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.

Due to the Covid 19 disruption, Iceland did not request advice for local stocks. First draft of advice was thus prepared for 13 stocks out of the 29. For the same reason, the meeting was conducted entirely by web-based correspondence. In response most discussions that were not pivotal for advisory work this year were postponed to next year's meeting. 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.

An important topic that was discussed regarded boarders of species whose distribution extends between two advisory bodies. In WGDEEP the issue is particularly relevant for blackspot seabream stock in ICES Subarea 9.

Main conclusions regarding each stock with advice 2020 were:

The advice on alfonsinos in 1-10, 12 and 14 refers to two species, *Beryx splendens* and *Beryx decadactylus*, that are often not differentiated in the reported landings. In recent years, landings of the two species have been stable.

The biomass of blue ling in 5b, 6 and 7 increased in recent years probably reflecting the low fishing mortality for several years. Both fishing mortality and the spawning stock biomass are well within sustainable levels.

Black scabbardfish in the Northeast Atlantic showed a slight reduction in abundance in the last two years. Fishing effort on this species have been decreasing probably associated with the ban of trawling in deeper areas.

Greater forkbeard in the Northeast Atlantic and adjacent waters is a bycatch species. The combined six survey biomass-index was reduced in two years. Landings have decreased since 2013. Discards are considered high but could not be quantified.

The advice on orange roughy in subareas 1–10, 12 and 14 is given for four years. This is an aggregating species and currently there are no evidences that the stock is recovering from overexploited status.

Roughhead grenadier in the Northeast Atlantic landings are mainly from Subarea 2 and divisions 5a, and 14b2. Landings from subareas 6 and 7 are potentially misreported.

Roughsnout grenadier in subareas 1–10, 12 and 14 landings were zero for more than10 years. Officially reported landings for the period 2006–2008 are considered species misreporting.

Roundnose grenadier in 3a is considered to be low level, which can be partly due to exceptionally high landings in the past, and present low levels of recruitment.

Roundnose grenadier in subareas 6–7 and divisions 5.b and 12.b landings have been at a very low level in last eight years. Recent survey biomass index is at low level.

Blackspot seabream in Subarea 10 landings have been stable for the last four years. Biomass index fluctuates but has been at relatively high level in recent years.

Blackspot seabream in Subareas 6, 7 and 8 abundance strongly declined in the mid-1970s, and is considered to be seriously depleted. Landings are mainly by-catches and surveys show persistent low occurrence of the species.

Blackspot seabream in Subarea 9 has been assessed based on biomass index from a target fishery operating in the Strait of Gibraltar, mostly operating out of Subarea 9. Currently the index is at very low level.

Tusk in Subarea 6b landings have strongly declined since 2000. The commercial biomass index is at a low but stable level. Potential causes for the decline are not fully understood.

The assessment unit of ling in area 5b is planned for ICES Benchmark in 2021.

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	2020
Reporting year in cycle	1/1
Chair(s)	Ivone Figueiredo, Portugal
	Elvar H. Hallfredsson, Norway
Meeting venue(s) and dates	24 April–1 May 2020, by correspondence, 22 participants

1 Ecosystem productivity and ecosystem approach in WGDEEP stocks

1.1 Ecosystem productivity and ecosystem approach for deep-water stocks

Deep-water stocks have overall lower biological productivity than continental shelf and coastal stocks. For ICES category 1 stocks this is conveyed in the assessment, forecast and advice by using the stock specific life history traits. Average natural mortality (M) is lower is deep-water stock, age-at-maturity is older and growth is slower. In other words, the lower productivity of deep-water ecosystem, 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 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, 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 2020 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 Fproxy 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. The groups 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 below the WG presents the most likely landings from these RA areas based on the official reports and discussions within the WG.

Table 1.1 Catches inside and outside the NEAFC Regulatory Area (RA) as estimated by ICES for the stock in WGDEEP.

WGDEEP Stock	Catch Inside NEAFC RA (t)	Catch Outside NEAFC RA (t)	Total Catches	Proportion of catch inside the NEAFC RA (%)	NEAFC RA areas where caught
2019					
alf.27.nea	5	289	294	1.7	27.10.b
aru.27.123a4	0	20212	20212	0	
aru.27.5a14	0	3209	3209	0	
aru.27.5b6a	0	17913	17913	0	
aru.27.6b7-1012	0	159	159	0	
bli.27.5a14	0	513	513	0	
bli.27.5b67	5	3213	3218	0.001	6.b.1
bli.27.nea	10	852	862	1	27.12.a.1, 27.12.b
bsf.27.nea	0	4317	4317	0	
gfb.27.nea	0	1850	1850	0%	
lin.27.1-2	0	11413	11413	0	
lin.27.3a4a6-91214	64	20713	20777	0.3	27.6.b.1
lin.27.5a	0	8269	8269	0	
lin.27.5b	0	7816	7816	0	
ory.27.nea	60	0	60	100	27.10.b,27.12.c,27.12.d
rhg.27.nea	0	259	259	0	
rng.27.1245a8914ab	0	192	192	0	
rng.27.3a	0	2	2	0	
rng.27.5a10b12ac14b	215	0	215	100	27.12.a.1
rng.27.5b6712b	544	145	689	78%	5.b.1.a, 6.b.1, 12.b
sbr.27.10	0	474	474	0	
sbr.27.6-8	0	98	98	0%	
sbr.27.9	0	60	60	0%	
tsu.27.nea	0	0	0	0	0

WGDEEP Stock	Catch Inside NEAFC RA (t)	Catch Outside NEAFC RA (t)	Total Catches	Proportion of catch inside the NEAFC RA (%)	NEAFC RA areas where caught
usk.27.1-2	0	12310	12310	0	
usk.27.12ac	0	0	0	0	
usk.27.3a45b6a7-912b	0	4863	4863	0	
usk.27.5a14	0	4010	4010	0	
usk.27.6b	4	96	100	4	27.6.b.1
2018					
alf.27.nea	0	266	266	0	
aru.27.123a4	0	23859	23859	0	
aru.27.5a14					
aru.27.5b6a	0	16033	16033	0	
aru.27.6b7-1012	0	149	149	0	
bli.27.5a14					
bli.27.5b67		0	3322	0	
bli.27.nea	24	324	348	7	27.12.b
bsf.27.nea	3	4513	4516	0	27.10.a.1, 27.12
gfb.27.nea	0	1801	1801	0%	
lin.27.1-2	0	11604	11604	0	
lin.27.3a4a6-91214	2	20552	20554	0.01	27.6.b.1
lin.27.5a					
lin.27.5b	0	6195	6195	0	
ory.27.nea	30	0	30	100	27.10.b,27.12.c
rhg.27.nea	0	330	330	0	
rng.27.1245a8914ab	0	268	268	0	
rng.27.3a	0	3	3	0	
rng.27.5a10b12ac14b	27	0	27	100	27.12.a.1
rng.27.5b6712b	1321	198	1519	86%	5.b.1.a, 6.b.1, 12.b

WGDEEP Stock	Catch Inside NEAFC RA (t)	Catch Outside NEAFC RA (t)	Total Catches	Proportion of catch inside the NEAFC RA (%)	NEAFC RA areas where caught
sbr.27.10	0	445	445	0	
sbr.27.6-8	0	133	133	0%	
sbr.27.9					
tsu.27.nea	0	0	0	0	
usk.27.1-2	0	10487	10487	0	
usk.27.12ac	0	0	0	0	
usk.27.3a45b6 a7-912b	0	4411	4411	0	
usk.27.5a14					
usk.27.6b	6	41	47	13	27.6.b.1
2017					
alf.27.nea	0	240	240	0	
aru.27.123a4	0	17835	17835	0	
aru.27.5a14					
aru.27.5b6a	0	16806	16806	0	
aru.27.6b7-1012	0	159	159	0	
bli.27.5a14					
bli.27.5b67	21	2658	2669	0.008	6.b.1
bli.27.nea	28	251	279	10	27.12.b
bsf.27.nea	1	5045	5046	0	27.10.a.1, 27.12
gfb.27.nea	0	1503	1503	0%	
lin.27.1-2	0	7971	7971	0	
lin.27.3a4a6-91214	34	20264	20296	0.2	
lin.27.5a					
lin.27.5b	0	5185	5185	0	
ory.27.nea	150	0	150	100	27.10.b
rhg.27.nea	0	294	294	0	
rng.27.1245a8 914ab	0	125	125	0	

WGDEEP Stock	Catch Inside NEAFC RA (t)	Catch Outside NEAFC RA (t)	Total Catches	Proportion of catch inside the NEAFC RA (%)	NEAFC RA areas where caught
rng.27.3a	0	2	2	0	
rng.27.5a10b12ac14b	84	0	84	100	27.12.a.1, 27.14.b.1
rng.27.5b6712b	1497	164	1661	90%	5.b.1.a, 6.b.1, 12.b
sbr.27.10	0	499	499	0	
sbr.27.6-8	0	126	126	0%	
sbr.27.9					
tsu.27.nea					
usk.27.1-2	0	7926	7926	0	
usk.27.12ac	0	0	0	0	
usk.27.3a45b6a7-912b	0	3916	3916	0	
usk.27.5a14					
usk.27.6b	3	44	47	6	27.6.b.1

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. During 2015 and 2016 Spain reported landings of roundnose grenadier from subdivision 14.b1 of 533 t (and 330 t from 12.a1) and 371 t (and 289 from 12.a1) respectively. In 2017 the official Spanish landings were reported as 84 t (16 from 12.a1 and 68 t from 14.b1).

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.

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 in recent years' catches were 45–313 t for both Subareas (2009–2014).

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.

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

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2.8 Tables

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

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).

Species	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018*	2019*
ALFONSINOS (*Beryx* spp.)	731	1510	384	229	725	484	199	243	172	139	161	192	211	252	312	245	232	222	168	131	292	156	149	157	138
ARGENTINES (*Argentina silus*)		1			2					4													0	0	
BLUE LING (*Molva dypterigia*)	602	814	438	451	1363	607	675	1270	1069	644	35	65	1			72	0	16	9		0		0	27.81	1
BLACK SCABBARDFISH (*Aphanopus carbo*)	304	455	203	253	224	357	134	1062	502	384	198	73		80	162	240	163	16	206	85	7	86	63	17	21
BLUEMOUTH (*Helicolenus dactylopterus*)	589	483	410	381	340	452	301	280	338	282	190	209	275	281	267	213	231	190	235	200	256	306	333	283	187
DEEP WATER CARDINAL FISH (*Epigonus telescopus*)						3		14	16	21	4	10	7	7	7	5	5	4	4	2	4		5	4	9
GREATER FORKBEARD (*Phycis blennoides*)	75	47	32	39	41	100	91	63	56	46	22	134	201	18	26	14	11	6	8	9	10	10	15	75	13
LING (*Molva molva*)	50	2	9	2	2	7	59	8	19		2				1			0	0		1		0	0	0
MORIDAE						1	88	113	140	91	69	127	86	53	68	54	55						169		
ORANGE ROUGHY (*Hoplostethus atlanticus*)	676	1289	814	806	441	447	839	28	201	711	324	104	20	108	26	74	112	139		47	84	93	<1	0	
RABBITFISHES (*Chimaerids*)			32	42	115	48	79	98	81	128	193				22	0		2	6				0	0	
ROUGHHEAD GRENADIER (*Macrourus berglax*)					3	7	10	7	2	28	8	8			6	0	0	2726	868	448			0	0	
ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	644	1739	8622	11979	9696	8602	7926	11 468	10 805	10 748	513	86	2	13	5	1691	3366	2724	1907	2075	862	659.95	84	27	215
RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)	1115	1052	1012	1119	1222	947	1034	1193	1068	1075	1383	958	1070	1089	1042	687	624	613	692	663	701	515	499	474	481
SHARKS, VARIOUS	1385	1264	891	1051	50	1069	1208	35	25	6	14	104	63	12	1	7	5	31	70				75		0
SILVER SCABBARDFISH (*Lepidopus caudatus*)	789	826	1115	1187	86	28	14	10	25	29	31	35	55	63	64	68	148	282	0	713	429	87	101	65	65
SMOOTHHEADS (*Alepocephalidae*)		230	3692	4643	6549	4146	3592	12538	6883	4368	6872							160	17				0	0	
Trachipterus sp																		54					0	0	
TUSK (*Brosme brosme*)	18	158	30	1	1	5	52	27	83	16	66	64	19		2	107	0	29			1		0	506	0
WRECKFISH (*Polyprion americanus*)	244	243	177	140	133	268	232	283	270	189	279	497	664	513	382	238	266	226	209	121	116	101	128	80	80
TOTAL	7222	10113	17861	22323	20993	17578	16533	17272	10950	8161	10364	2666	2674	2489	2393	3715	5218	7441	4398	4493	2,764	2,014	*1,621*	*1,716*	*1,211*

***- provisional data**

2.9 Figures

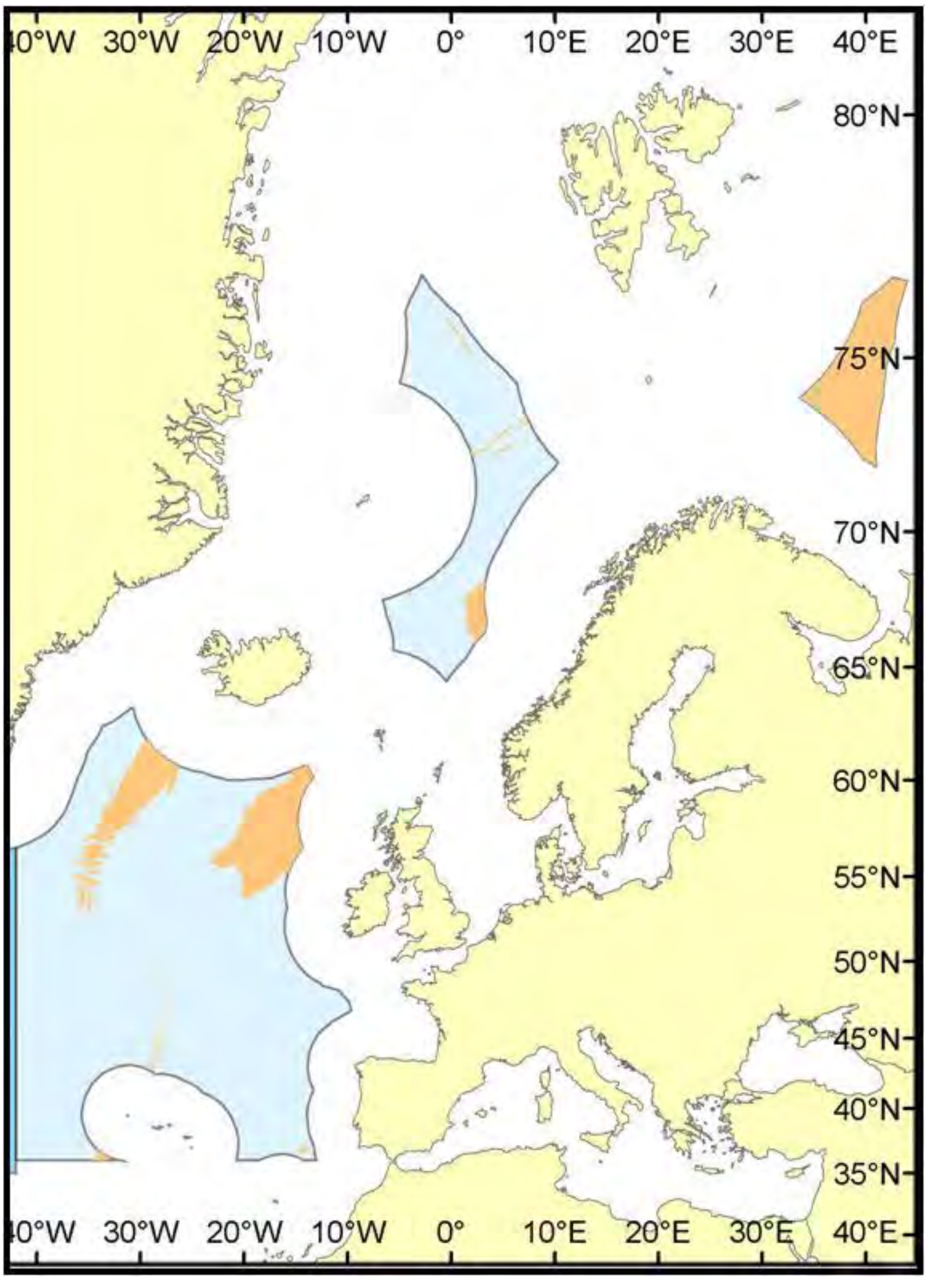

Figure 2.7.1. The NEAFC Regulatory Area (area beyond national jurisdiction) in the Northeast Atlantic (light blue polygons) with superimposed subareas shallower than 2000 m (light brown patches). Note that the NEAFC RA in the Barents Sea is entirely shallower than 2000 m, and that a high Arctic NEAFC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

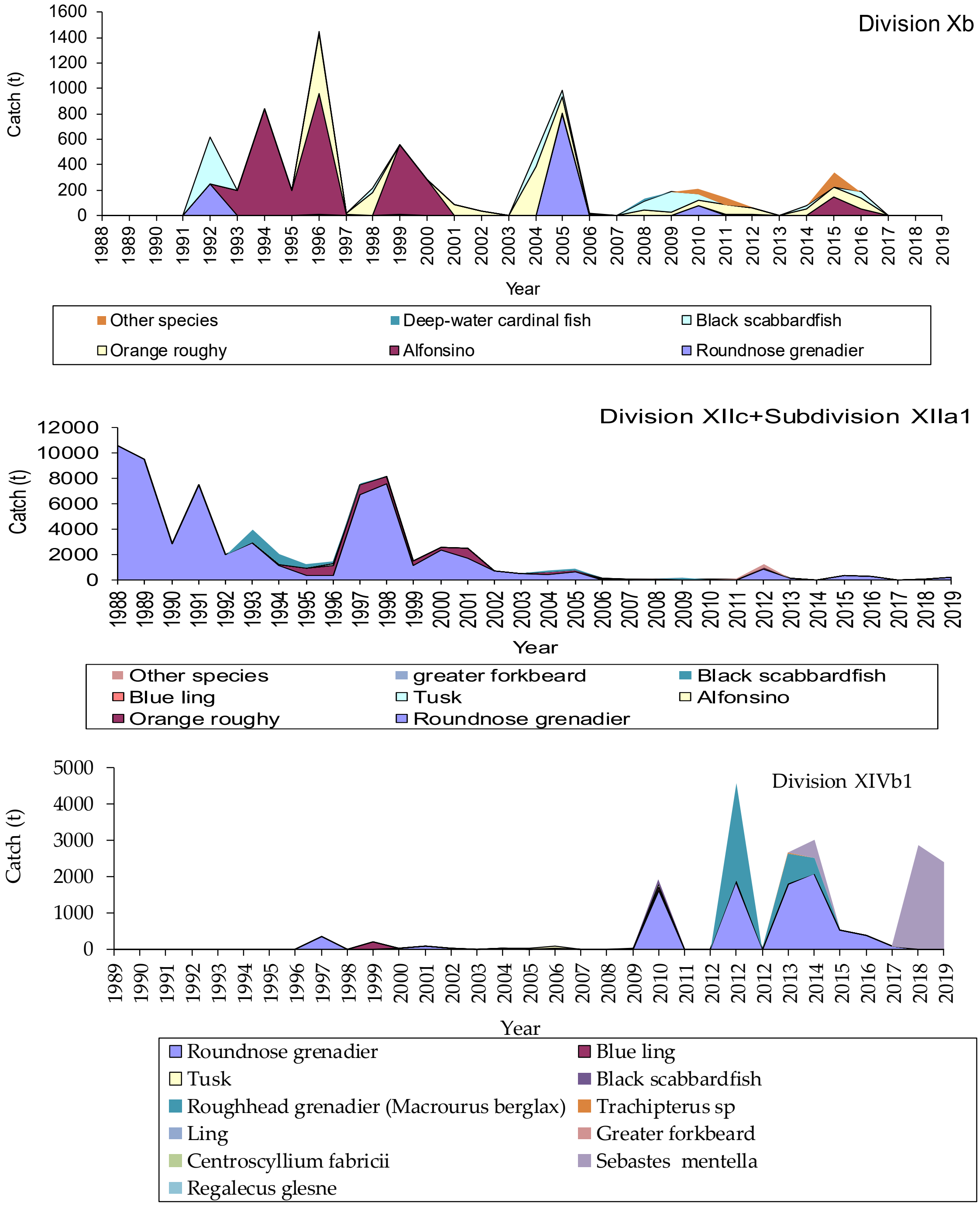

Figure 2.7.2. Annual catch of major deep-water species on MAR in 1988–2017.

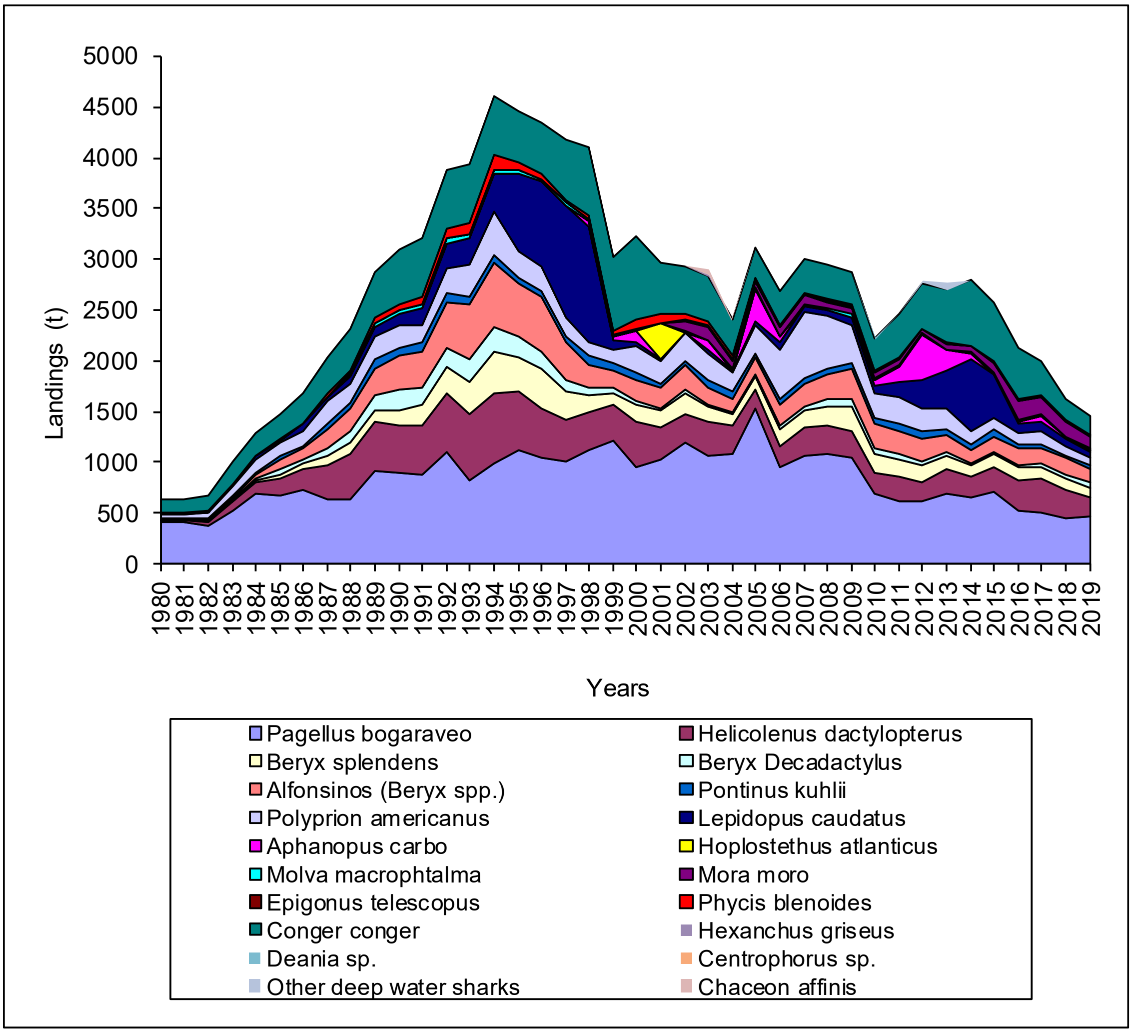

Figure 2.7.3. Annual landings of major deep-water species in Azores from hook and line fishery (1980–2017).

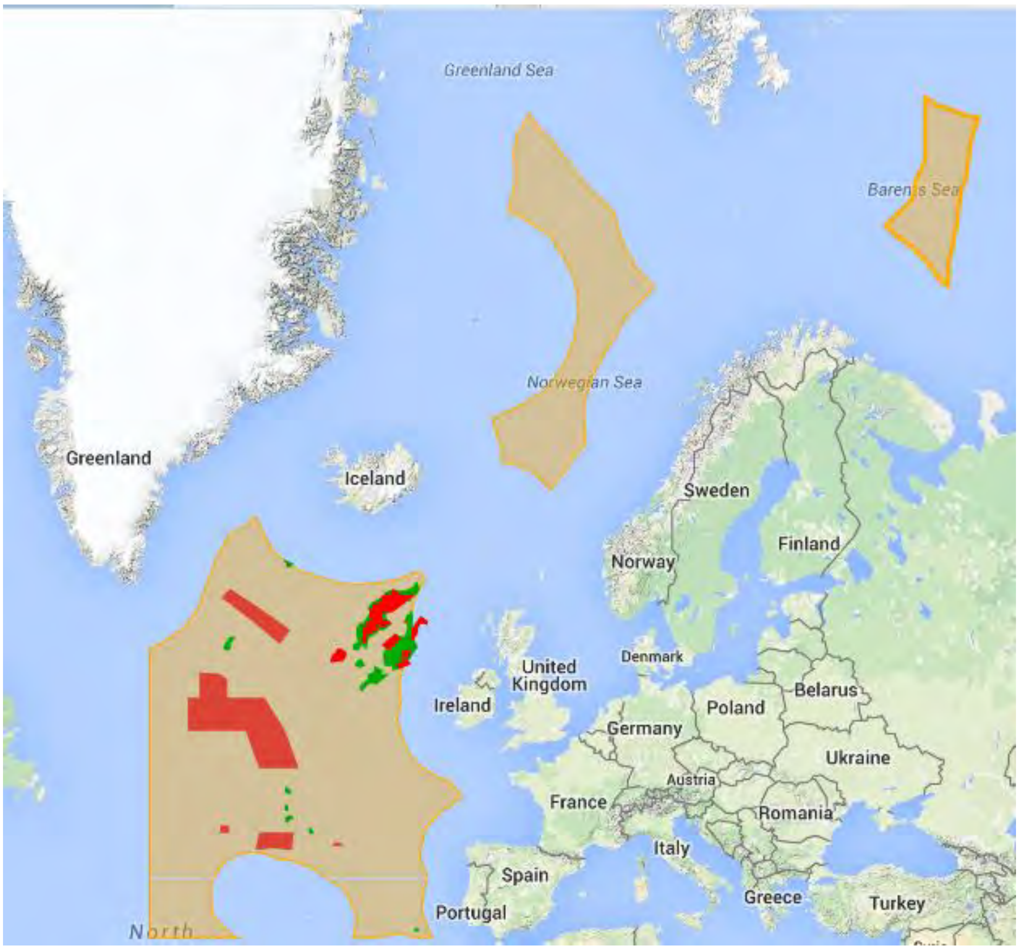

Figure 2.7.4. The regulatory area of NEAFC (light brown) and subareas of the Mid-Atlantic Ridge, seamounts and the Rockall-Hatton areas designated as bottom fishing closures (red), and 'existing fishing areas (green). Areas outside closures and 'existing fishing areas' are only open to pre-assessed exploratory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

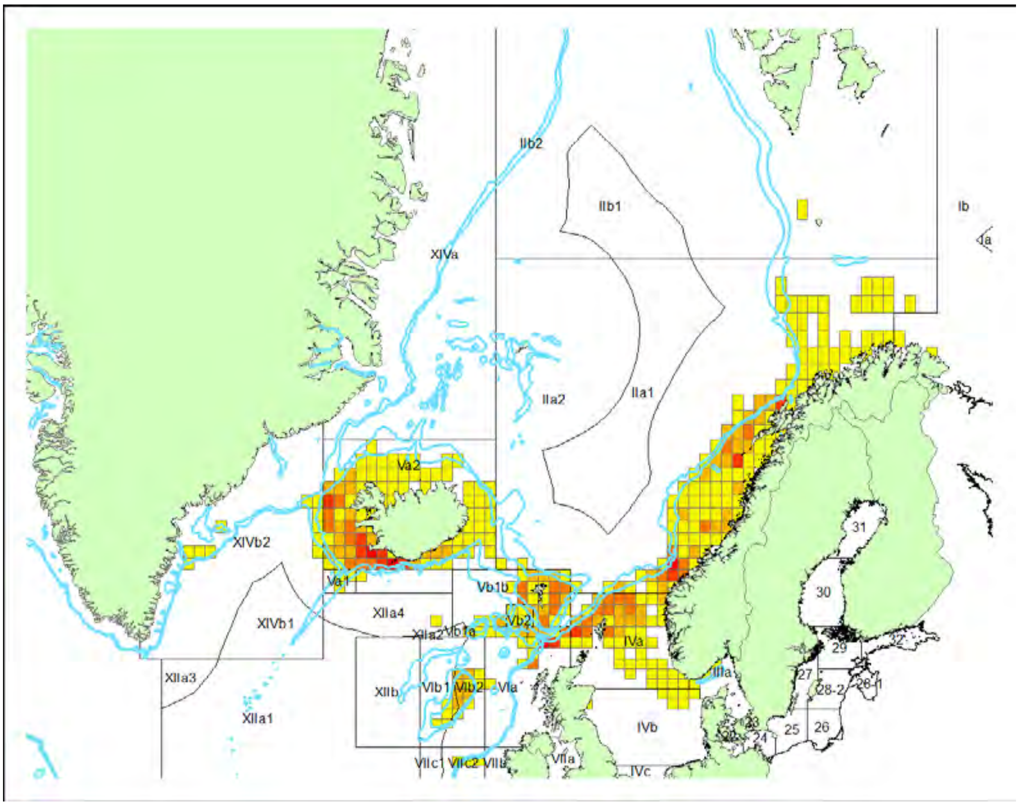

Figure 3.1. Map of fishery distribution (catches) in 2013 (data from Iceland, Faroes and Norway).

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

The longline fisheries in Faroese waters were mainly on the slope on the Faroe Plateau and a small amount of it was on the bank areas and Wyville-Thomson Ridge (Figure 3.2.1). Ling was also caught as bycatch by trawlers fishing saithe on the Faroe Plateau (Figure 3.2.2). In the latest years, foreign catches was mainly by the Norwegian longliners.

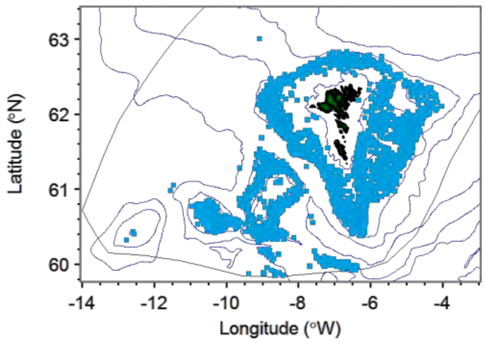

Figure 3.2.1. Ling in 5.b. Spatial distribution of the longline fishery 1985 to present, where ling was >30% of the total catches in the sets. These are the data behind the longliners cpue series of ling.

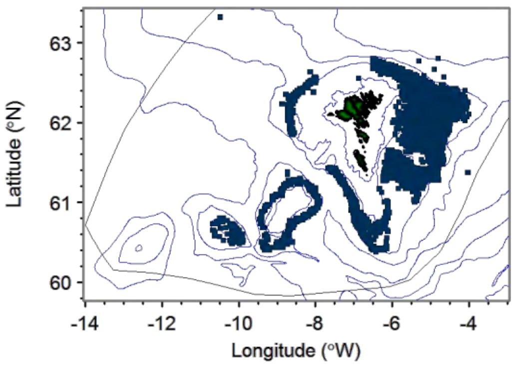

Figure 3.2.2. Ling in 5.b. Spatial distribution of pair trawler fishery 1994 to present, where ling was in the catch and saithe >60% of the total catch per haul. These are the data behind the pair trawler bycatch cpue series of ling.

3.2.2 Landings trends

Landings data for this stock are available from 1904 onwards (Figure 3.2.3). Landing statistics for ling by nation for the period 1988–2018 are given in Tables 3.2.1–3.2.3 and total landings data from 1904 onwards are shown in Figure 3.2.3.

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 2006–2019 this has decreased to around 10%. The preliminary landings of ling increased in 2019 to 7819 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.

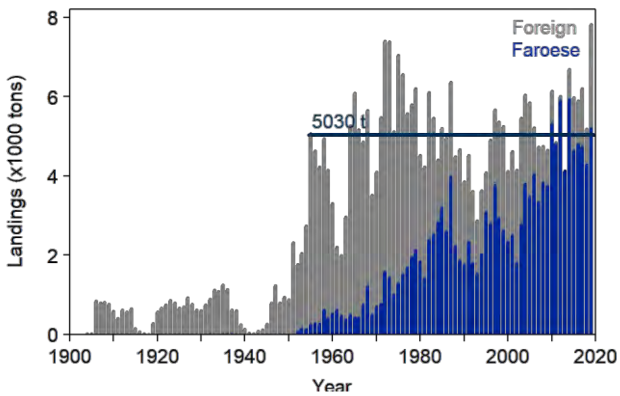

Figure 3.2.3. Ling in 5.b. Total international landings since 1904. The mean catches from 1955 to present were around 5000 tons.

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. The recommended minimum landing size for ling is 60 cm, but that is not enforced because of the discard ban. Mostly 25% of the ling catch (per settings/hauls) can be juveniles e.g. smaller than 75 cm. Other nations are regulated by TACs.

There is a bilateral agreed quota between Norway and Faroe Islands, but there was no such agreement in 2011–2013. In 2020, 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-2020.pdf).

In 2020, the Faroese Party will allow 5 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 3 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-2020.pdf).

Quotas of blue ling/ling* and other species for European Union vessels fishing in the Faroese zone in 2020 is 1885 tonnes and 700 tonnes, respectively. *By-catch of maximum of 665 tonnes of roundnose grenadier and black scabbard to be counted against this quota (føroyar-es-semja-um-fiskirættindi-fyri-2020.pdf).

3.2.5 Data available

Data on length, gutted weight and age are available for ling from the Faroese landings and Table 3.2.4 gives an overview of the level of sampling since 1996.

There are also catch and effort data from logbooks for the Faroese longliners and trawlers.

From the two annual Faroese groundfish surveys on the Faroe Plateau, especially designed for cod, haddock and saithe, biological data (mainly length and round weight, Table 3.2.4) as well as catch and effort data are available. Data of ling larvae from the annual 0-group survey on the Faroe Plateau was also investigated.

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

3.2.5.1 Landings and discards

Landings were 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 are available from the Faroese commercial longliners, the trawler fleet that captures ling as bycatch and from the two groundfish surveys (Figures 3.2.4–3.2.7).

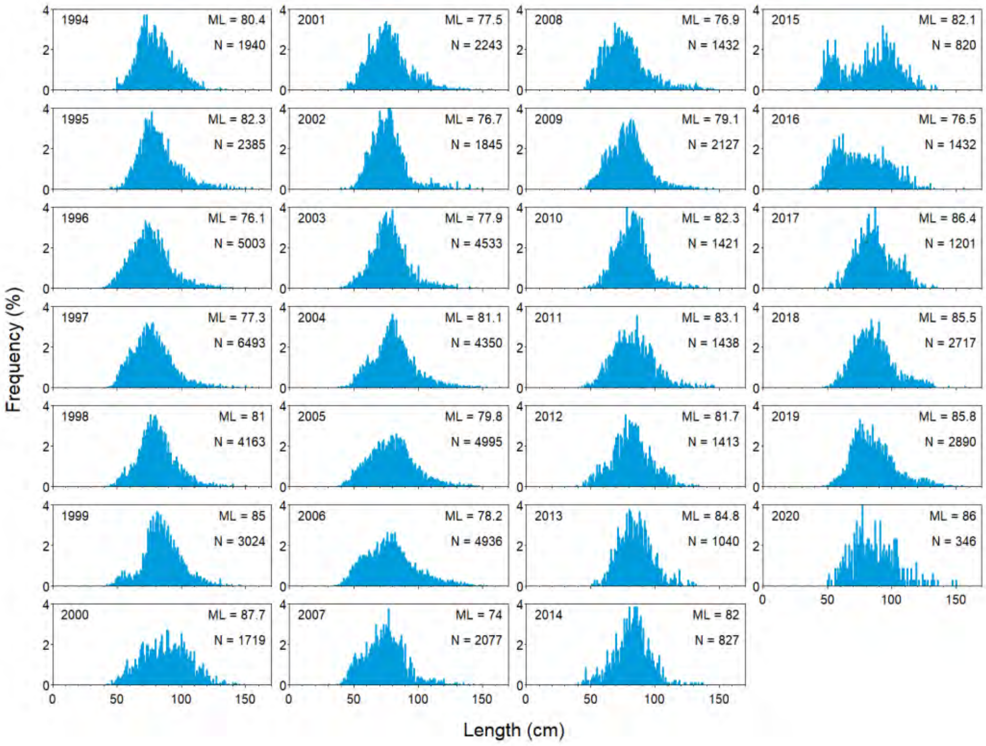

Figure 3.2.4. Ling in 5.b. Length frequencies from the landings of ling from Faroese longliners (>110 GRT). ML-mean length and N-number of length measures.

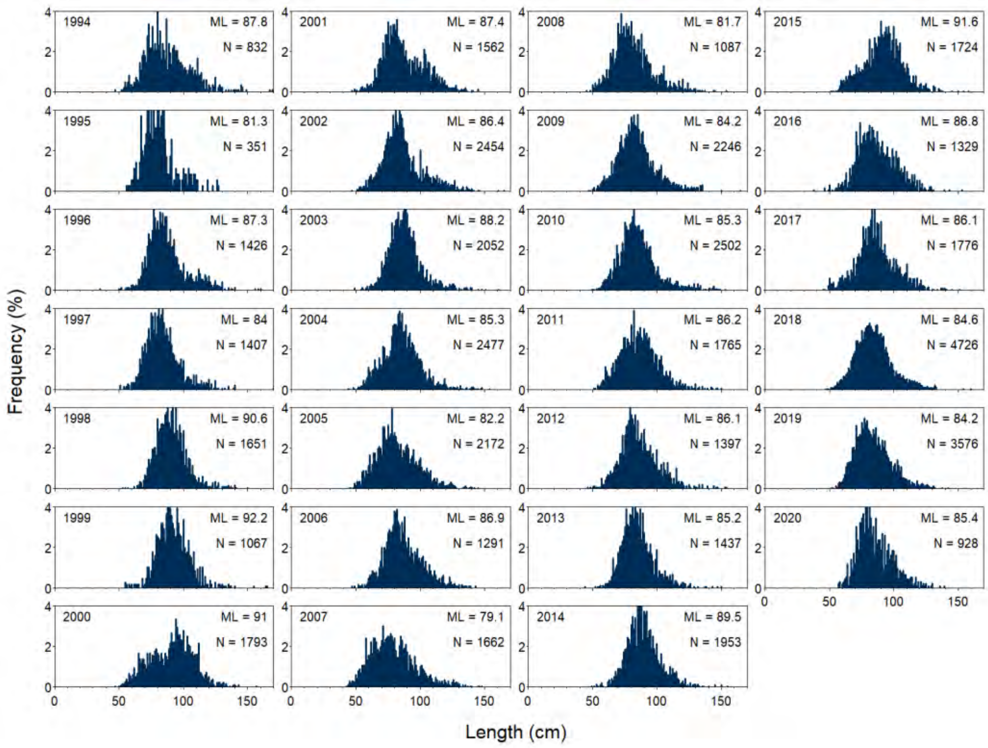

Figure 3.2.5. Ling in 5.b. Length frequencies from the landings of ling from Faroese trawlers (>1000 HP). ML-mean length and N-number of length measures.

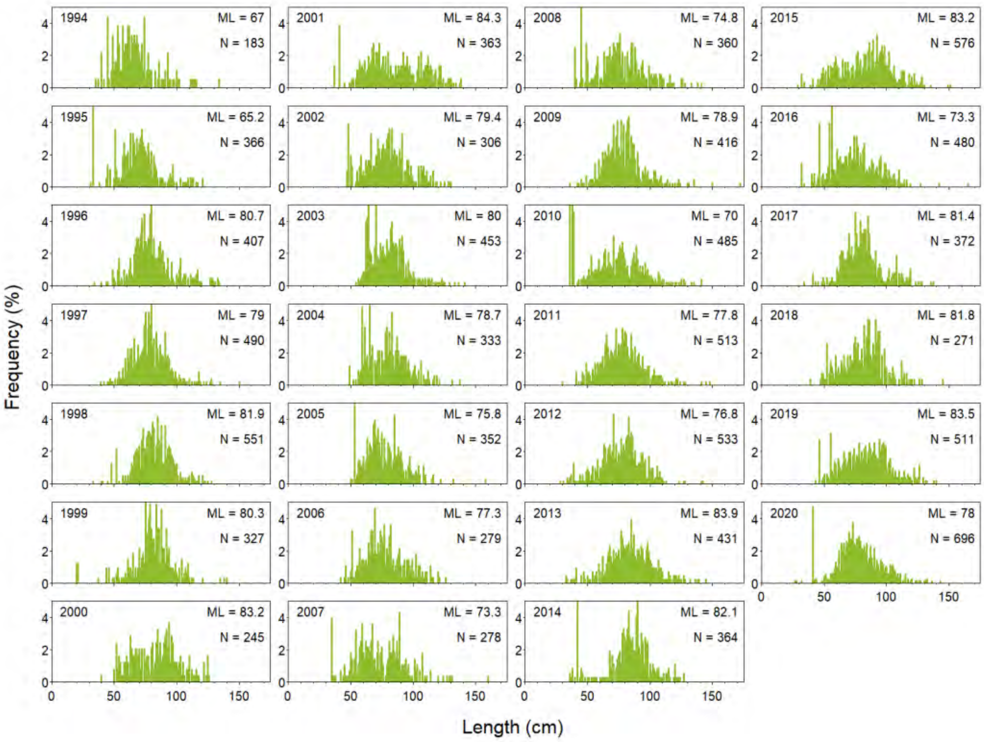

Figure 3.2.6. Ling in 5.b. Length frequencies from the spring groundfish survey. ML- mean length, N–number of calculated length measures. The small ling are often sampled from a subsample of the total catch, so the values are multiplied to total catch.

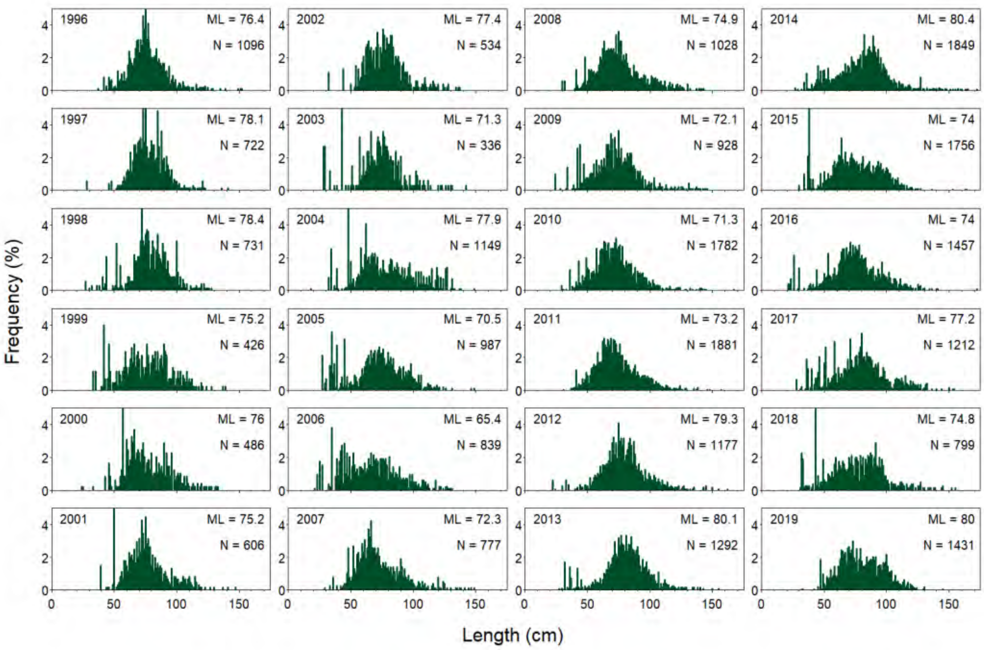

Figure 3.2.7. Ling in 5.b. Length frequencies from the summer groundfish survey. ML- mean length, N–number of calculated length measures. The small ling are often sampled from a subsample of the total catch, so the values are multiplied to total catch.

3.2.5.3 Catch-at-age

Catch-at-age data were provided for Faroese landings in 5.b for the period 1996 to present. In 2020, a new ALK- program was used to calculate the catch number at age from 1996 to 2019. Due to few age data in some years, there were needed to "borrow" ages from other years if the lengths were missing ages (see WD, WKGSS 2020). The age–length data was distributed on the lengths for the distinct years and fleets (longliners and trawlers) (Figure 3.2.8). The most common ages in the landings are from five to nine years and the mean age is around 7–8 years.

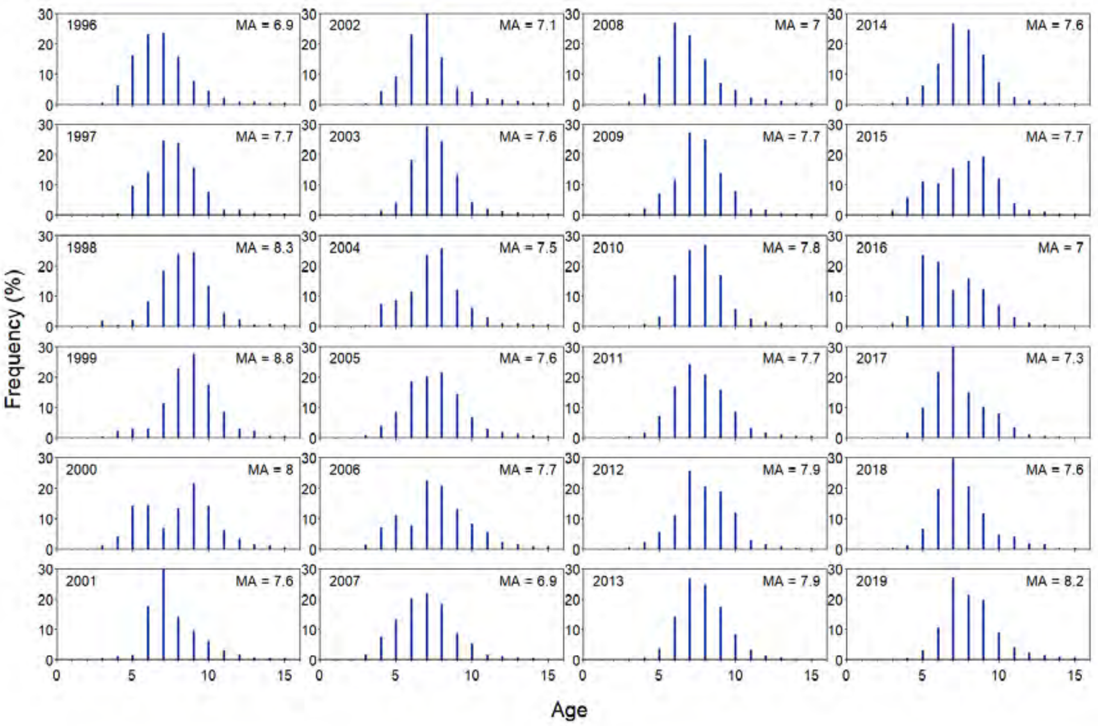

Figure 3.2.8. Ling 5.b. Catch-at-age frequencies used in the exploratory assessment. MA- mean age.

3.2.5.4 Weight-at-age

Mean weight-at-age data from the landings in 5.b was in 2020 modelled using the new ALK-program in the same way as calculation of the catch at age. There is no particular trends in the mean weights over the period (Figure 3.2.9).

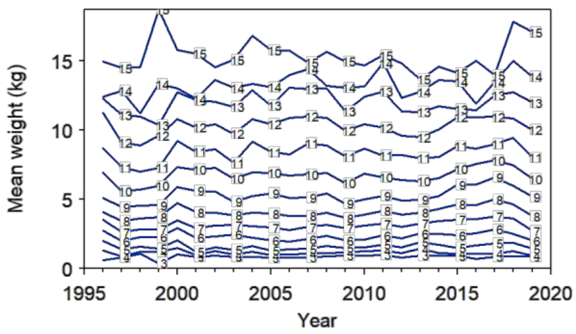

Figure 3.2.9. Ling in 5.b. Mean weight-at-age in the catches.

3.2.5.5 Maturity and natural mortality

Maturity ogives of ling are presented in a table below. The results fit well with the statement that ling become mature at ages 5–7 (60–75 cm lengths) in most areas, with males maturing at a slightly lower age than females (Magnusson *et al*., 1997).

Maturity parameters:

Area	Sex	A_{50}	N	L_{50}	N	RW_{50}	N	GW_{50}	N
Faroese waters	Combined	5.89	1677	68.86	1737	2069.5	1308	1435.2	295
Faroese waters	Female	6.21	846	71.81	871				
Faroese waters	Male	5.60	831	66.54	865				

The same maturity-at-age calculated from all data was used for all years in the assessment for sexes combined.

No information is available on natural mortality of ling in 5.b. Natural mortality of 0.15 was assumed for all ages in the exploratory assessment.

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) and Norwegian longliners fishing in Division 5.b. The Faroese cpue data are mainly from five longliners (GRT>110) and 6–10 pair trawlers (HP>1000). The effort obtained from the logbooks was estimated as 1000 hooks from the longliners, number of fishing (trawling) hours from the trawlers and the catch as kg stated in the logbooks. The selection of data and standardization are described in the stock annex for ling in 5.b. The data selected in the longliner series was only from sets where ling was more than 30% of the total catch to be able to compare with the Norwegian longliner series.

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). The sets where ling >30% of the total catch were used. The Norwegian and Faroese longliners are comparable and both have ling (and tusk) as target species.

Fisheries-independent cpue series

Cpue estimates (kg/hour) for ling are available from two annual groundfish trawl surveys on the Faroe Plateau designed for cod, haddock and saithe. The annual survey on the Faroe Plateau covers the main fishing areas and mainly a large part of the spatial distribution area. Information on the surveys and standardization of the data are described in the stock annex.

A potential recruitment index was calculated from ling less than 40 cm from the survey. In addition, an index was 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 3.2.4–3.2.5). The mean length from the Norwegian longliners fishing in Faroese waters, in the period 2003–2009 were around 87 cm. The Faroese trawlers have a slightly higher mean length compared with the Faroese longliners.

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 3.2.6–3.2.7).

Fluctuations in abundance

Information on abundance trends can be derived from the cpue data from the Faroese longliners (Figure 3.2.10), Norwegian longliners fishing in 5.b (Figure 3.2.11), bycatch from the Faroese pair trawlers fishing saithe (Figure 3.2.10) and from the Faroese groundfish surveys (Figure 3.2.12). Data from these series are presented in Table 3.2.5–3.2.6.

The Faroese longline cpue series and the Faroese trawl bycatch cpue series show an increasing trend since around 2001 (Figure 3.2.10). The Norwegian longline series show an increase after 2004, except in 2018 (Figure 3.2.11). It has to be noted that there are less than 100 fishing days from Norwegian longliners in Faroese waters in 2009–2014 (Table 3.2.6).

The two survey cpue series indicate a stable situation from the late 1990s and an increase in recent years (Figure 3.2.12). There was a decrease in 2018, but the values were still well above the mean value. In 2019, the survey value increased again and the spring survey in 2020 showed an increase well above the mean value again.

A potential recruitment index was calculated from the two surveys as 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 in 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 1983 to present, which also showed indications of high recruitment in some years (Figure 3.2.14). These recruitment indices support an indication of high recruitment in distinct years.

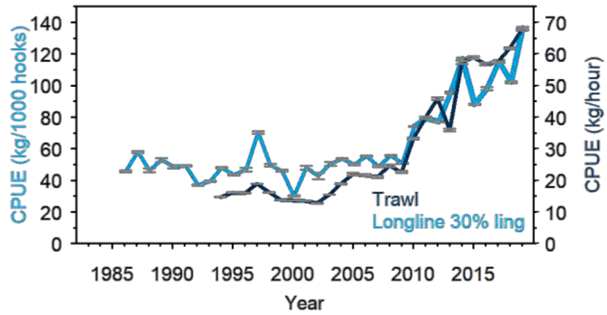

Figure 3.2.10. Ling in 5.b. Standardized cpue from Faroese longliners (turquoise line) and pair trawlers (bycatch, dark blue line) fishing in Faroese waters. Data from longliners (>110 GRT) are from sets where ling >30% of the total catch. Data from trawlers are from hauls where ling was caught and saithe >60% of the total catch. The error bars are SE.

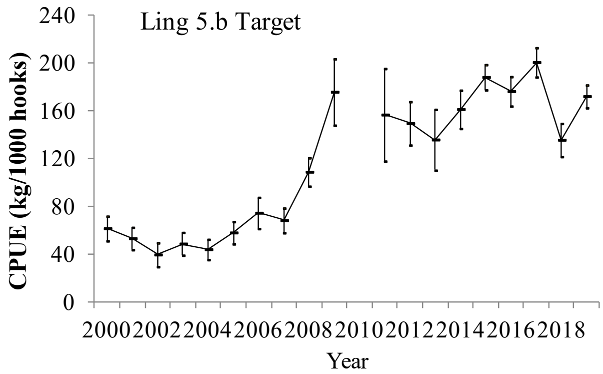

Figure 3.2.11. Ling in 5.b. Standardized cpue (kg/ 1000 hooks) of ling from Norwegian longliners fishing in 5.b. The bars denote the 95% confidence intervals (Helle and Pennington, WD 2019).

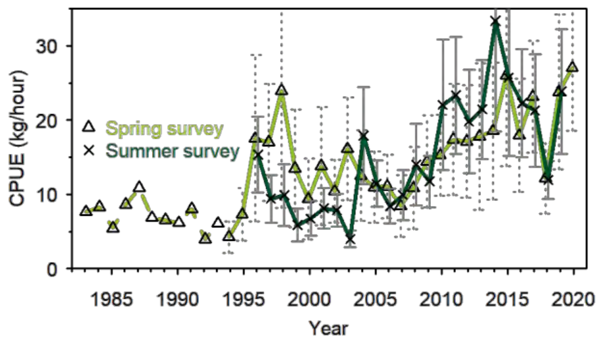

Figure 3.2.12. Ling in 5.b. Standardized cpue (kg/hour) from the two annual Faroese groundfish surveys on the Faroe Plateau. The error bars are SE. The data for 1983–1993 were not standardized.

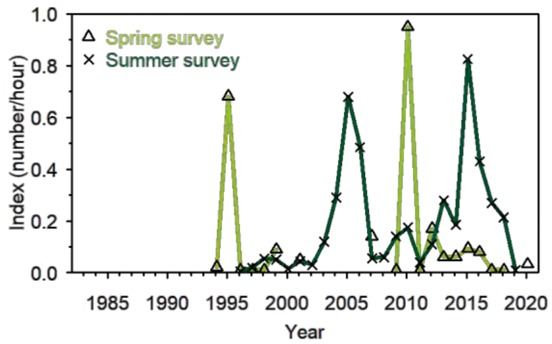

Figure 3.2.13. Ling in 5.b. Index (number/hour) of ling smaller than 40 cm from the spring- and summer survey on the Faroe Plateau.

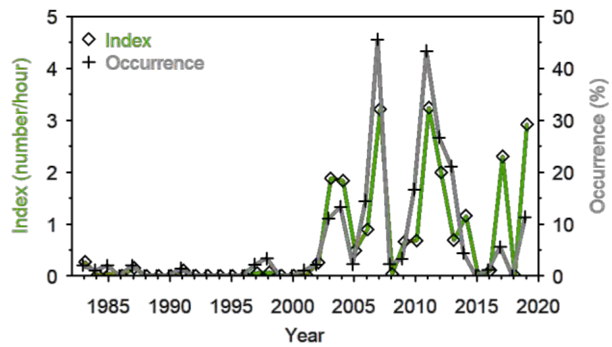

Figure 3.2.14. Ling in 5.b. Index (number/hour) and occurrence (%) of ling (2–3 cm in length) caught in the annual 0-group survey on the Faroe Plateau.

Analytical assessment

An exploratory assessment of ling in Division 5.b was done by using the age-based model SAM (lin5b_2020). In 2020, a recalculation of catch at age was done for all years 1996-2019 using a new ALK program made at the Faroe Marine Research Institute (WD WKGSS, 2020). The age reading from the actual year was used as background for the calculation. If some lengths for that actual year were missing ages, then the ages can be borrowed from other years. An overview of the sampling is in Table 3.2.4.

The summer survey series was used as tuning series. The summer surveys on the Faroe Plateau covers the main spatial distribution areas and the fishery areas. There are possibilities to include the Faroese spring survey and the two commercial indices in the tuning series also.

The SAM model fitted the cpue-data well, but the log q residuals showed some seasonal problems in following the cohorts. The settings in the SAM model were almost default and these settings will be closer investigated.

The results from the SAM model supports that ling in Faroese waters is at a high level as the SSB were above long-term mean in the latest years, even the recruitment is decreasing (Figure 3.2.15). The retrospective pattern showed that fishing mortality tended to be underestimated, whereas the recruitment and SSB tended to be overestimated.

Ling in Division 5b will be benchmarked in 2021.

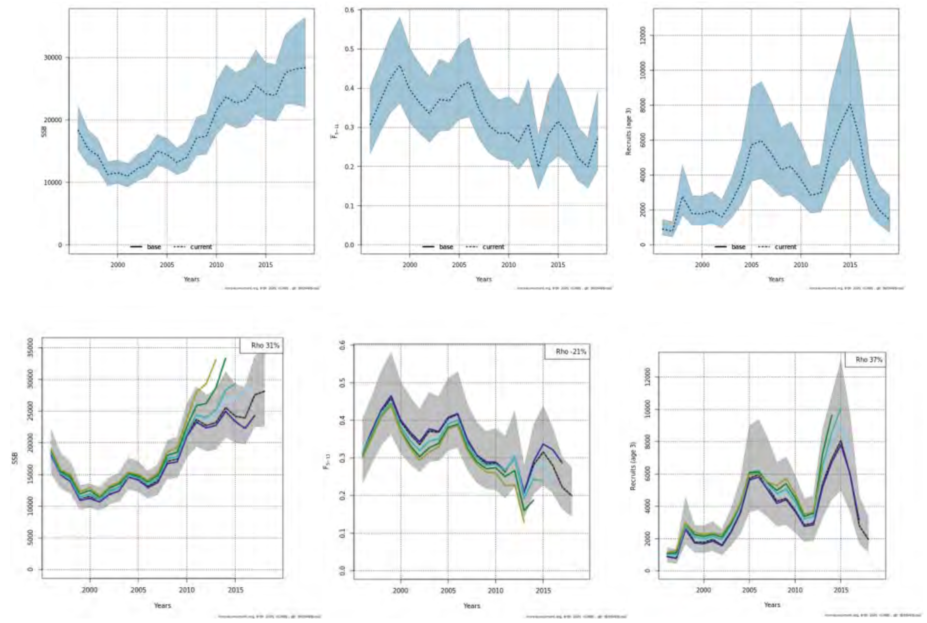

Figure 3.2.15. Ling in 5.b. Output from the exploratory age based assessment using SAM.

3.2.6.1 Reference points

There are no accepted reference points for this stock. The Length Based Indicator (LBI) is used as $F_{MSY\ proxy}$ reference point. The value is 98.0 cm (2018) which is the expected mean length of catch above L_{mean} when F=M (ICES, 2019). The adult abundance measured by surveys is above the average of the time-series, so expert judgement considered it likely that SSB is above any candidate values for MSY $B_{trigger}$.

Yield per recruit analysis in SAM from the exploratory assessment gave F_{MAX} = 0.23, $F_{0.1}$ =0.13 and $F_{0.35SPR}$ = 0.15 (Figure 3.2.16).

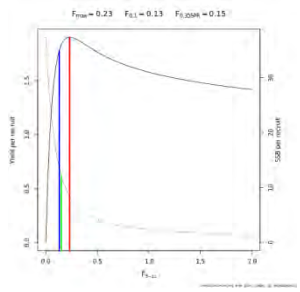

Figure 3.2.16. Ling in 5.b. Yield per Recruit output from the exploratory age based assessment using SAM.

3.2.7 Comments on assessment

All signs from commercial catches and surveys indicate that ling in Division 5.b at present is in a good state, and this is confirmed in the exploratory assessment.

There is a clear seasonal pattern in log q residuals and there need to be a closer look at the diagnostic to find the best settings. It is also necessary to look closer at the ALK for the whole period to solve the strong log q residual patterns. Still, the assessment is assumed to show there is an increase in stock biomass and spawning–stock biomass during the latest years.

For this stock unit, advice is given every second year, so the advice for 2020 also applies for 2021. The advice is based on trends in the cpue (kg/hour) from the Faroese summer survey on the Faroe Plateau (DLS method 3.2).

There are possibilities to increase ling in 5.b to a category 1 stock with the excising data.

3.2.8 Management consideration

Stability in landings and trends in abundance indices suggest that ling in Division 5.b has been stable since the middle of the 1980s, with an increasing trend in the last seven years. 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 recruitment in the last seven years compared to earlier levels.

The only species-specific management for Faroese fisheries of ling in Division 5.b is the recommended minimum landing size (60 cm), but this does not appear to be enforced because of the discard ban. Mostly 25% of the ling catch (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. The fisheries by other nations are regulated by TACs.

3.2.9 Application of MSY proxy reference points

Length-based indicator method (LBI)

The input parameters and the catch length composition for the period 1995–2019 are presented in the table below and in Figure 3.2.17. The length data used in the LBI model are data from the Faroese longliner and trawler fleets. The length data are not raised to total catch.

Input parameters for LBI.

Data type	Years/Value	Source	Notes
length–frequency distribution	1995–2019	Faroese long-liners and trawlers	
Length–weight relation	$0.0033 * \text{length}^{3.1311}$	Faroese survey data	combined sex
L_{MAT}	69 cm	Faroese survey data	
L_{inf}	185 cm	Faroese survey data	

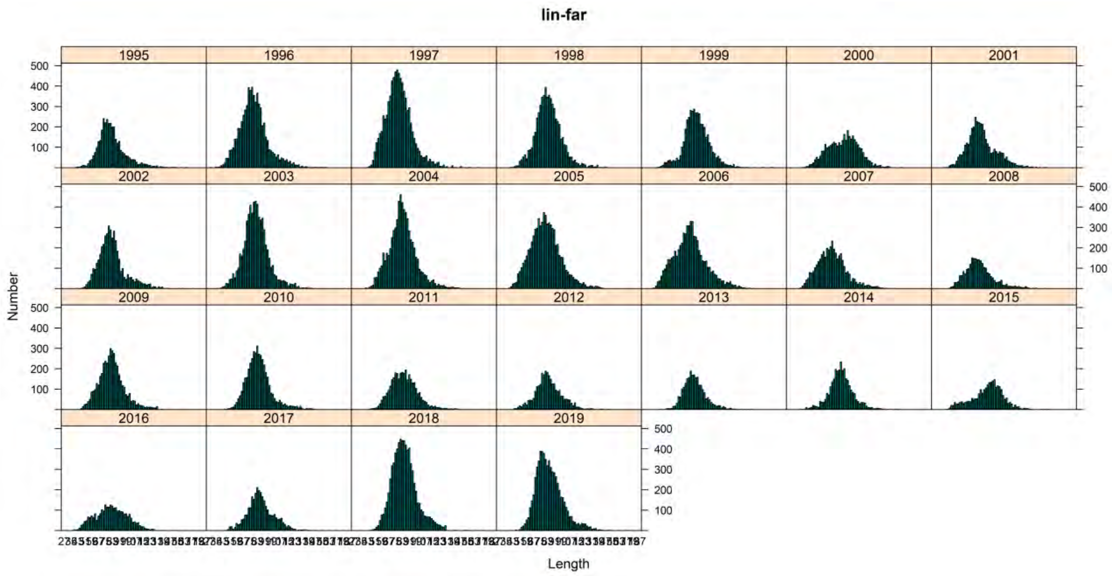

Figure 3.2.17. Ling in Faroese waters (5.b). Catch length distributions for the period 1995–2019 with 2 cm length bins (sex combined).

Output from the screening of length indicator ratios for combined sexes was conducted under three scenarios: (a) Conservation; (b) Optimal yield, and (c) maximum sustainable yield (Table below and Figure 3.2.18).

Analysing the results showed that the conservation of immature ling indicator, L_c/L_{mat}, was usually less than one, while $L_{25\%}/L_{mat}$ was usually around 1 (Figure 3.2.18). In 2015-2019, $L_{25\%}/L_{mat}$, has been greater than 0.96 (Table below).
The conservation of large ling indicator, $L_{max5\%}/L_{inf}$, was around 0.65 for the entire period (Figure 3.2.18), and between 0.64 and 0.67 in 2015-2019 (Table below). The indicator was less than 0.8, which suggests that there were few mega-spawners in the catch. Since the VBF produced an unusually high L_{inf}, the value used in the model was L_{max}. This could be the reason that the indicator ratio was less than 0.8. If we would have used a lower L_{inf} value, the indicator ratio would have been higher! The catch was lower than the length of optimal yield.
The MSY indicator ($L_{mean}/L_{F=M}$) was greater than 1 for almost the whole period (Figure 3.2.18), which indicates that ling in Faroese waters are fished sustainably. Only in 2018, the MSY indicator was 0.89.

Conclusion of LBI is that the overall perception of the stock during the period 2015–2019 is that ling in Faroese waters seems to be fished sustainably, except in 2018 (Table below). However, the results are very sensitive to the assumed values of L_{mat} and L_{inf}.

	Conservation				Optimizing Yield	MSY
Ling 5.b	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	$Lmean/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2016	0.54	0.96	0.64	0%	0.66	1.08
2017	0.71	1.07	0.65	0%	0.70	1.02
2018	0.96	1.04	0.66	0%	0.71	0.89
2019	0.60	1.03	0.68	1%	0.71	1.08

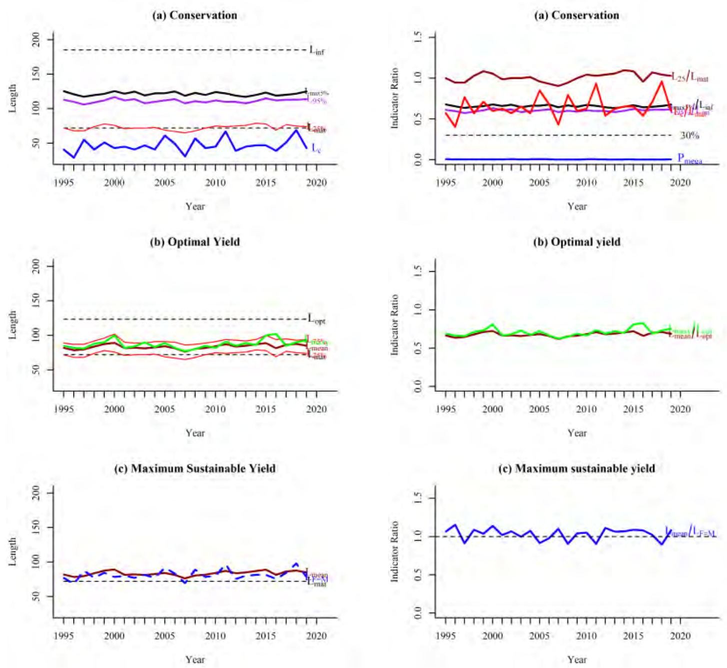

Figure 3.2.18. Ling in Faroese waters (5.b). Screening of length indicators ratios for sex combined under three scenarios: (a) Conservation, (b) Optimal yield, and (c) maximum sustainable yield.

Stochastic Production model in Continuous Time (SPiCT)

At the WGDEEP 2019 meeting, the conclusion was that SPiCT cannot be used for lin-27.5b assessment unit. Further investigation is needed.

The model was not updated at the WGDEEP 2020.

3.2.10 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

***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

Year	Faroes	France	Norway	Scotland	Total
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

*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

*Preliminary.

Table 3.2.4. Ling in 5.b. Overview of the sampling from commercial landings and different surveys since 1996.

	Commercial sampling			Survey sampling		
Year	Length	Gutted Weight	Age	Length	Round weight	Age
1996	6399	410	1084	1748	366	11
1997	7900	541	1526	1478	326	0
1998	5912	538	1081	1580	820	0
1999	4536	360	480	805	665	0
2000	3512	360	360	1237	684	14
2001	3805	420	420	1573	889	0
2002	4299	180	300	1492	817	0

	Commercial sampling			Survey sampling		
2003	6585	360	661	1608	887	0
2004	6827	1169	659	1968	1131	0
2005	7167	3217	540	1511	1050	0
2006	6503	4038	276	1338	937	0
2007	4031	1713	120	1166	969	0
2008	2521	1945	60	1454	1052	10
2009	4373	4348	232	1499	1039	0
2010	4345	4279	180	2392	1395	0
2011	3405	2828	0	2562	1949	0
2012	2810	2447	50	1855	1771	0
2013	2477	2076	0	1873	1652	274
2014	2985	2274	20	2923	2268	556
2015	2544	2171	210	3453	2502	418
2016	2761	2360	360	2490	2227	432
2017	2977	2426	480	1890	1469	437
2018	7443	7443	1672	2300	1634	792
2019	6466	6466	892	2273	1989	446

Table 3.2.5. Ling in 5.b. Data on the cpue series from Faroese commercial fleets and groundfish surveys. Only the spring survey data from 1986–1993 was not standardized. N- number of sets/hauls behind the commercial cpues.

	Longline			Trawl (bycatch)			Spring survey		Summer survey	
Year	Mean	se	N	Mean	se	N	Mean	se	Mean	se
1986	44.6	0.6	47				8.6			
1987	57.2	0.8	91				10.9			
1988	46.4	1.1	26				6.9			
1989	48.0	1.2	28				6.6			
1990	47.6	1.1	39				6.2			
1991	48.9	0.6	110				8.0			
1992	36.3	0.4	139				4.0			
1993	39.2	0.5	130				6.1			
1994	46.6	0.4	182	14.8	0.2	69	4.3	2.1		
1995	42.6	0.4	150	15.3	0.1	244	7.3	3.6		
1996	46.7	1.3	22	15.3	0.1	216	17.5	11.2	15.3	5.1
1997	69.7	1.0	91	18.4	0.1	586	16.9	7.9	9.4	3.2

	Longline			Trawl (bycatch)			Spring survey		Summer survey	
1998	49.7	0.7	77	15.4	0.1	597	23.9	15.8	9.9	4.1
1999	45.1	0.6	80	13.4	0.0	926	13.6	8.0	5.8	2.2
2000	29.6	0.5	68	13.3	0.0	851	9.4	5.4	6.8	2.3
2001	47.1	1.2	31	13.4	0.0	905	13.8	8.0	8.1	2.7
2002	39.2	1.8	9	12.5	0.0	792	10.4	4.2	7.9	2.2
2003	50.5	1.0	26	15.3	0.1	701	16.1	6.9	4.0	1.1
2004	52.6	0.7	73	18.9	0.3	591	12.5	6.1	17.9	6.5
2005	49.3	0.4	120	21.8	0.4	783	11.0	4.8	11.4	3.1
2006	54.8	0.5	135	22.6	0.5	666	11.1	4.3	8.4	2.4
2007	48.9	0.5	72	21.6	0.4	692	8.4	4.2	9.9	3.4
2008	55.6	0.4	175	25.1	0.5	612	10.8	5.6	14.0	5.5
2009	50.8	0.4	181	23.1	0.4	759	14.4	6.2	11.7	3.4
2010	74.3	0.4	823	29.7	0.4	968	15.2	5.4	22.1	8.8
2011	78.6	0.5	796	35.2	0.6	714	17.4	7.5	23.3	7.9
2012	77.5	0.5	679	41.7	0.6	1118	17.1	7.6	19.8	7.0
2013	96.1	0.8	368	35.9	0.5	928	17.8	9.9	21.4	6.7
2014	116.3	0.7	645	51.5	0.6	1275	18.5	9.2	33.4	14.9
2015	88.1	0.5	447	54.8	0.5	1614	26.0	12.3	25.7	10.5
2016	98.2	1.1	341	53.7	0.5	1256	17.9	7.6	22.3	7.3
2017	115.5	0.8	265	56.5	0.4	990	23.1	7.5	21.2	7.6
2018	102.1	0.5	450	61.4	0.3	1263	12.2	4.8	11.9	2.6
2019	136.3	0.9	305	67.7	0.3	1461	23.8	10.4	23.8	8.4
2020							27.0	8.5		

Table 3.2.6. Ling in 5.b. Data from the Norwegian longliners cpue series. Mean cpue is from longliners with more than 30% ling in the sets. SE- standard error * 1.96 = CI, N- number of days that the Norwegian longliners operated in an ICES subarea/division (Helle and Pennington, WD 2020).

Year	Mean cpue	SE*1.96	N
2000	61.5	10.3	288
2001	53.1	9.3	371
2002	39.4	10.0	355
2003	48.6	9.6	391
2004	43.9	8.5	571
2005	57.9	9.3	335
2006	74.5	13.1	125
2007	68.2	10.3	294
2008	108.9	11.9	167

Year	Mean cpue	SE*1.96	N
2009	176.0	27.8	39
2010			
2011	156.8	38.8	11
2012	149.7	18.2	50
2013	135.9	25.5	24
2014	161.4	16.1	83
2015	188.4	10.6	205
2016	176.5	12.4	163
2017	200.9	12.3	152
2018	135.7	13.9	124
2019	172.3	9.6	325

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. Around 50% of the Norwegian landings are taken by longlines and 45% by gillnets, partly in directed ling fisheries and as bycatch in other fisheries. 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 2019. There was no fishery in the NEAFC regulatory area in 2019.

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. 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 but with an increase in 2019. 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. However, with the increase in fishing days in 2019 the total number of hooks and total effort has increased (for more information see Helle and Pennington, WD 2019).

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.

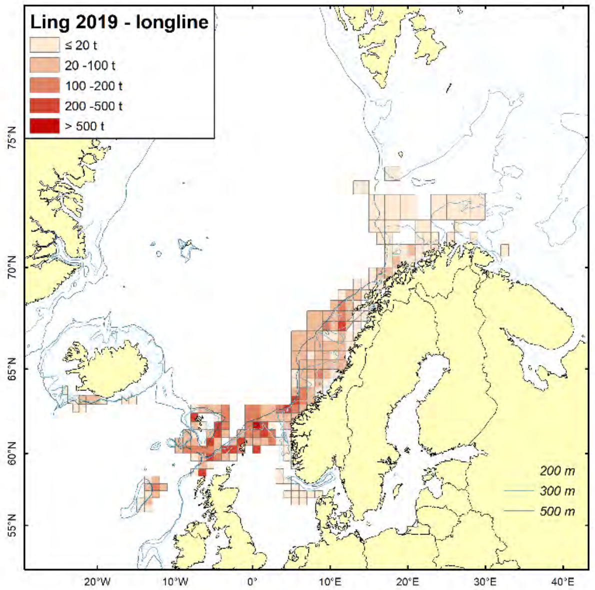

Figure 3.3.1. Distribution of the total catch of ling in Subareas 1 and 2 taken by the Norwegian longline fishery in 2019.

3.3.2 Landings trends

Landing statistics by nation in the period 1988–2019 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. The preliminary landings for 2019 are 11 413 t, a significant increase compared to the previous years. Total international landings in Areas 1 and 2 are given in Figure 3.3.2.

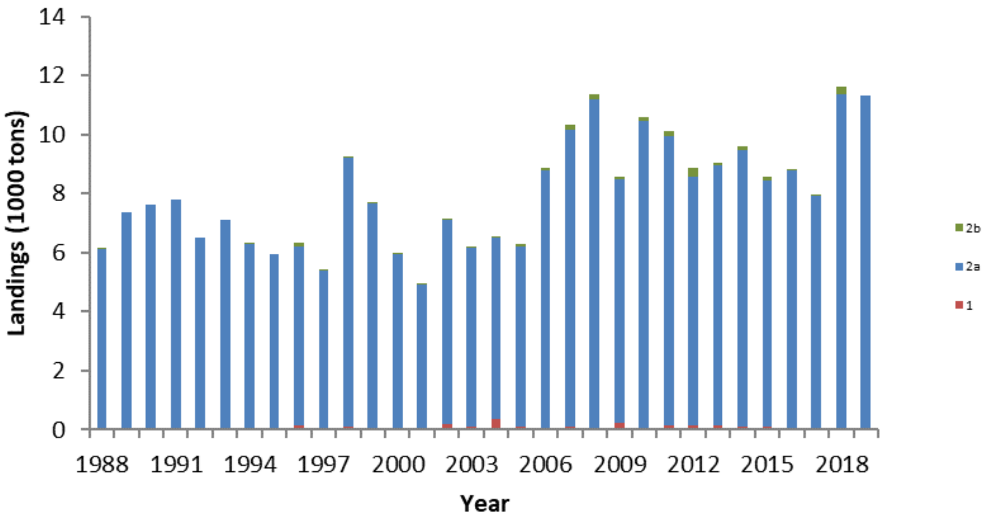

Figure 3.3.2. Total international landings of ling in Subareas 1 and 2.

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.

The quota for ling in EU and international waters was set at 36 t for 2020.

There is also a by-catch quota for 117 tons. The quota is exclusively for by-catches, and no directed fisheries are permitted under this quota

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 2019. 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 2019. 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.

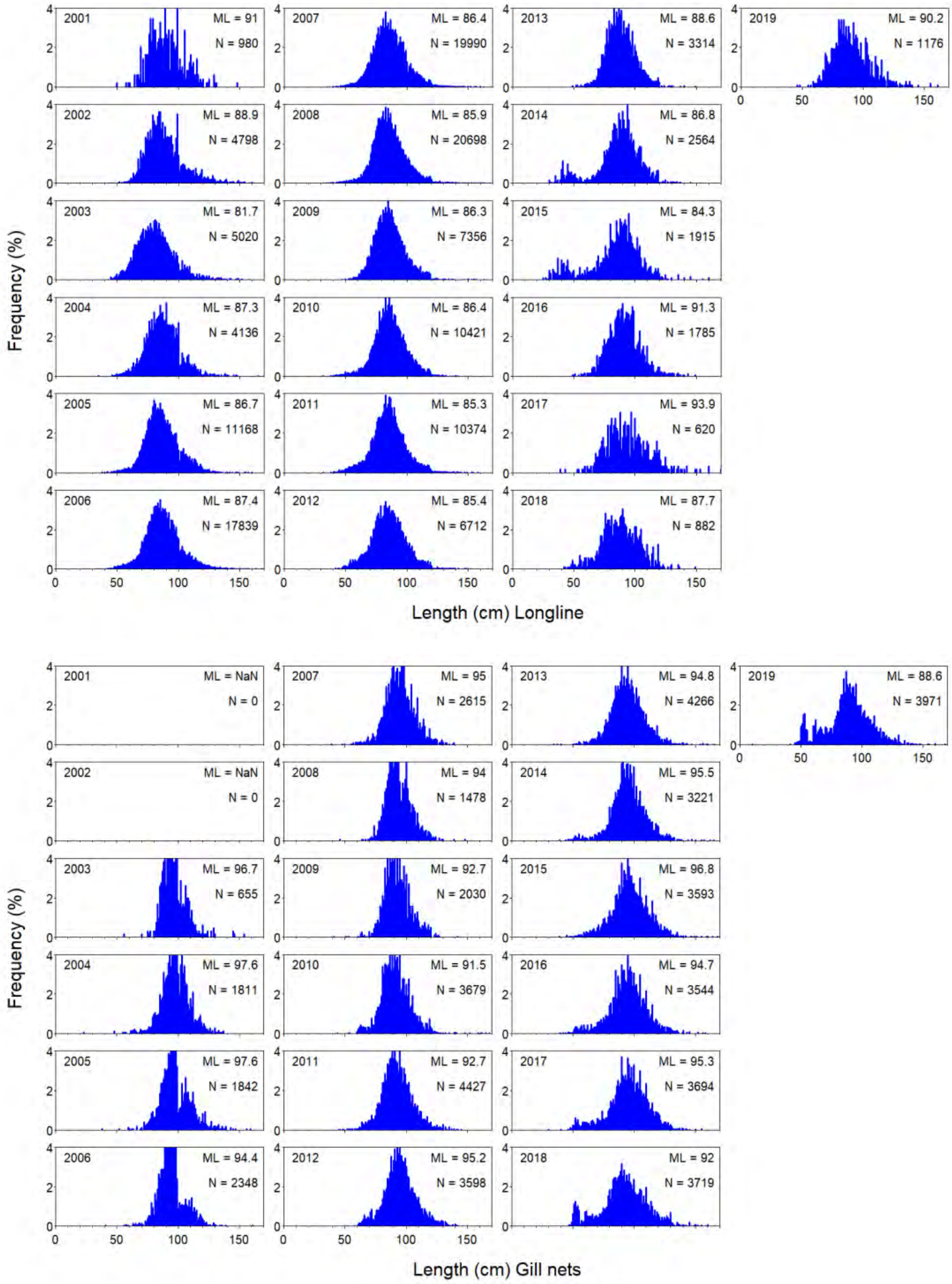

Figure 3.3.3. Plots of the length distributions of ling in Subareas 1 and 2 combined for the period 2001 to 2019 from the Norwegian Reference fleet.

