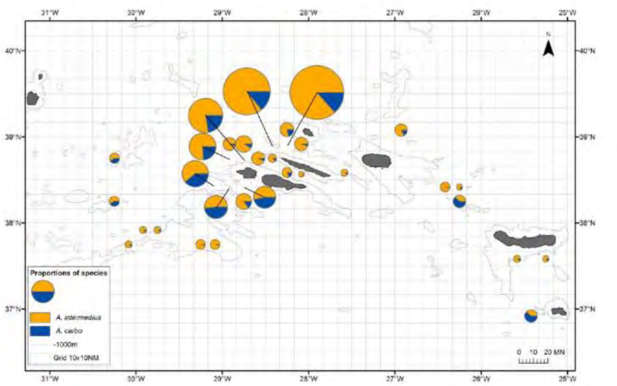
In Subarea 27.10, the commercial interest for the exploitation of black scabbardfish has varied over time, but apart from the data presented from the Faroese exploratory survey in 2008, the data available are only landings.

Results from the Azores (MARPROF project, unpublished data), based on counting of the vertebrae indicate that two species of *Aphanopus* coexist in ICES Division 27.10.a, *A.carbo* and *A. intermedius* (Besugo *et al.*, 2014 WD).

The spatial distribution of the proportion of co-occurrence of the two species, presented in Figure 9.4.5, shows that the overall proportion of *A. intermedius* in relation to the overall catches of *Aphanopus* species is about 0.75. It is important to note that the proportion can vary according to the sampling location.



(a)



(b)

Figure 9.4.5. bsf.27.nea. Other areas. Map of the sampling locations (a) and estimates of the proportion of each *A. carbo* and *A. intermedius* at different sampling points (b) in Division 27.10.a.

9.4.7 Comments on the assessment

Despite the variability on the overall landings along the years, data available suggest that ICES Subarea 27.10 is an area of major concentration of the species. This spatial aspect is consistent with the current perception on the spatial distribution of the species at NE Atlantic. However, the co-occurrence of two different species, *A. carbo* and *A. intermedius*, in ICES Subarea 27.10 (Besugo *et al.*, 2014 WD) needs to be, in the future, taken into consideration to provide advice for this stock.

9.4.8 Management considerations

The information available does not unequivocally support the assumption of a single stock for the whole NE Atlantic area, although the evidence is in line with it.

The co-occurrence of two different species, *A. carbo* and *A. intermedius*, in ICES Subarea 27.10 needs to be considered when providing advice for this stock.

9.4.9 Tables

Table 9.4.2a. Black scabbardfish other areas: subareas 27.2 and 27.3. Working Group estimates of landings.

Year	France	Faroes	Iceland*	France	Total
		27.2.a	27.2.a.2	27.3.a	
1988					**0**
1989	0				**0**
1990	1				**1**
1991	0				**0**
1992	0				**0**
1993	0				**0**
1994	0				**0**
1995	1				**1**
1996	0				**0**
1997	0				**0**
1998	0				**0**
1999	-				**0**
2000	-				**0**
2001	-				**0**
2002	-				**0**
2003	-				**0**
2004	-				**0**
2005	0	27			**27**
2006	-	-			**0**
2007	-	0			**0**
2008	-	-			**0**
2009	-	-			**0**

Year	France	Faroes 27.2.a	Iceland* 27.2.a.2	France 27.3.a	Total
2010	0	-			**0**
2011	-	-			**0**
2012					**0**
2013	-	-			**0**
2014	-	-			**0**
2015	-	-			**0**
2016	-	-		0	**0**
2017	-	-		-	**0**
2018	-	.	13	-	**13**
2019					**0**
2020	0				**0**

*** Preliminary catch statistics**

Table 9.4.2b. Black scabbardfish other areas: Subarea 27.4. Working Group estimates of landings. E is England, W is Wales, NI is Northern Ireland.

Year	France				Scotland				Germany *	E&W&NI	Netherlands**	Total
	27.4	27.4.a	27.4.b	27.4.c	27.4	27.4.a	27.4.b	27.4.c	27.4.a	27.4.a	27.4.c	
1988						-			.	-		**0**
1989	3					-			.	-		**3**
1990	70					-			.	-		**70**
1991	107					-			-	-		**107**
1992	219					-			-	-		**219**
1993	34					-			-	-		**34**
1994	45					-			3	-		**48**
1995	6					2			-	-		**8**
1996	6					1			-	-		**7**
1997	0					2			-	-		**2**
1998	2					9			-	-		**11**
1999		4				3			-	-		**7**
2000		2				3			-	-		**5**
2001		1				10			-	1		**12**
2002		0				24			-			**24**
2003		0				4			-			**4**

Year	France				Scotland				Germany *	E&W&NI	Netherlands**	Total
	27.4	27.4.a	27.4.b	27.4.c	27.4	27.4.a	27.4.b	27.4.c	27.4.c	27.4	27.4.a	
2004		4	1			0			-			**5**
2005		1	1			0			-			**2**
2006		13				0	0	0	-			**13**
2007		1	0			-			-			**1**
2008		0				0			-			**0**
2009		5	0			-	-	-	-	-		**5**
2010		13	2			-	-	-	-	-		**15**
2011		-	1			-	-	-	-	-		**1**
2012		0				-	-	-	-	-		**0**
2013		1	0	0		-	-	-				**1**
2014		10	0	0		0	0	0	0	0		**10**
2015		2	0	0		0	0	0	0	0		**2**
2016		9	-	-								**9**
2017		0	-	0		0	0	0				**0**
2018	-	1	-	0	0	-	-	-		0	0	**1**
2019		1										**1**
2020		0	3			0					0	**4**

***STATLAND data**

****Preliminary catch statistics.**

Table 9.4.2c. Black scabbardfish other areas: Subarea 27.10. Working group estimates of landings.

Year	Faroes	Portugal	France	Ireland	Total
1988	-	-			**0**
1989	-	-	0		**0**
1990	-	-	0		**0**
1991	-	166	0		**166**
1992	370	-	0		**370**
1993	-	2	0		**2**
1994	-	-	0		**0**
1995	-	3	0		**3**
1996	11	0	0		**11**
1997	3	0	0		**3**
1998	31	5	0		**36**
1999	-	46	-		**46**
2000	-	112			**112**
2001		+			**0**
2002	2	+			**2**
2003		91	0		**91**
2004	111	2			**113**
2005	56	323		0	**379**
2006	10	55			**65**
2007	0	0		0	**0**
2008	75	0		0	**75**
2009	157	5		0	**162**
2010	53	49		0	**102**
2011	25	139			**164**
2012	4	458			**462**
2013		206			**206**
2014	30	-			**30**
2015	234	7			**240**

Year	Faroes	Portugal	France	Ireland	Total
2016	50	36			**86**
2017	7	63			**70**
2018	-	14			**14**
2019	3	17			**20**
2020		0	0	0	**0**

Table 9.4.2d. Black scabbardfish other areas: Subarea 27.14. Working Group estimates of landings.

Year	Faroes 27.14	Spain	Greenland 27.14.b	Unallocated	Total
1988	-				**0**
1989	-				**0**
1990	-				**0**
1991	-				**0**
1992	-				**0**
1993	-				**0**
1994	-				**0**
1995	-				**0**
1996	-				**0**
1997	-				**0**
1998	2				**2**
1999	-		0		**0**
2000		90	0		**90**
2001		0	0		**0**
2002		8	0		**8**
2003		2	0		**2**
2004			0		**0**
2005	0		0		**0**
2006			0		**0**
2007	0		0		**0**
2008	0		0		**0**

Year	Faroes	Spain	Greenland	Unallocated	Total
	27.14		**27.14.b**		
2009	0		0		**0**
2010		111	0		**111**
2011	0		0		**0**
2012		39	0	49	**88**
2013		50	0	40	**90**
2014	0	0	0	0	**0**
2015	0	0	0	0	**0**
2016			0		**0**
2017	0	0	0	0	**0**
2018	0		0		**0**
2019					**0**
2020		0			**0**

9.5 Black scabbardfish in CECAF area

WGDEEP does not assess fisheries in Madeira (Eastern Central Atlantic area, CECAF) or in other areas outside the ICES area. Nonetheless, it is admitted that the incorporation of reliable CECAF data could provide a wider perception of the stock dynamics. Updated information on the black scabbardfish fishery in Madeira (CECAF 34.1.2) has been presented to WGDEEP (Sousa *et al.*, 2021 WD).

In 2015, STECF provided an exploratory assessment of the status of the species around Madeira (STECF-14–15). It was mentioned that, for the period 2000–2013, there was a general decline in fishing capacity and fishing effort. The number of vessels has also declined by 41% (34 to 20 vessels). Furthermore, in the second half of the last decade, some Madeiran vessels targeting the black scabbardfish have moved to new fishing grounds, some of them located outside the EEZ of Madeira (SE of the Azores and off the Canaries) (Figure 9.5.1).

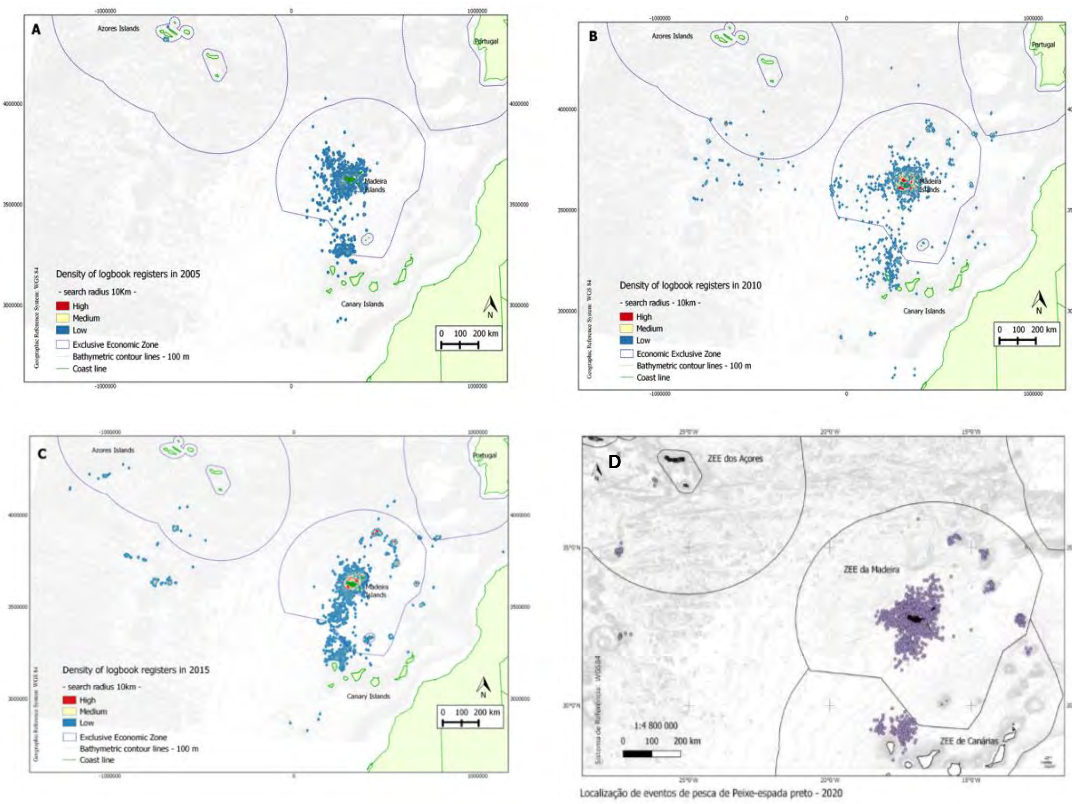


Figure 9.5.1. bsf CECAF area. Density plots illustrating the geographical distribution of the fishing sets with catches in 2005 (A), 2010 (B), 2015 (C) (Delgado *et al.*, 2018) and (D) 2020 (Sousa et al., 2021 WD).

Catches in CECAF 34 area were updated with fishery data from Madeiran longliners landings from 1990 to 2020 (Figure 9.5.1). These catches are recorded by the Regional Fisheries Department of Madeira. CECAF catches have been decreasing after the 1998 peak, but a slight increase was observed from 2012 to 2019 (Figure 9.5.2 and Table 9.5.1).

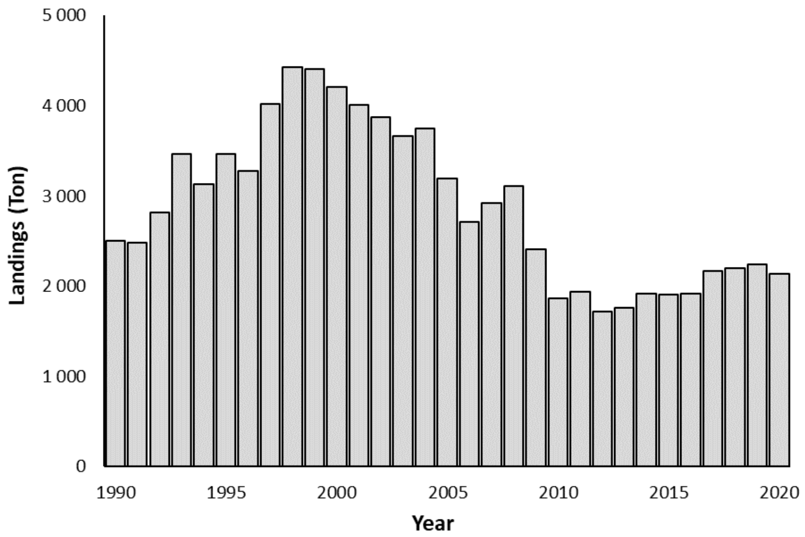


Figure 9.5.2. bsf CECAF 34. Time-series of annual Portuguese landings at CECAF area.

The EU TAC and total catches for CECAF 34 area from 2005 to 2020 are presented in Table 9.5.1.

Table 9.5.1. bsf. Black scabbardfish TACs and total landings in CECAF 34 area between 2005 and 2020.

Year	EU TAC CECAF 34.1.2 area	Landings CECAF 34.1.2. Area
2005	4 285	3 195
2006	4 285	2 717
2007	4 285	2 922
2008	4 285	3 109
2009	4 285	2 413
2010	4 285	1 860
2011	4 071	1 941
2012	3 867	1 716
2013	3 674	1 758
2014	3 490	1 913
2015	3 141	1 902
2016	2 827	1 917
2017	2 488	2 163
2018	2 189	2 199
2019	2 189	2 246
2020	2 189	2 136

Following the methodology adopted at WGDEEP 2016 (ICES, 2016), standardised annual catch estimates for the period from 1990 to 2020 of the nineteen resources (ordered in terms of total weight catch) and grouped into four groups (1, large pelagics; 2, elasmobranchs; 3, small pelagics; and 4, demersals) were determined based on data extracted from DSI/DRM database (Figure 9.5.3). The results do not support that given the diversity of species, which includes different taxonomic groups, lifestyles and both short- and long-lived organisms, the declining trends are reflecting changes on resources abundance which may imply that Madeiran waters are subject to severe over-exploitation. Further studies and a careful interpretation of trend variations of some resources are still required. It may happen that in some cases landing trends are not only related to the resources' abundance in Madeiran waters, but subject to other factors like variations on the market regulation (e.g. small pelagic fishery), environmental, application of TAC's and quotas, among others.

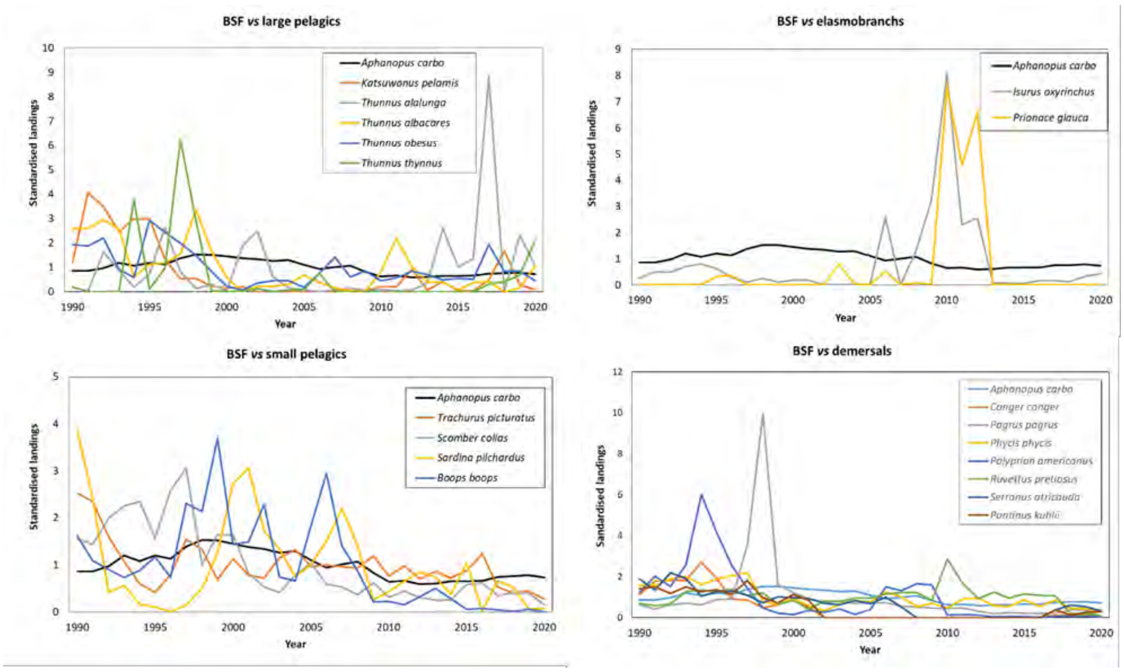


Figure 9.5.3. bsf CECAF area. Trends in standardised landings of black scabbardfish and the 19 other top ranked species in Madeiran landings.

For the period 2009–2020, the total length frequency distributions of the exploited population caught by the Madeiran longline fleet shows slight changes on the mean length throughout time (Figure 9.5.4). From 2011 to 2017 the mean length was constant at 118 cm TL, occurring a slight decrease in 2019 and 2020 (114 cm TL). The smaller number of vessels sampled in 2020 for length frequency distribution analysis, may have influenced the decrease in the estimated mean value.

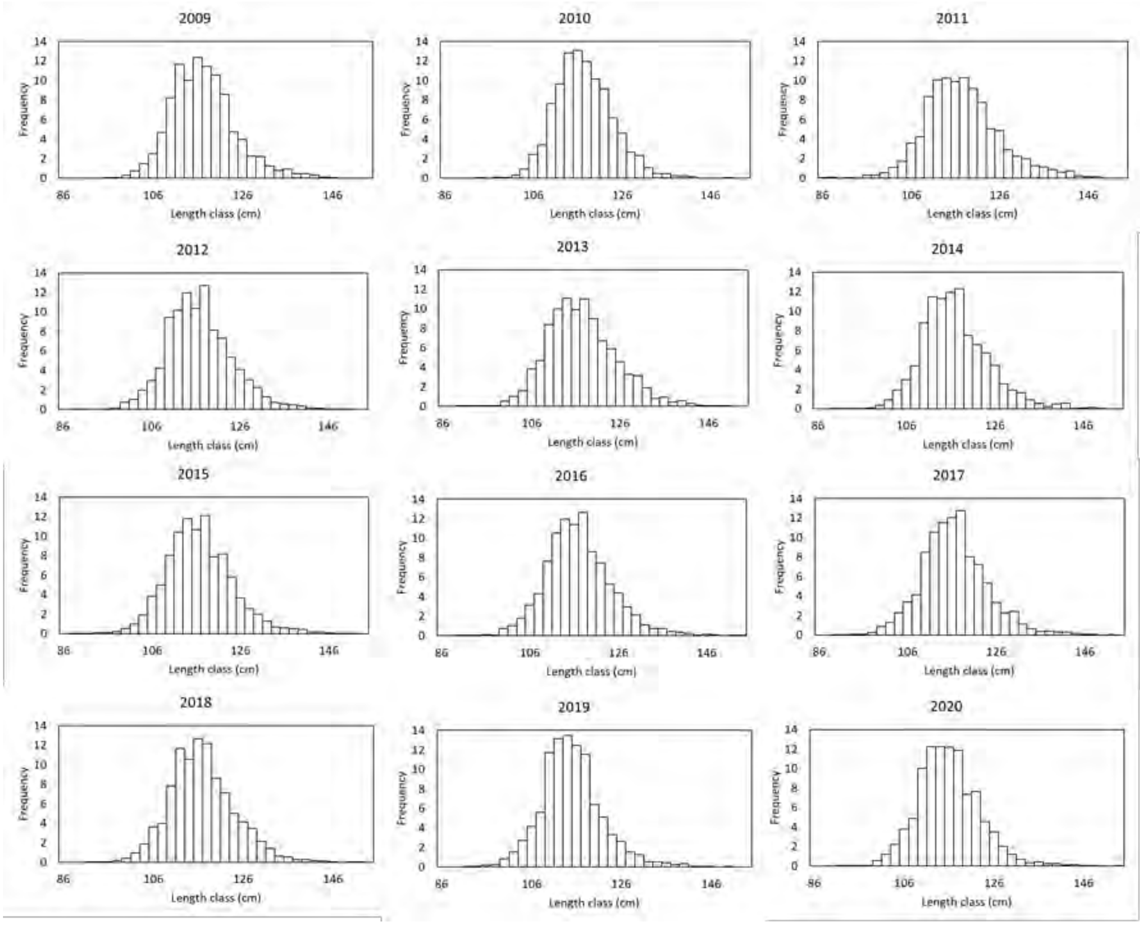


Figure 9.5.4. bsf CECAF. Annual length–frequency distribution of specimens landed by the Portuguese longliners operating along CECAF area.

In CECAF 34 area, the fishing effort that corresponds to the total number of hooks per year shows a continuous decrease from 2000 to 2020. Such decreasing trend is in line with the reduction in the number of active vessels (Figure 9.5.5).

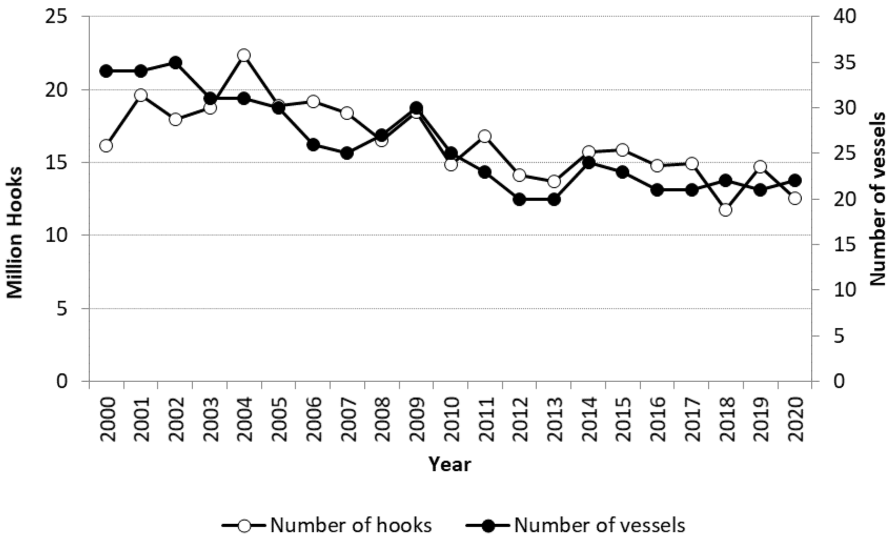


Figure 9.5.5. bsf CECAF 34 area. Time-series of the total annual effort estimated for the CECAF area (million hooks).

The nominal CPUE (Figure 9.5.6) shows an initial decreasing trend followed by a stable period (2010–2016) and a slight increase since 2017.

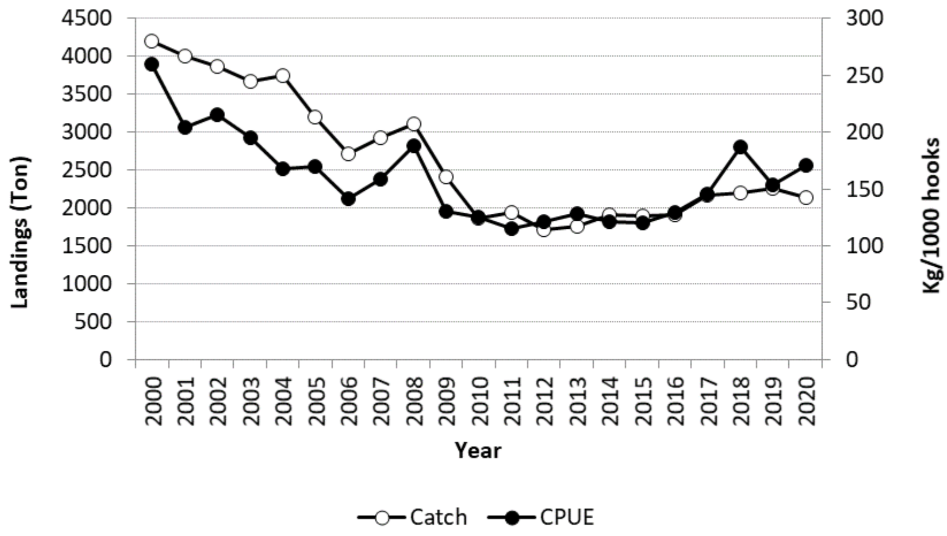


Figure 9.5.6. bsf CECAF 34 area. Time-series of landings per unit effort, nominal CPUE (kg/thousand hooks), in CECAF area.

For the period from 2008 to 2020, a standardised CPUE was obtained by adjusting a GLM model based on daily landings of commercial drifting longline fishery in CECAF 34 (Figure 9.5.7). The response variable (CPUE) was black scabbardfish catch in weight per fishing haul.

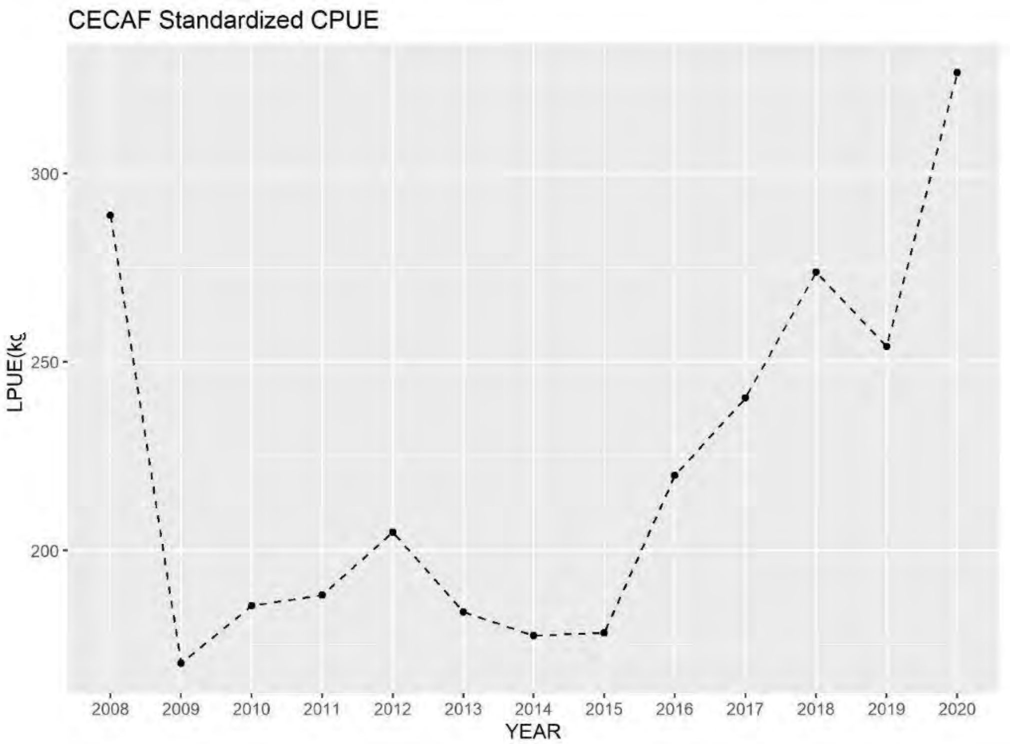


Figure 9.5.7. bsf.27.nea CECAF 34 area. Standardised CPUE (catch weight per fishing haul) from 2008 to 2020.

9.6 References

Besugo, A., Menezes G. and Silva, H. 2014. Genetic differentiation of black scabbard fish *Aphanopus carbo* and *Aphanopus intermedius* at the 2012 and 2013 Azorean commercial landings. Working Document to the 2014 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Biscoito M., Delgado J., Gonzaléz J.A., Sefanni S., Tuset V.M., Isidro E., García-Mederos A., Carvalho D., 2011. Morphological identification of two sympatric species of Trichiuridae, *Aphanopus carbo* and *A. intermedius*, in NE Atlantic. Cybium 35, 19-32.

Bordalo-Machado, P., and Figueiredo, I. 2007. A description of the black scabbardfish (*Aphanopus carbo* Lowe, 1839) fishery in the Portuguese continental slope. Working Document WD8 to the 2014 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Bordalo-Machado, P. and Figueiredo, I. 2009. The fishery for black scabbardfish (*Aphanopus carbo* Lowe, 1839) in the Portuguese continental slope. Reviews in Fish Biology and Fisheries 19(1): 49-67. DOI: 10.1007/s11160-008-9089-7

Christensen HT, and Hedeholm, R. 2016. Survey for Greenland halibut in ICES Area 14B, August/September 2015. Working Paper for ICES Northwestern Working Group April-May, 2016.

Delgado, J, Amorim, A., Gouveia, L., and Gouveia, N. 2018. An Atlantic journey: the distribution and fishing pattern of the Madeira deep sea fishery. Regional Studies in Marine Science. doi.org/10.1016/j.rsma.2018.05.001.

EU. 2016. Regulation (EU) 2016/2336 of the European Parliament and of the Council of 14 December 2016 establishing specific conditions for fishing for deep-sea stocks in the north-east Atlantic and provisions for fishing in international waters of the north-east Atlantic and repealing Council Regulation (EC) No 2347/2002.

Farias, I., Morales-Nin, B., Lorance, P. and Figueiredo, I. 2013. Black scabbardfish, *Aphanopus carbo*, in the northeast Atlantic: distribution and hypothetical migratory cycle. Aquatic Living Resources 26, 333–342.

Figueiredo, I. 2009. APHACARBO project. Working Document 5 to the 2009 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Figueiredo, I., Bordalo-Machado, P., Reis, S., Sena-Carvalho, D., Blasdale, T., Newton, A., and Gordo, L.S. 2003. Observations on the reproductive cycle of the black scabbardfish (*Aphanopus carbo* Lowe, 1839) in the NE Atlantic. ICES J. Mar. Sci. 60, 774-779.

ICES. 2011. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 2–8 March 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:17. 889 pp.

ICES. 2015. Report of the Benchmark Workshop on Deep-sea Stocks (WKDEEP), 3–7 February 2014, Copenhagen, Denmark. ICES CM 2014/ACOM:44. 119 pp.

ICES. 2016. Report of the Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 20–27 April 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:18. 648 pp.

ICES. 2018. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 11–18 April 2018, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:14. 771 pp.

Nakamura I., Parin N.V., 1993. Snake mackerels and cutlassfishes of the world (families Gempylidae and Trichiuridae). FAO Fish. Synop. 125, Vol. 15.

Neves, A., Vieira, A. R., Farias, I., Figueiredo, I., Sequeira, V., Serrano Gordo, L. 2009. Reproductive strategies in black scabbardfish (*Aphanopus carbo* Lowe, 1839) from the NE Atlantic. Scientia Marina, 73(S2), 19–31. https://doi.org/10.3989/scimar.2009.73s2019

Nielsen, J. 2020. Commercial catches of roundnose grenadier, roughhead grenadier, greater silver smelt, blue ling, tusk, black scabbard fish, ling and orange roughy in ICES division 14b in the period 1999-

2019. Working Document 02 to WGDEEP 2020 (Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources).

Nielsen, J. 2021. Commercial catches of roundnose grenadier, roughhead grenadier, greater silver smelt, blue ling, tusk, black scabbard fish, ling and orange roughy in ICES division 14b in the period 1999-2020. Working Document 04 to the ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Nielsen, J., Nogueira, A. and Christensen, H.T. 2019a. Survey results of roughhead grenadier, roundnose grenadier, greater silver smelt, blue ling, tusk, black scabbard fish, ling, and orange roughy in ICES division 14b in the period 1998-2016. Working Document 05 to the 2019 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Nielsen, J., Nogueira, A. and Christensen, H.T. 2019b. Commercial catches of roundnose grenadier, roughhead grenadier, greater silver smelt, blue ling, tusk, black scabbard fish, ling and orange roughy in ICES division 14b in the period 1999-2018. Working Document 06 to the 2019 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Ofstad, L.H. 2019. Black scabbard fish in Faroese waters (27.5.b). Working Document 01 to the 2019 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Pajuelo, J.G., González, J.A., Santana, J.I., Lorenzo J.M., García-Mederos, A., and Tuset, V. 2008. Biological parameters of the bathyal fish black scabbardfish (*Aphanopus carbo* Lowe, 1839) off the Canary Islands, Central-east Atlantic. Fish. Res. 92, 140-147.

Perera C.B., 2008. Distribution and biology of Black scabbarfish (*Aphanopus carbo* Lowe, 1839) in the Northwest of Africa. Master Thesis in Biology and Management of Marine Resources. Faculty of Sciences, University of Lisbon.

Sousa, R., Figueiredo, I., Farias, I., and Vasconcelos, J. 2021. Scabbard fish in the Madeira archipelago (CECAF 34.1.2). Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources. Copenhagen, 22th April - 28th May 2021.

Stefanni S., Bettencourt R., Knutsen H., and Menezes G. 2009. Rapid polymerase chain reaction–restriction fragment length polymorphism method for discrimination of the two Atlantic cryptic deep-sea species of scabbardfish. Mol. Ecol. Resour. 9, 528-530.

Stefanni S., and Knutsen H., 2007. Phylogeography and demographic history of the deep-sea fish, *Aphanopus carbo* (Lowe, 1839), in the NE Atlantic: vicariance followed by secondary contact or speciation? Mol. Phylogen. Evol. 42, 38-46.

10 Greater forkbeard (*Phycis blennoides*) in all ecoregions

10.1 The fishery

Greater forkbeard is as a bycatch species in the traditional demersal longline and trawl mixed fisheries targeting species such as hake, megrim, monkfish, ling, and blue ling in Subareas 6, 7, 8 and 9.

Spanish, French, Norwegian and UK trawl and longline are the main fleets involved in this fishery. Since 2009, 67% of landings have come from Subareas 6 and 7. Although it is not a large economic species in the all Northeast Atlantic, however, is locally important for certain fleets (LLS and OTB) fishing in subareas 6 and 7 with base port mainly in the North West of Spain and in France. The Irish mixed deep-water fishery around Porcupine Bank historically landed important quantities of this species but since 2006 the landings of this country have been reduced strongly. Many countries are involved in the fishery in subareas 1, 2, 3, and 4 that accounted the 16% of total landings since 2009, but most of the landings are traditionally reported by the Norwegian fleets. Russian, Swedish, Faroese and the Icelandic fisheries in the Northeast Atlantic (Division 5b) land small and occasional quantities of greater forkbeard as bycatch of the trawler fleet targeting roundnose grenadier, tusk and ling on Hatton and Rockall Banks.

A further 13.6% of landings in this period come from the French and Spanish trawl and longline fleets in Subareas 8 and 9 (mainly from 8). In Subarea 9 since 2001 small amounts of *Phycis* spp (probably *Phycis phycis*) have been landed in ports of the Strait of Gibraltar by the longliner fleet targeting scabbardfish in Algeciras, Barbate and Conil. Portuguese landings of *P. blennoides* are scarce, but important amounts of *Phycis* spp and *Phycis* species are reported every year in Subarea 9. Portuguese landings of *P. blennoides* present a marked seasonal pattern, being particularly higher between March and July. Reasons for this marked seasonality are unknown, but may be related to abundance variations of this species or to seasonality patterns in other fisheries where this species is taken as bycatch (Lagarto *et al*., 2016).

Minor quantities of *Phycis blennoides* are landed in Subarea 10 and divisions 5.a and 5.b. In subarea 12 there are not reported landings since 2012. In Subarea 10, the Azores deep-water fishery is a multispecies and multigear fishery dominated by the main target species *Pagellus bogaraveo*. Target species can change seasonally according to abundance and market prices, but *P. blennoides,* representing 0.5% of total deep-water landings in the last five years (2016-2020), can be considered as bycatch.

10.2 Landings trends

Tables 10.0a–i and Figure 10.1 show landings of greater forkbeard by country and subarea.

In Subareas 1, 2, 3 and 4 only Norwegian landings are significant reaching 229 t in 2020 in these combined subareas. The Norwegian longliners which fish in these areas catch *P. blennoides* as a bycatch in the ling fishery. The quantity of this bycatch depends on market price. After eight years without *P. blennoides* records, in 2002 the Norwegian fleet reported 315 t in Subareas 1 and 2 and 561 t in Subareas 3 and 4, since then the landings of this country have been significant but lower than in 2002. Denmark currently is the second country in landings and reported their first landings in subareas 3 and 4 since 2016 reaching 70 t in 2020 . Historically the main landings in 5.b come from France and Norway and in 2011 and 2012 reached the highest values because

Faroes reported 310 t and 145 t respectively. Afterwards, combined landings in this subdivision dropped to lower levels because the Faroese fleet did report only 0.15 t in the period from 2013 to 2020. Landings reported in 2020 by all countries were 31 t.

Traditionally, the most important landings in 6 and 7 come from Spain, France, Norway, UK and Ireland. Historical landings decreased since the peak of 4967 t in 2000 and they are especially low in 2009 and 2010 due to the low landings reported by Spain in those years. In 2020 the international reported landings were 869 t, mainly by France (360 t) and Spain (339 t), the lowest figure since 2010.

The main landings from subareas 8 and 9 come from Spanish fleets reaching on average are 285 t in the last ten years. In 2010 landings were the lowest of the series mainly due to the reduction of landings reported by Spain. Landings reported in 2020 by all countries were 281 t.

Historically in Subarea 10 landings come only from Portugal (although France reported 0.2 t in 2014) . After the peaks to 136 t in 1994 and 91 t in 2000 the average in this Subarea in the last ten years is 7 t. In 2017 for first time this country did not report any landing but in 2018 reached 14 t. In 2014 for first time France reported 0.2 t in this subarea. Landings reported in 2019 and 2020 by all countries were 0 t.

Although since 1991 several countries were involved in the fishery in Subarea 12 only Spain reported significant landings in the period 2002–2009, and from 2013 onwards no country reported landings in this subarea.

10.3 ICES Advice

For 2019 and 2020 ICES advised on "the basis of the precautionary approach that landings should be no more than 1346 tonnes".

10.4 Management

According to the Council Regulation (EU) 2018/2025, the TACs for greater forkbeard in all ICES subareas was no longer be set for 2019 and 2020. The ICES advice establishes that the absence of TACs would result in no or a low risk of unsustainable exploitation. Landings in subareas 1, 2, 3 and 4 include Norwegian landings.

PHYCIS BLENNOIDES	EU TAC	TOTAL INTERNATIONAL LANDINGS	
Subarea	2019-2020	2019	2020
1, 2, 3, 4	no TAC	376	305
5, 6, 7	no TAC	1260	900
8, 9	no TAC	214	281
10, 12	no TAC	0	0
Total	no TAC	1850	1486

10.5 Stock identity

ICES currently considers greater forkbeard as a single-stock for the entire ICES area. It is considered probable that the stock structure is more complex; however further studies would be required to justify change to the current assumption.

10.6 Data available

10.6.1 Landings and discard

Landings are presented in Table 10.0a–i and in Figure 10.1. Landings by fishing gear in 2020 are shown in Table 10.1a for countries reporting landings to InterCatch, and in Table 10.1b for Norway. The available discard estimates from 2013–2020 accounted 36%, 34%, 49%, 25%, 25%, 13% 17 and 15% of the total catches respectively (Table 10.2a and 10.2b). In 2020 the main reported discards come from subareas 7 (65%), 6 and 8 (12%), and 4 (11 %). Discards estimates in the first years of the series should be considered with caution because (i) not all countries report discards (ii) the method for estimating discards may not have been the same in all years. Nevertheless, in recent years (2015 onwards) discards of the most important countries in involved in the fishery (except Norway) are reported in InterCatch.

Series of Effort data (kWd) since 2014 of the Spanish, French, Swedish, German, Netherlands, UK (Scotland) and Irish fleets (OTB, LLS and GTR) have been provided by subarea (Figure 10.2b). The effort for a given year is calculated as the sum of kWd of those fleets/countries reported information in InterCatch. As greater forkbeard is a bycatch for many of the fleets, reporting catches the presented effort could not be representative specifically for this species.

A standardized CPUE was developed for reference fleet within the polyvalent Portuguese fleet, based on fishery dependent data collected from commercial landings for the period 2009-2020, particularly the landed weight (in Kg) by fishing trip. A fishing trip is defined from the moment the vessel leaves the dock to when it returns to the dock (Table 10.3). The standardized CPUE series, based on commercial data, suggest that the status of the greater forkbeard population inhabiting the Portuguese continental waters in recent years has been stable (Farias et al., 2021).

10.6.2 Length compositions

Figure 10.2a shows the available length frequencies of commercial fleets and indicates that discards in 2015 affected specially individuals smaller than 17 cm of which 100% were discarded. In 2016 and 2017 the length range of discarded greater forkbeard increased affecting in high proportion also individuals smaller than 36 cm and 45 cm respectively, but in 2018 the size of the individual discarded took place in the range from 8 to 33 cm, in 2019 and 2020 the situation is similar to 2016 and mostly of the discarded individuals are smaller than 33 cm. Figures 10.3, 10.4, 10.5, and 10.6a present the length–frequency distributions of Spanish Groundfish Survey in the Porcupine bank, Northern Spanish Shelf bottom-trawl, French IBTS until 2020, and Portuguese Crustacean Surveys/*Nephrops* TV Surveys (PT-CTS (UWTV (FU 28–29) until 2018.

10.6.3 Age compositions

Data of age proportion of the commercial Spanish fleets were provided in WGDEEP in 2020 for subareas 7, 8 and Division 9.a since 2011. The series show that most of greater forkbeard belongs to the age 1 in all subareas, although in 2019 individuals of age 2 reached 50% of the total and in 2016 61% in Subarea 8 and Division 9.a (Figure 10.6b).

10.6.4 Weight-at-age

This year the accumulated mean weight-at-length of the international commercial landings and discards reported to InterCatch from 2016 to 2020 was presented (Figure 10.7). The weight of discarded greater forkbeard in 2016, 2018 and 2019 were quite lower than landings weight since overall the fleets discard the smallest individuals (see Figure 10.2a)

10.6.5 Maturity and natural mortality

New information was provided for the Spanish Data Call to the WG in 2021:

	Value	Reference	Comments
L_{mat} males	27.5	CV= 2%	n=388; year= 2018+2019+2020; Males
L_{mat} females	47.2	CV= 3.3%	n=1025; year= 2018+2019+2020; Females
Li_{nf}	111.1	CV=11%	n=1076; year= 2018+2019+2020; Both sex
K	0.13	CV=15%	n=1075; year= 2018+2019+2020; Both sex

10.6.6 Catch, effort and research vessel data

In 2021 the following surveys covering the continental slope ofs, 3, 4, 6, 7, 8, and 9.a have been included in the analysis of biomass and abundance indices (Figure 10.8):

- Spanish Groundfish Survey in the Porcupine bank (SP-PorcGFS) in Divisions 7.c and 7.k. Biomass and abundance of greater forkbeard from 2001 to 2020 are presented in Figure 10.9.
- French EVHOE IBTS (FR-EVHOE) in Divisions 7.f, g, h, j; and 8.a,b,d. Abundance and biomass raised to the total subarea have been provided for a series from 1997 to 2020. This survey did not take place in 2017. (Figure 10.10).
- Irish Groundfish survey (IGFS) in Divisions 6.a South and 7.b. Abundance and biomass Indices (nº per hour and kg per hour) from the period 2005 to 2020. This survey provides abundance indices for the total catches and for individuals <32 cm by shelf and slope strata (Figure 10.11).
- Northern Spanish Shelf bottom-trawl survey (SP-NGFS) in Divisions 9.a and 8.c. Biomass and abundance (kg/30 min tow and No/30 min tow) of greater forkbeard in the Cantabrian Sea from 1983 to 2020 are presented in Figure 10.12.
- North Sea IBTS survey (NS-IBTS) in Divisions 4.abc, 3.a and 3.c. Abundance in number per hour from 1976 to 2020 is presented in Figure 10.13.
- Scottish Western Coast Groundfish IBTS survey (SWC-IBTS) in Divisions 5.b, 6.ab, 7.ab. No new information is available since 2014 onwards. Abundance in number per hour from 1986 to 2014 is presented in Figure 10.14.
- Scottish Deep-water trawler survey in Divisions 6.a. Biomass and abundance of greater forkbeard from 1998 to 2020 are presented in Figure 10.15. As it is a biennial since 2014 this survey did not take place in 2016 and 2018.

- Portuguese crustacean surveys/*Nephrops* TV Survey (PT-CTS (UWTV (FU 28–29) in Division 9.a South, Biomass in kg per hour from 1997 to 2018 is presented in Figure 10.16. This survey did not take place since 2019.

10.7 Data analyses

In the Spanish Groundfish Survey in the Porcupine bank the biomass and abundance of *P. blennoides* followed the pattern observed last year, but they increased slightly in this last survey, although the values still remain among the lowest in the time series (Figure 10.9). Biomass patches were widely found in the south, west and east area, but scarcely in the north, as in previous years (Figure 10.17). A small mode is seen at 20 cm and two more abundant at 31 cm and 40 cm (Figure 10.3) (Fernández-Zapico *et al.* 2021).

The EVHOE IBTS survey in Divisions 7.f,g,h,j and 8.a,b,d abundance shows no clear trend in the series, but has also peaks in 2002, 2007 and 2012. An important decrease was also observed since this year until 2016. In 2018 and 2019 a slight recovery but the biomass decreases again in 2020. The historical series indicates an increase in biomass since 1996, with peaks in 2004, 2007 and 2012 and a decrease from 2013 to 2015 and increases again until 2019. However, landings have decreased from 2012 onwards since the most important peak was in 2011. (Figure 10.10). The mean length has increased since the beginning of the series reaching the highest value in 2005, 2016 and 2020 (Figure 10.5).

Irish GFS indicates an increase in the abundance (No/hour) and biomass (Kg/hour) from 2009 to 2012 and 2013 respectively. From these years onwards a decrease in both parameters is shown to 2017 that is the lowest value of the series. In 2018 a slight recovery in biomass is recorded compared with values in 2017 but in 2019 and 2020 the trend decreased again (Figure 10.11).

In Northern Spanish Shelf bottom-trawl survey in 2020, 41% of the hauls where *P. blennoides* was found were additional hauls deeper than 500 m and contained 77% of the biomass. This last year the biomass in standard hauls remained low similarly to the values of the three previous years whereas the biomass in additional deep hauls remained being high, after the increase in 2019 (**Error! Reference source not found.**). The geographical distribution of *P. blennoides* remained similar to previous years, being widespread in the sampling area (Figure 10. 18). The length distribution in standard hauls remained showing low abundances per size and even fewer small (13-19 cm) and large (24-45 cm) specimens than in 2019. The largest individuals which ranged from 26 cm to 65 cm were found in the additional deeper hauls, although specimens around 35 cm were more abundant (**Error! Reference source not found.**10.4) (Ruiz-Pico *et al*., 2021).

The NS-IBTS shows an increase on abundance since 1976 although the average abundance recorded until 2010 (3.1 individuals/hour) was lower than 2011 onwards (22.0 individuals/hour). The abundance recorded in 2012 (40.2 individuals/hour) is the most important of the series although the trend shows a decrease since this year to 2016 (Figure 10.13). In 2017 the survey recovered one of the highest abundance values hour but dropped again to 9.3 individuals/hour in 2020.

No data for 2015 and 2016 have been updated in the DATRAS system for the SWC-IBTS. The trend series of abundance until 2014 is shown in the Figure 10.14.

The Scottish Deep-water trawler survey covers a core area of the continental slope of the Rockall Trough (6.a) from between 55 to 59°N long with the slope stratified by depth at 500, 1000, 1500 and 1800 m. Historical series of biomass index show a tooth saw profile from 1998 to 2015 with a peak in 2017 of 37.2 kg/hour but dropped again in 2019 to 16.5 kg/hour . The abundance shows the same profile of the biomass with an important increase from 2011 to 2013 and also a peak in

2017 (53.6 individuals/hour). In 2019 the abundance decreased slightly to similar values found in the period from 2011 to 2013 (Figure 10.15).

In the Portuguese survey in 9.a south the series of biomass show a decrease trend since 1997 to 2004 but with significant peaks in 1999 and 2002. In recent years *P. blennoides* standardized biomass index estimates are above the overall mean, showing an increasing trend, particularly from 2013 to 2018 (a slight decrease was observed in 2017 in relation to 2016 (Moura *et al* 2019). Values biomass are in the range of 0 kg/hour to 2.33 kg/hour (Figure 10.16). In the years 2008–2010, catch rates were relatively high in all geographical areas. Length data from specimens caught during held between 1997 and 2016 support that these years were of strong recruitment, particularly the years 2007 and 2008 (Figure 10.6). The size range observed in the Portuguese continental coast, provides evidence that the species is able to complete the life cycle in this area.

Although the data provided by the surveys have increased the area covered in the ecoregion, neither the available surveys nor discard data cover yet the entire distributional stock, especially in Subareas 1 and 2.

10.7.1 Exploratory assessment

No analytical assessment was presented in WGDEEP 2021.

10.7.2 Comments on the assessment

No analytical assessment was presented in WGDEEP 2021.

10.8 Management considerations

As Greater Forkbeard is a bycatch species in both deep-water and shelf fisheries, advice should take account of advice for the targeted species in those fisheries. The life-history traits do not suggest it is particularly vulnerable.

In the subareas 3 and 4 the NS IBTS survey shows an increase trend since 1976, more noticeable from 2010 onwards. In the areas Subareas 6, and 7 covered by the Porcupine and Irish IGFS surveys and the indices indicate a decrease in the abundance since 2013, and in biomass since 2014. However, in the northern area of the Subarea 6 covered by the Scottish deep-water survey it is observed an important increase of the biomass in 2017 perhaps due to the high abundance recorded in 2011 to 2013. The trend in Subarea 8 indicated by the Northern Spanish Shelf bottom-trawl (Division 8c) shows a decrease in biomass and abundance since 2017, and on the contrary, the French EVHOE (in Divisions 7.f, g, h, j; and 8.a,b,d) shows an increase in biomass an abundance in 2018 and 2019 and a decrease in 2020. In Division 9.a south annual standardized biomass index of the Portuguese survey suggests an increase of biomass and abundance since 2013. The standardized indicator of the combined six survey index indicates a reduction of the 21% in the biomass in last two years (2019-2020 over the period 2016-2018).

On the other hand, landings in all ecoregions have been reduced since 2013 below the biennial TAC established for this period. In this sense, although the TAC increased in 2015 and 2016 to 2856 t landings reported have always been below, especially in 2017 in which landings were only 59% of TAC. It was supposed that the removing of the TAC for 2019 and 2020 could increase the landings (and discards) but it does not seem to have affected the decreasing trend.

Although greater forkbeard is a bycatch of the traditional demersal trawl and longline mixed fisheries, and it is only locally important for certain fleets fishing in subareas 6 and 7 with base port mainly in the North West of Spain, discards of this species are considered high. Many of the countries involved in the fishery report data to InterCatch, and according to the information available, reported discards to catches ratio are high but have decreased from 2013 to 2020 (36%, 34%, 49%, 25%, 13%, % 17% and 15%). In the same sense, the commercial length frequencies are only partially available from some countries and areas and the historical series is still short.

10.9 Application of MSY proxy reference points

A Stochastic Production Model in Continuous Time (SPiCT) was applied in 2017 to the GFB stock using the historical series of landings since 1998 and the standardized biomass indicator (average) from six surveys: IGFS-WIBTS-Q4, EVHOE-WIBTS-Q4F, SpGFS-WIBTS-Q4, SpGFS-WIBTS-Q4, SDS, PT-CTS (UWTV (FU 28–29) from the period 2005–2016. The model did not converged, so a new model was adjusted and the series of landings were shortened to the same period of the Index series (from 2005 to 2016), but again the estimation did not converge.

The inputs and results of the first attempt are shown in the Figures 10.19 and 10.20.

10.10 Tables and Figures

Table 10.0a. Greater forkbeard *(Phycis blennoides)* in the Northeast Atlantic. Working group estimates of landings.

YEAR	1+2	3+4	5B	6+7	8+9	10	12	TOTAL
1988	0	15	2	1898	533	29	0	2477
1989	0	12	1	1815	663	42	0	2533
1990	23	115	38	1921	814	50	0	2961
1991	39	181	53	1574	681	68	0	2596
1992	33	145	49	1640	702	91	1	2661
1993	1	34	27	1462	828	115	1	2468
1994	0	12	4	1571	742	136	3	2468
1995	0	3	9	2138	747	71	4	2972
1996	0	18	7	3590	814	45	2	4476
1997	0	7	7	2335	753	30	2	3134
1998	0	12	8	3040	1081	38	1	4180
1999	0	31	34	3455	673	41	0	4234
2000	0	11	32	4967	724	91	6	5831
2001	8	27	102	4405	727	83	8	5360
2002	318	585	149	3417	715	57	81	5321
2003	155	233	73	3287	661	45	82	4536
2004	75	143	50	2606	720	37	54	3685
2005	51	83	46	2290	519	22	77	3087

YEAR	1+2	3+4	5B	6+7	8+9	10	12	TOTAL
2006	49	139	39	2081	560	15	42	2925
2007	47	239	56	1995	586	17	37	2978
2008	117	245	45	1418	446	18	17	2307
2009	82	149	22	796	203	13	44	1309
2010	132	186	61	824	69	14	0	1287
2011	113	179	319	1257	321	11	0	2201
2012	98	199	169	1802	366	6	0	2641
2013	83	179	11	1588	275	8	0	2143
2014	97	214	24	1566	360	9	0	2269
2015	121	215	34	1471	323	10	0	2174
2016	187	273	13	1265	263	10	0	2012
2017	80	155	9	1073	186	0	0	1503
2018	60	192	12	1264	258	14	0	1801
2019	192	184	18	1242	214	0	0	1850
2020	118	187	31	869	281	0	0	1486

Table 10.0b. Greater forkbeard *(Phycis blennoides)* in Subareas 1 and 2. Working group estimates of landings.

YEAR	NORWAY	FRANCE	RUSSIA	UK (SCOT)	UK (EWNI)	GERMANY	FAROE ISLANDS	TOTAL
1988	0							0
1989	0							0
1990	23							23
1991	39							39
1992	33							33
1993	1							1
1994	0							0
1995	0							0
1996	0							0
1997	0							0
1998	0							0

YEAR	NORWAY	FRANCE	RUSSIA	UK (SCOT)	UK (EWNI)	GERMANY	FAROE ISLANDS	TOTAL
1999	0	0						0
2000	0	0						0
2001	0	1	7					8
2002	315	0		1		2		318
2003	153	0				2		155
2004	72	0	3	0				75
2005	51	0						51
2006	46	0	3					49
2007	41	0	5	1	0			47
2008	112	0	4	1			0	117
2009	76	0	6	0				82
2010	127	4						132
2011	107	6						113
2012	98	0.4						98
2013	83	0.1		0				83
2014	96	0.4						97
2015	121							121
2016	187	0.3		0				187
2017	79	0.7		1				80
2018	60	0.1						60
2019	192	0.04						192
2020	118	0.1				0.0		118

Table 10.0c. Greater forkbeard *(Phycis blennoides)* in Subareas 3 and 4. Working group estimates of landings.

YEAR	FRANCE	NORWAY	UK (EWNI)	UK (SCOT)[(1)]	GERMANY	DENMARK	SWEDEN	NETHER-LANDS	TOTAL
1988	12	0	3	0					15
1989	12	0	0	0					12
1990	18	92	5	0					115
1991	20	161	0	0					181
1992	13	130	0	2					145
1993	6	28	0	0					34
1994	11			1					12
1995	2			1					3
1996	2	10		6					18
1997	2			5					7
1998	1		0	11					12
1999	3		5	23					31
2000	4		0	7					11
2001	6		1	19	2				27
2002	2	561	1	21	0				585
2003	1	225	0	7					233
2004	2	138		3					143
2005	2	81	0	1					83
2006	1	134	3						139
2007	1	236	0	2					239
2008	0	244		1					245
2009	4	142		3					149
2010	3	182		1					186
2011	17	160		1					179
2012	1	198							199
2013	1	178	0	0					179
2014	1	210		3					214
2015	1	213		1					215

YEAR	FRANCE	NORWAY	UK (EWNI)	UK (SCOT)[(1)]	GERMANY	DENMARK	SWEDEN	NETHER-LANDS	TOTAL
2016	1	267		2		3			273
2017	1	140		9		5	0		155
2018	1	150		2		37	2		192
2019	3	113		3		65	0		184
2020	3	111		2	0.1	70		0.4	187

(1) Includes Moridae, in 2005 only data from January to June.

Table 10.0d. Greater forkbeard *(Phycis blennoides)* in Division 5b. Working group estimates of landings.

YEAR	FRANCE	NORWAY	UK(SCOT)[(1)]	UK(EWNI)	FAROE ISLANDS	RUSSIA	ICELAND	TOTAL
1988	2	0						2
1989	1	0						1
1990	10	28						38
1991	9	44						53
1992	16	33						49
1993	5	22						27
1994	4							4
1995	9							9
1996	7							7
1997	7	0						7
1998	4	4						8
1999	6	28	0					34
2000	4	26	1	0				32
2001	9	92	1	0				102
2002	10	133	5	0				149
2003	11	55	7	0				73
2004	9	37	2	2				50
2005	7	39		0,3				46
2006	8	26			6			39
2007	11	34	0	0	9	2	0	58
2008	10	20	0		4	11	1	46

YEAR	FRANCE	NORWAY	UK(SCOT)[1]	UK(EWNI)	FAROE ISLANDS	RUSSIA	ICELAND	TOTAL
2009	0	13	3		3	2	0	24
2010	2	45	3	1	11		2	62
2011	7				310		1	319
2012	6	5			145	7	7	169
2013	7	3	0				0	11
2014	7	14	0		0		2	24
2015	5	27					2	34
2016	7	3	0				3	13
2016	7	3	0				3	13
2017	9		0					9
2018	5	7						12
2019	7	10						18
2020	7	24	0					31

(1) **Includes Moridae in 2005 only data from January to June.**

Table 10.0e. Greater forkbeard *(Phycis blennoides*) in Subareas 6 and 7. Working group estimates of landings.

YEAR	FRANCE	IRELAND	NORWAY	SPAIN[1]	UK (EWNI)	UK (SCOT) [2]	GERMANY	RUSSIA	FAROE ISLANDS	NETHERLANDS	TOTAL
1988	252	0	0	1584	62	0					1898
1989	342	14	0	1446	13	0					1815
1990	454	0	88	1372	6	1					1921
1991	476	1	126	953	13	5					1574
1992	646	4	244	745	0	1					1640
1993	582	0	53	824	0	3					1462
1994	451	111		1002	0	7					1571
1995	430	163		722	808	15					2138
1996	519	154		1428	1434	55					3590
1997	512	131	5	46	1460	181					2335
1998	357	530	162	530	1364	97					3040
1999	314	686	183	824	929	518	1				3455
2000	671	743	380	1613	731	820	8	2			4967

YEAR	FRANCE	IRE-LAND	NOR-WAY	SPAIN[(1)]	UK (EWNI)	UK (SCOT) [(2)]	GER-MANY	RUS-SIA	FAROE IS-LANDS	NETH-ER-LANDS	TO-TAL
2001	683	663	536	1332	538	640	10	4			4405
2002	613	481	300	1049	421	545	9	0			3417
2003	469	319	492	1100	245	661	1	1			3287
2004	441	183	165	1131	288	397		1			2606
2005	598	237	128	979	179	164		5			2290
2006	625	68	162	1075	148			2	0		2081
2007	578	56	188	875	117	179		2			1995
2008	711	43	174	236	31	196		27	0		1418
2009	304	7	222	48	31	184		1			796
2010	383	8	219	23	14	173		3	1		824
2011	378	6	309	326	27	210					1257
2012	381	9	225	992	1	194					1802
2013*	451	16	289	583	3.4	246		0			1588
2014	468	25	159	769	9	135					1566
2015	451	37	135	716	26	105					1471
2016	412	13	97	641	13	90					1265
2017	431	6	134	399	14	88					1073
2018	458	10	203	453	20	121					1264
2019	430	18	187	498	13	95					1242
2020	360	18	72	339	18	62				0.5	869

[(1)] Landings of *Phycis* spp Included from 1988 to 2012.

[(2)]Includes Moridae in 2005 only data from January to June.

Table 10.0f. Greater forkbeard *(Phycis blennoides*) in Subareas 8 and 9. Working group estimates of landings.

YEAR	FRANCE	PORTUGAL	SPAIN[(1)]	UK(EWNI)	UK (SCOT)	TOTAL
1988	7	29	74			110
1989	7	42	138			187
1990	16	50	218			284
1991	18	68	108			194
1992	9	91	162			262

YEAR	FRANCE	PORTUGAL	SPAIN[1]	UK(EWNI)	UK (SCOT)	TOTAL
1993	0	115	387			502
1994		136	320			456
1995	54	71	330			455
1996	25	45	429			499
1997	4	30	356			390
1998	3	38	656			697
1999	8	41	361			410
2000	36	91	375			502
2001	36	83	453			573
2002	67	57	418			542
2003	28	45	387			461
2004	44	37	446			527
2005	58	22	312	0		392
2006	54	10	257			321
2007	32	14	510	0		556
2008	41	13	123			178
2009	8	13	183	0		203
2010	10	12	48		0	69
2011	13	13	295			321
2012	46	5	315			366
2013	31	8	234	2		275
2014	38	6	315		0	360
2015	38	8	278			323
2016	30	7	226		0	263
2017	18	9	159		0	186
2018	31	9	218		0	258
2019	29	7	178	0	-	214
2020	38	5	238	0	0	281

(1) **Landings of *Phycis spp* Included from 1988 to 2012.**

Table 10.0g. Greater forkbeard *(Phycis blennoides*) in Subarea 10. Working group estimates of landings.

YEAR	PORTUGAL	FRANCE	TOTAL
1988	29		29
1989	42		42
1990	50		50
1991	68		68
1992	91		91
1993	115		115
1994	136		136
1995	71		71
1996	45		45
1997	30		30
1998	38		38
1999	41		41
2000	91		91
2001	83		83
2002	57		57
2003	45		45
2004	37		37
2005	22		22
2006	15		15
2007	17		17
2008	18		18
2009	13		13
2010	14		14
2011	11		11
2012	6		6
2013	8		8
2014	9	0	9
2015	10		10
2016	10		10

YEAR	PORTUGAL	FRANCE	TOTAL
2017			0
2018	14		14
2019			0
2020			0

Table 10.0h. Greater forkbeard *(Phycis blennoides)* in Subarea 12. Working group estimates of landings.

YEAR	FRANCE	UK(SCOT)[(1)]	NORWAY	UK(EWNI)	SPAIN[(2)]	RUSSIA	TOTAL
1988							0
1989							0
1990							0
1991							0
1992	1						1
1993	1						1
1994	3						3
1995	4						4
1996	2						2
1997	2						2
1998	1						1
1999	0	0					0
2000	2	4					6
2001	0	1	6	1			8
2002	0		2	4	74		81
2003	3		8	0	71		82
2004	3		6		44		54
2005	1	0	0		75		77
2006					42		42
2007					37		37
2008	0				17		17
2009	1		0		37	6	44
2010	0						0

YEAR	FRANCE	UK(SCOT)(1)	NORWAY	UK(EWNI)	SPAIN(2)	RUSSIA	TOTAL
2011	0						0
2012	0						0
2013							0
2014	0						0
2015							0
2016							0
2017							0
2018							0
2019							0
2020							0

(1) **Includes Moridae in 2005 only data from January to June.**

(2) **Landings of *Phycis spp* Included from 1988 to 2012.**

Table 10.0i. Greater forkbeard *(Phycis blennoides*). Working group estimates of landings. Catches inside and outside the NEAFC Regulatory Area (RA) as estimated by ICES for the stock in WGDEEP.

WGDEEP Stock gfb.27.nea	Catch Inside NEAFC RA (t)	Catch Outside NEAFC RA (t)	Total Catches	Proportion of catch inside the NEAFC RA (%)	NEAFC RA areas where caught
2020	0	1486	1486	0%	
2019	0	1850	1850	0%	
2018	0	1801	1801	0%	
2017	0	1503	1503	0%	

Table 10.1a. Greater forkbeard *(Phycis blennoides*). European landings (t) by métier in 2020.

Landings (t)	2020
Denmark	70
GNS_DEF	0.0
OTB_CRU	1.3
OTB_DEF	68.7
SDN_DEF	0.0
SSC_DEF	0.5
Ireland	18
OTB_DEF_100-119_0_0_all	15.6

Landings (t)	2020
OTB_DEF_70-99_0_0_all	2.8
Portugal	5
MIS_MIS_0_0_0	4.8
OTB	0.1
Spain	576
MIS_MIS_0_0_0_HC	4.0
OTB_DWS_100-129_0_0	0.0
OTB_DEF_70-99_0_0	16.6
OTB_DEF_100-119_0_0	88.1
OTB_DEF_>=70_0_0	15.7
OTB_MCD_>=55_0_0	6.6
GNS_DEF_80-99_0_0	5.8
PTB_MPD_>=55_0_0	3.5
LLS_DEF_0_0_0	348.1
OTB_MPD_>=55_0_0	7.7
GNS_DEF_>=100_0_0	3.7
OTB_DEF_>=55_0_0	72.8
GNS_DEF_120-219_0_0	2.0
GNS_DEF_60-79_0_0	0.7
LLS_DWS	0.3
LHM_DEF_0_0_0	0.1
GTR_DEF_60-79_0_0	0.4
UK (England)	18
GNS_DEF	3.0
LLS_DEF	0.1
MIS_MIS_0_0_0_HC	0.9
OTB_DEF	14.2
UK(Scotland)	64
LLS_DEF_0_0_0_all	1.4
MIS_MIS_0_0_0_HC	1.4

Landings (t)	2020
OTB_DEF_>=120_0_0_all	61.6
France	408
LLS_DEF	53.1
MIS_MIS_0_0_0	7.7
OTB_DEF_70-99_0_0	19.4
OTB_DEF_100-119_0_0	94.4
OTT-DWS	2.2
OTB_DWS_100-119_0_0_all	6.6
GNS_DEF_100-119_0_0_all	28.2
OTT_DEF_100-119_0_0	67.8
OTB_DEF_<16_0_0_all	0.0
OTT_DEF_>=70_0_0	5.8
OTB_DEF_>=70_0_0	3.0
OTT-DEF	0.0
OTB_DEF_>=120_0_0	65.5
OTB_DWS_>=120_0_0_all	48.7
OTT_CRU_100-119_0_0	0.1
OTT_DEF_70-99_0_0	0.0
GNS_DEF_120-219_0_0_all	2.1
OTB_CRU_100-119_0_0_all	3.6
OTM_DEF_100-119_0_0_all	0.0
Germany	0
OTB_DEF	0.1
Netherlands	1
TBB_CRU_16-31_0_0_all	0.4
OTM_SPF_32-69_0_0_all	0.5

Table 10.1b. Greater forkbeard *(Phycis blennoides*). Norwegian landings (t) by métier in 2020.

	Pot and Traps	Gillnets	Longlines	Longlines	Bottom trawl	Pelagic trawl	Purse Seiner
Norway	1.8	11.0	0.3	253.1	57.9	0.2	0.1

Table 10.2a. Greater forkbeard *(Phycis blennoides*). Reported of total discards (ton) of *P. blennoides* from 2013 to 2020 and proportion in the catches.

ton	2013	2014	2015	2016	2017	2018	2019	2020
DISCARDS	1185	1166	2068	677	513	263	366	256
LANDINGS	2143	2269	2175	2012	1503	1801	1850	1486
CATCHES	3328	3435	4243	2689	2016	2064	2216	1742
DISCARDS/CATCHES	36%	34%	49%	25%	25%	13%	17%	15%

Table 10.2b. Greater forkbeard (*Phycis blennoides*). Reported discards (ton) of P. blennoides from 2013 to 2020 by sub-area.

subarea	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
2								0	0
3	0.9	2	0	6	3	10	10	0	32
4	334	7	83	99	279	57	42	27	927
5			1	7	0	0		0	7
6	769	647	1359	225	51	47	45	32	3174
7			256	301	131	74	245	167	1174
8	82	510	302	25	39	67	18	30	1073
9			67	15	10	7	6		104
TOTAL	1185	1166	2068	677	513	263	366	256	

Table 10.3. Greater forkbeard (*Phycis blennoides*). Annual mean CPUE (Kg/trip) and GLM estimates, of the Portuguese Reference fleet as well as, upper and lower limits of the 95% CPUE confidence intervals for the period 2013-2020.

year	Observation (kg/trip)	CPUE Upper limit	CPUE Estimate (Kg/trip)	CPUE Lower limit
2013	10.39	13.43	10.39	8.04
2014	11.88	16.07	12.25	9.34
2015	10.83	16.09	12.32	9.43
2016	10.28	13.96	10.74	8.27
2017	9.81	12.72	9.68	7.37
2018	10.59	13.43	10.17	7.7

year	Observation (kg/trip)	CPUE Upper limit	CPUE Estimate (Kg/trip)	CPUE Lower limit
2019	8.83	12.56	9.57	7.29
2020	8.35	11.66	8.88	6.77

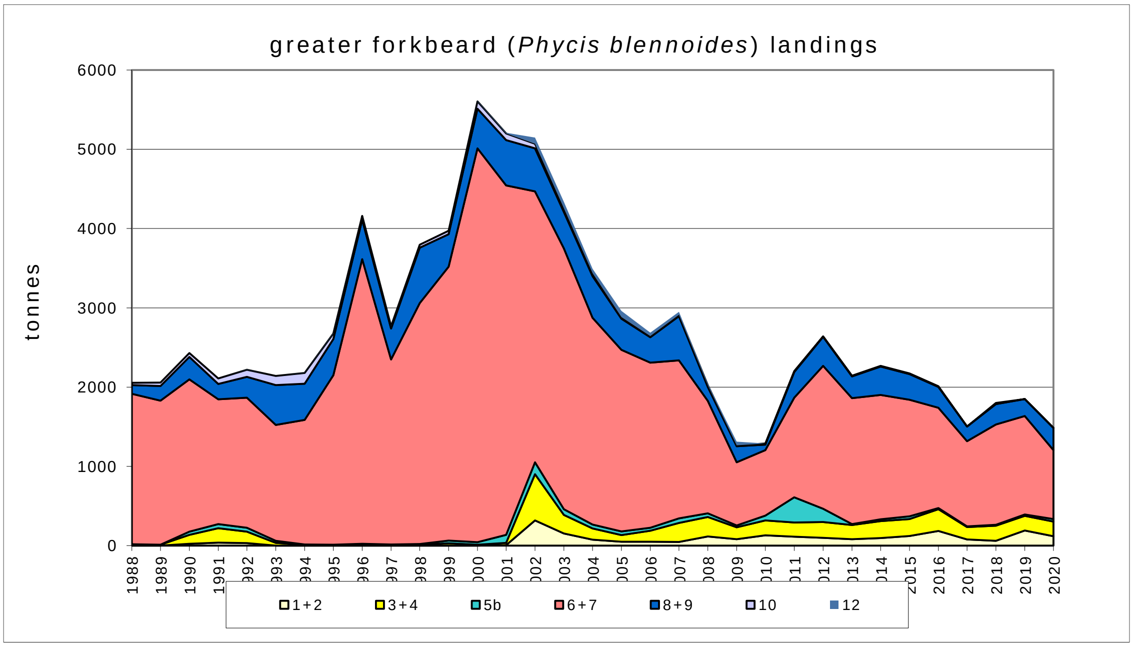


Figure 10.1. Greater forkbeard landing trends in all ICES subareas since 1988.

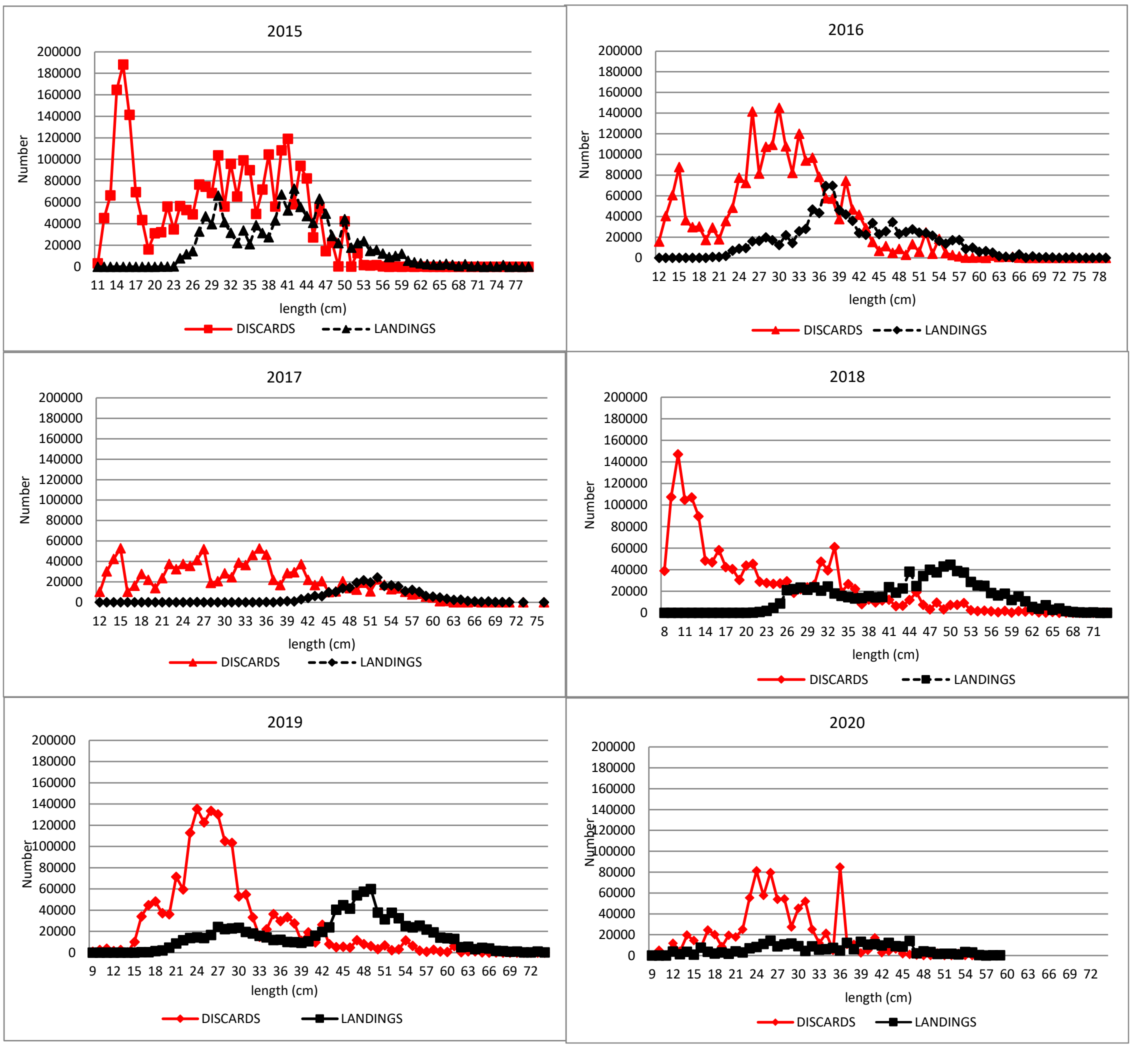


Figure 10.2a. Commercial length frequencies of the greater forkbeard landings and discards from 2015 to 2020 from France, Spain, Ireland, Portugal, Denmark, Sweden, UK (England), and UK (Scotland).

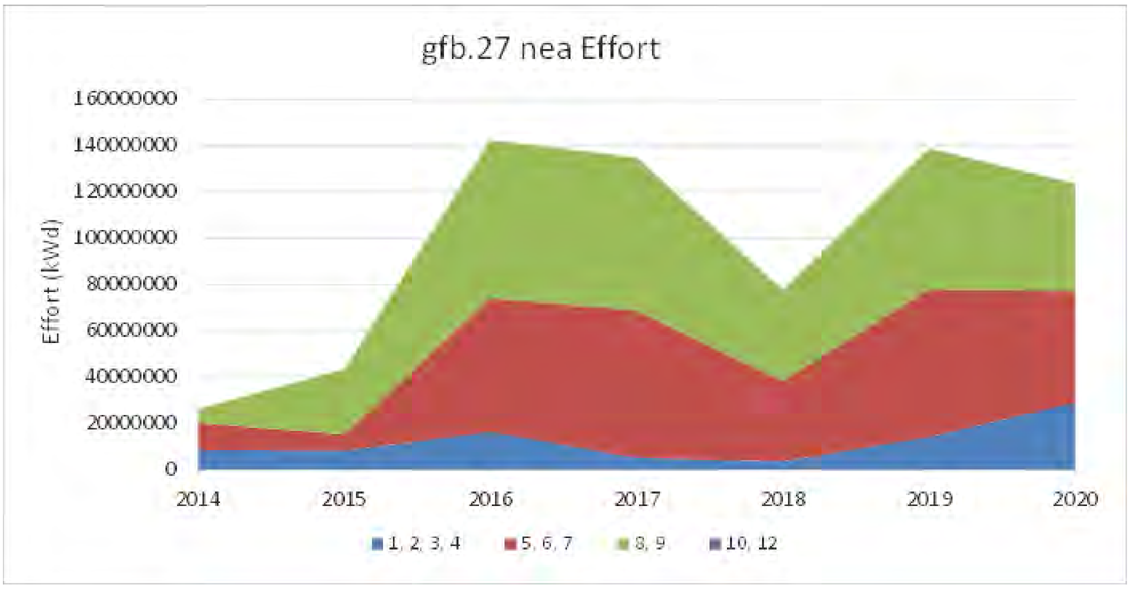


Figure 10.2b. Effort data (kWd) by stock units since 2014 of the Spanish, French, Swedish, UK (Scotland) and Irish fleets.

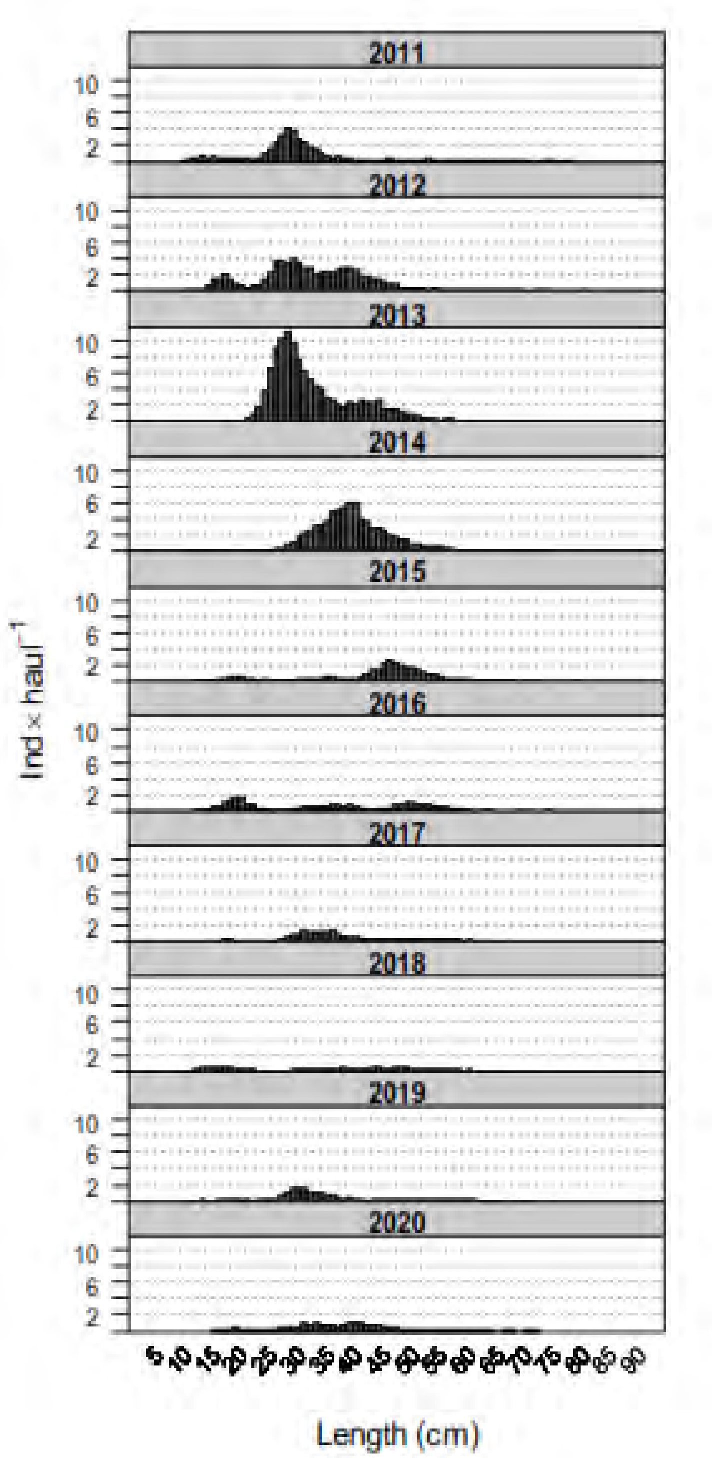


Figure 10.3. Mean stratified length distributions of greater forkbeard (*P. blennoides*) in Porcupine survey (Divisions 7.c and 7.k) time-series (2011–2020).

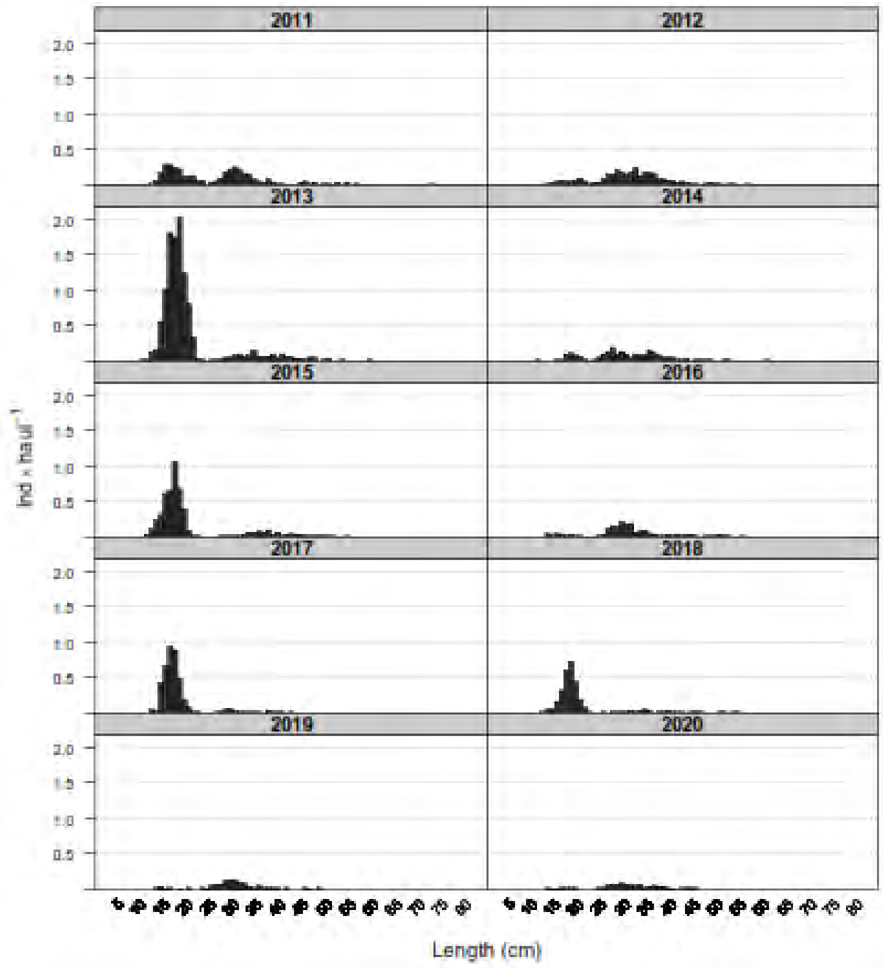


Figure 10. 4. Mean stratified length distributions of greater forkbeard (*P. blennoides*) in Northern Spanish Shelf survey (8.c and 9.a) in the period 2009–2018.

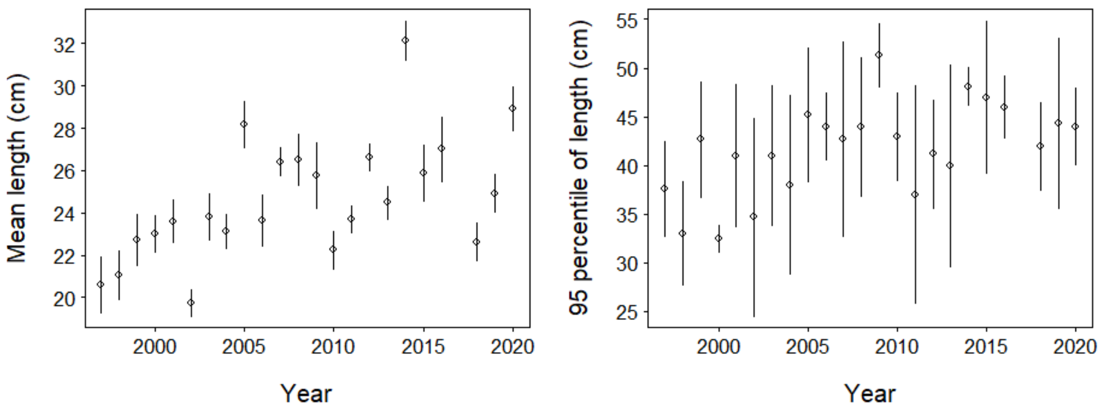


Figure 10.5. Greater forkbeard series of mean length from the French IBTS survey Divisions 7.fghj and 8.abd until 2020.

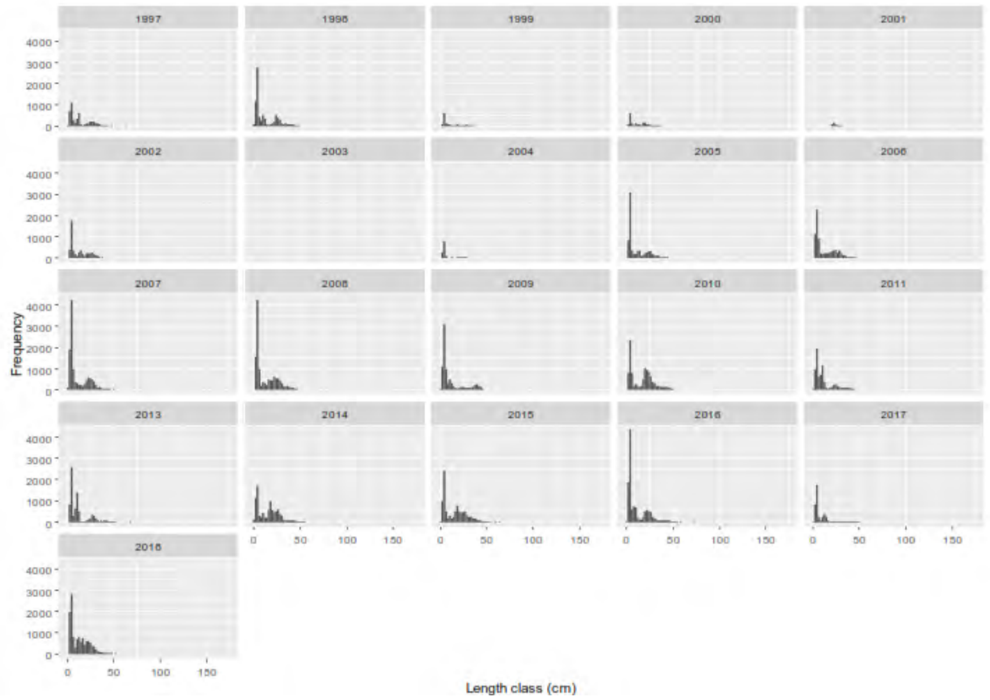
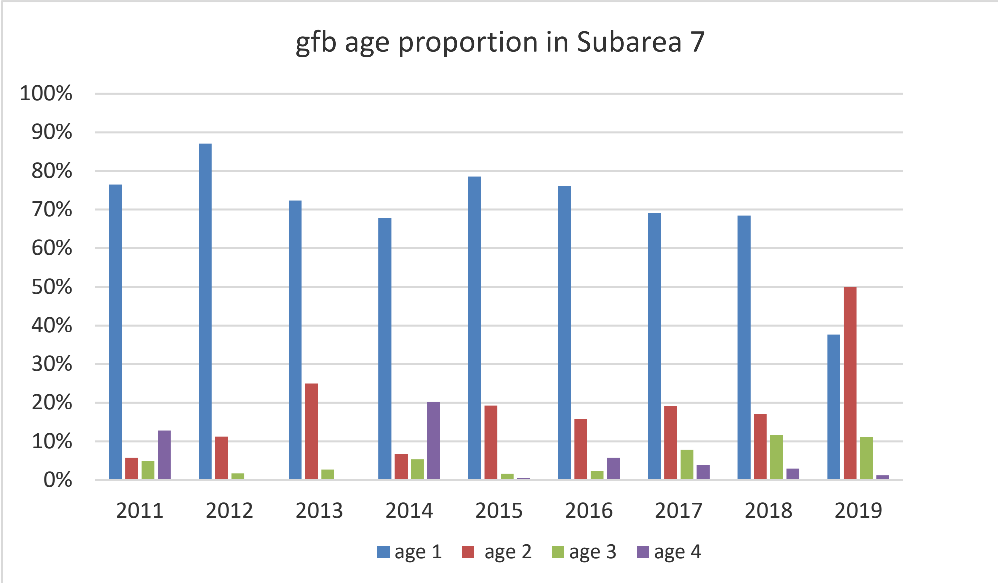


Figure 10.6a. Length frequency distribution of the greater forkbeard in the PT-CTS (UWTV (FU 28-29) until 2018.



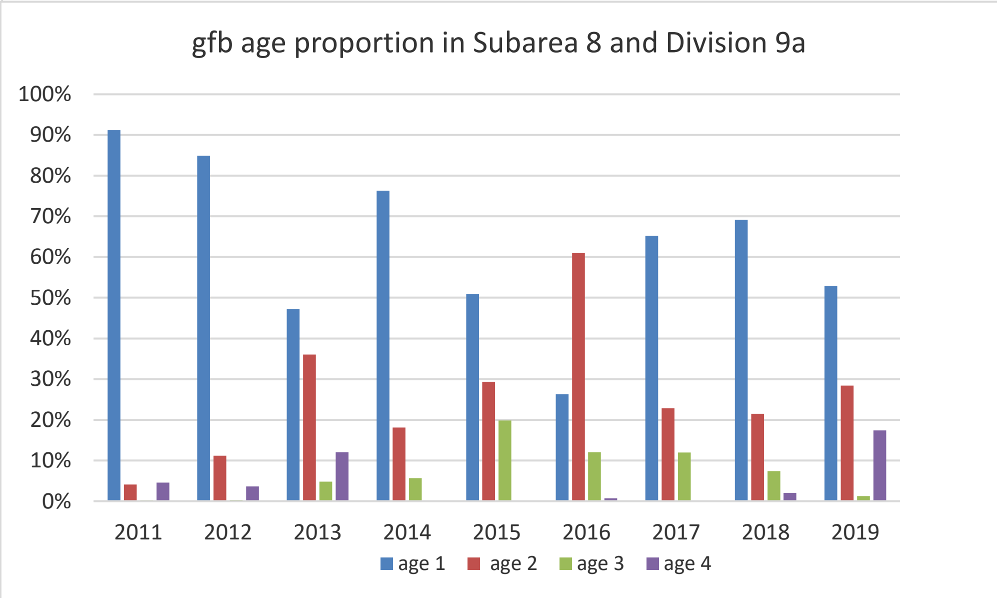


Figure 10.6b. Age proportion of the Spanish commercial fleets from 2011 to 2019 in subareas 7, 8 and Division 9a.

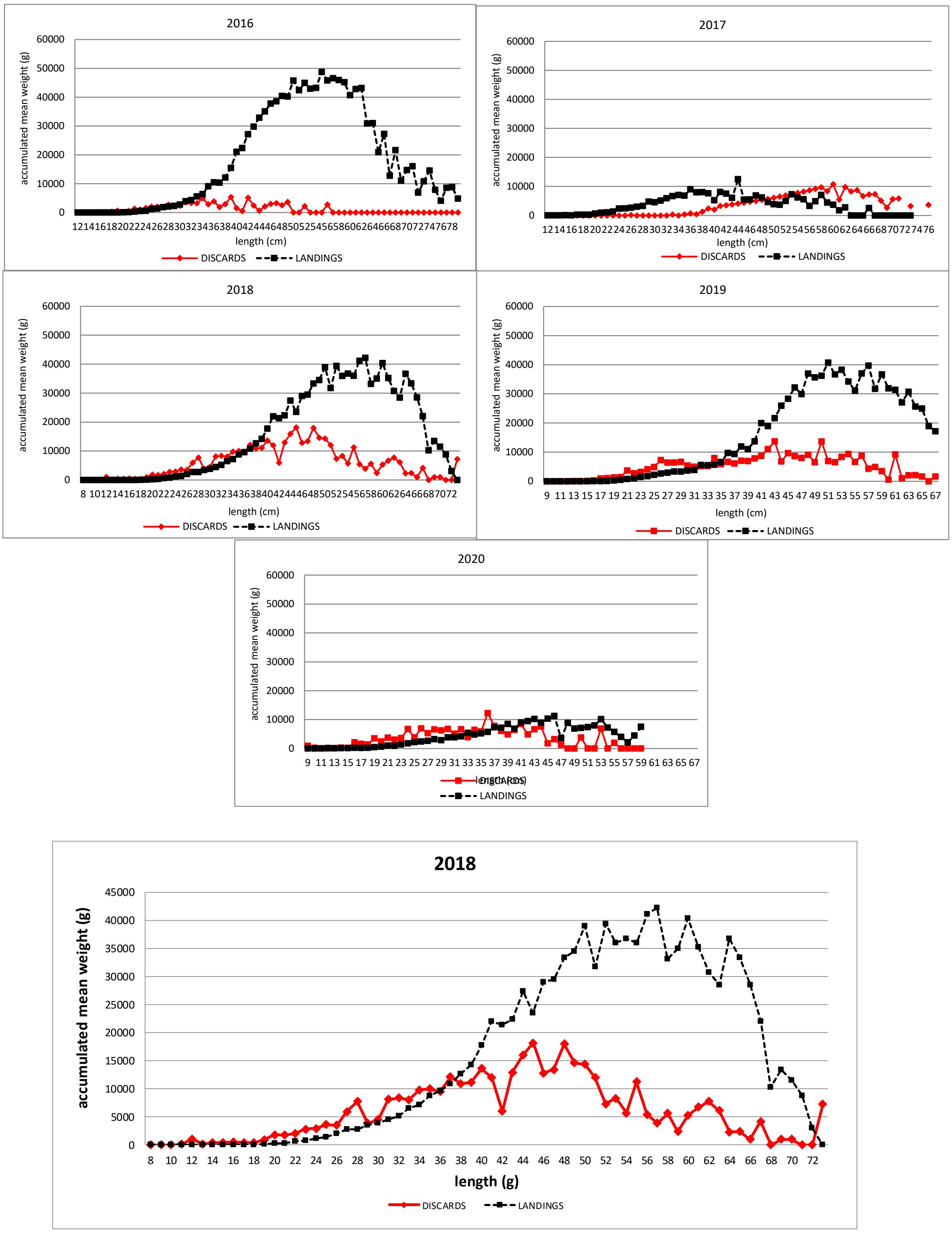


Figure 10.7 Accumulated mean weight at length of the international commercial landings and discards reported to InterCatch from 2016 to 2020.

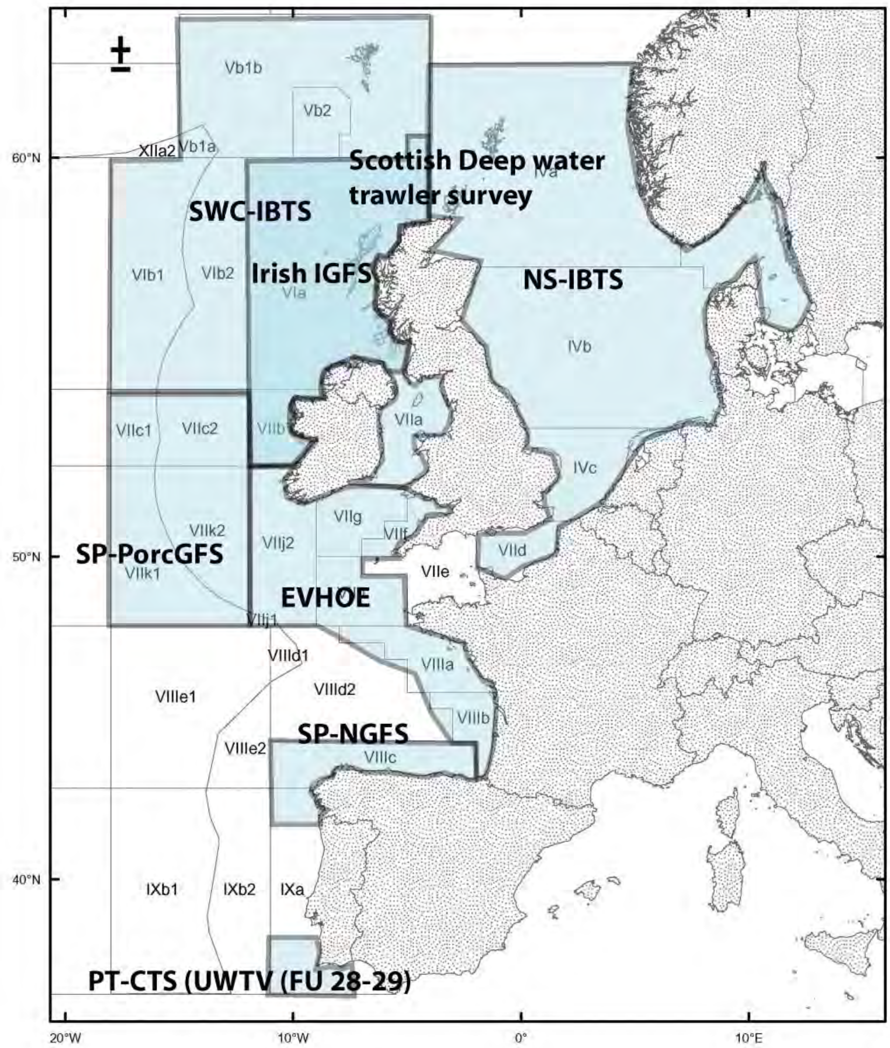


Figure 10.8. Map of the Divisions covered by the eight surveys used in the trend analysis of abundance and biomass of GFB.

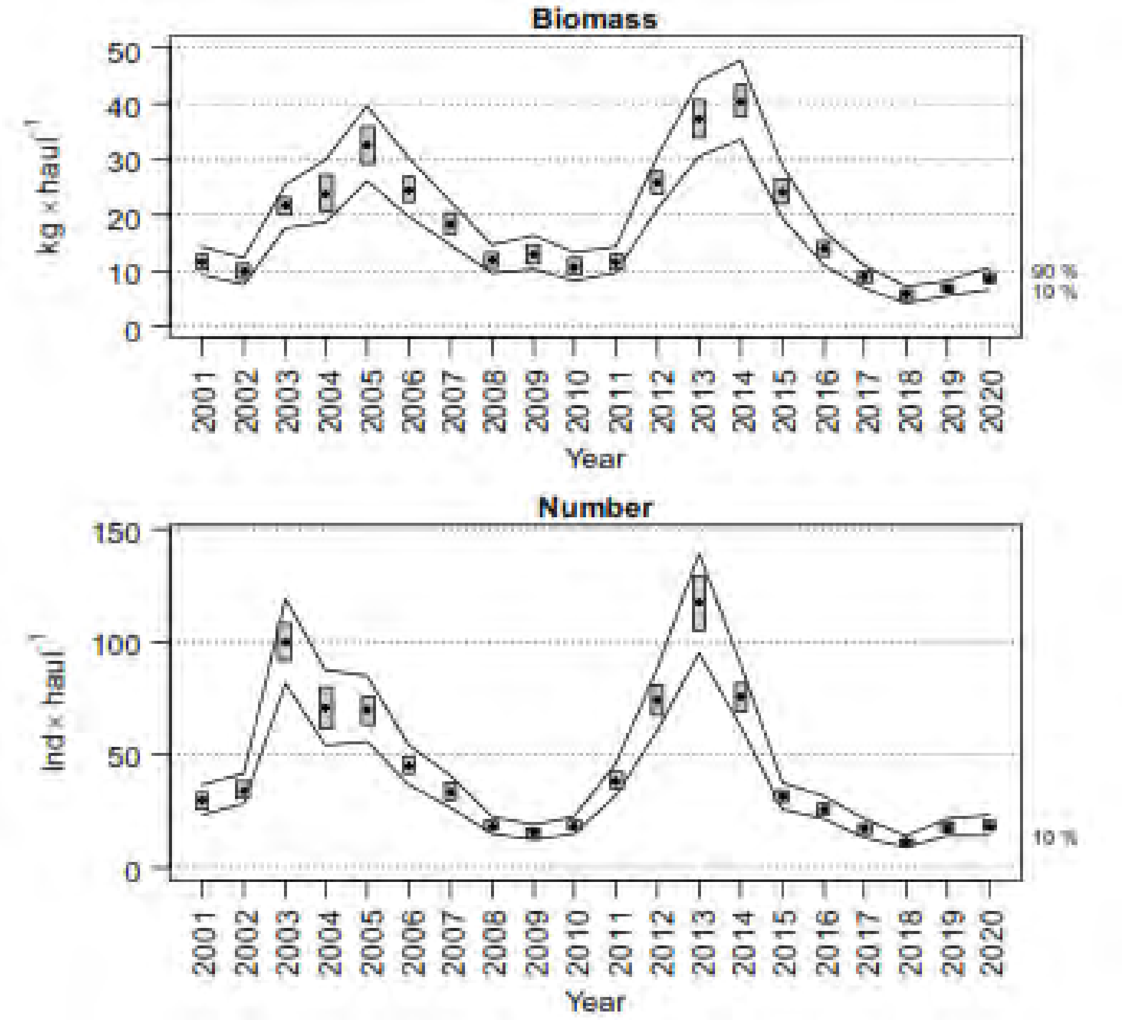


Figure 10.9. Evolution of *Phycis blennoides* biomass and abundance indices during Porcupine Survey time-series (2001–2020) in Divisions 7.c and 7.k. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000).

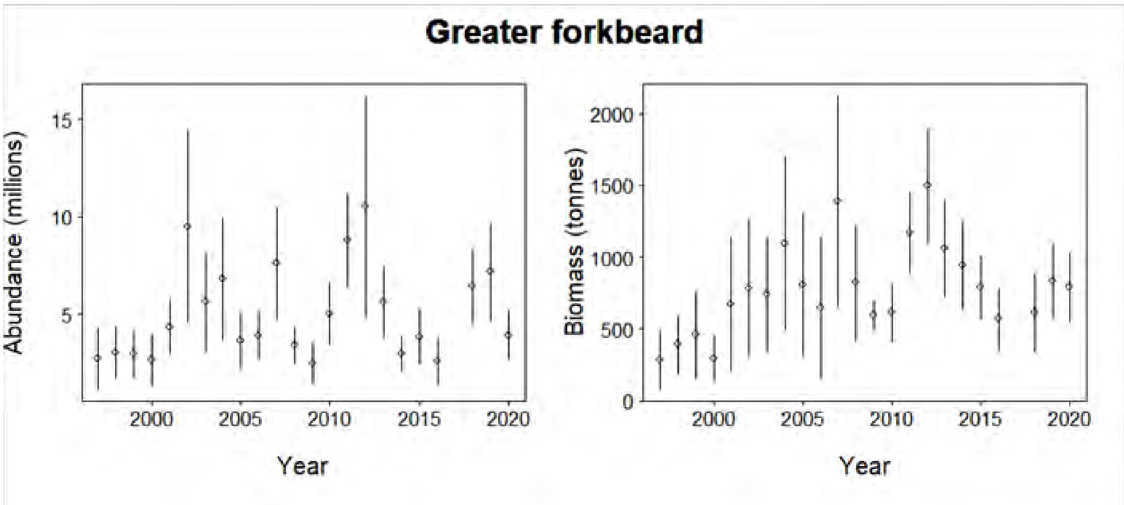


Figure 10.10. Greater forkbeard series of abundance and biomass of the French EVHOE IBTS survey in the Divisions 7.fghj and 8.abd combined until 2020.

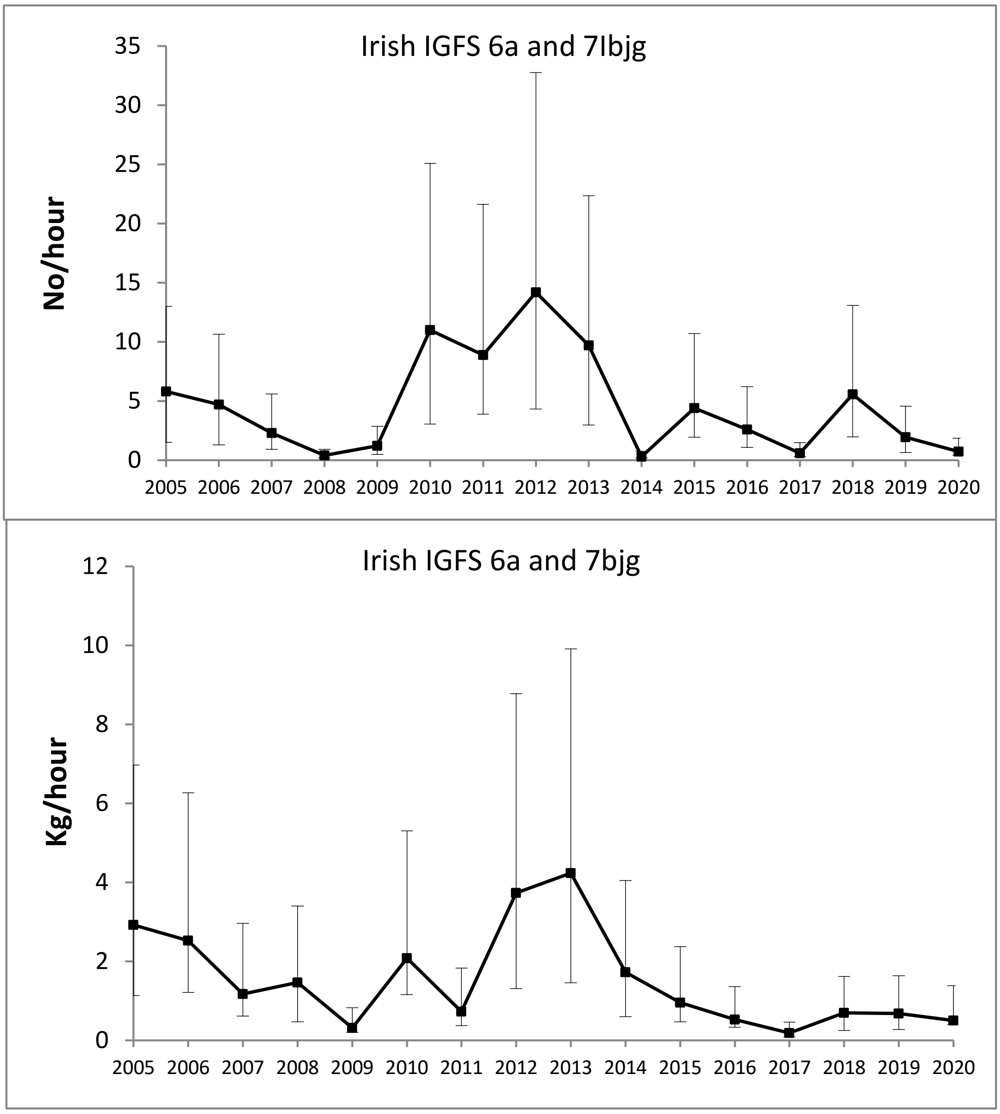


Figure 10.11. Abundance and biomass Indices (no. per hour and kg per hour) of Greater forkbeard total catches of the Irish IGFS Survey in the slope and shelf strata, 2005–2020.

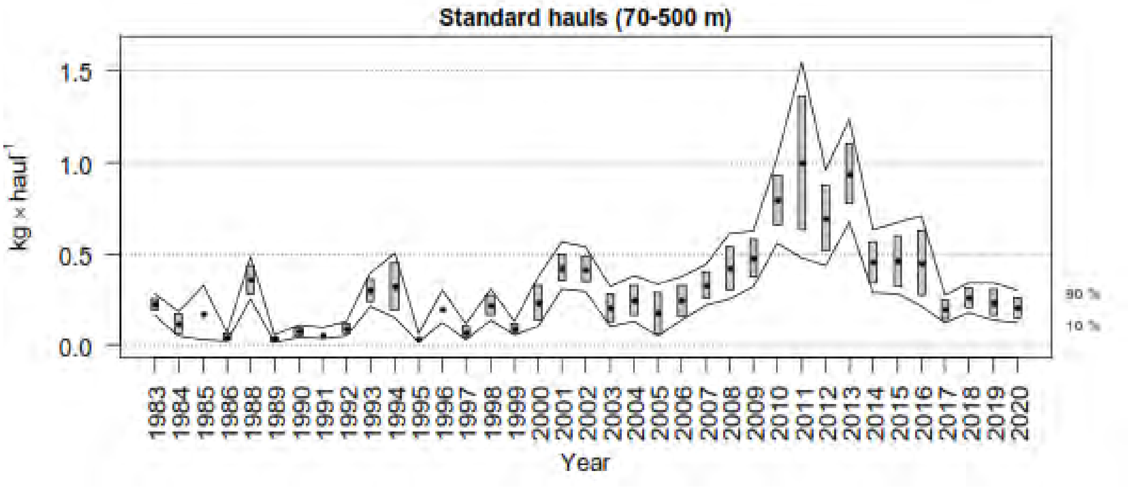


Figure 10.12. Changes in *Phycis blennoides* biomass index (kg/haul) during northern Spanish Shelf bottom-trawl survey time-series (1990–2020) in Divisions 9.a and 8.c.

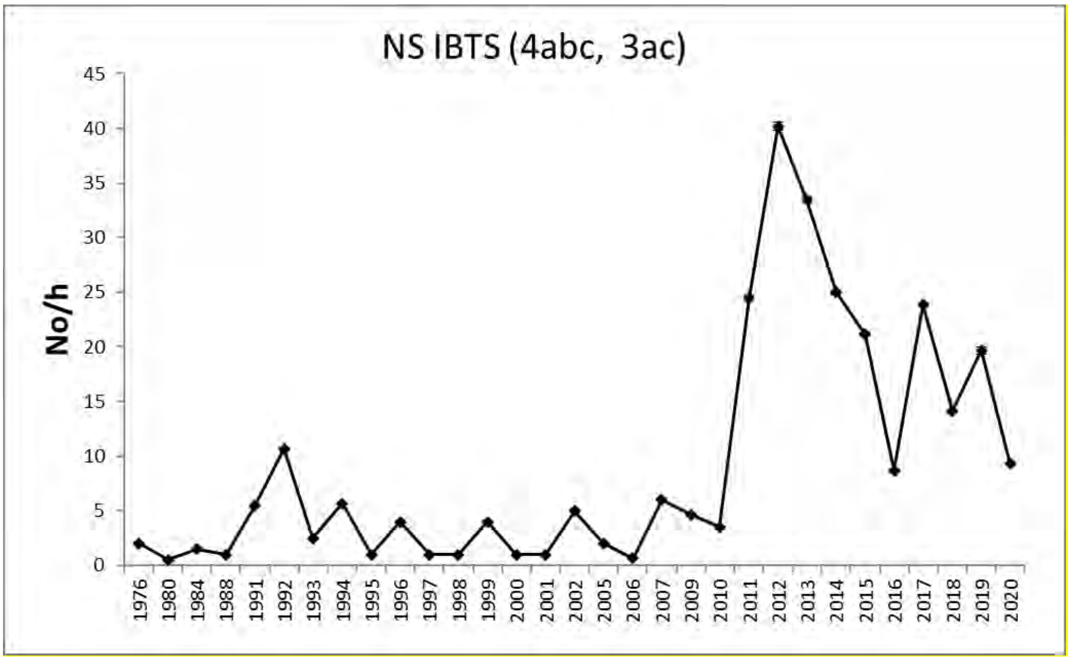


Figure 10.13. Greater forkbeard series of abundance (No/hour) of the North Sea IBTS survey (NS-IBTS) until 2020 in Divisions 4.abc and 3.ac.

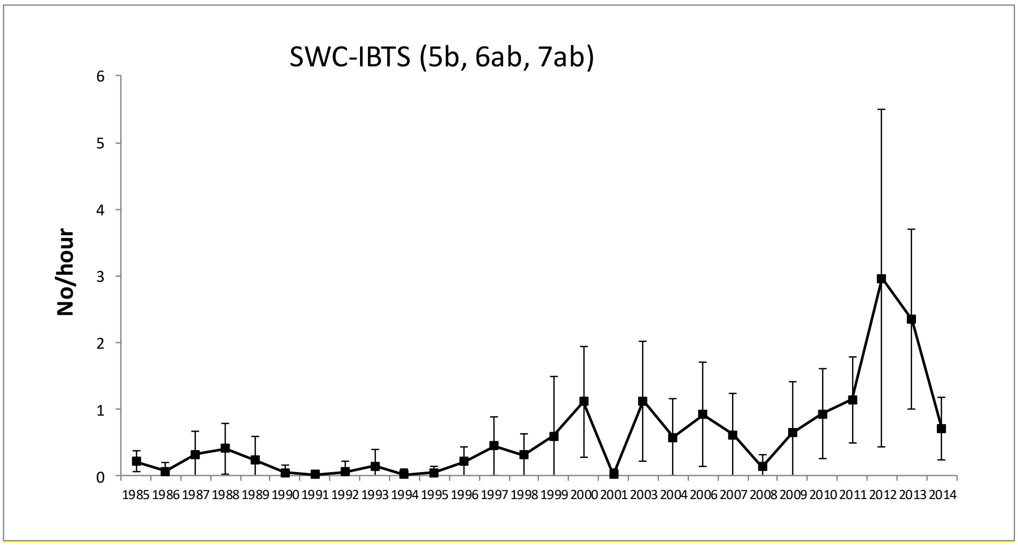


Figure 10.14. Greater forkbeard series of abundance (No/hour) of the Scottish Western Coast Groundfish IBTS survey (SWC-IBTS) until 2014 in Divisions 5.b, 6.ab and 7.ab.

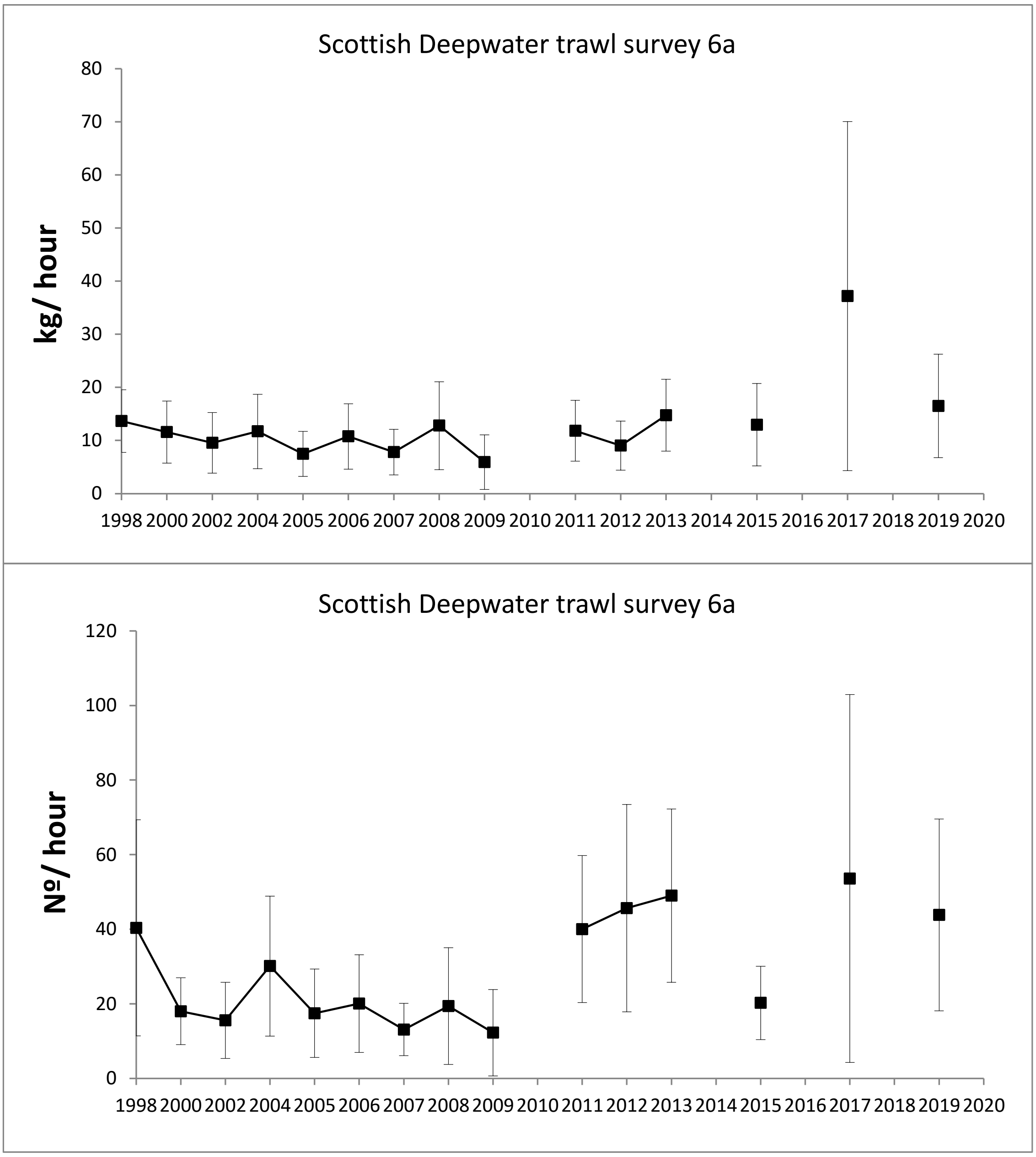


Figure 10.15. Greater forkbeard series of biomass (kg/hour) and abundance (Nº/hour) of the Scottish Deep-water trawl survey until 2020 in Division 6.a.

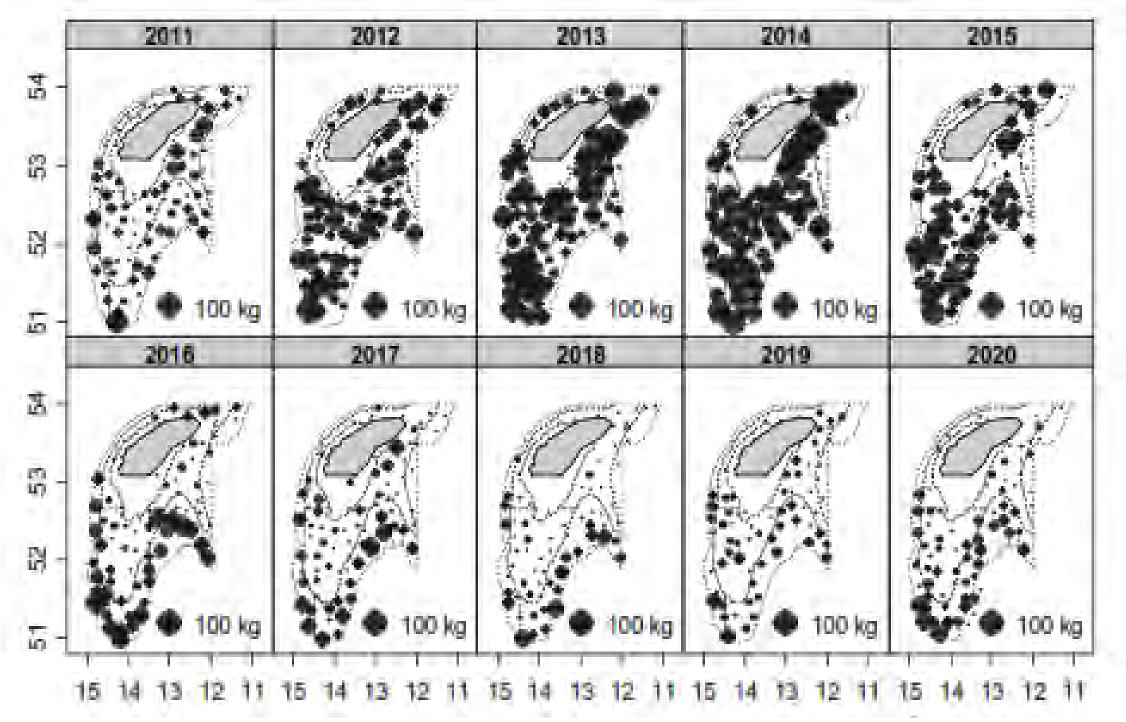


Figure 10.17. Geographic distribution of *Phycis blennoides* catches (kg/30 min haul) in Porcupine surveys between 2011 and 2020.

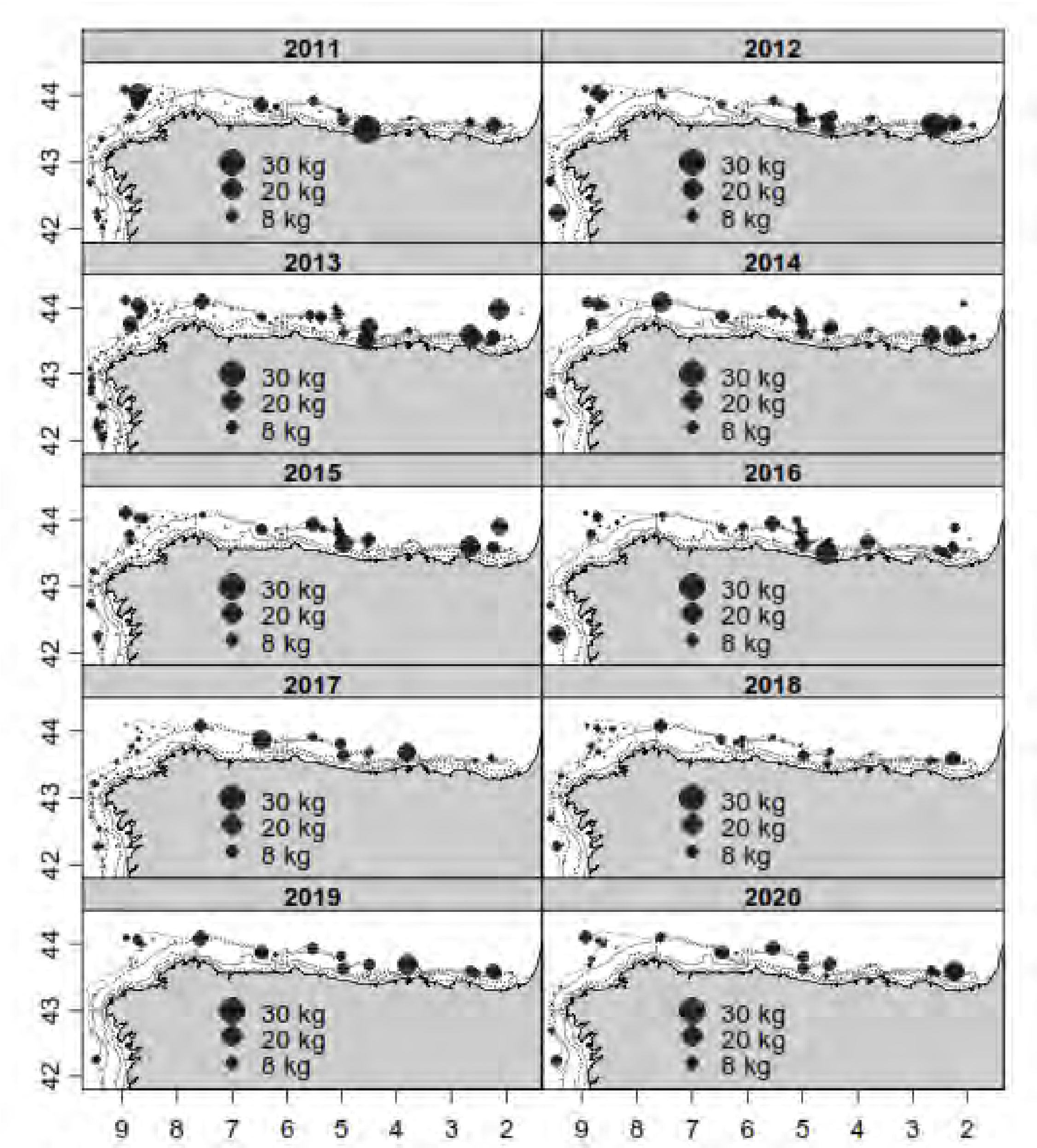


Figure 10.18. Catches in biomass of greater forkbeard on the Northern Spanish Shelf bottom-trawl surveys during the period: 20011–2020.

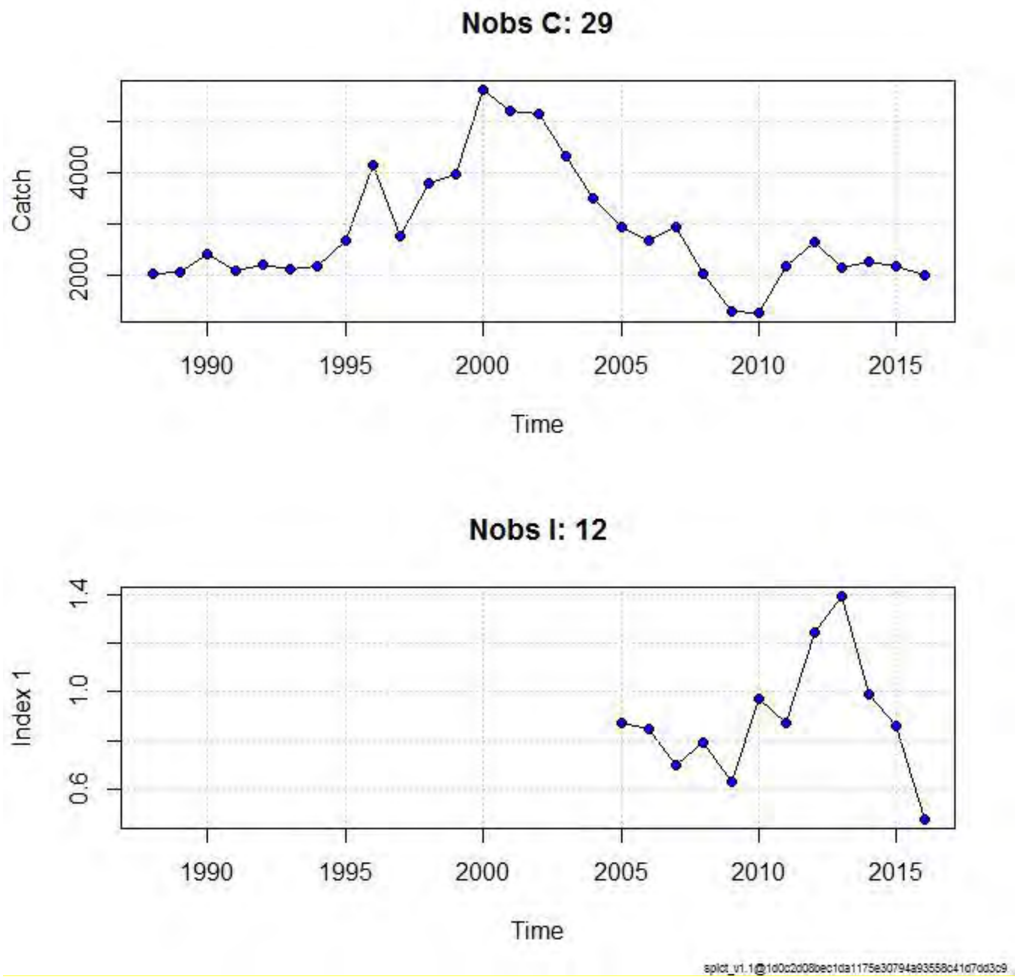


Figure 10.19. Inputs of the SPICT model used in the Greater Forkbeard stock.

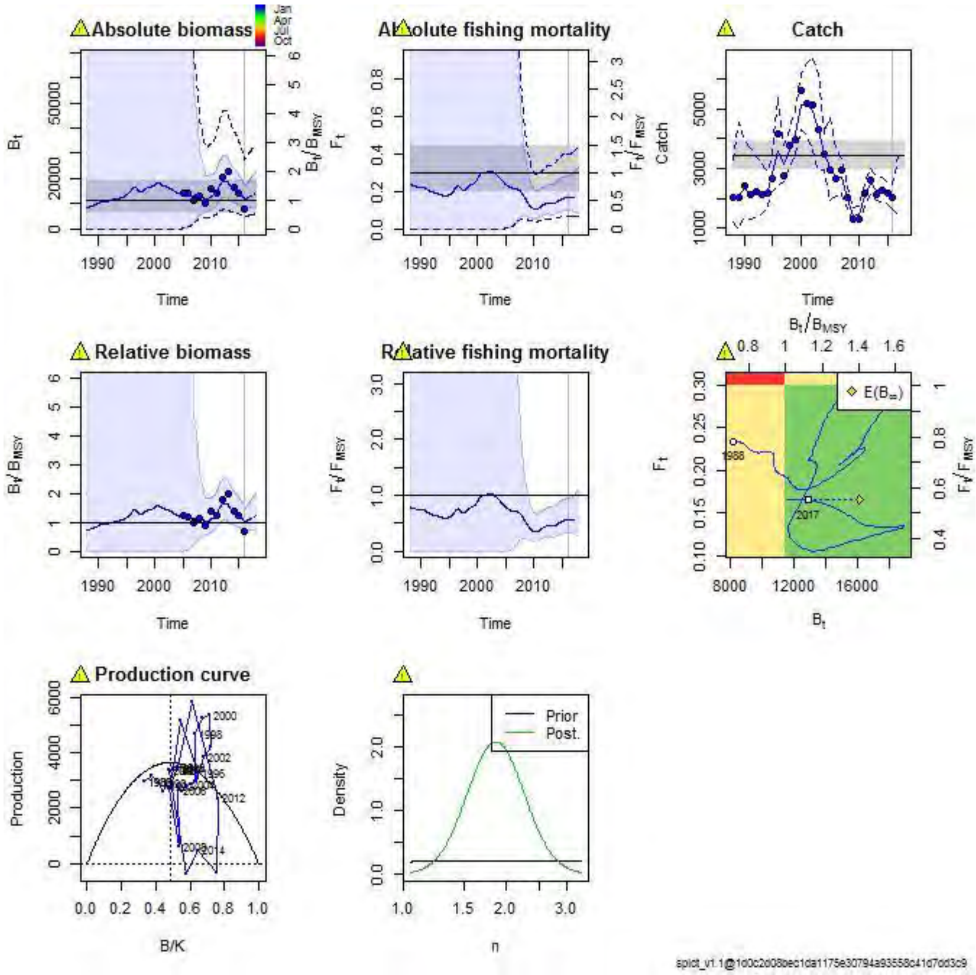


Figure 10.20. Results of the SPICT model for the Greater Forkbeard stock.

10.11 References

Lagarto N., Moura, T., Figueiredo I. 2016. Greater forkbeard *Phycis blennoides* in Portuguese waters (ICES division IXa). Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources Copenhagen, 20 -27th April 2016. 12 pp.

Farias, I., Moura, T., Figueiredo I. 2021. Greater forkbeard *Phycis blennoides* in Portuguese waters (ICES Division 27.9.a). Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources. 22th April -28th April 2021. 20 pp.

O. Fernández-Zapico, S. Ruiz-Pico, M. Blanco, F. Velasco & F. Baldó. 2021. Results on silver smelt (Argentina silus and *A. sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*), roughsnout grenadier (*Trachyrincus scabrus*), Spanish ling and ling (*Molva macrophthalma* and *Molva molva*) from the Porcupine Bank Survey (NE Atlantic) Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources By correspondence, 22th to 28th April, 2021. 17 pp.

S. Ruiz-Pico, O. Fernández-Zapico, M. Blanco, A. Punzón, I. Preciado, J.M. Gonzalez Irusta, F. Velasco. 2021. Results on greater forkbeard (*Phycis blennoides*), Spanish ling (*Molva macrophthalma*), roughsnout grenadier (*Trachyrincus scabrus*), bluemouth (*Helicolenus dactylopterus*) and other scarce deep water species on the Northern Spanish Shelf Groundfish Survey. Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources By correspondence, 22th to 28th April, 2021. 19 pp.

11 Alfonsinos/Golden eye perch (*Beryx* spp.) in all ecoregions

11.1 The fishery

Alfonsinos, *Beryx splendens* and *Beryx decadactylus*, are generally considered as bycatch species in the demersal trawl and longline mixed fisheries targeting other deep-water species. For most of the fisheries, the catches of alfonsinos are reported under a single category, as *Beryx* spp.

The proportions of each species in the catches are not well known. Detailed landings data by species are available only for the Portuguese (Azores) hook and line fishery in Division 10a2, where the landings of *B. decadactylus* averaged 20% of the catches of both species in the last twenty years, and for the Russian trawl fishery that targeted *B. splendens*. Portuguese, Spanish and French trawlers and longliners are the main fleets involved in this fishery.

Landings from a targeted fishery by Russian vessels operating in the NEAFC area (ICES Division 10.b) were available for the period 1993 - 2000 and some minor landings as bycatch in fisheries targeting other species since 2000. Since 2000 Currently, there are no target fisheries occurring in Mid-Atlantic Ridge (NEAFC) (see Section 4).

Currently landings are reported from bycatch fisheries occurring in the NEAFC regulatory area (RA) of ICES Division 10.b from Faroese vessels and in the EEZ of Portugal (Subarea 9), Spain (6, 7, 8 and 9), France (6, 7 and 8), and from a small-scale target fishery based in the Azores operation in Division 10.a (See Table 11.1 c, d and e).

11.1.1 Landings trends

The available landings data for Alfonsinos, (*Beryx* spp.), by ICES subarea/division as officially reported to ICES or to the working group, are presented in Tables 11.1(a–g), 11.2 and 11.3 and Figures 11.1–11.5. Total landings are stabilized since 2005, due to management measures introduced (TAC/quotas and effort regulation), being around 337 t between 2005 and 2020, with high landings during 2012 (605 t). Current catches are 171 t. Faroes reported a landing of 141 t for 2015, 48 t for 2016,5 t for 2019 from area 10.b. There were no landings reported during 2020.

11.1.2 ICES Advice

ICES advice that when the precautionary approach is applied, landings should be no more than 224 t in each of the years 2021 and 2022. ICES cannot quantify the corresponding catches.

11.2 Management

Fishing with trawl gears is forbidden in the Azores region (EC. Reg. 1568/2005). A box of 100 miles limiting the deep-water fishing to vessels registered in the Azores was created in 2003 under the management of fishing effort of the CFP for deep-water species (EC. Reg. 1954/2003). An EU TAC of 187 t for EC vessels is in force for the period 2021–2022 (see historical developments on the table down).

Technical measures were introduced in the Azores in 1998. During 2009 new measures were adopted, particularly to control the effort of longliners through restrictions on fishing area, minimum length, gear and effort. These measures were updated during 20152019. A network of MPAs was implemented on the Azores with closed access to deep-water fisheries (including Sedlo, D. J Castro and Formigas seamounts). The seamount (Condor) was closed to the fishery.

NEAFC adopted effort regulations for fisheries targeting deep-water species and in closed areas to protect vulnerable habitats on the RA. (http://neafc.org/managing_fisheries/measures/current).

Regulation	Species	Year	ICES Area	TAC	Landings
Reg 2270/2004	*Beryx* sp	2005	3, 4, 5, 6, 7, 8, 9, 10, 12	328	422
	Beryx sp	2006	3, 4, 5, 6, 7, 8, 9, 10, 12	328	367
Reg 2015/2006	*Beryx* sp	2007	3, 4, 5, 6, 7, 8, 9, 10, 12	328	396
	Beryx sp	2008	3, 4, 5, 6, 7, 8, 9, 10, 12	328	405
Reg 1359/2008	*Beryx* sp	2009	3, 4, 5, 6, 7, 8, 9, 10, 12	328	382
	Beryx sp	2010	3, 4, 5, 6, 7, 8, 9, 10, 12	328	296
Reg 1225/2010	*Beryx* sp	2011	3, 4, 5, 6, 7, 8, 9, 10, 12	328	331
	Beryx sp	2012	3, 4, 5, 6, 7, 8, 9, 10, 12	328	596
Reg 1262/2012	*Beryx* sp	2013	3, 4, 5, 6, 7, 8, 9, 10, 12	312	272
	Beryx sp	2014	3, 4, 5, 6, 7, 8, 9, 10, 12	296	282
Reg. 1367/2014	*Beryx* sp	2015	3, 4, 5, 6, 7, 8, 9, 10, 12	296	224
	Beryx sp	2016	3, 4, 5, 6, 7, 8, 9, 10, 12	296	252
Reg. 2285/2016	*Beryx* sp	2017	3, 4, 5, 6, 7, 8, 9, 10, 12	280	240
	Beryx sp	2018	3, 4, 5, 6, 7, 8, 9, 10, 12	280	263
Reg. 2025/2018	*Beryx sp*	2019	3, 4, 5, 6, 7, 8, 9, 10, 12	252	294
	Beryx sp	2020	3, 4, 5, 6, 7, 8, 9, 10, 12	252	171
Reg.	*Beryx sp*	2021	3, 4, 5, 6, 7, 8, 9, 10, 12	187	
Reg.	*Beryx sp*	2022	3, 4, 5, 6, 7, 8, 9, 10, 12		

11.3 Stock identity

No new information.

11.4 Data available

11.4.1 Landings and discards

Tables 11.1a–g, describe the alfonsinos landings by subarea and country. In 2014 discards estimates for the Azorean longliners were reported (WD, Pinho, 2014). Annual longline discard estimates by year for the sampled trip vessels with alfonsinos catches during the period 2004–2011 range from 0.8% to 8.6% for *B splendens* and 0.07% to 10.2% for the *B. decadactylus* (Table 11.4). In 2018, discards of combined alfonsinos from longline fisheries represented about 5.8% (8.6 t) of total landings. These discards are mostly a result of the Azorean management measures such as TAC and minimum length.

11.4.2 Length compositions

No new information.

11.4.3 Age compositions

No new information

11.4.4 Weight-at-age

No new information.

11.4.5 Maturity, sex-ratio, length–weight and natural mortality

No new information.

11.5 Data analyses

No new information

11.6 Comments on the assessment

No assessment was carryout this here.

11.7 Management considerations

The spatial distribution of the two Beryx species is closely associated with seamounts. This behaviour as well as their life history make them particularly vulnerable to exploitation been easily overexploited by trawl fishing. It is admitted that both species can only sustain low rates of exploitation.

The population dynamics *Beryx* species are uncertain. Recent age estimates suggest high longevity (>50 years), while other estimates suggest a longevity of ~15 years.

Because of their biology and aggregative behaviour, fisheries on those species should not be allowed to expand above current levels unless it can be demonstrated that such expansion is sustainable. Furthermore, to prevent wiping out entire subpopulations that have not yet been mapped and assessed the exploitation of new seamounts should not be allowed.

11.8 References

ICES. 2018. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP), 11- 18 April 2018, ICES Headquarters, Copenhagen. ICES CM 2018/ACOM:14.

Medeiros-Leal, W.M.M; Santos, R.V.S; Novoa-Pabon, A.M; Silva, H; Pinho, M.R. 2020. Updating Survey data from the Azores for deep-water species. Working Document (WD). ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 24 April to 01 May 2020.

Medeiros-Leal, W.M.M; Santos, R.V.S; Novoa-Pabon, A.M; Silva, H; Pinho, M.R. 2020. Data from deep-water fishery of the Azores (ICES subdivision 27.10.a.2). Working Document (WD). ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 24 April to 01 May 2020.

Santos, R. V. S.; Novoa-Pabon, A. M.; Silva, H. M.; Pinho, M. R. 2019. Can we consider the stocks of alfonsinos *Beryx splendens* and *Beryx decadactylus* from the Azores a discrete Fishery Management Unit? *Journal of Fish Biology*, 94(6): 993-1000. https://doi.org/10.1111/jfb.13937

Santos, R. V. S.; Medeiros-Leal, W., Novoa-Pabon, A. M.; Pinho, M. R. 2020. Updated standardized CPUE for Beryx decadactylus caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017. Working Document (WD). ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 24 April to 01 May 2020.

Santos, R. V. S.; Medeiros-Leal, W., Novoa-Pabon, A. M.; Pinho, M. R. 2020. Updated standardized CPUE for Beryx spp. (alf.27.nea) caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017. Working Document (WD). ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 24 April to 01 May 2020.

Santos, R. V. S.; Medeiros-Leal, W., Novoa-Pabon, A. M.; Pinho, M. R. 2020. Updated standardized CPUE for Beryx splendens caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017. Working Document (WD). ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 24 April to 01 May 2020.

11.9 Tables and Figures

Table 11.1a. Landings (tonnes) of *Beryx* spp. from Subarea 4.

YEAR	FRANCE	TOTAL
1988	0	0
1989	0	0
1990	1	1
1991	0	0
1992	2	2
1993	0	0
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0

YEAR	FRANCE	TOTAL
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	0
2008	0	0
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	3	3
2019	0	0
2020*	0	0

***Preliminary.**

Table 11.1b. Alfonsinos (*Beryx* spp.) from Division 5.b.

YEAR	FAROES	FRANCE	TOTAL
988			0
1989			0
1990		5	5
1991		0	0
1992		4	4
1993		0	0

YEAR	FAROES	FRANCE	TOTAL
1994		0	0
1995	1	0	1
1996	0	0	0
1997	0	0	0
1998	0	0	0
1999	0	0	0
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0
2010	0	0	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0	0	0
2015	0	0	0
2016	0	0	0
2017	0	0	0
2018	0	0	0
2019	0	0.1	0.1
2020*	0	0	0

***Preliminary.**

Table 11.1c. Alfonsinos (*Beryx* spp.) from Subareas 6 and 7.

YEAR	FRANCE	E & W	SPAIN	IRELAND	SCOTLAND	TOTAL
1988						0
1989	12					12
1990	8					8
1991						0
1992	3					3
1993	0		1			1
1994	0		5			5
1995	0		3			3
1996	0		178			178
1997	17	4	5			26
1998	10	0	71			81
1999	55	0	20			75
2000	31	2	100			133
2001	51	13	116			180
2002	35	15	45			95
2003	20	5	55	4		84
2004	15	3	46			64
2005	15	0	55	0		70
2006	27	0	51	0		78
2007	17	1	47	0		65
2008	22	0	32	0		54
2009	9	0	0	0	1	10
2010	4	0	0	0	1	5
2011	7	0	33	0	0	40
2012	4	0	337	0	0	341
2013	14	1	33	0	0	77
2014	10	0	38	0	0	49
2015	6	0		6	0	12
2016	5	0.45	13	0	1	20

YEAR	FRANCE	E & W	SPAIN	IRELAND	SCOTLAND	TOTAL
2017	7	0	11	0	0	18
2018	27	0.209	19	0	0	46
2019	57		24	0	0	81
2020*	7	3.1	0	0	0	11

*Preliminary.

Table 11.1d. Alfonsinos (*Beryx* spp.) from Subareas 8 and 9.

YEAR	FRANCE	PORTUGAL	SPAIN	E & W	TOTAL
1988					0
1989					0
1990	1				1
1991					0
1992	1				1
1993	0				0
1994	0		2		2
1995	0	75	7		82
1996	0	43	45		88
1997	69	35	31		135
1998	1	9	258		268
1999	11	29	161		201
2000	7	40	117	4	168
2001	6	43	179	0	228
2002	13	60	151	14	238
2003	10	0	95	0	105
2004	21	53	209	0	283
2005	9	45	141	0	195
2006	8	20	64	3	97
2007	8	45	67	0	120
2008	5	42	54	0	101
2009	1	42	18	0	61

YEAR	FRANCE	PORTUGAL	SPAIN	E & W	TOTAL
2010	12	27	1	0	41
2011	4	21	40	0	65
2012	4	11	27	0	42
2013	5	17	4	0	26
2014	3	18	81	0	102
2015	3	0	59		61
2016	3	1	71	0	76
2017	3	2	67	0	73
2018	6	0	52	0	58
2019	5	10	55		70
2020*	10	11			21

*** Preliminary.**

Table 11.1e. Alfonsinos (*Beryx* spp.) from Subarea 10.

	10.a	**10.b**				
YEAR	PORTUGAL	FAROES	NORWAY	RUSSIA**	E & W	TOTAL
1988	225					225
1989	260					260
1990	338					338
1991	371					371
1992	450					450
1993	533		195			728
1994	644		0	837		1481
1995	529	0	0	200		729
1996	550	0	0	960		1510
1997	379	5	0			384
1998	229	0	0			229
1999	175	0	0	550		725
2000	203	0	0	266	15	484
2001	199	0	0	0	0	199

	10.a	10.b				
2002	243	0	0	0	0	243
2003	172	0	0	0	0	172
2004	139	0	0	0	0	139
2005	157	0	0	0	0	157
2006	192	0	0	0	0	192
2007	211	0	0	0	0	211
2008	250	2	0	0	0	252
2009	311	1	0	0	0	312
2010	240	0	0	5	0	245
2011	226	4	0	5	0	235
2012	213	10	0	0	0	222
2013	168	0	0	0	0	168
2014	131	0	0	0	0	131
2015	151	141	0	0	0	292
2016	156	48	0	0	0	204
2017	149	0	0	0	0	149
2018	159	0	0	0	0	159
2019	138	5				143
2020*	139					139

*** Preliminary.**

**** Not official data from ICES Area 10.b.**

Table 11.1f. Alfonsinos (*Beryx* spp.) from Subarea 12.

YEAR	FAROES	TOTAL
1988		
1989		
1990		
1991		
1992		
1993		
1994		

YEAR	FAROES	TOTAL
1995	2	2
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	0
2008	0	0
2009	0	0
2010	0	0
2011	2	2
2012	0	0
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020*		

*** Preliminary.**

Table 11.1g. Landings of Alfonsinos (*Beryx* spp.) from Madeira (Portugal) outside the ICES area.

YEAR	*B. splendens*	*B. decadactylus*	TOTAL
1988*			
1989*			
1990*			
1991*			
1992*			
1993*			
1994*			
1995*			
1996*			
1997*			
1998*			
1999*			
2000*			
2001*			
2002*			
2003*			
2004*			
2005*			
2006*			
2007*			
2008	290	342	632
2009	88	16	104
2010	355	17	372
2011	79	137	216
2012	228	51	279
2013	38	11	49
2014	140	26	166
2015	63	12	75
2016	58	20	78

YEAR	*B. splendens*	*B. decadactylus*	TOTAL
2017	41	78	119
2018	234	83	317
2019	90	146	236
2020	12	11	23

* No information.

Table 11.1h. Reported landings for the alfonsinos, (*Beryx* spp.), by ICES subarea/division.

YEAR	4	5.b	6+7	8+9	10.a	10.b	12	TOTAL
1988			0	0	225	0		225
1989			12	0	260	0		272
1990	1	5	8	1	338	0		353
1991			0	0	371	0		371
1992	2	4	3	1	450	0		460
1993			1	0	533	195		729
1994			5	2	644	837		1488
1995		1	3	82	529	200	2	817
1996			178	88	550	960	0	1776
1997			26	135	379	5	0	545
1998			81	268	229	0	0	579
1999			75	201	175	550	0	1001
2000			133	168	203	281	0	785
2001			180	228	199	0	0	607
2002			95	238	243	0	0	577
2003			84	105	172	0	0	361
2004			64	283	139	0	0	485
2005			70	195	157	0	0	422
2006			78	97	192	0	0	367
2007			65	120	211	0	0	396
2008	0	0	54	101	250	2	0	407
2009	0	0	10	61	311	1	0	383

YEAR	4	5.b	6+7	8+9	10.a	10.b	12	TOTAL
2010	0	0	5	41	240	5	0	291
2011	0	0	40	65	226	9	2	342
2012	0	0	341	42	213	10	0	605
2013	0	0	77	26	168	0	0	272
2014	0	0	49	102	131	0	0	282
2015	0	0	12	61	151	141	0	365
2016	0	0	20	76	156	48	0	300
2017	0	0	18	73	149	0	0	240
2018	0	0	46	58	159		0	263
2019	0	0	81	70	143		0	294
2020*	0	0	11	21	139	0	0	171

*Preliminary.

Table 11.3. Reported landings of *Beryx splendens* and *B. decadactylus* in the Azores (ICES Division 10a2).

YEAR	*B. Splendens*	*B. Decadactylus*	TOTAL
1988	122	103	225
1989	113	147	260
1990	137	201	338
1991	203	168	371
1992	274	176	450
1993	316	217	533
1994	410	234	644
1995	335	194	529
1996	379	171	550
1997	268	111	379
1998	161	68	229
1999	119	56	175
2000	168	35	203
2001	182	17	199
2002	223	20	243

YEAR	*B. Splendens*	*B. Decadactylus*	TOTAL
2003	150	22	172
2004	110	29	139
2005	134	23	157
2006	152	40	192
2007	165	46	211
2008	187	63	250
2009	243	68	311
2010	189	51	240
2011	179	47	226
2012	175	37	213
2013	140	28	168
2014	109	22	131
2015	120	31	151
2016	127	29	156
2017	119	30	149
2018	107	50	157
2019	92	46	138
2020*	67	72	139

*Preliminary.

Table 11.4. Annual percentage of *Beryx* spp. discarded by year in the Azores (ICES Division 10a2) from the sampled trip vessels that caught and discard alfonsinos.

SPECIES	2004	2005	2006	2007	2008	2009	2010	2011
Beryx splendens	1,79	1,87	1,55	1,02	1,19	8,64	4,69	0,76
Beryx decadactylus	0,37	0,07	1,31	0,14	0,57	10,18	2,36	0,95

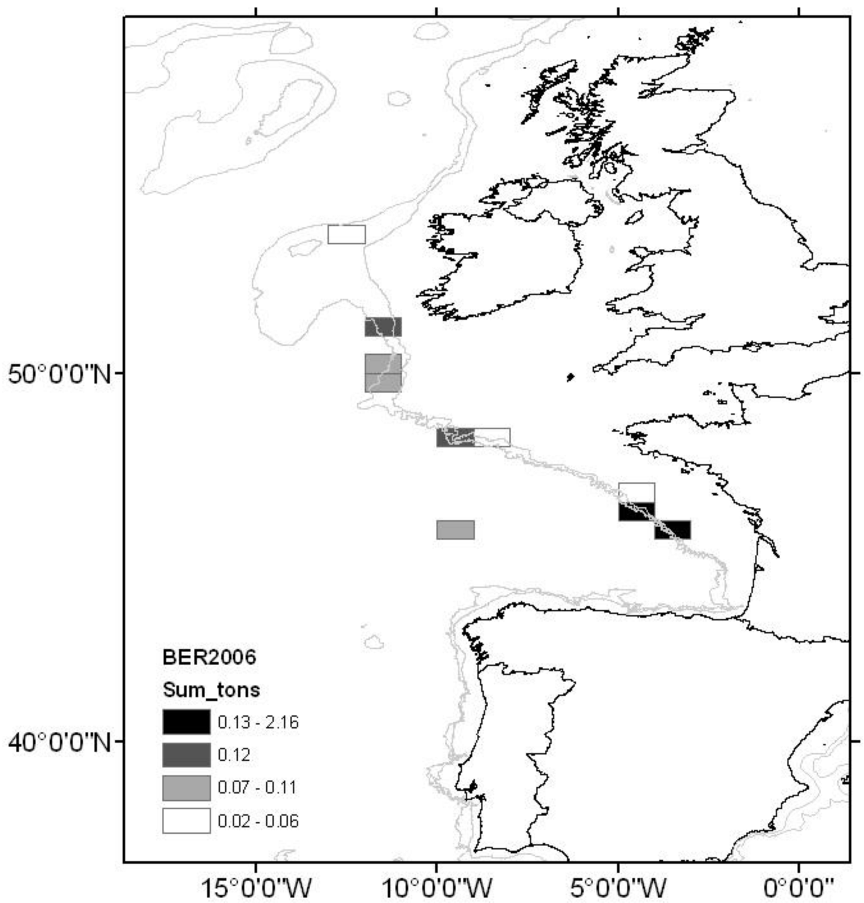


Figure 11.1. Catches of alfonsinos by French, Irish, UK (England and Wales and Scotland) and Icelandic vessels, 2006.

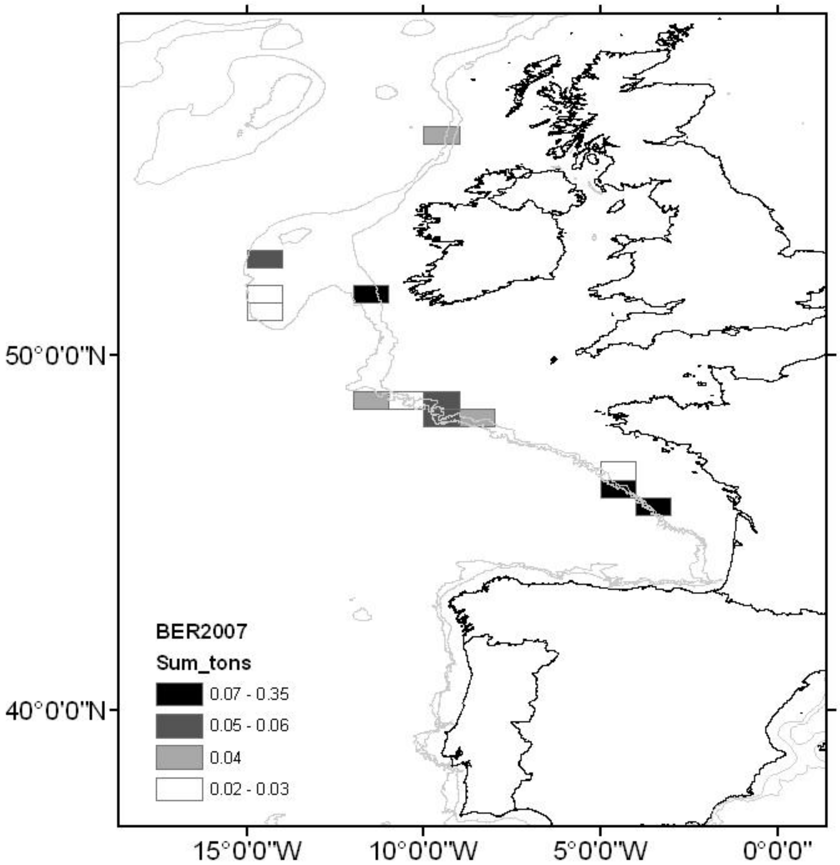


Figure 11.2. Catches of alfonsinos by French, Irish, UK (England and Wales and Scotland) and Icelandic vessels, 2007.

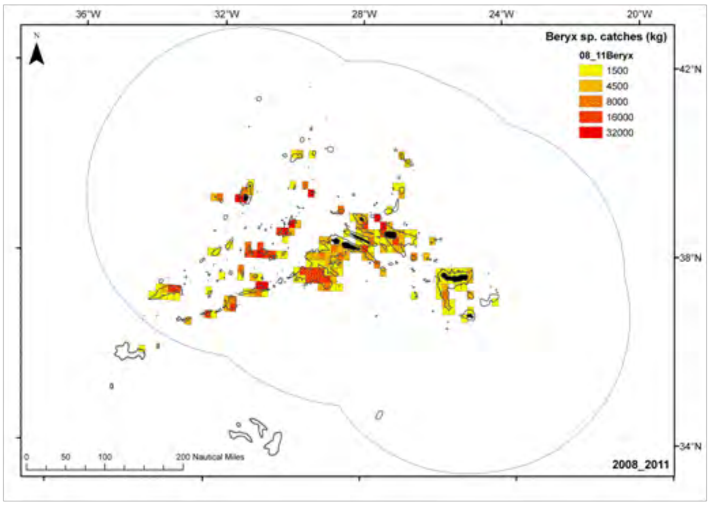


Figure 11.3. Catches of alfonsinos by Azores vessels, 2008–2011 (ICES, 10a2).

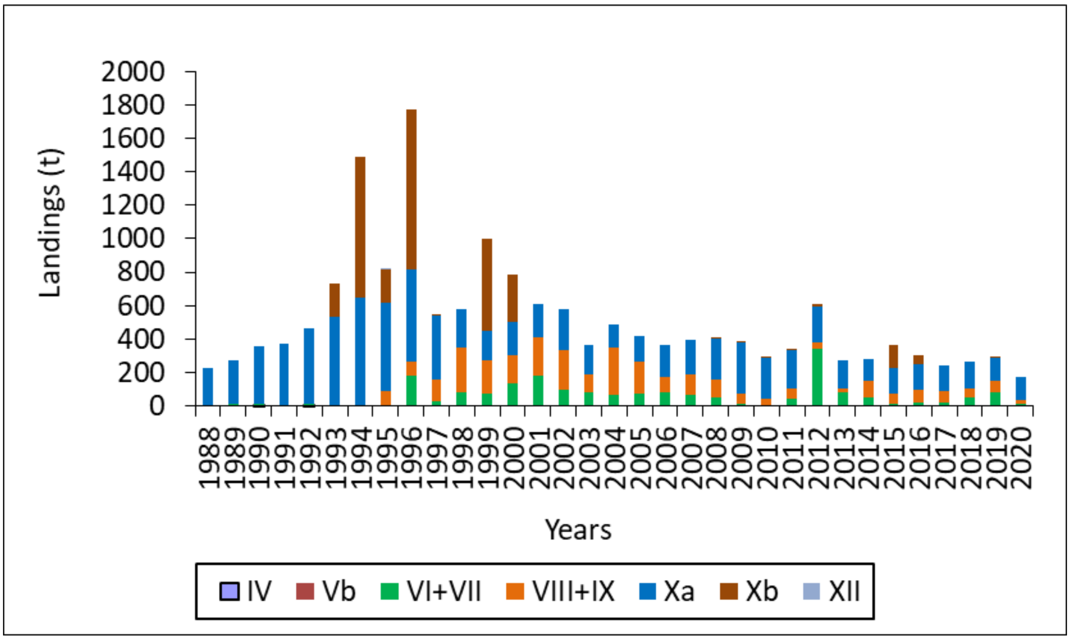


Figure 11.4. Reported landings for the alfonsinos, (*Beryx* spp), by ICES subarea/division.

12 Blackspot seabream (*Pagellus bogaraveo*)

12.1 Stocks description and management units

The stock structure of blackspot seabream in ICES area is still unknown. Thus, for stock assessment and scientific advice on management purposes ICES considers three different components : a) Subareas 6, 7, and 8; b) Subarea 9, and c) Subarea 10 (Azores region).

The interrelationships of the blackspot seabream from subareas 6, 7, and 8, and the northern part of Division 9.a, and their migratory movements within these areas have been observed by tagging studies (Gueguen, 1974). However, there is no evidence of movement to the southern part of 9.a where a target longline fisheries take places, which extends outside the ICES area.

Genetics studies show that there are no genetic differentiation between populations from different locations within the Azores region (east, central and west group of Islands, and Princesa Alice Bank) but there are genetic differences between Azores (ICES Subdivision 10.a.2) and mainland Portugal, ICES Division 9.a (Stockley et al., 2005). These results, combined with the known distribution of the species by depth, suggest that Subarea 10 component of this stock can effectively be considered as a separate assessment unit. Not genetic structure has been found on the Atlantic continental shelf with small genetic differentiation between the Mediterranean Sea and the Atlantic (Stockley et al., 2005, Pinera et al., 2007).

12.2 Blackspot seabream in Subareas 6, 7 & 8

12.2.1 The fishery

From the 1950s to the 1970s, the blackspot seabream was exploited mainly by French and Spanish bottom offshore trawlers, by artisanal pelagic trawlers in the eastern Bay of Biscay (ICES Divisions 8.a,b), and by Spanish longliners in the Cantabrian Sea (ICES Division 8.c), with smaller contributions from other fisheries (Lorance, 2011). Currently, EU Regulations state that no directed fisheries are permitted under the quota, therefore catches should be only bycatches.

In the period considered (1988–2020), most of the estimated landings from the Subareas 6, 7 and 8 were taken by Spain (70%), followed by France (18%), UK (10%) and Ireland (1%).

The fishery in Subareas 6, 7 and 8 strongly declined in the mid-1970s, and the stock is seriously depleted (Figure 12.2.1a and Table 12.2.1b). Since the 1980s, the species is mainly a bycatch from otter trawl, longline and gillnet fleets and only a few small-scale hand liners have been targeting the species. Since 1988 the landings from Subarea 8 represent 67% and 33% of total accumulated landings are from subareas 6 and 7. At present the blackspot seabream reported catches in these areas are almost all bycatches of longline and otter trawl fleets from France, Ireland and Spain.

12.2.2 Landings trends

Landings data by ICES Subareas reported to the working group are shown in Table 12.2.1a–c. Figure 12.2.1a presents an overview of the historical series of landings in Subareas 6, 7 and 8 since the middle of the last century. Figure 12.2.1b shows, in greater detail, landings of the same subareas since 1988. In 2014, UK (Scotland) reported landings for the first time in 7.j, and Netherlands since 2017 in Subarea 7. This ICES division represents part of the historical species distribution area (Olivier, 1928; Desbrosses, 1932).

For those three subareas combined, landings decreased from 461 t in 1989 to 52 t in 1996, increased again to a peak in 2007 (324 t) and then decreased in 2020 to 91 t in parallel to the reduction of the TAC in following years (from 350 t in 2003 and to 105 t in 2020).

12.2.3 ICES Advice

In 2018, ICES advised that when the precautionary approach is applied, there should be zero catch in each of the years 2019 and 2020.

12.2.4 Management

The EU TAC for subareas 6, 7, and 8 was set for the first time in 2003 and has been reducing since then from 350 t to 105 t in 2020. Landings in 2007, 2010, 2012, 2014, 2015, 2016 and 2018 were slightly above the TAC. A minimum landing size of 35 cm applied from 2010 to 2012 and a minimum conservation reference size of 33 cm applies since 11 May 2017 (commission implementing regulation (EU) 2017/787 of 8 May 2017).

***Pagellus bogaraveo* TACs and total landings in European countries in Subarea 27.6, 7, and 8 in recent years.**

Pagellus bogaraveo		
year	**TAC**	**landings**
2003	350	129
2004	350	183
2005	298	158
2006	298	139
2007	298	324
2008	298	159
2009	253	203
2010	215	281
2011	215	177
2012	215	257
2013	196	295
2014	178	256
2015	169	177
2016	160	164
2017	144	126
2018	130	133
2019	117	98
2020	102	91

Under Common Fisheries Policy it is stated that "Recreational fisheries can have a significant impact on fish resources and Member States should, therefore, ensure that they are conducted in a manner that is compatible with the objectives of the CFP" (Regulation (EU) no 1380/2013 of the European Parliament and of the Council). Therefore, a short account of regulations relevant to blackspot seabream in recreational fisheries is given here.

The Irish Specimen Fish Committee recommends that all recreational catches be returned alive, and the SI No. 747 of 2004 forbids commercial catching of blackspot seabream except where it is less than 5% of the total catch. In France, specific regulation for blackspot seabream set in 2019 forbids the landings of individuals smaller than 35 cm and the fishing of this species from 1 of January to 30 of June. Moreover, the French regulation, forbids the catch, landing and sale of this species to the purse seine fleet and established several catch limits by trip or by year to the rest of the fleets (trawlers, gillnetters and liners).

Since 2019 Spain has been established closure areas with the aim to protect the juveniles of this species (MAPA 2019). The regulation bans the Spanish trawling and deep-water long-liners fleets to fish in several areas of the centre and west of Division 8.c from April to September. Spain also established annually a maximum catch per day to the vessels involved in the fishery in subareas 6, 7, 8.

12.2.5 Data available

12.2.5.1 Landings and discards

The Spanish, French and UK extended landing time-series of *P. bogaraveo* in Northeast Atlantic were updated (Figure 12.2.1b). In recent years landings have been dropping in accordance to the continuous reduction of the biannual TAC since 2003.

Historically, discards are considered negligible, and estimates are available since 2014 representing between 0.0 % and 2.7% of the annual catches in all subareas (Table 12.2.2). Discards resulting from low quotas are compulsory as the fishery for the species ceases. In 2015 and 2016, discards in French fisheries may have resulted from legal closures of quota (MEDDE, 2015; MEEM, 2016). As the blackspot seabream is a highly valued species, it is likely that these reported discards are carcasses in bad condition recovered from nets, misidentification of the species in on-board observation and discards related to low quotas. The table 12.2.3, show that since 2017 there were not catches inside the NEAFC Regulatory Area (RA)

Misidentification in on-board observer program may occur as *P. bogaraveo* occurs at low abundance and other similar sparids species may also occur (*P. acarne*, *P. erythrinus*, *P. bellotii* and *Pagrus pagrus*).

12.2.5.2 Length compositions

Length–frequency distribution of commercial landings and discards since 2015, are presented (Figure 12.2.2). Length frequency distribution of discards reported data in InterCatch in 2017 were very scarce, therefore no length distribution for this year is presented. No length–frequency distribution for discards were presented in 2020 as in this year reported discards were 0 .

12.2.5.3 Age compositions

No age data were available to the working group. No age estimations are carried out for this stock.

12.2.5.4 Weight-at-age

Mean size and weight-at-age (Table 12.2.4) derived from Guéguen (1969) and Krug (1998) were used by Lorance (2011) as input data for the yield-per-recruit model used to simulate the effect of fishing mortality on the blackspot seabream stock of Bay of Biscay.

12.2.5.5 Maturity and natural mortality

Natural mortality of 0.2 was estimated by Lorance (2011). M was derived from the presumed longevity in the population according the rule M ¼ 4.22/t_{max}, where t is the maximum age in the population derived from data from many populations (Hewitt and Hoenig, 2005).

12.2.5.6 Catch, effort and research vessel data

At the current level of abundance, the blackspot seabream is rarely caught in the northern surveys by French EVHOE IBTS (Divisions 8.f,g,h,j; 8.a,b, and 7.d), Irish IGFS (Divisions 6.a South and 7.b), by Spanish Groundfish Survey in the Porcupine bank (SP-PorcGFS) in Divisions 7.c and 7.k, and is a scarce species in the Northern Spanish Shelf Groundfish Survey (SP-NGFS in Divisions 8c and 9a).

At the Northern Spanish Shelf Groundfish Survey *P. bogaraveo* is a scarce species. In 2019, both biomass (0.11 ± 0.11 Kg·haul^{-1}) and abundance (0.53 ± 0.53 ind·haul^{-1}) increased slightly after the decreasing trend from 2015, but for first time since 2013 no read sea breams were caught in 2020 (**Error! Reference source not found.**12.2.3, 12.2.4 and 12.2.5) (Ruiz-Pico et al 2021). Last information available indicated that specimens caught in 2019 ranged from 22 cm to 29 cm, with a mode in 25-26 cm (Figure 12.2.6) (Fernández-Zapico et al 2020).

In French surveys, similar to the current western IBTS, from early 1980s when the stocks were already low red seabream was still presented in 40–60% of the hauls. This proportion dropped to around zero by 1985 (Lorance, 2011). This observation indicates that the current survey is appropriate to detect and monitor a recovery of the stock if ever it happens. Catch of blackspot seabream in the EVHOE survey have been too rare to allow the calculation of a survey indicator. However, data from the survey are in accordance with a possible recent increase of the stock. In particular, a large catch of more than 1000 individuals occurred in the 2016 survey. Although, one single event is not significant, it is noteworthy that it occurred in the area where on-board observations of the species occur, and fishers report an increasing occurrence. These indications do not allow revising the stock status which should still be considered to lag below any possible reference point. However, they imply that a rebuilding has probably started. A quick appraisal of the level of occurrence that would be expected if the stock rebuilt to past levels can be found from two surveys carried out in the Bay of Biscay only in 1973 and 1976 with the same protocol and gear as the current EVHOE survey but covering only strata of Bay of Biscay shelf up to 200 m (Figure 12.2.7). In 1973 and 1976, blackspot seabream was caught in 25% and 55 % of the hauls respectively (Figure 12.2.8). Since the start of the current survey series in 1987, it has always been caught in less than 5% of the hauls in the same strata, some years not at all. In the same strata, it was caught in one out of more than 60 in each of 2015 and 2016. Therefore, a ten to thirty-fold increase in occurrence might occur to consider that the stock rebuilt to level from the 1960s and 1970s, where catch amounted to 15 000 t/year. The current monitoring with on-board observations and the EVHOE survey is insufficient to monitor this rebuilding accurately, while the stock is still low. The increase occurrence in on-board observations is however consistent with fishers reporting more encounter. If the increase persists, which is likely under the current management, occurrences in on-board observations and the survey might become significant in the next few years.

In the Irish IGFS (Divisions 6.a South and 7.b) is also a very scarce species and since 2010 only few kg in were caught in four years of the series. Also the occurrence along the whole stations in the survey is very low ranging since 2010 from 0% to 4.3% (Table 12.2.5)

12.2.6 Data analyses

Landings since 1988 are well below those recorded in the period from 1960 to 1986 in which landings ranged from 2000 t to up to 13 000 t (Figure 12.2.1a). Catches recorded in the surveys are very scarce and are mainly juveniles smaller than 30 cm.

In 2003 when TACs were set for this species there were conflicts between fishing métiers in this area small artisanal handliners requesting vessels targeting pelagic species, mostly sardine with trawls and seine, to avoid any bycatch of blackspot seabream. The introduction of the TAC and national quota had an impact on fishing practices.

In the same area, fishers report to encounter more frequently the species in recent years. This was investigated using French on-board observations (Figure 12.2.9). The method used consisted in estimating the proportion of fishing operations where the species was caught (landings and discards combined) in French on-board observations to the south of 49°N. The limit at 49°N north was set to include the south of the Celtic Sea to the West of Brittany, where the species was historically abundant. This was made for all bottom trawl types combined, and all bottom nets combined for years 2010 to 2016. Some increasing trend in the proportion of hauls with catch of the species can actually be seen for bottom trawls, although the proportion of positive hauls is still small (Figure 12.2.10).

12.2.7 Biological reference points

WKLIFE has not yet suggested methods to estimate biological reference points for stocks which have only landings data or are bycatch species in other fisheries. Therefore, no attempt was made to propose reference points for this stock.

12.2.8 Exploratory assessment

Ongoing studies carried out as part of the H2020 Pandora and the French National DynRose projects were presented to the group. This include an analysis of the essential habitats of the species and approaches to assess the current biomass.

The study of the habitats modelling applies several Species Distribution Model (SDM) in an Ensemble modelling approach. The study is carried out at the scale of whole species distribution area, including therefore not only the stock in the Celtic Sea and Bay of Biscay but also the area of the two other stock units considered by ICES (in Iberian and Azorean waters) and the Mediterranean western basin. Occurrence data from a number of sources including (1) French on-board observation, carried out in application of the EU data collection framework (DCF), (2) surveys, (3) CPUEs derived from the vessel monitoring system installed on Spanish artisanal vessels in the Strait of Gibraltar using GPRS/GSM (Burgos et al., 2013) and (4) data available from the WEB such as OBIS. Occurrence data were modelled using several physical chemical and biological environment variables including bathymetric, hydrological, seafloor and water data. Preliminary results suggest that only a low fraction of its potential habitat is occupied (realized habitat) by the blackspot seabream in the Bay of Biscay in recent years (Figure 12.2.11).

Approaches to assess the current biomass include acoustics and environmental DNA (eDNA) investigations. Acoustics surveys were carried out to the West of Brittany in 2019 and were presented during last year's meeting (ICES, 2020). In September 2020, a three days eDNA survey was carried out in the same area as the acoustic survey of 2019 (Figure 12.2.12). The results from the two approaches were consistent is terms of spatial distribution of the species. So far none of this method allow to derive a direct quantitative estimate of the biomass in the area surveyed and both have advantages and inconveniences. For acoustics, one drawback is that fishing operation are needed for identification of echoes and their classification. In the rocky area surveyed, this was done by handlining, which appeared to be selective as more species were identified from eDNA. In particular, with eDNA seabass seemed to occur at a similar abundance as blackspot seabream in the surveyed area, while it was not caught on handlines and the two species may have similar echoes. eDNA has a number of advantages, it covers all species (from microbes to mammals), all habitats (no issue like such as not trawlable grounds and does not depend on behaviour (egg daily vertical migration) and does need not need identification fishing. However, as no catches are implied, eDNA provides no information of population composition (size, sex).

12.2.9 Management considerations

In the 2014 advice, ICES recommend the establishment of a recovery plan for the stock. This stock is collapsed, and the advice is to reduce mortality by all means to allow the stock to rebuild, however neither a recovery plan nor scientific studies to support this recommendation have ever been applied in subareas 6, 7 and 8, only a minimum landing size of 35 cm was applied but only for the period from 2010–2012.

Measures should include protection for areas where juveniles occur. Recreational fisheries may be a significant proportion of the mortality of those juveniles owing to their coastal distribution. This was confirmed for the stock in Subarea 10 (Pinho, 2015).

Landings in 2007, 2010, 2012, 2014, 2015, 2016 and 2018 were slightly above the TAC.

12.2.10 References

Burgos, C., J. Gil, and L. A. del Olmo. 2013. The Spanish blackspot seabream (*Pagellus bogaraveo*) fishery in the Strait of Gibraltar: spatial distribution and fishing effort derived from a small-scale GPRS/GSM based fisheries vessel monitoring system. Aquatic Living Resources 26:399-407.

Desbrosses, P. 1932. La dorade commune (*Pagellus centrodontus* Delaroche) et sa pêche. Revue des Travaux de l'Office des Pêches Maritimes 5:167–222.

Guéguen, J. 1969. Croissance de la dorade, *Pagellus centrodontus* Delaroche. Revue des Travaux de l'Institut des Pêches Maritimes 33:251-264.

Hewitt, D. A. and J. M. Hoenig. 2005. "Comparison of two approaches for estimating natural mortality based on longevity." Fishery Bulletin 103: 433–437.

Krug, H. M., D. Rosa, G. Menezes, and M. Pinho. 1998. Age and growth of some demersal species of the Azores. Page 11 in ICES science conference, ICES CMO:84,11pp.

Lorance, P. 2011. "History and dynamics of the overexploitation of the blackspot seabream (*Pagellus bogaraveo*) in the Bay of Biscay." ICES Journal of Marine Science **68**(2): 290–301.

MAPA (Ministerio de Agricultura, Pesca y Alimentación) 2019. Orden APA/359/2019, de 26 de marzo, pola que se modifica la Orden AAA/661/2016, de 3 de abril, por la que se establecen criterios de desembarque de besugo capturado en aguas de la Unión y aguas internacionales de las zonas VI, VII y VIIdel Consejo Internacional para la Exploración del Mar (CIEM) en lo relativo al establecimiento de vedaen determinadas zonas del caladero Cantábrico Noroeste.

MEDDE (Ministère de l'écologie, du développement durable et et de l'énergie) 2015. Avis no 4 relatif à la fermeture de certains quotas et/ou sous-quotas de pêche pour l'année 2015, JORF n°0242 du 16 octobre 2016.

MEEM (Ministère de l'Environnement, de l'Energie et de la Mer) 2016. Avis n° 24 relatif à la fermeture de certains quotas et/ou sous-quotas de pêche pour l'année 2016, JORF n°0242 du 16 octobre 2016.

Olivier, R. 1928. Poissons de chalut, la dorade (*Pagellus centrodontus*). Revue des Travaux de l'Office des Pêches Maritimes I:5–32.

O. Fernández-Zapico, S. Ruiz-Pico, M. Blanco, I. Preciado, A. Punzón, F. Velasco. 2020. Results on Greater forkbeard (*Phycis blennoides*), Bluemouth (*Helicolenus dactylopterus*), Spanish ling (*Molva macrophthalma*) and Blackspot seabream (*Pagellus bogaraveo*) of the Northern Spanish Shelf Groundfish Survey. Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources Copenhagen, 24 April–1 May 2020. 19 pp.

S. Ruiz-Pico, O. Fernández-Zapico, M. Blanco, A. Punzón, I. Preciado, J.M. Gonzalez Irusta, F. Velasco. 2021. Results on greater forkbeard (*Phycis blennoides*), Spanish ling (*Molva macrophthalma*), roughsnout grenadier (*Trachyrincus scabrus*), bluemouth (*Helicolenus dactylopterus*) and other scarce deep water species on the Northern Spanish Shelf Groundfish Survey. Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources By correspondence, 22th to 28th April, 2021. 19 pp.

Pinera, J. A., G. Blanco, E. Vazquez, and J. A. Sanchez. 2007. Genetic diversity of blackspot seabream (*Pagellus bogaraveo*) populations off Spanish Coasts: a preliminary study. Marine Biology 151:2153-2158.

Pinho, M. (2015). "Harvesting juveniles of blackspot seabream (*Pagellus bogaraveo*) in the Azores (Northeast Atlantic): biological implications, management, and life cycle considerations." ICES Journal of Marine Science [ICES J. Mar. Sci.].

Stockley, B., G. Menezes, M. R. Pinho, and A. D. Rogers. 2005. Genetic population structure in the blackspot seabream (*Pagellus bogaraveo* Brunnich, 1768) from the NE Atlantic. Marine Biology 146:793-804.

12.2.11 Tables and Figures

Table 12.2.1a. Blackspot seabream in subareas 6 and 7; WG estimates of landings by country.

YEAR	FRANCE*	IRELAND	SPAIN	UK (E & W)	UK (Scot)	CH. ISLANDS*	NETHERLANDS	TOTAL
1988	52	0	47	153		0		252
1989	44	0	69	76		0		189
1990	22	3	73	36		0		134
1991	13	10	30	56		14		123
1992	6	16	18	0		0		40
1993	5	7	10	0		0		22
1994	0	0	9	0		1		10
1995	0	6	5	0		0		11
1996	0	4	24	1		0		29
1997	0	20	0	36				56
1998	0	4	7	6				17
1999	2	8	0	15				25
2000	4	n.a.	3	13				20
2001	2	11	2	37				52
2002	4	0	9	13				25
2003	13	0	7	20				40
2004	33		4	18				55
2005	29		4	7				41
2006	36	0	8	19				63
2007	46	0	27	57				130
2008	39	0	2	22				63
2009	34	1	16	10				61
2010	22	0	40	1				62
2011	21		11	4				37
2012	38		118					156
2013	28		146	4				178
2014	15		35	9	0			60

YEAR	FRANCE*	IRELAND	SPAIN	UK (E & W)	UK (Scot)	CH. ISLANDS*	NETHERLANDS	TOTAL
2015	13	0	21					34
2016	24	0	15	1	0			40
2017	15	1	19	1		0	0	37
2018	17	0	2	1			1	22
2019	19	0	15	1				35
2020	8		13	0				21

*Channel Islands

Table 12.2.1b. Blackspot seabream in Subarea 8; WG estimates of landings by country.

YEAR	FRANCE*	SPAIN	UK (E & W))	TOTAL
1988	37	91	9	137
1989	31	234	7	272
1990	15	280	17	312
1991	10	124	0	134
1992	5	119	0	124
1993	3	172	0	175
1994	0	131	0	131
1995	0	110	0	110
1996	0	23	0	23
1997	18	7	0	25
1998	18	86	0	104
1999	13	84	0	97
2000	11	189	0	200
2001	8	168	0	176
2002	10	111	0	121
2003	6	83	0	89
2004	37	82	8	128
2005	28	90	0	118
2006	20	57	0	77
2007	44	149	1	193
2008	55	40	0	95

YEAR	FRANCE*	SPAIN	UK (E & W))	TOTAL
2009	5	137	0	142
2010	61	157	0	218
2011	19	122	0	141
2012	18	82	0	101
2013	26	91	0	117
2014	36	161	0	196
2015	18	125	0	143
2016	7	117	0	124
2017	3	85	0	89
2018	6	105	0	111
2019	4	59	0	63
2020	4	59		63

Table 12.2.1c Blackspot seabream in Subareas 6, 7 and 8; WG estimates of landings by subarea.

YEAR	6 AND 7	8	TOTAL
1988	252	137	389
1989	189	272	461
1990	134	312	446
1991	123	134	257
1992	40	124	164
1993	22	175	197
1994	10	131	141
1995	11	110	121
1996	29	23	52
1997	56	25	81
1998	17	104	121
1999	25	97	122
2000	20	200	220
2001	52	176	227
2002	25	121	147

YEAR	6 AND 7	8	TOTAL
2003	40	89	129
2004	55	128	183
2005	41	118	158
2006	63	77	139
2007	130	193	324
2008	63	95	159
2009	61	142	203
2010	62	218	281
2011	37	141	177
2012	156	101	257
2013	178	117	295
2014	60	196	256
2015	34	143	177
2016	40	124	164
2017	37	89	126
2018	22	111	133
2019	35	33	98
2020	21	71	91

Table 12.2.2. Blackspot seabream in subareas 6, 7 and 8; WG estimates of discards in subareas 6, 7 and 8 since 2014.

	Discards (t)	Landings (t)	Catches (t)	Discards/Catches (%)
2014	2.40	256	258	0.9
2015	2.33	177	179	1.3
2016	0.91	164	165	0.6
2017	1.17	126	127	0.9
2018	2.3	133	136	1.7
2019	2.7	98	101	2.7
2020	0	91	91	0

Table 12.2.3. Blackspot seabream in Subareas 6, 7 and 8. Working group estimates of landings. Catches inside and outside the NEAFC Regulatory Area (RA) as estimated by ICES for the stock in WGDEEP.

WGDEEP Stock gfb.27.nea	Catch Inside NEAFC RA (t)	Catch Outside NEAFC RA (t)	Total Catches	Proportion of catch inside the NEAFC RA (%)	NEAFC RA areas where caught
2020	0	91	91	0%	
2019	0	98	98	0%	
2018	0	133	133	0%	
2017	0	126	126	0%	

Table 12.2.4 Mean size and weight-at-age of Blackspot seabream in Bay of Biscay. From Lorance (2011), derived from Guéguen (1969b) and Krug (1998).

Age group	Mean size (total length, cm)	Mean weight (g)	Proportion of mature females
0			0
1	11.2	18	0
2	17.6	72	0
3	22.3	149	0
4	26	239	0
5	29.2	342	0
6	31.9	449	0.007
7	34.3	562	0.05
8	36.1	658	0.15
9	37.9	765	0.31
10	39.5	870	0.45
11	40.9	969	0.54
12	42.3	1076	0.62
13	43.7	1190	0.68
14	44.8	1285	0.73
15	45.9	1386	0.77
16	46.7	1462	0.80
17	47.8	1572	0.83
18	49.2	1719	0.86
19	49.9	1796	0.88

Age group	Mean size (total length, cm)	Mean weight (g)	Proportion of mature females
20	50.2	1830	0.89

Table 12.2.5. Occurrence (kg and % of occurrence in the sampled stations) of the Blackspot seabream (*P. bogaraveo*) in Irish IGFS survey time-series (2010–2020).

	kg	% of occurrence in the stations
2010	0.2	0.8%
2011	0	0
2012	0.1	0.6%
2013	0	0
2014	0	00
2015	0	0
2016	2.1	2.4%
2017	8.2	4.3%
2018	0	0
2019	0	0
2020	0	0

Table 12.2.6. References and sources of reconstructed landings data in the Figure 12.2.1a.

France	-Years 1977–1987: Landings of P.bogaraveo (sic?) from the Northeast Atlantic. M. Pinho, pers. com. Source: SGDeep 1995. -Years 1950–1984: Landings of Pagellus sp. ("seabreams") from the Northeast Atlantic. Source: Dardignac (1988), quoted by Castro (1990). SGDeep
Portugal	-Years 1948–1987 Subarea 10: Landings of *P.bogaraveo* (*sic*). M.Pinho, pers. com. Source: H. Krug (for 1948–1969) and SGDeep 1995 (for 1970–1987). -Years 1948–1987, Subarea 9: Landings of *P.bogaraveo* (*sic*?). M.Pinho, pers. com. Source: H. Krug (for 1948–1969) and SGDeep 1995 (for 1970–1987).
Spain	-Years 1960–1986: Landings of *Pagellus* sp. ("seabreams") from the Northeast Atlantic. Source: Anuarios de Pesca maritima. Castro (1990). SGDeep 1996.Table 12.2.3. -Years 1983–1987: Landings of *P.bogaraveo* (*sic*) from Division 9.a correspond only to southern 9.a (Tarifa and Algeciras ports). Source: Cofradias de Pescadores.(WD Gil, 2004) and Cofradias de Pescadores. (Lucio, 1996). -Years 1985–1987: Landings of *Pagellus* sp. (mainly *P. bogaraveo*). Source: SGDeep 1996. Table 12.2.4. -Years 1948–1984: Landings of *P.bogaraveo* (*sic*) from "Division 8.c" mainly Division 8.c (eastern) and Division VIIIb (southern) correspond only to the Basque
UK	-Years 1978–1987: Landings of *P.bogaraveo* (*sic*?) from the Northeast Atlantic. M .Pinho, pers. com. Source: SGDeep 1995.
All countries	-Years 1979–1985 SGDeep official data -Years 1988–2020 WGDeep official data

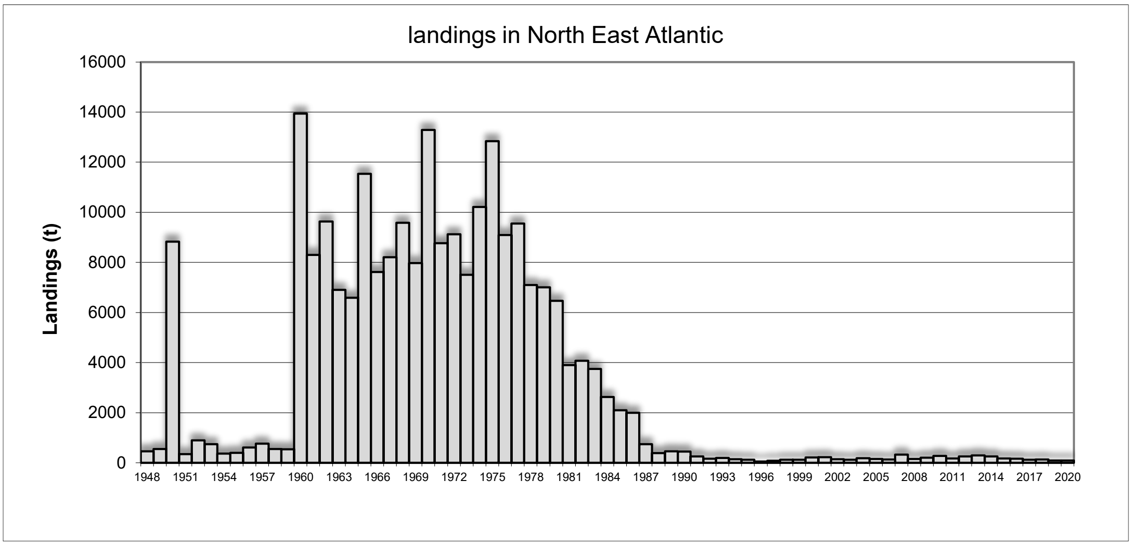


Figure 12.2.1a. Blackspot seabream in Subareas 6, 7 and 8. Source of the reconstructed landings of blackspot seabream in the Bay of Biscay.

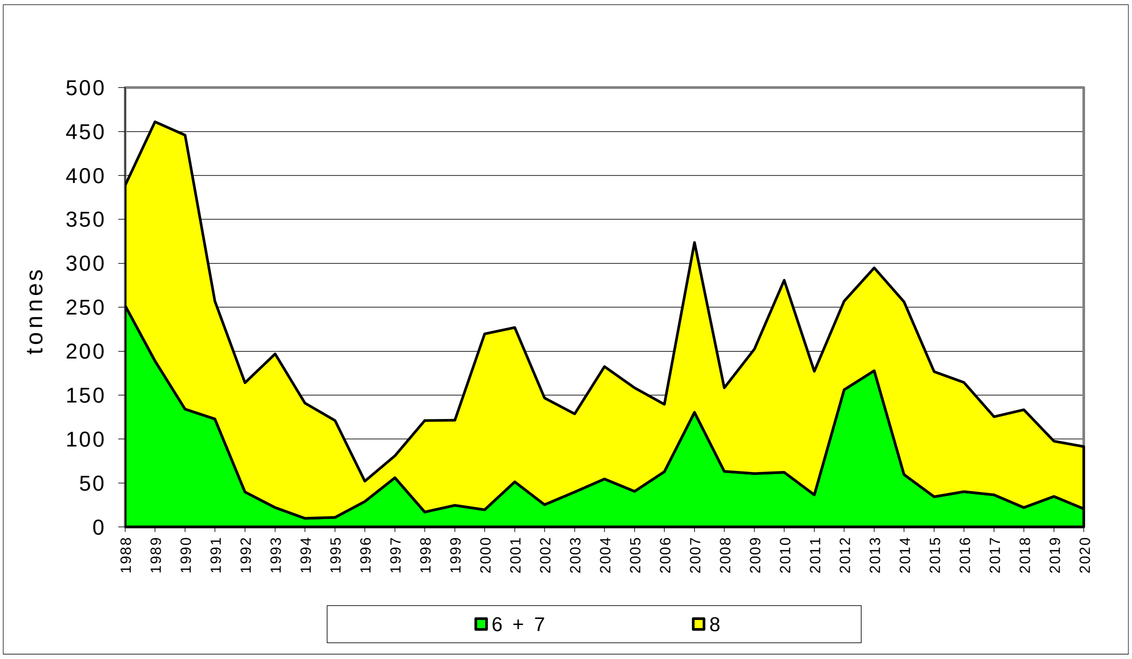
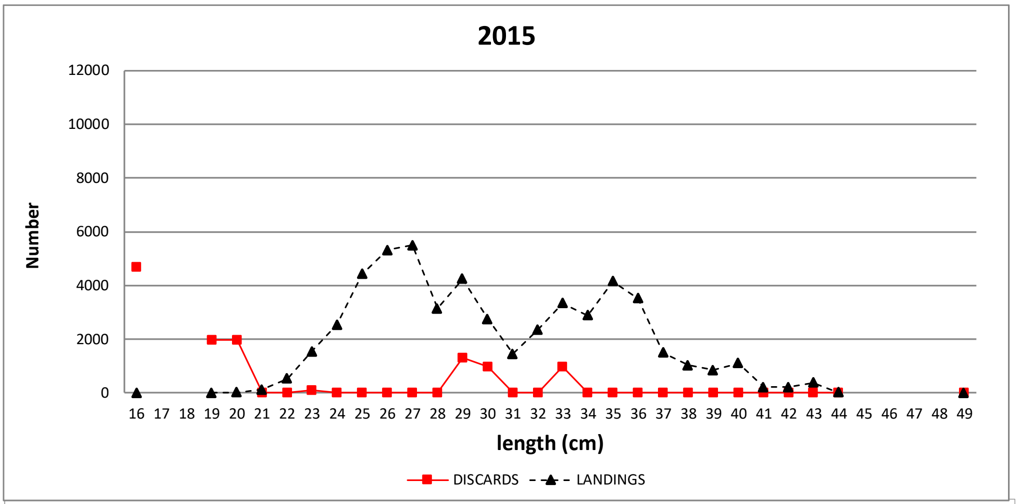


Figure 12.2.1b. Blackspot seabream landing trends in ICES Subareas 6 and 7 since 1988.


2015
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12000
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length (cm)
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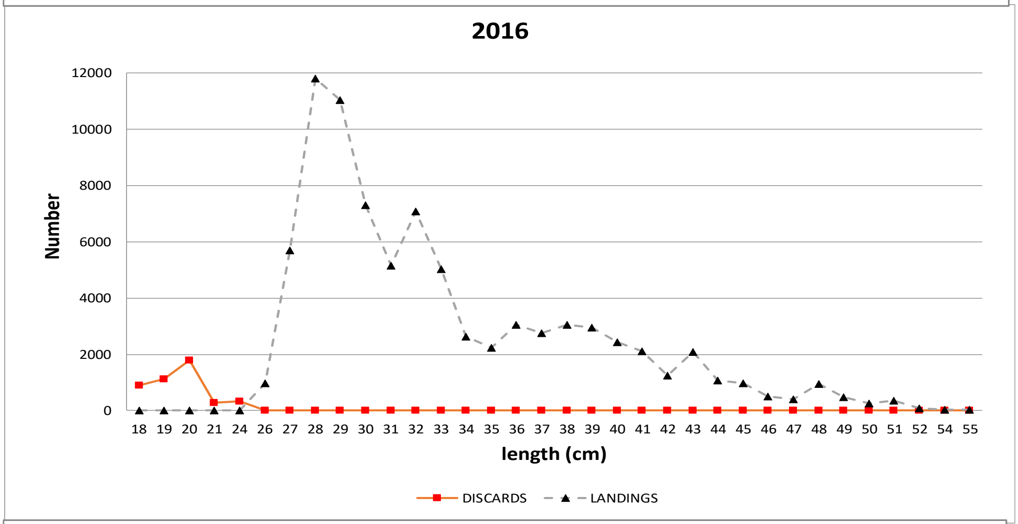
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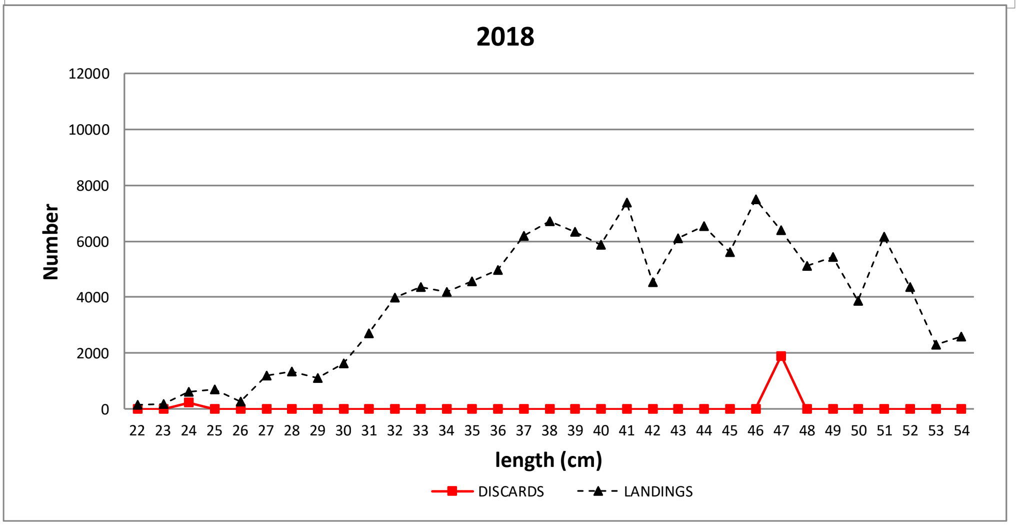
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length (cm)
DISCARDS
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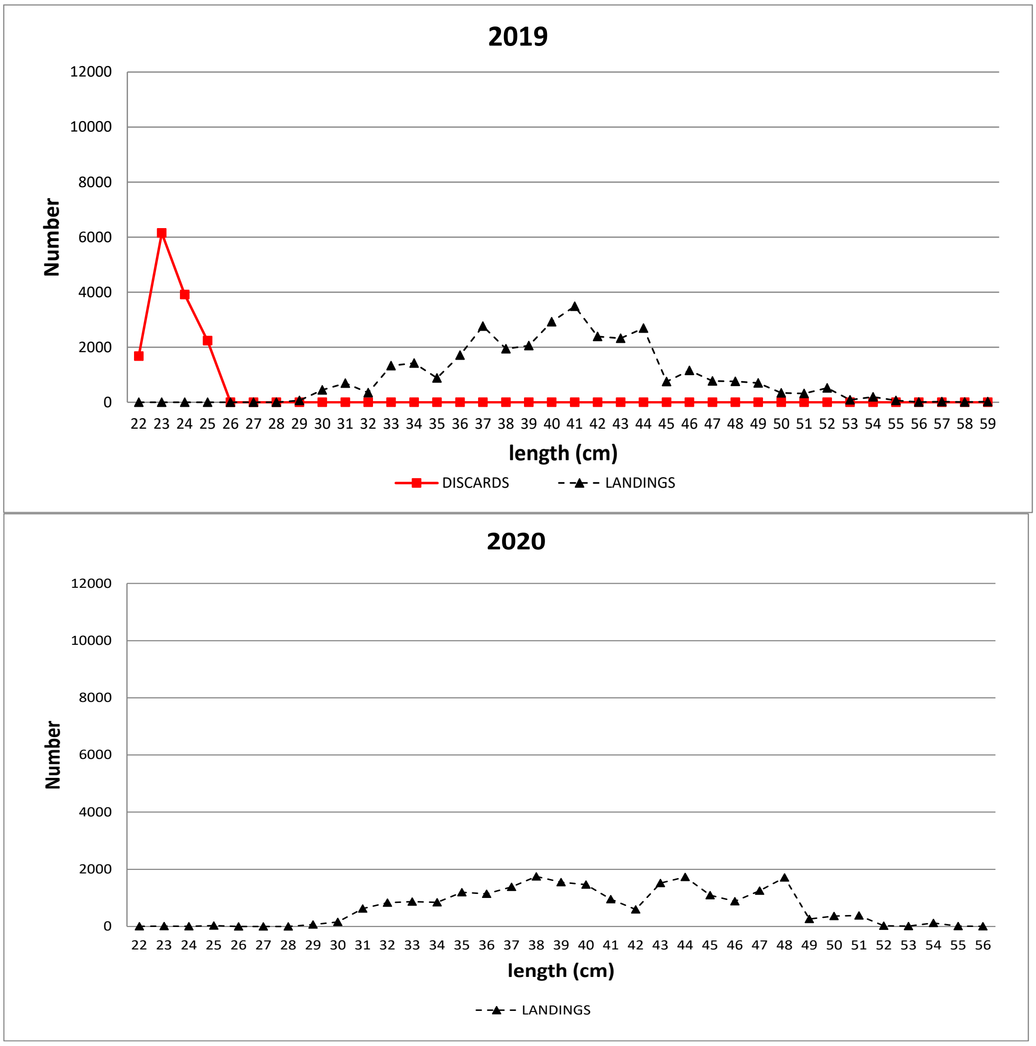

Figure 12.2.2. Length frequencies of the blackspot seabream in commercial catches, landings and discards since 2015, in Subareas 6, 7 and 8. No discards were reported for 2020.

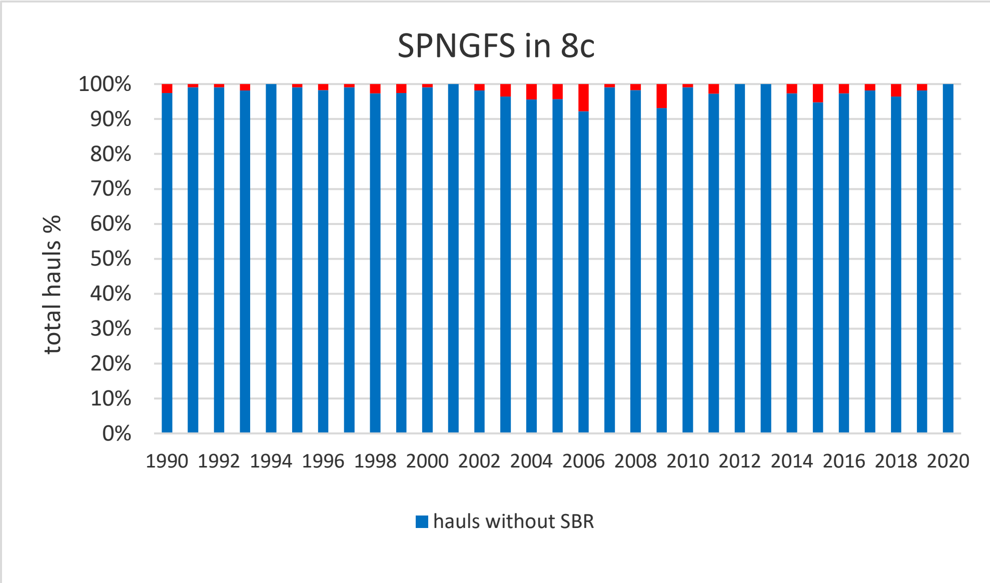

Figure 12.2.3. Occurrence (%) of the Blackspot seabream (*P. bogaraveo*) in Northern Spanish Shelf survey time-series (1990–2020).

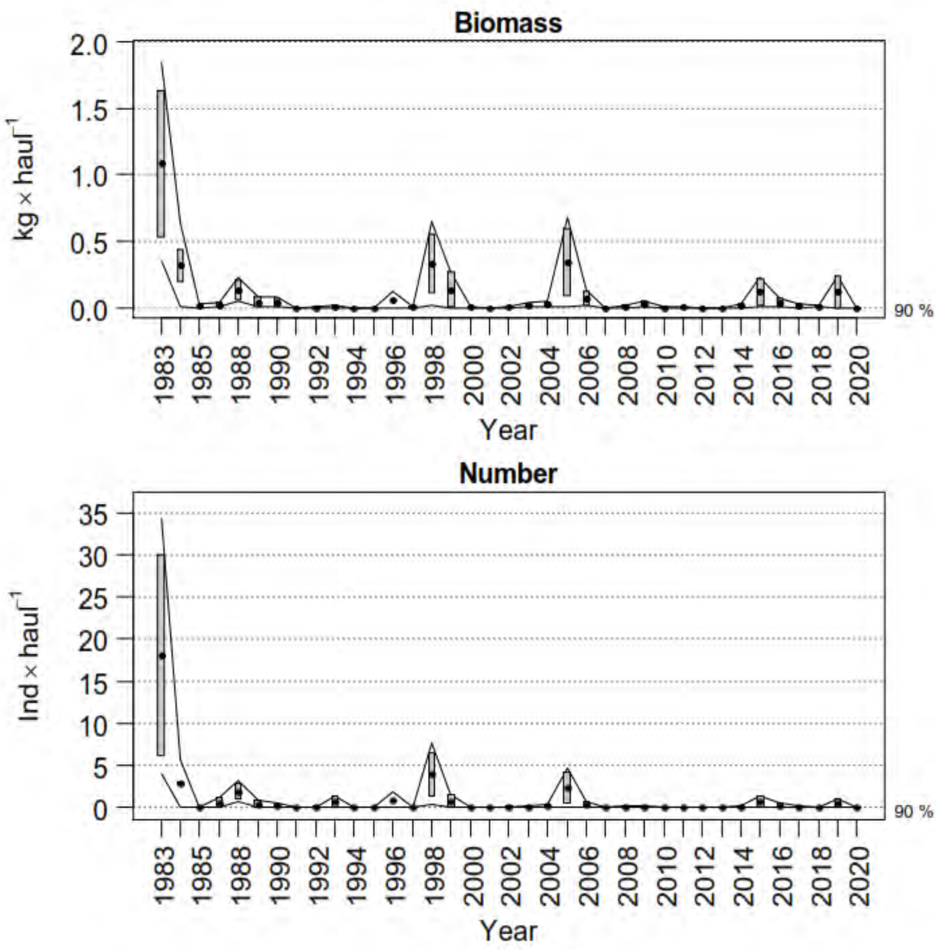

Figure 12.2.4. Evolution of Blackspot seabream (*P. bogaraveo*) mean stratified biomass (upper panel) and abundance (lower panel) in Northern Spanish Shelf survey time-series (1983–2020).

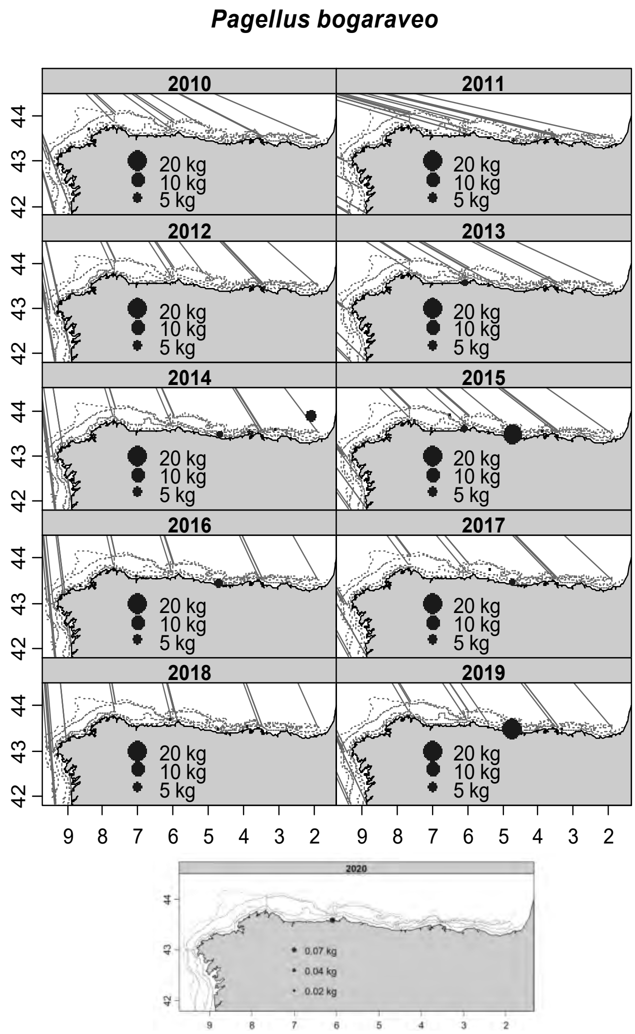

Figure 12.2.5. Catches in biomass of Blackspot seabream on the Northern Spanish Shelf bottom-trawl surveys, 2010–2020.

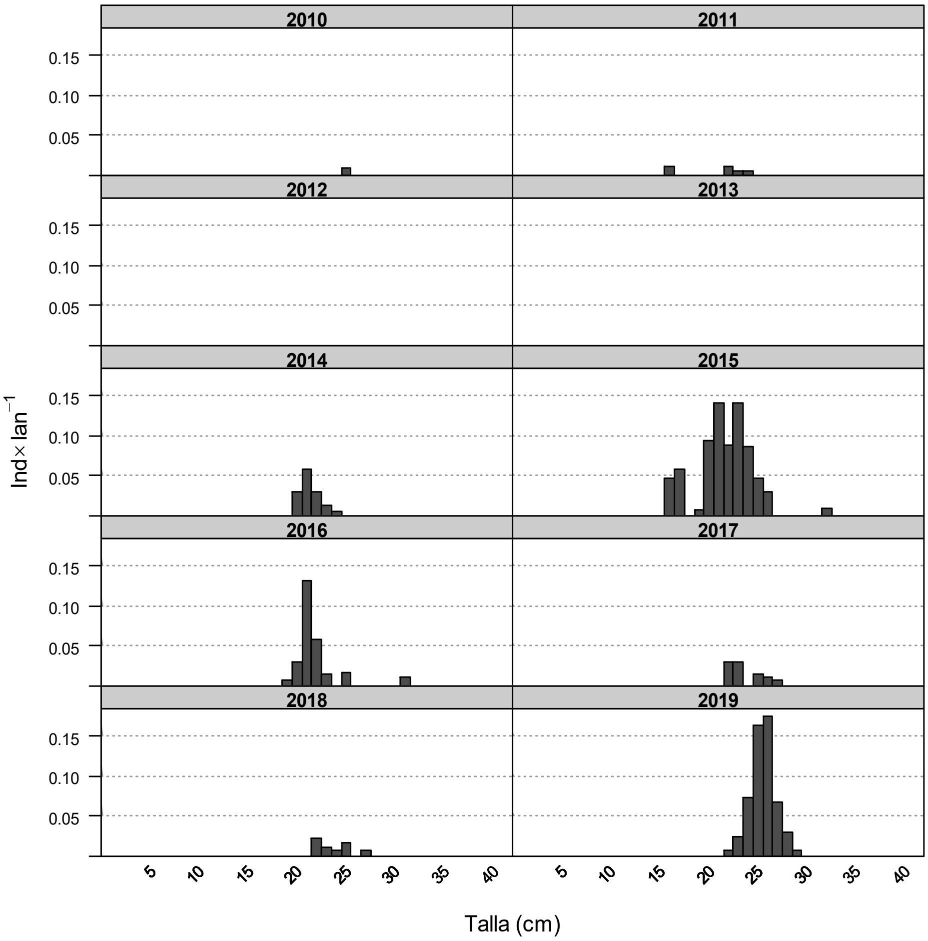

Figure 12.2.6. Mean stratified length distributions of Blackspot seabream (*P. bogaraveo*) in Northern Spanish Shelf surveys (2010–2019), no data before 2009.

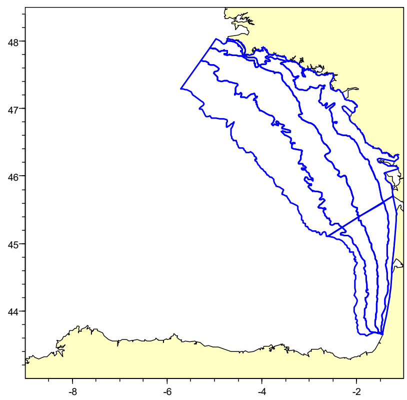

Figure 12.2.7. Strata covering the Bay of Biscay shelf, sampled in the current EVHOE survey and in two previous surveys in 1973 and 1976.

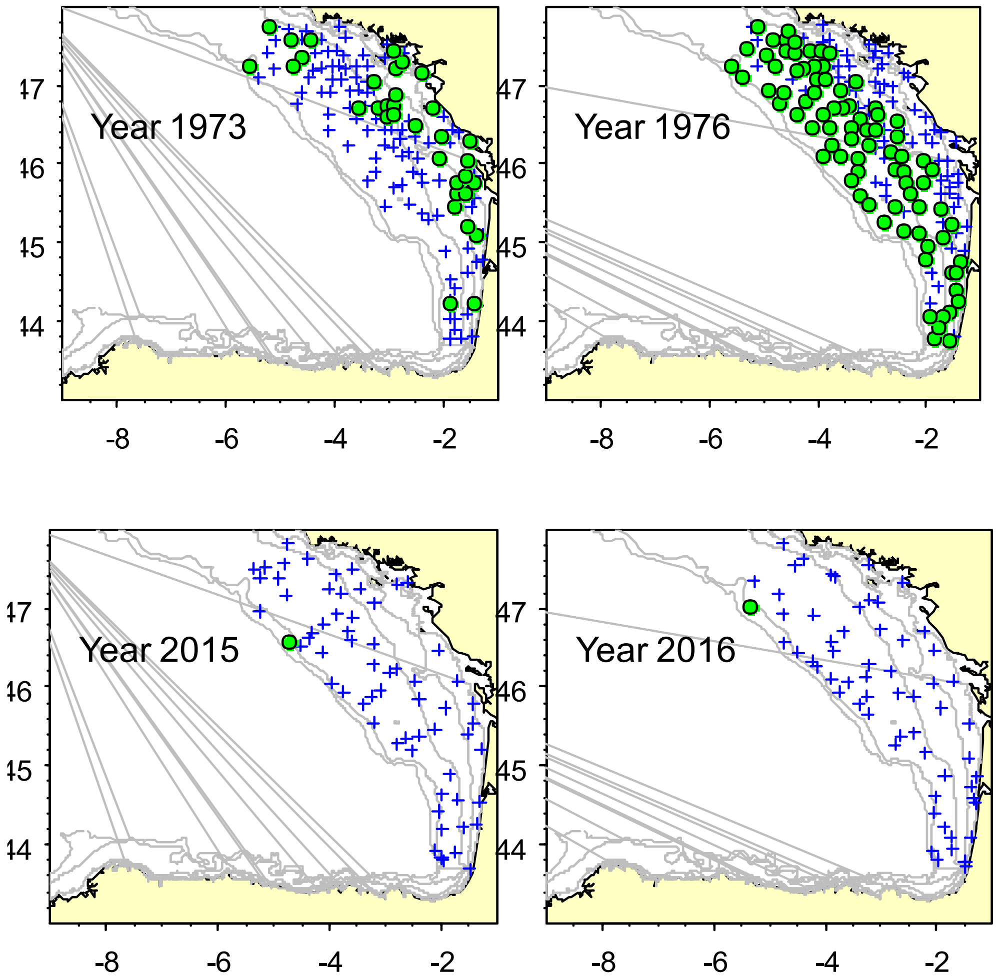

Figure 12.2.8. Occurrences of Blackspot seabream in surveys carried out in 1973 and 1976 and in the EVHOE survey in 2015 and 2016.

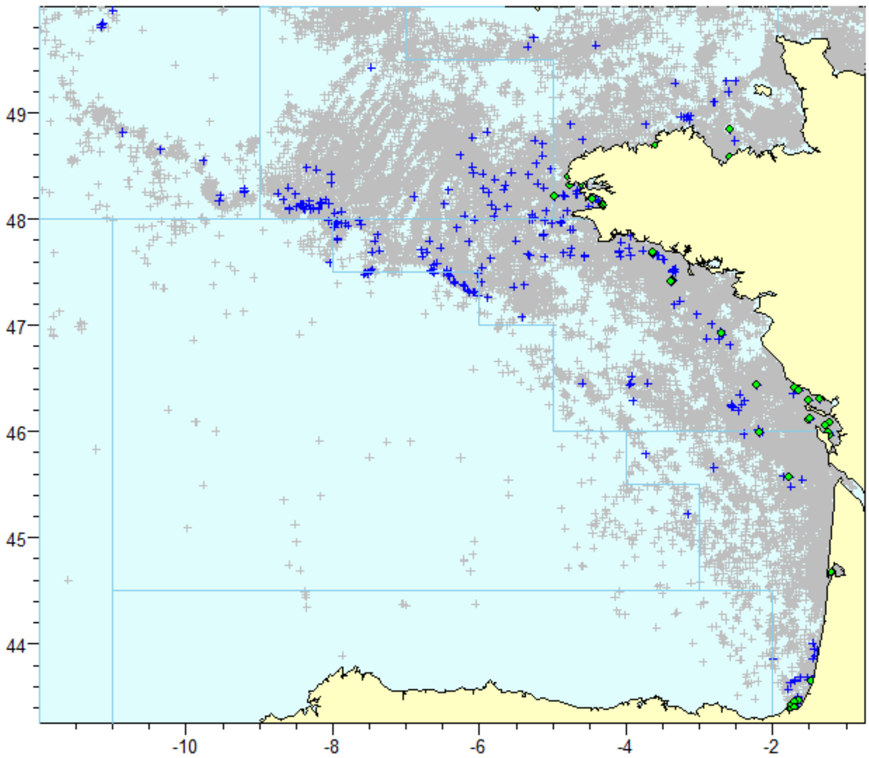

Figure 12.2.9. Geographical distribution on catch of the Blackspot seabream in French on-board observations 2010–2016 in the Bay of Biscay and southern Celtic Sea, all métiers. (Grey) all haul/sets observed, (Blue crosses) hauls with catch of blackspot seabream, (Green dots) hauls with catch of blackspot seabream <20 cm which species identification may be uncertain.

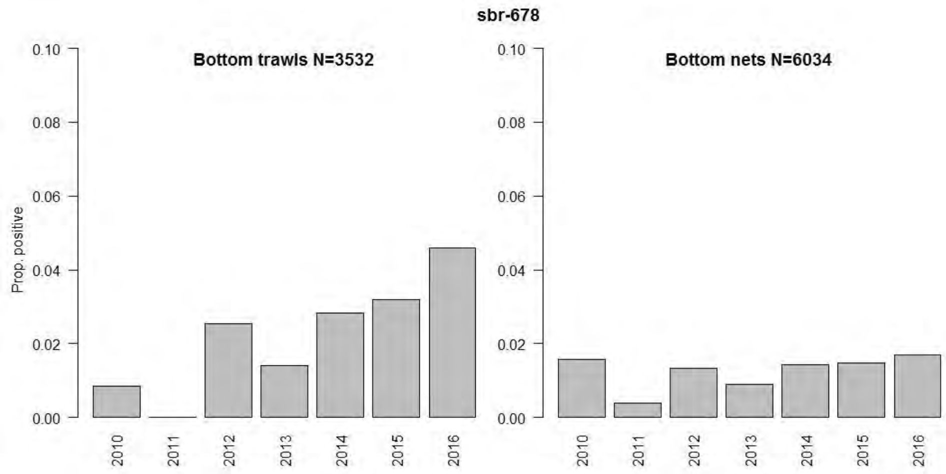

Figure 12.2.10. Proportion of fishing operations with catch of Blackspot seabream in bottom trawls (left) and bottom net (right) in French fisheries to the south of 49°N (ICES divisions 8.a–d and the southern part of 7.d and 7.h–k).

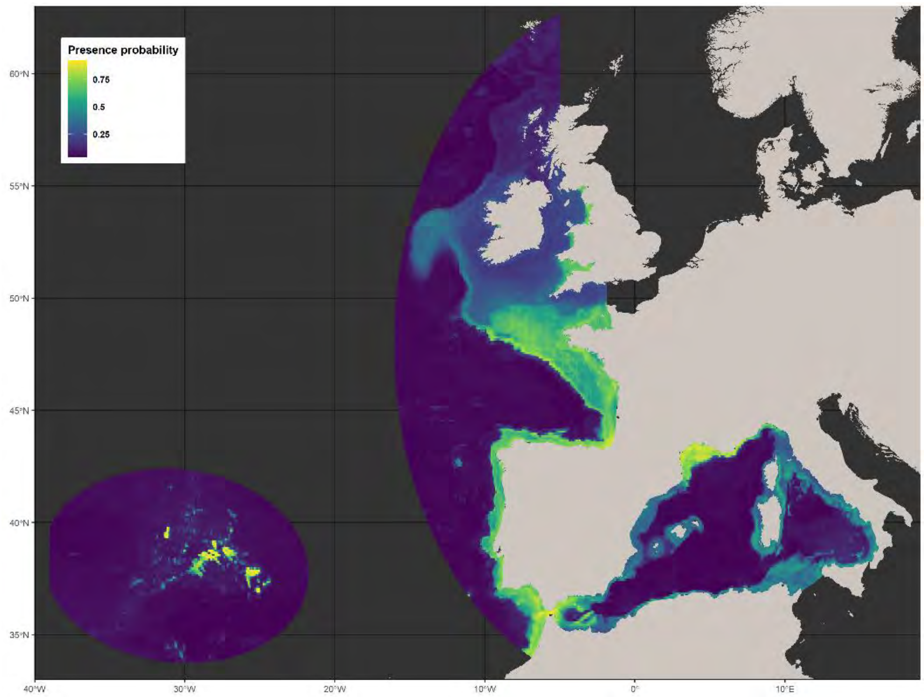

Figure 12.2.11. Potential habitat of the blackspot seabream in the Mediterranean Sea, Azorean waters and European Atlantic shelf estimated from the ensemble modelling.

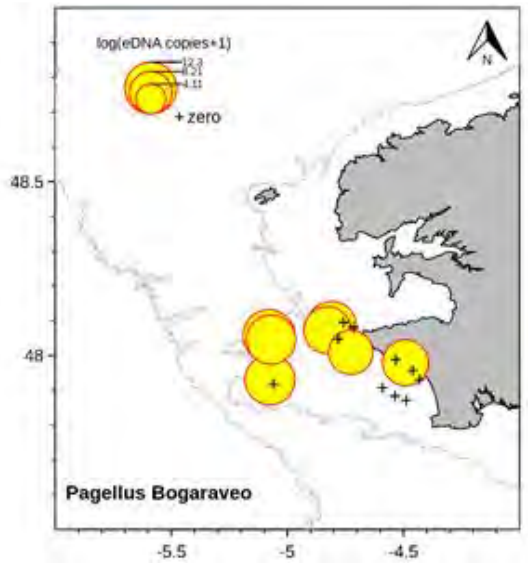

Figure 12.2.12. Number of eDNA copies (log scale) of blackspot seabream by location sampled in September 2020.

12.3 Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

12.3.1 The fishery

Pagellus bogaraveo is caught by Spanish and Portuguese fleets in Subarea 27.9. Spanish landings data from this area are available from 1983, Portuguese data from 1988 and Moroccan information from 2001. European landings in Subarea 27.9, most of which are taken with lines, are from Spain (~65%) and Portugal (~35%) 2015–2019.

An update of the available information on the Spanish target fishery, from the southern part of Subarea 27.9, Strait of Gibraltar region, has been provided to the WGDEEP (Gil *et al.*, WD 12 to the 2021 WGDEEP). Currently, less than 40 Spanish vessels are involved in the fishery. The fishing grounds of the Spanish fleet are on both sides of the Strait of Gibraltar and near, i.e. mostly less than 20 nautical miles, from the main ports (Tarifa and Algeciras). It should be noted that not all the catches/landings come exclusively from ICES Subarea 9 although it was considered to belong to the same stock, the fishing grounds encompass areas of different Regional Organizations/Commissions (ICES, GFCM and CECAF). Fishing takes advantage of the fluctuation of the tide at depths from 350 to 700 m with "*voracera*" gear, a mechanized handline. Since 2002 artisanal vessels from Conil port have joined the blackspot seabream fishery. Those vessel operate in other fishing grounds and use longlines. This section of the Spanish fleet is currently composed by about six vessels. Species landings are disaggregated into different commercial categories due to the wide size range of the catch and size-varying prices. Historically these categories have varied but from 1999 onwards have remained the same in all ports.

Since 2001, Moroccan longliners held a fishery in the Strait of Gibraltar area. These are about 102 vessels that are mainly based in Tangier. The average technical characteristics of these vessels are: 20 GRT and 160 HP. Moreover, 435 artisanal vessels (±15 CV, ≤2 GRT and 4–6 m length) also target this species in the Strait of Gibraltar area (COPEMED II, 2015). The WGDEEP considers the account of Moroccan catches appropriate as the fishery operates in the same area as the Spanish fishery and obviously targets the same stock. Landings information until 2019 was also available from GFCM Report on Benchmark sessions for the assessment of blackspot seabream in GSAs 1-3 (2020).

Detailed information from Portuguese fisheries has been updated to the Working Group by Farias and Figueiredo (WD 6 to the 2021 WGDEEP). As well as in other Spanish places in Subarea 27.9, it is admitted that there are no fisheries targeting the blackspot seabream in Portugal mainland although the species can be seasonally targeted: the species is usually caught as bycatch of fisheries targeting other species. In mainland Portugal, most of species landings are as fresh specimens and are derived from the polyvalent fleet, which uses mainly longlines. The main landing ports (≈89% of the species mainland Portugal total landings) from North to South are: Matosinhos (Portugal North), Aveiro, Nazaré and Peniche (Portugal Centre) and Sagres (Portugal Algarve).

In the Portuguese area of 27.9.a stock, Peniche is the most important landing port for blackspot seabream (landings between 1999 and 2019 represented nearly 50% of the Portuguese landings of the species. The species is mainly landed between December and March: this seasonal fishery pattern can reflect differences on the species' availability (coinciding with the spawning season) or differences on skippers' seasonal fishing grounds preferences (Farias and Figueiredo, WD 7 to the 2020 WGDEEP).

12.3.1.1 Landing trends

Since 1990, the maximum catch was reached in 1993–1994 and 1997 (about 1000 t) whereas the minimum (about 60 t) in 2019 and 2020 (Figure and Table 12.3.1). It should be noted that not all Spanish landings from the Strait of Gibraltar come from ICES Subarea 27.9. Moroccan landings from the Strait of Gibraltar area are supposed to be outside ICES Subarea 27.9: 2020 landings were not available.

12.3.2 Advice

The ICES advice for 2021 and 2022 was "that when the precautionary approach is applied, catches should be no more than 119 tonnes in each of the years 2021 and 2022. All catches are assumed to be landed."

12.3.3 Management

Since 2003, TAC and Quotas have been applied to the blackspot seabream fishery in Subarea 27.9. The table below shows a summary of *P. bogaraveo* recent years' TACs and European countries landings in this Subarea.

Pagellus bogaraveo **TACs and total landings in European countries in Subarea 27.9 in recent years.**

P. bogaraveo	2014–2015		2016–2017		2018–2019		2020–2021	
ICES Subarea	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings
9	780 – 374	262 –153 (142*)	183 – 174	165 (77*) – 130 (17*)	165 – 149	87 (8*) –56 (4*)	149 – 119	59 (3*) -

***from InterCatch info: landings from adjacent waters of the Strait of Gibraltar (FAO 34.1.11 and FAO 37.1.1).**

There is a minimum conservation reference size of 33 cm for this species in the Regions 1–5 (as defined in Article 2 of Regulation (EC) No 850/98) since 11 May 2017 (Commission Implementing Regulation (EU) 2017/787 of 8 May 2017). This size coincides with the previously applied minimum size in the Mediterranean Sea. The European Commission granted the exemption for the Strait of Gibraltar target fishery, which is expressed in the discard plan for certain demersal fisheries in South-Western waters for the period 2019-2021 (Commission Delegated Regulation (EU) 2018/2033).

European landings have always been below the adopted TACs although these have been reduced over the years. However, in the year 2016 (considering other areas such as FAO 34.1.11 and FAO 37.1.1) European countries landings (242 t) are above the 2016 TAC (183 t) for ICES Subarea 27.9 (Figure 12.3.1).

12.3.4 Stock identity

Stock structure of the species in ICES Subarea 27.9 is still unknown. Genetic studies showed a restricted gene flow among the populations located in the Azores (ICES Division 27.10.a.2) and those on the Portuguese continental slope (ICES Division 27.9.a) and Madeira (CECAF FAO Division 34.1.2) (Stockley *et al*., 2005; Piñera *et al*., 2007). Recent genetic studies using mitochondrial control region indicated a similar genetic diversity among sampling sites in the NE Atlantic and the Mediterranean, and no differentiation between the Azores and the remaining locations (Robalo *et al*., 2021).

In the Strait of Gibraltar area tagging surveys (56 days at sea in 2001, 2002, 2004, 2006 and 2008) have been conducted. A total of 4500 fish were tagged, of which 423 recaptures have been reported. The main results indicate the inexistence of significant movements. Although strict movements were noted: feeding grounds are distributed along the entire Strait of Gibraltar and the species seems to remain within this area as a resident population (Gil, 2006). Recaptures of tagged fish have also been reported by the Moroccan fishery.

Farias and Figueiredo (WD 14 to the WGDEEP 2019) presents information on blackspot seabream spatial distribution from Portuguese research surveys, considering the relative frequency of fishing hauls with species catch rates higher than 5 specimens in the 1990-2017 surveys. It is concluded that the species is not evenly distributed along the surveyed area, being more frequently caught at specific grounds, suggesting a patchy distribution. In the northern coast of Portugal, the species is caught down to 100 m deep, whereas preferred habitats are between 200 and 400 m deep in the southwestern coast (Figure 12.3.2). There is no evidence of movements between the northernmost component and the southern part of Subarea 27.9 where Spanish fishery takes place.

12.3.5 Data available

12.3.5.1 Landings and discards

Historical landing data series available to the Working Group are described in Section 12.3.1 and detailed in Table 12.3.1. It should be noted that since 2015 Spanish landings include adjacent areas outside ICES Subarea 27.9 (data are not separated in earlier years). In addition, Morocco landings from the Strait of Gibraltar area are available since 2001 (not in 2020), although fishing is supposed to have taken place outside ICES Subarea 9.

Portuguese and Spanish discard information was available to the Working Group from on-board sampling programme (EU DCF/NP). Given the low levels of discards, the discarded rate is admitted to be nearly zero for most assessment purposes and those that do occur are mainly related to catches of small individuals. Consequently all catches of blackspot seabream in management are 27.9a. are assumed to be landed.

12.3.5.2 Length compositions

Length frequencies of landings are available for the Spanish "*voracera*" blackspot seabream target fishery in the Strait of Gibraltar (1997–2020). Figure 12.3.3 show the updated length distribution data (from Gil *et al.*, WD 12 to the 2021 WGDEEP). The table below shows the mean and median landed size since 1997:

Summary statistics of *Pagellus bogaraveo* landed sizes by year since 1997.

Year	Mean	Std. Dev.	Median	Year	Mean	Std. Dev.	Median
1997	35.98	6.38	35	2009	38.29	6.23	37
1998	34.33	5.07	34	2010	36.03	5.28	35
1999	36.23	5.30	36	2011	36.33	6.36	34
2000	36.79	4.81	36	2012	36.40	5.91	35
2001	37.11	5.45	37	2013	34.80	3.64	34
2002	38.10	5.93	38	2014	37.11	5.14	36

Year	Mean	Std. Dev.	Median	Year	Mean	Std. Dev.	Median
2003	38.35	6.27	38	2015	39.15	5.79	38
2004	36.56	5.69	35	2016	37.47	5.28	37
2005	36.79	6.02	35	2017	37.72	4.37	37
2006	35.87	5.58	35	2018	37.84	4.67	37
2007	37.26	5.95	36	2019	37.27	4.21	37
2008	37.76	6.22	36	2020	37.37	4.30	37

Only one mean value (in 1998) is lower than the 2013 year´s mean landing size. However, changes are small and gradual. There seem to be a long-term slight decline, despite the mean length ups and downs over the last decade (Figure 12.3.3).

Length the frequency distribution by fishing segment (polyvalent and trawlers) from 2014 till 2020 landings are presented in Figure 12.3.4 (D 6 to the WGDEEP 2021). Differences in length distribution between the polyvalent the trawl segments indicates that polyvalent fleet catch larger fish than the trawl fleet.

It should be noted that in 2020 sampling effort in both countries were low due to the covid-19 disruption: 4 samples (72 specimens) in the polyvalent, 4 samples (52 specimens) in the trawl and 7 samples (517 specimens) in the target "*voracera*" fishery of the Strait of Gibraltar.

12.3.5.3 Age compositions

No new information was presented to the group.

12.3.5.4 Weight-at-age

No new information was presented to the group.

12.3.5.5 Maturity and natural mortality

No new information was presented to the group.

12.3.5.6 Catch, effort and research vessel data

Figure 12.3.5 and Table 12.3.2 present CPUE information, restricted to the Strait of Gibraltar fishery (Gil *et al.*, WD 12 to the 2021 WGDEEP). Effort, as indicated, from sales sheets is not standardized and is potentially underestimated in some years as the effort unit chosen may be inappropriate while CPUE estimated from VMS analysis shows the same trend.

Farias and Figueiredo (WD 6 to the 2021 WGDEEP) identify two reference fleets landing at Peniche port: a total of 40 fishing vessels (with more than 9 fishing trips per year and more than 6 months with positive landings of the species) were selected for the polyvalent (longliners) while 21 fishing vessels (with more than 9 fishing trips per year and more than 5 months with positive landings of the species) were selected for the trawl fleet. The GLM estimates of the reference fleets' CPUE, considered as landed weight per fishing trip, for the selected model are also presented in the WD. Catch rates derived from longliners are slightly higher than those from trawl – this probably reflects a difference on the species length composition between the two fleets (Figure 12.3.6).

12.3.5.7 Data analyses

The stock identity still unclear and there is not certain linkages between the Strait of Gibraltar populations and the populations in the northern and central area of Subarea 27.9.

The trend is clear in the target fishery of the Strait of Gibraltar. Landings declined significantly until 2013 which may be considered as an indication of a substantial reduction in exploitable biomass. Current CPUE low levels may also be consistent with an overexploited population.

However, the analysis from the Portuguese (Peniche port) reference fleets' CPUE is not in accordance with the clear decreasing trend observed in the Strait of Gibraltar target fishery: longlines and bottom trawl catch rates from West Portugal coast are relatively stable.

12.3.6 Management considerations

A TAC regime (119 t) was established for 2021 and 2022 for whole Subarea 27.9. Although the advice aims to reduce total catch within the whole fishing area, it should be noted that the current TAC does not limit the whole fishery because it only applies to Subarea 27.9, nevertheless catches in the GFCM area 37.1.1 and CECAF area 34.1.11 should be reported (Council Regulation (EU) 2016/2285). Recent landings are below the corresponding TAC levels but in 2016, European landings (including other areas such as FAO 34.1.11 and FAO 37.1.1) were above the 2016 TAC.

The combination of the minimum size of 33 cm for this species and the landing obligation (EU Regulation 2013/1380) might have an effect on certain fisheries: the exemption from the landing obligation of the target fishery of the Strait of Gibraltar ("*voracera*" gear) does not apply to other blackspot seabream catches in ICES Subarea 27.9.

It should be noted that GFCM started a work plan to establish a management plan for the Strait of Gibraltar target fishery in 2019 (Recommendation GFCM/41/2017/2 on the management of blackspot seabream fisheries in the Alboran Sea, geographical subareas 1 - 3, for a two-year transition period). The 2020 GFCM WGSAD endorsed the advice on the status of blackspot seabream in the Strait of Gibraltar – based on an update of the benchmarked gadget model – whereby the stock was considered in overexploitation and overexploited: $F_{current}$ ($F_{BAR4-16}$ = 0.49) is almost the double of the reference point (F_{MSY} = 0.26) estimated and agreed during the Benchmark process (GFCM, 2021). WGDEEP would like to express its concern on the fact that the population of blackspot seabream in the Strait of Gibraltar is being assessed within two different advisory bodies (ICES and GFCM), who derive scientific advice to managers: coordination between all parties would be welcomed.

As well as in other ICES Subareas (27.6, 27.7, 27.8 and 27.10), measures should include protection for areas where juveniles occur: recreational fisheries may be a significant proportion of the mortality of those juveniles owing to their coastal distribution.

Trends in abundance at the western coast of Portugal may not be properly represented by the trend in the Strait of Gibraltar: the CPUE of the Peniche reference fleets does suggest a different trend than the Strait of Gibraltar "*voracera*" fleet and there is no evidence of movements between the northernmost component and the southern part of Subarea 27.9, where Spanish fishery takes place. In fact, Strait of Gibraltar component might be more related to Mediterranean components. Therefore, it might not be appropriate to infer the stock status in all Division 9a from the Strait of Gibraltar target fishery CPUE.

12.3.7 Tables and Figures

Table 12.3.1. Blackspot seabream (*Pagellus bogaraveo*) in Subarea 27.9: Working Group estimates of landings (in tonnes). Spanish landings from 2012 are official statistics.

Year	Portugal	Spain	Morocco*	Unallocated	TOTAL
1983		101			101
1984		166			166
1985		196			196
1986		225			225
1987		296			296
1988	370	319			689
1989	260	416			676
1990	166	428			594
1991	109	423			532
1992	166	631			797
1993	235	765			1000
1994	150	854			1004
1995	204	625			829
1996	209	769			978
1997	203	808			1011
1998	357	520			877
1999	265	278			543
2000	83	338			421
2001	97	277	17		374 (17*)
2002	111	248	32		259 (32*)
2003	142	329	20		471 (20*)
2004	183	297	30		480 (30*)
2005	129	365	37		494 (37*)
2006	104	440	70		544 (70*)
2007	185	407	85		592 (85*)
2008	158	443	72		601 (72*)
2009	124	594	90		718 (90*)

Year	Portugal	Spain	Morocco*	Unallocated	TOTAL
2010	105	379	142		484 (142*)
2011	74	259	148		333 (148*)
2012	143	60	135	92	295 (135*)
2013	90	91	106		181 (106*)
2014	59	203	131		262 (131*)
2015	66	87 (142**)	224		295 (219*)
2016	70	95 (77**)	161		242 (161*)
2017	69	61 (18**)	190		148 (190*)
2018	58	29 (8**)	76		95 (76*)
2019	36	20 (4**)	119		60 (119*)
2020	43	16 (3**)	N/A		62 (N/A*)

***Morocco landings are available from the Benchmark workshop on blackspot seabream (GFCM 2020)**

****Figures in brackets includes blackspot seabream from other areas (FAO 34.1.11. and FAO 37.1.1).**

Table 12.3.2. Spanish "*voracera*" blackspot seabream fishery of the Strait of Gibraltar (ICES Subarea 27.9): Estimated CPUE using sales sheets or VMS data as effort unit (adapted from Gil *et al.*, WD 12 to the 2021 WGDEEP).

Year	cpue	VMS cpue
1983	78	
1984	76	
1985	71	
1986	61	
1987	76	
1988	73	
1989	89	
1990	77	
1991	70	
1992	86	
1993	85	
1994	94	
1995	60	
1996	104	

Year	cpue	VMS cpue
1997	77	
1998	61	
1999	55	
2000	45	
2001	56	
2002	47	
2003	53	
2004	47	
2005	68	
2006	70	
2007	51	
2008	52	
2009	67	55
2010	46	38
2011	42	31
2012	35	21
2013	30	14
2014	39	22
2015	49	32
2016	41	27
2017	33	14
2018	18	4
2019	24	8
2020	24	13

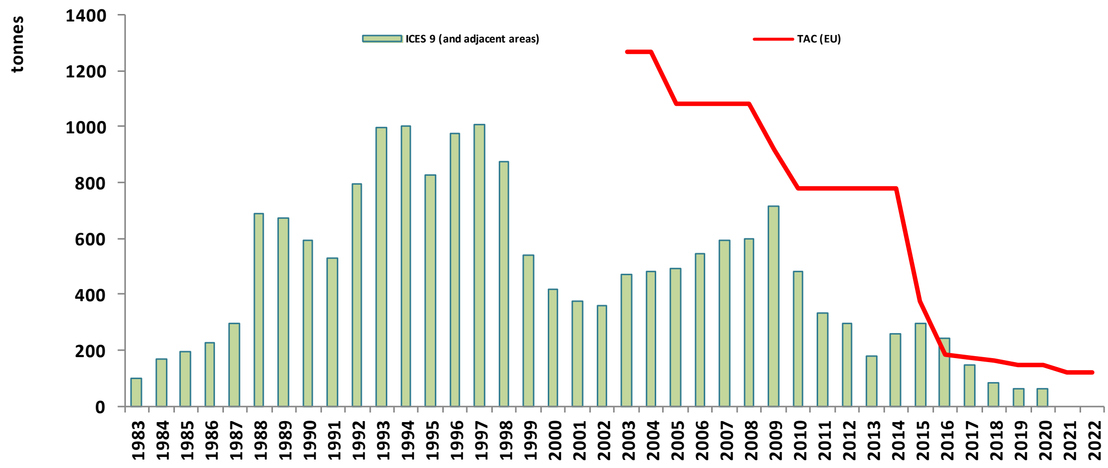

Figure 12.3.1. Blackspot seabream in ICES Subarea 27.9 (and adjacent waters): Total European landings (Morocco landings are not included) and EU TACs. Since 2015 landings from Strait of Gibraltar includes other areas (FAO 34.1.11 and FAO 37.1.1).

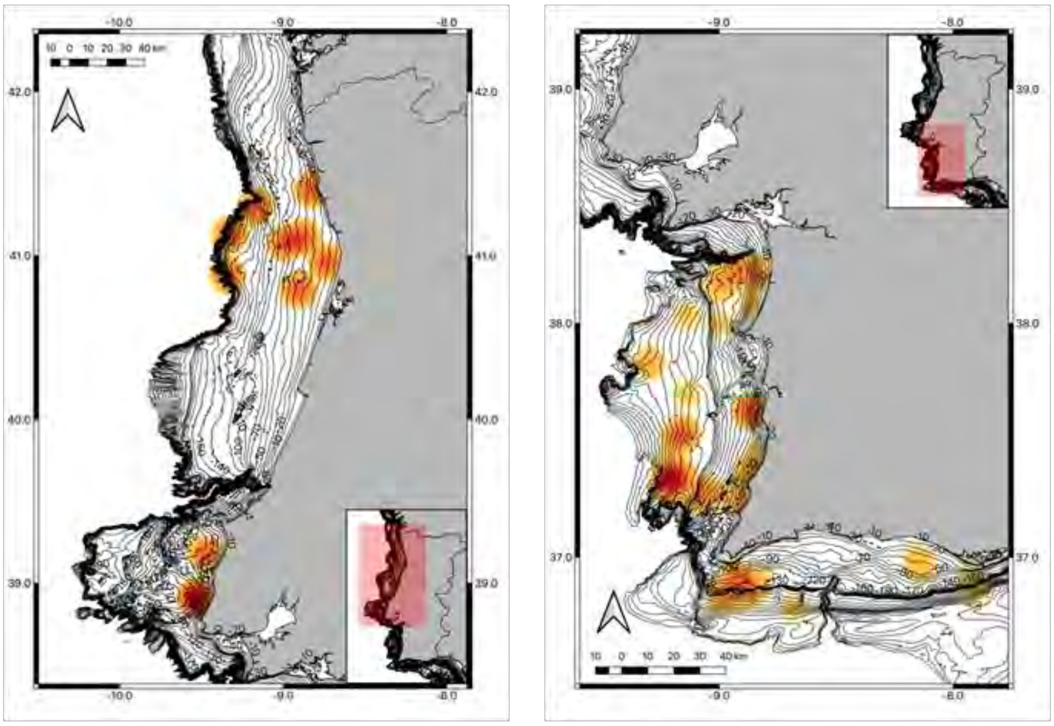

Figure 12.3.2. Blackspot seabream in ICES Subarea 9: Distribution *of Pagellus bogaraveo* along the Portuguese coast based on Portuguese surveys from the period between 1997-2011 and 2013-2017. The coloured blotches are hauls with *Pagellus bogaraveo* catches over 5 n.h-1. The colour intensity of the blotches reflects species occurrence (from Farias and Figueiredo, WD 14 to the 2019 WGDEEP).

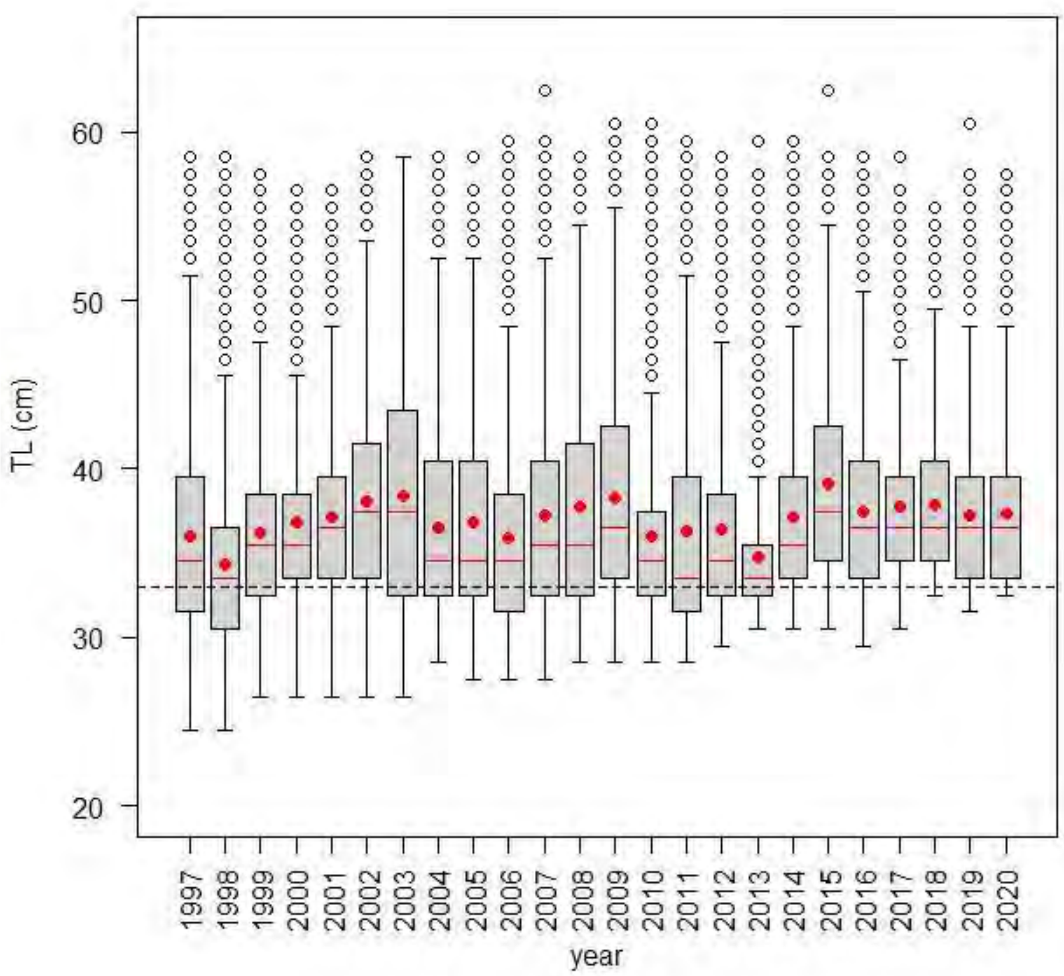

Figure 12.3.3. Spanish "*voracera*" blackspot seabream fishery of the Strait of Gibraltar: 1983–2020 (from Gil *et al.*, WD 12 to the 2021 WGDEEP). Dashed line (at 33 cm) represents the current minimum landing size for the species in Atlantic NE and Mediterranean European waters. Red dot are the mean value while red line represents the median.

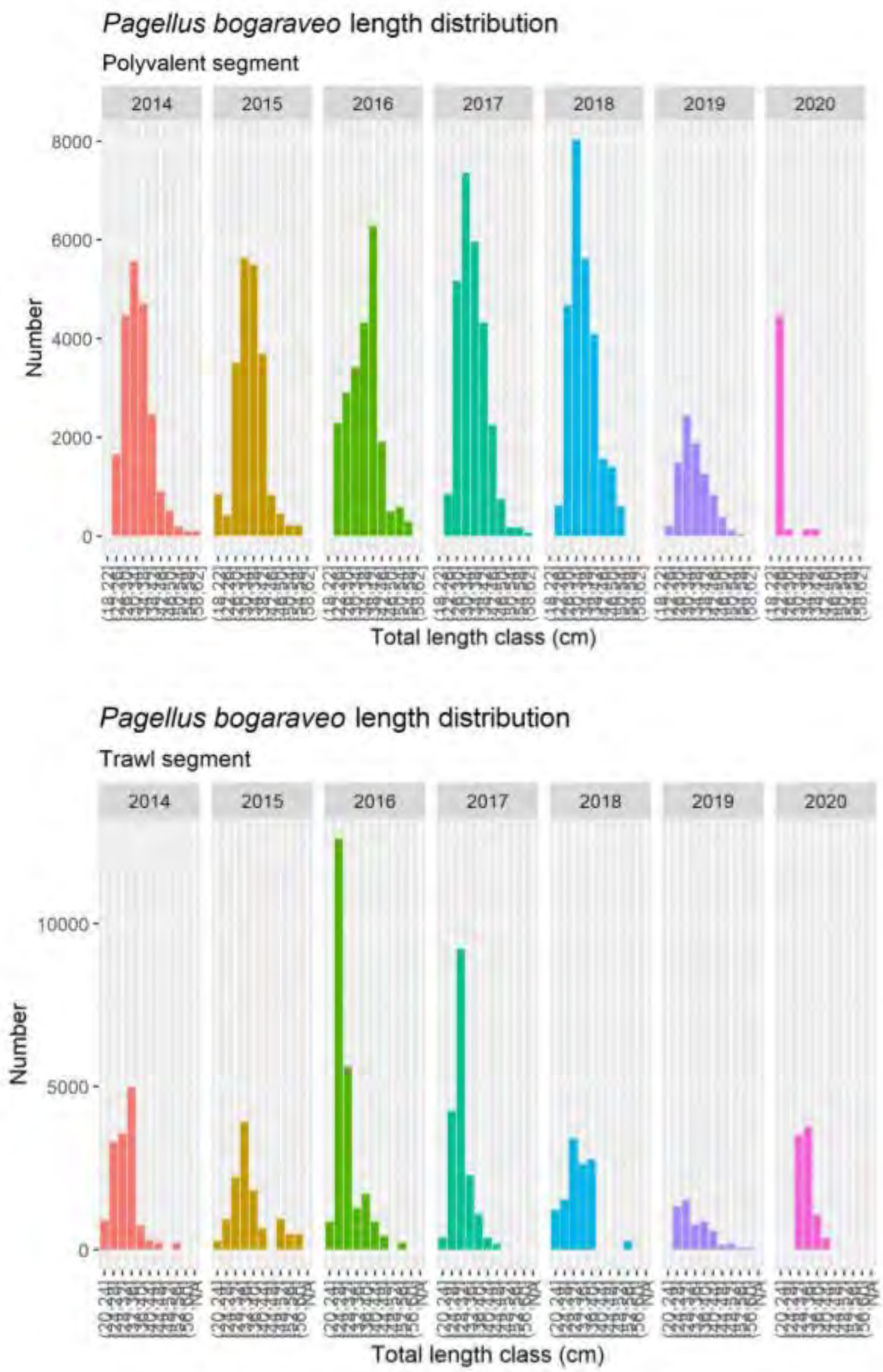

Figure 12.3.4. Peniche (Portugal) landing port: *Pagellus bogaraveo* length frequency distribution by fishing gear (polyvalent and trawl fleet) for the years 2014 to 2020 (from Farias and Figueiredo, WD 6 to the 2021 WGDEEP). Length classes are aggregated by 4 cms range (from 18-22 and 20-24 in polyvalent and trawl fleets, respectively).

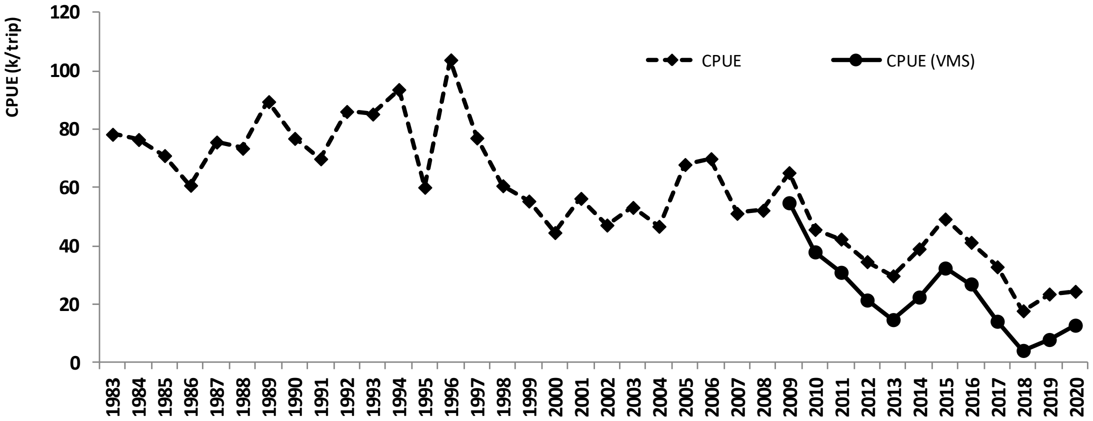

Figure 12.3.5. Blackspot seabream in ICES Subarea 27.9: Spanish "*voracera*" target fishery of the Strait of Gibraltar estimated CPUE, using sales sheets (dashed line: 1983-2020) and VMS data as unit of effort (solid line: 2009-2020) (from Gil *et al.*, WD 12 to the 2021 WGDEEP).

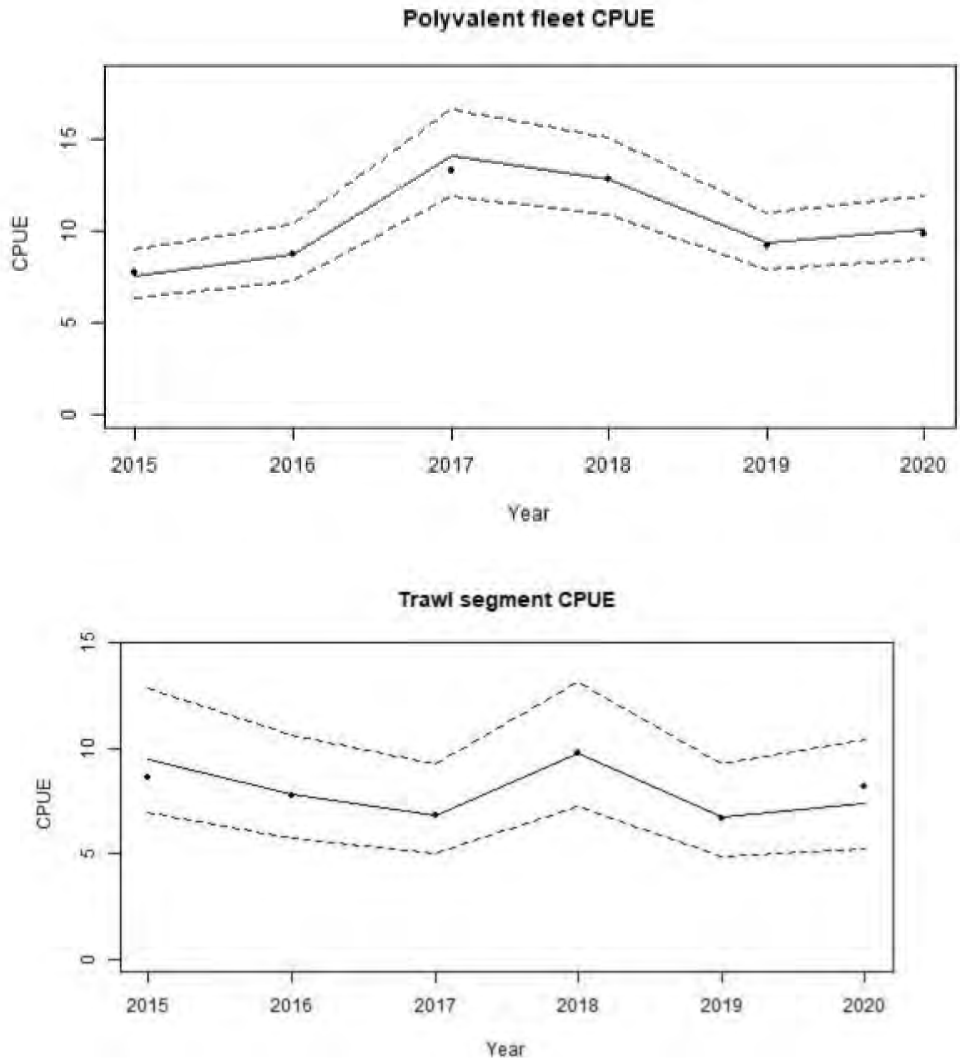

Figure 12.3.6. Blackspot seabream in ICES Subarea 27.9: Standardized annual estimates of CPUE by fleet segment (polyvalent and trawl) from the Peniche´s port reference fleets in 2015 - 2020 (from Farias and Figueiredo, WD 6 to the 2021 WGDEEP).

12.3.8 References

Farias, I. and I. Figueiredo. 2019. Pagellus bogaraveo in Portuguese continental waters (ICES Division 27.9.a). Working Document 14 to the 2019 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Farias, I. and I. Figueiredo. 2020. Pagellus bogaraveo in Portuguese continental waters (ICES Division 27.9.a). Working Document 7 to the 2020 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Farias, I. and I. Figueiredo. 2021. Pagellus bogaraveo in Portuguese continental waters (ICES Division 27.9.a). Working Document 6 to the 2021 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

GFCM. 2020. Report of the Benchmark sessions for the assessment of blackspot seabream in GSAs 1-3. General Fisheries Commission for the Mediterranean. 1–4 April 2019, 9-14 December 2019 and, 26 March, 8 April, 18 May and 28 May 2020.

GFCM. 2021 (*in prep*.). Report of the Working Group on Stock Assessment of Demersal Species (WGSAD). General Fisheries Commission for the Mediterranean. 18–30 January 2021.

Gil, J. 2006. Biología y pesca del voraz [Pagellus bogaraveo (Brünnich, 1768)] en el Estrecho de Gibraltar. Tesis Doctoral, Universidad de Cádiz (UCA, Spain).

Gil, J., L. Rueda, J.J. Acosta, C. Farias and M. Soriano. 2021. The Blackspot seabream Spanish target fishery of the Strait of Gibraltar: updating the available information. Working Document 19 to the 2021 ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP).

Piñera, J.A., G. Blanco, E. Vázquez and J.A. Sánchez, J.A. 2007. Genetic diversity of blackspot seabream (Pagellus bogaraveo) populations off Spanish Coasts: a preliminary study. Marine Biology 151: 2153-2158

Robalo, J.I., I. Farias, S.M. Francisco, K. Avellaneda, R. Castilho and I. Figueiredo. 2021. Genetic population structure of the Blackspot seabream (Pagellus bogaraveo): contribution of mtDNA control region to fisheries management, Mitochondrial DNA Part A, DOI: 10.1080/24701394.2021.1882445

Stockley, B., G. Menezes, M.R. Pinho and A.D. Rogers. 2005. Genetic population structure in the blackspot sea bream (Pagellus bogaraveo Brünnich, 1768) from the NE Atlantic. Marine Biology 146: 793–804.

12.4 Blackspot seabream (*Pagellus bogaraveo*) in Division 10.a.2

12.4.1 The fishery

Blackspot seabream (*Pagellus bogaraveo*) has been exploited in the Azores (ICES Division 10.a.2), at least since the XVI century as part of the Azorean demersal fishery. A directed hook exploits the species and line fishery that encompasses two fleet components: the artisanal (handlines) and the longliners (Pinho and Menezes, 2009; Pinho *et al.*, 2014). Important expansion of the fishery to offshore seamounts occurred during the 2000s (Ordinance No. 101/2002). This expansion was particularly held by the longline fleet because of the regional spatial management measures introduced (Santos et al., 2019). The artisanal fleet is composed of small open deck boats (<12 m) that operate in local areas near the coast of the islands using several types of handlines. Longliners are closed deck boats (>12 m) that operate in all areas but during the last years the fishery is only authorized to operate on offshore (>6 nm) banks and seamounts (Pinho *et al.*, 2014; Diogo *et al.*, 2015). The tuna fishery caught, until the end of the nineties, juveniles (age 0) of blackspot seabream as live bait, but in a seasonal and irregular way because these catches depend on tuna abundance and on the occurrence of other preferred bait species like *Trachurus picturactus* (Pinho *et al*., 2014).

The Azorean demersal fishery is a multispecies and multigear fishery where *P. bogaraveo* is considered the target species. The effect of these characteristics on the dynamics of the target fishery is not well understood given the plasticity of the fishery to the target effect related with variability of abundance and markets (prices of the fish in general along the year).

Landings trends

Historically, landings increased from 400 t at the start of the eighties to approximately 1000 t at the start of the nineties (Figure 13.4.1). This increase was mainly due to the development of new markets, increased fish value, entry of new and modern boats, better professional education of the fisher and introduction of bottom longline gear, permitting the expansion of the exploitable area to deeper waters, banks, and seamounts as well as the expansion of the fishing season (ICES, 2006). Between 1990 and 2009 the annual landings have fluctuated around 1000 t, with a peak in 2005. During the period 2010–2012 the landings decreased significantly to an average of 641 t, which correspond to about 57% of the TAC adopted for that period, maintaining thereafter around this value due to the TAC introduced. Since 2005 a continuous decrease of the landings has been observed. Currently the fishery is highly constrained by management measures. Landings of the last four years (2017, 2018,2019 and 2020) were: 499t, 445t, 474t and 491 respectively.

12.4.2 ICES Advice

ICES advised that when the precautionary approach is applied, catches should be no more than 610 tonnes in 2021 for area 10. All catches are assumed to be landed. The analysis for ICES advice have not been updated due to a lack of survey and fishery sampling data due to the Covid-19 disruption. The advice given in 2020 for 2021 remains valid and is rolled over for 2022.

12.4.3 Management

Under the European Union Common Fisheries policy, a TAC was introduced in 2003 (EC. Reg. 2340/2002). The recent time-series of TACs and landings from ICES Subarea 10 is given below.

Year	2007	2008	2009	2010	2011	2012	2013	2014
EU TAC	1136	1136	1136	1136	1136	1136	1022	920
Landings	1070	1089	1042	687	624	613	692	663
Year	2015	2016	2017	2018	2019	2020	2021	
EU TAC	678	507	517	517	576	553	*	
Landings	701	515	499	445	474	491		

***TAC for 2021 was not yet defined by the EC.**

Since 2003 deep-water fishing within 100 miles of the Azores baseline is restricted to vessels registered in the Azores under the management of fishing effort of the common fishery policy for deep-water species (EC. Reg. 1954/2003). In 2006 the Regional Azorean Government introduced a quota system by island and vessel. Specific access requirements and conditions applicable to fishing for deep-water stocks were established (EC. Reg 2347/2002). Fishing with trawl gears (EC. Reg. 1811/2004) and bottom gillnets (EC. Reg. 91/2005) are forbidden in the Azores region.

In 2009, the Regional Government introduce (Ordinance No. 1/2010) new technical measures, including the minimum landing size (30 cm total length), area restrictions by vessel size and gear, and gear restrictions (hook size and maximum number of hooks on the longline gear). The seamount (Condor), located approximately 17 km to the southwest off Faial Island, was closed to fisheries (Ordinance No. 48/2010) to allow a multidisciplinary research (ecological, oceanography and geological). During 2015, 2016 and 2017 additional technical measures were introduced which included limitation of the fishing area for long-liners, update of the minimum landing size to 33 cm (Ordinance No. 120/2016) and introduction of marine protected areas for coastal and oceanic areas (Santos *et al*., 2019). During 2017 new license limitations were introduced for littoral hook and line fisheries. Since 2018 the quota is managed by quarter, island and vessel. In 2019 some techniques measures have been changed by the Regional Government and European Union, as for example a closed season (Ordinance No. 74/2015) implemented in 2016, to reduce effort during the spawning aggregations (among January 15 and end of February), was revoked by Ordinance No. 63/2019 which allows fishing throughout the year. By the end of 2019 the Council Regulation (EU) 2019/1601 proceeded the reduction of Blackspot seabream fishery possibilities assigned to the European Union in 2020 from 576 t (EU Reg. 2019/124) to 553 t.

12.4.4 Data available

12.4.4.1 Landings and discards

Total annual landings data are available since 1980. However, detailed and precise landing data are available for the assessment since 1990 (WD15 Medeiros-Leal *et al*., 2021). Landings from Area 10.a.2 are presented in the Table 12.4.1 and Figure 12.4.1.

Information on the discards in the longline fishery has been collected in the Azores by a team of observers on board the longline fleet. During 2018 about 6% (12.7 t) of the total landings were discarded.

12.4.4.2 Length compositions

No new information.

12.4.4.3 Age compositions

No new information

12.4.4.4 Weight-at-age

No new information.

12.4.4.5 Maturity, sex-ratio and natural mortality

No new information

12.4.4.6 Catch, effort and research vessel data

There is no new information.

12.4.5 Data analyses

Catches in recent years are highly constrained by severe management measures. There is no new information available and data analysis (standardized fishery cpue and survey trend) was reported in the WGDEEP report 2020 (ICES, 2020).

Exploratory analysis

The length-based indicators (LBI), total mortality (Z), yield-per-recruit (YPR) and SPICT production model were explored and reported in the WGDEEP report 2020 (ICES, 2020). The results from these methods seem to be all in agreement suggesting that the stock has been explored at or above the MSY level. There is no new information available and data analysis for updating this exploratory analysis.

12.4.6 References

Diogo, H.; Pereira, J. G.; Higgins, R. M.; Canha, A.; Reis, D. 2015. History, effort distribution and landings in an artisanal bottom longline fishery: An empirical study from the North Atlantic Ocean. Marine Policy, 51: 75–85.

ICES. 2006. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources. ICES CM 2006/ACFM:28.

ICES. 2018. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP), ICES CM 2018/ACOM:

Medeiros-Leal, W.M; Santos, R.V.S; Novoa-Pabon, A.M; Silva, H; Pinho, M.R. 2020. Data from the deep-water fishery of the Azores (ICES subdivision 27.10.a.2). Working Document 17 (WD17). ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 24 April to 01 May 2020.

Medeiros-Leal, W.M; Santos, R.V.S; Novoa-Pabon, A.M; Silva, H; Pinho, M.R. 2021. Updating Survey data from the Azores for deep-water species. Working Document 15 (WD15). ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 22 April to 28 April 2021.

Novoa-Pabon, A. M.; Medeiros-Leal, W.; Pinho, M. R; Santos, R. V. S. 2020. Updated standardized CPUE for blackspot seabream (sbr.27.10) caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017. Working Document 13 (WD13). ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 24 April to 01 May 2020.

Ogle DH, Wheeler P, Dinno A (2020). *FSA: Fisheries Stock Analysis*. R package version 0.8.30, https://github.com/droglenc/FSA.

Pinho, M.R; Novoa-Pabon, A; Gil, J; Krug, H. 2015. Catch curve analysis for the red black spot seabream (*Pagellus bogaraveo*) stock from the Azores (ICES Xa2). Working Document ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 20 to 27 March 2015.

Pinho, M.R; Medeiros-Leal, W.M; Sigler, M.F, Santos, R.V.S; Novoa-Pabon, A.M. Menezes, G.M; Silva, H.M. Azorean Demersal Longline Survey Abundance Estimates: Procedures and Variability. in prep.

Pinho, M. R.; Menezes, G. 2009. Pescaria de demersais dos Açores. Boletim do Núcleo Cultural da Horta 2009:85-102. ISSN 1646-0022.

Pinho, M. R.; Diogo, H.; Carvalho, J.; Pereira, J. G. 2014. Harvesting juveniles of Red (Blackspot) seabream (*Pagellus bogaveo*) in the Azores: Biological implications, management and life cycle considerations. *ICES Journal of Marine Science*, 71, 2448–2456. doi: 10.1093/icesjms/fsu089.

Santos, R. V. S.; Silva, W. M.; Novoa-Pabon, A. M.; Silva, H. M.; Pinho, M. R. 2019. Long-term changes in the diversity, abundance and size composition of deep sea demersal teleosts from the Azores assessed through surveys and commercial landings. *Aquatic Living Resources*, *32*, 25. doi: 10.1051/alr/2019022

12.4.7 Tables and Figures

Table 12.4.1. Historical landings of blackspot seabream *Pagellus bogaraveo* from the Azores (ICES Area 10.a.2).

Year	Azores (10.a.2)	Total
1980	415	415
1981	407	407
1982	369	369
1983	520	520
1984	700	700
1985	672	672
1986	730	730
1987	631	631
1988	637	637
1989	924	924
1990	889	889
1991	874	874
1992	1090	1090
1993	830	830
1994	989	989
1995	1115	1115
1996	1052	1052
1997	1012	1012
1998	1119	1119

1999	1222		1222
2000	947		924
2001	1034		1034
2002	1193		1193
2003	1068		1068
2004	1075		1075
2005	1113		1113
2006	958		958
2007	1063		1070
2008	1089		1089
2009	1042		1042
2010	687		687
2011	624		624
2012	613		613
2013	692		692
2014	663		663
2015	701		701
2016	515		515
2017	499		499
2018	445		445
2019	474		474
2020	491		491

Table 12.4.2. Nominal and standardized bottom longline fishery abundance index (scaled cpue to the mean) of the black-spot seabream *Pagellus bogaraveo* in Subarea 10.

YEAR	NOMINAL cpue	STANDARDIZED cpue	Lower CI	Upper CI
1990	0.92	0.97	0.87	1.08
1991	0.92	0.94	0.81	1.07
1992	0.96	0.98	0.78	1.17
1993	0.79	1.01	0.87	1.15
1994	0.97	1.01	0.84	1.18
1995	1.09	1.08	0.92	1.23

YEAR	NOMINAL cpue	STANDARDIZED cpue	Lower CI	Upper CI
1996	1.24	1.5	1.25	1.75
1997	1.63	1.32	1.1	1.53
1998	1.03	1.21	1.06	1.35
1999	1.1	1.3	1.16	1.44
2000	0.82	0.82	0.75	0.9
2001	1.12	0.96	0.84	1.07
2002	1.24	1.02	0.9	1.15
2003	0.98	1	0.91	1.1
2004	1.42	1.08	0.96	1.19
2005	1.71	1.16	1.06	1.27
2006	1.26	0.95	0.86	1.04
2007	1.34	1.22	1.09	1.36
2008	1.21	1.13	1.02	1.24
2009	1.18	0.96	0.88	1.05
2010	0.62	0.72	0.66	0.78
2011	0.59	0.76	0.69	0.82
2012	0.62	0.81	0.74	0.88
2013	0.64	0.91	0.83	0.99
2014	0.67	0.83	0.76	0.90
2015	0.56	0.74	0.68	0.80
2016	0.39	0.61	0.56	0.67
2017	0.48	0.59	0.60	0.57
2018	na	na	na	na
2019	na	na	na	na
2020	na	na	na	na
na – not available				

Table 12.4.3. Survey relative abundance index in number of blackspot seabream *Pagellus bogaraveo* from the Azores (ICES Area 10.a.2).

Year	Lower	Index	Upper
1995	88	107	125
1996	33	41	49
1997	33	46	58
1998	na	na	na
1999	80	112	143
2000	38	52	67
2001	58	68	78
2002	126	138	150
2003	66	86	103
2004	69	94	120
2005	118	143	166
2006	na	na	na
2007	54	79	106
2008	84	101	119
2009	na	na	na
2010	53	67	83
2011	52	70	87
2012	49	58	69
2013	38	47	55
2014	na	na	na
2015	na	na	na
2016	114	137	158
2017	125	155	182
2018	92	114	136
2019	134	166	195
2020	na	na	na

na = Not available.

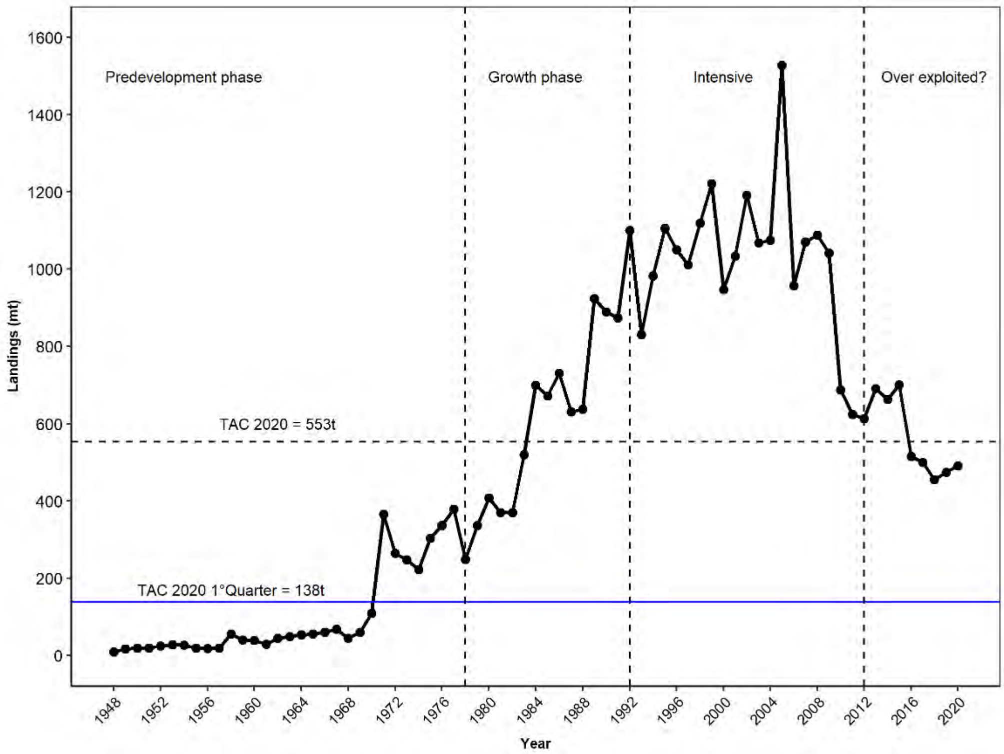

Figure 12.4.1. Historical landings of blackspot seabream *Pagellus bogaraveo* from the Azores (ICES Area 10.a.2).

13 Roughhead grenadier (*Macrourus berglax*) in the Northeast Atlantic

13.1 Stock description and management units

The population structure of roughhead grenadier in the Northeast Atlantic is poorly known. The species occurs at small abundance in some areas, mostly to the North of 60°N. The assessment unit considered by ICES is the whole Northeast Atlantic, this does not postulate anything about the population structure.

This stock is classified as Category 2 in the NEAFC categorization of deep-sea species/stocks in subareas 4, 12 and 14, which implies that directed fisheries are not authorised and that bycatches should be minimised in the NEAFC RA (NEAFC, 2016). In all other areas, this stock is classified as Category 4 in the NEAFC categorization of deep-sea species/stocks, which implies that fisheries are primarily restricted to Coastal State exclusive economic zones (EEZs) and therefore management measures are not taken by NEAFC unless complementary to coastal state conservation and management measures (NEAFC, 2016).

13.2 The fishery

There is no directed fishery for roughhead grenadier and catches are taken as by-catch from other fisheries. Unusually large catches (> 500 t) were reported in Subarea 6 in 2005–2007, in Subarea 12 in 2002, 2006 and 2009 as well as in Subarea 14 in 2010–2014. Afterwards in 2015–2017, the level of reported landings returned to past levels. These large catch are considered doubtful and suspected to correspond to species misreporting.

Roughhead grenadier was mostly caught with bottom trawl but, in Subarea 14 and Division 12.a, catches with pelagic trawl, a GLORIA type in the first year (2010) and a modified alfonsinos pelagic trawl in the following years, were reported. As significant catches of the species in pelagic trawls are unexpected, these reported catches could represent species misreporting of roundnose grenadier catches or errors of the reported fishing gear. No catches have been reported in Subarea 12 since 2017.

The Spanish fleet fishing grenadiers on the Mid-Atlantic ridge (MAR) consists of ten trawlers with an average length of 62 m and average Gross Tonnage of roughly 1000 t. This fleet alternates the redfish and grenadier fisheries. Most landings are taken in 14.b.1, where the fishing season lasts between three and seven months. Effort and catches peak in late spring and early summer. Since 2016 the presence of the Spanish fleet in this fishery has almost disappeared.

Most landings of roughhead grenadier from ICES Subarea 14 are from Norway and Greenland commercial trawl and longline fishery. Before 2014, the catch was dominated by trawlers, but from 2014 most catches are from the longline fishery. There are no reported landings from the Spanish fleet since 2017.

13.3 Landings trends

In subareas 1 and 2 there are landing records since 1990. The highest landings (400-800) occurred in the three first years and declined significantly thereafter. Since 2005 they are in the range of 30 to 50 t, except a higher level to 100 tonnes in 2016 and 153 tonnes in 2020. Most landings are from Norway with a smaller contribution from Russia. Landings from France are occasional and negligible, below 0.5 t in most years (Table 13.1).

Landing records from subareas 3 and 4 also started in 1990 and have been very low, peaking in 2005 at 39 t. The remaining years landings oscillated between 0 and 10 t, mostly to Norway, France, UK (Scotland) and Ireland have also reported landings in a few years (Table 13.2).

In Division 5.a, roughhead grenadier is occasionally caught. Before 2010, reported landings have been mostly below 10 tonnes per year and have increased to about 20 tonnes year afterwards. Between 2015-2019 reported landings from Iceland ranged between 20 and 40 tonnes (Table 13.3).

Landings have been reported in 5.b since 1997. The highest catch was 99 t in 1999, but in other years landings were < 12 t. In the last five years less than 1 t/year was reported, except 4 tonnes reported in 2018 by Norway (Table 13.4).

Landings from subareas 6 and 7 were mostly caught by the Spanish demersal multispecies fishery in Hatton Bank operated by freezer trawlers. The series starts in 1992, with official landings peaking during the period 2011–2013, when they reached 632 t in 2012 due to an exceptional report of 436 t by Lithuania. France has taken part in the fishery for a longer period but with much lower landings. Other minor participants in the fishery are Norway, UK, Ireland and Russia (Table 13.5). Landings from subareas 6 and 7 have declined since 2004, particularly in the last few years with the implementation of the regulation prohibiting bottom trawling below depths of 800 m. Any recent landings in subareas 6 and 7 are probably misidentification.

Occasional landings of less than 0.5 t have been reported from Subarea 8. These were considered as coding errors or area misreporting as the species is not known to occur in Subarea 8 and was never caught in surveys in this Subarea.

Official landings in Subarea 12 include landings from both the demersal multispecies fishery in Hatton Bank (12.b) and the pelagic redfish and grenadier fishery on the MAR (12.a). The series starts in 2000, and peaks in 2005 at 2200 t and in 2009 at 2832 t. Thereafter reported landings have decreased to 0 since 2017 (Table 13.6).

Low landings have been reported from Subarea 14 since 1993. In 2010–2014, Spain reported landings of 500–2700 tonnes/years (Table 13.7). Norway, Greenland and Russia reported landings earlier than other countries, and UK has occasionally also recorded very small catches. Landings decreased since 2013 but more strongly in 2019 to less than 85 t.

13.4 ICES Advice

The previous advice for roughhead grenadier was issued for 2016 to 2020 and stated that *"there should be no directed fisheries for roughhead grenadier, and bycatch should be counted against the TAC for roundnose grenadier to minimise the potential for species misreporting."*

The current advice was given in 2020 and states that "*when the precautionary approach is applied, there should be no directed fisheries for roughhead grenadier, and bycatch should be minimized for each of the years 2021 to 2025*."