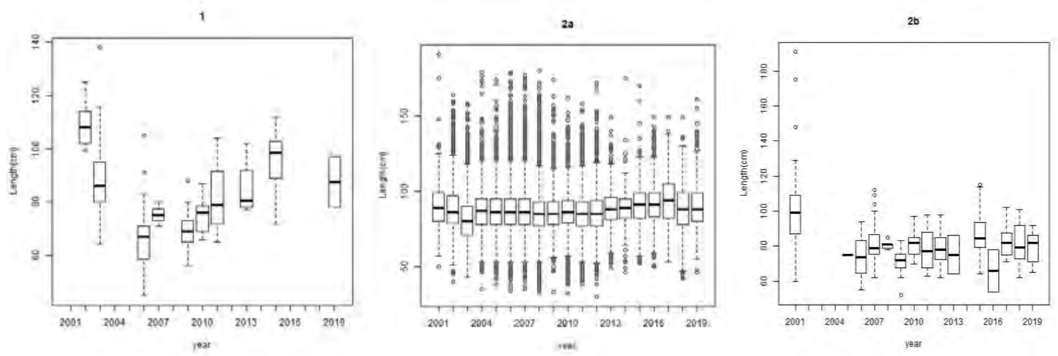

Figure 3.3.4. Box and whiskers plots for the length of ling in Areas 1, 2a and 2b for the period 2001 to 2019 from the Norwegian Reference fleet.

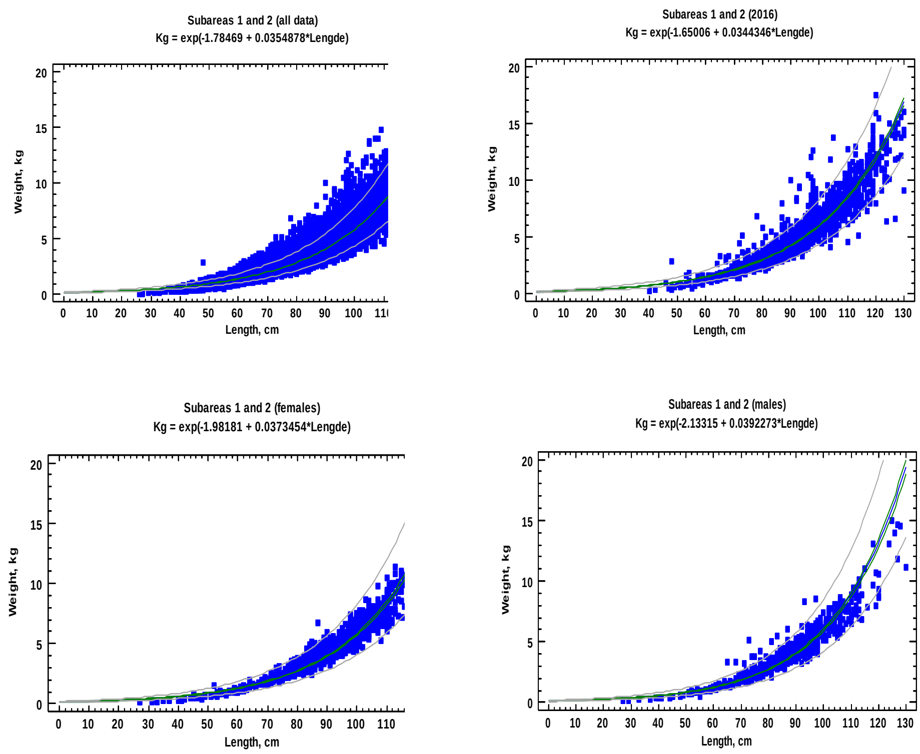

Figure 3.3.5. Weight–length relationship for the period 2008–2018, and only for 2018 (upper panel) and for females and for males, separately (lower panel). Data were collected by the Norwegian Reference Fleet.

3.3.5.3 Age compositions

The Catch-at-age composition for the longline fishery and for the gillnet fishery for 2010–2018 (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.

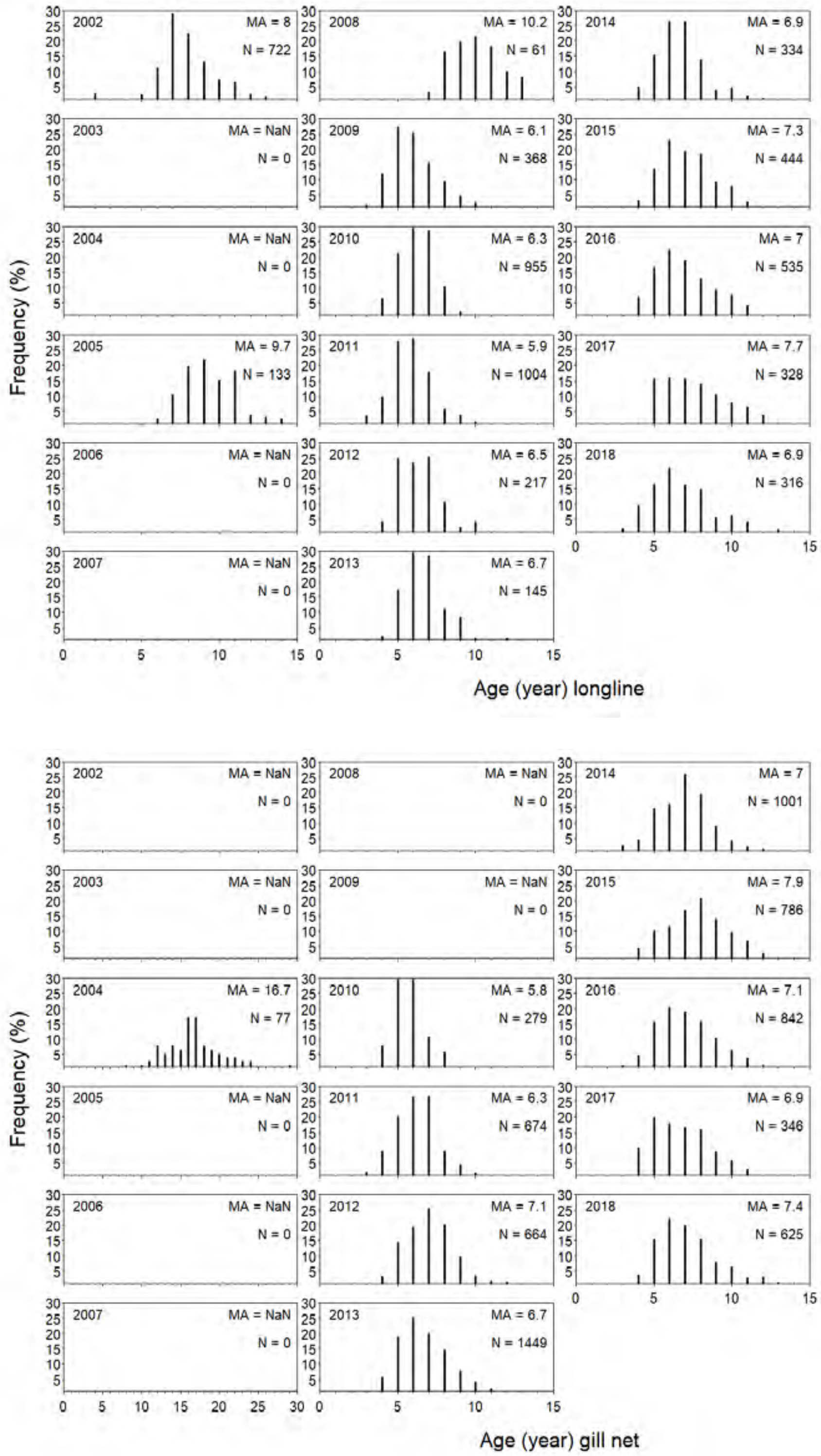

Figure 3.3.6. Ling in Areas 1 and 2, Catch-at-age composition. MA denotes mean age.

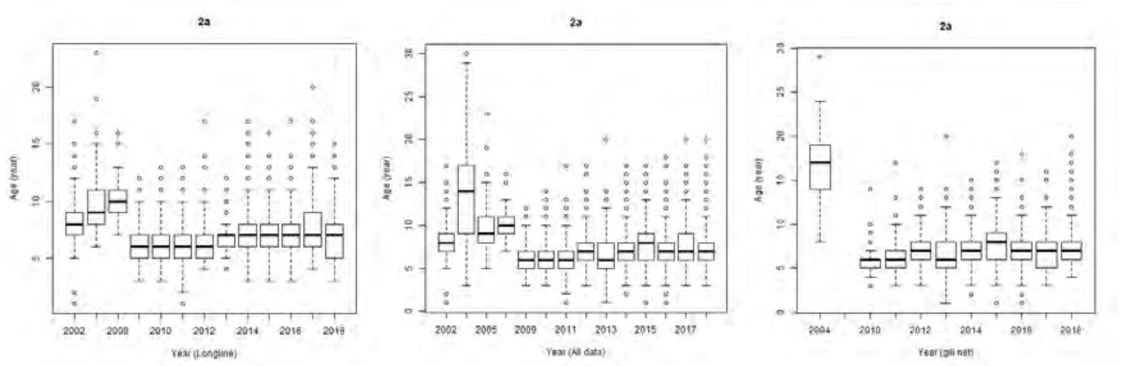

Figure 3.3.7. Age composition of the fish caught by longliners and gillnetters during the period 2002–2018.

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 2009–2018.

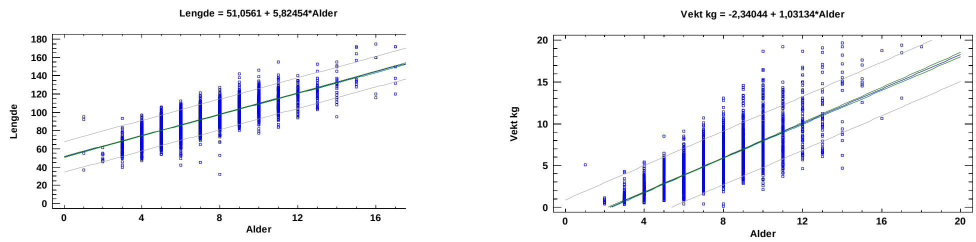

Figure. 3.3.8. Average mean length and mean weight versus age for the period 2010–2018.

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

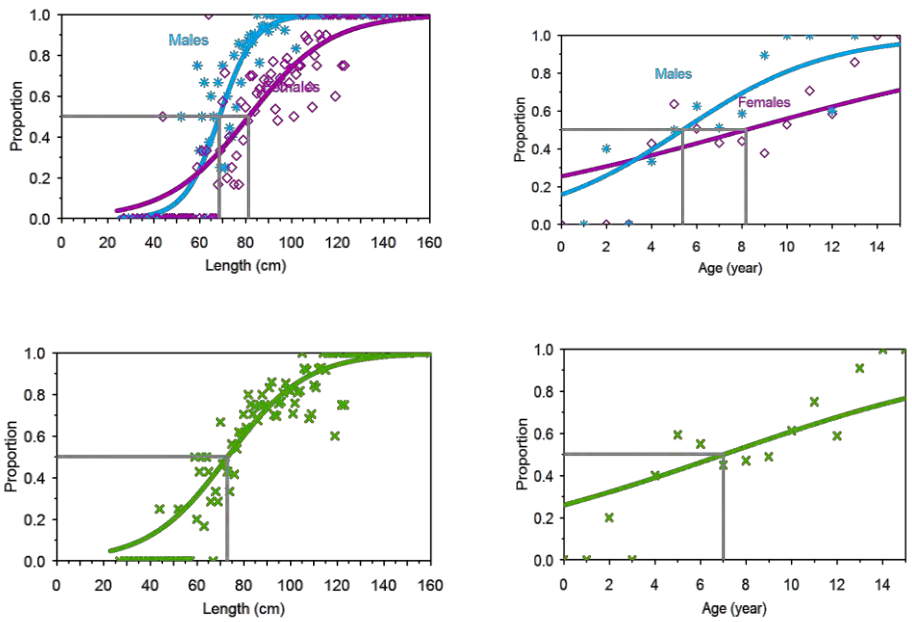

Figure 3.3.9. Maturity ogives for ling in Areas 1 and 2: males and females (upper panel) and for males and females combined (lower panel).

3.3.5.6 Catch and effort data

Two standardized cpue series for 2000–2019 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 2019. 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.

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.

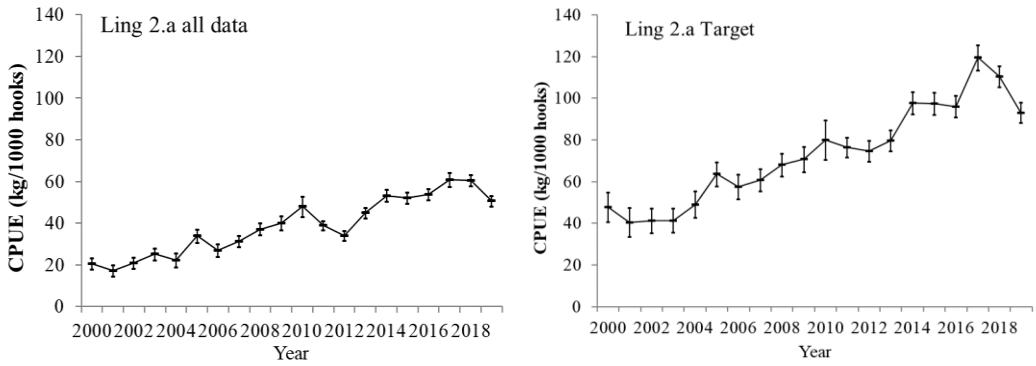

Figure 3.3.10. Estimate of cpue (kg/1000 hooks) for ling in Area 2a based; on all available data, and on catches when ling was considered the target species for 2000–2019. The bars denote the 95% confidence intervals. The data are from skipper's logbooks.

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 two 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 therefore, 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. Because of lower quotas for cod, 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 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.

3.3.9 Application of MSY proxy reference points

Two different methods were tested for ling in Areas 1 and 2: The Length-based indicator method (LBI) and SPiCT.

Length-based indicator method (LBI)
The input parameters and the length distributions of the catches for the period 2001–2019 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	2001–2019	Norwegian gill netters (Reference fleet) fishing in divisions 1,2a,2b	
Length–weight relation	0.0055* 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	

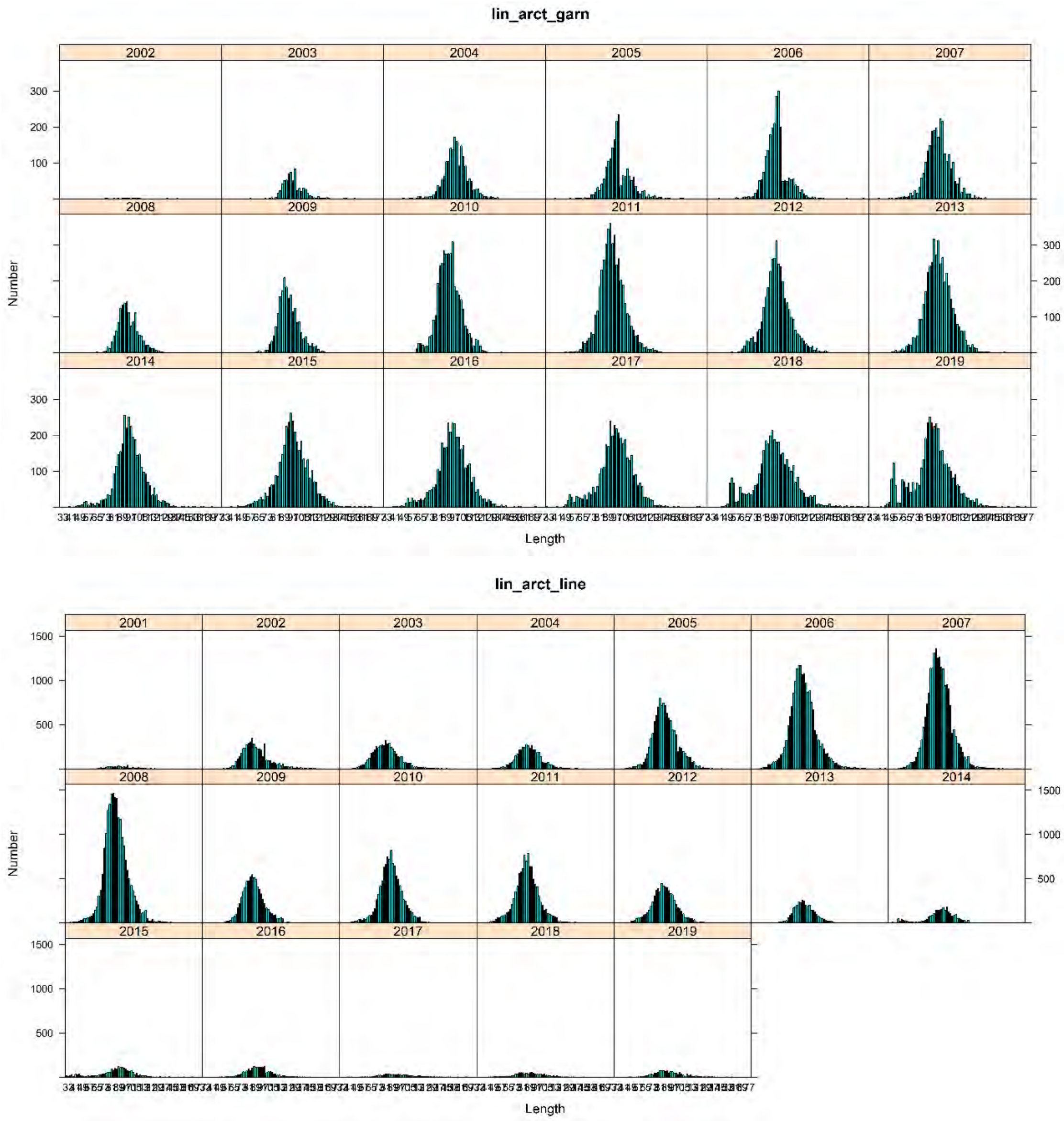

Figure 3.3.11. Ling in arctic waters (1, 2.a, 2.b), upper panel are length data from gillnetters, lower are from longliners. Catch length distributions, 2 cm length classes, for the period 2001–2019 (sex combined).

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.

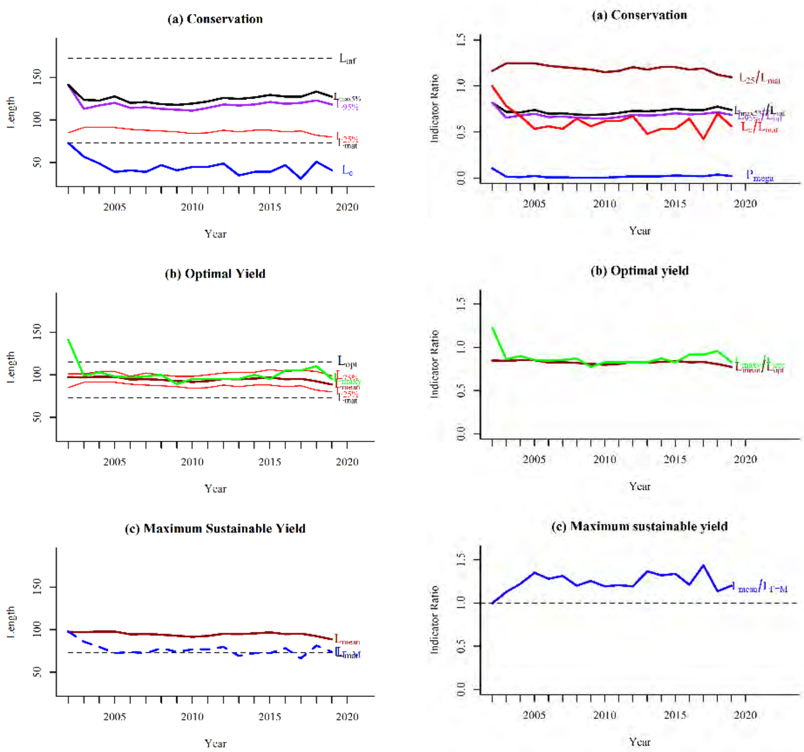

Figure 3.3.12a. Ling from gillnetters in arctic waters (1, 2.a, 2.b). Screening of the length indicator ratios for sex combined under three scenarios: (a) Conservation; (b) Optimal yield; and (c) maximum sustainable yield.

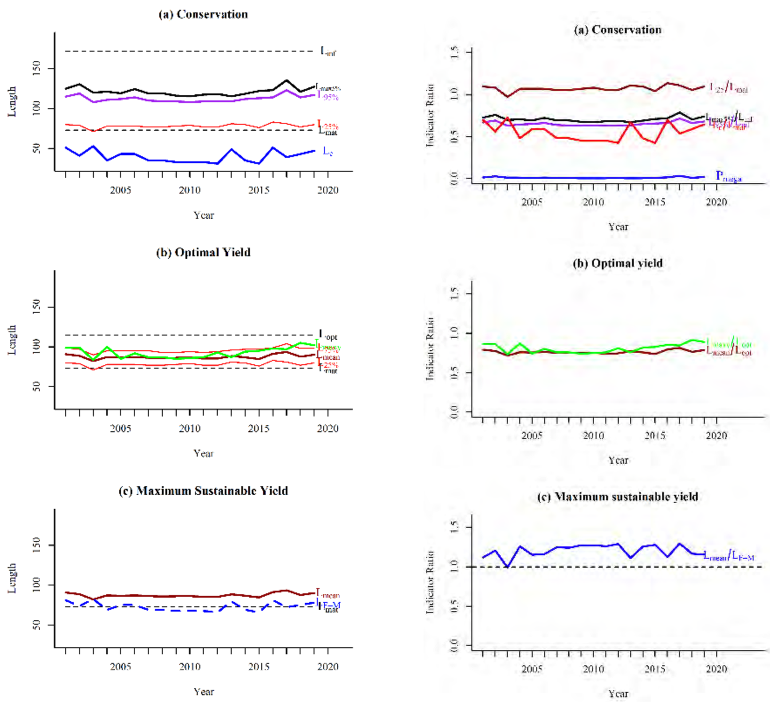

Figure 3.3.12b. Ling from longliners in arctic waters (1, 2.a, 2.b). Screening of the length indicator ratios for sex combined under three scenarios: (a) Conservation; (b) Optimal yield; and (c) maximum sustainable yield.

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 2016–2019, $L_{25\%}/L_{mat}$ 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 2017–2019 (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.

Conclusion: The overall perception of the stock during the period 2017–2019 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**
2017	0,42	1,19	0,74	2 %	0,83	1,44
2018	0,70	1,12	0,78	4 %	0,81	1,14
2019	0,56	1,10	0,74	2 %	0,77	1,20

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**
2017	0,53	1,11	0,79	3 %	0,82	1,30
2018	0,59	1,05	0,70	1 %	0,77	1,17
2019	0,64	1,10	0,74	2 %	0,79	1,15

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			
	2017	2018	2019	
MSY (F/F_{MSY})	✓	✓	✓	Fished sustainably

	Stock size			
	2017	2018	2019	
MSY $B_{trigger}$.(B/B_{MSY})	?	?	?	Unknown

<u>Results for the SPiCT model</u>:

The first run was carried out with standard settings in SPICT, and with catch data and CPUE for all available years. The model converged, and the plots from the diagnostics looked good, but there were large confidence intervals in the estimates (BMSY, MSY, FMSY, and K) (Tables 3.3.4 and 3.3.5).

There were 8 runs where the parameters n, α and β were varied and the landings period varied (Table 3.3.4). Overall, run number 7 was considered the best since the confidence intervals were smallest (Table 3.3.4).

The model estimates MSY of 12939 tons. The advice for 2020 and 2021 was 15 593 tons, so below the advice. Associated estimated BMSY was 81 551 tons, and FMSY was 0.159. The estimated carrying capacity (K) was about 160 000 tons.

The model indicates that the stock abundance is greater than BMSY and the fishing mortality is less than FMSY and will remain less than FMSY if future catches continue to be kept at the same level as in the previous years. The traffic light figure shows that the stock started in the red zone and are now in the green zone (Figure 3.3.13). This corresponds to the current perception of the development of the stock. The diagnostics do not show any patterns in the residuals and no significance for bias, auto correlation or normality. The retrospective plot showed that the test is robust.

Table 3.3.5. Ling in Subareas 1 and 2

Run	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	***9***
Landings period	1988-2018							2000-2018	
CPUE	2000-2018							2000-2018	
Parameter settings									
n	mod.est	no priors	2	mod.est	2	2	2	mod.est	no priors
Alfa	mod.est	no priors	1	1	mod.est	1	4	mod.est	no priors
Beta	mod.est	no priors	1	1	mod.est	mod.est	1	mod.est	no priors
Convergence	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Parameter estimates									
Bmsy	35198	44761	34364	28231	8209	34364	81511	33108	78729
cilow	4546	3630	4018	4980	38	4019	9626	2489	707
cihigh	272520	551893	293858	160048	1752693	293858	690190	440468	8766289
MSY	11476	12052	10624	11067	10001	10624	12939	11502	13895
cilow	7984	7093	8073	8297	8409	8073	7289	7689	3505
cihigh	16496	20480	13981	14760	11895	13981	22967	17206	55093
Fmsy	0,326	0,269	0,309	0,392	1,218	0,309	0,159	0,347	0,176
cilow	0,059	0,037	0,045	0,088	0,007	0,045	0,033	0,038	0,006

Run	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	***9***
cihigh	1,789	1,981	2,109	1,748	226,517	2,109	0,768	3,141	5,004
K	53361	66490	69135	42045	16438	69135	163195	48755	113952
cilow	7767	6148	8027	8801	78	8027	19247	3889	1035
cihigh	366603	719069	595430	200851	3456111	593430	1383719	611261	12543010
Diagnostics	OK- (shapiro)	OK (Lbox+Bias)	OK	OK-(shapiro)	OK-(shapiro)	OK	OK-(shapiro)	OK	OK
Retrospective	negative	negative	OK-	OK-	negative	OK	OK-	negative	negative

Table 3.3.5. Ling in Subareas 1 and 2

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: -34.4008865
Euler time step (years):  1/16 or 0.0625
Nobs C: 31,  Nobs I1: 20

Priors
    logn  ~  dnorm[log(2), 0.001^2] (fixed)
 logalpha  ~  dnorm[log(4), 0.001^2] (fixed)
  logbeta  ~  dnorm[log(1), 0.001^2] (fixed)

Model parameter estimates w 95% CI
          estimate        cilow        ciupp    log.est
 alpha  4.000002e+00 3.992170e+00 4.007849e+00  1.3862948
 beta   1.000001e+00 9.980426e-01 1.001963e+00  0.0000007
 r      3.177545e-01 6.578860e-02 1.534731e+00 -1.1464763
 rc     3.177541e-01 6.578880e-02 1.534724e+00 -1.1464775
 rold   3.177537e-01 6.578880e-02 1.534720e+00 -1.1464786
 m      1.296395e+04 7.283965e+03 2.307316e+04  9.4699279
 K      1.631947e+05 1.924706e+04 1.383719e+06 12.0026993
 q      1.238500e-03 1.573000e-04 9.748800e-03 -6.6938719
 n      2.000002e+00 1.996086e+00 2.003926e+00  0.6931483
 sdb    2.388070e-02 1.725370e-02 3.305290e-02 -3.7346866
 sdf    1.055306e-01 8.138800e-02 1.368348e-01 -2.2487539
 sdi    9.552270e-02 6.901520e-02 1.322111e-01 -2.3483918
 sdc    1.055307e-01 8.138830e-02 1.368346e-01 -2.2487532

Deterministic reference points (Drp)
         estimate        cilow        ciupp   log.est
 Bmsyd 8.159739e+04 9623.5418127 6.918590e+05 11.309553
 Fmsyd 1.588771e-01    0.0328944 7.673620e-01 -1.839625
 MSYd  1.296395e+04 7283.9652244 2.307316e+04  9.469928
Stochastic reference points (Srp)
         estimate        cilow        ciupp   log.est  rel.diff.Drp
 Bmsys 8.151099e+04 9626.3907236 6.901902e+05 11.308493 -0.0010600489
 Fmsys 1.587355e-01    0.0328189 7.677588e-01 -1.840516 -0.0008917379
 MSYs  1.293868e+04 7289.2524792 2.296661e+04  9.467976 -0.0019534239

States w 95% CI (inp$msytype: s)
                  estimate        cilow        ciupp    log.est
 B_2019.00       8.807678e+04 1.105649e+04 7.016258e+05 11.3859642
 F_2019.00       1.242176e-01 1.537140e-02 1.003812e+00 -2.0857206
 B_2019.00/Bmsy 1.080551e+00 7.827488e-01 1.491654e+00  0.0774711
 F_2019.00/Fmsy 7.825442e-01 4.370169e-01 1.401263e+00 -0.2452048