13.5 Management

There is no known management plan for roughhead grenadier in any ICES area. There is a quota for European Union vessels in Greenland waters of subareas 5 and 14. There has been no species-specific EU TAC and management measure for Union vessels in Union and International waters. Since 2015, bycatch of roughhead grenadier by EU vessels in Union and International waters should be reported under the roundnose grenadier quota for the same area and may not exceed

1% of the quota. No directed fisheries of roughhead grenadier are permitted. This accounting of roughhead grenadier landings under quotas for roundnose grenadier was subject to an action for annulment at the EU court of justice and was rejected (http://curia.europa.eu/juris/liste.jsf?language=en&num=C-128/15). In eastern Greenland, main fishing operations are in Subdivision 14.b.2 and here, the TAC of roundnose and roughhead grenadier combined has been 1000 t since 2010. This TAC has been set by the Greenland Government and is not based on a biological assessment.

Management measures adopted by NEAFC establish a total allowable catch limitation of 574 tonnes of roundnose grenadier in 2021 and no direct fisheries for roughhead grenadier and roughsnout grenadier should be authorised in NEAFC Regulatory Area. Any bycatches of these grenadiers as well as other grenadiers (Macrouridae) should be counted against the total allowable catch of roundnose grenadier.

13.6 Data available

13.6.1 Landings and discards

Earlier years data are WG estimates based on national submissions to ICES, which are not fully included in InterCatch.

Official landing data are available from subareas 1 and 2 since 1990, from subareas 3 and 4 since 1992, from Division 5.a since 1996, from Division 5.b since 1997, from subareas 6 and 7 since 1993, from Subarea 8 for 2002 and 2006, from Subarea 12 since 2000, and from Subarea 14 since 1993.

Discard data for most years from 1996 to 2015 from subareas 6, 12 and 14, collected by Spanish scientific observers, on-board commercial Spanish trawlers were used to estimate discard rates. Discard rates, estimated as the discarded catch divided by retained catch of the species, are high, averaging 0.77 ± 0.42 (mean ± standard deviation) for Subarea 6, 0.68 ± 0.23 for Subarea 12 and 0.53± 0.50 for Subarea 14.b (Table 13.8).

National catch statistics of Greenland were used to update catches in Subarea 14.b.2 from 1999 to 2020. Data from recent years may include both landings from Greenland and other countries vessels, wherefore it was unclear whether this implies double count with landings reported by other countries. Due to the lack of survey in East Greenland in 2020, no survey data is available in 2021. A potential misreporting is suspected for roughhead grenadier, as the scientific survey of this species, has revealed that roughhead grenadier is more abundant in ICES 14.b.2. (WGDEEP 2019, WD5) – a trend which is not supported by catches (WGDEEP 2021, WD04). Similarly, it is possible that a part of landings in subareas 6 and 7 are probably misidentification, since catches from fishery-independent surveys are negligible.

In 2019 and 2020, there was virtually no Russian directed fishery in the deep waters of the Northeast Atlantic and bycatches of roughhead grenadier were obtained in longline fisheries in the Norwegian seas, and in the trawl fisheries targeting Greenland halibut (*Reinhardtius hippoglossoides*) in the eastern part of the Fishing Zone of Greenland (WGDEEP 2020, WD 23). In 2020, a negligible proportion of roughhead grenadier has been caught as bycatch in the demersal fishery in the Barents Sea and off Greenland.

Landings of roughhead grenadier inside and outside the NEAFC Regulatory Area are provided in table 13.9.

There remains some uncertainty given that historical landings and discards data are not always accurately recorded, or not provided by all countries. Therefore, it is noted that available data needs to be reviewed to provide robust estimations.

13.7 Length composition of the landings and discards

Fishery length composition of landings from the Russian fishery are shown in Figure 13.3 for 2019. Information provided is based on daily fishing vessel reports, materials collected during research surveys and data collected by observers on board fishing vessels (WGDEEP 2020, WD23).

No new data was provided for 2020.

13.8 Age composition

No new data available to WGDEEP, but recent literature provided information on age composition and growth parameters for *M. berglax* in the Norwegian Sea shelf edge in ICES subareas 1 and 2, based on pooled length at age data from slope surveys 2009-2018 (Bergstad *et al*., 2021).

Age was derived from otolith readings. Where data was suitable, age distributions showed that sampled individuals consisted mainly of 5 to 25 years old, but older individuals (up to 30 years old) were also common. The oldest specimens recorded were around 50 years old. Estimated parameters of the von Bertalanffy growth functions were L_{inf}: 27.36 cm PAFL; K: 0.11 year^{-1}; t_0: -0.02 year for females; and L_{inf}: 22.85 cm PAFL; K: 0.13 year^{-1}; t_0: -0.74 year for males.

13.9 Weight-at-age

No new data available.

13.10 Maturity and natural mortality

Maturity data was last available for 2019, provided by the Russian investigations in the Norwegian Sea (ICES divisions 2.a and 2b) (WGDEEP 2020, WD23).

Deep-water fish catches were taken by bottom and pelagic trawls of 16-135 mm mesh size. The biological samples were collected according to the methods employed at PINRO (Anon., 2004). Mass measurement was based on the total length (hereinafter referred to as 'length'). Maturity stages were assigned using the following maturity scale: II – immature, III – maturing, IV – pre-spawning, V – spawning, VI – post-spawning, VI-VII – postspawning recovery.

8-76 cm long roughhead grenadier was observed in by-catches of bottom fishing and research trawls, the mean length of the studied individuals was 39.5 cm, while 27-49 cm long roughhead grenadier prevailed (Fig. 13.3). In November-December, mainly immature individuals were recorded in catches. Among the sampled individuals, there were also males with maturing sex products, as well as individuals of both sexes at the stage of post-spawning recovery (Fig. 13.4). Research vessel survey and cpue

13.10.1 Research vessel survey

The Icelandic autumn groundfish survey IS-SMH is the main source of fishery-independent data for *M. berglax* in Icelandic waters. Further, data can be compiled from several other older surveys of exploratory nature.

The IS-SMH survey covers Icelandic shelf and slope at depths from 20–1500 m. It is a stratified systematic survey with standardized fishing methods. Small-meshed bottom trawls (40 mm in the codend) equipped with rock-hopper are towed at a speed of 3.8 knots for a predetermined distance of 3 nautical miles (See the stock annex for greater silver smelt for a detailed description of methodology).

The Greenlandic annual bottom trawl survey is the main source for fishery-independent data for roughhead grenadier in Subarea ICES 14b2 (Greenland waters). This survey is depth stratified covering depths from 400-1500 m using Alfredo trawl towed at a speed between 2.5-3.0 knots with a 30 min bottom time (tows of at least 15 min are accepted). Survey period span from 1998 to present with no survey in 2001, 2017 and 2018.

Norway conducts a long-term monitoring survey of deepwater species on the shelf-break and upper slope off Norway and Spitsbergen (between 68 and 80° N in ICES subareas 1 and 2), since the mid-1990s. An analysis of the fisheries-independent time series (1997–2020) suggests that roughhead grenadier is widely distributed between 500-800 m deep. Trends in abundance is more variable, showing a decline in the northern areas, but such trend was not detected towards the southern parts of the Norwegian shelf-edge, suggesting that distribution extends southwards beyond the sampling area (Bergstad *et al*., 2021). Biomass indices varied without trends in the survey period. A considerable temporal variation in recruitment is reported by Bergstad *et al*. (2021), which can be linked to the seasonal variability in food supply (Priede, 2017).

13.10.2 Cpue

The data available to WGDEEP only allow an estimation of non-standardised cpue for the Spanish fleet operating in subareas 6, 12 and 14 in 1996–2015.

13.11 Data analyses

Length distributions from ICES Subarea 14.b.2 show that from 1998 to 2016 a single mode around 19 cm (total length) dominated the survey and from 2010 to 2016 a second and smaller mode around 29 cm (total length) is also evident (Fig. 13.1). From this survey, it is shown that the highest biomass and abundance in Subarea 14.b.2 is equally distributed between three depth strata of 601-800 m, 801-1000 m and 1001-1500 m (Table 13.10). Survey biomass index appears stable from 2008 until 2016 (Fig. 13.2).

13.12 Benchmark assessments

There has been no benchmark for this stock.

13.13 Management considerations

Only landings are available and the time-series considered reliable is restricted to 1992–2001. Years 2002–2015 are not considered because catches reported in some divisions are significantly larger than the historical landings and there are major doubts about the certainty of these catches (ICES, 2014). Information from scientific on-board observers and exploratory surveys in subareas 6, 12 and 14 indicates that the species occurs at low density over these fishing grounds.

Available biological data (length or age composition, weight-at-age, maturity, mortality) does not allow to assess changes in stock status.

The population structure of roughhead grenadier in the Northeast Atlantic is poorly known. The species occurs at small abundance in some areas, mostly to the North of 60°N. Available literature suggests a significant gene flow of the roughhead grenadier *Macrourus berglax* across the

North Atlantic (Coscia *et al*., 2018), in contrast to the depth-dependent genetic structure found in *Coryphaenoides rupestris* (Gaither *et al*., 2018).

Literature based mostly on survey data from Canadian waters indicates that this is a long-lived, slow-growing species, of low fecundity and vulnerable to overfishing (see Devine and Haedrich, 2008 and references therein; Gonzalez-Costas, 2010). Age estimations from otoliths have found specimens of up to 23 years (Savvatimsky, 1984) and the species has been classified as of concern due to a decline of >90% of the survey index within Canadian waters over a period of 15 years (COSEWIC, 2007).

Whilst roughhead grenadier continue to occur as a bycatch, the proportions reported remain relatively low. There is very limited data available for this species, and some of the reported landings data are considered to be species misreporting. Thus, no expansion of current fisheries should be permitted until adequate data are collected from the exploited population to identify stock structure and conduct an appropriate assessment.

13.14 References

Aleksandrov, DI, Khlivnoi, VN. 2020. Russian fisheries and investigations of deep-water fish in the Northeast Atlantic in 2019. WD23 WGDEEP 2020.

Anonymous, 2004. Study of ecosystem in fishery water bodies, collection and processing of information about marine biological resources, techniques and technologies of its development and processing. Issue 1. Instructions and methodical recommendations on the collection and processing of biological information in the seas of the European North and the North Atlantic. Second edition, revised and enlarged. Moscow, VNIRO Press, 300 pp. (in Russian).

Bergstad, OA, Hansen, HØ, Harbitz, A. 2021. Roughhead grenadier (*Macrourus berglax*) on the shelf edge of the northeastern Norwegian Sea, 1997–2020: Distribution, abundance, size and age structure, growth. Fisheries Research, 240, 105957.

Coscia, I, Castilho, R, Massa-Gallucci, A, Sacchi, C, Cunha, RL, Stefanni, S, Helyar, SJ, Knutsen, H, Mariani, S. 2018. Genetic homogeneity in the deep-sea grenadier *Macrourus berglax* across the North Atlantic Ocean. Deep Sea Research Part I: Oceanographic Research Papers, 132, 60-67.

COSEWIC. 2007. COSEWIC assessment and status report on the roughhead grenadier *Macrourus berglax* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 40 pp.

Devine, JA, Haedrich, RL. 2008. Population Trends and Status of Two Exploited Northwest Atlantic Grenadiers, *Coryphaenoides rupestris* and *Macrourus berglax*. American Fisheries Symposium, 63, 463-484.

Gaither, MR., *et al*. 2018. Genomics of habitat choice and adaptive evolution in a deep-sea fish. Nature Ecology and Evolution, 2, 680-687.

González-Costas F. 2010. An assessment of NAFO roughhead grenadier Subarea 2 and 3 stock. NAFO Scientific Council Research Document, 10/32. 29 pp.

ICES. 2020. Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES Scientific Reports. 2:38. 928pp. http://doi.org/10.17895/ices.pub.6015

NEAFC. 2016. The NEAFC approach to conservation and management of deep-sea species and categorization of deep-sea species/stocks. Adopted at the 35th Annual Meeting, November 2016.

Nilsen, J, Nogueira, A, Christensen, HT. 2019. Survey results of roughhead grenadier, roundnose grenadier, greater silver smelt, blue ling, tusk, black scabbard fish, ling, and orange roughy in ICES subdivision 14.b.2 in the period 1998-2016. WD05 WGDEEP 2019.

Nilsen, J. 2021. Commercial catches of roundnose grenadier, roughhead grenadier, greater silver smelt, blue ling, tusk, black scabbard fish, ling and orange roughy in ICES division 14b in the period 1999-2020. WD04 WGDEEP 2021.

Priede, IG. 2017. Deep-sea fishes: biology, diversity, ecology and fisheries. Cambridge University Press.

Savvatimsky, PI. 1984. Biological Aspects of Roughhead Grenadier (*Macrourus berglax*) from Longline Catches in the Eastern Grand Bank Area, 1982. NAFO Sci.Council Studies, 7:45–51.

13.15 Tables and Figures

Table 13.1. Official landings (t) of roughhead grenadier (*Macrourus berglax*) in Subareas 1 and 2.

Year	Germany	Norway	Russia	France	Spain	TOTAL
1988						
1989						
1990	9	580				589
1991		829				829
1992		424				424
1993		136				136
1994						0
1995				1		1
1996				3		3
1997		17		4		21
1998		55				55
1999				<0.5		0
2000		35	13	<0.5		48
2001		74	20	<0.5		94
2002		28	1	<0.5		29
2003		47	30			77
2004		78	1			79
2005		64	13	<0.5		77
2006		74	4	<0.5		78
2007		44	5			49
2008		49	6			55
2009		51	2			53
2010		39	6			45
2011		29				29
2012		54				54
2013		34	1	1		36

Year	Germany	Norway	Russia	France	Spain	TOTAL
2014						
2015	0	26	17	0	+	43
2016		38	62			100
2017	0	41	9	+	0	50
2018[1]	0	89	0	+	0	89
2019[1]	0	141	1	< 0.5	0	142
2020[1]	0	148	5	< 0.5	0	153
[1]–preliminary statistics.						

Table 13.2. Official landings (t) of roughhead grenadier (*Macrourus berglax*) in Subareas 3 and 4.

Year	France	Ireland	Norway	UK (Scot.)	TOTAL
1991					
1992			7		7
1993					
1994					
1995					
1996	4				4
1997	5				5
1998	1				1
1999	< 0.5				
2000	< 0.5	1	3	< 0.5	4
2001	< 0.5	1	9		10
2002	< 0.5		3	< 0.5	3
2003	< 0.5		2		2
2004	< 0.5		< 0.5	1	1
2005	1		38	< 0.5	39
2006	< 0.5				
2007					
2008					
2009					

Year	France	Ireland	Norway	UK (Scot.)	TOTAL
2010				< 0.5	
2011	2				2
2012	1			< 0.5	1
2013	1				1
2014					
2015	+	0	+	0	+
2016	< 0.5		< 0.5		< 1
2017	< 0.5		< 0.5		< 1
2018[1]	< 0.5	0	< 0.5	0	< 0.5
2019[1]	< 0.5	0	0	0	< 0.5
2020[1]	< 0.5	0	0	0	< 0.5
[1]–preliminary statistics.					

Table 13.3. Official landings (t) of roughhead grenadier (*Macrourus berglax*) in 5.a.

Year	Iceland	Norway	TOTAL
1995			
1996	15		15
1997	4		4
1998	1		1
1999			
2000	2		2
2001	1		1
2002	4		4
2003	33		33
2004	3		3
2005	5		5
2006	7		7
2007	2		2
2008	< 0.5		
2009	5		5

Year	Iceland	Norway	TOTAL
2010	22		22
2011	21		21
2012	16		16
2013	16		16
2014			
2015	20		20
2016	20		20
2017	40[1]		40[1]
2018[2]	20	< 0.5	20
2019[2]	28		28
2020[1]	44		44
[1]–revised catch data. [2]–preliminary statistics.			

Table 13.4. Official landings (t) of roughhead grenadier (*Macrourus berglax*) in Division 5.b.

Year	France	Norway	UK (Scot.)	Russia	TOTAL
1997	6				6
1998	9				9
1999	99				99
2000	1				1
2001	2	2			4
2002	3		< 0.5		3
2003	12				12
2004	9		1		10
2005	6				6
2006	10				10
2007	3			2	5
2008	1			2	3
2009					
2010		1			1
2011					

Year	France	Norway	UK (Scot.)	Russia	TOTAL
2012	2		1		3
2013	2				2
2014	< 0.5				
2015	1	+	0	0	1
2016					
2017	< 0.5	< 0.5			0.5
2018[1]	1	4	0	0	5
2019[1]	< 0.5	< 0.5	0	0	< 1
2020[1]	< 0.5	0	0	0	< 0.5
[1]—preliminary statistics.					

Table 13.5. Official landings (t) roughhead grenadier (*Macrourus berglax*) in Subareas 6 and 7.

Year	UK (E+W)	France	Norway	UK (SCO)	Spain	Ireland	Russia	Lithuania	TOTAL
1988									
1989									
1990									
1991									
1992									
1993	18								18
1994	5								5
1995	2	2							4
1996		13							13
1997		12							12
1998		10							10
1999		38							38
2000	< 0.5	3		8					11
2001		2	27	16					45
2002		4	2	6					12
2003		8	2		1				11
2004		6		5	0				11

Year	UK (E+W)	France	Norway	UK (SCO)	Spain	Ireland	Russia	Lithuania	TOTAL
2005		6		2	0				8
2006		10		< 0.5	0	75			85
2007		21			0	18			39
2008		2			222		4		228
2009		12		< 0.5	0				12
2010		8		1	51		1		61
2011		3			346				349
2012		1		4	191			436	632
2013		2			179				181
2014					42				42
2015		11	+		21				32
2016		35			32				67
2017		3	1		1	< 0.5			5
2018[1]	0	7	0	7	0	0	0	0	14
2019[1]	0	4	2	< 0.5	0	0	0	0	6
2020[1]	0	3	0	< 0.5	0	0	0	0	3
[1]—preliminary statistics.									

Table 13.6. Official landings (t) roughhead grenadier (*Macrourus berglax*) in Subarea 12.

Country	Norway	France	Spain	Russia	Lithuania	TOTAL
1999						
2000	7	< 0.5				7
2001	10	< 0.5				10
2002	7		1136			1143
2003	2	< 0.5	223			225
2004	27	< 0.5	725			752
2005		< 0.5	2200	5		2205
2006		< 0.5	968	8		976
2007			420			420
2008			252			252

Country	Norway	France	Spain	Russia	Lithuania	TOTAL
2009	6		2826			2832
2010			580			580
2011			441			441
2012			526		4	530
2013			210			210
2014			164			164
2015			53			53
2016	< 0.5		31			31
2017						0
2018[1]	0	0	0	0	0	0
2019[1]			0			0
2020[1]			0			0

[1]—preliminary statistics.

Table 13.7. Official landings (t) of roughhead grenadier (*Macrourus berglax*) in Subarea 14.

Country	Greenland	Norway	Russia	Spain	UK (E+W)	Germany	TOTAL
1992							
1993	18	34					52
1994	5						5
1995	2						2
1996							
1997							
1998		6					6
1999		14					14
2000							
2001		26					26
2002		49	4				53
2003		33					33
2004		46	9				55
2005	20	30	10				60

Country	Greenland	Norway	Russia	Spain	UK (E+W)	Germany	TOTAL
2006	4	1	3				8
2007	4	6	9				19
2008	12		3				15
2009	4	3			1		8
2010	12	1	13	1500	1		1527
2011	2		27	1516			1545
2012	14	16	18	2687			2735
2013			32	803			835
2014	62		11	450			523
2015	38	68	0	12			121
2016	74	73	8	4			159
2017	93	88[1]	17				198[1]
2018[2]	89	97	16	0	0		202
2019[2]	1	76	5	0			82
2020[2]	18	19	0	0	0	9	46
	[1]–revised catch data. [2]–preliminary statistics.						

Table 13.8. Average discard rate (discarded catch / total catch) 1996–2015, estimated from data collected by scientific observers on board commercial trawlers.

Year	6.b	12.a	12.b	14.b
1996			0.00	0.00
1997				
1998	0.42		0.56	
1999				
2000		1.00	0.41	0.12
2001	0.94		0.40	0.00
2002	0.79		0.50	1.00
2003	0.65		0.00	0.00
2004	1.00		0.97	
2005				
2006	0.33		0.00	

Year	6.b	12.a	12.b	14.b
2007				
2008	0.00		0.04	
2009			0.00	
2010			0.17	
2011				0.13
2012				
2013	1.00		1.00	1.00
2014				
2015	NA	NA	NA	NA
Mean	0.79	1.00	0.37	0.51

Table 13.9. Roughhead grenadier in the Northeast Atlantic. Landings inside and outside the NEAFC Regulatory Area (RA) as estimated by ICES. Landings in tonnes.

Year	Inside the NEAFC RA	Outside the NEAFC RA	Total landings	Proportion inside the NEAFC RA (%)
2016	4	373	377	1
2017	0	294	294	0
2018	0	330	330	0
2019	0	259	259	0
2020[1]	0	247	247	0

[1]—**preliminary statistics.**

Table 13.10. Biomass (t) and abundance (in numbers) with SE of roughhead grenadier expressed as mean catch per km² and total biomass by Q-subarea and depth stratum in ICES subarea 14.b.2 in 2016. Q-subareas encompass Q1-Q5 (see Nielsen *et al*. 2019) for which area and number of survey hauls in 2016 are listed.

				Biomass			***Abundance***		
Subarea	Depth strata	Area	Hauls	Mean/km²	Biomass	SE	Mean/km²	Abundance	SE
Q1	401-600	6975	12	0.0305	212.9	91.5	28.1	195794	91854
Q2	401-600	1246	5	0.6579	819.7	466.7	615.6	766985	379861
	601-800	1475	7	1.3791	2034.7	746.6	844.3	1245641	356006
	801-1000	1988	10	0.9196	1828.5	503.4	676.8	1345717	458547
	1001-1500	6689	7	0.2539	1698.3	612.7	298.0	1993532	768271
Q3	401-600	9830	11	0.0106	104.2	61.5	12.6	124283	84253
	601-800	3788	14	0.0121	45.7	18.6	7.9	30040	11284
	801-1000	755	6	0.0171	12.9	8.6	12.7	9610	6398
Q5	401-600	1819	3	0.0032	5.9	5.9	4.4	7970	7970
	601-800	257	6	0.0486	12.5	4.1	53.3	13700	2996
	801-1200	256	5	0.1387	35.5	7.9	285.6	72993	15673
	1201-1400	986	9	0.1037	102.2	29.0	147.4	145251	36288
	1401-1500	615	5	0.0672	41.3	14.1	87.7	53912	24270
All		36679	100	0.1896	6954.2	1191	163.7	6005430	1044

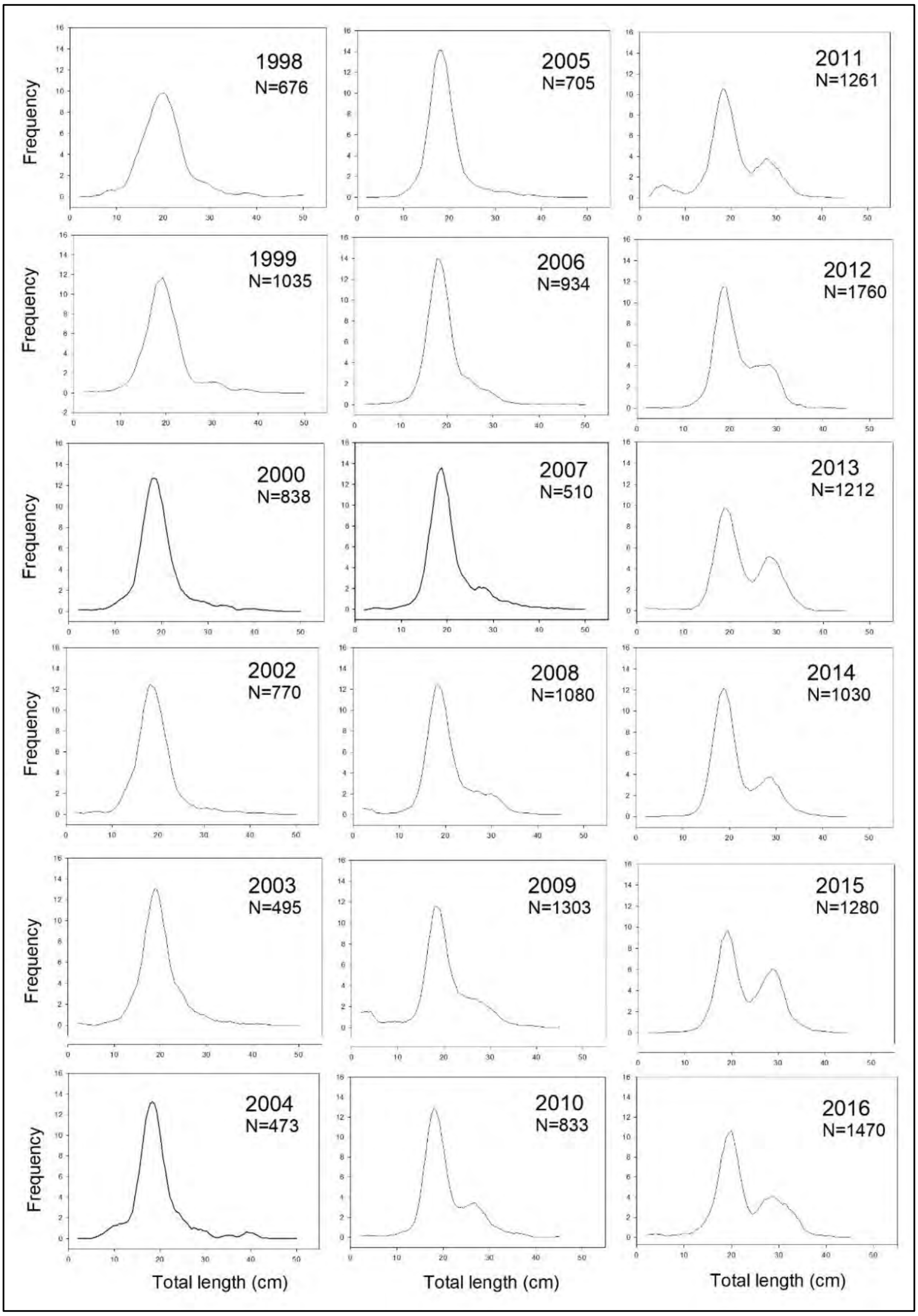

Figure. 13.1. Length frequency distribution of roughhead grenadier for years 19982016 in ICES subarea 14b2 (east Greenland). No survey in 2001, and since 2017.

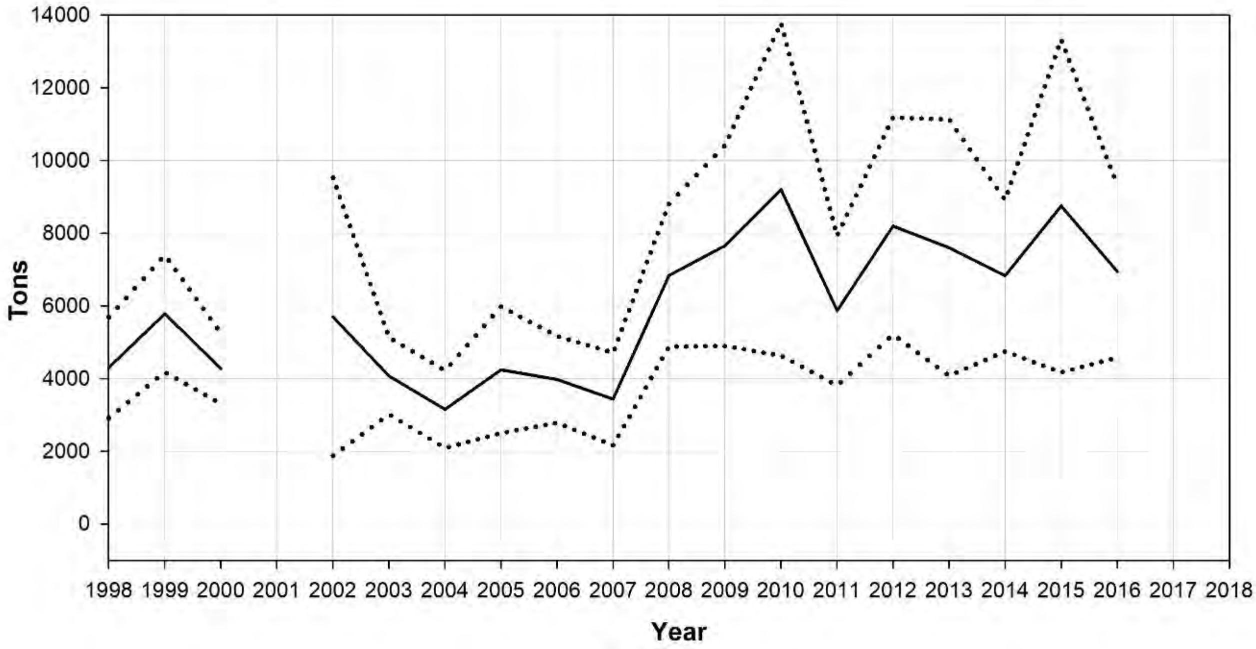

Figure 13.2. Estimated index biomass (solid line) of roughhead grenadier in ICES 14.b.2 plotted with +/- 2*SE. No survey in 2001, and since 2017.

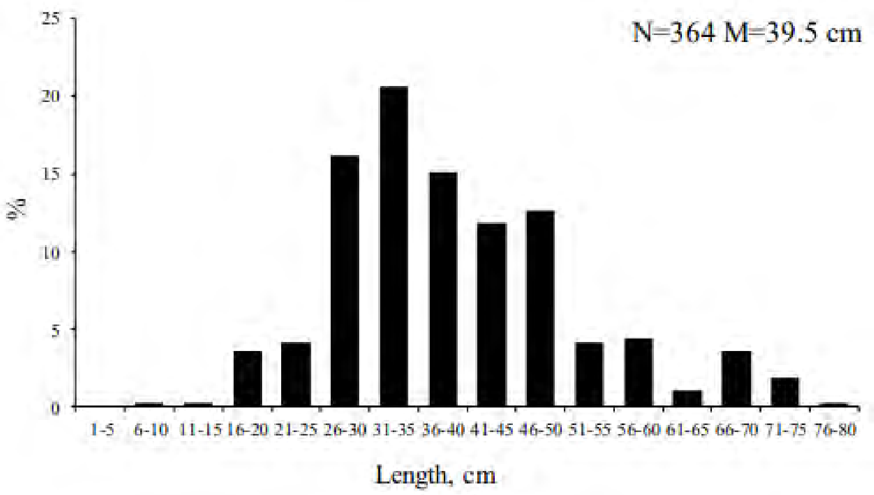

Figure 13.3. Length composition of roughhead grenadier in the Norwegian Sea (subareas 2a and 2b) in 2019.

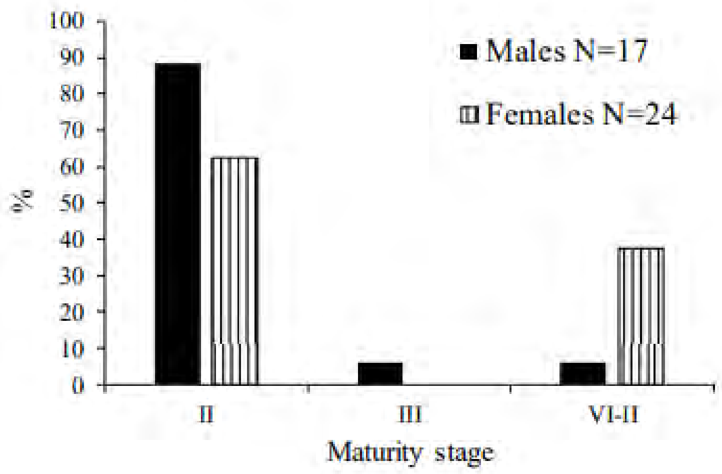

Figure. 13.4. Maturity of roughhead grenadier in the Norwegian Sea (subareas 2a and 2b) in November-December 2019.

14 Roughsnout grenadier (*Trachyrincus scabrus*) in the Northeast Atlantic

14.1 Stock description and management units

There are taxonomic issues with this stock. The roughsnout grenadier (*Trachyrincus scabrus*) was formerly *Trachyrincus trachyrincus,* with various spellings. The roughnose grenadier (*Trachyrincus murrayi*) is a closely related species that is abundant throughout the north of Northeast Atlantic (Jonsson, 1992). The scientific names and common name of these species changed over time. The similarity of the English names (roughsnout grenadier and roughnose grenadier) can increase the confusion.

Along the slope to the west of Scotland in ICES Division 6.a, only *Trachyrincus murrayi* was caught in surveys spanning depths from 500–2000 m and that took place in the 1970s and 1980s (Gordon and Duncan, 1984). In recent years, *Trachyrincus murrayi* was caught by the Marine Scotland deep-water research surveys in sufficient numbers to allow the estimation of population indicators (Neat and Burns, 2010).

In the published literature, there is no report of the occurrence of *Trachyrincus scabrus* at significant level in northern areas of the Northeast Atlantic. In particular, there are no records of the species in surveys held along the Mid-Atlantic Ridge (Fossen *et al*., 2008). *Trachyrincus scabrus* is not caught in Icelandic surveys where *Trachyrincus murrayi* is caught in large numbers. Similarly, to the East of Greenland (Division 14.a and 14.b.2) only *Trachyrincus murrayi* is caught in scientific surveys.

T. scabrus has been reported in the Porcupine Seabight (ICES Division 7.j,k) at depths 500–1300 m. The species was also recorded further south in the Cantabrian Sea (ICES Division 8.c). In the latter area, *T. scabrus* was report to occur at a high abundance on the Le Danois Bank (ICES Division 8.b) at depths from 500–800 m (Sanchez *et al*., 2008).

Unlike in the Atlantic Ocean, *Trachyrincus scabrus* occurs in most of the Mediterranean Sea, along the Spanish slope to the Ionian Sea (D'Onghia *et al*., 2004; Moranta *et al*., 2006). In the Mediterranean Sea high abundances were reported at depths ranging from 800–1300 m. In the Mediterranean Sea, *T. scabrus* reaches larger sizes than the other macrourid species occurring at the same depth range.

Therefore, *T. scabrus* is a species occurring in the Mediterranean Sea and in the Atlantic and does not seem to occur at levels susceptible to support commercial fisheries in most areas north of 52°N.

The other *Trachyrincus* species (*T. murrayi*) occurs in Subareas 5, 6 and 12. There is no known fishery for it. *T. murrayi* does not reach sufficient sizes to be of commercial interest. It is only a bycatch of deep-water fisheries in Subareas 5, 6, 7, 12 and 14.

As *T. scabrus* and *T. murrayi* can be misidentified in fisheries catches this chapter addresses the two species.

Landings of *T. scabrus* were reported for ICES subareas 6, 12 and 14. In these areas the species is considered to be at the most a minor bycatch. The occurrence of the species is not confirmed in subareas 12 and 14. It may be that only *T. murrayi*, occurs in these subareas. Therefore, the species identity of commercial landings reported as *T scabrus* needs to be confirmed. WGDEEP considered that the reporting of 0 landings in response to the data call for landings and discards in 2016 to 2019, confirms that landings reported before 2016 were misreporting, misidentification or coding errors.

14.2 Landings trends

Landings of 57 and 649 tonnes were reported in 2012 and 2014 respectively. In 2014, these came mainly from divisions 12.b and 14.b. (Table 14.1a)

In 2006–2008, Lithuania reported significant landings for subareas 6 and 12 (Table 14.1b, source ICES catch statistics 2006–2015). Landings reported by Spain in 2012-14 are not included in ICES catch statistics 2006–2017 (downloaded from the ICES website on 24.04.2020). No landings have been reported neither in preliminary catch statistics nor InterCatch from 2014 to 2020.

14.3 ICES Advice

The ICES advice for the years 2021–2025 is that "*when the precautionary approach is applied, there should be no directed fisheries for roughsnout grenadier and bycatch should be minimized for each of the years 2021 to 2025*."

The previous advice, for the years 2016–2020 further added " *and bycatch should be counted against the TAC for roundnose grenadier to minimize the potential for species misreporting*."

14.4 Management

There is no current species-specific management measure for the roughsnout grenadier. Despite the advice for years 2016–2020, the EU regulation for TACs of deep-water species in 2017–2018 and 2019-2020 made no mention of the roughsnout grenadier (Council regulation (EU) 2016/2285 and 2018/2025). There is no regulation for this species in other countries (Norway, Iceland, Faroe Islands) where these species should be landed when caught.

The EU regulation 2016/2336 establishing specific conditions for fishing for deep-sea stocks, does not mention *Trachyrincus* species.

14.5 Data availability

14.5.1 Landings and discards

Landings data are presented in Table 14.1a and 14.1.b.

T. murrayi is discarded by the French deep-water fishery. Both *T. murrayi* and *T. scabrus* are recorded in on-board observation but the identification of these species may be uncertain. The total catch of the two combined have a few percent of the total catch of roundnose grenadier (Table 14.2). Then, *T. scabrus* and *T. murrayi* have a minor contribution to the total catch in weight in ICES divisions 5.b and 6.a and Subarea 7, where the French fishery operates. These species have never been landed by the French fishery.

Discards of *Trachyrincus* spp. are expected to occur in all deep-water fisheries and also in the other fisheries along the upper slope such as fisheries targeting hake, monkfish and megrims, which may operate down to 800 m.

The stock was included in the data call for 2017 and data were delivered to WGDEEP through InterCatch and file provided by members. France, Spain and Portugal reported through InterCatch and no landings and discards were uploaded. The absence of landings matches expert knowledge that the species is not commercial. The absence of discards from InterCatch may come from the absence of landings so the standard raising variable being absent discards were raised to 0. Faroe Islands, Iceland and Norway, reported landings of deep-water species on the WGDEEP SharePoint and there were no landings of *Trachyrincus* spp. included. As the fisheries from these countries make no discards, there was no catch of roughsnout grenadier or these catches were not identified at species level.

Discards quantities for 2018 were reported to InterCatch by France, Portugal and Spain. The estimated raised discards were 91 kg from France, 651 kg from Spain and 0 from Portugal.

14.6 Length compositions

No length data are available. No length distribution was reported to InterCatch for 2016-2019.

In the Icelandic autumn survey specimens of *T. murrayi* with sizes up to 40 cm total length have been recorded. Nevertheless, the bulk of the catch is made of specimens with a length range from 5 to 20 cm.

T. murrayi of 45 cm total length would weigh less than 300 g using the following weight–length relationship estimated for *T. murrayi*: W=0.00129 LT^3.232 (Borges *et al*., 2003).

14.6.1 Age compositions and longevity

No age composition is available. There are however, some studies on growth and longevity.

In the Mediterranean *T. scabrus* has a maximum age of eleven years (Massutti *et al*., 1995).

Swan and Gordon (2001) analysed otoliths from 218 specimens of *T. murrayi*, with head length ranging from 2.1–11.7 cm and found up to nine growth bands on otolith. Converting the head length (HL) to total length (TL) by using the conversion estimated by the Swan and Gordon (2001): HL=3.630*HL+0.402 (n=488), the largest fish in the sample had 42 cm total length, which seems to be at or close to the maximum length of the species in the area.

It can be concluded that the two *Trachyrincus* species appear to have similar longevities, of around ten years. Similar lifespans have been estimated for other small macrourids (Coggan *et al*., 1999).

14.6.2 Weight-at-age

No weight-at-age data are available.

14.6.3 Maturity and natural mortality

No data were available.

14.6.4 Catch, effort and research vessel data

Population indicators of *T. murrayi* were estimated from data collected during deep-water research surveys held by the Marine Scotland. The abundance and length distribution varied along the period under analysis (2000–2008) and no trend was observed (Neat and Burns, 2008). As for *T. scabrus*, the species occurs at a too low level in the area covered by the survey to calculate indicators.

14.7 Data analyses

Available data on *T. murrayi* suggest that the species is too small to have commercial interest. In fact, the weight of the largest specimen caught in Icelandic survey (45 cm TL) was not more than 500 g. Available data on *T. scabrus* suggest that the species occurs at too low level in the Northeast Atlantic to support any commercial fishery.

14.7.1 Biological reference points

Not applicable.

14.8 Comments on assessment

Not applicable.

14.9 Management considerations

The roughsnout and roughnose grenadiers are small bycatch in some deep-water fisheries (see example in Table 14.2).

Owing to the smaller size and shorter longevity of *T. murrayi* and *T. scabrus* compared to the target species of deep-water fisheries, levels of fishing mortality that are sustainable to the target species are most likely to be also sustainable for these smaller species.

The only management that can be suggested is to include minor landings of any macrourid species in the TAC of the main grenadier species, the roundnose grenadier. This should not imply any increase of the TAC of roundnose grenadier, because the standing biomass of *Trachyrincus* spp. and all other macrourids are small compared to that of the roundnose grenadier in all ICES divisions. As these other macrourid species are of much smaller size than the roundnose grenadier, and therefore are not much retained by commercial trawls, the catch can only be minor compared to that of roundnose grenadier, when the latter is targeted. At depth shallower than the core depth range of the roundnose grenadier, the situation may be different with a much higher ratio of small macrourid to roundnose grenadier. As a consequence of the ban of fishing deeper than 800 m the core depth range of the roundnose grenadier is no longer accessible to trawler so the ratio of small macrourids to roundose grenadier in on-board observations has increased, although the absolute quantity of small macrourids has not (see analyse of data for years 2004-2019 in Table 14.2).

14.10 References

Coggan, R. A., J. D. M. Gordon, and N. R. Merrett. 1999. Aspects of the biology of *Nezumiaaequalis* from the continental slope west of the British Isles. Journal of Fish Biology 54:152–170.

D'Onghia, G., C. Y. Politou, A. Bozzano, D. Lloris, G. Rotllant, L. Sion, and F. Mastrototaro. 2004. Deep-water fish assemblages in the Mediterranean Sea. Scientia Marina (Barcelona) 68:87–99.

Fossen, I., C. F. Cotton, O. A. Bergstad, and J. E. Dyb. 2008. Species composition and distribution patterns of fish captured by longlines on the Mid-Atlantic Ridge. Deep-Sea Research Part Ii-Topical Studies in Oceanography 55:203–217.

Gordon, J. D. M., and J. A. R. Duncan. 1985. The ecology of deep-sea benthic and benthopelagic fish on the slopes of the Rockall Trough, Northeastern Atlantic. Progress in Oceanography 15:37–69.

Jonsson, G. 1992. Islenskirfiskar.Fiolvi, Reykjavik, 568 pp.

Neat, F., and F. Burns. 2010. Stable abundance, but changing size structure in grenadier fish (Macrouridae) over a decade (1998–2008) in which deepwater fisheries became regulated. Deep-Sea Research Part I-Oceanographic Research Papers **57**:434–440.

Massuti, E., B. Morales-Nin and C. Stefanescu. 1995. Distribution and biology of five grenadier fish (Pisces: Macrouridae) from the upper and middle slope of the northwestern Mediterranean. Deep-Sea Research 42(3):307–330.

Moranta, J., E. Massuti, M. Palmer, and J. D. M. Gordon. 2006. Geographic and bathymetric trends in abundance, biomass and body size of four grenadier fish along the Iberian coast in the western Mediterranean. Progress in Oceanography 72:63–83.

Sanchez, F., A. Serrano, S. Parra, M. Ballesteros, and J. E. Cartes. 2008. Habitat characteristics as determinant of the structure and spatial distribution of epibenthic and demersal communities of Le Danois Bank (Cantabrian Sea, N. Spain). Journal of Marine Systems 72:64–86.

14.11 Tables

Table 14.1a. Official landings of roughsnout grenadier by ICES Subarea reported by Spain in 2012-2014.

Year	6.b	12.a	12.b	14.b	Total
2012		54		3	57
2013					0
2014	42	4	155	448	649

Table 14.1b. Official landings of roughsnout grenadier by ICES Subarea reported by Lithuania.

Year	6	12	Total
2006	506	67	573
2007	442	101	543
2008	49	50	99

Table 14.2. Catch (discards and landings combined) in kg of macrourid species observed in on-board observations of the French deep-water trawl fishery. Data limited to hauls where the landings and discards where fully sampled. Ratio of TSU (considered as the combination of the two Trachyrincus species) to RNG and ratio of the total catch of other macrourid species to RNG. No data in 2007. Raw observations, i.e. cumulated catch in observed haul, no raising to fleet level.

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
RNG *(C. rupestris)*	243828	109136	31252		34938	130306	81899	78024	65339	45530	55508	18157	12714	3971	10917	5350
Coelorinchus caelorhincus		1	20		1230	3186	2970	2212	2035	2279	1225	1119	952	981	836	1121
Coelorinchus caudani	1				242											
Coelorinchus labiatus	5352	1744	1257		194	345	212	48	116	128	39	52	8			
Coryphaenoides guentheri	667	27				1062	33	6	2							
Coryphaenoides mediterraneus	62	123	42					76		1						
Hymenocephalus italicus									69		22	0				
Macrourus berglax	37	6614			1042	331	3562	23	775	677	616	71	188	165	665	335
Malacocephalus laevis	1	26	37		2196	2089	626	330	104	390	857	1262	298	124	266	928
Nezumia aequalis	176	40	114		397	740	237	423	414	303	280	189	224	214	207	153
Nezumia sclerorhynchus					27				72	6	1	83	116	219	157	66
TSU *(Trachyrincus murrayi)*	7304	4299	1783		1	697	61	304		229	306	70	3			116
TSU *(Trachyrincus scabrus)*	82		167		2	49	1066	134	1183	558	215	86	218	102	41	334
All species (except *C. Rupestris*)	6296	8575	1470		5328	7753	20784	3118	3587	3784	3040	2776	1786	1703	2131	2603
RatioTSU to RNG	0.030	0.039	0.062		0.000	0.006	0.014	0.006	0.018	0.017	0.009	0.009	0.017	0.026	0.004	0.084
Ratio all species to RNG	0.056	0.118	0.109		0.153	0.065	0.319	0.046	0.073	0.100	0.064	0.161	0.158	0.455	0.199	0.571

15 Atlantic wolffish (*Anarcichas lupus*) in Division 5.a (Icelandic grounds)

15.1 Atlantic wolffish in 5a

15.1.1 Fishery

The main fishing grounds for Atlantic wolffish are in the west and northwest part of the Icelandic shelf. From 2010, the proportion of the catch has been increasing in northwest of Iceland compared to west of Iceland. Catches at the main spawning ground (Látragrunn) west of Iceland have been decreasing since 2008 (Figures 15.1.1 and Figure 15.1.2). About 80% of the catch of Atlantic wolffish is caught at depths less than 120 m. Proportion of the catch taken at depth range 0-60 m decreased from 2003 to 2007, but since then it has been increasing. At the depth range 61-120 m the proportion of the catch has been rather stable since 2000. At depths from 121 to 180 m, which includes the main spawning ground (Látragrunn), it the proportion of the catch increased in 2003-2008 but since then it has been decreasing (Figure 15.1.3).

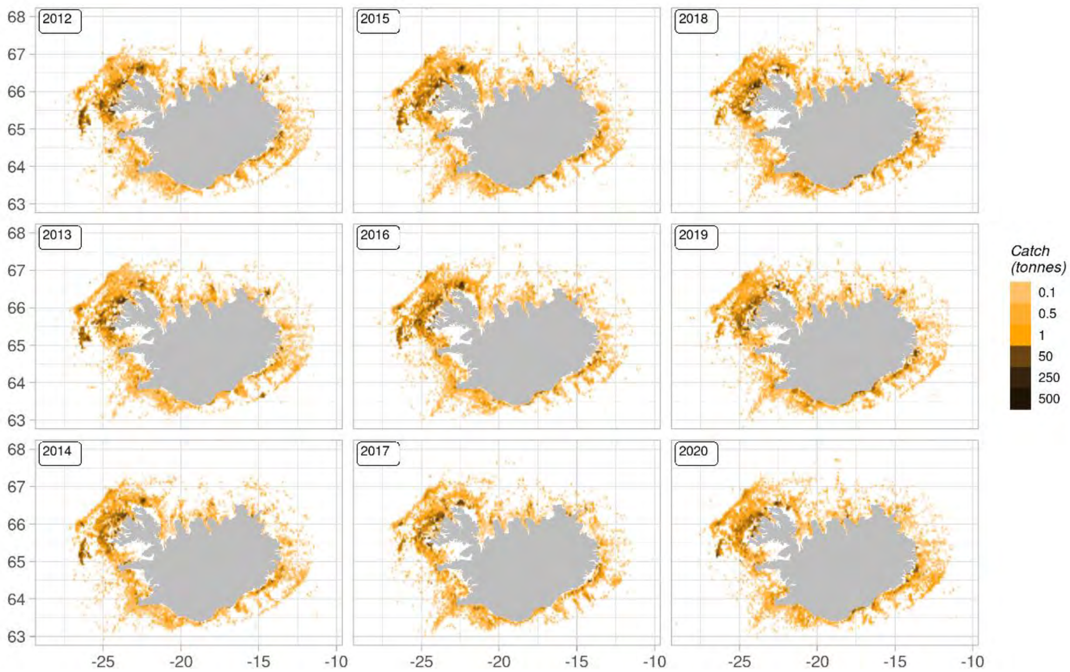

Figure 15.1.1 Atlantic wolffish in 5.a. Geographical distribution of the Icelandic fishery since 2012 as reported in logbooks. All gear types combined.

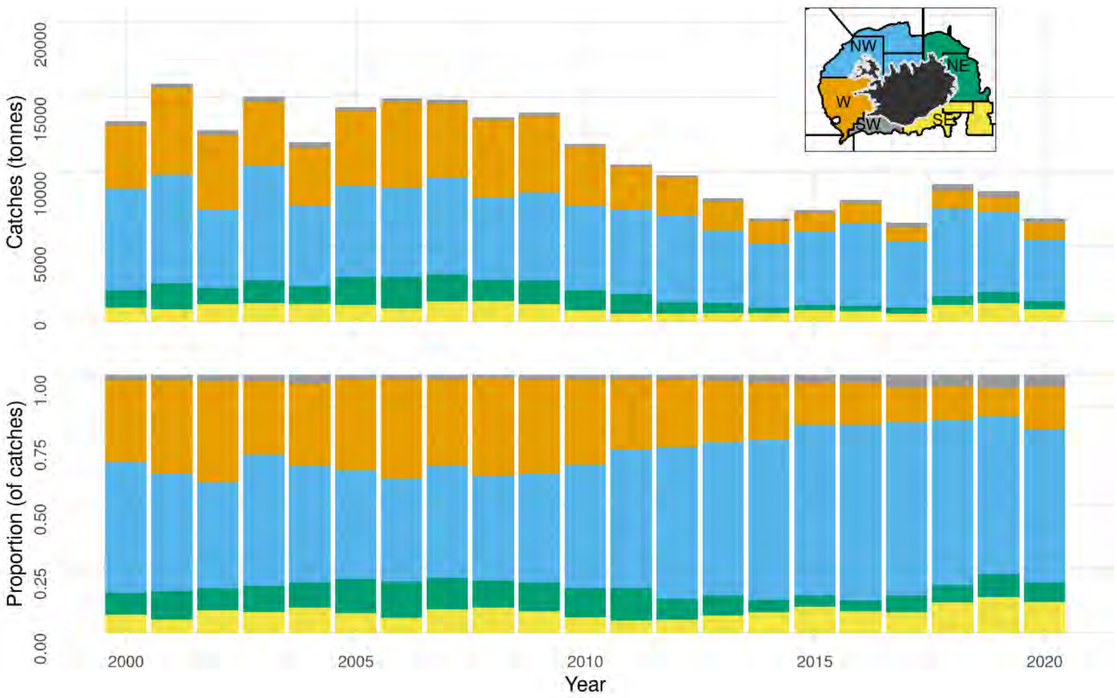

Figure 15.1.2: Atlantic wolffish in 5a. Spatial distribution of the Icelandic fishery by fishing area since 2000 according to logbooks. All gears combined.

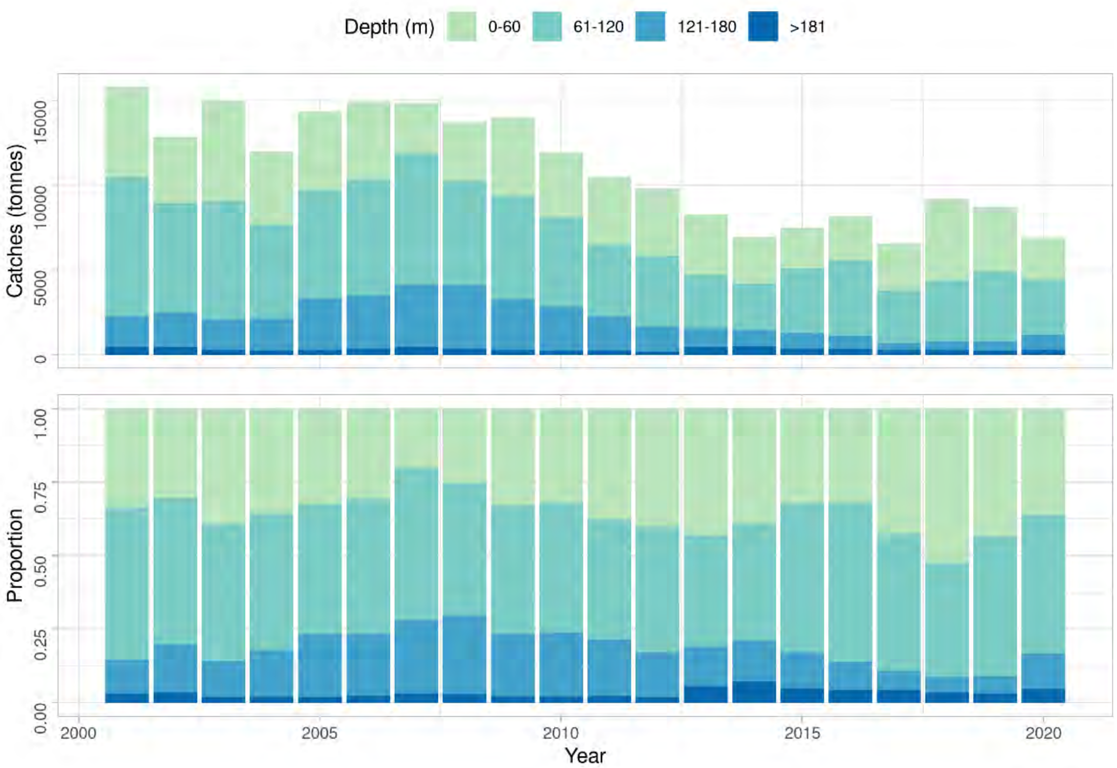

Figure 15.1.3. Atlantic wolffish in 5.a. Depth distribution of demersal trawl, longline and demersal seine catches according to logbooks.

15.1.2 Landings trend

More than 97% of the Atlantic wolffish catch is taken by longliners (50-65%), demersal trawlers (20-30%) and demersal seiners (about 10%) (Figure 15.1.4). These proportions have been relatively stable through the years. However, in 2004-2008 longline and demersal trawl catches were similar (40-50%) and in the last three years catches by demersal seiners hasve been increasing and are now greater than in demersal trawlers (Figure 15.1.4). Since 2001, the number of longliners and trawlers reporting Atlantic wolffish catches of 10 tonnes/year or more has decreased. In the longline fleet, the number of vessels has dropped from 198 in 2001, down to 67 in 2018. The number of trawlers has also decreased significantly from 76 in 2000 to 40 in the last year (Table 1).

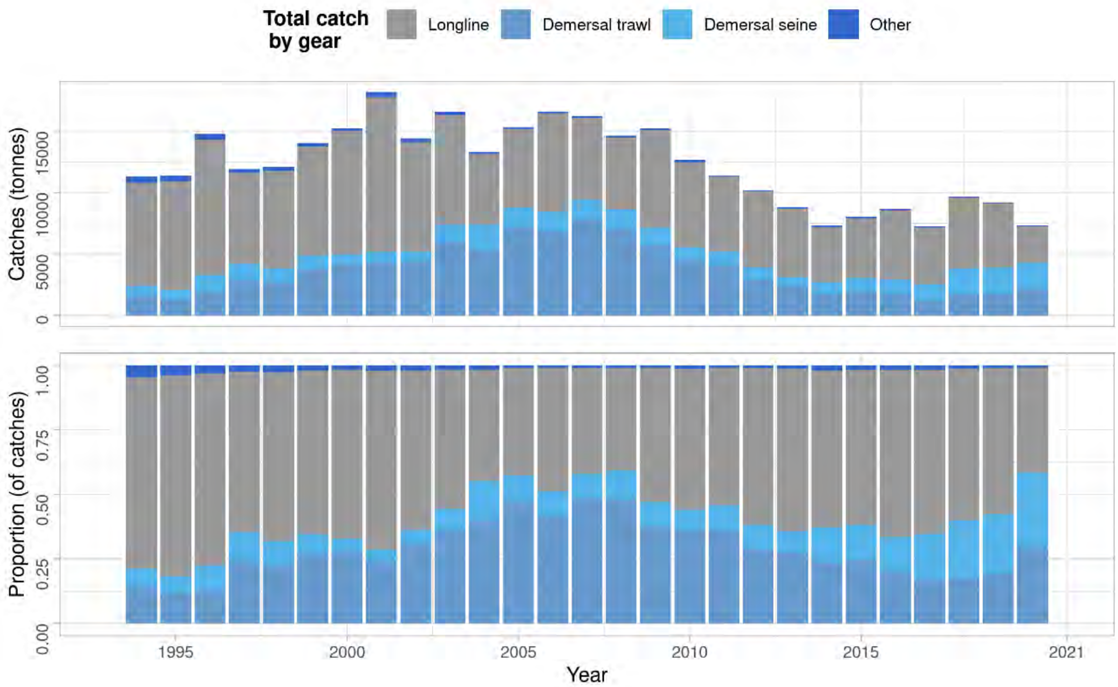

Figure 15.1.4. Atlantic wolffish in 5.a. Total catch (landings) by fishing gear since 1994, according to statistics from the Directorate of Fisheries.

In 1994 and 1995, more than 500 vessels accounted for 95% of the annual catch of Atlantic wolffish in Icelandic waters, but this number had dropped to 200 vessels in 2008 despite higher catches. Since 2010 the number of vessels accounting for 95% of the annual catch has remained relatively constant (about 150-200 vessels), despite catch reductions (Figure 15.1.5).

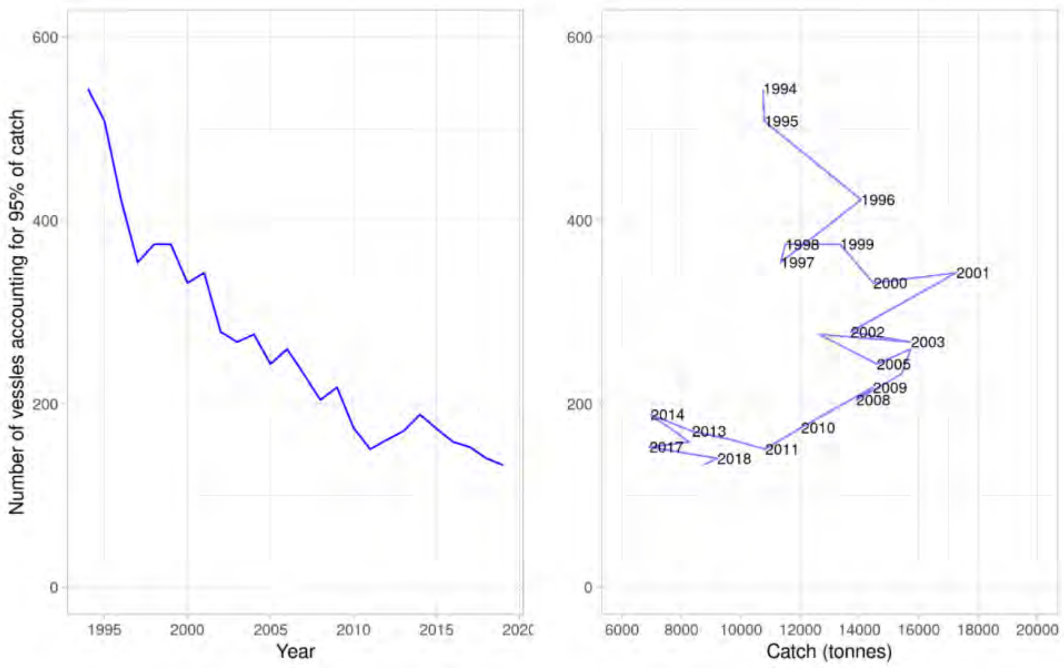

Figure 15.1.5. Atlantic wolffish in 5.a. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

15.1.3 Data available

The commercial catch samples taken are normally representative of the landings with most number of samples taken in areas of high catch intensity (Figure 15.1.7).

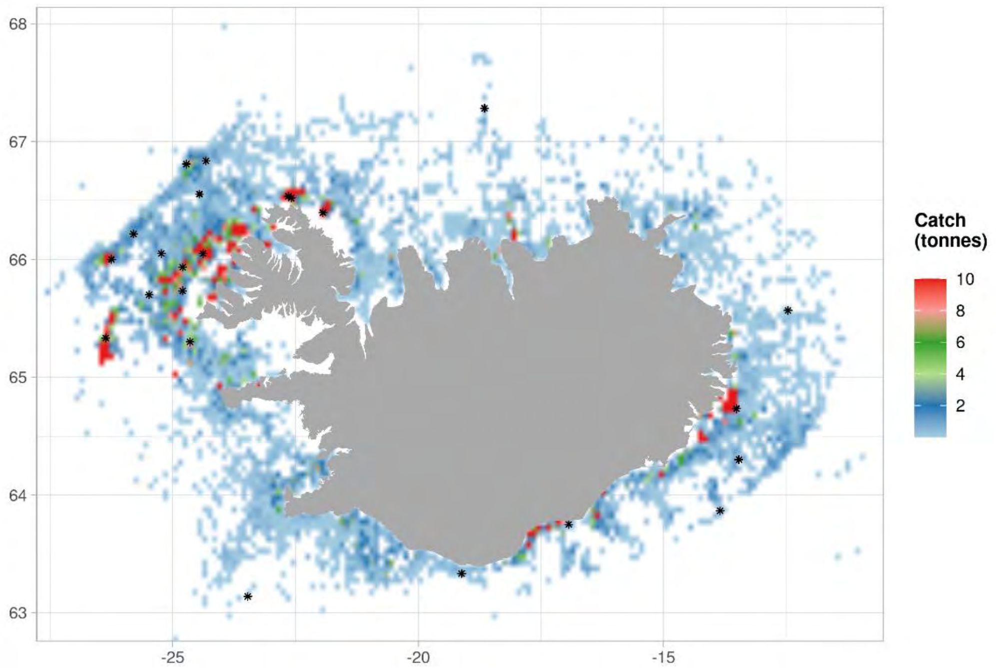

Figure 15.1.7. Atlantic wolffish in 5.a. Fishing grounds in 2020 as reported in logbooks and positions of samples taken from landings (asterisks).

15.1.3.1 Landings and discards

Landings by Icelandic vessels are given by the Icelandic Directorate of Fisheries. Landings of Norwegian and Faroese vessels are given by the Icelandic Coast Guard. Discarding is banned by law in the Icelandic demersal fishery, as well as in Norway. Measures in the Icelandic management system such as converting quota share from one species to another are used by the Icelandic fleet to a large extent, and this is thought to discourage discards in mixed fisheries.

15.1.3.2 Length composition

The length distribution of landed Atlantic wolffish has been relatively stable since 2004 (Figure 15.7.8). The average length in the commercial catch increased from about 65 cm in 2003 to about 70 cm in 2011 where from it has been similar.

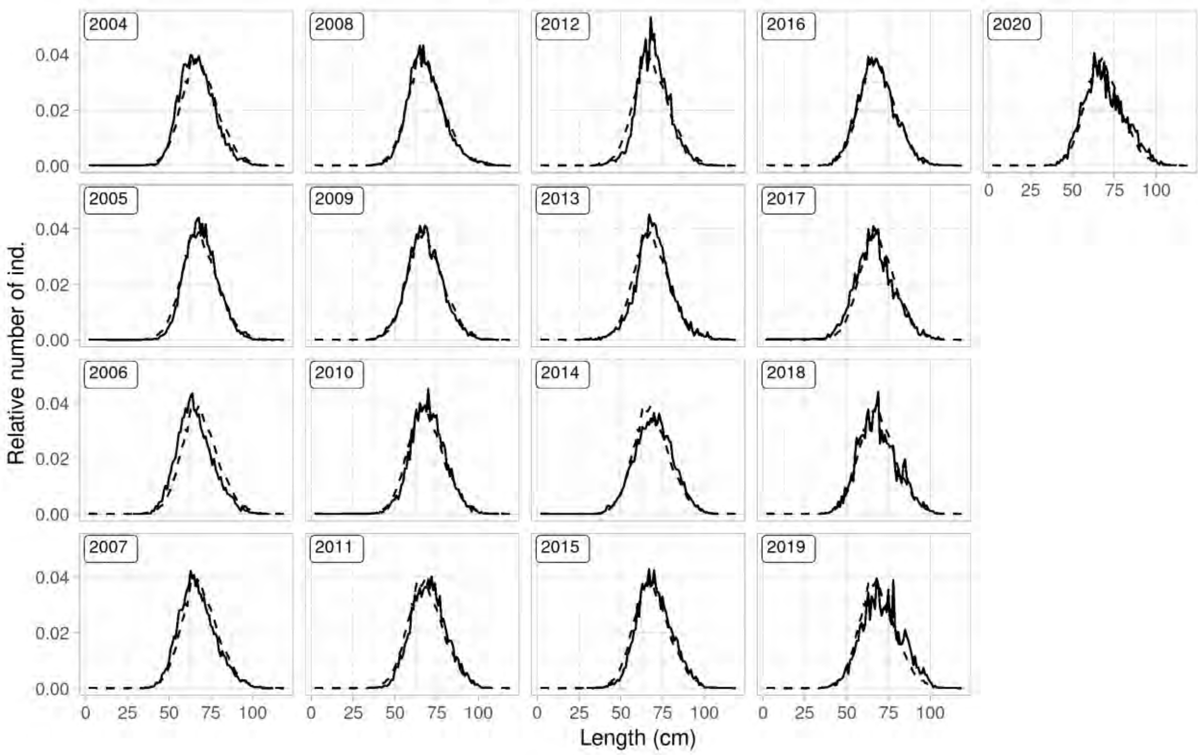

Figure 15.7.8. Atlantic wolffish in 5.a. Relative length distribution of fish sampled from landed catch. The dotted line represents the mean length distribution for all years.

Since 2004, the length frequency distribution in the spring survey has been bimodal because of a relatively greater decrease in number of fish at 40-60 cm (Figure 15.7.9). The mean length of Atlantic wolffish has been about 39 cm on average . It was, however, lowest in 1994-2004, about 37 cm, but in these years the recruitment index was high. Due to decreasing recruitment beginning 2004 (Figure 15.7.9), the mean length increased and was on the average about 41 cm in 2007-2019 (Figure 15.7.9). Mean length in the autumn survey oscillated from 34-40 cm in 1996-2019, with no clear trend (Figure 15.7.10).

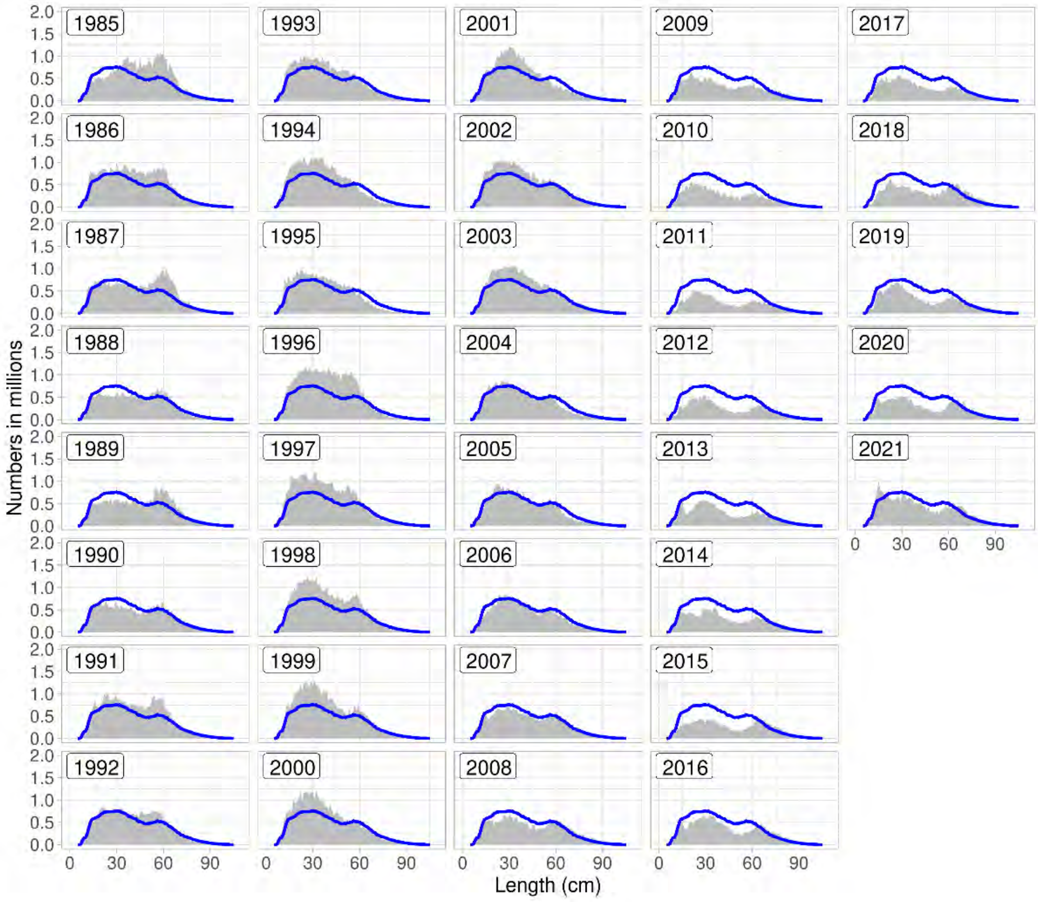

Figure 15.7.9. Atlantic wolffish in 5.a. Length-disaggregated abundance indices from the spring survey. The blue line shows the mean for all years.

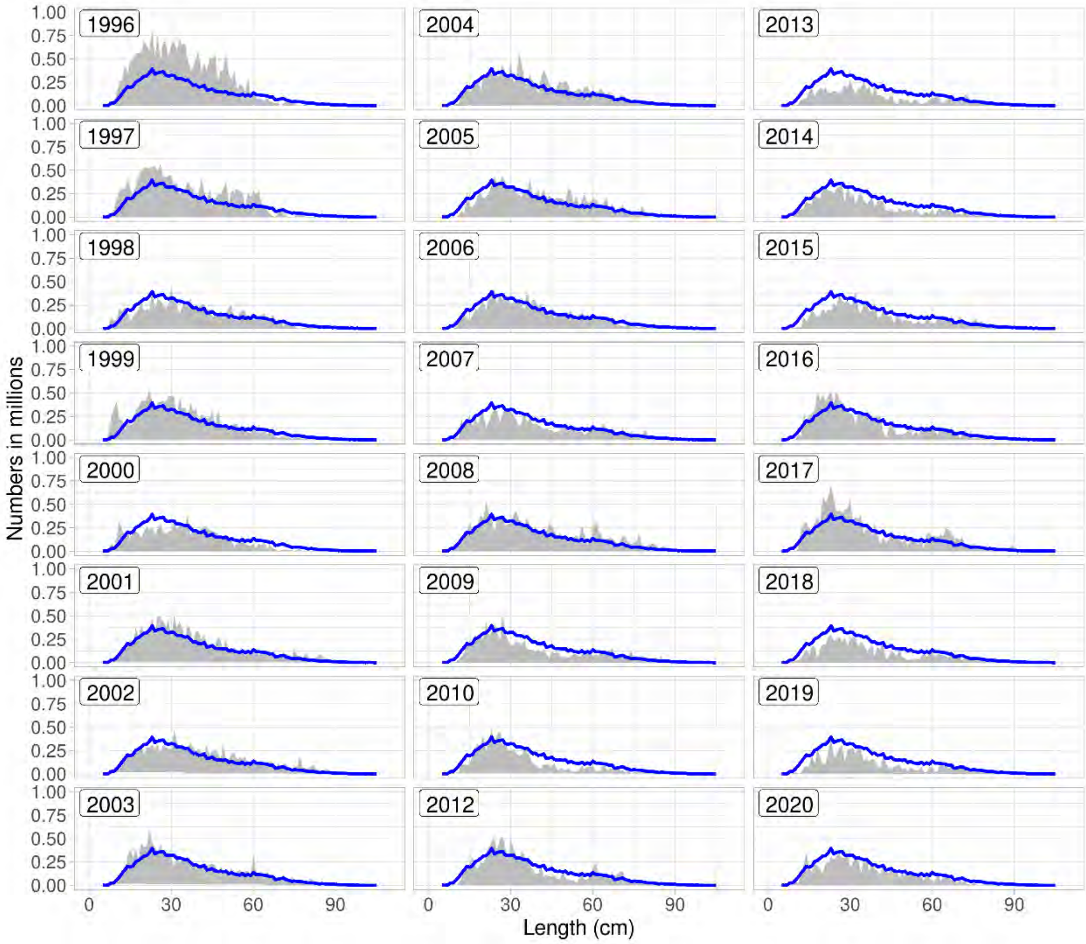

Figure 15.7.10. Atlantic wolffish in 5.a. Length-disaggregated abundance indices from the autumn survey. The blue line shows the mean for all years.

15.1.3.3 Age composition

Age composition data are available from surveys. Commercial age data are available from earlier periods (1978). In samples from commercial landings, the mean age of Atlantic wolffish was around 10.7 years in 1999. Since then, mean age in samples from commercial catches has generally been increasing to around 12 years in recent years.

15.1.3.4 Weight-at-age

Weight-at-age data in Icelandic waters are available from 1996.

15.1.3.5 Maturity and natural mortality

Females have the most reliable maturity designations; a maturation scale for males is unavailable. Therefore, maturity analysis is based on females caught during the autumn survey and in commercial catches from June – December. From these data, maturation occurs close to 60 cm and around age 10 but is highly variable and difficult to measure. No information is available on natural mortality. For assessment and advisory purposes, the natural mortality is set to 0.10 for all age groups.

15.1.3.6 Catch, effort and survey data

CPUE estimates of Atlantic wolffish in Icelandic waters are not considered representative of stock abundance, as changes in fleet composition, technical improvements and differences in gear setup among other things have not been accounted for when estimating CPUE. Non-standardised estimates of CPUE in longline (kg/1000 hooks), and demersal trawl (kg/hour), are calculated as the total weight in sets or tows in which Atlantic wolffish was more than 10% of the catch, according to logbooks. Effort of demersal trawl was defined as the number hours towed, and for longline number of hooks, in both cases where Atlantic wolffish was more than 10% of the catch. CPUE in longline vessels has been similar among years prior to 2018, around 100-150 kg/1000 hooks. CPUE of demersal trawl increased from about 230 to 400 kg/h in 2000-2005, but since 2006 it has fluctuated at around 250-300 kg/h (Figure 15.7.11). Both indices have shown a sharp decrease over the past three years. Fishing effort in longline increased from 66 million hooks in 2000 to 97 million hooks in 2001. Since then it has been generally decreasing and was around 22 million hooks in 2018. In demersal trawl, fishing effort increased from about 14 thousand tow-hours in 2004 to 23 thousand tow-hours in 2008, followed by a sharp decrease to 4.8 thousand tow-hours in 2014. Since then it has been at a similar level, but with a notable decrease in 2019 (Figure 15.7.11).

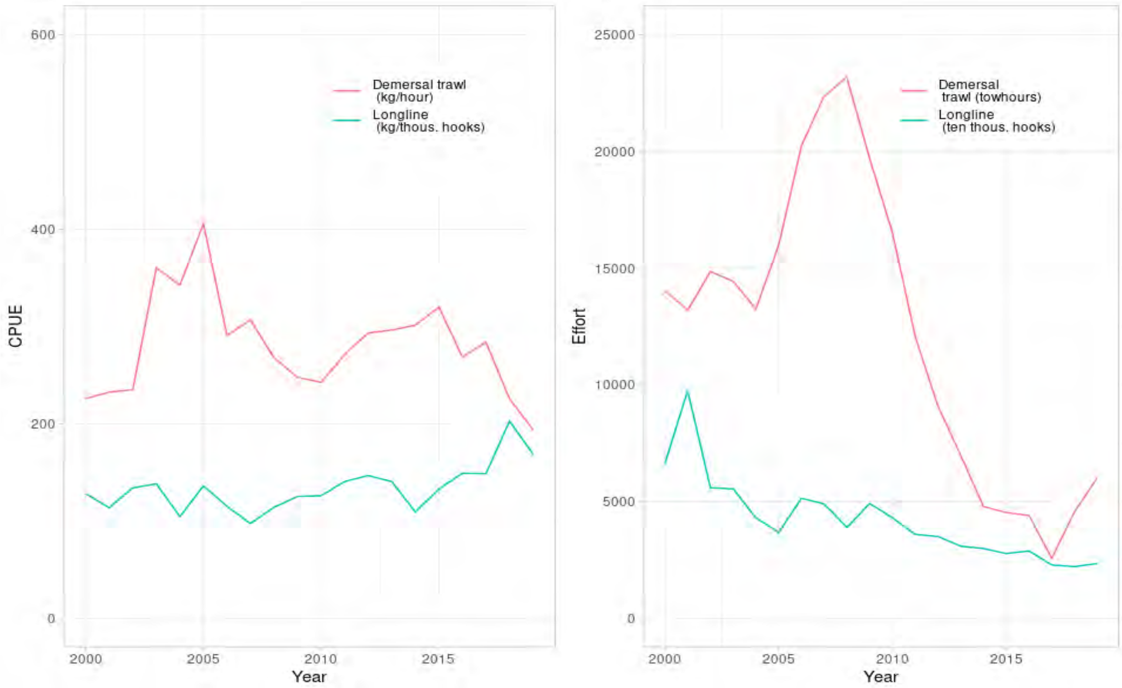

Figure 15.7.11. Atlantic wolffish in 5.a. Non-standardised estimates of CPUE (left) from demersal trawl (kg/h) and longline (kg/1000 hooks). Fishing effort (right) for longline (10000 hooks) for demersal trawl (tow-hours).

The Icelandic spring groundfish survey (hereafter spring survey, IGFS), which has been conducted annually in March since 1985, covers the most important distribution area of Atlantic wolffish in Icelandic waters. In addition, the Icelandic autumn groundfish survey (hereafter autumn survey, IAGS) was started in 1996 and expanded in 2000. However, a full autumn survey was not conducted in 2011 due to a labour strike. Because the spring survey covers the main distribution area, it is considered adequate to measure changes in abundance/biomass of Atlantic wolffish better than the autumn survey.

Total biomass and harvestable biomass indices decreased from 1985-1995. In 1996, the biomass index increased to 1998, then decreased to a historical low level in 2010-2012, but since then it has been increasing (Figure 15.7.12). The harvestable biomass has generally been increasing from 1995 with considerable oscillators. The recruitment index was high in the years 1992-2003, since 1999 it has been decreasing, which coincides with increasing effort and catch of trawlers at the main spawning ground west of Iceland (Látragrunn) during the spawning and incubation time. The recruitment index reached a historical low level in 2011, but since then it has been rather stable or increased slightly. This coincides with that the closed spawning/incubation area on Látragrunn was enlarged from 500 km² (from 2002) to 1000 km² in October 2010.

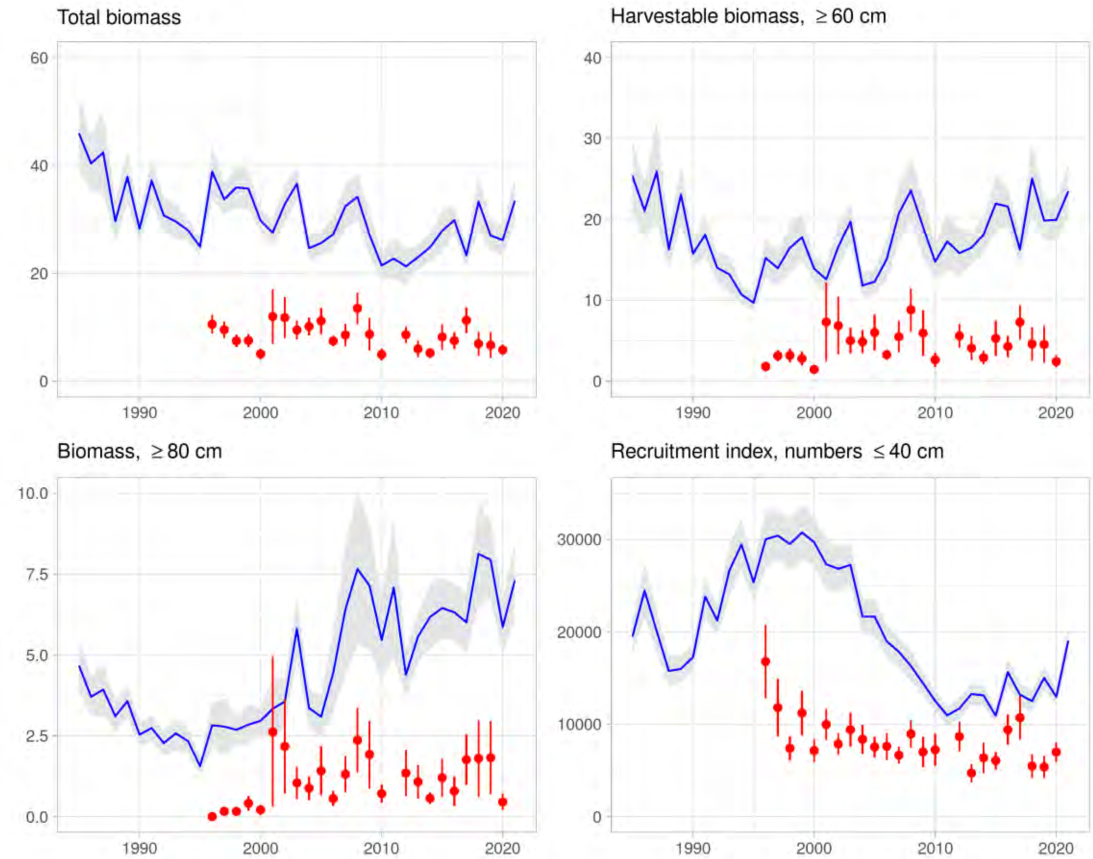

Figure 15.7.12. Atlantic wolffish. Total biomass indices (upper left) and harvestable biomass indices (≥60 cm, upper right), large fish biomass indices (≥80 cm, lower left) and juvenile abundance indices (≤40 cm, lower right), from the spring survey (blue) and the autumn survey (red), along with the standard deviation.

When the spring survey is conducted, Atlantic wolffish are on their feeding grounds which are commonly in relatively shallow waters. In the spring survey, the highest abundance has always been measured in the NW area (Figure 15.7.13).

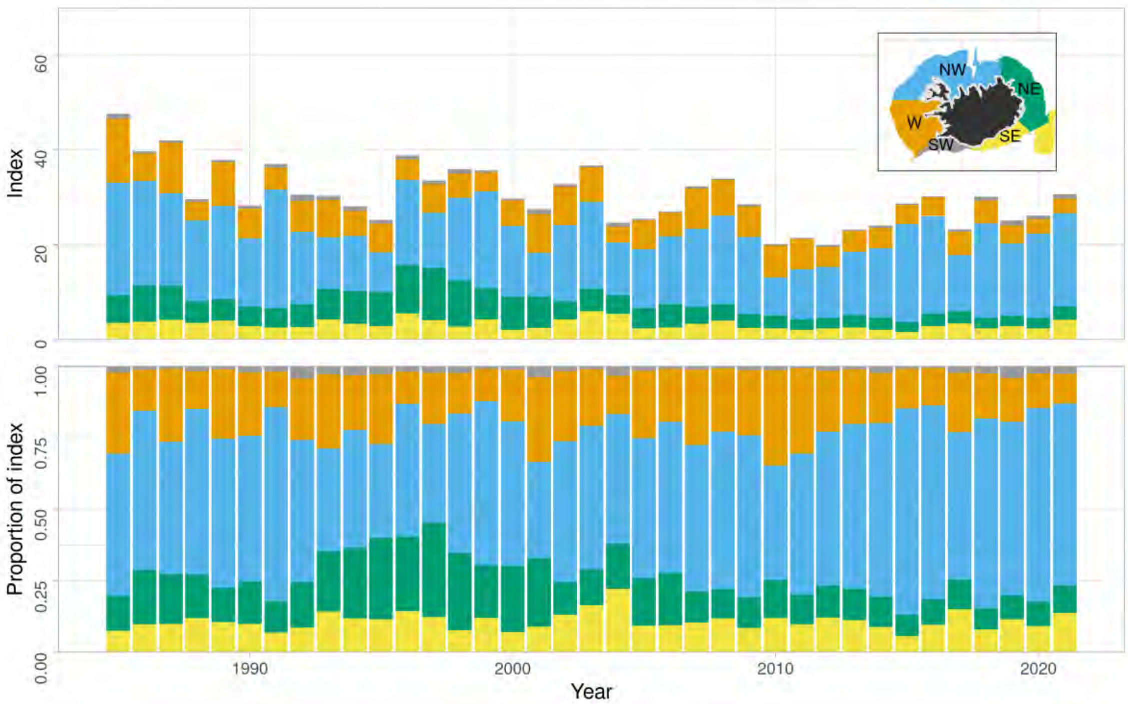

Figure 15.7.13. Atlantic wolffish in 5.a. Spatial distribution of biomass index from the spring survey.

15.1.4 Data analysis

Analytical assessment on wolffish in Icelandic waters using GADGET

Since 2001 the Gadget model (**G**lobally applicable **A**rea **D**isaggregated **G**eneral **E**cosystem **T**oolbox, see www.hafro.is/gadget) has been used for the assessment of Atlantic wolffish in Icelandic waters.

15.1.4.1 Data used by the assessment and model settings

In 2001-2010 natural mortality (M) was set at 0.15 and the advice based on F0.1 but since 2011 natural mortality has been set as M=0.10 and advice based on F_{MSY} (F_{max}). Weights of different likelihood components were estimated in the2011 assessment and again in the 2013 and 2015 assessments. The weights in the final run have been kept unchanged since 2013.

The parameters estimated in the model are:

- Initial numbers at age
- Recruitment at age 1 every year
- Size of recruits
- Selection pattern of the commercial fleet and survey.

Data used in the estimation are:

- Length distributions from survey and catches.
- Length-disaggregated abundance indices from survey in 6 groups. 5-13 cm, 14-19 cm, 29-29 cm, 30-55 cm, 56-74 cm, and 75-109 cm.
- Age data from survey and catches used as age-length keys.

Selection pattern of the fisheries and the survey are size based. According to the selection pattern, estimated by the model, the L50 of the commercial fleet is 62.9 cm that corresponds to approximately 13 years old fish. In the model the growth and selection pattern are fixed for all the simulation period. Still the size at age can changed as the fisheries are modelled to target the largest fish of each cohort leading to lower mean length at age of the survivors and some change in selection by age if fishing mortality varies much. Therefore, harvestable biomass is defined according to a selectivity pattern applied to the estimated biomass. To calculate harvestable biomass, the estimated biomass in each length group is multiplied by probabilities generated by a constant a logistic curve ($S(L) = 1/(1+\exp(-0.200*(L-62.9)))$, where L represents length in cm) that roughly represents the estimated selection pattern.

15.1.4.2 Diagnostics

Observed and predicted proportions by fleets

Overall, the fit of the predicted proportional length distributions is close to the observed distributions (Figures 15.1.14 and 15.1.15). The bimodality observed in the spring survey (Figure 15.1.14) is not observed in commercial catches because the commercial selectivity curve excludes most of the smaller fish in the left mode (Figure 15.1.15). In addition, preliminary analyses suggest that the cause of the bimodality in length distributions is spatial variation in growth, with Atlantic wolffish from the southwest attaining larger sizes at age than in the northeast of Iceland. Atlantic wolffish from the west and northwest, where most fishing occurs, also tend to attain larger sizes at age than in the northeast. Alternatively, or in addition, it is possible that this size range may have a higher catchability than others. Because the bimodality does not appear to represent cohort structure and spatial variation in growth is not included in the model, the model is not able to fit this bimodality in more extreme cases.

The survey age distributions fit well toward the end of the time series; however, the beginning of the time series shows that the first decade of the age distribution data do not fit well (Figure 15.1.16). This is likely to be due to either a change in growth or ageing. However, as the model fits well to more recent data, these minor misfits are unlikely to affect model results and projections. In general, the commercial catch age distributions are well-fitted by the model (Figure 15.1.17).

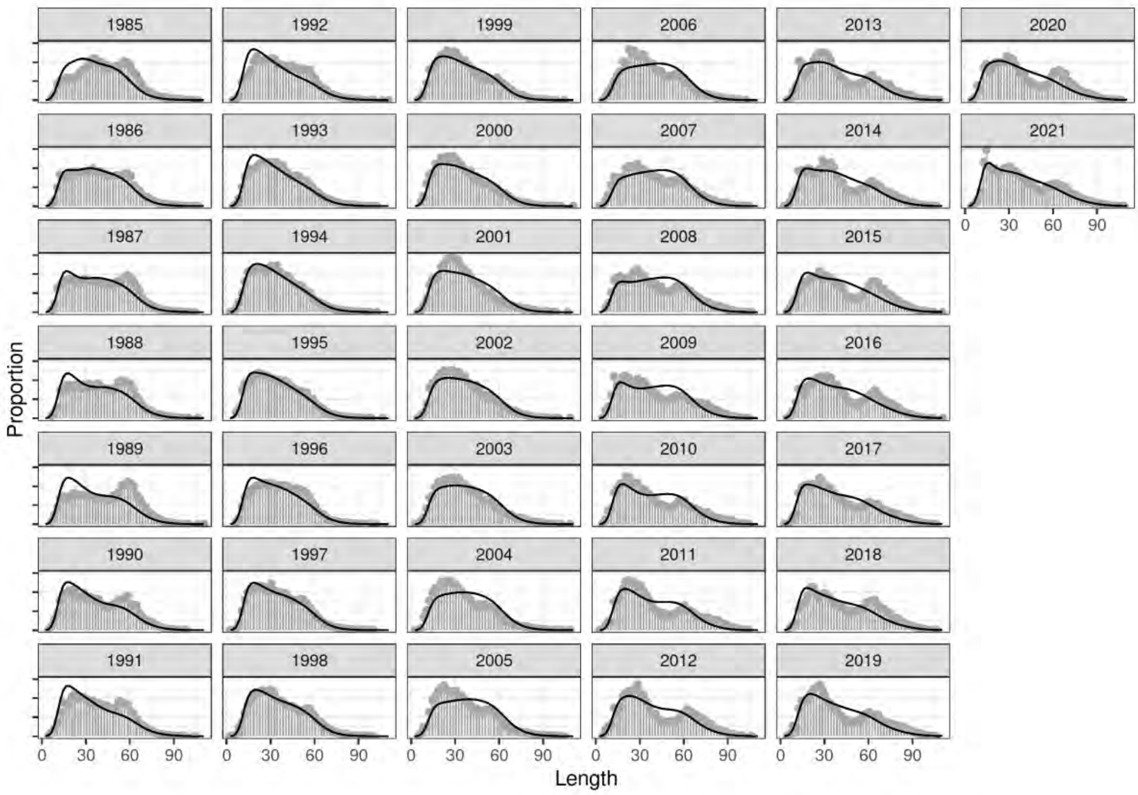

Figure 15.1.14 Atlantic wolffish in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the spring survey (grey lines and points).

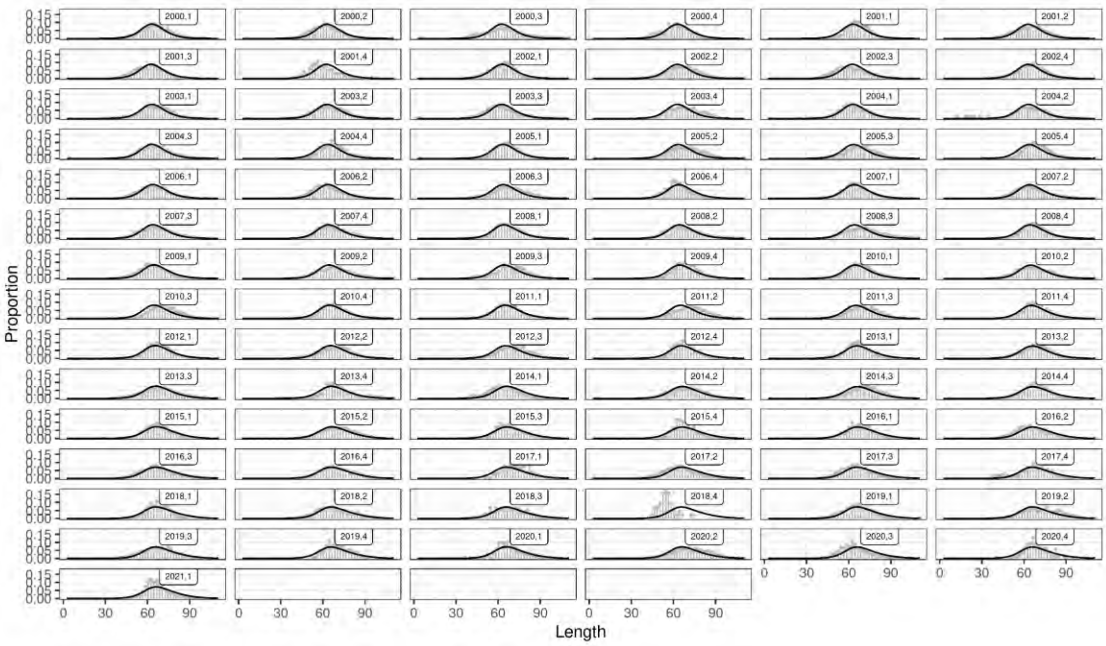

Figure 15.1.15. Atlantic wolffish in 5.a. Atlantic wolffish in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from commercial catches (grey lines and points).

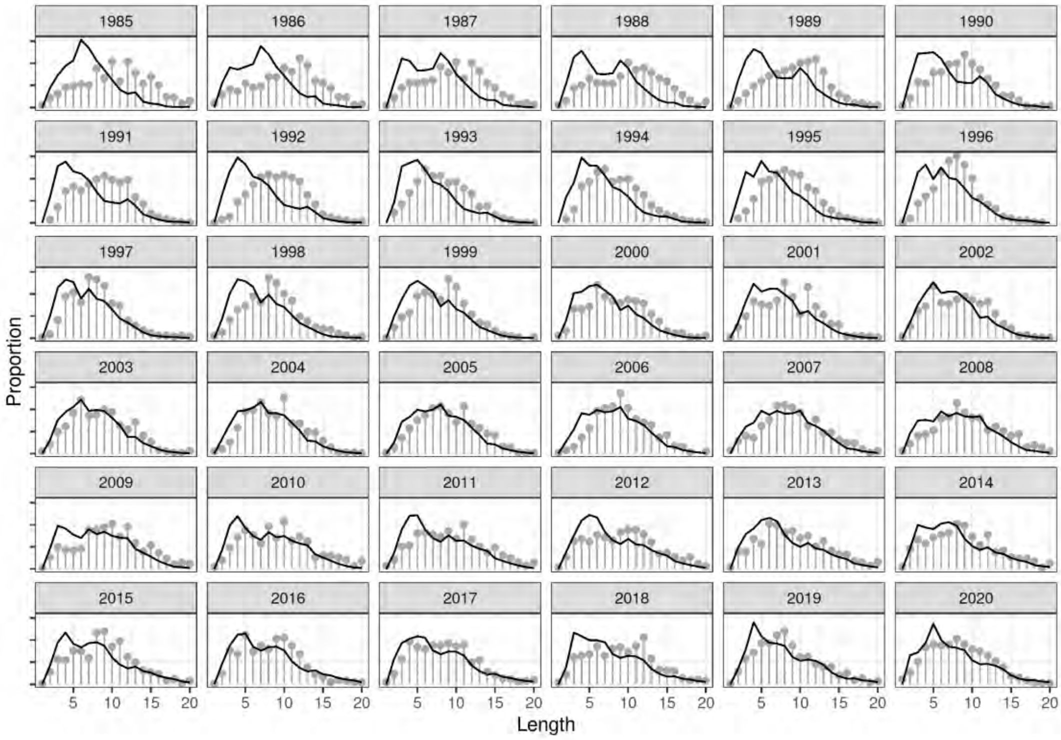

Figure 15.1.16. Atlantic wolffish in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the spring survey catches (grey lines and points).

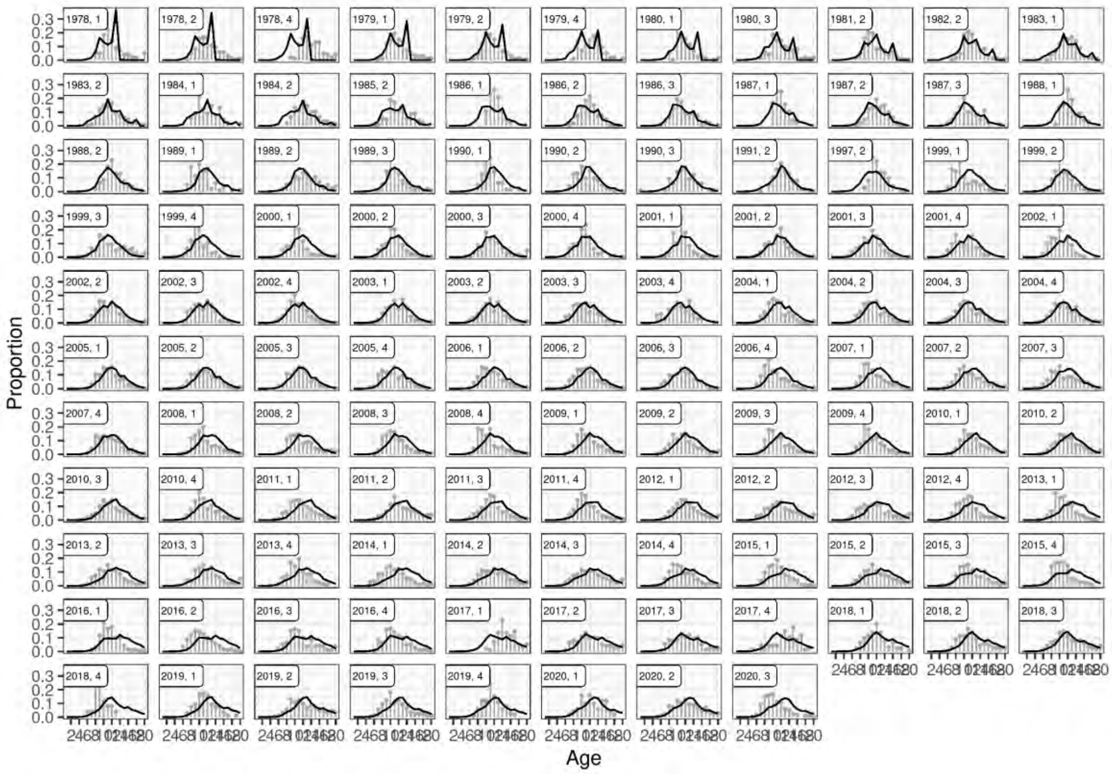

Figure 15.1.17. Atlantic wolffish in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in commercial catches (grey lines and points).

15.1.4.3 Model fit

In Figure 15.1.18 the length-disaggregated indices are plotted against the predicted numbers in the stock as a time series. The fit between observed and predicted is good for the first four and the last length groups (– < 13.5, 13.5–19.5, 19.5–29.5, 29.5–55.5, 55.5–74.5 and > 74.5 cm). However, for the size group 55.5-74.5 cm, which is the size accounting for the largest part of the harvestable biomass, the fit between observed and predicted is low. Part of the explanation for a poor fit is that there has been a small dynamic range of the stock in this size group (12-18 million fish). However, this is also the size range where bimodality in the length distributions (see Figure 15.1.14) interferes with the model fit to spring survey proportions at length, which is more likely explained by spatial variation in growth or catchability than cohort structure. Therefore, the model settings of having the same catchability all years for this size group could also be a problem: catchability might instead vary depending on which part of the range 55.5-74.5 cm is most heavily populated. Current values (intersection of the green lines in Figure 15.1.18) shows that the model predictions are lower in the terminal year for all length groups except 5.5-13.5cm. Although the model does not fit the 55.5-74.5 cm length group, it does not appear to be biased toward overestimation in this range because the model predictions are lower than the observed values towards the end of the time series.

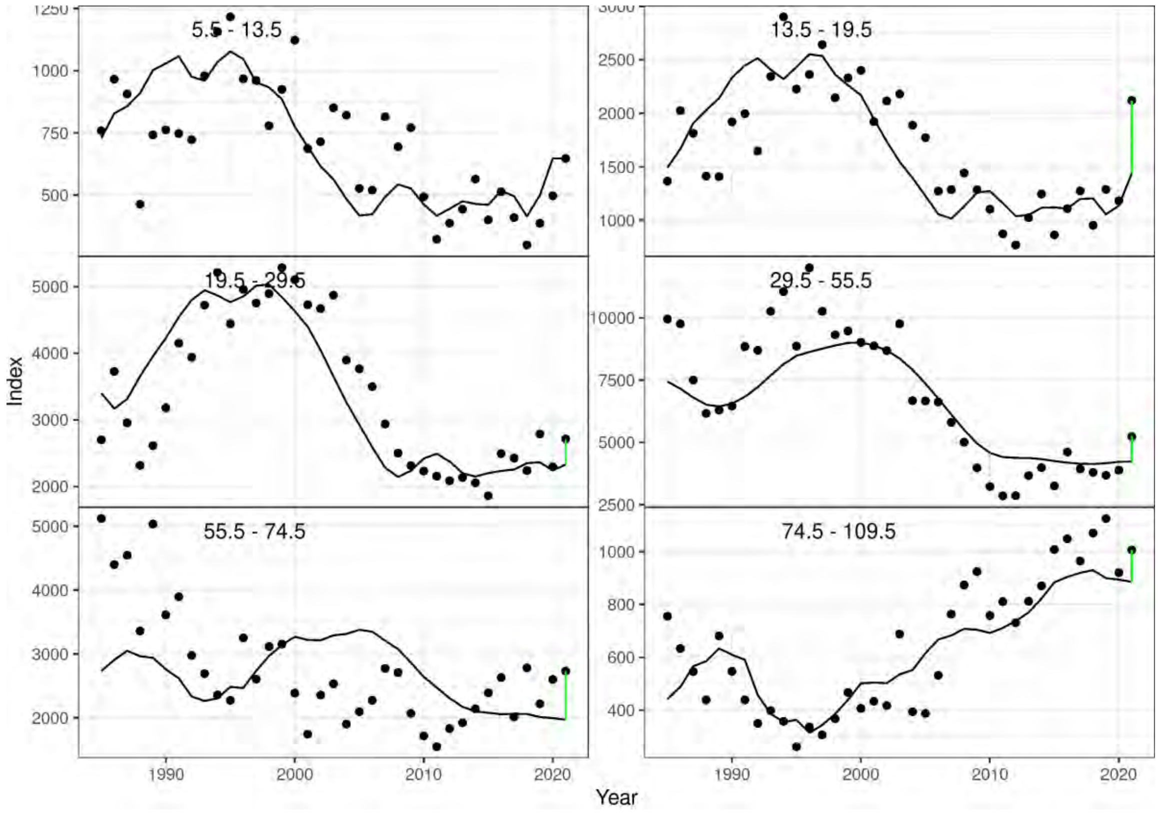

Figure 15.1.18. Atlantic wolffish. Fitted spring survey index by length group from the Gadget model (black line) and the observed biomass index in the survey (points). The green line indicates the difference between the terminal fit and the observations.

15.1.5 Model results

Model results show that Atlantic wolffish total biomass levels decreased from high levels in 2000 – 2006 to current levels. Excluding biomass values earlier than 1985, which are highly uncertain because spring survey data begin in 1985, current total biomass levels are on par with those in 2013, which represent a minimum in the more reliable post-1985 portion of the time series. This pattern contrasts with that of a higher value for harvestable biomass, which represents larger fish. This decrease in total biomass therefore indicates a smaller proportion of smaller fish contribution to total biomass and appears to be due to a halving of recruitment levels from roughly 20 million prior to 2000 to roughly 10 million after 2000. However, following a step decrease in landings and fishing mortality from high levels in 2009 to current levels, total biomass levels have been relatively stable after 2010 (Figure 15.1.19).

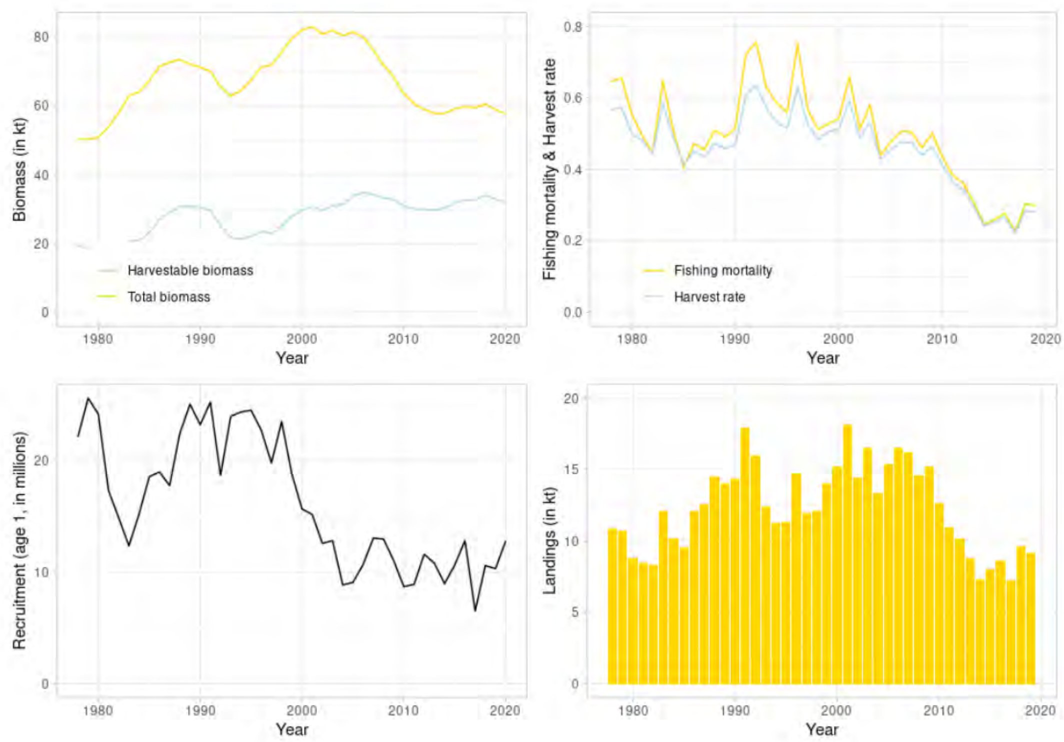

Figure 15.1.19. Atlantic wolffish in 5.a. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fish and harvest rate, recruitment and total catches.

15.1.6 Management

The Ministry of Industries and Innovation is responsible for management of the Icelandic fisheries and implementation of legislation. Atlantic wolffish was included in the ITQ system in the 1996/1997 quota year and as such subjected to TAC limitations. From that time to the fishing year 2004/2005, the catch was on average 5% more than recommended by the MRI, although in some years it was lower than advised TAC. In the fishing years 2005/2006 to 2011/2012, the catch was on average around 34% above the advised TAC. The main reasons were that national TAC was set higher than the advised TAC, and quota of other species were being transferred to Atlantic wolffish quota (Table 15.1.2, Figure 15.1.6). Net transfer of Atlantic wolffish quota for each fishing year is usually less than 10%.

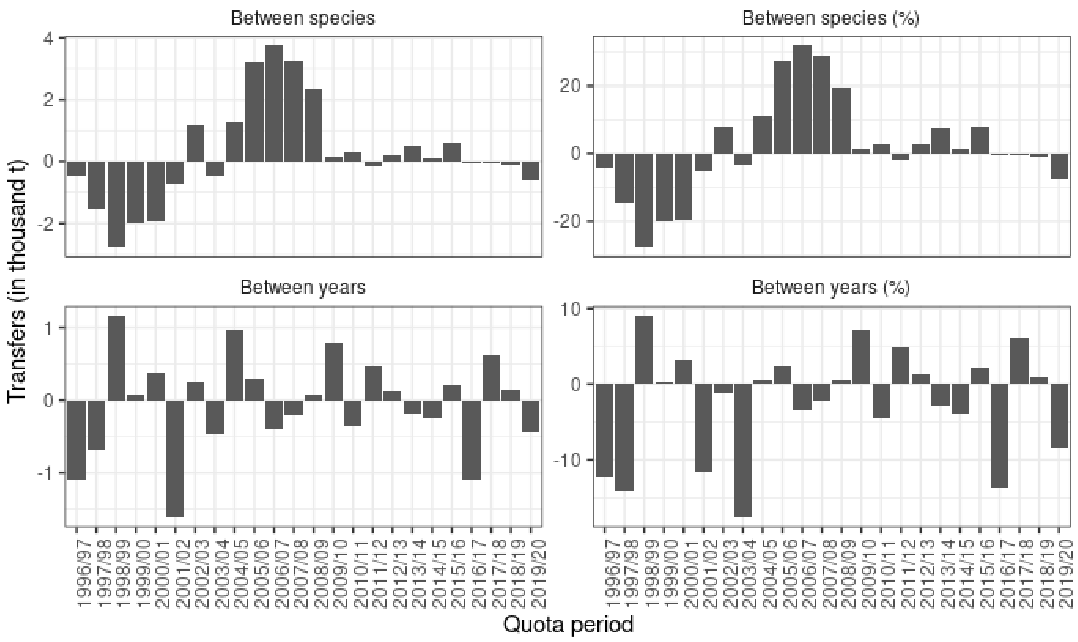

Figure 15.1.20: Atlantic Wolffish in 5.a. Net transfer of quota, from Atlantic Wolffish to other species, in the Icelandic ITQ system by fishing year.

15.1.7 Current Advisory Framework

The F used for advice is F_{max} from yield per recruit analysis of the stock (Figure 23). The model is size-based, and M = 0.1 is relatively low so F_{max} is expected to be precautionary harvesting strategy. Formal HCR evaluation is expected to take place in the winter 2022. The advice is based on F for fully recruited fish or 90 cm, which is set equal to F_{90cm} = 0.3 in the advice (blue solid line in Figure 15.1.20).

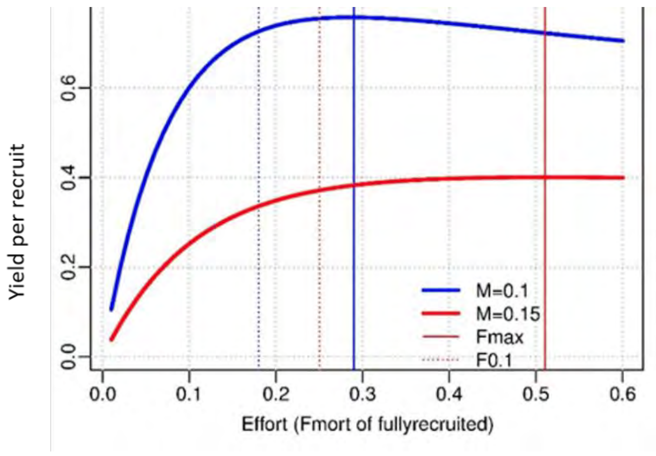

Figure 15.1.20. Atlantic wolffish. Yield per recruit as function of fishing mortality of fully recruited Atlantic wolffish.

15.1.8 Management considerations

A reduction in fishing mortality has led to harvestable biomass and SSB that seem to be stable. Atlantic wolffish is a slow-growing late-maturing species, therefore closures of known spawning areas should be maintained and expanded if needed. Similarly, closed areas fishing where there is high juvenile abundance should also be maintained and expanded if needed.

15.1.9 Ecosystem considerations

Most fishing for Atlantic wolffish occurs in the northwest and west of Iceland, where the fastest growing Atlantic wolffish are found. A likely cause for differences in growth is environmental differences between the relatively warm southwestern waters versus colder northeaster waters. However, Atlantic wolffish are also highly sedentary, especially while guarding nests during spawning and rearing season, and therefore additional metapopulation structure cannot be excluded. Therefore, it is possible that local depletion may occur in more heavily fished areas despite a stable overall biomass level.

Table 15.1.1. Atlantic wolffish in 5.a. Number of Icelandic vessels reporting catch of 10 tonnes/year or more of Atlantic wolffish, and all landed catch divided by gear type.

Number of vessels					Catch (tonnes)				
Year	Longliners	Trawls	Seiners	Other	Longline	Trawl	D. seine	Other	Sum
2000	172	76	20	1	9979	4173	834	241	15227
2001	198	76	19	4	12595	4319	862	394	18170
2002	151	65	14	3	8897	4423	800	304	14424
2003	142	63	25	1	8943	5960	1402	263	16568
2004	109	60	40	2	5746	5349	2010	216	13321
2005	96	64	34	0	6370	7247	1552	177	15346
2006	136	66	32	1	7962	6885	1569	144	16560
2007	124	65	27	1	6655	7857	1551	171	16234
2008	100	60	25	2	5810	7026	1642	152	14630
2009	124	58	34	1	7896	5709	1462	143	15210
2010	82	46	23	2	6923	4531	1033	175	12662
2011	68	36	18	0	6094	4062	1138	97	11391
2012	80	28	21	0	6209	2910	992	103	10214
2013	77	29	19	2	5537	2424	721	110	8792
2014	77	22	17	1	4463	1722	1006	138	7329
2015	68	34	18	2	4828	1926	1097	137	7988
2016	65	37	19	3	5563	1713	1201	148	8625
2017	65	26	19	1	4586	1243	1286	128	7243
2018	67	40	26	4	5657	1689	2185	125	9656

2019	66	36	22	1	5223	1748	2154	90	9215
2020					2984	2147	2147	54	7340

Table 15.1.2: Atlantic wolffish in 5.a. Advised TAC, national TAC and total landings since the quota year 2013/2014.

Fishing Year	MFRI Advice	National TAC	Landings
2013/14	7500	7500	7531
2014/15	7500	7500	7862
2015/16	8200	8200	8982
2016/17	8811	8811	7545
2017/18	8540	8540	9515
2018/19	9020	9020	9355
2019/20	8344	8344	7340
2020/21	7500	7500	7531
2021/22			

Table 15.1.3. Atlantic wolffish. Number of samples and aged otoliths from landed catch of Atlantic wolffish.

Year	Longline		Demersal trawl		Demersal seine	
	Samples	Otoliths	Samples	Otoliths	Samples	Otoliths
2010	29	1669	18	1040	5	285
2011	14	750	15	778	9	550
2012	26	1300	14	700	7	350
2013	25	1249	14	692	5	249
2014	30	800	26	675	28	700
2015	25	625	19	479	19	474
2016	25	625	13	325	9	225
2017	23	575	9	220	6	150
2018	22	550	9	225	17	425
2019	22	537	10	245	20	480
2020	9	223	12	294	16	386

16 Other deep-water species in the Northeast Atlantic

16.1 The fisheries

The following species are considered in this chapter: common mora (*Mora moro*) and Moridae, rabbit fish (*Chimaera monstrosa*, *Rhinochimaera atlantica* and *Hydrolagus* spp), Alepocephalidae including Baird's smoothhead (*Alepocephalus bairdii*) and Risso's smoothhead (*A. rostratus*), wreckfish (*Polyprion americanus*), blackbelly rosefish (*Helicolenus dactylopterus*), silver scabbardfish (*Lepidopus caudatus*), deep-water cardinal fish (*Epigonus telescopus*) Mediterranean slimehead, also known as silver roughy (*Hoplostethus mediterraneus*), Black gemfish (*Nesiarchus nasutus*) Atlantic thornyhead (*Trachyscorpia cristulata*), greater eelpout (*Lycodes esmarkii*), Norway redfish (*Sebastes viviparus*) and deep-water red crab (*Chaceon affinis*). Deepsea sharks are not considered as these species are in the remit of WGEF. The species considered include all teleost species from annex 1 of Council Regulation (EC) 2016/2336.

Mora, rabbitfish, smoothheads, blackbelly rosefish and deep-water cardinal fish are taken as bycatch in mixed-species demersal trawl fisheries in Subareas 6, 7 and 12 and to a lesser extent, 2, 4 and 5.

In Subarea 14b, Baird's smoothhead, rabbit fish and species of Moridae are caught as bycatch in demersal trawl fisheries for Greenland halibut (*Reinhardtius hippoglossoides*) but are most likely under reported in official reports from the area.

Mora, wreckfish, blackbelly rosefish and silver scabbardfish are caught in targeted and mixed species longline fisheries in Subareas 8, 9 and 10.

Deep-water red crab were formerly caught in directed trap fisheries principally in Subareas 6 and 7. This fishery reduced strongly from 826 tonnes in 2007 to 125 t in 2008 and have remained at a similar level since.

Although in annex 1 of Council Regulation (EC) 2016/2336 black gemfish and eelpouts (not only greater eelpout but all eelpouts were searched in catch statistics) were never landed from fisheries operating in the ICES area from 2006 to 2017.

16.1.1 Landings trends

Landings reported to ICES are presented in Tables 16.1–16.11, based on ICES catch statistics using historical nominal catches 1950-2010 and official nominal catches 2006-2018, downloaded from the ICES website in April 2021. For species not included in previous WGDEEP reports (Mediterranean slimehead, black gemfish, Atlantic thornyhead, Norway redfish) only data from 2006 to 2017 were extracted. Catch data in 2019 and 2020 were not available as they were not included in preliminary catch statistics and were not reported to InterCatch either. Formorid, wreckfish and blackbelly rosefish, 2019 landings from The Azores were available.

Mora moro and Moridae have been landed in variable quantity over time from subareas 6 to 10. Landings of chimaerids peaked to around 1000 t in the early 2000s and have shown large year-to-year variations since. Landings of smoothheads peaked to level over 10 000 tonnes in the early 2000s and have been around 400 tonnes in recent years. Landings of wreckfish peaked to more than 1000 tonnes in 2007. The main area is Subarea 10, where landings seem to be on a declining trend. Blackbelly rosefish is landed from subareas 6 to 10, in variable yearly quantity averaging to about 1000t per year. Silver scabbardfish is mostly landed from subareas 8, 9 and 10, landing have decline since the late 1990s. More than 1000 t/year of deepwater cardinal fish was landed in the early 2000. Landings almost ceased in recent years.

Mediterranean slimehead was landed in variable amount with greater quantities from Subarea 9 in years 2012-2015. Atlantic thornyhead was landed in small amount, typically less than one tonne per year from subareas 6, 7 and 8. Norway redfish was mostly landed from Subarea 5, in declining quantity over 2010-2017.

16.1.2 ICES Advice

ICES has not previously given specific advice on the management of any of the stocks considered in this chapter.

16.1.3 Management

No TACs are set for any of these species in EC waters or in the NEAFC Regulatory Area. None of these species were included in Appendix I of Council Regulation (EC) No 2347/2002 meaning that vessels were not required to hold a deep-water fishing permit in order to land them; they are therefore not necessarily affected by EC regulations governing deep-water fishing effort. They are now included in the Council Regulation (EC) 2016/2336 repealing the previous one.

16.2 Stock identity

No information available.

16.3 Data available

16.3.1 Landings and discards

Landings for all these species are presented in Tables 16.1–16.9. In 2021, other deep-water species landings were updated based on Official Nominal Catches 2006-2018 from the ICES website. Data for 2019-2020 were not available to the expert group.

In 2016, some data provided to the working group were not suitable. One country reported species which are not deep-water species, such as coastal Rajidae, another reported American plaice (*Hippoglossoides platessoides*) and Spotted wolffish (*Anarhichas minor*).

In some cases, considerable differences exist between the working group data and therefore, the official catch number for these species are presented in Tables 16.10–16.12. In Subareas 6 and 12 landings of silver scabbardfish are suspected to be misreported (probably of black scabbardfish, *Aphanopus carbo*) as the occurrence of the species is not supported by scientific evidence. These issues remain unresolved but need to be explored further.

The reported landings of blackbelly rosefish was high in 2016 and 2017 but similar to 2012–2013.

16.3.2 Length compositions

For several species data on length compositions are available from survey data. Length distributions of blackbelly rosefish in the Spanish Porcupine survey is shown in Figure 16.1 while Figure 16.2 presents the length–frequency distributions from the Spanish bottom-trawl survey in the Northern Spanish Shelf (SP-NGFS) in Divisions 9a and 8c. Trends in mean length of blackbelly rosefish in the French EVHOE survey (Bay of Biscay) is shown in Figure 16. 3. The cumulated length distribution of silver scabbardfish, common mora and wreckfish in Azorean surveys are presented in Figures 16.4, 16.5 and 16.6, respectively.

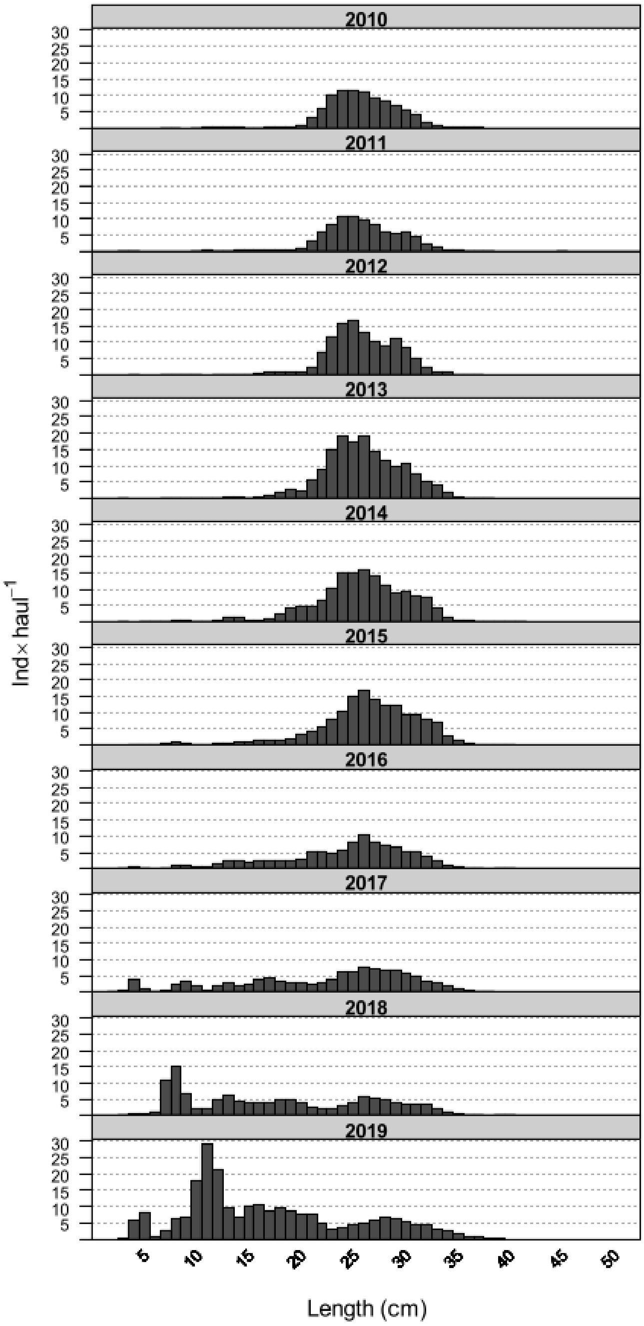

Figure 16.1. Mean stratified length distributions of *Helicolenus dactylopterus* in Porcupine surveys (2010-2019).

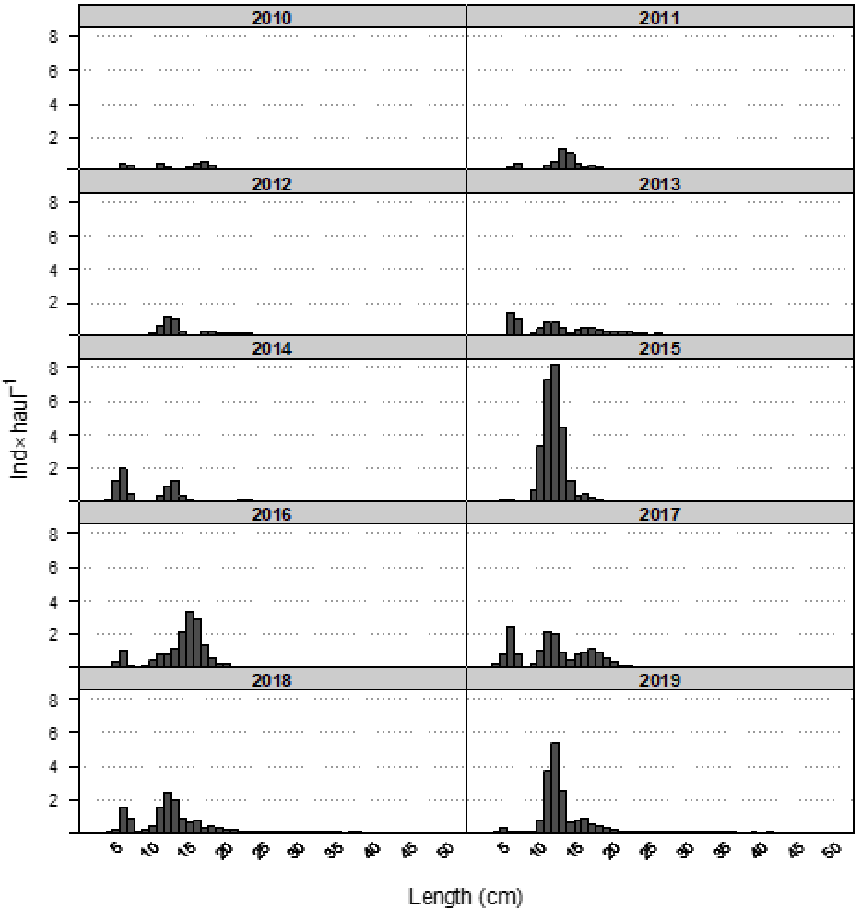

Figure 16.2. Mean stratified length distributions of bluemouth (*H. dactylopterus*) in Northern Spanish Shelf surveys (2010–2019).

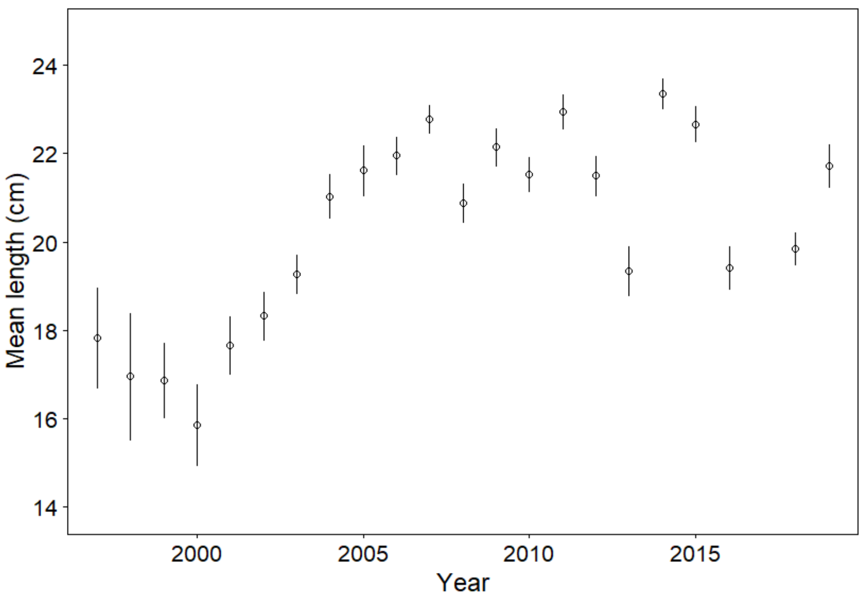

Figure 16.3 Mean length of *Helicolenus dactylopterus* in the French survey in Bay of Biscay and Celtic Sea (EVHOE) from 1997 to 2019 (no survey in 2017).

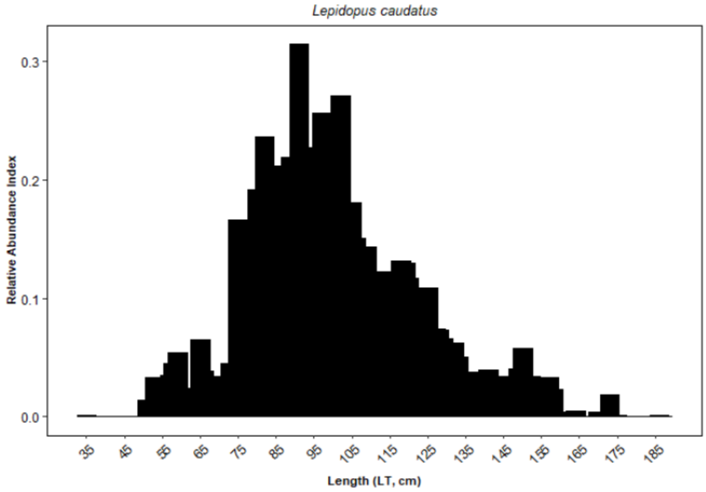

Figure 16.4. Mean length of *Lepidopus caudatus* in Azores bottom longline survey 1995–2016.

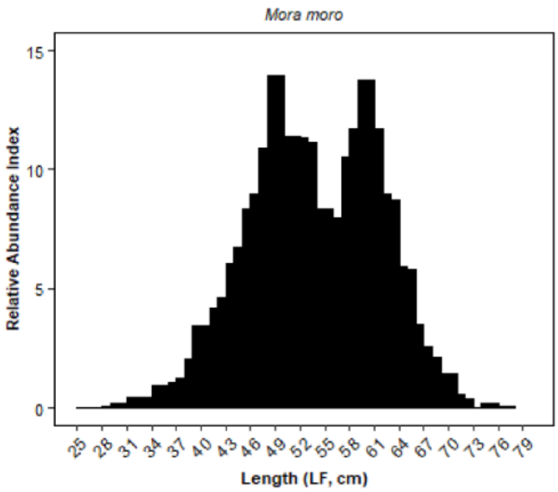

Figure 16.5. Mean length of *Mora moro* in Azores bottom longline survey 1995–2016.

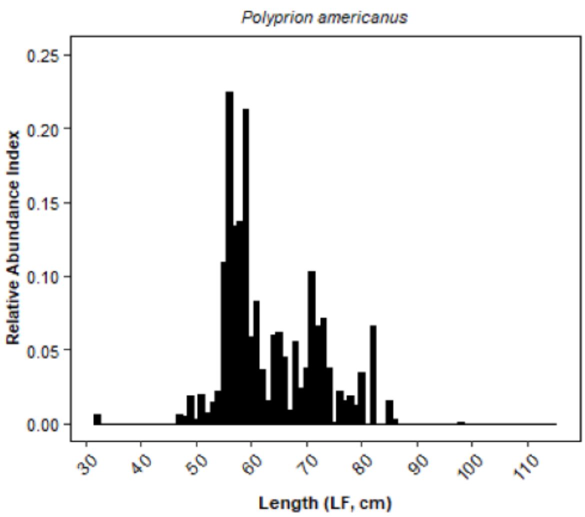

Figure 16.6. Mean length of *Polyprion americanus* in Azores bottom longline survey 1995–2016.

16.3.3 Age compositions

No new information.

16.3.4 Weight-at-age

No new information.

16.3.5 Maturity and natural mortality

No new information.

16.3.6 Catch, effort and research vessel data

For blackbelly rosefish standardized indices from the Spanish Porcupine Bank Survey (abundance and biomass), the French EVHOE survey in the Celtic Sea and Bay of Biscay (biomass), the Spanish bottom-trawl survey (SP-NGFS) in Divisions 9.a and 8.c and the Portuguese longline survey in the Azores Islands (abundance) and are given in Figures 16.7–16.11.

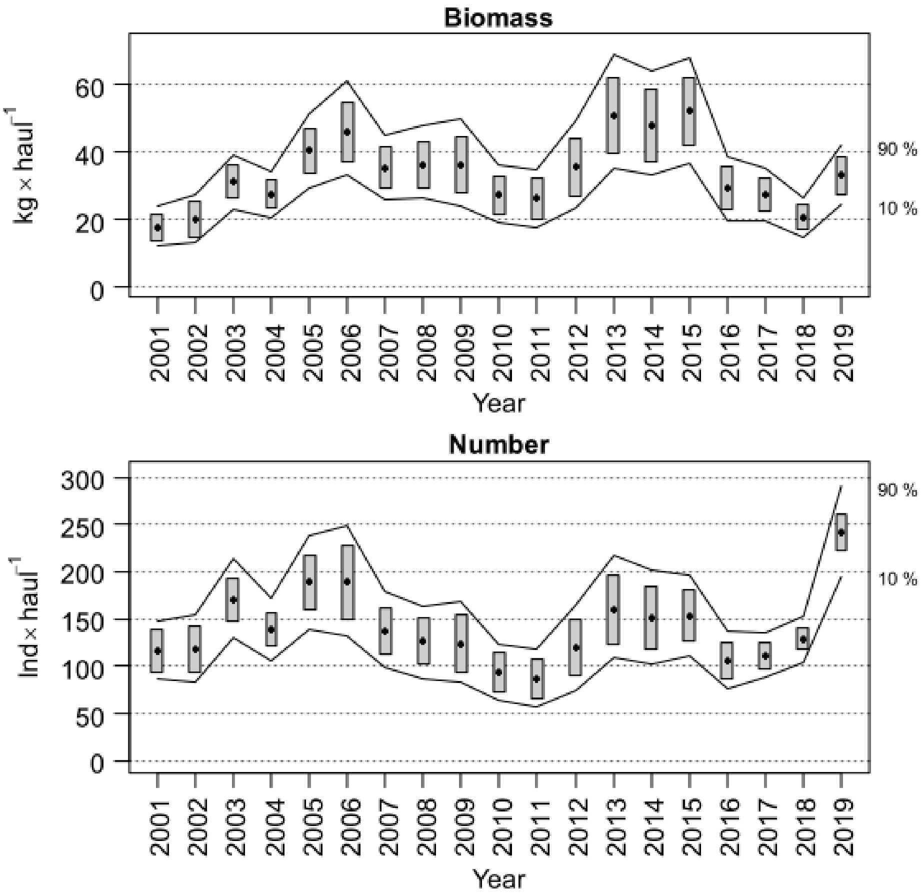

Figure 16.7. Trends of *Helicolenus dactylopterus* biomass and abundance indices during Porcupine Survey time-series (2001–2019). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

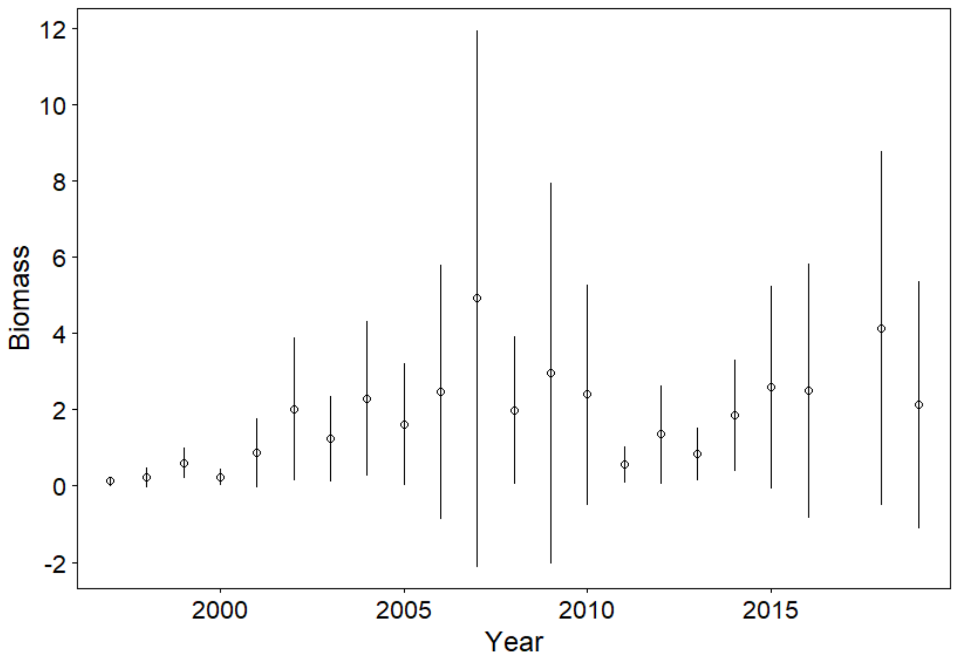

Figure 15.8. Survey biomass index from the French survey (EVHOE) for *Helicolenus dactylopterus*.

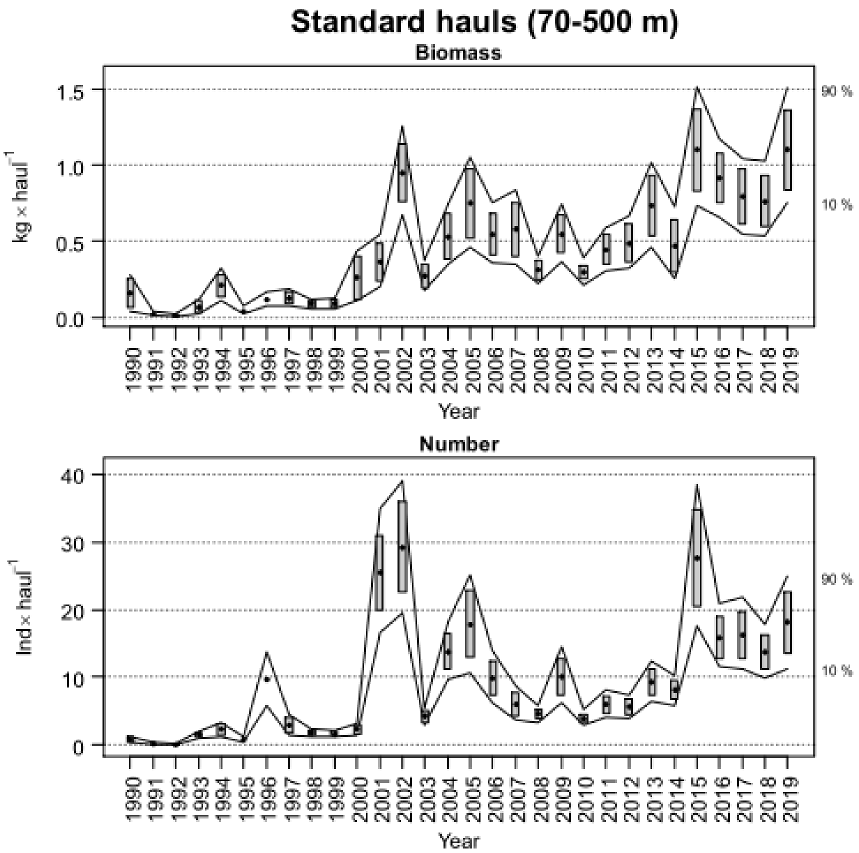

Figure 16.9. Evolution of *Helicolenus dactylopterus* mean stratified biomass and abundance in Northern Spanish Shelf surveys time-series (1990–2019). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000).

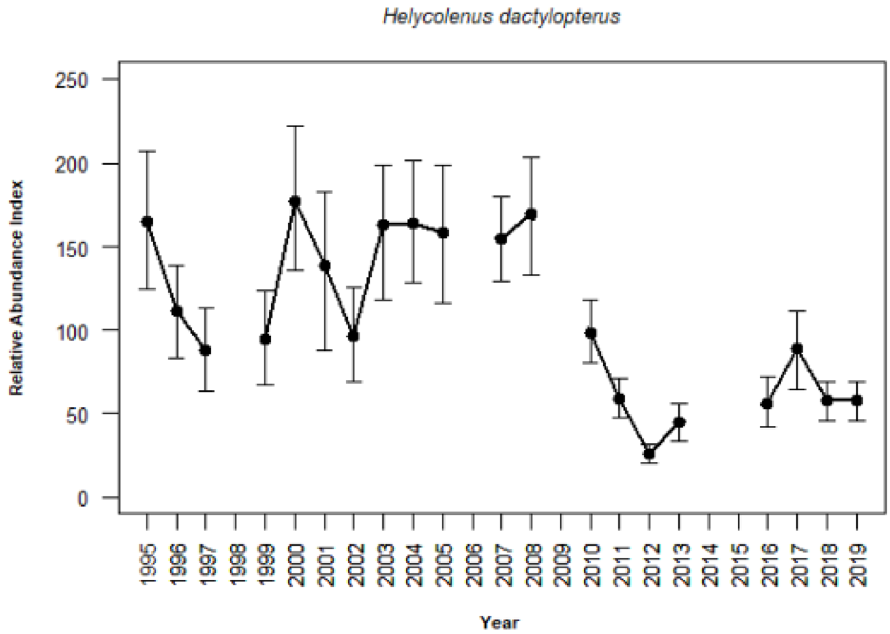

Figure 16.10. Annual bottom longline survey abundance index for *Helicolenus dactylopterus* in Azorean bottom longline surveys.

Abundance indices for silver scabbardfish, common mora and wreckfish from the Portuguese longline survey in the Azores Islands are given in Figures 16.11 to 16.13.

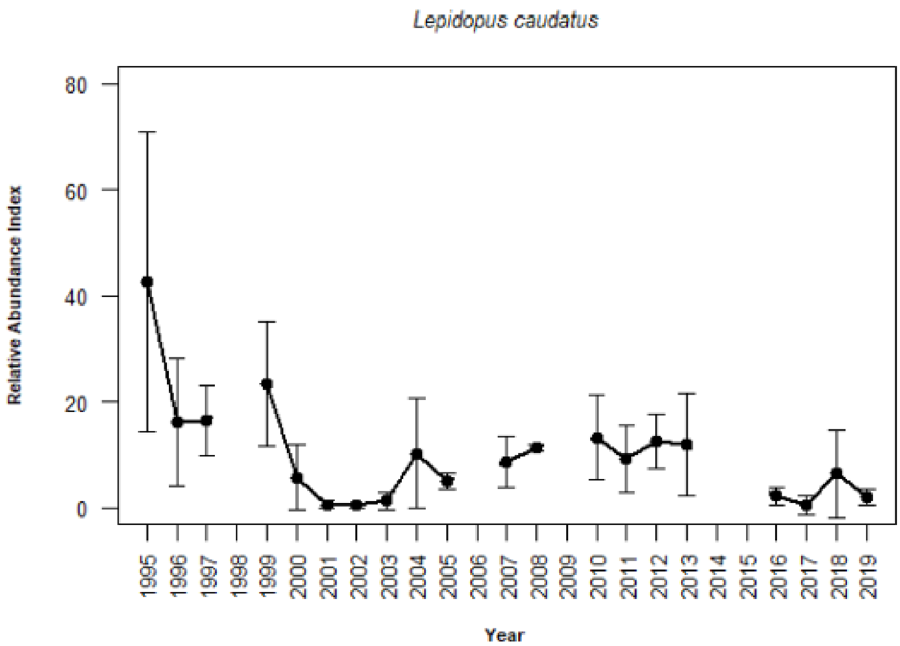

Figure 16.11. Annual bottom longline survey abundance index for *Lepidopus caudatus* in Azorean bottom longline surveys.

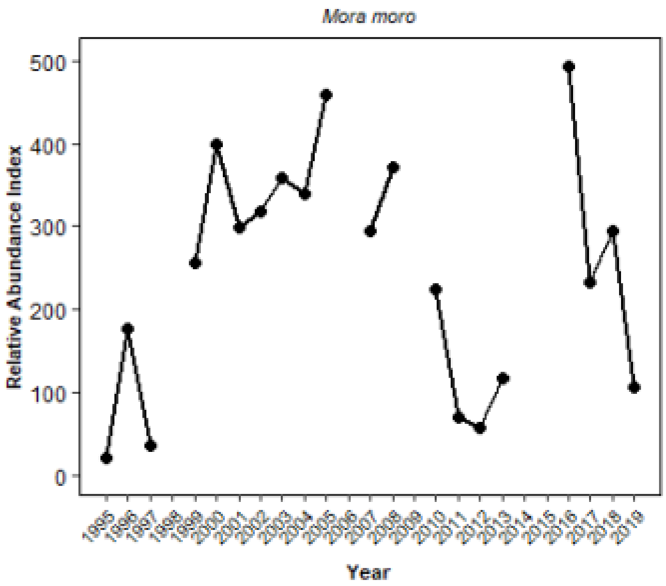

Figure 16.12. Annual bottom longline survey nominal cpue for *Mora moro* in Azorean bottom longline surveys.

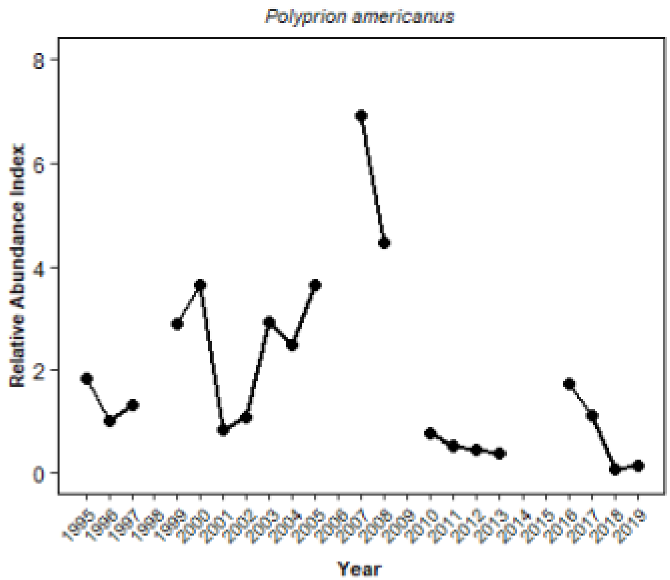

Figure 16.13. Annual bottom longline survey nominal cpue for *Polyprion americanus* in Azorean bottom longline surveys.

16.3.7 Data analysis

No new analyses were carried out in 2020. Updated surveys series from several species are included in working documents WD18, WD20, WD21.

16.3.8 Comments on the assessment

16.3.9 Management considerations

Currently no advice is required for these stocks.

Table 16.1. Official landings of *Mora moro* and *Moridae* (t).

Year	2	5b	6 and 7	8 and 9	10	12	14b	TOTAL
1988								
1989								
1990					2			2
1991		5	1		4			10
1992			25					25
1993			10					10
1994			10					10
1995				83				83
1996				52				52
1997				88				88
1998			41					41
1999		1	20					21
2000	8	3	159	25		1		196
2001	1	100	194	25		87		407
2002	1	19	159	10	100	13		302
2003		8	327	12	125	15	7	494
2004		1	71	15	87	4		178
2005		1	63	19	69			152
2006		5	111	45	92			253
2007		8	64	18	86			176
2008		4	57	4	53			118
2009		1		5	68			74
2010		11	1	4	54			70
2011		7	86	4	55			152
2012		5	71	1	31			108
2013			99	1	52			152
2014				1	54			55
2015				51	92			92
2016		1	40					41

Year	2	5b	6 and 7	8 and 9	10	12	14b	TOTAL
2017		3	30	62	169			264
2018					140*			140
2019					146*			146
* Only data from Azores								

Table 16.3. Official landings of rabbitfish (t) (*Chimaera monstrosa* and *Hydrolagus* spp).

Year	1 and 2	3 and 4	5a	5b	6 and 7	8	9	12	14	TOTAL
1991			499							499
1992		122	106							228
1993		8	3							11
1994		167	60		2					229
1995			106	1						107
1996		14	32							46
1997		38	16					32		86
1998		56	32		2			42		132
1999		47	9	3	237	2		114		412
2000	6	34	6	54	404	2		48		554
2001	7	23	1	96	797	7		79		1010
2002	15	24		64	570	6		98	1	778
2003	57	25	1	61	469	2		80	4	699
2004	22	40		100	444	6		128	5	745
2005	77	171		63	571	14		249	1	1146
2006	29	17	1	62	325	10			5	449
2007	64	2	1	78	391	3				539
2008	81	12	1	49	370	3				516
2009	89	6	2	6	47			70		220
2010	197	21	7	5	31			25		286
2011	150	7	4	2	88					251
2012	104	17	4	29	475	2		434		1065
2013	103	40	2	30	160	1		56		392

Year	1 and 2	3 and 4	5a	5b	6 and 7	8	9	12	14	TOTAL
2014		4		32	131	4		77		178
2015	79	14		25	30			1		149
2016	78	49		40	225	15	31	4		364
2017	69	32		105	174	1			1	382

Table 16.4. Official landings of Baird's smoothhead (t).

Year	5a	5b	6 and 7	12	14	TOTAL
1991			31			31
1992	10		17			27
1993	3			2		5
1994	1					1
1995	1					1
1996				230		230
1997				3692		3692
1999				4643		4643
1999				6549		6549
2000			978	4146	12	5136
2001			5305	3132		8897
2002			260	12 538	661	13 459
2003			393	6883	632	7908
2004		6	2657	4368	245	7276
2005		1	5978	6928		12 412
2006			4966	3512		8150
2007			2565	1781		4140
2008			896	744		1611
2009			295	508		803
2010			511	317		828
2011			187	252		252
2012			335	472		472
2013			342	351		693

Year	5a	5b	6 and 7	12	14	TOTAL
2014			235 0+	228		463
2015			127 3+	91		218
2016			131	258		389
2017	14		156	326		496
2018			77*	323*		400*
* Only data from Spain						

Table 16.5. Official landings of wreckfish (t).

Wreckfish (*Polyprion americanus*) All areas				
Year	**6 and 7**	**8 and 9**	**10**	**TOTAL**
1980			38	38
1981			40	40
1982			50	50
1983			99	99
1984			131	131
1985			133	133
1986			151	151
1987			216	216
1988	7	198	191	396
1989		284	235	519
1990	2	163	224	389
1991	10	194	170	374
1992	15	270	240	525
1993		350	315	665
1994		410	434	844
1995		394	244	638
1996	83	294	243	620
1997		222	177	399
1998	12	238	140	390
1999	14	144	133	291

Wreckfish (*Polyprion americanus*) All areas				
2000	14	123	263	400
2001	17	167	232	416
2002	9	156	283	448
2003	2	243	270	515
2004	2	141	189	332
2005		195	279	474
2006		331	497	828
2007	2	553	662	1217
2008	3	317	513	833
2009	8	13	382	403
2010	3	5	238	246
2011		150	266	416
2012		256	226	482
2013			209	209
2014		95	121	216
2015			116	116
2016	4	19	101	124
2017	9	114	131	254
2018			89*	89*
2019			80*	80*
* Only data from Azores				

Table 16.6. Official landings of blackbelly rosefish (t).

Year	3 and 4	5b	6	7	8 and 9	10	TOTAL
1980						18	18
1981						22	22
1982						42	42
1983						93	93
1984						101	101
1985						169	169

Year	3 and 4	5b	6	7	8 and 9	10	TOTAL
1986						212	212
1987						331	331
1988						439	439
1989			79	48	2	481	610
1990	4		69	31	5	480	589
1991	5		99	29	12	483	628
1992	3		112	47	11	575	748
1993	1		87	65	8	650	811
1994	2		62	55	4	708	831
1995	2		62	9		589	662
1996	2		77	10		483	572
1997	1		78	10	1	410	500
1998			53	92	3	381	529
1999	8	64	194	160	29	340	795
2000		16	213	119	33	441	822
2001			177	102	34	301	614
2002			81	115	18	280	494
2003			184	213	124	338	859
2004	2	3	142	291	135	282	855
2005			103	204	206	190	703
2006			59	160	287	209	715
2007			61	259	293	274	887
2008			105	193	214	281	752
2009			182	14	75	267	450
2010			195	6	120	213	294
2011			176	14	149	231	400
2012		2	161	944	1332	190	2629
2013			121	20	1320	235	1696
2014			25	23	141	200	389

Year	3 and 4	5b	6	7	8 and 9	10	TOTAL
2015		+	+			256	256
2016			452	516	537	306	1811
2017		3	135	647	595	344	1724
2018						283*	283*
2019						187*	187*
* Only data from Azores							

Table 16.7. Official landings of silver scabbardfish (t).

	6 and 7	8 and 9	10	12	TOTAL
1980			13		13
1981			6		6
1982			10		10
1983			43		43
1984			38		38
1985			28		28
1986			65		65
1987			30		30
1988		2666	70		2736
1989		1385	91	102	1578
1990		584	120	20	724
1991		808	166	18	992
1992		1374	2160		3534
1993	2	2397	1724	19	4142
1994		1054	374		1428
1995		5672	788		6460
1996		1237	826		2063
1997		1725	1115		2840
1998		966	1187		2153
1999	18	3069	86		3173
2000	17	16	27		60

	6 and 7	8 and 9	10	12	TOTAL
2001	6	706	14		726
2002	1	1832	10		1843
2003		1681	25		1706
2004		836	29		865
2005	57	527	31		615
2006	377	624	35	3	1039
2007	88	649	55	1	793
2008	40	845	63	0	948
2009	44	898	64	25	1031
2010	32	829	68	43	972
2011		927	148	82	1157
2012	655	36	271	244	1206
2013	200		361	123	648
2014	253		713	88	1056
2015			429	41	470
2016	188	134	87	33	442
2017	62	146	112	29	349
2018	‹1*		73*	13*	86*
2019			65*		65*
*Only data from Spain and Azores					

Table 16.8. Official landings of deep-water cardinal fish (t).

Year	5b	6	7	8 and 9	10	12	TOTAL
1990					3		3
1991					11		11
1992							0
1993		15	15				30
1994	4	35	182				221
1995	3	20	71				94
1996	8	13	32				53

Year	5b	6	7	8 and 9	10	12	TOTAL
1997	8	27	22				57
1998		86	29				115
1999	8	54	224	3			289
2000	2	121	181	5	3		312
2001	7	109	284	4			404
2002		97	888	8	14		1007
2003	2	47	1031	5	16	1	1102
2004	1	30	843	10	21	2	907
2005		50	637	8	4		699
2006		30	383	12	10		435
2007		6	218	19	7		250
2008		19	5	6	7		37
2009		8	2	130	7		147
2010		4	6		5		15
2011		3	2	128	5		138
2012		16	4	2	4		26
2013		10	1	1	4		16
2014		4	1	2	2		9
2015					4		4
2016					6		6
2017		12		3	8		23

Table 16.9. Official estimates of landings of deep-water red crab (t).

Year	4and5	6	7	8 and 9	12	Total
1995		6	4			12
1996	20	1288	77	2	17	1413
1997	58	139	48	11	4	437
1998	35	313	34	188	2	384
1999	642	289	46		3	980
2000	38	580	108			726

Year	4and5	6	7	8 and 9	12	Total
2001	13	335	20			368
2002	29	972	21		6	1028
2003	26	960	123		92	1201
2004	21	546	115		13	695
2005	94	626	184		15	1230
2006	16	185	19	310		530
2007	11	732	104	85	24	957
2008	2	124	1			127
2009	0	110	75	10	115	309
2010	2	247	79	46	71	445
2011		246	148	37	43	475
2012	10	67	45	10	21	153
2013	3	91	34	18	32	178
2014	1	112	29	3	48	194
2015		151	40	26	74	291
2016		103	55	41	23	222
2017	9	102	48	21		180

Table 16.10. Official landings (t) of Mediterranean slimehead, also known as silver roughy (*Hoplostethus mediterraneus*) by ICES Subarea from 2006 to 2017.

Year	27.7	27.8	27.9
2006	0	0	0.7
2007	0	0	0
2008	0	0	0.01
2009	0	0	0.01
2010	0	0	14
2011	0	0	3.38
2012	0	0	27.26
2013	0	0.82	34.93
2014	0	3.85	36.11
2015	0	6.9	14.98

Year	27.7	27.8	27.9
2016	0	2.68	1.62
2017	0.25	2.33	1.06

Table 16.11. Official landings (t) of Atlantic thornyhead (*Trachyscorpia cristulata*) by ICES Subarea from 2006 to 2017.

Year	27.4	27.6	27.7	27.8
2006	0	0	0.01	26
2007	0.01	4.6	13.73	1.41
2008	0	2.8	4.2	0.62
2009	0	1.6	4.61	0.6
2010	0	0	0	0
2011	0	0.38	2.59	0.4
2012	0	0.06	4.43	0.36
2013	0.01	0.07	2.05	0.48
2014	0	0	0.92	0.72
2015	0	0	0.75	0.58
2016	0	0.45	0.14	0.29
2017	0	0.02	0.26	0.04

Table 16.12. Official landings (t) of Norway redfish (*Sebastes viviparus*) by ICES Subarea from 2006 to 2017.

Year	27.2	27.5	27.6	27.12	27.14
2006	13	0	0	0	0
2007	7.3	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	0	2600.7	0	0	0
2011	0	1415	0	0	10
2012	0	532	0	1	1
2013	0	532	0	0	0
2014	1	546	0	0	4
2015	0	468	0	0	0
2016	0	0	0.3	0	0

Year	27.2	27.5	27.6	27.12	27.14
2017	0	170	0	0	0

Annex 1: List of participants

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Annex 2: Resolutions

WGDEEP – Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources

This resolution was approved 3 November 2020

2020/2/FRSG10 **Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources** (WGDEEP), chaired by Ivone Figueiredo, Portugal and Elvar Halldor Hallfredsson, Norway, will meet in Copenhagen, Denmark, 22–28 April 2021 to:

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

b) Complete the development of Stock Annexes for all the stocks assessed by WGDEEP, based on the most recent agreed assessment.

c) Update the description of deep-water fisheries in both the NEAFC Regulatory Area and ICES area(s) by compiling data on catch/landings, fishing effort (inside versus outside the EEZs, in spawning areas, areas of local depletion, etc.), and discard statistics at the finest spatial resolution possible by ICES Subarea and Division and NEAFC Regulatory Area. In particular, describe and prepare a first advice draft of any new emerging deep-water fishery with the available data in the NEAFC Regulatory Area.

d) Continue work on exploratory assessments for deep-water species.

e) Evaluate the stock status of stocks in Icelandic waters for the provision of annual advice in 2021.

f) Evaluate the stock status of stocks for the provision of biennial advice due in 2021.

The assessments will be carried out on the basis of the stock annex. 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 on the dates specified in the 2020 ICES data call.

WGDEEP will report by 7 May 2021 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Annex 3: Stock Annexes

The table below provides an overview of the WGDEEP stock annexes updated at the WGDEEP 2020 meeting. 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 *year*, *ecoregion*, *species* and *acronym* of the relevant ICES expert group

stock ID	stock name	Last updated	Link
aru.27.5b6a	Greater silver smelt (*Argentina silus*) in divisions 5.b and 6.a (Faroes grounds and west of Scotland)	April 2021	aru27.5b6a
aru.27.6b7-1012	Greater Silver Smelt (*Argentina silus*) in Subareas 7, 8, 9, 10 and 12, and Division 6b ((Irish Sea, West of Ireland, Porcupine Bank, Eastern and Western English Channel, Bay of Biscay, Portuguese Waters, Azores Grounds and Northeast Atlantic South, North of Azores and North Ireland))	April 2021	aru.27.6b711012
lin.27.1-2	Ling (*Molva molva*) in subareas 1 and 2 (Northeast Arctic))	April 2021	lin.27.1-2
lin.27.346-91214	Ling (*Molva molva*) in subareas 6-9, 12, and 14, and in in divisions 3.a and 4.a (Northeast Atlantic and Arctic Ocean)	April 2021	lin.27.346-91214
lin.27.5b	Ling (*Molva molva*) in Division 5.b (Faroes grounds)	April 2021	lin.27.5b
usk.27.1-2	Tusk (*Brosme brosme*) in subareas 1 and 2 (Northeast Arctic)	April 2021	usk.27.1-2
usk.27.3a45b6a7-912b	Tusk (*Brosme brosme*) in subareas 4 and 7–9, and in divisions 3.a, 5.b, 6.a, and 12.b (Northeast Atlantic)	April 2021	usk.27.3a45b6a7-912b

WGDEEP 2021, WD 01

CPUE Standardization of Silver smelt in 5b and 6a

M.A. Pastoors, L.H. Ofstad and H. Olsen

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09/04/2021

Abstract

At the WKGSS 2020 benchmark of Greater silver smelt in 5b and 6a, a combined and standardized CPUE series for the Faroe and EU fleets has been introduced (Quirijns and Pastoors 2020). On checking the data in preparation for WGDEEP 2020, a small error was detected in the way CPUE was calculated. This report provides a summary of the issue and proposed a method to repair the situation. The overall trend in CPUE is still similar although there are some differences in the most recent year.

1 Introduction

At the WKGSS 2020 benchmark of Greater silver smelt in 5b and 6a, a combined and standardized CPUE series for the Faroe and EU fleets has been introduced (Quirijns and Pastoors 2020). During WGDEEP 2020 two small errors were detected in the way CPUE was calculated and solutions to these errors were provided (Pastoors and Quirijns 2020). This report provides a an update of the CPUE calculation for Greater silver smelt, with the time series update to 2020 according to the method agreed in WGDEEP 2020.

2 Results

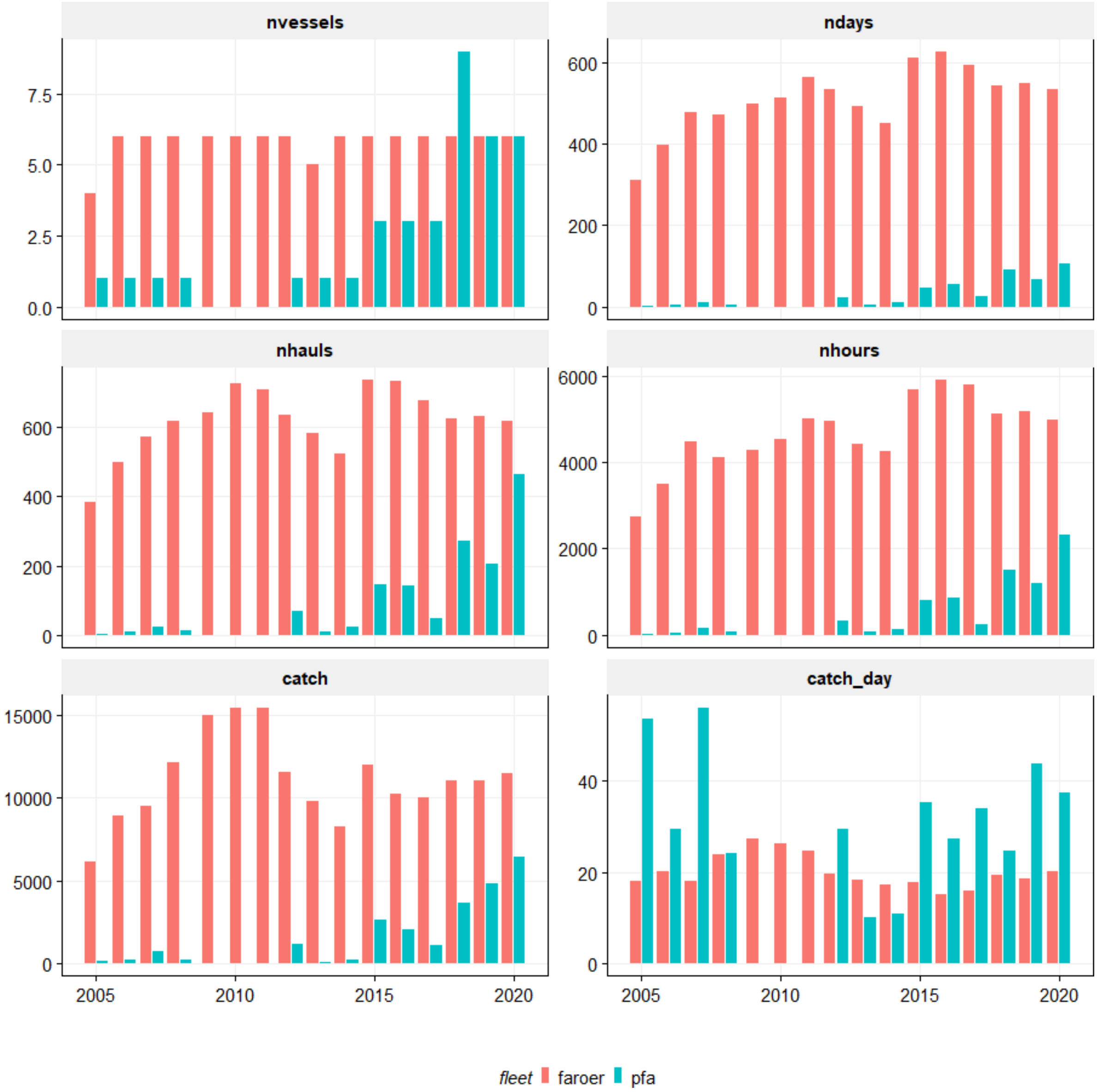


Figure 1: ARU.27.5b6a metrics describing the fisheries

The ‘raw’ (unstandardized) CPUE is based on the catch per day and per rectangle.

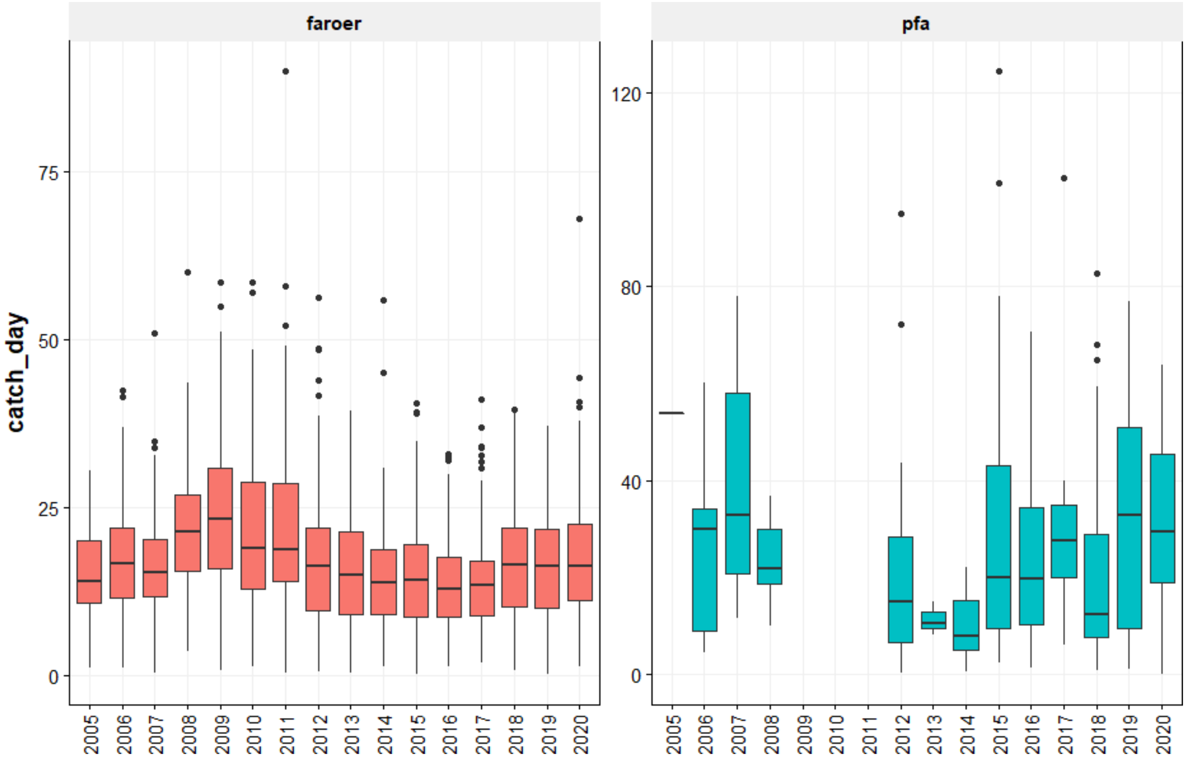


Figure 2: ARU.27.5b6a Catch per unit effort.

For the years 2015-2020, below are the spatial distributions of the used number of hauls by fleet.

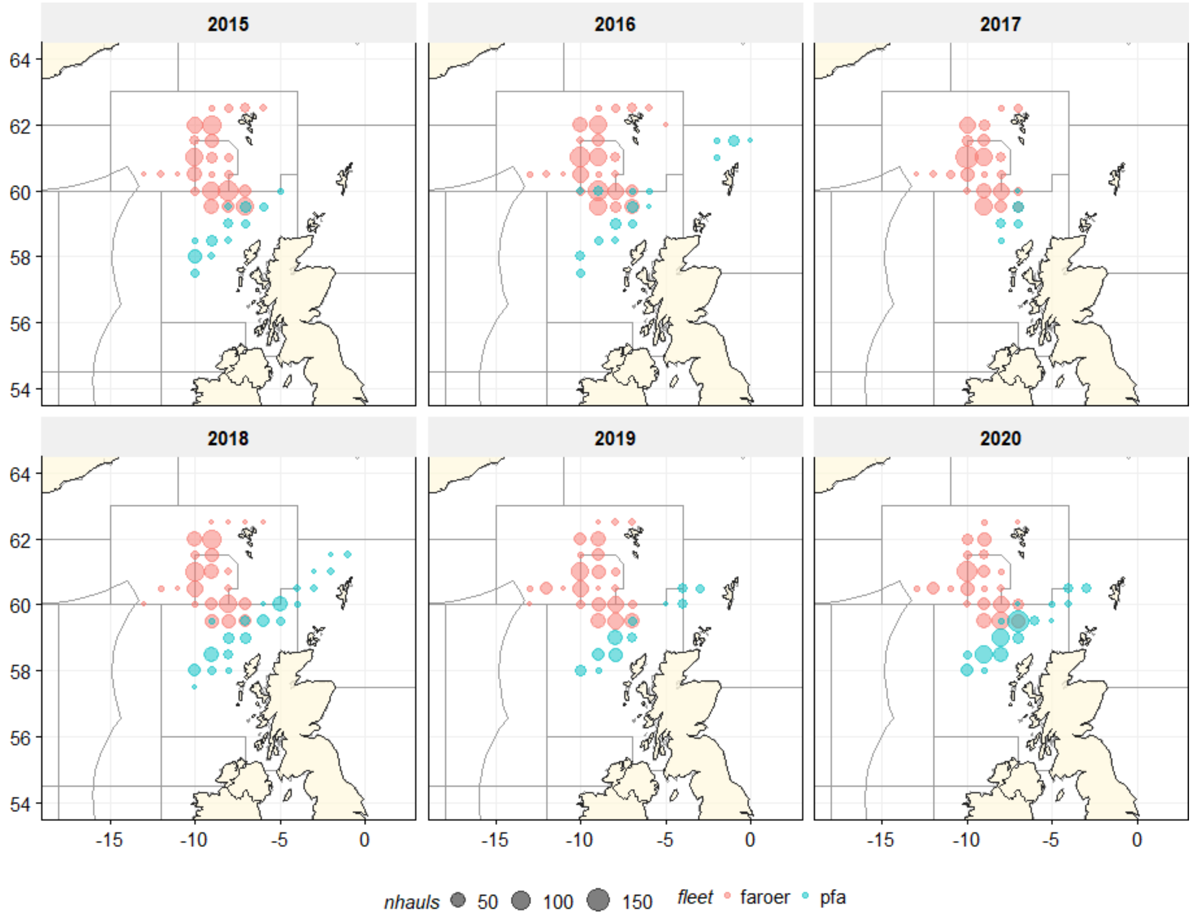


Figure 3: ARU.27.5b6a plot of the number of hauls by rectangle and day

Standardized CPUE index

We applied the same model for standardization of of CPUE: CPUE ~ year + week + depth, where CPUE is expressed as catch per day and per rectangle. Catches have first been summed by vessel, year, week and rectangle and the number of hauls and fishing days have been calculated. Then the catches and effort (fishing days) have been summed over all vessels by year and week and the average depth has been calculated. CPUE was then calculated as the average catch per rectangle and per day.

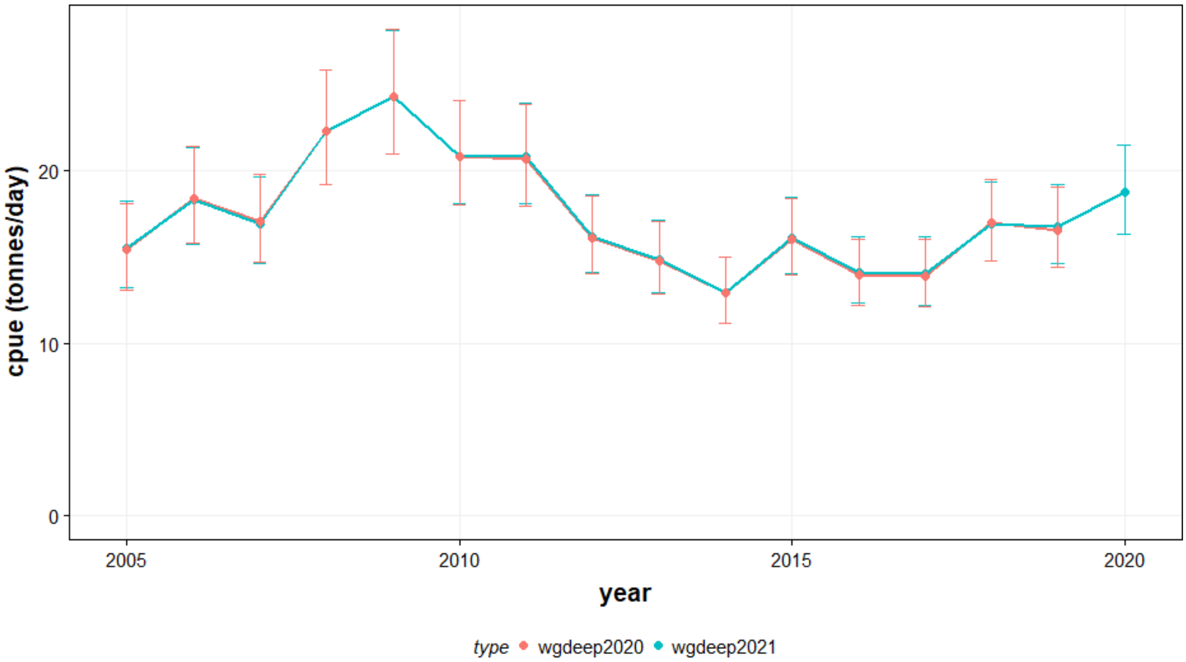
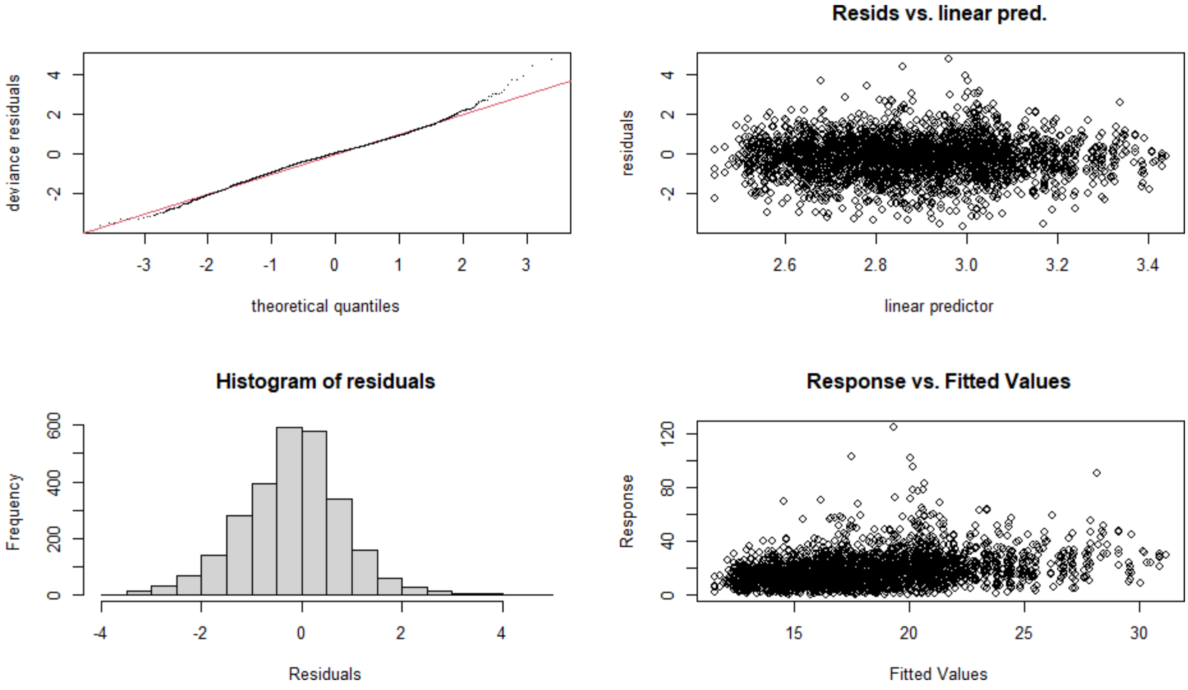


Figure 4: ARU.27.5b6a standardized CPUE (catch per rectangle and day), in comparison with WKGSS series

Model diagnostics

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Method: UBRE   Optimizer: outer newton
Model required no smoothing parameter selectionModel rank =  41 / 41
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Figure 5: ARU.27.5b6a standardized CPUE model diagnostics

Evaluation of explanatory variables

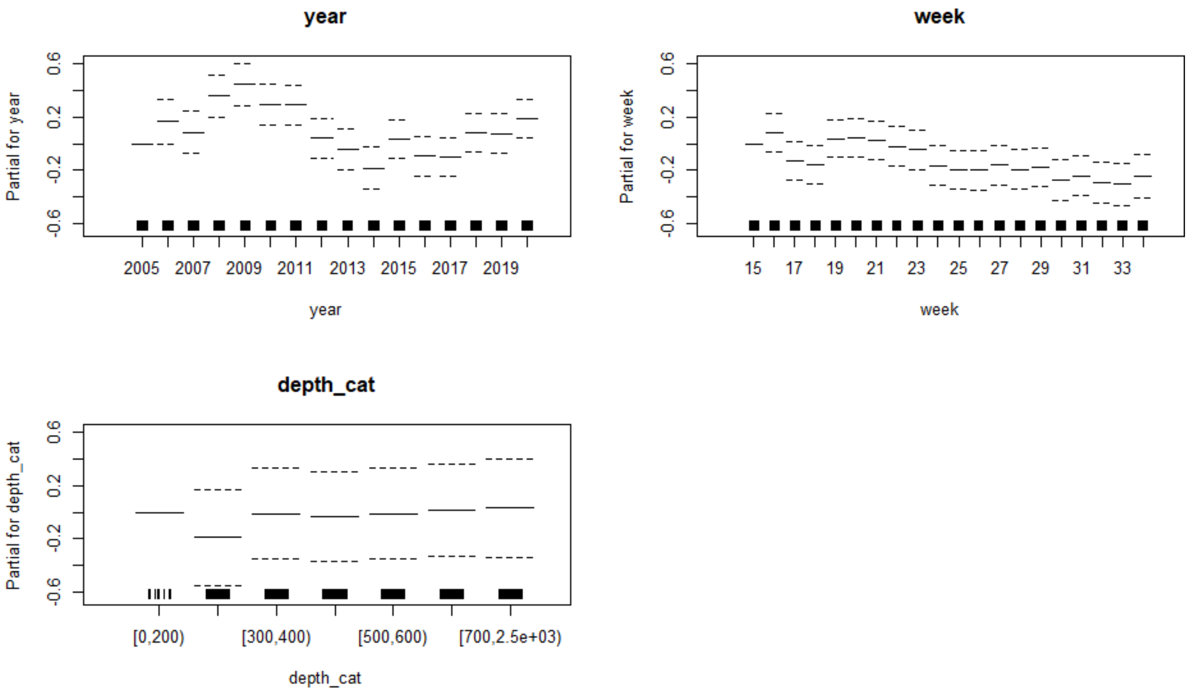

Figure 6: ARU.27.5b6a standardized CPUE explanatory variables

year	cpue	lwr	upr
2005	15.55	13.22	18.29
2006	18.34	15.75	21.36
2007	16.95	14.63	19.64
2008	22.29	19.23	25.84
2009	24.3	20.99	28.13
2010	20.87	18.09	24.09
2011	20.83	18.11	23.96
2012	16.2	14.09	18.61
2013	14.89	12.92	17.16
2014	12.94	11.19	14.98
2015	16.13	14.07	18.49
2016	14.13	12.34	16.18
2017	14.05	12.21	16.16
2018	16.91	14.77	19.37
2019	16.77	14.63	19.24
2020	18.74	16.33	21.5

Table 1: ARU.27.5b6a standardized commercial CPUE (tonnes/day) for greater silversmelt, with lower and upper values based on the standard error.

Single fleet analysis

A single fleet analysis was carried out by using the combined raw CPUE datasets and extracting the separate parts for the Faroese and PFA fleets. These data were then processed in a similar fashion as in the combined analysis. It is clear that the Faroese data is substantially more precise that the data from PFA as evident from the confidence intervals. This is likely due to the number of observations, where the dataset from Faroe Islands over all years is based on 10 times the number of hauls compared to the PFA data.

Figure 7: ARU.27.5b6a standardized single fleet CPUE (catch per rectangle and day)

3 Discussion

CPUE standardization using GLM procedures is a common way of dealing with CPUE information. Here we used aggregated data (catch per day) as the main response variable and year, week and depth category as explanatory variables. by area and period, which cannot use attributes that are related to the hauls. The standardized CPUE for WGDEEP 2021 is highly consistent with the CPUE that was calculated during WGDEEP 2020.

Both data sources (Faroese data and PFA data) indicate an increase in CPUE in the last 5-6 years although it does not reach the level seen in the late 2000s. The data from the Faroese fisheries are generated from a targetted fishery on silver smelt, while the data from the PFA is from a mixed fishery with blue whiting (blue whiting in the daytime, silver smelt in the nighttime). This probably leads to the higher uncertainties in the CPUE estimates for the PFA compared to the Faroese fleet. It is also noted that the number of observations in the PFA fisheries prior to 2015 is much lower than after 2015, because the self-sampling program only started in 2015.

4 References

Pastoors, M. A. and F. J. Quirijns (2020). Correcting an error in the CPUE Standardizing of Greater silversmelt for WGDEEP 2020, WD05.

Quirijns, F. J. and M. A. Pastoors (2020). CPUE standardization for greater silversmelt in 5b6a. WKGSS 2020, WD03.

PELAGIC FREEZER-TRAWLER ASSOCIATION

REPORT

PFA self-sampling report for WGDEEP 2021 (WD02)

M.A. Pastoors

PFA report 2021/04
20/04/2020

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Please cite as:

M.A. Pastoors (2021) **PFA self-sampling report WGDEEP 2021**. WGDEEP 2021, WD 02 / PFA report 2021/04

Summary

This report summarizes the self-sampling data collected by the Pelagic Freezer-trawler Association (PFA) with a focus on Argentines or Silversmelts. The self-sampling data consists of two main sources: (1) the historical catch per haul data derived from a limited number private logbooks of skippers, and (2) the self-sampling program that has been initiated from 2015 onwards on an increasing number of freezer-trawlers.

The PFA fishery for argentines takes place in the months April and May, and sometimes into June. The predominant fishing area is ICES division 27.6.a with also some catches being taken in 2.a, 4.a and 5.b. The fishery is combined with the fishery for blue whiting, whereby the catches of blue whiting take place during the day and catch of argentines mostly in the night.

Overall, the self-sampling activities for the argentines fisheries during the years 2000 – 2020 covered 48 fishing trips with 1248 hauls, a total catch of 30253 tonnes and 18635 individual length measurements.

The length compositions of argentines are relatively stable over the years, varying between 34 and 36 cm. A standardized CPUE series of the PFA fisheries is presented based on a GLM on CPUE (catch/rectangle/day) with year, week and depth as explanatory variables. Catch rates in 2019 and 2020 have been estimated higher than the preceding years, in line with reports from the skippers in the fleet.

1 Introduction

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 17 (in 2019) freezer trawlers in six European countries (www.pelagicfish.eu).

In 2015, the PFA has initiated a self-sampling programme that expands the ongoing monitoring programmes on board of pelagic freezer-trawlers by the specialized crew of the vessels. The primary objective of that monitoring programme is to assess the quality of fish. The expansion in the self-sampling programme consists of recording of haul information, recording the species compositions by haul and regularly taking random length-samples from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling programme is carried out by Martin Pastoors (PFA chief science officer) with support of Floor Quirijns (contractor).

2 Overview of self-sampling methodology

The PFA self-sampling programme has been implemented incrementally on many vessels that belong to the members of the PFA. The self-sampling programme is designed in such a way that it follows as closely as possible the working practices on board of the different vessels and that it delivers relevant information for documenting the performance of the fishery and to assist stock assessments of the stocks involved. The following main elements can be distinguished in the self-sampling protocol:

- haul information (date, time, position, weather conditions, environmental conditions, gear attributed, estimated catch, optionally: species composition)
- batch information (total catch per batch=production unit, including variables like species, average size, average weight, fat content, gonads y/n and stomach fill)
- linking batch and haul information (essentially a key of how much of a batch is caught in which of the hauls)
- length information (length frequency measurements, either by batch or by haul)

The self-sampling information is collected using standardized Excel worksheets. Each participating vessel will send in the information collected during a trip by the end of the trip. The data will be checked and added to the database by Floor Quirijns and/or Martin Pastoors, who will also generate standardized trip reports (using RMarkdown) which will be sent back to the vessel within one or two days. The compiled data for all vessels is being used for specific purposes, e.g. reporting to expert groups, addressing specific fishery or biological questions and supporting detailed biological studies. The PFA publishes an annual report on the self-sampling programme.

A major feature of the PFA self-sampling programme is that it is tuned to the capacity of the vessel-crew to collect certain kinds of data. Depending on the number of crew and the space available on the vessel, certain types of measurements can or cannot be carried out. That is why the programme is essentially tuned to each vessel separately. And that is also the reason that the totals presented in this report can be somewhat different dependent on which variable is used. For example the estimate of total catch is different from the sum of the catch by species because not all vessels have supplied data on the species composition of the catch.

The historical data retrieval program has been based on skippers' private logbooks that have been kept for fisheries practice recording. This data delivers information on the catch composition by haul and species. As part of a generic effort to retrieve the historical information, excel based versions of the logbooks have been converted into a standardized database. A major effort has been spent in making the information from the skippers' logbooks consistent and useable, so that the units are consistent between vessels and years. In addition, the species composition has been approximated from the logbooks using automated techniques. For example, skippers may have described the catch of a certain haul as "her 10% hom" which would then be converted to 90% herring and 10% horse mackerel. All conversion have been fully documented in R code. For this report, skippers' logbooks of 4 vessels have been used covering the period 2000-2015.

The freezer-trawler fishery is mostly focussed on the key target species herring, mackerel, horse mackerel and blue whiting. However, during the months april to june there is also a more limited directed fishery for greater argentine (Argentina silus) and lesser argentine (Argentina sphyraena), mostly in ICES division 27.6.a and 27.4.a.

For this report, the PFA self-sampling data has been filtered using the following criteria:

- hauls in divisions 27.2.a, 27.4.a, 27.5.b, 27.6.a
- catch of arg, aru, ary by trip and week at least 5% of the total catch of that trip and week.
- catch of arg, aru, ary by trip and week at least 50 tonnes.

3 Results

3.1 General summary of self-sampling for Silver smelts**

An overview of all the self-sampled trips for arg, aru, ary in 27.2.a, 27.4.a, 27.5.b, 27.6.a

year	nvessels	ntrips	ndays	nhauls	catch	nlength
2001	1	1	10	32	1,635	0
2003	1	1	18	43	2,132	0
2004	1	2	38	96	4,925	0
2005	1	1	7	14	1,340	0
2006	1	1	12	25	1,495	0
2007	1	1	13	29	1,505	0
2008	1	1	7	16	680	0
2012	1	2	27	74	3,044	0
2013	1	1	12	27	1,260	0
2014	1	1	14	30	1,885	0
2015	3	4	51	123	9,712	15,672
2016	3	3	73	158	11,025	10,166
2017	4	4	43	118	10,345	11,178
2018	9	9	103	273	17,215	17,783
2019	6	8	80	197	18,938	8,821
2020	6	8	117	319	22,536	18,781
(all)		48	625	1,574	109,672	82,401

Table 3.1.1: PFA fisheries for argentines (and blue whiting). Self-sampling Summary of number of vessels, trips, days, hauls, catch (tonnes) and number of fish measured.

The majority of hauls have been recorded in division 27.6.a (81%).

division	2001	2003	2004	2005	2006	2007	2008	2012	2013	2014	2015	2016	2017	2018	2019	2020	all	perc
27.6.a	32	4	65	3	2	17	16	70	27	25	116	97	109	239	175	281	1,278	81.2%
27.5.b	0	36	12	11	8	12	0	4	0	2	7	42	9	5	0	4	152	9.7%
27.4.a	0	0	0	0	13	0	0	0	0	3	0	19	0	26	22	34	117	7.4%
27.2.a	0	3	19	0	2	0	0	0	0	0	0	0	0	3	0	0	27	1.7%
(all)	32	43	96	14	25	29	16	74	27	30	123	158	118	273	197	319	1,574	100.0%

Table 3.1.2: PFA fisheries for argentines (and blue whiting). Self-sampling Summary of number of hauls per year and division.

Catch by species in the selected fisheries

species	english_name	scientific_name	2015	2016	2017	2018	2019	2020	all	perc
whb	blue whiting	Micromesistius poutassou	6,781	7,735	7,688	13,110	13,602	13,115	62,030	69.1%
arg	argentines	Argentina spp	2,841	2,551	2,438	3,682	4,824	7,561	23,897	26.6%
her	herring	Clupea harengus	0	0	0	0	0	1,438	1,438	1.6%
mac	mackerel	Scomber scombrus	29	27	124	264	446	312	1,203	1.3%
hke	hake	Merluccius merluccius	51	642	89	126	59	50	1,017	1.1%
hom	horse mackerel	Trachurus trachurus	0	50	0	1	2	0	52	0.1%
squ	various squids nei	Loliginidae, Ommastrephidae	10	0	3	3	3	14	33	0.0%
mcd	NA	Ceratoscopelus maderensis	0	0	0	0	0	23	23	0.0%
sqr	squid	Loligo vulgaris	0	0	0	4	1	16	21	0.0%
mzz	other fish	Osteichthyes	0	0	0	20	0	0	20	0.0%
oth	NA	NA	1	21	3	6	2	8	41	0.0%
(all)	(all)	(all)	9,713	11,026	10,346	17,215	18,938	22,537	89,774	100.0%

Table 3.1.3: PFA fisheries for argentines (and blue whiting). Self-sampling Summary of total catch (tonnes) by species.

Haul positions

An overview of all self-sampled hauls in the PFA fisheries for argentines (and blue whiting)..

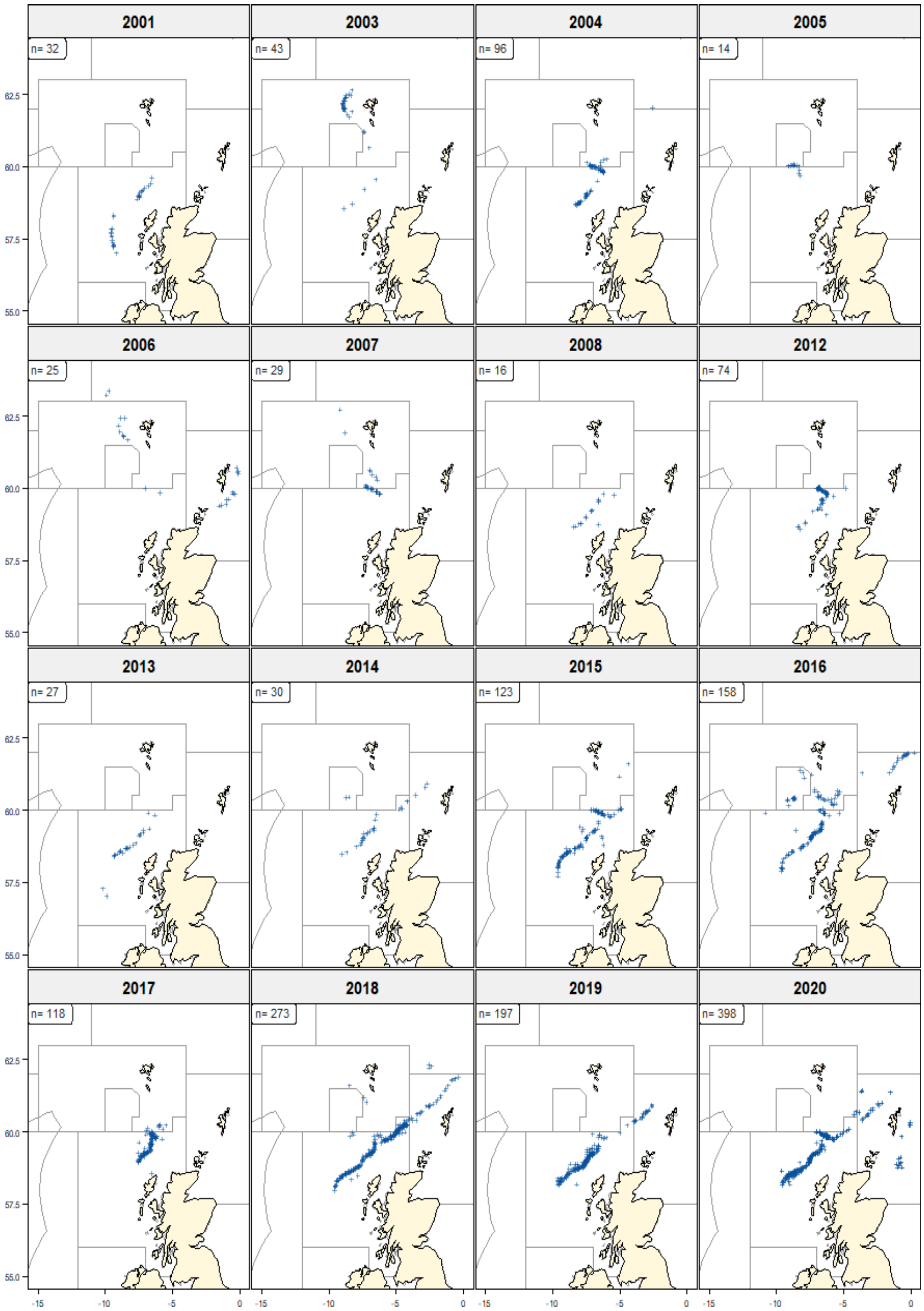


Figure 3.1.1: PFA fisheries for argentines (and blue whiting). Self-sampling haul positions. N indicates the number of hauls.

Total catch per rectangle for the main target species

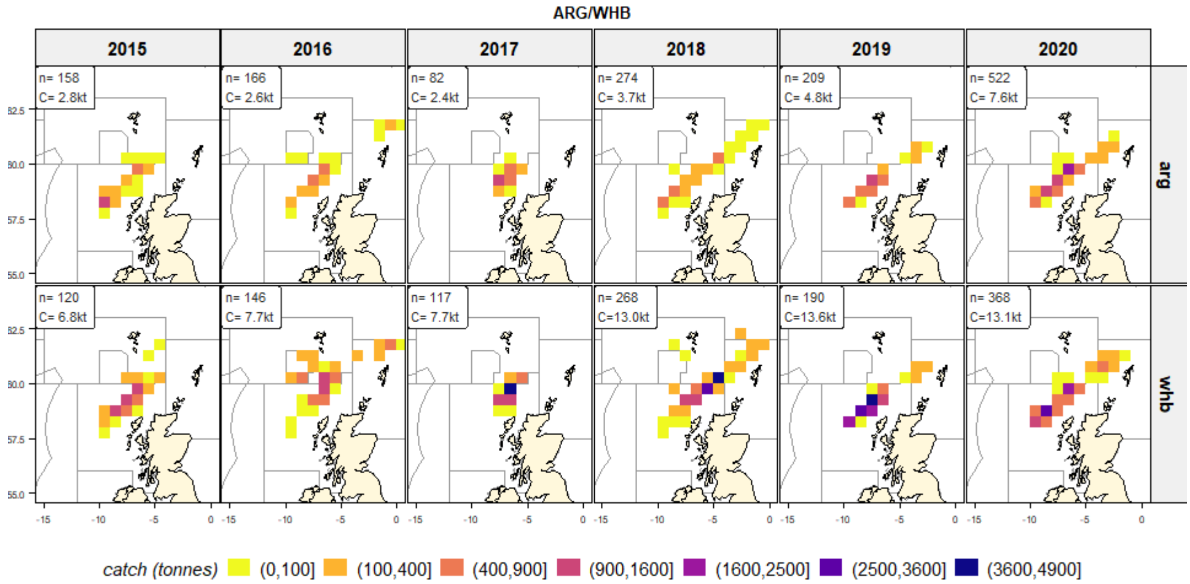


Figure 3.1.2: PFA fisheries for argentines (and blue whiting). Self-sampling catch per species and per rectangle. N indicates the number of hauls. Catch refers to the total catch per year.

Average fishing depth by rectangle

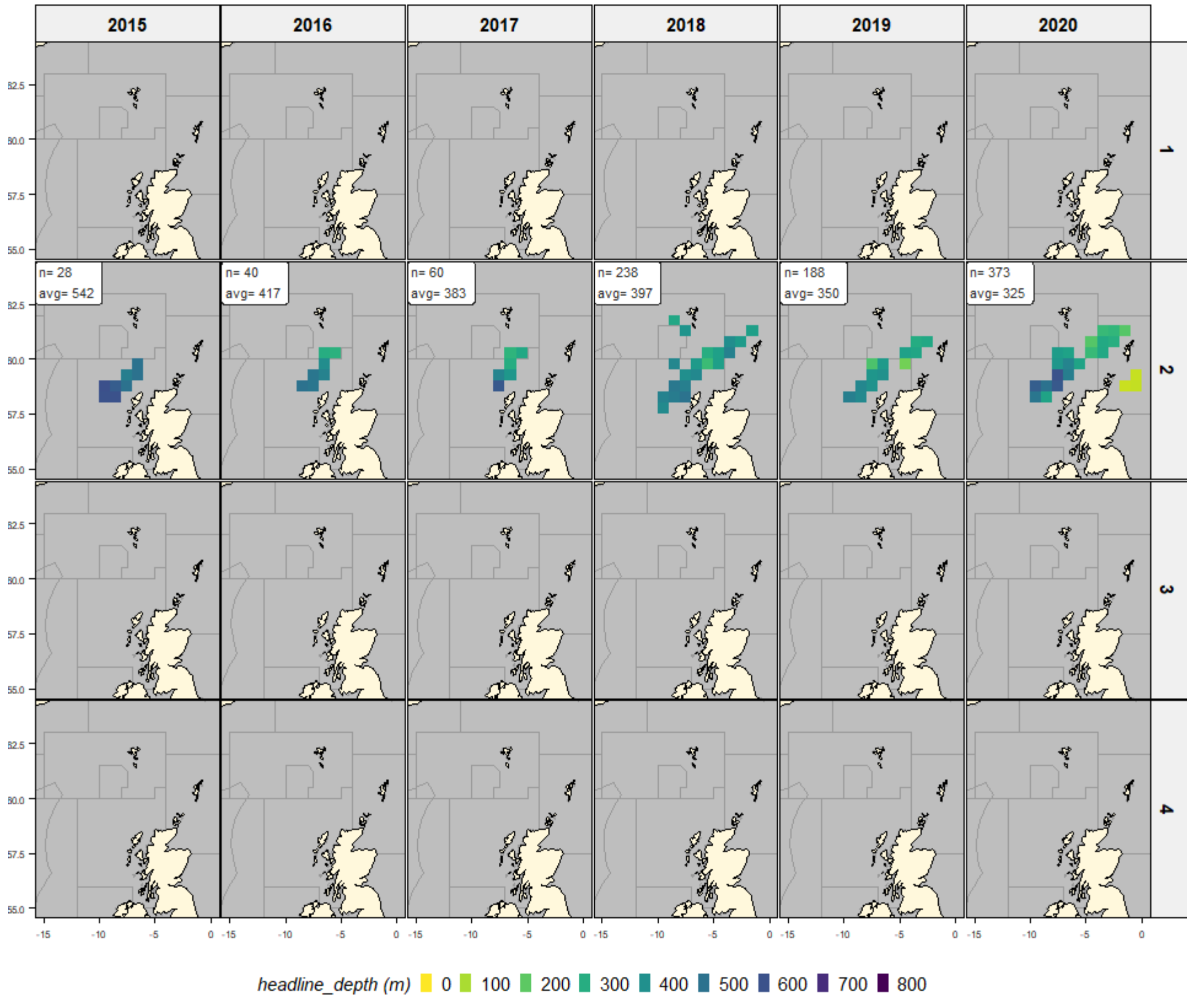


Figure 3.1.3: PFA fisheries for argentines (and blue whiting). Average fishing depth (m) by year and quarter. N indicates the number of hauls. Avg refers to the average fishing depth.

Average temperature at fishing depth by rectangle

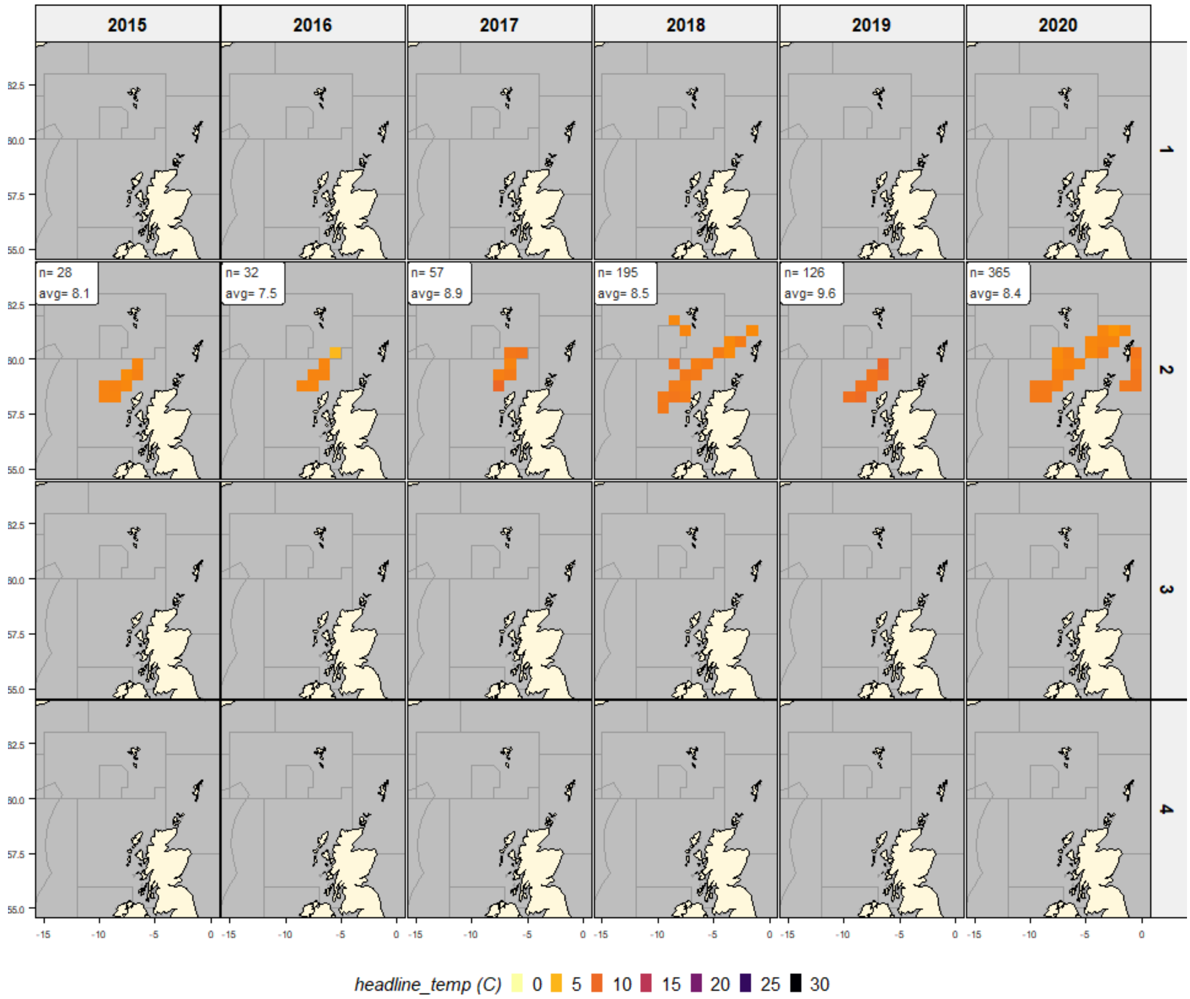


Figure 3.1.4: PFA fisheries for argentines (and blue whiting). Average temperature at fishing depth (C) by year and quarter. N indicates the number of hauls. Avg refers to the average temperature.

Average windspeed by rectangle

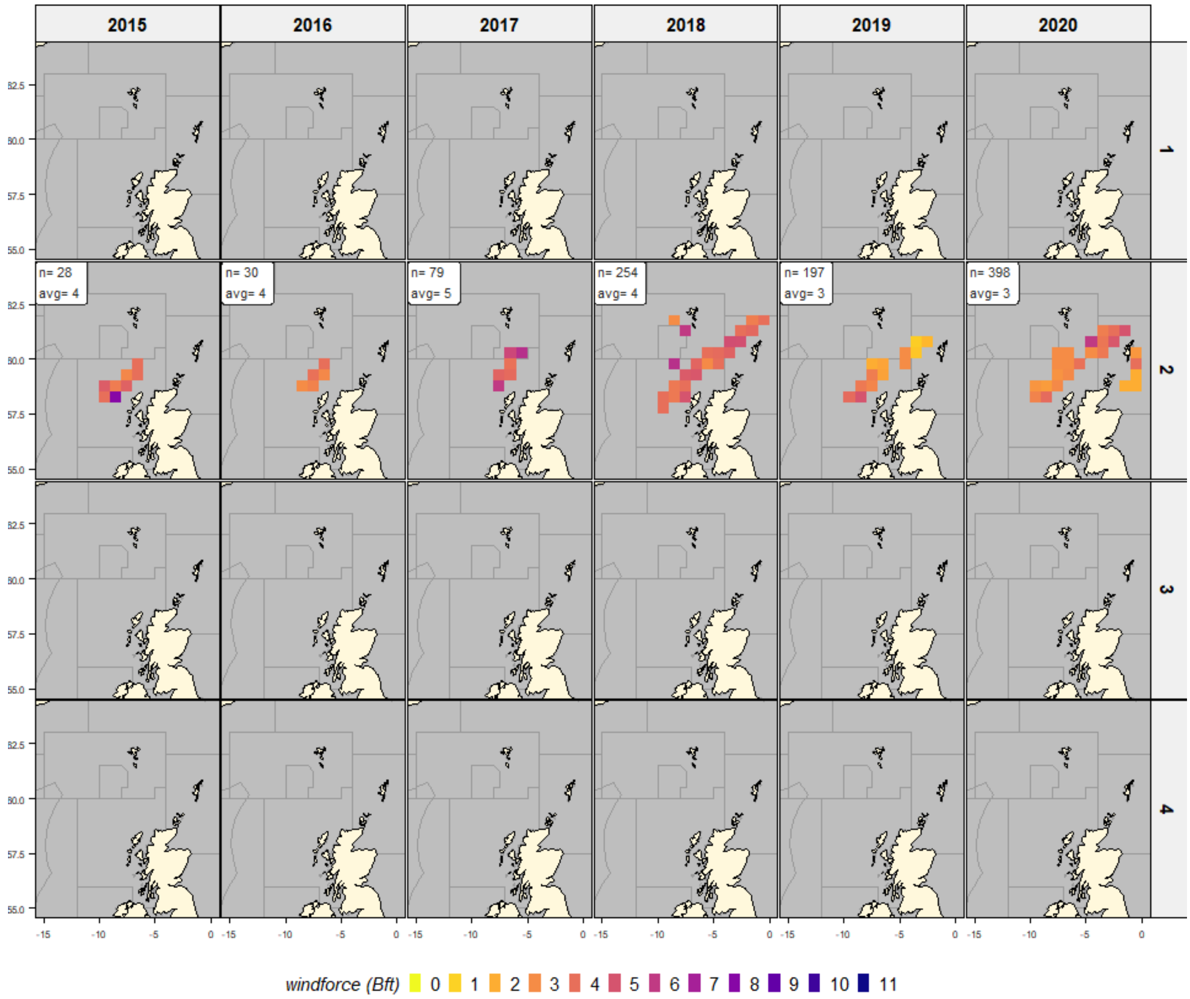


Figure 3.1.5: PFA fisheries for argentines (and blue whiting). Average wind speed (Bft) by year and quarter. N indicates the number of hauls. Avg refers to the average wind speed.

3.2 Argentines (ARG, Argentina spp.)

The Argentines fishery takes place as a summer fishery from June to September and a winter fishery in December. Overall, the self-sampling activities for the Argentines fisheries during the years 2000 – 2020 covered 48 fishing trips with 1685 hauls, a total catch of 30253 tonnes and 18635 individual length measurements. The main fishing areas are ICES divisions 27.4.a, 27.4.b and 27.7.d.

species	division	year	nvessels	ntrips	ndays	nhauls	catch	catchperc	nlength
arg	27.2.a	2004	1	1	1	1	80	3	0
arg	27.4.a	2014	1	1	1	3	9	5	0
arg	27.4.a	2016	2	2	8	18	150	6	362
arg	27.4.a	2018	5	5	13	25	181	5	239
arg	27.4.a	2019	1	1	9	21	329	7	628
arg	27.4.a	2020	3	3	9	17	490	6	377
arg	27.5.b	2003	1	1	12	28	821	100	0
arg	27.5.b	2004	1	2	6	8	182	7	0
arg	27.5.b	2005	1	1	2	3	108	100	0
arg	27.5.b	2006	1	1	4	6	222	94	0
arg	27.5.b	2007	1	1	4	6	130	18	0
arg	27.5.b	2012	1	1	4	4	25	2	0
arg	27.5.b	2015	2	3	4	5	155	5	637
arg	27.5.b	2016	2	2	8	14	139	5	119
arg	27.5.b	2017	1	1	1	1	6	0	2
arg	27.5.b	2018	1	1	1	1	4	0	6
arg	27.5.b	2020	1	1	2	2	87	1	48
arg	27.6.a	2001	1	1	6	9	121	100	0
arg	27.6.a	2003	1	1	3	4	0	0	0
arg	27.6.a	2004	1	2	23	61	2,272	90	0
arg	27.6.a	2006	1	1	1	2	14	6	0
arg	27.6.a	2007	1	1	8	17	599	82	0
arg	27.6.a	2008	1	1	5	12	216	100	0
arg	27.6.a	2012	1	2	25	67	1,246	98	0
arg	27.6.a	2013	1	1	11	23	127	100	0
arg	27.6.a	2014	1	1	10	19	186	95	0
arg	27.6.a	2015	3	4	47	105	2,686	95	5,178
arg	27.6.a	2016	3	3	45	86	2,262	89	1,063
arg	27.6.a	2017	4	4	38	81	2,432	100	980
arg	27.6.a	2018	9	9	83	204	3,498	95	1,396
arg	27.6.a	2019	6	8	59	129	4,495	93	3,038
arg	27.6.a	2020	6	8	97	266	6,984	92	4,557
arg	(all)	2001		1	6	9	121	100	0
arg	(all)	2003		2	15	32	821	100	0
arg	(all)	2004		5	30	70	2,534	100	0
arg	(all)	2005		1	2	3	108	100	0
arg	(all)	2006		2	5	8	236	100	0
arg	(all)	2007		2	12	23	729	100	0
arg	(all)	2008		1	5	12	216	100	0
arg	(all)	2012		3	29	71	1,271	100	0
arg	(all)	2013		1	11	23	127	100	0
arg	(all)	2014		2	11	22	195	100	0
arg	(all)	2015		7	51	110	2,841	100	5,815
arg	(all)	2016		7	61	118	2,551	100	1,544

arg	(all)	2017	5	39	82	2,438	100	982
arg	(all)	2018	15	97	230	3,683	100	1,641
arg	(all)	2019	9	68	150	4,824	100	3,666
arg	(all)	2020	12	108	285	7,561	99	4,982
arg	(all)	(all)	75	550	1,248	30,256		18,630

Table 3.2.1: Argentines. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), number of fish measured, catch rates (ton/effort).

Argentines (ARG). Catch by month

species	month	2001	2003	2004	2005	2006	2007	2008	2012	2013	2014	2015	2016	2017	2018	2019	2020	all	perc
arg	Apr	63	0	485	107	0	0	0	675	127	20	569	433	43	921	981	3,397	7,821	25.9%
arg	May	57	821	1,969	0	235	728	216	521	0	174	1,928	1,869	2,394	2,760	3,842	3,128	20,642	68.3%
arg	Jun	0	0	80	0	0	0	0	75	0	0	0	247	0	0	0	1,034	1,436	4.7%
arg	Jul	0	0	0	0	0	0	0	0	0	0	343	0	0	0	0	0	343	1.1%
arg	(all)	120	821	2,534	107	235	728	216	1,271	127	194	2,840	2,549	2,437	3,681	4,823	7,559	30,242	100.0%

Table 3.2.2: Argentines. Self-sampling summary with the catch (tonnes) by year and month.

Argentines (ARG). Catch by rectangle

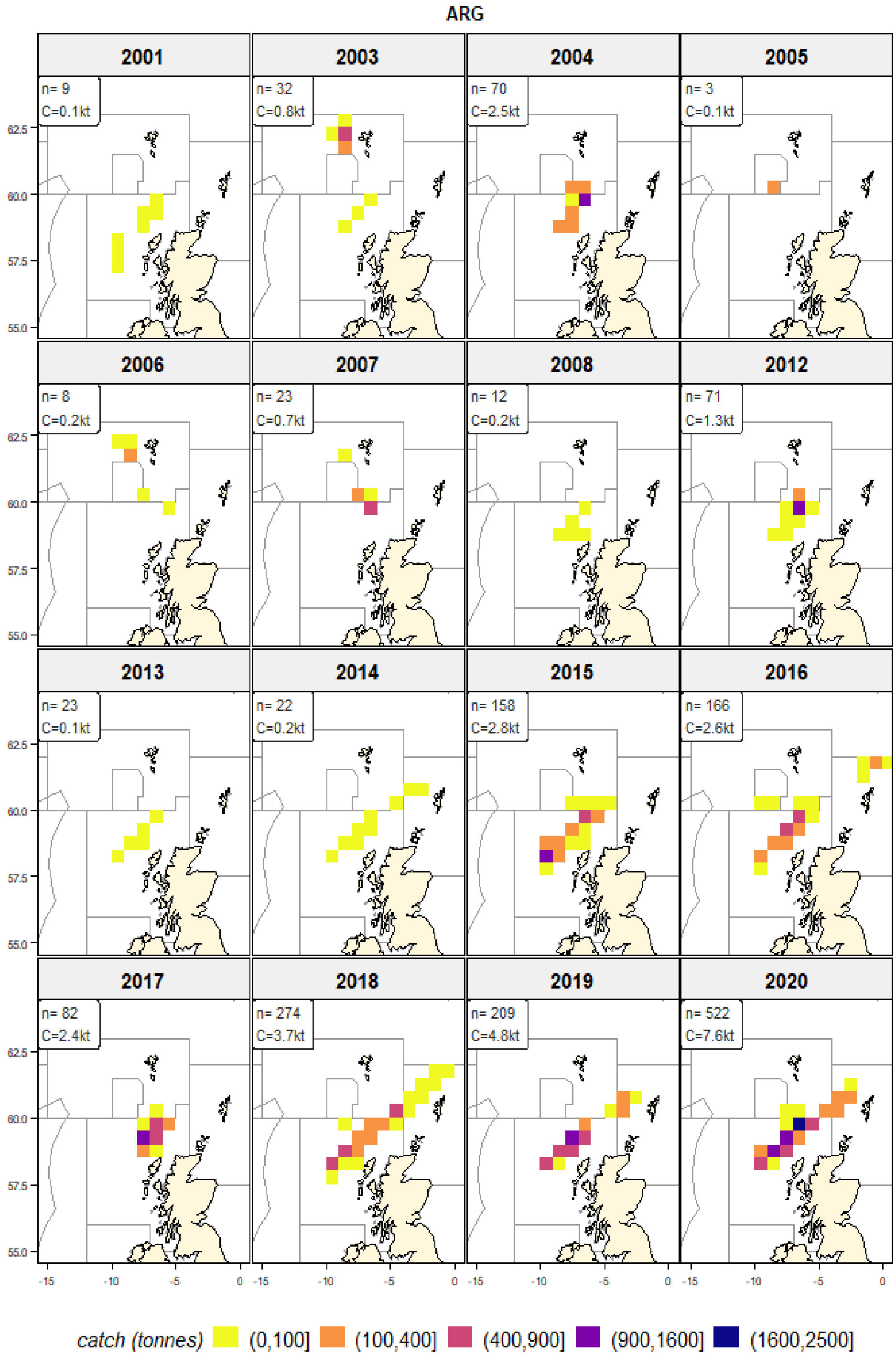


Figure 3.2.1: Argentines. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Argentines (ARG). Spatial-temporal evolution of the fishery

Spatial-temporal evolution of the fishery by year and month from the haul-by-haul catch information. THe fishing season is from June until September and a winter fishery in December. The midpoint of the distribution is indicated by the blue triangle. The catch has been used as weighting factor in the calculation of the midpoint.

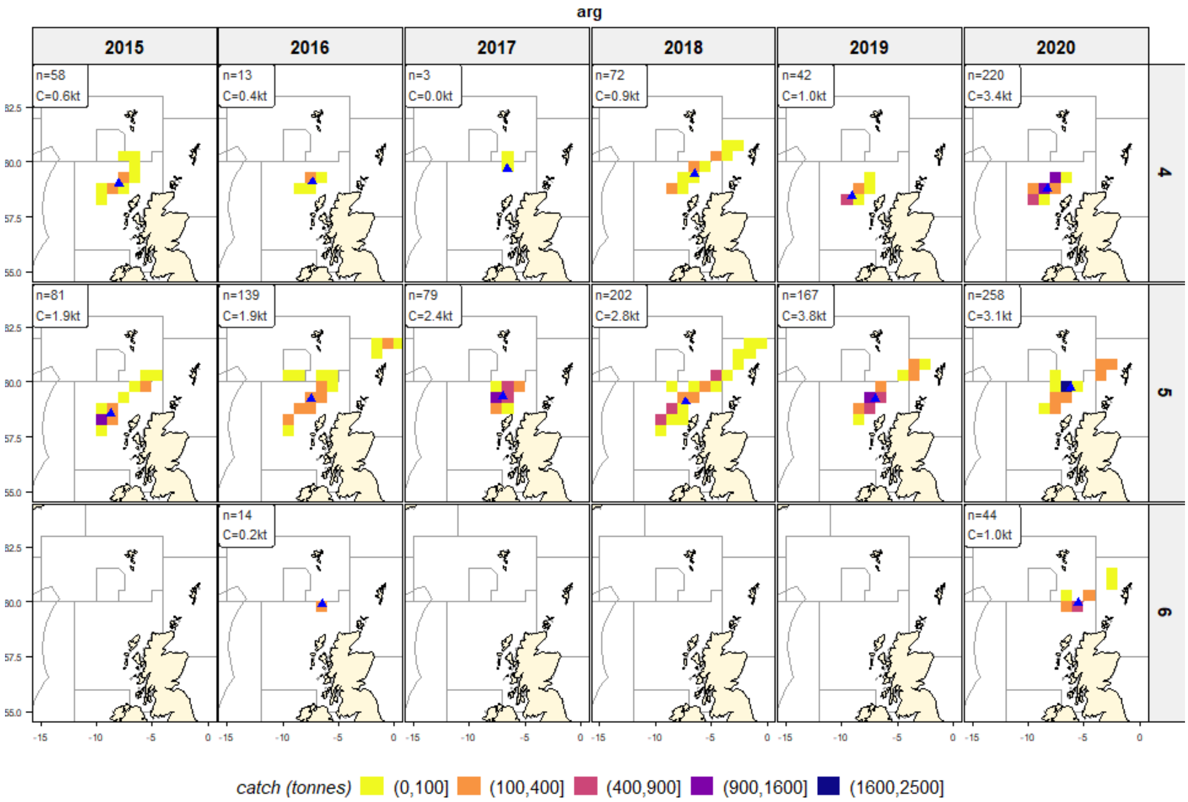


Figure 3.2.2: Argentines. Average catch per day per rectangle. N indicates the number of hauls; avg refers to the overall average catch per day.

Argentines (ARG). Length distributions of the catch

The length distribution of argentines in the catches is relatively stable between 34 and 36 cm.

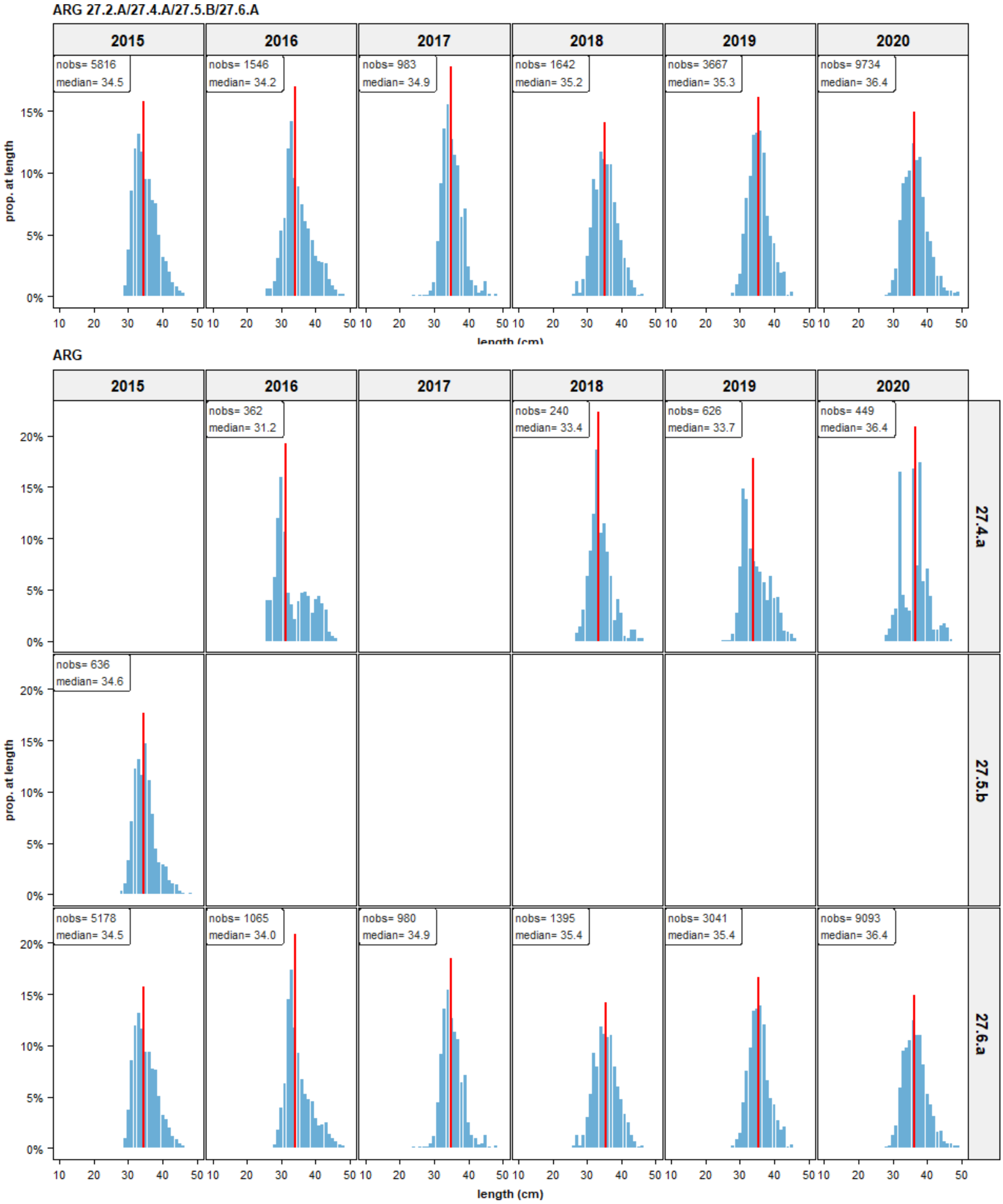


Figure 3.2.3: Argentines. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Catch at depth

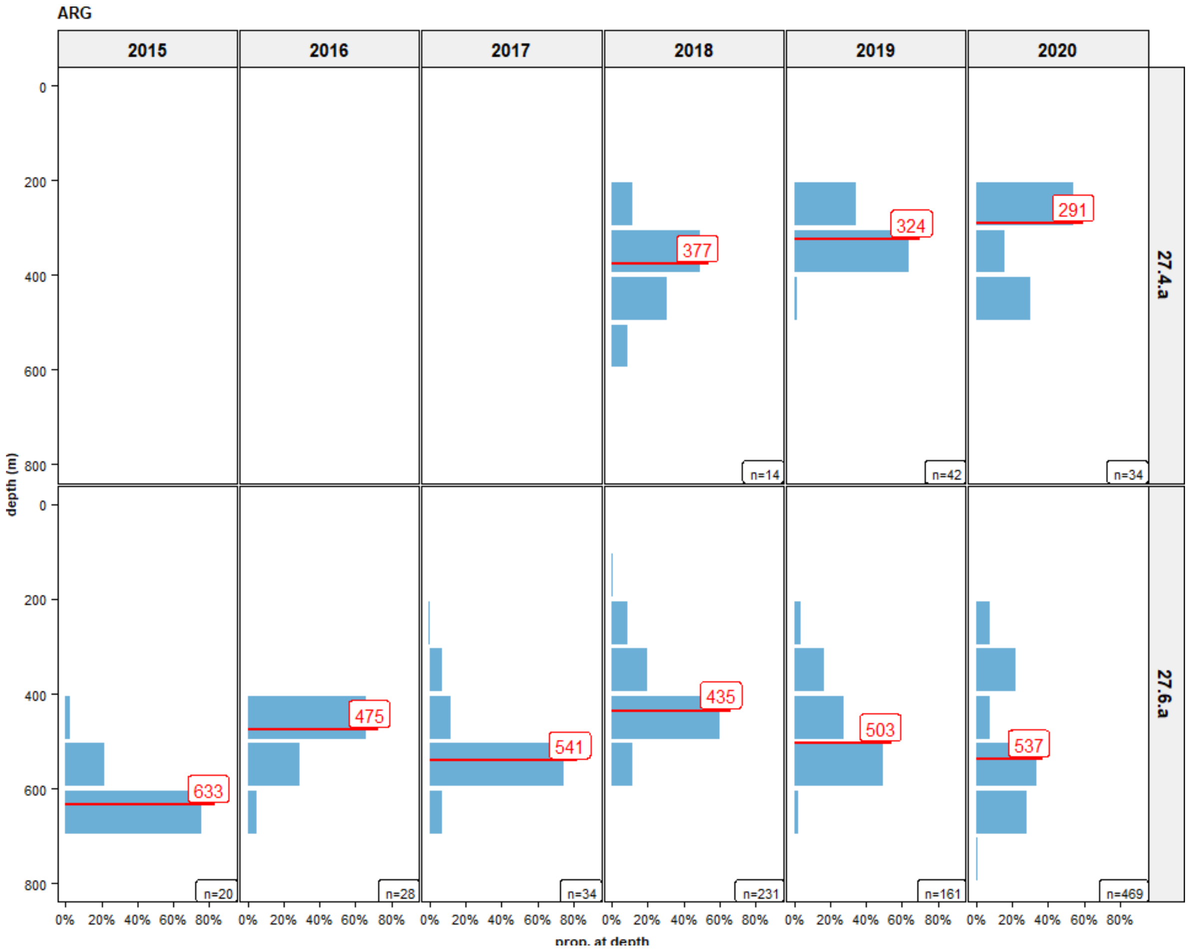


Figure 3.2.4: Argentines. Depth distributions by year and division. Nobs refers to the number of observations; median denotes the median length.

CPUE index

The catch rate in the fishery for argentines can be highlys fluctuating between hauls. Catch rate has been defined as catch (tons) per ICES rectangle and per day on a nominal scale. Catches have first been summed by vessel, year, week and rectangle and the number of hauls and fishing days have been calculated. Then the catches and effort (fishing days) have been summed over all vessels by year and week and the average depth has been calculated. CPUE was then calculated as the average catch per rectangle and per day. This follows the procedure explained in Quirijns and Pastoors (2020), although here only applied to the PFA fleet.

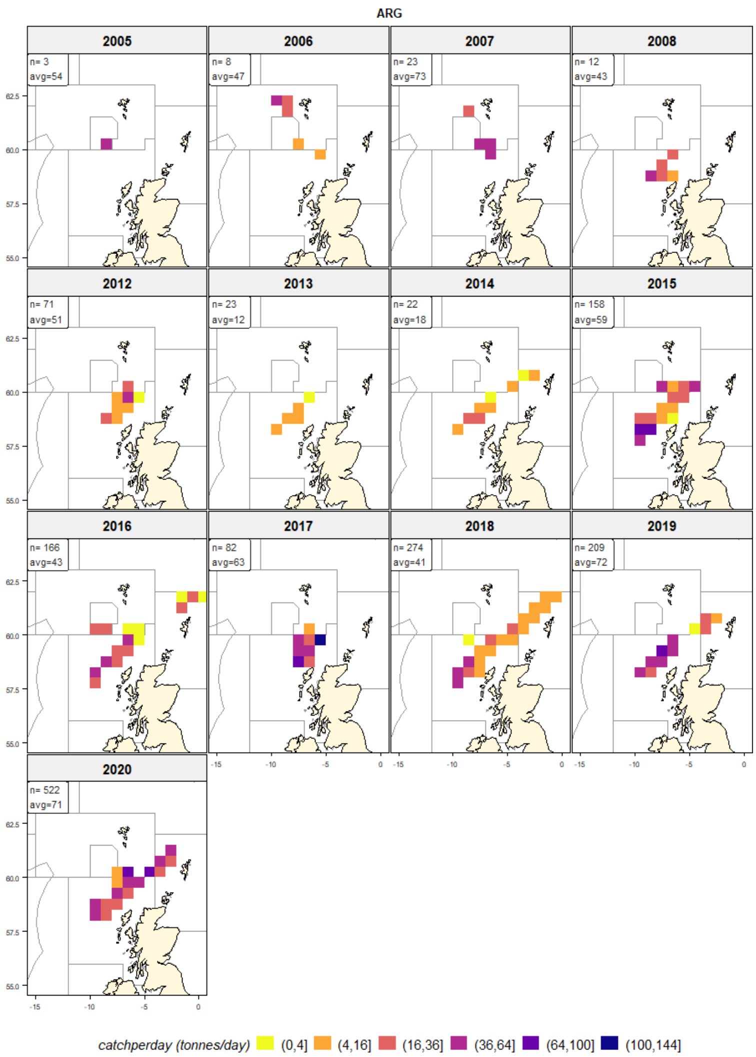
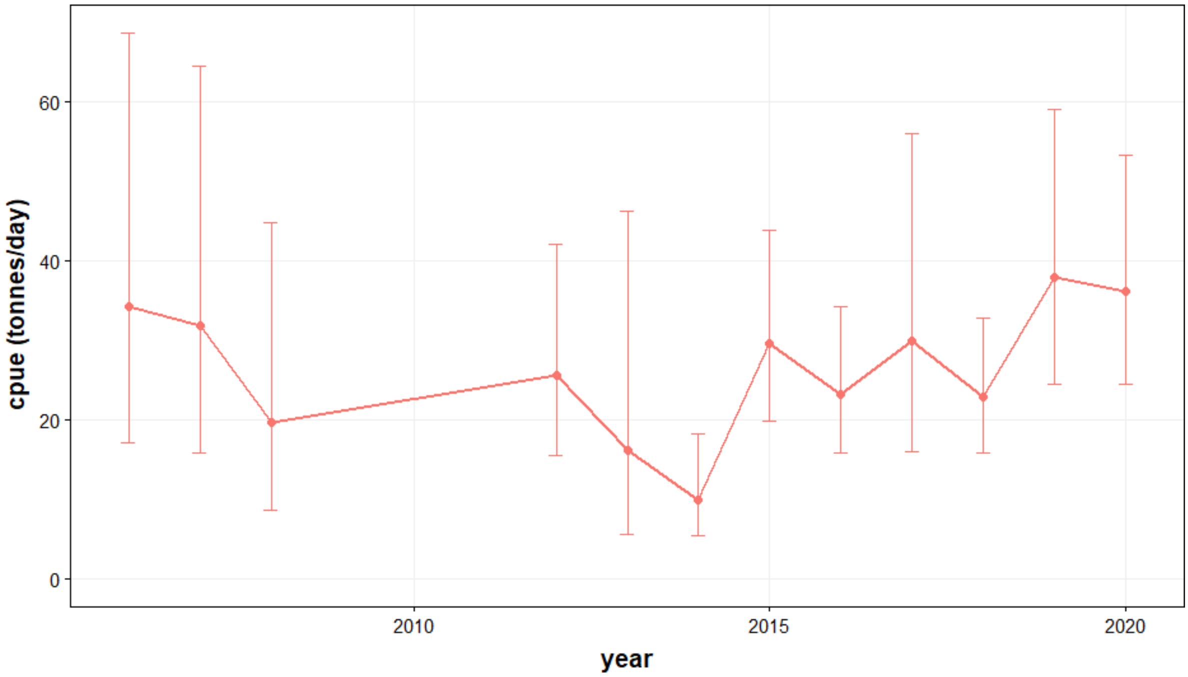


Figure 3.2.5: Argentines. Average catch per day per rectangle. N indicates the number of hauls; avg refers to the overall average catch per day.

The model used for standardization is: CPUE ~ year + week + depth, where CPUE is expressed as catch per day per rectangle. Catch rates in 2019 have been estimated higher than the preceding years, in line with reports from the skippers in the fleet.



4 Discussion and conclusions

By the end of 2019, all vessels were participating in the PFA self-sampling programme. Although the programme does not consist of a random selection of vessels – because the instructions to the vessel benefit from a continued application of data collection on the participating vessels – the overall fishing pattern does appear to represent the fisheries of the PFA vessels.

The definition of what constitutes 'a fishery' for a certain species is not well specified. In this report we selected all trips within divisions 27.2.a, 27.4.a, 27.5.b, 27.6.a and were the weekly catches had more than 50 tonnes of argentines and where the proportion of species in the catch of that week was at least 5%.

The standardized CPUE for the PFA fleet has now been included in the annual report. The standardized CPUE follows the approach documented in Quirijns and Pastoors 2020.

5 Acknowledgements

The skippers, officers and the quality managers of many of the PFA vessels have put in a lot of effort to make the PFA the self-sampling work. Without their efforts, there would be no self-sampling.

6 References

Quirijns, F. J. and M. A. Pastoors (2020). CPUE standardization for greater silversmelt in 5b6a. WKGSS 2020, WD03.

7 More information

Please contact Martin Pastoors (mpastoors@pelagicfish.eu) if you would have any questions on the PFA self-sampling program or the specific results presented here.

Not to be cited without prior reference to the authors

Update on Norwegian fishery independent information on abundance, recruitment, size distributions, and exploitation of roundnose grenadier (*Coryphaenoides rupestris*) in the Skagerrak and north-eastern North Sea (ICES Division IIIa)

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Introduction

The roundnose grenadier is a long-lived deepwater species which in the relevant study area reaches ages of 70 years or more and attains maturity at the age of 8-12 years (Bergstad 1990). It has a limited area of distribution within the Norwegian deep and in the deep Skagerrak basin (300-720m) (ICES Div. 4a & 3a). Analyses using microsatellite DNA have demonstrated that the Skagerrak grenadier is currently likely to be isolated from grenadier elsewhere in its North Atlantic distribution area (Knutsen *et al*., 2012). In 2003-2005 a major expansion of the previously quite minor targeted grenadier fishery occurred, and this expansion was followed by a complete closure of the fishery from 2006 onwards. Apart from previous targeted exploitation, grenadier is now a minor by-catch in the traditional trawl fishery for *Pandalus borealis* which is currently the major demersal trawl fishery in the area. Most shrimp fishing occurs shallower than the main distribution area of the grenadier.

This Working Document presents results derived from a research vessel bottom trawl survey conducted annually during the past 38 years (1984-2021). While the main objective of the survey is to monitor *Pandalus borealis*, the survey samples the entire depth range and distribution area of roundnose grenadier.

We report temporal variation in survey catch rates in terms of biomass and abundance (kg/hour and number/hour), length distributions, occurrence of recruits, and geographical distribution. We also attempt to estimate by-catch in the commercial shrimp fishery. Most of the information in this Working Document is an update of a WD first submitted to WGDEEP in 2009 (Bergstad *et al*. 2009). The survey series is currently the only information available to assess temporal variation and trends for the grenadier in this area. A full analysis of the time-series has been published (Bergstad *et al*., 2014), but this working paper extends the series to include the years 2014-2021.

Material and Methods

Data was collected from the annual *Pandalus borealis* shrimp survey performed by the Institute of Marine Research in the years 1984-2021 (Table 1). The survey is a depth stratified shrimp trawl survey with approximately 25% of the stations deeper than 300 m (depth range 117-534 m). The trawl used has small meshes overall and a 6mm cod-end liner and retains all sizes of grenadiers, including the smallest newly settled juveniles (Bergstad 1990, Bergstad and Gordon 1994). The stations are placed at random within strata and subareas, and the same sites area sampled every year. Although some changes occurred over the years (Table 1), the overall standardization was maintained throughout the time series (Bergstad *et al.* 2014).

Catch rates in terms of biomass and abundance were calculated for stations 300 m and deeper, i.e. excluding shallower survey depths where the species only occurs sporadically in small numbers (Bergstad 1990). Stations with zero catches were included, and the catches at non-zero stations were standardized by tow duration.

Annual length distributions were derived for the pooled standardized catches at 300m and beyond. In cases were catches were subsampled, length distributions were raised to the total catch prior to pooling.

Age data from selected surveys in 1987 and 2007-2019 were plotted as cumulative age distributions. Age and length data from 2008-2019 were analyzed for growth parameters.

Standardized mean catches by number of small juveniles of PAL ≤ 5 cm were calculated to show recruitment during the survey period.

A time series of maps showing geographical distributions by year were plotted, representing scaled catch rates at the actual sample sites for each survey year.

Data from the Norwegian reference fleet was collected to report bycatch on roundnose grenadier in the Norwegian shrimp fishery.
In an earlier first attempt to estimate commercial by-catch of grenadier, we derived a time-series of mean survey catch rate of grenadier from depths shallower than 400m (i.e. where shrimp fishing is carried out) and multiplied that with annual estimates of effort in the Norwegian shrimp fishery (extracted from Søvik and Thangstad, 2015). Most of the distribution area of grenadier lies within the Norwegian EEZ and the Norwegian trawler fleet is assumed to be predominant in that area.

Results

Biomass and abundance

The estimates of catch rates in terms of biomass (kg/h) and abundance (nos/h) varied substantially through the time series (Fig.1), but elevated levels were observed from 1998 to 2004. The decline from 2005 continued through the time series until 2017 which was the lowest on record. The observations from 2019-2020 remained low, but with a slight increase compared with 2017. For 2021, the catch rate has again declined and is now just slightly higher than the 2017 catch rate.

Size and age distributions

The time series of annual length distributions show a major shift in the early 1990s (Fig. 2). From 1992 the proportion of large fish with PAL>15cm declined to less than 10% which contrasts with the pre-1990 distributions dominated by large fish. From 1992, a pronounced mode of small fish can be followed in subsequent years, with modal length increasing through the time series.

The very recent distributions (2018-2021) contrasts with the pre-1990 distributions by having low proportions of large fish. The 2021 distribution is dominated with small fish but at low levels compared to the 1990's.

Age distributions and growth
The cumulative age distribution from the extracted data from 1987 (Bergstad, 1990) contrasts substantially with the distributions from 2007-2019 in terms of proportions of old fish (e.g. >20 years) (Fig. 3). In 1987, the proportion of fish > 20 years was over 50% (Table 4). In 2008, i.e. after the relatively large expansion in landings in 2003-2005 and ban on direct fishing introduced in 2006, only 8% of the aged fish were older than 20 years. In subsequent years the proportion of older fish apparently increased, and recent distribution from 2019 now show 36% fish > 20 years (Table 4). This is still very low compared with the 1987 situation.

Age at length was analyzed for the years 2008-2019 (Figure 9) and compared with data from 1987 (Bergstad, 1990) (Table 3). The growth rate coefficient (k) and the length infinity ($L\infty$) for females is in the same range as the data from 1987, but slightly lower for 2008-2019 data compared with data from 1987.

Occurrence of juveniles <5cm PAL
There is no indication of a pronounced recruitment pulse as that observed in the early 1990s, neither in the length distributions (Fig 2.), or in the time series of mean abundance of small fish < 5 cm (Fig. 4). The recruitment for 2021 is one of the lowest during the time series.

Geographical distribution
The area sampled in given year and the corresponding geographical distribution of grenadier catches is presented in Figure 5. The overall distribution area does not seem to have changed considerably during the time series 1984-2021. Catches of roundnose grenadier are restricted to the Norwegian Deep north to 59°N and extend eastwards into the Skagerrak basin. The highest catches were always found in the eastern Skagerrak part of the Norwegian Deep.

Commercial by-catch
For an assessment of the bycatch of roundnose grenadier in the Norwegian shrimp fishery, data from the Norwegian Reference fleet showed that < 1% of the tows with shrimp trawl caught roundnose grenadier (Table 5). The values for catch weights from the Reference fleet are low and in same level as the reported landings for the recent years. This indicates that the low reported Norwegian landings are realistic and that the landings are the bycatch amount taken by the Norwegian shrimp fishery.

The new data from the Norwegian Reference fleet suggest that the earlier attempt of estimating the bycatch in shrimp fishery is too high. The survey catches of shrimp (*Pandalus borealis*) drop off significantly by depth and few catches occur deeper than 400m (Fig. 6). The shrimp fishery is mostly conducted shallower than 300m. By-catch estimates derived using the mean annual survey catches of grenadier (at depths <400 m) and annual effort in the Subarea 3a and 4a Norwegian shrimp trawl fishery (Fig. 7) illustrate the likely historical variation in by-catch rates in the fishery. There is a recent trend towards very low levels (less than 100 tonnes), but by-catches in the shrimp fishery were probably historically less than 2000 tonnes/year yet probably higher in the mid-2000s when grenadier abundance appeared elevated.

Discussion

Despite high inter annual variability, the catch rates in terms of biomass and abundance from the survey suggest long term pattern of variation through the time series 1984-2021. An increase in biomass and abundance from the late 1980s until 1998-2004 seemed to be followed by a major decline from the mid-2000s onwards. In 2021 abundance and biomass estimates were still at low levels.

The survey catch rate declined in all areas, also where high survey catches were common, i.e. in the eastern part of the Skagerrak (Fig. 5).

The time-series of size distributions also suggest pronounced structural changes during the period 1984-2021. The distributions from the 1980s with a dominance of fish around 15 cm PAL contrasts with those from the late 1990s when the population was apparently rejuvenated by a pulse in recruitment from 1991-1992 onwards. The recruits from 1991-1992 can be tracked as a mode in the size distributions for 15 years until 2005. The distributions were dominated by old fish until 2012 although with consecutively low concentrations. From 2013 the distributions changed to younger fish primarily but still with low levels.

The difference in age distribution between 1987 and 2019 is primarily seen in the proportion of older fish, i.e. there is almost no fish older than 30 years in 2019 while almost 25% of the fish was older than 30 years in 1987. The most prominent difference between recent situation and that of 1987 concerning growth, was seen for females. It seems that the bulk of very large and old female individuals seen in 1987 is no longer present in recent years (Table 3).

High mean survey biomass coincided with very high commercial landings in 2004-05 (Fig. 8). The fishery may have utilized a period of elevated abundance resulting from what appears to be the single large pulse in recruitment in the 38 years surveyed. From recent length distributions no similar pulse in recruitment has been observed.

An interpretation of the patterns observed in the time-series of size and age distributions, the survey abundance index for small juveniles, and the survey index of all sizes combined is that the enhanced fishery in 2003-2005 had the combined effect of eroding both the accumulated fraction of older fish around 30 years that were found in the population in 1987 prior to the fishery and the younger fish resulting mainly from the recruitment pulse in the early 1990s. The very old fish never reappeared, and for three decades, recruitment has been consistently at a level well below the level observed in the single high event in the early 1990s. The recent recruitment has probably been too low to produce any increase in abundance.

The reported landings peaked in 2005 at about 11000 tonnes (Fig. 8) and have since declined to about a ton per year. From 2006 onwards this decline in landings is a result of regulations (Bergstad 2006) as the targeted fishery ceased. By-catches from shrimp fisheries still occur, however. The data from the Norwegian Reference fleet and our attempt to estimate by-catches suggests that current levels are minor, probably reflecting low grenadier abundance at relevant depths and introduction of sorting grids to the fishery.

The Norwegian bycatch of roundnose grenadier thus is well described through the reported landings. The Swedish and Danish fishery reports both landings and discards and therefore the bycatch from these fisheries should be counted for in the statistics. The level of landings and discards in recent years has been in total less than 2 tonnes per year.

Conclusion

The decline in abundance after 2005-2006 suggested by the survey catch rates may reflect the combined effect of the enhanced targeted exploitation in 2003-2005 and the low recruitment in the years following the single recruitment pulse in the early 1990s. The percentage of fish >15cm is now lower than recent years and there is no suggestion of a new recruitment pulse as seen in the 1990s. The current low abundance and truncated age structure in the population thus reflect both the exploitation and recruitment history spanning the past 2-3 decades. Since the targeted fishery has stopped and the by-catch in the shrimp fishery are low, there is a potential for recovery of the roundnose grenadier in Skagerrak. However, rejuvenation and growth of the population would at present seem unlikely due to low recruitment during the recent decades. The survey information suggests that it may be a feature of this population that only a single good recruitment event may be expected in a period of 3 decades.

References

Bergstad, O.A. 1990a. Ecology of the fishes of the Norwegian Deeps: Distribution and species assemblages. *Netherlands Journal of Sea Research* 25(1/2): 237-266.

Bergstad, O.A. 1990b. Distribution, population structure, growth and reproduction of the roundnose grenadier *Coryphaenoides rupestris* (Pisces:Macrouridae) in the deep waters of the Skagerrak. *Marine Biology* 107: 25 - 39.

Bergstad, O.A. and J.D.M. Gordon. 1994. Deep-water ichthyoplankton of the Skagerrak with special reference to *Coryphaenoides rupestris* Gunnerus, 1765 (Pisces: Macrouridae) and *Argentina silus* (Ascanius, 1775)(Pisces, Argentinidae). *Sarsia* 79:33-43.

Bergstad, O.A. 2006. Exploitation and advice options for roundnose grenadier in the Skagerrak (IIIa). Working Document for ICES WGDEEP, Vigo, 2006. 8 p.

Bergstad, O.A., Å. S. Høines, H. Øverbø Hansen, T. de Lange Wenneck, and I. Svellingen. 2008. Norwegian investigations on greater silver smelt (*Argentina silus*) and roundnose grenadier (*Coryphaenoides ruspestris*) in ICES Sub-areas II, III and IV in May-June 2007. WD to WGDEEP, 19p.

Bergstad, O.A., H.Ø. Hansen, and T. Jørgensen. 2009. Fisheries-independent information on temporal variation in abundance, size structure, recruitment and distribution of the roundnose grenadier *Coryphaenoides rupestris,* 1984-2009. Working Document for ICES WGDEEP, Copenhagen 2009.

Bergstad, O.A., H.Ø. Hansen and T. Jørgensen. 2014. Intermittent recruitment and exploitation pulse underlying temporal variability in a demersal deep-water fish population. ICES Journal of Marine Science, 71: 2088–2100.

ICES, 2014. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP). ICES CM 2014/ACOM:17

Knutsen, H., Jorde, P.E., Bergstad, O.A., and Skogen, M. 2012. Population genetic structure in a deepwater fish *Coryphaenoides rupestris*: patterns and processes. Marine Ecology Progress Series, 460: 233–246.

Munch-Petersen, S., Eigaard, O., Søvik, G. and Ulmestrand, M. 2011. The Northern shrimp (*Pandalus borealis*) stock in Skagerrak and the Norwegian Deep (ICES Divisions IIIa and IVa East). NAFO SCR Doc. 11/069.

Søvik, G. and Thangstad, T. 2014. The Norwegian fishery for Northern shrimp (Pandalus borealis) in Skagerrak and the Norwegian Deep (ICES Division IIIa and Iva east), 1970-2014. NAFO SCR Doc. 14/063.

Table 1. Summary of data on the bottom trawl survey series, 1984-2021. Rg- rockhopper ground gear. 'Strapping' – maximum width of trawl constrained by rope connecting warps in front of otter doors. MS – RV Michael Sars, HM – RV Håkon Mosby, KB – RV Kristine Bonnevie. Data from 2021 survey is included. All trawls were fitted with a 6mm mesh cod-end liner.

YEAR	Survey month	Vessel	IMR Gear code	Additional gear info.	No. trawls >300m	No. trawls >400m	No. trawls survey
1984	OCT	MS	3230	Shrimp trawl (see text)	10	1	67
1985	OCT	MS	3230	"	21	5	107
1986	OCT/NOV	MS	3230	"	24	9	74
1987	OCT/NOV	MS	3230	"	35	14	120
1988	OCT/NOV	MS	3230	"	31	11	122
1989	OCT	MS	3236	Campelen 1800 35mm/40, Rg	31	7	106
1990	OCT	MS	3236	"	26	5	89
1991	OCT	MS	3236	"	28	9	123
1992	OCT	MS	3236	"	27	10	101
1993	OCT	MS	3236	"	30	10	125
1994	OCT/NOV	MS	3236	"	27	10	109
1995	OCT	MS	3236	"	29	12	103
1996	OCT	MS	3236	"	27	11	105
1997	OCT	MS	3236	"	25	6	97
1998	OCT	MS	3270	Campelen 1800 20mm/40, Rg	23	6	97
1999	OCT	MS	3270	"	27	8	99
2000	OCT	MS	3270	"	25	10	109
2001	OCT	MS	3270	"	18	4	87
2002	OCT	MS	3270	"	24	6	82
2003	OCT/NOV	HM	3230	Shrimp trawl (as in 1984-1988)	13	0	68
2004	MAY	HM	3270	Campelen 1800 20mm/40, Rg	17	6	65
2005	MAY	HM	3270	"	23	8	98
2006	FEB	HM	3270	"	10	0	45
2007	FEB	HM	3270	"	11	1	66
2008	FEB	HM	3271	Campelen 1800 20mm/40, Rg and strapping*	18	5	73
2009	JAN/FEB	HM	3271	"	25	7	91
2010	JAN	HM	3271	"	24	7	98
2011	JAN	HM	3271	"	22	7	93
2012	JAN	HM	3271	"	20	5	65
2013	JAN	HM	3271	"	28	8	101
2014	JAN	HM	3271	"	16	7	69
2015	JAN	HM	3271	"	28	9	92
2016	JAN	HM	3271	"	28	9	108
2017	JAN	KB	3271	"	30	9	128
2018	JAN	KB	3271	Campelen 1800 20mm/40, Rg and strapping**	27	8	111

Table 1. Continued

YEAR	Survey month	Vessel	IMR Gear code	Additional gear info.	No. trawls >300m	No. trawls >400m	No. trawls survey
2019	JAN	KB	3296	Campelen 1800 20mm/40, Rg and strapping***	27	8	108
2020	JAN	KB	3296	"	26	7	106
2021	JAN	KB	3296	"	27	8	113

* Path width of the tow constrained by a 10 m rope connecting the warps, 200 m in front of otter boards. ** Path width of the tow constrained to a 15 m rope connecting the warps, 100 m in front of the otter boards. *** Same trawl and strapping but from 2019 there are inserted several floaters on the trawl to lighten the trawl (Nordsjørigging).

Table 2. Mean biomass index and mean abundance index from shrimp survey 1984-2021. Missing data are from surveys that are not representable according to roundnose grenadier catches (few stations > 300 m). Data from 2016 are considered unreliable according to gear inconsistencies.
Mean biomass (kg/h), Mean abundance (n/h), Number (n) and Standard error (2SE)

Year	n	(kg/h)	2SE(kg/h)	(n/h)	2SE(n/h)
1984	10				
1985	21	108.12	38.32	149.95	49.43
1986	24	83.75	32.16	117.83	46.99
1987	35	76.15	13.56	125.80	24.60
1988	31	72.14	13.92	105.19	21.22
1989	31	122.69	43.48	195.94	73.07
1990	26	49.81	18.20	72.66	27.55
1991	28	107.14	22.27	176.86	38.75
1992	27	188.54	67.53	698.52	337.67
1993	30	58.59	19.42	190.33	74.15
1994	27	87.19	21.21	372.96	143.56
1995	29	118.30	32.36	440.62	144.41
1996	27	99.63	31.68	268.01	116.92
1997	25	113.86	66.47	362.72	222.08
1998	23	255.54	87.80	812.82	336.85
1999	27	149.30	42.85	388.83	122.54
2000	25	129.27	30.39	389.06	107.71
2001	18	105.33	51.84	272.99	151.99
2002	24	174.77	66.27	371.70	129.97
2003	13				
2004	17	324.38	125.48	1143.35	487.33
2005	23	193.65	93.81	550.42	260.94
2006	10				
2007	11				
2008	18	95.58	65.81	259.10	208.53
2009	25	72.72	39.81	207.41	121.84
2010	24	33.24	21.47	77.21	54.81
2011	22	26.84	12.61	54.76	27.05
2012	20	16.69	11.97	34.40	23.83
2013	28	11.48	4.92	35.06	16.90
2014	16	25.62	15.76	49.56	28.69
2015	28	7.28	4.59	21.19	12.14
2016	28				
2017	30	6.64	2.41	15.74	6.73
2018	27	12.88	6.60	41.91	26.13
2019	27	14.59	5.77	40.09	18.05
2020	26	18.72	11.48	63.02	38.07
2021	27	9.59	5.03	26.14	14.19

Table 3. Estimated parameters of von Bertalanffy growth function on data from Skagerrak shrimp survey 2008-2019 and Skagerrak survey in 1987 as reported by Bergstad 1990. k=growth coefficient, L_{∞}=asymptotic length, t_0=theoretical age when length is zero, SE=standard error				
	Estimated parameter			
Parameter	**Shrimp survey 2008-2018**		**Skagerrak survey 1987**	
	Females (SE)	**Males (SE)**	**Females**	**Males**
k	0,079 (±0,005)	0,083 (±0,013)	0,100	0,105
L_{∞}	16,6 (±0,296)	14,2 (±0,546)	18,1	14,7
t_0	-3,2 (±0,427)	-5,1 (±1,13)	-0,9	-1,5

Table 4. Cumulative percentages (%) for selected ages from 1987 and 2007-2019.					
	Age				
Year	**5**	**10**	**20**	**30**	**50**
1987	9	21	45	75	96
2007	10	23	83	94	96
2008	22	40	92	99	100
2009	14	30	88	93	100
2010	12	29	71	96	99
2011	6	23	65	94	99
2012	10	28	48	96	100
2013	14	28	56	92	99
2014					
2015	7	17	48	95	100
2016					
2017	14	52	81	94	99
2018	23	50	77	99	100
2019	8	37	64	92	100

Table 5. Proportion of tows with shrimp trawl that caught roundnose grenadier. Data from Norwegian Reference fleet.				
Year	Total number of shrimp trawl	Number of trawl hauls that caught roundnose grenadier	Catch of roundnose grenadier (kg)	% of the total catch
2013	243	0		0
2014	288	2		0,69
2015	1489	14		0.94
2016	4811	23		0,48
2017	3798	20	29	0,53
2018	2849	19		0,67
2019	1233	4	80	0,32

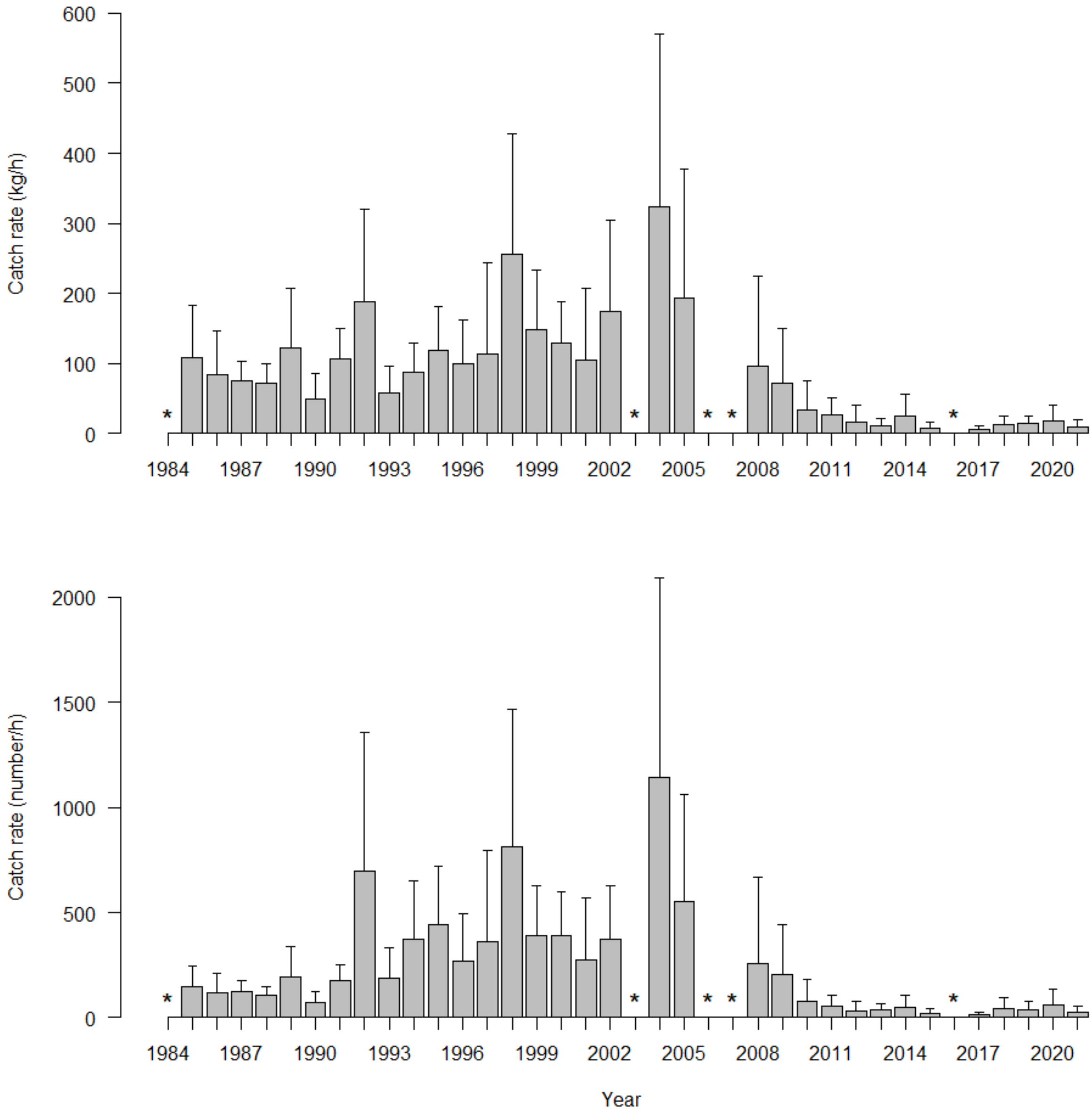


Figure 1. Standardized survey catch rates of grenadier, 1984-2021. Upper: Biomass (kg/h), Lower: Abundance (number/h). Standard error (2SE) shown by lines on top of bar. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years were excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.

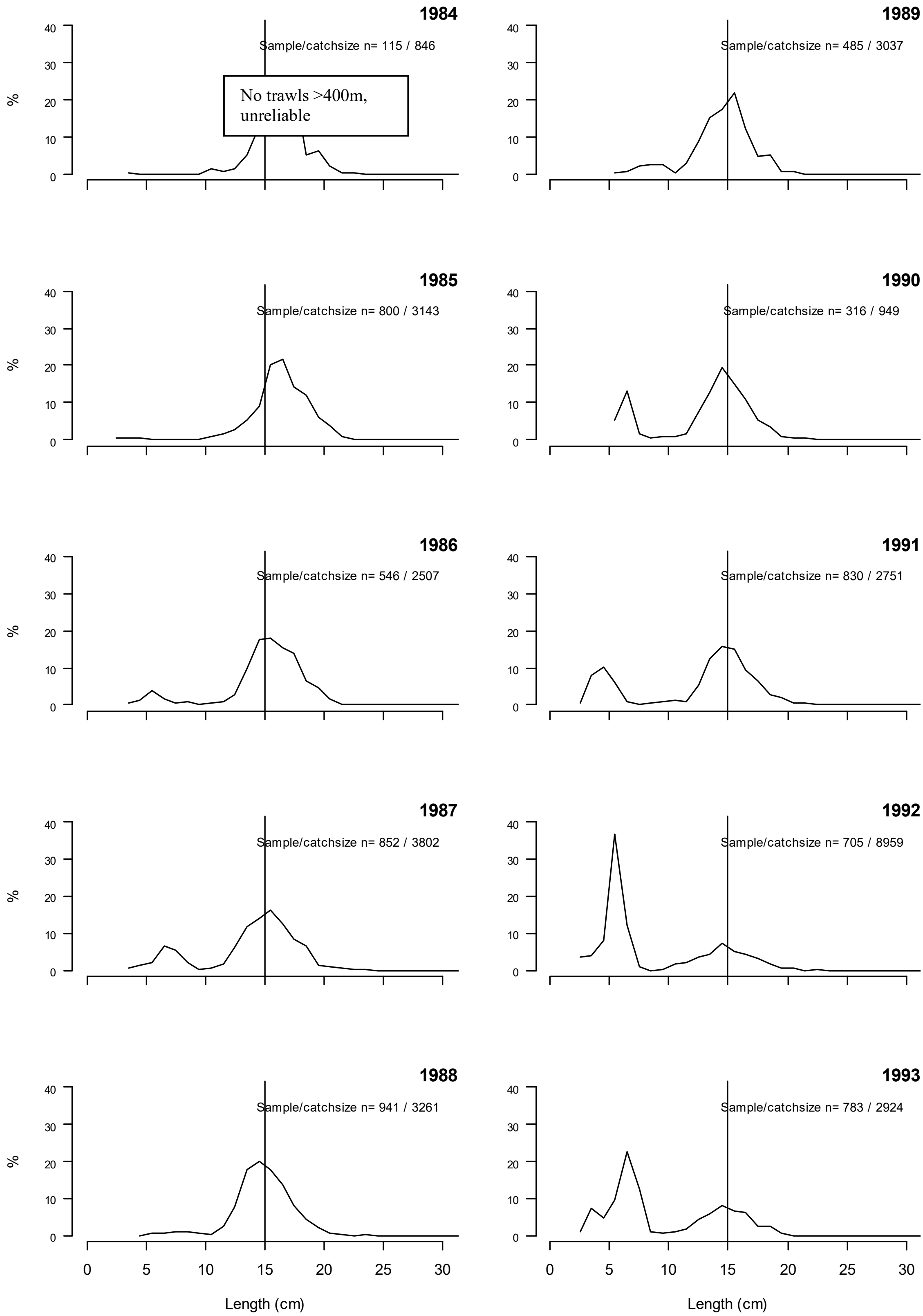
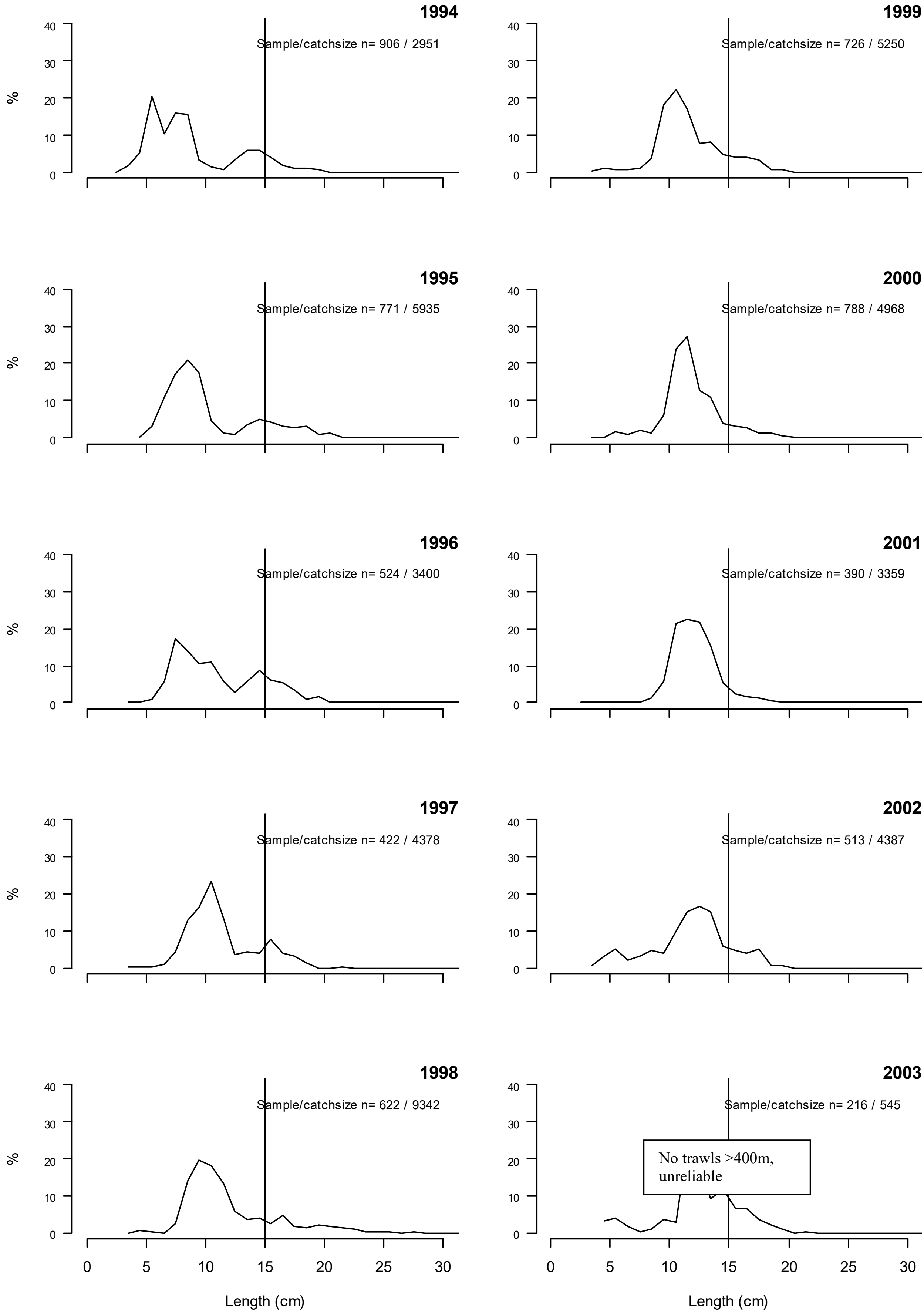


Figure 2. Length distributions of roundnose grenadier from annual *P. borealis* surveys, 1984-2021. Length is measured as PAL (cm). The length distributions are calculated as percentage number of fish in each centimetre length interval standardized to total catch number and trawling distance for each station each year. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years should be excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.



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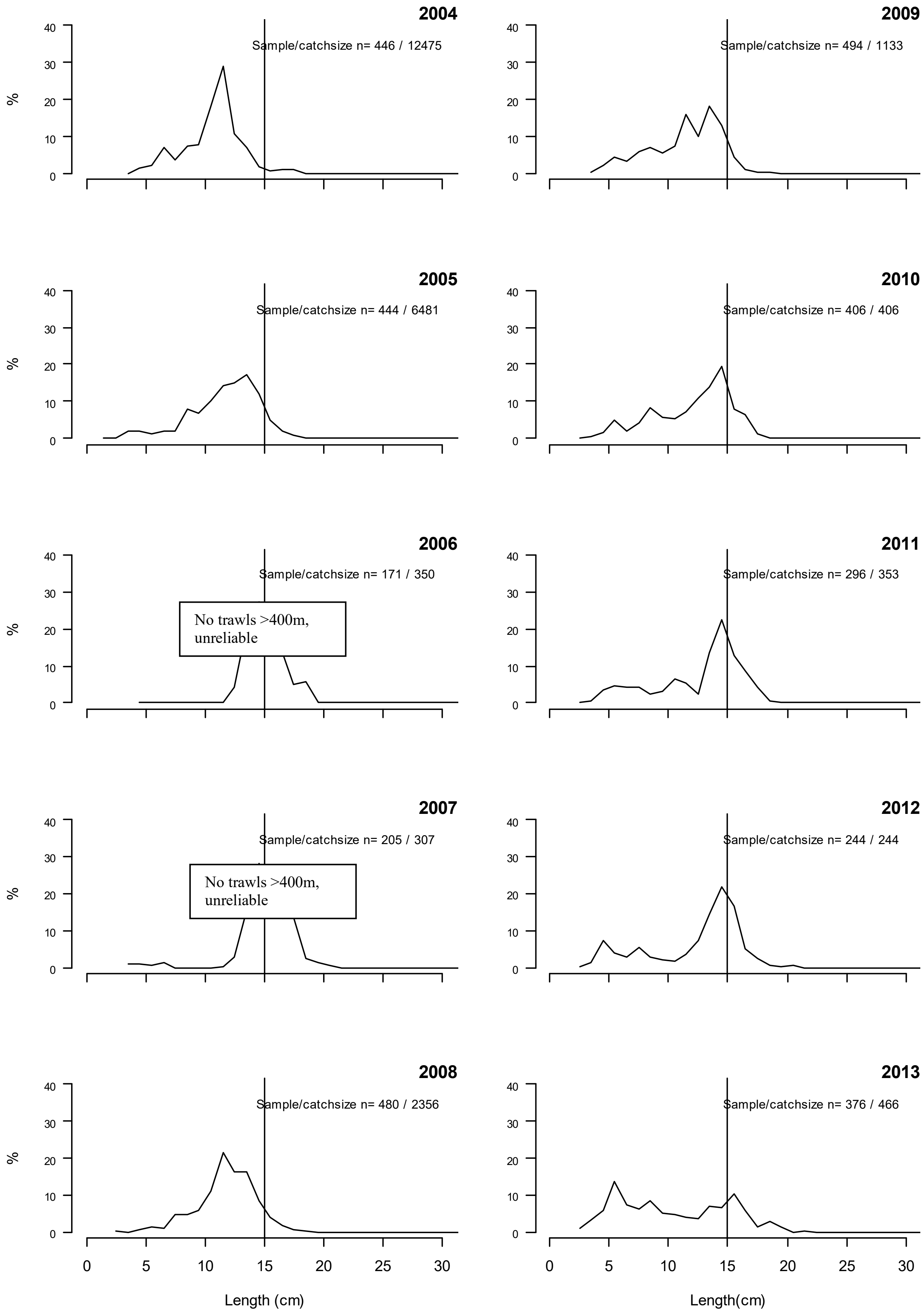

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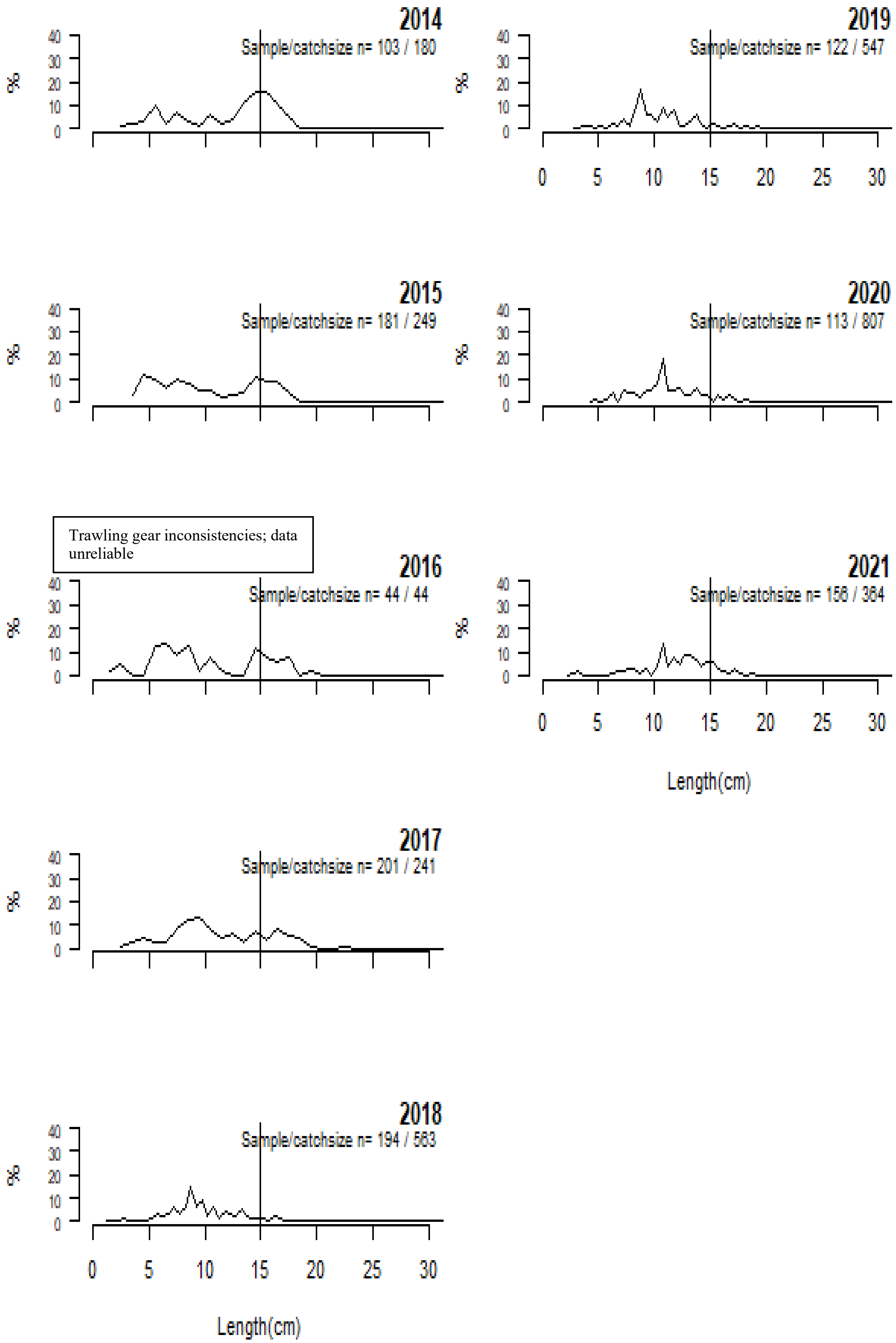

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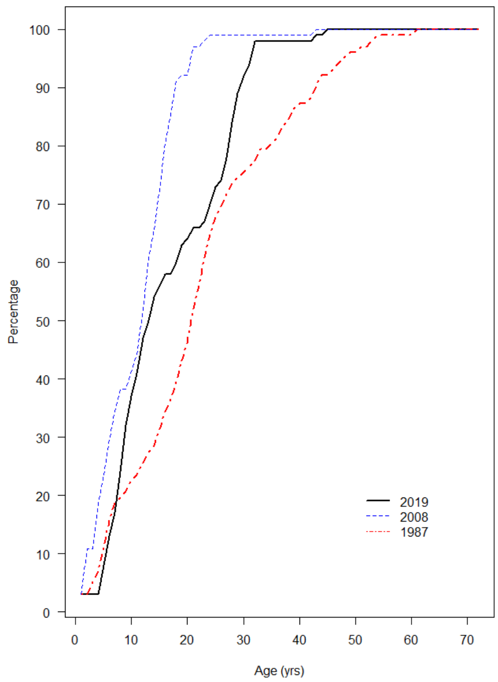


Figure 3. Cumulative age distributions of roundnose grenadier in the Skagerrak. Data from survey catches in Skagerrak in 1987, 2008 and 2019. The distribution from 1987 was modified from Bergstad (1990). Data from 2008 and 2019 was derived from the annual shrimp survey.