Predictions w 95% CI (inp$msytype: s)
                prediction        cilow        ciupp    log.est
 B_2020.00       8.984016e+04 1.084985e+04 7.439049e+05 11.4057874
 F_2020.00       1.252842e-01 1.537950e-02 1.020587e+00 -2.0771704
 B_2020.00/Bmsy 1.102185e+00 8.178692e-01 1.485337e+00  0.0972943
 F_2020.00/Fmsy 7.892638e-01 4.326632e-01 1.439774e+00 -0.2366547
 Catch_2020.00  1.134257e+04 8.990874e+03 1.430938e+04  9.3363181
 E(B_inf)       9.849968e+04           NA           NA 11.4978085
```

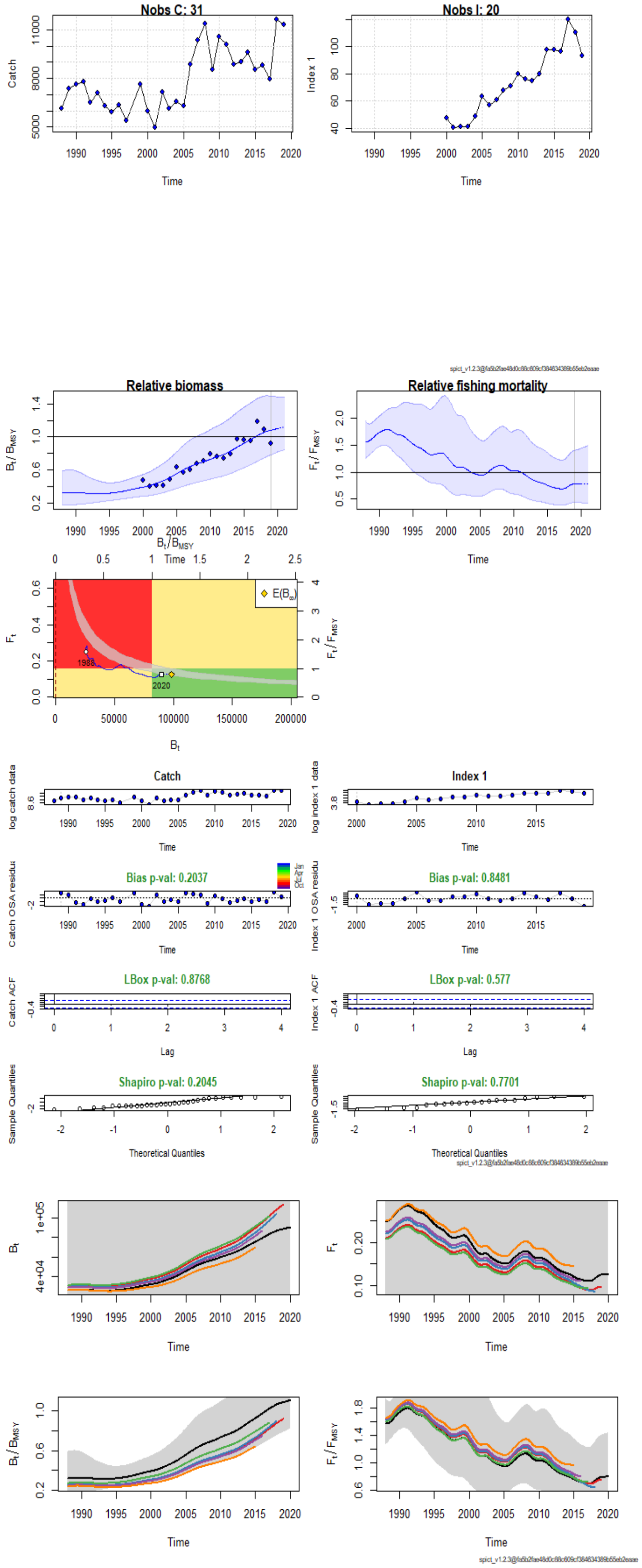

Figure 3.3.13. Ling in Subareas 1 and 2. Upper left corner shows the input data for the model, upper right corner the model output, lower left corner the model diagnostics and the lower right corner the retrospective analysis.

3.3.10 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

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

Year	Faroes	France	Germany	Norway	E & W	Scotland	Russia	Ireland	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	Faroes	France	Germany	Norway	E & W	Scotland	Russia	Ireland	Iceland	Spain	Greenland	Poland	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

*** *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
2007	180		0		180

Year	Norway	E & W	Faroes	France	Total
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

*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
2000	69	5891	4	5964
2001	66	4858	33	4957

Year	1	2.a	2.b	All areas
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	11316	55	11408

***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 3.1.1 and Table 3.1.1) which has increased since 2000 to around 60% in 2018. At the same time the proportion caught by gillnets has decreased from 20–30% in 2000–2007 to around 1.5% in 2019. Catches in trawls have varied less and have been at around 20% of Icelandic catches. (Figure 3.1.1, Table 3.1.1). 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 3.1.2). The main fishing grounds for ling as observed from logbooks are in the south, southwestern and western part of the Icelandic shelf (Figure 3.1.3 and Figure 3.1.4). 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 3.1.3). In recent years the main fishing pressure has shifted towards shallower waters (Figure 3.1.2).

Table 3.1.1: 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

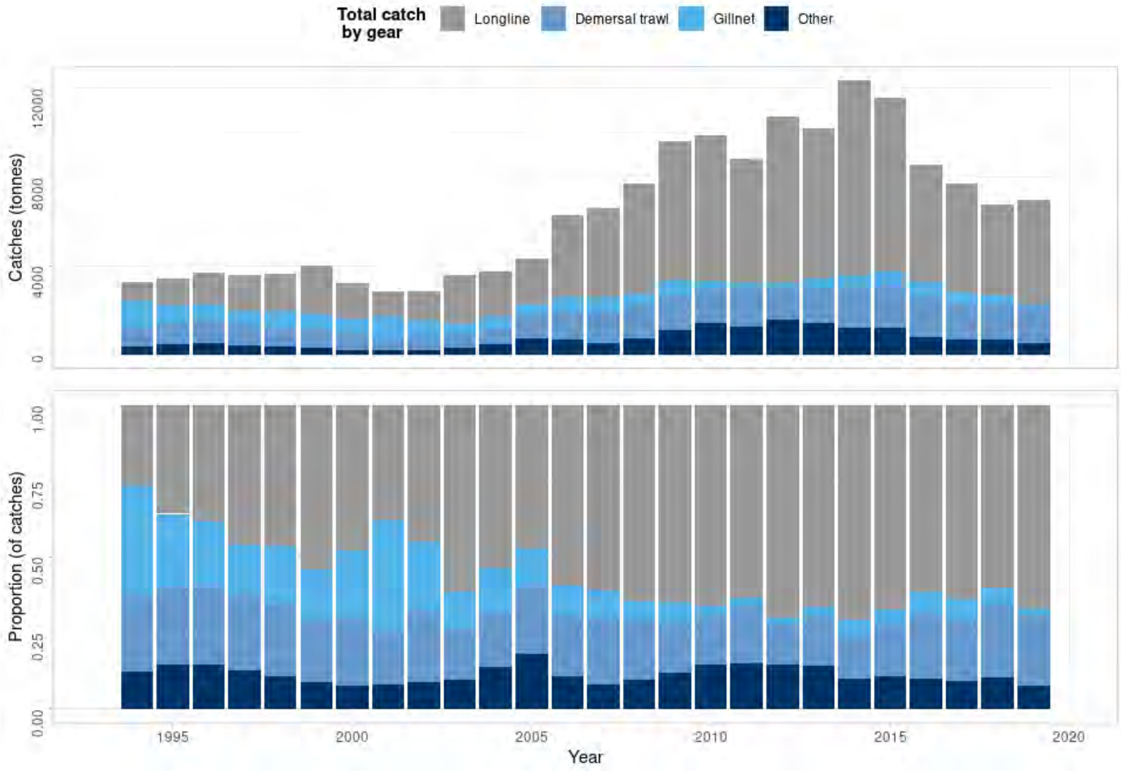

Figure 3.1.1: Ling in 5.a and 14. Commercial catches by gear as registered in Icelandic logbooks.

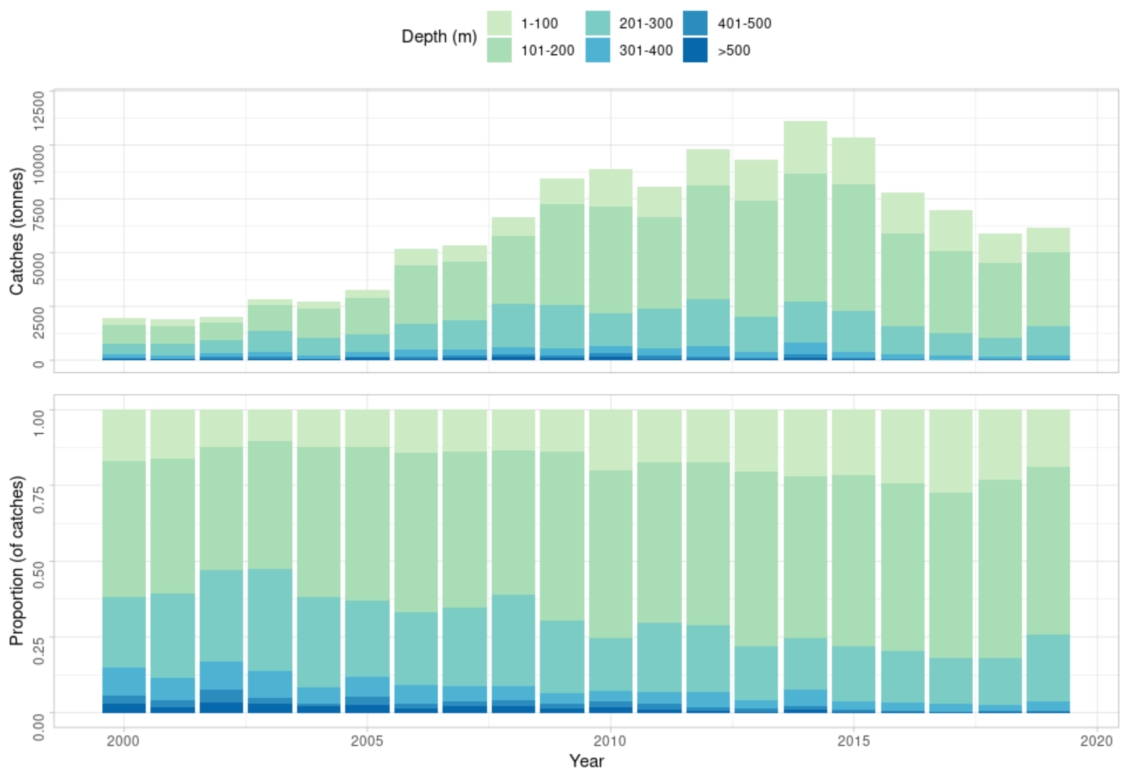

Figure 3.1.2: Ling in 5.a and 14. Depth distribution of catches in 5.a according to logbooks. All gears combined.

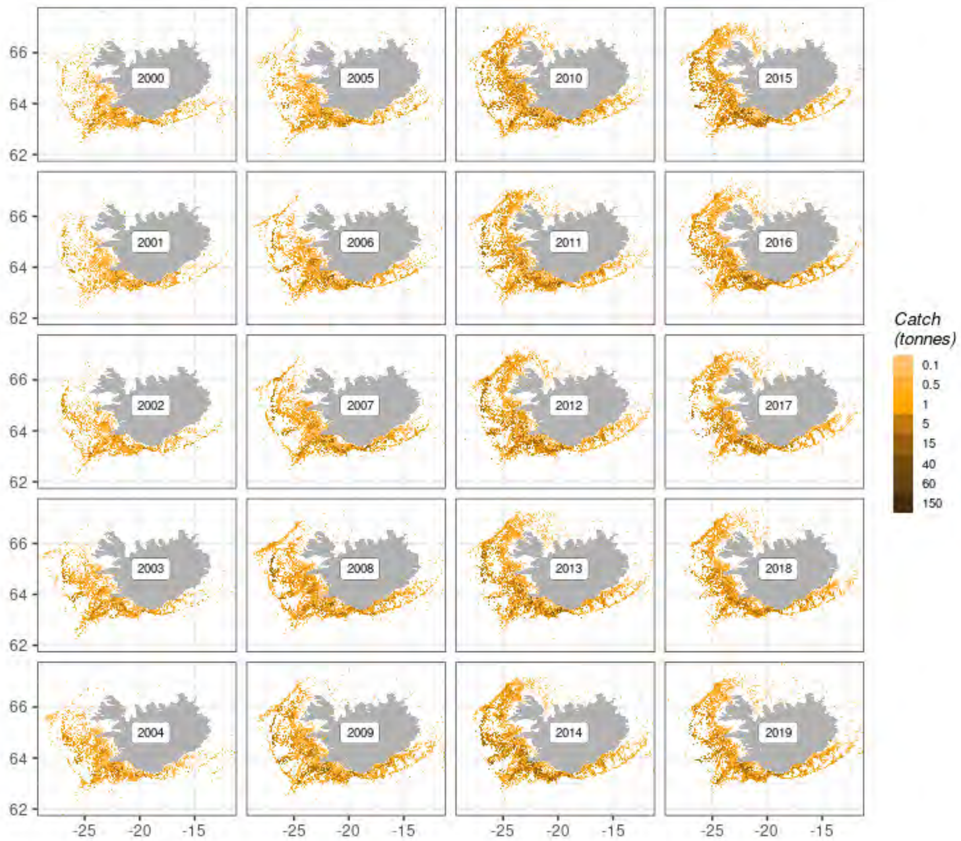

Figure 3.1.3: Ling in 5.a and 14.. Spatial distribution of the Icelandic fishery catches as reported in logbooks. All gears combined.

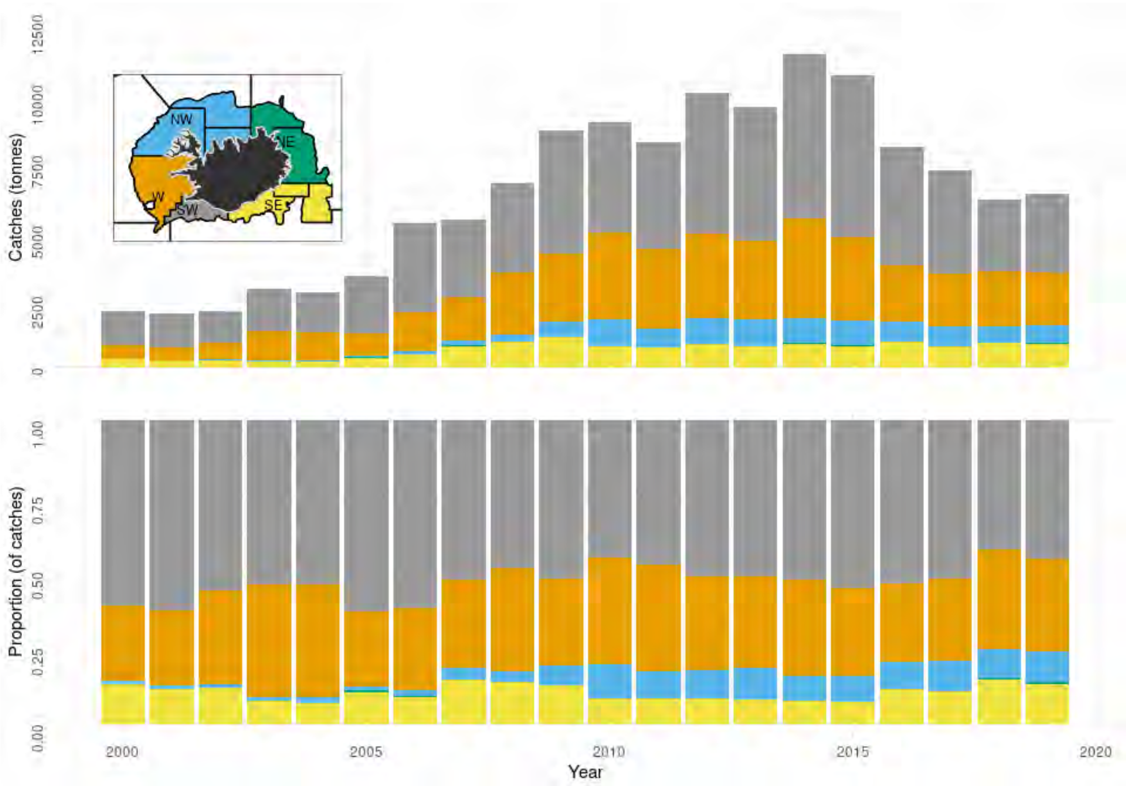

Figure 3.1.4: Ling in 5.a and 14. Changes in spatial distribution of the Icelandic fishery as reported in logbooks. All gears combined.

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 8269 tonnes in 2019 (Table 3.1.2 and Figure 3.1.5).

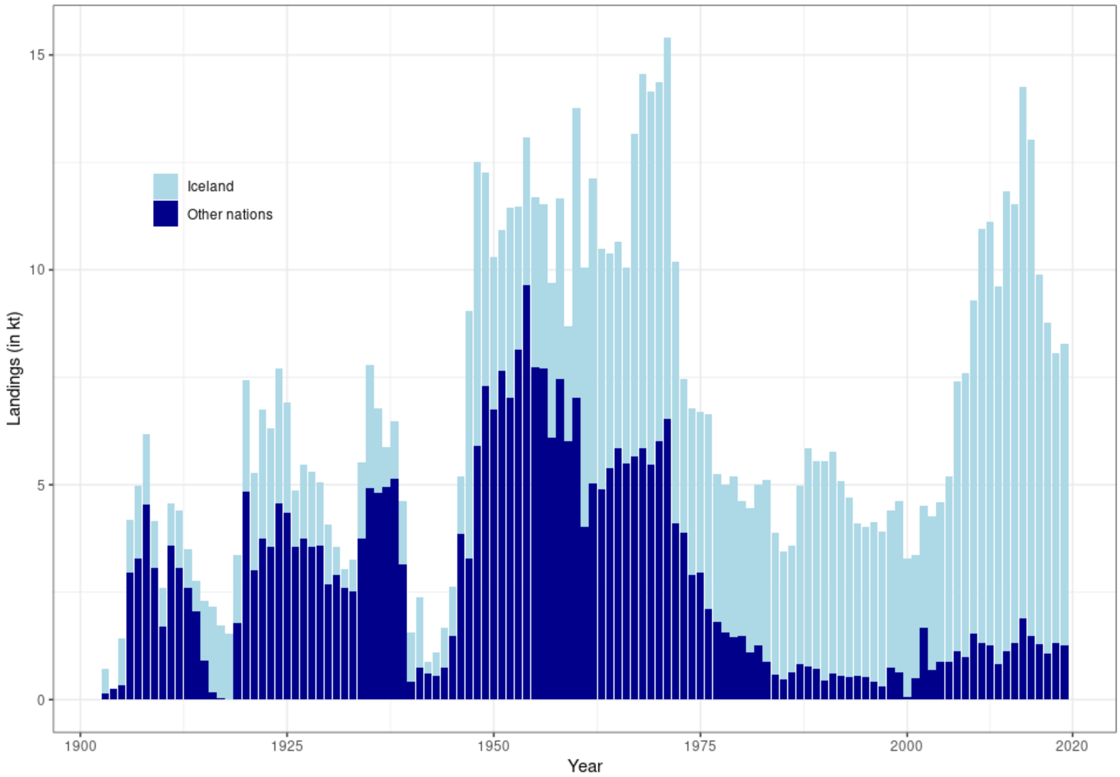

Figure 3.1.5: Ling in 5.a and 14. Landings in 5.a

Table 3.1.2: Ling in 5.a and 14. Landings (tonnes) by country 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
2003	16	13	62	9	3590
2004	18	15	54	14	3727
2005	23	12	47	18	4315

Year	Bottom trawl	Gill nets	Longlines	Other	Total
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

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 3.1.6, ICES (2012)).

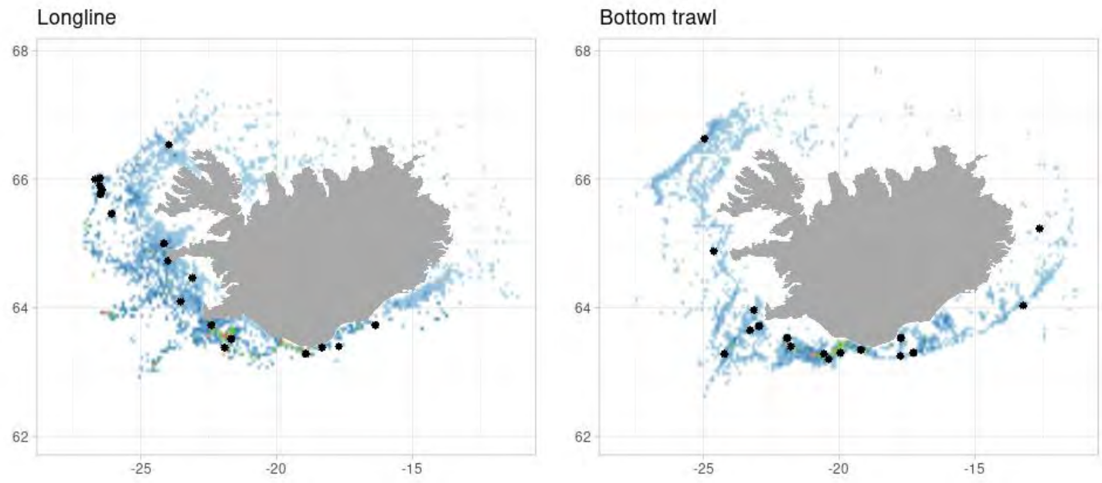

Figure 3.1.6: Ling in 5.a and 14. Fishing grounds in 2019 as reported by catch in logbooks (tiles) and positions of samples taken from landings (asterisks) by longliners and trawlers.

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 longline 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 3.1.3. 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 trawling fleet are presented in Figure 3.1.7. Sampling from commercial catches of ling is considered good; both in terms of spatial and temporal distribution of samples (Figure 3.1.6). Mean length as observed in length samples from longliners decreased from 2000-2008 from around 91 to 80 cm (Figure 3.1.7). This may be the result of increased recruitment in recent years rather than increased fishing effort. Mean length has varied in the period 2009-2018 between 82-96 cm with no clear trend. 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.

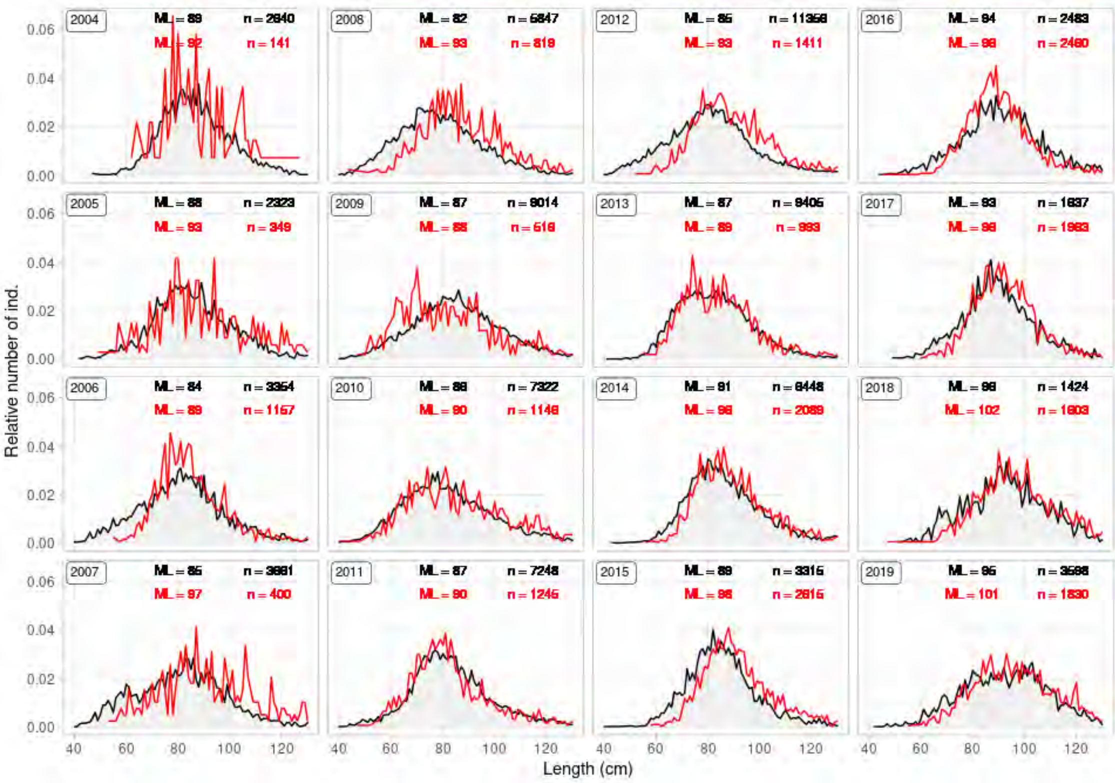

Figure 3.1.7: Ling in 5.a and 14. Length distribution from the Icelandic fleet (black line and grey area) and trawls (red line) from 2004-2019.

Table 3.1.3: 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
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

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 3.1.3). 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 3.1.8 shows both a recruitment index and the trends in biomass from both surveys. Length distributions from the spring survey are shown in Figure 3.1.9 (abundance) and changes in spatial distribution in the spring survey are presented in Figure 3.1.10.

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 3.1.8). In the years 1995 to 2003 these indices were half of the mean from 1985–1989. In 2003 to 2007, the indices increased and have been for the last five years the highest in the time-series. The index of the large ling (80 cm and larger) shows similar trend as the total biomass index (Figure 3.1.8). 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 but has since then started showing signs of an upward trend that has levelled off in the past two years (Figure 3.1.8). 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 3.1.8).

The shorter autumn survey shows that biomass indices were low from 1996 to 2000 but have increased since then (Figure 3.1.8). 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 3.1.8). 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 in recent years 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.

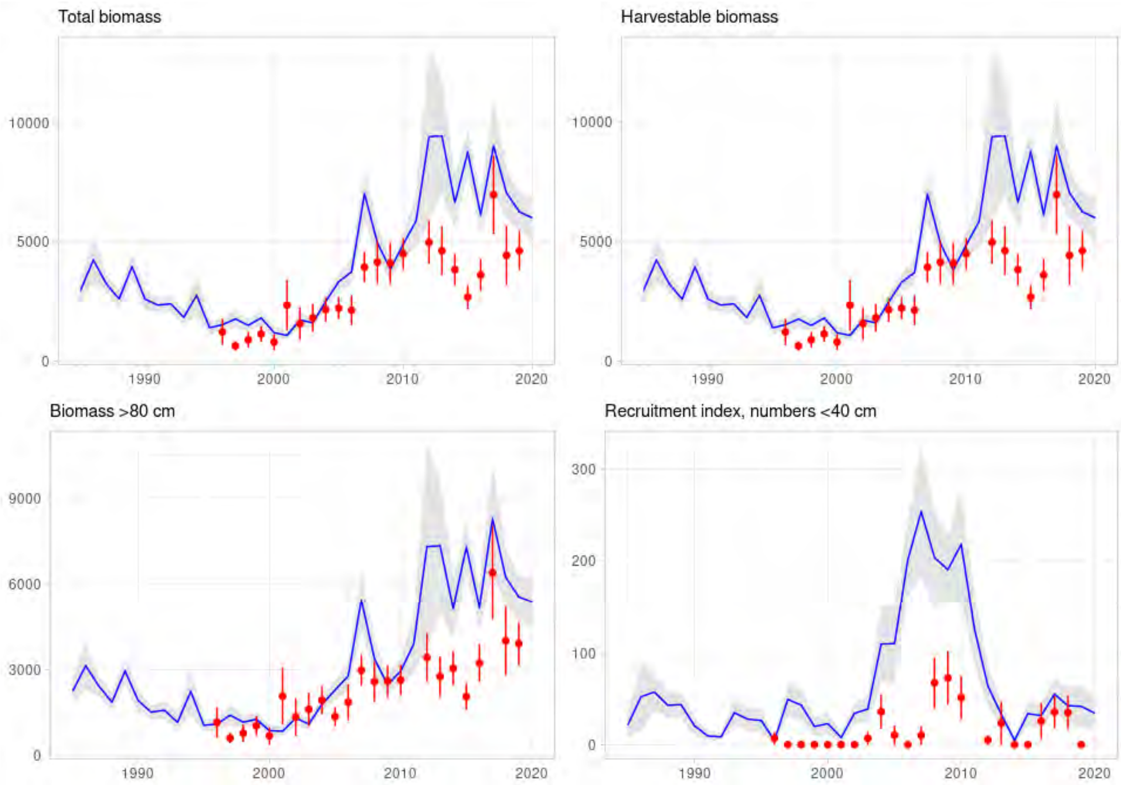

Figure 3.1.8: Ling in 5.a. and 14. a - Total biomass indices, b - biomass indices larger than 40 cm, c - biomass indices larger than 80 cm and d - abundance indices <40 cm. The lines with shaded area show the spring survey index from 1985 and the points with the vertical lines show the autumn survey from 1997. The shaded areas and vertical lines indicate +/- standard error.

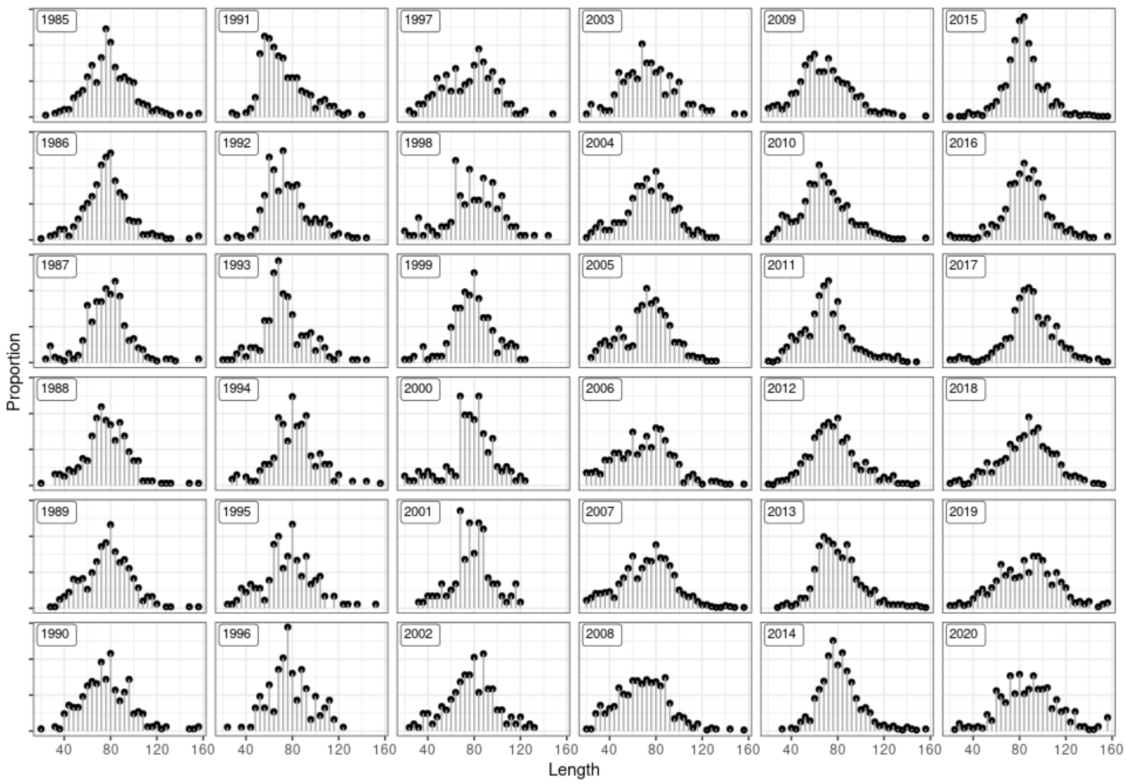

Figure 3.1.9: Ling in 5.a. and 14. Length distribution (3 cm grouping) from the spring survey.

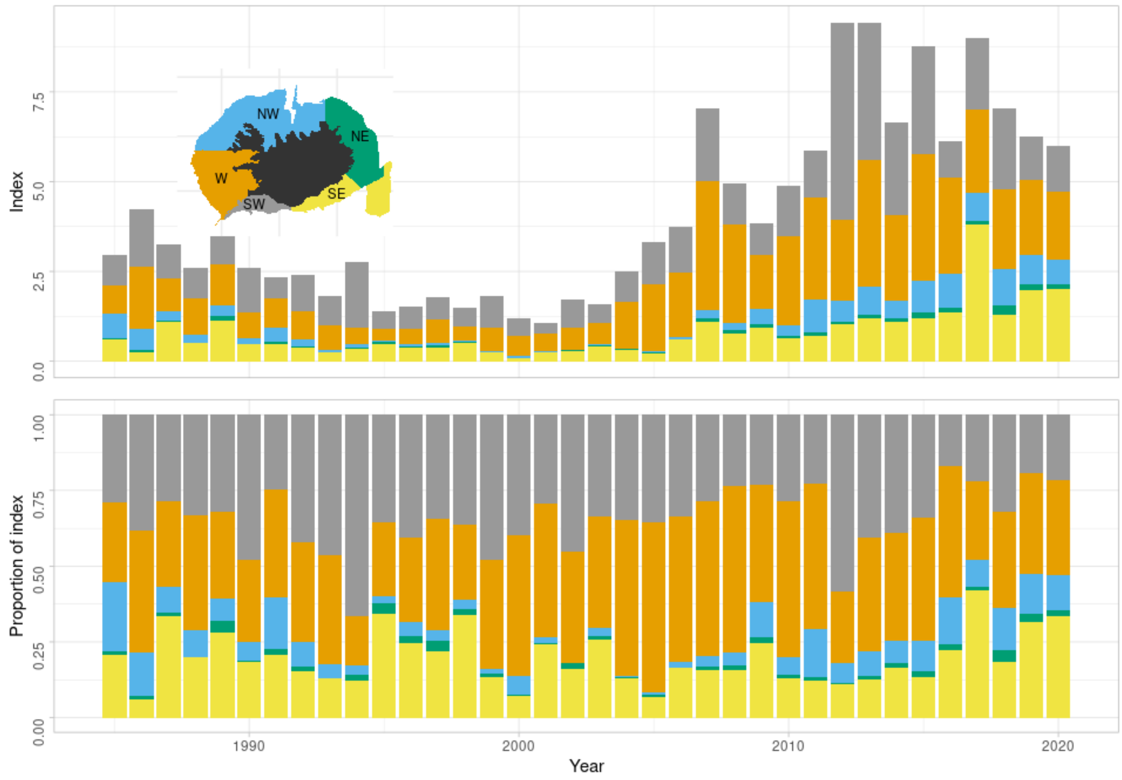

Figure 3.1.10: Ling in 5.a and 14. Estimated survey biomass in the spring survey by year from different parts of the continental shelf (upper figure) and as proportions of the total (lower figure).

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.

3.4.8.3 Diagnostics

3.4.8.3.1 Observed and predicted proportions by fleet

Overall fit to the predicted proportional length and age–length distributions was close to the observed distributions. (Figure 3.1.11, Figure 3.1.12 Figure 3.1.13, Figure 3.1.14). 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.

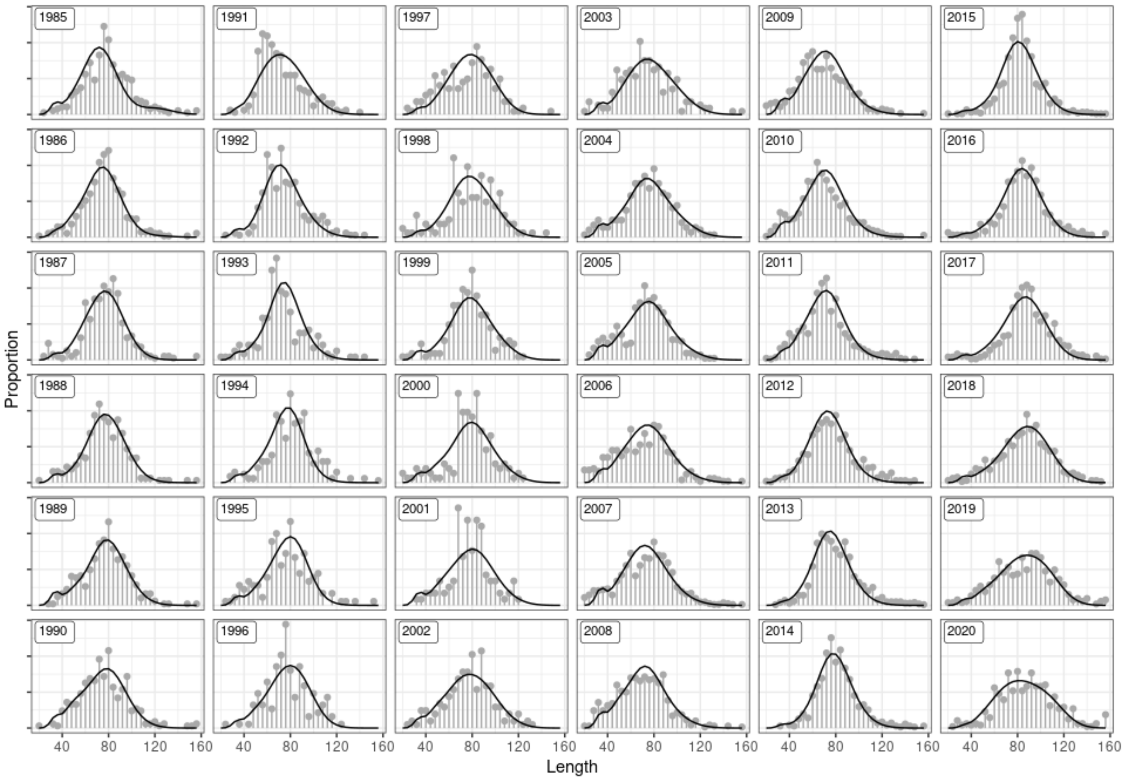

Figure 3.1.11: Ling in 5.a and 14. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the spring survey (grey lines and points)

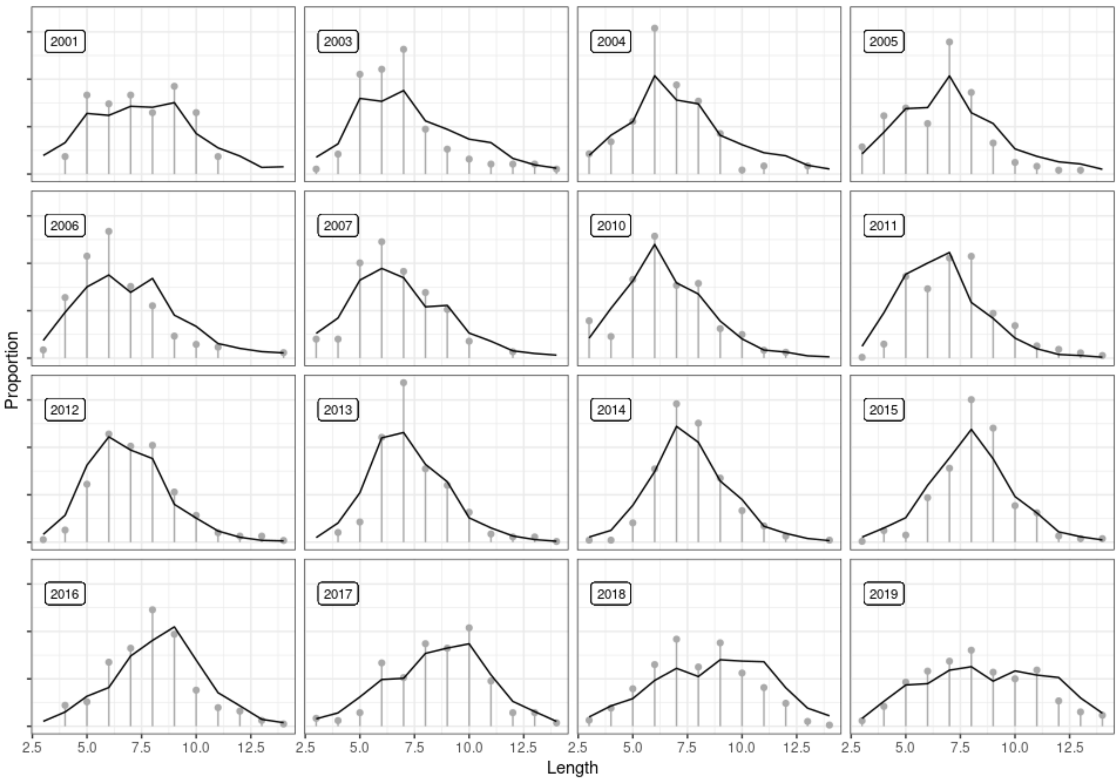

Figure 3.1.12: Ling in 5.a and 14. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the spring survey catches (grey lines and points).

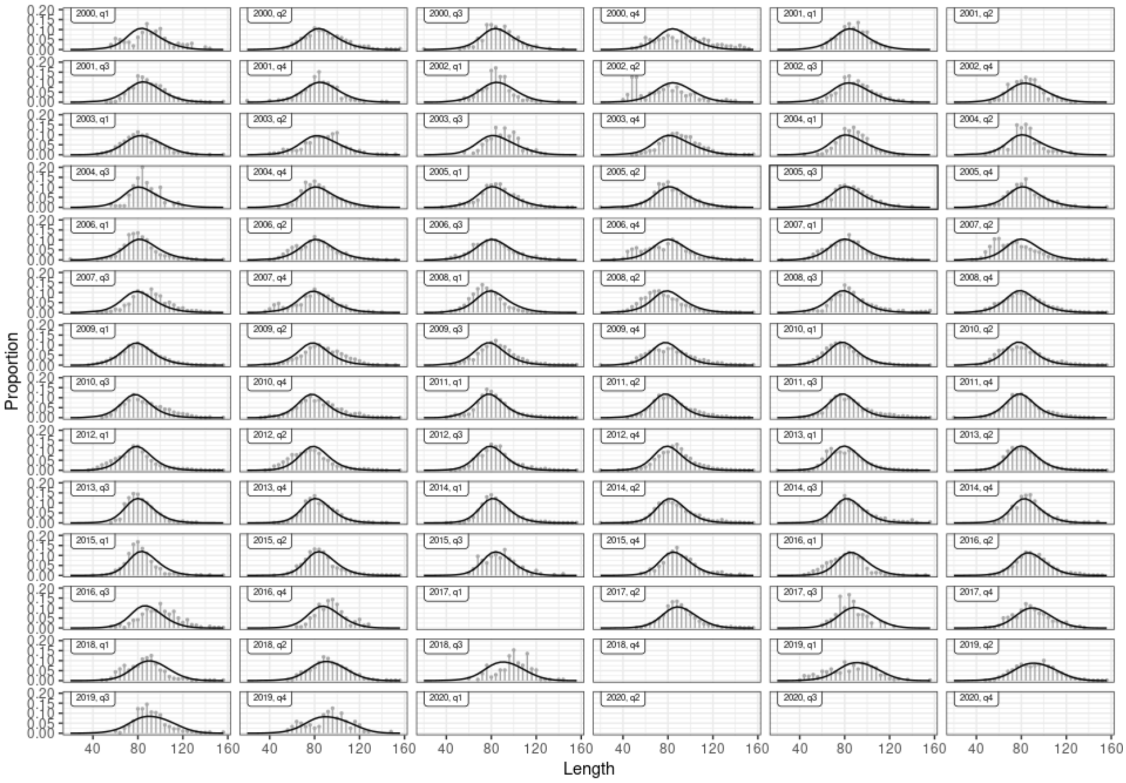

Figure 3.1.13: Ling in 5.a and 14. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from longline catches (grey lines and points).

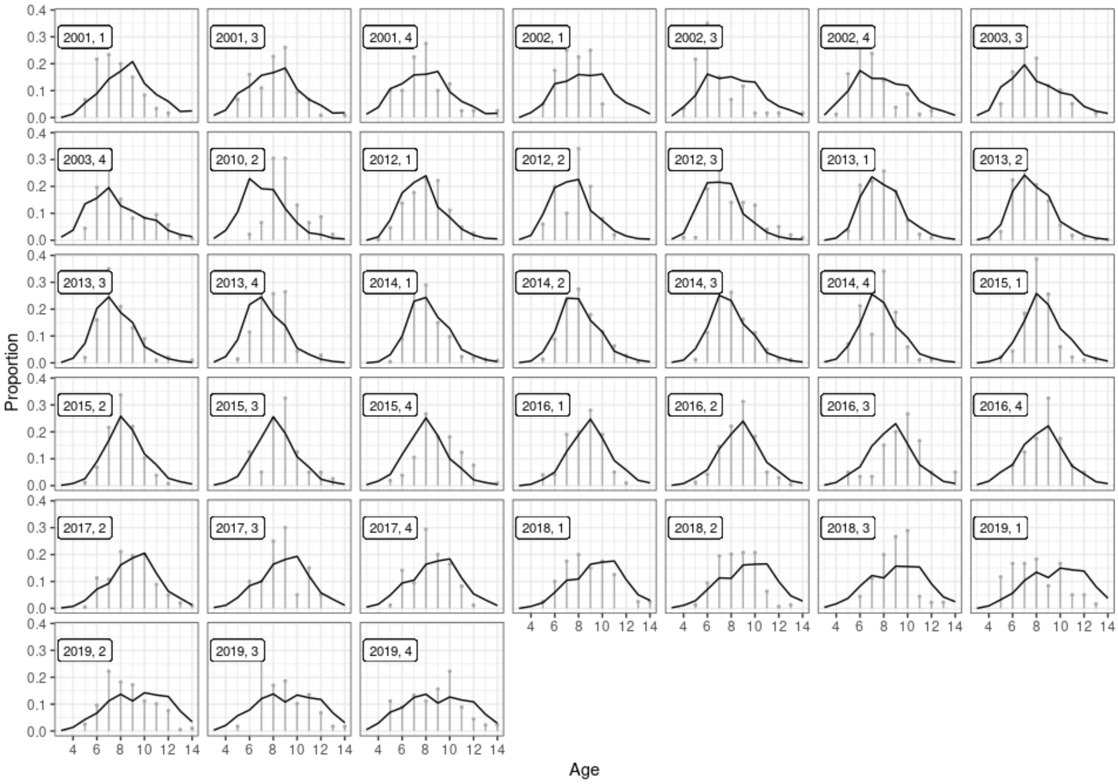

Figure 3.1.14: Ling in 5.a and 14. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in longline catches (grey lines and points).

3.4.8.4 Model fit

Figure 3.1.15 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 groups. Looking at the first three length groups (20–50, 50–60, 60–70) the model appears to discount the recruitment peak observed between 2005 and 2010 as the increase is not observed in the bigger length classes to the same degree. Summed up over survey biomass the model overestimates the biomass in the terminal years.

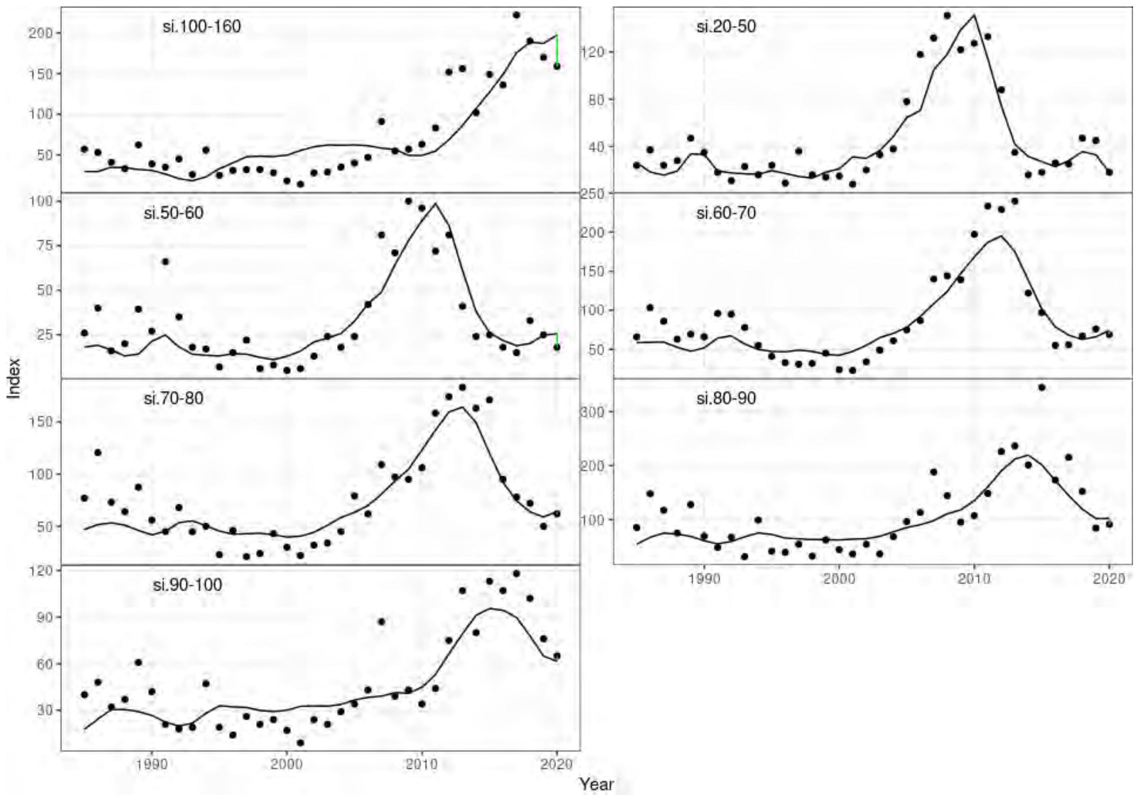

Figure 3.1.15: Ling in 5.a and 14. Fitted spring survey index by length group from the Gadget model (black line) and the observed number of ling caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

3.4.9 Results

The results are presented in Table 3.1.6 and Figure 3.1.16. Recruitment peaked in 2009 to 2010 but has decreased and is estimated to be at rather low level from 2012-present, with only a slight recovery in the last few years. Spawning–stock biomass has increased since 2000 and reached the highest SSB estimate in the time-series in 2015. Similarly, harvestable biomass is estimated to have decreased from the peak. Fishing mortality for fully selected ling (age 14–19) has decreased from 0.75 in 2009 to 0.26 over the past several years. This year's assessment shows an downward revision of SSB and an upward revision of fishing mortality compared to last year's assessment (Figure 3.1.17). As the spawning stock biomass has passed its peak levels exhibited during 2014 - 2018, which occurred due to the peak age 1 recruitment 2007 - 2011, it is expected that over the next several years, spawning stock biomass and harvestable biomass levels will decrease. It is also likely that downward corrections in biomass levels will accompany this trend, as this is a common pattern in retrospective analyses of analytical assessments as the direction of stock growth changes.

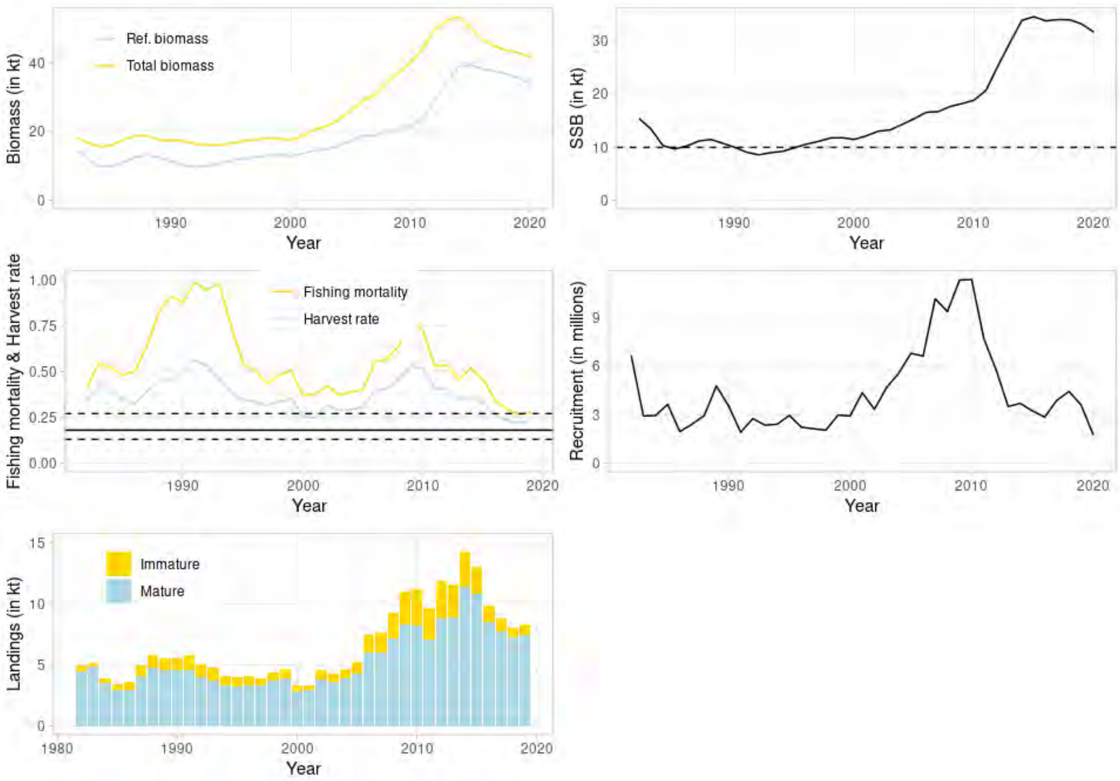

Figure 3.1.16: Ling in 5.a and 14. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes and harvest rate, recruitment and total catches. The dashed line in the SSB plot represents Bpa. The solid line in the harvest rate plot indicates the target harvest rate used 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.

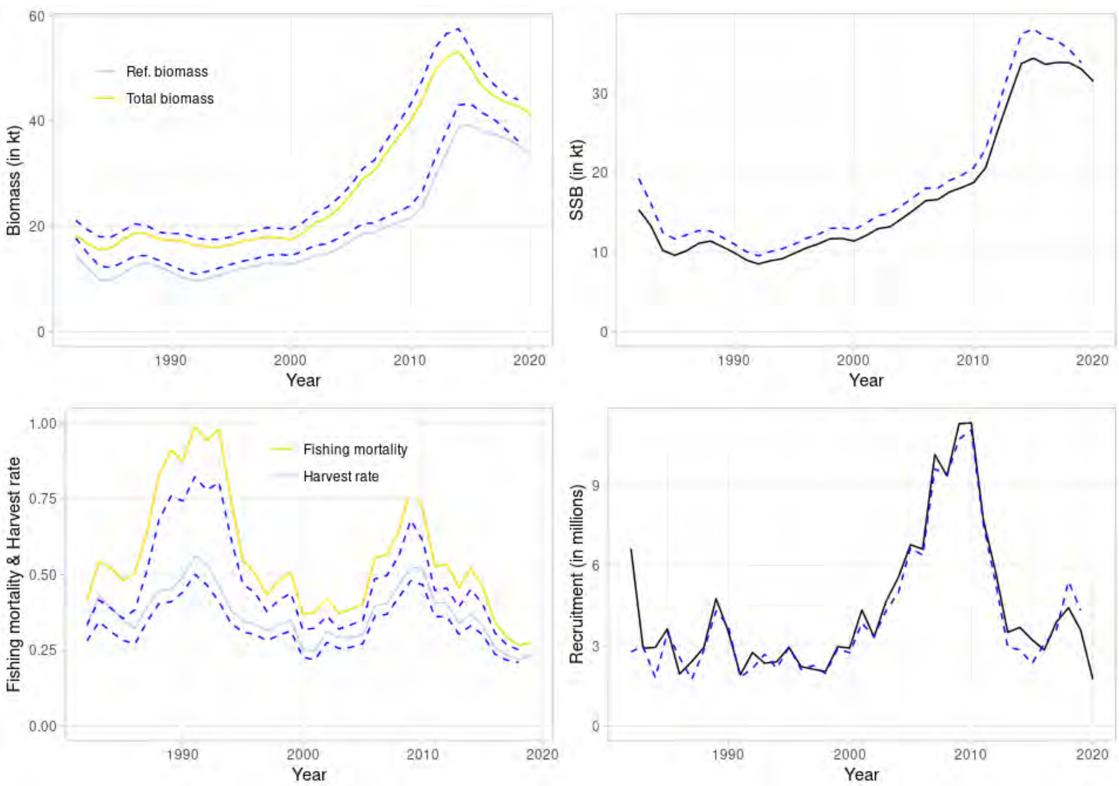

Figure 3.1.17: Ling in 5.a and 14. Commercial catches by gear as registered in Icelandic logbooks.

3.4.9.1 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 0.044 for SSB, -0.046 for F, and 0.099 for recruitment.

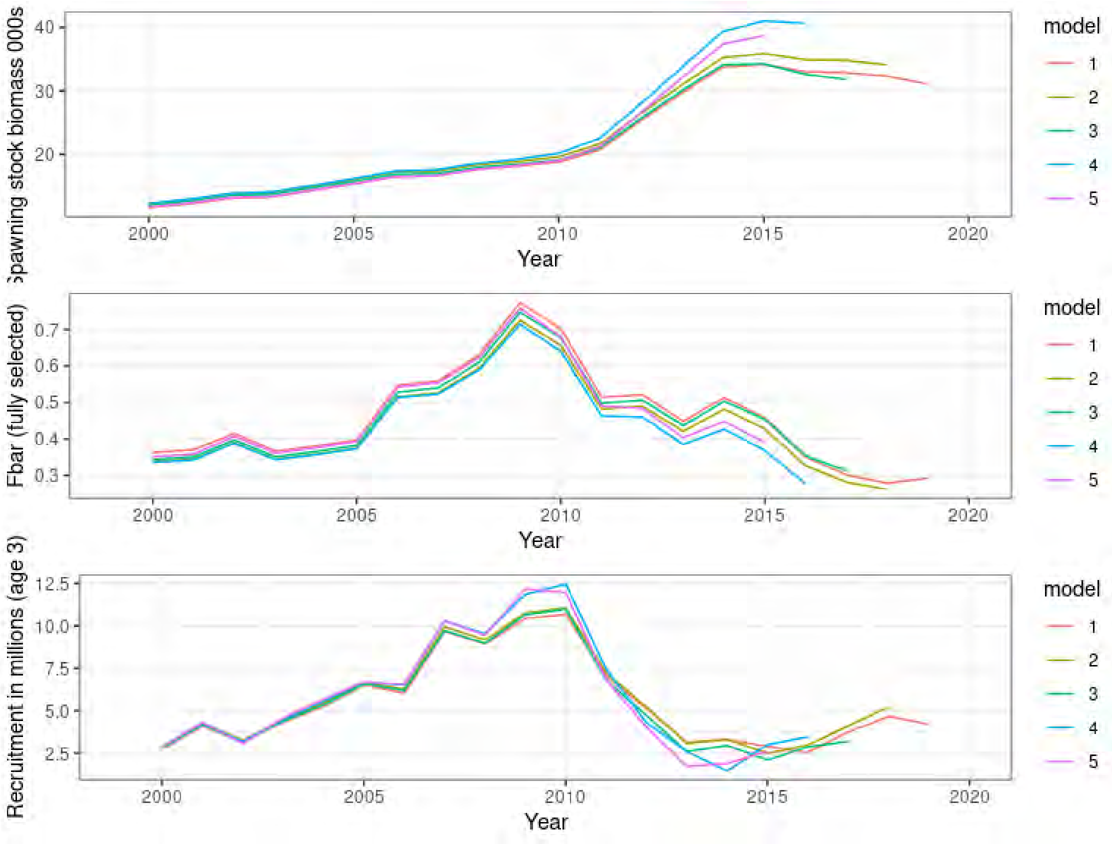

Figure 3.1.18: Ling in 5.a and 14. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 3) are shown.

3.4.10 ICES advice

In 2019, ICES advised that when the Iceland management plan was applied, catches in the fishing year 2019/2020 should be no more than 6 599 tonnes. Due to the Covid 19 disruption, no advice is requested from ICES by Iceland in 2020.

3.4.11 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 3.1.4). 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 3.1.19) 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 3.1.4: 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

Fishing Year	MFRI Advice	National TAC	Landings
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		

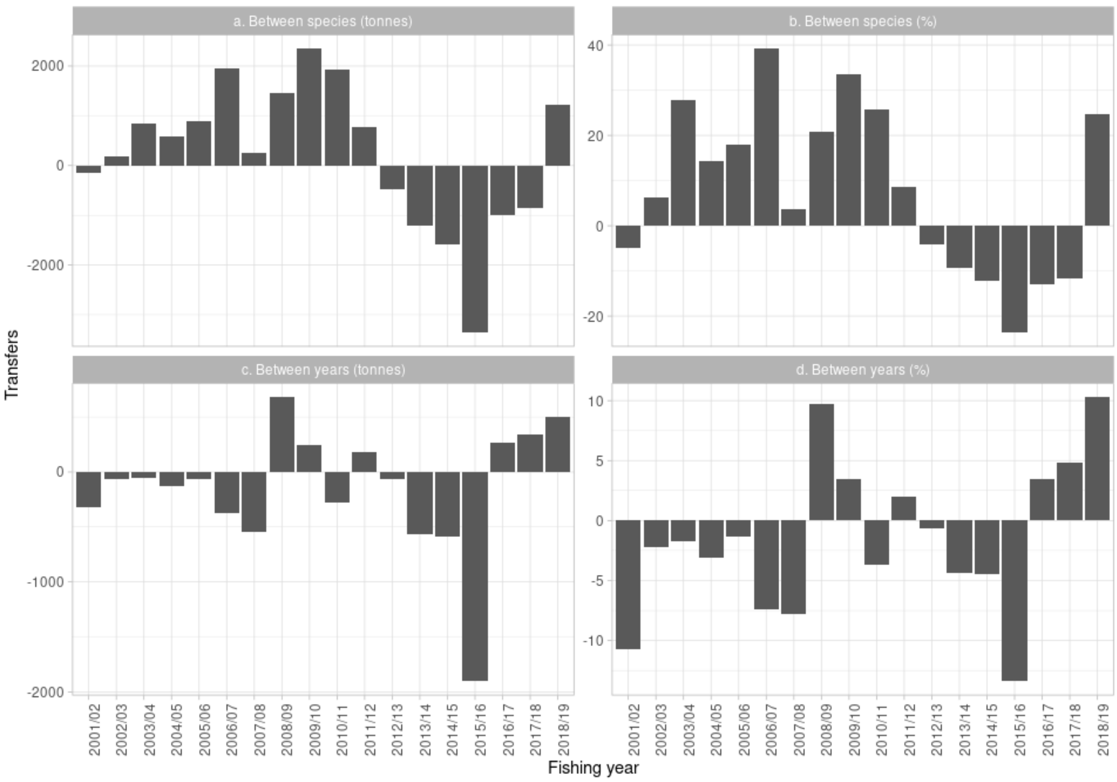

Figure 3.1.19: Ling in 5.a and 14. Net transfer of quota in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to ling, but negative values indicate a transfer of ling quota to other species. Between years (lower): Net transfer of quota for a given fishing year (may include unused quota).

3.4.12 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 3.1.20: 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.

3.4.13 Management considerations

All the signs from commercial catch data and surveys indicate that ling is at present in a good state. 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 3.1.5: 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

Year	Faroe Islands	Germany	Iceland	Norway	UK
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

Table 3.1.6. 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	18221	14374	15339	4133	4990	0.347	0.130
1983	16715	11335	13347	2790	5123	0.452	0.154
1984	15525	8988	10249	2709	3880	0.432	0.124
1985	15999	8732	9616	3474	3449	0.395	0.101
1986	17552	9821	10191	1795	3596	0.366	0.099
1987	18774	11280	11119	2214	4974	0.441	0.126
1988	18613	11683	11404	2836	5846	0.500	0.142
1989	17540	11051	10695	4636	5547	0.502	0.165
1990	17388	10228	9933	3391	5562	0.544	0.217
1991	17238	9154	9012	1661	5786	0.632	0.288
1992	16363	8251	8533	2563	5089	0.617	0.292
1993	16167	8621	8933	2256	4843	0.547	0.194
1994	16105	9376	9186	2261	4605	0.439	0.178

Year	Biomass	B40+	SSB	Rec3	Catch	HR	F
1995	16534	10274	9856	2819	4196	0.387	0.187
1996	17221	10963	10537	2096	4049	0.371	0.183
1997	17598	11339	11040	1969	3934	0.345	0.188
1998	18023	11898	11695	1922	4303	0.366	0.225
1999	17828	12052	11735	2852	4593	0.384	0.265
2000	17518	11767	11417	2810	3288	0.279	0.150
2001	18725	12565	12089	4181	3351	0.267	0.137
2002	20636	13380	12968	3168	4514	0.338	0.244
2003	21579	13470	13190	4438	4279	0.318	0.228
2004	23506	14391	14235	5373	4621	0.322	0.216
2005	25973	15648	15309	6525	5195	0.334	0.205
2006	29011	16909	16487	6310	7433	0.439	0.326
2007	30644	16813	16621	9777	7619	0.453	0.337
2008	34086	17593	17587	8995	9279	0.527	0.419
2009	37070	18089	18127	10758	10948	0.605	0.483
2010	40006	18321	18767	10827	11150	0.609	0.470
2011	44069	20107	20606	7094	9650	0.480	0.337
2012	49526	24962	25204	5170	11829	0.474	0.374
2013	52077	29482	29533	3115	11536	0.391	0.307
2014	53248	34604	33724	3401	14246	0.412	0.359
2015	50126	35774	34388	3054	13036	0.364	0.304
2016	46527	35363	33617	2654	9884	0.279	0.213
2017	44727	35436	33859	3710	8766	0.247	0.189
2018	43531	34921	33821	4271	8062	0.231	0.172
2019	42802	33932	33033	3545	8269	0.244	0.196
2020	41518	32142	31507	3545			0.216

3.4.13.1 Ecosystem considerations

Ling has recently exhibited spatial expansion toward the north (Figure 3.3.2) and a period of high recruitment around 2010 - 2013. 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.

3.4.14 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 Areas 3.a, 4, 6, 7, 8, 9, 10, 12, 14

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 conducted around Shetland and in the Norwegian Deep. There are little activity in Area 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 Area 6 is the Norwegian longline fishery. Catches of ling by trawl fisheries from the UK (Scotland) and from France are primarily bycatches.

When Areas 3–4 and 6–14 are summed over 1988–2019, 42% of the total landings were in Area 4, 30% in Area 6, and 24% in Area 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 27 in 2019. 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 4.a and 6.a. During the period 1974 to 2019 the total number of hooks per year has varied considerably, but with a downward trend since 2000. (For more information see Helle and Pennington, WD 2020).

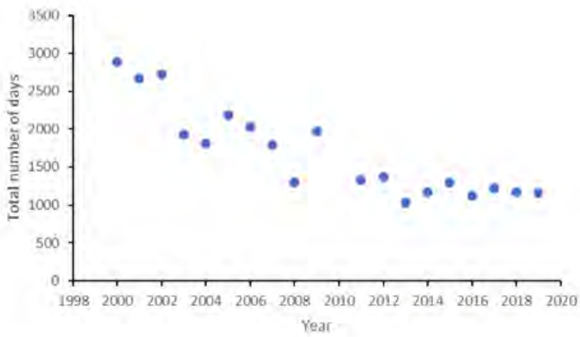

Figure 3.5.1. Total fishing days by the Norwegian longliners (2000-2019).

The French fishery

French fleets operating in 6, 7.bck 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 3.5.1 and 3.5.2.

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 2019 is 20 777t.

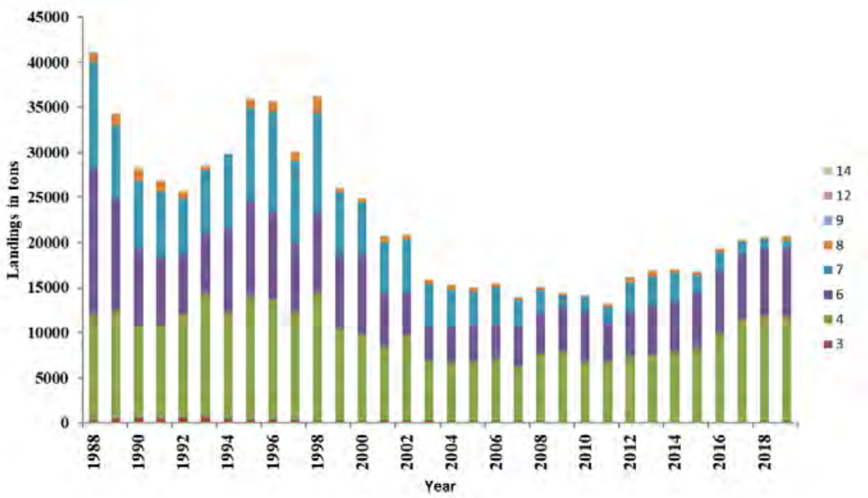

Figure 3.5.1. International landings of ling in areas 3.a, 4, 6, 7, 8, 9, 10, 12, 14.

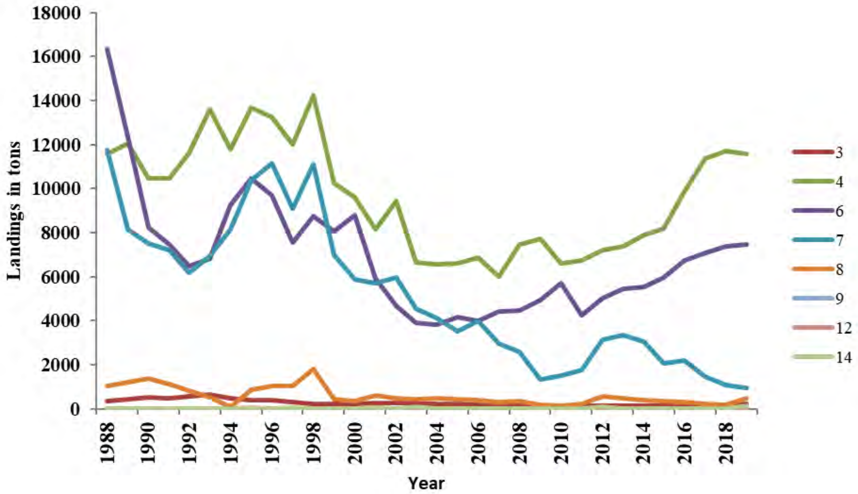

Figure 3.5.2. International landings of ling in areas 3.a, 4, 6, 7, 8, 9, 10, 12, 14.

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 the EC zone is 8000 t. The Faroe Islands has a quota of 200t in 6.a and 6.b. The quota for the EU in the Norwegian zone (Area 4) is set at 1 350 t.

EU TACs for areas partially covered in this section are for 2016–2020

	2016	2017	2018	2019	2020
Subarea 3	87 t	87	87	170	179
Subarea 4	2912 t	3494	3843	4035	4237
Subarea 6, 7 (EU and international waters)	10 297 t.	13 696	12 696	12 196	20396

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 2019, and by area and countries for 2019 (Table 3.5.5). Discarding has been increasing over this period; 1012 tons of ling were discarded in 2018.

Table 3.5.4. Total discards of ling by country for the years 2012 to 2019.

	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

Table 3.5.5 Reported discards in 2019 of ling by area and country for ling in tons.

Area	Country	Discards
27.4	Denmark	3
27.4.a	France	9
27.7.e	France	1
27.7.h	France	3
27.6.a	Ireland	12
27.6.b	Ireland	27
27.7.g	Ireland	29
27.7.j	Ireland	2
27.6.a	Spain	6
27.7.j.2	Spain	2
27.7.f	UK (England)	7
27.7.g	UK (England)	2
27.4.a	UK(Scotland)	914
27.6.a	UK(Scotland)	49
27.6.b.2	UK(Scotland)	30
Total		1096

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 from Areas 4a, 6a, 6b for ling are shown in Figure 3.5.3–3.5.5, respectively. Data are from the Norwegian longline reference fleet.

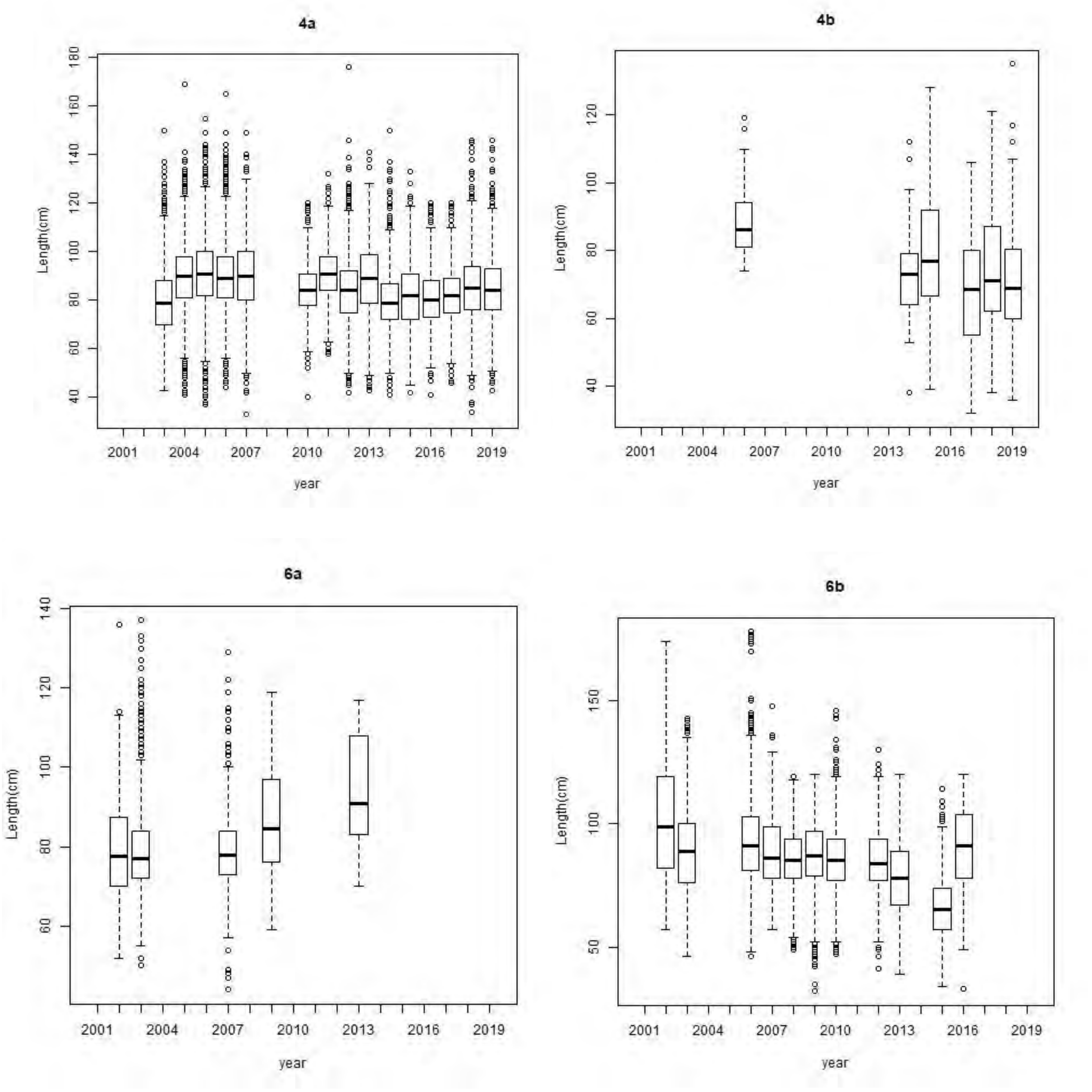

Figure 3.5.3. Box and whisker plots of the annual length distributions of ling based on data from the Norwegian longline reference fleet in Areas 4.a, 4.b, 6.a and 6.b.

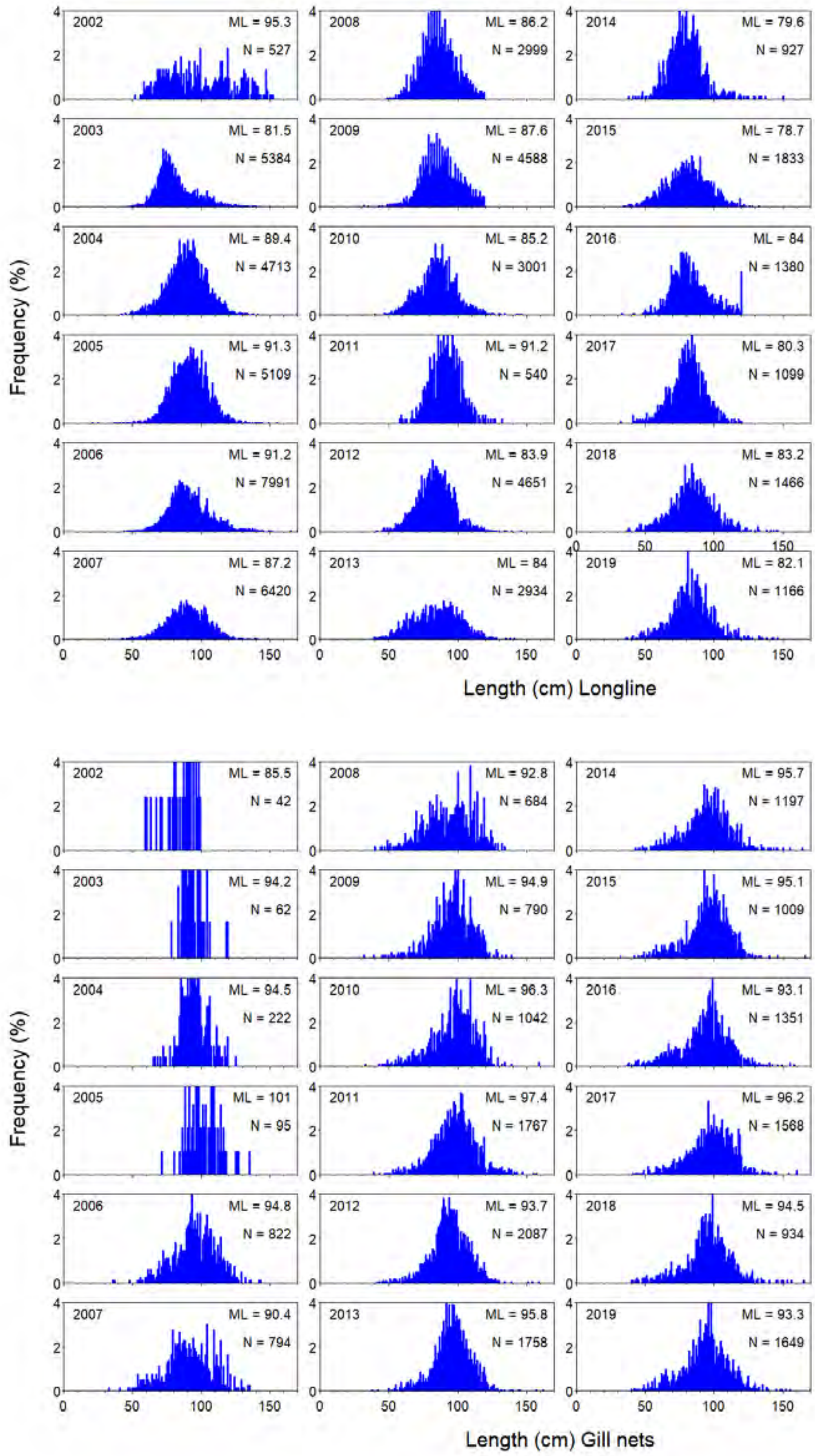

Figure 3.5.4. Length distributions of ling in Areas 3a, 4.a, 6.a and 6.b based on data from the Norwegian reference fleet.

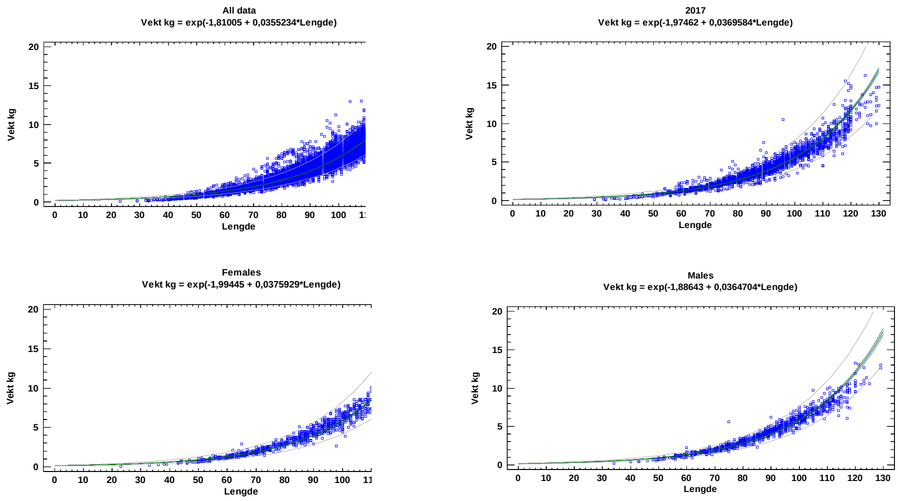

Figure 3.5.5. Weight as a function of length for ling based on all available Norwegian data.

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

In Figure 3.5.6 are the estimated length distributions of ling for the years 2001–2019. (For more information see Ruiz-Pico *et al.*, WD 2020).

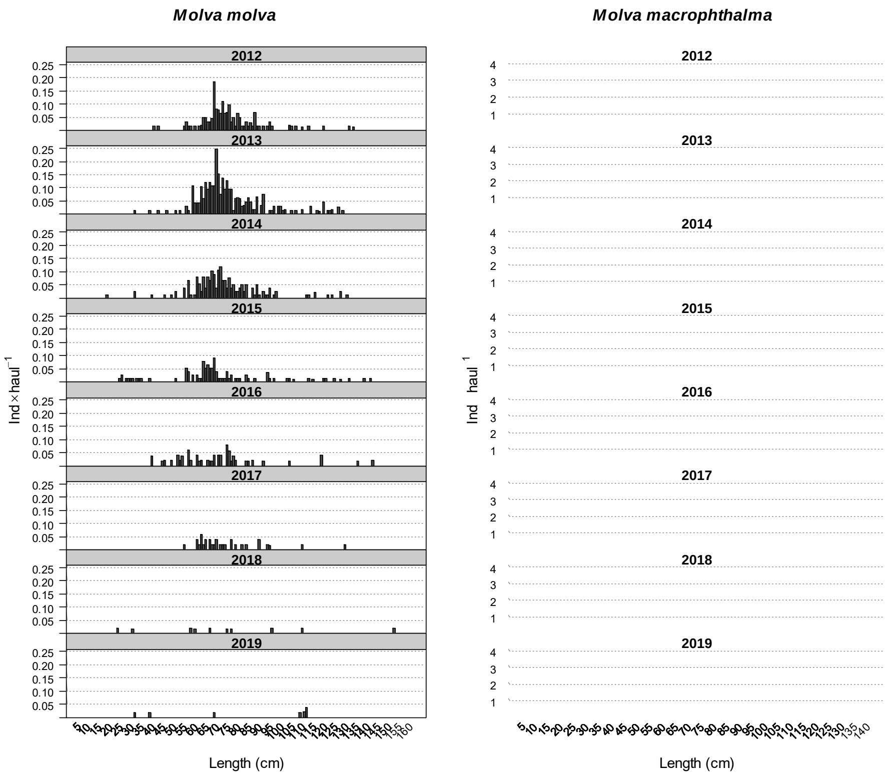

Figure 3.5.6. Estimated length distributions of ling (*M. molva*) based on the Porcupine Bank Spanish survey in the period 2012–2019.

3.5.5.3 Age compositions

Estimated age distributions for the years 2009–2018 based on data from the Norwegian Reference fleet for all areas combined (Figures 3.5.7) and box and whisker plots for the age composition of the fish taken by longliners and gillnetters in Area 4.a (Figure 3.5.8).

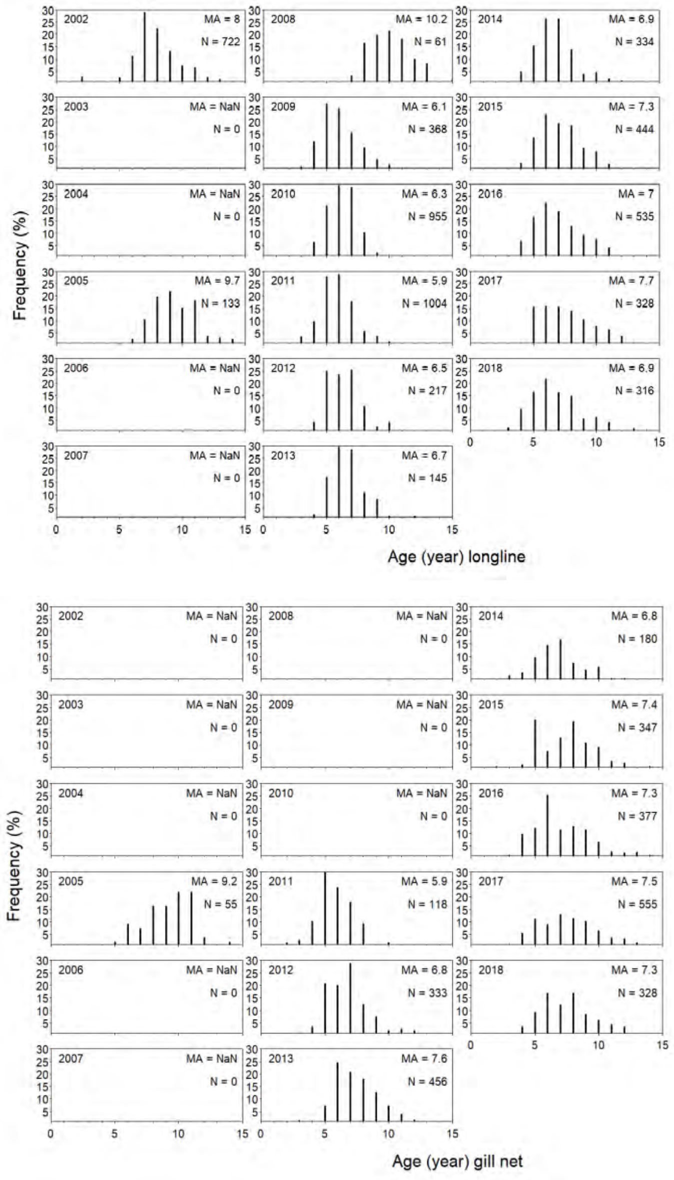

Figure 3.5.7. Age distributions for ling areas combined for all catches taken by longliners and by gill netters.

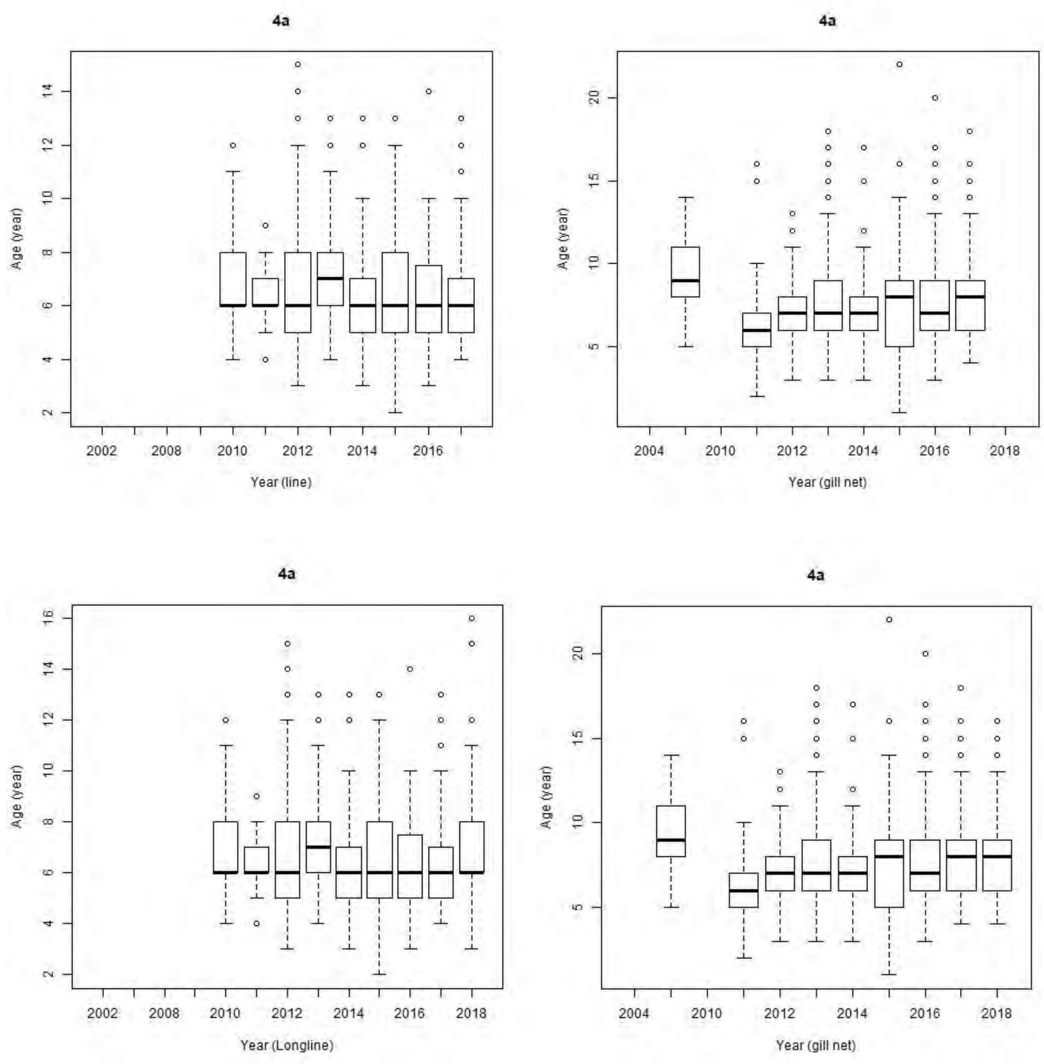

Figure 3.5.8. Age composition of the fish in area 4a taken by longliners and gillnetters.

3.5.5.4 Weight-at-age

Weight and length versus age for combined data from 2009 to 2017 for Areas 4.a and 6.a based on data from the longliners in the Norwegian reference fleet (Figure 3.5.9).

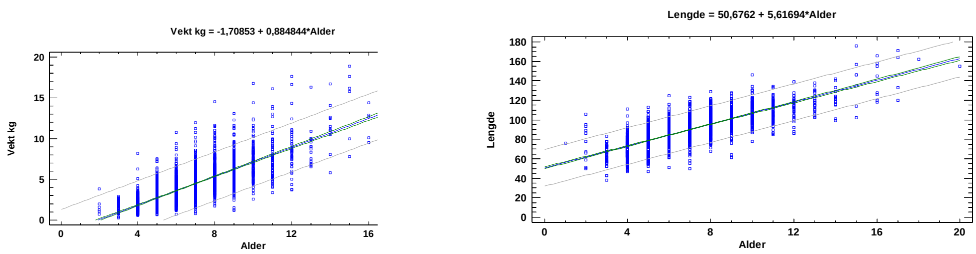

Figure 3.5.9. Weight versus age and length versus age for ling (combined data from 2009 to 2017) for Areas 4.a and 6.a based on the Norwegian longliner reference fleet.

3.5.5.5 Maturity and natural mortality

Maturity ogives for ling are in Figure 3.5.10. The maturity parameters were:

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

The results fit well with ling becomes mature at-ages 5–7 (60–75 cm lengths) in most areas, with males maturing at a slightly lower age than females (Magnusson *et al.*, 1997).

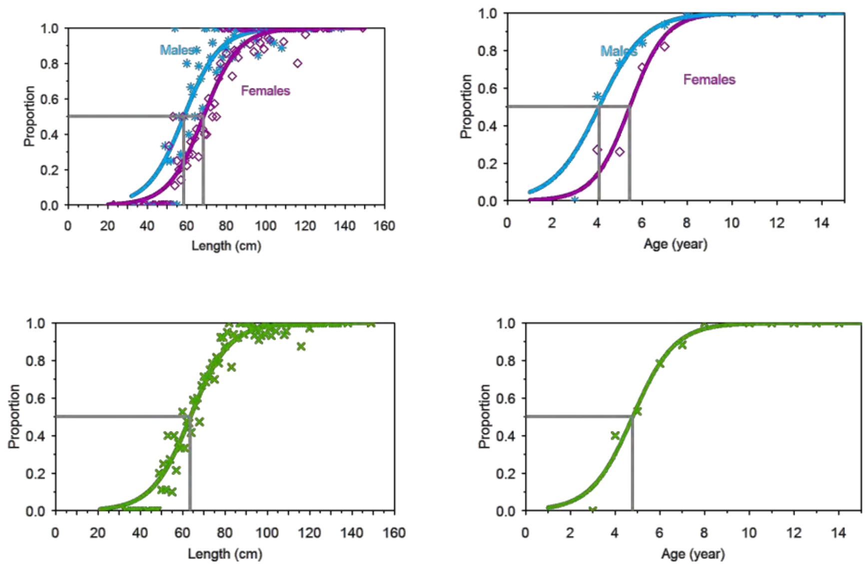

Figure 3.5.10. Ling (lin.27.3a4a6-91214), maturity ogives for age and length for males and females (top panel) and sexes combined (lower panel).

3.5.5.6 Catch, effort and research vessel data

Spanish Porcupine Bank survey

The Spanish bottom trawl survey on the Porcupine Bank (ICES divisions 7.c and 7.k) was 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. Area covered by the survey is shown in Figure 3.5.11.

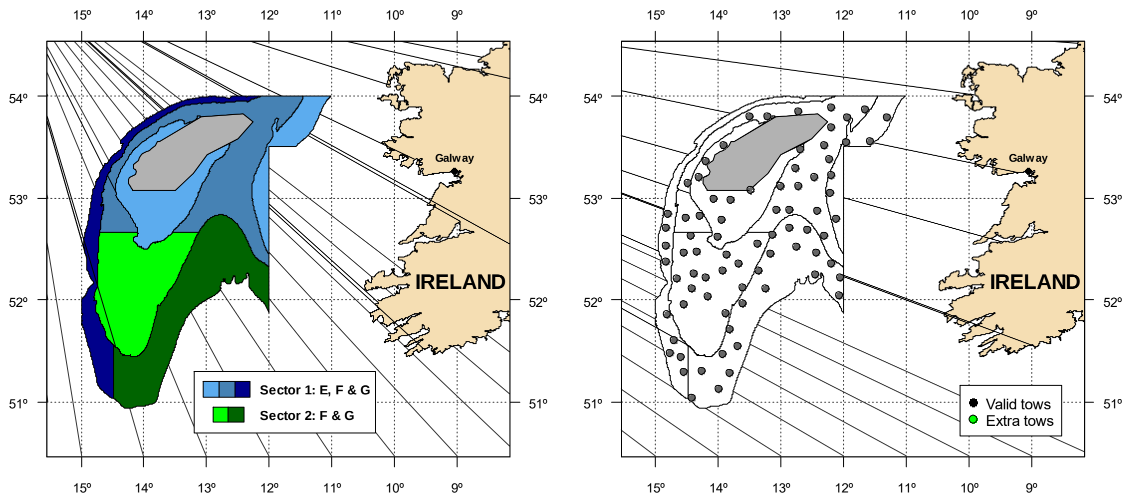

Figure 3.5.11. Left: Stratification design used in the Porcupine surveys starting in 2003: Previous years were re-stratified. Depth strata are: E) shallower than 300 m, F) 301 – 450 m and G) 451 – 800 m. Grey area in the middle of Porcupine bank denotes a large non-trawl able area. Right: distribution of hauls in 2019.

French IBTS survey

Ling are caught in small numbers in the French western-IBTS area, also referred to as EVHOE. Population indices (based on swept area for biomass, mean length, etc.) for the Bay and Biscay and Celtic Sea (ICES Divisions 7g,hjk and 8a,b,d) combined were provided for years 1997–2019 (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

Landing effort, measured in hours at sea, and landings per unit of effort (lpue) are provided by the French otter trawl, longline and gillnet fishery for areas 6 and 7.bck for the years 2000–2019.

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 2000–2019. 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 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.

For the standardised Norwegian cpue series, data were available from official logbooks from 2000 onwards. All catch data, and a subset where ling appeared to have been targeted (>30 % of total catch), were used to estimate a standardized cpue series.

A standardised commercial cpue series using data from the Norwegian longline reference fleet was based on methods described in Helle *et al*., 2015.

3.5.6 Data analyses

Length data analysis

Mean length of the commercial catches by the Norwegian longlining reference fleet fluctuate and are approximately the mean 90 cm for Areas 4 and 6.b and around 80 cm for Area 6.a. The series does not indicate any apparent time trends (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 compared with the longliners (Figure 3.5.4)

On Porcupine Bank based on Spanish surveys the estimated length distributions appear to be quite stable with a length range of approximately 30–130 cm. The mode of the distributions tends to be around 70 cm, and there are no clear recruitment signals, which implies that Porcupine Bank is not a recruitment area for young ling (Figure 3.5.14). For more information, see Ruiz-Pico *et al.*, WD 2020.

The French IBTS survey (EVHOE)

Ling are caught in small numbers (average of 14 individuals per year since 1997) in the French W-IBTS-Q4 (EVHOE) survey covering ICES divisions 7.g,hjk and 8.a,b,d. populations indices are however presented (Figure 3.5.12). but are not considered representative of stock trends in the area.

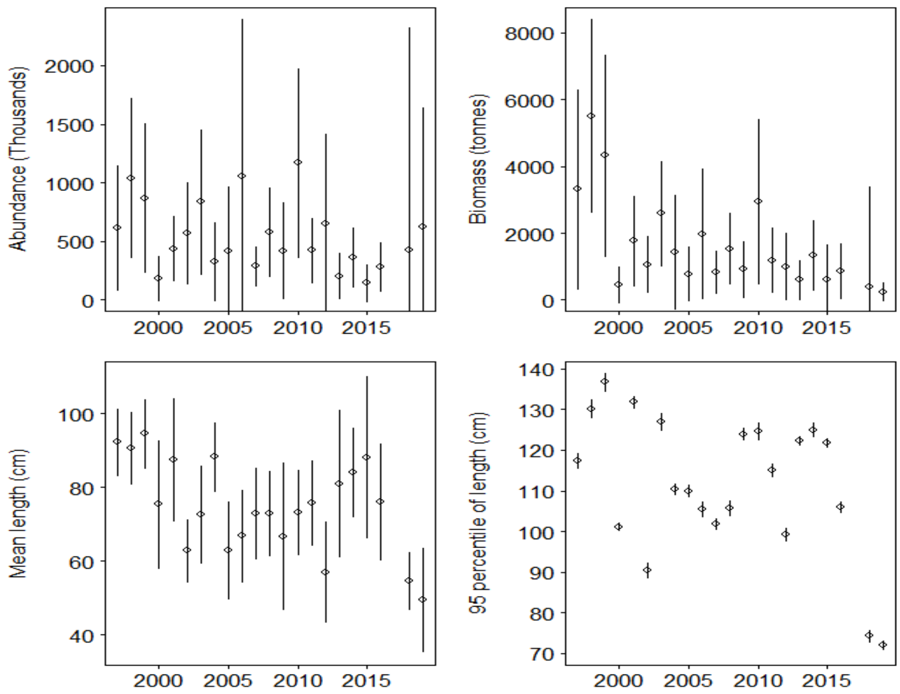

Figure 3.5.12. Population indices (swept area raised abundance and biomass, mean length and 95 percentile of the length distribution) of ling in the Bay and Biscay and Celtic Sea (ICES divisions 7.g,hjk and 8a,b,d) from the French EVHOE survey (W-IBTS-Q4), 1997–2019 (except 2017).

French landings per unit effort (lpue)

The landings of ling by otter trawlers increased from 2004–2014. During the last five years, there was a decrease in landings. For gillnetters and longliners, changes in landings are closely related to changes in effort (Figure 3.5.13).

Overall, while total fishing effort has decreased in the areas fished by the three major French fleets, there is a clear increasing trend in lpue for otter trawlers and a decrease since 2014 for gillnetters. The lpue seems to be low but stable for longliners

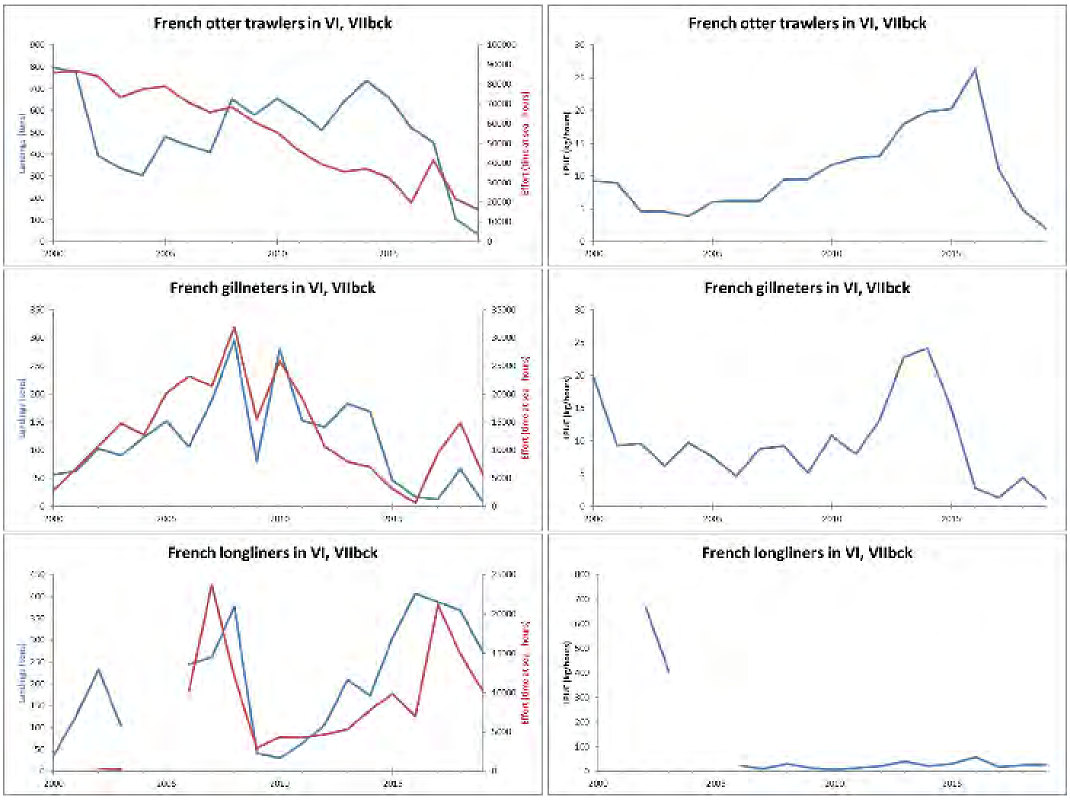

Figure 3.5.13. Ling lpue series for the main French fleet operating in 6, 7.b, c and k

Spanish ling 2019 Porcupine Bank (NE Atlantic) survey

Estimated biomass and abundance indices based on data from the Porcupine Survey for the years 2001–2019 are in Figure 3.5.14. 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.

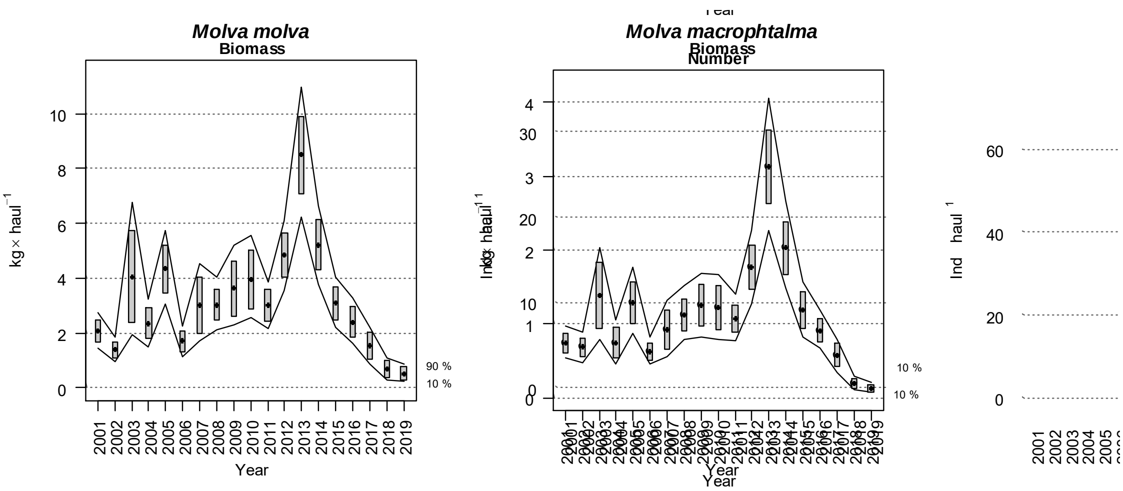

Figure 3.5.14. Estimated biomass and abundance indices based on the Porcupine Survey for the years 2001–2019. Boxes mark the parametric, based standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

Cpue series based on the Norwegian longline fleet

Figure 3.5.15 show the Norwegian CPUE series from 2000 to 2019. In areas 4a there was a steady increase in CPUE from 2002 until 2016. There was a negative trend in 2017 and 2018 but with a slight increase in 2019.This trend can be seen both when all data was used but with a larger increase in 2019 when ling was targeted. In 6a and 6b there was also a positive trend from 2002 to 2016 with a decreasing trend from 2017.

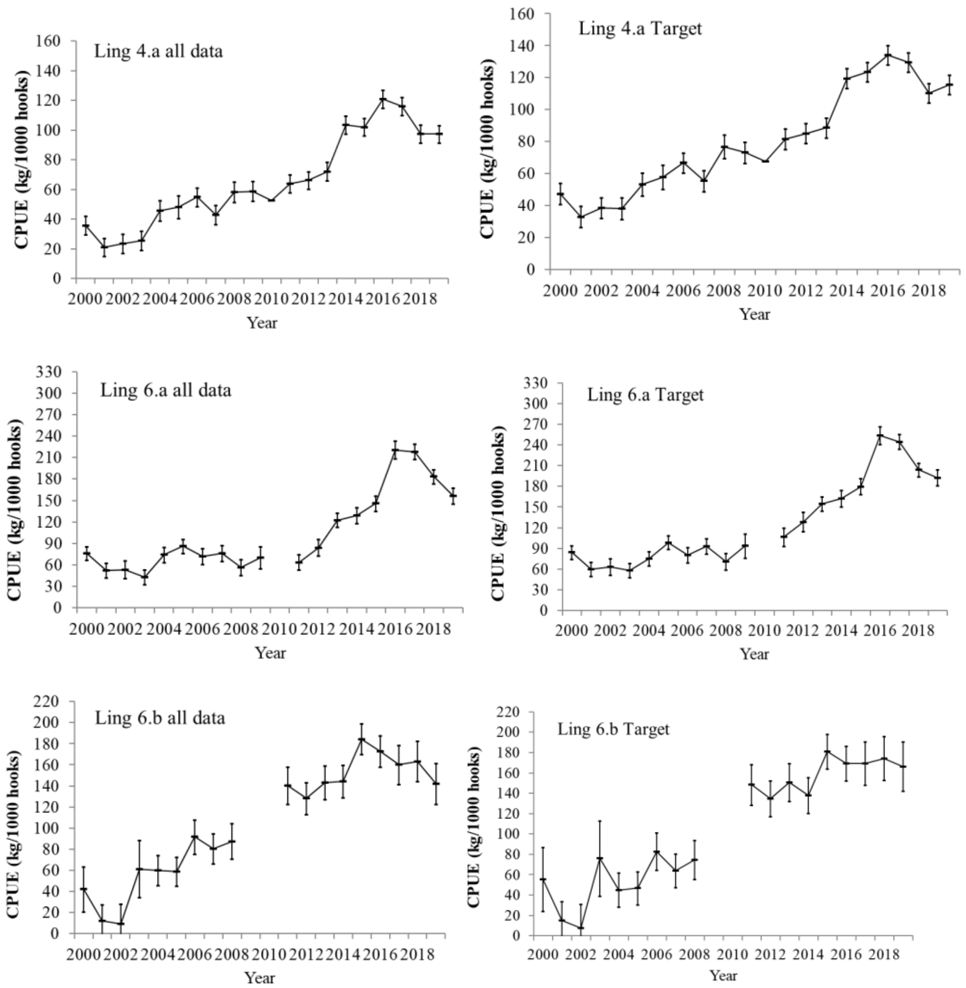

Figure 3.5.15. Cpue series for ling for the period 2000–2019 based on all available data and when ling appeared to have been targeted. The bars denote the 95% confidence intervals.

The ling stocks in Areas (3.a, 4, 6, 7, 8, 9, 10, 12, 14) were best covered by the Norwegian longline fleet. It was therefore decided in plenary that a combined cpue series should be made to give advice for the entire area, and the data from the targeted fishery should be used. The combined series were based on all available data and when ling was targeted is shown in Figure 3.5.16.

When all data for Areas 3.a, 4, 6, 7, 8, 9, 10, 12, 14 are combined: the cpue series, when all data are used and ling was targeted, indicates a steady increase since 2003 to 2017 and then decline in 2018 and 2019. For the targeted fishery, there was a decline in 2018 but with a slight increase in 2019. This increase is driven by an increase in area 4a.

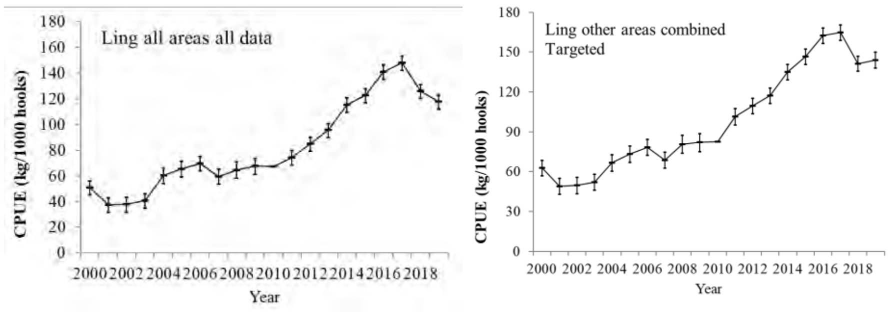

Figure 3.5.16. Cpue series for ling, areas 4a, 4b, 6a and 6b combined, for the period 2000–2019 for all data available and based on data when ling appeared to have been targeted. The bars denote the 95% confidence intervals.

Biological reference points

See Section 3.5.9.

3.5.7 Comments on the assessment

Data in Areas 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. The model SPiCT also shows that the relative biomass B_t/B_{MSY} is higher than 1, and the that the relative fishing mortality is low.

3.5.8 Management considerations

LBI and SPiCT indicate that ling are fishing sustainable.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). 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.

3.5.9 Application of MSY proxy reference points

Two different methods were tested for Ling, the Length based indicator method (LBI) and SPiCT.

Length-based indicator method (LBI)

Information used in LBI for ling in Division 3.a, 4.a, 4.b, 6.a, 6.b, 7.

Information and data

The input parameters and the catch length composition for the period 2002-2019 are in the following tables and figures. 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.

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

Data type	Source	Years/Value	Notes
Length frequency distribution	Norwegian long-liners (Reference fleet)	2002-2019	
Length-weight relation	Norwegian Reference fleet and survey data	$0.0055 * \text{length}^{3.0120}$	
L_{MAT}	Norwegian Reference fleet and survey data	64 cm	Combined sexes
L_{inf}	Norwegian Reference fleet and survey data	183 cm	

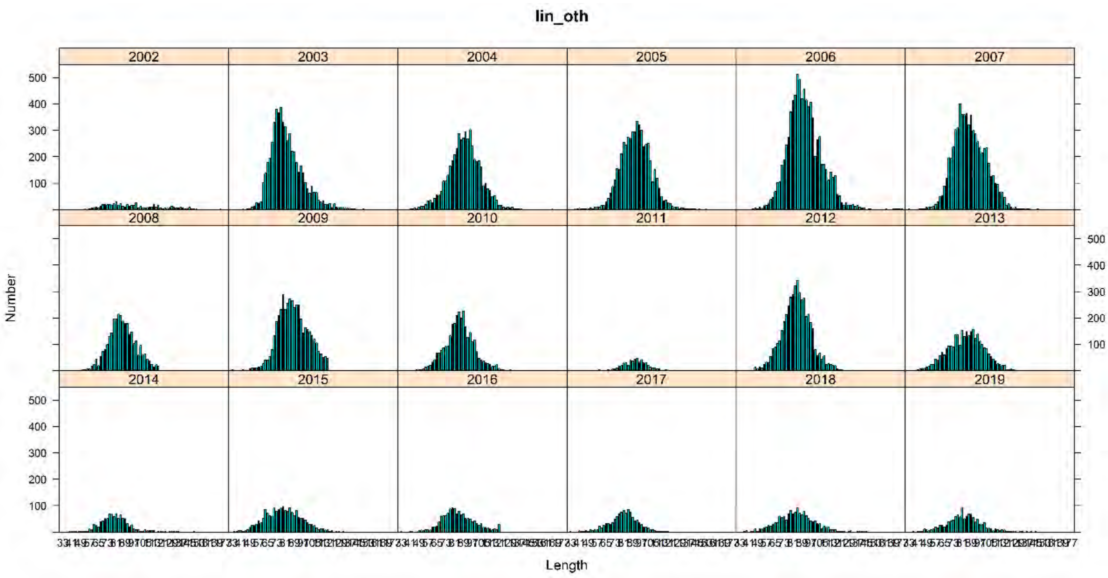

Figure 3.5.17 Ling in other areas (3.a, 4.a, 4.b, 6.a, 6.b, 7). Catch length composition for the period 2001–2019 at 2 cm length classes (sex combined).

Outputs

The screening of length indicator ratios for combined sexes was conducted under three scenarios: (a) Conservation,(b) Optimal yield, and (c) maximum sustainable yield. The results are presented in the following figures.

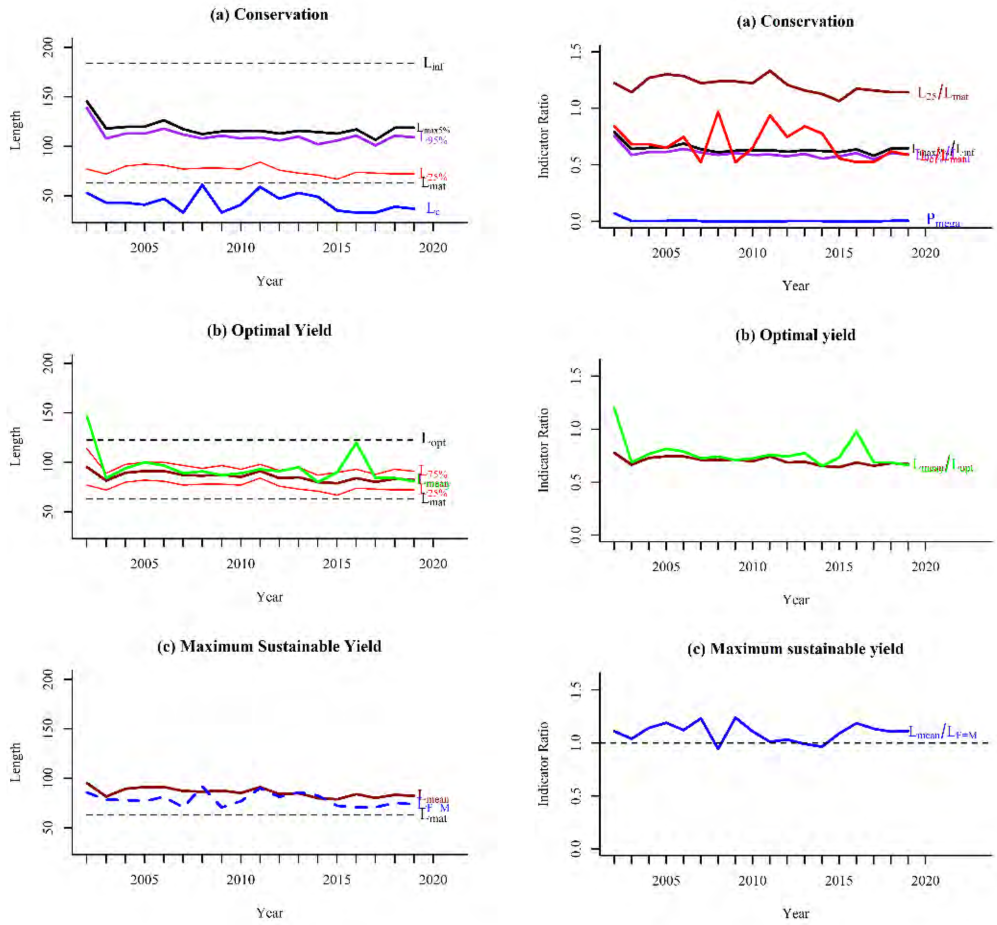

Figure 3.5.18. Ling in other areas (3.a, 4.a, 4.b, 6.a, 6.b, 7). Screening of length indicators ratios for sex combined under three scenarios: (a) Conservation, (b) Optimal yield, and (c) maximum sustainable yield.

Analysis of results

For the conservation of immature ling the model shows that L_c/L_{mat} is usually less than one, but $L_{25\%}/L_{mat}$ is usually greater than 1 (Figure 3.5.18). In 2017-2019, $L_{25\%}/L_{mat}$ has been greater than 1 (Table 3.6.7). The sensitivity measure, L_{mat}, suggests that there is no overfishing of immature ling.

The conservation measure for large ling shows that the indicator ratio of $L_{max5\%}/L_{inf}$ is around 0.6 for the whole period (Figure 3.5.18.) and between 0.58 and 0.65 in 2017-2019 (Table 3.6.7). Therefore, since the conservation indicator is less than 0.8, this implies that there are few of mega-spawners in the catch which indicates that there is a truncation point in the length distribution of the catch, i.e., the present catch levels are not optimal.

The MSY indicator ($L_{mean}/L_{F=M}$) is greater than 1 for the whole period (Figure 3.5.18.), which indicates that ling in other areas were fished sustainably. The sensitivity measure, L_{inf}, indicates that MSY is always higher than 0.94.

Table 3.5.7. **Ling in other areas (3.a, 4.a, 4.b, 6.a, 6.b, 7). The final 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**
2017	0,52	1,16	0,58	0 %	0,65	1,14
2018	0,62	1,14	0,65	0 %	0,68	1,11
2019	0,59	1,14	0,65	0 %	0,67	1,11

Conclusions

The overall perception of the stock during the period 2017-2019 is that ling in other areas seems to be fished sustainably (Table 3.5.8). However, the results are very sensitive to the assumed values of L_{mat} and L_{inf}..

Table 3.5.8 **Ling in other areas (3.a, 4.a, 4.b, 6.a, 6.b, 7). Stock status was based on LBI for MSY. The green marks for MSY were given because $L_{mean}/L_{F=M}$ > 1 in 2017 to 2019. Stock size is unknown since this method only provides exploitation status.**

	Fishing pressure			
	2017	2018	2019	
MSY (F/F_{MSY})	✓	✓	✓	Appropriate
	Stock size			
	2017	2018	2019	
MSY $B_{trigger}$.(B/B_{MSY})	?	?	?	Unknown

SPiCT

Ling in Areas 3.a, 4, 6, 7, 8, 9, 10, 12 and 14

The first run was carried out with standard settings in SPiCT, and with catch data and CPUE for all available years. The model converged, and the plots from the diagnostics looked good, but there were wide confidence intervals for the parameter estimates (BMSY, MSY, FMSY, and K) (Tables 3.5.9 and 3.5.10).

There were 7 runs where the parameters n, α and β were varied (Table 3.5.9). Overall, run number 3 was considered the best since the confinement intervals were smallest (Table 3.5.9). For this run, the parameter n was set to 2, while n, α and β were set to 1.

The model estimated MSY of 24 703 tons. The advice for 2020 and 2021 was 18 516 tons, which is considerably lower than any of the runs of the model. Associated BMSY was calculated to be 107 390 tons, and FMSY to 0.230. The estimated carrying capacity (K) is about 216 100 tons (Tables 3.5.9 and 3.5.10).

The model indicates that the stock abundance is above BMSY. The fishing mortality rate is less than FMS and will remain less than FMS if the catches continue to be kept at the same level as in previous years. The traffic light figure shows that the stock started in the yellow zone, went into the red zone and are now in the green zone (Figure 3.5.19). This corresponds to the present perception of the development of the stock. The diagnostics do not show any patterns in the residuals and no significance for bias or normality; the test for autocorrelation was significant. The retrospective plot showed that the test is relatively robust.

Table 3.5.9. Ling in Areas 3.a, 4, 6, 7, 8, 9, 10, 12 and 14.

Run	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Landings period	1988-2019						
CPUE	2000-2019						
Parameter settings							
n	mod.est	no priors	2	mod.est	2	2	2
Alfa	mod.est	no priors	1	1	mod.est	1	4
Beta	mod.est	no priors	1	1	mod.est	mod.est	1
Convergence	yes	yes	yes	yes	yes	yes	yes
Parameter estimates							
Bmsy	92458	88869	107390	107346	93751	95501	144744
cilow	40763	29603	54524	54630	56595	59121	68200
cihigh	209711	266787	211512	210934	155303	154268	307197
MSY	23064	22416	24703	24230	23981	24004	26209
cilow	18925	16660	20562	19776	21170	21071	20720
cihigh	28107	30161	29677	29687	27164	27346	33151
Fmsy	0,249	0,252	0,23	0,257	0,256	0,251	0,181
cilow	0,121	0,093	0,132	0,127	0,161	0,165	0,106
cihigh	0,514	0,686	0,401	0,401	0,272	0,384	0,31
K	245154	304788	216054	243826	188670	192080	289761
cilow	66197	12658	109486	86057	114243	118806	136490
cihigh	907901	7339088	426350	690830	311586	310546	615151
Diagnostics	OK- (Box)	OK Lbox	OK Lbox	OK Lbox	OK Lbox	OK Lbox	OK Lbox
Retrospektive	OK-	negative	ok	ok-	ok	ok	ok-

Table 3.5.10. Ling in Areas 3.a, 4, 6, 7, 8, 9, 10, 12 and 14

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: -39.3071311
Euler time step (years):  1/16 or 0.0625
Nobs C: 32,  Nobs I1: 20

Priors
    logn  ~  dnorm[log(2), 0.001^2] (fixed)
 logalpha  ~  dnorm[log(1), 0.001^2] (fixed)
  logbeta  ~  dnorm[log(1), 0.001^2] (fixed)