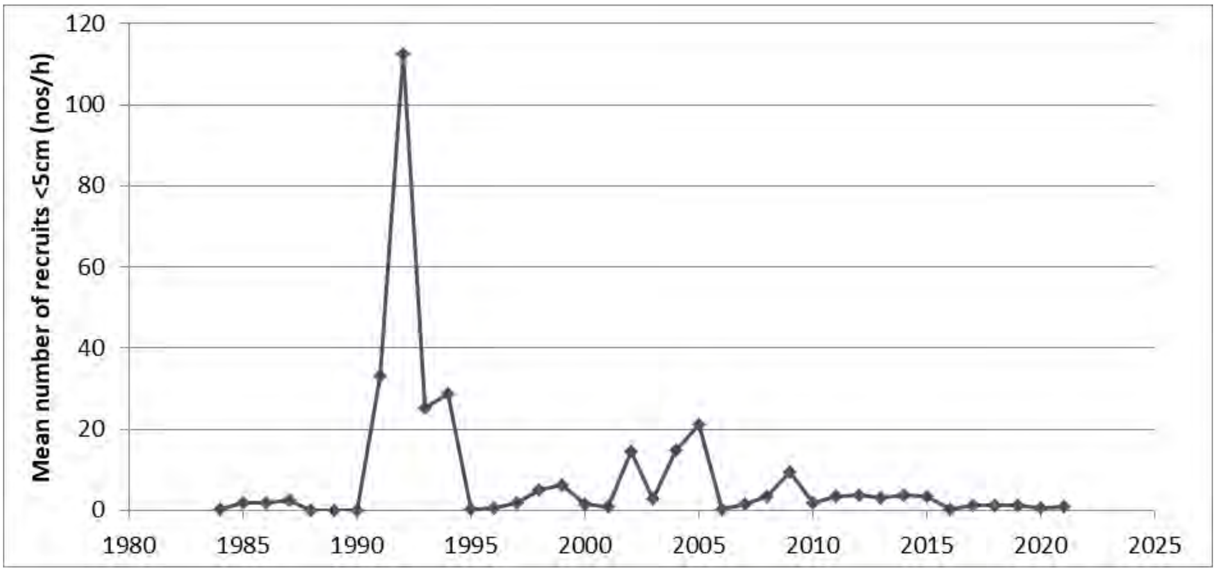


Figure 4. Mean catch rate of roundnose grenadier of PAL ≤ 5 cm, 1984-2021. Data from shrimp survey, trawls deeper than 300 m. *In 1984,2003,2006 and 2007, no trawls were made deeper than 400 m, and data from these years should be disregarded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.

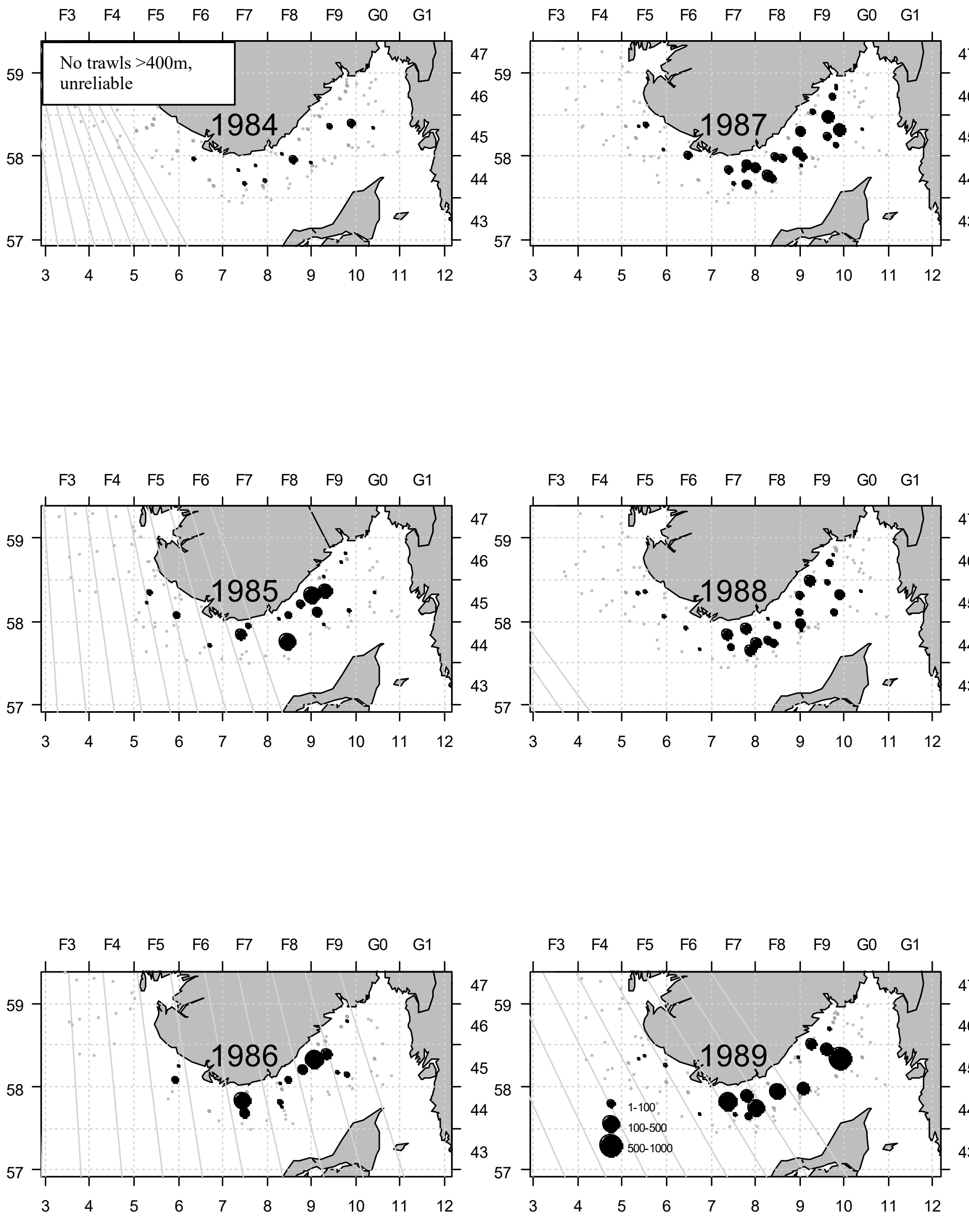
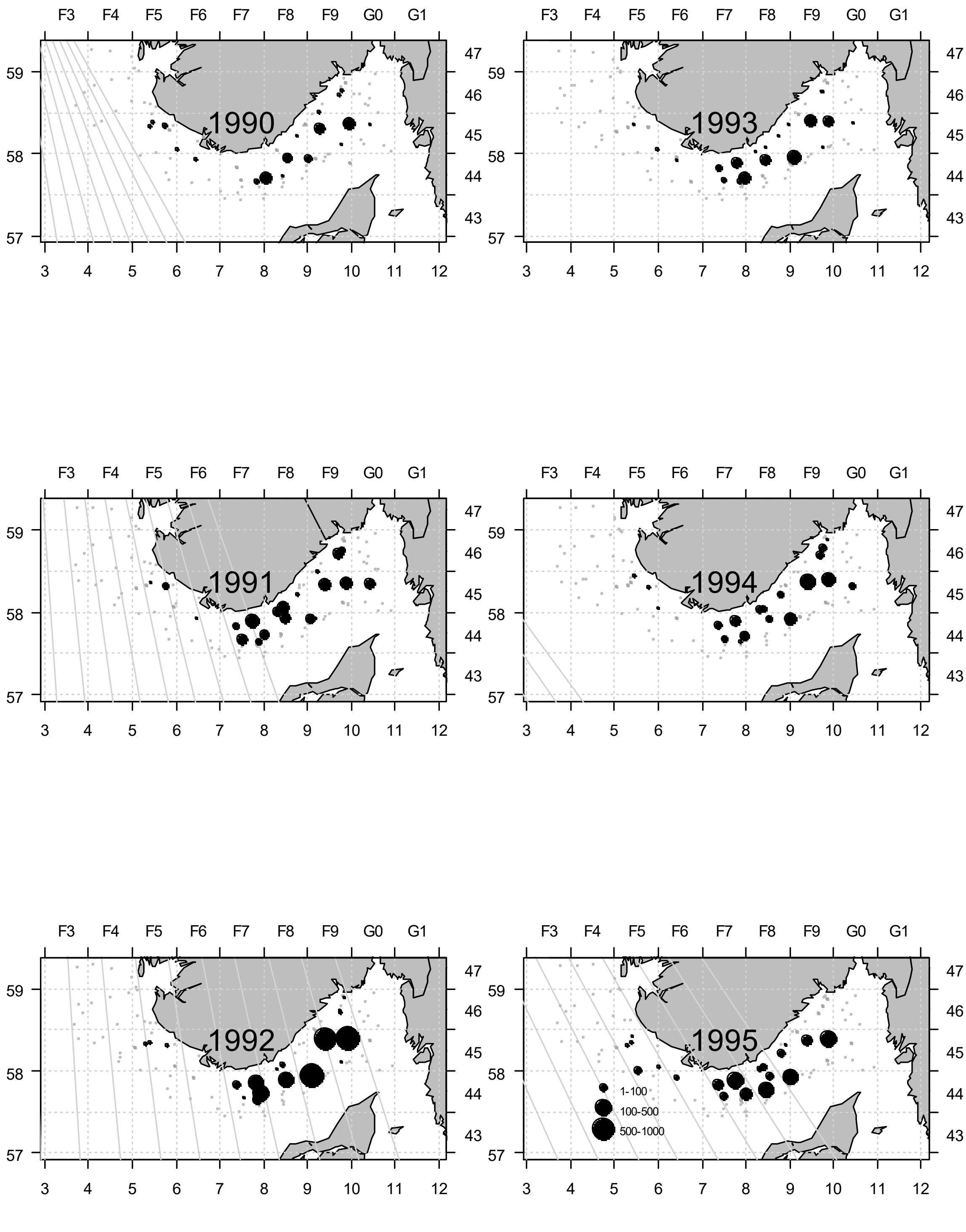


Figure 5. Geographical distribution of catches of roundnose grenadier (kg/h) from 1984-2021. Data from shrimp survey, trawls deeper than 300 m. Grey circles are trawls with no catch of grenadier. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years should be excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.



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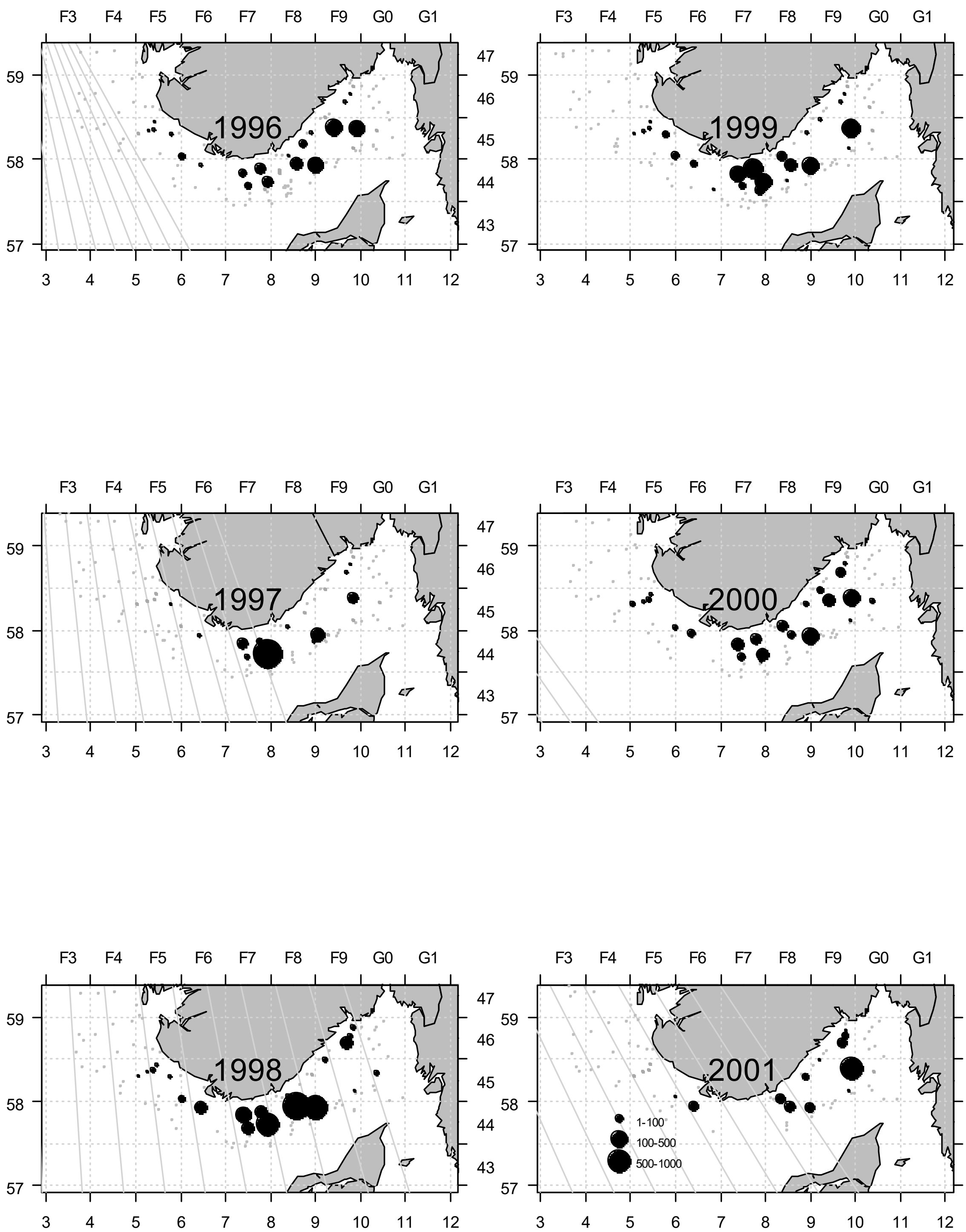

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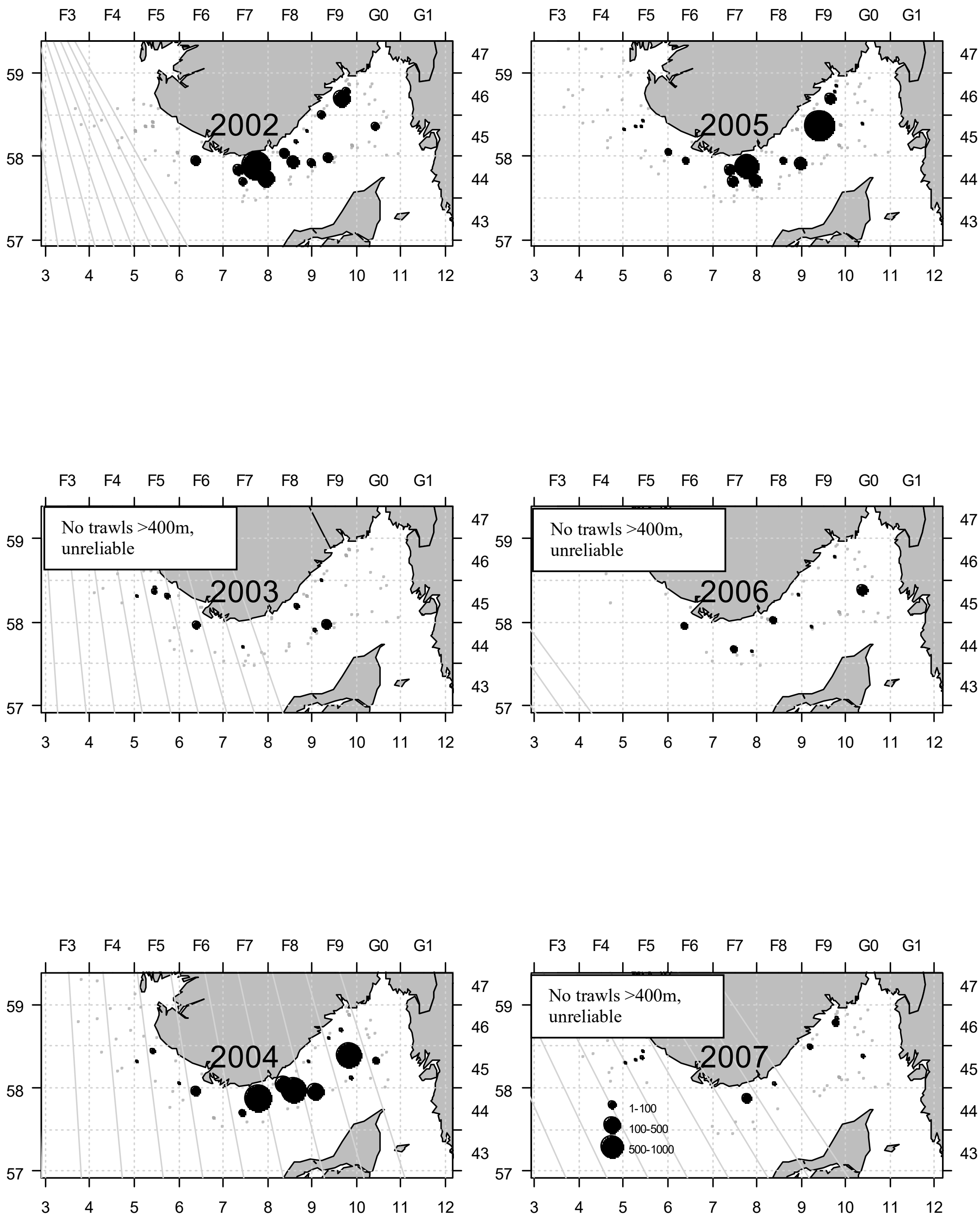

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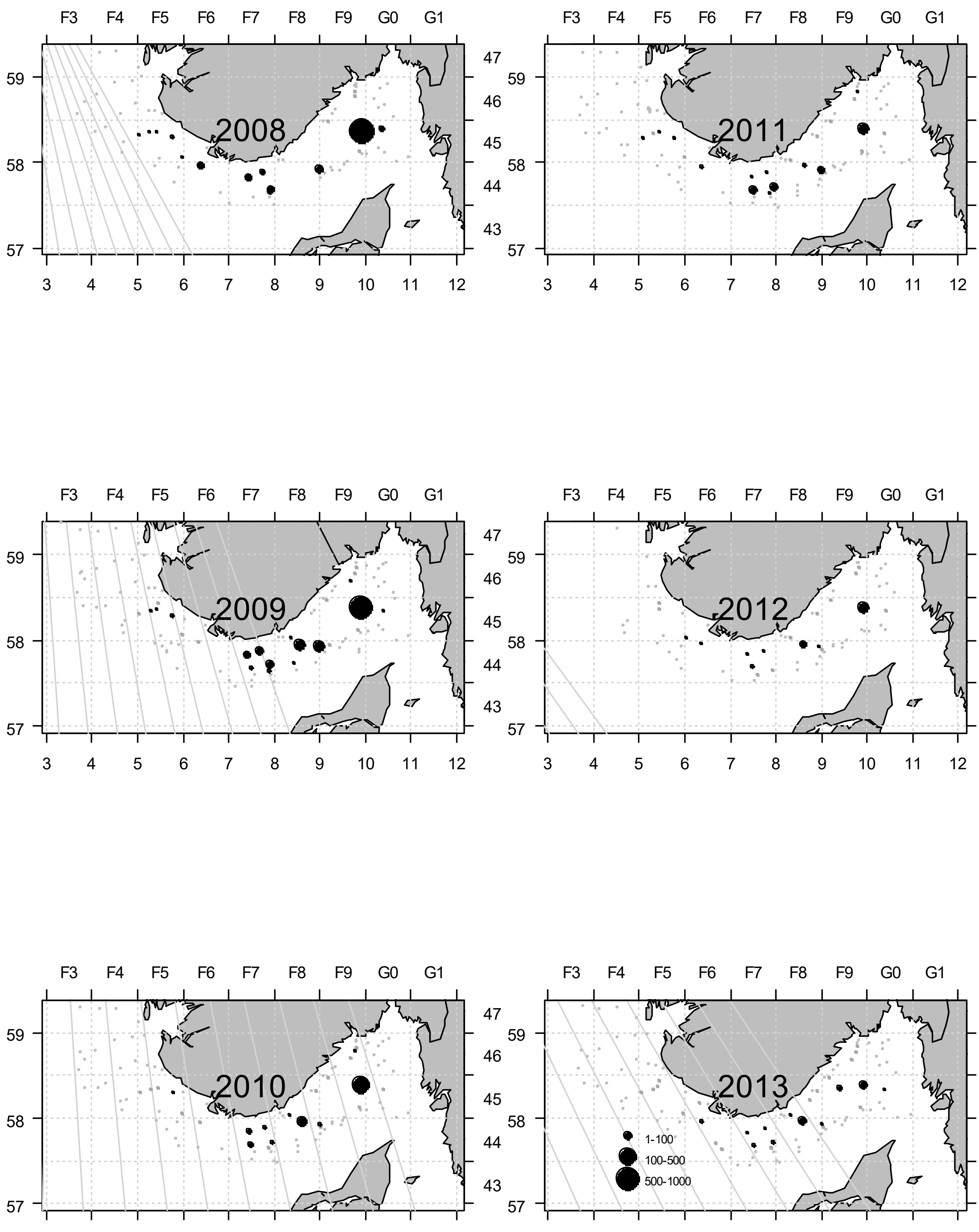

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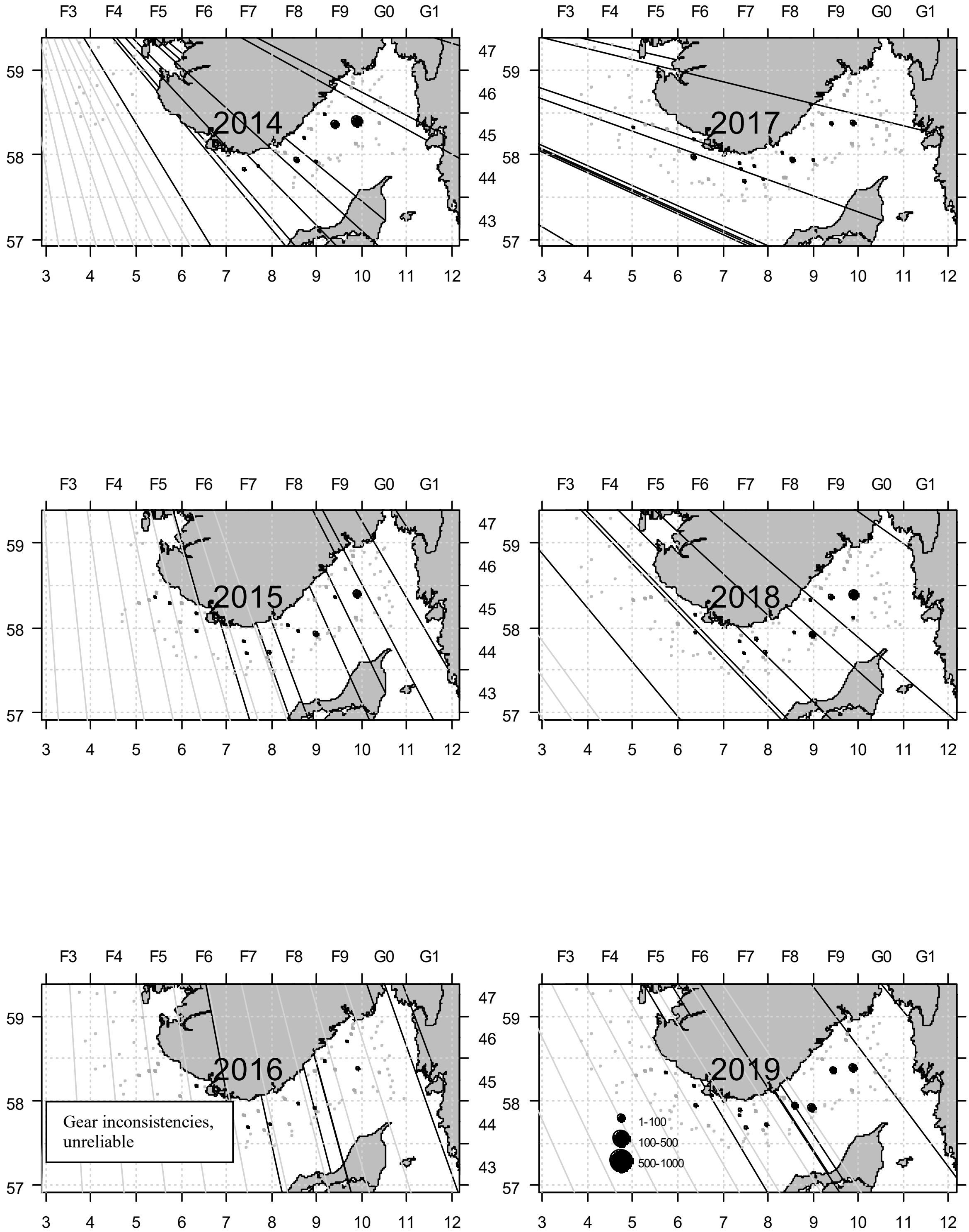

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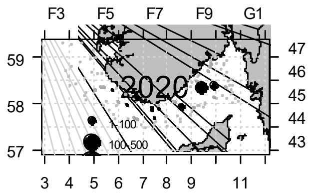

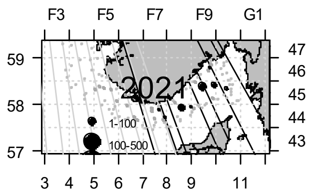

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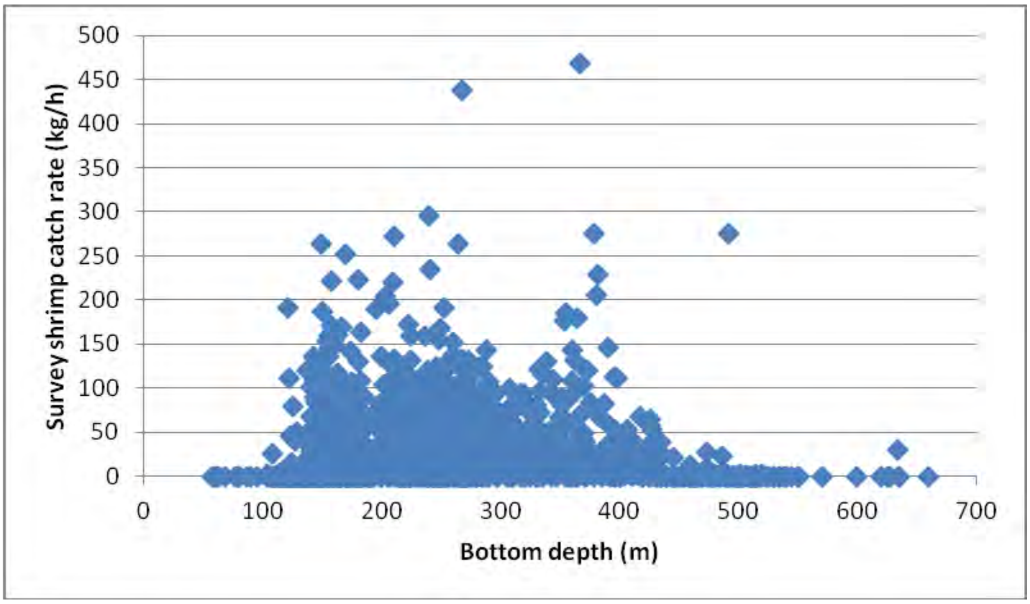

Figure 6. Depth distribution of deepwater shrimp (*Pandalus borealis*) as illustrated by catch rates in the Norwegian shrimp trawl survey, 1984-2013.

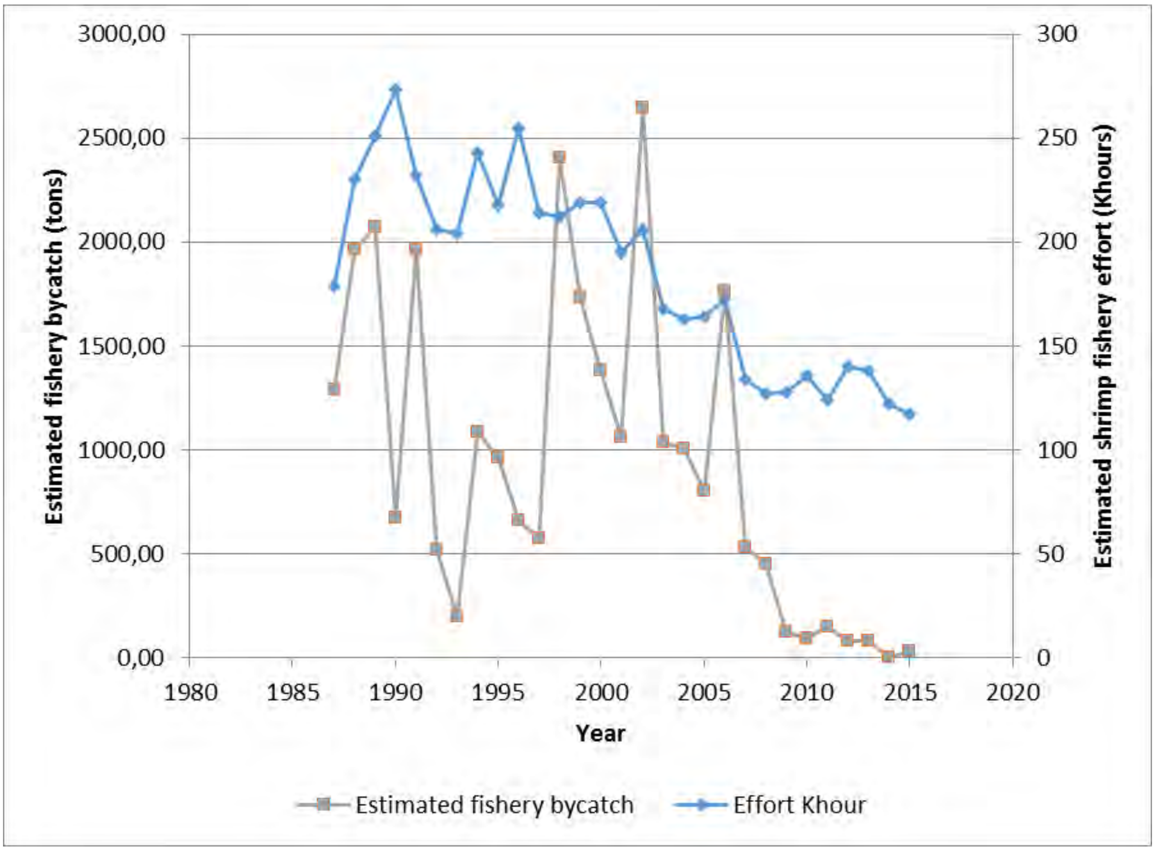

Figure 7. Estimated by-catch of roundnose grenadier in the Norwegian shrimp fishery in ICES Div. 3a and 4a, and the estimated commercial shrimp fishery effort in the same area. See text for explanation.

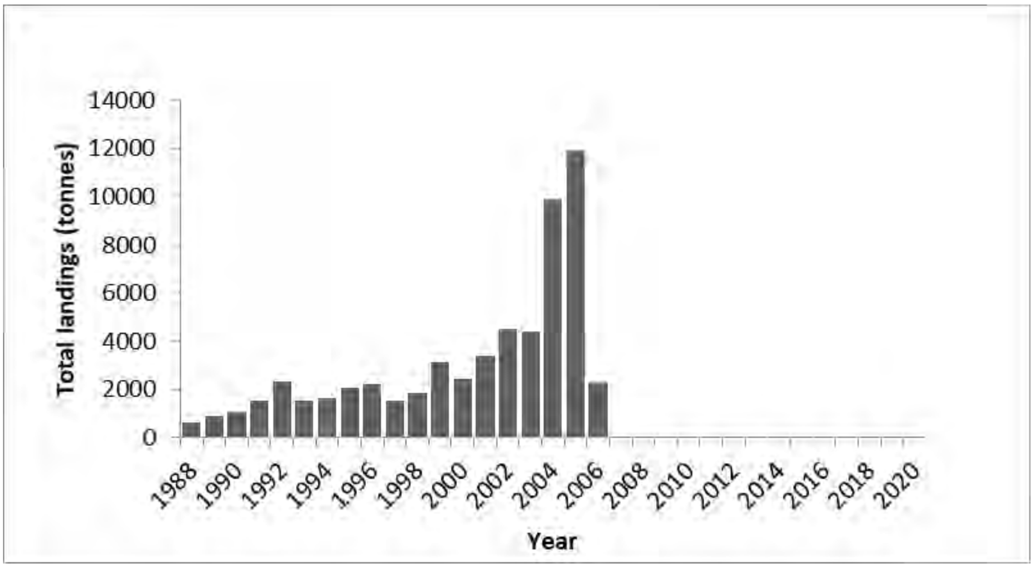

Figure 8. Total reported landings of roundnose grenadier in ICES Division 3a, 1988-2020. Landings from 2007 and later is very small and all less than 2 tons.

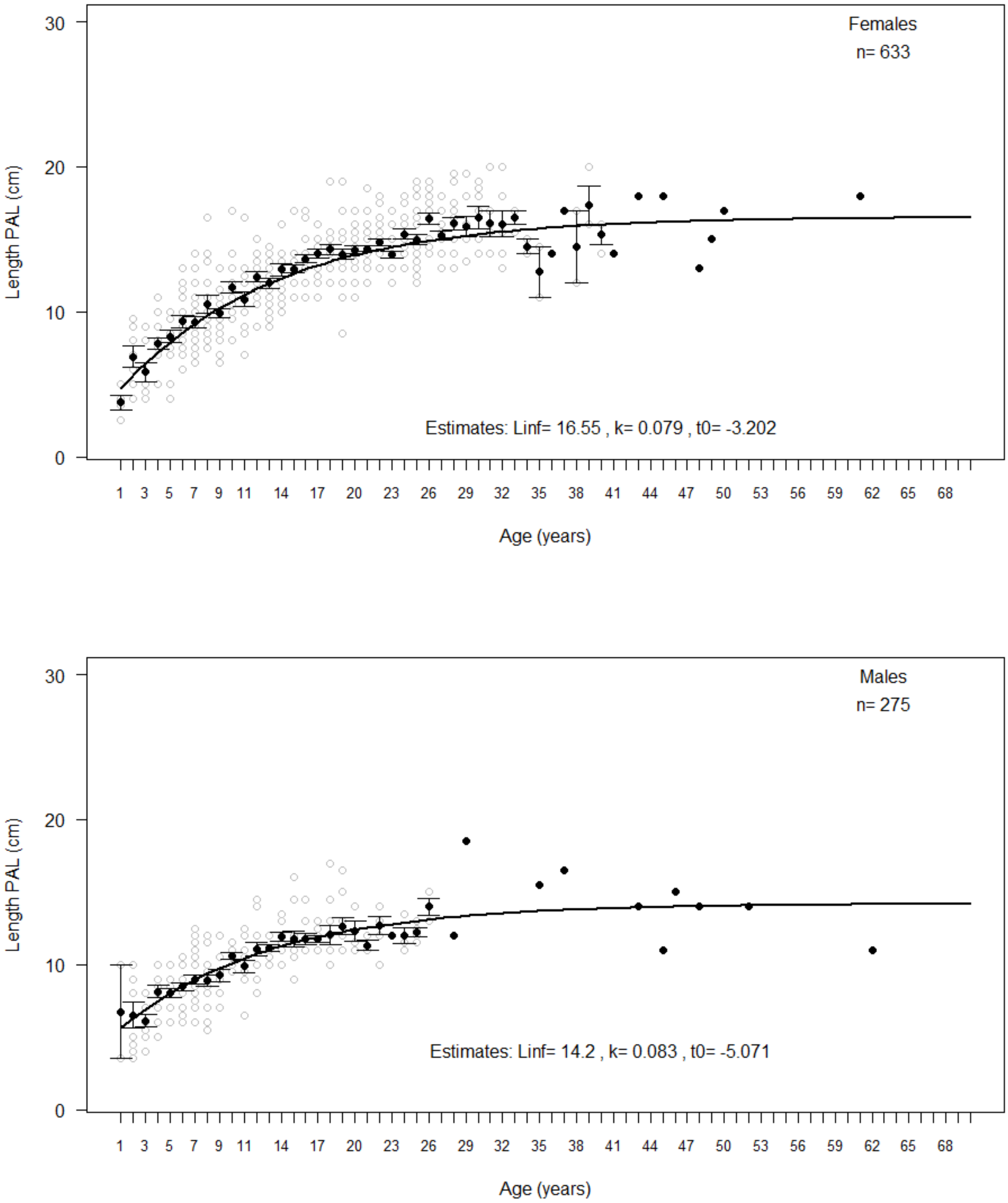

Figure 9. Length at age for female and male roundnose grenadier; data from Skagerrak 2008-2019. Mean values are estimated with ±SE where there is more than one value. Estimated von Bertalanffy growth curves with parameters for females and males.

Commercial catches of roundnose grenadier, roughhead grenadier, greater silver smelt, blue ling, tusk, black scabbard fish, ling and orange roughy in ICES division 14b in the period 1999-2020

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Introduction

This document present logbooks data of the commercial trawl and long line fishery in ICES 14b in the time period 1999 to 2020. The species presented here are roundnose grenadier (*Coryphaenoides rupestris*), roughhead grenadier (*Macrourus berglax*), greater silver smelt (*Argentina silus*), blue ling (*Molva dypterygia*), tusk (*Brosme brosme*), black scabbard fish (*Aphanopus carbo*) and ling (*Molva molva*). No information was available for orange roughy (*Hoplostethus atlanticus*).

Of the evaluated species, quotas have been set on grenadiers (roughhead grenadier and roundnose grenadier combined), tusk, blue ling and greater silver smelt. For grenadiers, TAC in 2007 was 3000 tons, in 2008-2009 it was 2000 tons and from 2010-2020 TAC has been 1000 tons. For greater silver smelt, TAC in 2013-2015 was 10.000 tons where after no qoutas have been set. For tusk, TAC in 2014 was 500 t and from 2015-2020 TAC has been set to 1500 tons. In 2014, TAC for blue ling was 500 tons but no quota has been made since. No scientific advice has been made for any of these species and the TAC is set by the Government of Greenland.

Materials and methods

Logbooks have been mandatory for vessels greater than 30’ft (9,4 m) since 2008. Data on all landings are reported to the Greenland Fishery License Authority (GFLK). Trawlers and longliners gather information on their fishery, including effort and location for individual fishing events and send the data to GFLK on a weekly basis. The data presented here is a mix of targeted catches and bycatch during fishery for Greenland halibut (*Reinhardtius hippoglossoides*).

Results and discussion

Roundnose grenadier (*Coryphaenoides rupestris*, RNG).

Catches of roundnose grenadier have been relatively stable (annual mean catch=89.2 tons) throughout the evaluated time period (1999 to 2020) ranging from 30.9 tons (2008) to 156.4 tons (2019) (**Table 1, Fig. 1**). In 2020, the bycatch was the lowest for more than 10 years reaching 42.2 tons. The majority of this is caught as bycatch by trawlers, whereas longlines conduct a smaller fraction (data not shown).

Due to the lack of survey in East Greenland in 2020, a survey document has not been made in 2021. However, from survey document from previous years (see WDs of 2019) it was established that roughhead grenadier (RHG) is much more common than roundnose grenadier in ICES 14b. Therefore, it is likely that there is misidentification of grenadier species confounding the logbook data of roundnose grenadier and roughhead grenadier. Regardless of this, the TAC of 1.000 tons for grenadiers in East Greenland (roughhead and roundnose combined) is not reached any years.

Roughhead grenadier (*Macrourus berglax*, RHG).

There are no catches of roughhead grenadier between 1999 and 2004. From 2005 to 2013 the average catch was 7.9 tons, whereas it increased to an average of 71.4 tons between 2014 and 2018. In 2019 catches dropped to only 1.0 tons and in 2020 is was 18. 4 tons (**Table 1, Fig. 1**). Before 2014, the catch is dominated by trawlers, but from 2014 and onwards catches are strongly dominated by longliners (data not shown). As mentioned for roundnose grenadier (RNG, see above), the catch of roughhead grenadier is possibly underestimated due to incorrect species identification. From 2014 until 2018 reported catches of roughhead grenadier on long lines are much higher, which might be linked to the onset of targeted long line fishery after tusk in 2014.

Greater silver smelt (*Argentina silus*, ARS).

There are no reported catches of greater silver smelt from 1999 to 2013. In 2014 to 2016 trawl catches ranged from 4.2 tons to 16.1 tons (increasing each year) and in 2017 and 2018 catches were 666.1 tons and 425 tons, respectively. In 2019, only 0.5 tons is reported, which increased to 22.1 tons in 2020 (**Table 1, Fig. 1**). The increase in 2017 and 2018, is due to the onset of targeted pelagic trawl fishery for the species since 2015. This targeted fishery ceased in 2019 thus low catches are reported since.

Blue ling (M*olva dypterygia*, BLI).

Catches of blue ling are relatively low and constant between 1999 to 2020(annual mean catch =13.1 tons, **Table 1, Fig. 1**). Blue ling is mostly caught in trawl fisheries and the composition between line and trawl catches remains relatively constant except in 2015, where the largest trawl catch of 65.5 tons is reported (data not shown).

Tusk (*Brosme brisme*, USK).

Catches of tusk have been low between 1999 to 2014 were much lower (mean annual catch=31.5 tons) compared to from 2015 to 2020 (mean annual catch =601.2 tons) (**Table 1, Fig. 1**). The catch is dominated by long lines throughout the time series (data not shown). The increase in catches corresponds with the initiation of targeted fishery in 2014 where TAC was 500 tons, which was increased by the Greenland government to 1500 tons from 2015 to 2019.

Ling (*Molva molva*, LIN).

Catches of ling is fluctuating between years with no apparent trend over time (**Fig. 1**). In 2005, 2006, 2008 and 2015 catches were above 15 tons, whereas catches were below 5 tons in 2000-2003, 2007, 2009-2010, 2013 and 2017-2020 (**Table 1, Fig. 1**). The majority of catches are from long lines (data not shown).

Black scabbard fish (*Aphanopus carbo*, BSF).

Catches of black scabbard fish has been zero all years except 2010 and 2011 where 100 and 300 kg were reported from trawl bycatch (**Table 1**).

Figures and tables

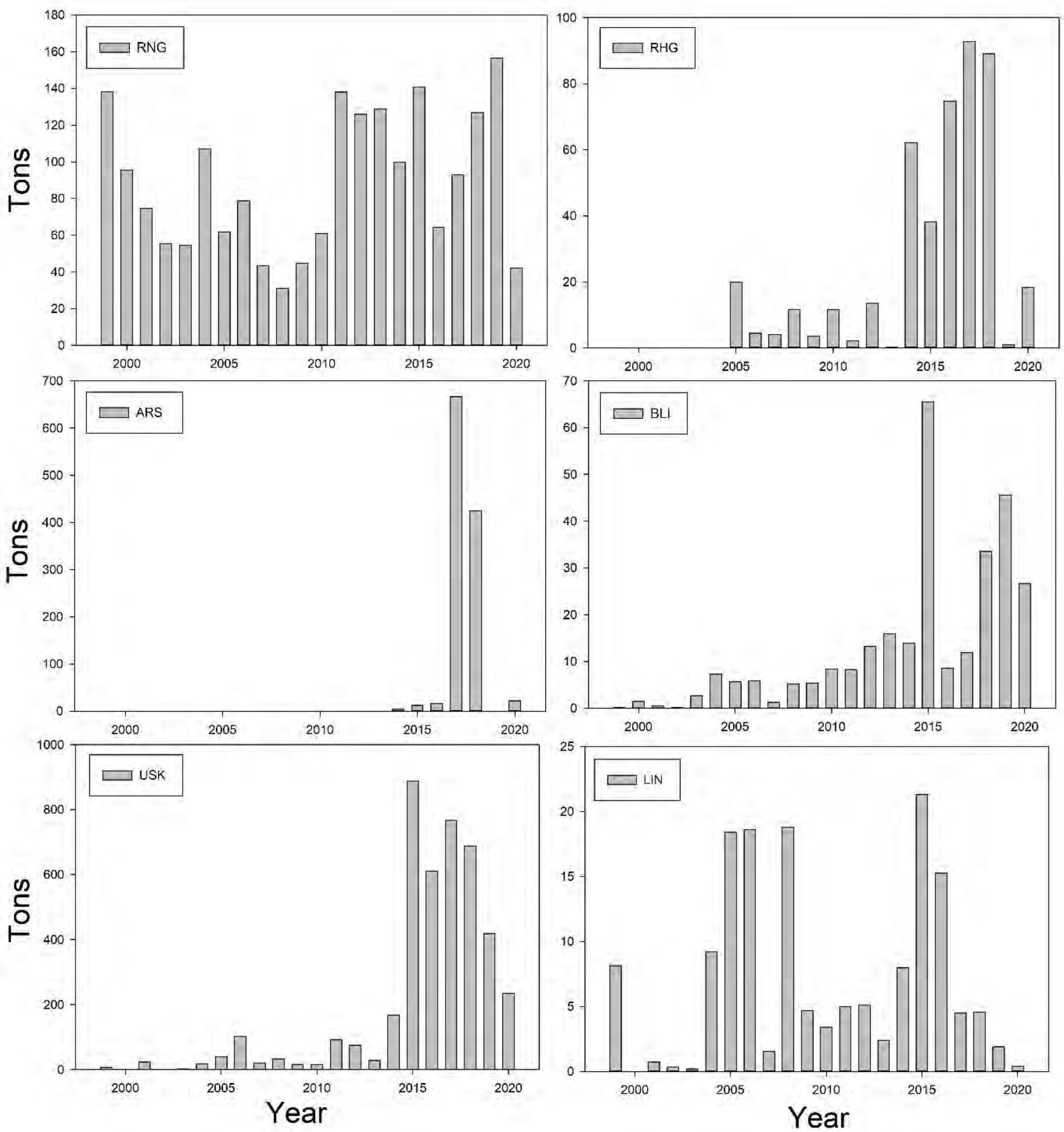

Fig. 1. Catches (trawl and longline combined) of roundnose grenadier (RNG), roughhead grenadier (RHG), greater silver smelt (ARS), blue ling (BLI), tusk (USK) and ling (LIN) from 1999 to 2020. Black scabbardfish can be seen in Table 1.

Table 1. Catches (tons) of roundnose grenadier (RNG), roughhead grenadier (RHG), greater silver smelt (ARS), blue ling (BLI), tusk (USK), black scabbard fish (BSF) and ling (LIN) from 1999 to 2020.

Year	RNG	RHG	ARS	BLI	USK	LIN	BSF
1999	138.1	0.0	0.0	0.2	7.2	8.2	0.0
2000	95.5	0.0	0.0	1.5	0.0	0.0	0.0
2001	74.7	0.0	0.0	0.6	23.6	0.7	0.0
2002	55.5	0.0	0.5	0.2	0.0	0.3	0.0
2003	54.5	0.0	0.0	2.7	2.2	0.2	0.0
2004	107.2	0.0	0.0	7.3	17.5	9.2	0.0
2005	61.9	20.0	0.0	5.7	40.2	18.4	0.0
2006	78.6	4.4	0.0	5.9	102.4	18.6	0.0
2007	43.4	4.1	0.0	1.3	20.0	1.5	0.0
2008	30.9	11.7	0.0	5.2	33.7	18.8	0.0
2009	44.6	3.6	0.0	5.4	16.4	4.7	0.0
2010	61.1	11.6	0.0	8.4	15.1	3.4	0.1
2011	138.0	2.2	0.0	8.3	91.1	5.0	0.3
2012	126.0	13.5	0.0	13.2	74.6	5.1	0.0
2013	128.9	0.3	0.0	15.9	28.2	2.4	0.0
2014	99.8	62.1	4.2	13.9	168.3	8.0	0.0
2015	140.8	38.2	12.2	65.5	887.8	21.3	0.0
2016	64.4	74.8	16.1	8.6	610.1	15.3	0.0
2017	92.9	92.8	666.6	12.0	768.3	4.5	0.0
2018	126.8	89.1	425.1	33.6	688.0	4.6	0.0
2019	156.4	1.0	0.5	45.6	419.0	1.9	0.0
2020	42.2	18.4	22.1	26.7	233.9	0.4	0.0

Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources

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Greater forkbeard *Phycis blennoides* in Portuguese waters (ICES Division 27.9.a)

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Abstract

This working document updates the information presented in previous WGDEEP meetings for the greater forkbeard *Phycis blennoides* in ICES Division 27.9.a (mainland Portugal), particularly fishery dependent and independent data and MSY length-based indicators (LBI). A new standardized biomass index series based on daily landings of a predefined reference fleet was constructed for the period 2013-2020. Regarding fishery independent data the annual standardized biomass index was estimated for the 1997-2018 Portuguese crustacean surveys/Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) time series. Length-based indicators LBI used to classify the stocks according to conservation/sustainability, yield optimization and MSY were estimated for exploited population in Portugal mainland based on length samples collected under the Portuguese DCF program.

1. General considerations

The greater forkbeard *Phycis blennoides* (Brünnich, 1768) is a demersal species from the family Gadidae. This species is widely distributed in the northeast Atlantic from Norway and Iceland to Cape Blanc in West Africa and in the Mediterranean Sea (Massutí et al., 1996), and occurs preferentially along the continental shelf and slope, at depths ranging between 60 and 1000 m deep (Massutí et al., 1996; Casas and Pineiro 2000; Garcia et al., 2000).

The greater forkbeard has a discrete recruitment period along the year and is available to fishing at the first years of life (Ragonese et al., 2002). The size of transition from the pelagic to the demersal habitat occurs at lengths around 6 cm in Atlantic waters (Casas and Piñeiro, 2000) and at a smaller size (4.5-5.0 cm total length) in the Mediterranean (Ragonese et al., 2002). In the Gulf of Tunis, age parameters were estimated as TL_{inf} = 57.17 cm, k = 0.193 $year^{-1}$, t_0 = –1.578 year for females, and TL_{inf} =44.74 cm, k = 0.313 $year^{-1}$, and t_0 =–1.210 year for males. Females grow faster than males, and the latter did not exceed 45 cm (Romdhani et al., 2016).

1.1. The greater forkbeard in Portuguese waters from ICES Division 27.9.a

In Portuguese continental waters, the length structure and the biology of greater forkbeard, namely reproduction, suggests that it completes the whole life cycle in the area (Lagarto et al., 2017). As in other geographic areas where the species occurs (e.g., in the Mediterranean), a depth effect on specimen's size is observed (Massutí et al., 1996): larger specimens occur deeper (>600 m deep) (Fig.1).

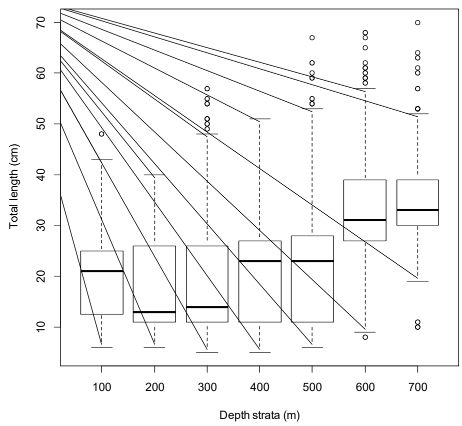

Figure 1. Inter-quartile total length range of *P. blennoides* by depth strata (m) caught during the Portuguese Crustacean Surveys/Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) undertaken between 1997 and 2016 (no survey was conducted in 2012).

2. Fishery dependent data in Portuguese waters from ICES division 27.9.a

In Portugal mainland there are no fisheries targeting greater forkbeard. This species is mainly caught as by-catch of other fisheries, particularly from the polyvalent fleet segment or multi-gear fleet, which is responsible for ~98% of the species total landings.

The Portuguese polyvalent segment includes vessels of different sizes usually licensed to operate with more than one fishing gear (e.g. gill and trammel nets, longlines, and traps). At each fishing trip, vessels belonging to this segment may deploy more than one fishing gear, depending on the targeted species and on the fishing grounds. The analysis of logbook data further indicates that, within the polyvalent segment, the greater forkbeard is mainly caught by demersal longlines.

Most greater forkbeard landings are reported at Peniche landing port, in the Centre of Portugal. A marked seasonal pattern on Portuguese landings is observed with higher values between May and July (Lagarto et al., 2017). Although the reasons for this seasonality are unknown, it is considered that they might be related to the dynamics of the fleets and particularly to changes on their target species.

2.1. Commercial landings

Official Portuguese annual greater forkbeard landing estimates in ICES division 27.9.a are presented in Table 1. It is worth mentioning that landings are likely to be biased due to species misidentification problems. It is admitted that greater forkbeard can be misidentified with its congener *Phycis phycis*. Moreover, the two *Phycis* species, and particularly at the beginning of time series, might be landed under the designation of *Phycis* spp. However, the fraction of *Phycis* spp. landings corresponding to *P. blennoides* is unknown and cannot be estimated as the level of DCF sampling coverage is insufficient.

Historically, the landings of greater forkbeard species are low, either because of its relatively low commercial value or to the low fishing effort at deeper fishing grounds.

Table 1. Official landings (ton) of *Phycis blennoides*, *Phycis phycis* and *Phycis* spp. by fleet from 2003 to 2020. *Phycis* spp. includes landings of *P. blennoides* and *P. phycis*. Source: DGRM (official landings).

	Phycis blennoides				*Phycis phycis*				*Phycis* spp.			
Year	TRAWL	PSEINERS	ARTISANAL	TOTAL	TRAWL	PSEINERS	ARTISANAL	TOTAL	TRAWL	PSEINERS	ARTISANAL	TOTAL
2003	0.08		10.87	10.95	0.75		5.69	6.44	7.87	0.50	314.14	322.51
2004	0.10	0.05	9.84	9.98	0.11		3.59	3.70	7.85	0.60	295.10	303.55
2005	0.17	0.03	14.00	14.20	1.06	0.02	83.49	84.57	5.68	0.13	183.03	188.84
2006	0.17		9.66	9.84	2.11	0.08	176.24	178.43	3.22	0.01	56.05	59.28
2007	0.10	0.02	13.40	13.52	2.69	0.28	215.65	218.62	4.01		25.20	29.21
2008	0.18	0.01	12.05	12.23	4.79	0.10	234.03	238.92	0.14		25.03	25.17
2009	0.10		14.64	14.74	11.20		452.92	464.13			18.61	18.61
2010	0.10		11.53	11.63	14.24		472.11	486.36			8.68	8.69
2011	0.04		13.43	13.48	7.08	0.01	450.68	457.76			5.91	5.91
2012	0.08		5.58	5.66	4.24	0.03	456.11	460.38			5.24	5.24
2013	0.11		7.67	7.78	4.22	0.92	274.22	279.35			3.78	3.78
2014	0.13		6.09	6.22	2.27	0.80	170.97	174.04			2.39	2.39
2015	0.04		7.39	7.43	5.32	0.73	154.72	160.77			1.58	1.58
2016	0.12		6.69	6.81	6.72	1.41	181.31	189.44			1.81	1.81
2017	0.20		8.85	9.05	4.13	1.69	172.38	178.21	0.00		1.27	1.28
2018	0.19		9.23	9.42	2.70	0.35	129.27	132.31			0.64	0.64
2019	0.02		7.12	7.14	2.03	0.313	133.35	135.69			1.34	1.34
2020	0.08		4.80	4.88	1.61	0.30	137.78	139.69			0.99	0.99

2.1. Biomass index

A standardized CPUE was developed for a reference fleet within the polyvalent fleet, based on fishery dependent data collected from commercial landings for the period 2009-2020, particularly the landed weight (in Kg) by fishing trip. A fishing trip is defined from the moment the vessel leaves the dock to when it returns to the dock.

To define the reference fleet only the daily landings data from 2013 onwards were considered, as in previous years landings under the generic *Phycis* spp. category were quite high (Table 1). Vessels with regular landings throughout this period were assigned to the reference fleet. Following this criterion, 9 vessels were selected.

The daily landings of the selected vessels (catch rate per trip) were explored. Figure 2 presents the histograms of the catch rate per trip (Fig. 2a) and of the log-transformed catch rate per trip (Fig. 2b) for the period 2013-2020.

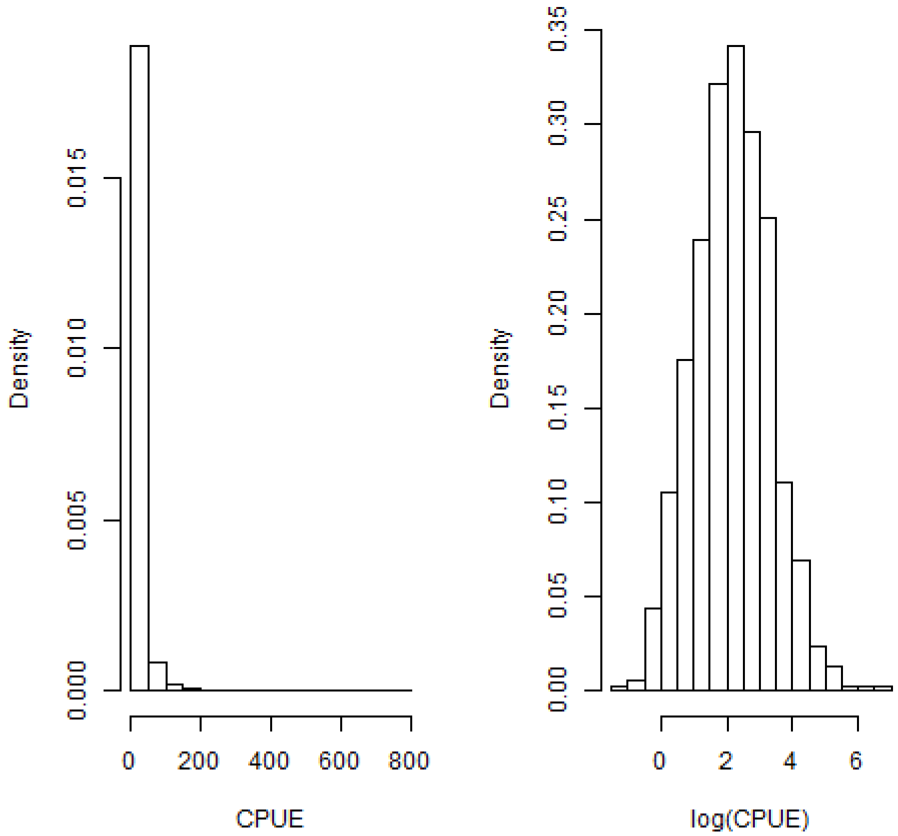

Figure 2. Reference fleet – Histogram of the daily landings of selected vessels (left) and of their log-transformed values (right) for 2013-2020.

Figure 3 presents a skewness-kurtosis plot as proposed by Cullen and Frey (1999) for the log-transformed empirical distribution. This plot is used as a tool to help choosing candidate distributions to fit the data. Values for common distributions are also displayed. While some distributions are just represented by a point on the plot, for others, areas of possible values are represented, consisting of lines (gamma and lognormal distributions, for example) or polygons (beta distribution, for example).

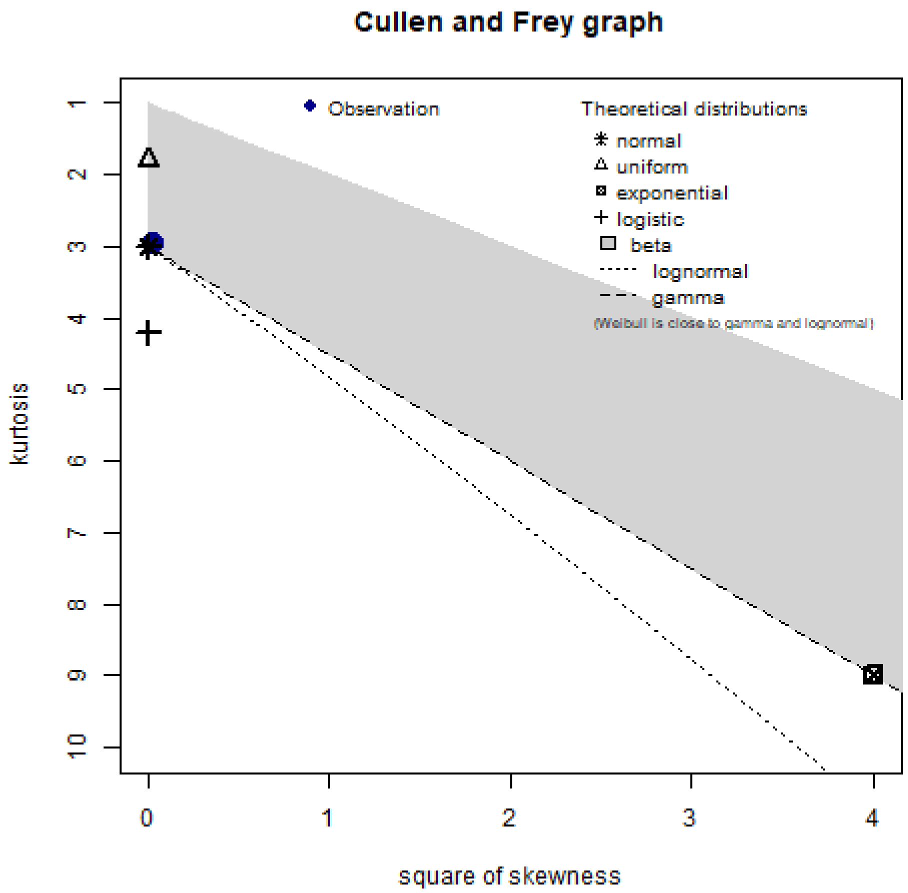

Figure 3. Reference fleet – Skewness-kurtosis plot as proposed by Cullen and Frey (1999) for the log-transformed catch rate (CPUE) empirical distribution.

The normal distribution indicates a better adjustment to the log-transformed catch by fishing trip data, CPUE (Fig. 3). The CPUE data were standardized through the adjustment of a generalized linear model (GLM). Several models were tested and the model with the best fit was selected based on the AIC criterion and residual analysis. The GLM model with a Normal distribution and an identity link function was selected as it was the one that provided the best fit for log-transformed CPUE. The variables considered in the selected model included Month, Vessel code and Year. The graphical analysis of the residuals suggests inexistence of strong violations of the model's assumptions (Fig. 4).

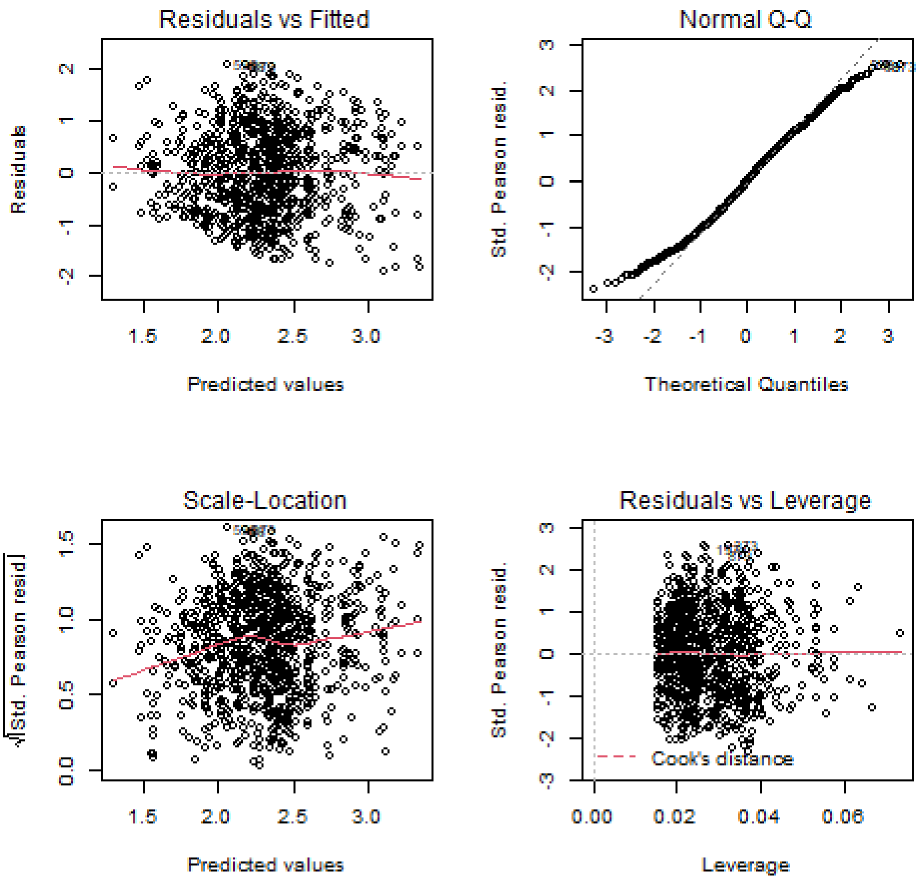

Figure 4. Reference fleet – Residual analysis plot of the selected model.

Figure 5 presents the CPUE estimates and the respective 95% confidence intervals of both log-transformed CPUE and the values in the original scale for the period 2013-2020. Estimated values on the original scale are presented in Table 2.

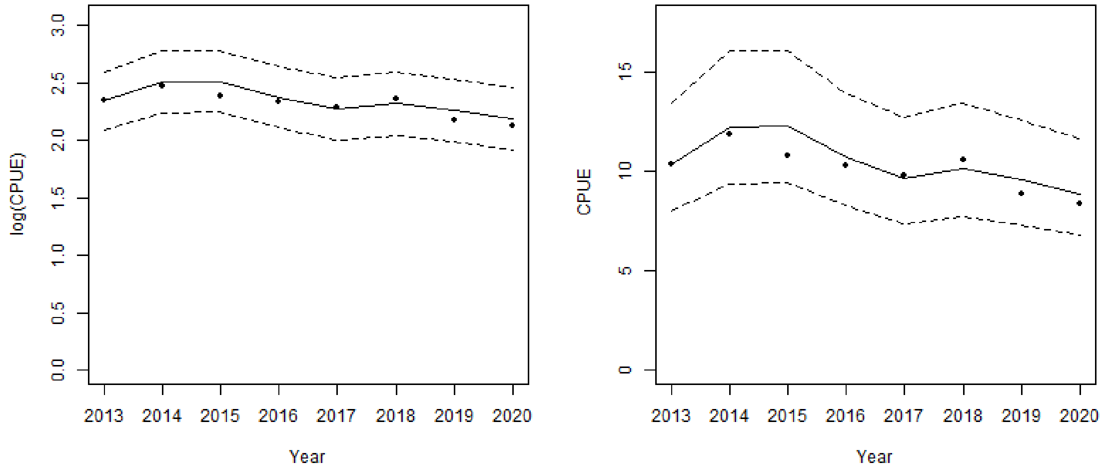

Figure 5. Reference fleet – CPUE (Kg/trip) estimates and 95% confidence intervals of log transformed catch rate and of values in on the original scale for the period 2013-2020. The black dots correspond to the observed mean annual catch rates.

Table 2. Reference fleet – Annual mean CPUE (Kg/trip) and GLM estimates, as well as, upper and lower limits of the 95% CPUE confidence intervals for the period 2013-2020.

Year	Observation Kg/trip	CPUE Upper limit	CPUE estimate Kg/trip	CPUE Lower limit
2013	10.39	13.43	10.39	8.04
2014	11.88	16.07	12.25	9.34
2015	10.83	16.09	12.32	9.43
2016	10.28	13.96	10.74	8.27
2017	9.81	12.72	9.68	7.37
2018	10.59	13.43	10.17	7.70
2019	8.83	12.56	9.57	7.29
2020	8.35	11.66	8.88	6.77

2.3. Length data

The greater forkbeard is sampled for length at several landing ports along the Portuguese continental coast under the national data collection program (PNAB/DCF). The total length of specimens sampled from 2014 to 2020 (under DCF market and onboard programs) ranged between 17 and 78 cm. The length frequency distributions slightly differed between the trawl and the polyvalent fleet segments (the length of specimens caught by trawlers are skewed to sizes smaller than those caught by polyvalent vessels) (Moura and Figueiredo, 2020). Given the very low landing values attributed to the trawl segment, it can be concluded that the length frequency distribution of the greater forkbeard exploited population is mainly derived from the polyvalent fleet segment catches.

Length-based indicators (LBI) screening methods were applied to the length frequency distributions of the greater forkbeard landed in Portugal mainland for the period 2014-2020. Due to the low number of samples available for 2018 and 2020, these years were excluded from the analysis.

The procedure followed the ICES Technical guidance for providing reference points for stocks in categories 3 and 4 (ICES, 2017). The L_{mat} and L_{inf} estimates adopted were those made available by Spain for sexes combined: 53.89 cm and 91.46 cm, respectively (ICES WGDEEP datacall, 2018). The length-weight relationship parameters ($Wt = 0.016\ TL^{2.843}$) were defined by Mendes et al. (2004).

Results from the LBI screening method are shown in Figure 6 and Tables 3a and 3b. Most of the ratios between indicators estimates are below the proposed expected values (see Table 4). These results are related to the poor representation, on landings, of all the size ranges of the population. Discards are known to occur but are unquantifiable. It is acknowledged that the largest specimens are discarded from the deep-water longline fisheries but numbers are relatively low (Lagarto et al., 2017). In addition, onboard data for this fleet is derived from a small area of the total stock distribution in the Portuguese continental waters. Thus, the fishing effort affecting the largest individuals is relatively low.

Table 3a. Results from LBI screening: indicator values.

Year	L75	L25	Lmed	L90	L95	Lmean	Lc	LFeM	Lmaxy	Lmat	Lopt	Linf	Lmax5
2012	41.5	34.5	37.5	46.5	48.5	40.09	34	48.365	37.5	53.9	61.0	91.46	50.8
2013	51.5	41.5	46.5	57.5	61.5	46.06	26	42.365	57.5	53.9	61.0	91.46	64.7
2014	49.5	36.5	44.5	53.5	59.5	44.40	30	45.365	50.5	53.9	61.0	91.46	63.1
2015	55.5	40.5	50.5	59.5	61.5	48.84	30	45.365	55.5	53.9	61.0	91.46	63.9
2016	49.5	33.5	39.5	54.5	58.5	45.22	34	48.365	50.5	53.9	61.0	91.46	61.6
2017	50.5	36.5	42.5	53.5	55.5	45.45	34	48.365	52.5	53.9	61.0	91.46	59.4
2019	51.5	45.5	49.5	58.5	63.5	52.57	46	57.365	51.5	53.9	61.0	91.46	66.5

Table 3b. Results from LBI screening: indicator ratios. Ref., Reference expected values from ICES (2017).

	MSY	Optimal yield	Conservation (immatures)		Conservation (large individuals)		
	L_{mean} / $L_{F=M}$	L_{mean}/L_{opt}	$L_{25\%}$ / L_{mat}	L_c/L_{mat}	$L_{95\%}$ / L_{inf}	$L_{max5\%}$ / L_{inf}	**Pmega**
year	**≥ 1**	**~1**	**>1**	**>1**	**>0.8**	**>0.8**	**>0.3**
2012	0.83	0.74	0.64	0.63	0.66	0.62	0.56
2013	1.09	0.85	0.77	0.48	0.76	0.94	0.71
2014	0.98	0.82	0.68	0.56	0.73	0.83	0.69
2015	1.08	0.91	0.75	0.56	0.80	0.91	0.70
2016	0.93	0.84	0.62	0.63	0.74	0.83	0.67
2017	0.94	0.84	0.68	0.63	0.75	0.86	0.65
2019	0.92	0.98	0.84	0.85	0.86	0.84	0.73

Table 4. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system (from ICES, 2017).

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	> 0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%}$ / L_{inf}		
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3–0.4	Pmega	> 0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	> 1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	> 1	
L_{mean}	Mean length of individuals > L_c	$L_{opt} = {}^2/_3\ L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{max_y}	Length class with maximum biomass in catch	$Lopt = {}^2/_3\ L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > L_c	$L_{F=M}$ = $(0.75L_c+0.25\ L_{inf})$	L_{mean} / $L_{F=M}$	≥ 1	MSY

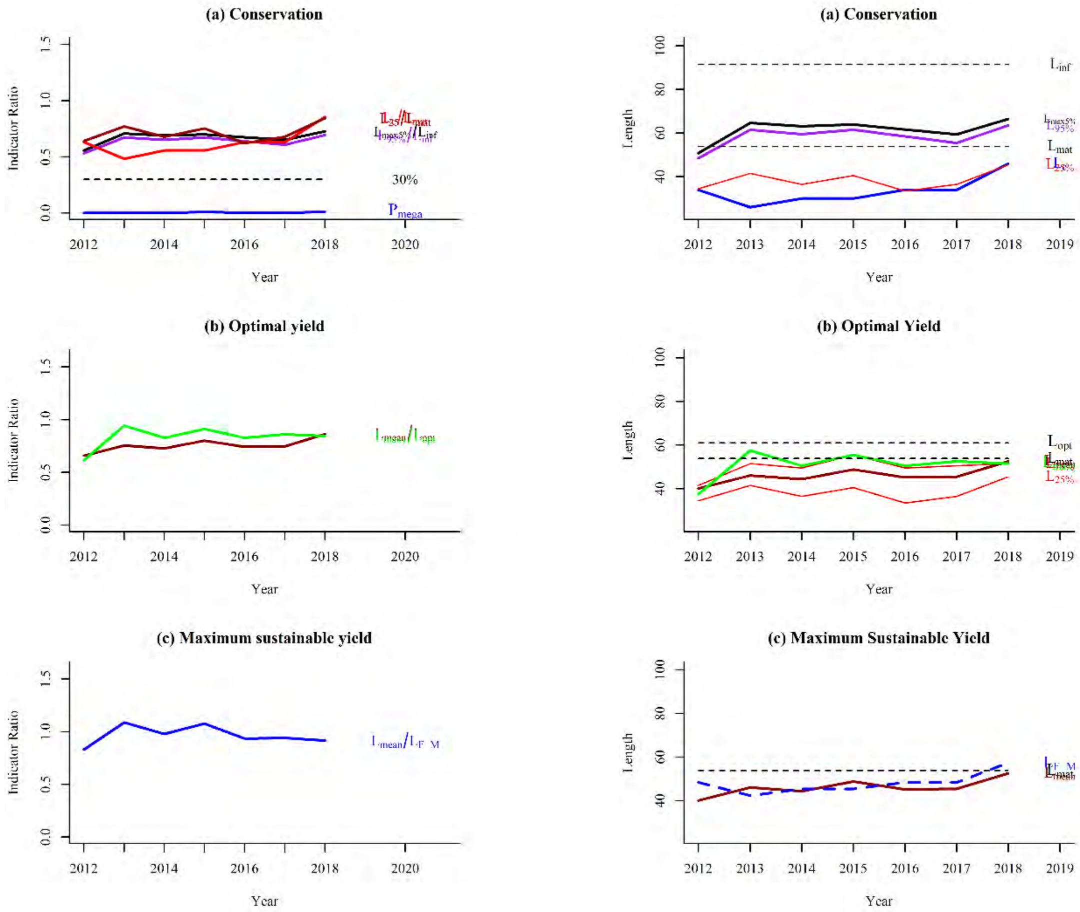

Figure 6. Results from LBI screening.

3. Fishery independent data in Portuguese waters from ICES division 27.9.a

Fishery independent data are available from two survey series (see Annex I for further information). From these, the Portuguese Crustacean Surveys/ Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) provided the best information to investigate the species dynamics in the Portuguese continental coast, given depth range of operation, which goes down to 750 m deep. The information collected on the species during these surveys has been used to estimate standardized relative biomass index. In 2019 and 2020, the PT-CTS (UWTV (FU 28-29)) survey was not performed, so the information here presented covers the time range from 1997 to 2018.

The spatial and bathymetric distribution of species in Portuguese waters was firstly investigated. An exploratory analysis using the data collected at PT-CTS (UWTV (FU 28-29))) surveys performed from 1997 to 2015 was conducted. Given the uncertainty in species identification at the beginning of the time series (it is possible that misidentification problems with *Phycis phycis* have occurred in the past), the analysis was conducted by restricting the depth to the range 500 and 750 m deep. In addition, given the low number of hauls, two geographical areas (or sectors) were not considered (Lisboa and Arrifana).

After the initial exploratory analysis, sector Milfontes was selected to provide the standardized relative biomass index estimates. For the considered time series, this sector is the one that presents a better temporal sampling coverage and also because it is not a zero inflated catch rate data sector.

The estimation of the standardized biomass index estimates was performed following the methodology described in Annex II.

For the time series 1997-2018, the biomass model results are presented in Figure 7 and Table 5. The standardized biomass index of the species increases in 2018 and is above the overall mean. The abundance index for 2017–2018 (2.05 $Kg.h^{-1}$) was 5% higher than the mean observed in the preceding three years (1.95 $Kg.h^{-1;}$ 2014–2016).

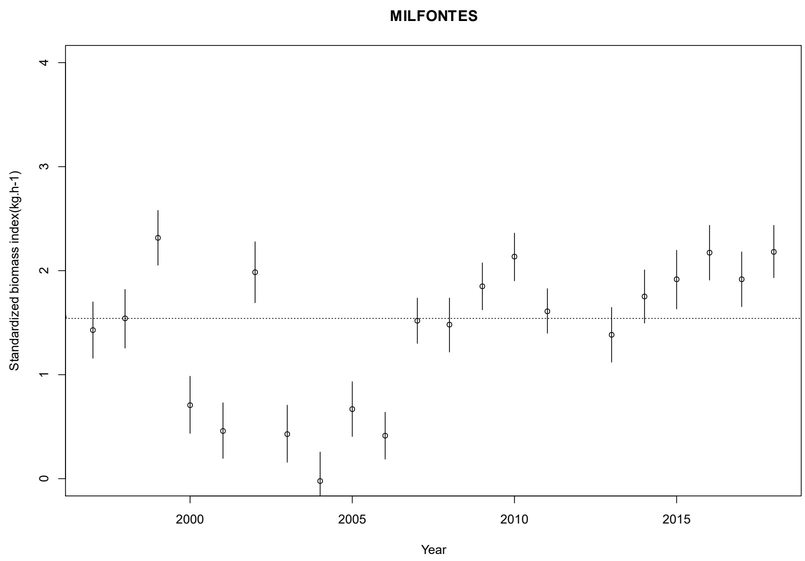

Figure 7. Standardized biomass index (kg.hour^{-1}) for the Portuguese Crustacean Surveys/Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) undertaken between 1997 and 2018. CPUE values estimated for the sector "Milfontes".

Table 5. Standardized biomass index (kg.hour-1) for the Portuguese Crustacean Surveys/Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) undertaken between 1997 and 2018 (no survey was conducted in 2012). Number of hauls included in the analysis by year and CPUE values estimated for the sector "Milfontes".

Year	n hauls [200, 750[m	Milfontes (kg.hour^{-1})	s.e.
1997	36	1.43	0.27
1998	51	1.54	0.28
1999	23	2.31	0.26
2000	45	0.71	0.27
2001	48	0.46	0.27
2002	48	1.98	0.29
2003	54	0.43	0.27
2004	51	0.00	0.28
2005	59	0.67	0.26
2006	59	0.41	0.23
2007	61	1.52	0.22
2008	62	1.48	0.26
2009	58	1.85	0.22
2010	47	2.13	0.23
2011	43	1.61	0.21
2012	---	---	---
2013	65	1.38	0.26
2014	66	1.75	0.26
2015	53	1.91	0.28
2016	64	2.17	0.26
2017	57	1.92	0.26
2018	47	2.18	0.25

The length range *P. blennoides* specimens caught in the PT-CTS (UWTV (FU 28-29))) surveys varied between 5 and 70 cm (Figure 8). For most of the years, two modes were observed. The modes were consistently registered at about 10 and 25 cm.

Regarding the smaller specimens and given the existence of just one spawning season for the species and the growth model proposed for the species, it is likely that the Portuguese survey data mainly reflects the juvenile biomass. Since the species spawning period occurs from October to December (data from the northwest of the Iberian coast, also ICES divisions 27.8.c and 9.a; Casas and Piñeiro, 2000), it is likely that the smaller specimens caught in the Portuguese survey taking place in May/June have grown about 10 cm in 6-9 months.

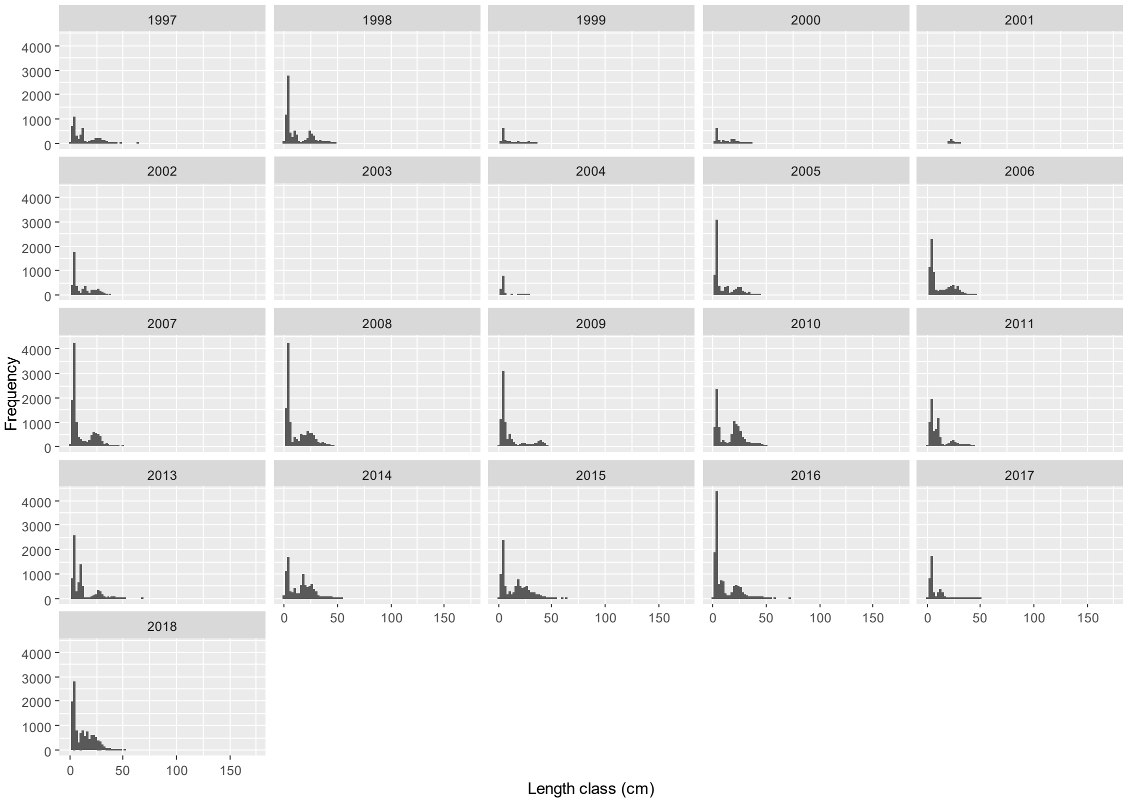

Figure 8. Length frequency distribution by year of the greater forkbeard in the PT-CTS (UWTV (FU 28-29))) survey.

4. Conclusions

The two standardized CPUE series based on commercial data suggest that the status of the greater forkbeard population inhabiting the Portuguese continental waters in recent years has been stable.

In recent years the standardized survey biomass estimates, which represents a relatively long time series, have been well above the overall mean and show an increasing trend. For the period between 1997 and 2016, an increasing trend was also observed for the juvenile component of the population, indicating that the fishing pressure over the Portuguese population has not seriously impaired the recruitment (Lagarto et al., 2017).

LBI screening results, particularly that of MSY, is close to the expected values, suggesting that the stock is in a fair status.

Given the fact that this species is not targeted by any fishery, the results obtained suggest that the Portuguese fisheries are not impairing the population of greater forkbeard, whose information for the Portuguese waters further indicates that the species is able to complete the whole life cycle in the area.

Worth to mention that the relative low fishing impact of the Portuguese fisheries in deeper grounds reduces the impact over the fraction of larger specimens of the population, as the species tends to be larger at greater depths.

References

Casas, J. M., Piñeiro, C. 2000. Growth and age estimation of greater fork-beard (*Phycis blennoides* Brünnich, 1768) in the north and northwest of the Iberian Peninsula (ICES Division VIIIc and IXa). *Fisheries Research*, 47(1), 19-25.

Cullen AC and Frey HC, 1999. Probabilistic techniques in exposure assessment. Plenum Press, USA, pp. 81-159.

García, L. M., Porte, C., Albaigés, J. 2000. Organochlorinated pollutants and xenobiotic metabolizing enzymes in W. Mediterranean mesopelagic fish. *Marine Pollution Bulletin*, 40(9), 764-768.

ICES 2017. ICES Technical guidance for providing reference points for stocks in categories 3 and 4. ICES Technical Guidelines.

Lagarto, N., Moura, T., Figueiredo, I. (2017). Greater forkbeard *Phycis blennoides* in Portuguese waters (ICES division IXa). Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources, Copenhagen, 2017. 16 pp. WD2017-06.

Massutí, E., Morales-Nin, B., Lloris, D. 1996. Bathymetric distribution and recruitment patterns of *Phycis blennoides* (Pisces: Gadidae) from the slope of the northwestern Mediterranean. *Scientia Marina*, 60(4): 481-488.

Mendes, B., Fonseca, P., Campos, A. 2004. Weight–length relationships for 46 fish species of the Portuguese west coast. Journal of Applied Ichthyology, 20(5): 355-361.

Moura, T., Figueiredo, T. 2020. Greater forkbeard *Phycis blennoides* in Portuguese waters (ICES Division 27.9.a). Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources, 24th April -1th May 2020.

Ragonese, S., Fiorentino, F., Rinelli, P., Greco, S. 2002. A procedure to evaluate the effect of lag-time in studying length structure and growth rate of young fish: the case of *Phycis blennoides* Brunnich, 1768 (Osteichthyes: Gadiformes) in the Central Mediterranean. *Scientia Marina*, 66(S2), 253-260.

Romdhani, A., Ktari, M. H., Dufour, J. L., Mahe, K., & Francour, P. (2016). Growth and age estimation of the greater forkbeard, *Phycis blennoides* (Actinopterygii: Gadiformes: Phycidae), from the Gulf of Tunis (central Mediterranean)). Acta Ichthyologica et Piscatoria, 46: 25-32.

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Annex I

Description of the Portuguese Crustacean Survey (PT-CTS (UWTV (FU 28-29))

The PT-CTS (UWTV (FU 28-29) have been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, former PIMAR) and the main objective is to monitor the abundance and distribution of the main crustacean species, namely the Norway lobster *N. norvegicus*, the rose shrimp *P. longirostris* and the red shrimp *A. antennatus*. PT-CTS (UWTV (FU 28-29)) have been conducted during the 2nd quarter (May-July) of the year and cover the southwest coast (Alentejo, FU 28) and south coast (Algarve, FU 29). The surveys have been carried with the Portuguese RV "Noruega", which is a stern trawler of 47.5 m length, 1500 horse power and 495 GRT. A regular grid composed by 22 rectangles in FU 28 and 59 rectangles in FU 29 is used, with one station within each rectangle. Each rectangle has 6.6´ of latitude x 5.5´ of longitude for the SW coast and *vice-versa* for the south coast, corresponding approx. to 33 nm^2. The grid was designed for a trawl survey to cover the main crustacean fishing grounds within the range of 200-750 m. The hauls fishing operations are carried out during daytime with a speed of 3 knots and the duration of each tow change in 2005 from 60 to 30 min. Although the crustacean species are the target (Norway lobster, rose shrimp and red and blue shrimp), data from all other taxa and species are also collected, as well as marine litter. Details about this survey can be found on Silva and Borges (2014) and ICES (2016).

References

ICES, 2016. Final report of the Working Group on Nephrops Surveys (WGNEPS), 10-13 November 2015, Cadiz, Spain. ICES CM 2015/SSGIEOM:30. 56 pp.

Silva, C., Borges, M.F. (2014). Crustáceos-2014, Julho. Relatórios de Campanha. 21p.

Annex II

Stock indicator for the greater forkbeard in Portuguese waters (ICES Division 27.9.a)

Generalized linear models (GLM) were adjusted to catch rates and several factors were used as explanatory variables. In the essayed models the catch rate of the species in each haul ($Kg.h^{-1}$) was the response variable. Apart from factor year, the remaining predictors were selected depending on their significance after the model adjustment. GLM models were adjusted through the use of package 'MASS' (Venables and Ripley, 2002) implemented in R software. In the model, error of the catch rate was assumed to follow a tweedie random variable, whose probability density function is expressed as:

$$f(y:\mu,\sigma^2,p) = a(y:\sigma^2,p)exp\left\{-\frac{1}{2\sigma^2}d(y:\mu,p)\right\}$$

where μ is the location parameter (mean of the distribution); σ^2 is the diffusion parameter and; p is the power parameter.

The Tweedie family of distributions is a family of exponential models with variance $Var(Y) = \sigma^2.\mu p$; depending on the p value it includes several distributions (Dunn and Smyth, 2008; Jørgensen, 1997). When $1<p < 2$ the distribution corresponds to mixed distributions known as compound Poisson models (Jørgensen, 1997), which, in the present case and due to the high frequency of zeroes, seems to be the most appropriate distribution to use.

The estimation of the p parameter was done following the procedure proposed by Shono (2008). According to this, the p parameter is estimated by maximizing the profile log-likelihood across the grid values of p in the range of $1 < p < 2$ through the explicit form of the probability density function. The package 'Tweedie' (Dunn, 2009) implemented in R was used to estimate p.

Standardized biomass index model included the factors Year and Sector and the continuous variable Depth:

$$CPUE= Year+Sector+Depth -1$$

Model´s adequacy was verified through the analysis of residuals. Fitted values were transformed ($2\mu^{1-(p/2)}$) to the constant information-scale, so that the expected pattern for the compound Poisson distribution was a straight line (McCullagh and Nelder, 1989; Draper et al., 1998; Ortiz and Arocha, 2004). Residuals were also analysed using Tweedie quantiles, and the graphical tools for residuals set with the tweedie distribution (qqplots) were constructed. Three types of plots were examined: (i) histogram of the deviance residuals; (ii) deviance residuals and Pearson residuals against the standardized fitted values to check for systematic departures from the assumptions underlying the statistical distribution; and (iii) Tweedie QQ-plot (with Tweedie quantiles) for deviance residuals and for Pearson residuals.

For the selected statistical model annual biomass index predictions in the original scale were obtained following the procedure referred in Candy (2004). The estimates of the variance of the sum of linear predictors used to estimate the approximate confidence intervals of annual indices were determined using the delta method implemented at the R package ‘msm’ (Jackson, 2013). The delta method is an approach for computing confidence intervals for functions of maximum likelihood estimates. This method allows finding approximations of the variance of functions of random variables based on Taylor series (Oehlert, 1992).

References

Candy, S. 2004. Modelling catch and effort data using generalised linear models, the Tweedie distribution. Random vessel effects and random stratum-by-year effects. CCAMLR Science, 11: 59-80.

Draper, N. R., Smith, H., Pownell, E. 1966. Applied regression analysis (Vol. 3). New York: Wiley.

Dunn, P.K., 2009. Tweedie: Tweedie exponential family models. R package version 1.6.2.

Dunn, P.K., Smyth, G.K. 2008. Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. Statistics and Computing, 18: 73–86.

Jackson, C. 2013. Package 'msm': Multi-state Markov and hidden Markov models in continuous time. R package version 1.1.4.

Jørgensen, B. 1997. The Theory of Dispersion Models. Chapman and Hall, London, p. 237.

McCullagh, P., Nelder, J.A. 1989. Generalized Linear Models. London, Chapman Hall.

Oehlert, G.W. 1992. A note on the delta method. The American Statistician, 46: 27-29.

Ortiz, M., Arocha, F. 2004. Alternative error distribution models for standardization of catch rates of non-target species from a pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery. Fisheries Research, 70: 275-297.

Shono, H. 2008. Application of the Tweedie distribution to zero-catch data in CPUE analysis. Fisheries Research, 93: 154-162.

Venables, W.N., Ripley, B.D. 2002. Modern Applied Statistics with S. Fourth ed. Springer, New York

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Pagellus bogaraveo in Portuguese continental waters (ICES Division 27.9.a)

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1. Introduction

Pagellus bogaraveo (Brünnich, 1768), the blackspot seabream, distributes between southern Norway and Cape Blanc, in the Mediterranean Sea, and in the Azores, Madeira, and Canary Archipelagos (Desbrosses, 1932; Pinho and Menezes, 2005).

Spawning occurs in shallow waters, where juveniles of age groups 0 and 1 are reported to remain at depths lower than 170 m, close to the coast, in the Azores (Menezes et al., 2001), the Bay of Biscay (Lorance, 2011), and the Mediterranean Sea (Biagi et al., 1998; Félix-Hackradt et al., 2013). When juveniles reach 150–180 mm total length (TL), they migrate along the slope to depths deeper than 200 m, following an ontogenetic migration towards deeper waters (Olivier, 1928; Desbrosses, 1932; Morato et al., 2001; Spedicato et al., 2002). Nevertheless, fish with sizes larger than 40 cm have been occasionally caught in coastal waters (Priol, 1932).

In Cadiz waters, the main spawning period occurs during the 1st quarter (Gil, 2010), whereas in the Azores spawning is from March to April (Martins *et al.*, 2007).

The blackspot seabream is a protandric hermaphrodite – individuals are first functional males and then develop into functional females (Buxton and Garratt, 1990; Krug, 1990; Gil, 2006). In the Azores, the age of first maturity is about 8 years old for females (Krug, 1990).

In the Northeast Atlantic, *P. bogaraveo*'s stock structure is still unknown. Genetic studies showed a restricted gene flow among the populations located in the Azores (ICES Division 27.10.a.2) and those on the Portuguese continental slope (ICES Division 27.9.a) and Madeira (CECAF FAO Division 34.1.2) (Stockley *et al.*, 2005; Pinera et al., 2013). Mitochondrial control region showed similar genetic diversity among sampling sites in the NE Atlantic and the Mediterranean, and no differentiation between the Azores and the remaining locations (Robalo et al., 2021).

Despite the poor knowledge on the species stock structure, ICES adopts three management components for management purposes: (a) Subareas 27.6, 27.7, and 27.8; (b) Subarea 27.9; and (c) Subarea 27.10 (Azores) (ICES, 2007). These components were established to better record the available information and do not have implicit the existence of three different stocks of *P. bogaraveo*. There is no evidence of movements between the northernmost component and the southern part of Subarea 27.9 where a targeted fishery takes place in the Strait of Gibraltar (ICES, 2019).

The Spanish longline fishery operating in the Strait of Gibraltar has been managed as a regulated open-access fishery since its initial exploitation, in 1983 (Gil et al., 2019). In 2001, Moroccan longliners started a target fishery in the same area. Therefore, two directed fisheries are presently taking place in the Spanish and Moroccan Exclusive Economic Zone (EEZ) (ICES, 2017a).

Total Allowable Catch (TAC), Portuguese quota, and official landings are presented for continental Portugal (ICES Division 27.9.a) between 2014 and 2020 (Table 1).

Table 1. *Pagellus bogaraveo* Total Allowable Catch (TAC) and Portuguese quota and official landings in ICES Subarea 27.9, between 2014 and 2020.

Year	TAC EU ICES Subarea 27.9	Portugal quota ICES Subarea 27.9	Official Portuguese landings ICES Division 27.9.a
2014	780	166	59
2015	374	80	66
2016	183	39	70
2017	174	37	69
2018	165	35	58
2019	149	32	36
2020	149	32	43

1.1. Fishery in Portugal continental

In continental Portugal, *P. bogaraveo* is mainly caught as by-catch of fisheries targeting other species, although some vessels are licensed to target the species.

Fishery data and information collected through enquiries made to Peniche (Portuguese central western coast) skippers with experience on *P. bogaraveo* fishing has shown that: (i) the species tends to gather at specific fishing grounds with particular seamount-like topographic features, being mainly caught at depths around 250 m; (ii) the fishing grounds substrates are mainly composed by muddy sand, rock, and sand; (iii) the species length range is not different between the different fishing grounds. Some skippers additionally referred that, during winter, the species migrates, driven by environmental factors or biological conditions, such as reproduction (Araújo et al., 2016).

Information on blackspot seabream collected from 1990 to 2018 in the Portuguese Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) and the Portuguese Autumn Groundfish Surveys (PT-GFS) conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA) supports the hypothesis of a patchy distribution, as the species is more frequently caught at specific grounds (Farias and Figueiredo, 2019). It is important to note that the PT-CTS (UWTV (FU 28-29)) survey design is considered inadequate to estimate the species abundance or biomass, as the species distributes preferentially at non-trawlable areas. Fishery independent information has not been updated since 2018 since no survey was performed in 2019 and 2020.

2. Methodology

1.1. Fishery dependent data

1.1.1. Landings and mean price in continental Portugal

Portuguese landings in ICES Division 27.9.a were characterized. Fishery dependent data were collected from commercial landings for the period between 2009 and 2020.

Pagellus bogaraveo total landings in weight (ton) and value (euro) were analysed by year, fishing segment and NUTS (Nomenclature of Territorial Units for Statistics). The EU NUTS classification system (https://ec.europa.eu/eurostat/web/regions/background) is a regional system that divides each EU Member States territorial area into units, providing a harmonised hierarchy between regions. Following the criteria adopted under this system, continental Portugal is divided into 5 different NUTS II (level 2) corresponding: North; Centre; Lisbon Metropolitan Area; Alentejo; and Algarve.

1.1.2. Landings and mean price by fleet and selected NUTS II

Pagellus bogaraveo total landings in weight (ton) and value (euro) were analysed throughout the year, between 2009 and 2020, by fishing segments (polyvalent and trawl), considering the NUTS II with the most representative landings of the species: North, Centre, and Algarve.

1.1.3. Landings in the most important Portuguese continental ports

Pagellus bogaraveo total landings in weight (ton) were analysed throughout the year, between 2009 and 2020, by fishing segments (polyvalent and trawl) for NUTS II landings ports with the highest landings of the species. Matosinhos port belongs to NUTS II North; Aveiro, Nazaré, and Peniche ports belong to NUTS II Centre; and Sagres belongs to NUTS II Algarve.

1.2. LPUE

1.2.1. Reference fleet

Reference fleets for the polyvalent and for the trawl fishing segments were defined for the main landing port, Peniche. The criteria adopted for the selection of fishing vessels were defined according to the number of fishing trips with positive landings of the species and the number of months of the year with positive landings of the species, during the period between 2015 and 2020.

For the polyvalent fishing segment, the criteria adopted for the selection of fishing vessel were: more than 9 fishing trips per year and more than 6 months with positive landings of the species.

For the trawl fishing segment, the criteria adopted for the selection of fishing vessel where: more than 9 fishing trips per year and more than 5 months with positive landings of the species.

1.2.2. CPUE adjustment

For each selected vessel, data available at fishing trip level was further analysed. The landed weight of the species (in kg) per fishing trip corresponds to the total weight landed by the vessel after each trip. A trip is defined from the moment the vessel leaves the dock to when it returns to the dock.

The landed weight per fishing trip was considered as an indicator of biomass index, further referred as CPUE. Important to note that discards of the species are negligible in Portuguese continental fisheries.

CPUE data were standardized through the adjustment of generalized linear models (GLM). The model with the best adjustment was selected based on the AIC criterion and on the analysis of residuals.

1.3. Length distribution

Pagellus bogaraveo DCF length sampling data available for the polyvalent and the trawl segments for Portugal continental were analysed by year in the period between 2014 and 2020. Numbers-at-length were raised to the total landings.

1.4. LBI

Length-based indicators (LBI) screening methods were applied to *P. bogaraveo* length data for Portugal continental. The procedure followed the ICES Technical guidance for providing reference points for stocks in categories 3 and 4 (ICES, 2017b). The L_{mat} and L_{inf} estimates were adopted from Krug (1990).

The length-weight relationship parameters ($W = 1.17542e\text{-}05 \times L^{3.0366}$) were estimated based on biological sampling data collected in 2020 and following the procedure in fishR Vignette (Ogle, 2013).

Selected indicators, reference points, indicator ratios and their expected values are presented in Table 2 (ICES, 2017b).

Table 2. Selected indicators for LBI screening plots (ICES, 2017b).

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%} / L_{inf}$	> 0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%} / L_{inf}$		
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3–0.4	Pmega	> 0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%} / L_{mat}$	> 1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	> 1	
L_{mean}	Mean length of individuals > L_c	$L_{opt} = {}^2/_3\ L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{max_y}	Length class with maximum biomass in catch	$Lopt = {}^2/_3\ L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > L_c	$L_{F=M} = (0.75L_c+0.25L_{inf})$	$L_{mean} / L_{F=M}$	≥ 1	MSY

2. Results and discussion

2.1. Fishery dependent data

2.1.1. Landings and mean price in continental Portugal

In the period between 2009 and 2020, the species was landed in all five NUTS II of the Portuguese continental coast (Figure 1). Landing ports in central Portugal (NUTS II "Centro") showed the highest landings in weight followed by the Algarve (South Portugal), that was around four times lower, and the North (NUTS II "Norte") that was up to 8 times lower. Similar proportions were found between the NUTS in terms of value of the species (Figure 2).

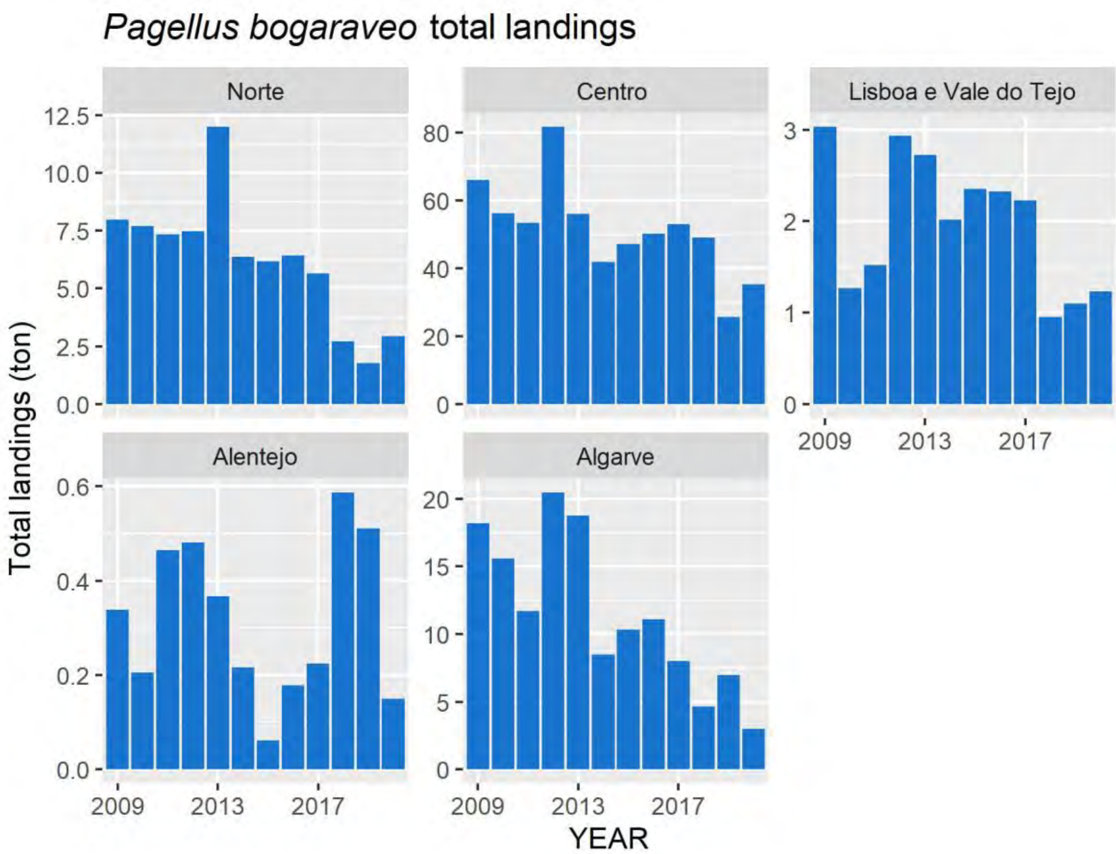

Figure 1. *Pagellus bogaraveo* total landings in tonnes in each NUTS II in continental Portugal between 2009 and 2020.

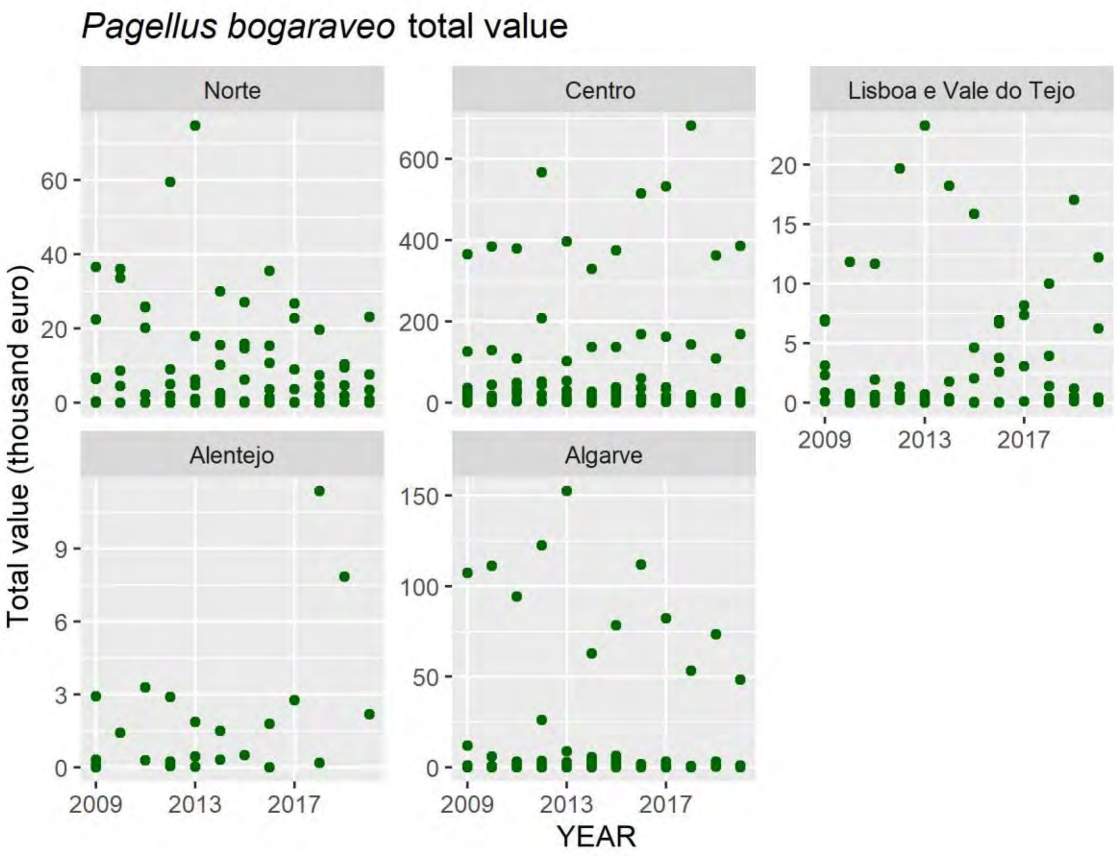

Figure 2. *Pagellus bogaraveo* total value in thousands of euros in each NUTS II in continental Portugal between 2009 and 2020.

In all NUTS II, the polyvalent fishing segment presented the highest landing values, followed by the trawl segment, with purse seine showing nearly negligible landings (Figure 3). These differences were more evident in central Portugal (NUTS II "Centro"), where the polyvalent represented around 60% of the species landings, the trawl segment represented nearly 40%, and the purse-seine fishery less than 1%.

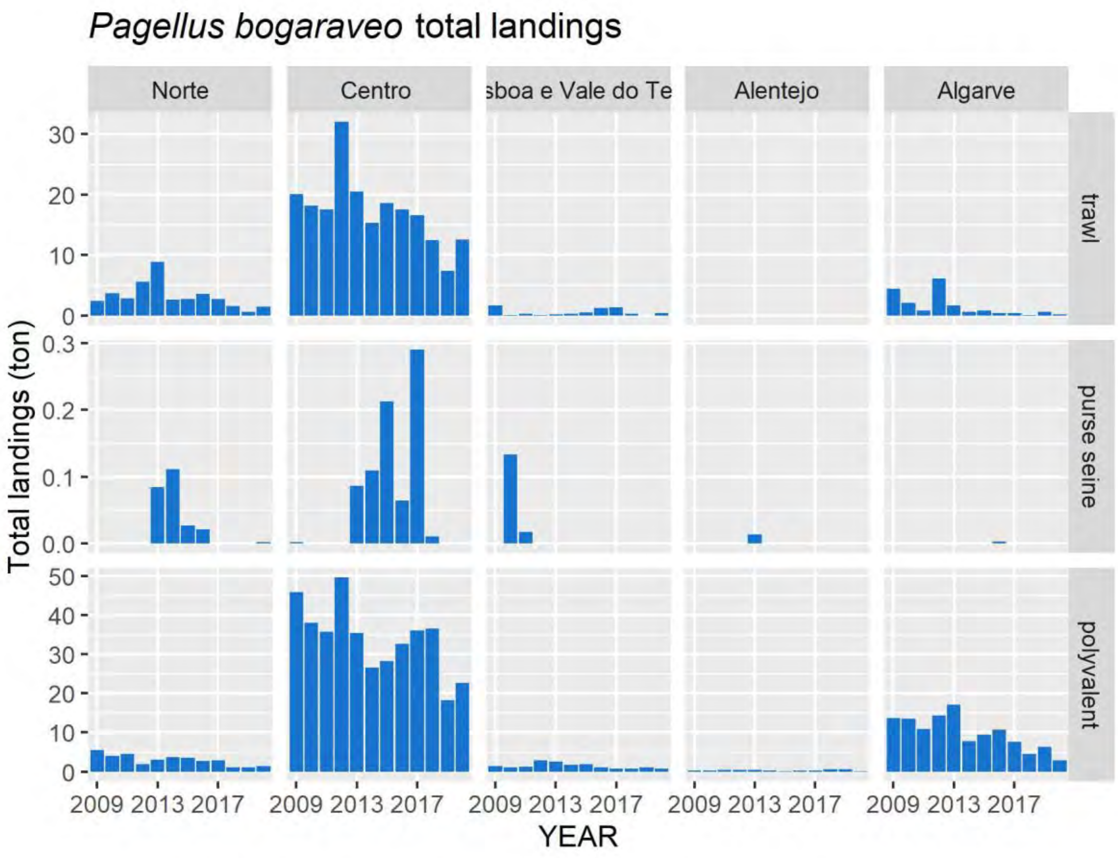

Figure 3. *Pagellus bogaraveo* total landings in tonnes by fishing segment (trawl, purse seine, and polyvalent) in each NUTS II in continental Portugal between 2009 and 2020.

The number of vessels landing *P. bogaraveo* was higher for the polyvalent fishing segment than for the trawl segment in all NUTS II (Figure 4). For the period between 2009 and 2019, a decreasing trend in the number of vessels landing the species was observed, which is probably associated with the continuous EU TAC reduction in Subarea 27.9 since 2004 (ICES, 2017a). However, the number of vessels landings *P. bogaraveo* has increased in 2020 in the North and Centre (NUTS II "Norte" and "Centro", respectively).

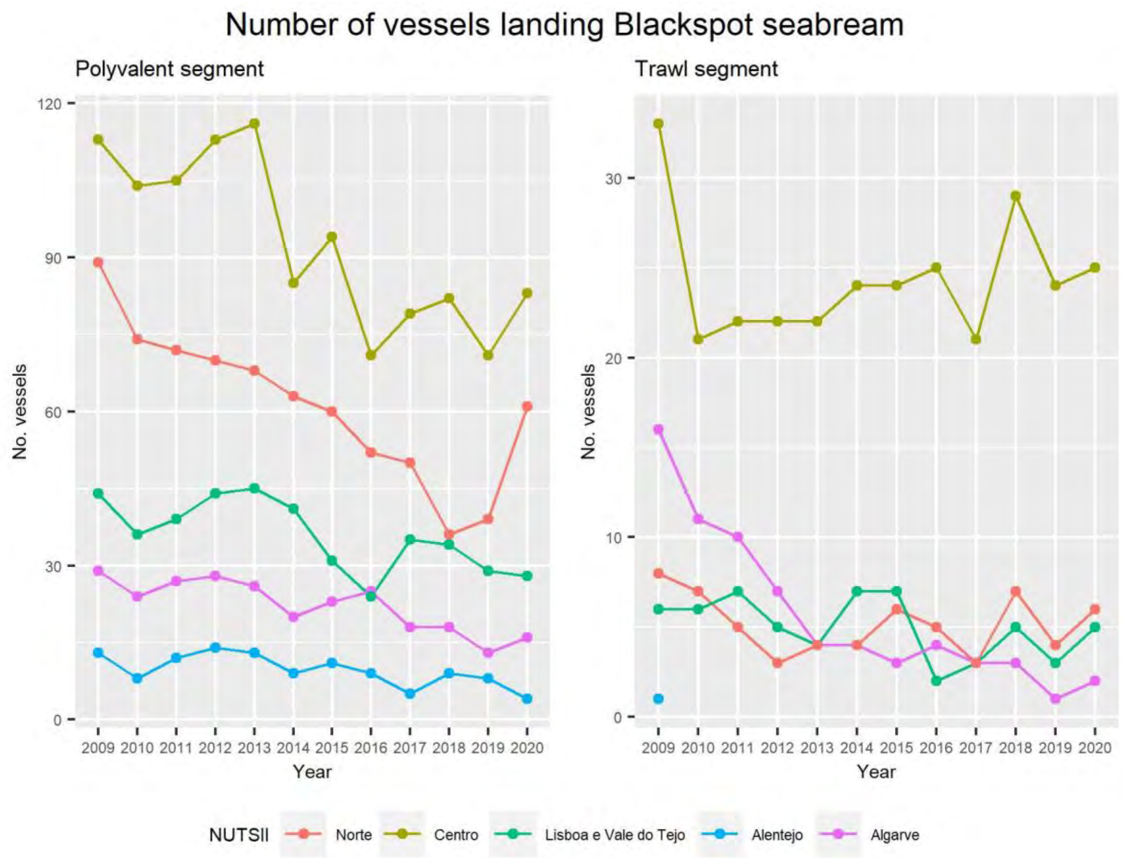

Figure 4. Number of vessels landing *Pagellus bogaraveo* in each NUTS II in continental Portugal, by year and by fishing segment (polyvalent and trawl), from 2009 to 2020.

2.1.2. Landings and mean price by fleet and selected NUTS II

Polyvalent fishing segment landings were higher in the winter months (late and early months of the year), more accentuated in the Centre region (NUTS II "Centro") (Figure 5). In the North (NUTS II "Norte") and Algarve, some years showed a peak in summer months but with little effect in terms of total landings when considering all the regions. From 2009 to 2020, there was a decreasing trend in the species landings in the three considered NUTS II.

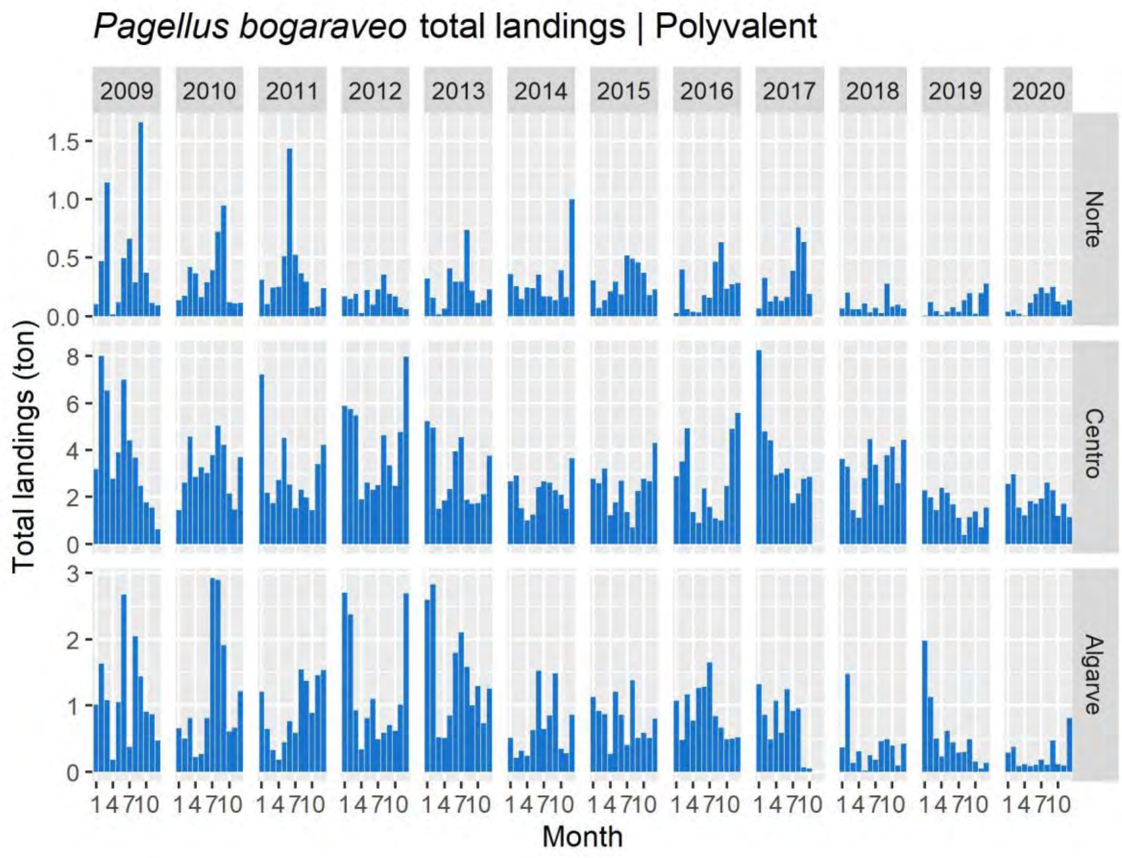

Figure 5. *Pagellus bogaraveo* landings (tons) from the polyvalent fleet by month and year at the three most important NUTS II in continental Portugal, from 2009 to 2020.

The trawl fishing segment shows a sharp decrease in total landings by month from 2013 to the 2020 (Figure 6). In the North (NUTS II "Norte") and in the Centre (NUTS II "Centro"), landings were also higher at the beginning and end of the year. In the South (NUTS II "Algarve"), landings occurred mainly in the summer months from, 2009 to 2016, and in the winter in later years.

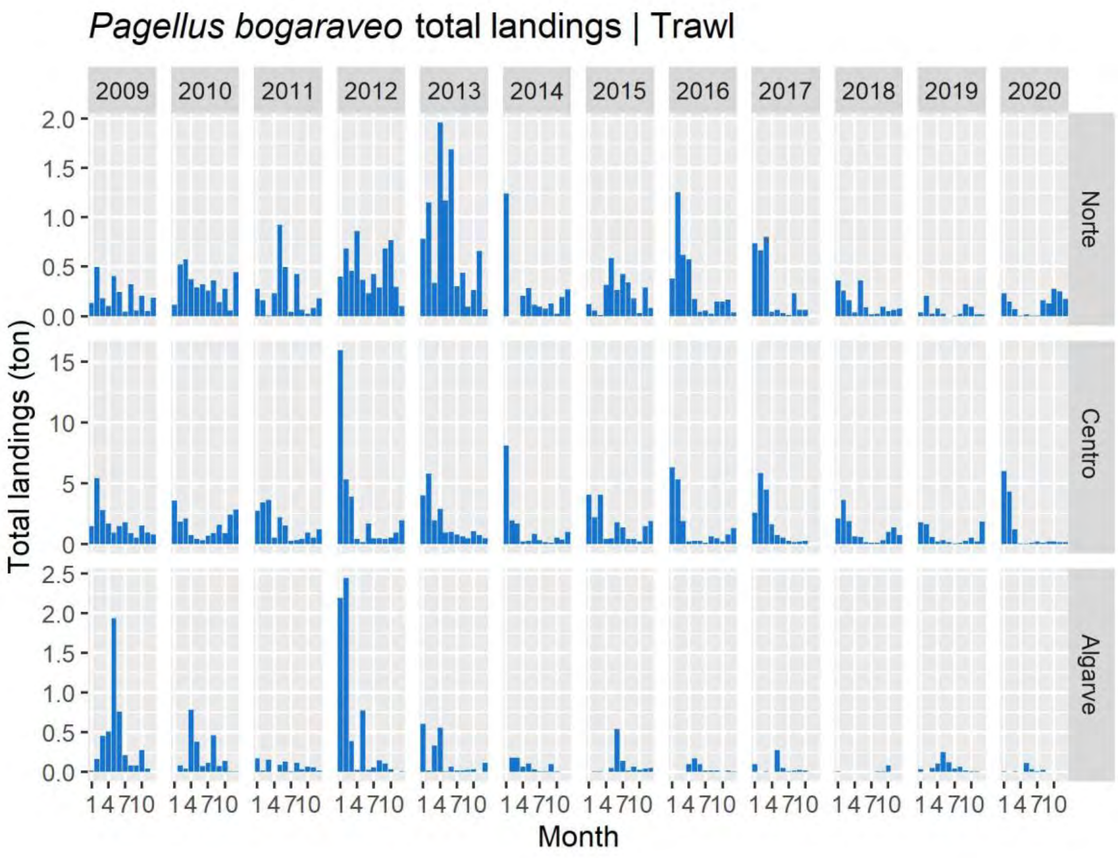

Figure 6. *Pagellus bogaraveo* landings (tons) from the trawl fleet by month and year at the three most important NUTS II in continental Portugal, from 2009 to 2020.

For the three main NUTS II, the mean price per Kg along the months of the year for the polyvalent fleet (Figure 7) and the trawl fleet (Figure 8) show variations and are more variable in the polyvalent segment and in the last months of the year, more markedly since 2015.

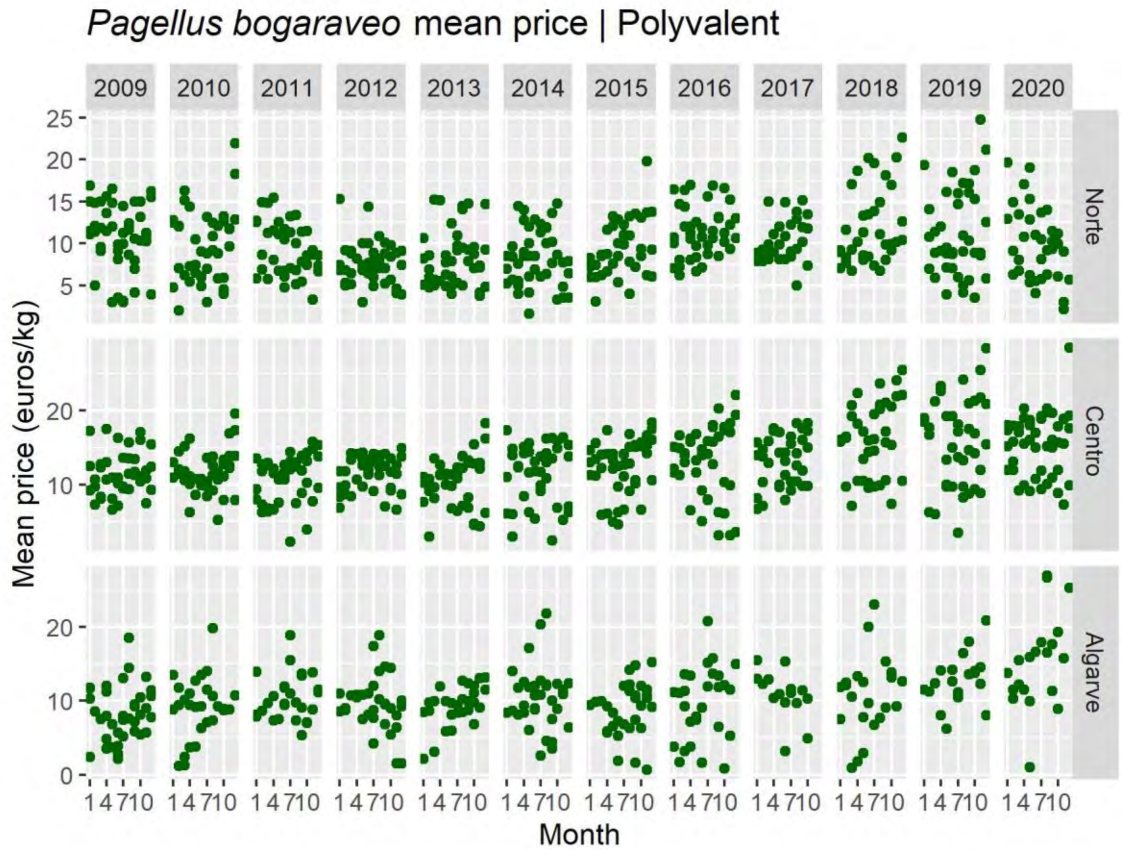

Figure 7. Mean price (in euro per Kg) of *Pagellus bogaraveo* landed by the polyvalent fishing segment by month and year for the three main NUTS II in continental Portugal between 2009 and 2020.

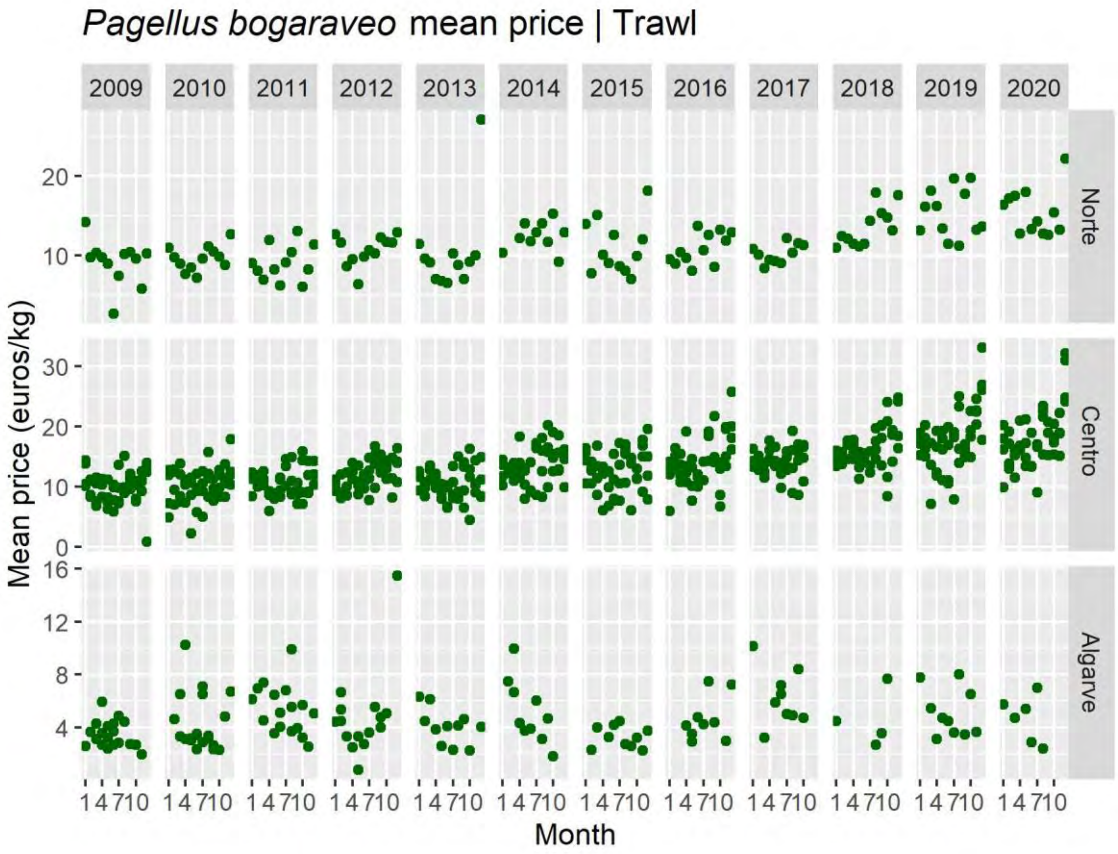

Figure 8. Mean price (in euro per Kg) of *Pagellus bogaraveo* landed by the trawl fishing segment by month and year for the three main NUTS II in continental Portugal between 2009 and 2020.

2.1.3. Landings in the most important Portuguese continental ports

P. bogaraveo landed weight by trip is presented in Figure 9 for the polyvalent segment and in Figure 10 for the trawl segment. Peniche port (Portuguese central western coast) was the most important landing port (landings between 1999 and 2020 represented nearly 50% of the Portuguese landings of the species in ICES Division 27.9.a) for both fishing segments. Extreme values were excluded from the plots for better visualization of data. In the later years, the highest landing values are registered between December and March.

P. bogaraveo total landings by most important ports and by fleet segment are summarised in Annex 1.

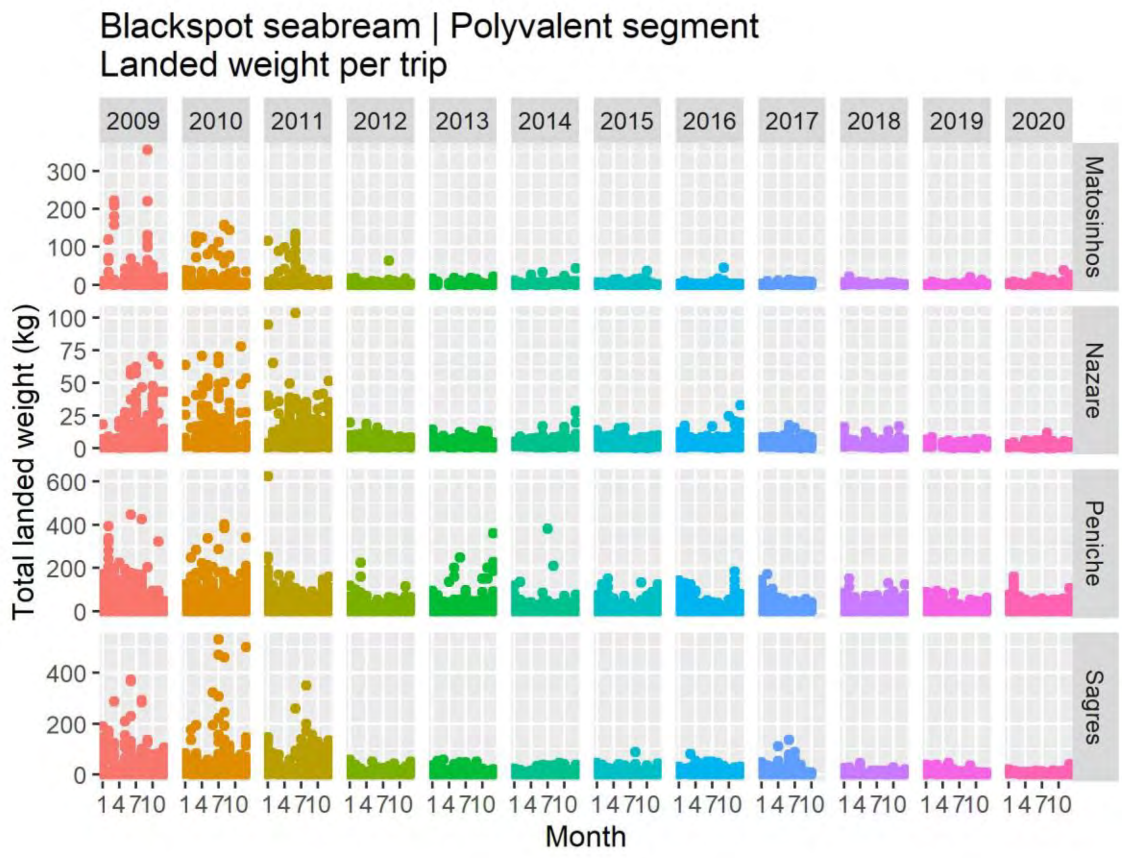

Figure 9. *Pagellus bogaraveo* total landed weight (kg) from the polyvalent fishing segment by month and year at the most important ports in Portugal continental, from 2009 to 2020.

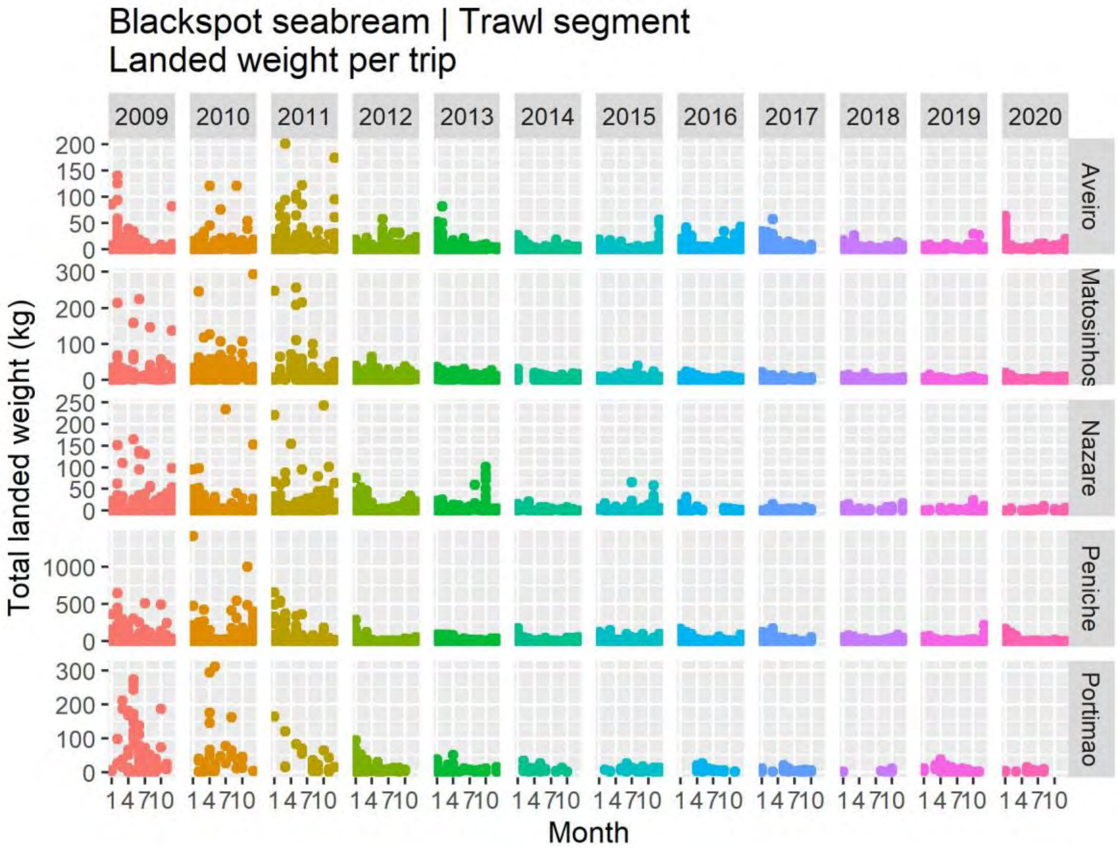

Figure 10. *Pagellus bogaraveo* total landed weight (kg) from the trawl fishing segment by month and year at the most important ports in continental Portugal, from 2009 to 2020.

2.2. LPUE

2.2.1. Reference fleet

A total of 40 fishing vessels were selected for the polyvalent fleet landing in Peniche port and a total of 21 fishing vessels were selected for the trawl fleet landing in Peniche port.

2.2.2. CPUE adjustment

GLM was adjusted to annual log-CPUE estimations for Peniche's polyvalent reference fleet considering a normal distribution and the identity link function. The GLM estimates of the annual CPUE for Peniche's polyvalent reference fleet for the selected model are presented in Figure 11 and Table 3. CPUE for the polyvalent reference fleet has been stable throughout the considered time period, showing a slight decreasing trend from 2017 to 2019, followed by a slight increase in 2020.

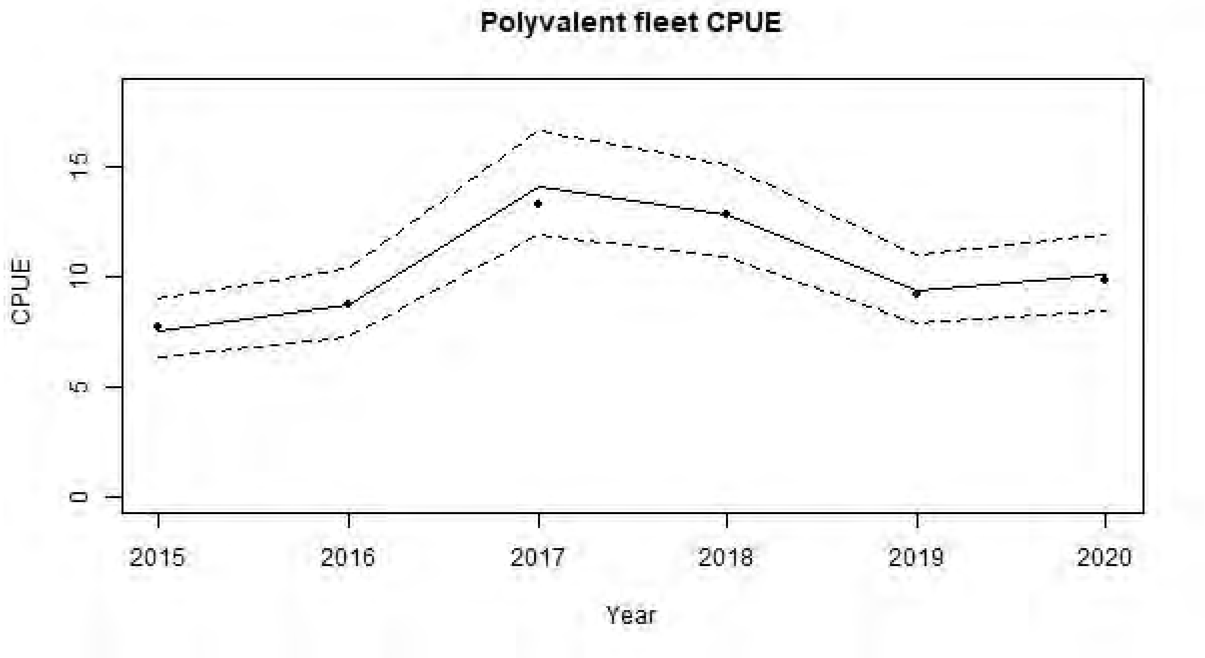

Figure 11. *Pagellus bogaraveo* standardized annual estimates of CPUE for Peniche polyvalent fishing segment reference fleet from 2015 to 2020.

Table 3. *Pagellus bogaraveo* CPUE series estimates for Peniche polyvalent reference fleet. 95% confidence interval.

Year	CPUE obs	CPUE pred. lower	CPUE pred	CPUE pred. upper
2015	7.72	6.37	7.59	9.05
2016	8.72	7.30	8.71	10.38
2017	13.30	11.94	14.11	16.69
2018	12.84	10.90	12.84	15.12
2019	9.19	7.92	9.35	11.04
2020	9.88	8.52	10.10	11.97

The analysis of the residuals of the fitted model is presented in Figure 12.