Model parameter estimates w 95% CI
          estimate        cilow         ciupp    log.est
 alpha  1.000000e+00 9.980422e-01 1.001962e+00  0.0000003
 beta   9.999908e-01 9.980328e-01 1.001953e+00 -0.0000092
 r      4.621719e-01 2.658638e-01 8.034298e-01 -0.7718183
 rc     4.621721e-01 2.658649e-01 8.034271e-01 -0.7718178
 rold   4.621724e-01 2.658642e-01 8.034300e-01 -0.7718174
 m      2.496352e+04 2.072467e+04 3.006935e+04 10.1251709
 K      2.160539e+05 1.094858e+05 4.263502e+05 12.2832833
 q      9.597000e-04 5.069000e-04 1.816900e-03 -6.9488783
 n      1.999999e+00 1.996083e+00 2.003923e+00  0.6931467
 sdb    6.528400e-02 4.702750e-02 9.062790e-02 -2.7290082
 sdf    9.801490e-02 7.419570e-02 1.294808e-01 -2.3226357
 sdi    6.528400e-02 4.702750e-02 9.062790e-02 -2.7290079
 sdc    9.801400e-02 7.419490e-02 1.294799e-01 -2.3226448

Deterministic reference points (Drp)
         estimate        cilow         ciupp   log.est
 Bmsyd 1.080269e+05 5.474291e+04 2.131750e+05 11.590136
 Fmsyd 2.310861e-01 1.329325e-01 4.017136e-01 -1.464965
 MSYd  2.496352e+04 2.072467e+04 3.006935e+04 10.125171
Stochastic reference points (Srp)
         estimate        cilow         ciupp   log.est rel.diff.Drp
 Bmsys 1.073902e+05 54524.961110 2.115115e+05 11.584224 -0.005929169
 Fmsys 2.300388e-01     0.132033 4.007926e-01 -1.469507 -0.004552598
 MSYs  2.470324e+04 20562.979182 2.967713e+04 10.114690 -0.010536220

States w 95% CI (inp$msytype: s)
                  estimate        cilow         ciupp    log.est
 B_2019.00       1.530987e+05 7.951625e+04 2.947726e+05 11.9388381
 F_2019.00       1.319336e-01 6.752310e-02 2.577855e-01 -2.0254564
 B_2019.00/Bmsy 1.425630e+00 1.147685e+00 1.770888e+00  0.3546139
 F_2019.00/Fmsy 5.735278e-01 4.292571e-01 7.662870e-01 -0.5559489

Predictions w 95% CI (inp$msytype: s)
                prediction        cilow         ciupp    log.est
 B_2020.00       1.533574e+05 7.789459e+04 3.019272e+05 11.9405265
 F_2020.00       1.325182e-01 6.668460e-02 2.633453e-01 -2.0210350
 B_2020.00/Bmsy 1.428039e+00 1.156639e+00 1.763121e+00  0.3563022
 F_2020.00/Fmsy 5.760691e-01 4.180883e-01 7.937454e-01 -0.5515276
 Catch_2020.00  2.031805e+04 1.610983e+04 2.562555e+04  9.9192650
 E(B_inf)       1.518214e+05           NA           NA 11.9304599
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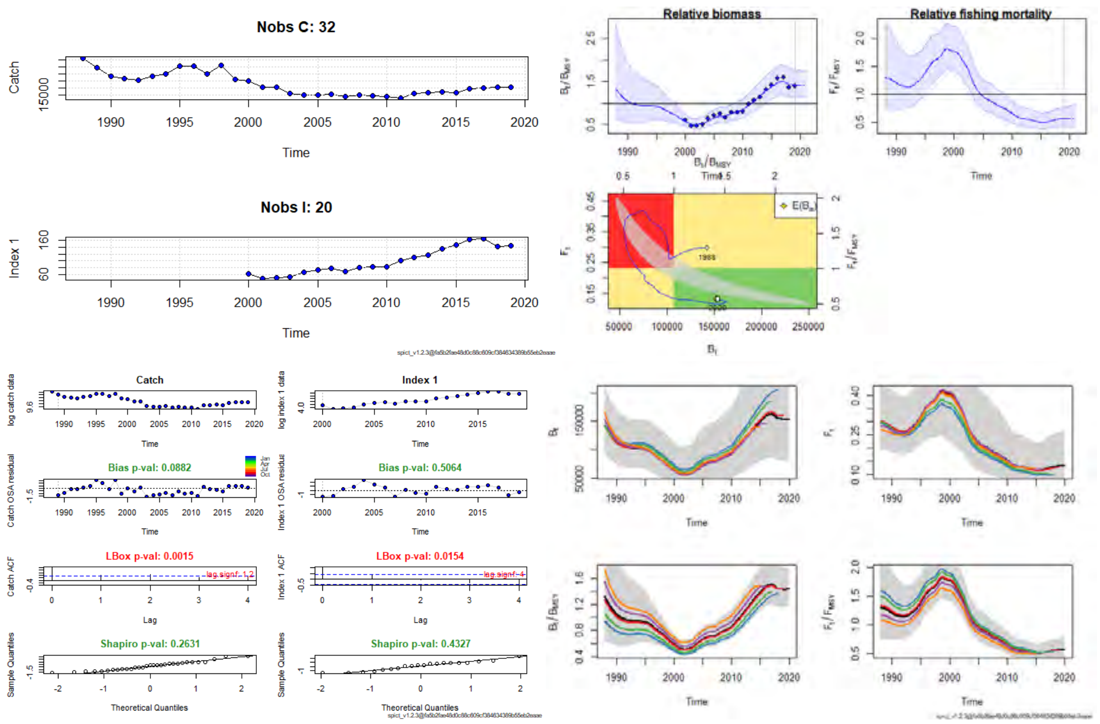

Figure 3.5.19. Ling in Areas 3.a, 4, 6, 7, 8, 9, 10, 12 and 14. Upper left corner shows the input data for the model, upper right corner the model output, lower left corner the model diagnostics and the lower right corner the retrospective analysis.

3.5.10 Tables

Table 3.5.1. Ling 3a, 4a, 6, 7, 8, 9, 12 and 14. WG estimates of landings.

Ling 3

Year	Belgium	Denmark	Germany	Norway	Sweden	E & W	France	Total
1988	2	165	-	135	29	-		331
1989	1	246	-	140	35	-		422
1990	4	375	3	131	30	-		543
1991	1	278	-	161	44	-		484
1992	4	325	-	120	100	-		549
1993	3	343	-	150	131	15		642
1994	2	239	+	116	112	-		469
1995	4	212	-	113	83	-		412
1996		212	1	124	65	-		402
1997		159	+	105	47	-		311
1998		103	-	111	-	-		214
1999		101	-	115	-	-		216
2000		101	+	96	31			228
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

Year	Belgium	Denmark	Germany	Norway	Sweden	E & W	France	Total
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			178
2019*		139		38	27		1	204

*Preliminary.

Table 3.5.1. (continued).

Ling 4.a

Year	Belgium	Denmark	Faroes	France	Germany	Neth.	Norway	Sweden1)	E&W	N.I.	Scot.	Total
1988	3	408	13	1143	262	4	6473	5	55	1	2856	11 223
1989	1	578	3	751	217	16	7239	29	136	14	2693	11 677
1990	1	610	9	655	241	-	6290	13	213	-	1995	10 027
1991	4	609	6	847	223	-	5799	24	197	+	2260	9969
1992	9	623	2	414	200	-	5945	28	330	4	3208	10 763
1993	9	630	14	395	726	-	6522	13	363	-	4138	12 810
1994	20	530	25	n/a	770	-	5355	3	148	+	4645	11 496
1995	17	407	51	290	425	-	6148	5	181		5517	13 041
1996	8	514	25	241	448		6622	4	193		4650	12 705
1997	3	643	6	206	320		4715	5	242		5175	11 315
1998	8	558	19	175	176		7069	-	125		5501	13 631
1999	16	596	n.a.	293	141		5077		240		3447	9810
2000	20	538	2	147	103		4780	7	74		3576	9246
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		1022		926	130	5	6062	16	74		3208	**11443**

***Preliminary.**

[(1)] Includes 4b 1988–1993.

Table 3.5.1. (continued).

Ling 4.bc.

Year	Belgium	Denmark	France	Sweden	Norway	E & W	Scotland	Germany	Netherlands	Total
1988					100	173	106	-		379
1989					43	236	108	-		387
1990					59	268	128	-		455
1991					51	274	165	-		490
1992		261			56	392	133	-		842
1993		263			26	412	96	-		797
1994		177			42	40	64	-		323
1995		161			39	301	135	23		659
1996		131			100	187	106	45		569
1997	33	166	1	9	57	215	170	48		699
1998	47	164	5		129	128	136	18		627

Year	Belgium	Denmark	France	Sweden	Norway	E & W	Scotland	Germany	Netherlands	Total
1999	35	138	-		51	106	106	10		446
2000	59	101	0	8	45	77	90	4		384
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**

***Preliminary.**

Table 3.5.1. (continued).

Ling 6.a update for Spain.

Year	Belgium	Denmark	Faroes	France (1)	Germany	Ireland	Norway	Spain(2)	E&W	IOM	N.I.	Scot.	Total
1988	4	+	-	5381	6	196	3392	3575	1075	-	53	874	14 556
1989	6	1	6	3417	11	138	3858		307	+	6	881	8631
1990	-	+	8	2568	1	41	3263		111	-	2	736	6730
1991	3	+	3	1777	2	57	2029		260	-	10	654	4795
1992	-	1	-	1297	2	38	2305		259	+	6	680	4588
1993	+	+	-	1513	92	171	1937		442	-	13	1133	5301
1994	1	1		1713	134	133	2034	1027	551	-	10	1126	6730
1995	-	2	0	1970	130	108	3156	927	560	n/a		1994	8847
1996			0	1762	370	106	2809	1064	269			2197	8577
1997			0	1631	135	113	2229	37	151			2450	6746
1998				1531	9	72	2910	292	154			2394	7362
1999				941	4	73	2997	468	152			2264	6899
2000	+	+		737	3	75	2956	708	143			2287	6909
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

Year	Belgium	Denmark	Faroes	France [(1)]	Germany	Ireland	Norway	Spain(2)	E&W	IOM	N.I.	Scot.	Total
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**

***Preliminary. (1) Includes 6.b until 1996 (2) Includes minor landings from 6.b.**

Table 3.5.1. (continued).

Ling 6.b.

Year	Faroes	France [(2)]	Germany	Ireland	Norway	Spain [(3)]	E & W	N.I.	Scotland	Russia	Total
1988	196		-	-	1253		93	-	223		1765
1989	17		-	-	3616		26	-	84		3743
1990	3		-	26	1315		10	+	151		1505
1991	-		-	31	2489		29	2	111		2662
1992	35		+	23	1713		28	2	90		1891
1993	4		+	60	1179		43	4	232		1522
1994	104		-	44	2116		52	4	220		2540
1995	66		+	57	1308		84		123		1638
1996	0		124	70	679		150		101		1124
1997	0		46	29	504		103		132		814
1998		1	10	44	944		71		324		1394
1999		26	25	41	498		86		499		1175
2000	+	18	31	19	1172		157		475	7	1879
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

Year	Faroes	France [2]	Germany	Ireland	Norway	Spain [3]	E & W	N.I.	Scotland	Russia	Total
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**

***Preliminary. [1] Includes XII. [2] Until 1966 included in 6.a. [3] Included in Ling 6.a.**

Ling 7

Year	France	Total
1988	5057	5057
1989	5261	5261
1990	4575	4575
1991	3977	3977
1992	2552	2552
1993	2294	2294
1994	2185	2185
1995	-1	
1996	-1	
1997	-1	
1998	-1	
1999	-1	

***Preliminary.**

Table 3.5.1. (continued).

Ling 7.a.

Year	Belgium	France	Ireland	E & W	IOM	N.I.	Scotland	Total
1988	14	-1	100	49	-	38	10	211
1989	10	-1	138	112	1	43	7	311
1990	11	-1	8	63	1	59	27	169
1991	4	-1	10	31	2	60	18	125
1992	4	-1	7	43	1	40	10	105
1993	10	-1	51	81	2	60	15	219
1994	8	-1	136	46	2	76	16	284
1995	12	9	143	106	1	-2	34	305
1996	11	6	147	29	-	-2	17	210
1997	8	6	179	59	2	-2	10	264
1998	7	7	89	69	1	-2	25	198
1999	7	3	32	29		-2	13	84
2000	3	2	18	25			25	73
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

Year	Belgium	France	Ireland	E & W	IOM	N.I.	Scotland	Total
2016	1		10				13	24
2017			9				15	24
2018		1	9				8	18
2019*	2		3				7	12

Preliminary. [1] French catches in 7 not split into divisions, see Ling 7. [2] Included with UK (EW).

Table 3.5.1. (continued).

Ling 7.b, c.

Year	France [1]	Germany	Ireland	Norway	Spain [3]	E & W	N.I.	Scotland	Total
1988	-1	-	50	57		750	-	8	865
1989	-1	+	43	368		161	-	5	577
1990	-1	-	51	463		133	-	31	678
1991	-1	-	62	326		294	8	59	749
1992	-1	-	44	610		485	4	143	1286
1993	-1	97	224	145		550	9	409	1434
1994	-1	98	225	306		530	2	434	1595
1995	78	161	465	295		630	-2	315	1944
1996	57	234	283	168		1117	-2	342	2201
1997	65	252	184	418		635	-2	226	1780
1998	32	1	190	89		393		329	1034
1999	51	4	377	288		488		159	1366
2000	123	21	401	170		327		140	1182
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

Year	France (1)	Germany	Ireland	Norway	Spain (3)	E & W	N.I.	Scotland	Total
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**

***Preliminary. (1) See Ling 7. (2) Included with UK (EW). (3) Included with 7.g–k until 2011.**

Table 3.5.1. (continued).

Ling 7.d, e.

Year	Belgium	Denmark	France (1)	Ireland	E & W	Scotland	Ch. Islands	Nether-lands	Spain	Total
1988	36	+	-1	-	743	-				779
1989	52	-	-1	-	644	4				700
1990	31	-	-1	22	743	3				799
1991	7	-	-1	25	647	1				680
1992	10	+	-1	16	493	+				519
1993	15	-	-1	-	421	+				436
1994	14	+	-1	-	437	0				451
1995	10	-	885	2	492	0				1389
1996	15		960		499	3				1477
1997	12		1049	1	372	1	37			1472
1998	10		953		510	1	26			1500
1999	7		545	-	507	1				1060
2000	5		454	1	372		14			846
2001	6		402		399					807

Year	Belgium	Denmark	France [1]	Ireland	E & W	Scotland	Ch. Islands	Nether-lands	Spain	Total
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					**115**

***Preliminary.**

Table 3.5.1. (continued).

Ling 7.f.

Year	Belgium	France [1]	Ireland	E & W	Scotland	Total
1988	77	-1	-	367	-	444
1989	42	-1	-	265	3	310
1990	23	-1	3	207	-	233
1991	34	-1	5	259	4	302
1992	9	-1	1	127	-	137
1993	8	-1	-	215	+	223
1994	21	-1	-	379	-	400

Year	Belgium	France [1]	Ireland	E & W	Scotland	Total
1995	36	110	-	456	0	602
1996	40	121	-	238	0	399
1997	30	204	-	313		547
1998	29	204	-	328		561
1999	16	108	-	188		312
2000	15	91	1	111		218
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**

***Preliminary. [1] See Ling 7.**

Table 3.5.1. (continued).

Ling 7.g–k.

Year	Belgium	Denmark	France	Germany	Ireland	Norway	Spain (2)	E&W	IOM	N.I.	Scot.	Total
1988	35	1	-1	-	286	-	2652	1439	-	-	2	4415
1989	23	-	-1	-	301	163		518	-	+	7	1012
1990	20	+	-1	-	356	260		434	+	-	7	1077
1991	10	+	-1	-	454	-		830	-	-	100	1394
1992	10	-	-1	-	323	-		1130	-	+	130	1593
1993	9	+	-1	35	374			1551	-	1	364	2334
1994	19	-	-1	10	620		184	2143	-	1	277	3254
1995	33	-	1597	40	766	-	195	3046		-3	454	6131
1996	45	-	1626	169	771		583	3209			447	6850
1997	37	-	1574	156	674		33	2112			459	5045
1998	18	-	1362	88	877		1669	3465			335	7814
1999	-	-	1220	49	554		455	1619			292	4189
2000	17		1062	12	624		639	921			303	3578
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

Year	Belgium	Denmark	France	Germany	Ireland	Norway	Spain (2)	E&W	IOM	N.I.	Scot.	Total
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**

***Preliminary. (1) See Ling 7. (2) Includes 7.b, c until 2011. (3) Included in UK (EW).**

Table 3.5.1. (continued).

Ling 8.

Year	Belgium	France	Germany	Spain	E & W	Scot.	Ireland	Total
1988		1018			10			1028
1989		1214			7			1221
1990		1371			1			1372
1991		1127			12			1139
1992		801			1			802
1993		508			2			510
1994		n/a		77	8			85
1995		693		106	46			845
1996		825	23	170	23			1041
1997	1	705	+	290	38			1034
1998	5	1220	-	543	29			1797
1999	22	234	-	188	8			452
2000	1	227		106	5			339
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

Year	Belgium	France	Germany	Spain	E & W	Scot.	Ireland	Total
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		326			1	**466**

Ling 9.

Year	Spain	Total
1997	0	0
1998	2	2
1999	1	1
2000	1	1
2001	0	0
2002	0	0
2003	0	0
2004		
2005		
2006		
2007	1	1

Table 3.5.1. (continued).

Ling 12.

Year	Faroes	France	Norway	E & W	Scotland	Germany	Ireland	Total
1988				-				0
1989				-				0
1990				3				3
1991				10				10
1992				-				0
1993				-				0
1994				5				5
1995	5			45				50
1996	-		2					2
1997	-		+	9				9
1998	-	1	-	1				2
1999	-	0	-	-	+	2		2
2000		1	-		6			7
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

Year	Faroes	France	Norway	E & W	Scotland	Germany	Ireland	Total
2016								0
2017								0
2018								0
2019*								0

Table 3.5.1. (continued).

Ling 14.

Year	Faroes	Germany	Iceland	Norway	E & W	Scotland	Russia	GREENLAND	Total
1988		3	-	-	-	-			3
1989		1	-	-	-	-			1
1990		1	-	2	6	-			9
1991		+	-	+	1	-			1
1992		9	-	7	1	-			17
1993		-	+	1	8	-			9
1994		+	-	4	1	1			6
1995	-	-		14	3	0			17
1996	-			0					0
1997	1			60					61
1998	-			6					6
1999	-			1				8	9
2000			26	-				0	26
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

Year	Faroes	Germany	Iceland	Norway	E & W	Scotland	Russia	GREENLAND	Total
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

***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	9246	384	6909	1879		73	1182	846	218	3578	339	1	7	26	24 916
2001	262	7854	284	5143	788		87	1226	807	220	3360	594	0	59	37	20 720
2002	263	9072	309	4127	533		119	964	891	453	3526	467	0	8	23	20 756
2003	261	6433	234	3246	660		112	524	787	176	2940	436		19	83	15 912
2004	232	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		0	8	13078
2012	145	7018	192	3655	1390		14	1013	436	167	1520	552		0	111	16213
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	9739	150	5659	1088		24	570	293	114	1172	287			35	19283
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*	204	11443	158	6543	904		12	313	115	26	465	466		0	128	20777

***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 14. All remaining areas are grouped together as “other areas". This latter unit includes Subareas 1 and 2 and Division 4.a and 3.a where historical landing have been significant and subareas 8 and 9, where the species does not occur. Landings reported in 8 and 9 are 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 (12.a1, 12.a2, 12.a4 and 12.c) and the western slope of the Hatton Bank (12.b). None of these have represented major landings in the 2000s. However, based upon the continuity of bathymetric features and lesser abundance, blue ling from the western Hatton Bank is likely to be similar to those from the northern Hatton Bank (6.b). Therefore, including ICES Division 12.b in the assessment unit for 5.b, 6 and 7 could be considered. Because of the much lesser abundance of blue ling on the Hatton Bank, this should not impact significantly on the assessed stock biomass and dynamics.

Historical total international landings show that blue ling have been exploited for long. Before the start of the time-series used 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 is known to form spawning aggregations. From 1970 to 1990, the bulk of the fishery for blue ling was seasonal fisheries targeting these aggregations which were subject to sequential depletion. Known spawning areas are shown in Figure 4.1.3. In Iceland, the depletion of the spawning aggregation in a few years was documented (Magnússon, 1995) and blue ling is an aggregating species at spawning time. To prevent depletion of adult populations temporal closures have been set in the Icelandic and EU EEZs as well as in the NEAFC RA.

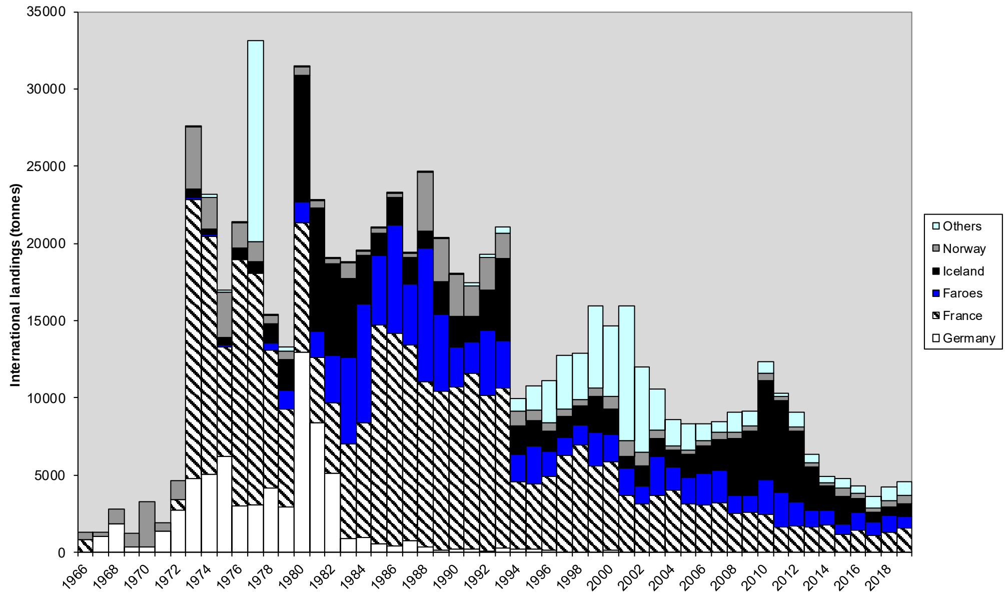

Figure 4.1.1. Total international landings of blue ling in the Northeast Atlantic, by country, 1966–2018.

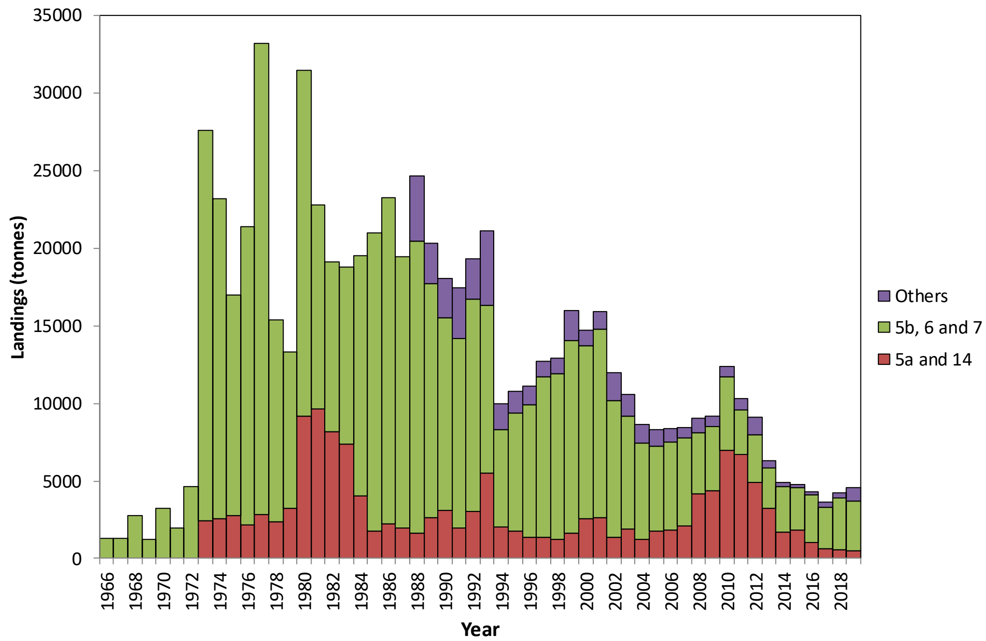

Figure 4.1.2. Total international landings of blue ling in the Northeast Atlantic, by stock unit, 1966–2018.

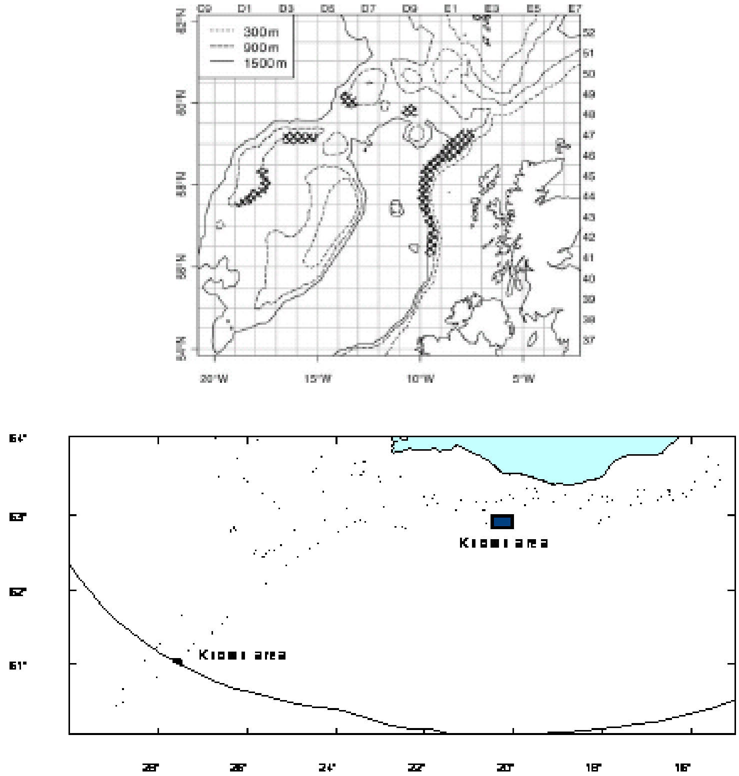

Figure 4.1.3. Known spawning areas of blue ling in Icelandic water (lower panel) and to the West of Scotland (upper panel, from Large *et al.*, 2010).

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

4.2.1 Fishery

The change in geographical distribution of the Icelandic blue ling fisheries from 2000 to 2019 (Figure 4.1.1 and Figure 4.1.2), indicates an expansion of the fishery of blue ling to northwestern waters. This increase may partly be the result of increased availability of blue ling in the north-western area.

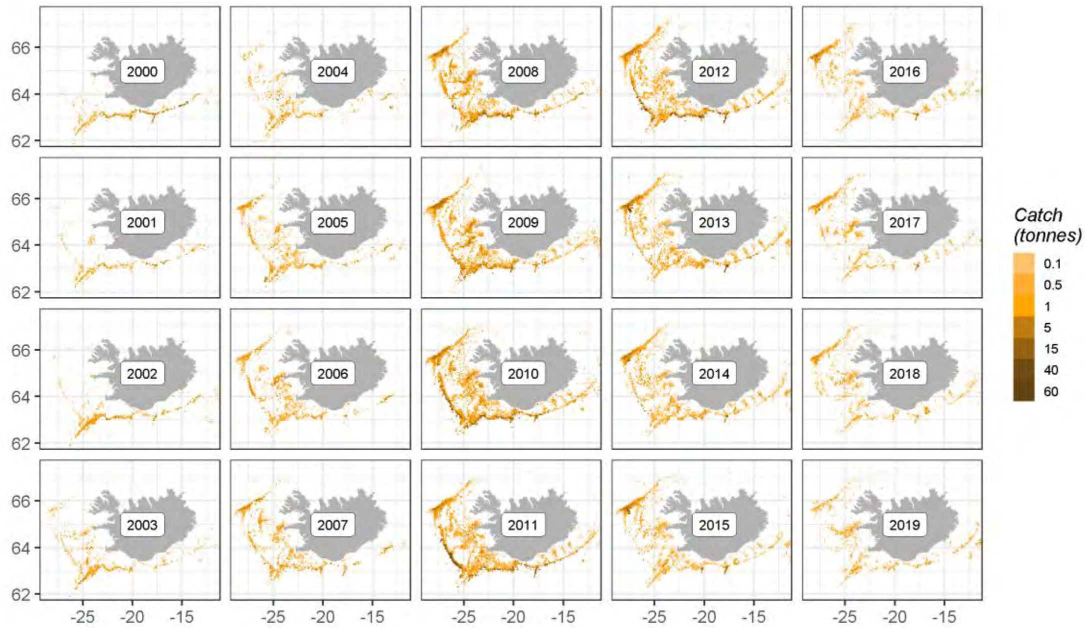

Figure 4.1.1. Blue ling in 5.a and 14. Geographical distribution of the Icelandic blue line fishery since 1999 as reported in logbooks. All gear types combined.

Before 2008, the majority of blue ling catches were taken by trawlers, as bycatch in fisheries targeting Greenland halibut, redfish, cod and other demersal species (Table 4.1.1). 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 2007 there was a substantial change in the fishery for blue ling (Table 4.1.1 and Figure 4.1.3). 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. The trend has reversed and in 2015–2019 the proportion of longline catches decreased to 20–30%. At the same time longliners started fishing in deeper waters than before 2008 and until 2013 the bulk of the longline catches were taken at depths greater than 500 m. In recent years, the depth distribution resembles the distribution observed before 2008, or at depths less than 400 m (Figure 4.1.4). Historically the fisheries in Subarea 14 have been relatively small but highly variable.

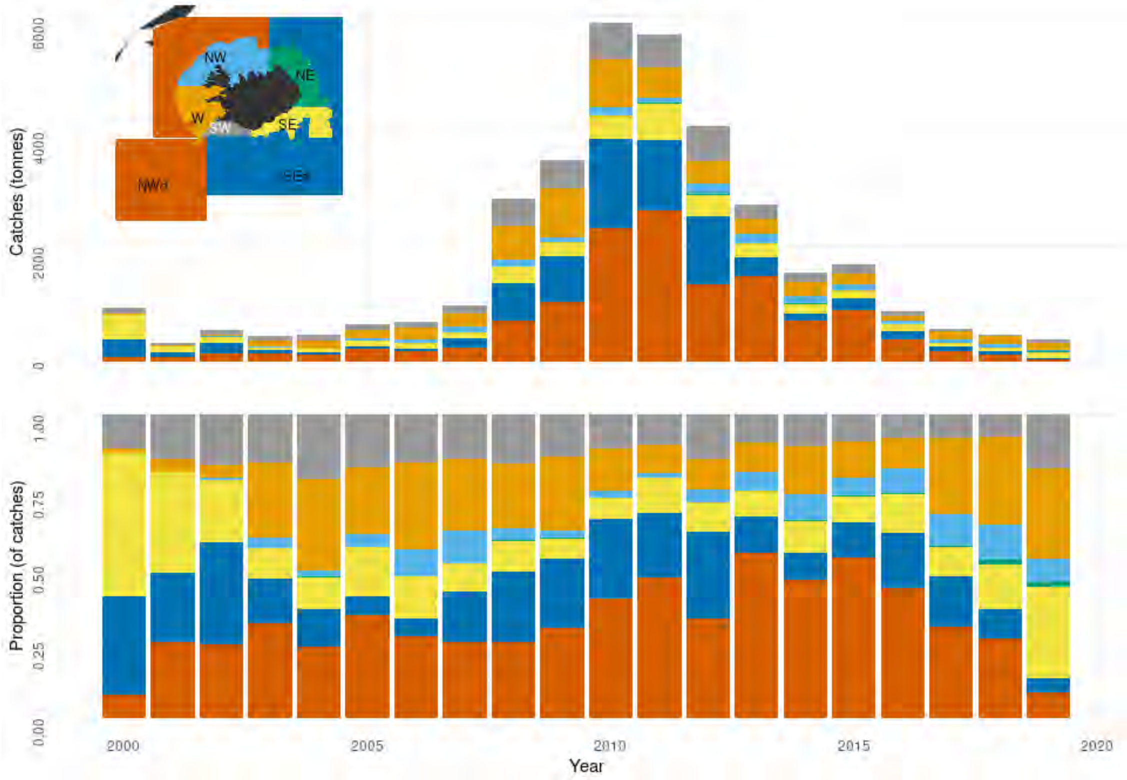

Figure 4.1.2: Blue ling in 5.a and 14. Catch distribution and proportions by area according to logbooks. All gears combined.

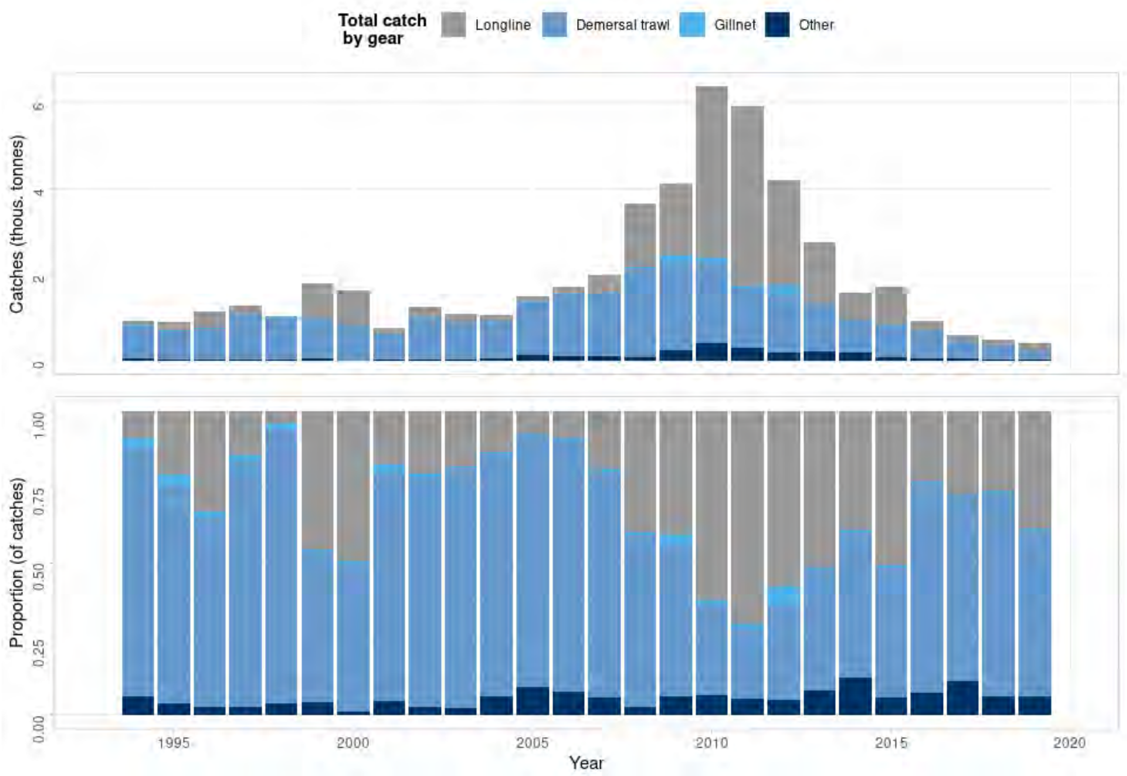

Figure 4.1.3: Blue ling in 5.a and 14. Total catch (landings) and proportion by fishing gear since 2000. according to logbooks.

The total landings of the Icelandic fleet in 2019 were 424 t (Table 4.1.1). Catches of blue ling 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 decreased compared to 2010 or by around 5900 tonnes (Table 4.1.1).

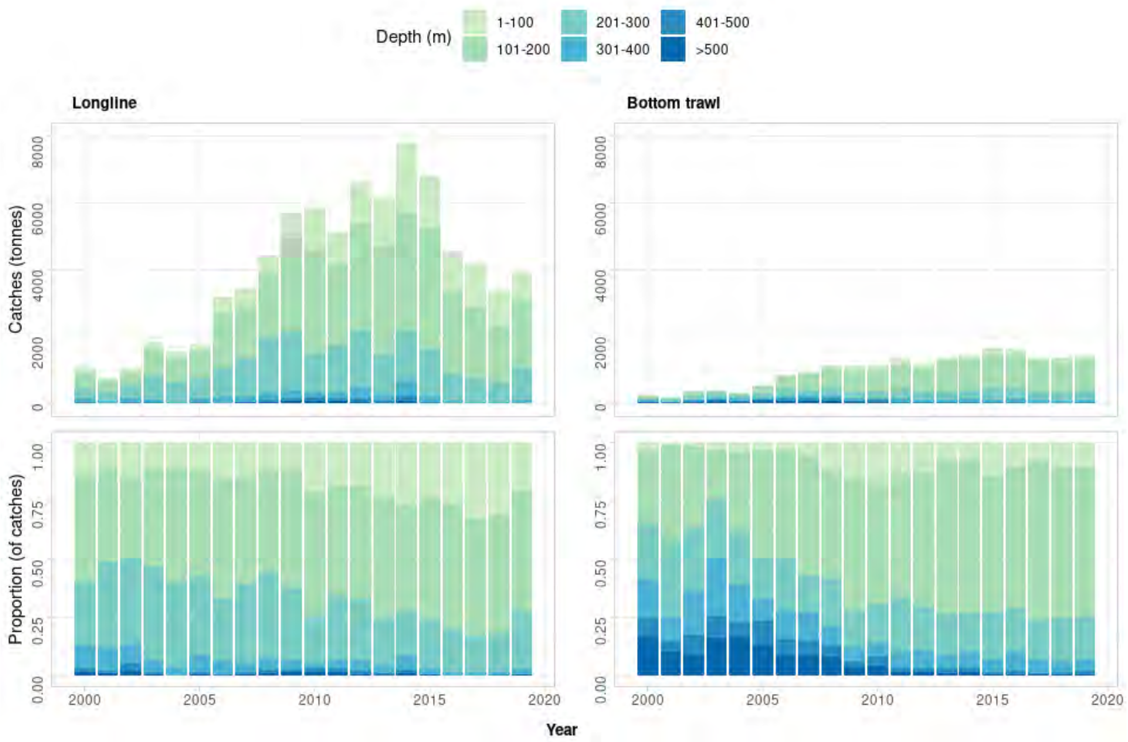

Figure 4.1.4: Blue ling in 5.a and 14. Depth distribution and proportion of longlines (left) and trawls (right) catches according to logbook entries.

4.2.2 Landings trend

The preliminary total landings in 5.a in 2019 were 424 t of which the Icelandic fleet caught 415 t. (Table 4.1.1 and Figure 4.1.5). Catches of blue ling in 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 5.a decreased compared to 2010 or by around 6500 tonnes (Table 4.1.1). Total international landings from 14 (Table 4.1.2) 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), but there is no further information available on this fishery. These larger landings are very occasional, and in most years, total international landings have been between 50 and 200 t. Preliminary landings in 2019 were 63 t.

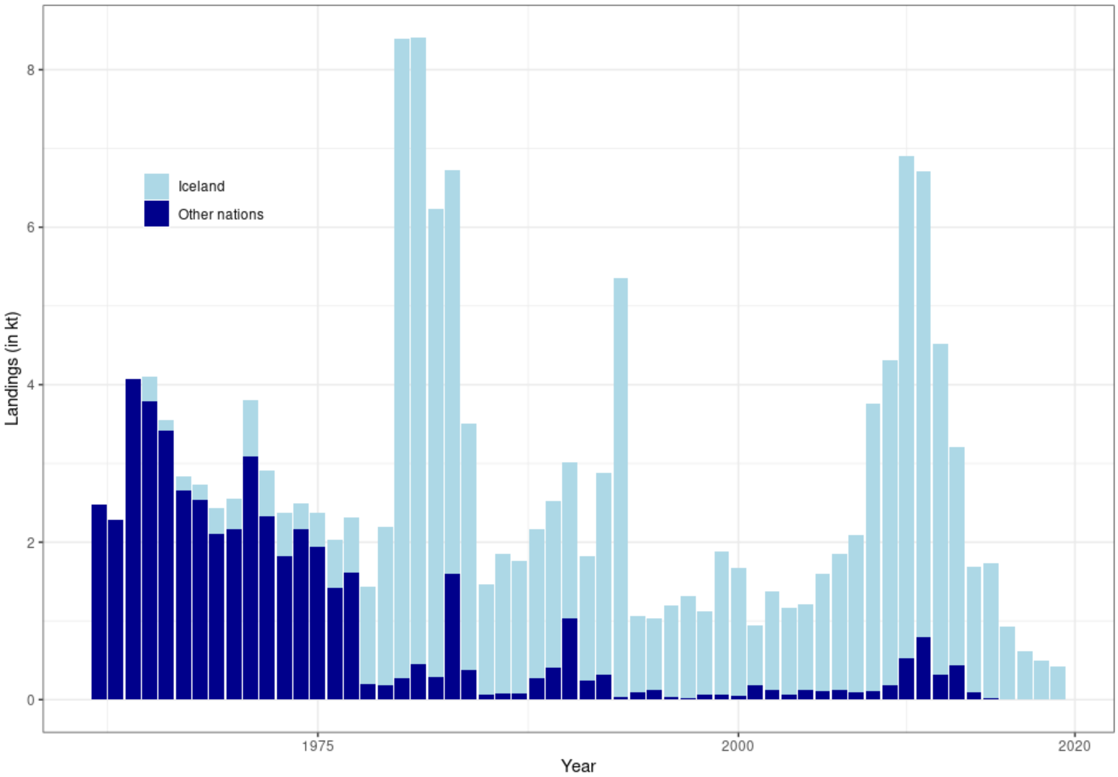

Figure 4.1.5: Blue ling in 5.a and 14. Nominal landings.

4.2.3 ICES advice

No advice is requested from ICES by Iceland this year due to the Covid 19 disruption.

Last year's assessment was 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 was estimated to have decreased by more than 20%, thus the uncertainty cap was applied. As the precautionary buffer had not been applied within the previous two years, it was also applied. ICES advised that when the precautionary approach is applied, catches in 2020 should be no more than 483 tonnes. All catches are assumed to be landed.

The basis for the advice 2012-2019 was the following: The ICES framework for category 3.3 stocks was applied (ICES, 2012). 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 F_{proxy} 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 F_{proxy} and that the F_{proxy} is likely no longer appropriate. Consequently, the ICES framework for category 3.2 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 1520 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 4.1.6).

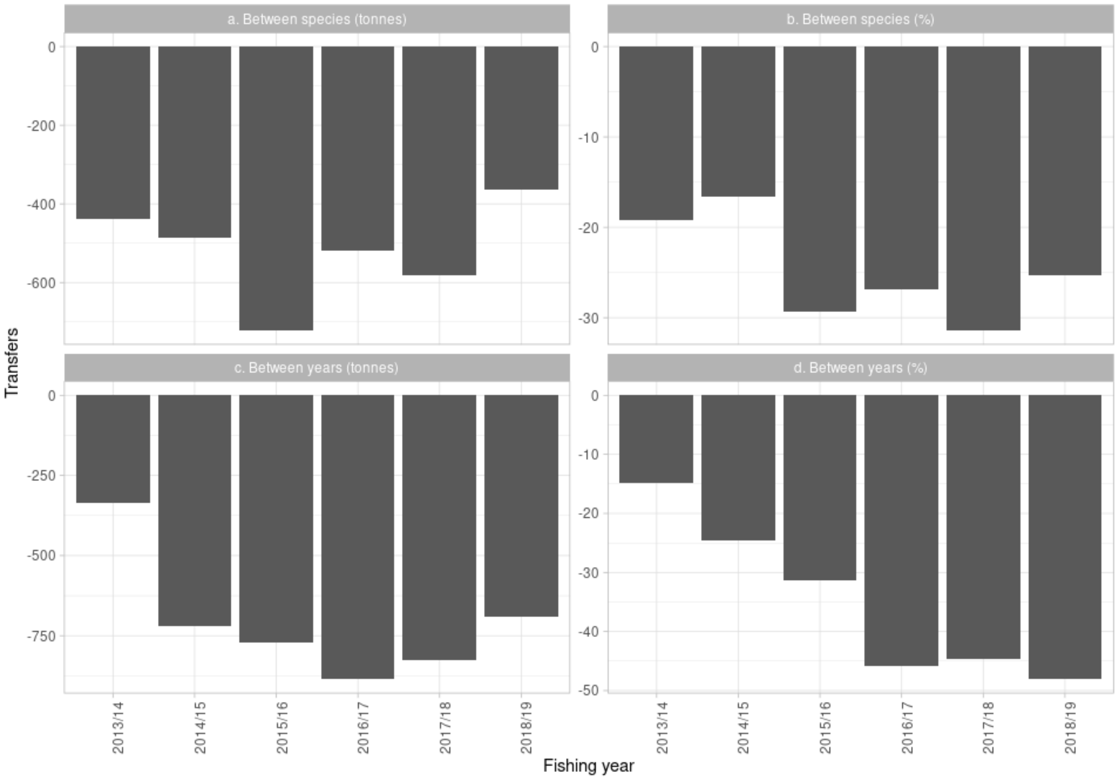

Figure 4.1.6: Blue ling in 5.a and 14. Net transfer of quota, from blue ling to other species, in the Icelandic ITQ system by fishing year.

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 4.1.1 and Table 4.1.2. 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 before 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 2004– 2019 are shown in Figure 4.1.7. Due to a mistake, no length measures were called for from commercial catches in 2017. Mean length from trawls increased from 86 cm in 2012 to 108 cm in 2019. On average mean length from longlines is higher than from trawls.

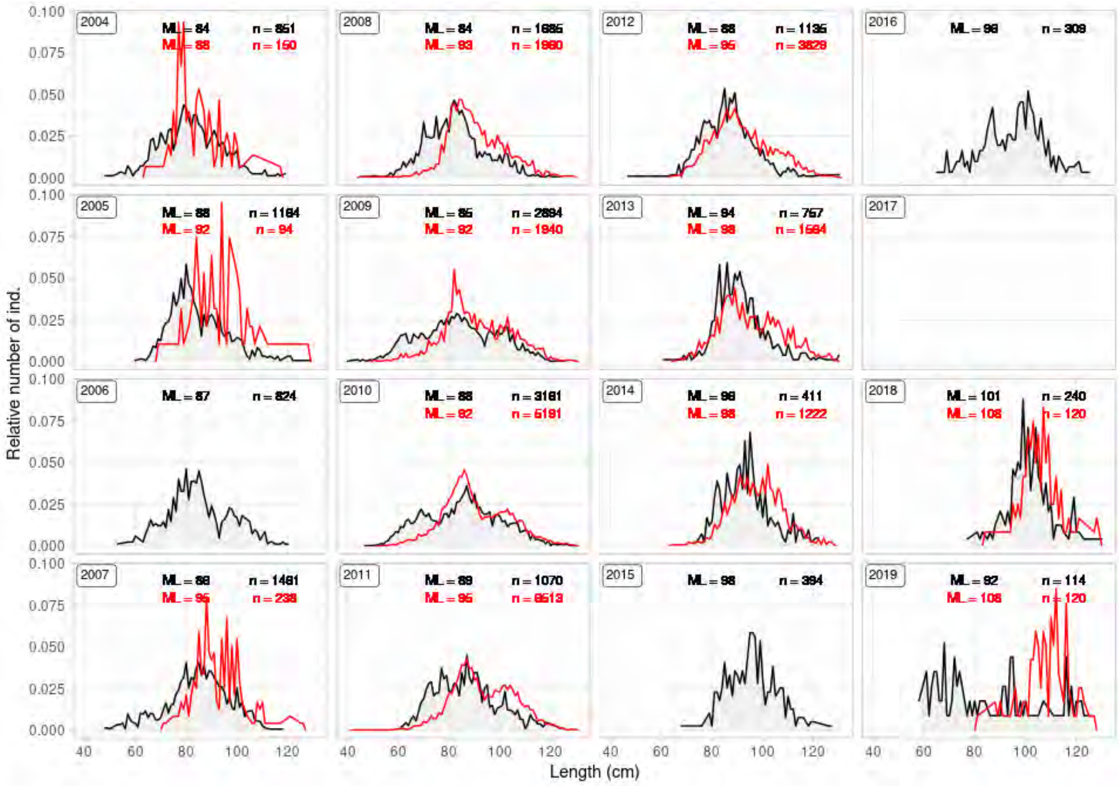

Figure 4.1.7: Blue ling in 5a. Length distribution of blue ling from trawls (grey area) and longlines (red lines) of the Icelandic fleet since 2004. No data available in 2017.

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 4.1.8. 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 and effort may be informative regarding the development of the fishery. CPUE from longlines was high from 2008 to 2013 but has decreased markedly since. No marked changes were observed from trawls from 2000 apart from an increase in 2017. At the same time, effort has been reduced substantially since 2011. 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.

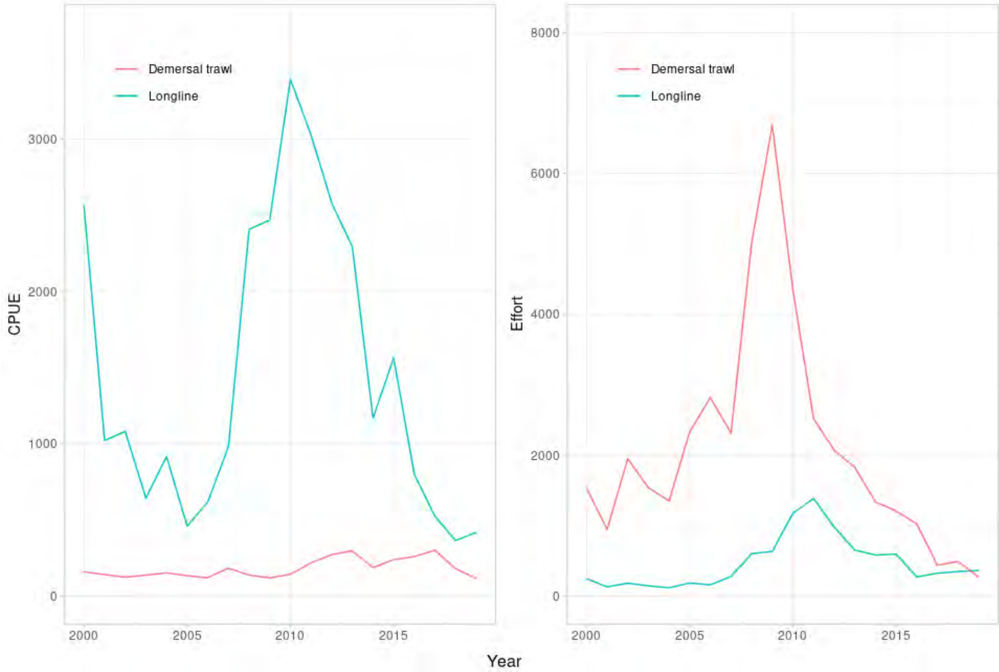

Figure 4.1.8: Blue ling in 5.a and 14. Nominal cpue and effort from longlines (blue line) and trawls (red line) in 5.a based on logbook data where blue ling was either recorded in catches or above certain level.

Time-series stratified abundance and biomass indices from the spring and autumn trawl surveys are shown in Figure 4.1.9 and length distributions from the autumn survey and its spatial distribution in Figure 4.1.10 and Figure 4.1.11. 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.

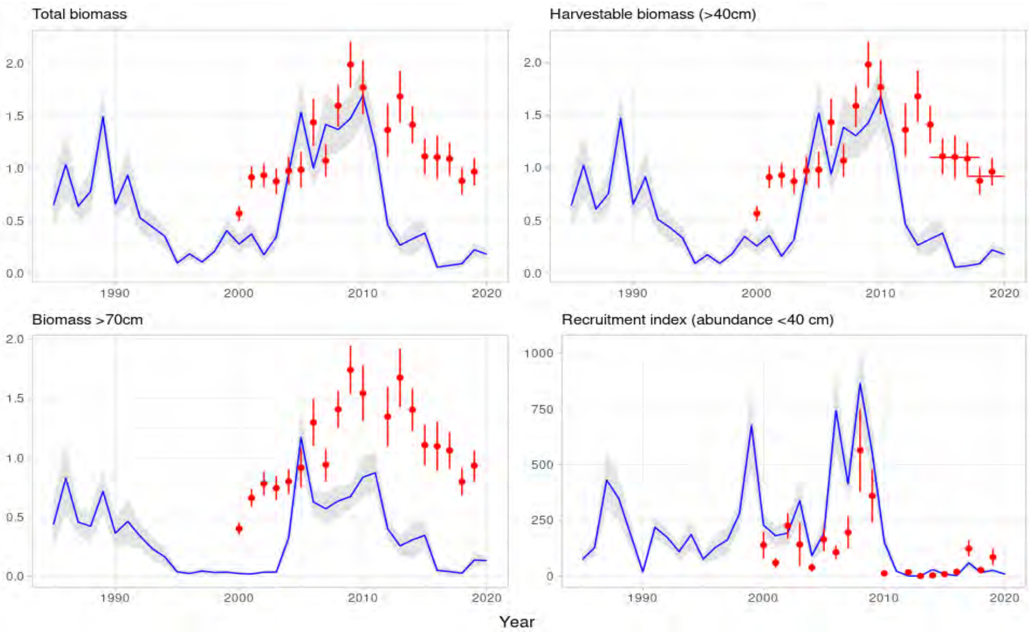

Figure 4.1.9: Blue ling in 5.a and 14. Abundance indices for blue ling in the Icelandic autumn survey since 2000 (red points and vertical lines) and the spring survey since 1985 (faded lines and shaded area). Total biomass index (top-left), biomass of 40 cm and larger (top-right), biomass of 70 cm and larger (bottom-left) and abundance - standard error of the estimate.

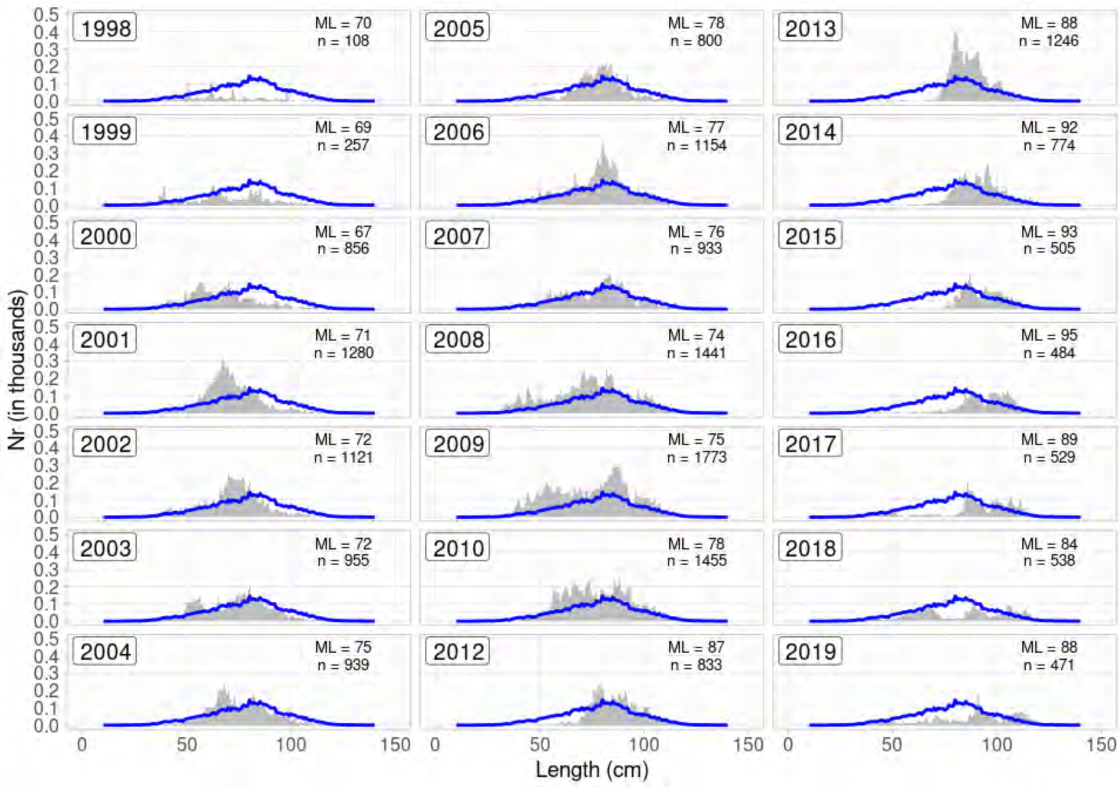

Figure 4.1.10: Blue ling in 5.a and 14. Length distribution from the Icelandic autumn survey since 1998. Blue line is the average by length over the displayed period.

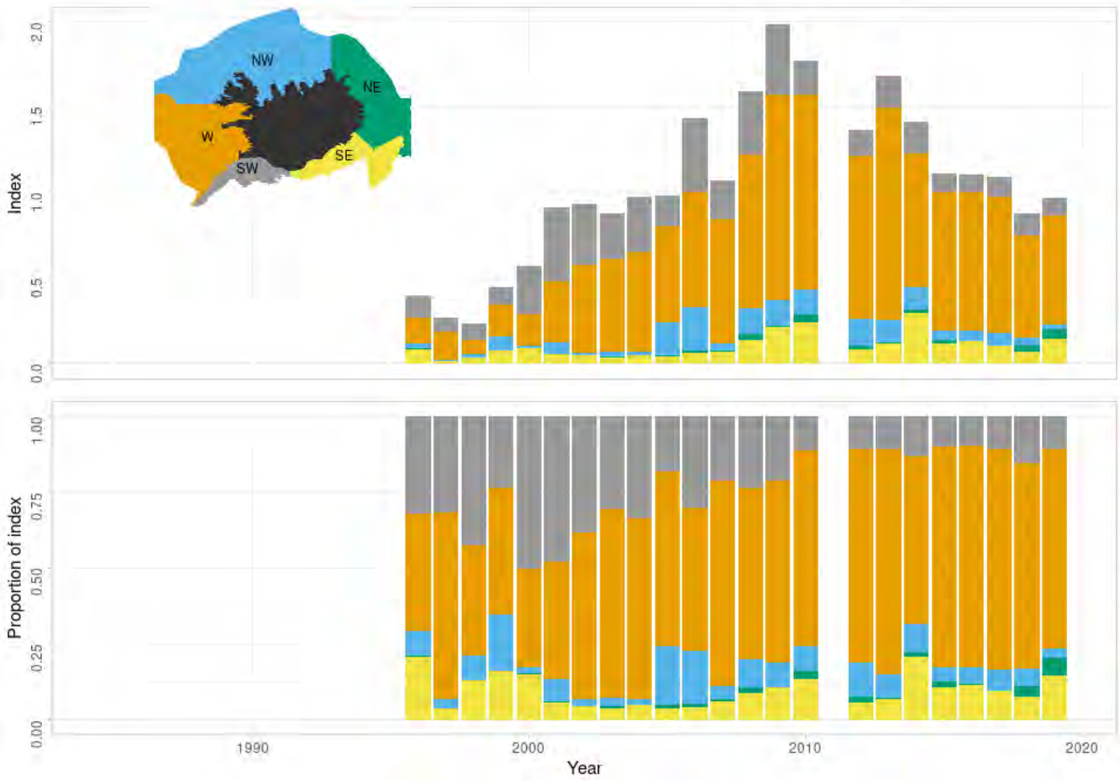

Figure 4.1.11: Blue ling in 5.a and 14. Non-standardised estimates of CPUE (left) and fishing effort (right) from longlines and trawls based on logbook data where blue ling was recorded in catches

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. This can be seen when looking at Table 4.1.1. 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 2019 longliners caught 161 or 38% of the catches, trawls 229 or 55% % and other gear 25, or 6%. As longliners take on average larger blue ling (Figure 4.1.7) 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 in 2011 but in longlines in 2012 and 2013. The expansion of the longline fleet to deeper waters (Figure 4.1.4) may be the result of decreased catch rates in shallower areas.

CPUE and effort As stated above cpue indices from commercial catches are not considered a reliable index of stock abundance. Therefore, the rapid increase in cpue 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 4.1.8). 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 4.1.8).

Surveys The spring survey covers only the shallower part of the depth distributional range of blue ling and shows high interannual variance (Figure 4.1.9). 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 4.1.9). 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 4.1.9 and Figure 4.1.10). 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 4.1.12 and Table 4.1.5). 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.

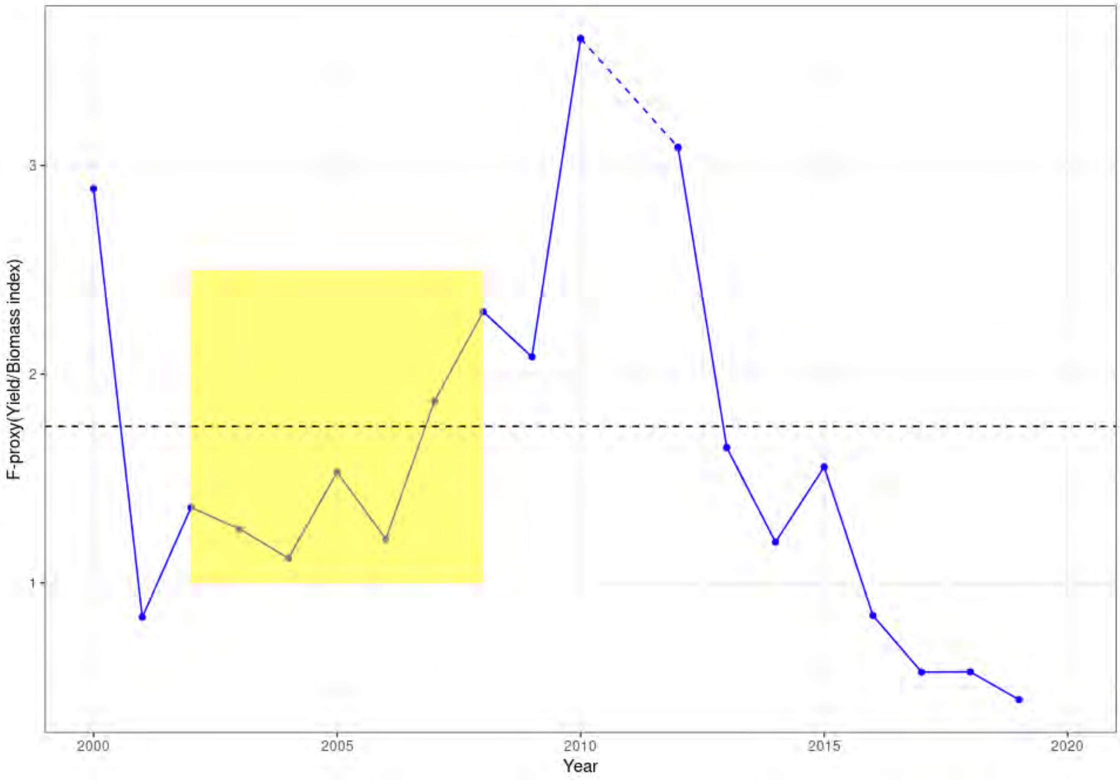

Figure 4.1.12: Blue ling in 5.a and 14. Changes in relative fishing mortality (Yield/Survey biomass >39 cm). The yellow box highlights the reference period used as basis for the advice in 2012-2019, and the horizontal dotted line used to be the target Fproxy

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 2020.

4.2.6.1 Comments on the assessment and advice

The assessment presented above is based on the ICES DLS approach for category 3.s 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 basis for the advice 2012-2019 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 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. 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.

4.2.7 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 4.1.1: 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
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	229	1	161	25	57	8	53	416

Table 4.1.2: 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
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

YEAR	FAROE	GERMANY	GREENLAND	ICELAND	NORWAY	RUSSIA	SPAIN	UK	DENMARK	TOTAL
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	46	0	36	0	0	0	0	89

Table 4.1.3: 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	236		

Table 4.1.4: 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	

Year	Faroe	Germany	Iceland	Norway	UK
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	1		502		
2019	5		415	4	

Table 4.1.5: 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

Year	Iceland	Greenland	Index	Fproxy
2019	423.983	89	963.9	0.53215

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. Faroese vessels have been fishing almost exclusively in 5.b, French and Scottish vessels have been mostly fishing in 6.a, with a smaller catch in 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 are also reduced 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 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.

In 2019, 94.2 % of the landings were from bottom trawlers and 5.8% from longliners. 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 revised 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.

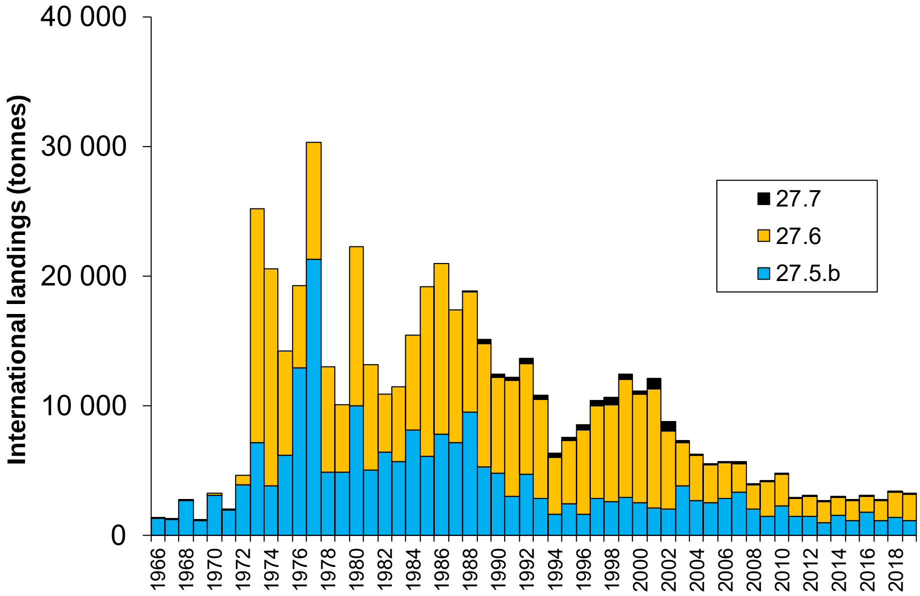

Figure 4.3.1. International landings for bli.27.5b67 in ICES subareas 6 and 7 and Division 5b.

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 2019 and 2020 is "when the MSY approach is applied, catches should be no more than 11778 tonnes in 2019 and no more than 11150 tonnes in 2020."

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 5.b, 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 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(4)	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	

(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) including a quota of 419 t to Germany, which was caught as ling without blue ling landings

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.

Since 2015, the EU TAC in EU and international waters has been 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 implies 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. 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.

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 2019 were not uploaded to InterCatch but provided to the expert group.

InterCatch showed that international discards in 2018-19 were less than 1% of landings for country reporting through InterCatch. Faroese vessels are considered making no discards. The estimated proportion of blue ling discarded in the French fisheries has been less than 0.5% in all year since 2009, well below the maximum 5% level where discards are considered negligible in ICES advice. This low discarding proportion comes from the absence of catch of small blue ling on most of the fishing grounds.

Similarly, Spanish observer on board trawlers fishing in 6.b reported that discards for this species are negligible, in the range of 0–0.5% of the catch.

4.3.5.2 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. 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.

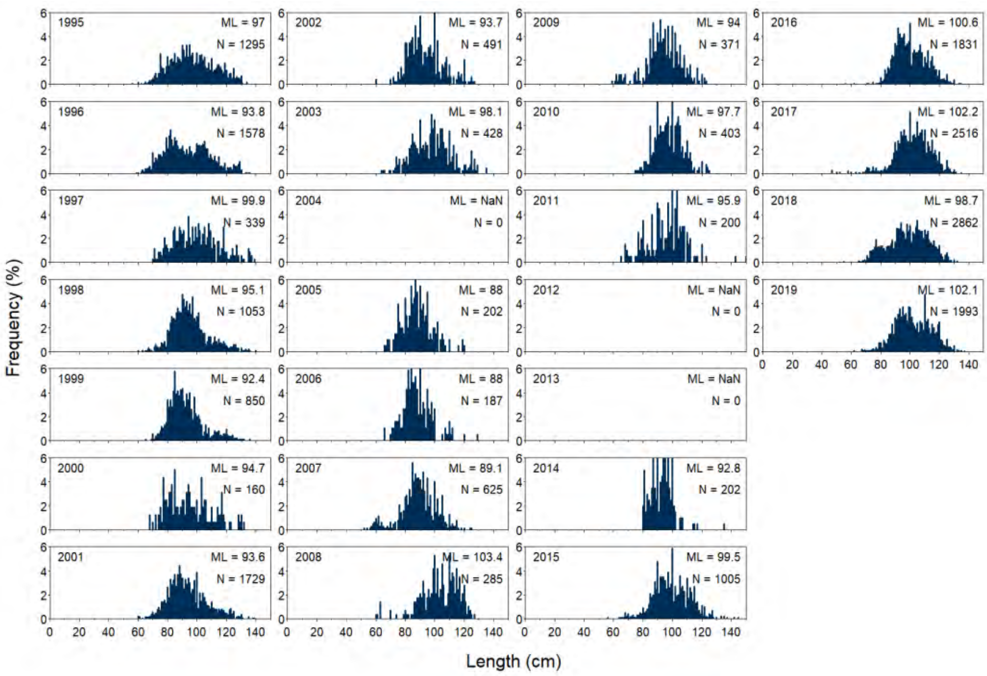

Figure 4.3.2. Length composition of blue ling landings from Faroese otter-board trawlers >1000 HP in ICES 5.b.

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).

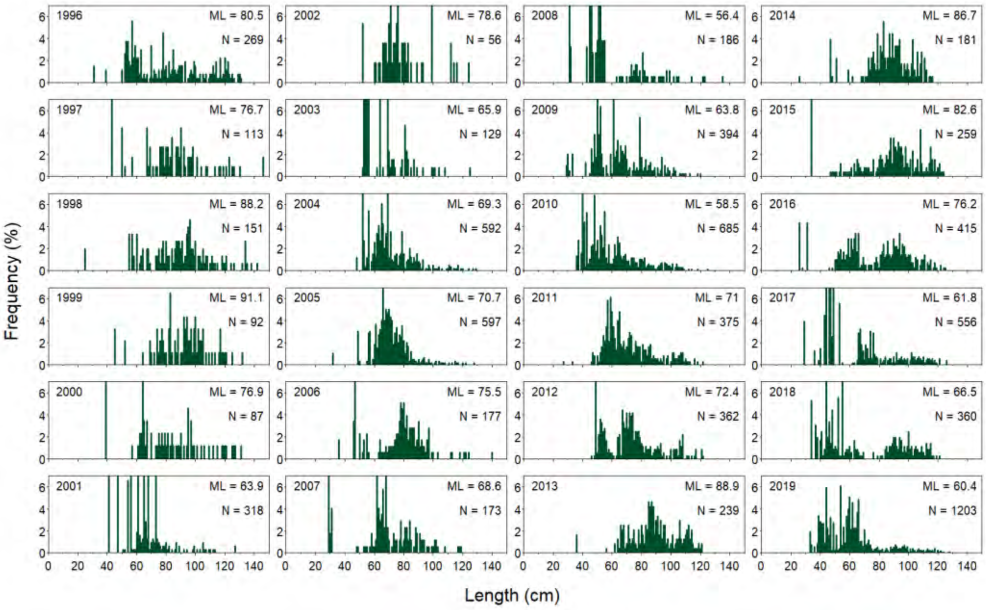

Figure 4.3.3. Length composition of blue ling in the Faroese summer groundfish survey on the Faroe Plateau.

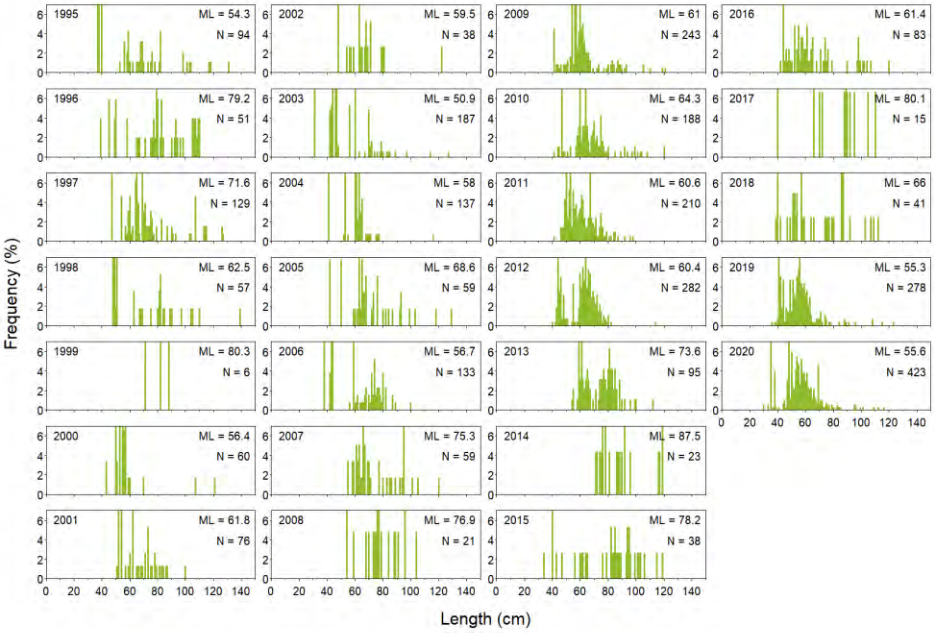

Figure 4.3.4. Length composition of blue ling in the Faroese spring groundfish survey on the Faroe Plateau.

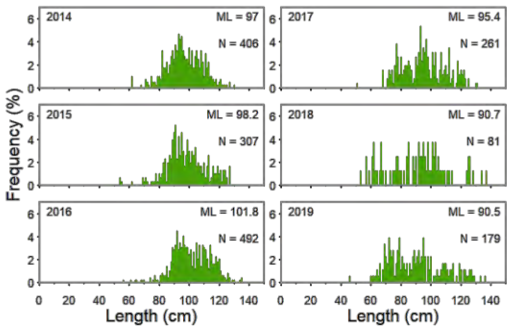

Figure 4.3.5. Length composition of blue ling in the Faroese deep-water survey in Faroese waters.

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).

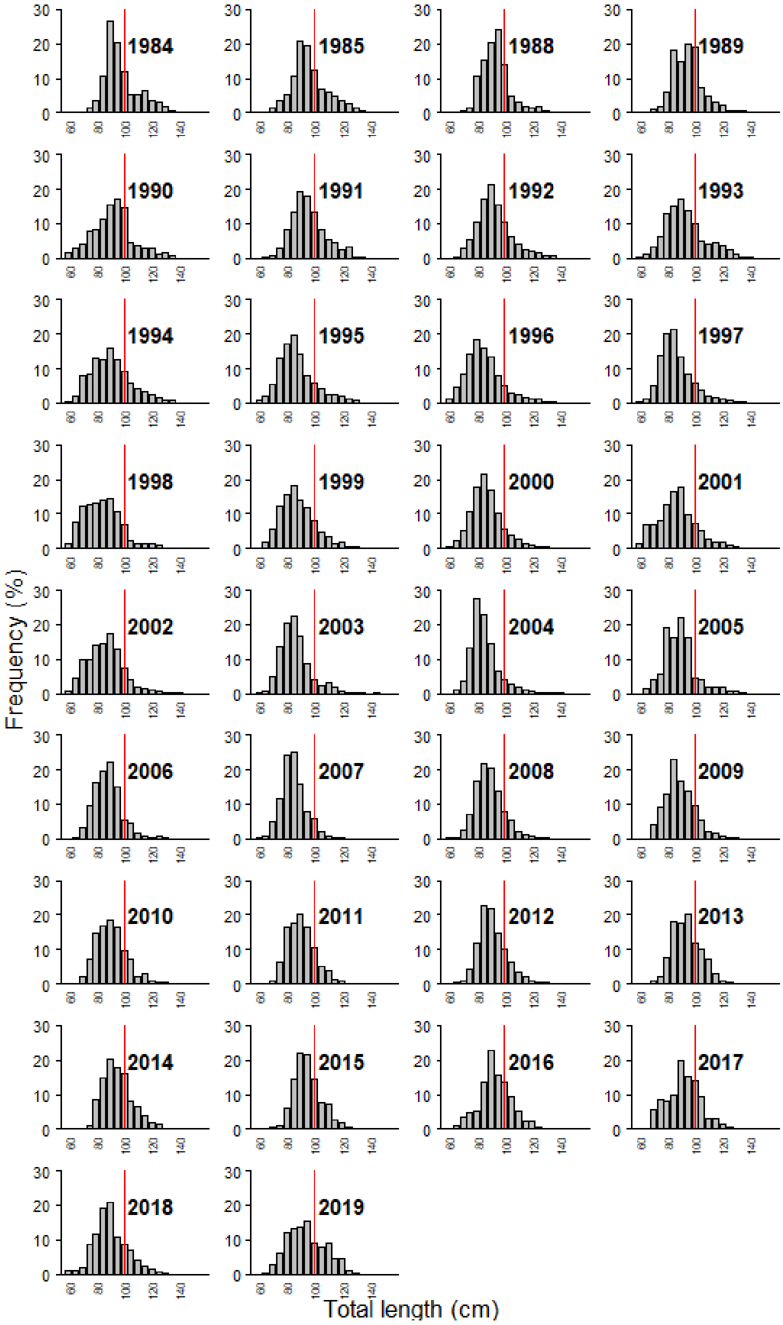

Figure 4.3.6. Length distribution of French landings from 1984 to 2019 (no data in 1986-87) by 5 cm intervals. The red line represent the 100 cm size class.

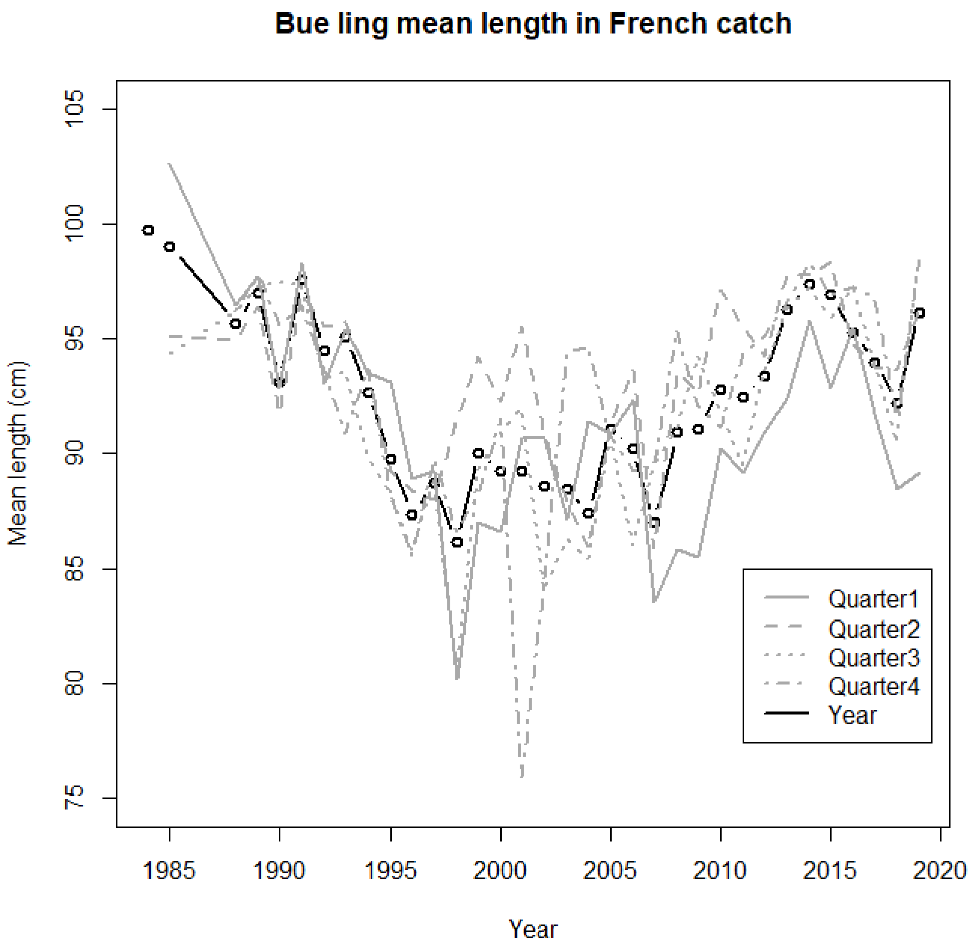

Figure 4.3.7. Quarterly mean length in French trawlers landings, 1984–2019 (no data in 1986-87).

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.

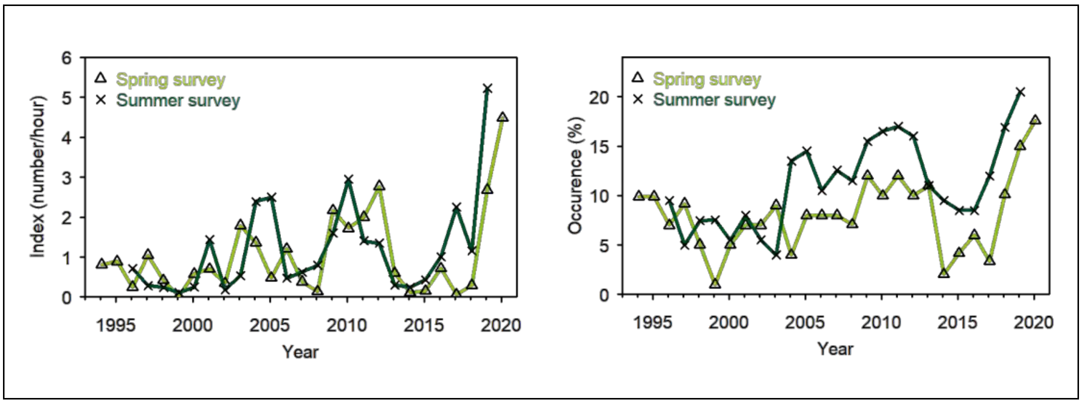

Figure 4.3.6. Juvenile (<80 cm) blue ling caught in groundfish surveys on the Faroe Plateau (left) number per hour and (right) occurrence.

The indices of total biomass from Faroese are uncertain with high values in 2004, 2005 and since 2009 for the summer survey and a sharp and recent increase are observed in the spring survey (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.

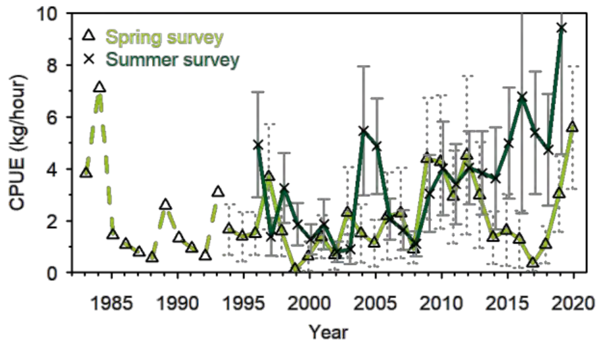

Figure 4.3.7. Biomass indices (kg.hour^{-1}) of blue ling in Faroese surveys.

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)

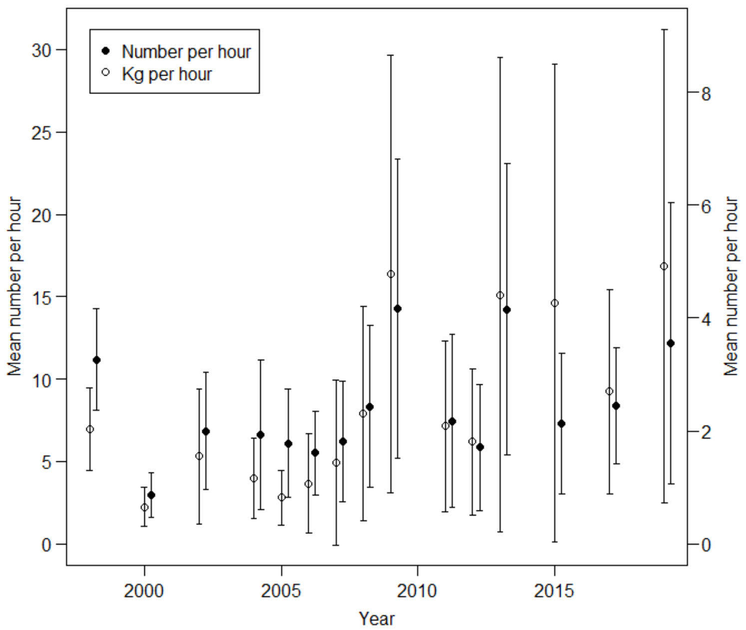

Figure 4. 3.8. Biomass and abundance indices of blue ling from the Marin Scotland deep-water survey.

Multiyear catch curve (MYCC) model

The fit of the model reflects a sustained increase of the stock biomass since 2003. The stock biomass in 2003 is estimated to 53 000 tonnes and is the historic low, the biomass has almost doubled since at 99 000 t.

Results of the Multiyear catch curve (MYCC, see stock annex) model are presented in Figures 4.3.9 to 4.3.11. The fit of the model to the landings, considered equivalent to total catch as discards are negligible was good for recent years. The model shows erratic variation for years 1995-2003 where the quality of catch data was probably poorer and age data to fit the model start only in 2009 and do not inform much on early years (Figure 4.3.9a). The fit to proportion-at-age is generally correct, age 9 in 2018 was not well fitted, but there are only two data points to fit this value at the moment (Figure 4.3.9b). Age 9 in the two early years were also not well fitted which come from a low proportion of this age groups in these years, while larger numbers of the same cohorts were caught in subsequent years. Importantly, the plot shows that there is no cohort effect.

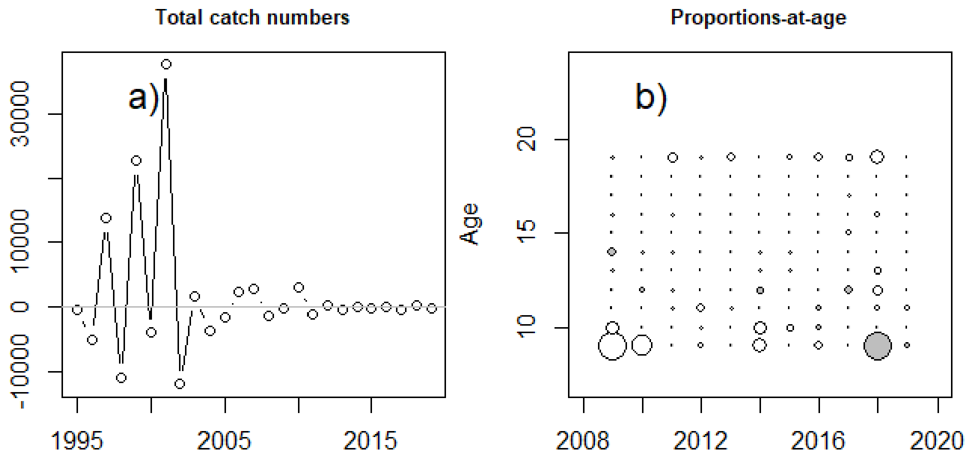

Figure 5.3.9. Diagnostic plot of the fit to the MYCC, a) residuals and b) proportion-at-age.

The total mortality was estimated to have decreased from 2001 and stabilized at 0.14-0.15 since 2013 (Figure 4.3.10). As in previous assessment, the fishing mortality has been smaller than the F_{MSY}=0.12 reference point for the stock since 2004. It has been smaller than 0.07 (MSY F_{lower}) since 2008. The total number of individuals of age 9 and over was estimated to 22.6 million at the start of 2020. The recruitment estimate is more uncertain. Remember that the recruitment is at age 9, younger age groups are not fully recruited as they occur in smaller abundance than age 9, only smaller number are observed before age 6.

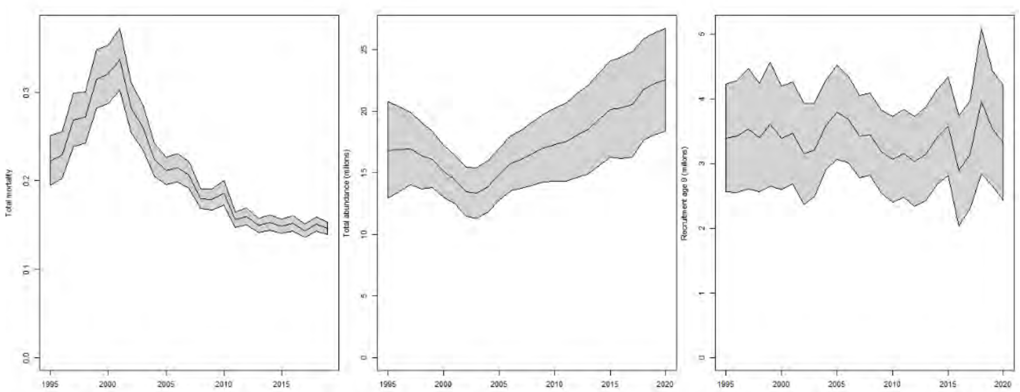

Figure 4.3.10. Model estimates 1995-2020, (left) total mortality *Z*, (centre) total abundance of fully recruited age groups (9 and older), (right) recruitment.

Stock Reduction Analysis (SRA) using FL_{aspm}.

The model was not fitted in 2020.

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). Lastly, reference points with and without using the ICES advice rule (AR) were developed. The AR is based on the F_{MSY} fishing mortality reference point, that provides the exploitation rate to give catch advice, and the biomass reference point MSY $B_{trigger}$, below which F is reduced linearly from F_{MSY} at MSY $B_{trigger}$. MSY F_{upper} with no AR is remained here to show that without the AR a smaller fishing mortality would apply.

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

With an increasing number of years in the modelling, the accuracy of estimates increases. The current fishing mortality is estimated to be very low with a high precision. Simple observation of the data from indicators are in line with model results. Large fish are observed in the catch and surveys, reflecting that the fishing mortality is low, fish survive to an old age and growth. Age estimates confirm the occurrence of fish up to age 20 in abundance and some individuals of more than 30 years are found, although these large ages are uncertain.

Following reference points development carried out in 2015 for stocks of ICES category 1, F_{MSY} for the stock was set to 0.12 in 2016, and this resulted in an increase of the catch advice from 2017 compared to previous years. The last advice before 2016, delivered in 2014, was based on an F_{proxy} defined as F50%SPR=0.07. The FMSY at 0.12 needs to be revised in the future, because the variability of the stock dynamics was not captured in the calculation of this reference points (ICES, 2015).

4.3.7.1 Management considerations

In recent years, the EU TAC in EU waters and international waters of Division 5b and subareas 6 and 7 was set to the advice level. This presents a risk of fishing beyond MSY levels because total catches from the stocks include catch counted against this EU TAC and catches in Faroese waters, from the Faroese vessels and some EU fleets to which the Faroe Islands allocate a quota in Faroese waters.

Nevertheless, 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).

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

YEAR	FAROES	FRANCE(1)	GERMANY(1)	NORWAY	UK (E & W) (1)	UK (Scot.)	IRELAND	RUSSIA(1)	TOTAL
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

(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

YEAR	FAROES	NORWAY	SCOTLAND	France	TOTAL
2019	64	56	0	0	120

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
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

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

(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

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

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		

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 (Division 12.b) and 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 is now very low and landings are now reported mostly from Division 2a. In 2019, 53% 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.

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 26% of that level. However, the total landings have increased since 2016 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).

4.4.3 ICES Advice

The ICES advice for 2020 and 2021 is:

"*ICES advise that when precautionary approach is applied, there should be zero catches in each of the years 2020 and 2021. This advice is unlikely to change until the scientific information is sufficient to assess the status of the stock. Closed areas to protect spawning should be maintained*."

4.4.4 Management

A 2020 precautionary TAC for EU vessels in international waters of 12 was set to 137 tonnes and value for bycatches only; no directed fishery for blue ling is allowed in this area. TACs for vessels in EU waters and international waters of 5.b, 6 and 7 were set to 11 150 tons; of this a quota for Norwegian and Faroese vessels was set to 250 and 150 tonnes respectively, each to be fished in Union waters of 2.a, 4, 5.b, 6 and 7. In Union and international waters of 2 and 4, a precautionary TAC for EU vessels was set to 32 tonnes. In Union and international waters of 3.a, a precautionary TAC for EU vessels was set to 5 tonnes.

4.4.5 Data availability

4.4.5.1 Landings and discards

Landings data are presented in Table 4.4.0a–f. Denmark reported 0,75 tons of discards in 2019.

4.4.5.2 Length compositions

No new length compositions are available. There are length compositions from the Spanish fishery from 2017.

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 Subarea 1, 2, 3.a and 4 combined (Figure 4.4.5.). The cpue series is calculated from 2000–2019 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 4.4.2-4.4.4). 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 for this species since the fishery is exclusively done on larger individuals.

The landings have declined for all areas and the mean landings are now less than 30% 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 has landed 389 tons (45% of total landings for the whole stock area) from this Subarea.

The historical Norwegian landings, mainly in 2.a show that landings 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 2016 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.

In Subarea 4 an increase on French and Norwegian landings were registered in 2010-2012. The landings then decreased to less than 100 tons and the landings have been stable around this level since 2015.

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 there was also some landings from Division 12a.

The length compositions from Spanish landings from 2017 show lengths from 69-129 cm (Figure 4.4.6). 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 2000–2019. 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

Not applicable.

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 4.4.1).

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

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

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
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

Year	Faroes	France	Germany	Greenland	Norway	E & W	Scotland	Sweden	Russia	Total
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

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
2003	18	1			19
2004	18	1			19
2005	48	1			49
2006	42				42
2007					0
2008		2			2
2009		+			0
2010		+			0

Year	Denmark	Norway	Sweden	FRANCE	Total
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

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
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

Year	Denmark	Faroes	France (4ab)	Germany	Norway	E & W	Scotland	Ireland	Total
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

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

Year	Fa-roes	France	Ger-many	Spain	E & W	Scot-land	Nor-way	Ice-land	Po-land	Lithua-nia	Rus-sia	unallo-cated	To-tal
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

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

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

Year	1	2	3	4	12	Total
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
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

Table 4.4.1 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
2019*	10	852	862

4.4.10 Figures

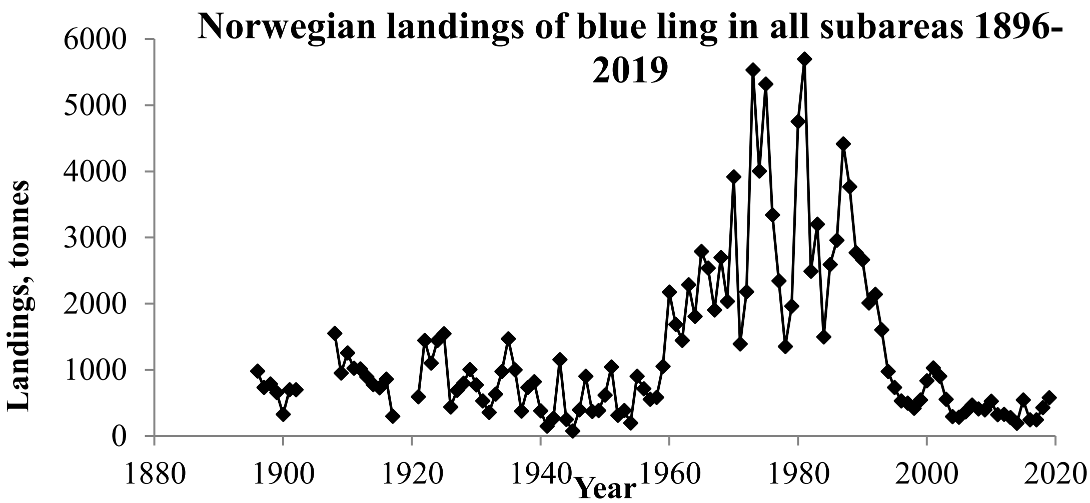

Figure 4.4.1. Reported Norwegian landings on blue ling from 1896–2019.

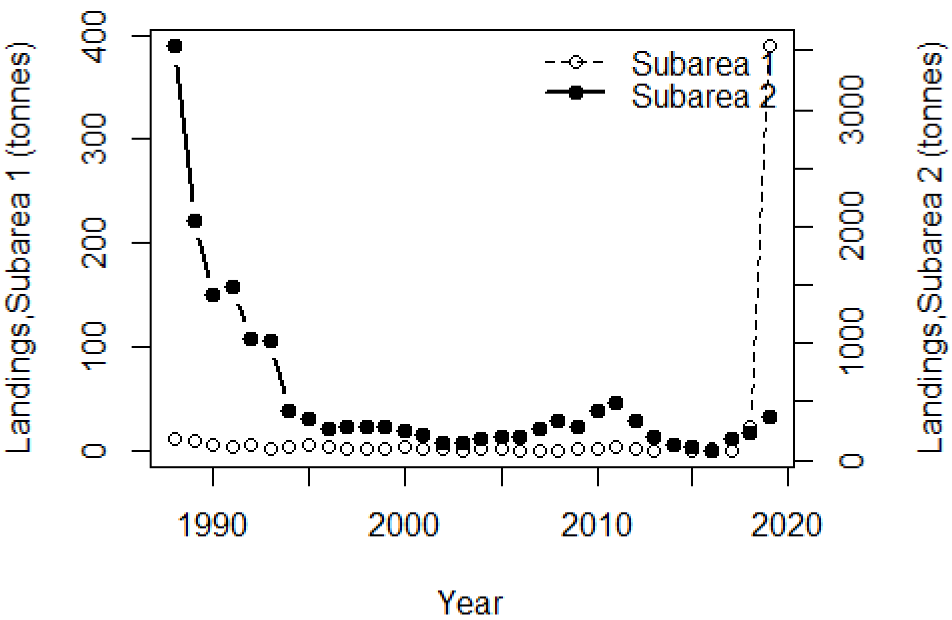

Figure 4.4.2. Landings of blue ling in Subareas 1 and 2. Subarea 1: open circles, left axis. Subarea 2: filled circles, right axis.

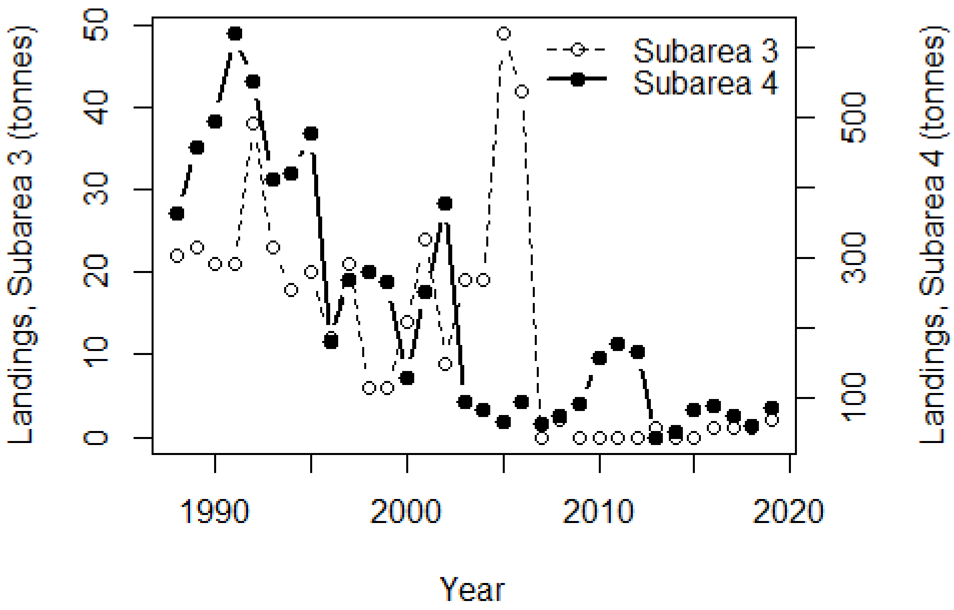

Figure 4.4.3. Landings of blue ling in Subareas 3 and 4. Subarea 3: open circles, left axis. Subarea 4: filled circles, right axis.

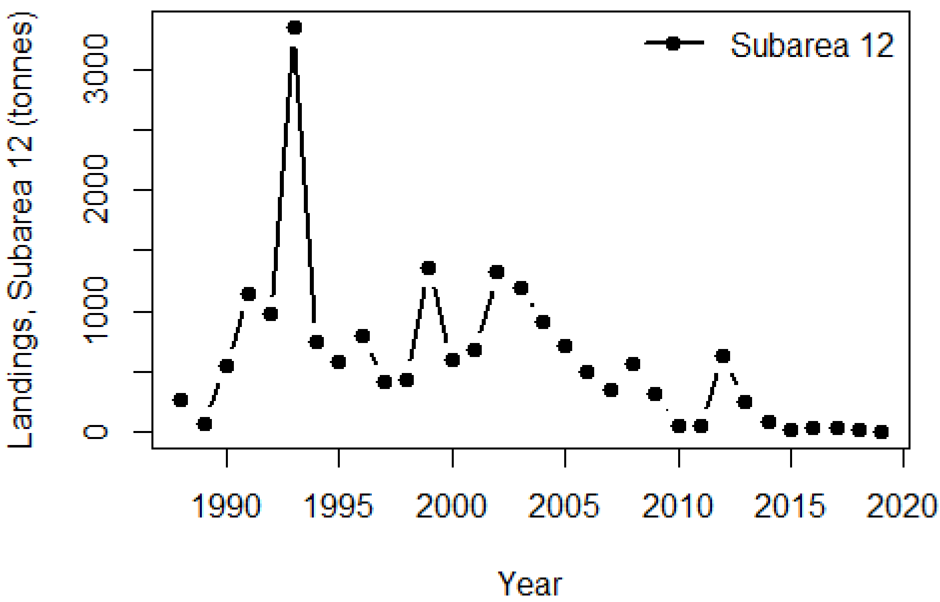

Figure 4.4.4. Landings of blue ling in Subarea 12.

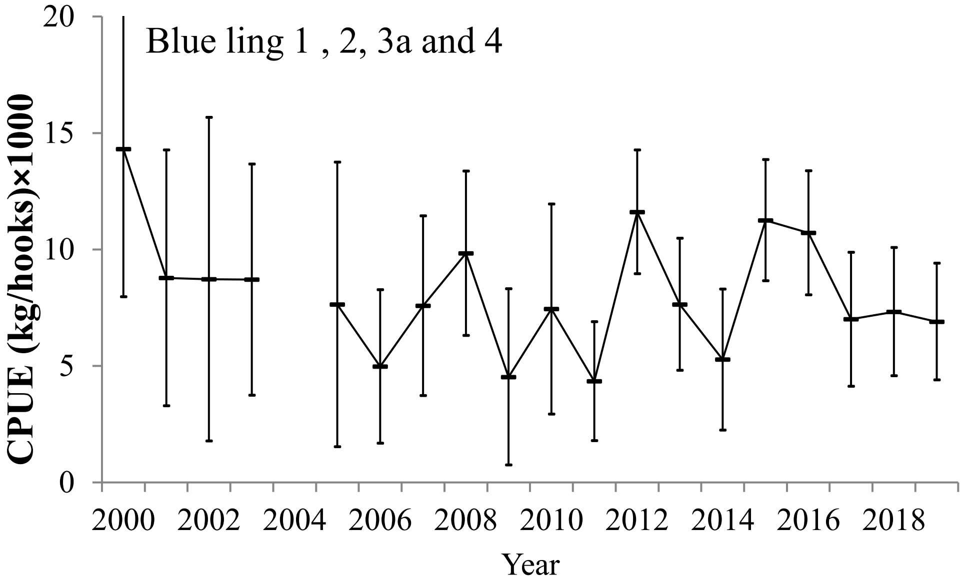

Figure 4.4.5. Norwegian cpue (kg/1000 hooks) from longlines catches in areas 1, 2, 3.a and 4 from 2000–20.

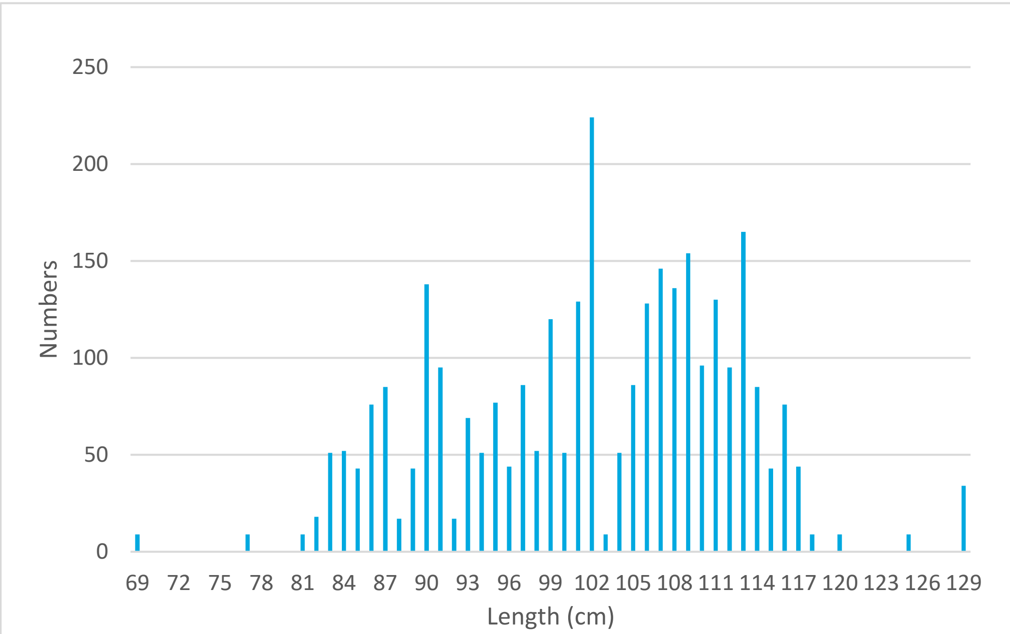

Figure 4.4.6. Length composition from Spanish landings from area 12b in 2017

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.

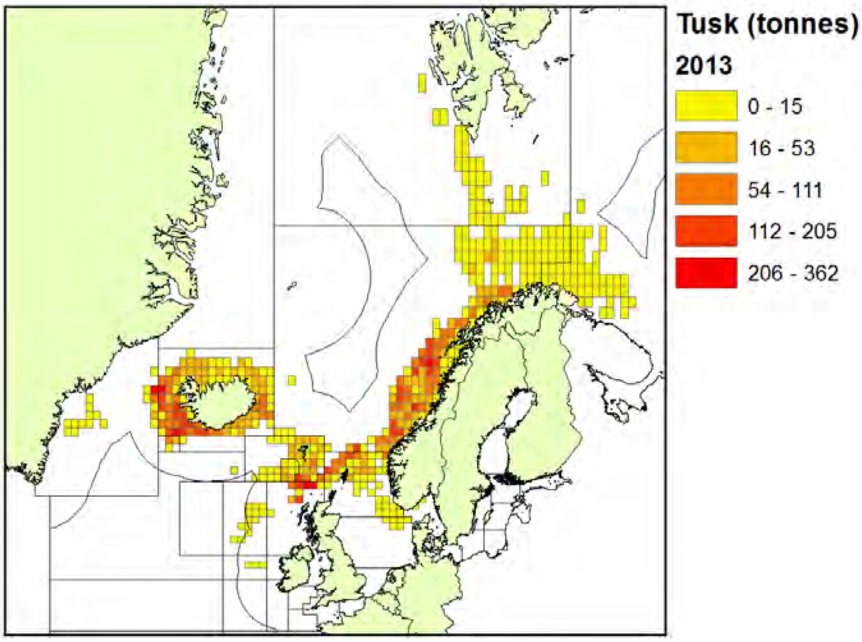

Figure 5.1. Reported landings of tusk in the ICES area by statistical rectangle in 2013. Data are from Norway, Faroes, Iceland, France, UK (England and Wales) and Spain. Landings shown in account for 99% of all reported landings in the ICES area.

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

5.2.1 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 decreased substantially from 308 in 2007 – to 255 in 2008 (Table 5.1.1) and has continued to decrease since. Most of tusk in 5.a, around 97% of catches in tonnes, is caught on long lines, and this had been relatively stable proportion since 1992 (Table 5.1.1).

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

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 south, south-western and western part of the Icelandic shelf (Figure 5.1.2 and Figure 5.1.3). The main trend in the spatial distribution of tusk catches in 5.a according to logbook entries is the decreased proportion of catches caught in the southeast and increased catches on the western part of the shelf. 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.

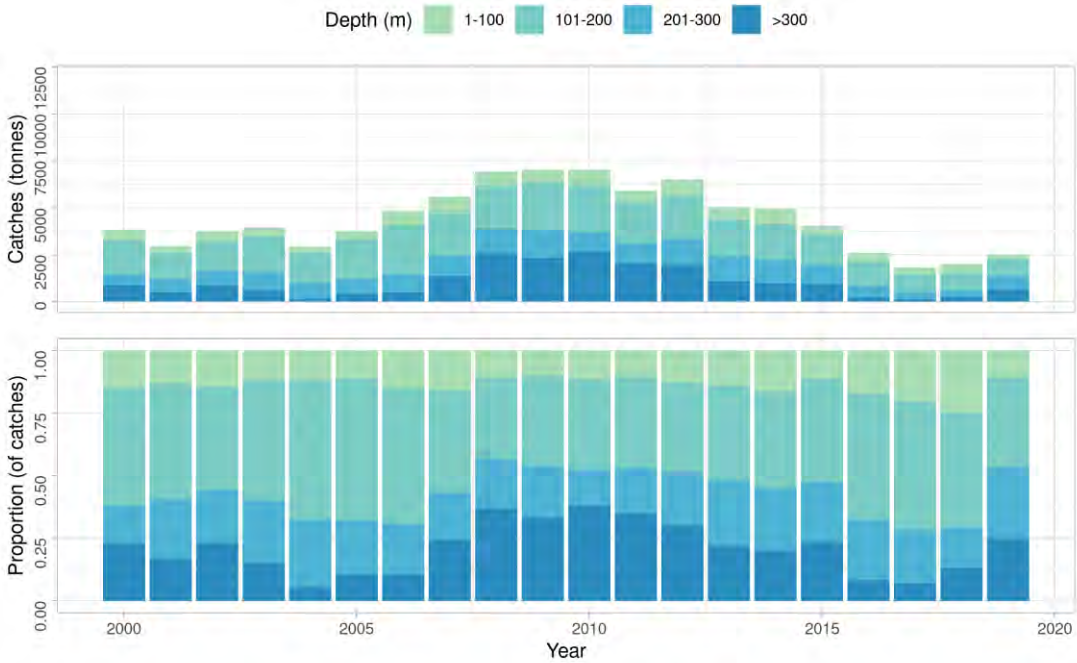

Figure 5.1.1: Tusk in 5.a and 14. Depth distribution of catches in 5.a according to logbooks. All gears combined.

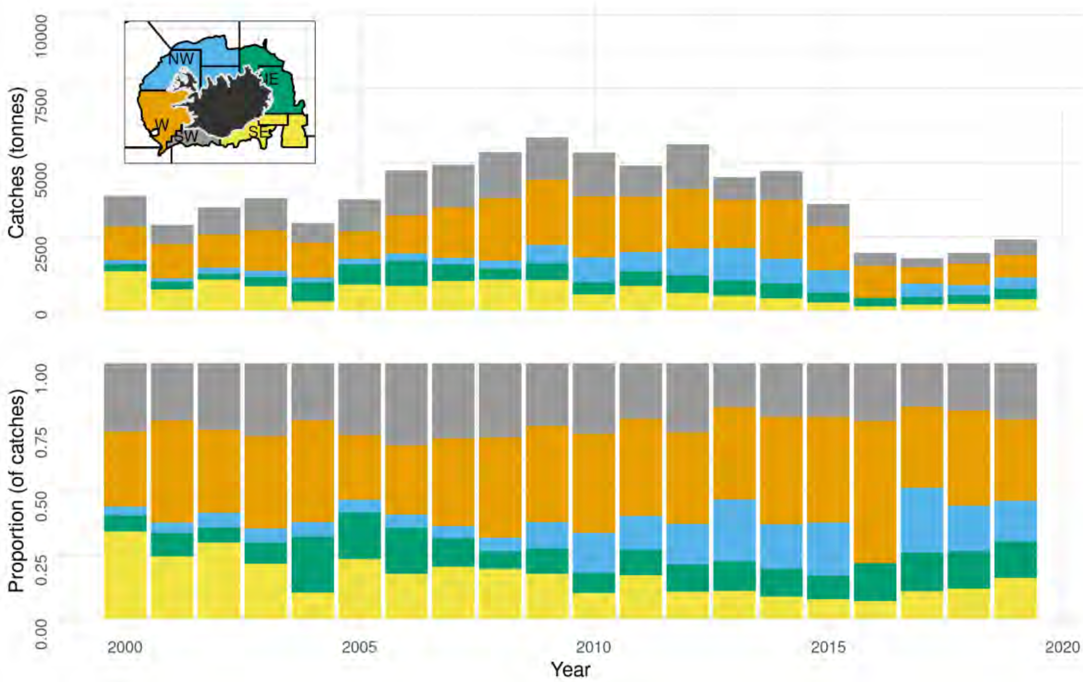

Figure 5.1.2: Tusk in 5.a and 14. Catch distribution and proportions by area according to logbooks. All gears combined.

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.

5.2.2 Landing trends

The total annual landings from ICES Division 5.a were around 3445 tonnes in 2019 (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).

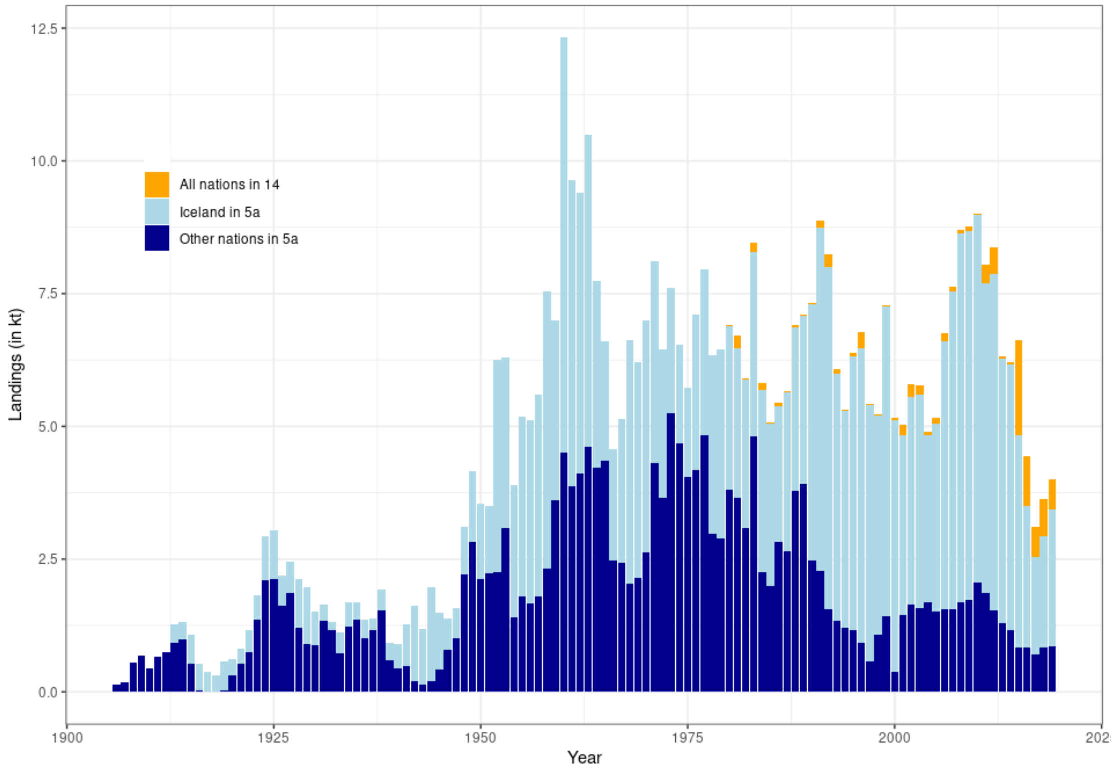

Figure 5.1.4: Tusk in 5.a and 14.Nominal landings within Icelandic waters by Icelandic vessels (light blue) or foreign vessels (dark blue), or within Greenlandic waters (orange). (source for 14: STATLANT).

5.2.2.1 ICES advice

No advice was requested from Iceland in 2020 due to the Covid 19 disruption.

ICES advised that when the Iceland management plan was applied, catches in the fishing year 2019/2020 should be no more than 3 856 tonnes.

5.2.2.2 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.

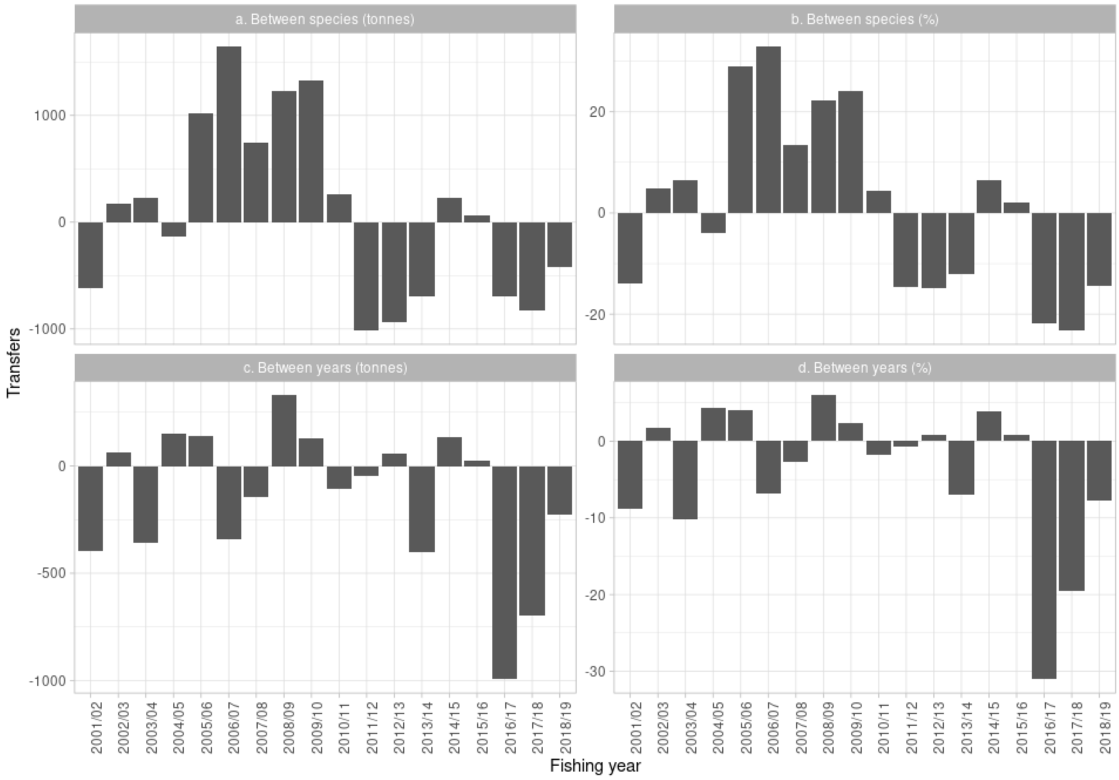

Figure 5.1.5: Tusk in 5.a and 14. Net transfer of quota in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to tusk, but negative values indicate a transfer of tusk quota to other species. Between years (lower): Net transfer of quota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

5.2.3 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 2019 is shown in Figure 5.1.6.

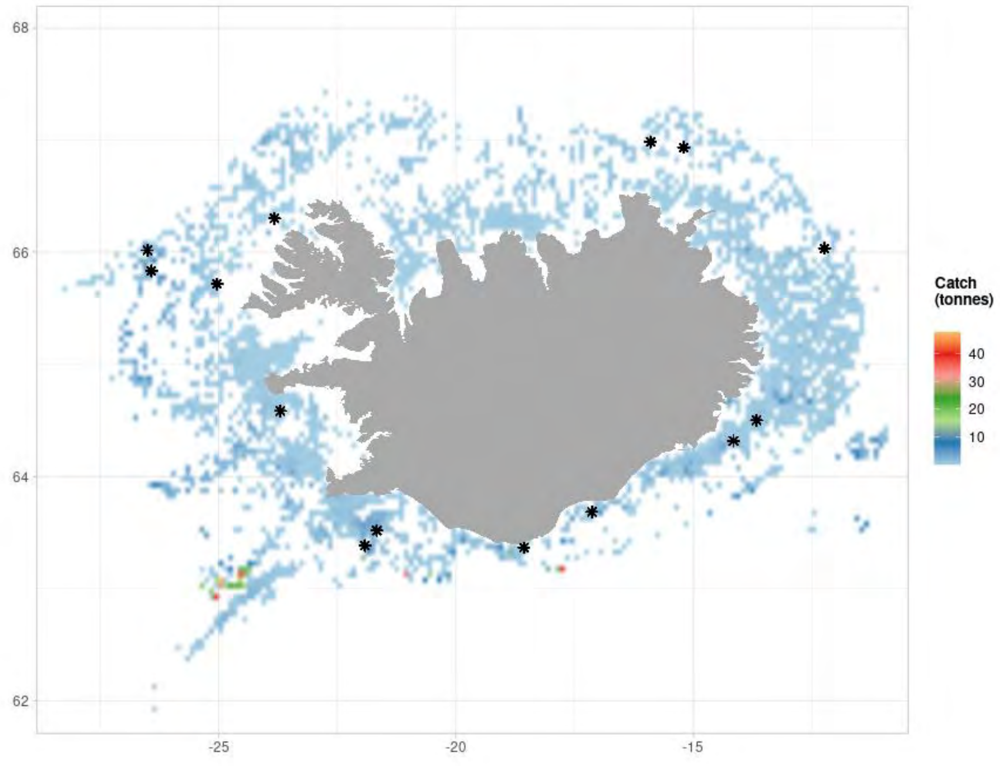

Figure 5.1.6: Tusk in 5.a and 14. Fishing grounds in 2019 as reported by catch in logbooks (tiles) and positions of samples taken from landings (asterisks) by longliners.

5.2.3.1 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.

5.2.3.2 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

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).

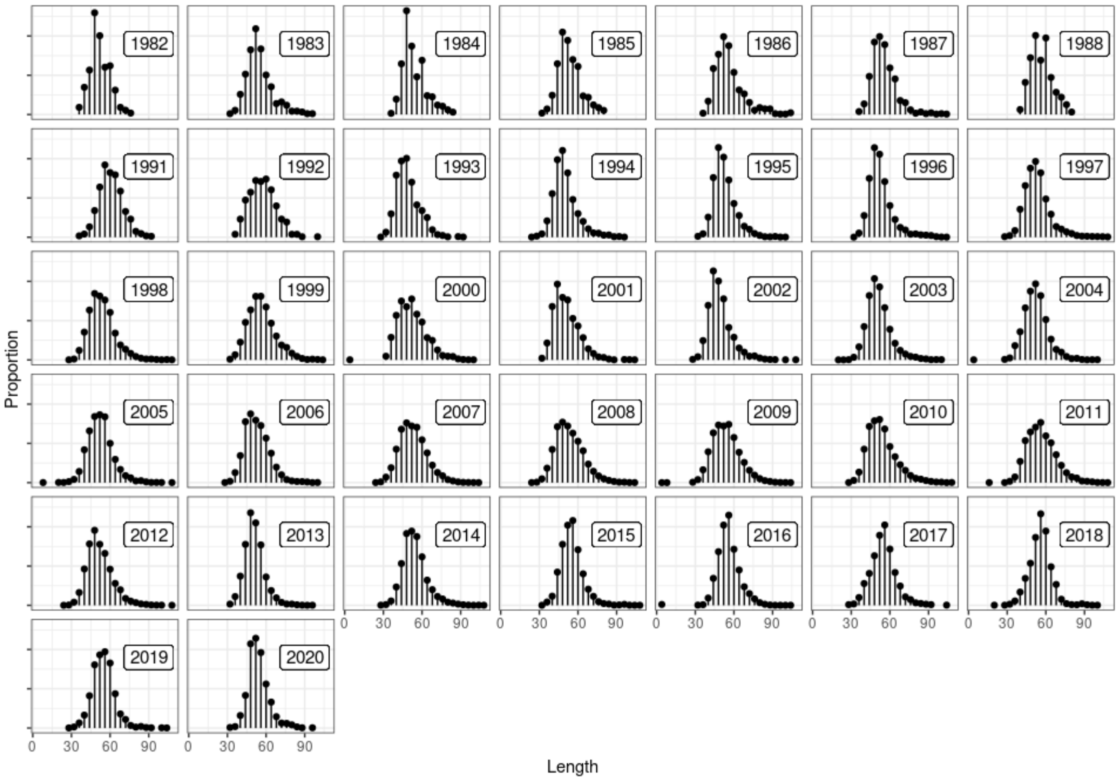

Figure 5.1.8: Tusk in 5.a and 14. Length distributions from Icelandic commercial longline catches.

5.2.3.3 Age compositions

Table 5.1.6 gives an overview of otolith sampling intensity by gear types from 2000 to 2019 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

Year	No. samples (catch)	No. otoliths (catch)	No.samples (survey)	No.aged (survey)
2015	26	505	260	573
2016	14	290	259	676
2017	8	152	245	571
2018	9	179	247	549
2019	15	321	251	704

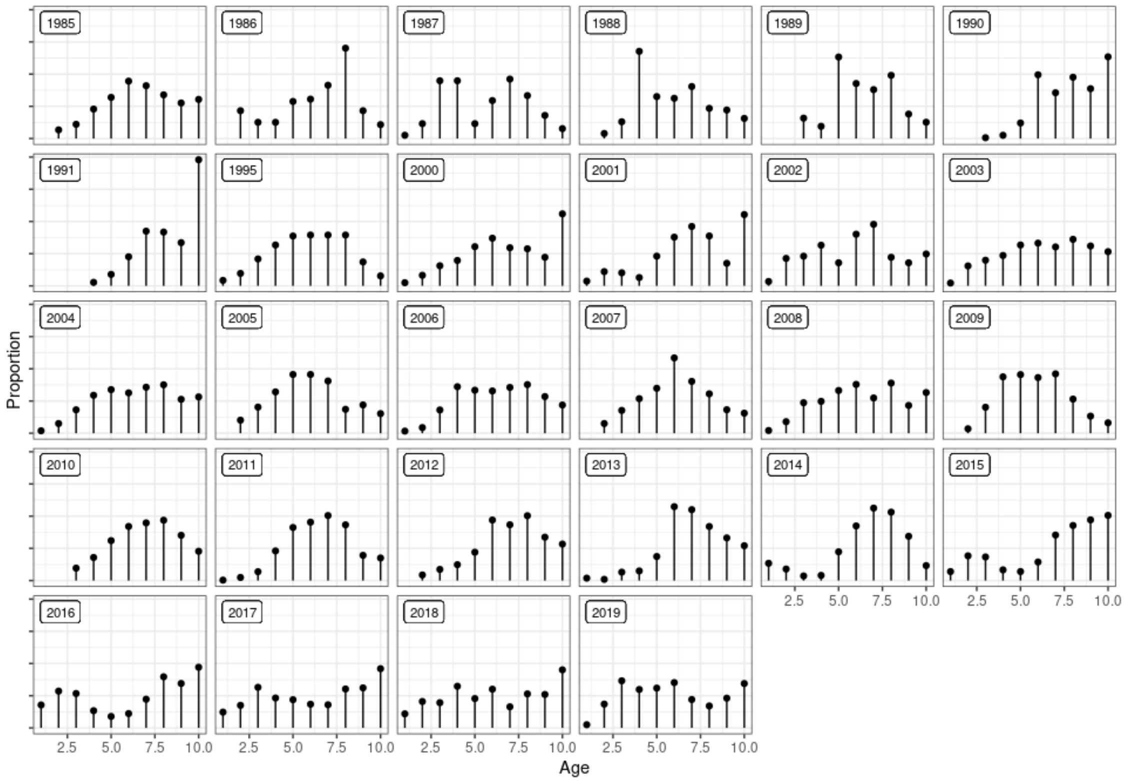

Figure 5.1.9: Tusk in 5.a and 14. Age distributions in proportions in 5.a from the Iceland spring survey.

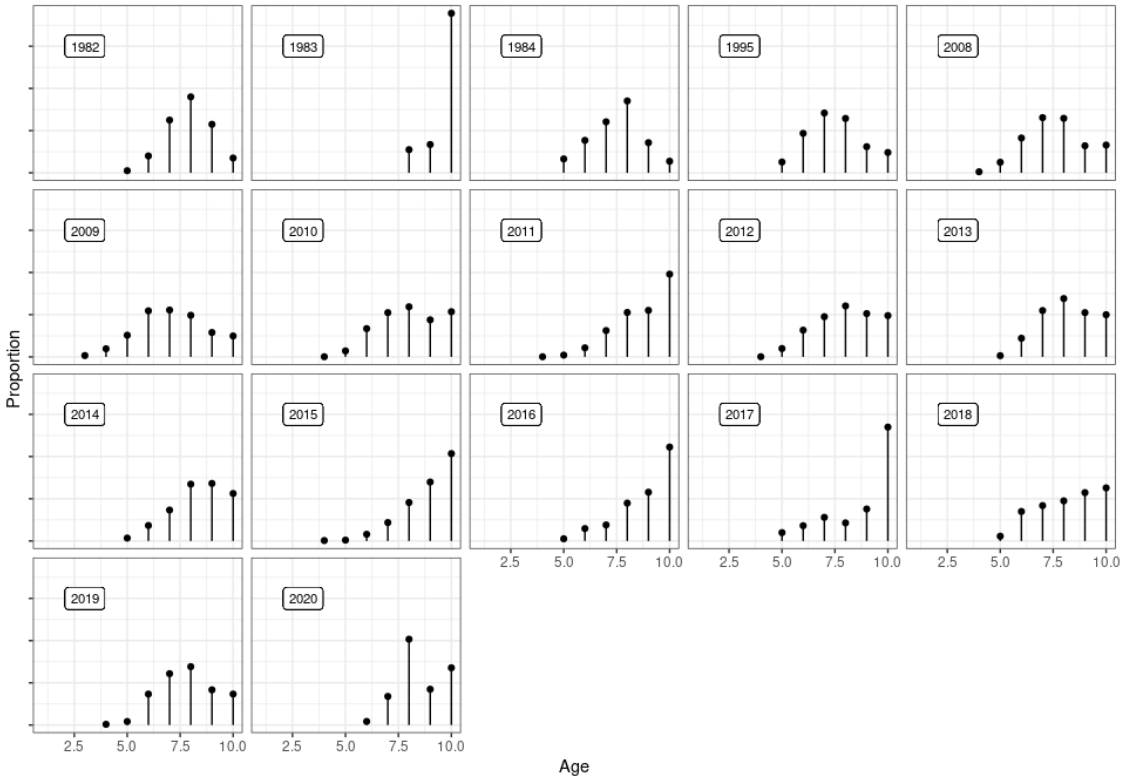

Figure 5.1.10: Tusk in 5.a and 14. Age distributions in proportions in 5.a (from longlines). Samples for 2019 are only from January – March.

5.2.3.4 Weight at age

Weight-at-age data from 5.a are limited to 2008–2020. No data are available from 14.

5.2.3.5 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.

5.2.3.6 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.

5.2.3.7 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 both a 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.

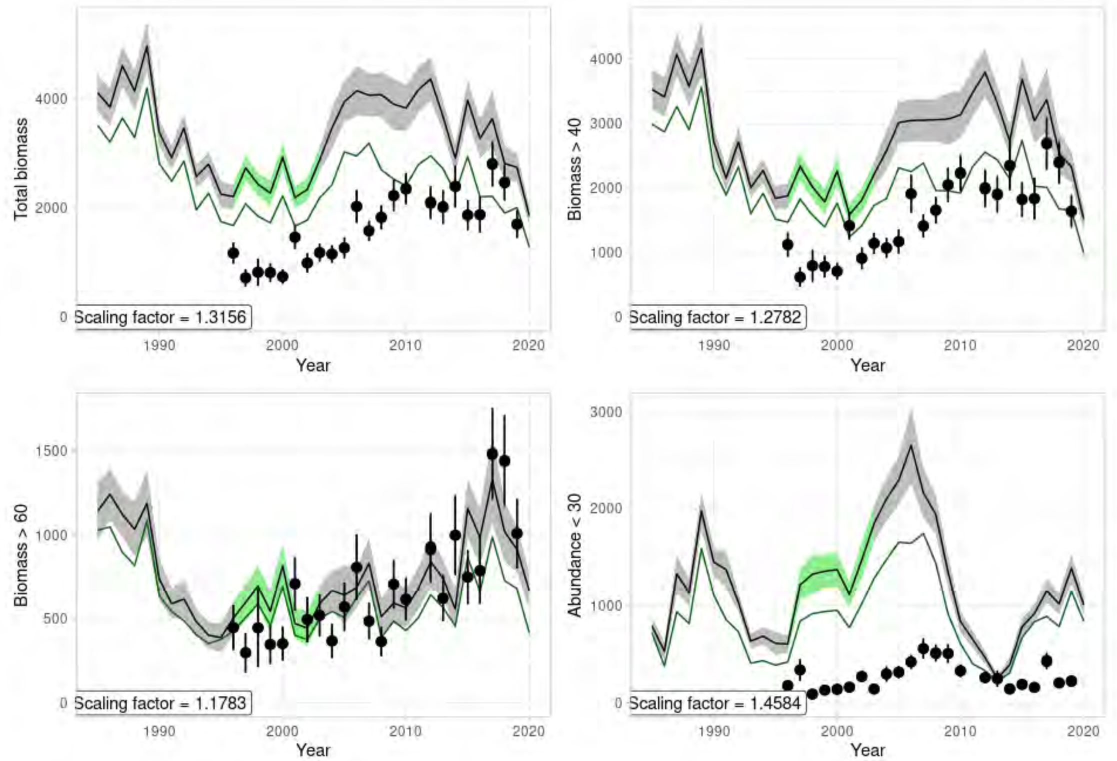

Figure 5.1.11: Tusk in 5.a and 14. Aa) Total biomass indices, b) biomass indices larger than and including 40 cm, c) biomass indices larger than and including 60 cm and d) abundance indices smaller than and including 30 cm. The lines with shaded areas show the spring survey index from 1985 and the points 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.

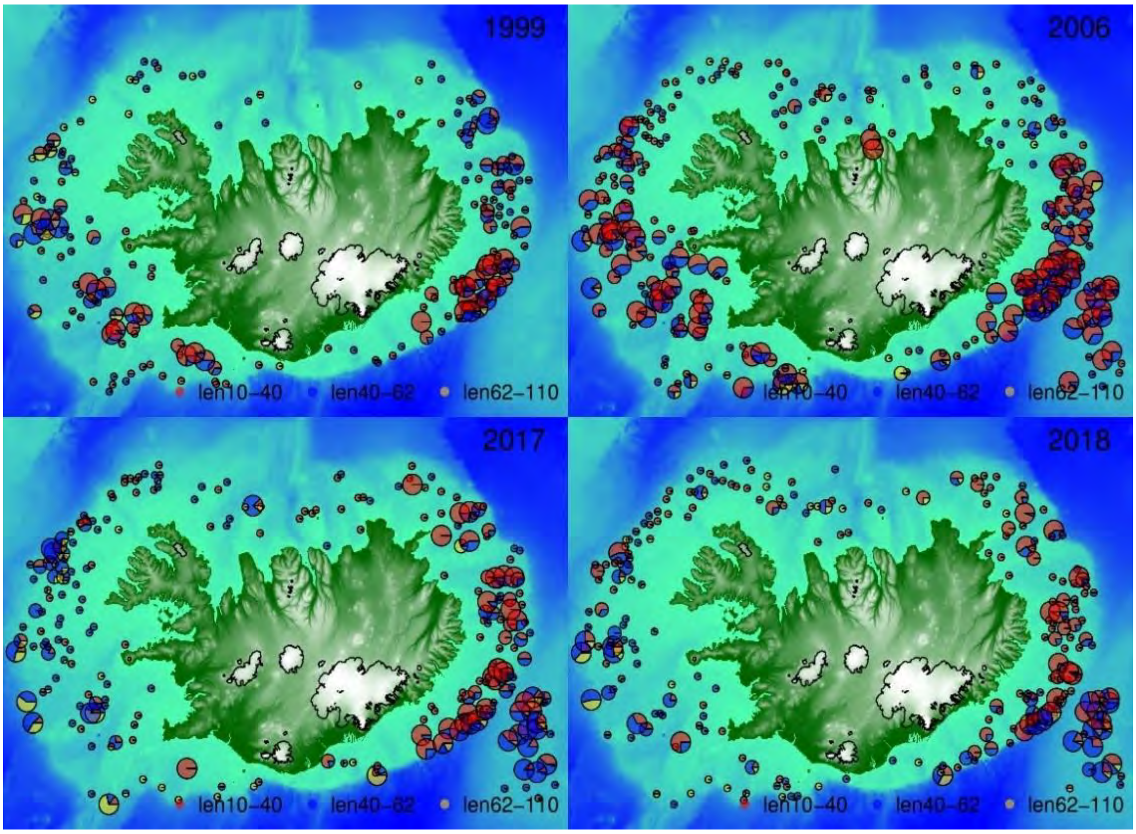

Figure 5.1.12: Tusk in 5.a and 14. Changes in spatial distribution divided by size. Size of pie is indicative of numbers of specimens caught at the tow-station.

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.

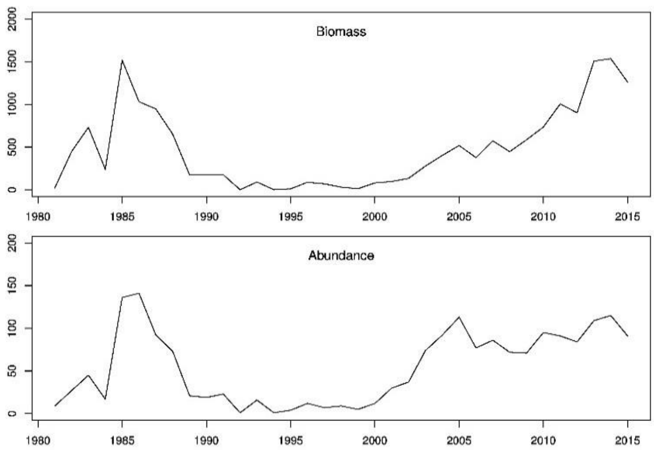

Figure 5.1.13: Biomass and abundance estimates from the Walter Herwig survey in 14. The data are just the total number caught and then converted to weight.

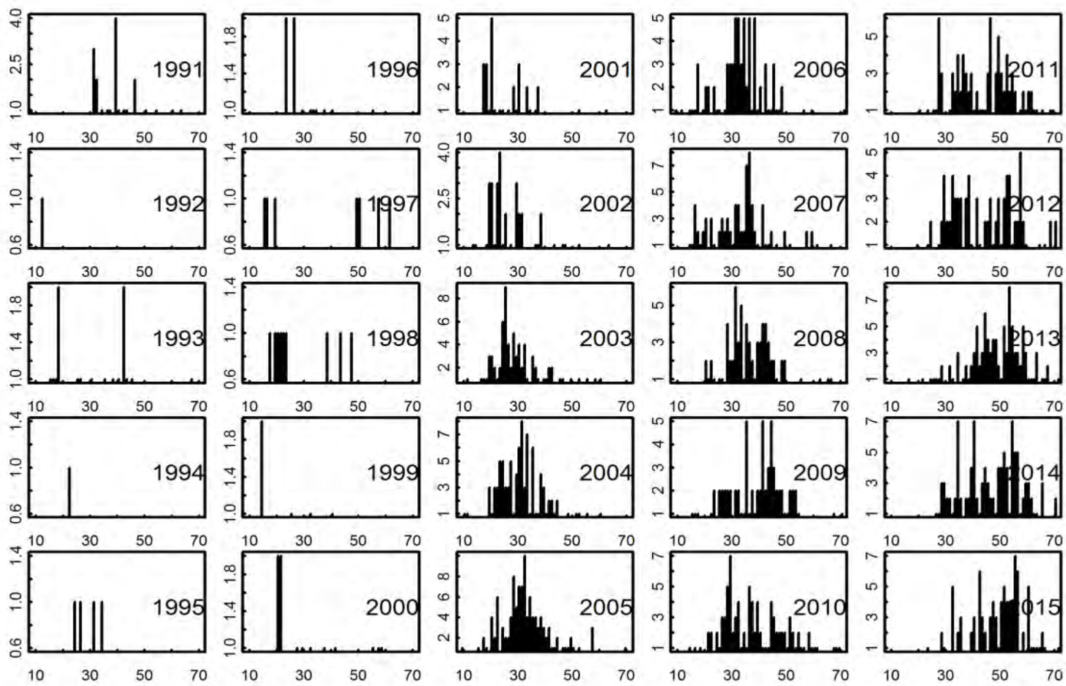

Figure 5.1.14: Length distributions from the Walter Herwig survey in 14.

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.

5.2.4 Data analyses

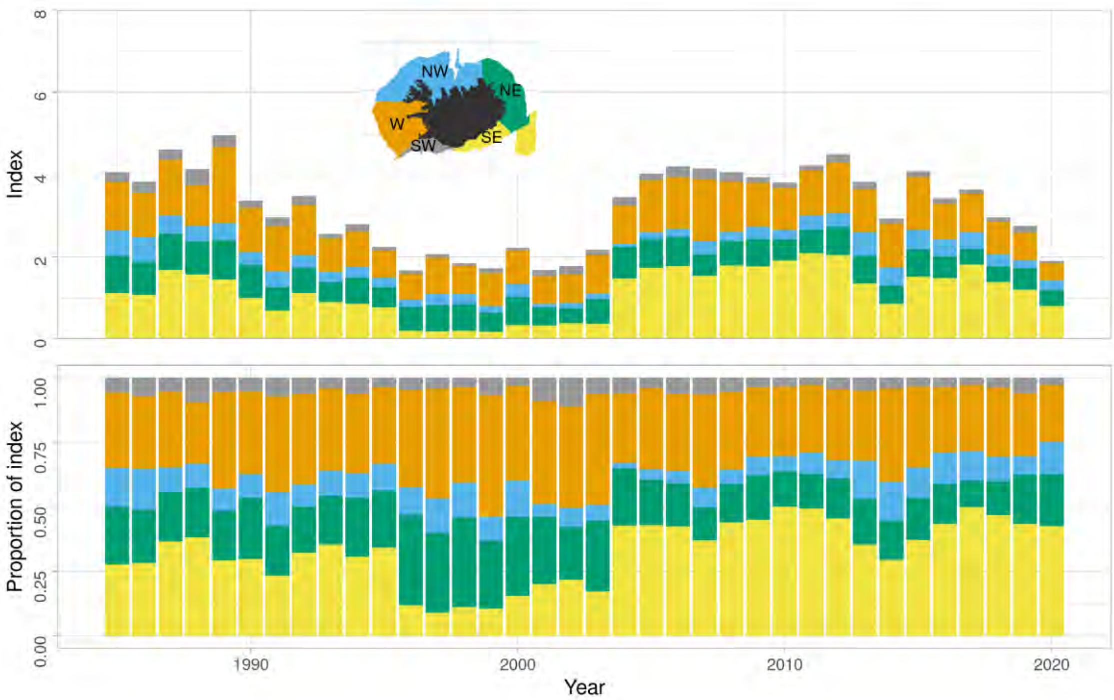

Figure 5.1.15: Tusk in 5.a and 14. Estimated survey biomass in the spring survey by year from different parts of the continental shelf (upper figure) and as proportions of the total (lower figure).

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.

5.2.4.1 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)).

5.2.4.2 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.

5.2.4.3 Diagnostics

Observed and predicted proportions by fleets: Overall the fit of the predicted proportional 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.

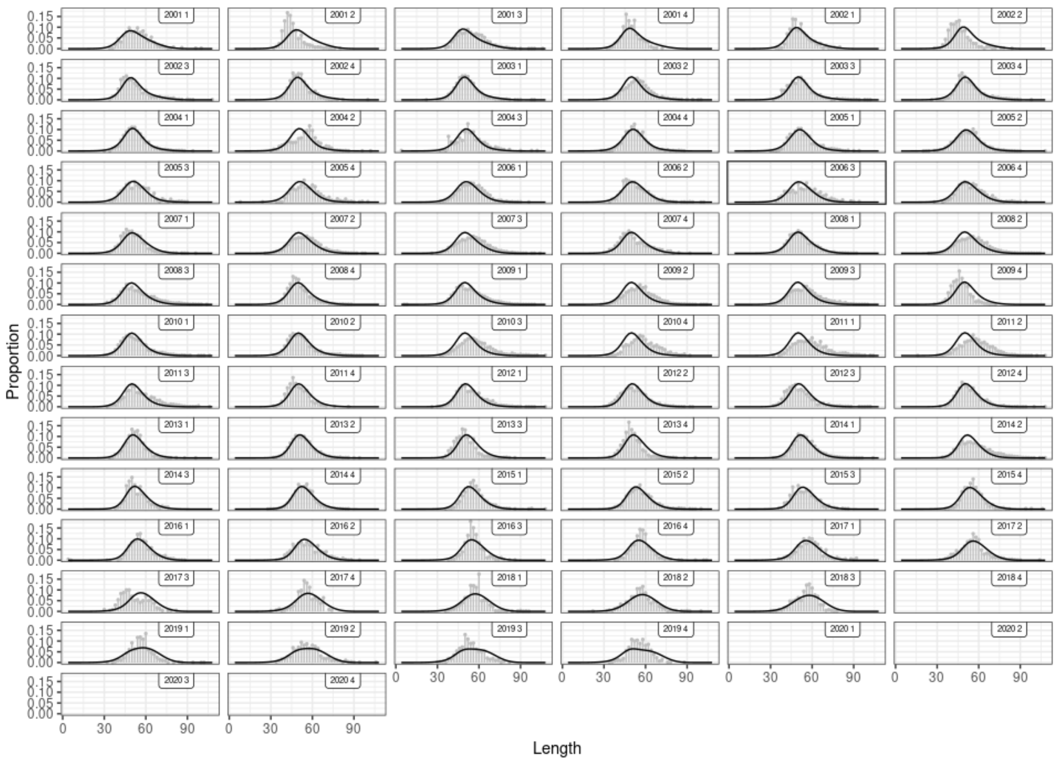

Figure 5.1.16: Tusk in 5.a and 14. Proportional fit (black line) to observed length distributions (grey points and bars) from commercial catches (longlines) by year and quarter from Gadget.

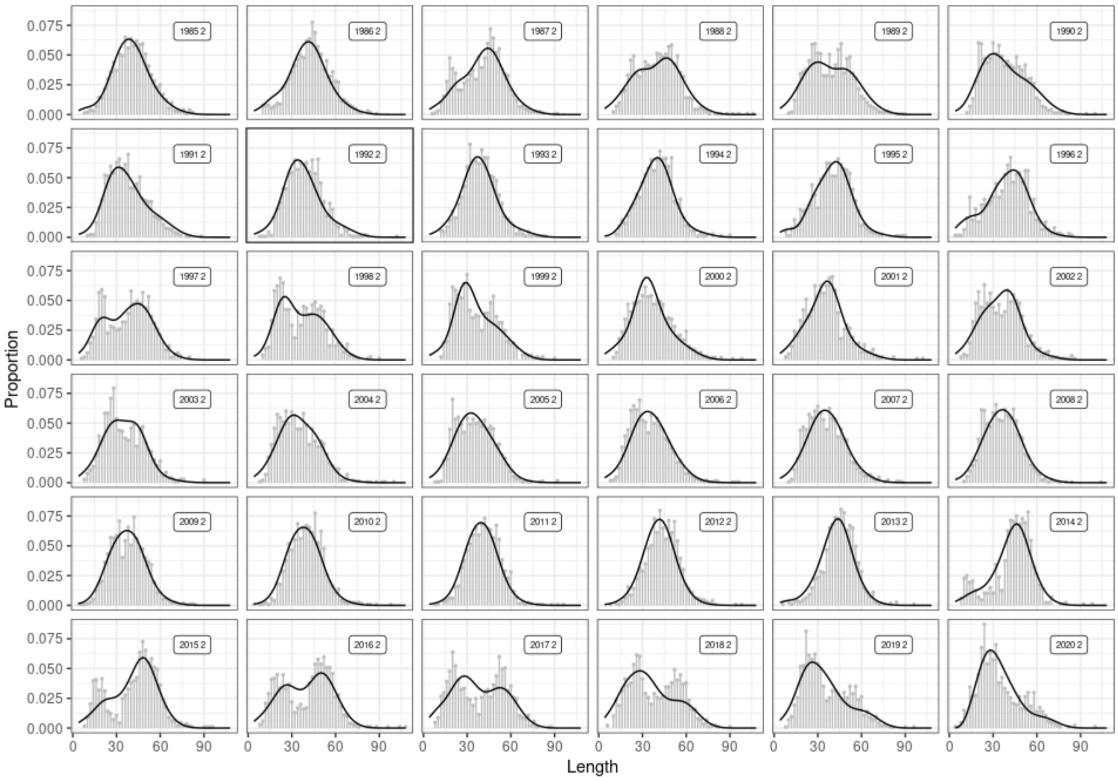

Figure 5.1.17: Tusk in 5.a and 14. Proportional fit (black line) to observed length distributions (points and blue bars) from the Icelandic spring survey by year from Gadget.

Model fit: In Figure 5.1.18 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.

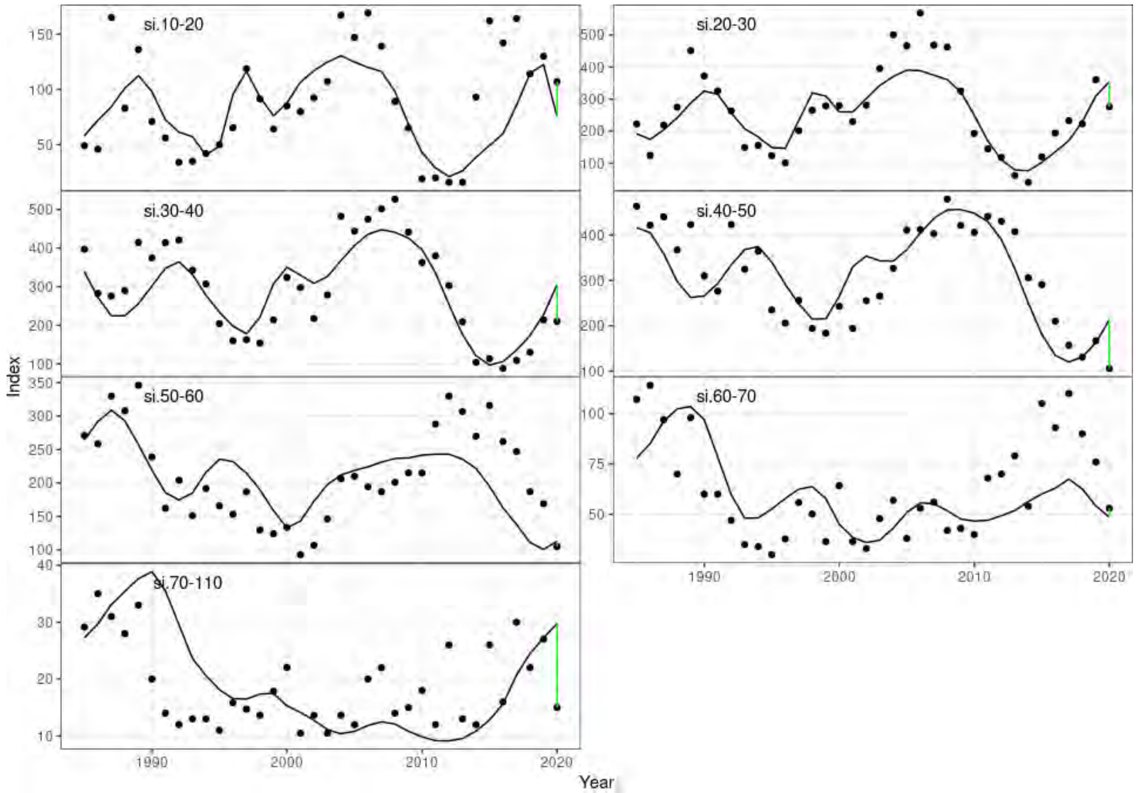

Figure 5.1.18: Tusk in 5.a and 14. Gadget fit to indices from disaggregated abundance by length indices from the spring survey.

5.2.4.4 Model results

The results are presented in Table 5.1.7 and Figure 5.1.19. In comparison with last year, there has been a small downward correction of the whole time series of biomass levels 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 but only slightly above B_{pa} since 2005.

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 5.1.18 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 2017–2019 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 - 2019 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 affect 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 out-migration 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 2014–2019 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.

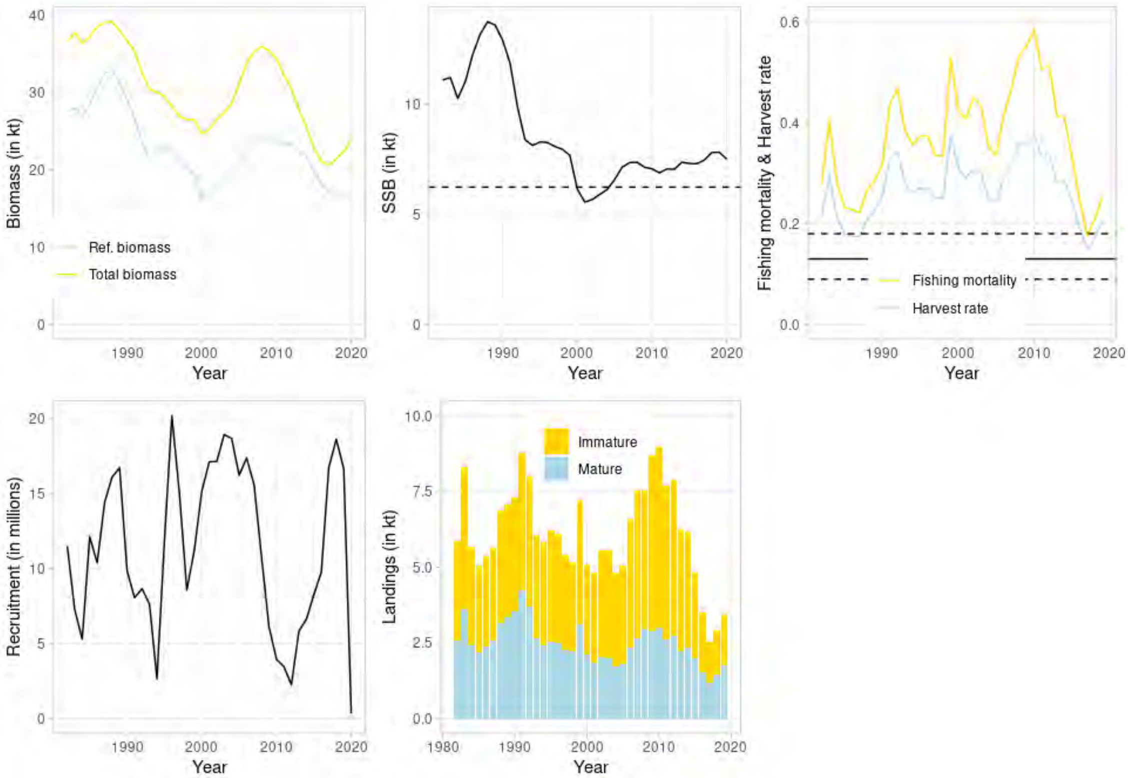

Figure 5.1.19: Tusk in 5.a and 14. Estimates of recruitment, biomass, harvestable biomass and fishing mortality for tusk for the age groups most important in the fishery i.e. ages 7 to 10 (solid line).

5.2.4.5 Retrospective analysis

The results of an analytical retrospective analysis are presented (Figure 5.1.20). Additional plots are provided due to the large downward revision detected this year. The analysis indicates that there was a small upward revisions of biomass over the first 3 years of the 5-year peel followed by a larger downward revision of biomass (SSB) over the last 2 years of the peel, and consequently a downward then upward revision of F. Estimates of recruitment are decently stable except for larget overestimates in 2016 and 2017 leading to a strong retrospective pattern. Growth parameter estimates are very stable, across all peels and the current model, except for a slight increase in recruitment standard deviation, which has the effect of increasing the mean length at recruitment in predictions slightly over time. A different view of recruitment length can then change the numbers estimated at recruitment. 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 5.1.21), 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 5.1.22). 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 5.1.22). 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 (5.1.23).

Mohn's rho was estimated to be 0.182 for SSB, -0.144 for F, and -0.418 for recruitment.

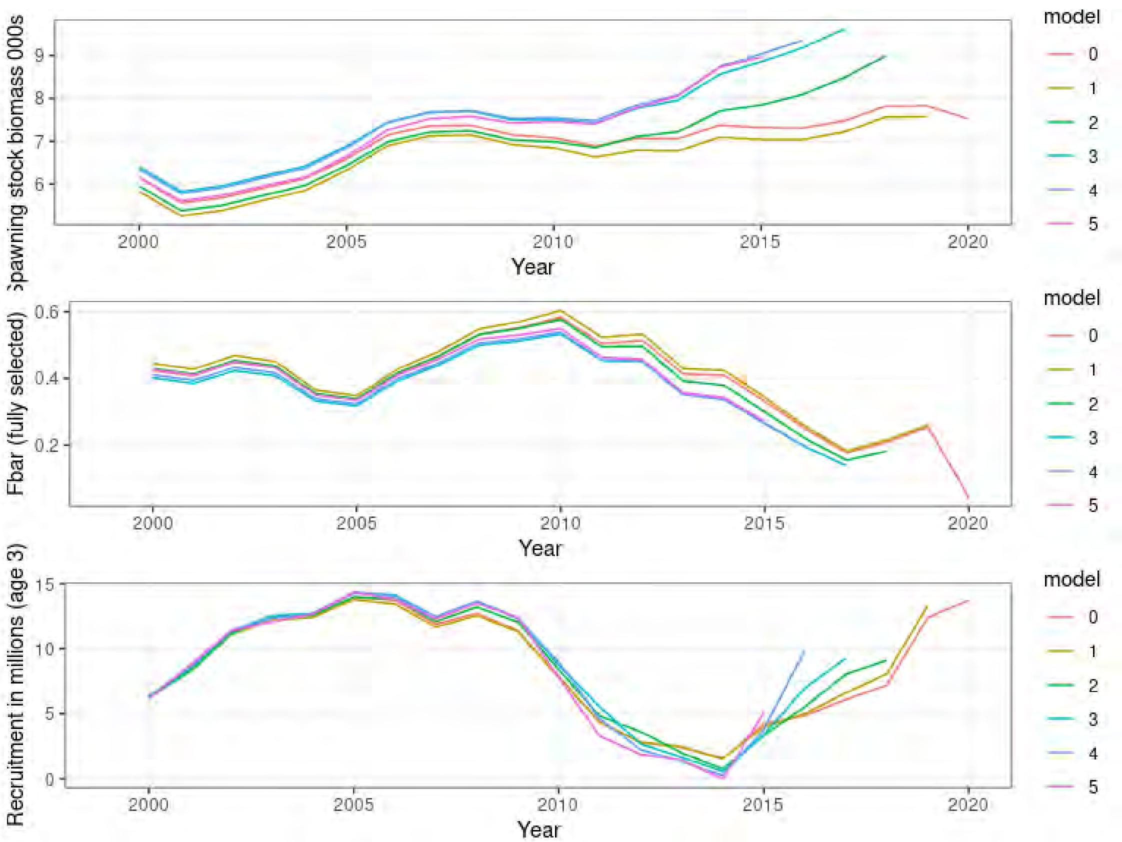

Figure 5.1.20: Tusk in 5.a and 14. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 3) are shown.

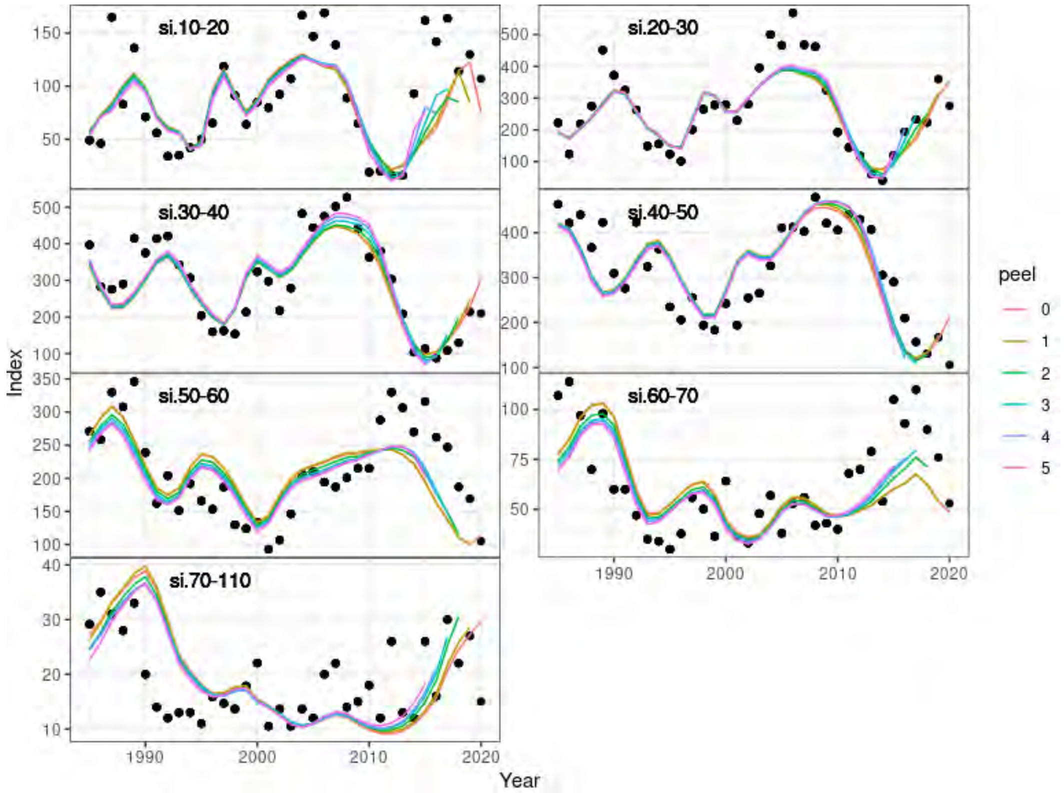

Figure 5.1.21: Tusk in 5.a and 14. Retrospective plots illustrating stability in model fits to survey indices over a 5-year 'peel' in data.

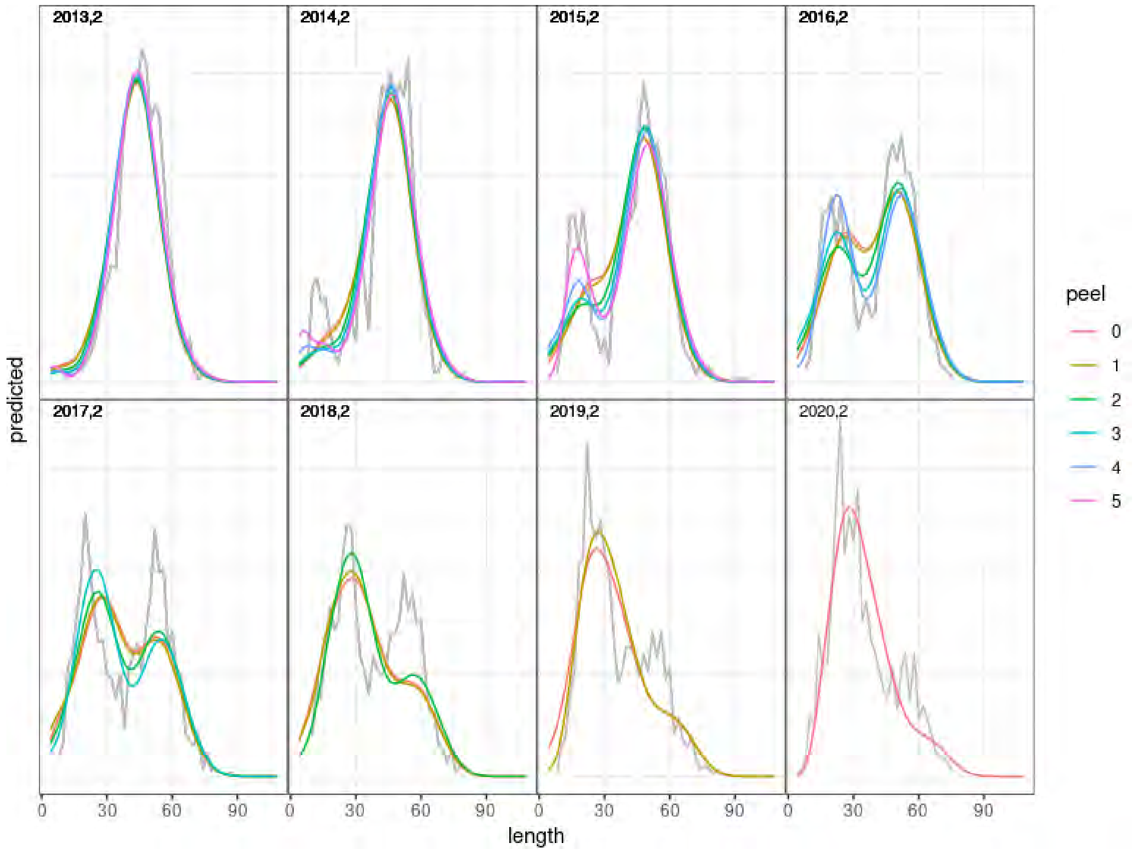

Figure 5.1.22: Tusk in 5.a and 14. Retrospective plots illustrating stability in fit length distribution data from the spring survey over a 5-year 'peel' in data.

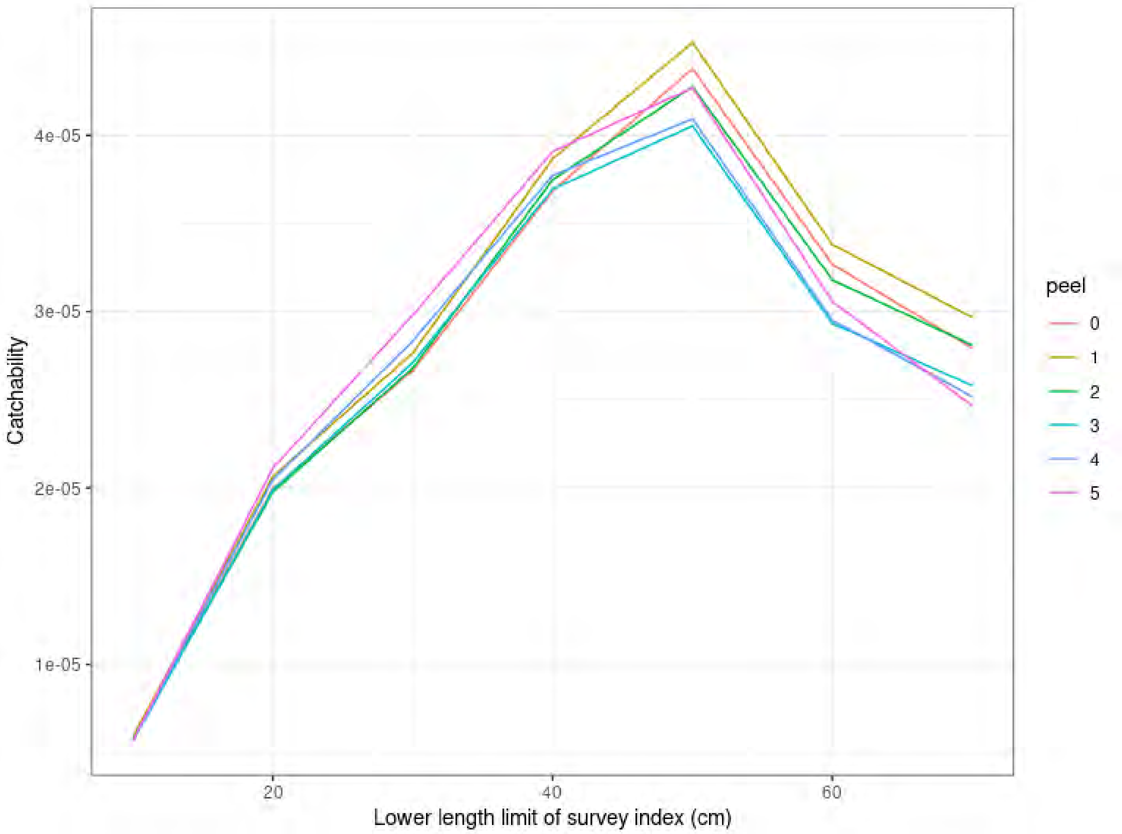

Figure 5.1.23: Tusk in 5.a and 14. Retrospective plots illustrating stability in catchability estimates over a 5-year 'peel' in data.

5.2.5 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.
	$H_{p.\mathbf{05}}$	0.371	The harvest rate that has an annual probability of 5% of SSB < $B_{l}im$.
	$F_{p.\mathbf{05}}$	0.356	The median fishing mortality when an harvest rate of $H_{p.\mathbf{05}}$ is applied.
Precautionary approach	B_{lim}	4.46 kt	$B_{pa}/e^{\mathbf{1.645}\sigma}$ 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	$F_{lim}/e^{\mathbf{1.645}\sigma}$ 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 $B_{trigger}$) 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.

5.2.6 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.

5.2.6.1 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 5.1.2. 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
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

YEAR	FAROE	DENMARK	GERMANY	ICELAND	NORWAY	UK	TOTAL
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

Table 5.1.2. 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

YEAR	FAROE	DEN-MARK	GREEN-LAND	GER-MANY	ICE-LAND	NOR-WAY	RUSSIA	SPAIN	UK	TOTAL
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
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

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
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

YEAR	BIOMASS	B40+	SSB	REC3	CATCH	HR	F
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
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			

5.2.7 References

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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 2019 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 2018, while in 2015 Greenland reported 2 tons.

5.3.3 ICES Advice

Advice for 2018 and 2019: ICES advises that when the precautionary approach is applied, there should be zero catches in each of the years from 2020 to 2024.

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

*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

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

*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 1988–2019 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 54 days in 2019 (Figure 5.4.1). The number of hooks set per day decreased from an average of 35 000 in 2018 to 28 800 in 2019.

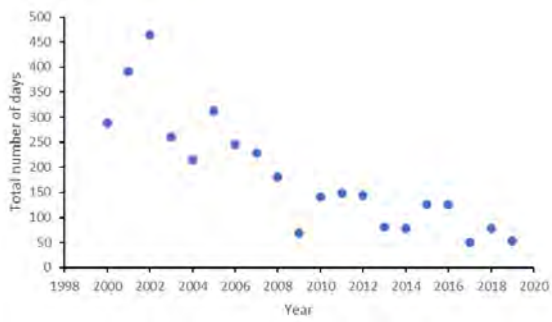

Figure 5.4.1. Estimated total number of days the Norwegian longline fleet fished for tusk (bycatch) during the period 2000 to 2019 based on logbooks.

5.4.2 Landings trends

Landing statistics by nation in the period 1988–2019 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 2019 the landings decreased to 100 tons (Figure 5.4.1).

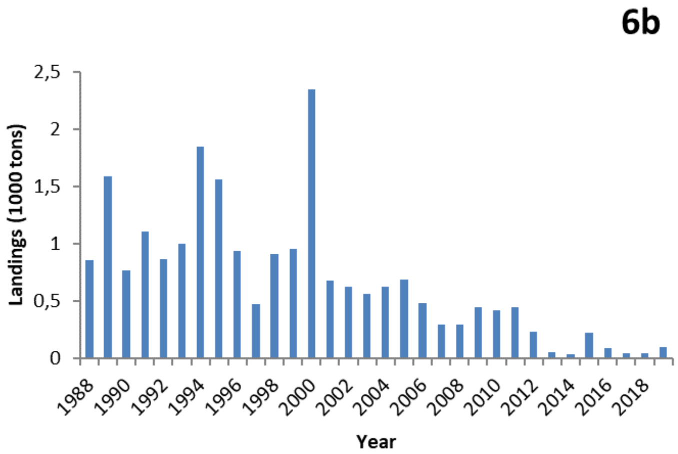

Figure 5.4.1. The international total landings of tusk from Subarea 6.b.

5.4.3 ICES Advice

Advice for 2019 to 2020: ICES advises that when the precautionary approach is applied, catches should be no more than 280 tonnes in each of the years 2019 and 2020. If discard rates do not change from 2017, this implies landings of no more than 216 tonnes.

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). In 2019, the Norwegian quota in the EU zone was 2923 t (up to 2000 t are interchangeable with ling quota).

EU TACs cover Subareas 5, 6, 7 (EU and international waters) and in 2019 is set at 1207 t.

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. In 2016 there were reported 7 tons of discarded tusk, 14 tons in 2017, while in 2018 the catch increased to 21 tons. In 2019 12 tons were discarded (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

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 2019).

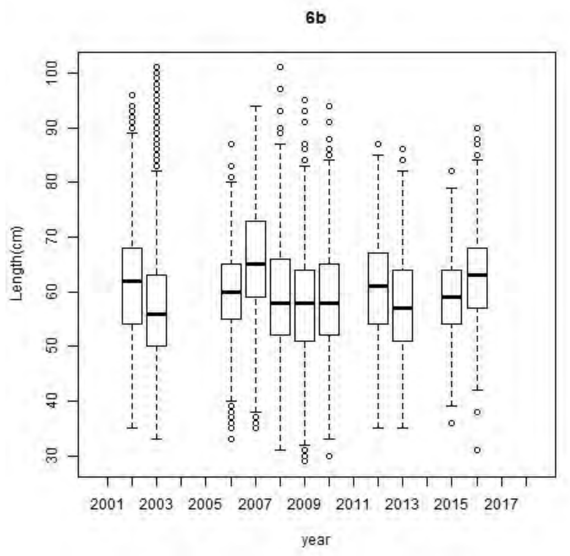

Figure 5.4.3. The length distribution of tusk based on data provided by the Norwegian reference fleet for 2002–2016 (no data are available for 2004, 2011, 2014 and 2017–2019).

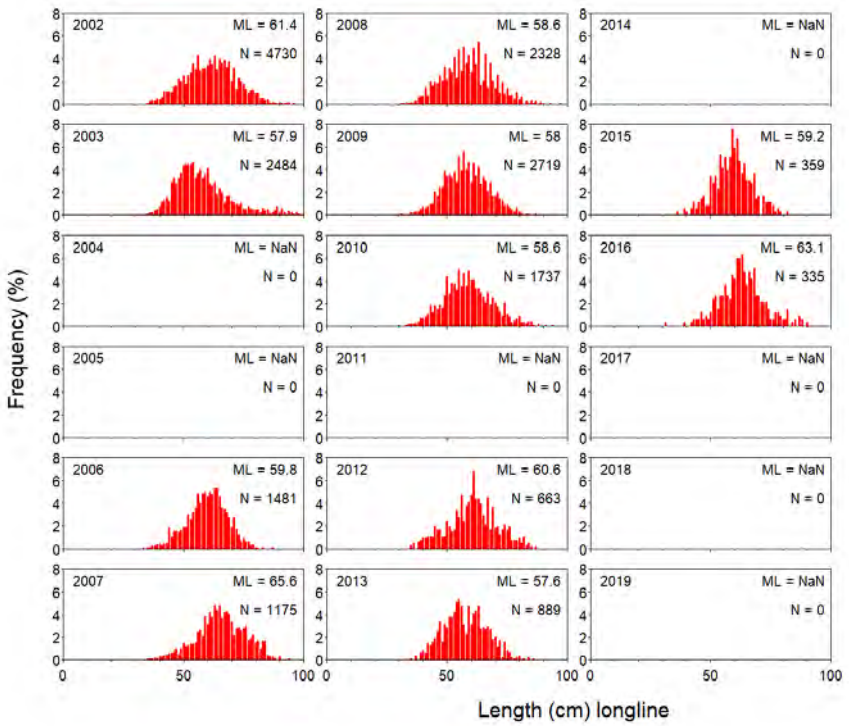

Figure 5.4.4. The length distribution of tusk based on data provided by the Norwegian reference fleet for 2002–2016 (no data are available for 2004, 2005, 2011, 2014, 2017–2019).

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 2000–2019. 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).

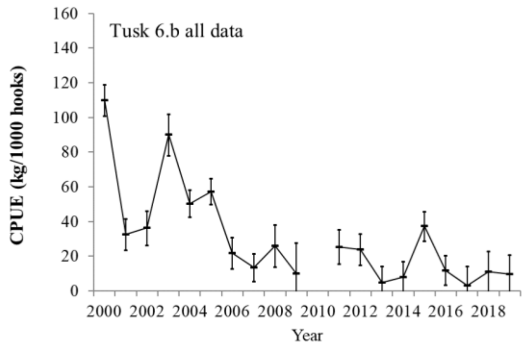

Figure 5.4.5. Estimated cpue (kg/1000 hooks) series for tusk in Subarea 6.b based on skipper's logbooks (during the period 2000–2019). The bars denote the 95% confidence intervals.

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 54 days in 2019 (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 cpue series for the targeted fishery for tusk also shows a stable 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 2019.

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

*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
2009	452	469

Year	6.b	All areas
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

***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 2018. 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. 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. In 2019 there was a large increase in the average number of fishing days per vessel from 79 in 2018 to 128 in 2019, resulting in a much higher fishing pressure than the previous years (For more information see Helle and Pennington, WD 2020).

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 2011–2018 is 43% less than the average effort during the years 2000–2003. However, in 2019 the effort increased considerably. 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.

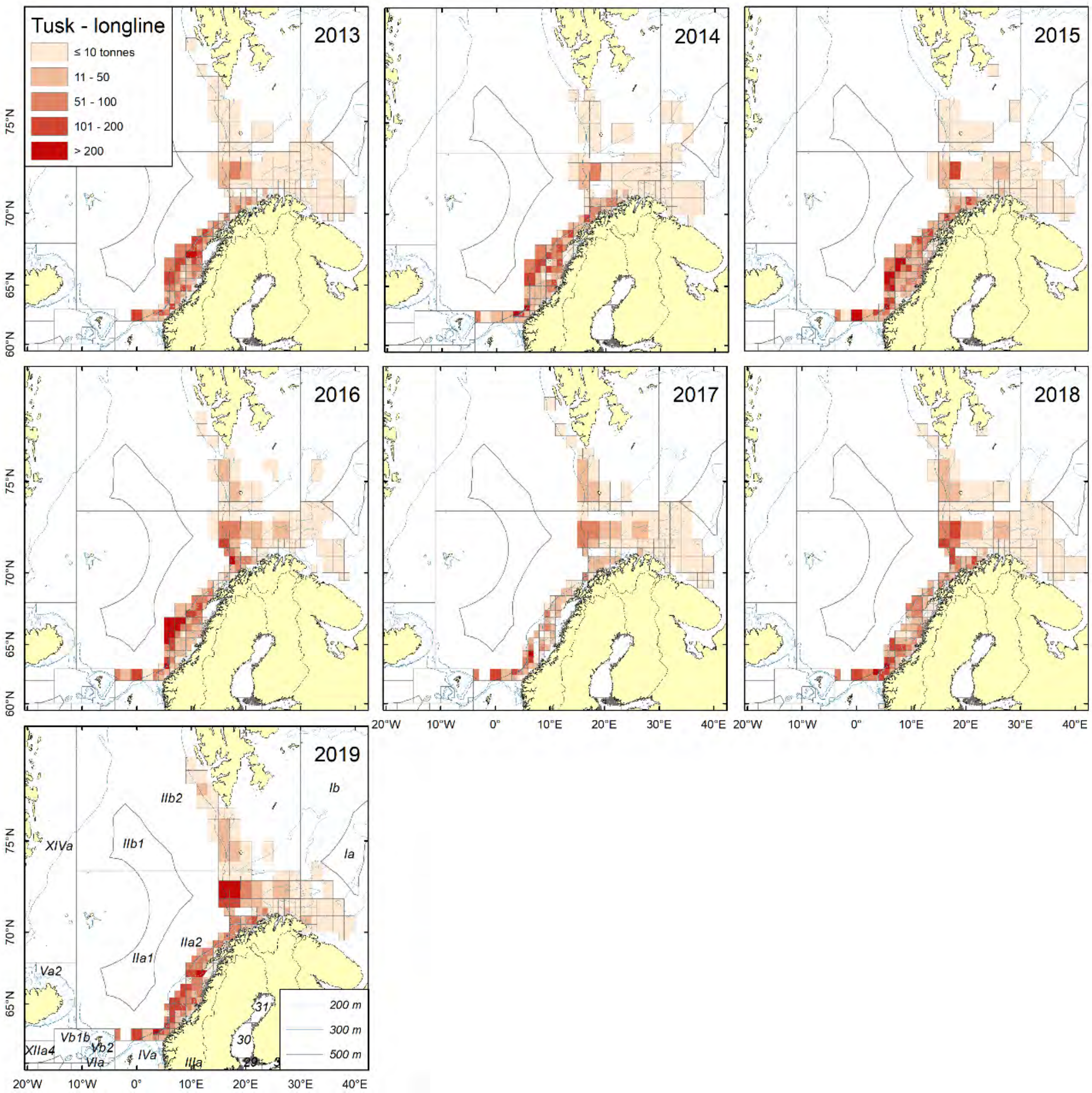

Figure 5. 5.1. Distribution of catches for the Norwegian longline fishery in Subareas 1 and 2 in 2013 to 2019.

5.5.2 Landings trends

Landing statistics by nation from 1988 to 2019 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 2019 are 12 310 t.

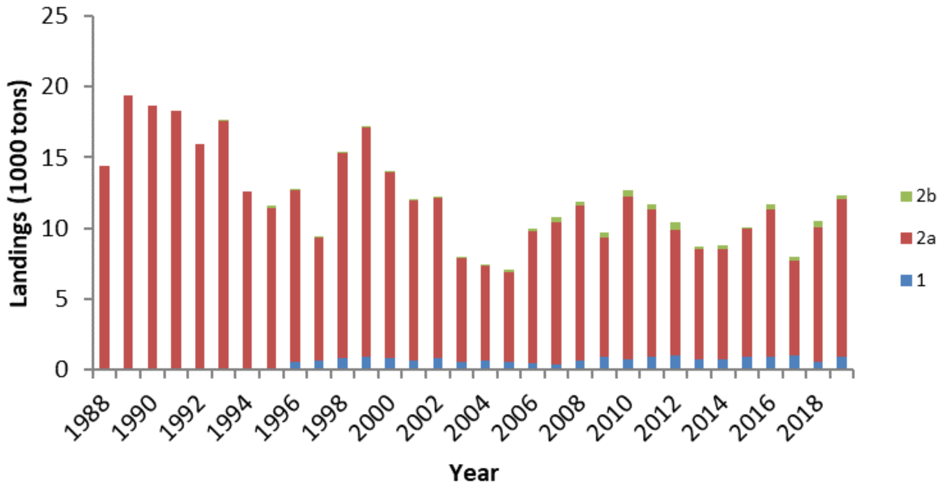

Figure 5.5.2. Total yearly landings of tusk in Areas 1 and 2 for 1988–2019.

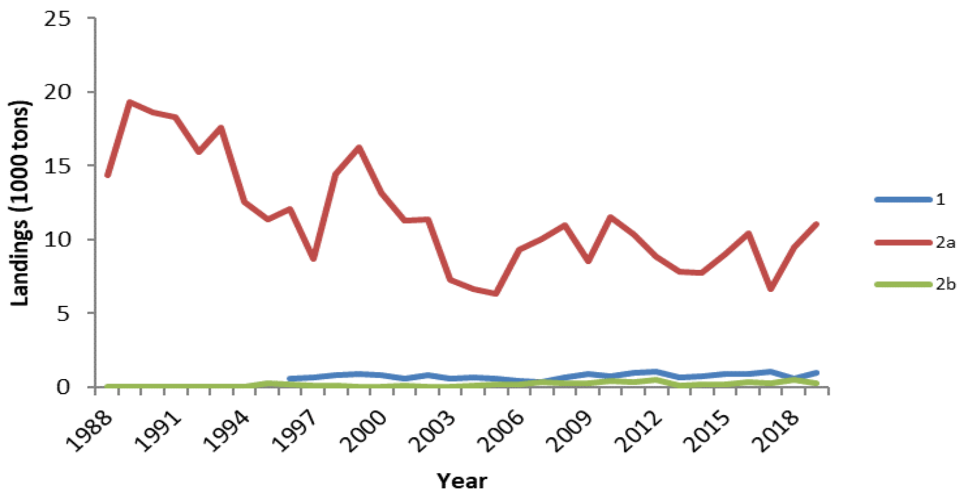

Figure 5.5.3. Total yearly landings of tusk in Areas 1 and 2 for 1988–2019.

5.5.3 ICES Advice

Advice for 2020 and 2021: 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.

The EU TAC (for community vessels fishing in community waters and waters not under the sovereignty or jurisdiction of third countries in 1, 2 and 14) was set to 21 t in 2020.

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. Germany reported 7 tons discarded tusk in 2019. 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 2001–2019.

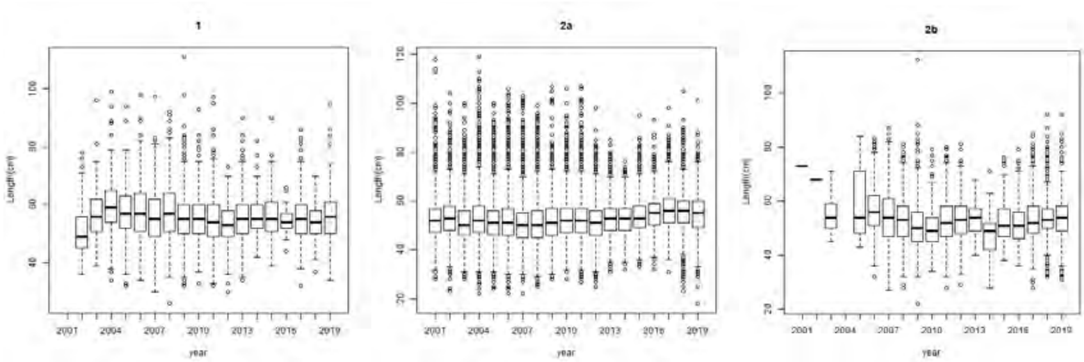

Figure 5.5.4. Box and whisker plots showing the length distribution of tusk. The data were provided by the Norwegian reference fleet for the period 2001–2019.

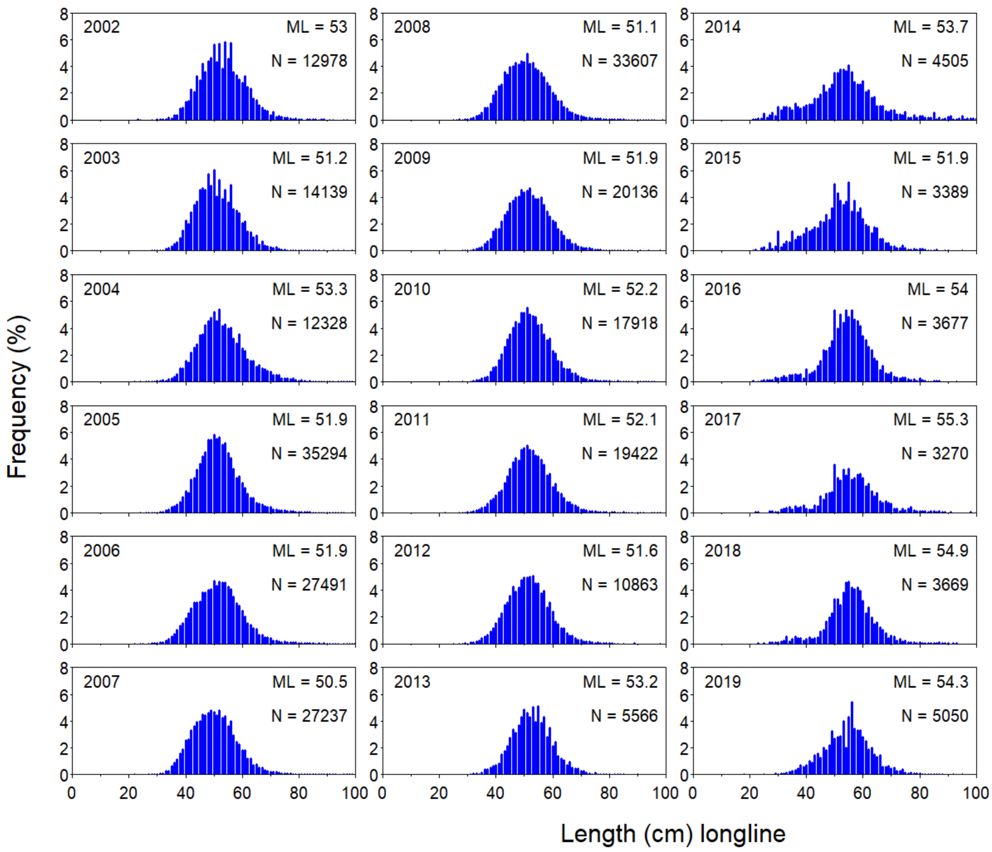

Figure 5.5.5. The estimated length distributions of the catch of tusk by Norwegian longliners combined for the Areas 1, 2.a and 2.b.

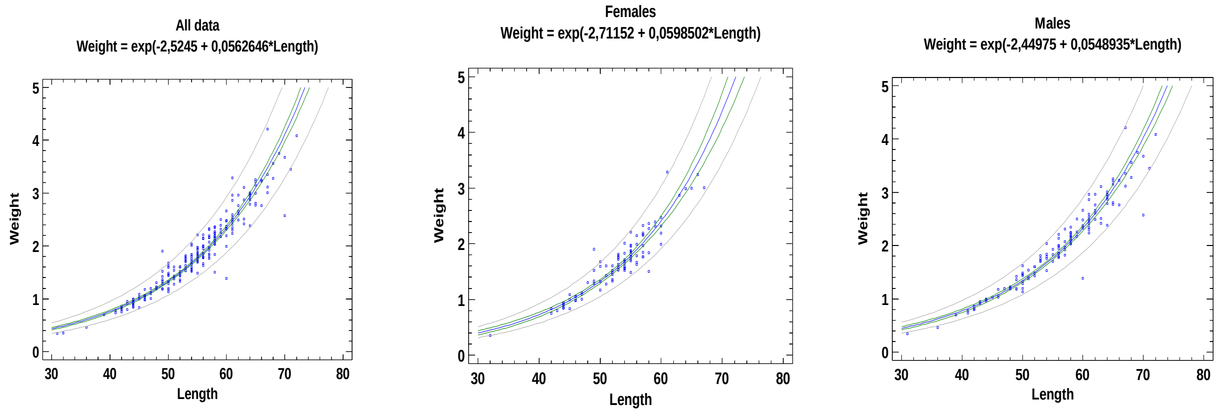

Figure 5.5.6. Length–weight relationship for tusk.

5.5.5.3 Age compositions

The average length and weight-at-age for males and females based on the combined data for the years 2000–2002, 2004, 2005, 2010, 2011, 2013-2016 are shown in Figure 5.5.7 and the catch-at- age compositions from the longline fishery in areas 1 and 2 are shown in Figure 5.5.8.

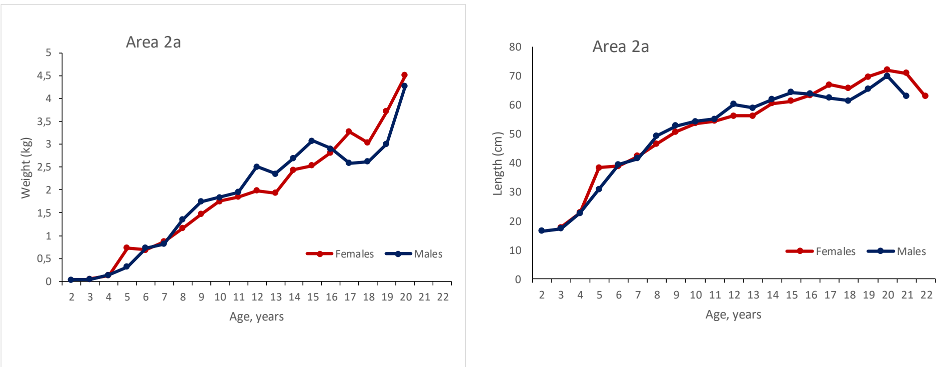

Figure 5.5.7. Average length and weight-at-age for all available data for the years 2000–2002, 2004, 2005, 2010, 2011, 2013–2016.

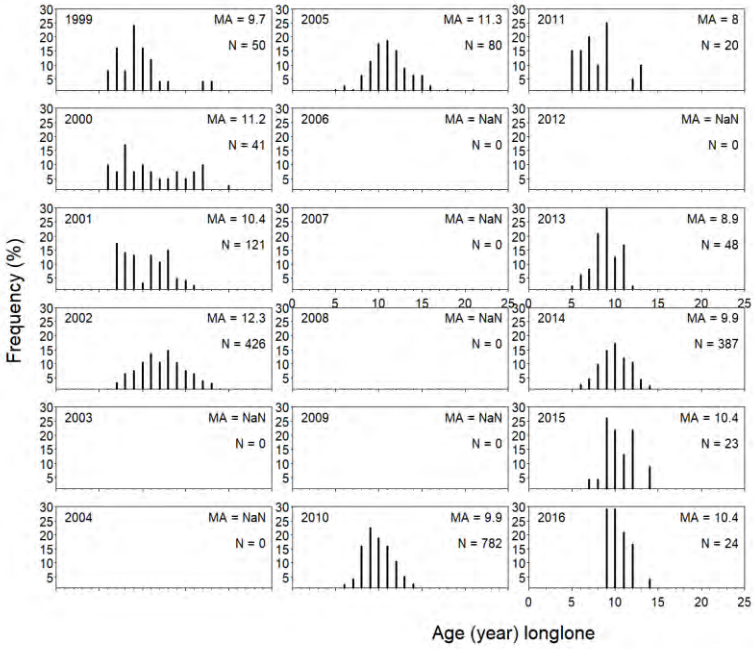

Figure 5.5.8. Catch-at- age composition from the longline fishery in areas 1 and 2.

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

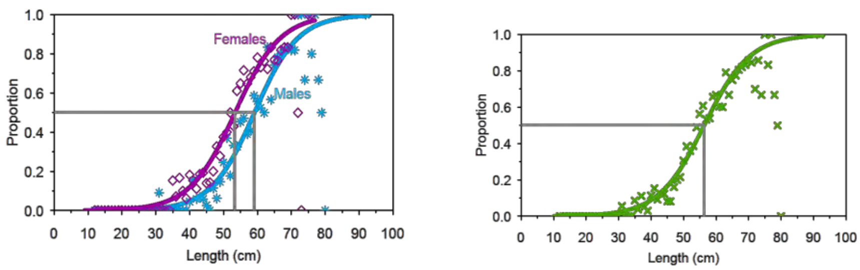

Figure 5.5.9. Tusk Area 1 and 2, Maturity ogive on length for males and females, and all data combined.

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 2000–2019. 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, 2020. Two cpue series, one based on all data and one when tusk was targeted were presented (Figure 5.5.9). No research vessel data are available.

5.5.6 Data analyses

Length distribution

There was an increase in average length over the period 2002 to 2019 (Figure 5.5.10). The reason, perhaps, are the use of larger hooks used by the longliners and not necessarily a real change in the population.

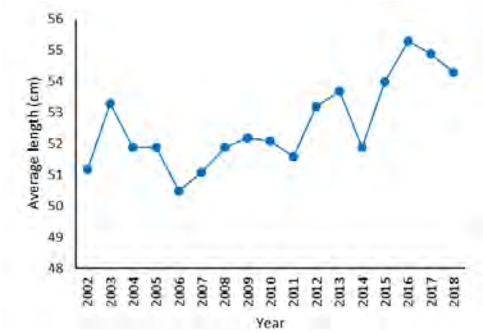

Figure 5.5.10. Average length of tusk from the long line fishery 2002-2019.

Assessment

No analytical assessments were possible due to lack of age-structured data and/or tuning series.

CPUE

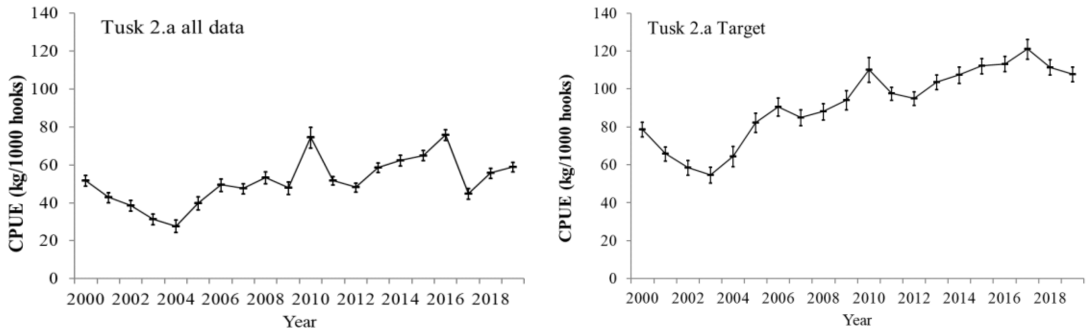

Figure 5.5.11. Estimates of cpue (kg/1000 hooks) of tusk based on skipper's logbook data for 2000–2019. The bars denote the 95% confidence interval.

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 (Figure 5.5.11).

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

Two different methods were tested for tusk in 2020 for the areas 1 and 2: The Length-based indicator method (LBI) and SPiCT.

Results for the LBI

Information and data

The input parameters and the catch's length distribution for the period 2001-2019 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	2001-2019	Norwegian long-liners (Reference fleet)	
Length-weight relationship	$0.0106 * \text{length}^{3.0168}$	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.	

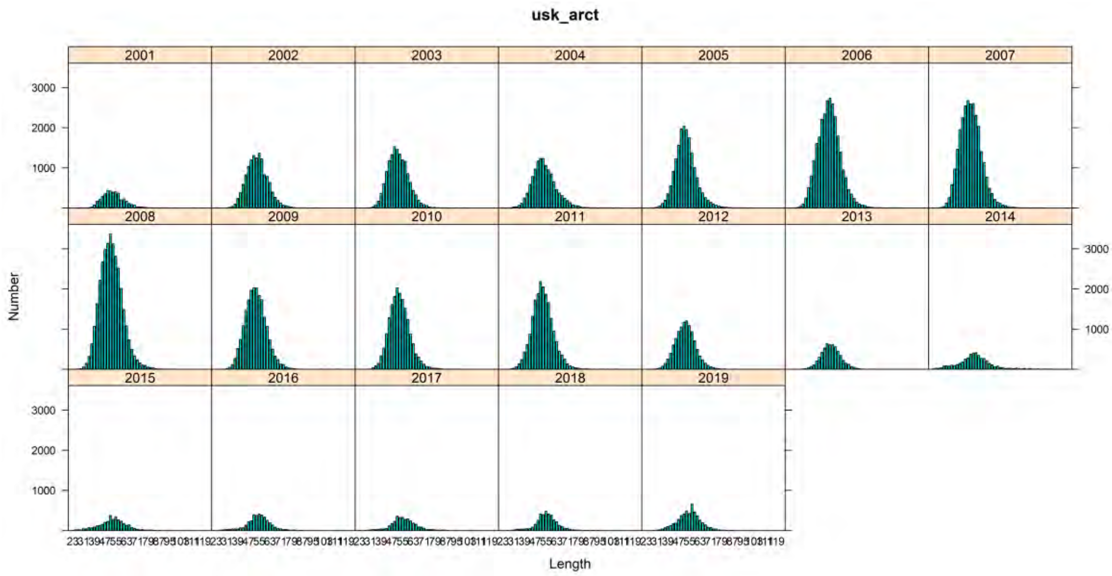

Figure 5.5.10 **Tusk in arctic waters (1, 2a, 2b). The length distribution (2 cm length bins) based on data from the Norwegian longline fleet for the period 2001–2019 (sex combined).**

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.

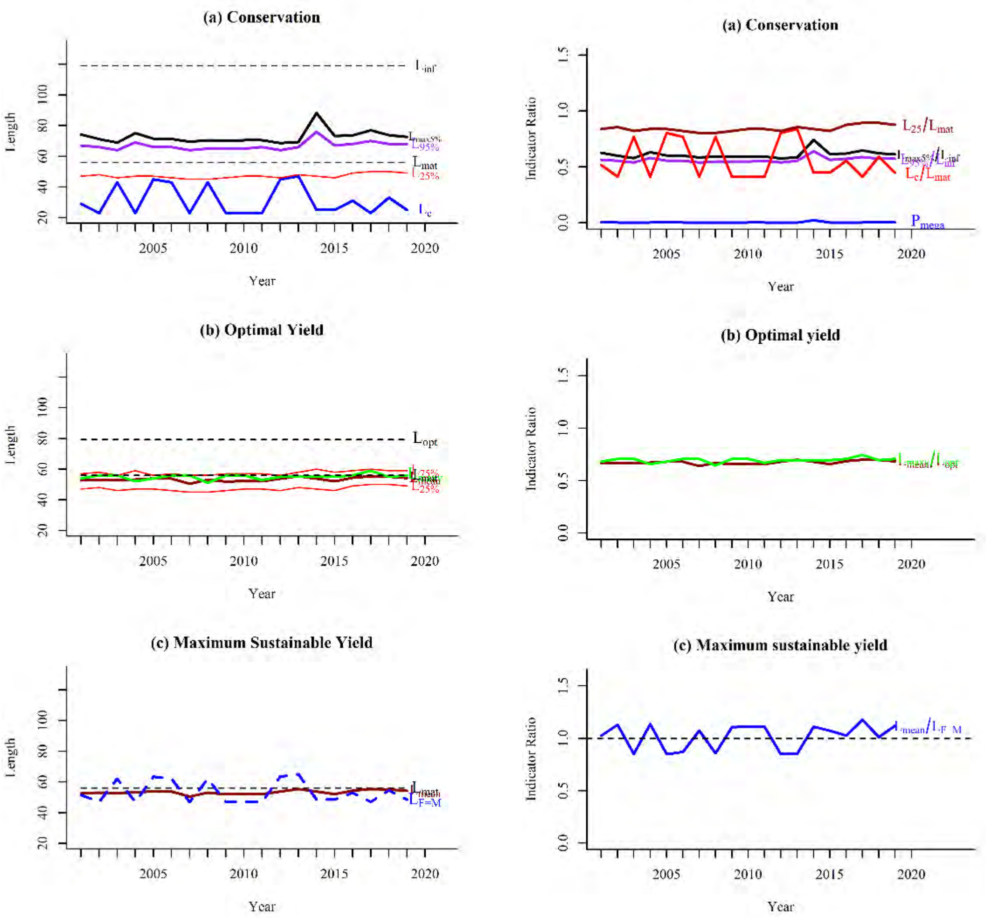

Figure 5.5.11 **Tusk in arctic waters (1, 2.a, 2.b). Using length indicators ratios for sex combined to examine three scenarios: (a) Conservation, (b) Optimal yield, and (c) maximum sustainable yield.**

Analysis of results

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 6.5.11, 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 2017-2019 (Table 6.5.11), 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 4.3.11), 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 2017–2019 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

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**
2017	0,41	0,89	0,65	0 %	0,70	1,18
2018	0,59	0,89	0,62	0 %	0,70	1,01
2019	0,45	0,88	0,61	0 %	0,68	1,12

Conclusion: The overall perception of the stock during the period 2017–2019 is that tusk in arctic waters seems to be fished sustainably (Table 5.5.3 and 5.5.4). However, the results are very sensitive to the assumed values of L_{mat} and L_{inf}.

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 unsustainably
Stock size				
	2016	2017	2018	
MSY $B_{trigger}$.(B/B_{MSY})	?	?	?	Unknown

Results for the SPiCT model:

The first run was carried out with standard settings in SPICT, and with catch data and CPUE for all available years. The model converged, and the plots from the diagnostics looked good, and there were relatively small confidence intervals in the parameter estimates (BMSY, MSY, FMSY, and K) (Tables 5.5.3 and 5.5.4).

Two other runs with different settings were also tested. The second run was without priors, and in the third run the parameter n was set to 2, while α and β were set to 1. Comparing these two runs, number one appeared to give the best result (Table 5.5.5).

The model estimated MSY was 11,248 tons. The advice for 2020 and 2021 was 11,077 tons, so the estimated MSY was slightly above the recommended level. Associated BMSY was 25 916tons, and FMSY was 0.434. The estimated carrying capacity (K) was about 89,000 tons.

The model indicates that stock abundance was greater than BMSY and the fishing mortality less than FMSY and will continue to be lower if the catches continue remain at the same level as in the previous years. The traffic light shows that the stock was in the red zone and is now in the green zone. This corresponds to the present perception of the development of the stock. The diagnostics do not show any patterns in the residuals and no significance for bias, auto correlation or normality. The retrospective plot shows that the test is robust.

Table 5.5.5. Tusk in Subareas 1 and 2. Output from SPICT

Run	1	2	3
Landings period	1988-2019		
CPUE	2000-2019		
Parameter settings			
n	mod.est	no priors	2
Alfa	mod.est	no priors	1
Beta	mod.est	no priors	1
Convergence	Yes	Yes	Yes
Parameter estimates			
BMSY	25916	25763	33460
cilow	13994	13164	20716
cihigh	47996	50417	54043
MSY	11248	11255	12293
cilow	10274	10260	11028
cihigh	12314	12345	13704
FMSY	0,434	0,437	0,367
cilow	0,244	0,235	0,221
cihigh	0,772	0,815	0,610
K	89052	91167	67066

Run	1	2	3
cilow	50758	45797	41475
cihigh	156237	181482	108446
Diagnostic	OK	OK	OK- Lbox
Retrospective	OK	OK	OK

Table 5.5.6 Tusk in Subareas 1 and 2. Output from SPICT

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: -14.4363982
Euler time step (years):  1/16 or 0.0625
Nobs C: 32,  Nobs I1: 20

Priors
     logn  ~  dnorm[log(2), 2^2]
 logalpha  ~  dnorm[log(1), 2^2]
  logbeta  ~  dnorm[log(1), 2^2]

Model parameter estimates w 95% CI
            estimate        cilow        ciupp    log.est
 alpha  2.294944e+00 1.478311e-01 3.562694e+01  0.8307086
 beta   4.160544e-01 1.702721e-01 1.016616e+00 -0.8769392
 r      2.804878e-01 8.363950e-02 9.406243e-01 -1.2712252
 rc     8.679757e-01 4.877974e-01 1.544456e+00 -0.1415915
 rold   7.930175e-01 1.367980e-02 4.597116e+01 -0.2319100
 m      1.125055e+04 1.027646e+04 1.231697e+04  9.3281724
 K      8.905246e+04 5.075842e+04 1.562369e+05 11.3969809
 q      3.085300e-03 1.917700e-03 4.963800e-03 -5.7810963
 n      6.463032e-01 1.326890e-01 3.148021e+00 -0.4364865
 sdb    2.131510e-02 2.008800e-03 2.261746e-01 -3.8483389
 sdf    2.339612e-01 1.525555e-01 3.588062e-01 -1.4526000
 sdi    4.891700e-02 2.682970e-02 8.918750e-02 -3.0176302
 sdc    9.734060e-02 5.293900e-02 1.789832e-01 -2.3295392

Deterministic reference points (Drp)
           estimate        cilow        ciupp    log.est
 Bmsyd 2.592365e+04 1.399995e+04 4.800275e+04 10.1629111
 Fmsyd 4.339879e-01 2.438987e-01 7.722282e-01 -0.8347387
 MSYd  1.125055e+04 1.027646e+04 1.231697e+04  9.3281724
Stochastic reference points (Srp)
           estimate        cilow        ciupp    log.est  rel.diff.Drp
 Bmsys 25915.837959 1.399356e+04 4.799570e+04 10.1626096 -3.015787e-04
 Fmsys     0.434025 2.438642e-01 7.724696e-01 -0.8346532  8.555966e-05
 MSYs  11248.120660 1.027437e+04 1.231416e+04  9.3279563 -2.160741e-04

States w 95% CI (inp$msytype: s)
                   estimate        cilow        ciupp    log.est
 B_2019.00      3.686515e+04 2.192446e+04 6.198736e+04 10.5150220
 F_2019.00      3.157151e-01 1.771184e-01 5.627649e-01 -1.1529151
 B_2019.00/Bmsy 1.422495e+00 1.008273e+00 2.006889e+00  0.3524124
 F_2019.00/Fmsy 7.274123e-01 4.637556e-01 1.140964e+00 -0.3182618

Predictions w 95% CI (inp$msytype: s)
                 prediction        cilow        ciupp    log.est
```

```
B_2020.00      3.571038e+04 2.075885e+04 6.143072e+04 10.4831967
F_2020.00      3.348400e-01 1.784394e-01 6.283244e-01 -1.0941025
B_2020.00/Bmsy 1.377937e+00 9.816007e-01 1.934299e+00  0.3205872
F_2020.00/Fmsy 7.714763e-01 4.637708e-01 1.283340e+00 -0.2594493
Catch_2020.00  1.179571e+04 8.280854e+03 1.680246e+04  9.3754909
E(B_inf)       3.288697e+04           NA           NA 10.4008318
```