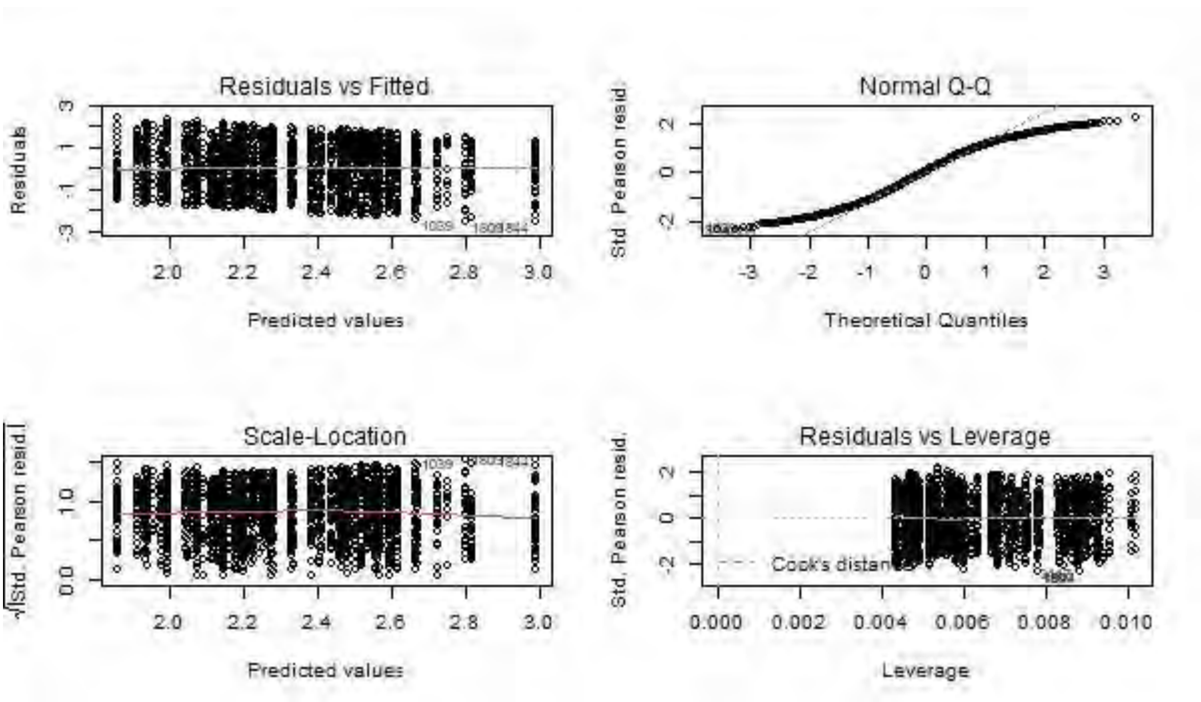

Figure 12. *Pagellus bogaraveo* analysis of the residuals of standardized annual estimates of CPUE for Peniche polyvalent fishing segment reference fleet from 2015 to 2020.

GLM was adjusted to annual log-CPUE estimations for Peniche's trawl reference fleet considering a normal distribution and the identity link function. The model was selected based on AIC and analysis of the residuals. The GLM estimates of the annual CPUE for Peniche's trawl reference fleet for the selected model are presented in Figure 13 and Table 4. CPUE for the trawl reference fleet has been relatively stable, with a slight fluctuation between 2015 and 2020.

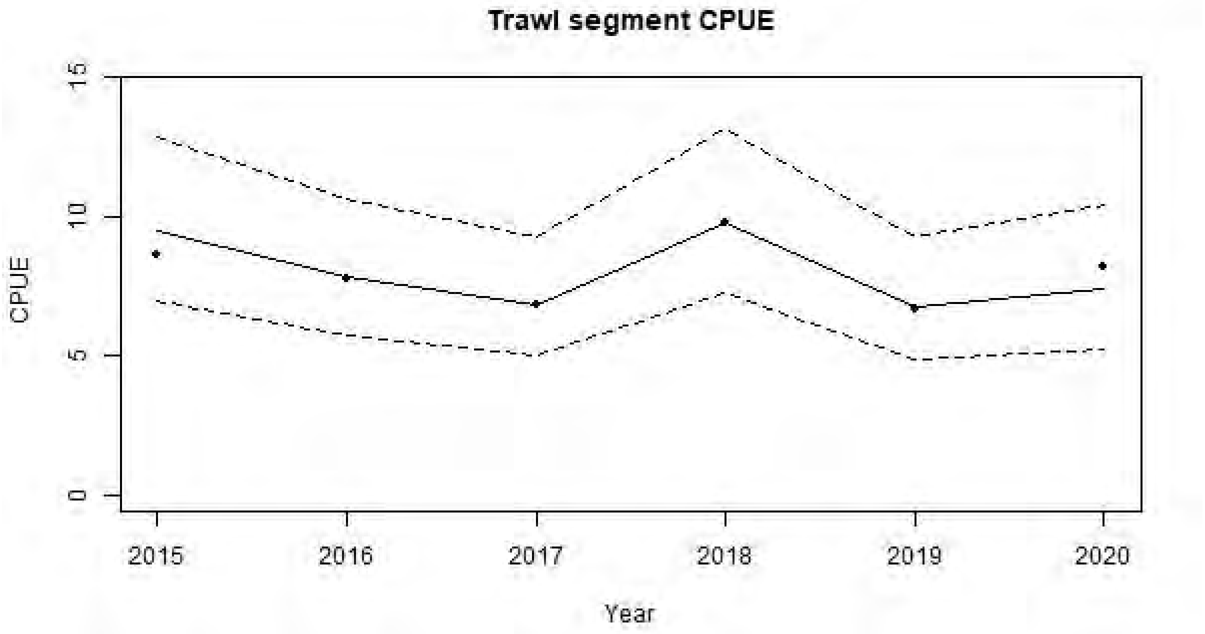

Figure 13. *Pagellus bogaraveo* standardized annual estimates of CPUE for Peniche trawl fishing segment reference fleet from 2015 to 2020.

Table 4. *Pagellus bogaraveo* CPUE series estimates for Peniche trawl reference fleet. 95% confidence interval.

Year	CPUE obs	CPUE pred. lower	CPUE pred	CPUE pred. upper
2015	8.65	6.99	9.49	12.89
2016	7.80	5.76	7.83	10.64
2017	6.85	5.04	6.84	9.29
2018	9.79	7.28	9.79	13.17
2019	6.68	4.88	6.72	9.26
2020	8.21	5.28	7.43	10.46

The analysis of the residuals of the fitted model is presented in Figure 14.

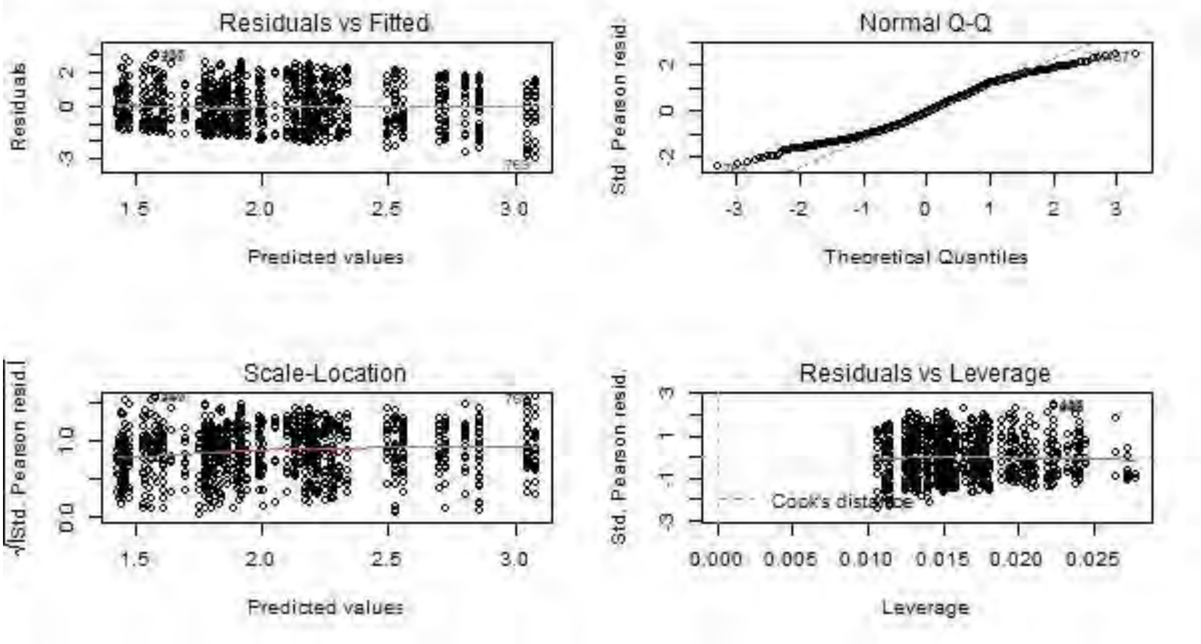

Figure 14. *Pagellus bogaraveo* analysis of the residuals of standardized annual estimates of CPUE for Peniche trawl fishing segment reference fleet from 2015 to 2020.

2.3. Length distribution

P. bogaraveo length distributions were extrapolated from DCF length sampling data available for the polyvalent (Figure 15) and the trawl (Figure 16) fishery segments for Portugal continental by year in the period between 2014 and 2020.

The smaller sizes are poorly represented probably because the minimum landing size of *P. bogaraveo* is 33 cm and the discards of specimens bellow that size are negligible given that the species shows a very high survival rate (Serra-Pereira et al., 2019).

In 2020, only 4 samples were measured from the polyvalent segment, which corresponded to 72 specimens, and only 4 samples from the trawl segment, which included 52 specimens.

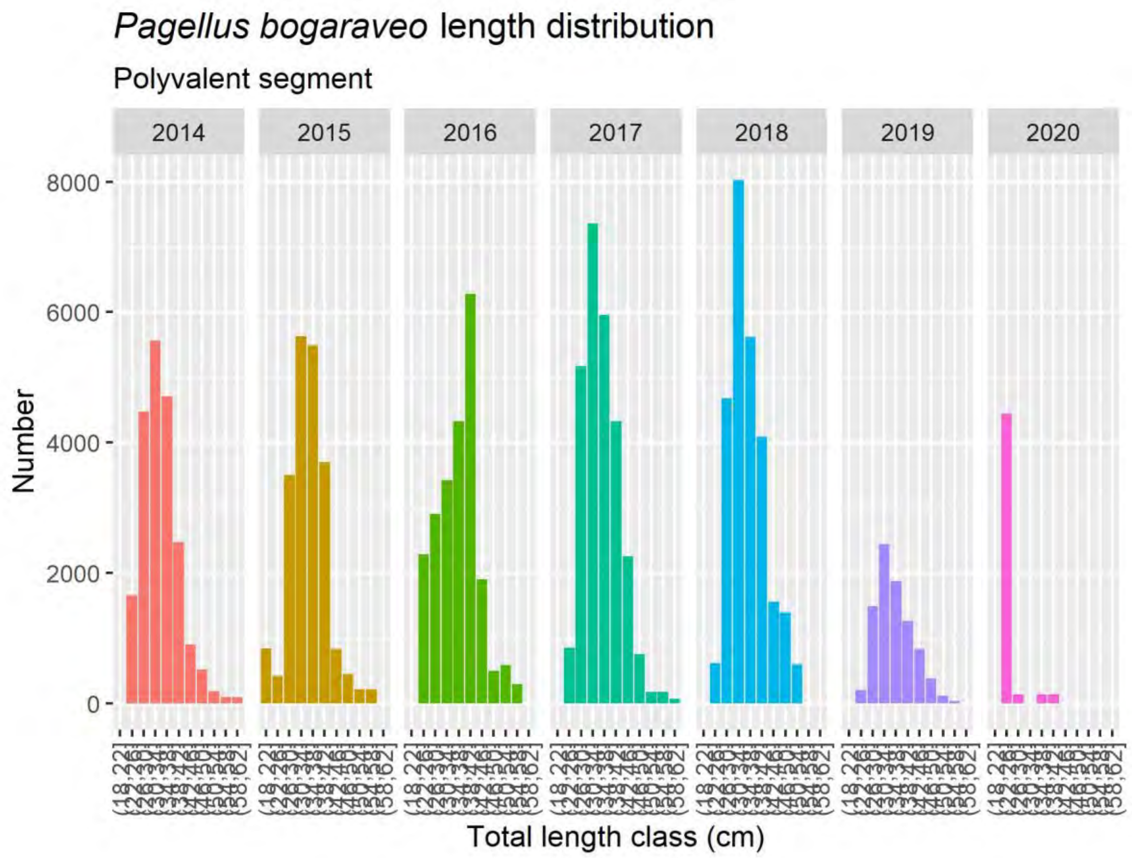

Figure 15. *Pagellus bogaraveo* extrapolated length frequency distributions for the polyvalent fishing segment for the years between 2014 and 2020. (4 cm total length classes)

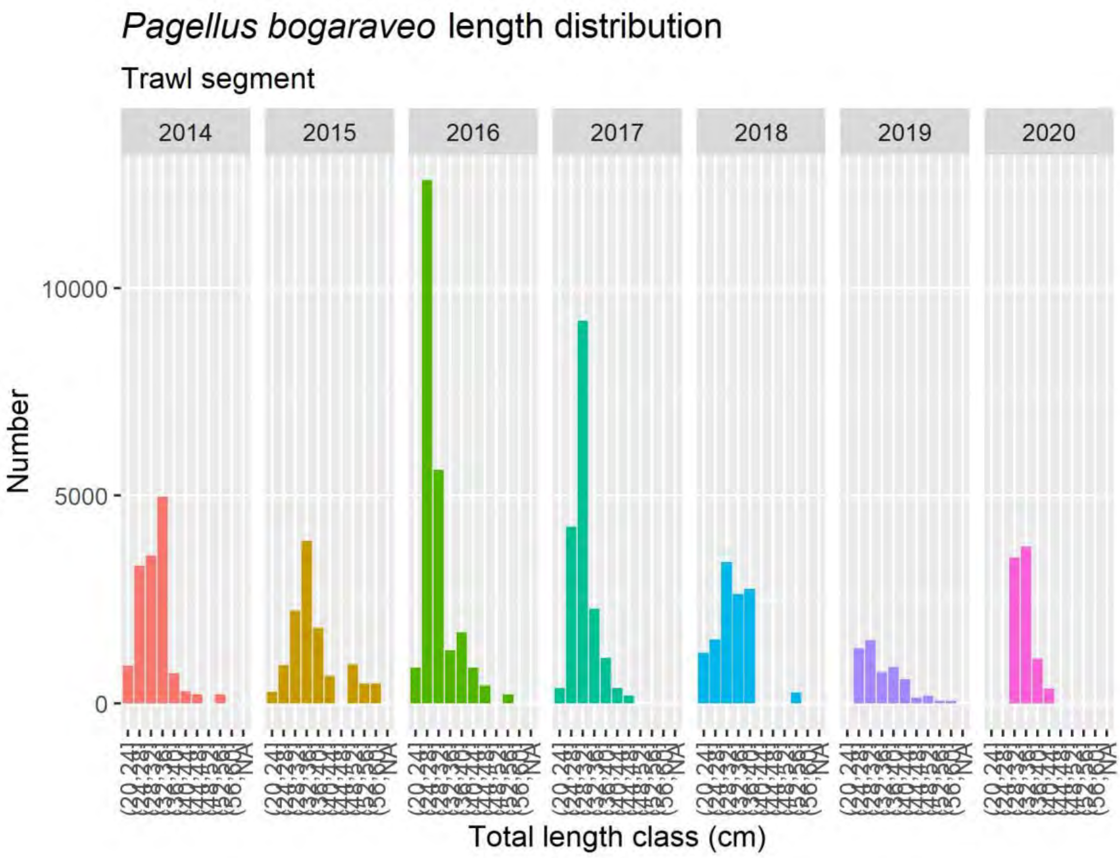

Figure 16. *Pagellus bogaraveo* extrapolated length frequency distributions for the trawl fishing segment for the years between 2014 and 2020. (4 cm total length classes)

Differences in length distribution between the polyvalent segment and the trawl segment result from the fact that polyvalent vessels operate in areas farther from the coast and at higher depths, where larger fish are more common (Farias et al., 2018).

2.4. LBI

Results from the LBI screening method are shown in Tables 5 and 6 and Figure 17. Nearly all LBI estimates decreased between 2019 and 2020.

Table 5. *Pagellus bogaraveo* in ICES Division 27.9.a. Results from LBI screening.

Year	L_{75}	L_{25}	L_{med}	L_{90}	L_{95}	L_{mean}	L_c	$L_{F=M}$	L_{maxy}	L_{mat}	L_{opt}	L_{inf}	$L_{max5\%}$
2014	36	29	33	39	42	33.39	26	35.42	34	39.1	42.45	63.68	46.88
2015	38	32	35	41	45	36.50	30	38.42	36	39.1	42.45	63.68	52.09
2016	38	27	31	42	45	33.52	26	35.42	40	39.1	42.45	63.68	49.58
2017	36	30	32	40	43	34.95	30	38.42	31	39.1	42.45	63.68	46.15
2018	38	31	34	41	44	35.78	30	38.42	37	39.1	42.45	63.68	47.60
2019	39	31	34	43	46	35.28	26	35.42	38	39.1	42.45	63.68	49.03
2020	34	25	32	37	38	33.35	26	35.42	34	39.1	42.45	63.68	41.42

Table 6. *Pagellus bogaraveo* in ICES Division 27.9.a. LBI screening ratios.

	Conservation						Optimizing Yield	MSY
	L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{95\%}/L_{inf}$	L_{maxy}/L_{opt}	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref.	> 1	> 1	> 0.8	≈ 1	> 0.8	>30%	≈ 1 (>0.9)	≥ 1
2014	0.66	0.74	0.66	0.80	0.74	2.5%	0.79	0.94
2015	0.77	0.82	0.71	0.85	0.82	4.8%	0.86	0.95
2016	0.66	0.69	0.71	0.94	0.78	3.5%	0.79	0.95
2017	0.77	0.77	0.68	0.73	0.72	1.8%	0.82	0.91
2018	0.77	0.79	0.69	0.87	0.75	2.8%	0.84	0.93
2019	0.66	0.79	0.72	0.90	0.77	4.0%	0.83	1.00
2020	0.66	0.64	0.60	0.80	0.65	0.00	0.79	0.94

Although some of the ratio estimates, particularly those of Conservation, are below the proposed expected values, MSY is consistence with an adequate exploitation.

Regarding the Conservation ratios, the results might reflect some of EU size measures, such as the adopted minimum landing size (MLS). L_c/L_{mat} and $L_{25\%}/L_{mat}$ estimates might be related with the fact that *P. bogaraveo* is a protandric hermaphrodite and the L_{mat} assumed in the screening was that of females, which is above the MLS.

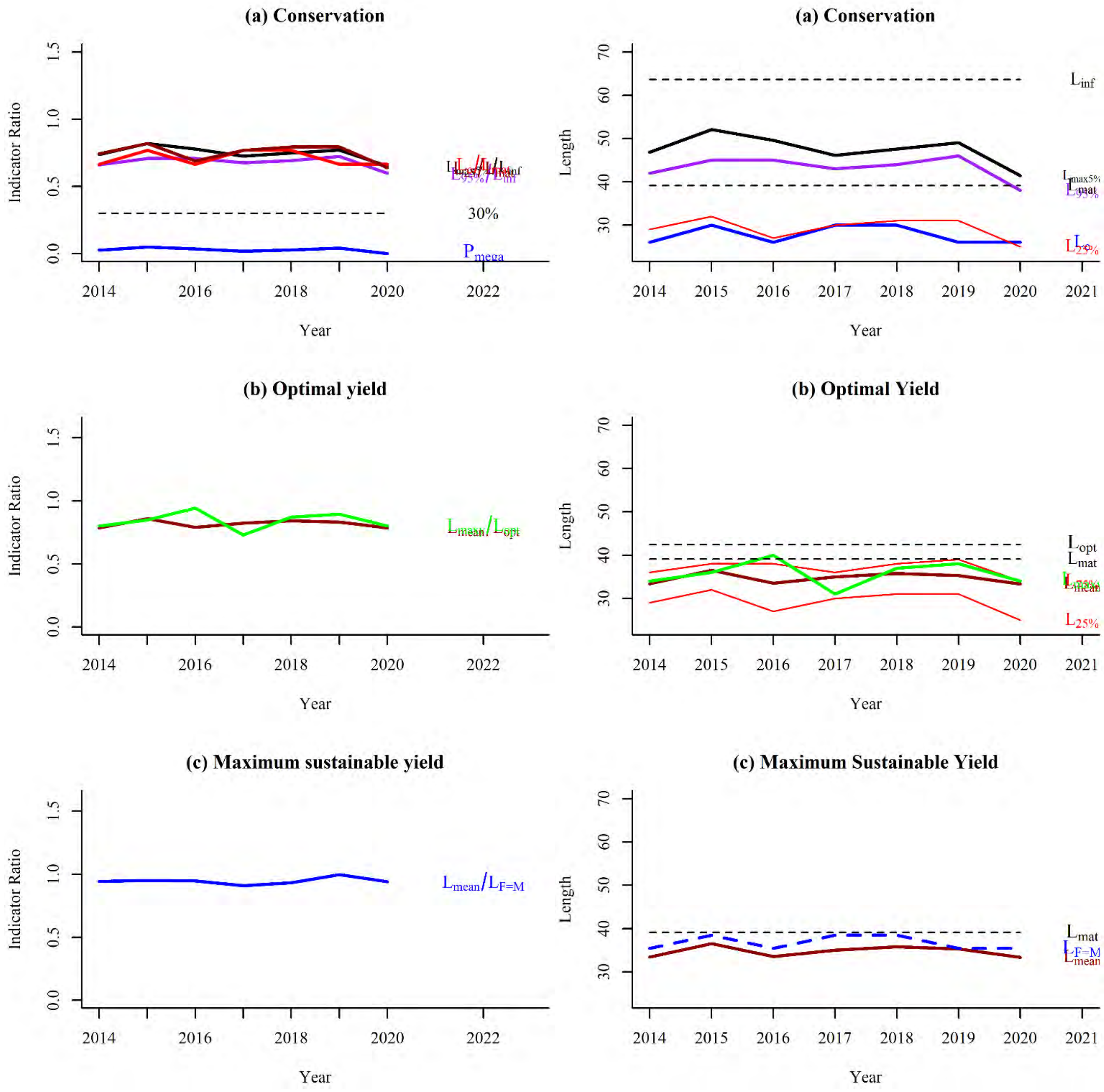

Figure 17. *Pagellus bogaraveo* in ICES Division 27.9.a. Results from LBI screening.

References

Araújo, G., Moura, T., Figueiredo, I. 2016. Notes on *Pagellus bogaraveo* in the Portuguese continental waters (ICES division IXa). Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources. Copenhagen, 20th -27rd April 2016.

Biagi, F., Gambaccini, S., Zazzeta, M. 1998. Settlement and recruitment in fishes: the role of coastal areas. Italian Journal of Zoology, 65(Suppl.): 269–274.

Desbrosses, P. 1932. La dorade commune (*Pagellus centrodontus*) et sa pêche. Revue du Travail de l'Office des Pêches maritime, 5: 167–222.

Farias, I., Araújo, G., Moura, T., Figueiredo, I. 2018. Notes on *Pagellus bogaraveo* in the Portuguese continental waters (ICES Division 9.a). Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources, Copenhagen, 11th-18th April 2018.

Farias, I., Figueiredo, I. 2019. *Pagellus bogaraveo* in Portuguese continental waters (ICES Division 27.9.a). Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources. Copenhagen, 2nd – 9th May 2019.

Félix-Hackradt, F.C., Hackradt, C.W., Treviño-Otón, J., Segovia-Viadero, M., Pérez-Ruzafa, A., García-Charton, J.A. 2013. Environmental determinants on fish post-larval distribution in coastal areas of south-western Mediterranean Sea. Estuarine, Coastal and Shelf Science, 129: 59 – 72.

Gil J., 2010. Spanish information about the red seabream (*Pagellus bogaraveo*) fishery in the Strait of Gibraltar region. A CopeMed II contribution to the SRWG on shared demersal resources. Ad hoc scientific working group between Morocco and Spain on Pagellus bogaraveo in the Gibraltar Strait area (Málaga, Spain. 22 July, 2010). GCP/INT/028/SPA-GCP/INT/006/EC. CopeMed II Occasional Paper No 2: 30 pp.

Gil, J., Rueda, L., Burgos, C., Farias, C., Arronte, J.C., Acosta, J.J., Soriano, M. 2019. The Blackspot seabream Spanish target fishery of the Strait of Gibraltar: updating the available information. Working Document presented to the ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (ICES WGDEEP 9, Copenhagen, 2 – 8 May 2019.

Gil, J., Sobrino, I. 2001. Studies on reproductive biology of the red (blackspot) seabream [*Pagellus bogaraveo* (Brunnich, 1768)] from the Strait of Gibraltar (ICES 9a/SW Spain). Sci. Counc. Res. Doc. NAFO. No. 01/86, 6 pp.

ICES. 2007. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP). ICES CM 2007/ACFM: 20. 478 pp.

ICES. 2017a. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 24 April–1 May 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:14. 702 pp.

ICES. 2017b. ICES Technical guidance for providing reference points for stocks in categories 3 and 4. ICES Technical Guidelines.

Krug, H. 1990. The Azorean blackspot seabream, *Pagellus bogaraveo* (Brunnich, 1768) (Teleotei, Sparidae). Reproductive cycle, hermaphroditism, maturity and fecundity. Cybium, 14: 151 – 159.

Lorance P., 2011. History and dynamics of the overexploitation of the blackspot seabream (*Pagellus bogaraveo*) in the Bay of Biscay. ICES J. Mar. Sci. 68, 290–301.

Martins, A.M., Amorim, A.S.B., Figueiredo, M.P., Souza, R.J., Mendonça, A.P., Bashmachnikov, I.L., Carvalho, D.S. 2007. Sea surface temperature (AVHRR, MODIS) and ocean colour (MODIS) seasonal and interannual variability in the Macaronesian islands of Azores, Madeira, and Canaries. In Proceedings SPIE on Remote Sensing of the Ocean, Sea Ice and large Water Regions. 10 October, 6743, 67430A, 15 pp.

Menezes, G., Rogers, A., Krug, H., Mendonça, A., Stockley, B. M., Isidro, E., Pinho, M. R., Fernandes, A. 2001. Seasonal changes in biological and ecological traits of demersal and deep-water fish species in the Azores. Final Report European Commission DGXIV/C/1 Contract 97/081. University of the Azores, Faial, Azores, Portugal, pp 1–162 plus appendices.

Ogle, D. 2013. fishR Vignette - Length-Weight Relationships, December 16.

Pinera, J.A., Blanco, G., Vazquez, E., Sanchez, J.A. 2007. Genetic diversity of blackspot seabream (*Pagellus bogaraveo*) populations off Spanish Coasts: a preliminary study. Marine Biology 151: 2153-2158.

Robalo, J.I., Farias, I., Francisco, S.M., Avellaneda, K., Castilho, R., Figueiredo, I. 2021. Genetic population structure of the Blackspot seabream (*Pagellus bogaraveo*): contribution of mtDNA control region to fisheries management, Mitochondrial DNA Part A, DOI: 10.1080/24701394.2021.1882445

Pinho, M. R., Menezes, G. 2005. Azorean Deepwater Fishery: Ecosystem, Species, Fisheries and Management Approach Aspects. Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries, Conference Poster and Dunedin Workshop Papers. FAO Fish. Proc. 3/2.

Serra-Pereira, B., Tomé, P., Bento, T., Farias, I., Figueiredo, I. 2019. Blackspot seabream (*Pagellus bogaraveo*) in Portugal continental (ICES Division 27.9.a): fisheries characterization and survivability experiments. Working Document presented to the ICES Working Group on the

Biology and Assessment of Deep-Sea Fisheries Resources (ICES WGDEEP 9, Copenhagen, 2 – 8 May 2019.

Stockley, B., Menezes, G., Pinho, M.R., Rogers, A.D. 2005. Genetic population structure in the blackspot sea bream (*Pagellus bogaraveo* Brünnich, 1768) from the NE Atlantic. Marine Biology 146: 793–804.

ANNEX I

Table 7. *Pagellus bogaraveo* total landed weight (ton) by fleet segment in the six most important landing ports for the species. Ports are organized by NUTS II.

		North			Centre				Lisbon Metrop. Area	Algarve	
Year	Gear	Matosinhos	Povoa do Varzim	Viana do Castelo	Aveiro	Figueira da Foz	Nazare	Peniche	Sesimbra	Sagres	Portimao
2009	Polyvalent	4.24	0.66	0.5734	0.06	0.43	3.42	41.98	0.59	13.47	0.05
	Trawl	2.43	-	-	1.43	0.64	2.69	15.32	1.55	-	4.32
2010	Polyvalent	2.64	0.45	0.8427	0.09	0.50	3.83	33.65	0.91	13.33	0.05
	Trawl	3.73	-	-	1.12	1.05	1.47	14.50	0.05	0.00	1.90
2011	Polyvalent	2.27	0.34	1.8148	0.52	0.20	3.92	31.09	0.97	10.63	0.20
	Trawl	2.90	-	-	3.03	0.79	2.32	11.43	0.32	-	0.74
2012	Polyvalent	1.03	0.29	0.5313	0.53	0.24	3.99	44.85	2.18	13.88	0.05
	Trawl	5.56	-	-	3.63	1.80	5.33	21.29	0.09	-	6.14
2013	Polyvalent	1.55	0.52	0.6831	0.74	0.10	2.60	32.05	2.21	16.70	0.03
	Trawl	8.91	-	-	4.79	1.51	3.34	10.89	0.18	-	1.73
2014	Polyvalent	1.05	0.35	1.9169	0.36	0.02	1.80	24.36	1.55	6.89	0.41
	Trawl	2.62	-	-	1.09	0.48	1.11	12.61	0.31	-	0.62
2015	Polyvalent	1.32	0.80	1.3293	0.55	0.06	2.82	24.88	1.46	8.65	0.07
	Trawl	2.70	-	-	1.99	0.93	1.38	14.30	0.51	-	0.90
2016	Polyvalent	0.86	0.35	1.3854	0.34	0.09	2.28	29.87	0.49	10.45	0.02
	Trawl	3.62	-	-	3.68	0.70	0.95	12.26	1.26	-	0.40
2017	Polyvalent	1.73	0.43	0.775	0.55	0.09	2.43	33.04	0.58	7.35	-
	Trawl	2.71	-	-	2.78	1.12	0.57	12.09	1.41	-	0.46
2018	Polyvalent	0.54	0.19	0.4024	0.20	0.02	1.02	35.40	0.52	4.50	0.00
	Trawl	1.58	-	-	1.07	1.10	0.60	9.66	0.28	-	0.09
2019	Polyvalent	0.49	0.23	0.3601	0.31	0.03	0.49	17.35	0.95	6.25	-
	Trawl	0.63	-	-	0.58	0.44	0.35	6.08	0.02	-	0.66
2020	Polyvalent	0.90	0.14	0.3199	1.37	0.04	0.53	20.72	0.73	2.60	0.10
	Trawl	1.46	-	-	1.51	0.40	0.12	10.54	0.46	-	0.17

Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources

Copenhagen, 22nd April – 28th April 2021

Demographic analysis of *Pagellus bogaraveo* population in Portuguese continental waters

(ICES Division 27.9.a)

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1. Introduction

Pagellus bogaraveo (Brünnich, 1768), the blackspot seabream, occurs between southern Norway and Cape Blanc, in the Mediterranean Sea, and in the Azores, Madeira, and Canary Archipelagos (Desbrosses, 1932; Pinho and Menezes, 2005). The blackspot seabream is a protandric hermaphrodite; individuals are first functional males and then develop into functional females (Buxton and Garratt, 1990; Krug, 1990; Gil, 2006). Spawning occurs in shallow waters and later, juveniles (with sizes around 150 to 180 mm total length, TL) migrate down to depths deeper than 200 m (Desbrosses, 1932).

In the Northeast Atlantic, *P. bogaraveo*'s stock structure is still unknown. ICES adopted, for management purposes, three management units: (a) Subareas 27.6, 27.7, and 27.8; (b) Subarea 27.9; and (c) Subarea 27.10 (Azores) (ICES, 2007). The definition of these management units was performed as way to better record the fishery information available and do not have implicit the existence of three different stocks of *P. bogaraveo*.

At the northern part of the ICES 27.9 management unit (continental Portugal) information of species spatial dynamics suggests the inexistence of movements between the northernmost and the southern part, where a target fishery takes place in the Strait of Gibraltar (ICES, 2019). In continental Portugal, the blackspot seabream is mainly caught as by-catch of fisheries although targeting occurs for some vessels. Peniche (Portuguese central western coast) is the most important landing port. For this area, fishery data on *P. bogaraveo* as well as information collected through enquiries made to Peniche skippers (Araújo et al., 2016) showed that:

(i) the species tends to gather at specific fishing grounds with particular seamount-like topographic features, being mainly caught at depths around 250 m;

(ii) the fishing grounds substrates are mainly composed by muddy sand, rock, and sand;

(iii) the species length range is similar between the different fishing grounds.

Information on blackspot seabream collected from 1990 to 2018 in the Portuguese Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) and the Portuguese Autumn Groundfish Surveys (PT-GFS) conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA) supports the hypothesis of a patchy distribution, as the species is more frequently caught at specific grounds (Farias and Figueiredo, 2019).

Given the inexistence of fishery independent data and the lack of long-term species-specific data for ICES 27.9 management unit, ICES advice has been based on biomass trend analysis derived exclusively from the Spanish target fishery, the "voracera" (ICES, 2020). The perception of stock status that supports ICES advice does not consider the aggregative characteristics of species spatial dynamics, although there are clear evidences that the species is capable of completing its life cycle in areas of higher aggregation. In those areas, the demographic structure includes all the ontogenic stages of the species' life cycle.

Demographic models provide an opportunity for better understanding dynamics of species populations even when limited data are available. Demographic analysis differs from traditional full stock assessment since the input is only biological information and it cannot make the harvest control rule or total annual catch directly (Geng et al., 2021). The principle for demographic analysis is changing harvest survival rate based on different management strategy, and finding a maximum harvest rate (HMSY) leading to a population growth rate (λ) equal to one where the stock can be sustained. These models allow the estimation of a variety of parameters that summarise a population's growth rate, generation length, reproductive outputs and stable-age distribution. In particular, matrix demographic models can be structured to examine either stage or age-classes – allowing them to be tailored to the information available – and the elasticities of individual matrix elements can provide useful information on the ages or life stages that will respond best to management measures (Heppell et al., 2000). In these models, λ is the dominant eigenvalue and the stable age or stage distribution and reproductive values are the corresponding right and left eigenvectors, respectively. The finite rate of population growth can be related to the intrinsic rate of population growth (r) as

$$\lambda = e^{r}.$$

Population growth is stable when λ=1, decreasing when λ<1 and increasing when λ>1 (Smart et al., 2017).

The present work uses static demographic models constructed using only life history parameters to provide management-relevant information on species, namely to assess the potential effects on the adoption of different management strategies.

2. Methodology

Life history parameters

Life history parameters relevant for the species were extracted from the literature to form the foundation of vital rates to use in demographic analyses (Table 1). Vital rates were defined as lower level components of the demographic estimates that underlie the stage matrix elements (Brault and Caswell, 1993).

Natural mortality and survivorship estimation

Natural mortality (M) was estimated using indirect methods. These included the age-independent equation proposed by Hewit and Hoenig (2005) invariant method and age-dependent method proposed by Charlov et al. (2012):

$$M_l = k\left(\frac{l}{L_\infty}\right)^{-1.5} = k\left(\frac{L_\infty}{l}\right)^{1.5}$$

where M_a is mortality at length l, k is the individual growth rate and L_∞ is the maximum body size (the last two are estimated from fitting the von Bertalanffy growth equation).

Estimates of natural mortality were used to calculate the stage specific natural mortality (M_{st}), which, in the case of varying natural mortality of a specific stage, is a weighted mean of number of specimens in the stage. The survival probability of stage-specific (S_{st}) was determined as

$$S_{st} = e^{-M_{st}}$$

Stage transition

For each stage, the individuals in one stage of the demographic matrix can survive in one of two ways: stay in the same stage, or transit to the next stage. The probability of staying in the same stage after one year is the time lag used in the present analysis and the probability of moving on to the next stage is calculated using the von Bertalanffy growth parameters from Gil (2006),

$$L_t = 58 \times \left(1 - e^{-0.169(t-(-1.1674))}\right).$$

Sex change

Within each stage the probability of males changing to females was estimated based on Krug (1998),

$$P_f = \frac{e^{-7.55+0.251L_F}}{1 + e^{-7.55+0.251L_F}}$$

where L_F is the fork length, which was converted to total length using $L_T = 1.13\ L_F - 0.04$ (Krug, 1989).

Reproduction

The annual contribution of new elements to the population was exclusively based on the mean number of eggs laid per female, by length class weighted by the number of elements in length classes from stage IV. The mean number of eggs laid by female is a function of length and was calculated using the expression from Krug (1989),

$$F = 1028.44\ e^{0.15L_F}$$

Demographic matrix model

A stage-structured matrix (Lefkovitch matrix) was built with the purpose of describing how blackspot seabream population changes over time as a function of the average vital rates. In this study, year is the time-lag unit considered for different stage-classes. Additionally, the impacts due to the density dependence on the vital parameters were not considered.

Blackspot seabream stage matrix model was constructed using the modular approach proposed by Buckland et al. (2004) and by considering a population vector of four stage classes: juvenile males with total length (TL) lower than 30 cm (n_1); males with TL varying between 30 and 39 cm; females with lengths varying between 30-39 cm and mature females with length larger than 39 cm.

For modelling the blackspot seabream population four sub-processes were considered: fertility (γ), survival (φ), growth (β), and sex change (α). It is assumed that sub-processes occur sequentially according to the following order Survival -> Growth -> Sex change -> Reproduction.

Following this modular approach, the population matrix is translated as

$$\begin{bmatrix} (1-\beta_1)\varphi_1 & 0 & \varepsilon\gamma_1\beta_3\varphi_3 & \varepsilon\gamma_1\varphi_4 \\ (1-\alpha)\beta_1\varphi_1 & (1-\alpha)\varphi_2 & 0 & 0 \\ \alpha\beta_1\varphi_1 & \alpha\varphi_2 & (1-\beta_3)\varphi_3 & 0 \\ 0 & 0 & \beta_3\varphi_3 & \varphi_4 \end{bmatrix}$$

where ε is the probability of surviving the first stage and entering the following stage.

Monte Carlo simulations

The estimates of vital rates are difficult to obtain and are subject to high uncertainty (Caswell et al., 1997). In the present work, uncertainty on vital rates was incorporated into demographic analyses. Monte Carlo simulations were used to stochastically vary specific vital rates and, by that, incorporate uncertainty into matrix projections and demographic parameters. This was done by randomly selecting vital rates from assumed statistical distributions and then perform demographic analyses for 10,000 simulations.

Management scenarios

The impact on fishing mortality on the population evolution in all stage-classes excluding the first class was evaluated by considering different stage-independent mortality rates (F), which were incorporated into the survivorship elements of the demographic matrix as:

$$S_{st} = e^{-(M_{st}+F)}$$

The effects of a stage-independent F were examined by calculating the limiting level of F that produces a stable population. This was estimated by systematically increasing F equally across all stages, excluding the first (which includes specimens with size lower than the minimum landing size adopted for the species). The exclusion of the first stage class is justified by the technical management, minimum landing size, settled by the EU (2019).

3. Results

Under the two different natural mortality estimation procedures (*i.e.*, constant survivorship and size-varying survivorship) the proportion of individuals in each stage class are presented (Fig. 1 and 2).

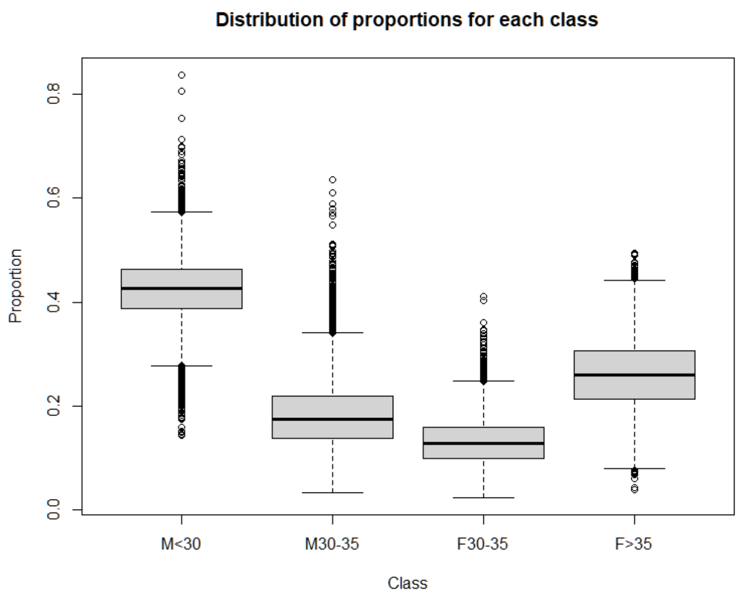

Figure 1. Distribution of proportions by stage class for invariant natural mortality.

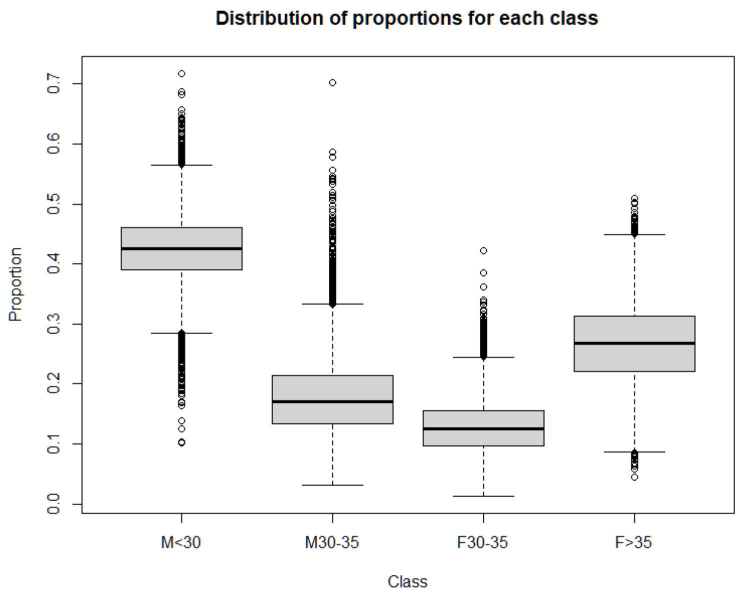

Figure 2. Distribution of proportions by stage class for size-varying survivorship.

Under different fishing mortalities, the 95% interquantile intervals of λ are presented for the two survivorships considered (Fig. 3 and 4).

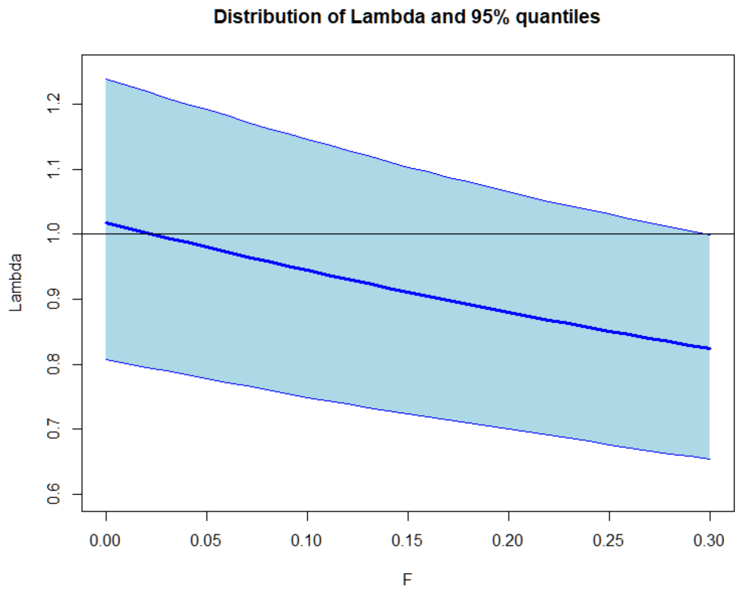

Figure 3. The relationship between the finite rate of population increase (λ) and instantaneous fishing mortality (F) for invariant survivorship. The shaded areas represent the 95% interquartile interval of the Monte Carlo simulations.

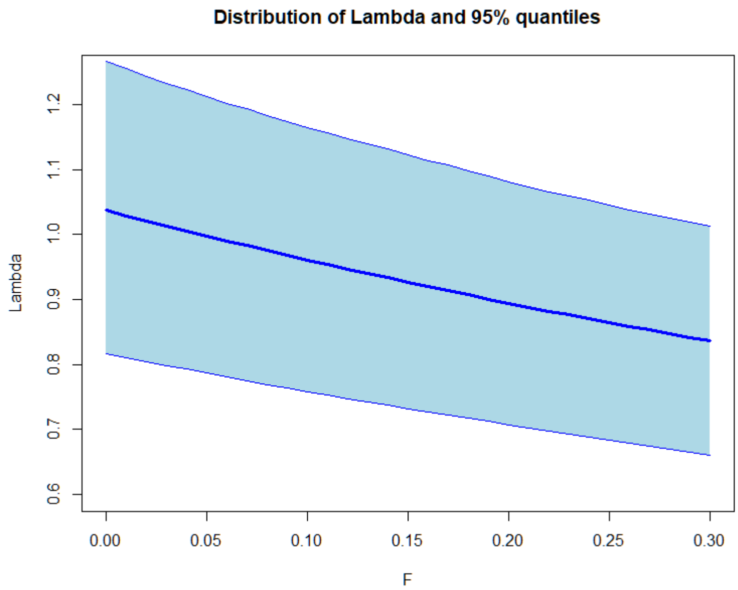

Figure 4. The relationship between the finite rate of population increase (λ) and instantaneous fishing mortality (F) for size-varying survivorship. The shaded areas represent the 95% interquartile interval of the Monte Carlo simulations.

The demographic estimates under different stage-independent fishing mortalities are presented in Table 1.

Table 1. Demographic estimates under different stage-independent fishing mortalities. Values in parentheses are the 95% interquartile interval of the Monte Carlo simulation.

Fishing mortality	Constant M	Variable M
0	1.02 (0.81 - 1.25)	1.04 (0.82-1.27)
0.01	1.01 (0.80 - 1.24)	1.03 (0.81-1.26)
0.05	0.98 (0.78 - 1.20)	1.00 (0.79-1.21)
0.1	0.95 (0.75 - 1.16)	0.96(0.76-1.16)
0.15	0.91 (0.73 - 01.12)	0.93 (0.73-1.12)
0.2	0.88 (0.70 -1.076)	0.89 (0.71-1.08)
0.3	0.83 (0.66 - 1.01)	0.84 (0.66-1.01)

Table 2 shows the proportion of $\lambda \geq 1$ in 10,000 simulations for the different F considered for the two different natural mortality estimation procedures (*i.e.*, constant survivorship and size-varying survivorship).

Table 2. Proportion of $\lambda \geq 1$ in 10,000 simulations for the different F considered for constant survivorship (Constant M) and size-varying survivorship (Variable M).

F	Constant M	Variable M
0	0.56	0.62
0.02	0.51	0.57
0.03	0.48	0.54
0.04	0.44	0.51
0.05	0.42	0.49
0.07	0.37	0.43
0.09	0.32	0.37

4. Discussion

The present work is preliminary and allowed us to perceive the impacts of different fishing scenarios on the finite rate of population increase. The results obtained led us to question the vital rates included as input in the demographic matrix, taking into consideration the fact that these estimates were derived from studies carried out on highly exploited populations (Azores and Strait of Gibraltar). The F values found were quite low when compared with growth rate of the species as well as the F reference values determined in other studies for congener species.

Finally, the stability of the index of biomass in recent years (2015-2020) derived for the reference fleet in continental Portugal (Farias and Figueiredo, 2021 WD) associated with low EU quotas assigned for Portugal will be considered in the next steps of the analysis. In particular, the analysis of vital parameters will be considered and contrasted with the length distribution of the population in Portuguese continental waters.

References

Araújo, G., Moura, T., Figueiredo, I. 2016. Notes on *Pagellus bogaraveo* in the Portuguese continental waters (ICES division IXa). Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources. Copenhagen, 20th -27th April 2016.

Brault, S., Caswell, H. 1993. Pod-specific demography of killer whales (*Orcinus orca*). Ecology, 74(5), 1444-1454. https://doi.org/10.2307/1940073

Buckland, S.T., Newman, K.B., Thomas, L., Koesters, N.B. 2004. State-space models for the dynamics of wild animal populations. Ecological Modelling 171(1–2), 157-175. https://doi.org/10.1016/j.ecolmodel.2003.08.002

Buxton, C. D., and Garratt, P. A. 1990. Alternative reproductive styles in seabreams (Pisces: Sparidae). Environmental Biology of Fishes, 28: 113–124. https://doi.org/10.1007/BF00751031

Caswell, H., S. Brault, A. J. Read, T. D. Smith. 1998. Harbor porpoise and fisheries: an uncertainty analysis of incidental mortality. Ecologic1997al Applications 8: 1226– 1238. https://doi.org/10.1890/1051-0761(1998)008[1226:HPAFAU]2.0.CO;2

Charnov, E.L., Gislason, H., Pope, J.G. 2012. Evolutionary assembly rules for fish life histories. Fish and Fisheries. https://doi.org/10.1111/j.1467-2979.2012.00467.x.

Desbrosses, P. 1932. La dorade commune (*Pagellus centrodontus*) et sa pêche. Revue du Travail de l'Office des Pêches maritime, 5: 167–222.

EU, 2019. Regulation (EU) 2019/1241 of the European Parliament and of the Council of 20 June 2019. Official Journal of the European Union L 198/105. 25.7.2019.

Farias, I., Figueiredo, I., 2019. *Pagellus bogaraveo* in Portuguese continental waters (ICES Division 27.9.a). Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources. Copenhagen, 2nd – 9th May 2019.

Farias, I., Figueiredo, I., 2021. *Pagellus bogaraveo* in Portuguese continental waters (ICES Division 27.9.a). Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources. Copenhagen, 22nd – 28th April 2021.

Geng, Z., Wang, Y., Kindong, R., Zhu, J., Dai, X. 2021. Demographic and harvest analysis for blue shark (*Prionace glauca*) in the Indian Ocean. Regional Studies in Marine Science 41, 101583. https://doi.org/10.1016/j.rsma.2020.101583

Gil, J., 2006. Biología y pesca del voraz (*Pagellus bogaraveo*) en el Estrecho de Gibraltar (PhD Thesis). University of Cádiz, Spain.

Heppell, S. S., Caswell, H., & Crowder, L. B. 2000. Life histories and elasticity patterns: perturbation analysis for species with minimal demographic data. Ecology, 81(3), 654-665. https://doi.org/10.1890/0012-9658(2000)081[0654:LHAEPP]2.0.CO;2

Hewitt, D. A., Hoenig, J. M. 2005. Comparison of two approaches for estimating natural mortality based on longevity. Fishery Bulletin, 103(2), 433. https://scholarworks.wm.edu/vimsarticles/566

Hutchings JA, Kuparinen A. 2017 Empirical links between natural mortality and recovery in marine fishes. Proc. R. Soc. B 284: 20170693. https://doi.org/10.1098/rspb.2017.0693

ICES. 2007. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP). ICES CM 2007/ACFM: 20. 478 pp.

ICES. 2019. Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES Scientific Reports. 1:21. 988 pp. http://doi.org/10.17895/ices.pub.5262

ICES. 2020. Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES Scientific Reports. 2:38. 928pp. http://doi.org/10.17895/ices.pub.6015

Krug, H. M. 1989. The Azorean blackspot seabream, *Pagellus bogaraveo* (Bruennich, 1768) (Teleostei: Sparidae): age and growth. Cybium, 13: 347–355.

Krug, H. M. 1990. The Azorean blackspot seabream, *Pagellus bogaraveo* (Bruennich, 1768) (Teleostei, Sparidae). Reproductive cycle, hermaphroditism, maturity and fecundity. Cybium, 14: 151–159.

Pinho, M. R., Menezes, G., 2005. Azorean Deepwater Fishery: Ecosystem, Species, Fisheries and Management Approach Aspects. Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries, Conference Poster and Dunedin Workshop Papers. FAO Fish. Proc. 3/2.

Smart, J.J., Chin, A., Tobin, A.J., White, W.T., Kumasi, B., Simpfendorfer, C.A. 2017. Stochastic demographic analyses of the silvertip shark (*Carcharhinus albimarginatus*) and the common blacktip shark (*Carcharhinus limbatus*) from the Indo-Pacific. Fisheries Research 191, 95–107. https://doi.org/10.1016/j.fishres.2017.03.002

ANNEX I

Pagellus bogaraveo total landed weight (ton) by fleet segment in the six most important landing ports for the species. Ports are organized by NUTS II (Farias and Figueiredo, 2021 WD).

		North			Centre				Lisbon Metrop. Area	Algarve	
Year	**Gear**	**Matosinhos**	**Povoa do Varzim**	**Viana do Castelo**	**Aveiro**	**Figueira da Foz**	**Nazare**	**Peniche**	**Sesimbra**	**Sagres**	**Portimao**
2009	Polyvalent	4.24	0.66	0.5734	0.06	0.43	3.42	41.98	0.59	13.47	0.05
	Trawl	2.43	-	-	1.43	0.64	2.69	15.32	1.55	-	4.32
2010	Polyvalent	2.64	0.45	0.8427	0.09	0.50	3.83	33.65	0.91	13.33	0.05
	Trawl	3.73	-	-	1.12	1.05	1.47	14.50	0.05	0.00	1.90
2011	Polyvalent	2.27	0.34	1.8148	0.52	0.20	3.92	31.09	0.97	10.63	0.20
	Trawl	2.90	-	-	3.03	0.79	2.32	11.43	0.32	-	0.74
2012	Polyvalent	1.03	0.29	0.5313	0.53	0.24	3.99	44.85	2.18	13.88	0.05
	Trawl	5.56	-	-	3.63	1.80	5.33	21.29	0.09	-	6.14
2013	Polyvalent	1.55	0.52	0.6831	0.74	0.10	2.60	32.05	2.21	16.70	0.03
	Trawl	8.91	-	-	4.79	1.51	3.34	10.89	0.18	-	1.73
2014	Polyvalent	1.05	0.35	1.9169	0.36	0.02	1.80	24.36	1.55	6.89	0.41
	Trawl	2.62	-	-	1.09	0.48	1.11	12.61	0.31	-	0.62
2015	Polyvalent	1.32	0.80	1.3293	0.55	0.06	2.82	24.88	1.46	8.65	0.07
	Trawl	2.70	-	-	1.99	0.93	1.38	14.30	0.51	-	0.90
2016	Polyvalent	0.86	0.35	1.3854	0.34	0.09	2.28	29.87	0.49	10.45	0.02
	Trawl	3.62	-	-	3.68	0.70	0.95	12.26	1.26	-	0.40
2017	Polyvalent	1.73	0.43	0.775	0.55	0.09	2.43	33.04	0.58	7.35	-
	Trawl	2.71	-	-	2.78	1.12	0.57	12.09	1.41	-	0.46
2018	Polyvalent	0.54	0.19	0.4024	0.20	0.02	1.02	35.40	0.52	4.50	0.00
	Trawl	1.58	-	-	1.07	1.10	0.60	9.66	0.28	-	0.09
2019	Polyvalent	0.49	0.23	0.3601	0.31	0.03	0.49	17.35	0.95	6.25	-
	Trawl	0.63	-	-	0.58	0.44	0.35	6.08	0.02	-	0.66
2020	Polyvalent	0.90	0.14	0.3199	1.37	0.04	0.53	20.72	0.73	2.60	0.10
	Trawl	1.46	-	-	1.51	0.40	0.12	10.54	0.46	-	0.17

Preliminary data on age and growth of Ling (*Molva molva*) in ICES divisions 7.d–j

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The present document refers to an update of data provided by the UK (England & Wales) to the ICES WGDEEP 2021 as a preliminary baseline information on biological parameters of ling (*Molva molva*) in the Celtic Seas Ecoregion. Age estimates varied from 2 to 17 years. The estimated values of von Bertalanffy growth function for ling were L_{∞} = 148.81 cm, K = 0.11 year^{-1} and t_0 = –2.19 year.

Introduction

Ling (*Molva molva*) is regularly found in the northern North Sea and along the continental margin to the West of the British Isles, with the principal spawning grounds observed in the Bristol Channel and Irish Sea (Ellis et al., 2012). Despite being considered a deep-water species, ling typically lives at 100-400 m but may occur as deep as 1000 m. Juveniles may be found in shallow areas, migrating into deeper waters with increasing size (Hislop et al., 2015).

Historically, reported landings of ling in ICES Subarea 7 indicate an increasing trend from the 1960s, reaching a maximum in 1980s (Vieira et al., 2019). Data from recent years have shown a marked decline and most landings are from Spanish, French and Irish longline fleets, although the species is also regarded as a valued bycatch in other fisheries (Hislop et al., 2015; ICES, 2020). For this reason, ling has not traditionally been considered an important commercial species compared to others and consequently has not been subject to routine biological sampling.

Age and growth estimation is important to study and assess the status of marine resources, but this parameter remains poorly known for most deep-sea species (Bergstad, 1995; Vieira et al., 2019). Owing to limited information of ling life-history parameters, no stock-management reference points are defined for this stock and a precautionary approach was advised in 2018 for stocks in ICES subareas 6–9, 12, and 14, and in divisions 3.a and 4.a (ICES, 2020).

Additionally, estimated age distributions for the entire stock is based on data from the Norwegian Reference fleet for all areas combined. Here, we evaluated the age and growth of ling, landed in UK (England) ports between 2011 and 2020 and caught in ICES divisions 7.d–j, aiming to provide additional biological data to support the development of analytical assessments.

Methods

Data was collected from the market sampling programme by Cefas observers between 2010 and 2020 under the European Union's Data Collection Framework (DCF). Otoliths from 2541 individuals were collected in different seasons from the region (divisions 7.d-j) between 2011-2020 for age determination (Table I). Total length (TL) of each fish was measured to the nearest centimetre (cm). One random otolith was selected from the pair and mounted on a prepared mould, covered with black polyester resin, and thin sections cut transversally through the nucleus with a single blade low speed saw (Struers Accutom 50). Otolith sections were read under a stereo microscope with a combination of reflected and transmitted lights, and at various magnifications.

The von Bertalanffy growth function (VBGF) was fitted for pooled data (combined sexes) following the equation:

$$L_t = L_\infty\left[1 - e^{-K(t-t_0)}\right]$$

where L_t is size-at-age t, L_∞ is the asymptotic length, K is a curvature parameter and t_0 is the age at which the fish have a theoretical length of zero.

Results and discussion

This preliminary assessment provides estimates of age and growth of ling *Molva molva* from southwestern areas of the British Isles (ICES divisions 7.d–j), through the analysis of annual growth increments deposited on sagittal otoliths.

Age estimates ranged from 2 to 17 years (48 to 142 cm total length), with sampled fish consisting mainly of individuals less than 9 years old (Figure 1). The estimated values of von Bertalanffy growth function for ling were L_∞ = 148.81 cm, K = 0.11 year^{-1} and t_0 = – 2.19 year

(Table II). Comparison of estimated growth parameters with those obtained from available literature (e.g. Grotnes and Hareide, 1989; Magnussen, 2007; Drazen and Haedrich, 2012; Hislop et al., 2015; Priede, 2017), showed that ling has a relatively slow growth rate.

For the analysed size range, relatively simple ageing techniques provided relatively precise age readings (~70% agreement between readings). However, data presented here does not include validation of age readings through the analysis of edge growth (annual marginal increments), which remains an important aspect for future analysis and intercalibration exercises (Bergstad et al., 1998).

Growth in ling was previously examined by Bergstad and Hareide (1996) from different ICES divisions (2.a, 4.a, 5.b, 6.a and 6.b) and Magnussen (2007) in the Faroe Bank (Figure 2). This study reported growth rates of the species that were similar to those from our growth model (age range = 4–15; L_∞ = 119 cm; K = 0.136 year^{-1}). The parameters estimated here are also similar to those currently used when simulating fish stocks to evaluate management procedures (WKLIFE, 2020), where the growth coefficient K is regarded the most important factor influencing the sensitivity analysis of the operating models used to test catch rules for data-limited stocks (Fischer et al., 2020).

Table I. Summary of length-at-age data for *Molva molva* aged using otoliths.

Year	N	Age (years)		Total length (cm)	
		Min	Max	Mean (S.D.)	Min-Max
2011	333	3	17	83.0 (± 13.27)	59-140
2012	268	2	12	83.4 (± 14.46)	48-130
2013	280	2	10	82.9 (± 11.61)	61-119
2014	193	2	9	87.6 (± 15.07)	52-129
2015	222	2	11	90.5 (± 16.18)	50-129
2016	298	2	12	86.0 (± 15.08)	57-142
2017	187	3	11	90.3 (± 13.89)	62-136
2018	266	2	12	89.0 (± 14.16)	49-133
2019	276	2	10	87.1 (± 13.30)	52-123
2020	218	2	9	80.9 (± 11.46)	56-130
Total	**2541**				

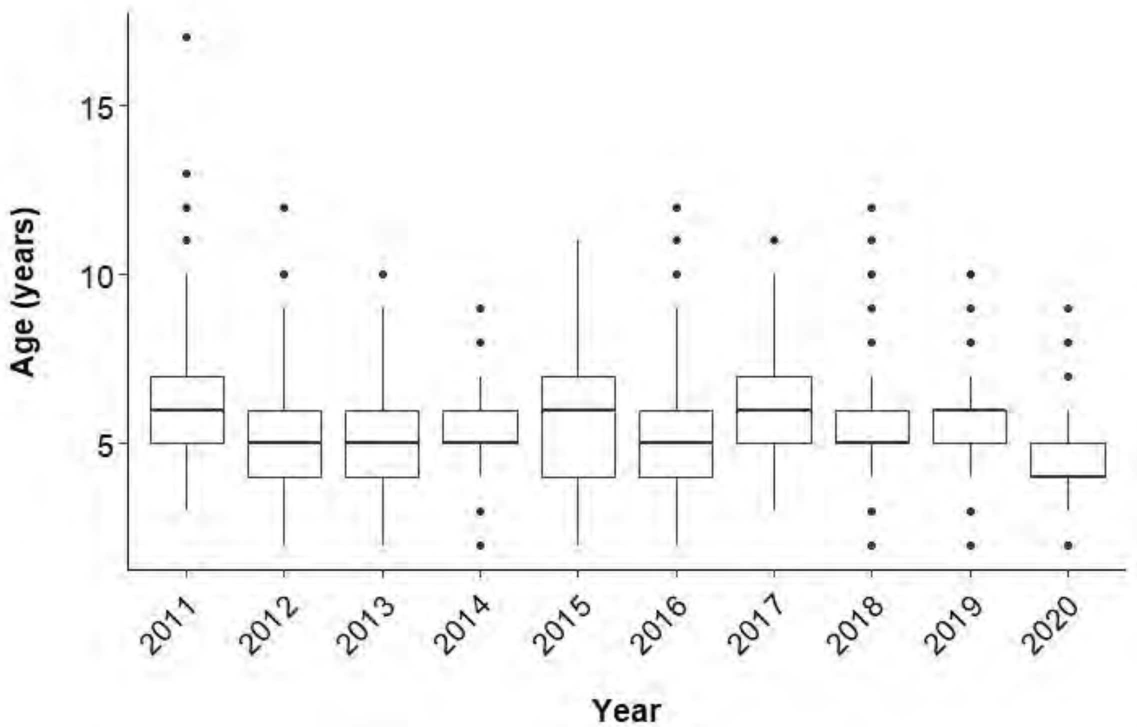

Figure 1. Age composition of *Molva molva* caught in ICES divisions 7.d–j between 2011-2020.

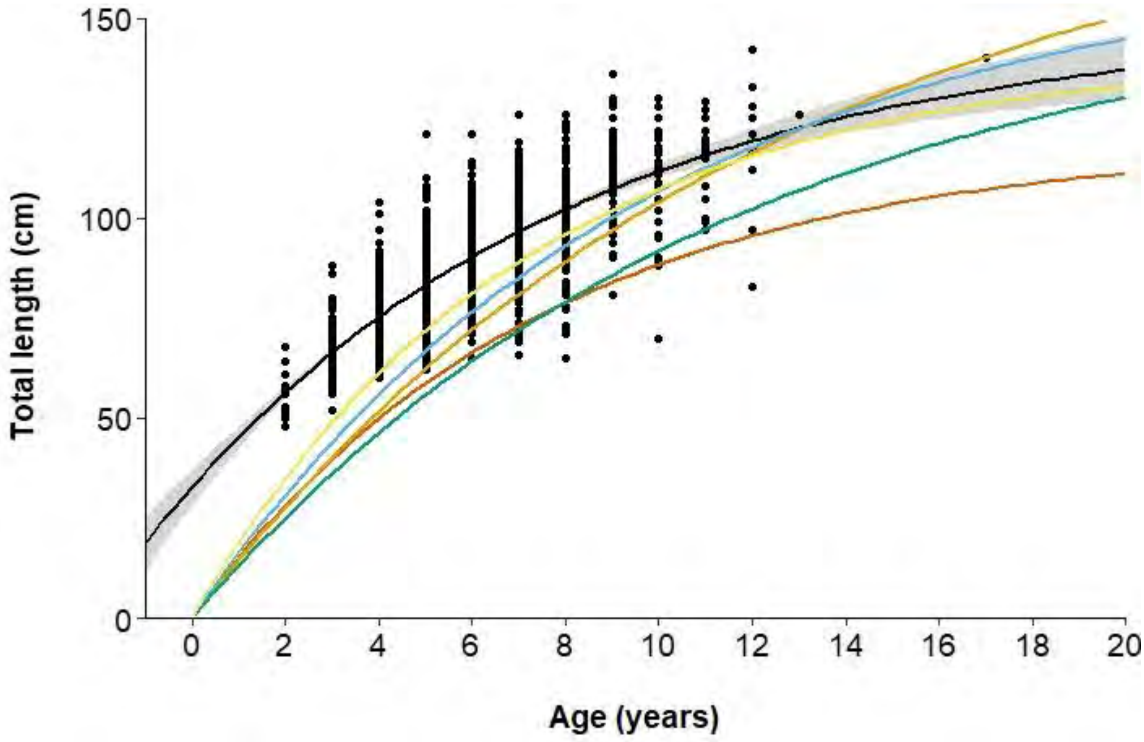

Figure 2. von Bertalanffy growth function for *Molva molva* caught in ICES divisions 7.d–j between 2011-2020, showing predicted mean lengths-at-age (black line) and the lower and upper confidence interval values for predicted mean lengths-at-age (shaded area). For comparison, growth functions extracted from literature are also shown: (—) Faroe Bank (Magnussen, 2007); (—) N. North Sea; (—) West of Scotland; (—) Rockall; (—) Norwegian Sea (based on data from Bergstad and Hareide, 1996).

Table II. Estimated parameters and bootstrap confidence intervals of von Bertalanffy growth function on data from ICES divisions 7.d-j between 2011-2020. L_∞ = asymptotic length (cm), K = growth coefficient (year^{-1}), t_0 = theoretical age when length is zero.

Estimated parameter		**2.5 % CI**	**97.5 % CI**
L_∞	148.81	135.61	168.13
K	0.11	0.09	0.15
t_0	–2.19	-2.84	-1.61

References

Bergstad, O. A. (1995). Age determination of deep-water fishes: experiences, status and challenges for the future. In *Deep-water fisheries of the North Atlantic Oceanic slope* (pp. 267-283). Springer, Dordrecht.

Bergstad, O. A. & Hareide, N. R. (1996). Ling, blue ling and tusk of the North-East Atlantic. Fisken og Havet 15, 1–126.

Bergstad, O. A., Magnusson, J. V., Magnusson, J., Hareide, N. R. & Reinert, J. (1998). Intercalibration of age readings of ling (*Molva molva* L.) blue ling (*Molva dipterygia* Pennant, 1784) and tusk (*Brosme brosme* L.). *ICES Journal of Marine Science*, *55*(2), 309-318.

Drazen, J. C. & Haedrich, R. L. (2012). A continuum of life histories in deep-sea demersal fishes. *Deep Sea Research Part I: Oceanographic Research Papers*, *61*, 34-42.

Ellis, J. R., Milligan, S. P., Readdy, L., Taylor, N. & Brown, M.J. (2012). Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56 pp.

Fischer, S. H., De Oliveira, J. A. & Kell, L. T. (2020). Linking the performance of a data-limited empirical catch rule to life-history traits. *ICES Journal of Marine Science, 77*(5), 1914-1926.

Grotnes, P. & Hareide, N. R. (1989). Assessment of Stocks of Ling (*Molva molva* L.) and Tusk (*Brosme brosme* Ascanius) around the Faroe Islands, 1971–1987. *ICES CM*.

Hislop, J., Bergstad, O.A., Jakobsen, T., Sparholt, H., Blasdale, T., Wright, P., Kloppmann, M., Hillgruber, N. & Heessen, H. (2015). 32. Cod fishes. 32.18 Ling - *Molva molva* (Linnaeus, 1758). Pp 232-234. In: Heessen, H. J., Daan, N. & Ellis, J. R. (Eds.) *Fish atlas of the Celtic Sea, North Sea, and Baltic Sea: Based on international research-vessel surveys*. Wageningen Academic Publishers. 572pp.

ICES (2020). Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES Scientific Reports. 2:38. 928pp. http://doi.org/10.17895/ices.pub.6015

ICES (2020). Tenth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE X). ICES Scientific Reports. 2:98. 72pp. http://doi.org/10.17895/ices.pub.5985

Magnussen, E. (2007). Interpopulation comparison of growth patterns of 14 fish species on Faroe Bank: are all fishes on the bank fast-growing? *Journal of Fish Biology*, *71*(2), 453-475.

Priede, I. G. (2017). *Deep-sea fishes: biology, diversity, ecology and fisheries*. Cambridge University Press.

Vieira, R. P., Trueman, C. N., Readdy, L., Kenny, A. & Pinnegar, J. K. (2019). Deep-water fisheries along the British Isles continental slopes: status, ecosystem effects and future perspectives. *Journal of Fish Biology*, *94*(6), 981-992.

The development of the Norwegian longline fleet's fishery for ling, tusk and blue ling during the period 2000-2020

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Introduction

Ling, tusk and blue ling were fished by Norway for centuries, and the amount landed has been recorded since 1896 (Figure 1). The major catches of these species are taken by longliners, and the catches are to a large degree bycatches. The fishery for these species is mainly influenced by the size of various quotas for other species, especially the quota for Arcto Norwegian cod. Therefore, total catch may not be a good indicator of the condition of these stocks (Figure 2).

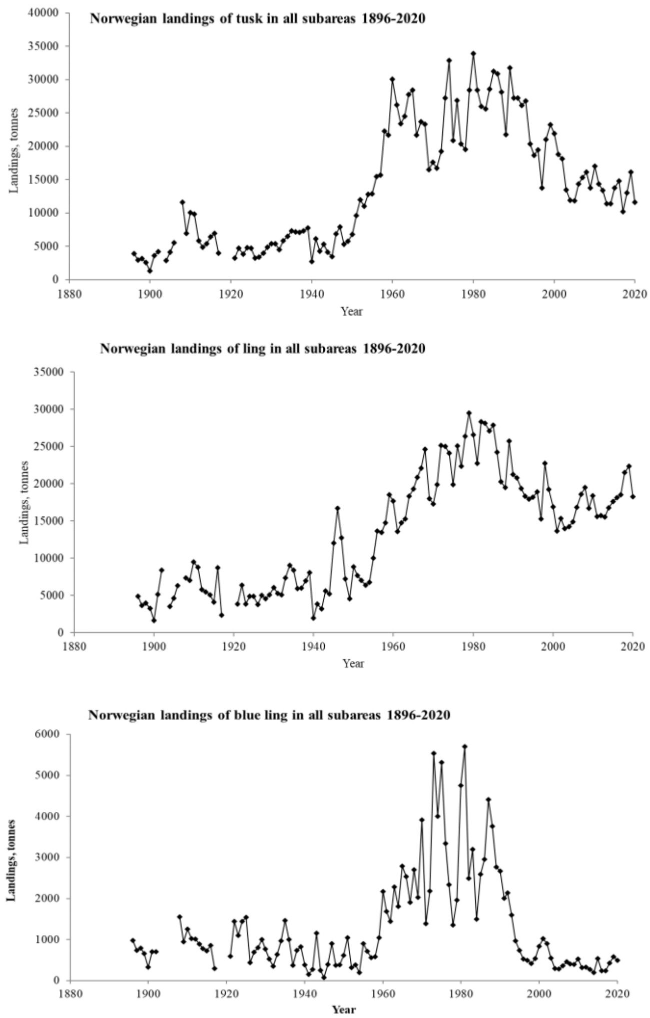


Figure 1. Reported Norwegian landings of tusk, ling and blue ling for the period 1896 -2020.

Scientific surveys do not cover the main habitats of ling, blue ling and tusk. Therefore, these stocks need to be monitored based on commercial data. One possible way to track their abundance, based only on commercial data, would be to develop a catch per unit of effort series for the fishery. But again, the major challenge for any cpue series: It is easy to generate a cpue series, and it is difficult to determine if the series track abundance.

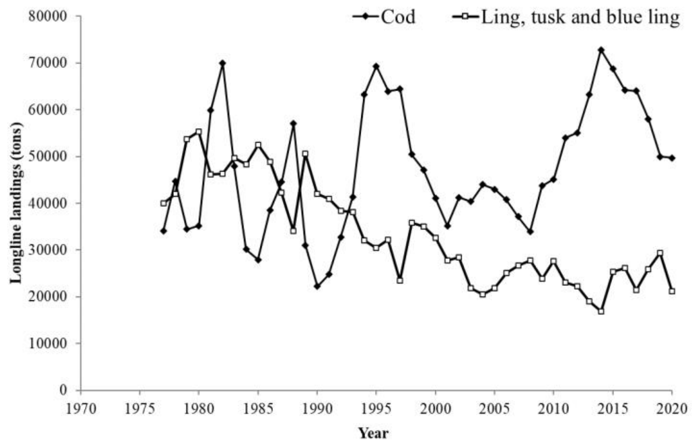


Figure 2. Total landings by longliners of cod (diamonds) and the combined total landings of ling, tusk and blue ling (open squares) for the period 1977- 2020.

Development of the Norwegian fleet of longliners, 1977- 2020

In addition to data on total landings*, the Norwegian Directorate of Fisheries (NDF) provides data on number of fishing vessels participated in the fishery, the gear employed, areas fished and changes in vessel ownership. In Table 1 are; the number of long liners during the period 1977 to 2020, the total landed catch by the fleet, and the average annual catch per vessel. The number of vessels increased from 36 in 1977 to a peak of 72 in 2000, and after that the number decreased to 25 in 2014-2017, the last few years the number of vessels have increased again and in 2020 there were 30 vessels fishing more than 8 tons ling, tusk and blue ling.

The number of vessels declined mainly because of changes in the law concerning the quotas for cod. The decrease the number of vessels was accompanied by a decrease in total catches until 2004; afterwards, the landings have been varying but stable (Figure 3a). The catch-per-vessel was relatively stable from 1980 until 2003. In the period 2003- 2019 there was a steady increase in catch-per-vessel with a sharp decrease in 2020 (Figure 3b).

In 2012 new regulations were initiated and the number of cod quotas each vessel from 3 to 5. This caused a further reduction in the number of long-liners; from 36 in 2012, to 25 in 2015 to 2018. In 2020 there were 30 vessels.

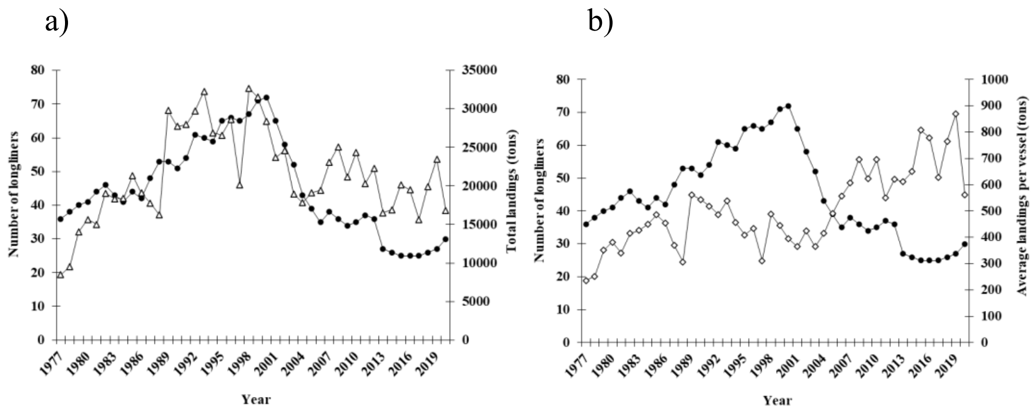


Figure 3. a) The number of long liners (filled circles) and the average landings per vessel of ling and tusk (open diamonds) in the period 1977-2020 and, b) the number of longliners and the total landings of ling and tusk (open triangles).

Logbooks

All available logbooks for the years 2000-2020 are now in the database, and the data have undergone extensive quality control procedures. The data for 2010 are incomplete because of problems getting some of the logbook data, both for the paper logbooks and for the electronic logbooks. In 2010, electronic logbooks were implemented for the longline fleet. The Norwegian Directorate of Fisheries has received the data, but because of lack of quality control, the 2010 data will not be released. Some fishermen didn't send paper logbooks because they had delivered the data electronically. Because of this, logbooks from only 11 of 35 vessels are available for 2010. The quality of the logbooks varies considerably, and a serious problem is that some lack information on the number of hooks used per day. The data from 2011 are almost complete with data from 35 of 37 vessels. In 2012 to 2020 all logbooks are available, though some days have been deleted due to punching errors.

Days in the fishery

The Norwegian longline logbooks provide information on the geographical distribution of the fleet. In Table 2 are the average number of days a vessel spent fishing for tusk, ling and blue ling, jointly or separately, for all ICES Subareas and Divisions. After 2000, when new quota regulations for cod were introduced, the number of days each vessel fished for three-deep-water species increased, and by 2005 the number of days in the fishery was twice that was in 2000. The data for 2006 show that the number of days in the fishery has decreased by more than 20 percent compared with 2005 and 2007. The data were checked for errors, but none were discovered. The number of fishing days has trended downward since 2007, most

[*] The data provided by the NDF are; the total landed catch, the logbook data, and the catch along with its location.

likely because of the record large stock of Arcto Norwegian cod. This trend changed dramatically in 2019 when the number of fishing days per vessels increased from 134 days in 2018 to 192 days in the tusk fishery and in the ling fishery it changed from 94 in 2018 to 125 in 2019. However, in 2020 the total number of fishing days had declined to 147.

Division 2a has been the main fishing grounds since 2000, followed by 4a and 5b (Table 2).

Average number of hooks per day

Table 3 are estimates of the average number of hooks used per day in each ICES area and in the total fishery for the 2000-2020. For all areas combined, there was a steady increase in the number of hooks used from 2000 through 2009. This is also the general trend for subareas (Figure 4). The combined time series for 1972-1994 (Bergstad and Hareide, 1996) and the series based on data from 2000-2012 show that the average number of hooks has increased from 10 000 hooks per day in 1972 to around 38 200 in 2020 (Figure 6).

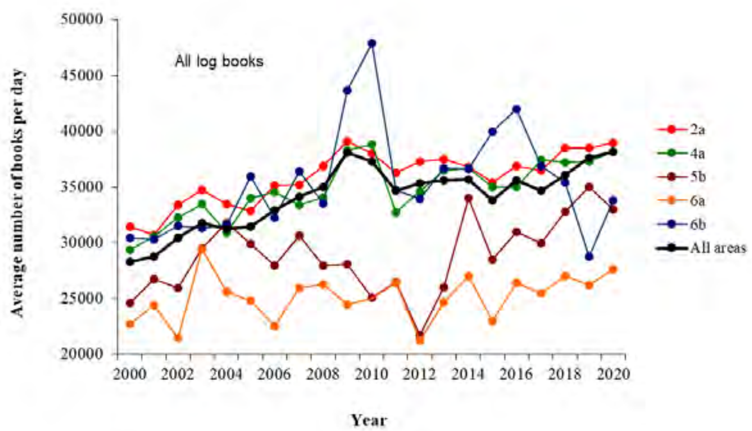


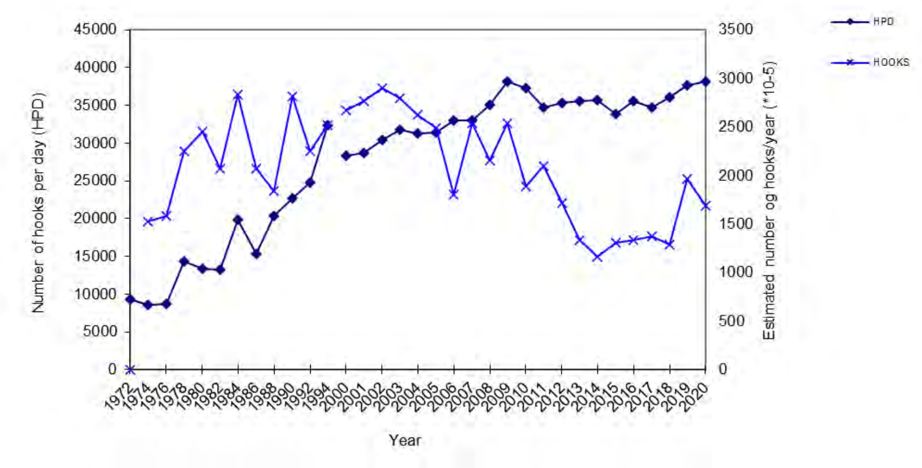
Figure 4. Average number of hooks the Norwegian longliner fleet used per day in each of the ICES subareas and in the total fishery for the years 2000-2020 for the fishery for tusk, ling and blue ling.

Total number of hooks per year

Based on the number of vessels, the number of hooks per day, and the number of days each vessel participated in the fishery, estimates of the total number of hooks used per year were generated (Tables 1, 2 and 3). Table 4 and Figure 5 show the estimated number of hooks (in thousands) set in each of the ICES subareas and in the total for all areas for the years 2000-2020. During the period 1974 to 2013 the total number of hooks per year has varied considerably, after this the number of hooks per year have been stable but with ab increase in 2019 and 2020 (Figure 6).

The total number of hooks per year takes into account; the number of vessels, the number of hooks per day, and the number of days each vessel participated in the fishery, may be a suitable measure of tracked applied effort. Based on this measure of effort, it appears that the average effort for the years 2011-2020 is 40% less than the average effort during the years 2000-2003.

a.



b.

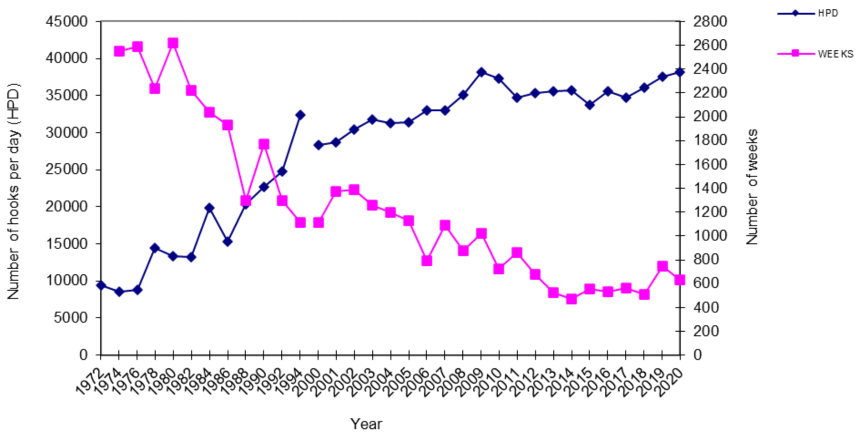


Figure 5. The combined time series for 1972-1994 (Bergstad and Hareide, 1996) and the series based on data from 2000-2020: a) The numbers of hooks used per day, and the total number of hooks used per year; b) The numbers of hooks used per day, and the total number of weeks the long liners participated in the fishery for ling and tusk.

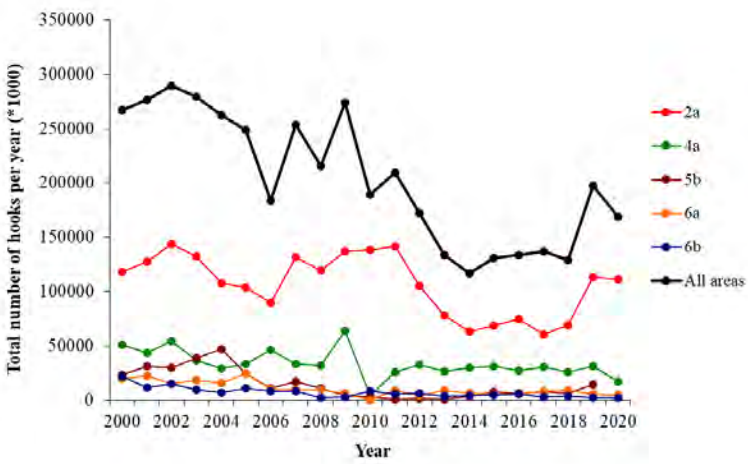


Figure 6. Estimated total number of hooks (in thousands) the Norwegian longliner fleet used in the ICES subareas with highest catches and in the total fishery for the years 2000-2020 for the fishery for tusk, ling and blue ling.

The size of the vessels
There was a steady increase in the average size of the vessels from 34 m in 1977 to 45.4 m in 2020. Figure 7 show the average size of the vessels and the smallest and the largest vessel in the fleet for the period 1977 to 2020.

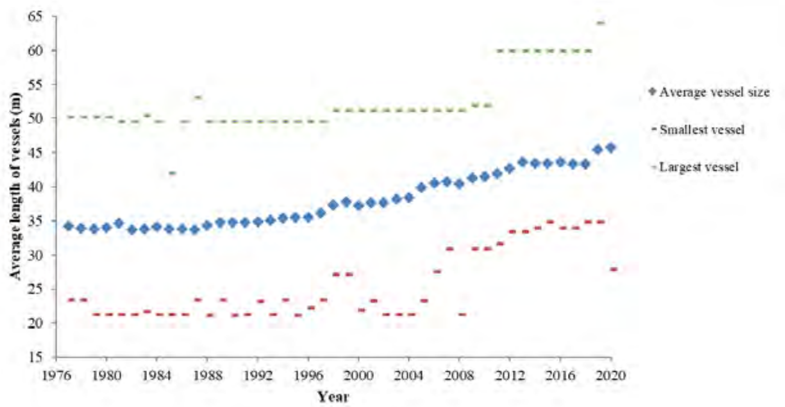


Figure 7. Average size of longliners >21 m for the period 1977-2020.

Fishing area

Approximately 65-70% of the commercial catches of ling are taken by vessels using demersal longlines, either target species or bycatch (Helle and Pennington, 2015), and the remains are taken by mainly gillnets but also some by trawlers. Although the tusk fishery takes place from Rockall to the southern Barents Sea (Helle and Pennington, 2004), between 70 to 80 percent of the catches by Norwegian vessels are from the Norwegian Economic Zone.

Figure 8 show all the catches of ling registered in the electronic logbooks by longliners in 2013-2020 in areas 1 and 2.

Tusk are mainly fished by longliners (approximately 90 percent of the total catch). Figure 9 show all catches of tusk registered in the electronic logbooks by longliners in Areas 1 and 2 during the period 2013 to 2020.

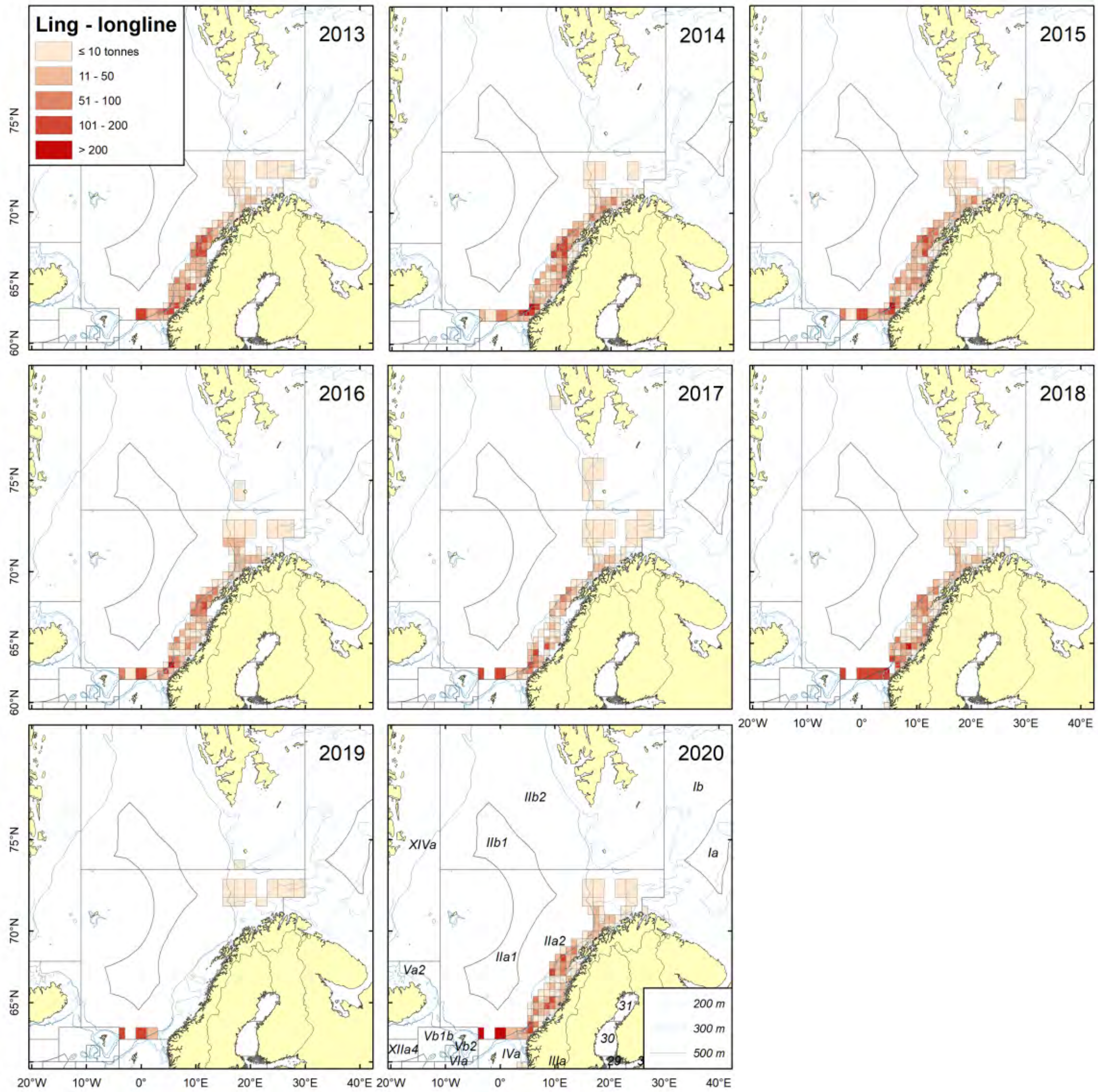


Figure 8. Distribution of the catches using longlines by the Norwegian fishery for ling in 2013 to 2020 in areas 1 and 2.

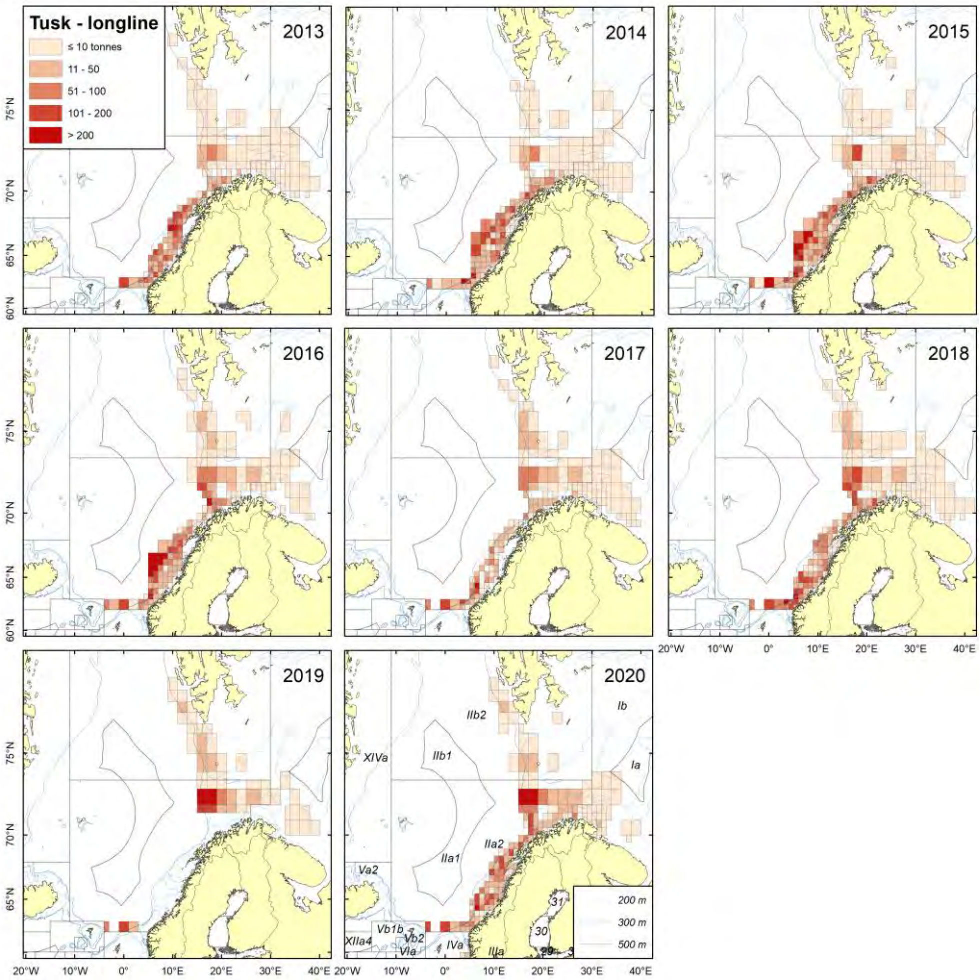


Figure 9. Distribution of the catches using longlines by the Norwegian fishery for tusk in 2013 to 2020 in areas 1 and 2.

CPUE

Based on methods described in Helle *et al.*, 2015 to derive a cpue series were for ling and tusk calculated two ways; using all data available and catches for which ling and tusk were targeted (>30 percent of the daily total catch).

In Figures 11 and 13 are plots of the estimated cpue series for the most important ICES subareas for ling and tusk: based on all the available data, and a cpue series based on only those catches that ling or tusk appear to be targeted; included plots of estimated 95% confidence intervals.

Ling:

Both cpue series for ling in Area 2a indicate an upward trend for until 2017. After 2017, there have been a declining trend.

In Areas 4a there was a steady increase in cpue from 2002 until 2016 and were down in 2017 and 2018 but with a slight increase in 2019 and 2020.

In 6a and 6b there were also a positive trend from 2002 to 2016 with decreasing from 2017 to 2019. In 2020 there were a large increase in area 6a for both series.

When all ling data for Areas 3.a, 4, 6, are combined for a cpue series, and ling was targeted a cpue series, both indicate a steady increase since 2003 to 2017 and then a decline in 2018. In 2020 there were an increase. This increase is driven by an increase in areas 4a and 6a (Figure 12).

Tusk:

Both cpue series in Area 2a are relative stable since 2011.

The series in Area 4a based on all the catches indicates at first a stable series and then a slightly decreasing trend for the last four years, while the series based on the targeted fishery shows a clear and positive upward trend from 2002 until 2013, after this there was a declining trend, and this trend is especially clear for the targeted fishery.

The series in Area 5b shows a stable trend from 2000 to 2008, afterwards it increased until 2012, then decreased until 2017 and a relatively large increase in 2018 and a small decrease in 2019 and 2020.

In area 6a a cpue series based on the Norwegian longline data shows an increase in cpue from 2004 to 2008, afterwards it has remained at a high and slightly increasing level when all data are used, and a sharp increase from 2018 to 2019 for the targeted fishery followed by a decrease in 2020 (Figure 13).

The combined cpue series for areas 4a, 5b and 6a. shows an increasing trend from 2000 to 2010, after 2010 cpue was at a high and stable level, declined in 2017 but increased again in 2018 and 2019 with a decrease in 2020.

The cpue series for Area 6b when all data were used, a catch from longliners show a decrease from 2000 to 2006. After 2006, the cpue was low but at a stable level. There was no or insignificant direct fishery for tusk the last years.

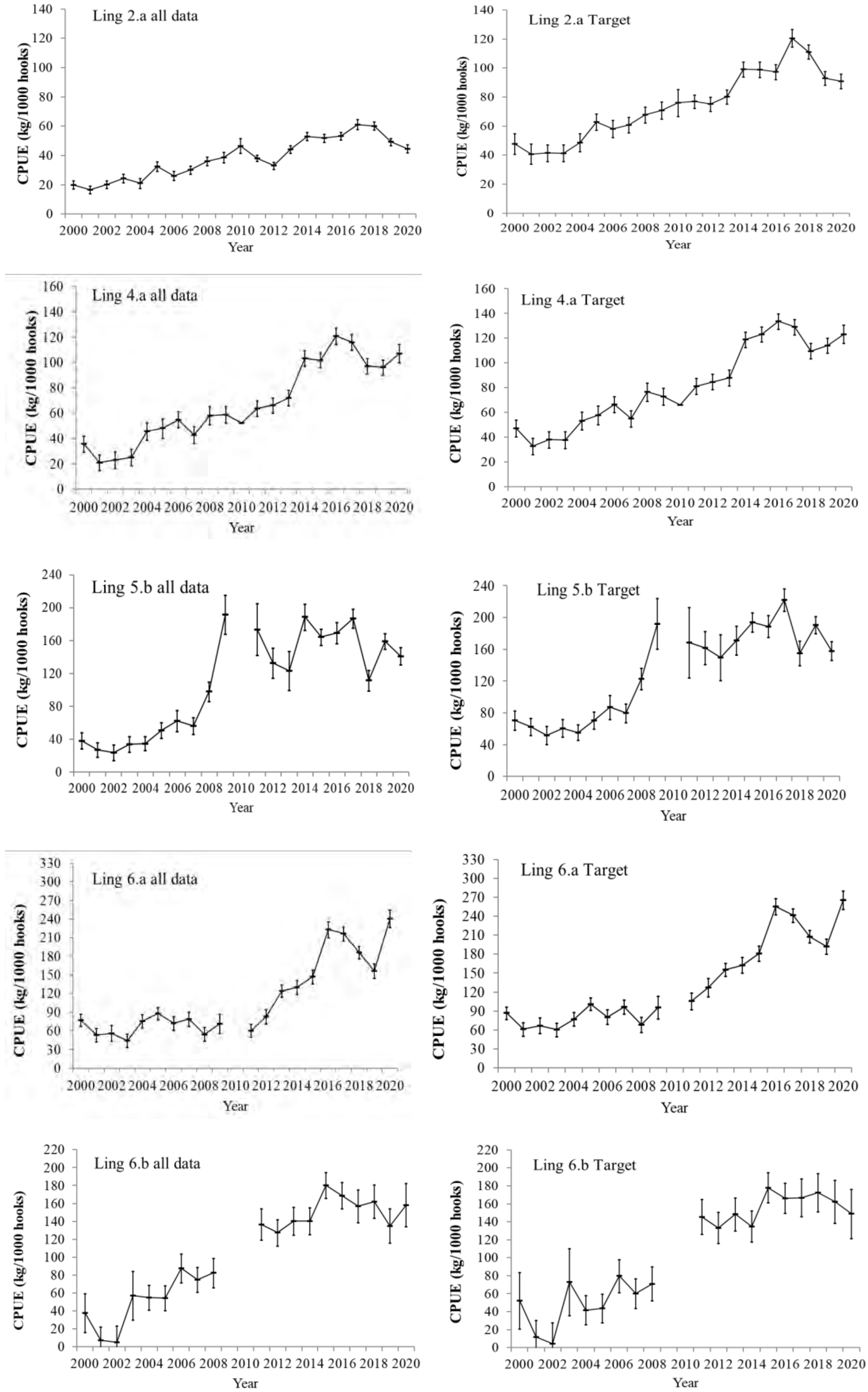


Figure 11. Estimated cpue (kg/1000 hooks) of ling in Subareas 2a, 4a, 5b, 6a and 6b based on skipper's logbooks during the period 2000-2020. The bars denote the 95% confidence intervals.

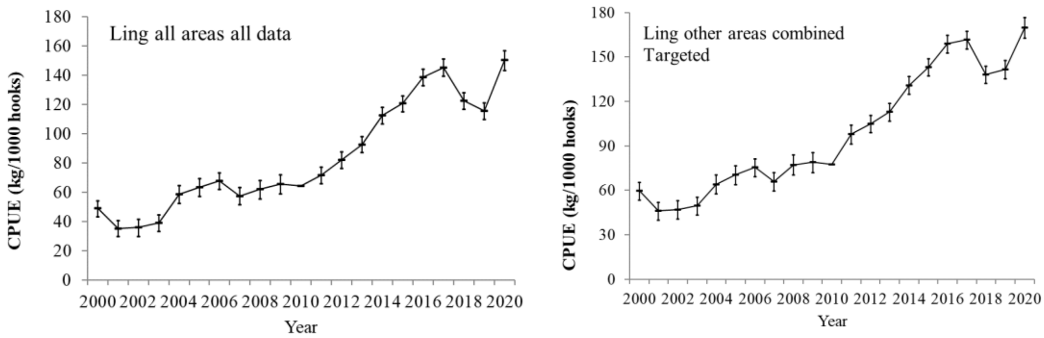


Figure 12. Ling areas combined (3, 4, 6) based on skipper's logbooks during the period 2000-2020. The bars denote the 95% confidence intervals.

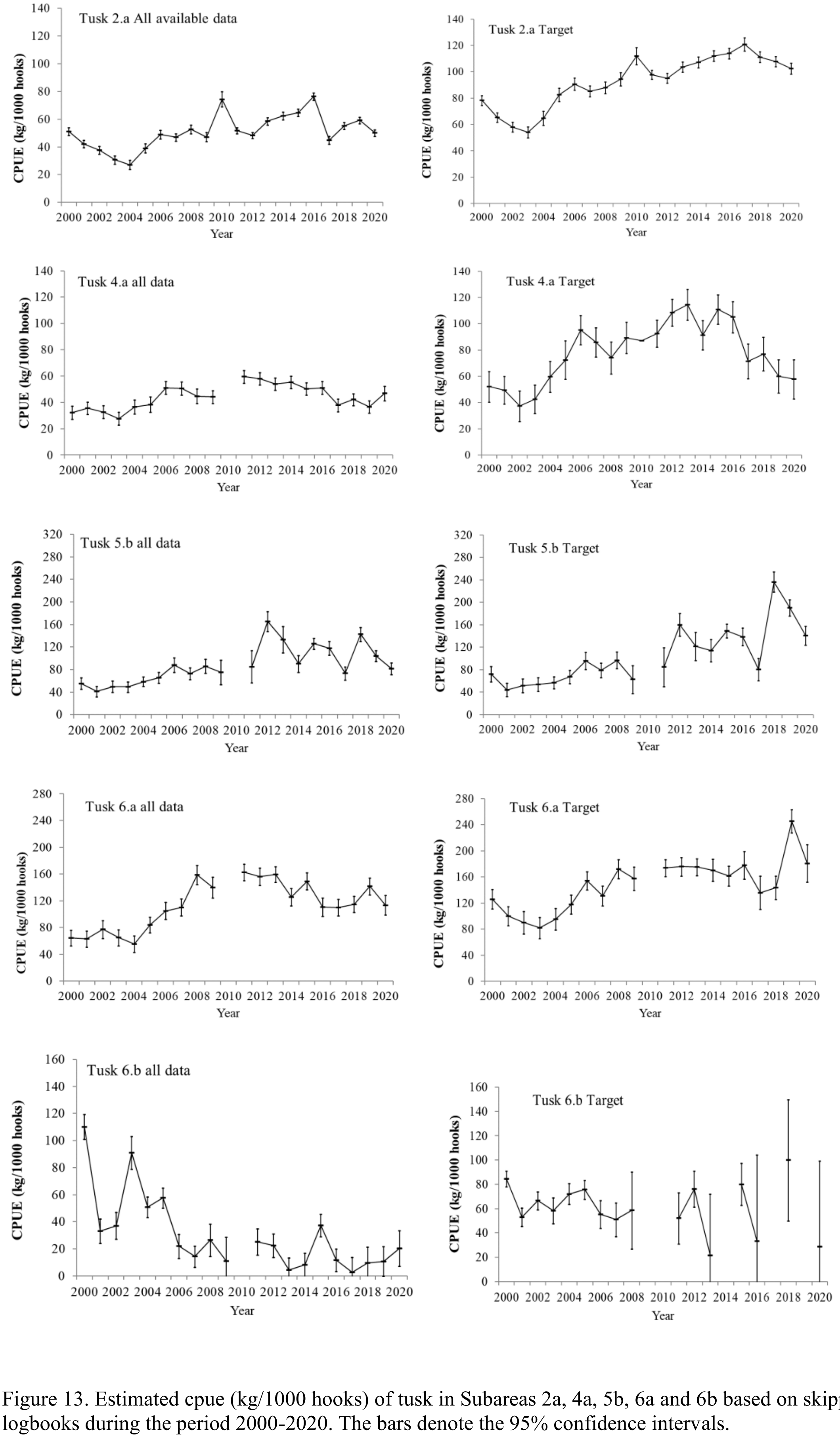


Figure 13. Estimated cpue (kg/1000 hooks) of tusk in Subareas 2a, 4a, 5b, 6a and 6b based on skipper's logbooks during the period 2000-2020. The bars denote the 95% confidence intervals.

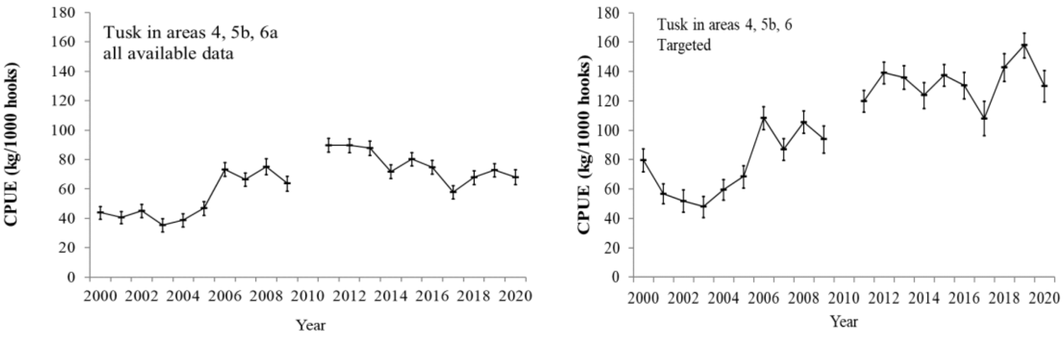


Figure 14. Tusk in other areas combined (4, 5b, 6a) based on skipper's logbooks during the period 2000-2020. The bars denote the 95% confidence intervals.

Blue ling

The cpue series for blue ling based on longline data shows a low and stable level for the Areas 1, 2, 3a and 4. Although there were no direct fishery in these areas, the stock doesn't seem to show any recovery.

A low and steady population for blue ling were in subareas 5a and 14 and in Areas 5b, 6 and 7. When only data from 6a, there was a positive trend from 2004 to 2015, after this the trend has been declining.

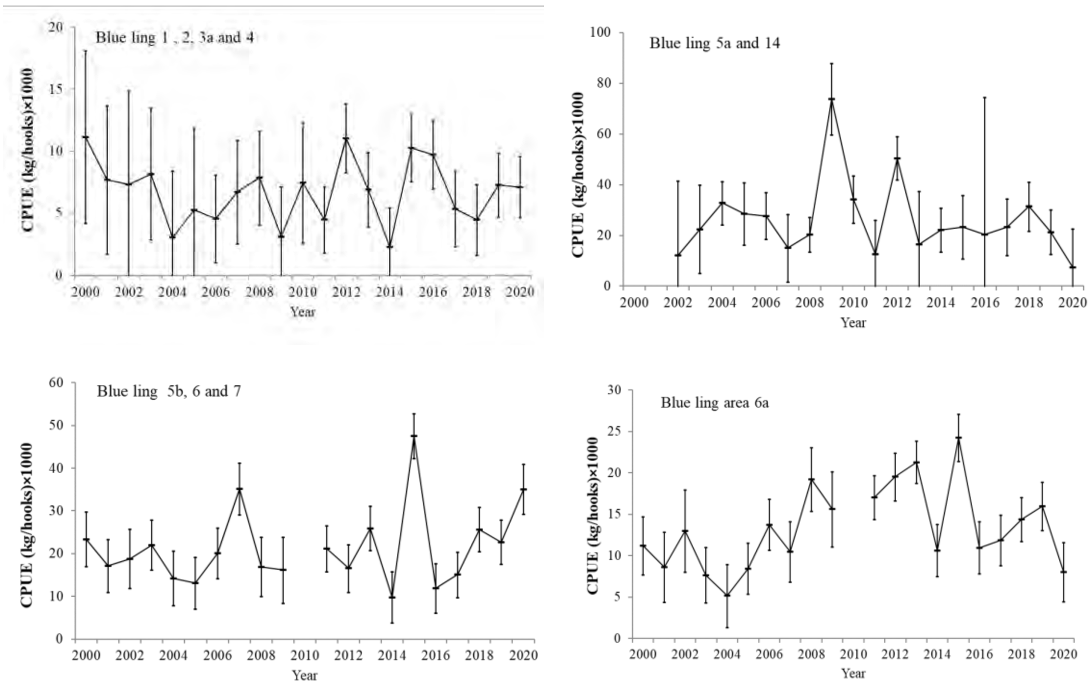


Figure 15. Estimated cpue (kg/1000 hooks) of blue ling in Subareas: 1, 2, 3.a; 4, 5.a; 14, 5.b, 6; 7; and in Subarea 6.a. All data from skipper's logbooks during the period 2000-2020. The bars denote the 95% confidence intervals.

Conclusions and discussion.

Legislation enacted since 2000 for regulating the cod fishery caused a continuous reduction in the number of longliners in the fishery for tusk, ling and blue ling, and by 2009, there were only 34 vessels above 21m in the fishery. Due to recent regulations, the number of vessels were 26 in 2018 and increased to 30 in 2020. Because of this decrease the number of vessels were 58 % fewer since 2000, the total number of hooks employed reduced, the total number of weeks fished, and until 2020, there were a significant reduction in effort. Compared with 2000, a decrease in total effort has occurred even though there was an increase in the number of hooks set per vessel/day until 2020. The large increase in effort in 2019 is probably due to reduction in cod quotas. This fishery should be monitored and reported to prevent overfishing (Figures 5 and 6).

During the period 1998 through 2003, the total landings declined from 32 675 to 19 000 tons, while the catch-per-vessel remained relatively constant. The total catches were stable during the years 2004 through 2006, but after that, there was a sharp increase in 2007 and 2008. The average catch-per-vessel has increased considerably during 2003- 2008, afterwards the catch has been relatively stable.

It should be noted that using the total landings as a measure of stock development can be very misleading. For example, there is a negative correlation between the landings of cod and the total landings of ling, blue ling and tusk (Figure 2), which is due to cod being the most valued species. Therefore, the decrease in total landings does not indicate a reduced stock size, but only an increase in cod quotas.

If a stock is not covered by a scientific survey, then a commercial cpue index is often used to track temporal trends in abundance. It is widely recognised that caution must be used when interpreting a cpue series based on commercial catch data. But by considering: the application and distribution of fishing effort; species specific knowledge, such as when a species is targeted or if it is a preferred species; patterns in the total catch by fleet and by vessel; etc., then based on all these factors, a reliable assessment of a stock’s condition.

References

Bergstad, O. A. and Hareide, N.-R. 1996. Ling, blue ling and tusk of the North-East Atlantic. Fisken og havet nr. 15.126pp.

Helle, K., and Pennington, M. 2004. Survey design considerations for estimating the length composition of the commercial catch of some deep-water species in the Northeast Atlantic. Fisheries Research, 70: 55-60.

Helle, K., M. Pennington, N-R. Hareide and I. Fossen. 2015. Selecting a subset of the commercial catch data for estimating catch per unit effort series for Ling (Molva molva L.). Fisheries Research 165: 115-120.

ICES. 2006. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP). ICES Document CM 2006/ACFM: 28, 494 pp.

ICES. 2010. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP). ICES Document CM 2010/ ACOM: 17. 616 pp.

Magnusson, J. V., Bergstad, O. A.. Hareide, N-.R., Magnusson, J., Reinert, J. 1997. Ling, blue ling and Tusk of the Northeast Atlantic. Nordic Council of Ministers, TemaNord 1997:535, 64 pp.

Table 1. Summary statistics for the Norwegian longliner fleet during the period 1995-2019 (vessels exceeding 21m).

Year	Number of longliners	Total landed catch by fleet	Catch per vessel (Tons)
1977	36	8471	235
1978	38	9563	252
1979	40	14038	351
1980	41	15651	382
1981	44	15002	341
1982	46	19079	415
1983	43	18338	426
1984	41	18398	449
1985	44	21364	486
1986	42	19080	454
1987	48	17788	371
1988	53	16253	307
1989	53	29816	563
1990	51	27726	544
1991	54	27979	518
1992	61	29718	487
1993	60	32290	538
1994	59	26908	456
1995	65	26571	409
1996	66	28645	434
1997	65	20173	310
1998	67	32675	488
1999	71	31528	444
2000	72	28391	394
2001	65	23681	364
2002	58	24619	424
2003	52	18969	365
2004	43	17815	414
2005	39	19106	490
2006	35	19475	556
2007	38	23060	607
2008	36	25069	696
2009	34	21158	622
2010	35	24360	696
2011	37	20344	550
2012	36	22302	620
2013	27	16522	612
2014	26	16907	650
2015	25	20189	808
2016	25	19478	779
2017	25	15663	627
2018	26	19895	765
2019	27	23498	870
2020	30	16827	561

Table 2. Average number of days that each Norwegian longliner operated in an ICES subarea/division.

All species	1	2a	2b	3a	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	9	54	2	+	24	2		13	12	10	2	+	6	131
2001	5	64	9		22		1	18	14	6	1	5	3	148
2002	10	74	2		29			20	12	8		1	8	164
2003	12	73	3	1	21	1	3	25	12	6		3	9	169
2004	20	75	11		22		2	34	14	5	1	1	9	195
2005	23	81	14		25		2	21	25	8	0,4		5	203
2006	11	73	3		38		3	11	13	7				159
2007	15	101	21		27	3	2	15	10	6	1			201
2008	7	90	18	1	26		4	11	10	2			2	171
2009	19	103	20	1	49	1	2	4	7	2			3	211
2010	8	104	13		3		1	3		5			5	145
2011	12	103	4		21	3	2	1	9	4				159
2012	9	78	4		26	1	2	2	5	5	1		2	135
2013	6	63	2		22	2	2	1	11	4			1	114
2014	5	66	2		31	1	2	4	9	4			2	126
2015	8	77	4		36	1	2	11	9	5			2	155
2016	4	81	7		31	1	2	8	8	5			3	150
2017	12	66	15		33		2	10	13	3			4	158
2018	4	69	6		27	1	2	7	13	4			4	137
2019	5	109	14		31	1	2	15	8	3			6	194
2020	6	95	7		15		2	11	6	2			3	147

Tusk	1	2a	2b	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	3	34	1	18	1		11	12	4	2	1	2	88
2001	1	57		22		1	18	14	6	1	3	1	124
2002	5	66	2	28			20	12	8			2	141
2003	5	58		19	2	3	25	12	5			1	130
2004	6	60	1	21		2	34	14	5	1		3	148
2005	5	69	2	25		2	21	23	8	0		3	158
2006	1	67	1	37		3	11	13	7				140
2007	5	89	3	26		2	15	10	6	0			157
2008	4	92	4	30		4	14	15	5				169
2009	6	87	2	56	2	2	4	7	2			1	159
2010	4	93	2	2		3			4			2	112
2011	12	103	4	21		2	1	9	4				155
2012	9	78	4	25		2	2	5	4	1		2	132
2013	6	63	2	22		2	1	11	3			1	111
2014	5	66	2	31		2	4	9	3			2	125
2015	8	77	4	36	1	2	11	9	5			2	154
2016	4	81	7	30		2	8	8	5			3	148
2017	12	66	15	31		2	10	13	2			3	154
2018	4	69	6	26		2	7	13	3			4	134
2019	5	109	14	30	1	2	15	8	2			6	192
2020	6	95	7	15		2	11	6	2			3	146

Ling	**2a**	**3a**	**4a**	**4b**	**5a**	**5b**	**6a**	**6b**	**7c**	**14b**	**All areas**
2000	23	+	19	1		12	13	4	3		76
2001	40		22	+	1	17	13	5	1		100
2002	50		29			18	11	7			114
2003	40	1	20	1	3	24	12	4			104
2004	37		22		2	34	14	5	1		115
2005	51		25		2	21	23	8	+		126
2006	54		38		3	11	13	7			126
2007	65		27	3	2	15	10	6	1		128
2008	52	1	25		4	11	9	2			104
2009	65	1	49		2	4	7	2			130
2010	70		3		3			7			83
2011	73		21	3	4	2	8	4			113
2012	59		26	1	2	2	5	5	1		98
2013	44		22	1	2	1	11	4			85
2014	53		31	1	2	4	9	4		1	106
2015	54		37	1	2	11	9	5		1	122
2016	55		31	1	2	7	8	5		1	111
2017	27		33		2	10	13	3			88
2018	41		27	1	2	6	13	4			94
2019	66		31	1	2	14	8	3			125
2020	47		15		2	10	6	2			83

Blue ling	**2a**	**4a**	**5a**	**5b**	**6a**	**6b**	**12**	**14b**	**All areas**
2000	1	1		4	9	1	2	+	18
2001	1	+	1	3	6	1	5		15
2002	1	1		4	4	2		+	11
2003	1		1	5	8	2	2	+	14
2004	+	1	2	5	6	+		+	14
2005	+	1	1	1	10			+	14
2006	1	2	2	4	8	+			18
2007	1	2	1	5	6	1			16
2008	2	4	3	4	10			1	25
2009	1	4	2	3	6			1	17
2010	2	1	2					2	7
2011	2	2		1	7				12
2012	1	2		2	5			1	12
2013	1	2		1	8				13
2014	1	3	1	2	5	1		1	12
2015	3	4	1	5	7				20
2016	1	4		3	6				15
2017	1	3		5	7			1	17
2018	1	3		4	8			1	17
2019	4	3		6	6			2	21
2020	6	4		3	4				17

Table 3. Average number of hooks that the Norwegian longliner fleet used per day in each of the ICES subareas/divisions and in the total fishery for the years 2000-2016 in the fishery for tusk, ling and blue ling. n is the total number of days with hook information contained in the logbooks.

All		1	2a	2b	3a	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	**Average**	31688	31439	35409	30250	29378	30263		24594	22763	30471	29600	18136	2815	28325
	n	353	1916	71	4	685	38		411	435	227	80	22	191	4429
2001	**Average**	33325	30703	34638		30553	33500		26760	24419	30340	33108	17548	2465	28743
	n	163	2196	315		727	10		613	447	140	37	175	135	4958
2002	**Average**	35432	33431	34756		32291	33867		25939	21484	31557			9458	30432
	n	263	2031	45		667	15		475	186	149			251	4083
2003	**Average**	35045	34766	34776	33037	33484	32559	22605	29513	29421	31325		13063	11515	31794
	n	376	1839	67	27	510	34	38	515	302	97		48	228	4081
2004	**Average**	32431	33475	31859		30934		25815	31804	25636	31559	25250		12474	31285
	n	433	1389	217		439		54	693	308	111	28		105	3777
2005	**Average**	32671	32861	35082		34039		23100	29885	24807	35949	33429		18960	31438
	n	316	1248	207		331		30	374	369	137	7		91	3110
2006	**Average**	33182	35140	39298		34561		21526	27943	22504	32273				32959
	n	187	1252	57		673		57	159	248	139				2711
2007	**Average**	34380	35207	37881	35000	33414	38086	25414	30681	25958	36400	31071			34110
	n	318	2103	328	8	587	58	58	355	249	145	14			4223
2008	**Average**	36833	36890	39650	36467	34056	31500	32704	27968	26319	33514			9464	35042
	n	96	1500	297	15	395	10	71	188	138	35			45	2790
2009	**Average**	39184	39142	43744	34636	38299	30167	26106	28123	24455	43645			7034	38127
	n	267	1419	281	11	680	6	33	57	99	31			38	2922
2010	**Average**	40519	38057	41607		38838		20182	25067		47904			7672	37296
	n	19	1089	135		37		11	30		52			58	1491
2011	**Average**	37205	36260	35280	35275	32737	37343	28062	26492	26424	34727			25750	34668
	n	411	3622	126	8	740	104	63	24	310	137			4	5549
2012	**Average**	36434	37298	38357		34639		33647	21702	21249	33934	39064		9091	35381
	n	307	2817	157		933		68	63	196	176	22		59	4765
2013	**Average**	39500	37500	42000		36500	43000	30900	26000	24700	36700	31000		27500	35600
	n	211	2073	81		710	34	69	34	351	132	10		36	3678
2014	**Average**	37699	36782	39660		36715	44614	35015	34000	26979	36551			22374	35676
	n	112	1501	44		707	22	46	101	214	97			65	2909
2015	**Average**	36100	35400	43500		35000	40800	31600	32400	30700	29000			29800	33800
	n	209	1902	91		908	33	54	276	222	130			53	3878
2016	**Average**	40000	36900	42000		35000	35000	37000	31000	26400	42000			31400	35600
	n	100	2025	175		775	25	50	200	200	125			75	3750
2017	**Average**	41700	36500	43000		37400	40300	33700	30000	25500	36900			25400	34700
	n	302	1660	374		815	11	54	260	320	78			89	3963
2018	**Average**	42800	38500	42000		37200	44500	42600	32800	27000	35400			35400	36100
	n	99	1776	142		692	34	51	148	295	96			105	3738
2019	**Average**	43000	38500	44300		37300	43800	38400	35000	26200	28800			26800	37600
	n	123	2956	381		842	31	63	393	218	79			172	5258
2020	**Average**	44600	39000	45900		38200		41400	33000	27600	33800			23300	38200
	n	168	2853	221		464		59	315	181	56			88	4405

Table 4. Estimated total number of hooks (in thousands) that the Norwegian longliner fishery for tusk, ling and blue ling used in each of the ICES subareas/divisions and in the total area for the years 2000-2020.

All	1	2a	2b	3a	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	20534	117708	5099	218	50765	4358		23020	19667	21939	4262	1306	1216	267161
2001	10831	127724	20263		43691			31309	22221	11833	2152	5703	481	276508
2002	20551	143486	4032		54313			30089	14953	14642			4389	289469
2003	21868	131972	5425	1718	36565	1693	3526	38367	18359	9773		2038	5389	279406
2004	27891	107957	15069		29264		2220	46497	15433	6785	1086		4827	262325
2005	29306	103808	19155		33188		1802	24476	24187	11216	521		3697	248895
2006	12775	89783	4126		45966		2260	10758	10239	7907				183567
2007	19081	131569	29434		33381	4228	1881	17028	9604	8081	1150			253676
2008	9282	119524	25693	1313	31876		4709	11075	9475	2413			681	215719
2009	25313	137075	29746	1178	63806	1026	1775	3825	5820	2968			717	273523
2010	11345	138527	18931		4078		706	2632		8383			1343	189277
2011	16965	141922	5363		26124	4257	2133	1007	9037	5279				209464
2012	11805	104733	5523		32422	1230	2423	1566	3825	6108			655	171952
2013	7821	77963	2772		26500	1419	2039	858	8966	3633			1815	133752
2014	4901	63118	2062		29592	1160	1821	3536	6313	3801			1163	116875
2015	7220	68145	4350	0	31500	1020	1580	8910	6907,5	3625	0	0	1490	130975
2016	4000	74722	7350	0	27125	875	1850	6200	5280	5250	0	0	2355	133500
2017	12510	60225	16125	0	30855		1685	7500	8288	2768	0	0	2540	137065
2018	4451	69069	6552	0	26114	1157	2215	5970	9126	3682	0	0	3682	128588
2019	5805	113306	16745	0	31220	1183	2074	14175	5659	2333	0	0	4342	196949
2020	8028	111150	9639	0	17190	0	2484	10890	4968	2028	0	0	2097	168462

Working Document to be presented to the Working Group on the
Biology and Assessment of Deep Sea Fisheries Resources

ICES WGDEEP, April- May 2021, By correspondence

Results on greater forkbeard (*Phycis blennoides*), Spanish ling (*Molva macrophthalma*), roughsnout grenadier (*Trachyrincus scabrus*), bluemouth (*Helicolenus dactylopterus*) and other scarce deep water species on the Northern Spanish Shelf Groundfish Survey

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Abstract

This working document presents the results on the most significant deep fish species on the Spanish Groundfish Survey on the northern Spanish shelf in 2020. Biomass, abundance, length distributions and geographic ranges were analysed for greater forkbeard (*Phycis blennoides*), Spanish ling (*Molva macrophthalma*), roughsnout grenadier (*Trachyrincus scabrus*), bluemouth (*Helicolenus dactylopterus*) and other scarce deep sea species. The biomass of *M. macrophthalma* and *T. scabrus* decreased whereas *P. blennoides* and *H. dactylopterus* increased. *Aphanopus carbo, Beryx spp*. and *Pagellus bogaraveo* were scarce as usual and *Coryphaenoides rupestris* was not found in this last survey.

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 shelves (ICES Divisions 8c and 9a North).

The aim of this working document is to update the results (abundance indices, length frequencies and geographic distribution) of the most common deep water fish species on the bottom trawl surveys on the Northern Spanish Shelf after the results presented previously (Blanco *et al*. 2019, Fernández-Zapico *et al*. 2020). The species analyzed are *Phycis blennoides* (greater forkbeard), *Molva macrophthalma* (spanish ling), *Trachyrincus scabrus* (roughsnout grenadier), *Helicolenus dactylopterus* (bluemouth), and some other scarce species as *Aphanopus carbo* (black scabbardfish), *Coryphaenoides rupestris* (roundnose grenadier), *Beryx spp.* (alfonsinos) and *Pagellus bogaraveo* (blackspot seabream). Although results on *Helicolenus dactylopterus* were not included in the ICES data call, they are also updated considering its remarkable abundance and geographical distribution in the surveyed area, and the fact that these indices were used in the WGDEEP report when reviewing the abundance and status of the stock on the north-eastern Atlantic.

Material and methods

The area covered in the Northern Spanish Shelf Groundfish Survey on the Cantabrian Sea an Off Galicia (Divisions 8c and Northern part of 9a; SPNGFS) extends from longitude 1° W to 10° W and from latitude 42° N to 44.5° N, following the standard IBTS methodology for the western and southern areas (ICES, 2017). The sampling design is random stratified with five geographical sectors (MF: Miño-Finisterre, FE: Finisterre-Estaca de Bares, EP: Estaca de Bares - Peñas, PA: Peñas - Ajo, AB: Ajo - Bidasoa) and three depth strata (70-120 m, 121-200 m and 201-500) (Figure 1, ICES, 2017). The shallower depth stratum was changed in 1997 from 30-100 m to 70-120 m, due to the small area and scarcity of trawlable shallower grounds.

Nevertheless, some extra hauls are carried out every year, if possible, to cover shallower (<70 m) and deeper (>500 m) grounds. These additional hauls are plotted in the distribution maps, although they are not included in the calculation of the stratified abundance indices since the coverage of these grounds (shallower and deeper) are not considered representative of the area. However, 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.

The standardized indices of the deep water fishes analyzed in this report probably underestimate its real biomass due to the fact that most of its catches might happen out of the standard stratification area, in additional hauls deeper than 500 m. For this reason, the catches in standard and deeper additional hauls were plotted in this report.

Results

This last survey was carried out under the COVID-19 pandemic situation, therefore participants were decreased and the objectives were rearranged. Nonetheless, 123 valid hauls were carried out, 109 of these were standard hauls and 14 additional hauls (2 of them shallower than 70 m and 12 of them between 500 m and 800 m) (Figure 1).

The total stratified catch per haul increased considerably in 2020, recovering the high values of the time series (Figure 2).

In 2020, as usual, most of the biomass of *P. blennoides, M. macrophthalma*, *T. scabrus, A. carbo* and *Beryx spp*. was found in the additional deep water hauls (>500 m) in contrast to *H. dactylopterus* which was mainly found in standard hauls. *P.bogaraveo* was scarcely found out the stratification in the shallow area (<70 m). The biomass of *P. blennoides* increased slightly whereas *M. macrophthalma* and *T. scabrus* decreased. The biomass of *H. dactylopterus* increased reaching the highest value of the time series, but the abundance decreased and small specimens were not as abundant as previous years. Only a few specimens of *A. carbo, Beryx spp*. and *P. bogaraveo* were found and *C. rupestris* was not.

Phycis blennoides (greater forkbeard)

In 2020, 41% of the hauls where *P. blennoides* was found were additional hauls deeper than 500 m and contained 77% of the biomass. This last year the biomass in standard hauls remained low similarly to the values of the three previous years whereas the biomass in additional deep hauls remained being high, after the increase in 2019 (Figure 3).

The geographical distribution of *P. blennoides* remained similar to previous years, being widespread in the sampling area (Figure).

The length distribution in standard hauls remained showing low abundances per size and even fewer small (13-19 cm) and large (24-45 cm) specimens than in 2019 (Figure 5). The largest individuals which ranged from 26 cm to 65 cm were found in the additional deeper hauls, although specimens around 35 cm were more abundant (Figure 6).

***Molva macrophthalma* (Spanish ling)**

This last year, the biomass of *M. macrophtalma* decreased sharply in standard hauls whereas increased slightly in additional hauls (Figure 7). Most of the biomass (91%) was found in these deeper hauls (> 500 m) which were 45% of the total hauls with *M. macrophtalma*.
The species kept on being widespread in the study area but present in fewer spots this last survey (Figure 8).
The little abundance of specimens in standard hauls was strikingly evident this last survey (Figure 9). Only 31 specimens which ranged from 21 cm to 73 cm were found there, most of them around 21 and 29 cm. In contrast, in additional deeper hauls larger specimens, up to 115 cm, were found (Figure 10).

***Trachyrincus scabrus* (roughsnout grenadier)**

T. scabrus has been found mostly in additional hauls (>500 m) in the last decade. In 2020, all the biomass was found in these deep hauls and catches decreased slightly (Figure 11).
The geographical distribution showed fewer spots of biomass this last survey, but in the usual deep areas of Galicia and the northeastern Cantabrian Sea (Figure 12).
Specimens ranged from 80 mm to 265 mm, although more abundance of large specimens (200-210 mm) was found (Figure 13).

***Helicolenus dactylopterus* (bluemouth)**

Although bluemouth is not requested for ICES DCF Data Call, the biomass and abundance are significant in the area and useful for the assessment of the stock (ICES, 2017).
H. dactylopterus has been mainly found in standard hauls, therefore the catches of the additional deeper hauls are not plotted.
In 2020, the biomass slightly increased reaching the highest value of the time series whereas the abundance decreased, although it remained among the medium-high values of the time series (Figure 14).
The geographical distribution of *H. dactylopterus* remained similar to the previous year, with greater biomass in the Galician area, although bigger spots near Finisterre than previous years, and the usual spot in the easternmost Ajo-Bidasoa sector (Figure 15).
Length distribution showed fewer recruits than the previous year and a smooth mode around 15 cm, after the remarkable mode of 12 cm in 2019 (Figure 16).

Other scarce deep water species

Other species scarcely caught in the survey were *Aphanopus carbo*, *Coryphaenoides rupestris, Beryx spp.* and *Pagellus bogaraveo.* They have been mainly found out of the standard stratification, the first three species in deeper additional hauls (>500 m) whereas *P. bogaraveo* in shallower additional hauls (< 70 m).
This last survey *C. rupestris* was not found.

A. carbo was caught in two hauls at 847 m in Galician area and at 530 m in eastern Cantabrian Sea (Figure 17 and Figure 18), with a total of eleven specimens which ranged from 87 to 109 cm.

Beryx spp. were found in three hauls at 140 m, 530 m and 607 m in the Cantabrian sea (Figure 19 and Figure 20). Four specimens were *B. decadactylus* and two *B. splendens* and all of them ranged from 26 to 30 cm.

Only one specimen of *P. bogaraveo* of 18 cm was found at 58 m depth near Peñas Cape (Figure 21 and Figure 22).

Acknowledgements

We would like to thank R/V *Miguel Oliver* crew and the scientific teams from IEO that made possible SPNSGFS Surveys.

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References

Blanco, M., Ruiz-Pico, S., Fernández-Zapico, O., Preciado, I., Punzón, A., Velasco, F, 2019. Results on greater forkbeard (*Phycis blennoides*), Bluemouth (*Helicolenus dactylopterus*), Spanish ling (*Molva macrophthalma*) and Blackspot seabream (Pagellus bogaraveo) of the Northern Spanish Shelf Groundfish Survey. Working document presented to the WGDEEP, Copenhagen, Denmark, 2-16 May 2019.

Fernández-Zapico, O., Ruiz-Pico, S., Blanco, M., Preciado, I., Punzón, A., Velasco, F., 2020. Results on greater forkbeard (*Phycis blennoides*), Bluemouth (*Helicolenus dactylopterus*), Spanish ling (*Molva macrophthalma*) and Blackspot seabream (Pagellus bogaraveo) on the Northern Spanish Shelf Groundfish Survey. Working document presented to the WGDEEP, by correspondence, 24 April-1 May 2020.

ICES, 2017. Manual of the IBTS North Eastern Atlantic Surveys. Series of ICES Survey Protocols SISP 15. 92 pp. http://doi.org/10.17895/ices.pub.3519

Punzón, A., Serrano, A., Castro, J., Abad, E., Gil, J. & Pereda, P., 2011. Deep-water fishing tactics of the Spanish fleet in the Northeast Atlantic. Seasonal and spatial distribution. Sci. Mar., 2011, 75(3), 465-476.