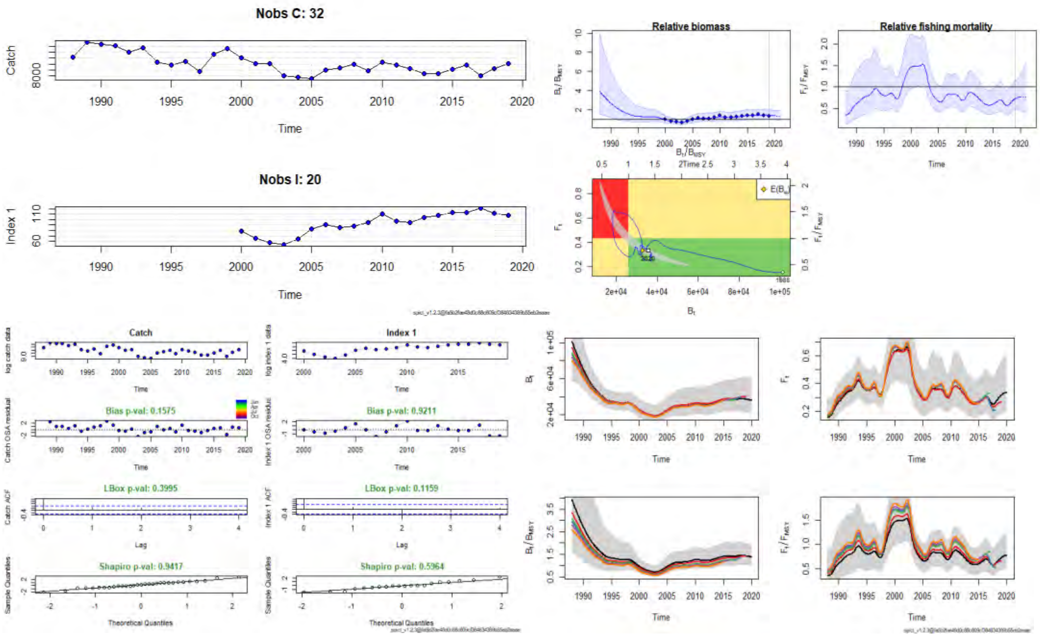

Figure 5.5.12. Tusk in Subareas 1 and 2. Upper left corner shows the input data for the model, upper right corner the model output, lower left corner the model diagnostics and the lower right corner the retrospective analysis.

5.5.10 Tables

Table 5.5.7 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

Year	Norway	Russia	Faroes	Iceland	Ireland	France	Total
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

*Preliminary.

Table 5.5.8 b. Tusk in Division 2.a. Official landings.

Year	Faroes	France	Germany	Greenland	Norway	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

Year	Faroes	France	Germany	Greenland	Norway	E & W	Scotland	Russia	Ireland	Iceland	Total
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
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

***Preliminary.**

(1) Includes 2.b.

Table 5.5.9 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

Year	Norway	E & W	Russia	Ireland	France	Total
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
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

Table 5.5.10 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
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

Year	1	2a	2b	All areas
2017	1037	6655	234	7926
2018	557	9466	464	10487
2019	946	11070	294	12310

***Preliminary.**

5.6 Tusk (*Brosme brosme*) in areas 3.a, 4.a, 5.b, 6.a, 7, 8, 9 and other areas of 12

5.6.1 The fishery

Summaries of tusk fisheries are in the Overview Sections: 3.3., 3.4, 3.5 and 3.6.

Tusk is bycatch in the trawl, gillnet and longline fisheries in areas 3.a, 4.a, 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 1988–2019, 35% of the landings have been in Area 4, 47% in Area 5.b, and 17% 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 increased from an average 7 days per vessel in 2018 to 14 days per vessel in 2019.

5.6.2 Landings trends

Landing statistics by nation in 1988–2019 are in Table 5.6.1 and are shown by year in Figure 5.6.1.

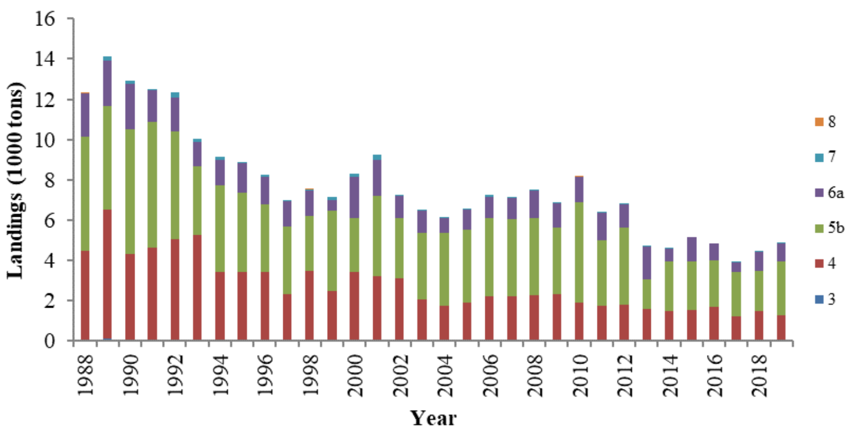

Figure 5.6.1. Landings of tusk per year for 1988–2019.

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 4 862 tons in 2019 (Figures 5.6.1 and 5.6.2).

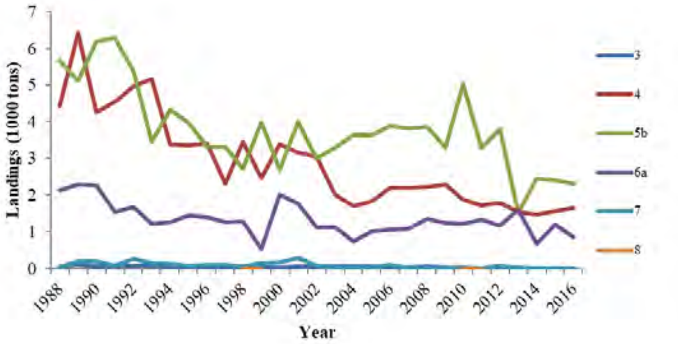

Figure 5.6.2. Landings of tusk by area for 1988–2019.

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 the Faeroes in 5.b, which is 2 000 t for 2020. Norway also has a licensing scheme in EU waters, and in 2020 the Norwegian quota in the EC is 2 923 tons.

In 2020, 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 on board. No more than three vessels can simultaneously be operating. Two of these vessels can do experimental fishery in deep waters around Outer Bailey and Bill Baileys Banks at depth between 500 and 700 meters, and catches do not exceed 500 tonnes of deep-sea species.

The quota for the EU in the Norwegian zone (Subarea 4) is set at 170 t, but only three vessels can be operating simultaneously.

EU TACs for areas partially covered are in 2020: Subarea 3:31 t, Subarea 4: 251 T, and in subareas 5, 6, 7 (EU and international waters): 1 207 (Table 5.6.2).

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
2019	31	251	170	1207	2923
2020	31	251	170	1207	2923

NEAFC recommended that in 2009 the effort in areas beyond national jurisdictions shall 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

In 2020, 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 2013–2019 (Table 5.6.3), and by area and country for 2019 (Table 5.6.4).

Table 5.6.3 Total discards of tusk by country for 2013 to 2019.

	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

Table 5.6.4. Discards of tusk in 2019 by area on country.

Area	Country	Discards
27.4	Germany	5
27.4	UK(Scotland)	64
27.4.a	France	4
27.6.a	France	1
Total		73

5.6.5.2 Length compositions

Figure 5.6.3 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 2001–2019, 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.

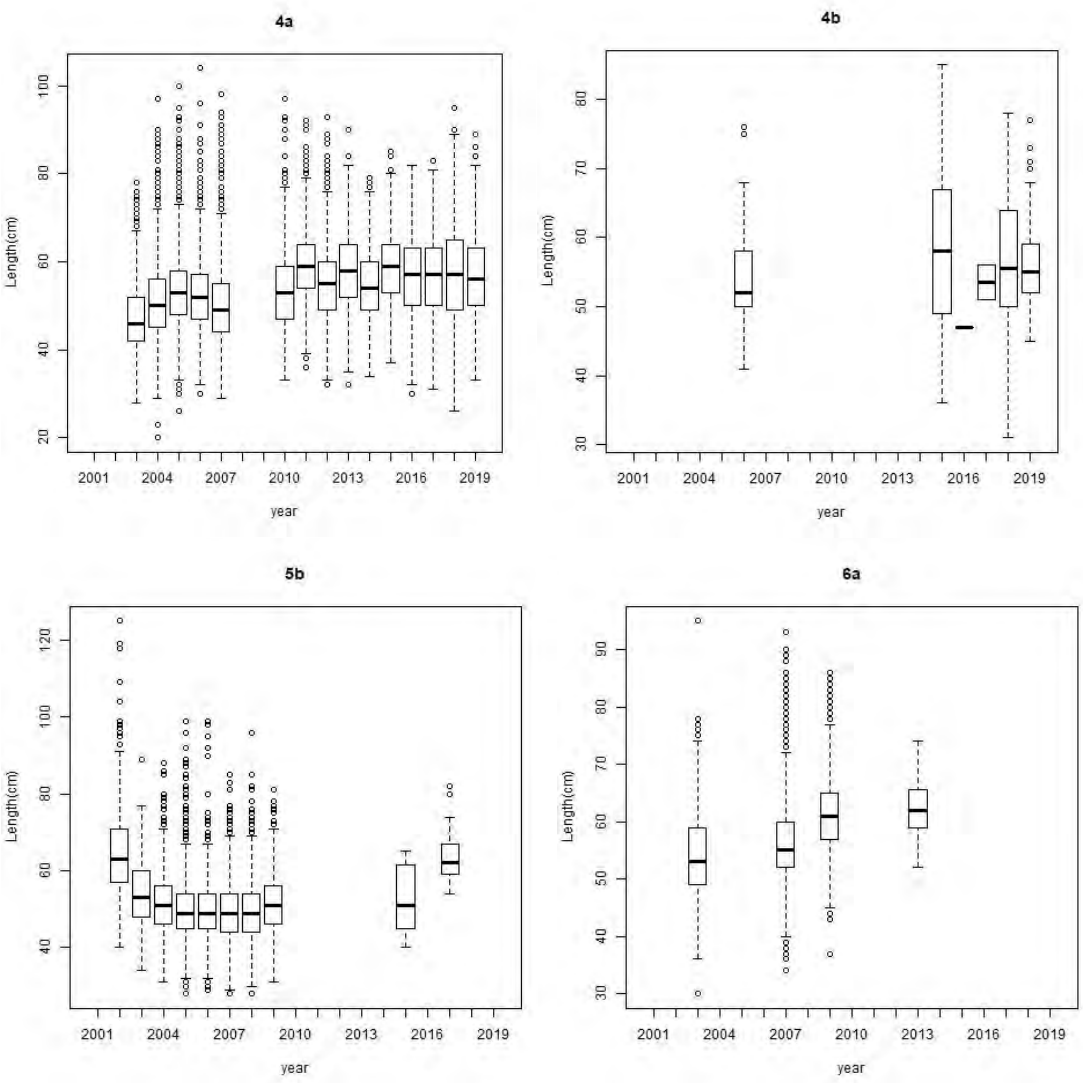

Figure 5.6.3. Length distributions of tusk in Areas 4.a, 4.b, 5.b and 6.a for 2001–2019, based on length data from the Norwegian reference fleet.

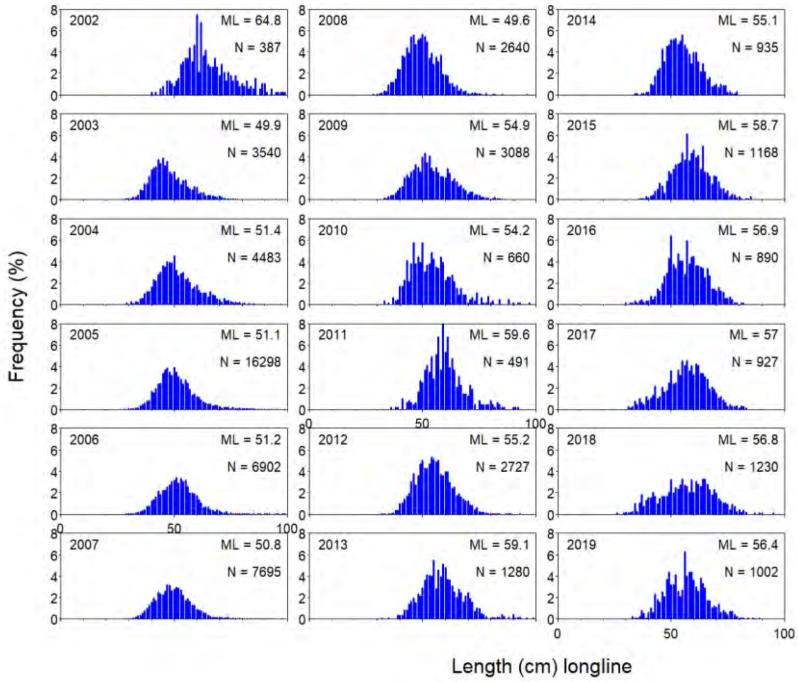

Figure 5.6.4. The estimated length distributions of the catch of tusk by Norwegian longliners, combined, for Areas 4.a, 5.b and 6.a.

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 several trawl surveys conducted in Faroese waters: the annual Faroese spring survey (1994-present, Figure 5.6.6) and summer survey (1996-present, Figure 5.6.7), deep-water survey (2014–2016, Figure 5.6.8), the annual Greenland halibut survey (1995-present, Figure 5.6.9), redfish trawl survey (2003–2011, Figure 5.6.10) and the blue ling survey (2000-2003, Figure 5.6.11).

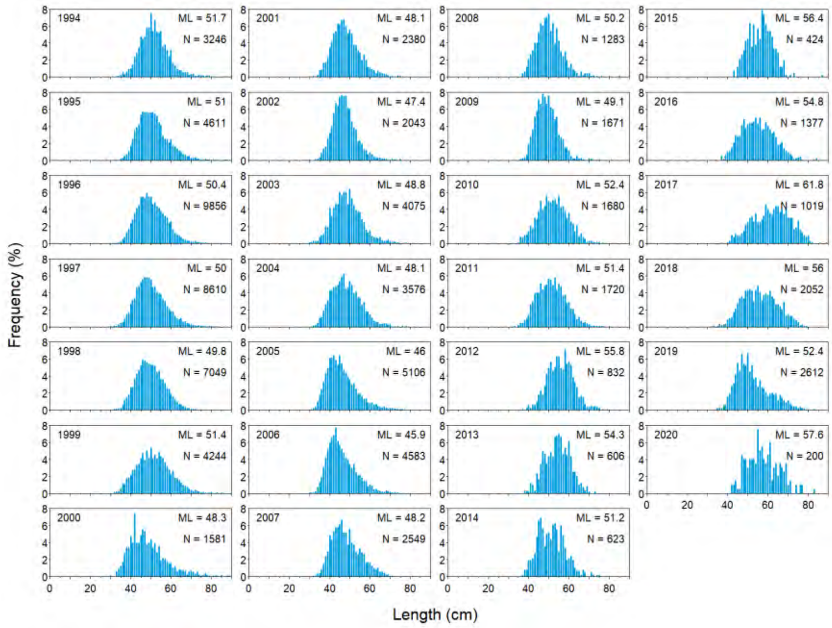

Figure 5.6.5. The estimated length distributions of the catch of tusk by Faroese longliners (>100 BRT) in Area 5.b.

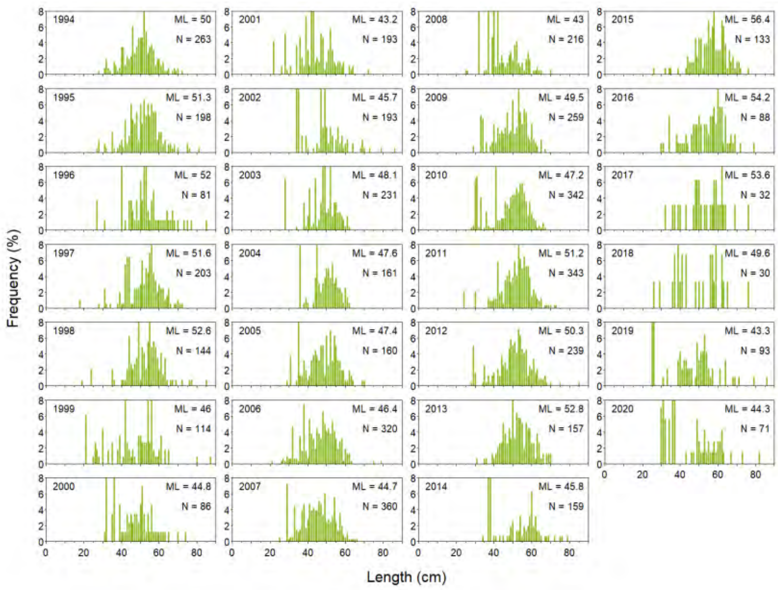

Figure 5.6.6. Estimated length distributions of tusk in Area 5.b based on data from the Faroese spring groundfish surveys.

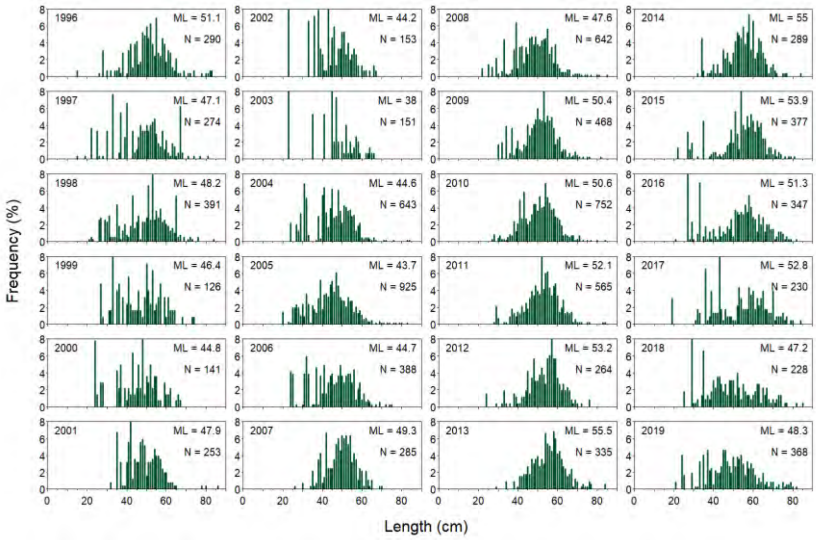

Figure 5.6.7. Estimated length distributions of tusk in Area 5.b based on data from the Faroese summer groundfish surveys.

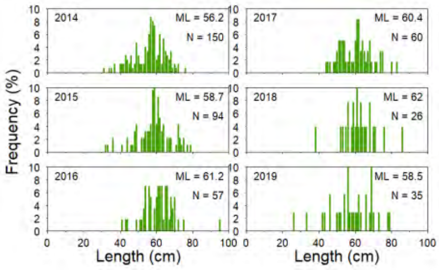

Figure 5.6.8. Length distributions of tusk in area 5.b. Data from the deep-water surveys in 2014–2019.

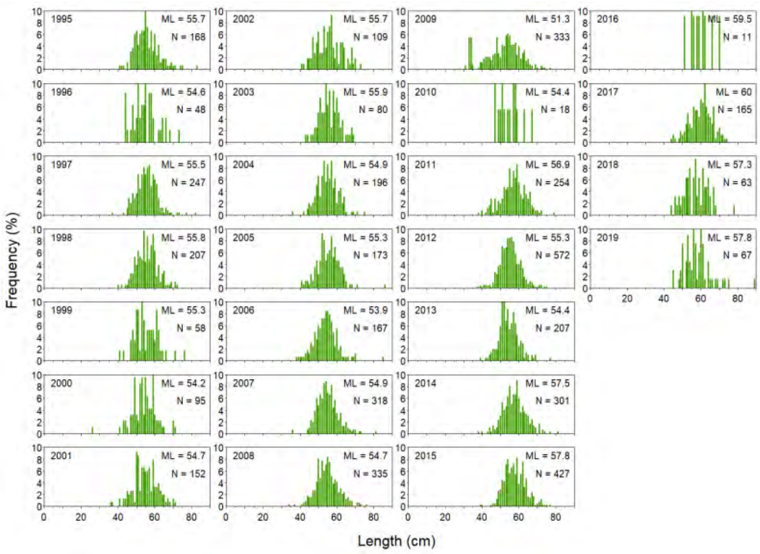

Figure 5.6.9. Length distributions of tusk in area 5.b based on the annual Faroese Greenland halibut trawl surveys.

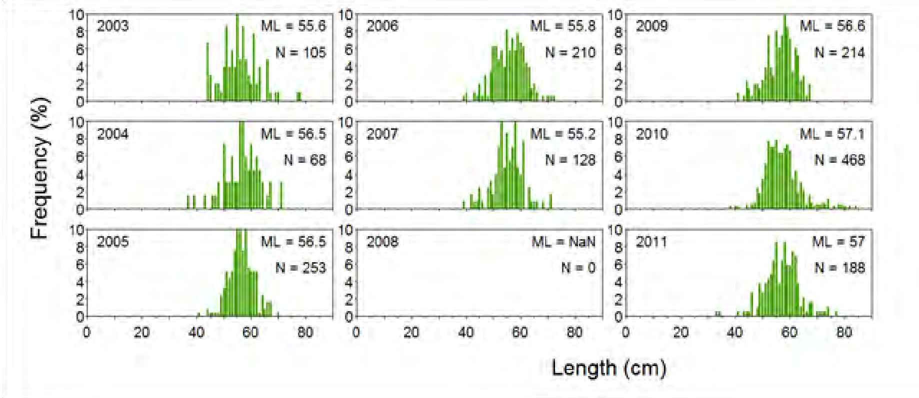

Figure 5.6.10. Length distributions of tusk in area 5.b based on the redfish trawl surveys 2003–2007, 2009–2011.

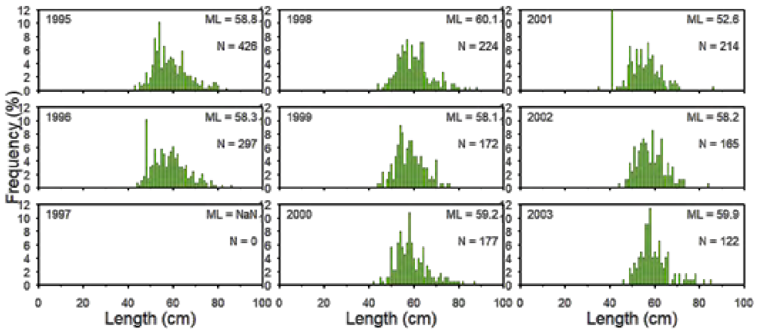

Figure 5.6.11. Length distributions of tusk based on the blue ling surveys in 2000–2003.

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 2000–2019. 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 have 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.

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 2019, the mean length was 52.4 cm and the maximum was 80 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 some mean lengths seem too high. The reason behind the overestimation of length is probably that small tusk below commercial landing size are discarded, and based on the remainders, overestimated the mean length of the tow. Few tusks smaller than 30 cm are reported to be caught in these surveys. The mean length of tusk caught in the Faroese deep-water survey was around 56–58 cm (Figure 5.6.8). The mean length of tusk in the Faroese Greenland halibut-, redfish- and blue ling surveys, which used a commercial trawl, varied around 55 cm (Figure 5.6.9–5.6.11).

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 5.6.12).

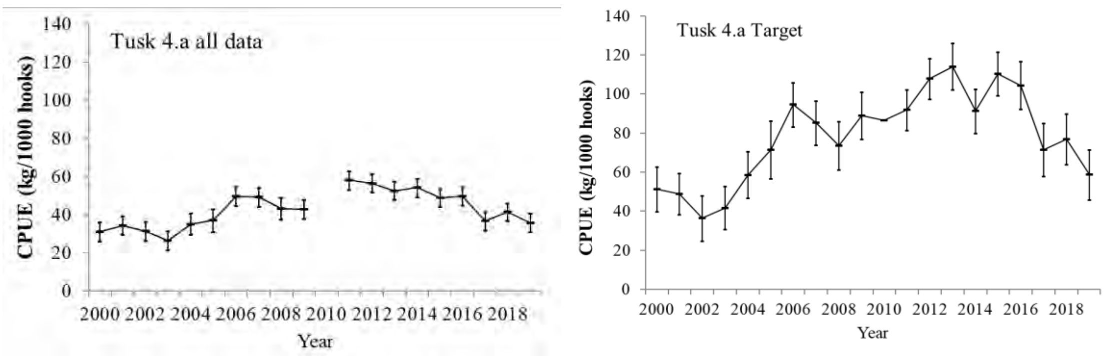

Figure 5.6.12. Tusk cpue series in 4.a for 2000–2019 based on all available data and when tusk appeared to be targeted. The bars denote the 95% confidence intervals.

5.b

The standardized cpue from the annual Faroese groundfish surveys in spring (1994-present) and summer (1996-present) are in Figure 5.6.13. In addition, a CPUE series for the spring survey, 1983-1993, based on non-stratified data, are in Figure 5.6.13. The cpue series for the annual groundfish surveys show a downward trend during the last years with an increase in 2019. 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, have been low but increasing during the last two years (Figure 5.6.14).

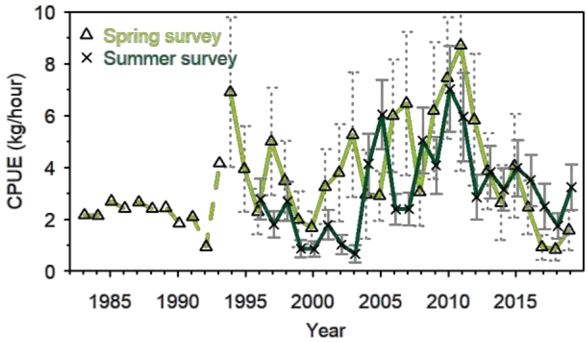

Figure 5.6.13. Tusk 5.b. Standardized cpue from the annual trawl groundfish surveys. The spring survey data from 1983–1993 are not stratified.

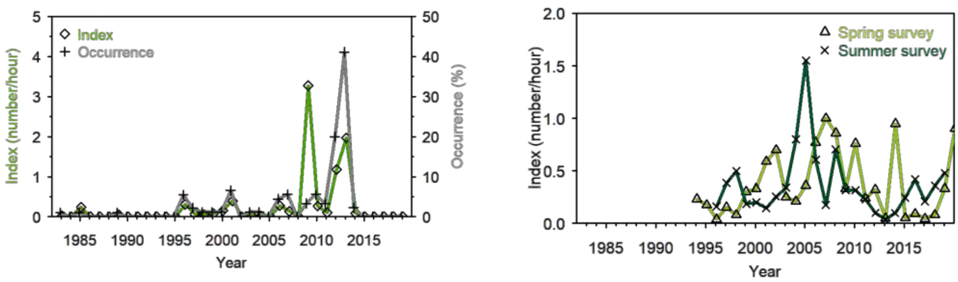

Figure 5.6.14. Tusk 5.b. Abundance index for tusk (2–3 cm in length in number/hour) on the Faroe Plateau based on the 0-group survey (left figure) and abundance index for tusk <40 cm from the annual spring and summer trawl survey on the Faroe Plateau (right figure).

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 a small decrease in 2019 (Figure 5.6.15).

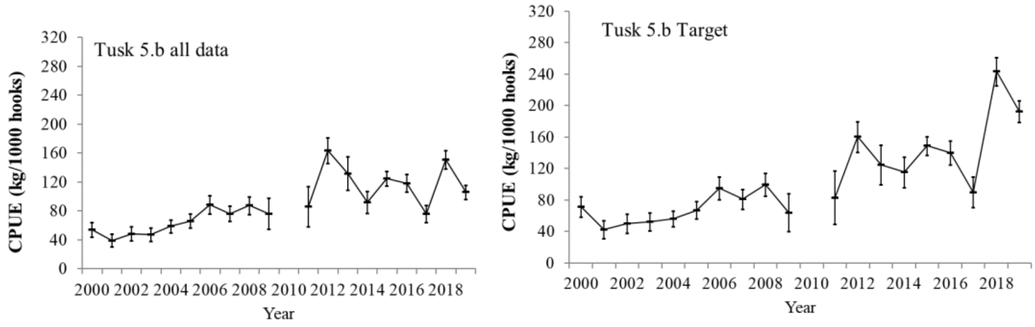

Figure 5.6.15. Tusk cpue series in 5.b for 2000–2019 based on all available data and when tusk appeared to be targeted. The bars denote the 95% confidence intervals.

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 and a sharp increase from 2018 to 2019 for the targeted fishery(Figure 5.6.16).

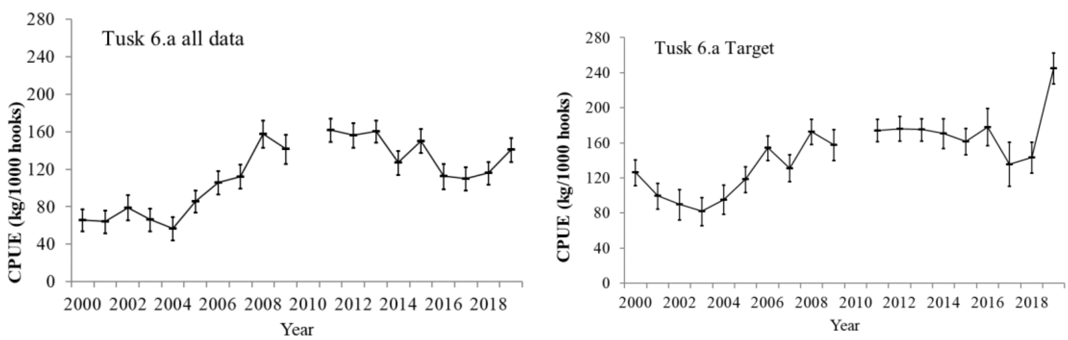

Figure 5.6.16. Two cpue series for tusk in area 6.a from 2000–2016 based on all available data and when tusk appeared to be targeted. The bars denote the 95% confidence intervals.

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 5.6.17).

The combined Norwegian longline cpue series 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 (Figure 5.6.17).

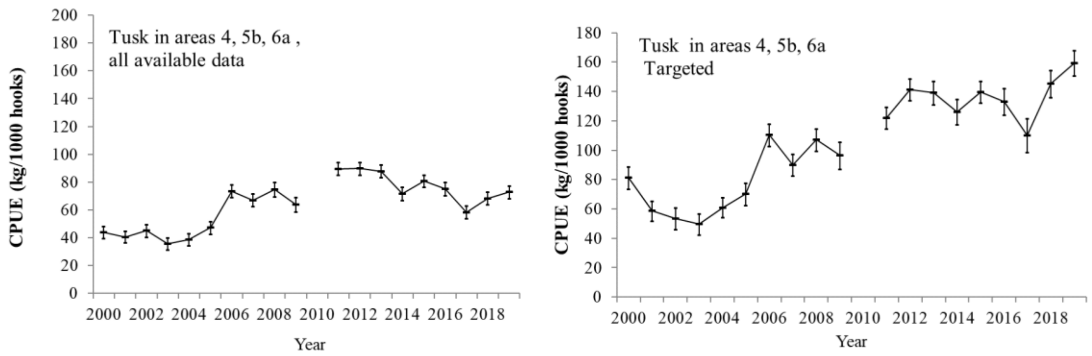

Figure 5.6.17. A combined cpue series for all "other tusk" areas for 2000–2019 based on data from the Norwegian longline fleet when tusk was targeted (>30% of total catch). The bars denote the 95% confidence intervals.

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 in order 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. There are conflicting results between the two models LBI and SPiCT. LBI shows that tusk are not fished sustainably, while SPiCT shows high relative biomass and low fishing mortality.

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

Two different methods were tested for tusk in other areas, the Length-based indicator method (LBI) and SPiCT.

Length-based indicator method (LBI)

Information used in LBI for tusk in division 3.a, 5.b, 6.a, and subarea 4, 6, 8, 9, and 12.

Information and data

The input parameters and the catch length composition for the period 2002-2019 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 Lengths grouped into 2 cm bins
	2002-2019	Norwegian long-liners fishing in divisions 4.a, 4.b, 5.b, 6.a	
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)	

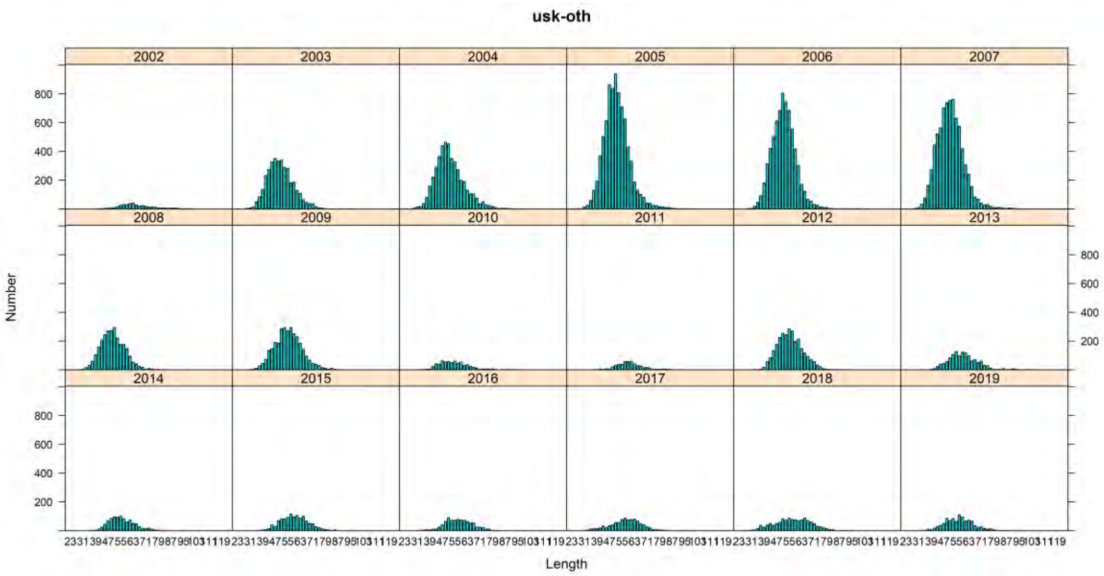

Figure 5.6.18. Tusk in other areas (3.a, 4.a, 5.b, 6.a, 7, 8, 9, 12). Catch length distributions (2 cm bins) have not been raised to total catch for the period 2002–2019 (combined sexes).

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 5.6.19.

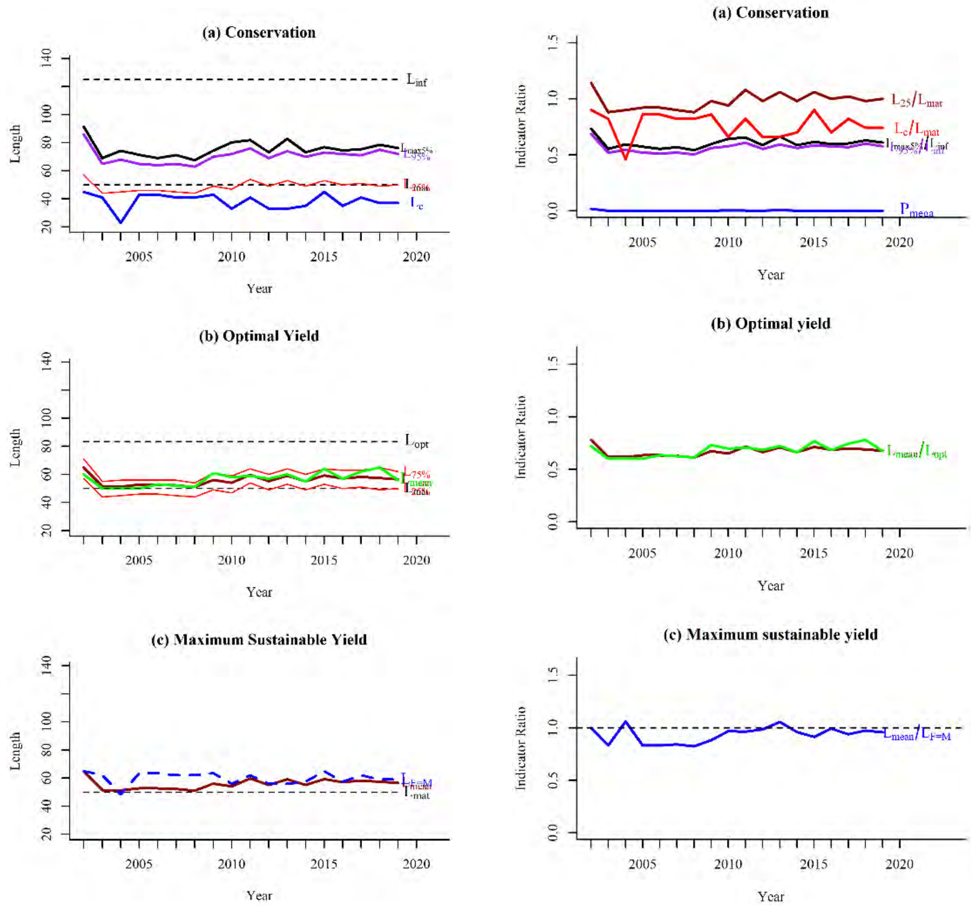

Figure 5.6.19 Tusk in other areas (3.a, 4.a, 5.b, 6.a, 7, 8, 9, 12). Screening of length indicators ratios for sexes combined under three scenarios: (a) Conservation, (b) Optimal yield, and (c) maximum sustainable yield.

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 2017-2019, the ratios were between 0.98 and 1,02 (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 2017-2019 (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 almost the entire period (Figure 5.6.19), which indicates that tusk in other areas were fished unsustainably, however for the last three years it was very close to 1, between 0.94 and 0.97. 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 final results based on 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**
2017	0,82	1,02	0,60	0 %	0,70	0,94
2018	0,74	0,98	0,63	0 %	0,69	0,97
2019	0,74	1,00	0,61	0 %	0,68	0,96

Conclusions

The overall perception of the tusk stock in these areas during the period 2017–2019, based on the LBI results, is that tusk seems to be overexploited and fished unsustainably (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			
	2017	2018	**2019**	
MSY (F/F_{MSY})	✖	✖	✖	Fished unsustainably

	Stock size			
	2017	2018	**2019**	
MSY $B_{trigger.}$(B/B_{MSY})	?	?	?	Unknown

SPiCT

The input data were landings in 1988–2019, and the cpue index for the targeted fishery from 2000–2019 (Figure 5.6.20).

The first run was carried out with standard settings for SPICT, and with catch data and CPUE for all years. The model converged, and the plots from the diagnostics looked good, but there were relatively large confidence intervals for the parameter estimates (BMSY, MSY, FMSY, and K) (Tables 5.6.8 and 5.6.9).

There were 4 runs where n, α and β were varied (Table 5.6.8). All these runs were relatively like the first run. Overall, run number 3 was considered the best. In this run, the parameter n was set to 2, while α and β were set to 1.

The model estimated a MSY of 8991 tons. The advice for 2020and 2021 is 8627 tons, almost identical to the model result. Associated BMSY was 21 283 tons, and FMSY was 0.422. The estimated carrying capacity (K) was about 43,000 tons.

The model indicates that stock abundance is greater than BMSY and the fishing mortality rate is less than FMSY and will continue if the catches continue to be kept at the same level as in the previous years.

The traffic light figure shows that the stock started in the yellow zone, went into the red zone and are now in the green zone. This corresponds to the present perception of the development of the stock. The diagnostics do not show any patterns in the residuals and no significance for bias, auto correlation or normality. The retrospective plot indicated that the test was robust.

Table 5.6.8. Tusk in areas 3.a, 4.a, 5.b, 6.a and 7

Run	**1**	**2**	**3**	**4**
Landings period	1988-2019			
CPUE	2000-2019			
Parameter settings				
n	mod.est	No priors	2	2
Alfa	mod.est	No priors	1	4
Beta	mod.est	No priors	1	1
Convergence	Yes	Yes	Yes	Yes
Parameter estimates.				
B_{MSY}	24628	24818	21283	24045
cilow	16884	17788	11071	13647
cihigh	35822	34626	40914	42366
MSY	10105	10177	8991	9094
cilow	8794	8946	7864	8181
cihigh	11613	11578	10278	10107
F_{MSY}	0,409	0,41	0,422	0,378
cilow	0,287	2,297	0,221	0,22
cihigh	0,588	0,566	0,807	0,651
K	38705	38458	43054	48155
cilow	26801	27660	22329	27311
cihigh	55896	53470	83016	84905
Diagnostic	OK	OK	OK	OK
Retrospective	negative	negative	OK	OK

Table 5.6.9. Tusk in areas 3.a, 4.a, 5.b, 6.a and 7.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: -28.3531482
Euler time step (years):  1/16 or 0.0625
Nobs C: 32,  Nobs I1: 20

Priors
     logn  ~  dnorm[log(2), 0.001^2] (fixed)
 logalpha  ~  dnorm[log(1), 0.001^2] (fixed)
  logbeta  ~  dnorm[log(1), 0.001^2] (fixed)

Model parameter estimates w 95% CI
            estimate        cilow        ciupp    log.est
 alpha  1.000002e+00 9.980435e-01 1.001964e+00  0.0000016
 beta   9.999925e-01 9.980344e-01 1.001954e+00 -0.0000075
 r      8.504943e-01 4.474699e-01 1.616512e+00 -0.1619375
 rc     8.504934e-01 4.474712e-01 1.616504e+00 -0.1619386
 rold   8.504925e-01 4.474698e-01 1.616506e+00 -0.1619396
 m      9.154357e+03 8.001242e+03 1.047366e+04  9.1219852
 K      4.305432e+04 2.232915e+04 8.301587e+04 10.6702177
 q      4.075800e-03 2.127400e-03 7.808700e-03 -5.5026897
 n      2.000002e+00 1.996086e+00 2.003926e+00  0.6931482
 sdb    1.094549e-01 8.002930e-02 1.497000e-01 -2.2122426
 sdf    1.042307e-01 7.696440e-02 1.411566e-01 -2.2611490
 sdi    1.094551e-01 8.002950e-02 1.497001e-01 -2.2122410
 sdc    1.042299e-01 7.696370e-02 1.411558e-01 -2.2611565

Deterministic reference points (Drp)
           estimate        cilow        ciupp    log.est
 Bmsyd 2.152717e+04 1.116459e+04 4.150793e+04  9.9770710
 Fmsyd 4.252467e-01 2.237356e-01 8.082522e-01 -0.8550858
 MSYd  9.154357e+03 8.001242e+03 1.047366e+04  9.1219852
Stochastic reference points (Srp)
          estimate        cilow        ciupp    log.est rel.diff.Drp
 Bmsys 21282.60296 1.107068e+04 4.091432e+04  9.9656453 -0.011491238
 Fmsys     0.42247 2.212124e-01 8.068306e-01 -0.8616368 -0.006572575
 MSYs   8990.58268 7.864062e+03 1.027848e+04  9.1039329 -0.018216187

States w 95% CI (inp$msytype: s)
                   estimate        cilow        ciupp    log.est
 B_2019.00      3.651762e+04 1.901108e+04 7.014525e+04 10.5055502
 F_2019.00      1.295013e-01 6.679320e-02 2.510820e-01 -2.0440646
 B_2019.00/Bmsy 1.715844e+00 1.436473e+00 2.049548e+00  0.5399049
 F_2019.00/Fmsy 3.065336e-01 2.325258e-01 4.040965e-01 -1.1824278