Figures

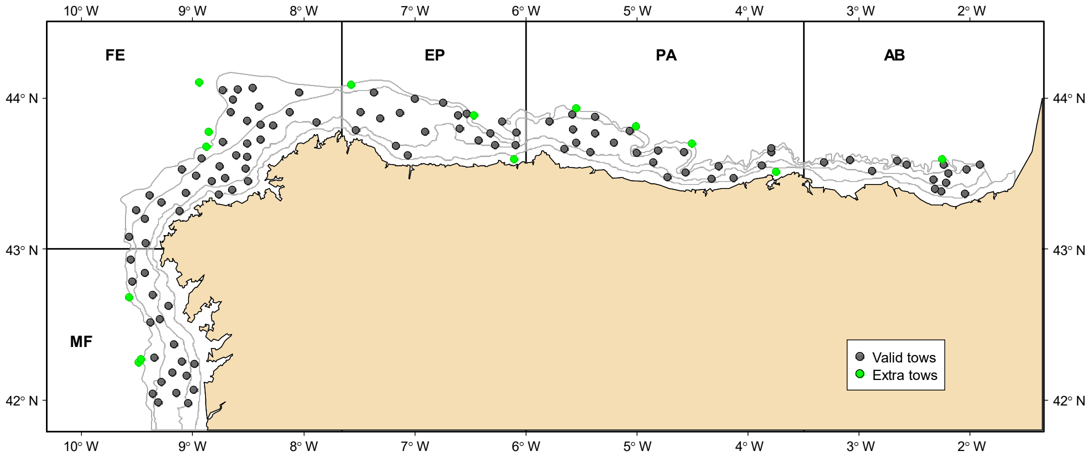


Figure 1 Stratification design and hauls on the Northern Spanish shelf groundfish survey in 2020; Depth strata are: A) 70-120 m, B) 121 – 200 m and C) 201 – 500 m. Geographic sectors are MF: Miño-Finisterre, FE: Finisterre-Estaca, EP: Estaca-cabo Peñas, PA: Peñas-cabo Ajo, and AB: Ajo-Bidasoa

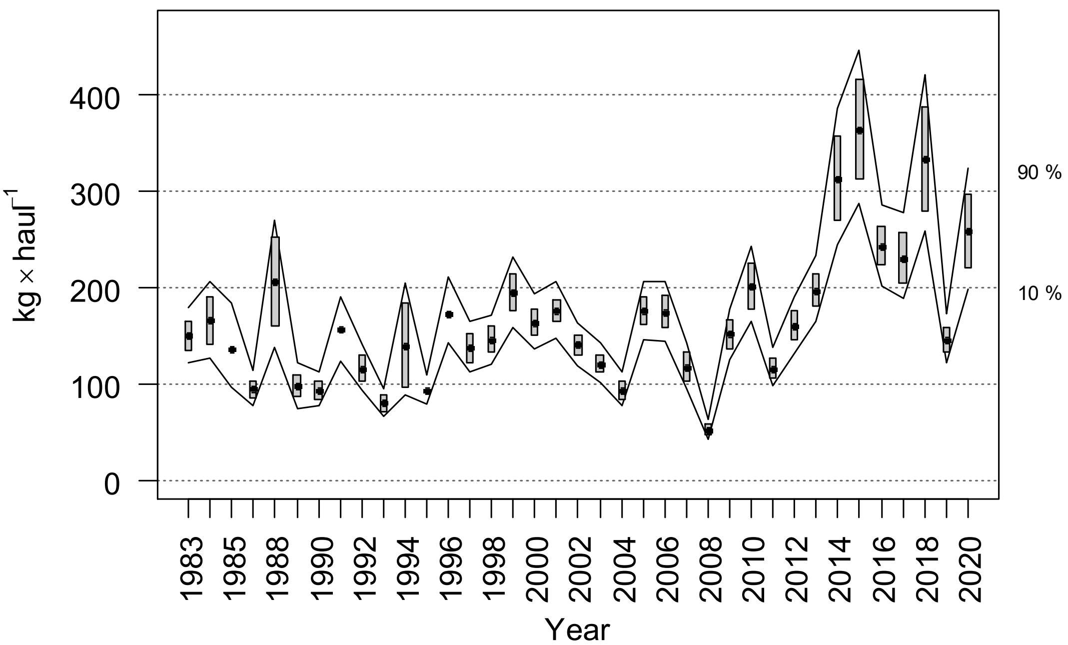


Figure 1 Evolution of the total catch in biomass on the Northern Spanish shelf groundfish survey

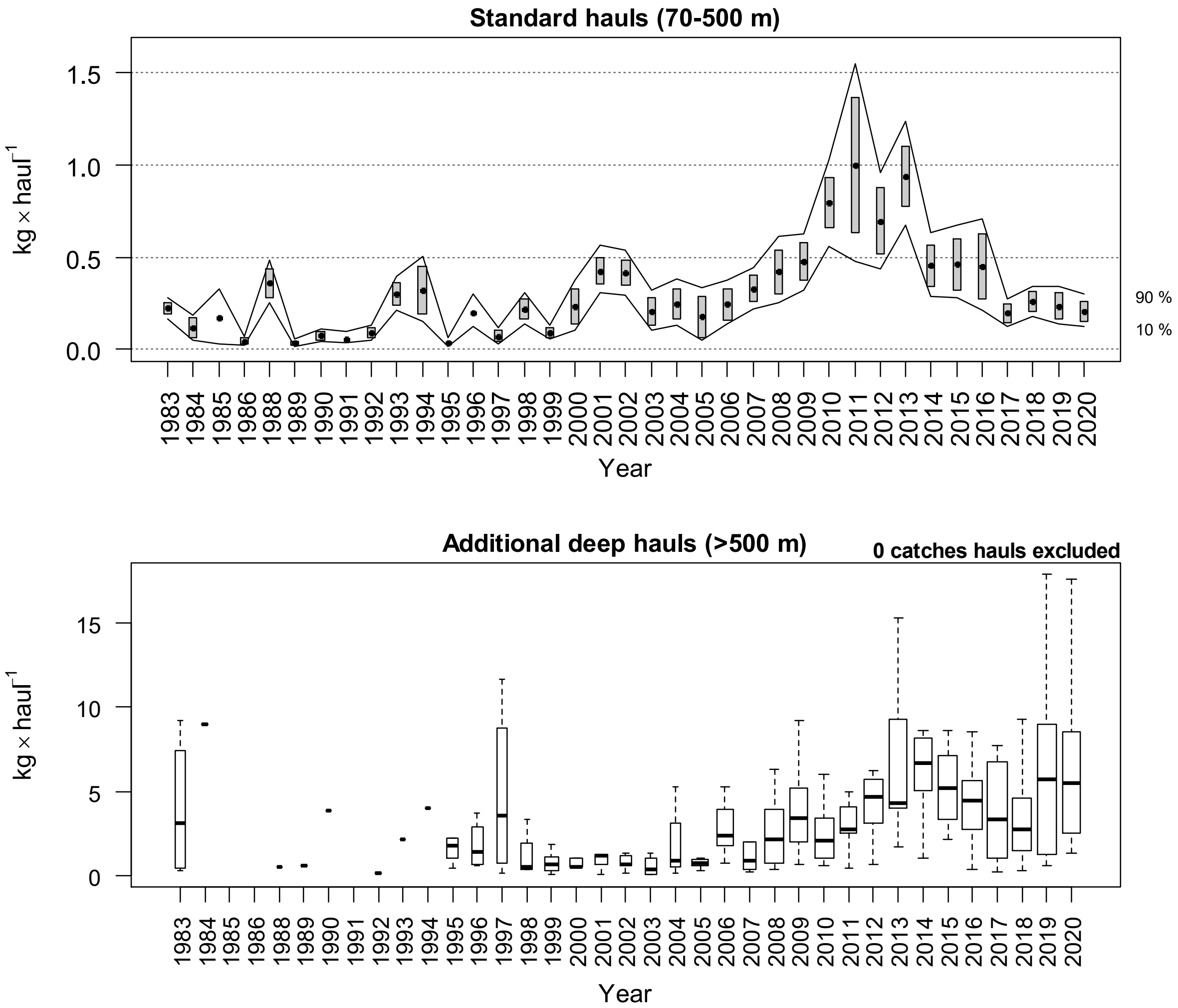


Figure 3 Evolution of *Phycis blennoides* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

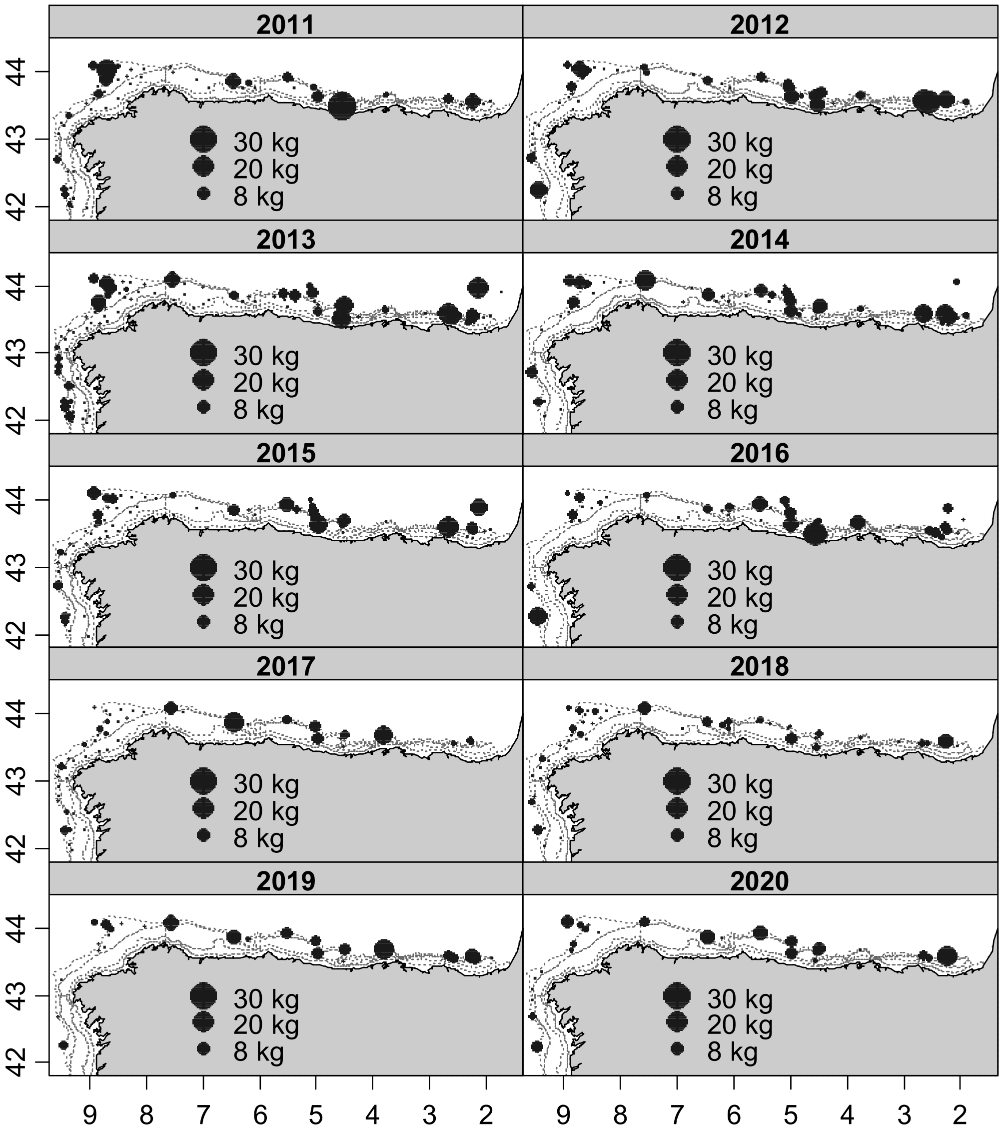


Figure 4 Geographic distribution of *Phycis blennoides* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

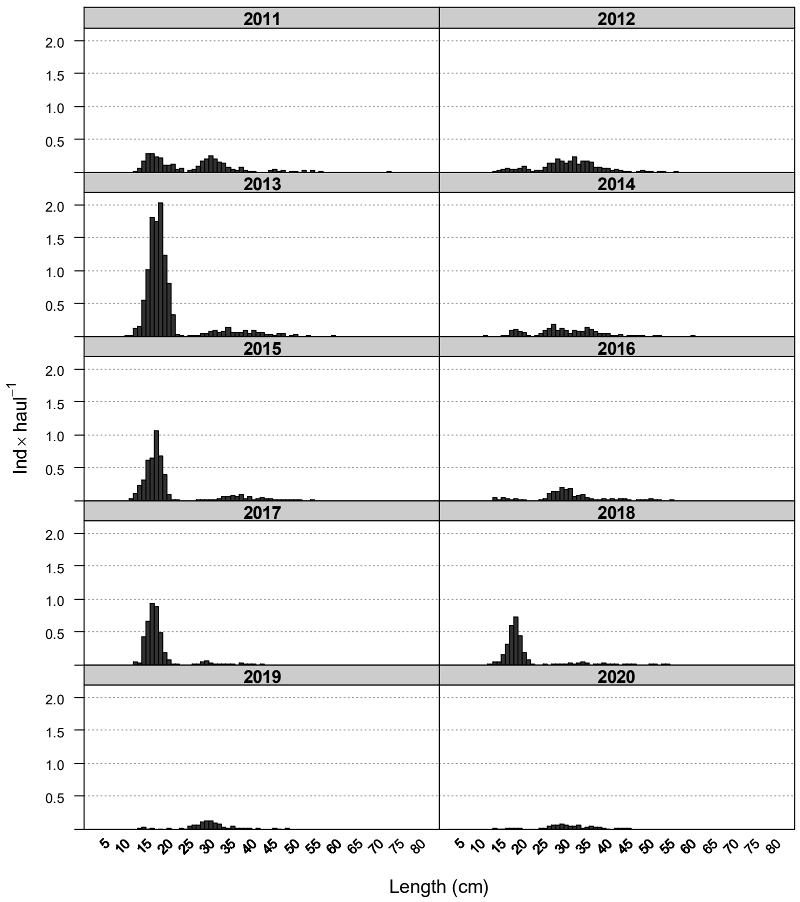
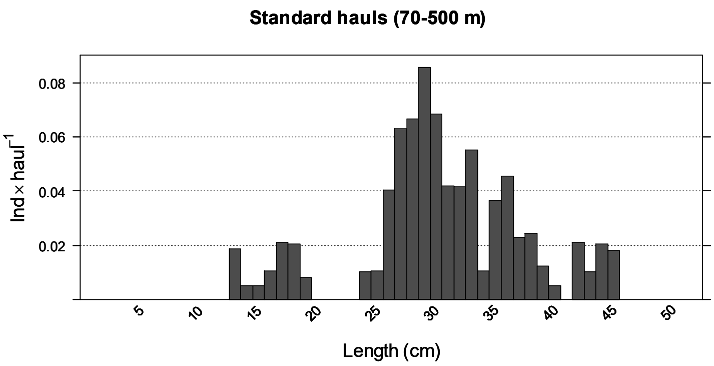


Figure 5 Mean stratified length distributions of *Phycis blennoides* in Northern Spanish Shelf surveys in the last decade



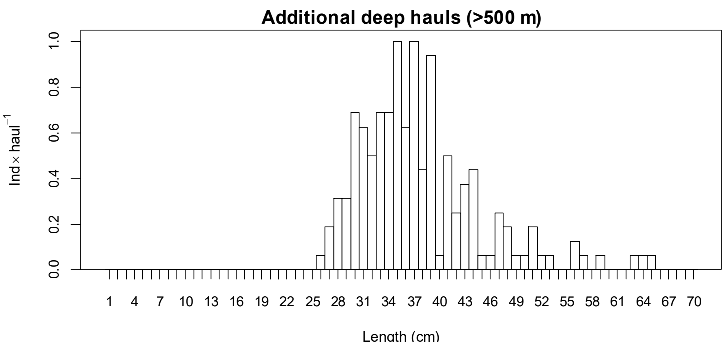


Figure 6 Mean length distributions of *Phycis blennoides* in additional hauls (>500 m) and in the standard hauls (70-500 m) in the North Spanish Shelf survey 2020

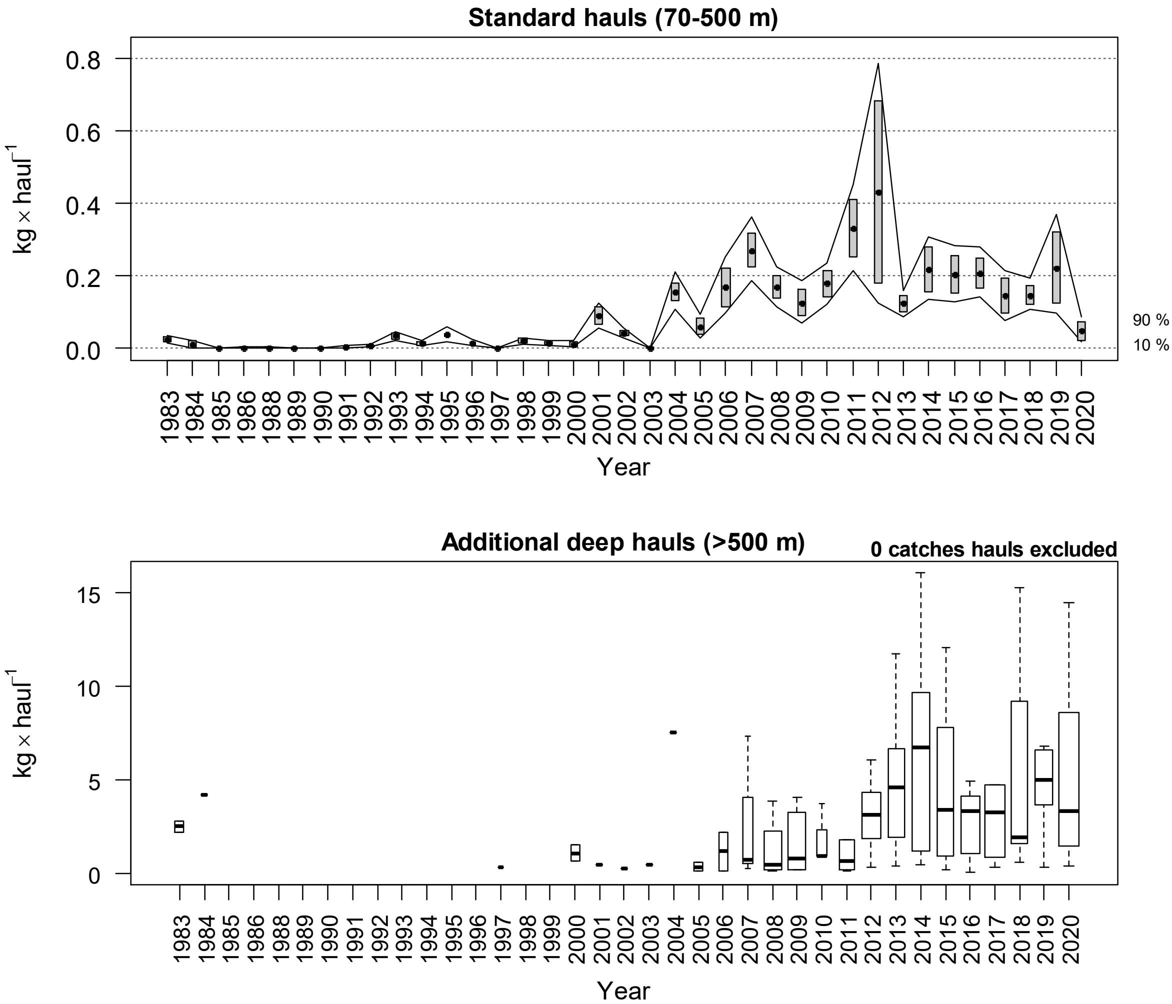


Figure 7 Evolution of *Molva macrophtalma* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

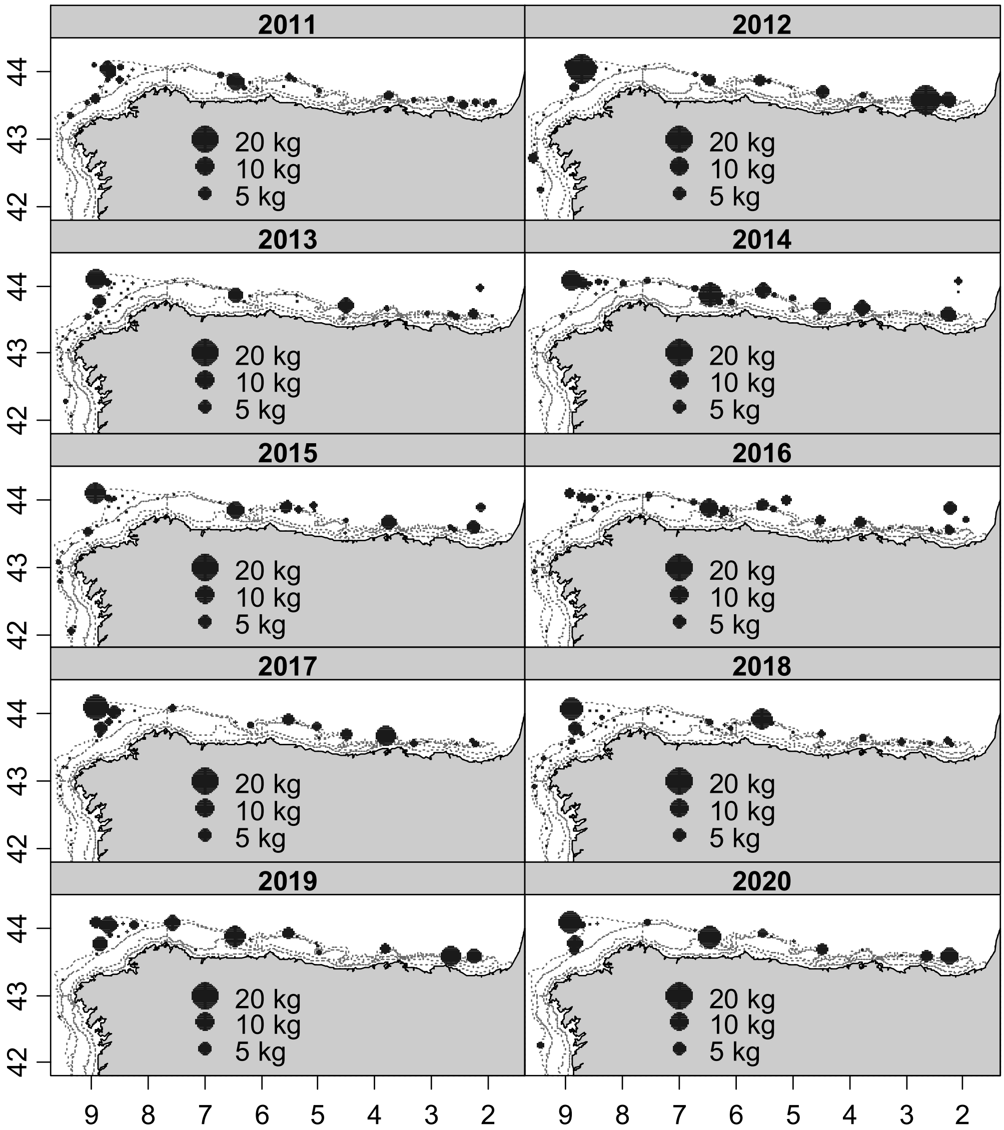


Figure 8 Geographic distribution of *Molva macrophtalma* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

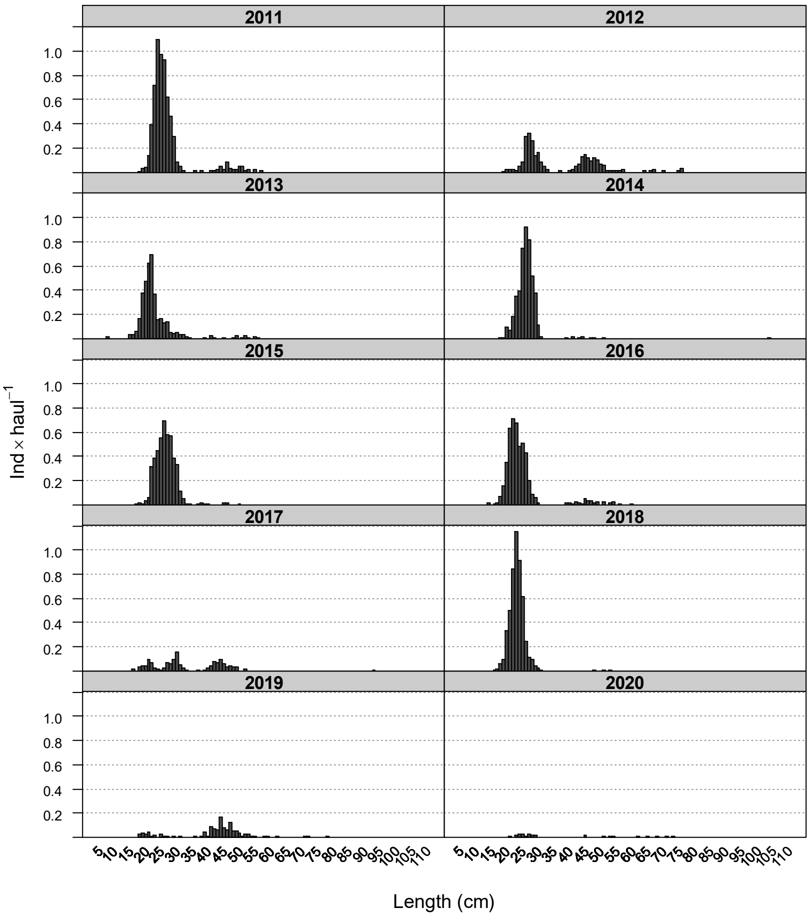
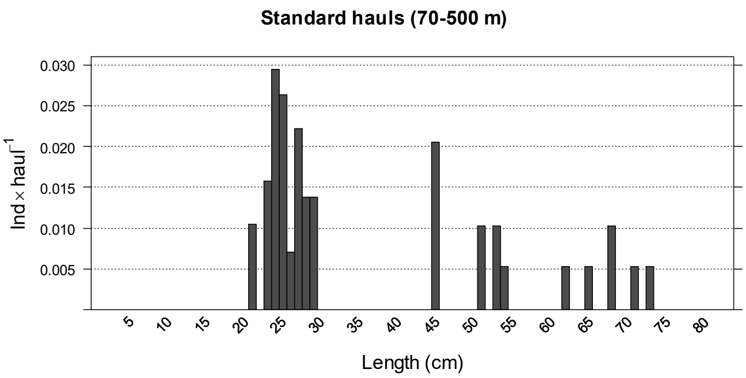


Figure 9 Mean stratified length distributions of *Molva macrophtalma* in Northern Spanish Shelf surveys in the last decade



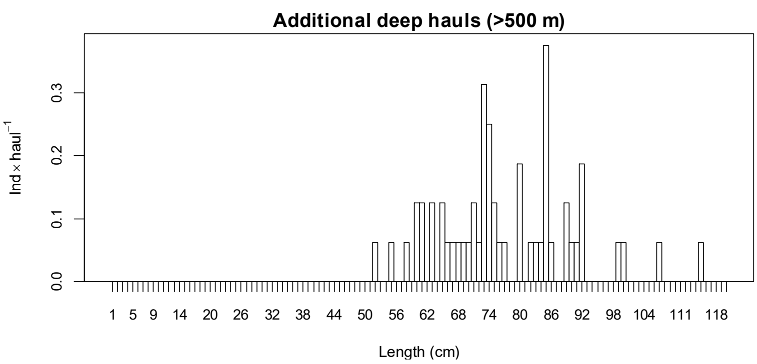


Figure 10 Mean length distributions of *Molva macrophtalma* in additional hauls (>500 m) and in the standard hauls (70-500 m) in the North Spanish Shelf survey 2020

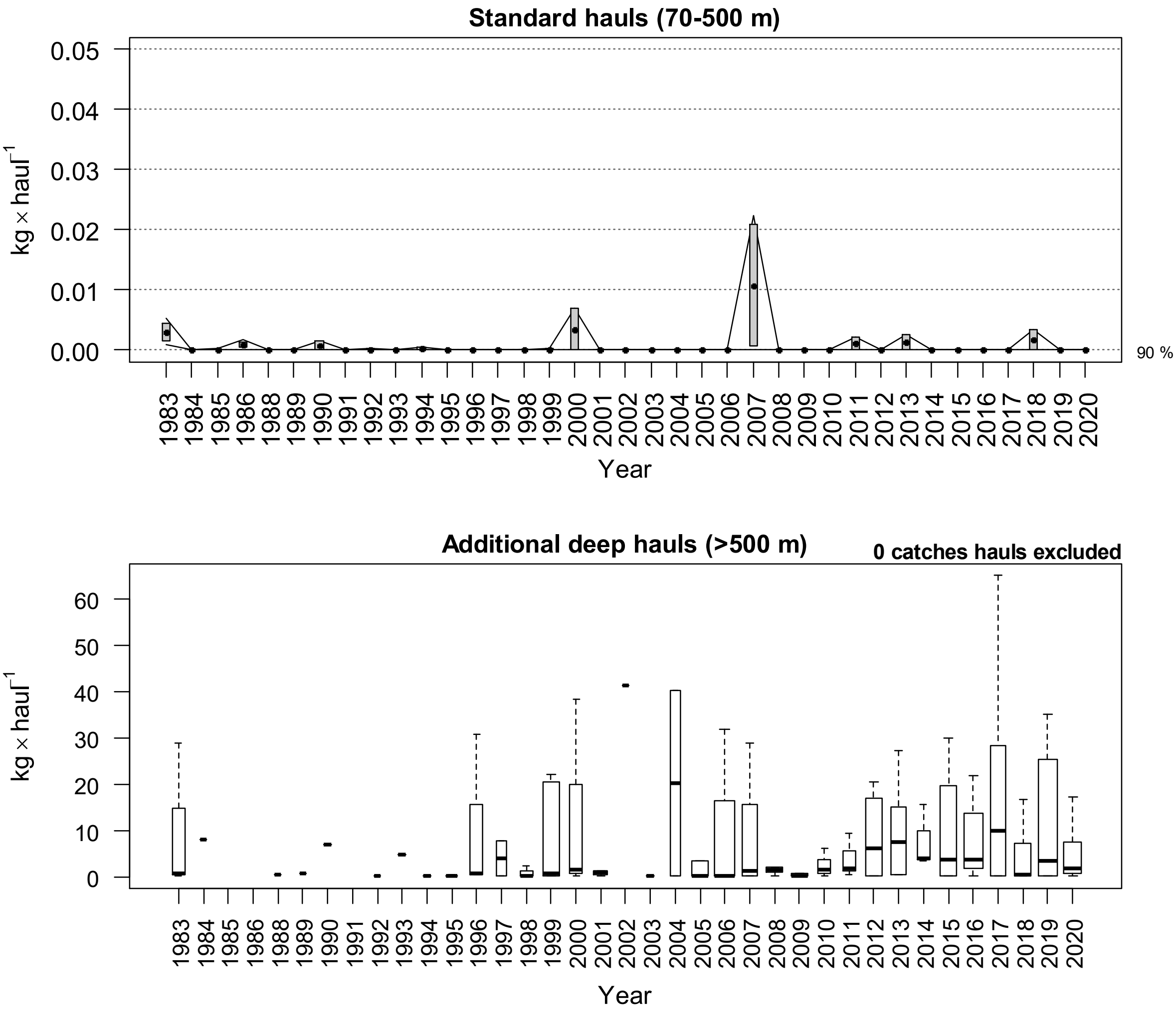


Figure 11 Evolution of *Trachyrincus scabrus* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

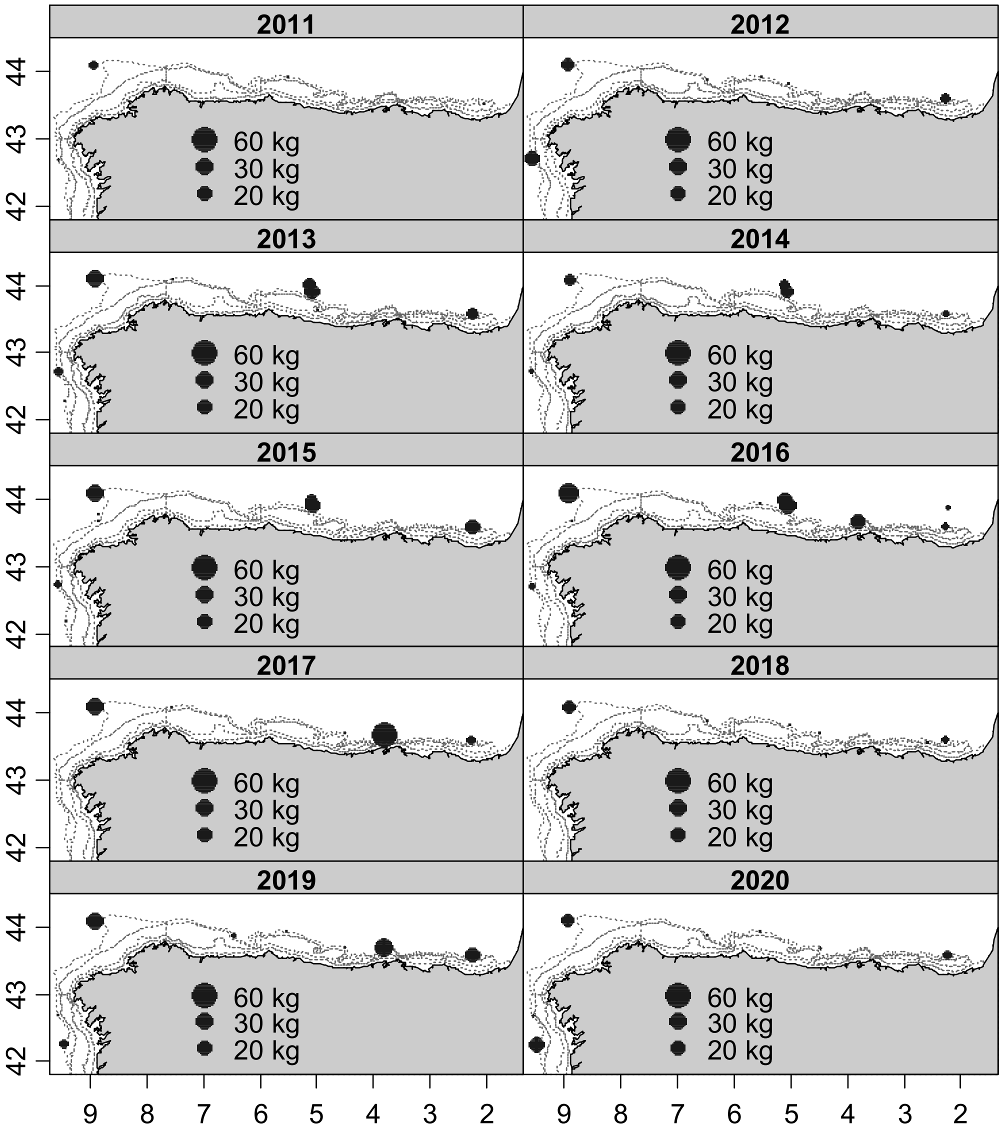


Figure 12 Geographic distribution of *Trachyrincus scabrus* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

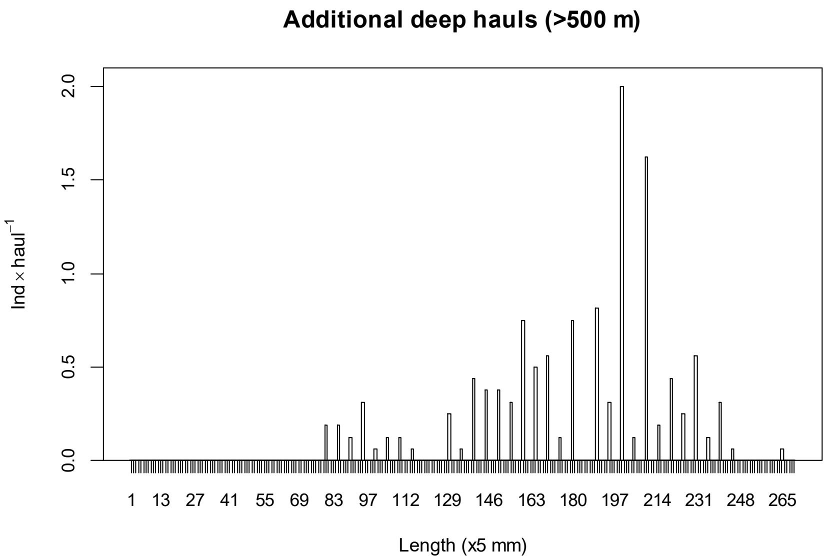


Figure 13 Mean length distributions of *Trachyrincus scabrus* in additional hauls (>500 m) in the North Spanish Shelf survey 2020

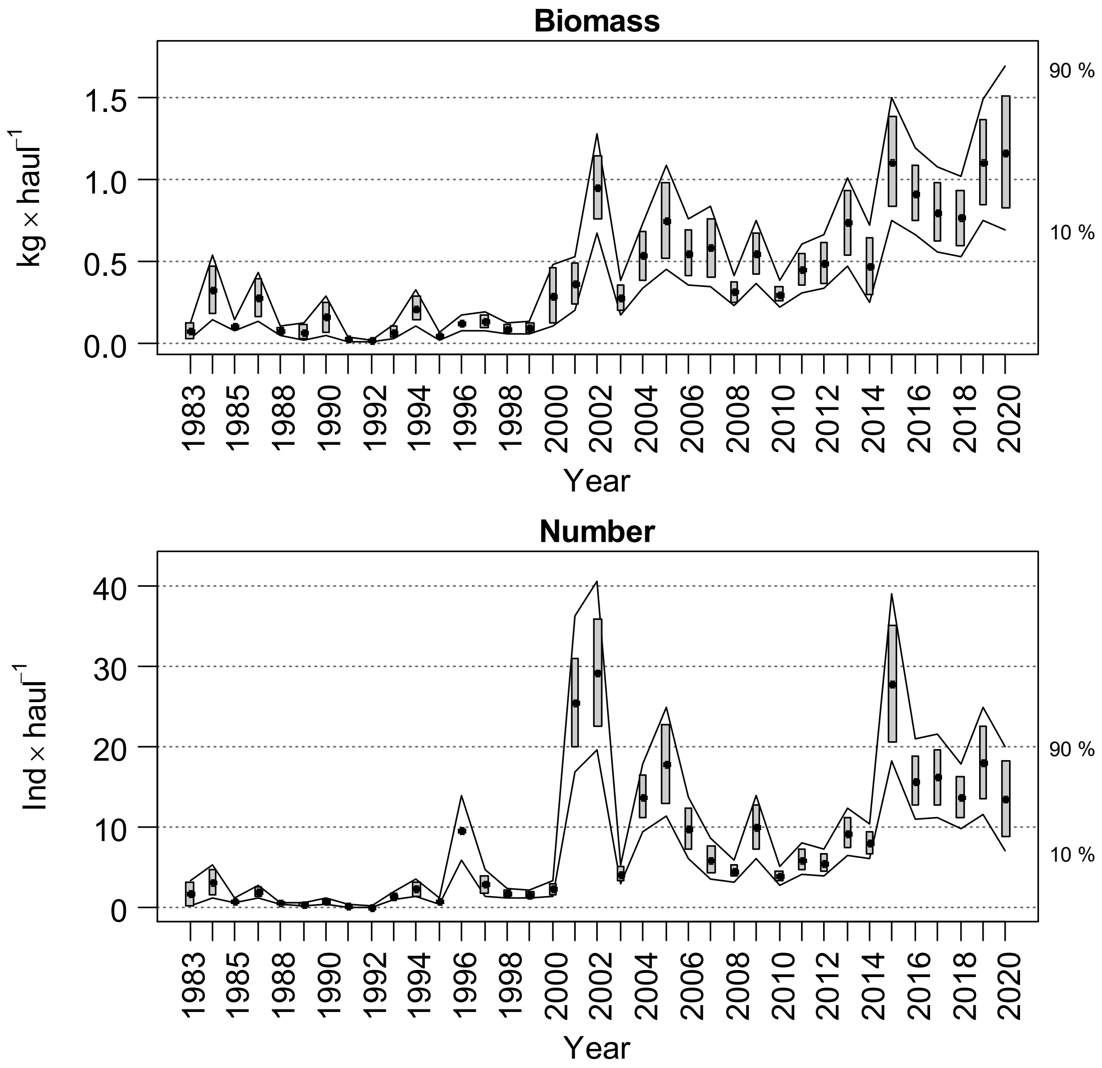


Figure 14 Evolution of *Helicolenus dactylopterus* mean stratified biomass and abundance in Northern Spanish Shelf surveys time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

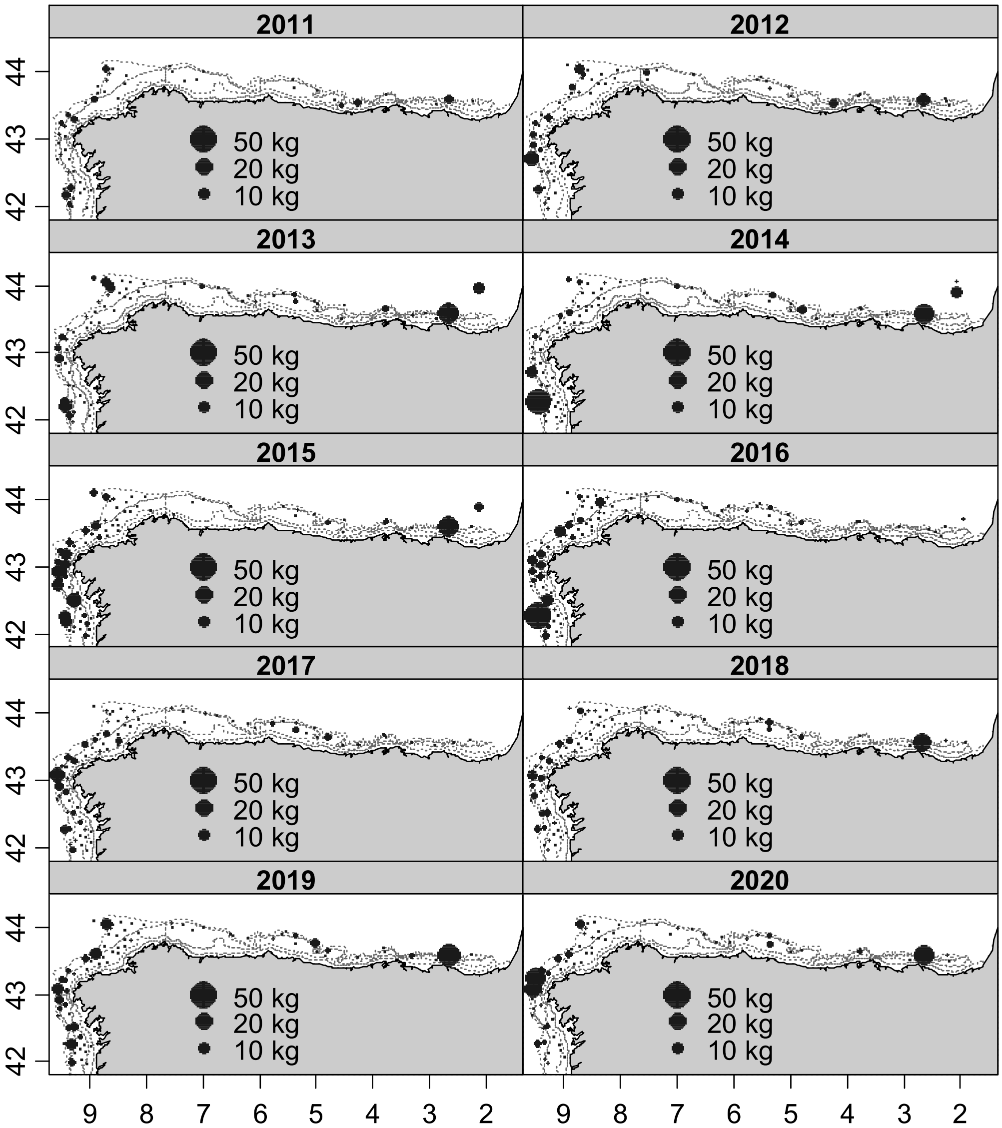


Figure 15 Geographic distribution of *Helicolenus dactyloperus* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

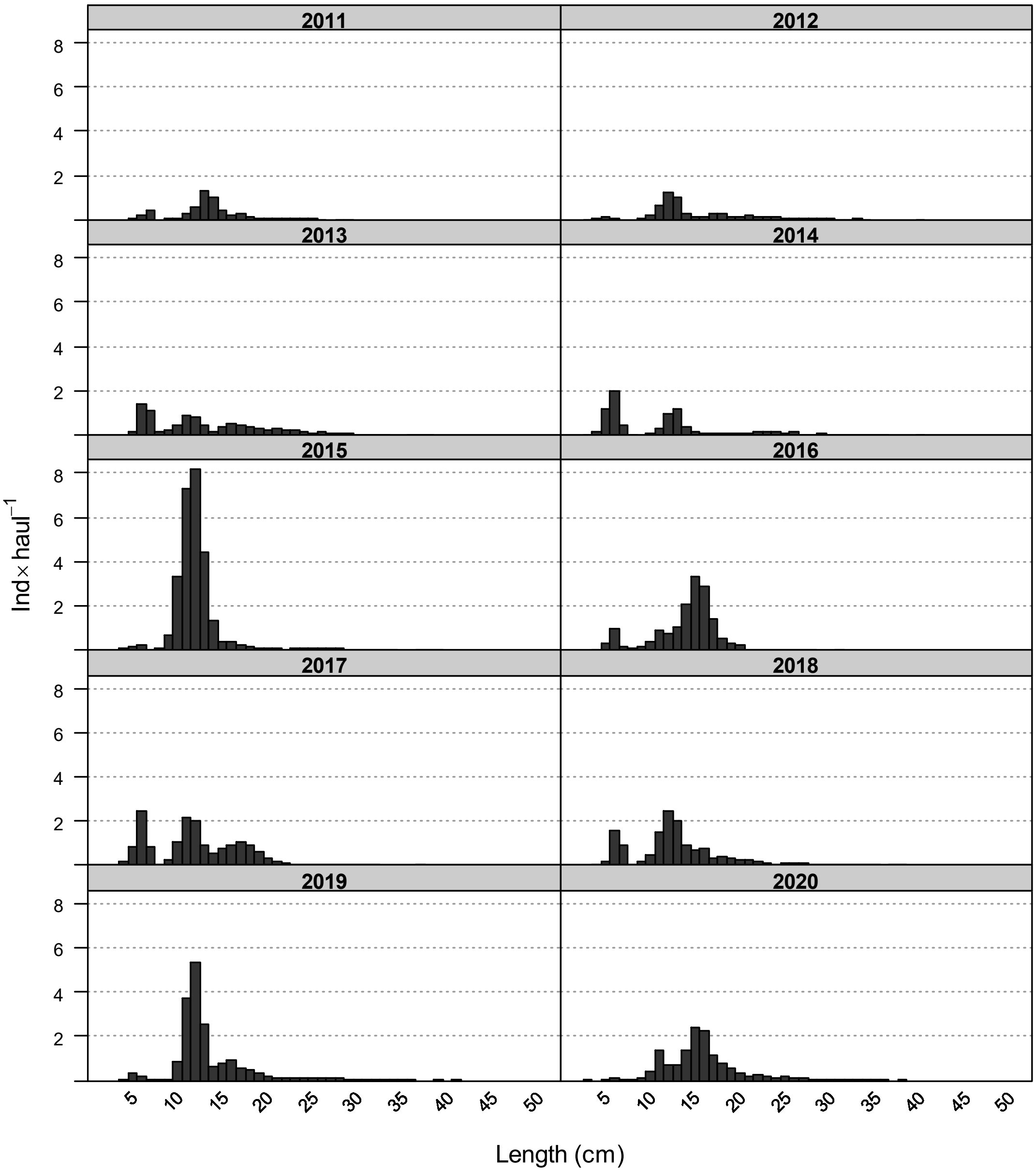


Figure 16 Mean stratified length distributions of *Helicolenus dactyloperus* in Northern Spanish Shelf surveys in the last decade

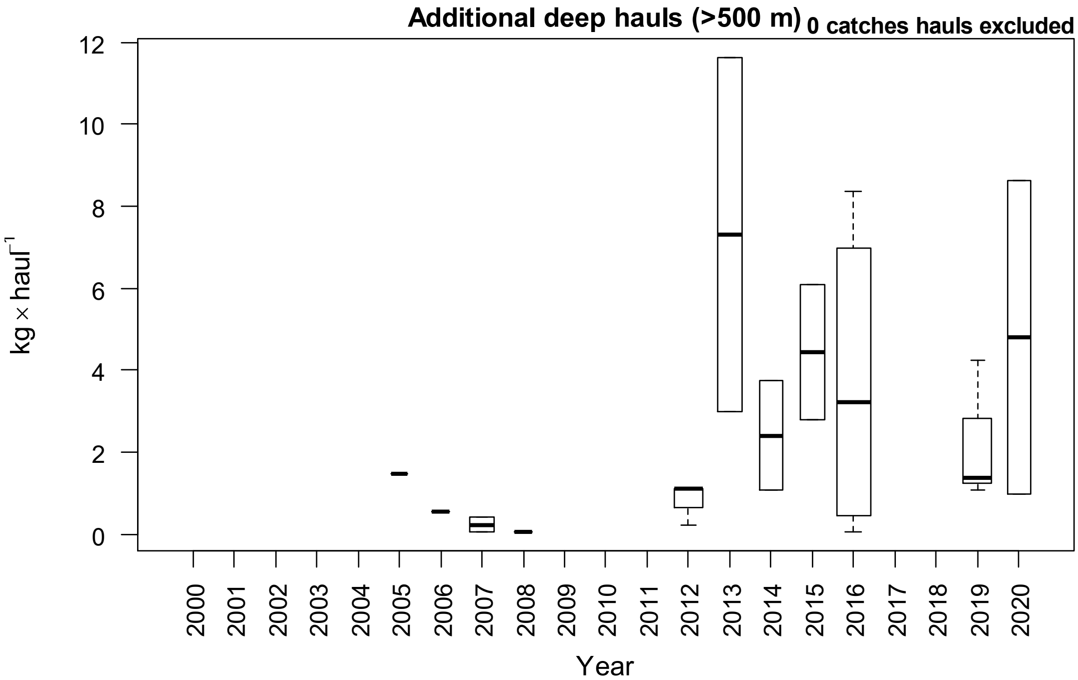


Figure 17 Evolution of *Aphanopus carbo* biomass in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

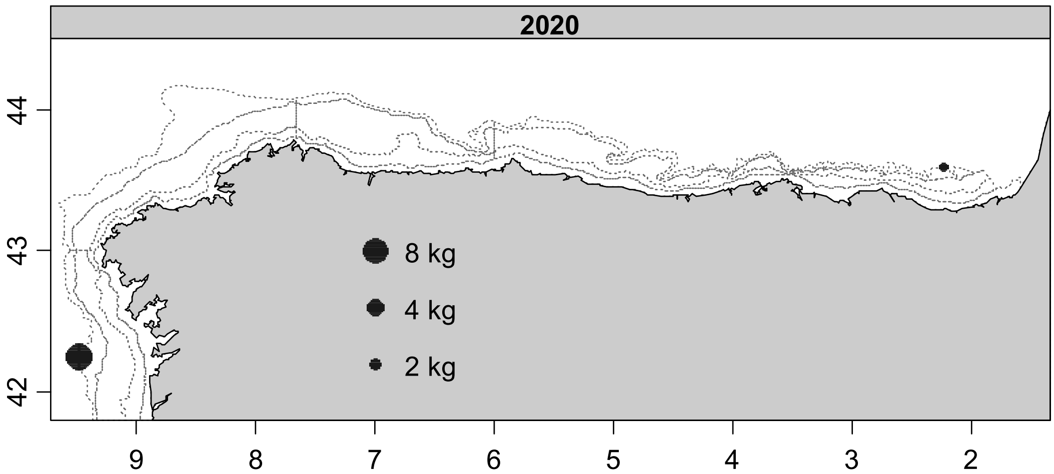


Figure 18 Geographic distribution of *Aphanopus carbo* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl survey 2020

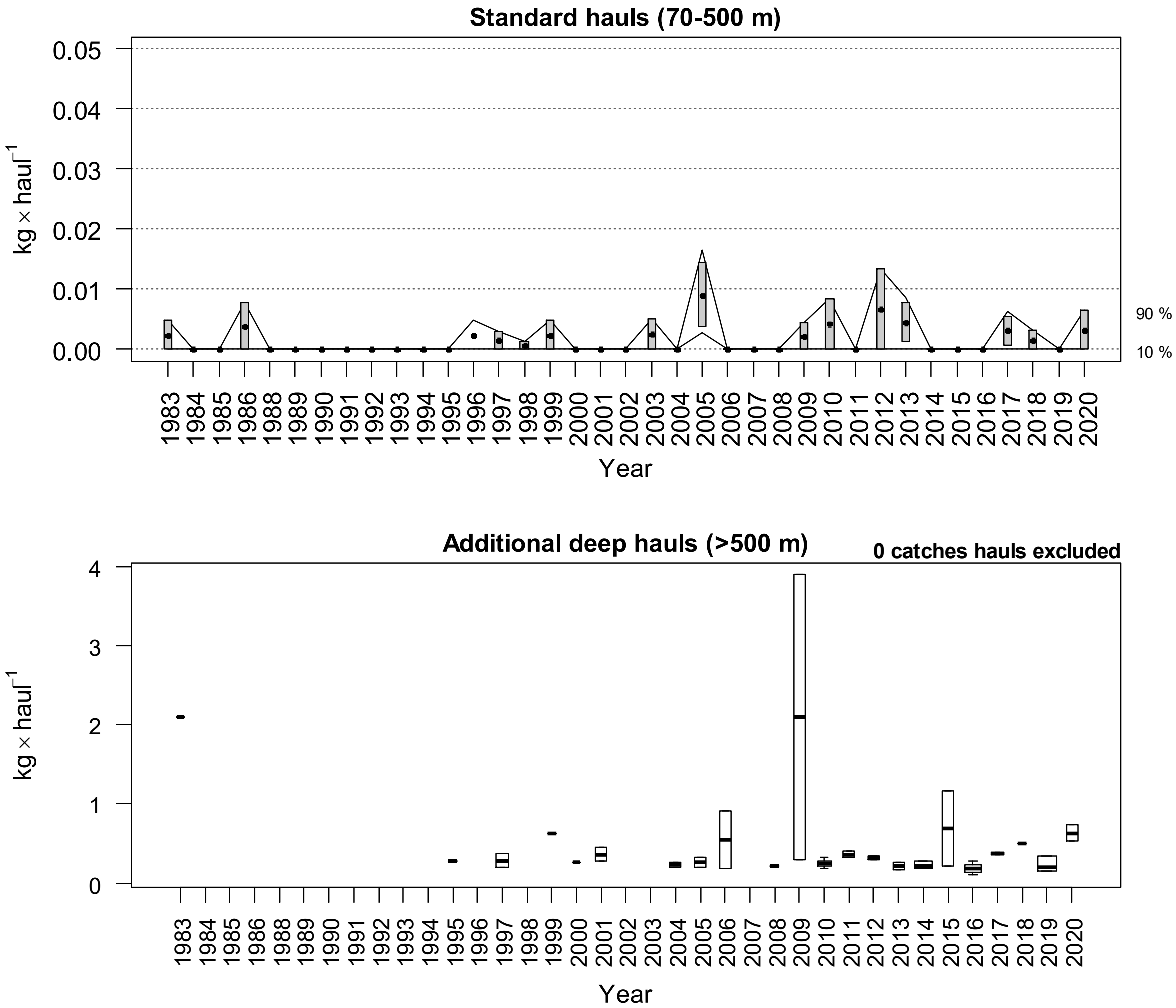


Figure 19 Evolution of *Beryx spp.* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

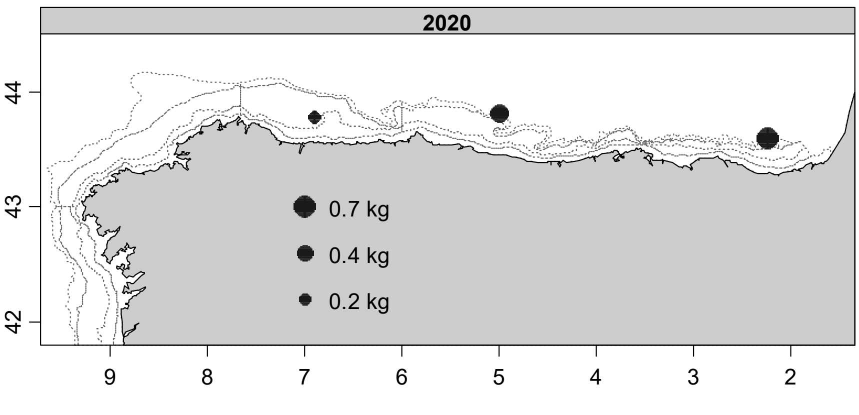


Figure 20 Geographic distribution of *Beryx* spp. catches (kg•haul-1) in the Northern Spanish Shelf bottom trawl survey 2020

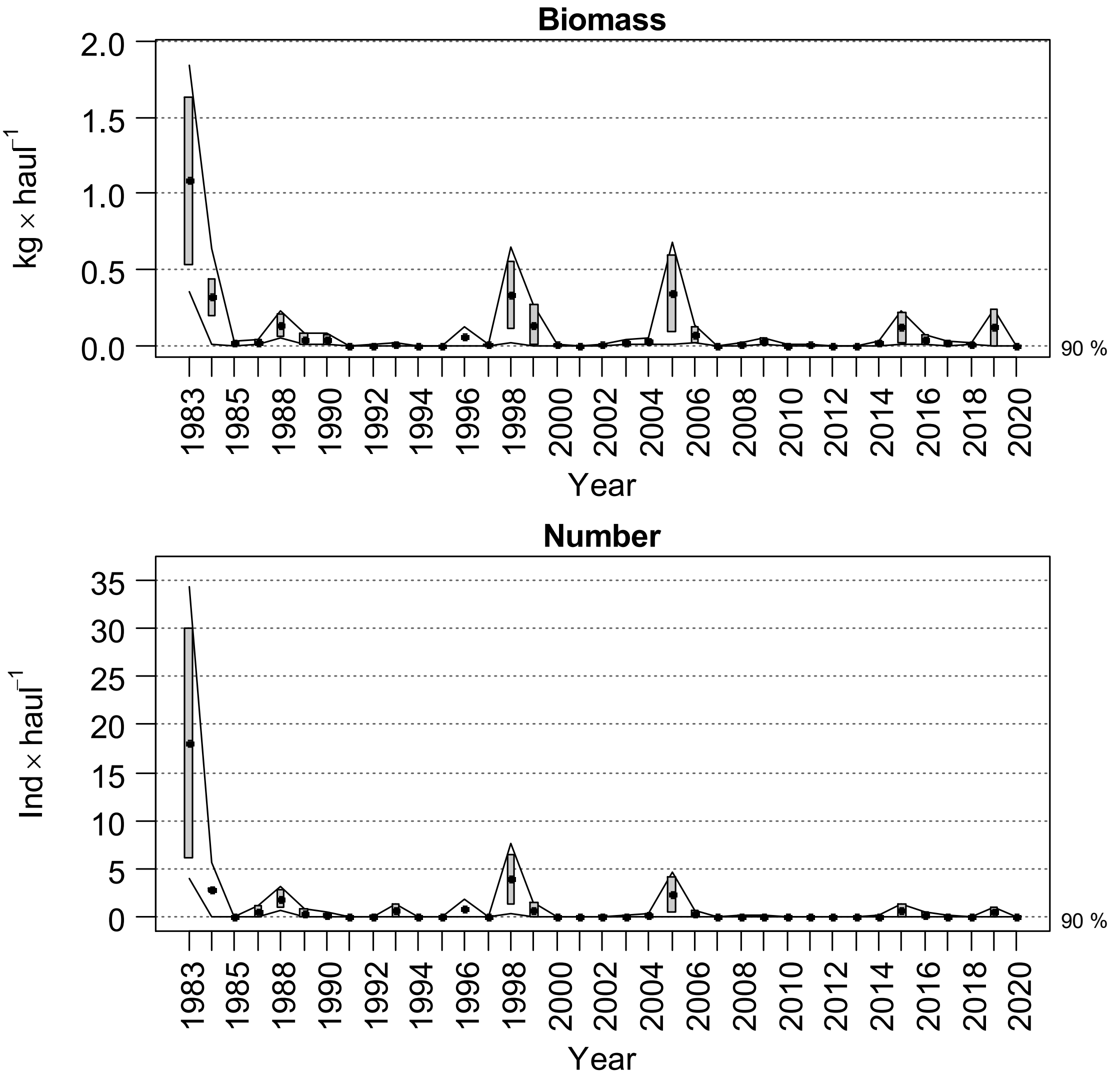


Figure 21 Evolution of *Pagellus bogaraveo* mean stratified biomass and abundance in Northern Spanish Shelf surveys time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

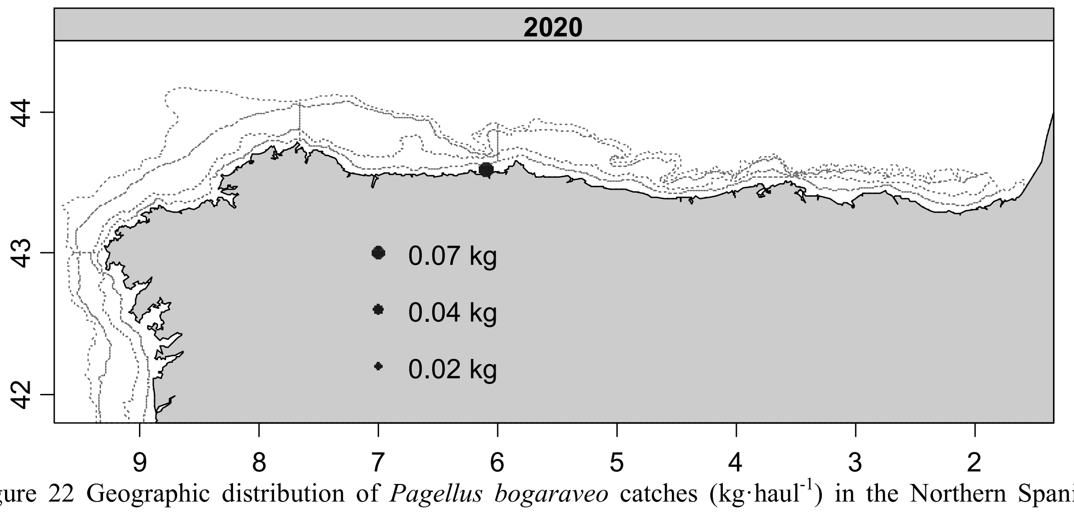


Figure 22 Geographic distribution of *Pagellus bogaraveo* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl survey 2020

Working Document to be presented to the Working Group on the
Biology and Assessment of Deep Sea Fisheries Resources

ICES WGDEEP, 22th - 28th April 2021, By correspondence

Results on silver smelt (*Argentina silus* and *A. sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*), roughsnout grenadier (*Trachyrincus scabrus*), Spanish ling and ling (*Molva macrophthalma* and *Molva molva*) from the Porcupine Bank Survey (NE Atlantic)

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Abstract

This working document presents the results of the most significant deep fish species caught in 2020 on the Porcupine Spanish Groundfish Survey (SP-PORC-Q3). Biomass, abundance, geographical distribution and length ranges were analysed for silver smelt (*Argentina silus* and *A. sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater fork-beard (*Phycis blennoides*), roughsnout grenadier (*Trachyrincus scabrus*), Spanish ling and ling (*Molva macrophthalma* and *Molva molva*) and other scarce deep sea species. The biomass of most of these species decreased this last survey, only *A. silus* and *P. blennoides* increased, althought *H. dactylopterus* increased in abundance. Signs of recruitment have been found for *H. dactylopterus* and *T. scabrus*.

Introduction

The Spanish bottom trawl survey on the Porcupine Bank (ICES Divisions 7c and 7k) has been carried out annually on the third-quarter (September) since 2001 to study the distribution, relative abundance and biological parameters of commercial fish 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 deep water fish species on the Porcupine bottom trawl surveys after the results presented previously (Baldó *et al.* 2008, Velasco *et al.* 2009, 2011, 2012, 2013, Fernández-Zapico *et al.* 2015, 2017, Ruiz-Pico *et al.* 2016, 2018, 2019, 2020). The species analysed were: *Argentina silus* (greater silver smelt), *Argentina sphyraena* (lesser silver smelt), *Helicolenus dactylopterus* (bluemouth), *Phycis blennoides* (greater forkbeard), *Trachyrincus scabrus* (roughsnout grenadier), *Molva molva* (ling), *Molva macrophthalma* (Spanish ling) and some other scarce deep sea species as *Aphanopus carbo* (black scabbardfish), *Coryphaenoides rupestris* (roundnose grenadier) and *Beryx spp.* (alfonsinos).

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, 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 1). 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).

The tow duration is 20 min since 2016, but the results were extrapolated to 30 min of trawling time to keep up the time series.

Results and discussion

In spite of the problems created by the pandemic and the COVID-19 disruption, the Porcupine Groundfish Survey was carried out without major problems, apart from an initial of 9-day delay that did not affect the overall survey duration.

In 2020, 81 valid standard hauls and 10 additional hauls were carried out. Among the additional hauls, three of them have been carried out into the standard stratification, to improve coverage in the gaps left by random sampling and seven of them, between 839 and 1425 m, to explore the continuity of the fish community in Porcupine Seabight (Figure 1).

The total stratified catch per haul increased significantly in 2020 compared to the previous year, becoming the second highest catch in the historical series below the year 2015 (Figure 2). Fish represented 96% of the total catch, and the selected deep water fish represented 14% of that total fish catch, with the following percentages per species: *Argentina silus* (61%), *Helicolenus dactylopterus* (17%), *Argentina sphyraena* (9%), *Trachyrincus scabrus* (5%), *Phycis blennoides* (5%), *Molva macrophtalma* (2%) and *Molva molva* (0.1%).

In 2020, only the biomass of *A. silus* and *P. blennoides* increased compared to the previous year. The rest of the species decreased. However, *H. dactylopterus* increased in abundance due, in part, to a high number of individuals smaller than 11cm, although they were also less than last year. Signs of recruitment have also been found for *T. scabrus*. Only a few specimens of *A. carbo, Beryx spp*. and *C. rupestris* were found.

Argentina silus (greater silver smelt) and *Argentina sphyraena* (lesser silver smelt)

In 2020, both the biomass and the number of *A. silus*, which is the species that historically contributes the most to the genus in the Porcupine survey, increased considerably, breaking the downward trend of recent years and staying in the medium-high values of the historical series. *A. sphyraena*, by contrast, decreased sharply, getting medium-low values of the time series (Figure 3; Figure 4 and Figure 5).

Both species were found in the north of the bank, where the decline of *A. sphyraena* and the increment of *A. silus* with respect to the previous year were observed, and *A. silus* was also present in the south part of the bank, as usual (Figure 6 and Figure 7).

The abundance of small individuals of *A. silus* decreased compared to the previous year, although a mode at 17 cm was appreciated, whereas the abundance around a second mode at 22 cm increased greatly. *A. sphyraena* kept a similar size distribution to the 2019 survey, with a single mode at 22 cm (Figure 8).

***Helicolenus dactylopterus* (bluemouth)**

Although bluemouth is not requested in the ICES DCF Data Call, biomass and abundance are significant in the area and useful for the assessment of the species (ICES, 2015).

The abundance of this species has continued to increase since 2017, reaching the highest value of the time series in 2020. The biomass, however, has decreased slightly in the last survey, keeping medium values in the series (Figure 9). Recruitment broke the increasing trend of the last three years but still has a relatively high value (Figure 10).

The geographical distribution of *H. dactylopterus* was similar to that of the previous year, although the biomass points were more widely distributed throughout the bank, Recruits distributed both on the Irish shelf and in the southeast area of the bank, barely deeper than 500 m (Figure 11).

The figure 12 shows two well defined modes in 8 cm and 14 cm. A slight decrease in the abundance of the largest sizes (25 to 39 cm) can also be seen.

***Trachyrincus scabrus* (roughsnout grenadier)**

T. scabrus has been included in this report since last year.

Biomass and abundance are significant in the area. In the last three years they were among the highest values of the time series, although in this last survey, both biomass and abundance decreased slightly (Figure 13).

The species was found in the deepest southeast area and in the deepest west area, as usual in the time series (Figure 14).

The length distribution in 2020 showed a small mode at 7 cm and a more abundant one at 18.5 cm (Figure 15).

***Phycis blennoides* (greater fork-beard)**

The biomass and abundance of *P. blennoides* followed the pattern observed last year, but they increased slightly in this last survey, although the values still remain among the lowest in the time series. (Figure 16).

Biomass patches were widely found in the south, west and east area, but scarcely in the north, as in previous years (Figure 17).

A small mode is seen at 20 cm and two more abundant at 31 cm and 40 cm (Figure 18).

***Molva molva* (ling) and *Molva macrophthalma* (Spanish ling)**

These two species were comparatively analysed in this working document as in previous reports.

M. molva was scarcer than *M. macrophtalma* in the area, as usual. Both species have followed a downward trend since 2014, although *M. macrophthalma* broke that trend last year with a slight increase, dropping again slightly this last survey. However, *M. molva* continued to decline, reaching the lowest value of the time series in 2020 (0.13 kg haul^{-1} and 0.06 ind. haul^{-1}) (Figure 19).

M. molva showed a scarce geographical distribution in this latest survey, whereas *M. macrophtalma* showed biomass patches around the bank, especially in the south part of the study area (Figure 20).

The size distribution of *M. macrophtalma* showed a mode around 56 cm. On the other hand, the smallest and the largest individuals of *M. molva* from last year were not found, the few specimens of this species presented sizes of 50 cm, 53 cm, 67 cm, 69 cm and 70 cm (Figure 21).

Other deep water fish species

In 2020, the deep water species *Aphanopus carbo, Coryphaenoides rupestris* and *Beryx splendes* have been scarcely found in the study area.

The species *A. carbo* and *C. rupestris* were found only in the deep hauls between 839 and 1425 m carried out to explore the continuity of the fish community in Porcupine Seabight, out of the standard stratification, in the southeast part of the bank.

Two individuals of the species *B. splendens*, with sizes 25 and 34 cm, were found in the standard stratification, in the southern part of the bank, in two hauls.

Beryx decadactylus, which was scarcely found other years, has not been caught in 2020.

Acknowledgements

We would like to thank the *R/V Vizconde de Eza* crew and the IEO scientific teams that made thePorcupine Spanish Groundfish Survey possible. They are included in the ERDEM project, whichhas been co-funded by the EU through the European Maritime and Fisheries Fund (EMFF) withinthe National Program of collection, management and use of data in the fisheries sector and supportfor scientific advice regarding the Common Fisheries Policy.

References

Baldó, F.; Velasco, F.; Blanco, M. and Gil, J. 2008. Results on Argentine (*Argentina spp.*), Bluemouth (*Helicolenus dactylopterus*), Greater forkbeard (*Phycis blennoides*) and Blue ling (*Molva dypterigia*) from the 2001-2007 Porcupine Bank (NE Atlantic) bottom trawl surveys. WD presented to the ICES WGDEEP, Copenhagen, Denmark, 03-10 March 2008. 16 pp.

Fernández-Zapico O., Ruiz-Pico S., Velasco F., Baldó F. 2015. Results on silver smelt (*Argentina silus* and *Argentina sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*) and ling (*Molva molva* and *Molva macrophthalma*) from 2001 to 2015 Porcupine Bank (NE Atlantic) survey. Working document presented to the WGDEEP, Copenhagen, Denmark, 20-27 March 2015. 18 pp

Fernández-Zapico O., Ruiz-Pico S., Velasco F., Baldó F. 2017. Results on silver smelt (*Argentina silus* and *Argentina sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*) and Spanish ling (*Molva macrophthalma*) and ling (*Molva molva*) from 2016 Porcupine Bank (NE Atlantic) survey. Working document presented to the WGDEEP, Copenhagen, Denmark, 24 April-1 May 2017.

ICES, 2015. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources, Copenhagen, Denmark, 20-27 March 2015. ICES CM 2015/ACOM:17. 738 pp.

ICES, 2017. Manual of the IBTS North Eastern Atlantic Surveys. Series of ICES Survey Protocols SISP 15. 92 pp. http://doi.org/10.17895/ices.pub.35

Kingsley, M.C.S.; Kanneworff, P. and Carlsson, D.M. 2004. Buffered random sampling: a sequential inhibited spatial point process applied to sampling in a trawl survey for northern shrimp Pandalus borealis in West Greenland waters. ICES Journal of Marine Science, 61: 12-24.

Ruiz-Pico S., Fernández-Zapico O., Velasco F., Baldó F. 2016. Results on silver smelt (*Argentina silus* and *Argentina sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*) and ling (*Molva molva* and *Molva macrophthalma*) from 2001 to 2015 Porcupine Bank (NE Atlantic) survey. Working document presented to the WGDEEP, Copenhagen, Denmark, 20-27 March 2016. 18 pp

Ruiz-Pico S., Fernández-Zapico O., Blanco M., Velasco F., Baldó F. 2018. Results on silver smelt (*A. silus* and *Argentina sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*) and Spaninsh ling (*Molva macrophthalma*) and ling (*Molva molva*) from the Porcupine Bank survey (NE Atlantic). Working document presented to the WGDEEP, Copenhagen, Denmark, 11-18 Apr 2018. 20 pp

Ruiz-Pico S., Blanco M., Fernández-Zapico O., Velasco F., Baldó F. 2019. Results on silver smelt (*A. silus* and *Argentina sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*), Spaninsh ling (*Molva macrophthalma*) and ling (*Molva molva*) from the Porcupine Bank survey (NE Atlantic). Working document presented to the WGDEEP, Copenhagen, Denmark, 2-9 May 2019. 20 pp

Ruiz-Pico S., Fernández-Zapico O., Blanco M., Velasco F., Baldó F. 2020. Results on silver smelt (*A. silus* and *Argentina sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*), roughsnout grenadier (*Trachyrincus scabrus*), Spaninsh ling (*Molva macrophthalma*) and ling (*Molva molva*) from the Porcupine Bank survey (NE Atlantic). Working document presented to the WGDEEP, Copenhagen, Denmark, 25 Apr-1 May 2020. 22 pp

Velasco, F. and Serrano, A., 2003. Distribution patterns of bottom trawl faunal assemblages in Porcupine Bank: implications for Porcupine surveys stratification design. WD presented to the ICES IBTSWG, Lorient, France 25-28 March 2003. 19 pp.

Velasco, F.; Blanco, M.; Baldó, F. and Gil, J. 2009. Results on Argentine (*Argentina* spp.), Bluemouth (*Helicolenus dactylopterus*), Greater forkbeard (*Phycis blennoides*) and Spanish ling (*Molva macrophthalma*) from 2008 Porcupine Bank (NE Atlantic) survey. Working document presented to the WGDEEP, Copenhagen, Denmark, 9-16 March 2009. 17 pp.

Velasco, F.; Blanco, M.; Baldó, F. and Gil, J. 2011. Results on Argentine (*Argentina* spp.), Bluemouth (*Helicolenus dactylopterus*), Greater forkbeard (*Phycis blennoides*) and Spanish ling (*Molva macrophthalma*) from 2010 Porcupine Bank (NE Atlantic) survey. Working document presented to the WGDEEP, Copenhagen, Denmark, 2-8 March 2011. 17 pp.

Velasco, F.; Blanco, M.; Baldó, F. and Gil, J. 2012. Results on Argentine (*Argentina* spp.), Bluemouth (*Helicolenus dactylopterus*), Greater forkbeard (*Phycis blennoides*) and Spanish ling (*Molva macrophthalma*) from 2011 Porcupine Bank (NE Atlantic) survey. Working document presented to the WGDEEP, Copenhagen, Denmark, 28 March-5 April 2012. 20 pp.

Velasco, F.; Blanco, M.; Baldó, F. and Gil, J. 2013. Results on Argentine (*Argentina* spp.), Bluemouth (*Helicolenus dactylopterus*), Greater forkbeard (*Phycis blennoides*) and Spanish ling (*Molva macrophthalma*) from 2012 Porcupine Bank (NE Atlantic) survey. Working document presented to the WGDEEP, Copenhagen, Denmark, 14-20 March 2013. 19 pp.

Figures

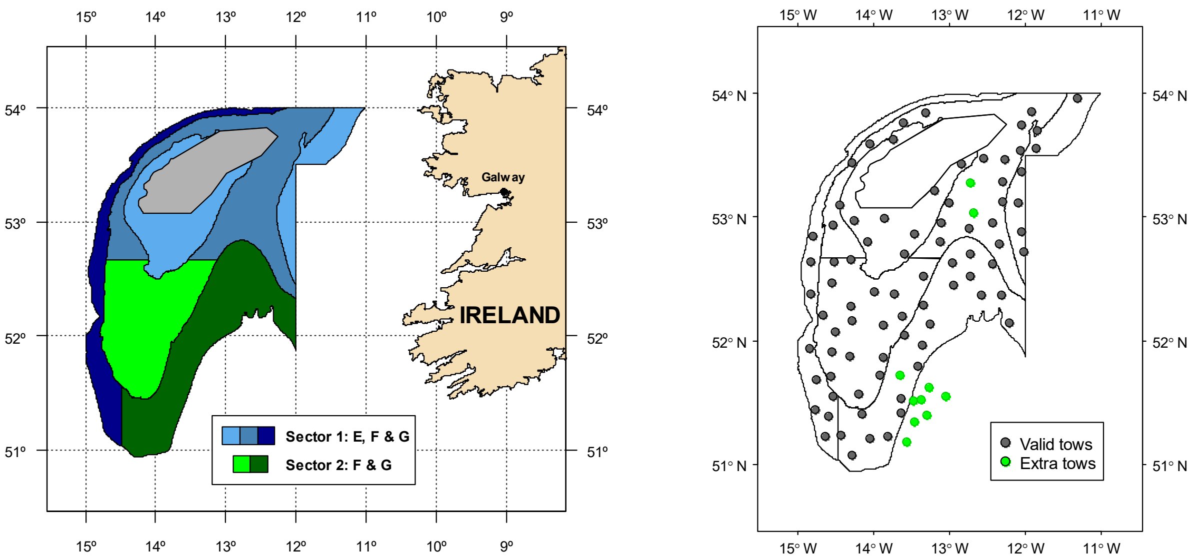

Figure 1. Left: Stratification design used in Porcupine surveys from 2003, previous data were re-stratified. Depth strata are: E) shallower than 300 m, F) 301 – 450 m and G) 451 – 800 m. Grey area in the middle of Porcupine bank corresponds to a large non-trawlable area, not considered for area measurements and stratification. Right: distribution of hauls performed in 2020.

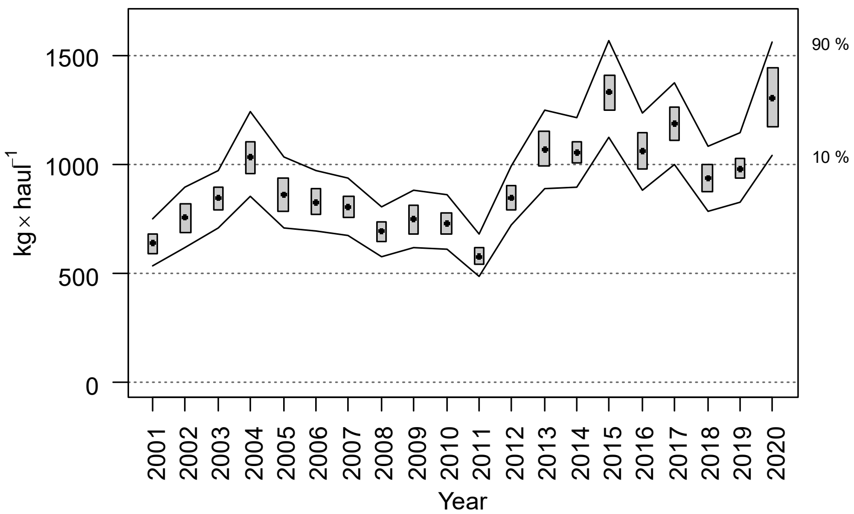

Figure 2. Evolution of the total catch in Porcupine surveys (2001-2020)

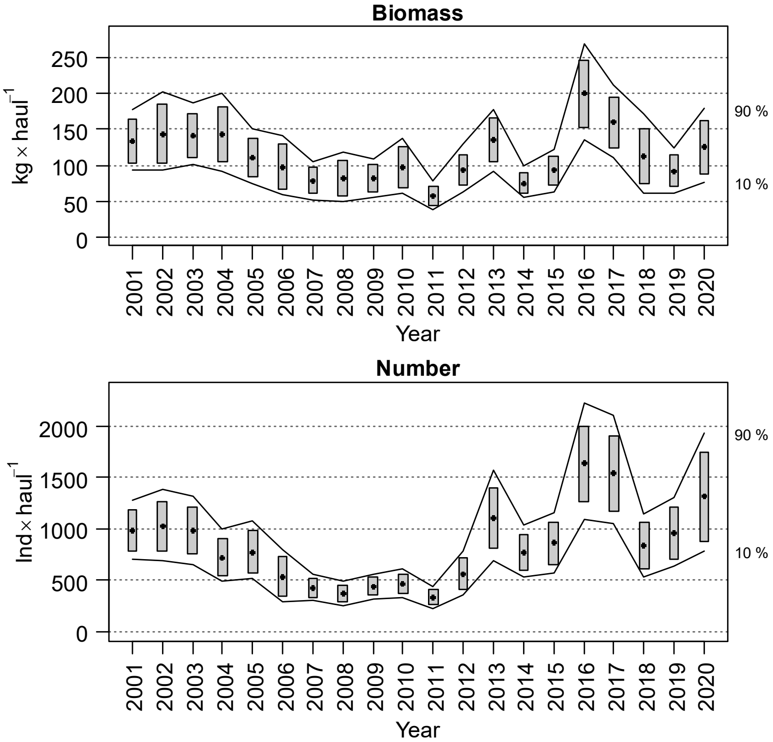

Figure 3. Evolution of *Argentina* spp. (mainly *Argentina silus*) biomass and abundance indices in Porcupine surveys (2001-2020). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000)

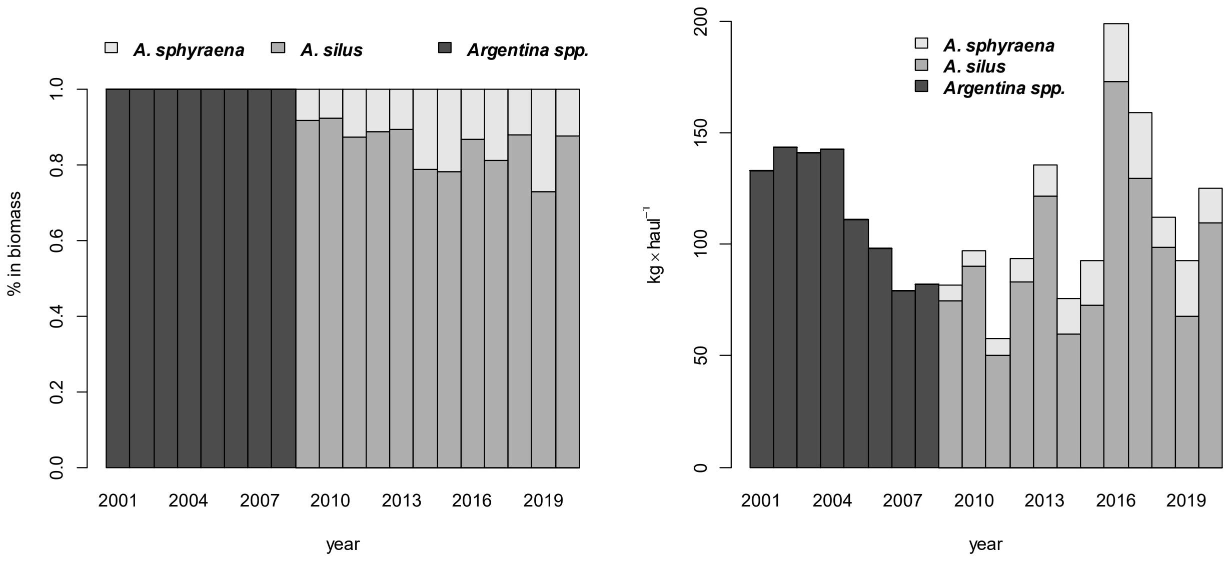

Figure 4. Share and abundance of Argentine species in Porcupine surveys (2001-2020)

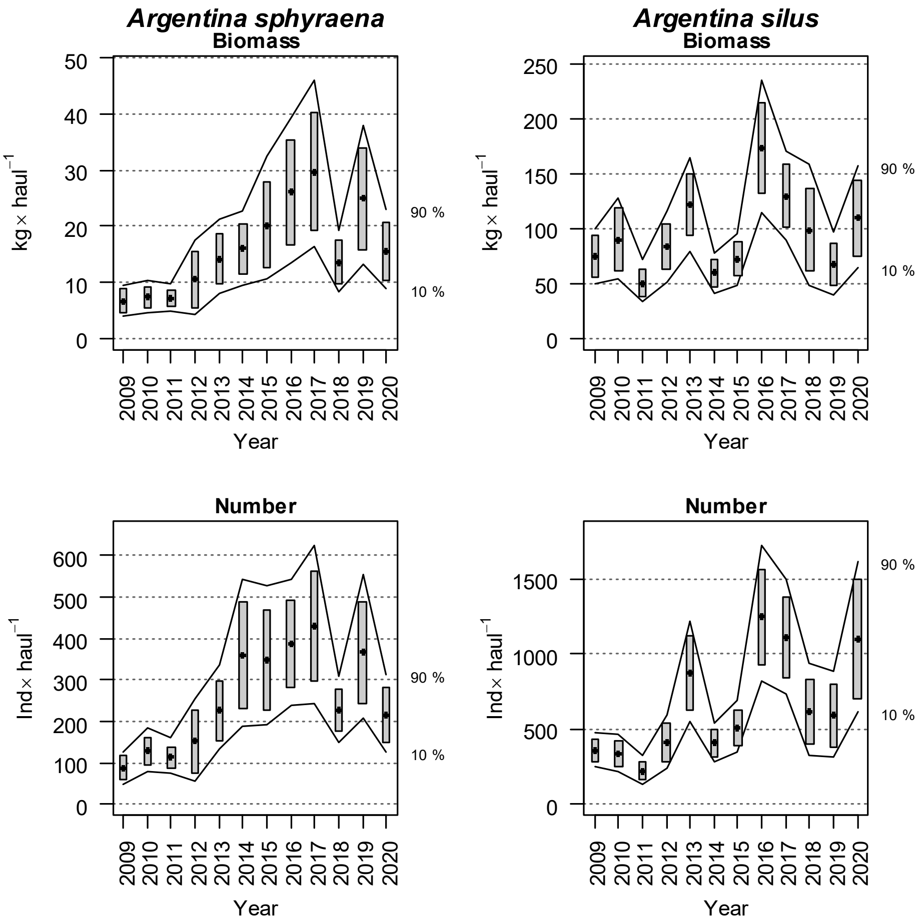

Figure 5. Evolution of *Argentina sphyraena* and *Argentina silus* biomass and abundance indices in Porcupine surveys (2009-2020). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000)

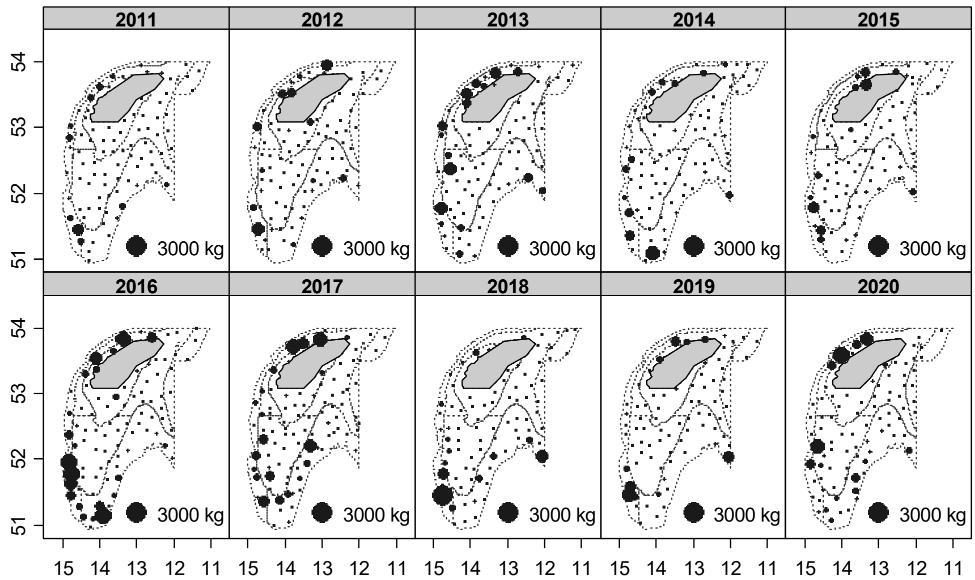

Figure 6. Geographic distribution of *Argentina* spp. catches (kg/30 min haul) in Porcupine surveys (2011-2020)

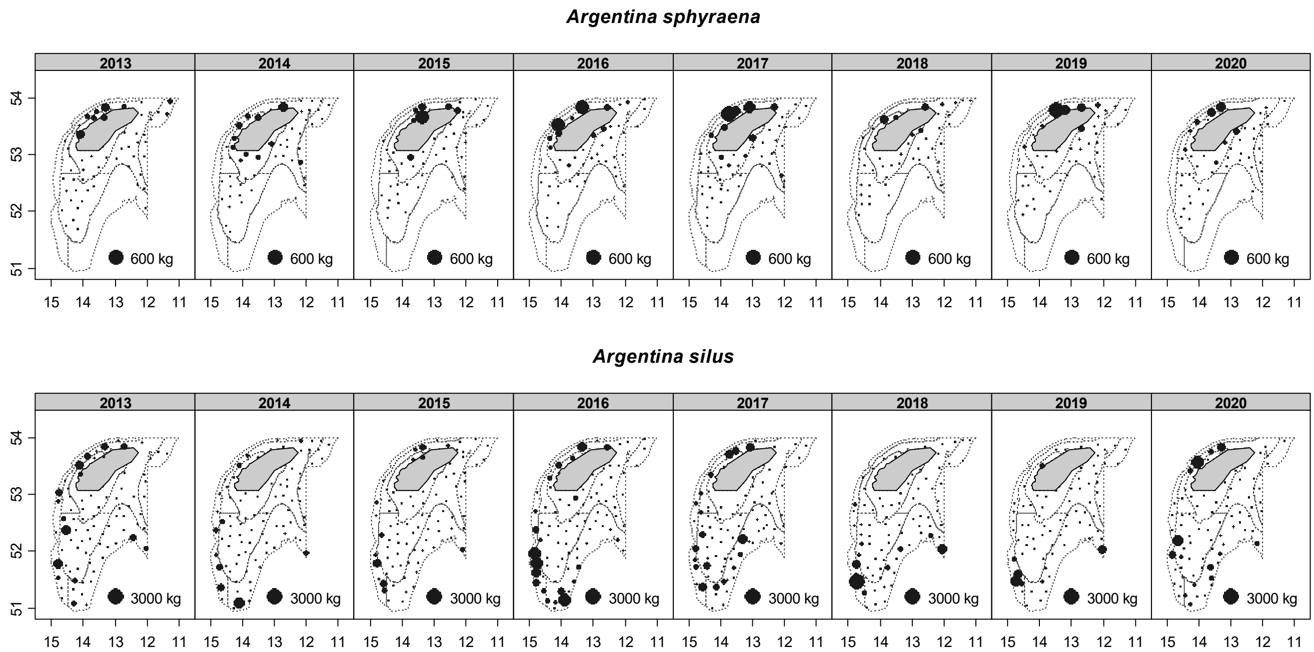

Figure 7. Geographic distribution of *Argentina sphyraena* and *Argentina silus* catches (kg/30 min haul) in Porcupine surveys (2013 - 2020)

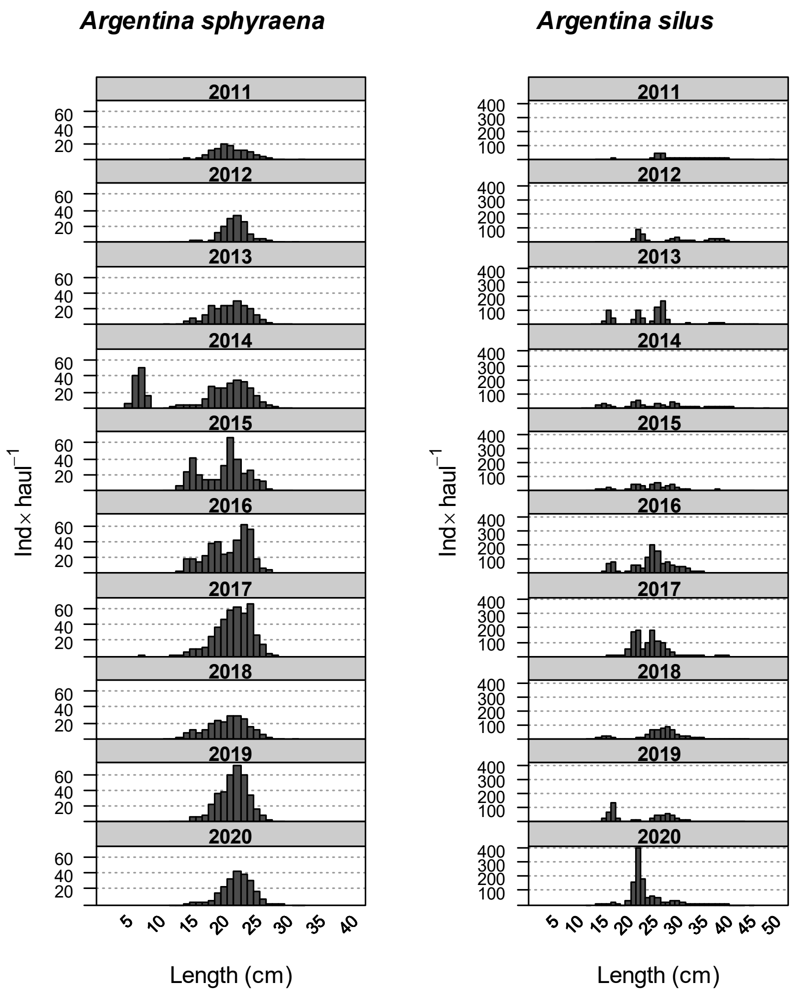

Figure 8. Mean stratified length distributions of *Argentina sphyraena* and *Argentina silus* in Porcupine surveys (2011-2020)

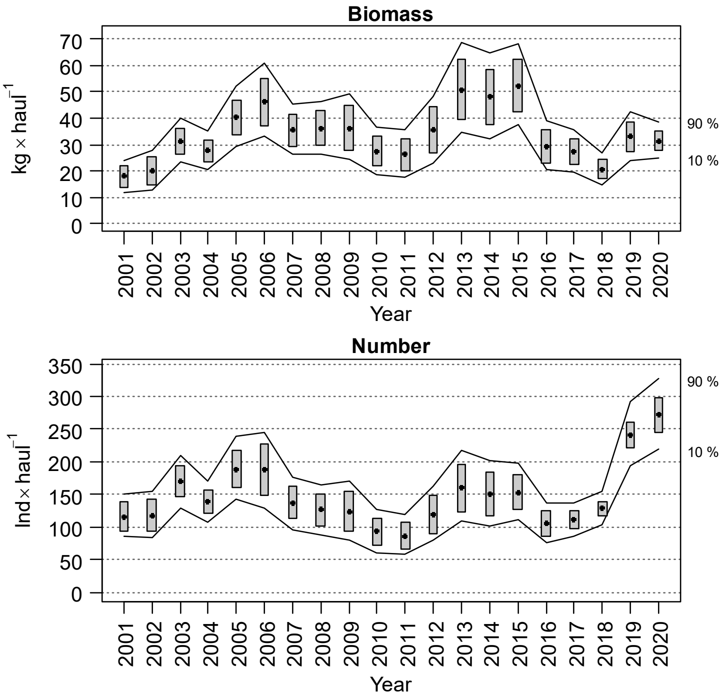

Figure 9. Evolution of *Helicolenus dactylopterus* biomass and abundance indices in Porcupine surveys (2001-2020). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000)

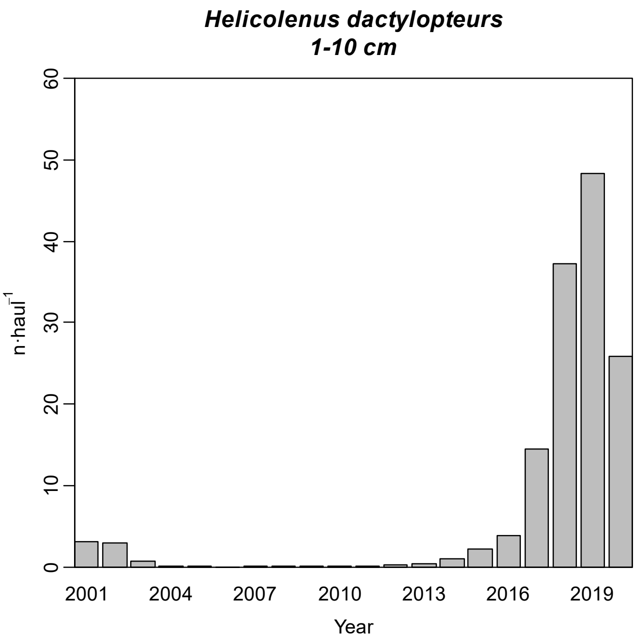

Figure 10. Mean stratified abundance of *Helicolenus dactylopterus* recruits (1-10 cm) in Porcupine surveys (2001-2020)

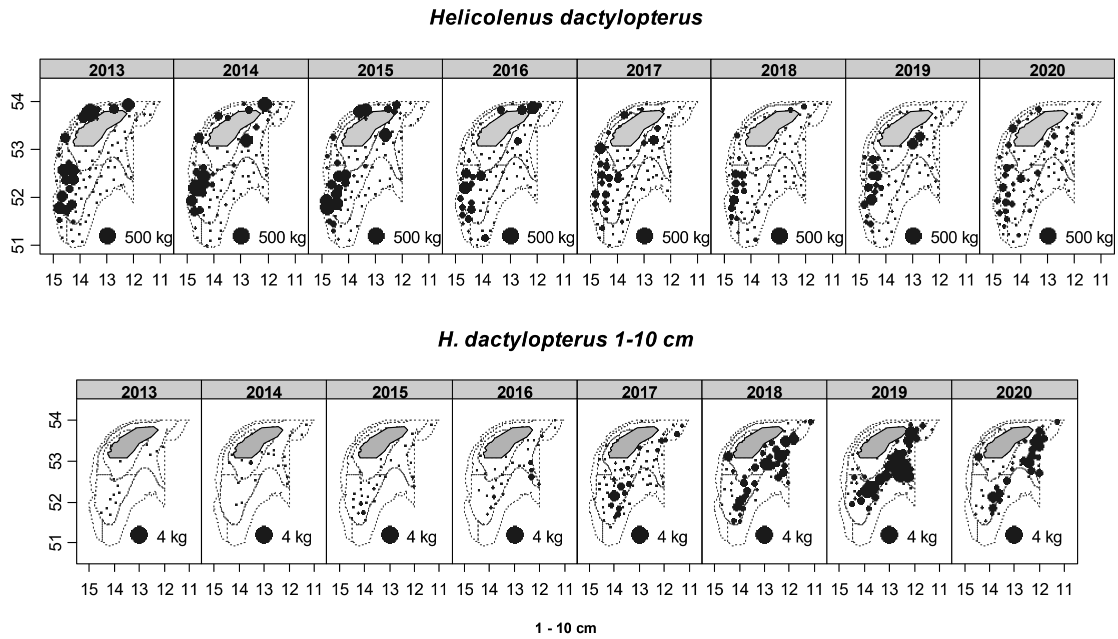

Figure 11. Geographic distribution of *Helicolenus dactylopterus* catches (kg×30 min haul-1) and recruits (1-10 cm) in Porcupine surveys (2013-2020)

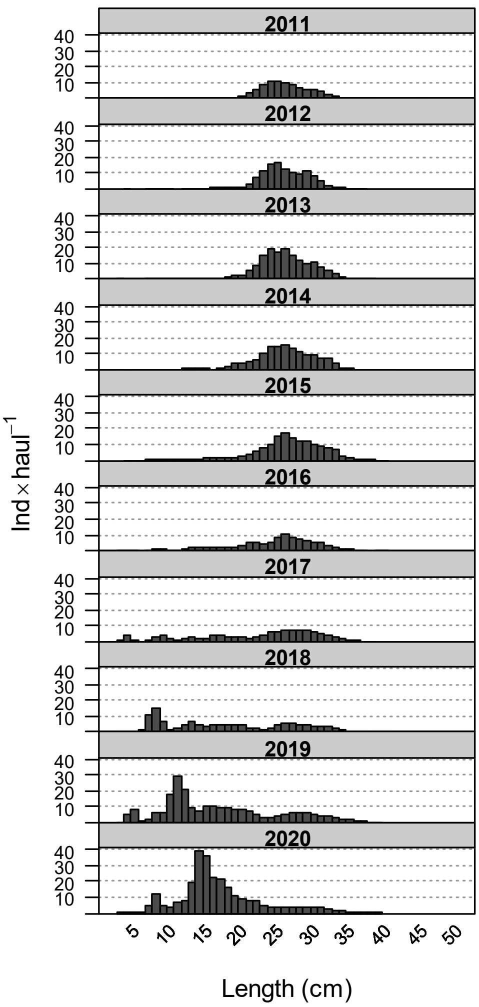

Figure 12. Mean stratified length distributions of *Helicolenus dactylopterus* in Porcupine surveys (2011-2020)

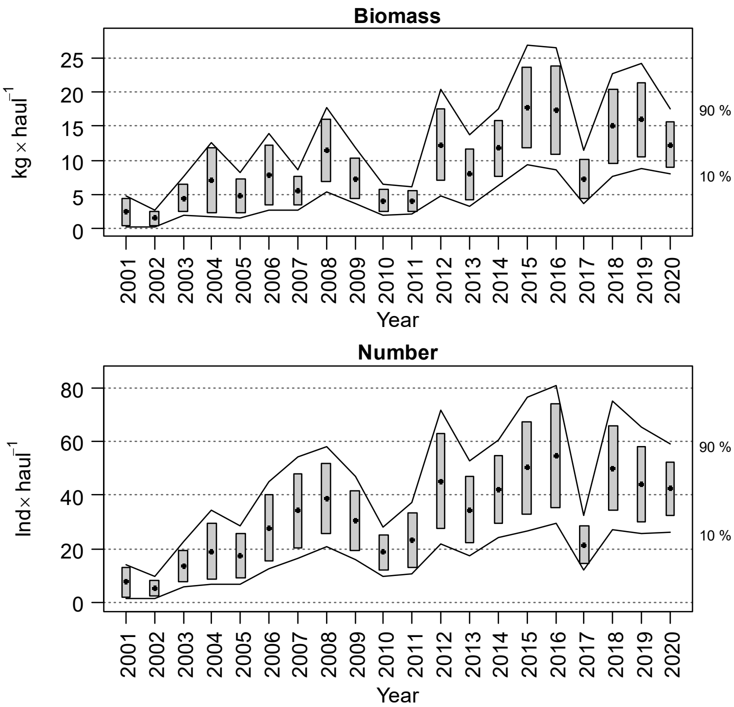

Figure 13. Evolution of *Trachyrincus scabrus* biomass and abundance indices in Porcupine surveys (2001-2020). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000)

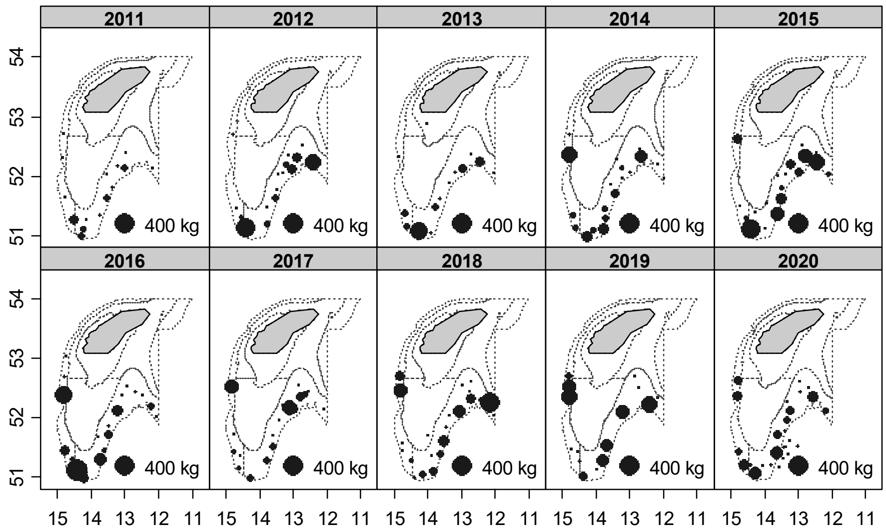

Figure 14. Geographic distribution of *Trachyrincus scabrus* catches (kg/30 min haul) in Porcupine surveys (2011-2020)

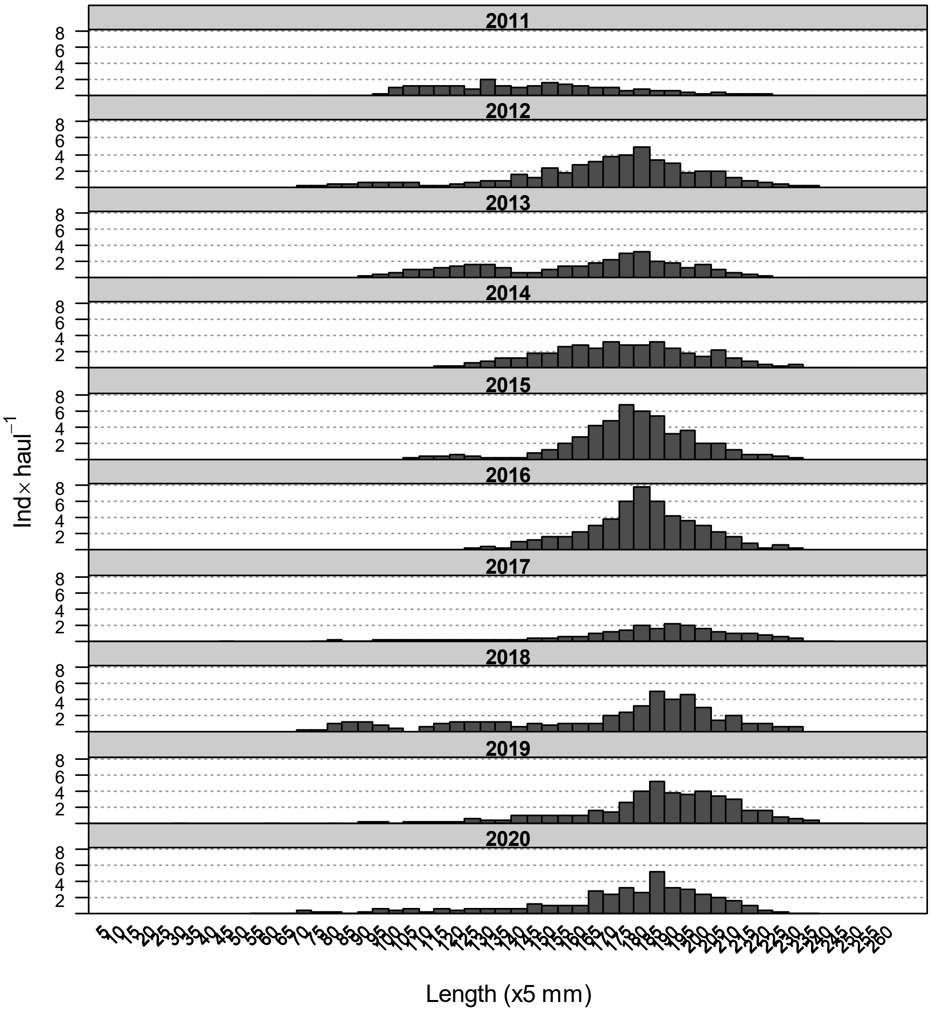

Figure 15. Mean stratified length distributions of *Trachyrincus scabrus* in Porcupine surveys (2011-2020)

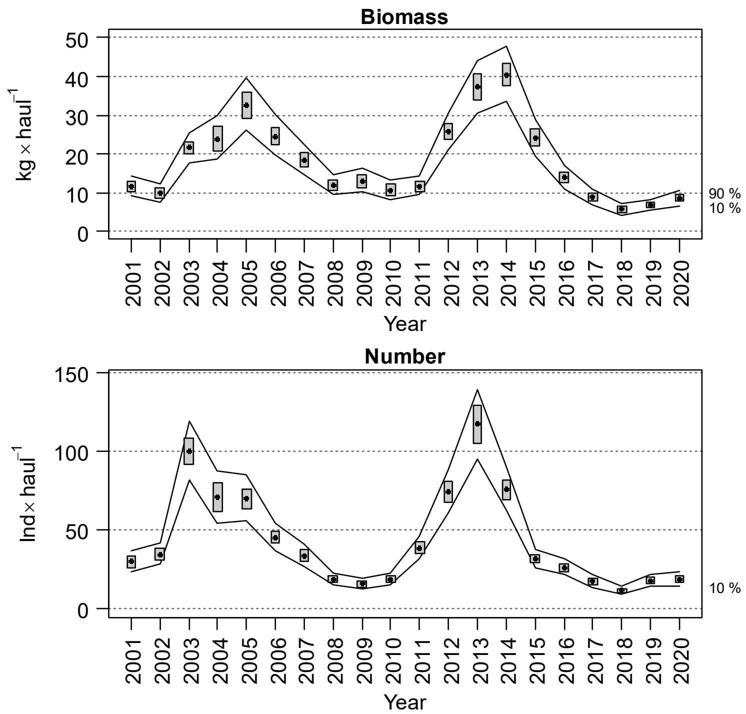

Figure 16. Evolution of *Phycis blennoides* biomass and abundance indices in Porcupine surveys (2001-2020). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000)

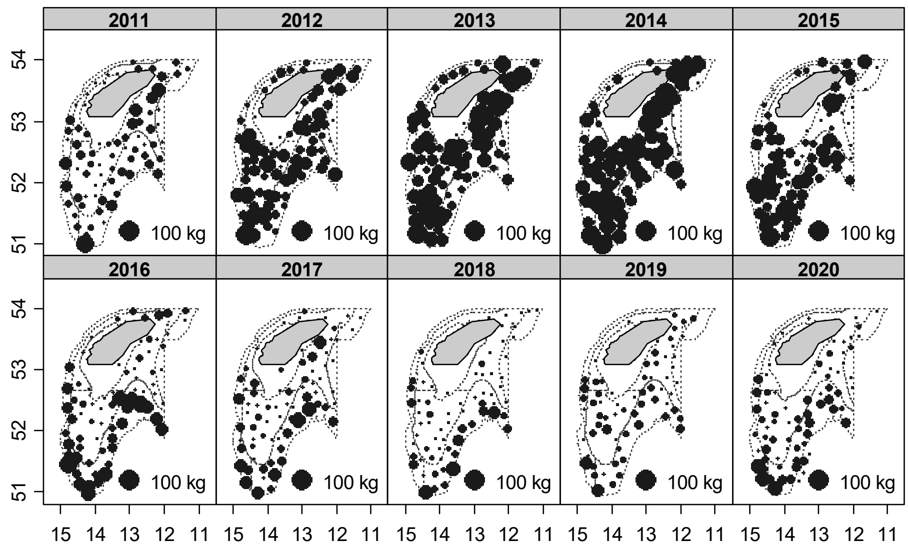

Figure 17. Geographic distribution of *Phycis blennoides* catches (kg×30 min haul^{-1}) in Porcupine surveys (2011-2020)

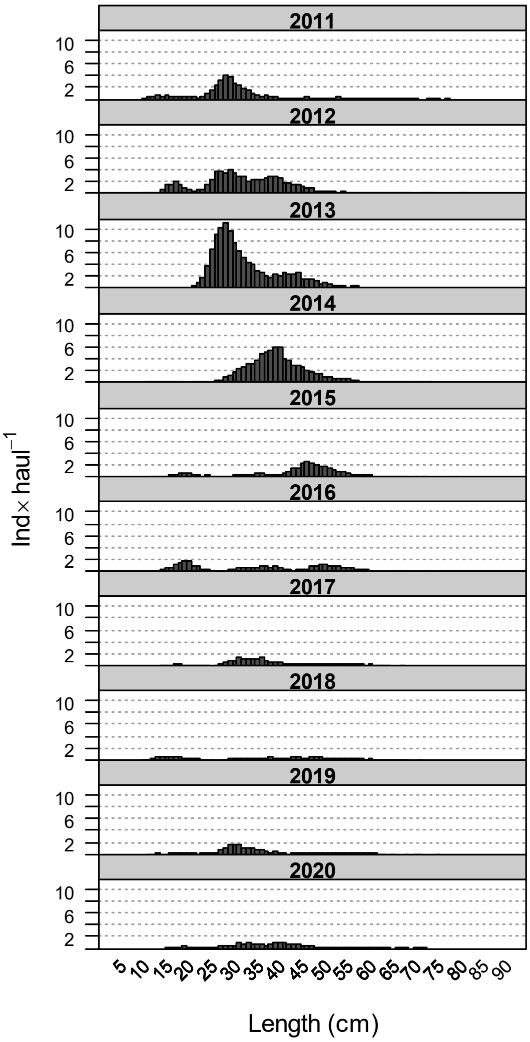

Figure 18. Mean stratified length distributions of *Phycis blennoides* in Porcupine surveys (2011-2020)

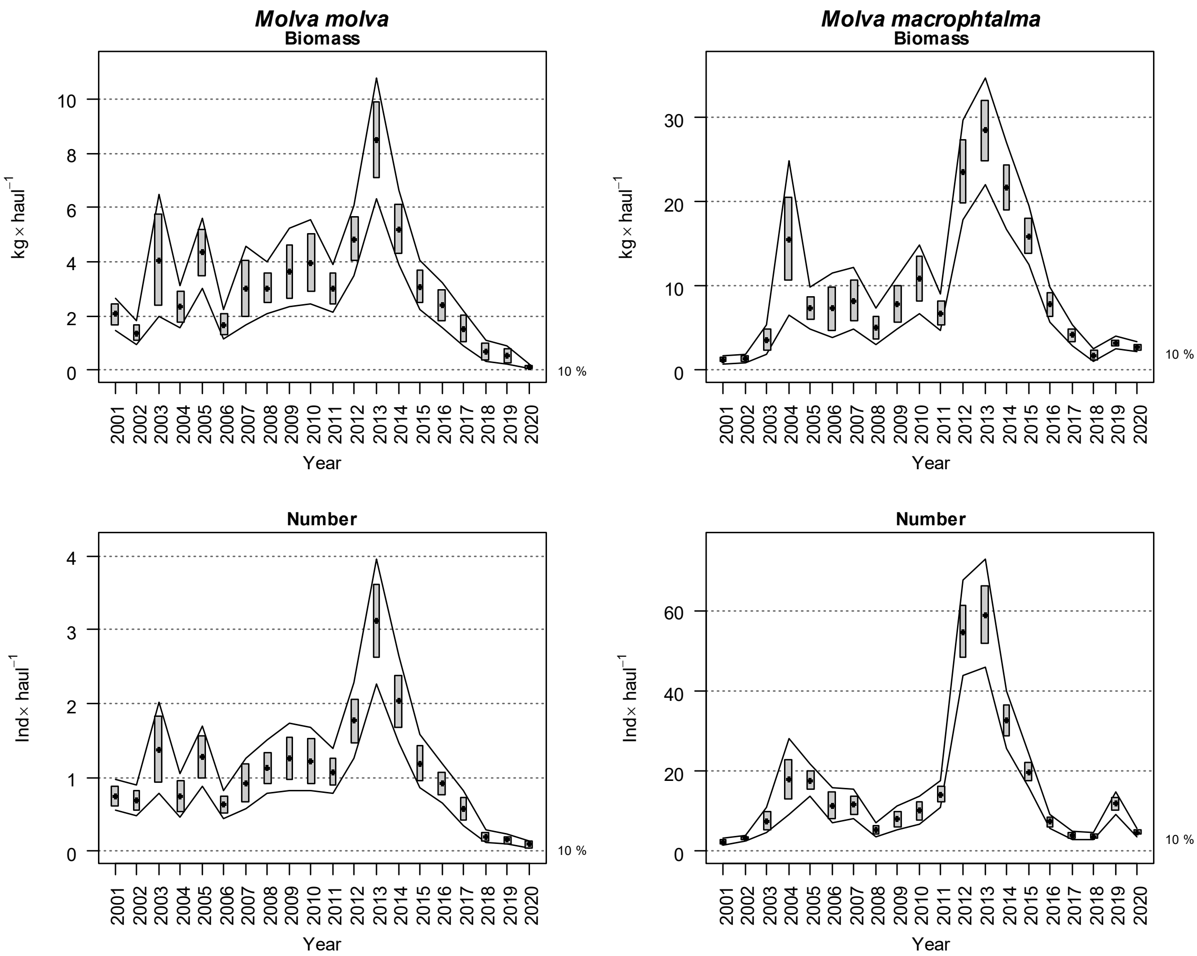

Figure 19. Evolution of *Molva molva* and *Molva macrophtalma* biomass and abundance indices in Porcupine surveys (2001-2020). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000)

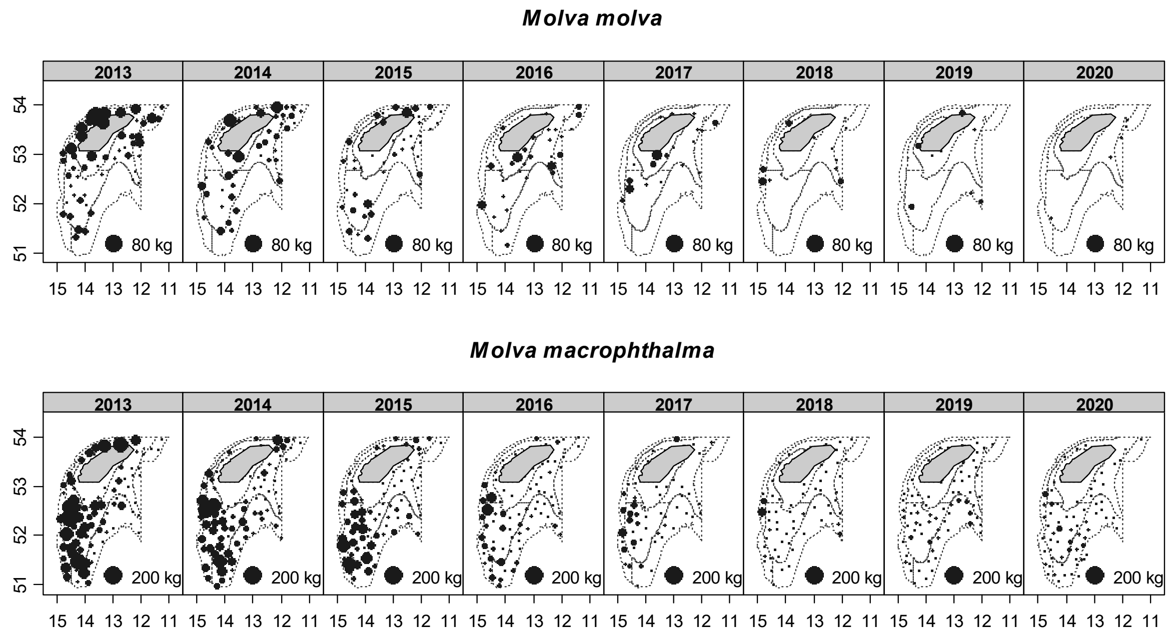

Figure 20. Geographic distribution of *Molva molva* and *Molva macrophtalma* catches (kg×30 min haul^{-1}) in Porcupine surveys (2013-2020)

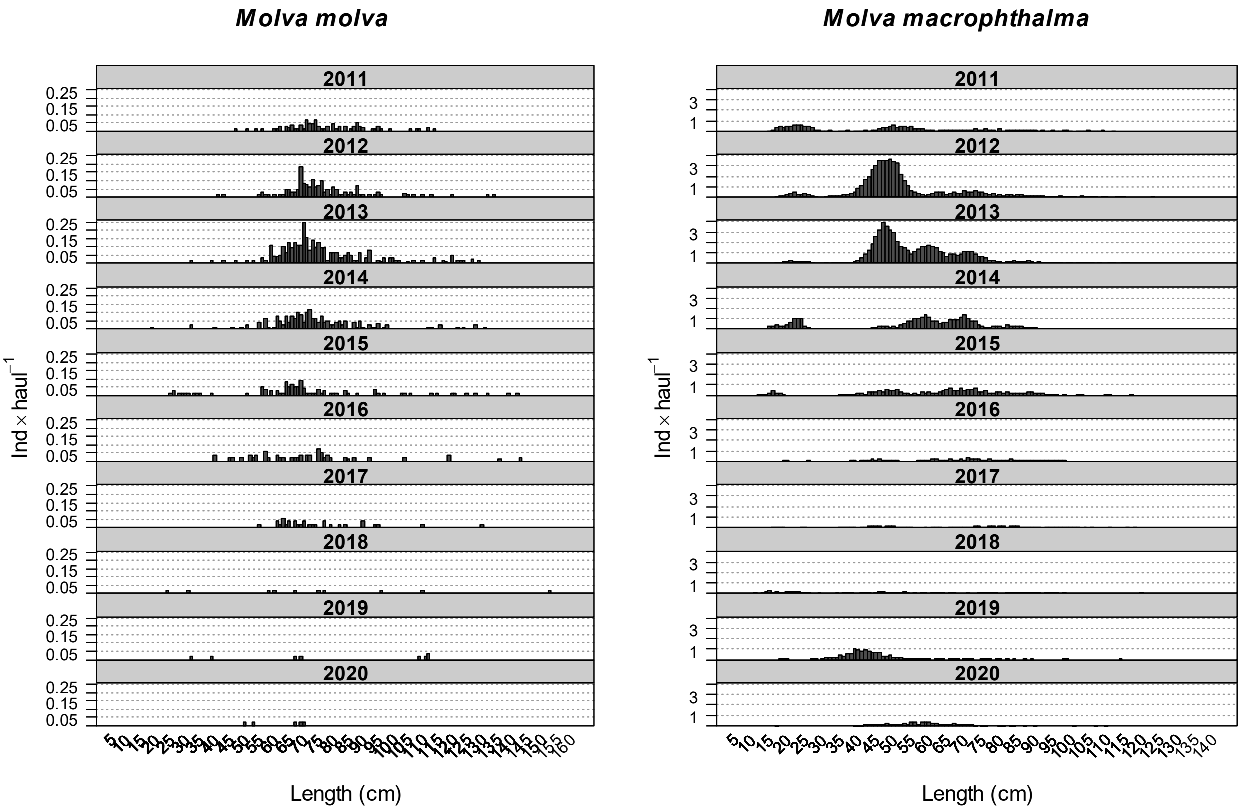

Figure 21. Mean stratified length distributions of *Molva molva* and *Molva macrophtalma* in Porcupine surveys (2011-2020)

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ICES WGDEEP, 22th – 28th April 2021(by correspondence)

The Blackspot seabream Spanish target fishery of the Strait of Gibraltar: updating the available information

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Abstract

This paper includes the available information of the Blackspot seabream (Pagellus bogaraveo) Spanish "voracera" target fishery of the Strait of Gibraltar. The documents presented in previous years were updated with the 2020 information: data about landings, fishing effort, CPUEs and landings length frequencies are presented to its discussion within the 2021 WGDEEP.

1. Introduction and fishery description

Since the earlies 1980´s a Spanish artisanal fishery targeting to Blackspot seabream (*Pagellus bogaraveo*, namely "*voraz*") have been developed in the Strait of Gibraltar area (ICES 9a South). This fishery has already been broadly described in previous Working Documents presented to the ICES WGDEEP (Gil *et al*., 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019 and 2020). Spanish Blackspot seabream fishery in the Strait of Gibraltar is almost a mono-specific fishery with a clear target species which represents the 74% from the total landed species which constitutes a fleet component by itself (Silva *et al*., 2002).

In 2006, 2008, 2010, 2012 and 2016 different trials were attempted to assess this resource within the ICES WGDEEP (ICES, 2006, 2008, 2010, 2012, 2016, 2018 and 2020). Finally, 2020 scientific advice was based on abundance indexes (DLS category 3). All the available information from this target fishery (including the abundance index used as the basis for the assessment) was updated with 2020 data.

Thus, the main objective of this paper is to provide to the 2021 ICES WGDEEP a summary of the available information of this deep-water fishery located in a very narrow place in the ICES area 9 South East boundary line.

2. Material and methods

Fishery information from the sale sheets was gathered for the period 1983-2020: monthly landings, monthly number of sales (as a proxy of fishing trip) and the number of days in which those sales were carried out. Moreover, landings length distributions was also estimated from the data collected by IEO monitoring programme (Gil *et al*., 2000).

Geo-referenced information from SLSEPA devices (a sort of Vessel Monitoring System) on the "*voracera*" fleet operating at the Strait of Gibraltar were more recently available (from 2009 onwards): this monitoring system, locally called "green boxes" (to differentiate them from the EU VMS "blue boxes"), send every three minutes to a control centre several information about the fishing boat: time, positions, course and speed. Data were filtered and analyzed, according to the protocols proposed by Burgos *et al*. in 2013, to estimate fishing effort and catch rates of the Blackspot seabream Spanish target fishery.

3. Results and discussion

- <u>Landings data</u>: Figure 1 shows a continuous increase of Spanish landings from the beginning of the time series to reach a maximum in 1994. Since then landings´ trend decreased till 2002, despite the peaks in 1996 and 1997. Again, it shows an increasing trend from 2003 to 2009, decreasing afterwards except for a slight increase in 2014. Landings in 2018 show the lowest values of the series, with only 8 tons landed from the Spanish "voracera" fleet.

Until now, discards can be assumed to be zero or negligible. However, the established minimum landing size of 33 centimeters for the species (both for NE Atlantic and Mediterranean Sea) and the landing obligation (EU Regulation 2013/1380) don´t might have an effect on the discards of this target fishery because its high survival exemption.

Hence landings are currently being used as a proxy of catches. However, it should be noted that not all the Spanish catches/landings come exclusively from ICES area 9 but they are considered from the same stock unit because the fishing area (Strait of Gibraltar) is placed between different Advice bodies/Regional Fisheries Organizations (ICES, GCFM and CECAF) boundaries.

Data from Moroccan longliners fishing Blackspot seabream in the Strait of Gibraltar area are available since 2001. The information are available on FAO GFCM statistics (WGSAD-SAC and SRC-WW) so, when possible, it is included in the WGDEEP landings estimates because

Moroccan boats target the same population sharing the main fishing grounds with Spain (ICES, 2016).

- <u>CPUEs</u>: Nominal abundance index shows ups and downs throughout the historical series (Figure 2). It is important to emphasize that the effort unit chosen (number of sales) may not be appropriate as does not consider the missing effort. So in the most recent years, when the resource is not quite abundant, the missing effort might increase substantially (fishing boats with no catches and no sale sheet records). Therefore, the LPUE trend since the first fishery´s decline (1997) should be interpreted with caution because it cannot be a real image of the resource abundance. A severe decreasing trend is observed since 2010, whereas it increases in the last two years (2014 and 2015),similarly to landings. But, like in landings in 2016 - 2018 the signal fall again and start recovering since then.

Table 1 updates the available information from regional VMS (SLSEPA), following the data compilation and its process described by Burgos *et al*. in 2013.

Table I. Estimates of fishing effort and CPUEs (2009-2020) from the "*voracera*" fleet targeting Blackspot seabream based on regional VMS (SLSEPA) and fishery statistics (sales sheets).

Data source		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
VMS	**Landings (k)**	459,010	274,882	190,786	79,163	37,799	94,261	137,344	73,508	24,716	4,402	4,825	1,579
	No. Sales	7,200	5,863	4,711	2,946	2,086	2,989	3,079	1,873	1,017	309	248	62
	Fishing days (fishing trips)	8,373	7,238	6,160	3,686	2,695	4,191	4,234	2,724	1,740	1,046	607	125
	CPUE 1 (landings/No. sales)	64	47	40	27	18	32	45	39	24	14	19	25
	CPUE 2 (landings/fishing days)	55	38	31	21	14	22	32	27	14	4	8	13
	Missing effort	14	19	24	20	23	29	27	31	42	70	59	50
TOTAL	**Landings (k)**	579,140	316,365	239,790	126,006	66,159	137,623	166,440	99,726	42,991	7,633	18,693	12,838
	No. Sales	8,892	6,932	5,659	3,638	2,222	3,527	3,384	2,418	1,308	429	794	525
	CPUE 1 (landings/No. sales)	65	46	42	35	30	39	49	41	33	18	24	24

CPUE 1 (nominal) estimated from total landings and number of sales decreased in the period 2009-2013 from 65 to 30 k fishing trip^{-1} for the total "*voracera*" fleet as well as the (nominal) CPUE 1 for the fleet equipped with the SLSEPA device (64 to 19 k fishing trip^{-1}). Afterwards, it increases till 49 and 45 k fishing trip^{-1} in 2015, respectively. As expected, CPUE 2 (landings/fishing days), where the effort is estimated from the VMS device also declined with lower values than CPUE 1 because the fact of the missing effort. So, as expected, 2009 - 2019 CPUEs estimates from VMS analysis shows the same trend but lower values than the nominal one, from sale sheets (Figure 2).

- <u>Length frequencies</u>: The mean length of landings seems to have decreased in two different periods: from 1995 to 1998 and from 2009 to 2013 (Figure 3). Knowledge about the geographic and bathymetric distribution related to length of the species is scarce. Last years' median value is quite stable and above the 33 cm minimum reference size for this species in the Atlantic and Mediterranean European waters.

4. Main conclusions

The general trend for the time series of both, landings and CPUEs, continues showing a decreasing pattern during the last years, exhibiting the lowest values of the whole series in 2018. This might be a consequence of an overexploitation status of the stock, which is addressing the fishery into a critical situation.

It should be noted that GFCM started a work plan to establish a management plan for this target fishery in 2019 (Recommendation GFCM/41/2017/2 on the management of blackspot sea bream fisheries in the Alboran Sea, geographical subareas 1 - 3, for a two-year transition period).

Acknowledgments

We would like to express our most sincere gratefulness to all those Institutions and people for their collaboration in the execution of the monitoring of the Spanish "*voracera*" fishery: Spanish Institute of Oceanography (IEO), Consejería de Agricultura y Pesca de la Junta de Andalucía, Tarifa´s Fishermen Brotherhood and its 1st sale fishmarket staff.

References

BURGOS, C., J. GIL and L.A. del OLMO, 2013. The Spanish blackspot seabream (*Pagellus bogaraveo*) fishery in the Strait of Gibraltar: Spatial distribution and fishing effort derived from a small-scale GPRS/GSM based fisheries vessel monitoring system. Aquatic Living Resources, 26: 399–407.

GFCM. 2019. Report of the Third meeting of the Subregional Committee for the Western Mediterranean. SAC/SRC-WM. Sète, France 5 April 2019. 38 pp.

GIL, J., J. J. ACOSTA, C. FARIAS and M.M. SORIANO, 2012. Updating the information about the Red seabream (*Pagellus bogaraveo*) Spanish fishery in the Strait of Gibraltar (ICES Subarea IX). Work. Doc. to the 2012 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., J. J. ACOSTA, M.M. SORIANO, C. FARIAS and C. BURGOS, 2011. The Red seabream (*Pagellus bogaraveo*) fishery in the Strait of Gibraltar: ICES Subarea IX updated data.

Work. Doc. to the 2011 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., C. BURGOS, C. FARIAS, J.J. ACOSTA and M. SORIANO, 2017. The Spanish Red seabream fishery of the Strait of Gibraltar: an update of the available information. Work. Doc. to the 2017 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., C. BURGOS, C. FARIAS, J.J. ACOSTA and M. SORIANO, 2018. The Blackspot seabream Spanish target fishery of the Strait of Gibraltar: an update of the available information. Work. Doc. to the 2018 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., J. CANOURA, C. BURGOS and C. FARIAS, 2005. Update of the Red seabream (Pagellus bogaraveo) fishery data in the Strait of Gibraltar (ICES IXa south) including biological information. Work. Doc. to the 2005 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., J. CANOURA, C. BURGOS & C. FARIAS, 2009. The Red seabream (*Pagellus bogaraveo*) fishery in the Strait of Gibraltar: Data updated for assessment of the ICES Subarea IX Work. Doc. to the 2009 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., J. CANOURA, C. BURGOS and C. FARIAS, 2010. The Red seabream (*Pagellus bogaraveo*) Spanish fishery in the Strait of Gibraltar: Useful information that should be considered for the ICES Subarea IX assessment update exercise. Work. Doc. to the 2010 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., J. CANOURA, C. BURGOS, C. FARIAS and V. POLONIO, 2008. Red seabream (*Pagellus bogaraveo*) assessment of the ICES IX from the information available of the fishery in the Gibraltar Strait. Work. Doc. to the 2008 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., J. CANOURA, C. BURGOS and I. SOBRINO, 2007. Red seabream (*Pagellus bogaraveo)* fishery of the Strait of Gibraltar (ICES IXa south): Update of the available information. Work. Doc. to the 2007 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., S. CERVIÑO and B.T. ELVARSSON, 2016. A preliminary gadget model to assess the Spanish Red seabream fishery of the Strait of Gibraltar. Work. Doc. to the 2016 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., C. FARIAS, C. BURGOS, J.J. ACOSTA and M. SORIANO, 2016. Updating the available information from Spanish Red seabream fishery in the Strait of Gibraltar. Work. Doc. to the 2016 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., C. FARIAS, J. CANOURA and J.J. ACOSTA, 2013. The Red seabream fishery in the Strait of Gibraltar: update of the available information from the fishery statistics and some considerations about the current knowledge on the target species growth. Work. Doc. to the 2013 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., C. FARIAS, J. CANOURA, J.J. ACOSTA, M. SORIANO and C. BURGOS, 2015. Updating the available information from Spanish Red seabream fishery in the Strait of Gibraltar. Work. Doc. to the 2015 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., C. FARIAS, C. BURGOS, J.J. ACOSTA and J. CANOURA, 2014. The red seabream fishery in the Strait of Gibraltar: an update of the available information. Work. Doc. to the 2014 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., L. RUEDA, C. BURGOS, C. FARIAS, J.C. ARRONTE, J.J. ACOSTA and M.M. SORIANO, 2019.The Blackspot seabream Spanish target fishery of the Strait of Gibraltar: updating the available Information. Work. Doc. to the 2019 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., L. RUEDA, C. FARIAS, J.C. ARRONTE, J.J. ACOSTA and M.M. SORIANO, 2020. The Blackspot seabream Spanish target fishery of the Strait of Gibraltar: updating the available information. Work. Doc. to the 2020 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., I. SOBRINO and M. P. JIMÉNEZ, 2000. A brief description of the Strait of Gibraltar red seabream (*Pagellus bogaraveo*) fishery. Working Document to the 2000 Report of the *ICES Study Group on the Biology and Assessmnet of Deep-sea Fisheries Resources* (SGDEEP).

GIL, J. and I. SOBRINO, 2001. New biological information about the red seabream (*Pagellus bogaraveo*) of the Strait of Gibraltar (ICES IXa). Work. Doc. to the 2001 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J. and I. SOBRINO, 2002. Update of the information about the red *seabream (Pagellus bogaraveo*) from the Strait of Gibraltar (ICES IXa south). Work. Doc. to the 2002 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J. and I. SOBRINO, 2004. Red seabream *(Pagellus bogaraveo*) fishery of the Strait of Gibraltar (ICES IXa south): Update of the information available. Work. Doc. to the 2004 Report of the *ICES Working Group on the Biology and Assessement of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., I.SOBRINO and J. CANOURA, 2003. Update of the information about the red *seabream (Pagellus bogaraveo*) fishery in the Strait of Gibraltar (ICES IXa south). Work. Doc. to the 2003 Report of the *ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources* (WGDEEP).

GIL, J., I.SOBRINO and J. CANOURA, 2006. The fishery of the Strait of Gibraltar (ICES IXa south): Update of the information available required for the assessment of the red seabream (Pagellus bogaraveo). Work. Doc. to the 2006 Report of the *ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources* (WGDEEP).

ICES, 2006. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES CM 2006/ACFM: 28.

ICES, 2008. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES CM 2008/ACOM: 14.

ICES, 2010. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES CM 2010/ACOM: 17.

ICES, 2012. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES CM 2012/ACOM: 17.

ICES, 2016. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES CM 2016/ACOM: 18.

ICES, 2018. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES CM 2018/ACOM: 14.

ICES, 2020. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES Scientific Reports. 2:38. 928 pp. http://doi.org/10.17895/ices.pub.6015.

SILVA, L., J. GIL and I. SOBRINO, 2002. Definition of fleet components in the Spanish artisanal fisheries of the Gulf of Cádiz (SW Spain, ICES Division IXa). *Fisheries Research* 59 (2002):117-128.

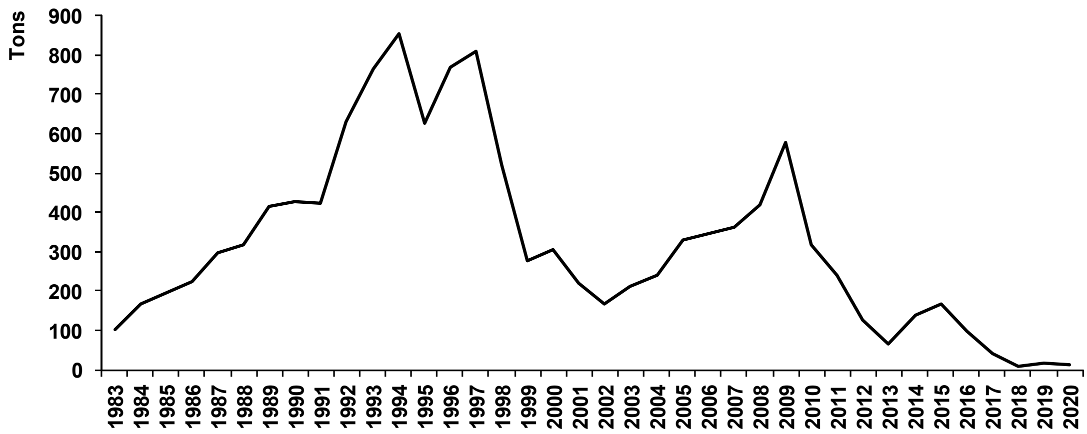

Figure 1. Blackspot seabream Spanish "*voracera*" fishery of the Strait of Gibraltar: total landings in tones (1983-2020).

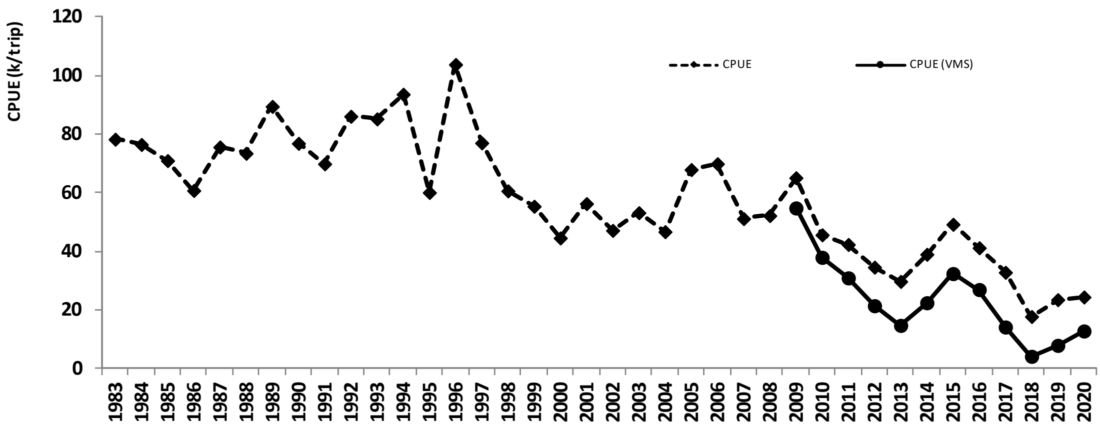

Figure 2. Blackspot seabream Spanish "*voracera*" fishery of the Strait of Gibraltar: sale sheets CPUE (1983-2020) and VMS CPUE (2009-2020).

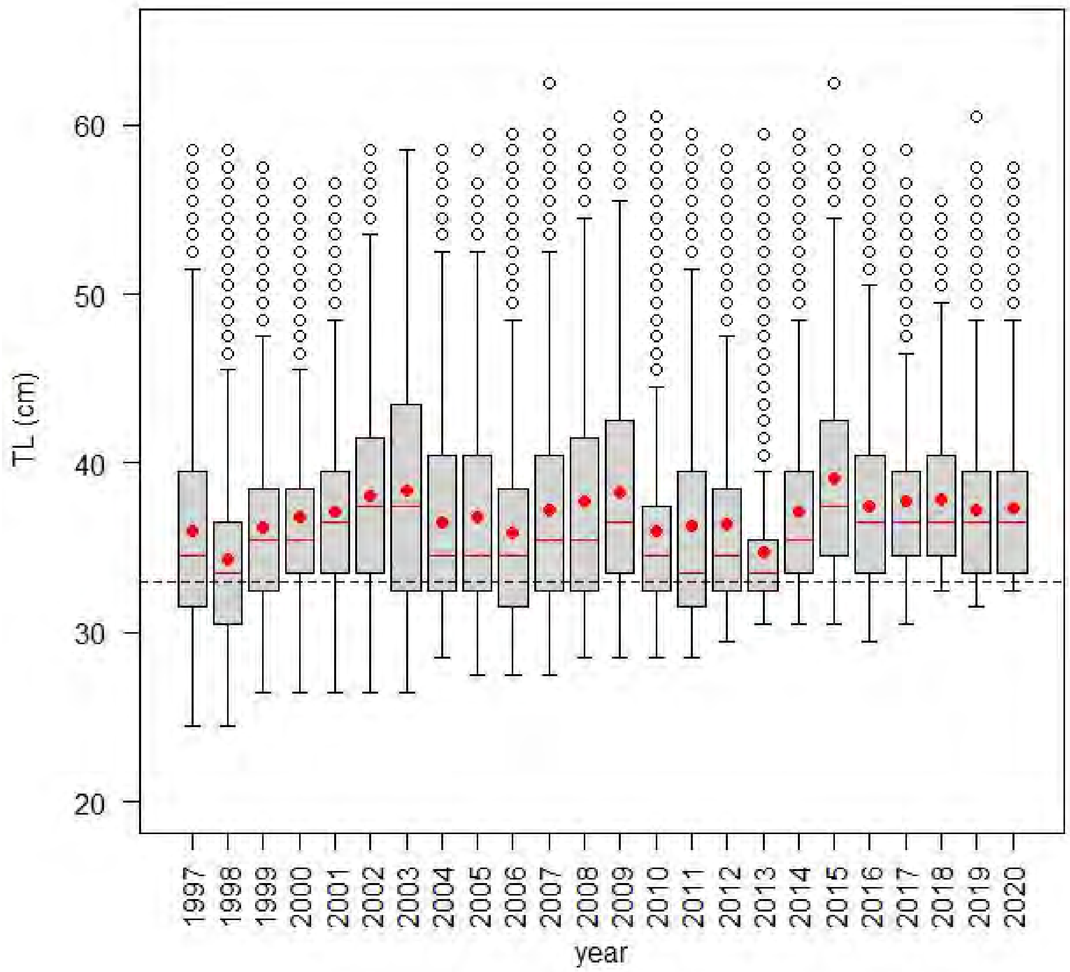

Figure 3. Blackspot seabream Spanish "*voracera*" fishery of the Strait of Gibraltar: 1997 – 2020 landings length distribution descriptive statistics (red dot: mean value, red line: median value, box and whiskers: Interquartile Range plus Q_1-3IQR and Q_3+3IQR, circles: outliers).

Blue ling unwanted catch estimates for Scotland

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RE: MSS WGDEEP 2021 submission of blue ling (*Molva dypterygia*; BLI) discard weights for stocks bli.27.nea and bli.27.5b67.

Estimates of unwanted catch (termed discards by ICES) of blue ling for Scotland have been updated. This correction has resulted in a substantial increase in the estimated discard weight relative to previous Scottish BLI discard weight submissions. Table 1 provides a comparison of the 2015-2020 BLI discard weights estimated with and without the correction. The correction does not affect the landed weights. Although the relative shape of the landings length frequency distributions (LFDs) remains the same, the correction reduces the mean weight per length by 6%. The relative shape of the discard LFDs is not affected by the correction.

We propose updating the 2015-2019 BLI submissions to InterCatch at a time convenient to the blue ling stock assessors

Table 1. 2015 – 2020 blue ling (BLI) Scottish catch weights by year and stratum, with a comparison of estimated discard weight before and after the correction. Including only strata with non-zero values 2015 – 2020.

Stratum	Year	Landed weight (tonnes)	Discard weight (95% CI) with correction (tonnes)	Discard weight (95% CI) without correction (tonnes)
27.4.a TR1†	2020	10.090	* 0	0
	2019	4.348	14.110 (0 - 50.161)	0.023 (0 – 0.073)
	2018	3.582	0.774 (0 - 2.225)	* 0.002 (0 – 0.005)
	2017	4.849	2.403 (0 - 7.993)	* 0.117 (single trip)
	2016	6.365	0	* 0
	2015	2.560	0	0
27.6.a TR1	2020	710.116	* 9.239 (0 – 28.199)	0.015 (0 – 0.045)
	2019	718.094	29.598 (0 – 128.998)	0.031 (0 – 0.144)
	2018	734.798	14.746 (0 – 69.208)	* 0.017 (0 – 0.070)
	2017	640.454	0	0
	2016	272.461	18.130 (0.399 – 58.651)	* 0.036 (0.002 – 0.080)
	2015	370.186	11.439 (0 – 59.720)	* 0.056 (0 – 2.272)
27.6.b.2 TR1	2020	0	* 2.869 (0 – 10.624)	0.007 (0 – 0.026)
	2019	0	0	0
	2018	1.369	11.641 (0 – 22.524)	* 0.015 (0 – 0.029)
	2017	0	0	0
	2016	0	0.0913 (0 – 0.192)	0
	2015	0	0	0

* Current submission in InterCatch
† TR1 is allocated to fleet OTB_DEF_>=120_0_0_all in InterCatch

Stock bli.27.5b67
The discard weight estimates for '27.6.a TR1' and '27.6.b.2 TR1' contribute to the stock bli.27.5b67. The total catches estimated by ICES for bli.27.5b67 have been in excess of 10,000 tonnes since 2017 (Table 2), therefore the revised discard weights represent less than 0.3% of the catch during this time. In 2015 and 2016, the catches for bli.27.5b67 were < 5046 tonnes, therefore the revised discard weights represent ca. 0.2 % and 0.4 % respectively.

Stock bli.27.nea
Stratum '27.4 TR1' contributes to the stock bli.27.nea, for which zero catches have been advised since 2018. Total catches estimated by ICES for bli.27.nea in 2018 were 348 tonnes, for which the revised discard weight represents 0.2 %. In 2017 the bli.27.nea catch was 280 tonnes, and the revised discard weight represents 0.9 %.

Table 2. ICES Blue ling (BLI) advice, catches and discards 2015 to present.

Stock (Advice ref.)	Catch advice (Year: tonnes)	ICES catches (Year: tonnes)	Discards (tonnes)
bli.27.nea (ICES, 2019)	2020-2023: 0 2018-2019: 0 2017: - 2016: - 2015: -	 2018: 348 (Area 4.a: 60) 2017: 280 (Area 4.a: 74) 2016: 205 (Area 4.a: 87) 2015: 208 (Area 4.a: 83)	Negligible (2018: 0.302) (2017: 0.925)
bli.27.5b67 (ICES, 2020)	2020: 11150 2019: 11778 2018: 10763 2017: 11314 2016: 5046 2015: 5046	2020: ≤ 11150 2019: ≤ 11778 (EU landings: 3218) 2018: ≤ 10763 (EU landings: 3322) 2017: ≤ 11314 (EU landings: 2669) 2016: < 5046 (EU landings: 3059) 2015: < 5046 (EU landings: 2748)	Negligible

References
ICES. 2020. Blue ling (*Molva dypterygia*) in subareas 6–7 and Division 5.b (Celtic Seas and Faroes grounds). In Report of the ICES Advisory Committee, 2020. ICES Advice 2020, bli.27.5b67. https://doi.org/10.17895/ices.advice.5819.

ICES. 2019. Blue ling (Molva dypterygia) in Subareas 1, 2, 8, 9, and 12, and Divisions 3.a and 4.a (other areas). In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, bli.27.nea, https://doi.org/10.17895/ices.advice.4813

Discards of deepwater species by the Portuguese bottom otter trawl fisheries in ICES Division 27.9.a

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Abstract

The information on discards produced by Portuguese vessels operating with bottom otter trawl fleet in Portuguese ICES Division 27.9.a is compiled. The sampling effort, species frequencies of occurrence and discard estimates are presented, for the period 2004-2019. The species included are the WGDEEP stocks black scabbardfish (*Aphanopus carbo*), alfonsinos (*Beryx spp*), roughhead grenadier (*Macrourus berglax*), blackspot(=red) seabream (*Pagellus bogaraveo*), greater forkbeard (*Phicys blennoides*) and ling (*Molva molva*). The samples were collected by the Portuguese onboard sampling programme (PNAB/EU DCF). The low frequency of occurrence registered by most of these species in OTB fisheries for the period 2004-2019 indicates that discards can be considered negligible for the most WGDEEP stocks, with exception of greater forkbeard for some of the years of that period. In 2020, the Portuguese onboard sampling programme was compromised by the pandemic situation due to Covid-19 and the sampling only occurred in the first quarter. For this reason, the sampling effort was not representative of the fishing effort of the bottom otter trawl fleet (OTB) and the algorithm usually used for discards estimation cannot be applied. For the species presenting low frequencies of occurrence in the discards of sampled hauls in the previous period (2004-2019), discards for 2020 were considered zero or negligible. In the case of more frequent species (e.g. greater forkbeard) a new discard estimation approach was developed and the results obtained are presented.

1. Introduction

This working document compiles the information available, from the period 2004-2019, on the discards of black scabbardfish (*Aphanopus carbo*), alfonsino nei (*Beryx spp*), roughhead grenadier (*Macrourus berglax*), blackspot(=red) seabream (*Pagellus bogaraveo*), greater forkbeard (*Phicys blennoides*) and ling (*Molva molva*) produced by the Portuguese bottom otter trawl fleet (OTB) (Table 1). The data was collected by the Portuguese onboard sampling programme and a summary of the onboard sampling and discards estimation are presented in Sections 2 and 3. The discard series obtained for the period 2004-2019 is presented in Section 3. Due to the pandemic situation in 2020, very few trips were sampled in the first quarter of the year for the bottom otter trawl targeting demersal species (OTB_DEF), and no trips were sampled in the bottom otter trawl targeting crustaceans. Since this sampling effort was not representative of the fishing effort of the fleet, the discard raising procedure previously used (Jardim and Fernandes, 2013) cannot be used to estimate discards at fleet level for 2020, and a new approach for discard estimation is presented.

Table 1 – Species composition and common names of the WGDEEP species

Species	3-alpha code	English name	Portuguese name
Aphanopus carbo	BSF	Black scabbardfish	Peixe-espada-preto
Beryx spp	ALF	Alfonsino nei	Imperadores
Macrourus berglax	RHG	Roughhead grenadier	Granadeiro
Pagellus bogaraveo	SBR	Blackspot(=red) seabream	Goraz
Molva molva	LIN	Blue ling	Maruca
Phicys blennoides	GFB	Greater forkbeard	Abrótea-do-alto

2. Onboard sampling

The Portuguese onboard sampling program, included in the EU DCF/PNAB, uses a stratified random sampling design and the vessel selection is based on an opportunistic sampling of cooperative commercial vessels between 12 and 40 meters over-all length (LOA). For sampling purposes, the bottom otter trawl fleet is split into two components: a crustacean fishery (OTB_CRU) that operates cod-end mesh sizes 55-59mm and >70mm targeting deep-water rose shrimp, Norway lobster and blue whiting and a demersal species fishery (OTB_DEF) that operates cod-end mesh size 65-69mm and >70mm and targets horse-mackerel, cephalopods and other finfish. Annual sampling targets are fixed for each fishery, namely 12 trips in the OTB_CRU fishery, 27 trips in the OTB_DEF fishery. Table 2 presents the sampling levels of the period 2004-2020.

Table 2 – Sampling levels of the Portuguese onboard sampling programme in the OTB_DEF and OTB_CRU fisheries for the period 2004-2020.

Year	Trips sampled		Hauls sampled		Hours fished	
	OTB_CRU	OTB_DEF	OTB_CRU	OTB_DEF	OTB_CRU	OTB_DEF
2004	17	24	111	125	479	315
2005	15	39	74	159	372	349
2006	7	42	30	194	133	380
2007	12	38	73	162	263	287
2008	12	34	66	128	255	254
2009	16	38	84	135	314	264
2010	16	31	103	116	375	208
2011	13	30	56	83	217	161
2012	13	31	68	60	302	130
2013	6	27	28	50	118	108
2014	10	24	42	52	167	112
2015	13	26	51	48	201	105
2016	12	29	42	61	172	143
2017	10	32	28	69	128	155
2018	11	22	40	47	174	86
2019	8	23	27	45	119	98
2020	0	4	0	6	0	11

The sampling protocol used in Portuguese sampling of the OTB fisheries is detailed in Jardim, *et al* (2012). A brief account follows. Two observers are deployed per fishing trip. Several hauls are made on each fishing trip and observers take a sample from the haul's catch, sort the specimens into retained and discarded fraction and register the weight and length composition of each species fraction. Observers collect concurrent fishing effort information (e.g. hours fished) and register environmental information (GPS coordinates, depth, bottom type, etc.). The on-board sampling protocols of the OTB_CRU, OTB_DEF fisheries have suffered only minor changes and adaptations between 2004 and 2010. In 2011 the size of catch samples taken from the OTB fishery was doubled (from 1 to 2 boxes of catch) and the within-trip selection of hauls and sets was standardized to “at least, every other haul/segment”.

3. Data analysis

The procedures used to raise discard data from samples to haul and fleet level, considering each fishery have been previously described in Jardim and Fernandes (2013) and Fernandes *et al.* (2017). A brief account follows.

3.1 Estimates of discards at haul level

In the OTB fisheries, the total volume discarded (in kg) in each haul is estimated by multiplying the ratio of discard and retained sample weights (all species combined) by the total retained weight in the haul (all species combined). The volume of discards of individual species in each haul is calculated *a posteriori* by multiplying the proportion (in weight) of species discards in the catch sample by the total catch volume estimated for each haul (total volume discarded + total volume landed) (Fernandes *et al.*, 2017).

3.2 Estimates of discards at fleet level (2004-2019)

The procedure generally used to raise discards from haul to fleet level in the Portuguese trawl fisheries is described in Jardim and Fernandes (2013). This procedure relies on haul level discard data (discards per hour) and effort data (fishing hours and fishing trips) derived from logbooks, sales slips and, for 2012-2019 periods, VMS (Vessel Monitoring System) data was also used. Using this procedure species with low frequency of occurrence or abundance in discards (i.e., a large number of zeros in the data set) cannot be reliably estimated at fleet level, because the discard estimation algorithm is sensitive to large numbers of zeros in the dataset (Fernandes *et al.*, 2021; Jardim *et al.*, 2011).

Summary discard information for the period 2004-2019 is presented in Tables 3-7. Frequencies of occurrence of the WGDEEP species in the sampled hauls are presented in Table 3 and Table 4. Discards information (mean number of individuals in the sampled hauls, standard deviation and range) are summarized in Table 5 and Table 6. Greater forkbeard (GFB) is the only species presenting discard volumes in some years of the period and the results are presented in Table 7.

Table 3 – Frequency of occurrence (%) of species in discards of hauls sampled from the OTB_DEF fishery. See Table 1 for species codes.

3-alpha code	2004	2005	2006	2007	2008	2009	2010	2011
BSF	2	1	2	--	--	--	--	--
ALF	--	--	--	--	--	--	--	--
RHG	--	--	--	--	--	--	--	--
LIN	--	--	--	--	--	--	--	--
SBR	--	--	1	1	--	--	--	--
GFB	5	--	2	1	--	4	2	--

3-alpha code	2012	2013	2014	2015	2016	2017	2018	2019
BSF	--	--	--	--	--	--	--	--
ALF	--	--	--	--	--	--	--	--
RHG	--	--	--	--	--	--	--	--
LIN	--	--	--	--	--	--	--	--
SBR	--	--	--	--	--	1	--	--
GFB	--	2	--	2	--	--	--	--

Table 4 – Frequency of occurrence (%) of species in discards of hauls sampled from the OTB_CRU fishery. See Table 1 for species codes.

3-alpha code	2004	2005	2006	2007	2008	2009	2010	2011
BSF	6	1	--	--	--	--	--	--
ALF	1	--	13	--	--	--	--	2
RHG	--	--	--	--	--	--	--	--
LIN	--	--	--	--	--	--	--	--
SBR	--	--	--	1	--	--	1	--
GFB	30	42	57	26	64	31	32	25

3-alpha code	2012	2013	2014	2015	2016	2017	2018	2019
BSF	--	--	--	4	--	7	--	7
ALF	--	--	--	--	--	--	5	--
RHG	--	--	--	--	--	--	--	--
LIN	--	--	--	--	--	--	--	--
SBR	1	--	--	--	--	--	--	--
GFB	35	29	36	51	36	54	25	41

Table 5 – Discards (in number of specimens per haul) of species in the OTB_DEF fishery (2004-2019); See Table 1 for species codes; "--" indicates no occurrence; SD – standard deviation.

	BSF			SBR			GFB		
Year	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
2004	0.4	3.6	0-37	--	--	--	2.4	12.3	0-106
2005	1.0	10.1	0-121	--	--	--	--	--	--
2006	0.9	8.3	0-109	0.5	5.3	0-72	1.6	12.7	0-140
2007	--	--	--	0.3	2.5	0-24	0.3	2.5	0-25
2008	--	--	--	--	--	--	--	--	--
2009	--	--	--	--	--	--	1.5	10.2	0-106
2010	--	--	--	--	--	--	0.5	3.9	0-36
2011	--	--	--	--	--	--	--	--	--
2012	--	--	--	--	--	--	--	--	--
2013	--	--	--	--	--	--	0.1	0.4	0-3
2014	--	--	--	--	--	--	--	--	--
2015	--	--	--	--	--	--	0.4	2.8	0-20
2016	--	--	--	--	--	--	--	--	--
2017	--	--	--	0.2	1.7	0-14	--	--	--
2018	--	--	--	--	--	--	--	--	--
2019	--	--	--	--	--	--	--	--	--

Table 6 – Discards (in number of specimens per haul) of species in the OTB_CRU fishery (2004-2019); See Table 1 for species codes; "--" indicates no occurrence; SD – standard deviation.

	BSF			ALF			SBR			GFB		
Year	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
2004	3.5	19.7	0-174	0.4	4.6	0-48	--	--	--	56.1	239.2	0-2216
2005	0.3	2.5	0-21	--	--	--	--	--	--	29.5	80	0-599
2006	--	--	--	47.3	237.2	0-1300	--	--	--	180.8	812.3	0-4550
2007	--	--	--	--	--	--	0.3	2.5	0-21	61.7	407	0-3500
2008	--	--	--	--	--	--	--	--	--	94.4	148.6	0-823
2009	--	--	--	--	--	--	--	--	--	27.9	65.8	0-421
2010	--	--	--	--	--	--	0.5	4.8	0-49	43.9	134.1	0-912
2011	--	--	--	0.4	2.8	0--21	--	--	--	13.1	33.5	0-203
2012	--	--	--	--	--	--	0.4	3.5	0-29	23.3	44.9	0-214
2013	--	--	--	--	--	--	--	--	--	13.6	30.2	0-119
2014	--	--	--	--	--	--	--	--	--	71.1	139.7	0-601
2015	0.5	4.8	0-25	--	--	--	--	--	--	107.3	488.0	0-3527
2016	--	--	--	--	--	--	--	--	--	36.2	82.1	0-360
2017	1	2.6	0-14	--	--	--	--	--	--	23.9	34.6	0-144
2018	--	--	--	--	--	--	--	--	--	44.1	125.8	0-522
2019	5	26.0	0-137	--	--	--	--	--	--	20.9	31.9	0-120

Table 7 – Greater forkbeard discarded in the Portuguese OTB_CRU fishery (2004-2019); volume (in metric tons) and CVs (% in brackets). See Table 1 for species codes; "(a)" = low frequency of occurrence (< 30%).

Year	GFB
2004	30 (33%)
2005	31 (48%)
2006	264 (5%)
2007	(a)
2008	25 (50%)
2009	33 (25%)
2010	18 (31%)
2011	(a)
2012	7 (63%)
2013	(a)
2014	31 (31%)
2015	28 (30%)
2016	64 (21%)
2017	16 (45%)
2018	(a)
2019	45 (43%)

4. Discards estimation procedure (2020)

In what concerns to 2020, discards cannot be estimated with the same raising procedure because there is no representative sampling effort in OTB fisheries. A preliminary analysis performed to investigate the OTB fleet fishing pattern (e.g. fishing days, fishing duration in hours, number of hauls per trip, landed weights) showed no significant differences between 2020 and the previous sampling period (2004-2019). For this reason, the WGDEEP species that presented frequencies of occurrence below 30% in all the previous sampling period were also considered to have no or negligible discards in 2020. The only species with discard estimates in some of the years included in the period 2004-2019 was the greater forkbeard, in OTB_CRU. For this species, a new approach for calculating discard estimates for 2020, using standardized discards-per-unit-effort (DPUE – discarded weight per hour) series, was explored and developed. The complete methodology of this approach is described in Coelho *et al.* (*in press*.). A brief account follows. Exploratory analysis of the data was first performed, using the haul level data. The generalized linear model (GLM) with log-link function as a Tweedie regression model was used to estimate the standardized DPUE year trend. The Tweedie distribution method selected is a way for dealing with a high mass of zeros and uses the statistical distribution from the Tweedie family of distributions, that allows for zero observations (Dunn and Smyth, 2008; Coelho *et al*, *in press*). In the case of greater forkbeard, the percentage of zero discards was 63.8%, for the 2004-2019 period. The GLM fitting approach included the choice of the response variable, the choice of the error distribution and link function, the selection of the explanatory variables, the extraction of the standardized series and the analysis of the performance between the alternative models. In the case of the greater forkbeard, the simple effects model including the explanatory variables 'fishing area' (SW and S), 'quarter', 'total haul catches' (without GFB) and 'landings per-unit-effort of *Nephrops'* presented the best results among the different models tested. The criteria used for selecting the best model fit were the analysis of residual distribution patterns, the relationship between predicted vs. observed DPUE, the deviance explained and also the value of the Akaike Information Criterion (AIC). The mean estimates of the standardized DPUE were computed with least square means (Coelho, *et al*. *in press*).

The final step for obtaining the discard estimate of greater forkbeard for OTB_CRU in 2020, was to calculate the average of the standardized DPUEs from the period 2017-2019 and multiply it by the fishing effort (in fishing hours) of the OTB_CRU fleet. The Figure 1 presents the standardized DPUE series obtained for 2004-2019 (black line), including the estimate of 25 tonnes in 2020, and the discard estimates provided to WGDEEP in the period 2004-2019 (red dots) (Table 7).

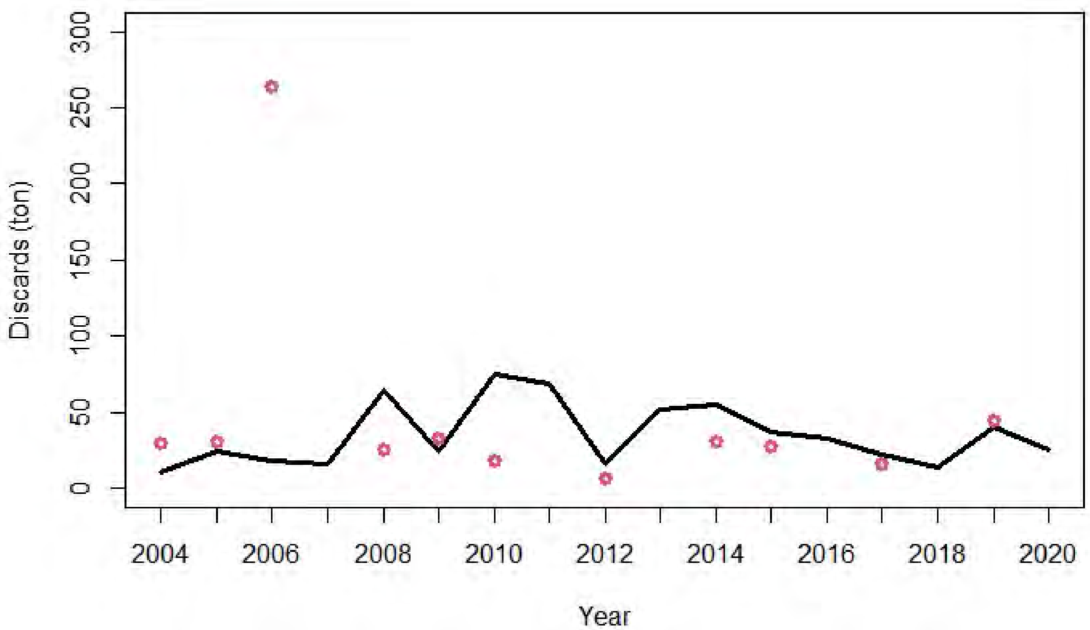

Figure 1 - Annual discard estimates obtained from the discard raising procedures using standardized DPUE (black line) and from annual fleet-based (red dots), previously reported to WGDEEP.

References

Coelho, R., Fernandes, A.C., Mendes, H., Moura, T., Pereira, B., Silva, A.V., Silva, C., Azevedo, M., (*in press*). Report of the workshop on modelling Catch-Per-Unit-Effort (WKCPUE). **Relatórios Científicos e Técnicos do IPMA (http//ipma.pt)**

Dunn, P.K., Smyth, G.K. 2008. Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, 18: 73–86. doi: 10.1007/s11222-007-9039-6

Fernandes, A.C., M. Oroszlányová, C. Silva, M.Azevedo, R. Coelho. 2021. Investigating the representativeness of onboard sampling trips and estimation of discards based on clustering. Fisheries Research, 234, 105778. https://doi.org/10.1016/j.fishres.2020.105778

Fernandes, A. C., Prista N., Azevedo. M., 2017. Discards from the Portuguese bottom otter trawl operating in ICES Division 27.9.a (2004-2015). Relat. Cient. Tec. do IPMA (http//ipma.pt) nº18. 18p + Anexos

Jardim, E., Fernandes, A.C., 2013. Estimators of discards using fishing effort as auxiliary information with an application to Iberian hake (Merluccius merluccius) exploited by the Portuguese trawl fleets. Fisheries Research 140: 105-113.

Jardim, E., Prista, N., Fernandes, A.C., Silva, D., Ferreira, A. L., Abreu, P., Fernandes, P., 2012. Manual de procedimentos a bordo: arrasto de fundo com portas. Relat. Cient. Téc. Inst. Invest. Pescas Mar, nº 55, 20 pp. + Anexos.

Jardim, E., Alpoim, R., Silva, C., Fernandes, A. C., Chaves, C., Dias, M., Prista, N., Costa, A. M., 2011. Portuguese data provided to WGHMM for stock assessment in 2011. Working Document presented at the ICES Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM), 5-11 May 2011, ICES Headquarters, Copenhagen, Denmark. ICES CM 2011/ACOM: 11, 625 pp.

The ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP 2021).

Updating data from deep-water fishery of the Azores (ICES subdivision 27.10.a.2)

by

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Abstract

This document resumes and updates the information of the demersal/deep-water fishery from the Azores for the 2021 ICES working group WGDEEP. A general summary description of the fishery is presented including information on landings, spatial distribution of effort and catches.

1. Description of the Fishery

The Azores demersal/deep-water fisheries are a multispecies and multigear fishery with economically important and represent more than 70% of the annual total landed catch of the region (Menezes e Pinho, 2009; Santos et al., 2020). About 70 demersal species are landing in the Azores, from which around 24 are classified as deep-water representing their landings in the last three years about 2200 tons in weight and around 13 million Euros in value at the first sale on the auctions (Fig. 1). The dynamic of the fishery seems to be dominated by the main target species *Pagellus bogaraveo*. However, others commercially important species are also caught (*Beryx* spp., *Polyprion americanus* and *Helicollenus dactylopterus*) and the target species seems to change seasonally according abundance, species vulnerability and market (Pinho and Menezes, 2005; Pinho et al., 2014; Santos et al., 2019).

The fishery is clearly a typical small scale, where the small vessels (<12m; 90% of the total fleet) predominate, using mainly traditional bottom longline and several types of hand lines.

The ecosystem is a seamount type with fishing operations occurring in all available areas, from the islands coasts to the seamounts within the Azorean EEZ. Few seamounts are explored outside the EEZ, being the most frequently visited those at south on Fishery Committee for the Eastern Central Atlantic (CECAF) areas (WD Pinho, 2018). The fishery takes place at depths until 1000 m, catching species from different assemblages (shallow, intermediate and deep), with a mode on the 200-700 m strata, the intermediate strata (slope) where the most commercially important species occur (Menezes et al., 2006; Santos et al., 2019). No major changes are observed on the vessels regime of operation and spatial distribution of effort although in the recent five years more vessels change from the longline to hand lines gear.

Since the end nineties the landings of most of the commercially important species start to decrease (Table 1, Fig. 2 and 3). This was a result of intensive fishing as a consequence of the development or entry of new and more technological vessels to the fishing, expanding the fishing areas to offshore seamounts and increasing the catchability (Diogo et al, 2015). Notably, the target species of the fishery, *Pagellus bogaraveo* seems to be the more resilient species with landings starting to decrease a decade later with an important decrease on landings observed during the last four years (see Fig. 2). The fishery is currently limited by the management rules to constrain the catches (TAC/quota).

To avoid species overexploitation technical measures were introduced by the regional government since 1998 (including fishing restrictions by area, vessel type and gear, fishing licence based on landing threshold, minimum lengths and closed areas to fishing; Santos et al., 2019). Under the E. C. Common Fisheries Policy, TAC's where introduced for some species, namely blackspot seabream, black scabbardfish, alfonsinos, and deep-water sharks (Table 2). During 2017 red seabream quotas were allocated by island, vessel and access conditions regulated by quater. In 2019 some techniques measures have been changed, as for example a closed season (EC. Reg 74/2015) implemented in 2016, to reduce effort during the spawning period, was revoked and the minimum lengths were revised by EC. Reg. 63/2019.

Since 2002, the use of bottom longline in the coastal areas was significantly reduced, because the local authorities have banned the use of this gear in the coastal areas on a range of 6 miles for local vessels and coastal vessels with a length lower than 24m and 30 miles for larger vessels. As a consequence, the smaller boats that operate in this area have changed their gears to several types of handlines, which may have increased the pressure on some species included the red seabream. The deep water bottom longline is currently a seamount fishery. As a consequence, the fishery expanded to offshore seamounts areas, with high concentration on the seamounts along the Mid Atlantic Ridge, including small vessels, targeting mainly red blackspot seabream (*Pagellus bogaraveo*), bluemouth (*Helicolenus dactylopterus*), alfonsinos (Beryx spp.) and wreckfish (*Polyprion americanus)* (Fig. and 2) (see Diogo et al, 2015).
All this changes in the fishing pattern of the fleet may explain the changes in the landings of some species that were more vulnerable to the use of bottom longlines (Table 1, Fig. 3). An important issue is the effect of the management measures on the dynamic of the fishery, which may difficult the interpretation of the landings or abundance trends due to spatio-temporal target effects (Santos et al., 2019). The alfonsinos fishery for example has a fishing season shorter and shorter during each year due to quota limitation and target effect from the offshore longline fishery.

2. Landings

Total landings in weight of deep-water species increase until 1994, decreasing thereafter with an abrupt decrease in 1999 due to a general decrease observed on landings by species with a particular crash observed for the silver scabbard fish (*Lepidopus caudatus*) (Fig. 2 and 3). Landings in value increase until 2007 decreasing thereafter. The landings of the major deep-water species caught by the Azores fleet, for the period 1980 to 2020, are resumed in Table 1 and Figures 3. The fishery has expanded to more offshore areas, with high effort on the seamounts along the Mid Atlantic Ridge (WD Pinho, 2018). This area expansion is a consequence of the decrease on the abundance observed for almost all the demersal/deep water species in the coastal and nearby areas since 1994 (Fig. 2 and 3).

Disaggregated landing data by vessel is available since 1985. Information by gear type and effort data are collected by shore based samplers that inquire the fishing masters during the landings operations. The present reported annual catches in weight include only the official landings collected in the Azorean port auctions, since the discards and the frozen or transformed fish are not quantified on the landings.

The present accepted definition of "deep-water species" presents some conflicts with the case of the Azores fishery, since the local ecosystem is a natural deep-water one, the dynamics of some species covers both strata, shallow and deep, and literally all the Azorean fleet can be considered as a deep-water fishery. However, landings of some deep-water species as defined by ICES (Annex I species, EC Reg. 2347/2002) represents actually a minor fraction of total demersal landings because the exploitation of these species is not economical profitable under the actual framework of a small scale fishery (see Table 1).

3. Discards

Discards data were analysed for the period 2004-2011 for the bottom demersal/deep-water metier using DCF data. There is new information only for 2018, however, with the same level of discards for the period 2004-2011, because the exploitation pattern of the fleets is similar, particularly for the longliners. Due to the value of the species negligible discard are expected.

4. *Length compositions*

Fishery biological data were not update because the DCF data was not available.

5. Fishery abundance index

Standardized fishery abundance index was not updated for a number of species, because the DCF data was not available.

Acknowledgements

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References

Diogo, H.; Pereira, J. G.; Higgins, R. M.; Canha, A.; Reis, D. 2015. History, effort distribution and landings in an artisanal bottom longline fishery: An empirical study from the North Atlantic Ocean. Marine Policy, 51: 75-85.

ICES. 2010. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources. ICES CM 2010/ACOM:17.

Menezes, G. M.; Sigler, M. F.; Silva, H. M.; Pinho, M. R.. 2006. Structure and zonation of demersal and deep-water fish assemblages off the Azores Archipelago (mid-Atlantic). *Marine Ecology Progress Series*, 324:241-260.

Pinho, M. R. 2018. Data from deep water fishery of the Azores. Working Document (WD). ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 11 to 18 April 2018.

Pinho, M. R.; Menezes, G. 2005. Azorean Deepwater Fishery: Ecosystem, Species, Fisheries and Management Approach Aspects. *Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries,* Conference Poster and Dunedin Workshop Papers. FAO Fish. Proc. 3/2.

Pinho, M. R.; Menezes, G. 2009. Pescaria de demersais dos Açores. Boletim do Núcleo Cultural da Horta 2009:85-102. ISSN 1646-0022.

Pinho, M. R.; Diogo, H.; Carvalho, J.; Pereira, J. G. 2014. Harvesting juveniles of Red (Blackspot) seabream (*Pagellus bogaveo*) in the Azores: Biological implications, management and life cycle considerations. Ices Journal of Marine Science. doi:10.1093/icesjms/fsu089.

Santos, R. V. S.; Silva, W. M. M. L.; Novoa-Pabon, A. M.; Silva, H. M.; Pinho, M. R. 2019. Long term changes in the diversity, abundance and size composition of deep sea demersal teleosts from Azores assessed through surveys and commercial landings. Aquatic Living Resources, 32, https://doi.org/10.1051/alr/2019022

Santos, R., Medeiros-Leal., W. and Pinho, M. (2020). Stock assessment prioritization in the Azores: procedures, current challenges and recommendations. Arquipelago. Life and Marine Sciences 37: 45 - 64. https://doi.org/10.25752/arq.23647

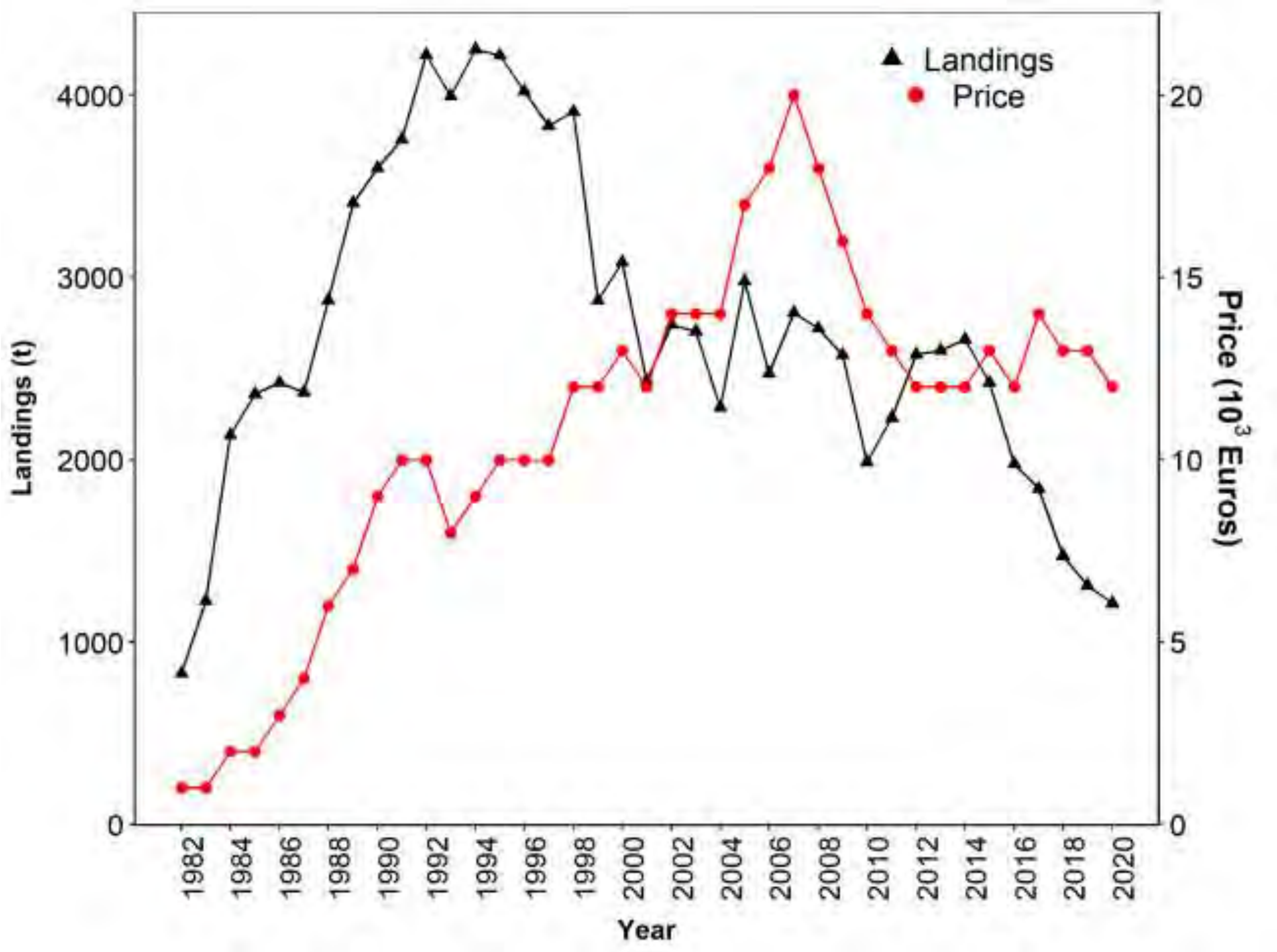

Figure 1. Total landings, in weight and value, of deep-water species from Azores (1980-2020). Important historical management events are also shown on the graph.

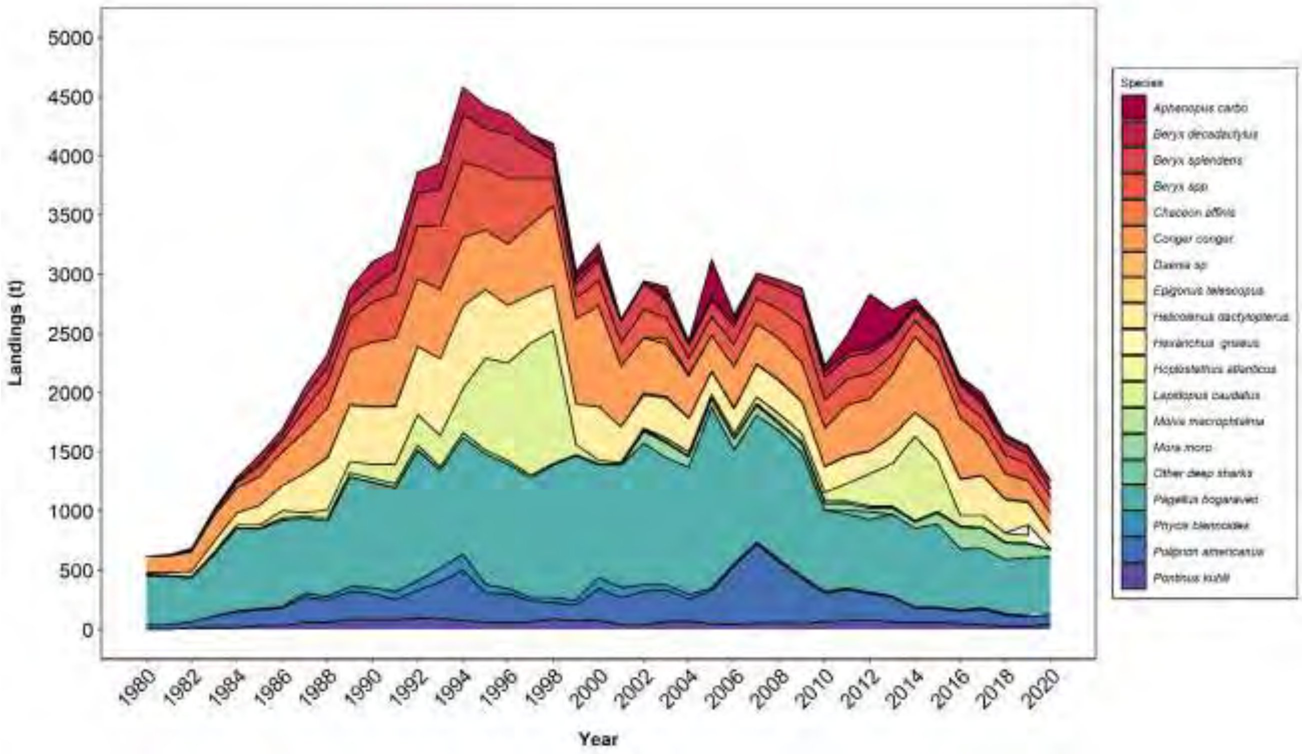

Figure 2. Overview (1980-2020) of the deep-water species landings from the Azores (ICES 10 a2).

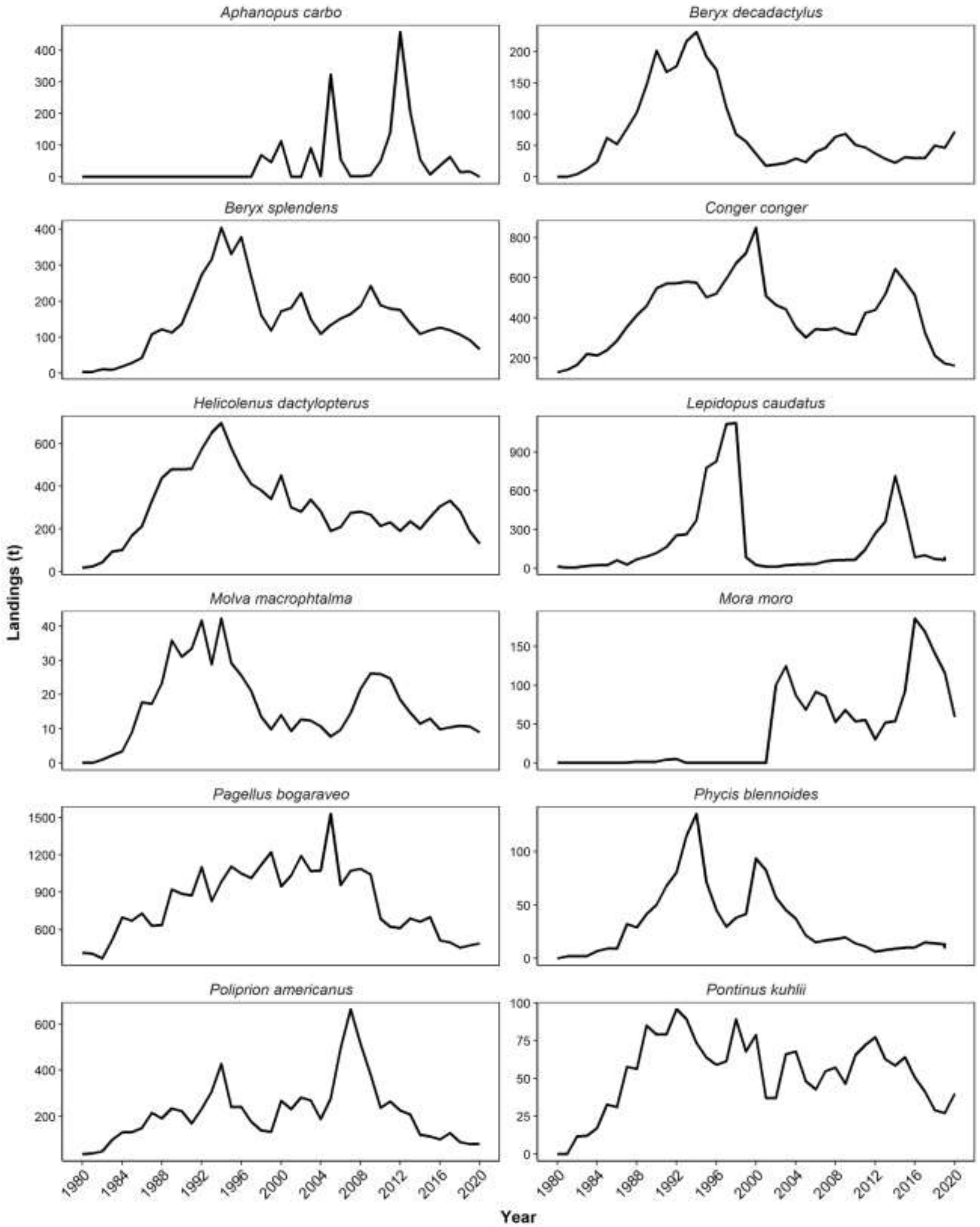

Figure 3. Annual landings of major demersal/deep-water species of the Azores (1980-2020).

Table 1. Landings (tons) of deep-water species from the Azores (ICES area X). + landed as mixed species; * Include 270t from CECAF 34.2.0.

Year	*Aphanopus carbo*	*Beryx decadactylus*	*Beryx splendens*	*Conger conger*	*Epigonus telescopus*	*Helicolenus dactylopterus*	*Hoplostetus atlanticus*	*Molva macrophalma*	*Mora moro*	*Pagellus bogaraveo*	*Phycis blenoides*	*Polyprion americanus*	*Lepidopus caudatus*	*Dalatias licha*	*Hexanchus griseus*	*Deania sp. (+)*	*Centrophorus sp. (+)*	*Other deep water sharks (+)*	*Chaceon affinis*
1980			3	131		18				415	0	38	13						
1981			4	143		22				407	2	40	6						
1982		4	11	166		42		1		369	2	50	10						
1983		13	10	222		93		1		520	2	99	18						
1984		24	19	214		101		1		700	7	131	23						
1985		62	29	241		169		2		672	9	133	25						
1986		52	42	287		212		3		730	9	151	63						
1987		77	108	356		331		9		631	32	216	30						
1988		103	122	413		439		18		637	29	191	70						
1989		147	113	459		481		17		924	42	235	91						
1990		201	137	547	3	480		23	2	889	50	224	120						
1991		168	203	570	11	483		36	4	874	68	170	166						
1992		176	274	572	+	575		35	+	1090	91	233	255						
1993		217	316	581	+	650		33	+	830	115	309	266						
1994		234	410	575	+	708		42	+	989	136	433	374						
1995		194	335	507	+	589		29	+	1115	71	244	780	321					
1996		171	379	521	+	483		26	+	1052	45	243	826	216					
1997		111	268	596	+	410		21	+	1012	30	177	1115	30					
1998	5	68	161	672	+	381		14	+	1119	38	140	1187	34					
1999	46	56	119	723	+	340		10	+	1222	41	133	86	31					
2000	112	35	168	831	+	441		13	+	947	91	263	27	31					
2001	+	17	182	509	+	301	343	9	+	1034	83	232	14	13					
2002	+	20	223	465	14	280	+	13	100	1193	57	283	10	35	7		4		
2003	91	22	150	443	15	338	+	12	125	1068	45	270	25	25	2		6		49
2004	2	29	110	354	6	282	+	11	87	1075	37	189	29	6	1	1	1		13
2005	323	23	134	304	4	190	+	8	69	1383*	22	279	31	14	1	1	1		
2006	55	40	152	346	10	209	+	10	92	958	15	497	35	10	1	1	3		
2007	0.2	46	165	340	7	274	+	14	86	1063	17	662	55	7	1	0.3	3	1	
2008	0.2	63**	187**	349	7	281	+	22	53	1089	18	513	63	10	0.4	6	3	0.1	0.1
2009	5	68**	243**	326	7	267	+	26	68	1042	20	382	64	6	0.3	0	3	0.4	
2010	49	51	189	318	5	213	+	26	54	687	14	238	68	2	1	3	1	1.8	0
2011	139	47	179	426	5	231	+	25	55	624	11	266	148	0	0	0	0	4.6	0
2012	458	37	175	441	4	190	+	19	31	613	6	226	271	0	0	0	0	31.1	0
2013	206	28	140	517	4	235	+	15	52	692	8	209	361	0	0	0	0	69.7	0
2014	54	22	109	644	2	200	+	11	54	663	9	121	713	0	0	0	0	0.0	0
2015	7	31	120	583	4	256	+	13	92	701	10	114	429	0	0	1	0	0.0	0
2016	36	29	127	513	6	306	+	10	186	515	10	101	87	0	0	1	0	0.1	0
2017	63	30	119	329	5	333	+	10	169	499	15	128	101	0	0	2	0	0.0	1
2018	14	50	107	214	4	283	+	11	140	445	14	89	73	0	0	1	0	0.0	2
2019	17	46	92	174	9	187	+	11	116	473	13	80	65	0	0	0	0	0.0	2
2020	0	72	67	164	5	130	0	9	59	491	9	81	88	0	0	0	0	0.0	2

\+ landed as mixed species
** includes 270 t from CECAF 34.2.0

Table 2. Historical quotas for deep-water species of the Azores (ICES X).

Regulation	Species	Year	ICES Area	TAC/Quota PT	Landings PT	Landing Azores
	P. bogaraveo	2003	X	1116	1068	1068
	P. bogaraveo	2004	X	1116	1075	1075
Reg 2270/2004	*P. bogaraveo*	2005	X	1116	1528	1528
	P. bogaraveo	2006	X	1116	958	958
Reg 2015/2006	*P. bogaraveo*	2007	X	1116	1071	1071
	P. bogaraveo	2008	X	1116	1089	1089
Reg 1359/2008	*P. bogaraveo*	2009	X	1116	1042	1042
	P. bogaraveo	2010	X	1116	687	687
Reg 1225/2010	*P. bogaraveo*	2011	X	1116	624	624
	P. bogaraveo	2012	X	1116	613	613
Reg 1262/2012	*P. bogaraveo*	2013	X	1004	692	692
	P. bogaraveo	2014	X	904	663	663
Reg. 1367/2014	*P. bogaraveo*	2015	X	678	701	701
	P. bogaraveo	2016	X	507	515	515
Reg 2285/2016	*P. bogaraveo*	2017	X	507	499	499
	P. bogaraveo	2018	X	507	445	445
Reg 2025/2018	*P. bogaraveo*	2019	X	566	473	473
	P. bogaraveo	2020	X	553	491	491
Reg 2270/2004	*Beryx sp*	2005	III, IV, V, VI, VII, VIII, IX, X, XII	214	202	157
	Beryx sp	2006	III, IV, V, VI, VII, VIII, IX, X, XII	214	212	192
Reg 2015/2006	*Beryx sp*	2007	III, IV, V, VI, VII, VIII, IX, X, XII	214	256	211
	Beryx sp	2008	III, IV, V, VI, VII, VIII, IX, X, XII	214	292	250
Reg 1359/2008	*Beryx sp*	2009	III, IV, V, VI, VII, VIII, IX, X, XII	214	353	311
	Beryx sp	2010	III, IV, V, VI, VII, VIII, IX, X, XII	214	267	240
Reg 1225/2010	*Beryx sp*	2011	III, IV, V, VI, VII, VIII, IX, X, XII	214	247	226
	Beryx sp	2012	III, IV, V, VI, VII, VIII, IX, X, XII	214	224	213
Reg 1262/22012	*Beryx sp*	2013	III, IV, V, VI, VII, VIII, IX, X, XII	203	185	168
	Beryx sp	2014	III, IV, V, VI, VII, VIII, IX, X, XII	193	149	131
Reg. 1367/2014	*Beryx sp*	2015	III, IV, V, VI, VII, VIII, IX, X, XII	194	151	151
	Beryx sp	2016	III, IV, V, VI, VII, VIII, IX, X, XII	195	158	156
Reg 2285/2016	*Beryx sp*	2017	III, IV, V, VI, VII, VIII, IX, X, XII	182	151	149
	Beryx sp	2018	III, IV, V, VI, VII, VIII, IX, X, XII	182	157	157
Reg 2025/2018	*Beryx sp*	2019	III, IV, V, VI, VII, VIII, IX, X, XII	164	148	138
	Beryx sp	2020	III, IV, V, VI, VII, VIII, IX, X, XII	164	150	139
	Aphanopus carbo	2003	VIII, IX, X	4000	2630	91
	Aphanopus carbo	2004	VIII, IX, X	4000	2463	2
Reg 2270/2004	Aphanopus carbo	2005	VIII, IX, X	3956	2746	323
	Aphanopus carbo	2006	VIII, IX, X	3956	2674	55
Reg 2015/2006	Aphanopus carbo	2007	VIII, IX, X	3956	3453	0
	Aphanopus carbo	2008	VIII, IX, X	3956	3602	0
Reg 1359/2008	Aphanopus carbo	2009	VIII, IX, X	3561	3601	5
	Aphanopus carbo	2010	VIII, IX, X	3561	3453	49
Reg 1225/2010	Aphanopus carbo	2011	VIII, IX, X	3561	3476	139
	Aphanopus carbo	2012	VIII, IX, X	3561	2668	458
Reg 1262/22012	Aphanopus carbo	2013	VIII, IX, X	3659	2336	206
	Aphanopus carbo	2014	VIII, IX, X	3659	2163	54
Reg. 1367/2014	Aphanopus carbo	2015	VIII, IX, X	3660	2535	7
	Aphanopus carbo	2016	VIII, IX, X	3661		36
Reg 2285/2016	Aphanopus carbo	2017	VIII, IX, X	3294		63
	Aphanopus carbo	2018	VIII, IX, X	2965		14
Reg 2025/2018	Aphanopus carbo	2019	VIII, IX, X	2801		17
	Aphanopus carbo	2020	VIII, IX, X	2801		0
Reg 2270/2004	Phycis blenoides	2005	X and XII	43	22	22
	Phycis blenoides	2006	X and XII	43	10	15
Reg 2015/2006	Phycis blenoides	2007	X and XII	43	14	17
	Phycis blenoides	2008	X and XII	43	13	18
Reg 1359/2008	Phycis blenoides	2009	X and XII	36	13	20
	Phycis blenoides	2010	X and XII	36	12	14
Reg 1225/2010	Phycis blenoides	2011	X and XII	36	13	11
	Phycis blenoides	2012	X and XII	36	5	6
Reg 1262/22012	Phycis blenoides	2013	X and XII	36	8	8
	Phycis blenoides	2014	X and XII	36	6	9
Reg. 1367/2014	Phycis blenoides	2015	X and XII	37	8	10
	Phycis blenoides	2016	X and XII	38	10	10
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	Phycis blenoides	2018	X and XII	36	14	14
Reg	Phycis blenoides	2019	X and XII			13
	Phycis blenoides	2020	X and XII			9
Reg 2270/2004	Deep-water sharks	2005	X	120 (1)	4	4
	Deep-water sharks	2006	X	120 (1)	4	4
Reg 2015/2006	Deep-water sharks	2007	X	20	4	4
	Deep-water sharks	2008	X	20	9	9
Reg 1359/2008	Deep-water sharks	2009	X	10	4	4
	Deep-water sharks	2010	X	0	4	4
Reg 1225/2010	Deep-water sharks	2011	X	0	0	0
	Deep-water sharks	2012	X	0	0	0
Reg 1262/2012	Deep-water sharks	2013	X	0	0	0
	Deep-water sharks	2014	X	0	0	0
Reg. 1367/2014	Deep-water sharks	2015	X	0	0	0
	Deep-water sharks	2016	X	0	0	0
Reg 2285/2016	Deep-water sharks	2017	X	10	0	0
	Deep-water sharks	2018	X	10	0	0
Reg 2025/2018	Deep-water sharks	2019	X	7	0	0
	Deep-water sharks	2020	X	7	0	0
Reg 1225/2010	Hoplostethus atlanticus	2010-12	X	0	0	0
Reg 1262/22012	Hoplostethus atlanticus	2013-14	X	0	0	0
Reg. 1367/2014	Hoplostethus atlanticus	2015-16	X	0	0	0
Reg 2285/2016	Hoplostethus atlanticus	2017-18	X	0	0	0

(1) Reg. 860/2005
(2) Em Dezembro de 2009 podem ser pescados até 10 % das quotas de 2010.
(3) Permitida tolerância de 3% do tac 2009 (PT=10t)

Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources

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Scabbard fish in the Madeira archipelago (CECAF 34.1.2)

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Abstract

This working document updates the information existing from the previous WGDEEP meeting of 2020 for the *Aphanopus* spp. in CECAF fishing area 34. Mainly an update on the time-series of annual Portuguese landings (by vessel segment), length distributions and unstandardized CPUE at CECAF area. A standardized biomass index series based on daily landings of commercial mid-water drifting longline fishery in Madeira was also updated with data from 2020.

1. INTRODUCTION

The fishery for deep-water species carried out in the Madeira EEZ and international adjacent waters (CECAF 34.1.2. area), dates back to the 17th century (Merrett and Haedrich, 1997) and for several decades this was the only fishery targeting scabbard fish in the Northeast Atlantic (Bordalo-Machado and Figueiredo, 2009). This fishery as an important and irreplaceable economic and social value in the Madeira fisheries sector. In Madeira, exploited deep-water fish stocks are overwhelmingly dominated by two scabbard fish species: *Aphanopus carbo* Lowe 1839 and *Aphanopus intermedius* Parin, 1983, which represent about half of the overall landings throughout the year (Delgado et al. 2013, 2018; Hermida and Delgado 2016). This deep-sea fishery targeting the black and intermediate scabbard fish, off the Madeira archipelago, is recognized as an artisanal and selective activity targeting predominantly adult individuals and presenting a low rate of bycatch (Severino et al., 2009).

Both scabbard fish species occur at a wide depth range, from 200 m in the northern part of the NE Atlantic (Nakamura and Parin, 1993) to 2300 m off the Canary Islands (Pajuelo et al., 2008) for *A. carbo*, although more frequent at 800-1300 m in Madeira (Morales-Nin and Sena-Carvalho, 1996) and to 1350 m for *A. intermedius* (Delgado et al., 2013). *Aphanopus carbo* and *A. intermedius* seem to be adapted to a strong activity of migrating upwards at night to feed on crustaceans, cephalopods and fishes (Tuset et al., 2010). Furthermore, these two sympatric species move to reproduction areas off Macaronesian archipelagos (i.e., Madeira and the Canary

Islands) and the northwest coast of Africa (Figueiredo et al. 2003; Pajuelo et al. 2008; Perera 2008; Farias et al. 2013). The spawning season of both *Aphanopus* species has been reported to take place from October to December (Figueiredo et al. 2003; Delgado et al. 2013).

The black and intermediate scabbard fish fishery represents one of the most profitable commercial activities on small-scale fisheries in Madeira archipelago. In 2020, the commercial landings in weight of *Aphanopus* spp. reached annual catches of up to 2136 tonnes yielding a total first sale value of *ca* 6.5 M€.

WGDEEP does not assess fisheries in Madeira (Eastern Central Atlantic area, CECAF) or in other areas outside the ICES area. Nonetheless, it is admitted that the incorporation of reliable CECAF data could provide a wider perception of the stock dynamics of these migratory species in the northeast Atlantic.

1.1. Fishery in Madeira

In compliance with the Multiannual Union Programme for Data Collection (EU-MAP), the Madeira fishing fleet targeting the deep water species, *A. carbo* and *A. intermedius*, uses a specialized fishing gear with longlines (LLD_DWF_0_0_0). The fishing gear is a mid-water horizontal drifting longline, set in the water column usually at depths of between 800 and 1300 m (**Figure 1**).

This fishery is known by its highly selective nature, concerning the bycatches of non-target species and the length structure of the catches of the targeted species – constituted almost exclusively by adult specimens over 90 cm total length. The catches of sub adult individuals scarcely achieve around 0.5% of the total number of individuals captured.

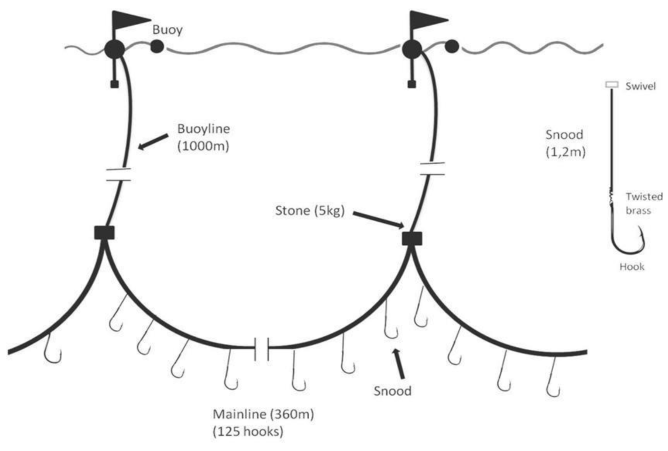

Figure 1 – Mid-water horizontal drifting longline used by the Madeira fishing fleet.

There is a combination of prevailing factors that result in a fishery with such unique features. Such factors are the geographical area of the fishery, where, according to the migratory model proposed by Farias et al. (2013), only adult specimens are available to this type of fishery and the highly selective nature of the fishing methodology itself, namely the fact that the passive fishing gear is operated strictly within a depth layer of the water column, between 1000 and 1200 meters deep, without being anchored, and always well above the seafloor. The gear aims to catch the black scabbard fish in its daily vertical migration to feed, thus minimizing the probability of capture of benthic by-catch species.

This fishery, carried out by the fishing vessels targeting the black and intermediate scabbard fish registered in Madeira, which was traditionally performed mostly around the islands of Madeira and Porto Santo and the seamounts inside the Madeira EEZ, has undergone considerable geographic expansion in recent decades in the Northeast Atlantic, mostly from 2005 onwards, and initiated a process of expansion looking for new fishing areas (**Figure 2**). Progressively, new fishing grounds located in international waters SE of the Azores, off the Canaries and the "rediscovery" of the seamounts within the Madeira EEZ became indispensable for this fishery and bilateral agreements with the Azores and the Canaries were made to allow the fleet access to those areas.

In 2015, STECF provided an exploratory assessment of the status of the species around Madeira (STECF-14–15). It was mentioned that, for the period 2000-2013, there was a general decline in fishing capacity and fishing effort. The number of vessels has also declined by 41% (34 to 20 vessels). Furthermore, in the second half of the last decade, some Madeiran vessels targeting the black and intermediate scabbard fish have moved to new fishing grounds, some of them located outside the EEZ of Madeira (SE of the Azores and off the NW of the Canaries) (Figure 2).

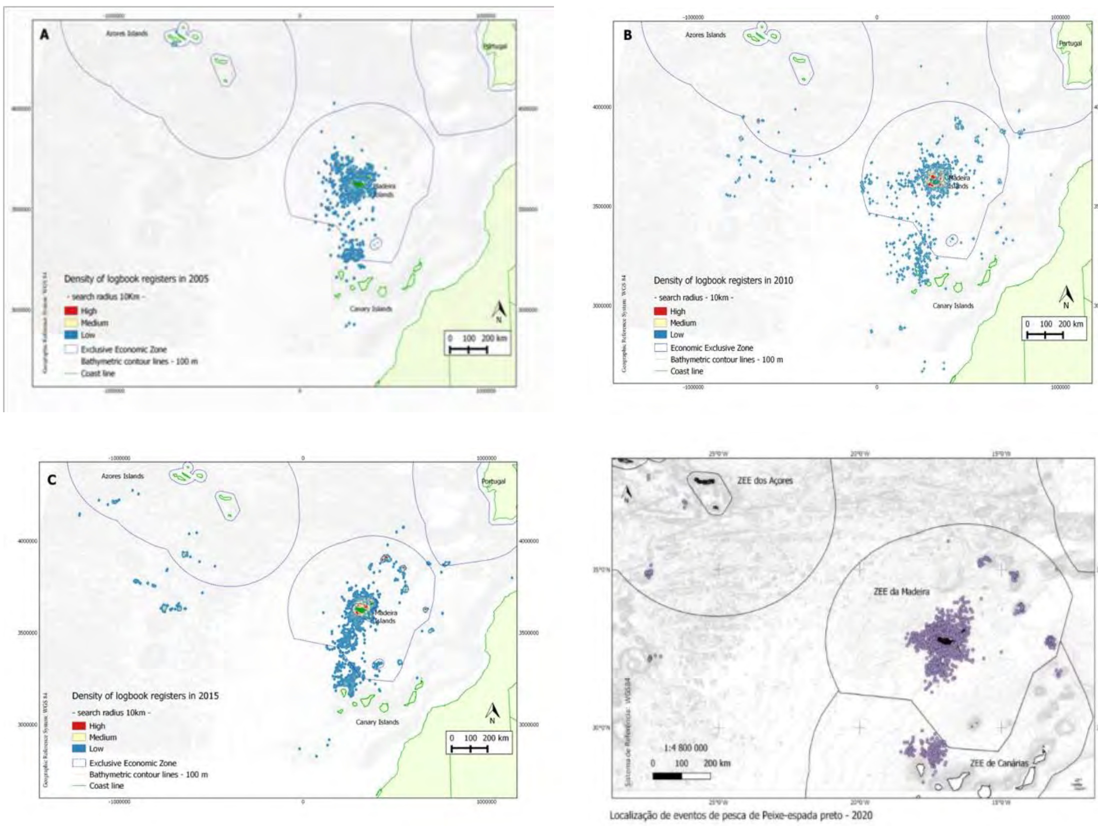

Figure 2 - Density plots illustrating the geographical distribution of the fishing sets with catches in 2005 (A), 2010 (B), 2015 (C) (Delgado *et al.*, 2018) and 2020 (D): density maps estimated with the software Quantum GIS 2.2, module "heatmap" covering a search radius of 10 Km (Regional Directorate of the Sea - Madeira).

From 2019 to the present, most of fishery targeting the black and intermediate scabbard fish have been carried out within the Madeira EEZ. However, the fishing grounds off the Northwest of Canaries continues to be a relevant fishing area for the Madeira fishing fleet, due to the availability of black and intermediate scabbard fish and the lack of interest in these species by the Canary fishing fleet, which makes profitability the capture of them by the fishing fleet from Madeira. The capture of *Aphanopus* spp. in the Azores fishing grounds by the fishing fleet from Madeira has been decreasing since 2015. According to the fishermen the effort is not profitable due to the distance between Madeira and Azores.

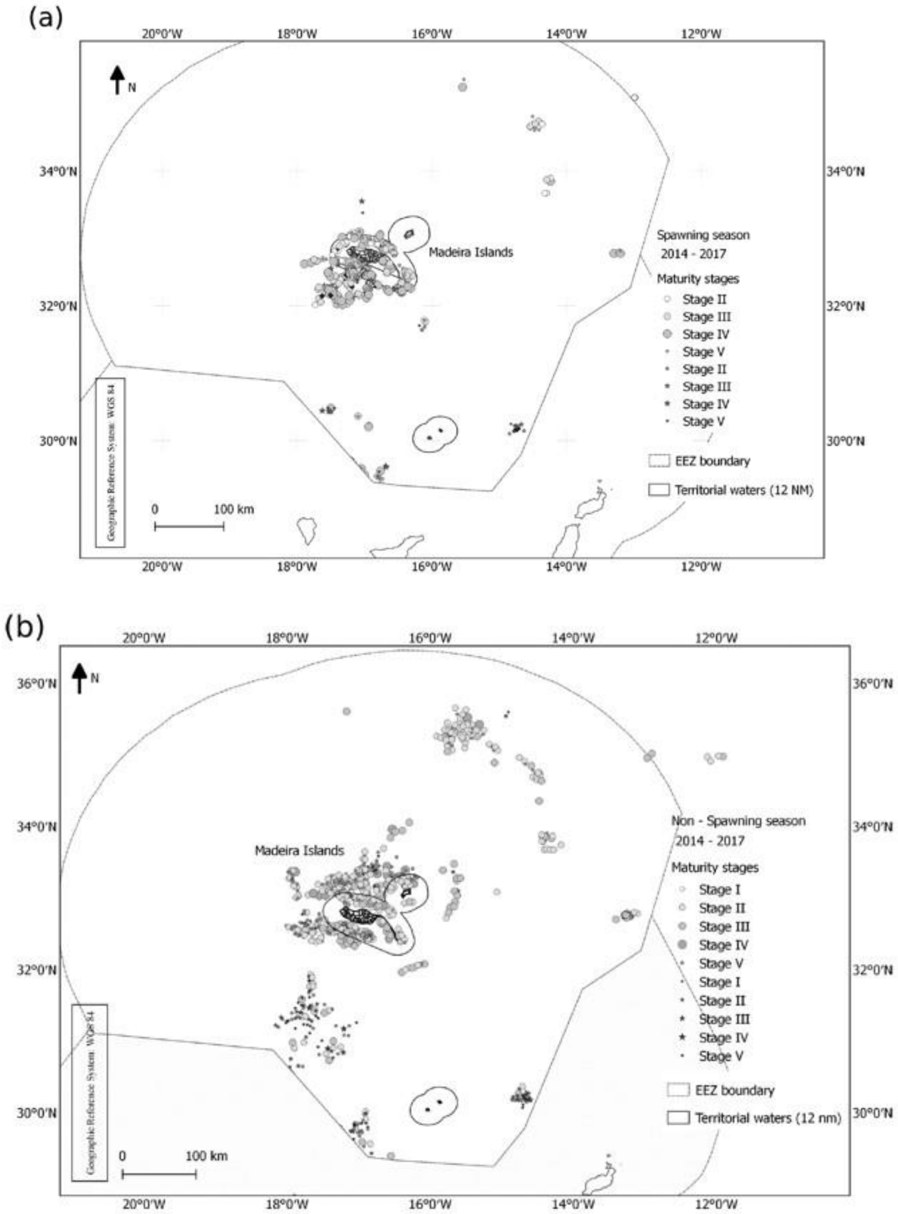

Figure 3 - Map showing both *Aphanopus* species distribution, *A. carbo* (grey circles) and *A. intermedius* (grey stars), during spawning (a) and non-spawning (b) seasons according to the distance from the coast (<12 and >12 nautical miles; 1 n.m. = 1.852 km) (Vasconcelos et al., 2020).

The enlargement of the maritime area covered by the fishing operations was prompted by the decrease of the abundance of the resource in the traditional fishing grounds, near the islands of Madeira and Porto Santo. And also due to the improvement of the fishing fleet of Madeira verified in the last years. This search for new fishing grounds was driven by the need to stabilise catches that suffered a severe decline from 2000 onwards. A relative stabilisation of the fishery was achieved in the last years but the enormous increase in the costs led several vessels to leave the activity.

Though, most of the *Aphanopus* spp. fishery still remains concentrated off the islands of Madeira and Porto Santo, especially during the spawning season from October to December, mainly the fishery operated by the small vessels (< 12 m). Migrations to areas less than 12 n.m. from the coast, were observed for *A. carbo* throughout the spawning season (**Figure 3**) (interannual database from 2014-2017; Vasconcelos et al., 2000). The mature stages IV and V were the ones that overwhelmingly dominated this migration pattern to shallower areas. This migration of mature adults towards areas near the coast, especially during spawning, occurs simultaneously with a noticeable increase of the proportion of fishing events inside the EEZ (<12 n.m.), making them more susceptible to mid-water drifting longline fishery (Vasconcelos et al., 2000).

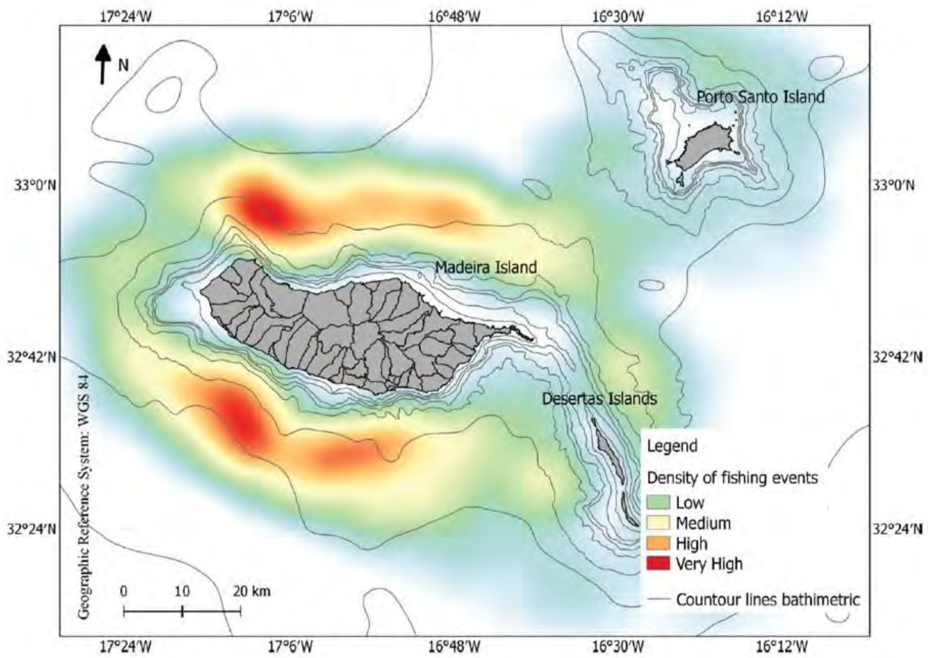

Figure 4 - Kernel density estimation plot showing the mean density values of the fishing events during the spawning season per compartment of 10 km × 10 km generated for the study area and for the period 2014–2017. Low: 1–10; Medium: 11–20; High: 21–30; and Very High: >31 fishing events (Vasconcelos et al., 2020).

There are three main aggregation areas identified off Madeira (**Figure 4**), where fishing events occurs during spawning, mainly the fishing grounds from Câmara de Lobos and Ribeira Brava at the south coast of Madeira and Porto do Moniz-Seixal at the north coast (Vasconcelos et al., 2000). The fishing grounds are located at an average distance of 2 to 4 n.m. offshore, although the same depths are found over a wider range of 3 to 6 n.m. offshore (Vasconcelos et al., 2000). Most likely, these areas correspond to areas with environmental and sea bottom topography that favour reproduction, as these areas generally correspond to canyons where there are prominent folds in the bathymetry towards the coast and its nearby steep slopes. These represent very closed geological formations with the dimension of extensive canyons, probably protected from strong currents and where high densities of spawning individuals aggregate, facilitating high probability of successful external fertilization (Vasconcelos et al., 2000).

2. METHODS

2.1. Fishery dependent data

2.1.1. Landings and mean price in Madeira archipelago

Portuguese total landings of *Aphanopus* spp. in CECAF area 34 (in weight, ton, and value, euro) were analysed by year. Fishery dependent data were collected from commercial landings for the period between 1990 and 2020.

2.1.2. Landings and mean price in Madeira archipelago by vessel length category

Portuguese landings of *Aphanopus* spp. in CECAF area 34 (in weight, tonnes, and value, euro) were analysed by year and by fishing vessel segment (vessel length category). Fishery dependent data were collected from commercial landings for the period between 2008 and 2020. The active fishing fleet at CECAF area is grouped into the following categories: VL0010 (vessel size less than 10 m), VL1012 (vessel size between 10 and 11.99 m), VL1218 (vessel size between 12 and 17.99 m) and VL1824 (vessel size between 18 and 23.99 m).

2.2. Length distribution

Aphanopus spp. length sampling data available for Madeira were analysed considering both species combined by year for the period between 2009 and 2020. Numbers-at-length were raised to the total landings.

2.3. CPUE

All landings from the commercial mid-water drifting longline fishery at all the fishing ports of Madeira (mainly port of Funchal), in the Northeast Atlantic (32°00’–33°30’N, 15°30’–18°00’W) were considered for this analysis, during the period between 2008 and 2020. From each fishing trip data on total weight landed of the species (in kg), vessel name and corresponding length category, engine power (KW), number of days at sea, number of fishing days and fishing operations, and the total number of hooks were examined. A trip was defined from the moment the vessel leaves the dock to when it gets back to the dock.

The standardized CPUE model based on daily landings of commercial mid-water horizontal drifting longline fishery in Madeira was updated with data from 2020.

3. RESULTS AND DISCUSSION

3.1. Fishery dependent data

3.1.1. Landings and mean price in Madeira archipelago

The annual landings of black and intermediate scabbard fish derived from Madeiran mid-water longliners for the period between 1990 and 2020 are presented in **Figure 5**.

Catches in CECAF 34 area were updated with fishery data from Madeiran mid-water longliners landings from 1990 to 2020. These catches are recorded by the Regional Fisheries Department of Madeira (**Figure 5**). CECAF catches have been decreasing after the 1998 peak, but a slight increase was observed since 2012 (landings in 2020 were around 2136 tons).

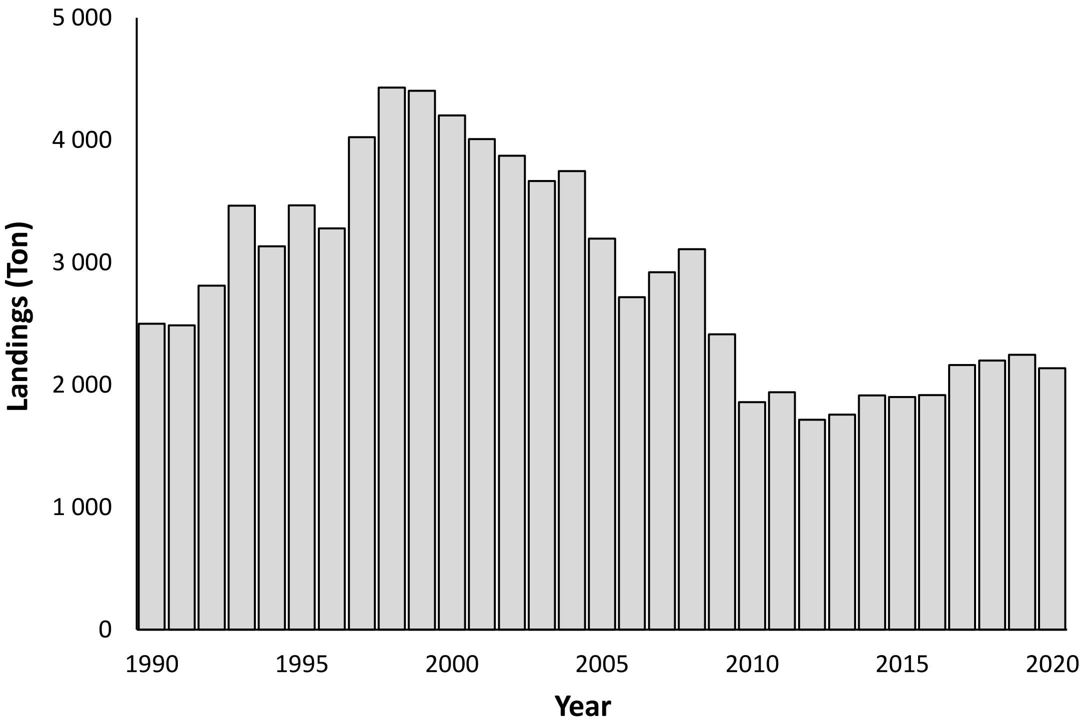

Figure 5 - Time-series of annual Portuguese landings of *Aphanopus* spp. at CECAF area (1990-2020).

The EU TAC and total catches for CECAF 34 area from 2005 to 2020 are presented in **Table 1.** It was observed a relevant decrease in the EU TAC for the *Aphanopus* spp. fishery in CECAF 3.3.1.2, from 4285 tons in 2005 to 2189 tons in 2020.

Table 1 - Black scabbard fish TACs and total landings in CECAF 34 area between 2005 and 2020.

Year	EU TAC CECAF 34.1.2 area	Landings CECAF 34.1.2. Area
2005	4 285	3 195
2006	4 285	2 717
2007	4 285	2 922
2008	4 285	3 109
2009	4 285	2 413
2010	4 285	1 860
2011	4 071	1 941
2012	3 867	1 716
2013	3 674	1 758
2014	3 490	1 913
2015	3 141	1 902
2016	2 827	1 917
2017	2 488	2 163
2018	2 189	2 199
2019	2 189	2 246
2020	2 189	2 136

Following the methodology adopted at WGDEEP 2016 (ICES, 2016), standardised annual catch estimates for the period from 1990 to 2020 of the nineteen resources (ordered in terms of total weight catch) and grouped into four groups (1, large pelagics; 2, elasmobranchs; 3, small pelagics; and 4, demersals) were determined based on data extracted from DSEIMar/DRM database (**Figure 6**).

The results do not support that, given the diversity of species, which includes different taxonomic groups, lifestyles and both short- and long-lived organisms, the declining trends are reflecting changes on resources abundance, which would imply that Madeiran waters are subject to severe over-exploitation. Further studies and a careful interpretation of trend variations of some resources are still required. It may happen that in some cases landing trends are not only related to the resources' abundance in Madeiran waters, but subject to other factors like variations on the market regulation (e.g. small pelagic fishery), environmental, application of TAC's and quotas, among others.

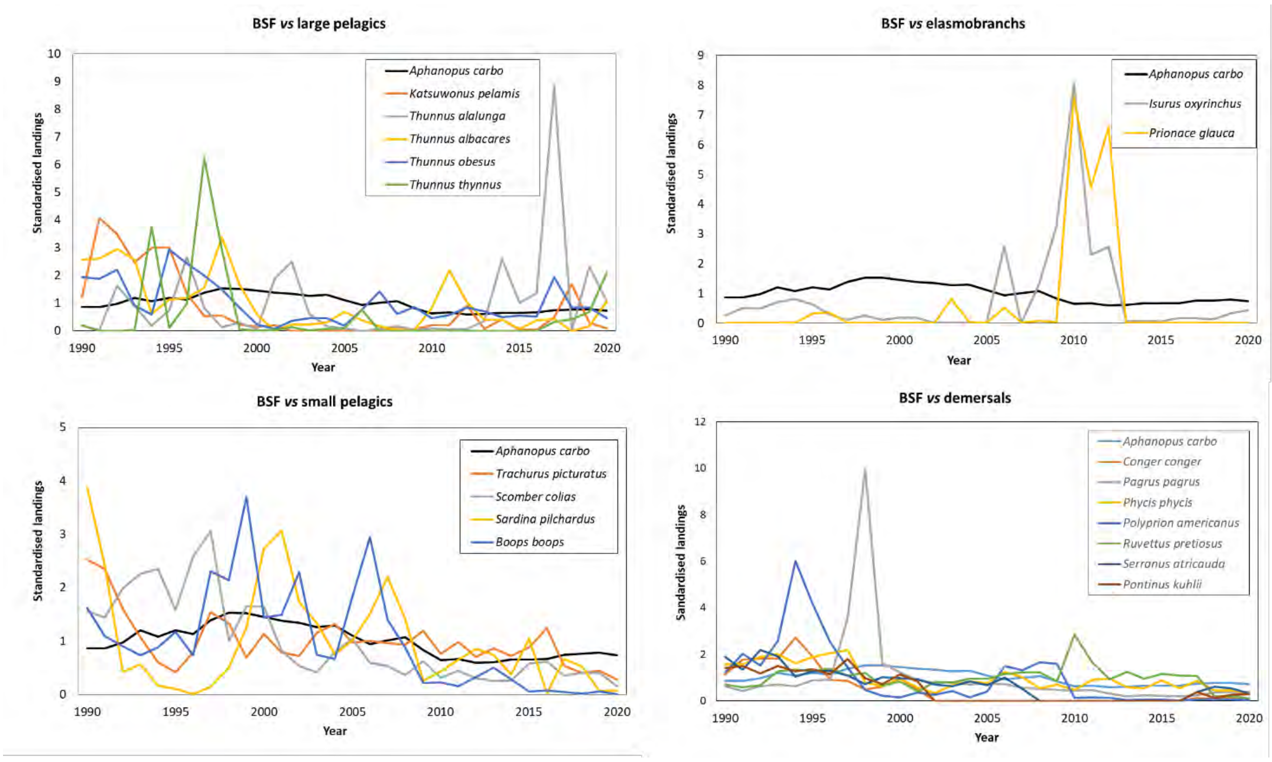

Figure 6 - Trends in standardised landings of black scabbard fish and the 19 other top ranked species in Madeiran landings.

The first sale value of *Aphanopus* spp., in millions of euros, for the period between 2008 and 2020 is presented in **Figure 7**. This value followed the same trend observed in the annual landings in terms of weight. A slight decrease was observed in 2020 yielding a total first sale value of *ca.* 6.5 M€.

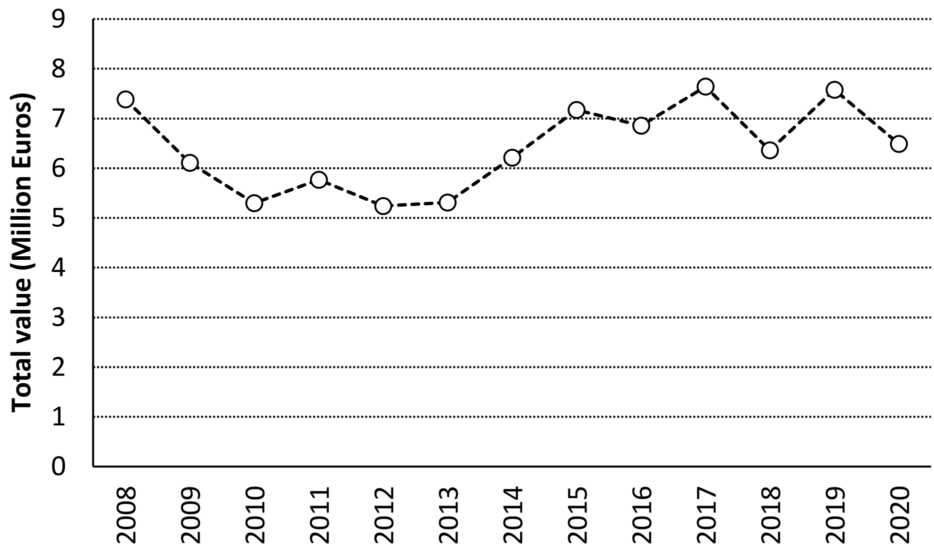

Figure 7 – Economic value of the catches of *Aphanopus* spp., in millions of euros, for CECAF 32.1.2., between 2008 and 2020.

3.1.2. Landings and mean price in Madeira archipelago by vessel length category

The number of vessels in activity in Madeiran longline fleet has steadily decreased during the last two decades (**Figure 8**).

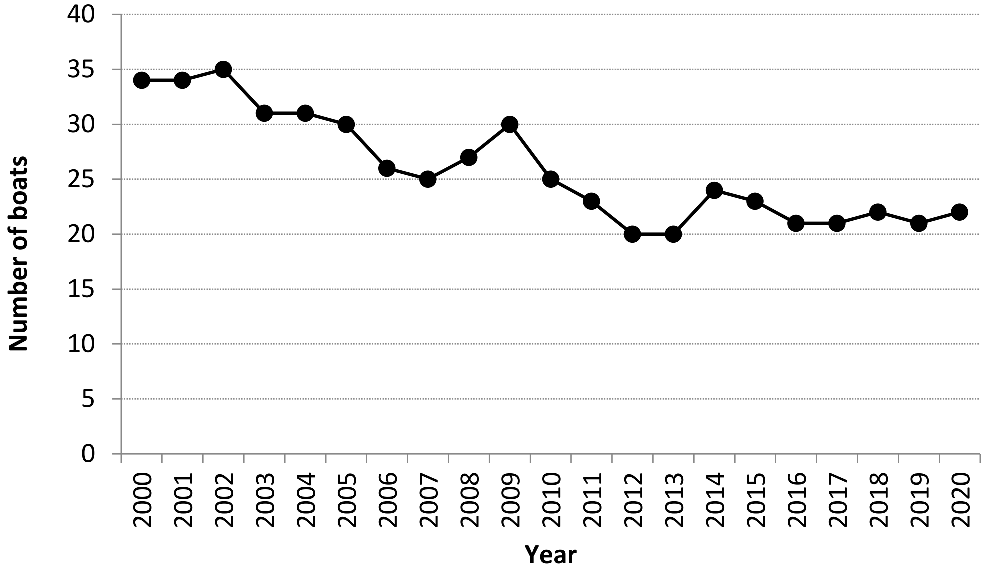

Figure 8 - Number of vessels active in the fishery of *Aphanopus* spp. at CECAF area between 2000 and 2020.

Though, in the last years, the fishery as achieved a certain stability in the number of active vessels, as the small number of vessels remaining in the fishery are small artisanal vessels (**Figure 9**). In 2020, 50% of the active vessels were grouped between 12 and 18 m of overall length, thus hardly having operational conditions to make any significant increase in the present total number of hooks used in each fishing set.

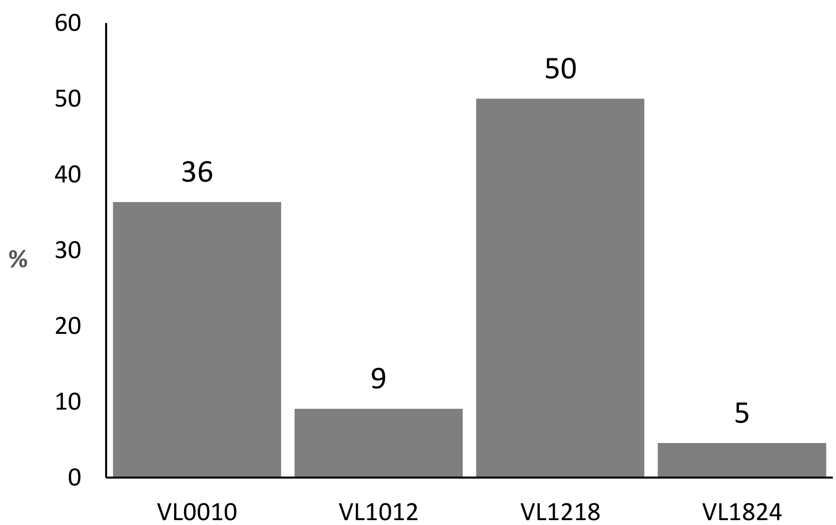

Figure 9 - Composition of the active fleet in the fishery of *Aphanopus* spp. at CECAF area in 2020 per vessel length category (n=22 vessels).

A time-series of annual Portuguese landings at CECAF area per vessel length is represented in **Figure 10**. The majority of the annual landings in Madeira are made by vessels of the length segments VL1218 and VL1824, wherein 79% of the total landings in 2020 were captured by VL1218.

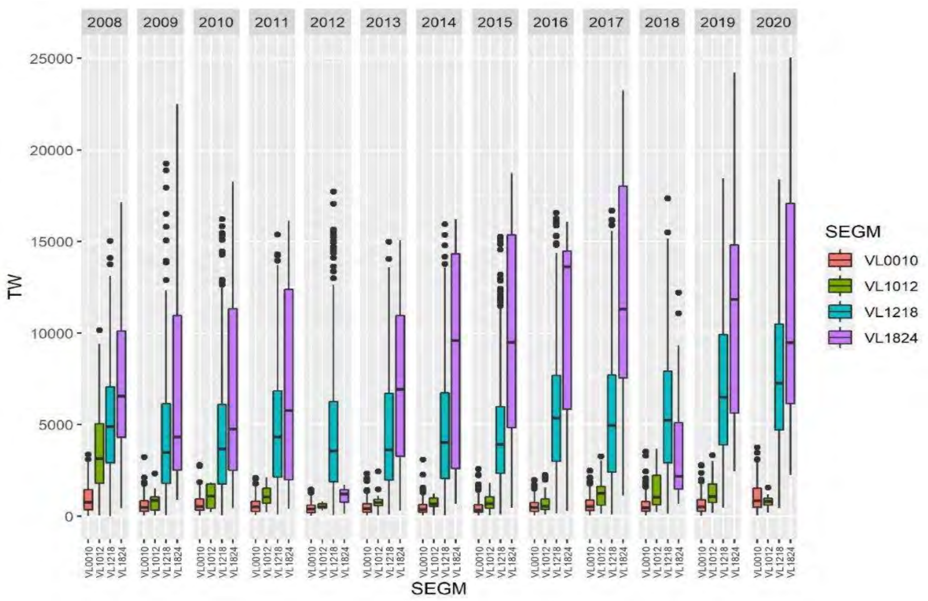

Figure 10 - Time-series of annual Portuguese landings of *Aphanopus* spp. at CECAF area per vessel length category (2008-2020).

The vessel length category VL1218 presented the highest landing values, followed by the vessel segment VL1824 (**Figure 11**). Though the number of vessels in the segment VL1824 represents only 5% of the total active fleet in Madeira, their contribution is higher than both vessel segments VL0010 and VL1012 together. The decrease observed in the economic value for the vessel segment VL1218 in 2020 is related to the decrease in effort performed by the vessels in this length category.

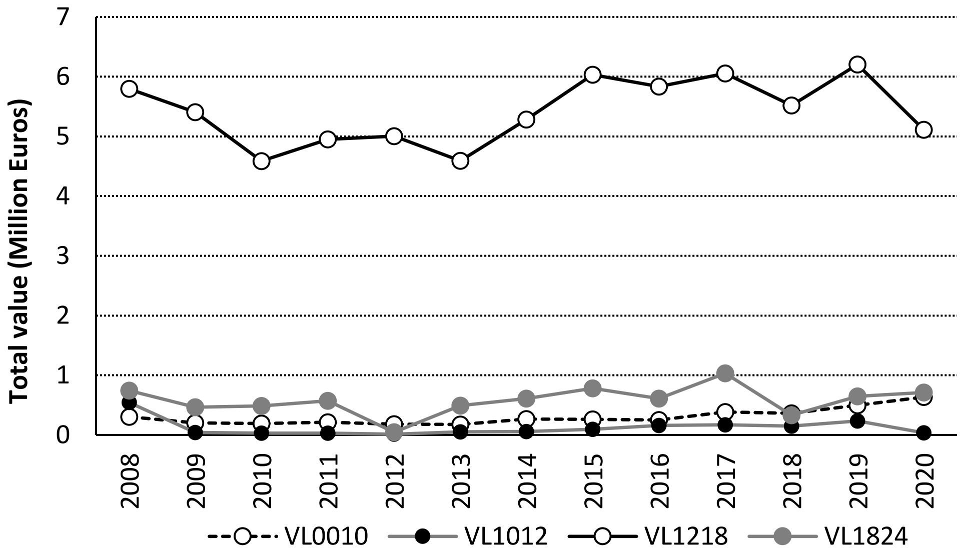

Figure 11 – Economic value of the catches of *Aphanopus* spp., in millions of euros per vessel category between 2008 and 2020.

3.2. Length distribution

Annual total length–frequency distributions of the exploited population caught by the Madeiran longline fleet in CECAF area for the period 2009-2020 are presented in **Figure 12**. The analysis of this figure indicates neither great changes on the length range between years nor on the mean length (around 114-118 cm total length, TL). From 2011 to 2017 the mean length was constant at 118 cm TL, occurring a slight decrease in 2019 and 2020 (114 cm TL). The smaller number of vessels sampled in 2020 for length frequency distribution analysis, may have influenced the decrease in the estimated mean value.

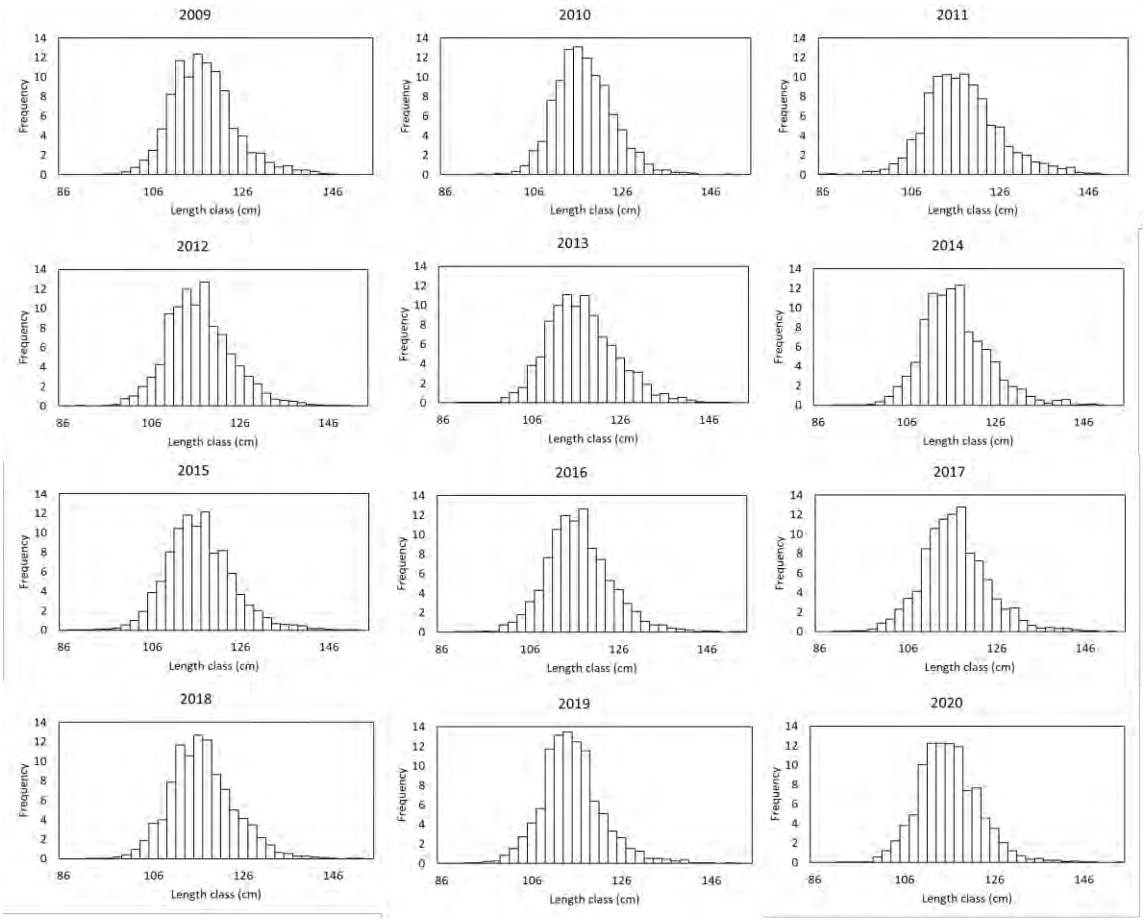

Figure 12 - Annual length–frequency distribution of specimens of *Aphanopus* spp. landed by the Portuguese mid-water longliners operating along CECAF area.

3.3. CPUE

Regarding the fishing effort in total number of hooks accumulated per year (**Figure 13**), there was an overall decrease in the available period, reflecting the decline of the number of vessels. The year of 2004 stands for the highest (22 M) total number of hooks in the period available, since then effort has declined, and it is rather constant in the last years around 14-15 M hooks per year, with the exception of the year 2018 and 2020 (*ca.* 12 M). From 2019 to 2020, it was also observed a decrease of *ca.* 2.2 M hooks.

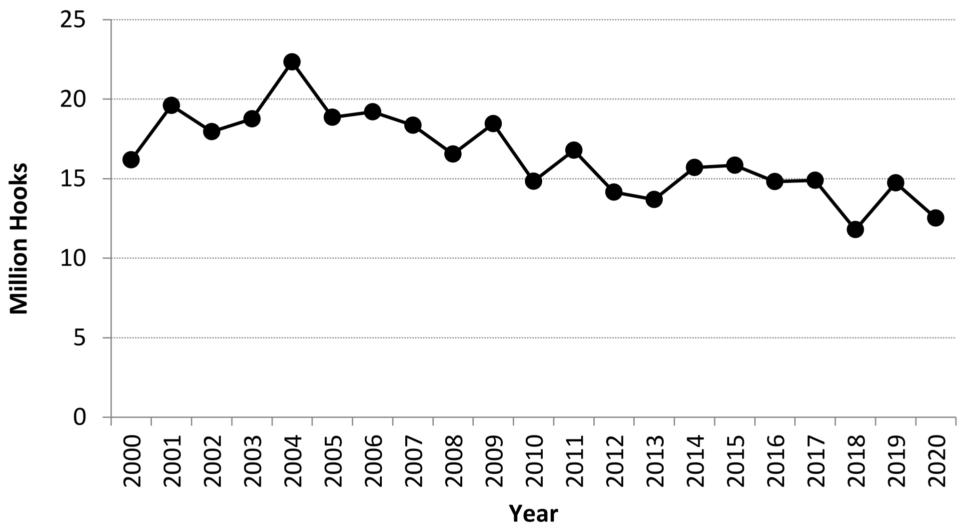

Figure 13 - Time-series of the total annual effort estimated for the CECAF area (million hooks) for the *Aphanopus* spp. fishery.

In CECAF 34 area, the fishing effort that corresponds to the total number of hooks per year shows a trend of a continuous decrease from 2000 to 2020. Such decreasing trend is in line with the reduction of the number of active vessels (**Figure 14**).

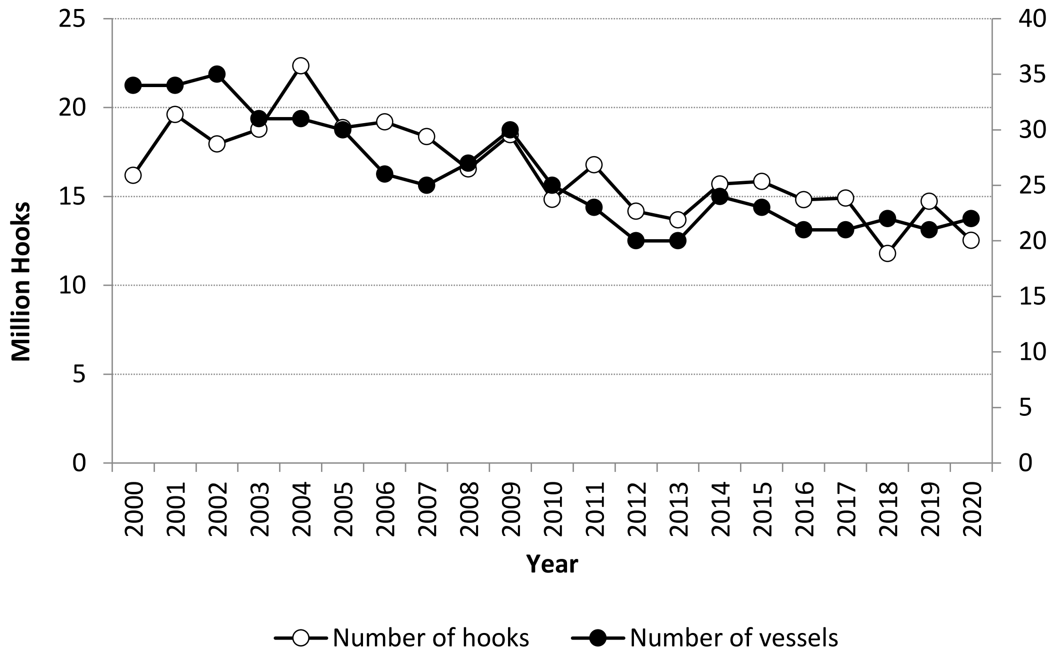

Figure 14 - Time-series of the total annual effort estimated for the CECAF area (million hooks and vessels) for the *Aphanopus* spp. fishery.

The unstandardized CPUE had an overall decline along the analysed period (**Figure 15**). The variation observed in the years 2000-2006 was about -45% in CPUE, corresponding to an increase of 16% in the fishing effort. From 2006 to 2008 there was a slight recovery of the landings and of the unstandardized CPUE. The decreasing trend of landings restarted in 2008, but all indicators analysed reached a certain level of stability between 2010 and 2016, and even a slight recovery was observed in 2020.

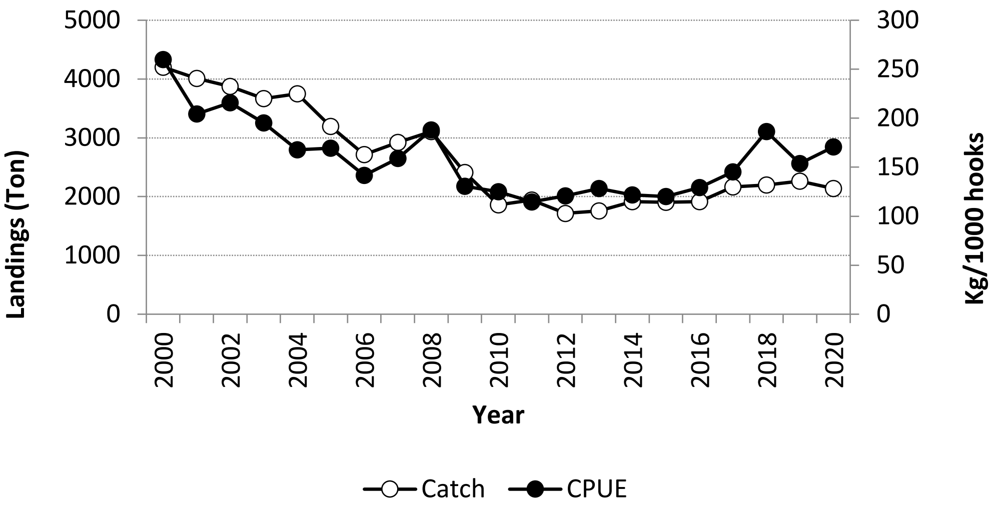

Figure 15 - Time-series of Landings per unit effort, CPUE unstandardized (kg / thousand hooks) of *Aphanopus* spp. in CECAF area.

A standardized CPUE model based on daily landings of commercial drifting longline fishery in CECAF 34 area is being developed for the period of 2008-2020. An exploratory data analysis showed a high correlation between the number of hooks per haul and the number of hauls (**Figure 16**), but no other variable showed highly correlation with the number hooks per haul.

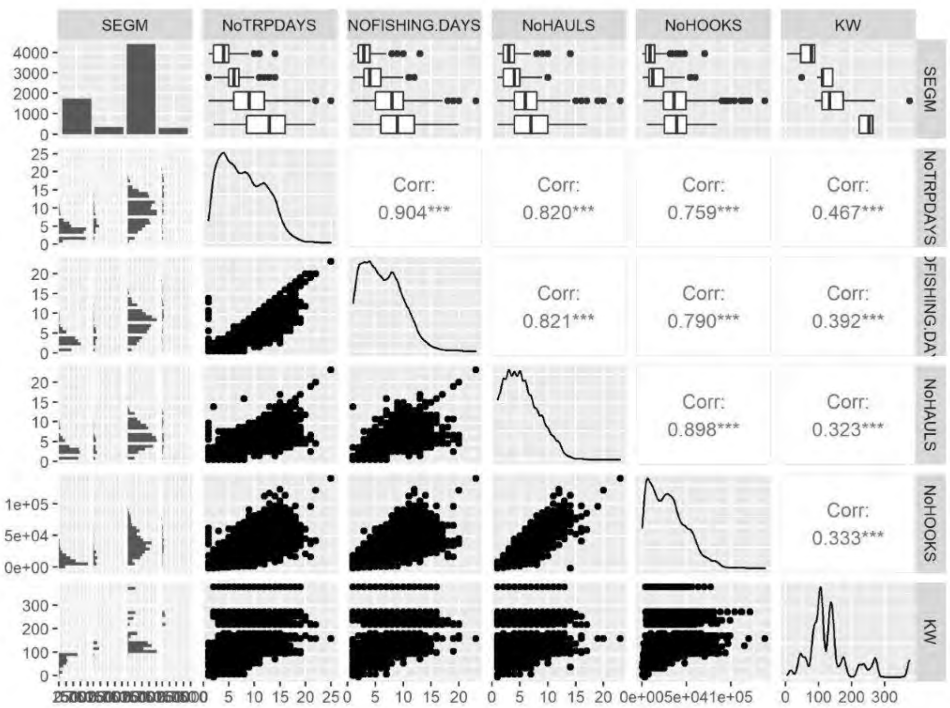

Figure 16 - Exploratory data analysis showing the correlation between the potential variables for the CPUE standardised model of *Aphanopus* spp.

For the period from 2008 to 2020, a standardised CPUE was obtained by adjusting a GLM model based on daily landings of commercial mid-water horizontal drifting longline fishery in CECAF 34 (**Figure 17**). The response variable (LPUE) was black and intermediate scabbard fish landings in weight per fishing haul (kg/haul).

The exploratory standardised CPUE data analysis per year and by vessel segment showed a recovery in the last five years, especially in the vessel segments smaller than 18 meters from 2016 to 2019 (which represents 95% of the Madeira mid-water drifting longline fleet) and in the vessel segment bigger than 18 meters in 2020 (which represents 5%). However, these are just preliminary results and further analyses need to be performed.

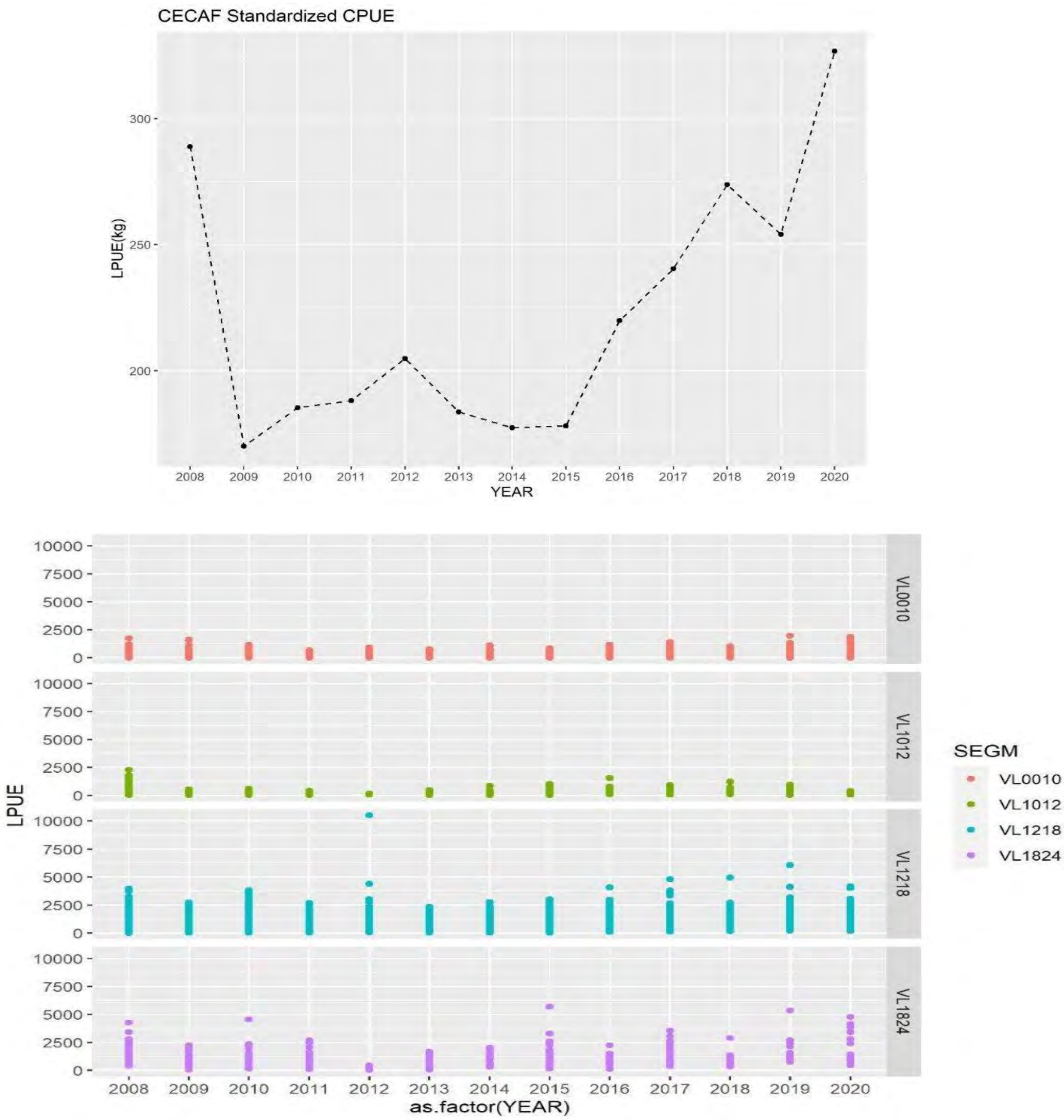

Figure 17 - Time-series of the standardized CPUE (kg/haul) of *Aphanopus* spp., all segments combined (upper) and by vessel segment (lower).

REFERENCES

Bordalo-Machado, P. and Figueiredo, I. 2009. The fishery for black scabbardfish (*Aphanopus carbo* Lowe, 1839) in the Portuguese continental slope. Rev. Fish Biol. Fish. 19: 49-67. doi:10.1007/s11160-008-9089-7.

Delgado, J., Reis, S., González, J.A., Isidro, E., Biscoito, M., Freitas, M., and Tuset, V.M. 2013. Reproduction and growth of *Aphanopus carbo* and *A. intermedius* (Teleostei: Trichiuridae) in the northeastern Pacific. J. Appl. Ichthyol. 29: 1008– 1014. doi:10.1111/jai.12230.

Delgado, J., Amorim, A., Gouveia, L., and Gouveia, N. 2018. An Atlantic journey: The distribution and fishing pattern of the Madeira deep sea fishery. Reg. Stud. Mar. Sci. 23: 107–111. doi:10.1016/j.rsma.2018.05.001.

Farias, I., Morales-Nin, B., Lorance, P., and Figueiredo, I. 2013. Black scabbardfish, *Aphanopus carbo*, in the northeast Atlantic: distribution and hypothetical migratory cycle. Aquat. Living Resour. 26(4): 333–342. doi:10.1051/alr/2013061.

Figueiredo, I., Bordalo-Machado, P., Reis, S., Sena-Carvalho, D., Balsdale, T., Newton, A., and Gordo, L.S. 2003. Observations on the reproductive cycle of the black scabbardfish (*Aphanopus carbo* Lowe, 1839) in the NE Atlantic. ICES J. Mar. Sci. 60: 774–779. doi:10.1016/S10543139(03)00064-X.

Hermida, M., and Delgado, J. 2016. High trophic level and low diversity: Would Madeira benefit from fishing down? Mar. Pol. 73: 130–137. doi:10.1016/j.marpol. 2016.07.013.

Merrett, N.R. and Haedrich, R.L. 1997. Deep-Sea Demersal Fish and Fisheries. Chapman and Hall, London.

Morales-Nin, B., Sena-Carvalho, D., 1996. Age and growth of the black scabbardfish *Aphanopus carbo* off Madeira. Fish. Res 25, 239–251.

Nakamura, I., Parin, N.V., 1993. Snake mackerels and cutlassfishes of the world (families gempylidae and trichiuridae). FAO Fish. Synop. 125 (15), 1–136.

Pajuelo, J.G., González, J.A., Santana, J.I., Lorenzo, J.L., García-Mederos, A., and Tuset, V. 2008. Biological parameters of the bathyal fish black scabbardfish (*Aphanopus carbo* Lowe, 1839) off the Canary Islands, Central-east Atlantic. Fish. Res. 92: 140–147. doi:10.1016/j.fishres.2007.12.022.

Perera, C.B. 2008. Distribution and biology of black scabbardfish (*Aphanopus carbo* Lowe, 1839) in the Northwest of Africa. M.Sc. thesis, Faculty of Sciences, University of Lisbon, Portugal

Severino, R.B., Afonso-Dias, I. Delgado, J. and Afonso-Dias, M. (2009). Aspects of the biology of the leaf-scale gulper shark *Centrophorus squamosus* (Bonnaterre, 1788) off Madeira archipelago. Arquipélago. Life and Marine Sciences, 26: 57-61.

Vasconcelos, J., Sousa, R., Henriques, P., Amorim, A., Delgado, J., Riera, R. 2020. Two sympatric, not externally discernible, and heavily exploited deepwater species with coastal migration during spawning season: implications for sustainable stocks management *of Aphanopus carbo* and *Aphanopus intermedius* around Madeira. Canadian Journal of Fisheries and Aquatic Sciences 77(1), 124-131. https://doi.org/10.1139/cjfas-2018-0423.

Annex 5: Audits

Review of ICES Scientific Report, (expert group/workshop title) (year) (dates): WGDEEP, 22-28 April 2021

Reviewers: James Bell

Expert group Chair: Ivone Figueiredo (POR) & Elvar Hallfredsson (NOR)

Secretariat representative: David Miller

Stock: lin.27.1-2

Assessment type:

Update

1) **Assessment:**

   Accepted

2) **Forecast:**

   Not presented

3) **Assessment model:**

   ICES category 3 stocks using a standardized CPUE index from Norwegian longline target fishery (where ling >30% of catch), data since 2000.

   Length-based Indicator ($L_{mean}/L_{F=M}$) as F_{MSY} proxy, data since 2001

4) **Consistency:**

   Advice based on a standardized CPUE series from the Norwegian longline reference fleet which covers the main area of the stock's distribution.

   Age structure consistent between years (2002-19). No age data for most recent year but length-frequencies consistent (modal length consistently between ~88-97 cm for the period 2002-20).

5) **Stock status:**

   The estimated biomass index have decreased by 16 % (index ratio= 0.84). Abundance indices have different steepness, but both increased steadily until a peak in 2017, declining thereafter. Indices now at lowest levels since 2013 but remain well above the mean for the full time-series.

Assessment against LBI reference points suggests a small improvement in 2020 ($L_{max5\%}/L_{INF}$ now above target, other indicators as in previous years). The MSY indicator ($L_{mean}/L_{F=M}$) is greater than 1 for almost the whole period.

6) **Management plan:**

None.

There is no quota or minimum landing size for the Norwegian ling fishery but any vessels participating in the directed fishery for either ling or tusk in Subareas 1 & 2 must have a specific license.

Quota for ling in EU and international waters historically very small (36 t in 2020).

General comments

The assessment appears to have carried out according to the agreed protocol and the most recent advice.

It should be noted that decreasing Barents Sea cod quotas may lead to increased pressure upon ling in the future.

Gillnetting now accounts for the bulk of the catch, at 59% of total weight, and longlining, upon which the CPUE trends assessment is based, only 37%. It may be worth investigating a CPUE index based on records from this fishery in future.

Technical comments

Table 5: According to the first sentence, 2022-2023 advice catch should be “10 479” tons instead of “10 478”.

Conclusions

The assessment has been completed correctly.

Review of ICES Scientific Report, *(WGDEEP2021, 22-28 April 2021)*
Reviewers: Bruno Almón

Expert group Chair: Elvar H. Hallfredsson and Ivone Figueiredo

Secretariat representative: David Miller and Eirini Glyki

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
The advice is based on an analytical length-based approach (ICES category 1) and is delivered annually.

For advice other than single-stock summary fisheries advice

Section: Report chapter and Stock Annex.

Short description
Both the report and Stock Annex are well documented. I would only suggest some mention of the absence of advice in 2020, either in the report or in the Stock Annex, to facilitate the monitoring of what has been done over time.

Comments
Last update of the Sock annex was in May 2017. Since the assessment is annual and the same method has been used in 2018, 2019 and 2020 only some suggestions have been made regarding small typos in the text.

For single-stock summary sheet advice

Stock

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Update
2) Assessment: accepted- analytical length-based (ICES category 1)
3) Forecast: accepted- short-term forecast to the end of 2022
4) Assessment model: gadget model
5) Consistency: Annual advice under a management plan (from 1st September till the next year end of August). The model was benchmarked in 2014. Due to the Covid 19 disruption, no advice was requested from ICES by Iceland in 2020, but it was accepted in 2019.
6) Stock status: Fishing pressure on the stock is at/below FMSY and spawning-stock size is at/above MSY Btrigger, Bpa, and Blim.
7) Management plan: The Icelandic Ministry of Industries and Innovation's fisheries management plan for Icelandic ling has been evaluated by ICES in 2017. It was considered to be precautionary and conforms to the ICES MSY approach.

General comments
Is well documented and consistent with previous advices. It was easy to follow and interpret.
Technical comments
Spawning stock biomass shows a downward revision of recent biomass levels, causing an upward revision in harvest rate, which falls within the expected bounds of model uncertainty.

Conclusions
The assessment has been performed correct and consistently with the previous assessment (2019).

Review of ICES Scientific Report, (*expert group/workshop title*) (*year*) (*dates*):
WGDEEP, 2021, 22-28 April
Reviewers: Guzman Diez

Expert group Chair: Ivone Figueiredo & Elvar Hallfredsson

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For advice other than single-stock summary fisheries advice

Section:

Short description

Comments

(Repeat for all sections)

For single-stock summary sheet advice

Stock**: (bli27.5a14). Blue ling (Molva dypterygia) in Subarea 14 and Division 5.a**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: ICES category 3 stocks
5) Consistency: The Icelandic autumn trawl survey (IS-SMH) was used as the index for the stock . Survey covers the full depth range and geographical distribution of the stock.
6) Stock status: The index is estimated to have decreased by 14%,
7) Management plan: ICES is not aware of any agreed precautionary management plan for blue ling in this area.

General comments
The text is written according to the standards sentences and tables for the advice sheets. Catch advice calculation is clear.

Technical comments.
The last Stock Annex was updated in 2019 and the assessment data and method (survey trend) used in the advice are described in the SA.

Conclusions
The assessment has been performed correctly.

Review of ICES Scientific Report, Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 22-28 April 2021
Reviewers: **Rui Vieira**

Expert group Chair: **Ivone Figueiredo (POR) & Elvar Hallfredsson (NOR)**

Secretariat representative: **David Miller**

Tusk (*Brosme brosme*) in Subarea 14 and Division 5.a (East Greenland and Iceland grounds) (usk.27.5a14)

Short description of the assessment as follows:

1) Assessment type: **update**
2) Assessment: **accepted**
3) Forecast: **accepted**
4) Assessment model: **Analytical length-based assessment (Gadget model) that uses catches in the model and in the forecast**
5) Consistency: **There was retrospective analysis leading to a correction of the whole times series of biomass levels as well a revision of biomass trends estimated over the last decade.**
6) Stock status: **Fishing pressure above HR_{MSY} and spawning-stock size is at/above MSY $B_{trigger}$, B_{pa}, and B_{lim}.**
7) Management plan: **There is a Management plan for the stock component in Division 5.a (Icelandic tusk), which has been evaluated by ICES. WKICEMSE 2017 concluded that the HCR was precautionary and in conformity with the ICES MSY approach. Reference points defined for the stock are provided in the full report (ICES, 2021).**

General comments

The text is well written, and it is according to the standards sentences and tables for the advice sheets. Catch advice, quality of the assessment and related limitations are well described. Data is available in the sharepoint.

Technical comments

This advice refers only to the tusk stock component in Division 5.a. because catch data from Subarea 14 are not used in the assessment. This limitation is considered in the advice and agreed by the working group. In comparison with previous assessments, there has been a downward correction of the whole times series of biomass levels as well as a large downward revision of biomass trends estimated over the last decade.

Table 2: According to the first sentence, advice catch for 2021/2022 should be “2172” tons instead of “2171”.

Catch values in tables 7-10 don’t match up. Please revise and check report tables accordingly.

Table 10 is missing. Renumber table 11.

Conclusions

The assessment has been performed correctly, but values in tables need to be checked.

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (expert group/workshop title) (year) (dates): WGDEEP, 22th-28th April 2021
Reviewers: Ricardo Sousa
Expert group Chair: Ivone Figueiredo (POR) & Elvar Hallfredsson (NOR)
Secretariat representative: David Miller

Stock: Blackspot sea bream in subarea 10 (sbr.27.10)

1) **Assessment type:**

   Update

2) **Assessment:**

   Trend based assessment (ICES category 3 stock).

3) **Forecast:**

   Not presented.

4) **Assessment model:**

   ICES Survey trend based assessment (based on Azorean bottom longline survey).

5) **Consistency:**

   Advice is consistent with reported data.

6) **Stock status:**

   Stock and exploitation status are currently unknown because the reference points are undefined.

7) **Management plan:**

   None.

General comments

The stock section is properly documented. The analyses have not been updated due to a lack of survey and fishery sampling due to the Covid-19 disruption.

Minor suggestions and comments were sent to the stock coordinator.

Technical comments

None

Conclusions

The assessment has been completed correctly.

Review of ICES Scientific Report, Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 22-28 April 2021
Reviewers: **Régis Santos**

Expert group Chair: **Ivone Figueiredo (POR) & Elvar Hallfredsson (NOR)**

Secretariat representative: **David Miller**

Tusk (*Brosme brosme*) in Subareas 1 and 2 (usk.27.1-2)

Short description of the assessment as follows:

1) Assessment type: **update**
2) Assessment: **accepted**
3) Forecast: **not presented**
4) Assessment model: **CPUE trends-based assessment (ICES, 2019).**
5) Consistency: **Consistent with the last year's assessment.**
6) Stock status: **Reference points are undefined for this stock.**
7) Management plan: **ICES is not aware of any agreed precautionary management plan for tusk in this area.**

General comments
The report was well documented and with updated data. The advice was drafted according to the correspondent report section.

Technical comments
The Stock Annex needs to be updated and completed.

Conclusions
The assessment has been performed correctly.

Review of **Ling 27.5b**, WGDEEP 2021, 22 to 28 April
Reviewers: **Wendell Medeiros Leal**

Expert group Chair: **Ivone Figueiredo and Elvar Hallfredsson**

Secretariat representative: **David Miller**

Stock: Ling (*Molva Molva*) in Division 5.b

Short description of the assessment as follows:

1) **Assessment type:** Benchmark
2) **Assessment:** Accepted
3) **Forecast**: Accepted
4) **Assessment model:** Age-based analytical assessment (SAM) that uses catches in the model and in the forecast.
5) **Consistency:** The assessment of ling in division 5.b was upgraded from category 3 to category 1 and the reference points estimated were approved in the WKBARFAR benchmak in February 2021.
6) **Stock status**: F_{pa} and F_{lim} < Fishing pressure > F_{MSY}; SBB > MSY $B_{trigger}$ B_{pa} and Bl_{im}; R, seems back to be increase again in recent years.
7) **Management plan:** A harvest control rule was adopted in 2020, and applied for the first time in 2021. The number of fishing days was decided according to the stock status of cod, haddock and saithe. The management plan also opens up for the development of special bycatch rules, but this has not yet been integrated. Plan is not evaluated by ICES, but will likely be sent to review in 2021.

General comments

The text it is according to the standards sentences and tables for the advice sheets. Stock development over time, catch scenarios, quality and basis of the assessment, reference points and history of the catch and landings are well described.

Technical comments

The stock annex has been updated, describing the traits of life-history and biology of ling in division 5.b, and also detailed information about the age-based analytical assessment (SAM).

Minor revision in the stock annex and report text are required.

Conclusions

The assessment has been performed correctly.

Review of ICES Scientific Report, ICES WGDEEP 2021 22-28 April
Reviewer: Juan Gil Herrera

Expert Group Chairs: Ivone Figueiredo (POR) and Elvar H. Hallfredsson (NOR)

Secretariat representative: David Miller

For single-stock summary sheet advice

Stock: Greater silver smelt (*Argentina silus*) in Subarea 14 and Division 5.a (East Greenland and Iceland grounds) – aru.27.5a14

Short description of the assessment as follows:

1) **Assessment type:** ICES category 1 (upgrade/update from benchmark model)
2) **Assessment:** Accepted
3) **Forecast:** Accepted
4) **Assessment model:** gadget model
5) **Consistency:** 2020 Benchmark for GSS in 5.a and 14 concluded that a length- and age-based gadget model sufficiently reduced uncertainty in the assessment and the advice could be based on the ICES MSY advice rule.
6) **Stock status:** $F_{current(2020)} < F_{MSY}$ while $SSB_{2021} > B_{pa} > B_{lim}$ unless is estimated to be slightly decreased from 2020 high historical level.
7) **Management plan:** No management plan.

General comments: Stock benchmarked quite recently, in 2020 ... so the Stock Annex is up to date. Data and info (Advice sheet, Stock annex and Report chapter) are available at the SharePoint. Its text, figures and tables follows ICES standards. Quality of the assessment and issues relevant for the advice are clearly described.
The usual mess with "calendar" and (Icelandic) "fishing year" ... but, it is what it is!!
There´s an interesting suggestion (from the Stock Annex): it was planned that short-term projection in advice sheets will include different scenarios as Fpa, Flim and no fishing and not only at Fmsy as implemented in the advice rule.

Technical comments:

Catches in Figure 1 includes Division 5a and also Subarea 14 from 2014: it would be useful split bars in two colours since then (just a suggestion!!).
Tables should be renumbered from 3 because "*basis of the advice*" and "*reference points*" Tables has 3 both. "Reference points" Table should be number 4 and so on ... till 9 instead 8.

Conclusions: The assessment has been completed correctly, following the 2020 Benchmark.

Review of ICES Scientific Report, (WGDEEP, 22-28 April 2021
Reviewers: Elisa Barreto

Expert group Chair: Ivone Figueiredo and Elvar Hallfredsson

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

For single-stock summary sheet advice

Stock**: lin.27.3a4a6-91214**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: a standardized cpue series from the Norwegian long-line fleet
5) Data issues: Data are as described in stock annex.
6) Consistency: The stock size relative to candidate reference points is unknown, but the stock has been increasing since 2004. The precautionary buffer was applied this year. The average discard rate in the three last years was 4.4% and this has been used to provide landings advice.
7) Stock status: no reference have been defined for this stock.
8) Management Plan: ICES is not aware of any agreed management plan for this stock in this area.

General comments

The ICES framework for category 3 stocks was applied. The basis for the advice is the precautionary approach.

It is well documented and easy to follow and interpret.

Technical comments

Minor typos in the report, stock annex and advice sheet section were carried out.

Conclusions

The assessment has been performed correctly.

Review of ICES Scientific Report, (WGDEEP, 22-28 April 2021
Reviewers: Martin Pastoors

Expert group Chair: Ivone Figueiredo and Elvar Hallfredsson

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group
For single-stock summary sheet advice
Stock**: aru.27.6b7_1012**
Short description of the assessment as follows (examples in grey text):

7) Assessment type: update
8) Assessment: accepted
9) Forecast: not presented
10) Assessment model: a survey series (Spanish Porcupine survey)
11) Data issues: Data are as described in stock annex.
12) Consistency: The stock size relative to candidate reference points is unknown. According to the survey, the combined index of greater and lesser Silver smelt has been fluctuating over time between 2000 and 2020. Recent index values are lower than the index values of 2-4 years ago. The uncertainty cap was applied. The precautionary buffer was applied this year. The discard rate in 2020 was 77% and this has been used to provide landings advice.
13) Stock status: no reference have been defined for this stock.
14) Management Plan: ICES is not aware of any agreed management plan for this stock in this area.

General comments

The ICES framework for category 3 stocks was applied, using the Spanish Porcupine biomass index for Greater Silver smelt. The basis for the advice is the precautionary approach.

Technical comments

The assessment and advice are appropriately documented. However, it would be good to be more clear on what data is available and what data has been used for the advice. E.g.:

- The WG report does not contain a table with all catches by area (although that does appear in the advice document)
- Several survey indices from the Spanish Porcupine survey are presented in the report (kg/haul, individuals/haul for either ARU, ARY and ARG). It is not made clear which index is finally being used. A table with survey values is not presented in the report (but it is presented in the advice).
- The calculation of the 2/3 rule is based on the ARU index in kg/haul, but the survey plot in advice document is the ARG index in kg/haul. This is an inconsistent use of the survey information.
- The 'advice' table is constructed based on the premise of a landings advice, but in practice, ICES has issued catch advice for this stock. The basis for the advice is not specified in the stock annex. However, due to the very low landings in recent years, relative to the overall catch, application of the 2/3 rule on the basis of landings generates a very different catch (44 tonnes), compaed to the application of the 2/3 rule on the catches (123 tonnes). It is recommended to be more specific on these choices in the stock annex.

Conclusions

The assessment has been performed correctly, but some the interpretation of which survey index and which catch basis is used for the advice would benefit from better descriptions.

6 May 2021, Martin Pastoors

Review of ICES Scientific Report, *(*WGDEEP2021*, 22-28 April 2021)*
Reviewers: Erik Berg

Expert group Chair: Elvar H. Hallfredsson and Ivone Figueiredo

Secretariat representative: David Miller and Eirini Glyki

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
The advice is based on an analytical assessment (SAM)(ICES category 1) and is delivered annually from 2022 (previously each second year).

For advice other than single-stock summary fisheries advice

Section: Report chapter and Stock Annex.

Short description
Both the report and the advice are well documented.
Stock annex updated according to the new assessment model (from 2021).New reference points from 2021.

Comments
Only small comments which are corrected by authors.
For single-stock summary sheet advice

Stock

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Analytical
2) Assessment: accepted- analytical SAM (ICES category 1)
3) Forecast: accepted- short-term forecast to the end of 2022
4) Assessment model: SAM
5) Consistency: New model from 2021. Benchmarked 2020/2021.
6) Stock status: Fishing pressure below FMSY and spawning-stock size above Bpa.
7) Management plan: NA.

General comments

Conclusions
The assessment and the forecast are performed correct. New model and new reference points makes it impossible to check the consistently with previous assessments.

Review of ICES Scientific Report
WGDEEP 2021 (22nd-28th April)
Reviewers: Inês Farias

Expert group Chair: Elvar Hallfredsson and Ivone Figueiredo

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Data sets have been updated with available information.

For advice other than single-stock summary fisheries advice

Section:

Short description

Comments

(Repeat for all sections)

For single-stock summary sheet advice

Stock **aru.27.123a4**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: benchmark
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: SPiCT assessment
5) Consistency: SPiCT assessment was examined but not recommended due to uncertainty in the results in retrospective analysis. However, the biomass outputs from SPiCT were considered indicative of stock trends and proposed as input to ICES two-over-three rule.
6) Stock status: Fishing pressure on the stock is below F_{MSY}; No reference points for stock size have been defined for this stock.
7) Management plan: ICES is not aware of any agreed precautionary management plan for greater silver smelt in these areas.

General comments
The advice sheet was easy to follow and interpret. Data have been updated with available information. Minor formatting changes were made in this audit.

Technical comments
The assessment is in accordance to the WKGSS 2020 benchmark workshop.

Conclusions
(Single tables or figures can be added in the text, longer texts should be added as annexes.)

The assessment has been performed correctly.

Review of ICES Scientific Report, Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 22-28 April 2021
Reviewers: **Vladimir Khlivnoi**

Expert group Chair: **Ivone Figueiredo (POR) & Elvar Hallfredsson (NOR)**

Secretariat representative: **David Miller**

Tusk (*Brosme brosme*) in subareas 4 and 7–9, and in divisions 3.a, 5.b, 6.a, and 12.b (Northeast Atlantic)

Short description of the assessment as follows:

1) Assessment type: **update**
2) Assessment: **accepted**
3) Forecast: **not presented**
4) Assessment model: **CPUE trends-based assessment (ICES, 2019).**
5) Consistency: **Consistent with the last year's assessment.**
6) Stock status: **Reference points are undefined for this stock.**
7) Management plan: **ICES is not aware of any agreed precautionary management plan for tusk in this area.**

General comments
The ICES framework for category 3 stocks was applied. The basis for the advice is the precautionary approach.

The report was well documented and with updated data. The advice was drafted according to the correspondent report section.

Technical comments
Minor typos were find in the report.

Conclusions
The assessment has been performed correctly.

Annex 2: WGDEEP 2021 productivity changes survey

Stock code	**Biomass/stock trend/assessment; catch/bycatch status/trend**					**Short term forecast**				
	Variability/ change in length distribution	*Variability/ change in weight-at-age*	*Variability/ change in maturity-at-age*	*Variability/ change in natural mortality*	*Variability/ change in sex ratio*	*Environmentally driven recruitment*	*Truncating recruitment time-series*	*Recent or trend in weight-at-age*	*Recent or trend in maturity-at-age*	*Recent or trend in natural mortality*
alf.27.nea	0	0	0	0	0	0	0	0	0	0
aru.27.123a4	3	1	1	0	0	0	0	0	0	0
aru.27.5a14	3	1	3	0	1	0	3	1	3	0
aru.27.5b6a	3	3	1	0	0	0	0	0	0	0
aru.27.6b7-1012	1	0	0	0	0	0	0	0	0	0
bli.27.5a14	1	0	0	0	1	0	0	0	0	0
bli.27.5b67	3	3	0	0	0	0	0	0	0	0
bli.27.nea	0	0	0	0	0	0	0	0	0	0
bsf.27.nea	3	2	0	3	0	0	0	0	0	0
gfb.27.nea	1	1	0	0	0	0	0	0	0	0
lin.27.1-2	1	1	0	0	0	0	0	0	0	0
lin.27.3a4a6-91214	1	1	0	0	0	0	0	0	0	0
lin.27.5a	3	1	1	0	1	0	3	1	1	0

Stock code	Biomass/stock trend/assessment; catch/bycatch status/trend					Short term forecast				
	Variability/ change in length distribution	*Variability/ change in weight-at-age*	*Variability/ change in maturity-at-age*	*Variability/ change in natural mortality*	*Variability/ change in sex ratio*	*Environmentally driven recruitment*	*Truncating recruitment time-series*	*Recent or trend in weight-at-age*	*Recent or trend in maturity-at-age*	*Recent or trend in natural mortality*
lin.27.5b	3	3	1	0	0	0	0	0	0	0
ory.27.nea	1	0	0	0	0	0	0	0	0	0
rhg.27.nea	0	0	0	0	0	0	0	0	0	0
rng.27.1245a8914ab	0	0	0	0	0	0	0	0	0	0
rng.27.3a	1	0	0	0	0	0	0	0	0	0
rng.27.5a10b12ac14b	0	0	0	0	0	0	0	0	0	0
rng.27.5b6712b	0	0	0	0	0	0	0	0	0	0
sbr.27.10	1	1	1	0	1	0	0	0	0	0
sbr.27.6-8	1	1	0	0	0	0	0	0	0	0
sbr.27.9	1	1	1	1	1	0	0	0	0	0
tsu.27.nea	1	0	0	0	0	0	0	0	0	0
usk.27.1-2	1	1	1	0	0	0	0	0	0	0
usk.27.12ac	0	0	0	0	0	0	0	0	0	0
usk.27.3a45b6a7-912b	1	1	0	0	0	0	0	0	0	0
usk.27.5a14	3	1	1	0	1	0	3	1	1	0
usk.27.6b	1	0	0	0	0	0	0	0	0	0

Stock code	MSE (management/rebuilding plans). Uncertainty or differing operating models					Advice	Distribution and habitats		
	Environmentally driven recruitment	Truncating recruitment time series	Variable weight-at-age (environment or density driven)	Recent or trend in maturity-at-age (environment or density driven)	Dynamics in natural mortality	Specific productivity information used (e.g. escapement rule)	Influence of population state	Habitat suitability/quality	Within-species stock mixing
alf.27.nea	0	0	0	0	0	0	0	0	0
aru.27.123a4	0	0	0	0	0	0	0	0	1
aru.27.5a14	0	0	0	0	0	0	1	1	1
aru.27.5b6a	0	0	0	0	0	0	0	0	1
aru.27.6b7-1012	0	0	0	0	0	0	0	0	1
bli.27.5a14	0	0	0	0	0	0	1	1	0
bli.27.5b67	0	0	0	0	0	0	0	0	1
bli.27.nea	0	0	0	0	0	0	0	0	0
bsf.27.nea	0	0	0	0	0	0	0	0	3
gfb.27.nea	2	2	0	0	0	0	0	0	0
lin.27.1-2	0	0	0	0	0	0	0	0	0
lin.27.3a4a6-91214	0	0	0	0	0	0	0	0	0
lin.27.5a	0	0	0	0	0	0	1	1	0
lin.27.5b	0	0	0	0	0	0	0	0	0

Stock code	MSE (management/rebuilding plans). Uncertainty or differing operating models					Advice	Distribution and habitats		
	Environmentally driven recruitment	Truncating recruitment time series	Variable weight-at-age (environment or density driven)	Recent or trend in maturity-at-age (environment or density driven)	Dynamics in natural mortality	Specific productivity information used (e.g. escapement rule)	Influence of population state	Habitat suitability/quality	Within-species stock mixing
ory.27.nea	0	0	0	0	0	0	0	1	0
rhg.27.nea	0	0	0	0	0	0	0	0	0
rng.27.1245a8914ab	0	0	0	0	0	0	0	0	0
rng.27.3a	0	0	0	0	0	0	0	0	0
rng.27.5a10b12ac14b	0	0	0	0	0	0	0	0	0
rng.27.5b6712b	0	0	0	0	0	0	0	0	0
sbr.27.10	0	0	0	0	0	0	0	0	0
sbr.27.6-8	1	1	0	0	0	0	0	0	0
sbr.27.9	0	0	0	0	0	0	0	0	1
tsu.27.nea	0	0	0	0	0	0	0	0	0
usk.27.1-2	0	0	0	0	0	0	0	0	0
usk.27.12ac	0	0	0	0	0	0	0	0	0
usk.27.3a45b6a7-912b	0	0	0	0	0	0	0	0	0
usk.27.5a14	0	0	0	0	0	0	1	1	0
usk.27.6b	0	0	0	0	0	0	0	0	0