Predictions w 95% CI (inp$msytype: s)
                 prediction        cilow        ciupp   log.est
 B_2020.00      3.652646e+04 1.868579e+04 7.140090e+04 10.505792
 F_2020.00      1.306945e-01 6.611200e-02 2.583653e-01 -2.034893
 B_2020.00/Bmsy 1.716259e+00 1.420433e+00 2.073695e+00  0.540147
 F_2020.00/Fmsy 3.093580e-01 2.265305e-01 4.224701e-01 -1.173256
 Catch_2020.00  4.759689e+03 3.657570e+03 6.193905e+03  8.467938
 E(B_inf)       3.578425e+04           NA           NA 10.485263
```

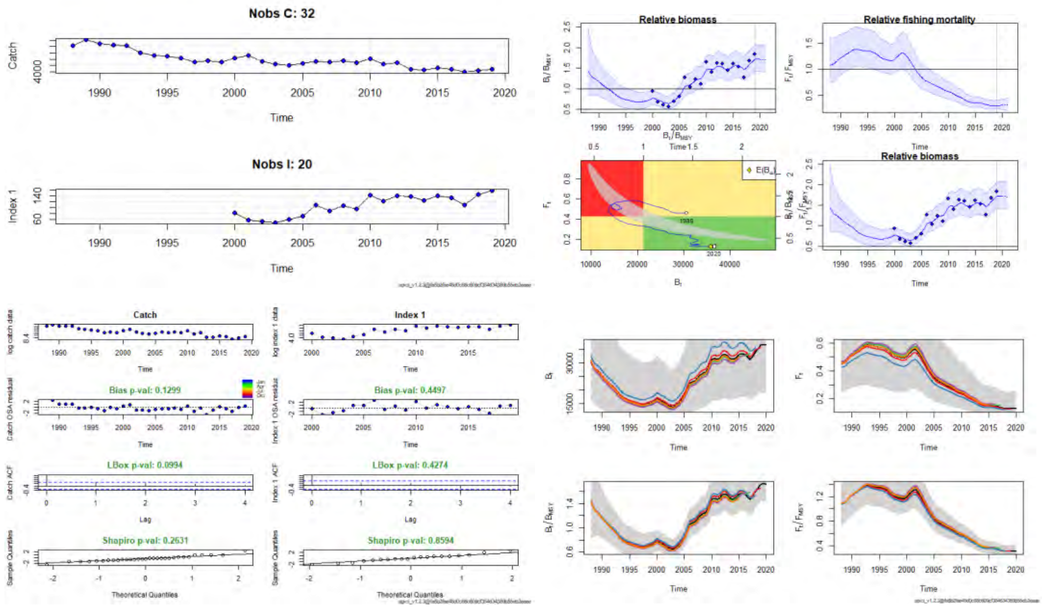

Figure 5.6.20. Tusk in areas 3.a, 4.a, 5.b, 6.a and 7. Upper left corner shows the input data for the model, upper right corner the model output, lower left corner the model diagnostics and the lower right corner the retrospective analysis.

5.6.10 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

Year	Denmark	Norway	Sweden	Total
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
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

***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
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

Year	Denmark	Faroes	France	Germany	Norway	Sweden(1)	E & W	N.I.	Scotland	Ireland	Total
2017	37		5	2	1121				41		1206
2018	37		6	1	1341	1			53		1439
2019*	46		9	2	1139	1	4		46		1247

(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
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

Year	Denmark	France	Norway	Germany	E & W	Scotland	Ireland	Sweden	Total
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

(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

Year	Denmark	Faroes(4)	France	Germany	Norway	E & W	Scotland (1)	Russia	Total
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
2017		1472	18		544		1		2035
2018		1119	14		849		1		1983
2019*		1110	13		835		2		1960

1) Included in 5.b$_2$ until 1996.

(2) Includes 5.b$_2$.

(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

Year	Faroe	Norway	E & W	Scotland [(1)]	France	Total
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
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

(1)Includes 5.b1.

(2)See 5.b_1.

(3)Included in 5.b_1.

***Preliminary.**

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
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	0	940	144
2019*	130		7	669			71	50		927	130

Not allocated by divisions before 1993.

*** Preliminary.**

Table 5.6.1. (Continued).

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

Year	France	E & W	Scotland	Total
1999	-	-	+	+
2000		-	+	+
2001		-	1	1
2002	n/a	-	-	-
2003		-	-	-
2004				
2005				
2006				
2007				
2008				
2009				
2010				
2011				
2012				
2013				
2014				
2015				
2016				
2017				0
2018				
2019*				

***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

Year	France	Ireland	Norway	E & W	N.I.	Scotland	Total
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
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

***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
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

Year	France	Germany	Ireland	Norway	E & W	Scotland	Spain	Total
2016								0
2017								0
2018								0
2019*								0

***Preliminary.**

Tusk 8.a

Year	E & W	France	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			

Year	E & W	France	Total
2010		4	4
2011		0	0
2012			0
2013			0
2014			0
2015			0
2016			0
2017			0
2018			0
2019*			0

***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

Year	3	4.a	4.b	5.b1	5.b2	6.a	7.a	7.b,c	7.g-k	8.a	All areas
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
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

***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 (WD, 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.

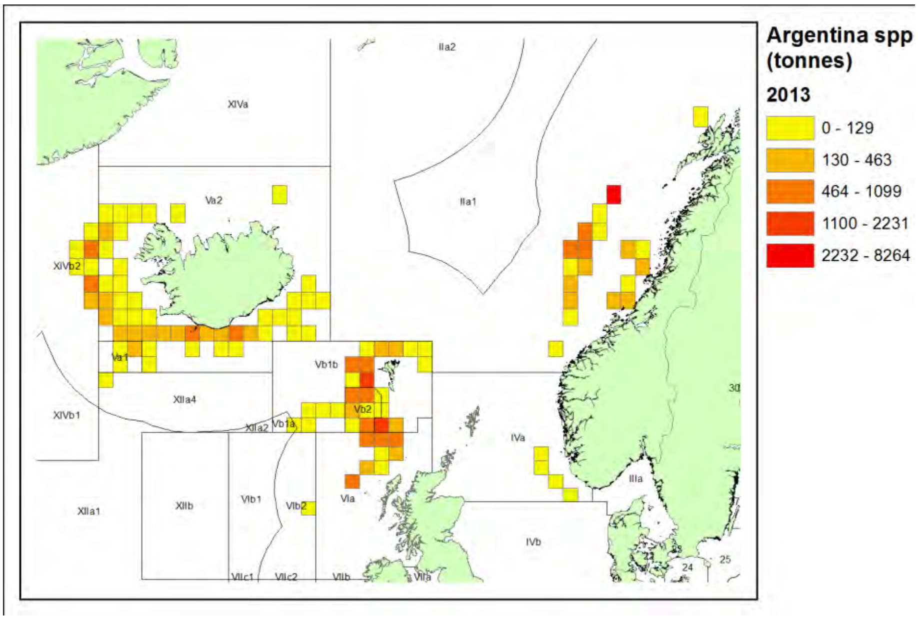

Figure 6.1.1. Catches of greater silver smelt by Iceland, Norway, Faroes and the Netherlands in 2013. Some catches of *A. sphyraena* and *Argentina* unidentified may be included in the Norwegian and Dutch landings.

Three of these stock units have not been benchmarked, hence stock structure was one subject at the benchmark for greater silver smelt WKGSS 2020. The results from the benchmark are currently under revision and will be presented during WGDEEP 2021.

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 have increased from 350t to 5500t in 2016 and 2017, reaching the highest landings so far in 2018 with 7786 t and a slight reduction in landings in 2019 to 7227 t.

6.2.2 Landing trends

International landings are summarised in Tables 6.2.1–6.2.4. The variation through the time-series primarily reflects the developments in the Norwegian target fisheries in Subarea 2. The landings from 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.

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 in 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 21685t 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 12000t per year in accordance with annual TAC regulations reintroduced in 2007. In 2018 the landings increased to 15800t, while in 2019 the landings were around 12500 t.

Since 2014 marked increase is observed in catches in area 3 and 4, and these have risen in 2018 and 2019 to substantial 7786 t and 7227 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 (Table 6.2.5). In the end of 2018, 267 samples of Argentines from the industry was 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 2019 total landings were 20220 t (Table 6.2.1–6.2.3). Landings from Subarea 2 were 12501 t and the remainder were reported from 4 and 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 applied in 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 12 000 t unilateral Norwegian TAC was introduced in 2007 and this TAC was maintained until 2015 when for 2016 it was increased to 13 047 t, which also was the TAC for 2017. In 2018 and 2019 the TAC was 13770 t. The TAC for 2020 is 9 033 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 area 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 greeter 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 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 2019 and 2020 the EU TAC for 1+2 =90 t, and for 4 + 3 the TAC was 1334 t.

This management unit is not distributed in international waters, hence the 2019 TACs described above totalling 13 770 t (Norway) and 90 (EU; area 1 and 2) +1334 t (EU; 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 2014–2019 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 2.a for the period 2009–2019 and for bycatches by Norwegian vessels in 4.a for the years 2011, 2013, 2014 and 2016-2019 (Figure 6.2.4–6.2.6). For each year these distributions are derived by pooling multiple samples from landing sites and samples provided by commercial vessels (WD by Hallfredsson *et al.*, WGDEEP 2016).

Length information is available from the Norwegian slope March/April survey in 2.a conducted in 2009 and 2012, and biennially since then (Figure 6.2.7) (Heggebakken *et al* 2019, WKGSS WD18).

Length information is available from the annual Norwegian shrimp survey in 3.a–4.a, 1984–2019 (Figure 6.2.16).

Length information is available from Russian by-catches in 1 (Figure 6.2.18) and in 2 (2a+2b) (Figure 6.2.19).

6.2.5.3 Age compositions

Age compositions from Norwegian catches 2013-2018 are presented in Figure 6.2.8.

Age distributions by depth from the Norwegian slope survey in March 2018 are shown in Figure 6.2.9.

6.2.5.4 Weight-at-age

No new data on weight-at-age were presented.

6.2.5.5 Maturity and natural mortality

No new data on maturity and natural mortality were presented.

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 (area 1 and 2). Additionally, trawl surveys were conducted in 2.a in 2003–2005.

For area 4 and 3a information is available from the Norwegian shrimp survey in years 1984–2019. Stations are in the depth range of 80-660 meters, with around 25% of the stations deeper than 300 meters.

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 6.2.8) 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 changes in the size and age composition in the recent nine years when the target fishery has been regulated with TACs and other measures. Length and age distributions in the Norwegian survey sampling the entire geographical and depth range show higher length and age ranges, however, with deeper than 400 m samples having proportion of old fish closer to those observed in the 1980s (Figure 6.2.9). The fishery is mainly conducted shallower than 400 m (Figure 6.2.12).

In Division 3.a there has been a declining trend in the length distributions throughout the 1984–2019 shrimp survey time-series, but with some reappearance of large fish in the most recent years (Figure 6.2.16).

In Division 4.a size distributions from the bycatch (Figure 6.2.6) suggest that the catches comprise rather variable but smaller fish than those in the target fishery landings in 2.a. This probably reflects that the slope of the Norwegian Deep in 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 area 2 biomass estimates based on the acoustic observations and trawl swept area estimates show increasing trend from 2012-2016 (Table 6.2.6, Figure 6.2.11). The latest survey shows however a declining trend, to around the 2014 values for the acoustic estimate and to the 2012 values for swept area estimate. Greater silver smelt has been distributed rather evenly from 300–500 m depth in the surveys according to acoustics, which contrasts with the catches that are mostly conducted at depths around 300–400 m (Figure 6.2.10-6.2.12). There is a rather high CV in the trawl estimates, and the acoustic biomass estimates are considerably higher than the trawl indices. It is possible that this reflects that the trawl indices don't show the more pelagic part of the vertical distribution of this bento-pelagic fish. One should however be careful in the interpretation of absolute biomass values from different methods, and the comparison might thus not be fully appropriate. It is reassuring that both methods show similar trends. Greater silver smelt seemed to be more northerly distributed in 2018 compared to previous years. Registrations were strikingly low at the slope south from around 67°N (Figure 6.2.10).

Swept area biomass indices and swept area abundance indices for greater silver smelt from the annual Norwegian shrimp survey in 3.a and southeastern parts of 4.a are shown in Figure 6.2.15. 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).

The catch rates in terms of numbers and weight from the survey in 3.a and 4.a suggest pronounced variation and trends (Figure 6.2.15). The survey catches rates first declined steadily and then rather abruptly to unprecedented low levels in 2006. After 2010, indices showed abrupt increase until around 2015 and have been at a relatively high level since then.

A preliminary catch CPUE based on electronic logbook data 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.

Exploratory assessment

Exploratory assessment surveying different DLM assessments (SPiCT, LBI, DLMtools) was presented at the 2018 meeting (Hallfredsson, WD WGDEEP 2018). The stock was one of three argentine stocks subject to benchmark in 2020. For the benchmark Hallfredsson *et al* (2020, WKGSS WD17) examined different scenarios using the Surplus Production in Continuous-Time (SPiCT) model and suggested that the indices from SPiCT can be used as input in the "2 over 3" assessment approach for this stock. Results and recommendations from the benchmark will be presented at WGDEEP 2021.

Existing abundance, length and age dataseries for this stock are rather short in time. However, if the time-series are maintained they may support more analytical assessment in 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 labor-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.

6.2.7 Comments on the assessment

The ICES framework for category 3 stocks was applied (ICES, 2012) in 2019, for a two years advice (2020 and 2021). For draft advice, the Norwegian acoustic survey in Subarea 2 was applied as an index for the stock development. The advice is based on a comparison of the two latest index values with the three preceding values, combined with latest advice. For years where index values are not available the values are obtained by interpolation. The index is estimated to have decreased by 18% and neither the uncertainty cap nor the precautionary buffer was applied to calculate the catch advice. This was later reversed by ADGDEEP, and the precautionary buffer was applied. The stock status relative to candidate reference points is unknown. An LBI length-based analysis was presented at the 2018 meeting (Hallfredsson, WD WGDEEP 2018) and revisited during the benchmark (Figure 6.2.13). The index ratio $L_{mean}/L_{F=M}$ is higher than 1 which indicates that the exploitation status is within precautionary levels. Excepted mean length of catch above L_{mean} when F=M is 33.25cm. The LBI-analysis was based on length-distributions in the direct fisheries in area 1 and 2 for 2009-2018. Discarding is considered negligible.

6.2.8 Management considerations

Advice is given every second year for this stock and the 2019 advice applies for 2020 and 2021.

The size and age distributions of landings in the major fishery, i.e. the target fishery in the Norwegian EEZ, remains stable, suggesting that the prior decline in the proportions of large fish in the catches observed during the first decades of the fishery has halted. Furthermore, corresponding data from Norwegian surveys show that larger and older fish occur in adjacent and deeper areas than the areas being used by the fishery (Figure 6.2.9 and 6.2.12). The fishing areas (both for the target fishery and bycatch fisheries) have remained the same since the early 1980s. The exception is the 3.a where a target fishery was conducted until the mid-1990s but not since.

Acoustical biomass estimates for Division 2.a in 2012 showed some reduction compared to 2009, but from 2012-2016 a marked upward trend has showed, as does the trawl index. However, from 2016-2018 the acoustical biomass estimates and the trawl index has declined. Some concerns regarding the acoustic indices from the Norwegian Sea south-east slope survey have been addressed, and before the benchmark in 2020 recalculations of the acoustical biomass indices was performed (Figure 6.2.17) in the Matlab program that has been used for this index (Harbits 2010, WKDEEP 2010). This resulted in differences in the index between 2019 calculations and the 2020 recalculations. Since this index is the one used as an input in the "2 over 3" assessment approach, the advices given in previous years were also recalculated (Table 6.2.7). Regarding the advice, the uncertainty cap and the precautionary buffer have levelled out the differences in the index, and the advice does not differ significantly between the old index and the recalculated one. Thus, it was considered unnecessary to reopen the advice. In a working document for the 2020 benchmark Heggebakken *et al* (WKGSS WD 18) suggest that StoX will be used from now on to calculate this index.

The Norwegian shrimp survey data from Division 3.a suggest that the abundance in that area has increased in recent years after an abrupt decline in 2004–2005. The apparently rather rapid increase in the abundance index in recent years may suggest that immigration from northern areas (in 4.a or 2.a) may have happened. The abrupt decline in 2005 may partly have resulted from high incidental mortality due to greater silver smelt being a bycatch in the roundnose grenadier fishery which peaked in 2003–2005.

The bycatch in area 4 has increased rapidly since 2012 and was 7786 tons and 7227 tons in 2018 and 2019, respectively. This is an alarming level. 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 these for the most are greater silver smelt catches (ICES WGDEEP 2019 WD7).

6.2.9 References

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6.2.10 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	Iceland	SUM
1988	1062	0	0	1	0	13014	5	14	0	0	0	0	14096
1989	1322	0	0	0	335	10495	0	23	1	0	0	0	12176
1990	737	0	0	13	5	10686	0	0	0	0	0	0	11441
1991	1421	0	0	0	3	8864	0	0	6	1	0	0	10295
1992	3564	0	0	1	70	8932	0	0	101	0	0	0	12668
1993	2353	0	0	0	298	8481	0	0	56	0	0	0	11188
1994	1118	0	0	0	0	6221	0	0	614	0	0	0	7953
1995	1061	0	0	357	0	6419	0	0	20	0	0	0	7857
1996	1446	0	0	0	0	6817	0	0	0	0	0	0	8263
1997	1455	542	0	1	0	5167	0	0	0	0	0	0	7165
1998	748	428	0	169	277	8655	0	0	0	0	0	0	10277
1999	1420	0	0	0	7	7151	0	0	18	0	0	0	8596
2000	1039	273	10	0	3	6107	0	195	18	9	0	0	7654
2001	907	1011	3	0	0	14360	0	7	233	28	0	0	16549
2002	614	484	4	0	0	7406	0	0	164	0	0	0	8672

year	Denmark	Sweden	Ireland	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Iceland	SUM
2003	918	42	0	4	617	8351	0	7	22	4	4	0	9969
2004	910	0	36	4	4277	11574	0	4	12	0	0	0	16817
2005	470	0	0	1	28	17066	0	16	0	0	14	0	17595
2006	335	0	0	6	0	25149	0	4	2	0	0	0	25496
2007	0	0	0	0	0	16373	0	1	0	0	0	0	16374
2008	0	0	0	0	0	13424	0	0	0	0	0	0	13424
2009	0	0	0	0	0	13495	0	0	0	0	0	0	13495
2010	0	0	0	0	0	12865	0	0	33	0	0	0	12898
2011	0	0	0	0	0	12060	0	0	0.4	4	0	0	12064
2012	0	0	0	0	0	12352	0	0	0	1.2	114	18	12485
2013	0	0	0	0	0	13227	0	0	0	2.3	0	0	13229
2014	40	1	0	204	345	14471	0	0	0	1	0	0	15062
2015	0	1	0	0	0	15235	0	0	0	0	0	0	15236
2016	0	1	0	38	11	18835	0	7	0	1.4	0	0	18893
2017	0	1	0	0	10	17788	0	35	0	0	0	0	17835
2018	18	4	0	67	152	23609	0	9	0	0	0	0	23859
2019*	0	0	0	143	349	19720	0	8	0	0	0	0	20220

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

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
2005	470				470
2006	324				324
2007					0
2008					0
2009					0
2010					0
2011					0
2012					0
2013					0
2014			2	1	3

Year	Denmark	Germany	Norway	Sweden	TOTAL
2015			22	1	23
2016			101	1	102
2017			3	(1)	3(1)
2018				(3.6)	(3.6)
2019*				(66)	(66)

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	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
2005			1	28	3				32
2006	11		6		3468	2			3487
2007					3101				3101
2008					1548				1548

Year	Denmark	France	Germany	Netherlands	Norway	Scotland	Ireland	Russia	TOTAL
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	7227	(39)			7719(39)

Table 6.2.5. Catches (t) registered as greater silver smelt (GSS), lesser silver smelt (LSS) and mix of both species (LSS/GSS) in Norwegian fisheries as registered port landings (upper table) and logbooks (lower table). Included in 2.a2 is also minor catches from area 1.b and 2.b2 (less than 0.5 tons)

ICES area	LSS	LSS/GSS	GSS	Total
2.a2	0	12493	0	12493
4.a	7205	5	11	7221
4.b	6	0	0	6
Total	7211	12498	11	19720

ICES area	LSS	LSS/GSS	GSS	Total
2.a2	100	1625	11262	12987
3.a	29			29
4.a	5824	970	8	6802
4.b	10			10
Total	5963	2595	11270	19828

Table 6.2.6. GSS in 2.a. Biomass estimates (t) for greater silver smelt in Norwegian slope surveys conducted in March 2009, 2012, 2014, 2016 and 2018. For acousic methods see Harbitz, WD ICES, WKDEEP 2010.

	SWEPT-AREA, BOTTOM TRAWL							ACOUSTICS				
Area	**SW**	**SE**	**NW**	**NE**	**Total**	**std**	**CV**	**SW**	**SE**	**NW**	**NE**	**Total**
2004					43978	20366	0.46					
2005					114644	39648	0.35					
2009	24171	44961	484	997	70613	18952	0.27	122026	91901	1069	1787	216783
2012	4505	28778	1053	155	34491	12996	0.38	66961	96643	10941	3352	177897
2014	104726	18818	2769	0	126313	98011	0.78	209771	111156	7216		328143
2016	53868	118059	4256	47	176230	81894	0.46	113942	456046		1573	571561
2018	6375	22878	4703	2282	36238	7744	0.21	51226	238676	10719	990	301611

SW = Latitude < 70°N, depth 500–750 m.

SE = Latitude < 70°N, depth 300–500 m.

NW = Latitude > 70°N, depth 500–750 m.

NE = Latitude > 70°N, depth 300–500.

***In 2014 the survey was conducted without the use of a midwater trawl. This might reduce accuracy and precision of the estimates because the allocation of backscattering strength to species categories in the pelagic zone could not be supported by catch information from targeted trawl tows.**

Table 6.2.7. Comparison in advice using the old index estimates versus new index estimates in the Matlab approach.

Matlab NEW index			Old advice		
Advice draft 2015			Advice 2015		
Index A (2015–2016)		482388	Index A (2015–2016)		288173
Index B (2012–2014)		378127	Index B (2012–2014)		189705
Index ratio (A/B)		1.28	Index ratio (A/B)		1.52
Uncertainty cap	Applied	1.2	Uncertainty cap	Applied	1.2
Average catches (2012, 2013, 2		13591	Adviced catch for 2016 and 2		13 591
Discard rate		Negligible	Discard rate		Negligible
Precautionary buffer	Applied	0.8	Precautionary buffer	Applied	0.8
catch advice*		13047.36	catch advice*		13047
Difference from old advice		0			
Advice draft 2017			Advice 2017		
Index A (2015–2016)		554038	Index A (2015–2016)		510707
Index B (2012–2014)		438786	Index B (2012–2014)		253020
Index ratio (A/B)		1.26	Index ratio (A/B)		2.02
Uncertainty cap	Applied	1.2	Uncertainty cap	Applied	1.2
Last advice		13047	Adviced catch for 2016 and 2		13047
Discard rate		Negligible	Discard rate		Negligible
Precautionary buffer	Not applie	0.8	Precautionary buffer	Not applied	0.8
catch advice*		15657	catch advice*		15657
Difference from old advice		0			
Advice draft 2019			Advice 2019		
Index A (2017–2018)		407014	Index A (2017–2018)		369099
Index B (2014–2016)		544688	Index B (2014–2016)		449852
Index ratio (A/B)		0.75	Index ratio (A/B)		0.82
Uncertainty cap	Applied	0.8	Uncertainty cap	Not applied	
Last advice		15657	Adviced catch for 2018 and 2		15657
Discard rate		Negligible	Discard rate		Negligible
Precautionary buffer	Applied	0.8	Precautionary buffer	Applied	0.8
catch advice*		10020	catch advice*		10277
Difference from old advice		-257			

6.2.11 Figures

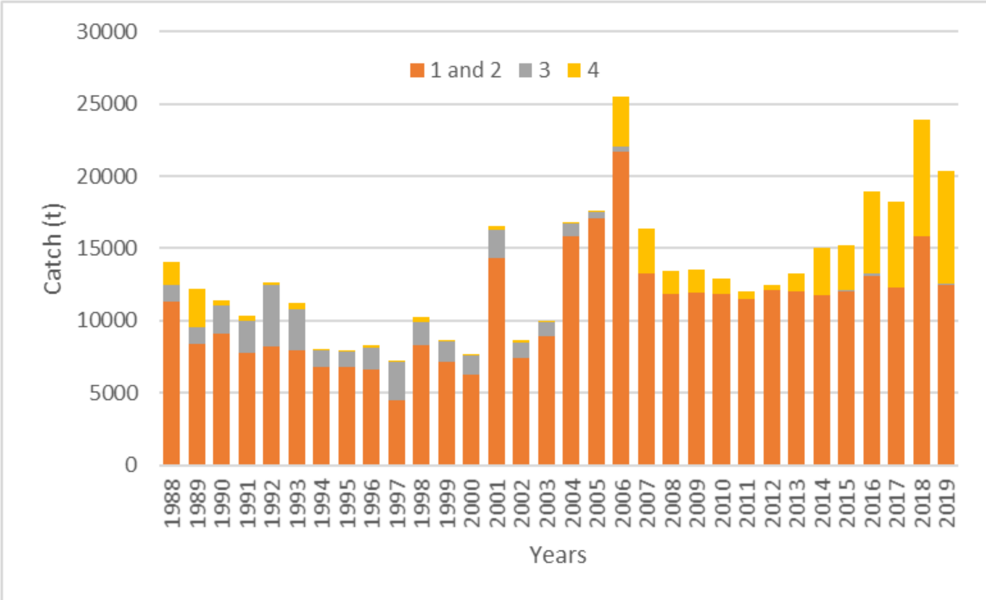


Figure 6.2.1. Total catch of greater silver smelt in Subareas 1, 2, 3 and 4.

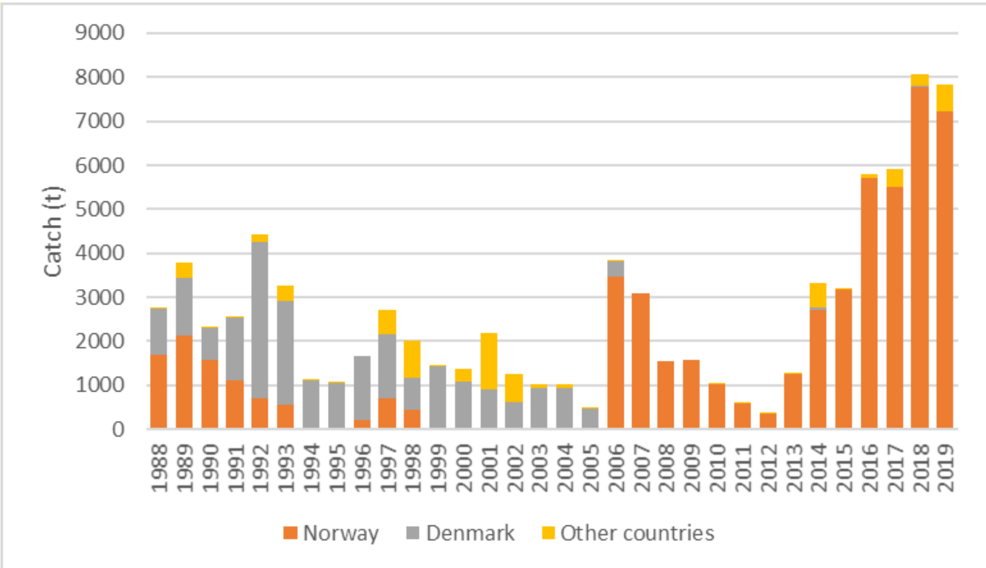


Figure 6.2.2. Total catch of greater silver smelt in Subareas 3 and 4, by countries.

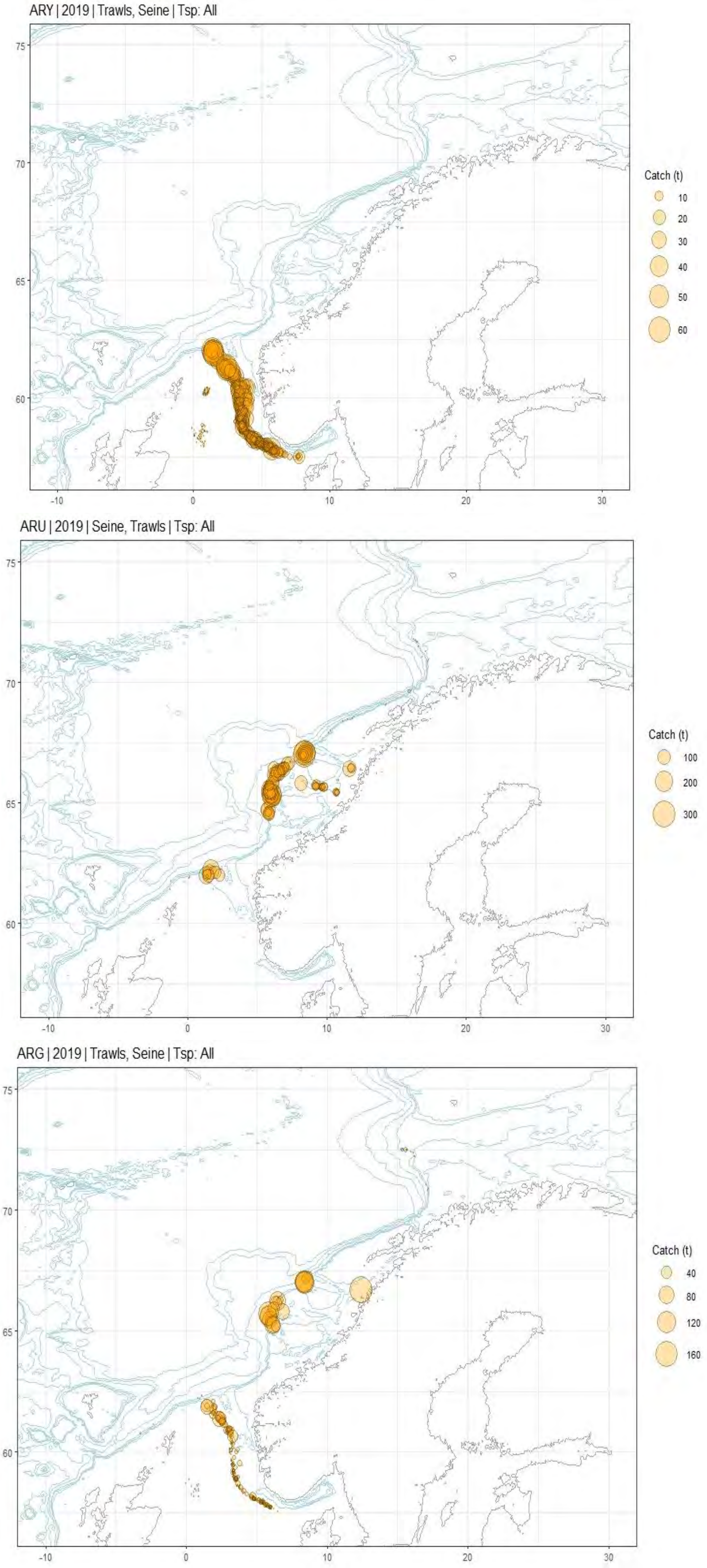


Figure 6.2.3. Norwegian catches in 2019 based on logbooks, included bycatch. Uppermost, middle and lowermost panels show catches registered as lesser silver smelt, greater silver smelt and mix of both species, respectively. Bubble sizes reflect sizes of single catches. NB: Catch representing max bubble size varies between panels.

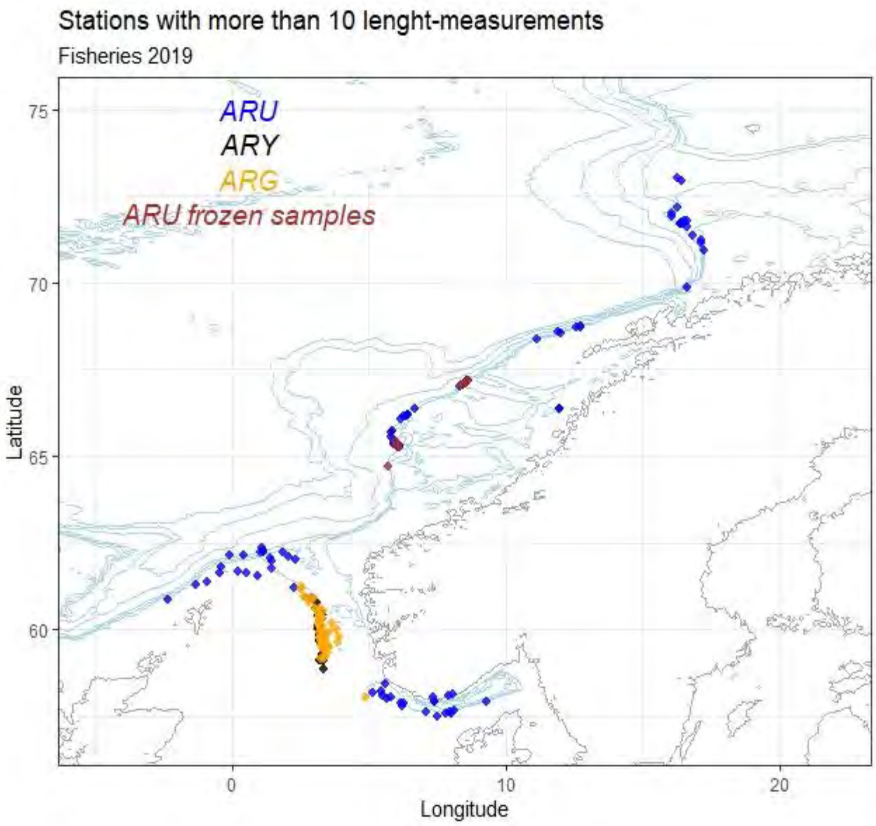
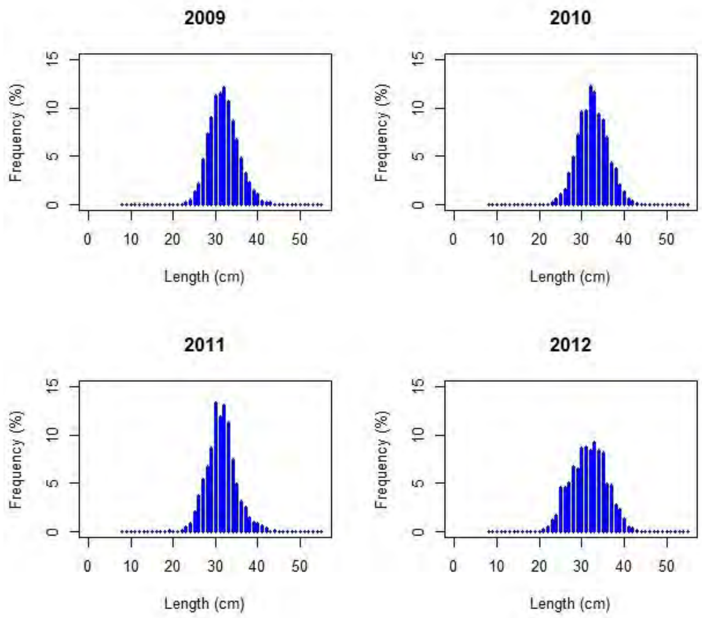


Figure 6.2.4. Positions from the fisheries for 2019 with length measurement landed as GSS, LSS, GSS/LSS and frozen samples.



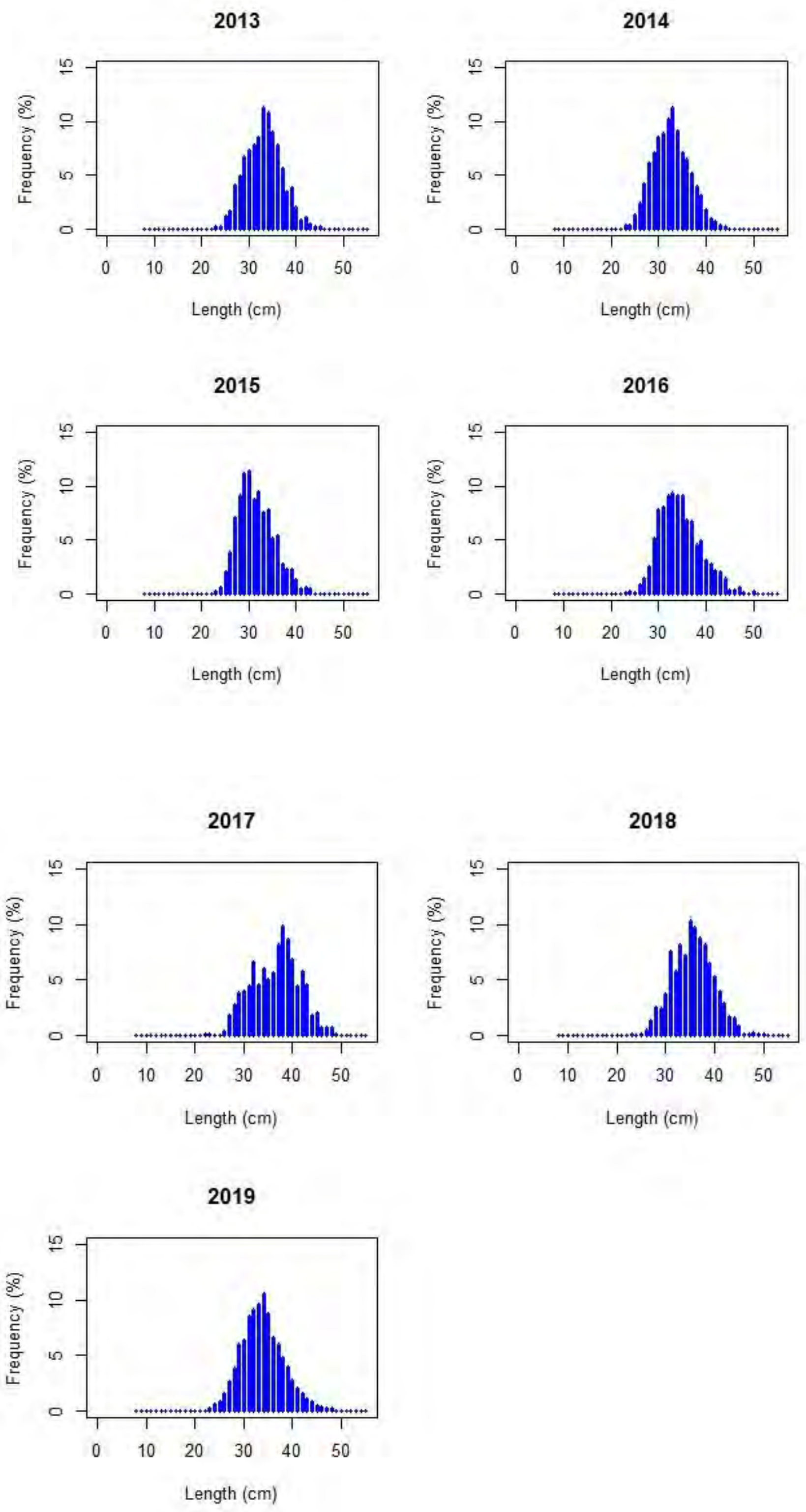


Figure 6.2.5. Greater silver smelt in 1, 2, 4 and 3.a. Length distributions from the target fisheries in 2009–2019 north of 62°N (approximately area 1 and 2).

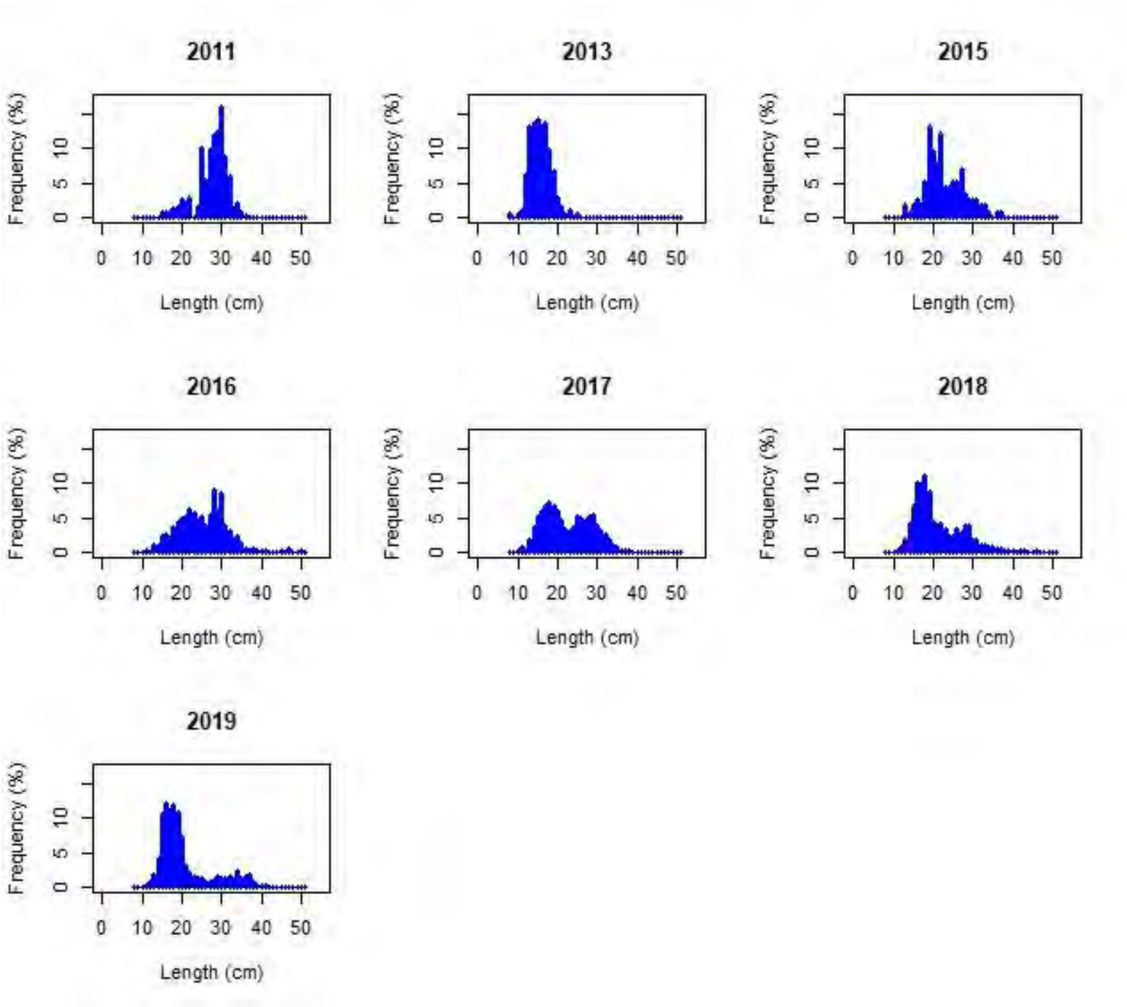


Figure 6.2.6. Greater silver smelt in 1, 2, 3.a and 4. Length distributions in annual samples from Norwegian bycatches south of 62°N (approximately area 3 and 4.).

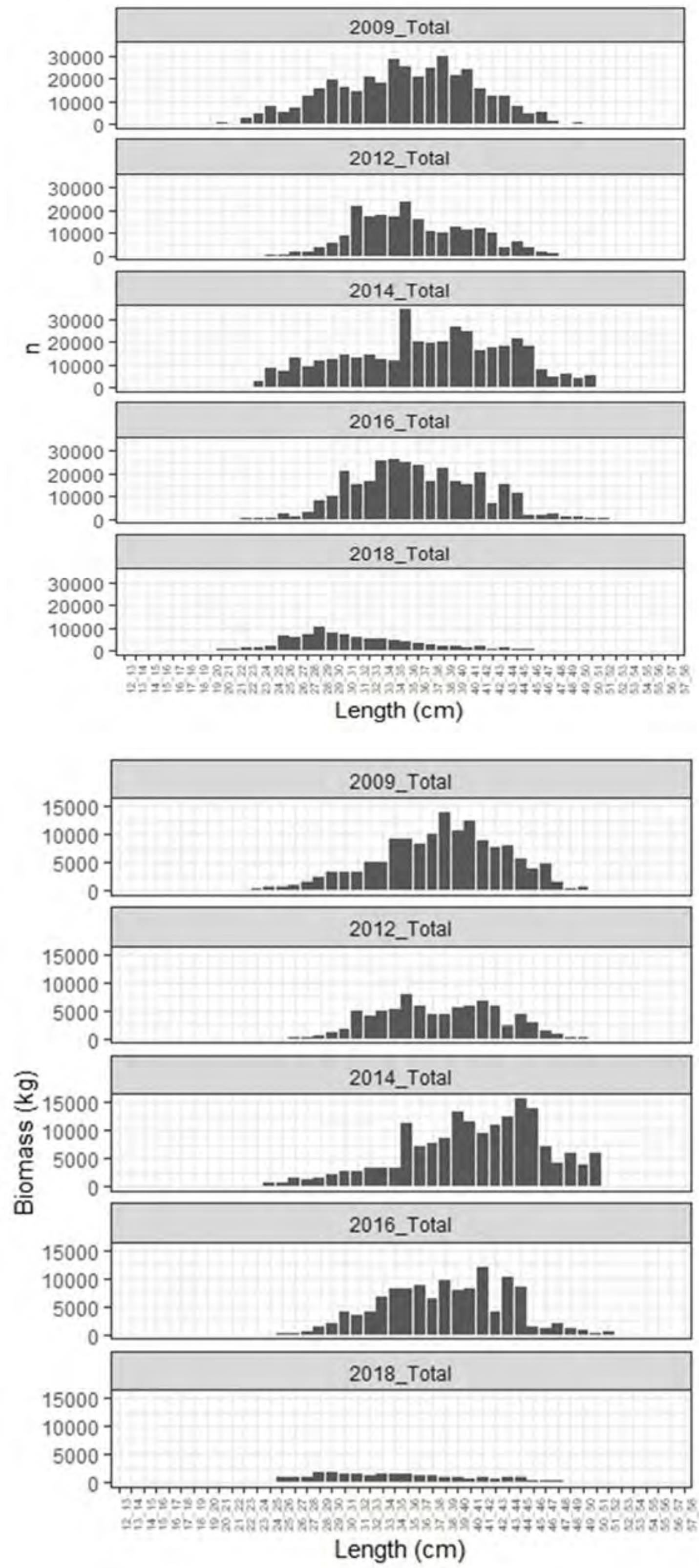


Figure 6.2.7. Length distributions in numbers (upper panels) and biomass (kg) (lower panels) for greater silver smelt in the Norwegian Sea south-east slope survey in 2009, 2012, 2014, 2016 and 2018. No apparent substantial difference between years is seen, and few individuals have lengths outside the range 20–50 cm.

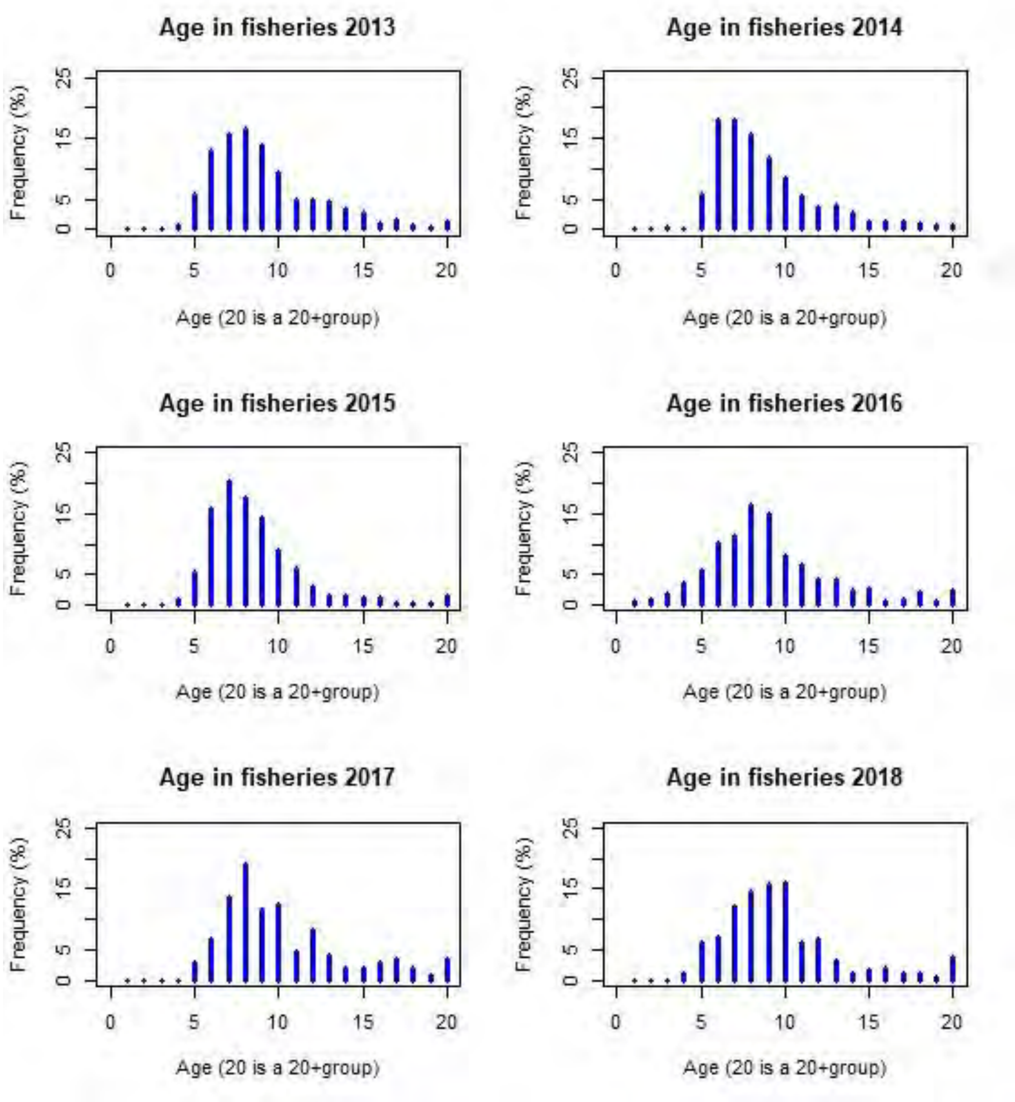


Figure 6.2.8. Greater silver smelt in 1, 2, 3, and 4. Age composition of Norwegian landings samples, 2013-2018. No otoliths read so far from the fisheries in 2019.

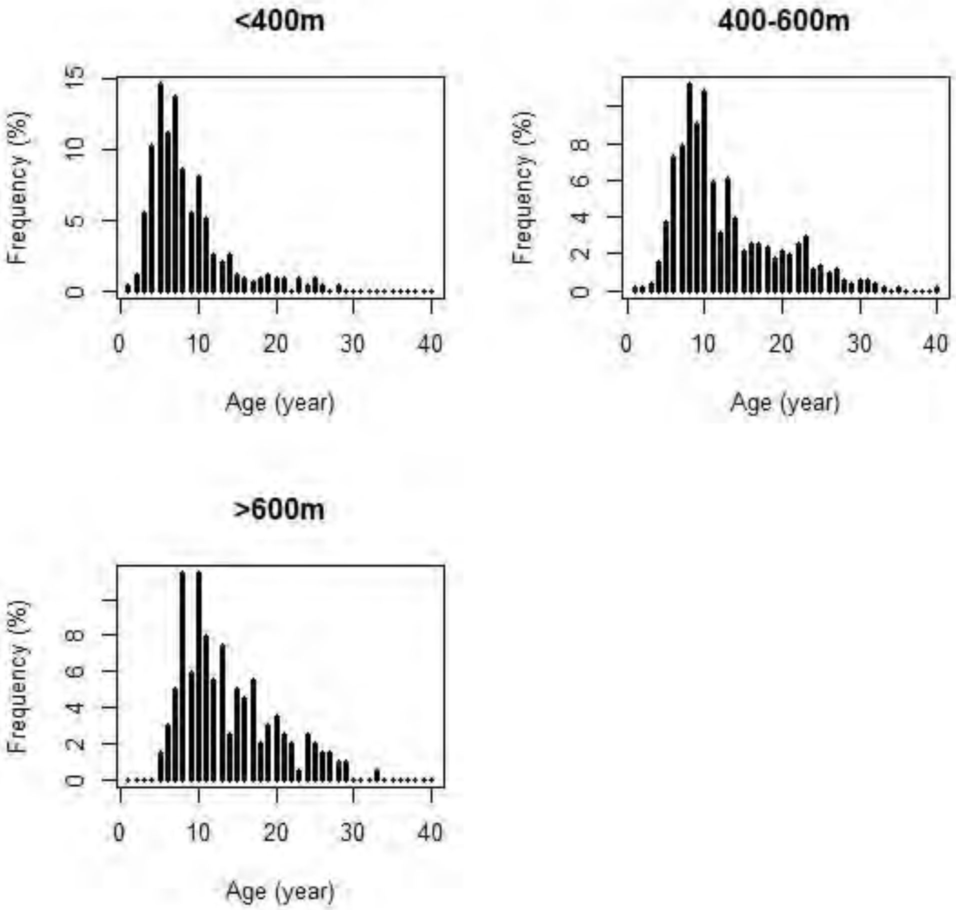


Figure 6.2.9. Greater silver smelt in 1, 2, 3, and 4. Age compositions by depth zones in the Norwegian slope survey in March–April 2018.

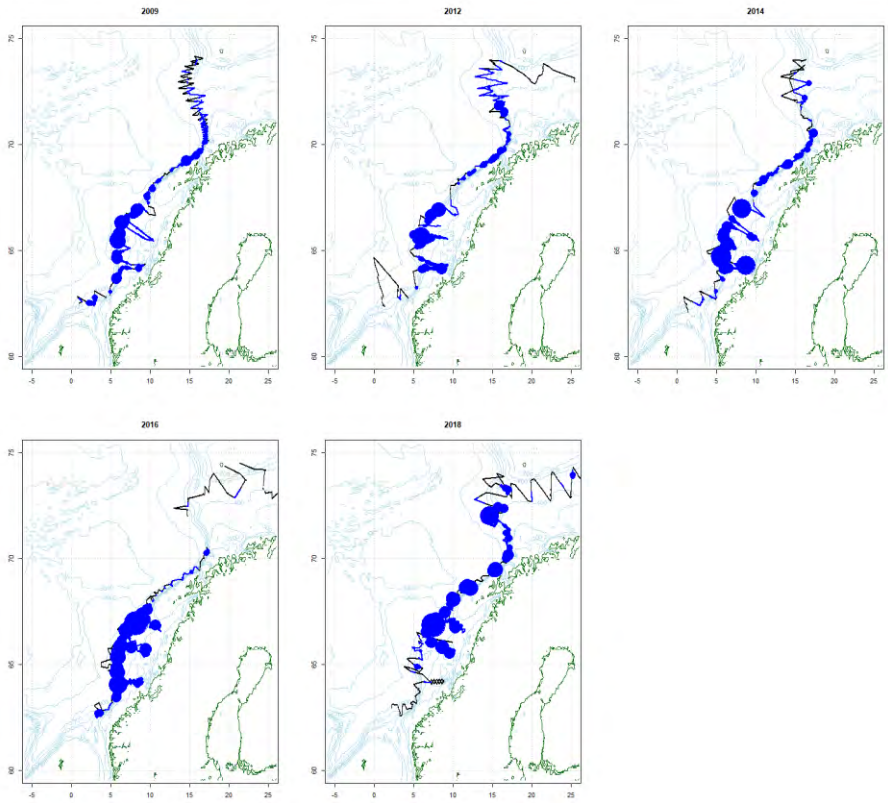


Figure 6.2.10. Greater silver smelt in 2.a. Acoustic backscattering strength estimates SA-values) in Norwegian continental shelf and slope surveys March–April 2009, 2012, 2014, 2016 and 2018.

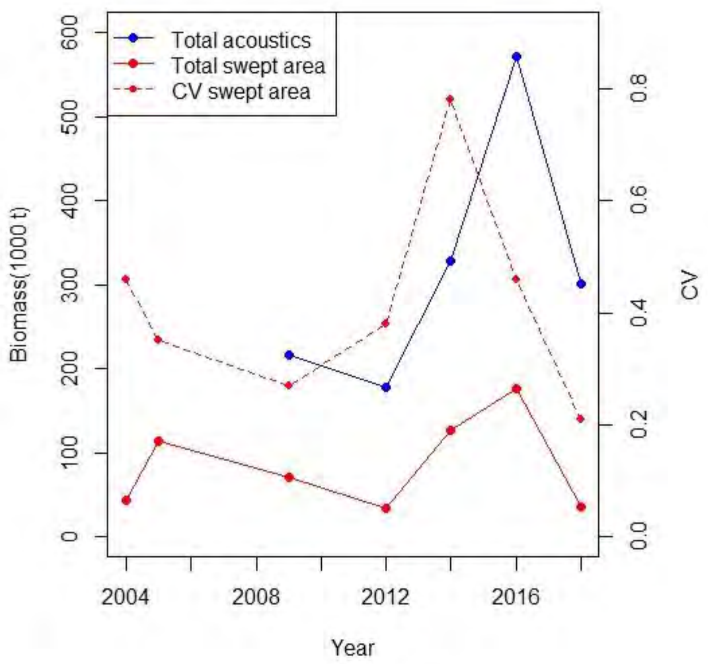


Figure 6.2.11. Estimated biomass for greater silver smelt for acoustic surveys in March–April 2009, 2012, 2014, 2016 and 2018 (for method see Harbitz, 2010), and bottom trawl swept area estimates from the same surveys and 2004 and 2005 in addition. Also shown is CV for the trawl estimates.

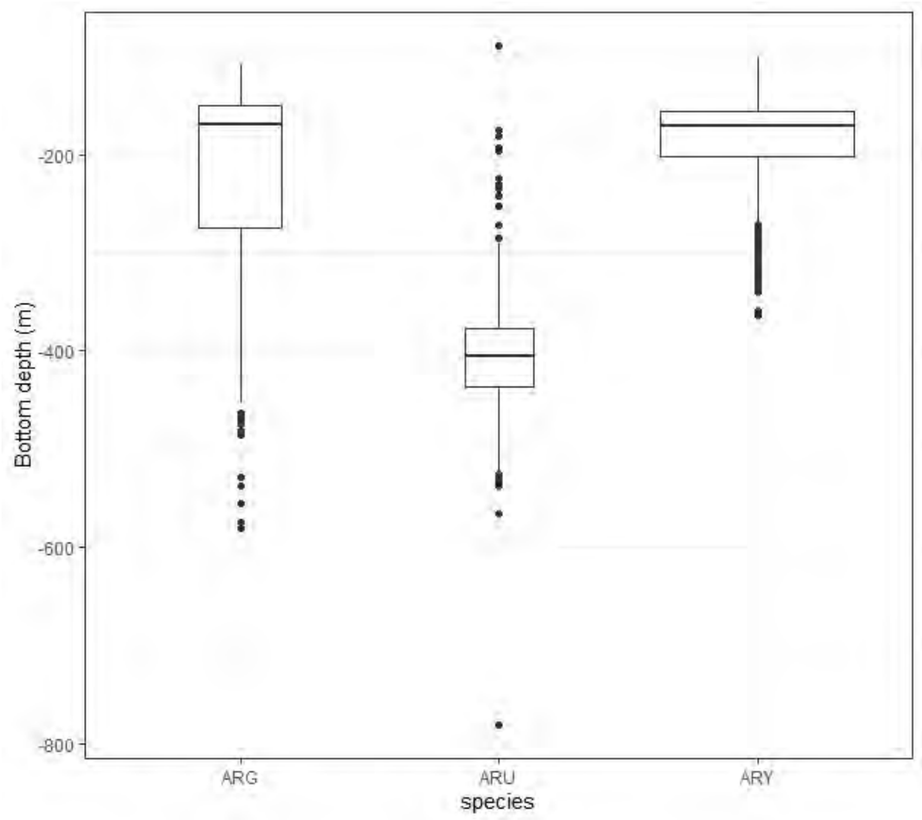


Figure 6.2.12. Boxplot showing depth where catches were registered in 2019 according to logbooks as respectively ARG (mixed greater silver smelt and lesser silver smelt), ARU (greater silver smelt) and ARY (lesser silver smelt).

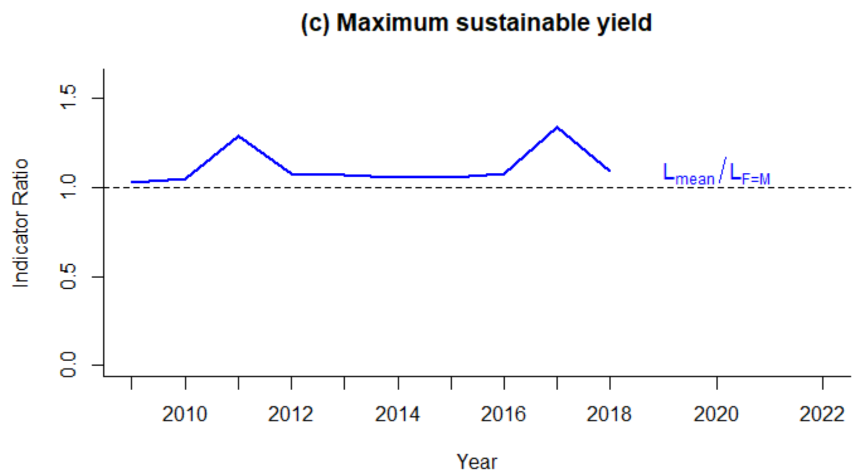


Figure 6.2.13. Greater silver smelt in subareas 1,2 and 4, and in division 3a. Index ratio Lmean/LF=M from the length-based indicator method used for the evaluation of the exploitation status in subarea 1 and 2. The exploitation status is below FMSY$_{proxy}$ when the index ratio value is higher than 1.

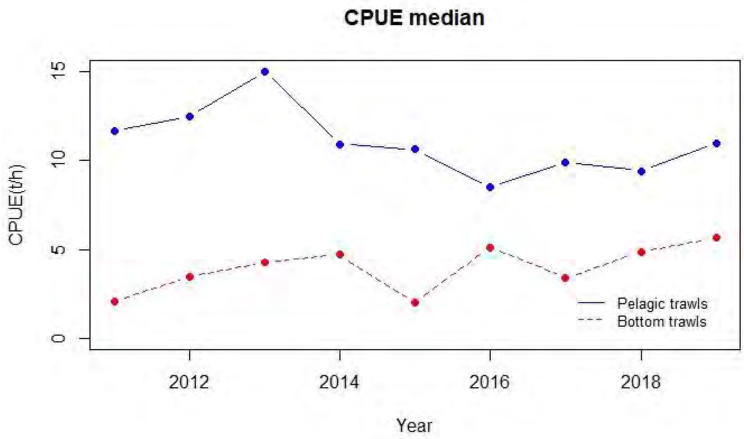


Figure 6.2.14. CPUE from the Norwegian direct fisheries on greater silver smelt in area 2a, based on electronic logbooks 2011-2019.

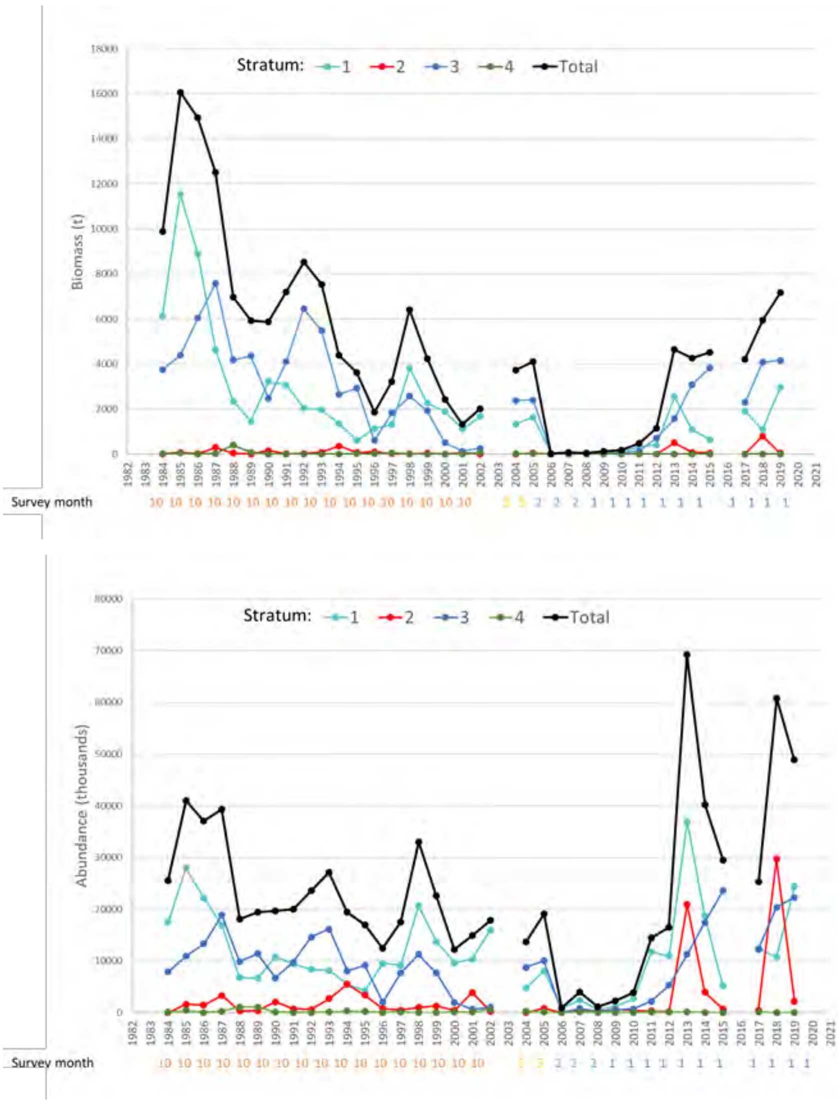


Figure 6.2.15. Swept area biomass index (upper panel) and swept area abundance index (lower panel) for greater silver smelt in the shrimp survey in North Sea/Skagerrak. Total and by stratum.

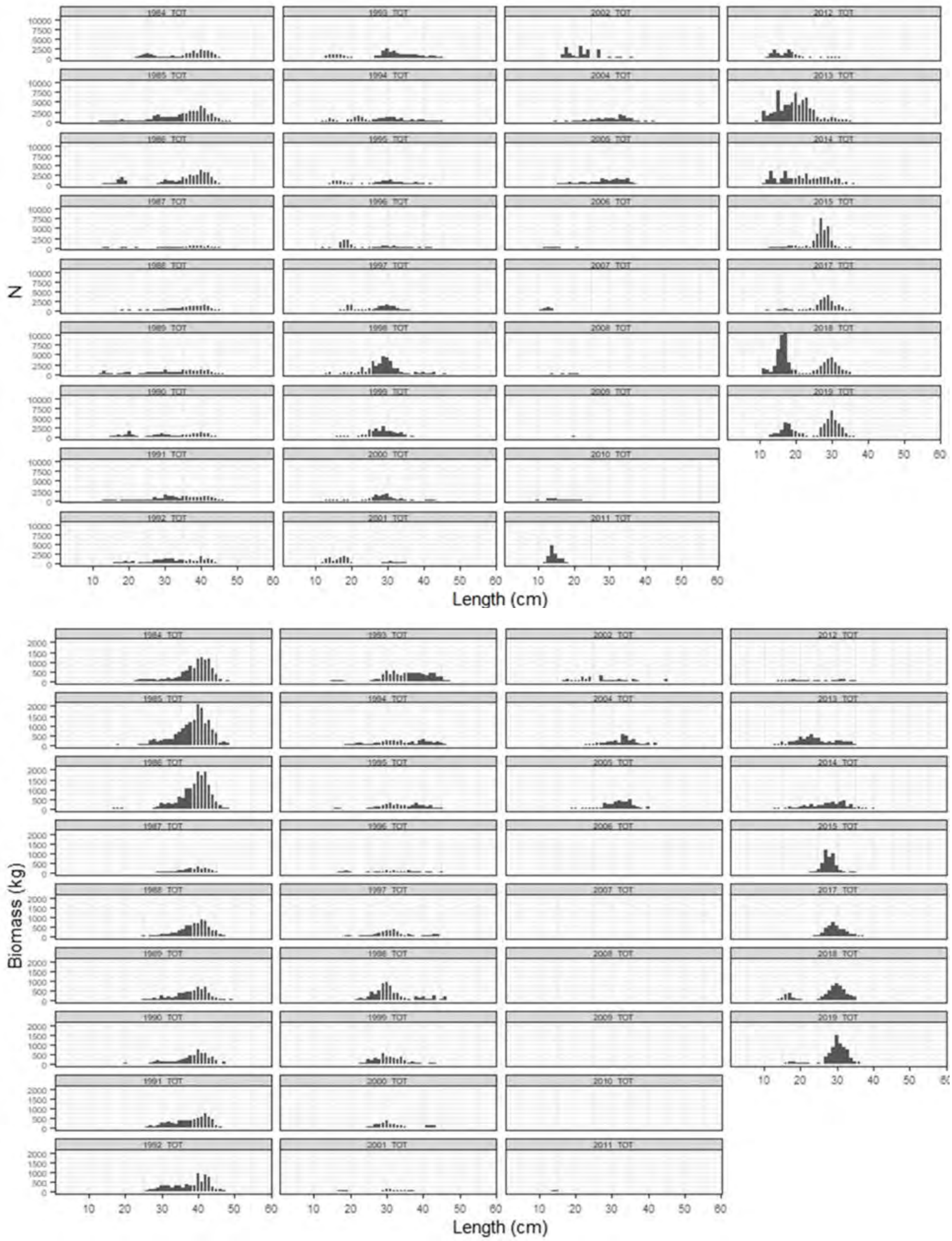


Figure 6.2.16. Length distributions in numbers (upper panels) and biomass (lower panels) for greater silver smelt in the North Sea/Skagerrak survey.

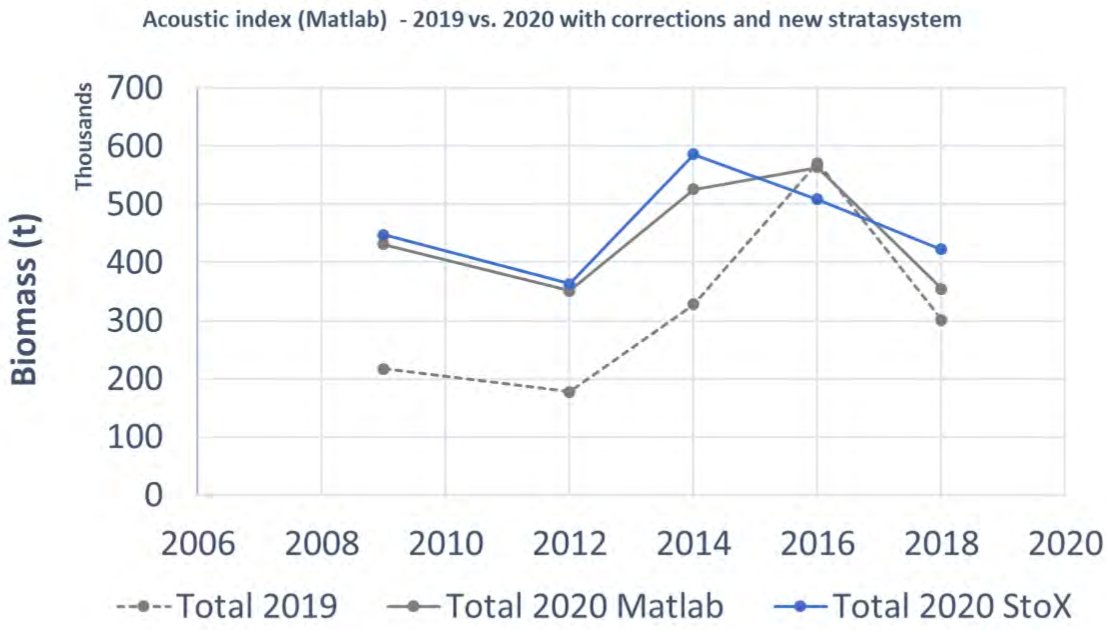


Figure 6.2.17. Acoustic biomass index from the Norwegian Sea south-east slope survey from 2009-2018. Stippled grey lines: 2019 estimates based on the Matlab approach. Solid grey lines: 2020 re-estimations based on the Matlab approach. Solid blue line: 2020 estimates based on the StoX approach.

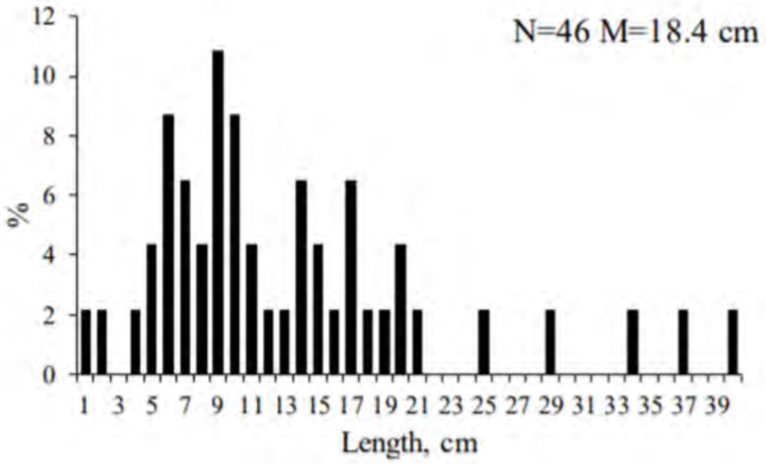


Figure 6.2.18. Russian length compositions of greater silver smelt in the Barents Sea (I) in 2019.

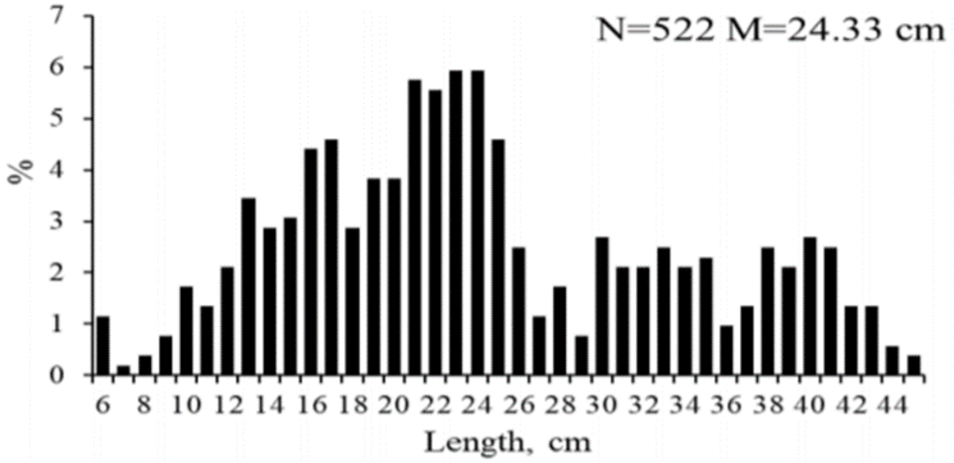


Figure 6.2.19. Russian length compositions of greater silver smelt in the Norwegian Sea (2.a+2.b) in 2019.

6.3 Greater silver smelt (*Argentinus 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 6.1.1). 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 6.1.1).

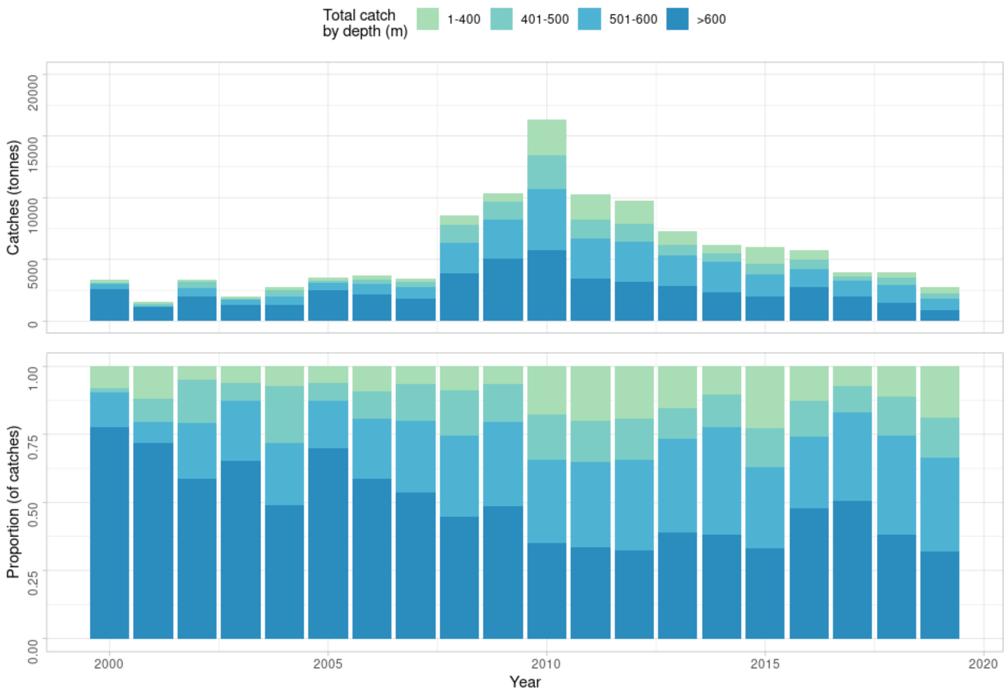


Figure 6.1.1: Greater silver smelt in 5.a and 14. Depth distribution of catches in 5.a according to logbooks. All gears combined.

Table. 6.1.1. Greater silver smelt in 5.a and 14. Landings records from the Icelandic directorate of Fisheries and Greenland (WD05, annexed to this report).

Year	Inside the NEAFC RA	Outside the NEAFC RA		Catches
		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		Catches
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

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 6.1.2). 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 6.1.2).

Table 6.1.2: 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	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	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	19	487	1309724	77	0.4074652

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 in 1996– 2019 is presented in Figure 6.1.2 and Figure 6.1.3. With the exception of 1996, most of the catches have been from the southern edge of the Icelandic shelf. However, in recent years 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 6.1.2 and Figure 6.1.3).

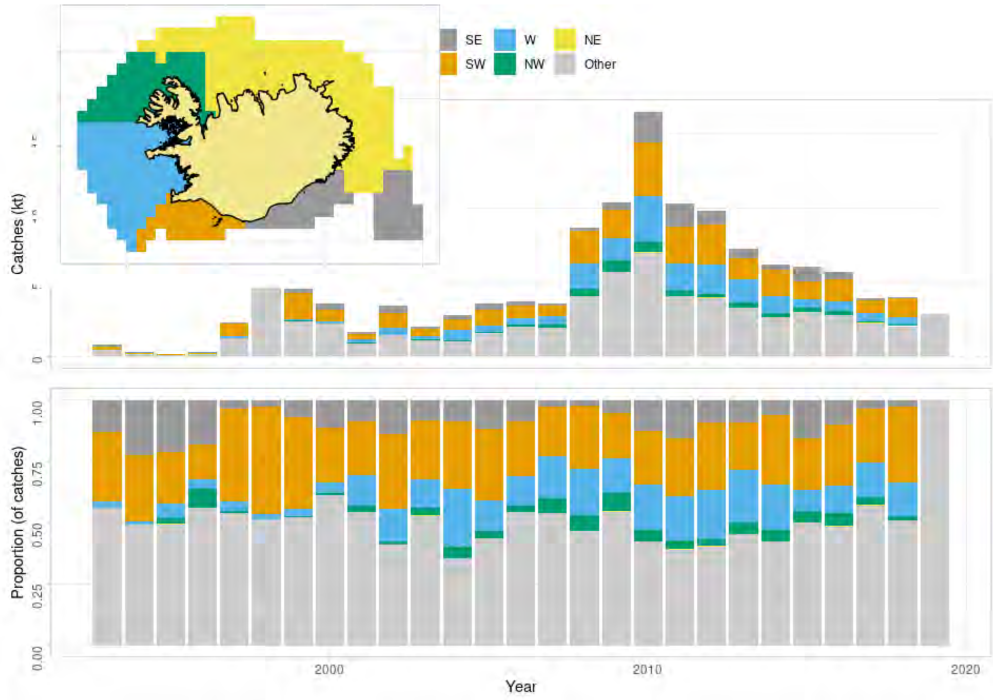


Figure 6.1.2: Greater silver smelt in 5.a and 14. Spatial distribution of catches defined by regions deeper than 400 m by year (See stock annex for details). Above are the catches on absolute scale and below in proportions. All gears combined.

Figure 6.1.3: 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 6.1.1 and Figure 6.1.4. 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 2019 amounted to approximately 3210 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.

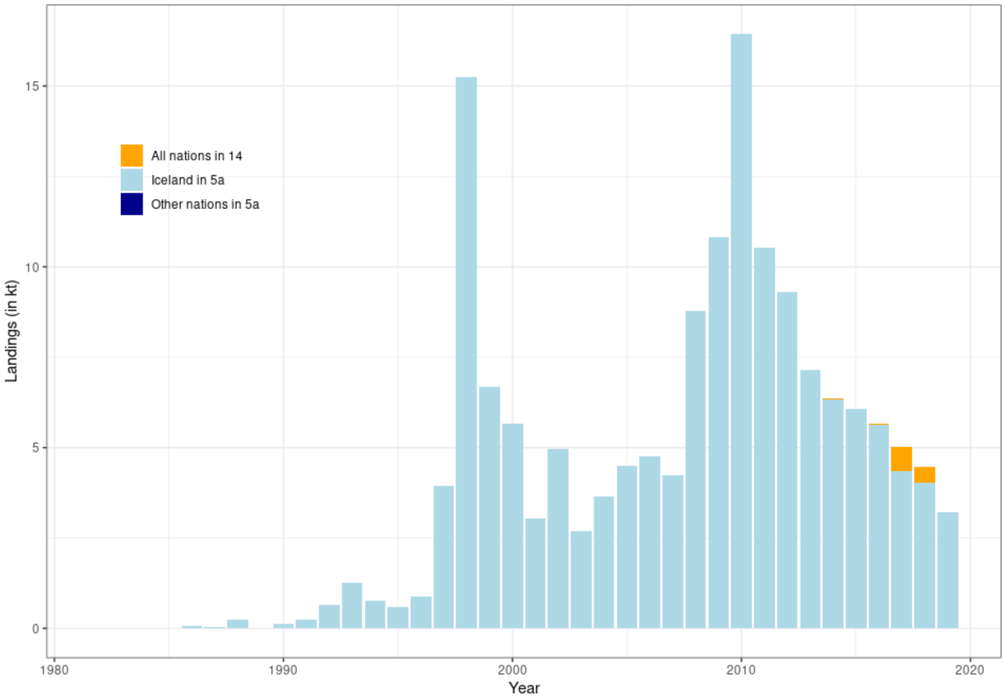


Figure 6.1.4: Greater silver smelt in 5.a and 14. Nominal landings. 23 tonnes were landed by foreign vessels (England and Wales) in 1999, which is the only year of catches reported by foreign vessels.

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 6.1.3). The sampling does seem to cover the spatial and temporal distribution of catches. The sampling coverage by gear in 2019 is shown in Figure 6.1.5. However, recent years have experienced a large decline in sampling. No age data were collected in 2019.

Table 6.1.3: 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	
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			

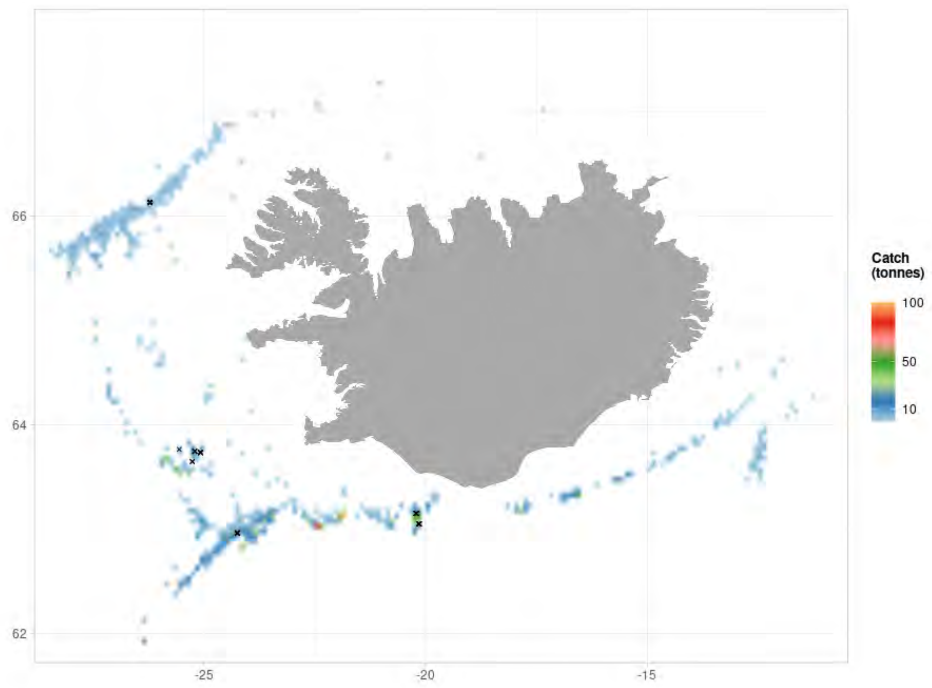


Figure 6.1.5: Greater silver smelt in 5.a and 14. Fishing grounds in 2019 as catches reported in logbooks (tiles) and positions of samples taken from landings (asterisks) by main gear types.

6.3.5.1 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.

6.3.5.2 Length compositions

(Table 6.1.2) 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 6.1.6 and Figure 6.1.7 respectively.

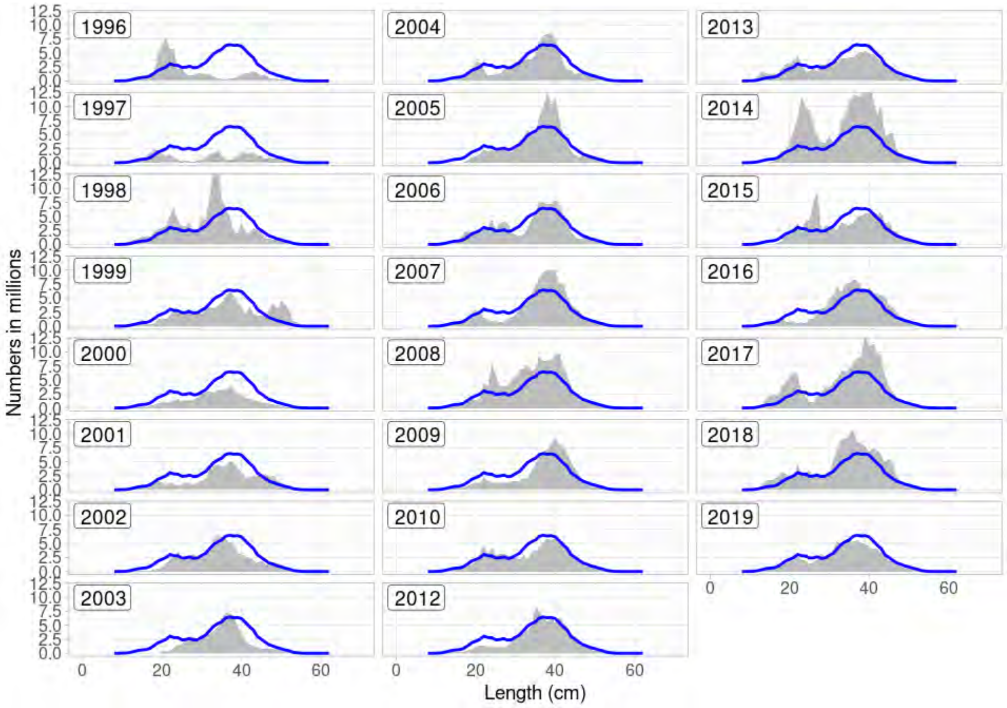


Figure 6.1.6: Greater silver smelt in 5.a and 14. Length disaggregated abundance indices from the autumn survey. The blue line shows the mean for all years.

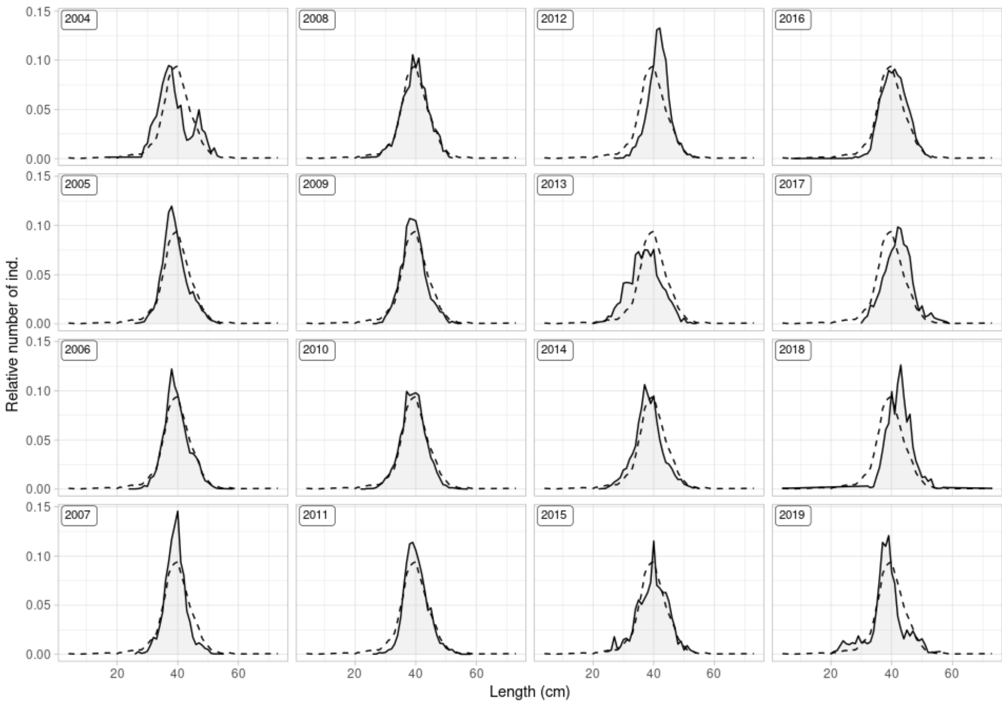


Figure 6.1.7: Greater silver smelt in 5.a and 14. Length distributions from commercial catches.

6.3.5.3 Age compositions

(Table 6.1.2) gives the number of samples and measurements available for calculations of catch in numbers of greater silver smelt in 5.a. Age distributions estimated from as catch in numbers are given in Figure 6.1.8.

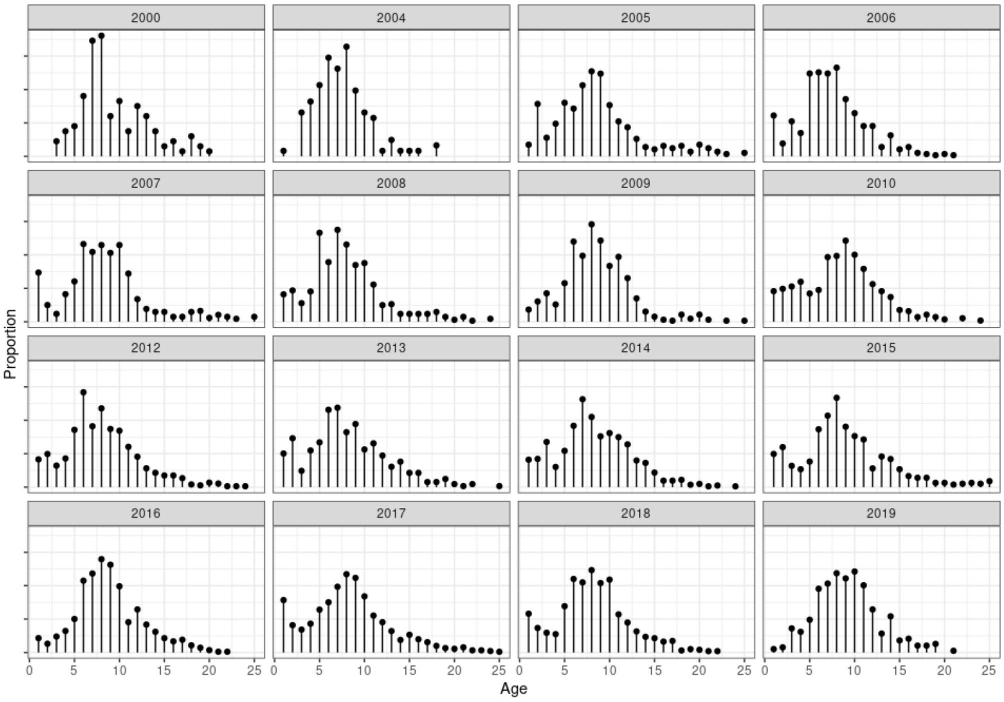


Figure 6.1.8: Greater silver smelt in 5.a and 14. Age distributions in proportions in 5.a from the Icelandic autumn survey.

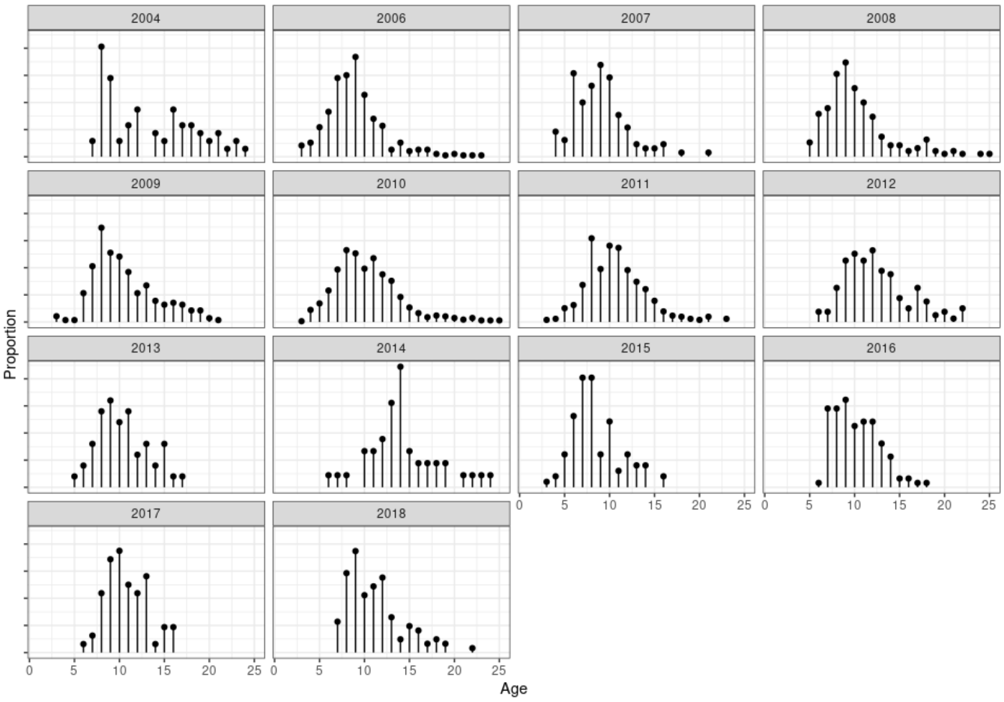


Figure 6.1.9: Greater silver smelt in 5.a and 14. Catch in numbers at age. Estimates for 2002 are based on limited number of aged otoliths. No age data are available for 2019.

6.3.5.4 Weight at age

No marked changes can be observed in mean weight-at-age from commercial catches between 1997–1998 and 2006–2013.

6.3.5.5 Maturity at age and natural mortality

Estimates of maturity ogives of greater silver smelt in 5.a were presented at the WKDEEP 2010 meeting for both age and length (WKDEEP 2010, GSS-04) 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.

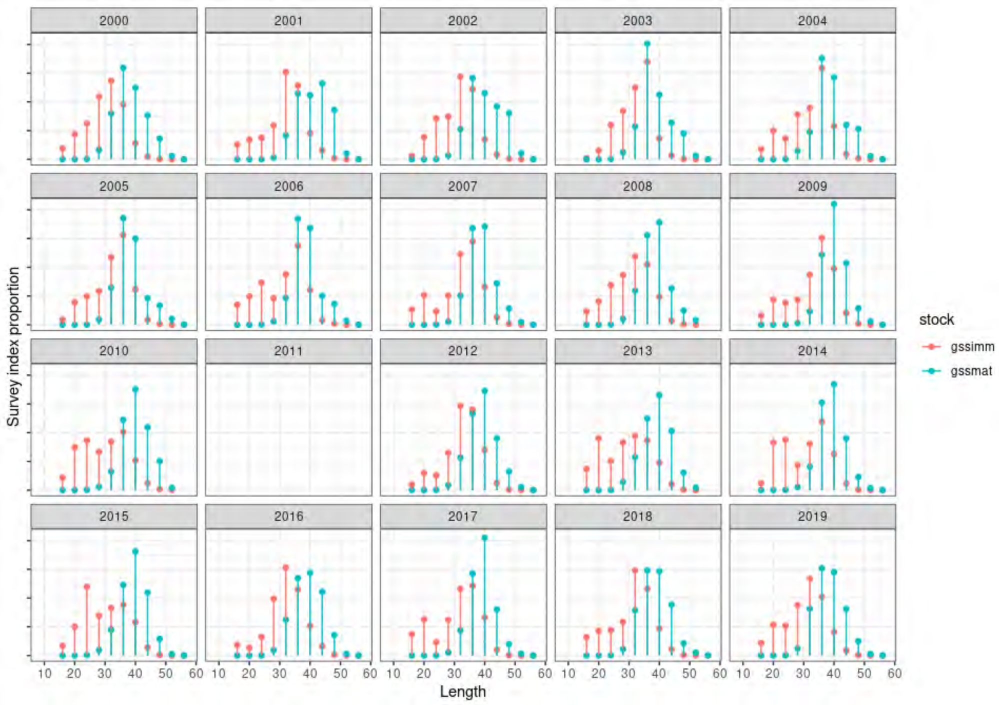


Figure 6.1.10: Greater silver smelt in 5.a and 14. Length distributions from the autumn survey since 2000. Red areas are immature greater silver smelt and green represent mature greater silver smelt.

6.3.5.6 Catch, effort and research vessel data

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.

6.3.5.7 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 6.1.11 gives trends in biomass density and juvenile density (numbers) for the spring survey in 1985 to 2020 and for the autumn survey in 2000 to 2019. 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 due to the fact that 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. Therefore, a special stratification scheme was developed and the autumn survey index is winsorized when used in the previous advisory procedure (See stock annex for details). A comparison of indices, with or without winsorization are shown in Figure 6.1.12. No substantial changes in spatial distribution are seen in general Figure 6.1.13.

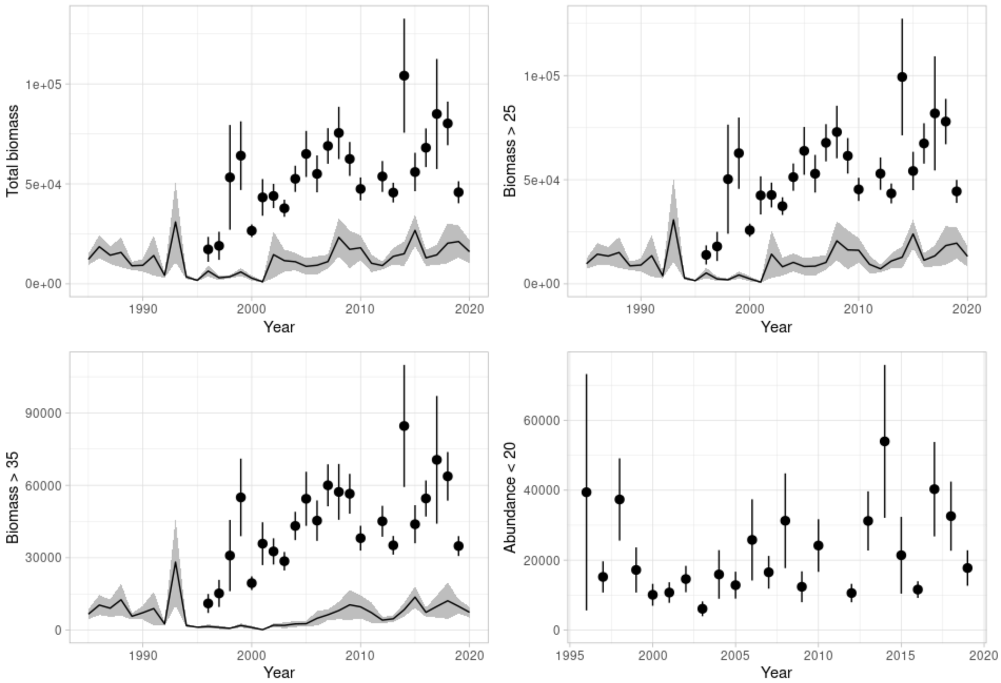


Figure 6.1.11. Greater silver smelt in 5.a and 14. Indices calculated from the Icelandic spring survey (black lines and shaded area) and from the autumn survey (dots and vertical lines). Vertical lines and shaded area represent +/- 1 standard error.

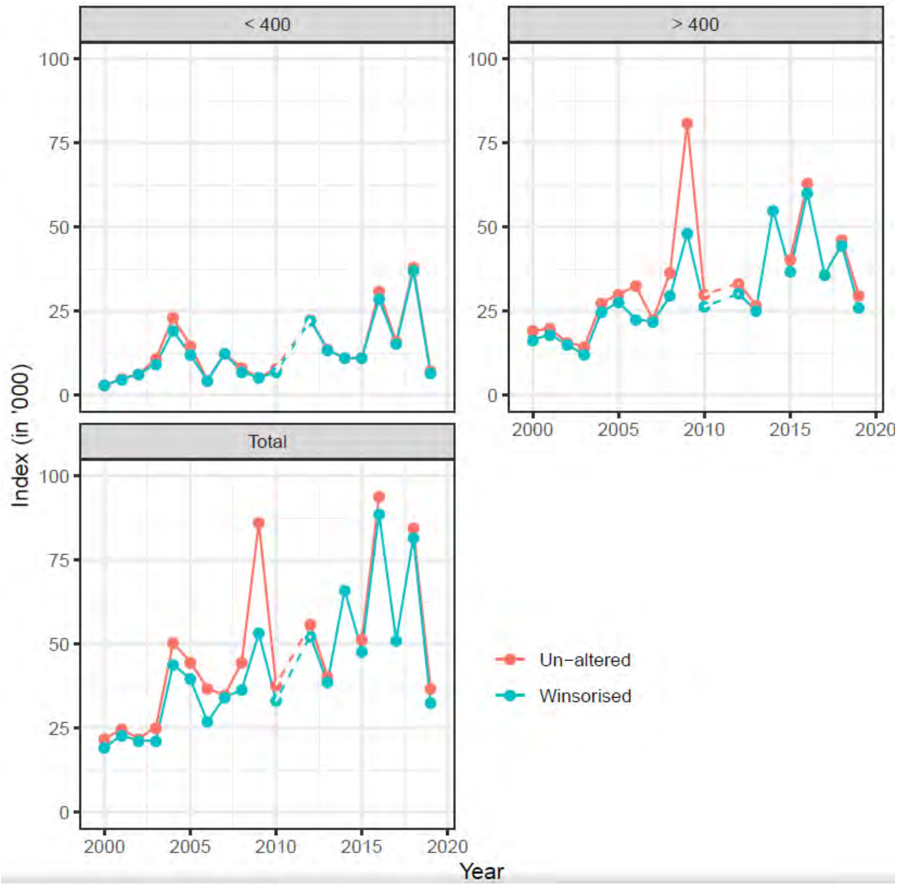


Figure 6.1.12. Greater silver smelt in 5.a and 14. Winsorized indices of Icelandic autumn surveys used in previous assessments for category 3.3 assessments.

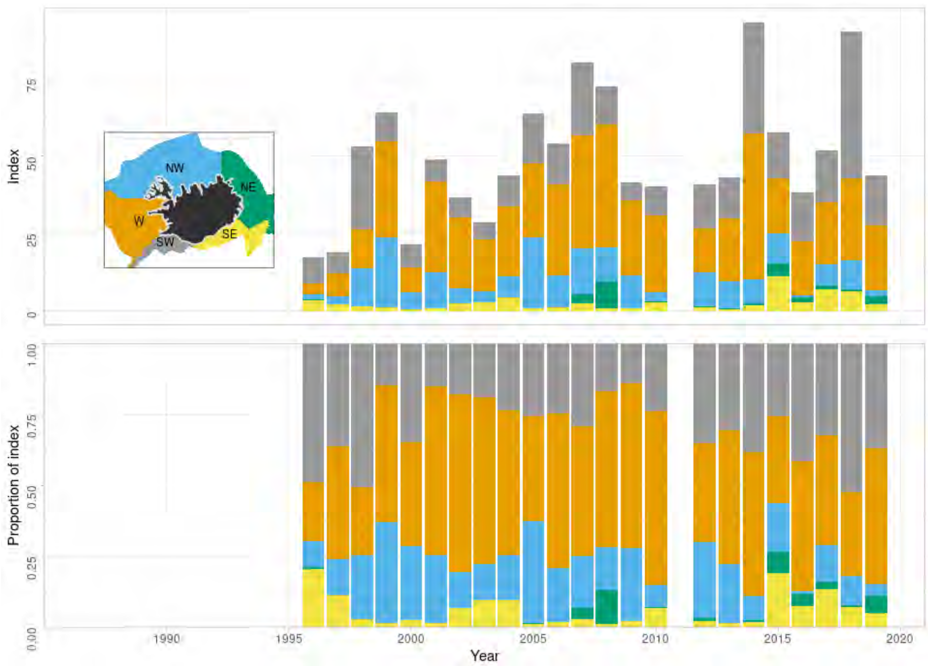


Figure 6.1.13: Greater silver smelt in 5.a and 14. Estimated survey biomass in the autumn survey by year from different parts of the continental shelf (upper panel) and as a proportion of the total (lower panel)

6.3.6 Data analyses

6.3.6.1 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 6.1.2 and Figure 6.1.3). 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 6.1.4 and Table 6.1.1). 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 6.1.6 and Figure 6.1.7). 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 6.1.8 and Figure 6.1.9). 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.

6.3.6.2 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 6.1.11).

The observed trends in the biomass indices from the autumn survey have a considerably different trend than those observed in the spring survey (Figure 6.1.11). 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. As noted in the section above, the Winsorized index appears to be less sensitive to the few large hauls in the 2009 and 2014 survey years (Figure 6.1.12).

6.3.6.3 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 (ICES 2016).

6.3.6.4 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 2016).

6.3.6.5 Diagnostics

6.3.6.5.1.1 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 6.1.14, Figure 6.1.15 Figure 6.1.16, Figure 6.1.17). This peak does not shift from year to year and therefore is considered due to 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.

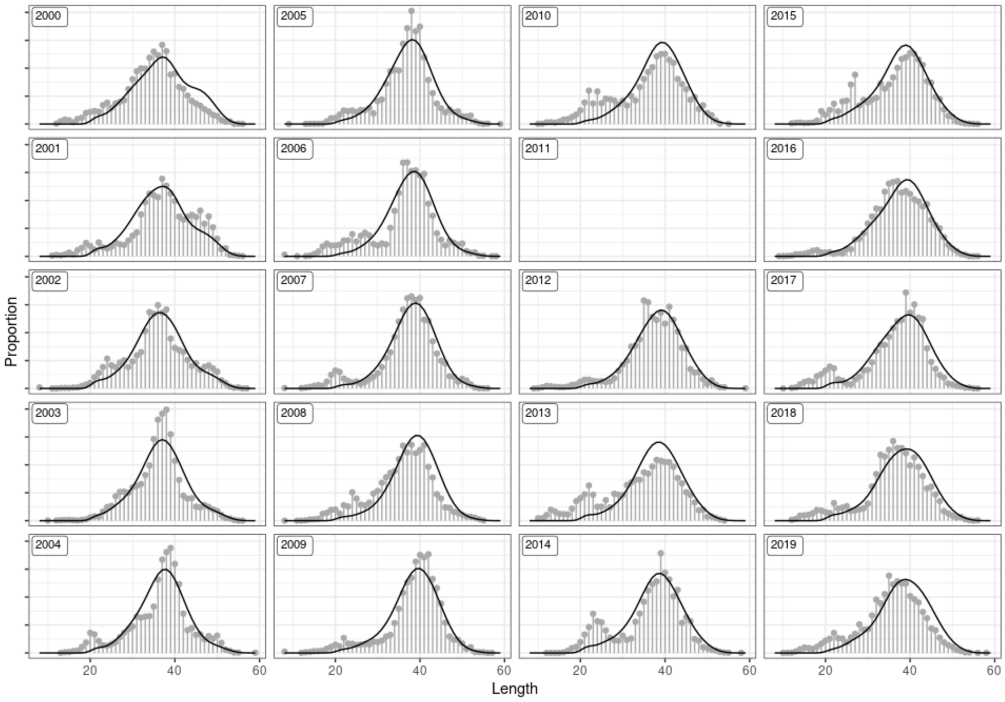


Figure 6.1.14: Greater silver smelt in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the autumn survey (green lines and points)

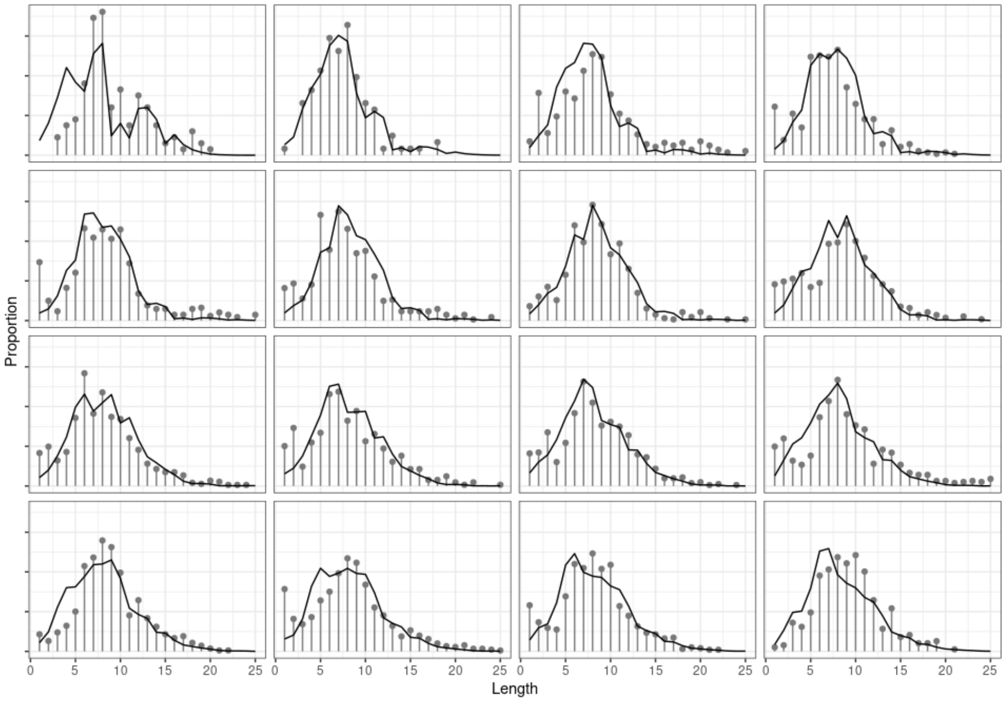


Figure 6.1.15: Greater silver smelt in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the autumn survey catches (grey lines and points).

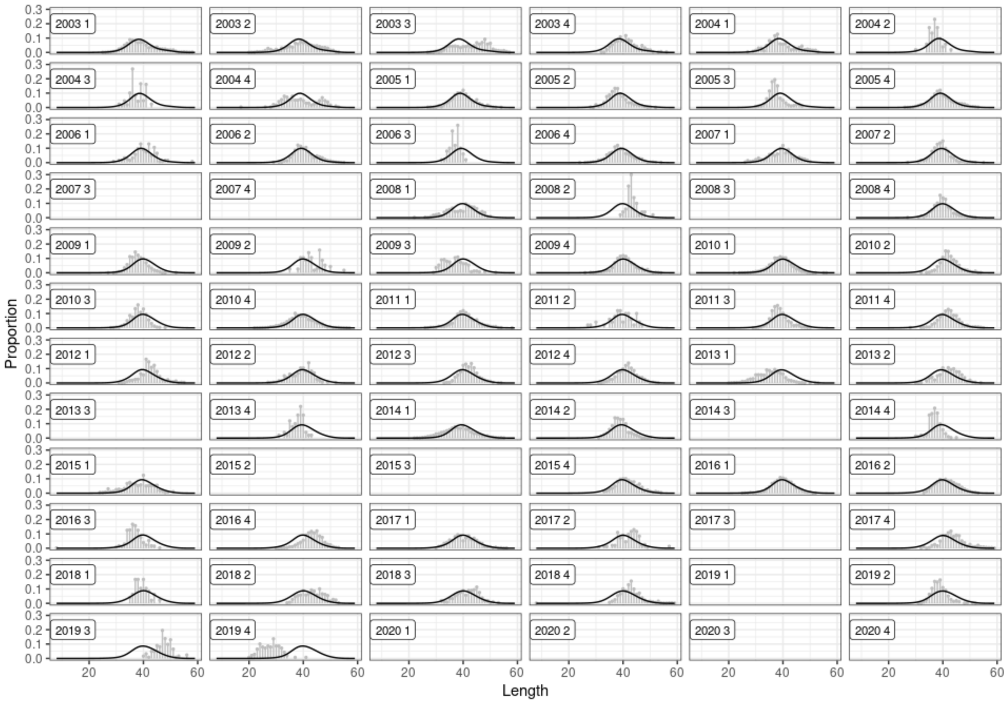


Figure 6.1.16: Greater silver smelt in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from commercial catches (grey lines and points).

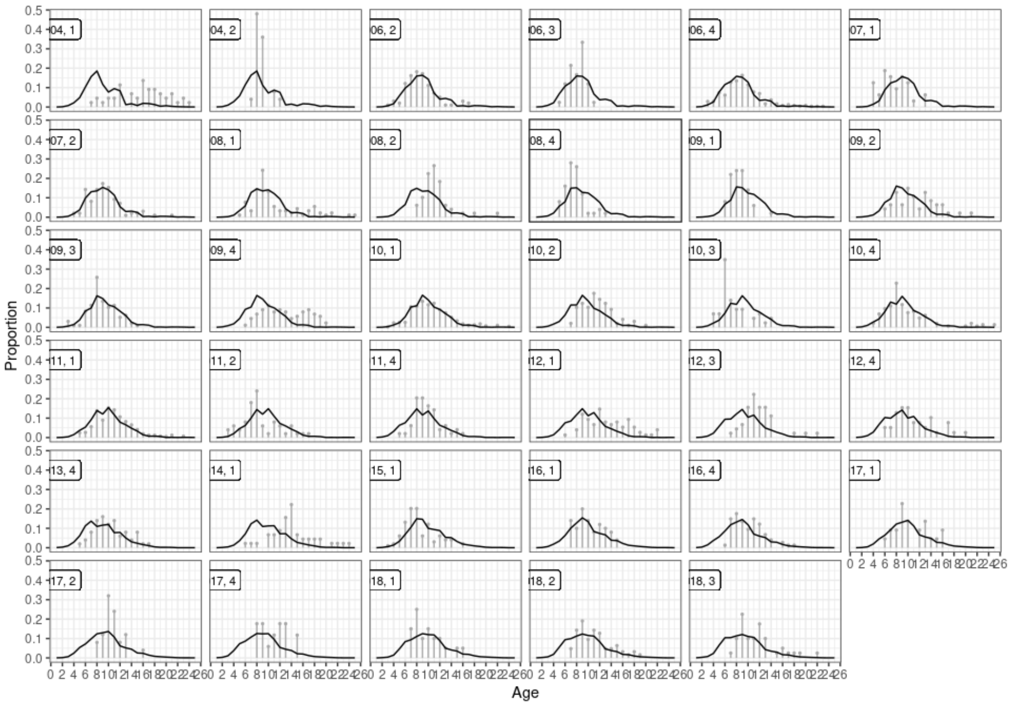


Figure 6.1.17: Greater silver smelt in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in commercial catches (grey lines and points).

6.3.6.5.1.2 Model fit

Figure 6.1.16 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 survey indices for the smallest tow size classes (10–25 and 25–30 cm) due to generally low selectivity the peak on small-sized fish that likely results from aggregation rather than cohort dynamics (see previous section). The terminal estimate has a large overestimation due to very low survey indices this year, indicating the potential for overestimation of biomass this year and downward revisions in coming years, if this trend continues.

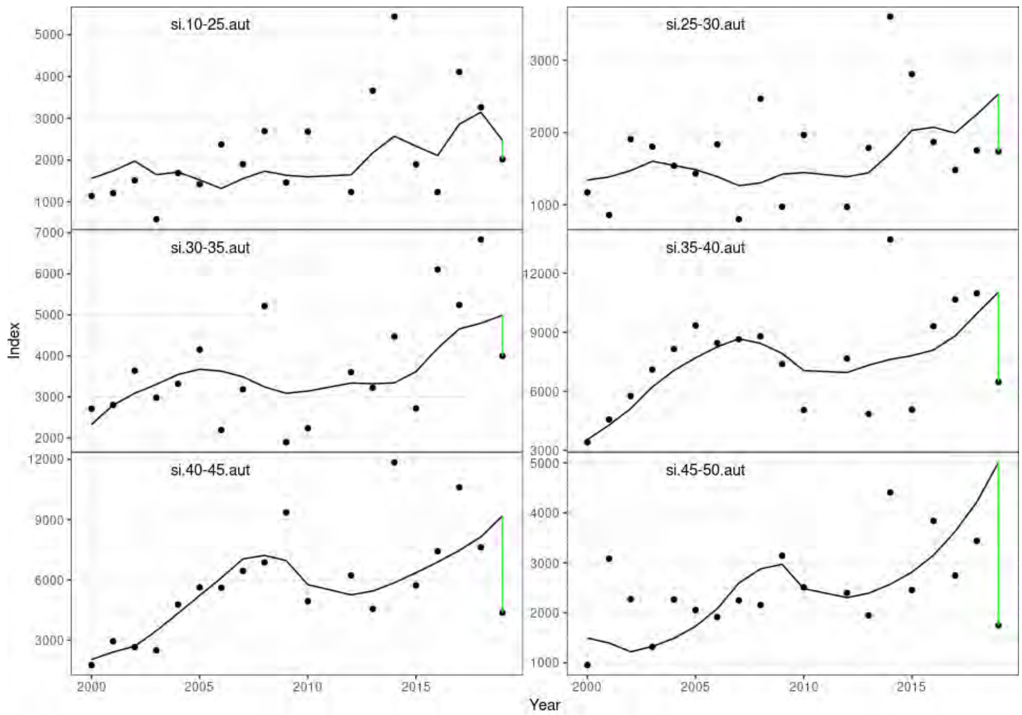


Figure 6.1.18: Greater silver smelt in 5.a. Fitted autumn survey index by length group from the Gadget model (black line) and the observed number of greater silver smelt caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

6.3.6.6 Results

The results are presented in Table 6.1.4 and Figure 6.1.19. 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 the time-series in the terminal year. Fishing mortality for greater silver smelt (age 6–14) has decreased from 0.3 in 2010 to 0.05 over the past several years, due to greater regulation of the fishery as well as reduced commercial interest.

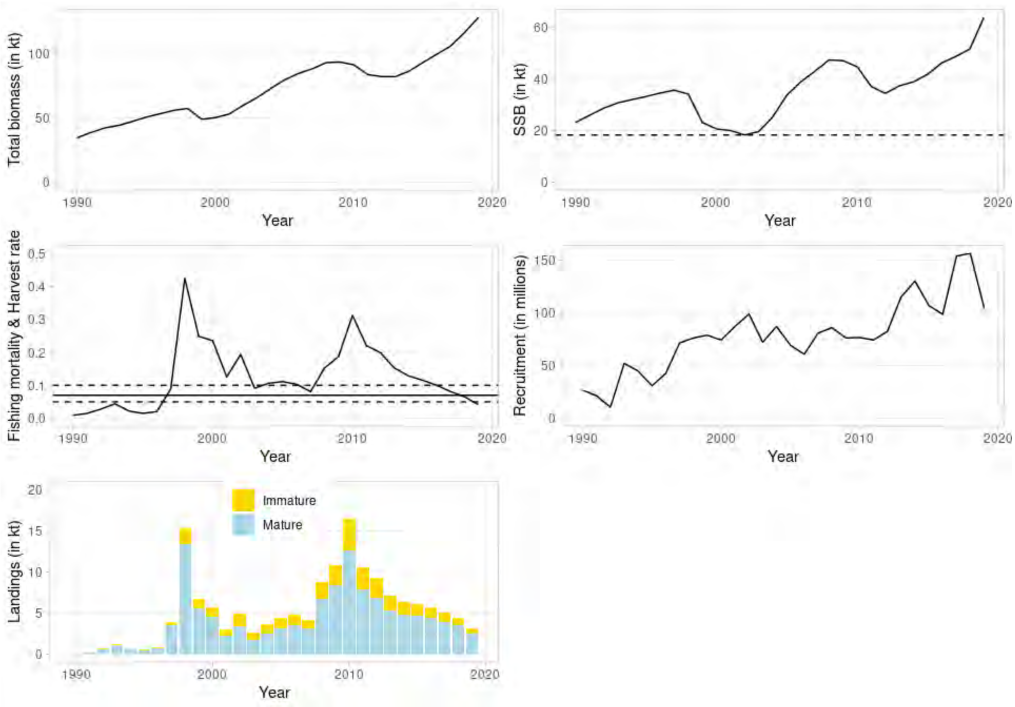


Figure 6.1.19: Greater silver smelt in 5.a and 14. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes and harvest rate, recruitment and total catches. The dashed line in the SSB plot represents Bpa. The solid line in the fishing mortality plot indicates the fishing 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 6.1.4: 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
1990	34469	113	23134	26613	0.009
1991	38514	246	25934	21417	0.015
1992	42100	657	28678	10525	0.028
1993	44034	1254	30753	52063	0.044
1994	47163	756	31970	44792	0.022
1995	50477	586	33158	30781	0.015
1996	53033	881	34489	42667	0.020
1997	55735	3935	35620	71436	0.089
1998	57202	15242	34100	76240	0.425
1999	48793	6681	23138	78770	0.249
2000	50091	5657	20618	74119	0.235
2001	52880	3043	20024	87090	0.125
2002	59575	4961	18300	98811	0.194
2003	65557	2680	19617	72166	0.091

Year	Total Biomass	Catch	SSB	Rec.	F
2004	72644	3645	25325	87053	0.106
2005	79385	4482	33667	69299	0.111
2006	84260	4769	38867	60704	0.103
2007	87891	4227	42971	80769	0.081
2008	92695	8778	47299	85945	0.153
2009	93107	10828	47006	76198	0.187
2010	90958	16428	44661	76598	0.312
2011	83416	10516	37060	74266	0.220
2012	81806	9289	34368	82276	0.199
2013	81789	7155	37305	115138	0.153
2014	86143	6348	38863	130104	0.129
2015	92865	6070	41734	106951	0.116
2016	99197	5662	46151	98526	0.101
2017	105640	5011	48601	153784	0.081
2018	115989	4460	51516	156267	0.066
2019	127640	3208	63729	104364	0.042

6.3.6.7 Retrospective analysis

An analytical retrospective analysis are presented. The analysis indicates that there was an upward revision of biomass over the first 3 years of the 5-year peel followed by a downward revision of biomass (SSB) over the last 2 years, and subsequently an 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.

Mohn's rho was estimated to be 0.097 for SSB, -0.083 for F, and -0.667 for recruitment.

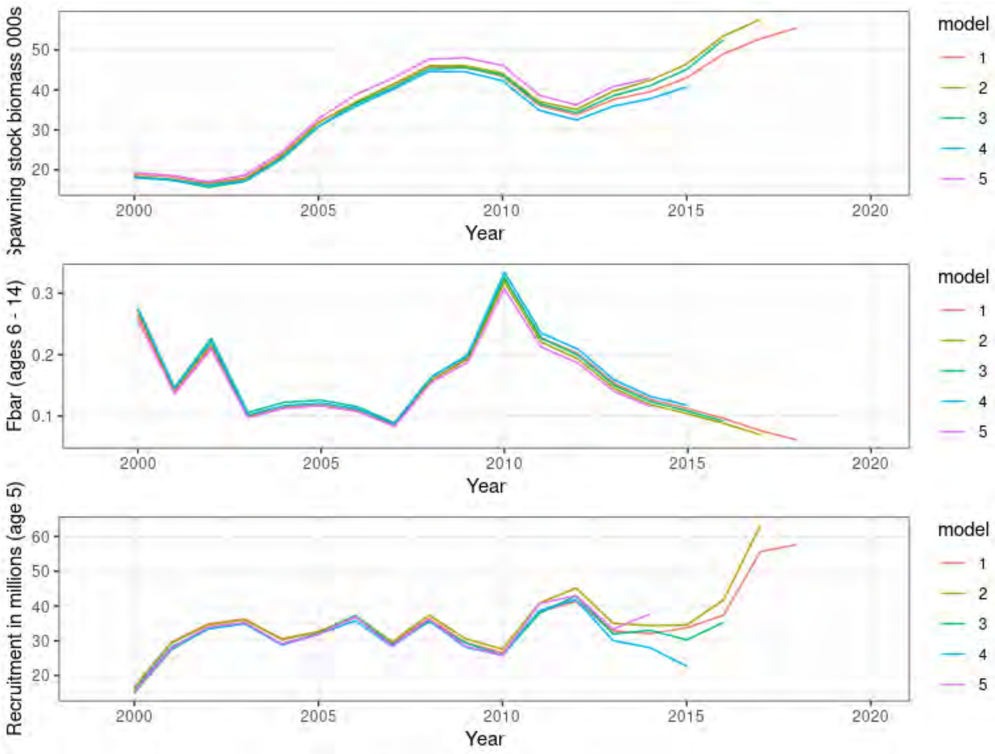


Figure 6.1.20: Greater silver smelt in 5.a and 14. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 5) are shown.

6.3.7 ICES advice

No advice from ICES is requested by Iceland in 2020 due to the Covid 19 disruption.

The ICES advice for 2019/20 is: Based on the ICES approach for data-limited stocks, ICES advises that catches should be no more than 2019 amounted to approximately tonnes. The basis for the advice was the following: For data-limited stocks with reliable abundance information from fisheries-independent data and a target F_{proxy}, where abundance is considered above MSY Btrigger, ICES uses a harvest control rule that calculates catches based on the F_{proxy} target multiplied by the most recent survey biomass estimates.

In past years, an F_{proxy} of 0.171 was applied (with no uncertainty cap) as a factor to the 2019 survey index biomass estimate of 55 693, resulting in catch advice of no more than 9 124 t. In 2020 this stock was benchmarked (WKGSS 2020) and a length- and age-based assessment was accepted as a category 1 assessment method.

6.3.8 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, and 7 603 t for 2018/2019 (Table 6.1.5).

Table 6.1.5: 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		

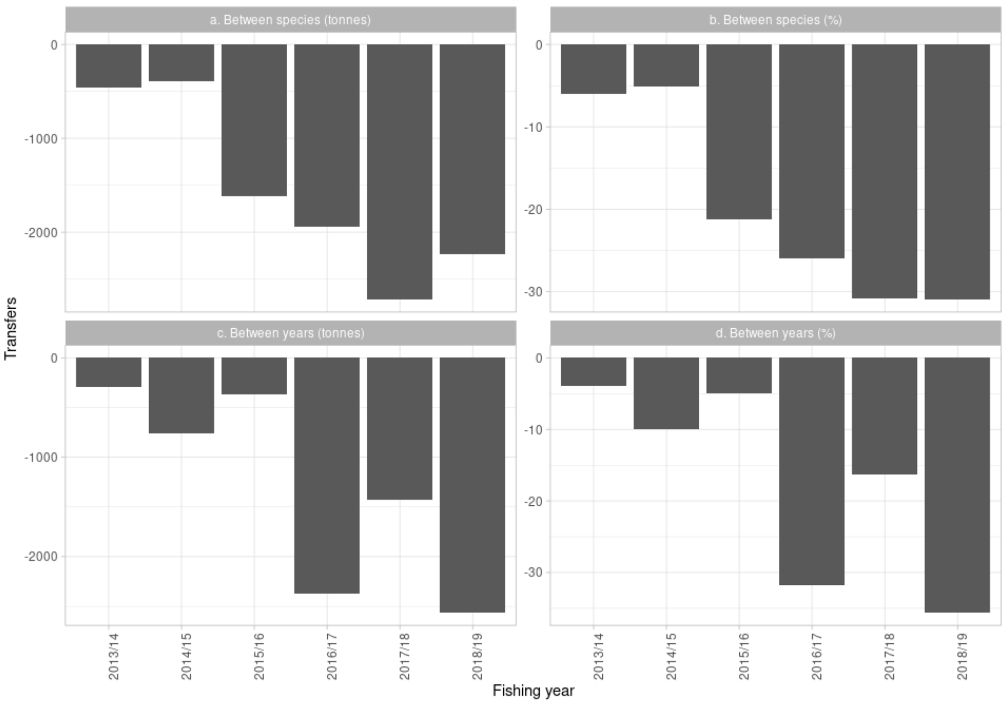


Figure 6.1.21: Greater silver smelt in 5.a and 14. An overview of the net transfers of quota between years and species transformations in the fishery in 5.a.

6.3.9 Current advisory framework

The current advisory framework is currently under consideration as part of the WKGSS 2020 benchmark proceedings (WKGSS 2020, pending). Pending results of this benchmark, 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 6.1.22: Greater silver smelt in 5.a and 14. Reference points

The ICES MSY advice rule is applied for this stock. 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 $SSB_y > B_{trigger}$, scaled by $\frac{SSB_y}{B_{trigger}}$ while while $B_{lim} \leq SSB_y < B_{trigger}$, and set to 0 while $SSB_y \leq B_{lim}$.

6.3.10 Management considerations

Exploitation of greater silver smelt has been reduced in recent years, coming down from a relatively high levels in 1998 and 2010, to levels lower than the average exploitation rate in the reference period.

6.3.10.1 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.

6.3.11 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.

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 2019, 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 (65%) and the remainder mainly by Faroese trawlers (35%, 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 did not develop until the mid-1990s and the early 2000s for Division 6.a.

In Faroese waters, the greater silver smelt fishing grounds, from the mid-1990s to 2007, were located north and west on the Faroe Plateau and around Faroe Bank/Lousy Bank 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 islands (Figure 6.4.2). 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 updated in 2019 (Pastoors, WD 2019). The self-sampling program consists of historical information derived from skipper's notes (2002-2019) and new information collected as part of the research program within the PFA. An overview of catch rates of silver smelt (both *Argentina silus* and *Argentina Sphyraena*) from both the Faroese and European fisheries is shown in Figure 6.4.3.

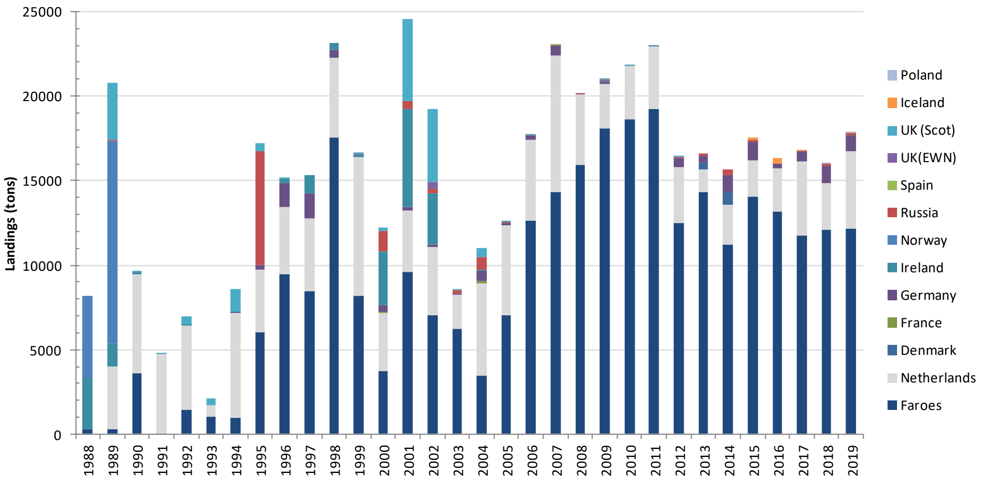


Figure 6.4.1. Greater silver smelt in 5.b and 6.a. Total landings of greater silver smelt in 5.b and 6.a by countries.

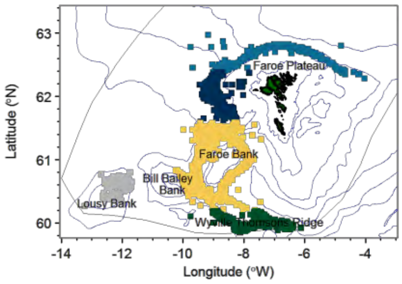


Figure7.4.2. Greater silver smelt in 5.b. Spatial distribution of the Faroese directed trawl fishery of greater silver smelt

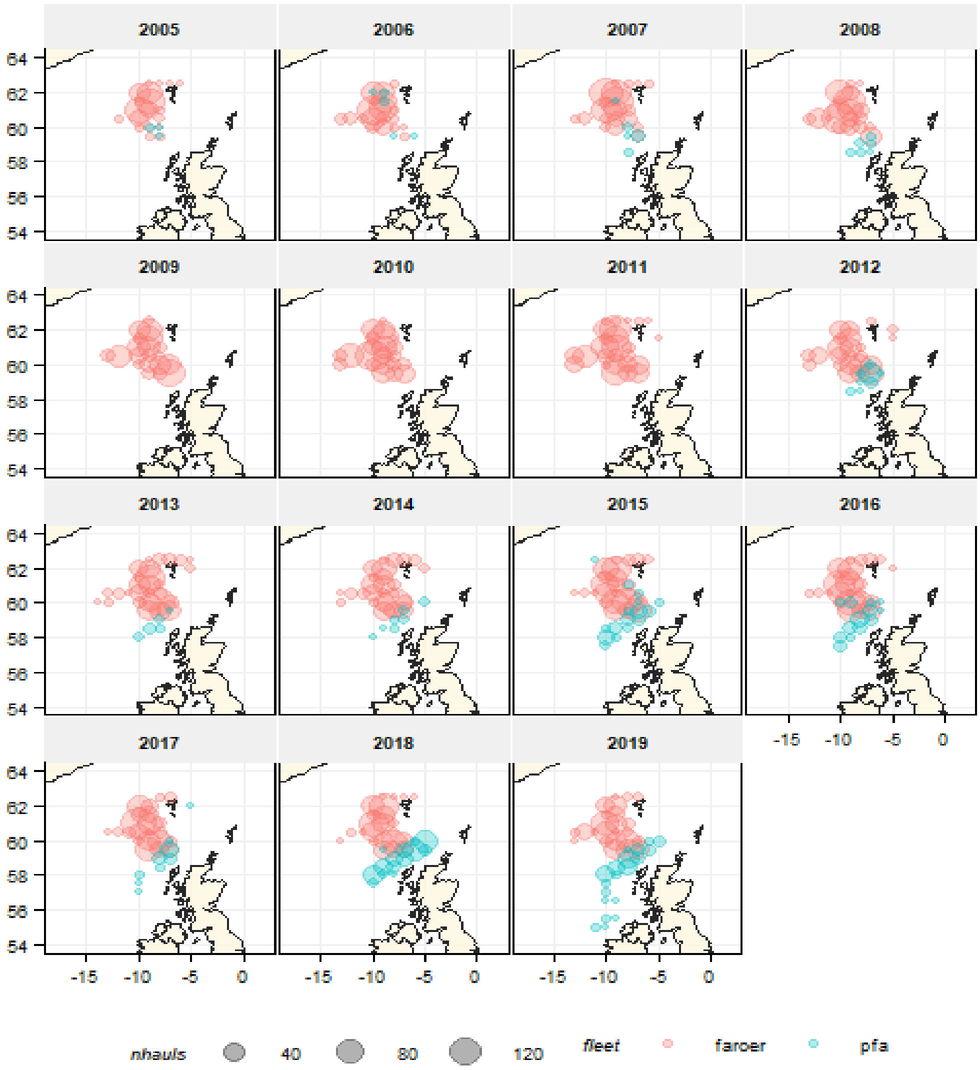


Figure 6.4.3. Greater silver smelt in 5.b and 6.a. Number of hauls of commercial fisheries available for standardized CPUE calculation in areas 5b and 6a (WKGSS, WD03).

Landing trends

Landings in Division 5.b increased rapidly from 2004 (5300 tonnes) to 2006 (12 500 tonnes) and further increased with landings in 2011 being 15 600 tonnes (Table 6.4.2). Since then landings have been around 10 000–13 000 tonnes, in 2019 the preliminary catch was 9319 tonnes in 5.b. 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 boats were targeting mackerel rather than greater silver smelt, and a shift in fishing more in the Wyville-Thomson area inside the Faroese EEZ that is partly in Division 6.a.

In Division 6.a landings have increased, reaching a maximum of 14 466 tonnes in 2001 and then decreased. Since 2004 landings varied between 5000 and 7500 tonnes. Preliminary landings in 2019 were 8538 tonnes.

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. The advice was based on a category 3 approach (ICES, 2012) where the Faroese summer groundfish survey was used as the index for the stock development. The next advice year for greater silver smelt is 2021. During the benchmark of this stock that was carried out in february 2020 (WKGSS 2020), an age based assessment approach was selected. The advice in 2021 will likley be based on a category 1 approach. Discarding is known to take place, but ICES cannot quantify the corresponding catches.

6.4.3 Management

The EU introduced TAC management for greater silver smelt in 2003 and sets a TAC 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 for the EU fishery in Subareas 5, 6 and 7 for the period 2014-2019 is presented in the table below.

In the period from 2010–2013, the Faroese greater silver smelt fishery was managed by an agreement between the Faroese fleet that were licensed to conduct direct greater silver smelt fishery and the Faroese authorities, guided by the stock assessment and scientific advice of Faroe Marine Research Institute. Under 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 for greater silver smelt applicable for Faroese trawlers fishing inside the Faroese EEZ. Six trawlers had licences to target greater silver smelt, the technical measures continued to apply and the TAC are presented in the table below. The reason for this reduction in TAC was the decrease in the biomass index as estimated by the exploratory assessment of greater silver smelt in Faroese waters.

The table below summarizes the ICES advice for greater silver smelt and the TACs that have been set by the Faroese authorities and the European Union. The summed TACs of the Faroe Islands and EU exceed the ICES advice for the years where advice has been provided for this stock unit.

	Area\Year	2014	2015	2016	2017	2018	2019	2020
ICES advice	5b, 6a	*	*	10030	10030	12036	12036	7703
TAC Faroe Islands	5b, 6a	16000	14400	13000	11500	11700	11700	11700
TAC EU	5,6,7 1)	4316	4316	4316	3884	4661	4661	3729
Summed TACs		20316	18716	17316	15384	16361	16361	15429

1) 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.

6.4.4 Data available

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 (Pastoors, WD 2019).

Biological data (mainly length and round weight), as well as catch and effort data were available for greater silver smelt from the two annual Faroese groundfish surveys on the Faroe Plateau. These surveys are especially designed for cod, haddock and saithe. In addition, a Faroese deep-water survey has been conducted since 2014 and this covers the greater silver smelt fishery areas in 5b.

A Scottish deepwater survey was in WKGSS February 2020 included in the SAM assessment as a biomass index, which covers the European fisheries in 6a (Campell 2020, WD01 WKGSS).

6.4.4.1 Landings and discards

Landings data are presented by area and countries (Tables 6.4.1 and 6.4.2, Figure 6.4.1). Landings were available for all relevant fleets.

Discarding is banned inside the Faroese EEZ and all catches are assumed to be landed. In the European Union, the landing obligation for pelagic fisheries entered into force from 2015 onwards. Catches of all species caught during pelagic fisheries are to be landed, except for protected species which need to be immediately discarded after capture. From 2019 onwards, the EU landing obligation will be applied to demersal fisheries.

For this stock unit, information on discards from non-Faroese fisheries are available from InterCatch and from other sources (Table below). It is assumed that bycatches are generally to be 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 300–700 m (e.g. Girard and Biseau, WD 2004). New calculation of the estimates for 2012 and 2013 reduce strongly the discards reported by Spain, and 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 2015–2019 were mainly in Division 6.a and it was from the French and Scottish deep-water fisheries (data from WGDEEP and Inter-Catch) (table below). For the years 2015-2019 the average discard rates are 4.6% of the total catches

	Division 5.b			Division 6.a				5.b and 6.a	
Year	France	Germany	Nether-lands	France	Germany	Nether-lands	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			64	77	0.4

1) Discard rate in recent years (2014-2019)

The landings statistics are regarded as being adequate for assessment purposes.

6.4.4.2 Length compositions

Length frequency distributions of commercial catches are from Faroese commercial trawl catches in 5.b (Figure 6.4.4) and from the PFA fisheries in Divisions 4a, 5b and 6a (Pastoors, WD06 2020) (Figure 6.4.5). Length measurements from the Dutch fishery in 6.a were available (Figure 6.4.6 and 7.4.7).

Length distributions from the Faroese spring- and summer groundfish surveys on the Faroe Plateau in Division 5.b are presented in Figures 6.4.8 and 6.4.9. Length distributions from the Faroese deep water survey are presented in Figure 6.4.10.

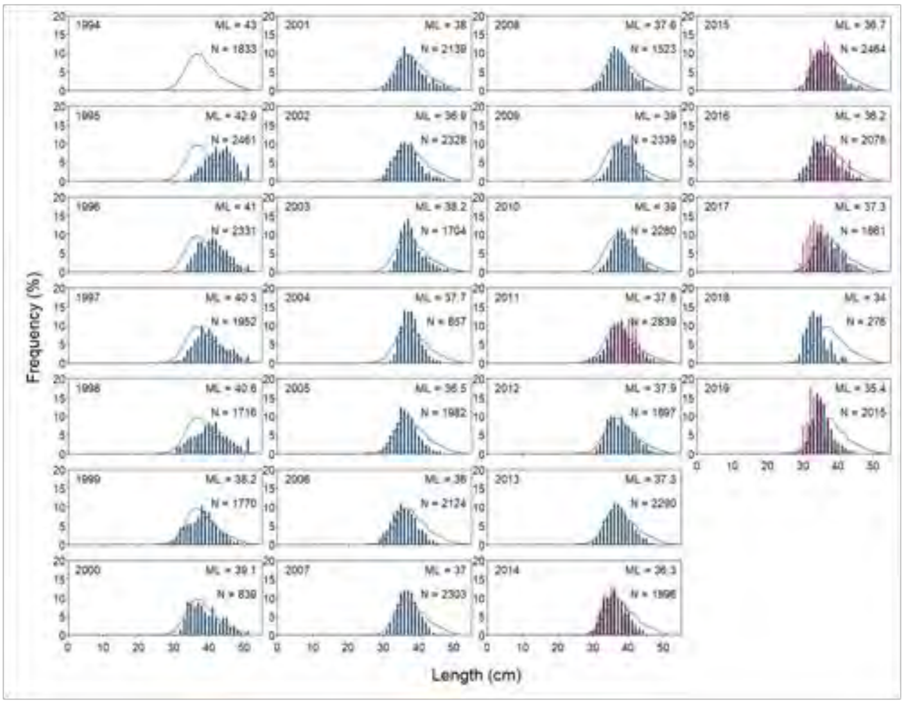


Figure 6.4.4. Greater silver smelt in 5.b. Length frequencies of greater silver smelt in the Faroese catches. ML= mean length (cm) and N= number of length measurements.

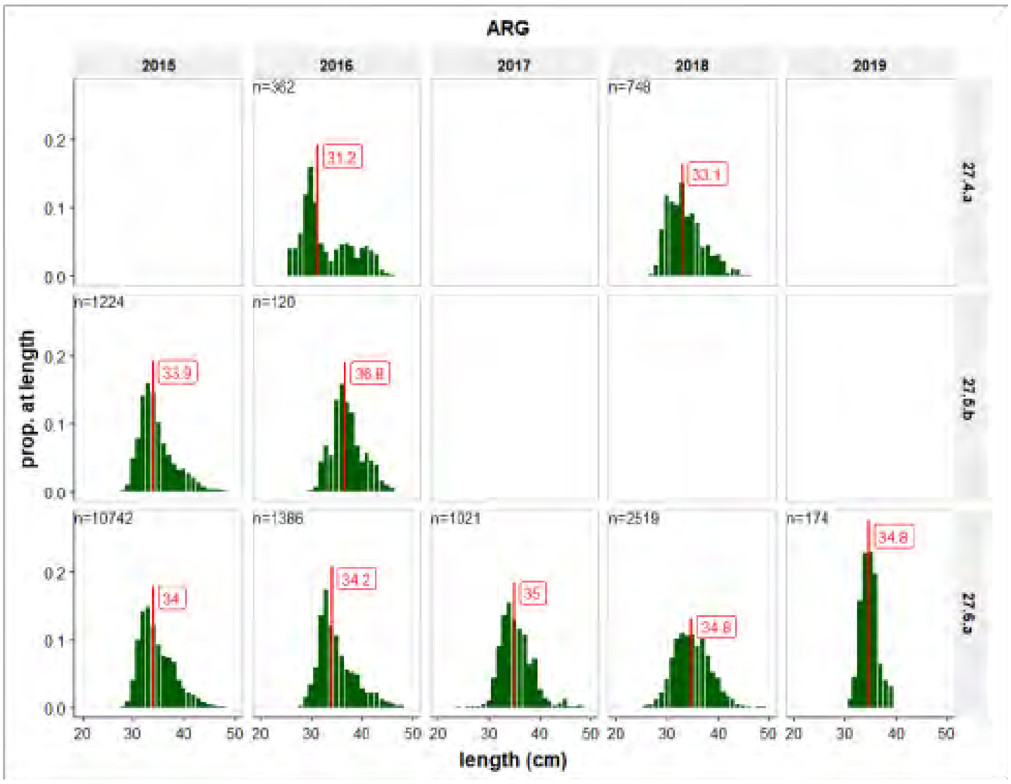


Figure 6.4.5. Greater silver smelt in 5.b and 6.a. Relative length frequencies in PFA self-sampled fisheries in division 4a, 5b and 6a. Median length in red. Number of length measurement in top left (Pastoors, WD WGDEEP 2019).

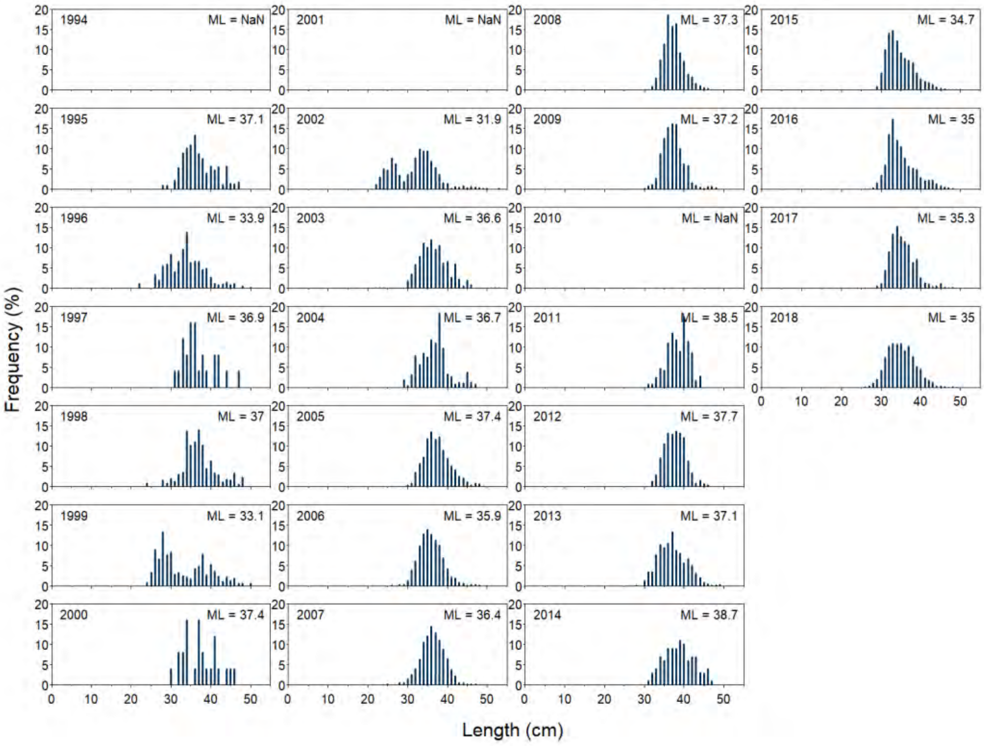
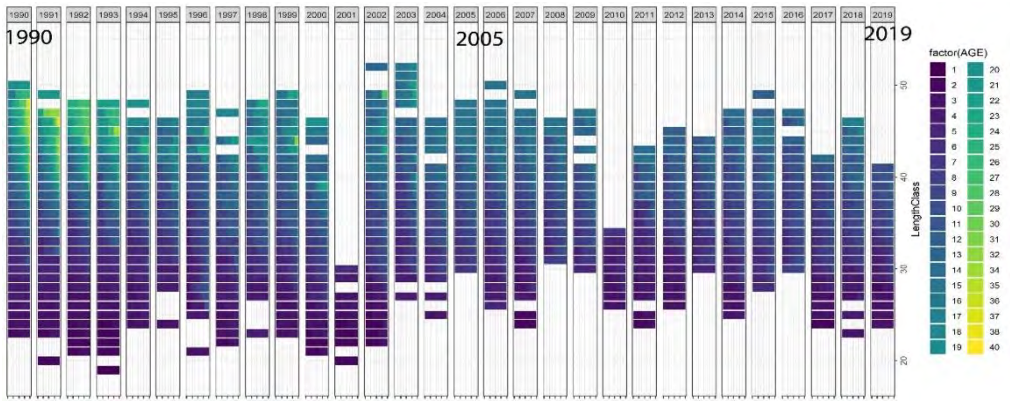


Figure 6.4.6. Greater silver smelt in 6.a. Length frequencies of greater silver smelt from the Dutch trawl catches in Division 6.a (data from InterCatch and other sources). ML= mean length (cm).



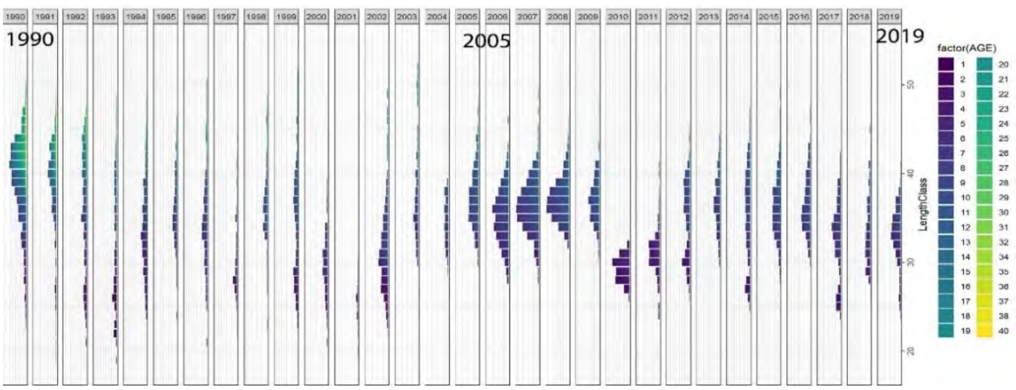


Figure 6.4.7 Greater silver smelt in 6.a. Length distributions from WMR (upper) marked sampling decomposed by the proportions of the ages in each length classes in each year as indicated by the colours (WKGSS WD02). The yellowish colors indicate older fish and Greater silver smelt in 6.a. Data in the previous figure shown as number histograms indicating the sample size at each length group (WKGSS WD02).

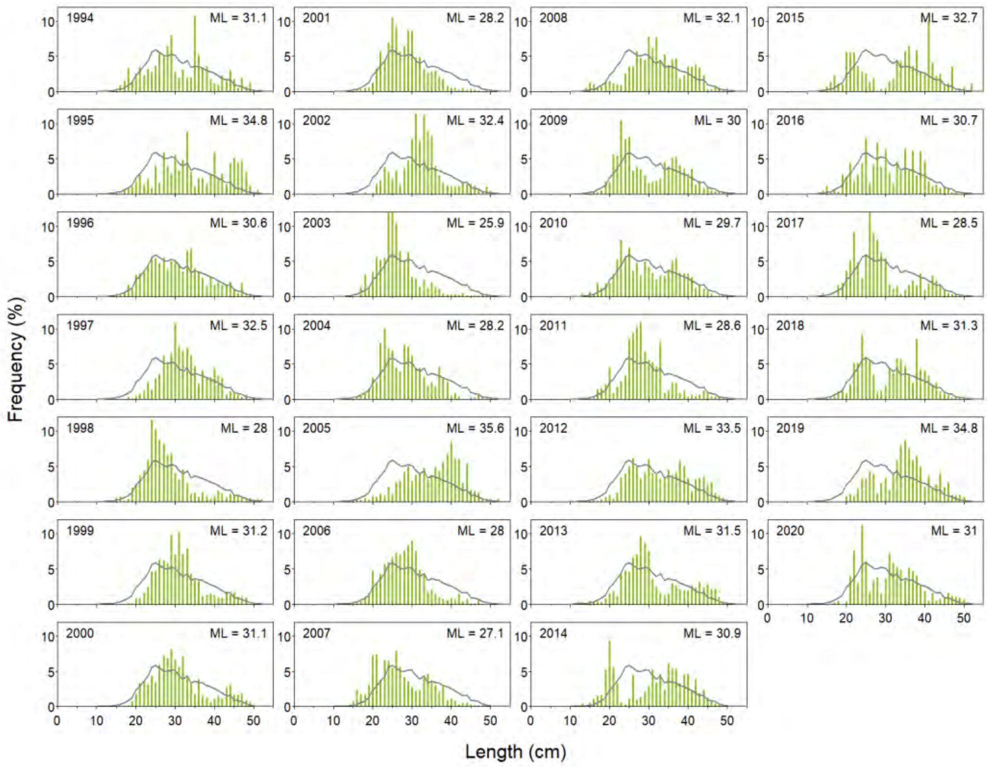


Figure 6.4.8. Greater silver smelt in 5.b. Length frequencies from the Faroese spring groundfish survey. ML= mean length. Greater silver smelt is sampled from a subsample of the total catch, so the values are multiplied to total catch.

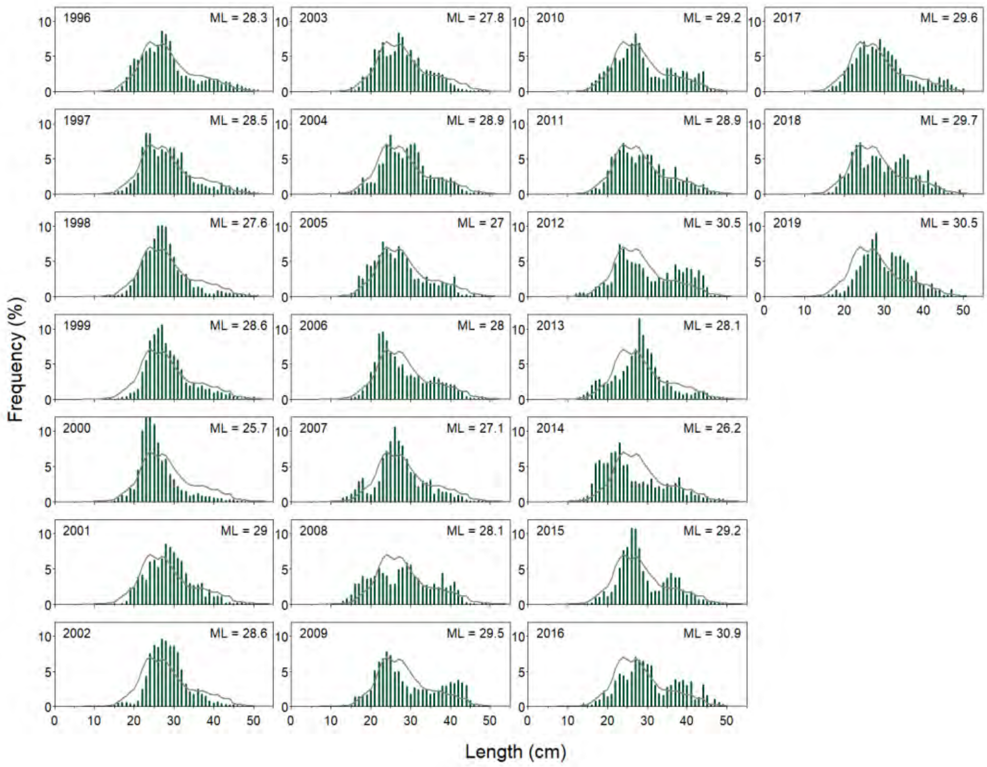


Figure 6.4.9. Greater silver smelt in 5.b. Length frequencies from Faroese summer groundfish survey. ML= mean length. Greater silver smelt is sampled from a subsample of the total catch, so the values are multiplied to total catch.

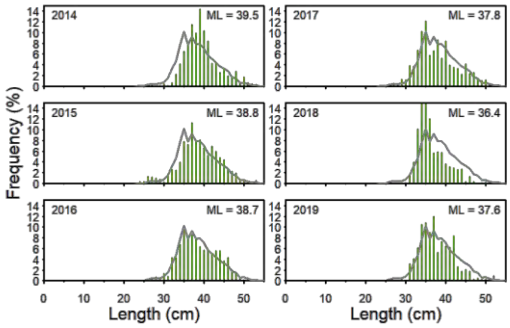


Figure 6.4.10. Length distributions in the Faroese deep water survey, 2014-2019. This survey was used as an age aggregated tuning series in the SAM assessment at the WKGSS 2020.

6.4.4.3 Age compositions

Age frequency distributions from Faroese landings in Faroese waters are presented in Figure 6.4.11. These data were used in the age based SAM assessment. In addition, age data are available from the Dutch and Scottish fishery in Division 6.a in some years.

There are also sporadic age data of greater silver smelt from the Faroese groundfish surveys in Division 5.b.

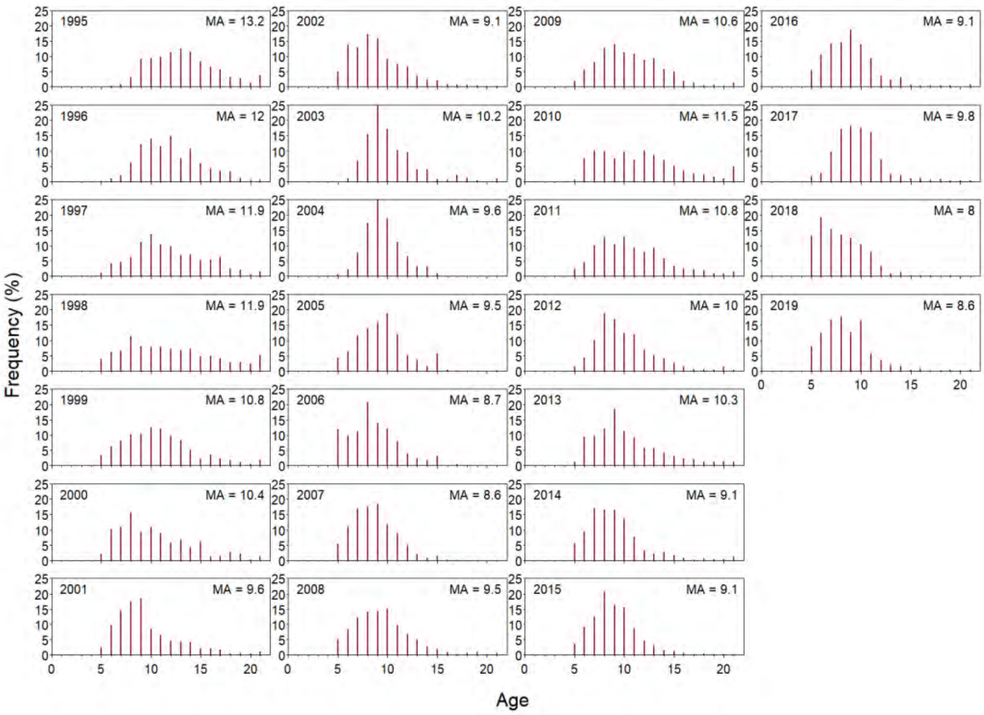


Figure 6.4.11. Greater silver smelt in 5.b. Age frequencies used in the SAM assessment in 5.b from commercial pair trawlers with mean age (MA) 1995–2018. From 2005 to present a combined catch at age from Faroese and EU data (InterCatch) was used.

6.4.4.4 Weight-at-age

Catch weight at age is the output from InterCatch for 2005-2019 and Faroese data 1995-2004 (Figure 6.4.12). In case of missing data, the average from the previous 5 years is used; this applies to the years 1995-2004. Stock weights at age are set to the same values as catch weight at age (1995-2019, ages 5 to 21+). These data were used in the approved SAM assessment.

Figure 6.4.12. Greater silver smelt 5.b and 6a. Mean weight-at-ages 4–21+ of greater silver smelt in the commercial catch.

6.4.4.5 Maturity and natural mortality

Most of the greater silver smelt caught in commercial catches in Division 5.b is mature (Ofstad, WD14 WGDEEP 2017, WKGSS 2020 report).

Proportion mature is the same for the whole period. The background data are from different Faroese surveys in the period 2000-2019, table below. There are no maturity data from the Scottish deepwater survey.

In the previous exploratory assessment (WGDEEP 2019), the instantaneous mortality rate (M) was used at 0.1. The reason for that was that, for a virgin population in 1995, it was observed that 20% of the fish in the catch were 14+ years old (mean age of around 18 years). This corresponds to an M of 0.11, i.e. justifies the choice of M=0.10.

In the benchmark, the natural mortality was changed to 0.15 (Woods *et al*. 2020,WD 16 WKGSS 2020). This new value was based on results using life history parameters in a DLS program, where the mortality rate was estimated to lie between 0.15 and 0.22. The group discussed this and agreed to set M= 0.15 (Woods *et al*. 2020,WD 16 WKGSS 2020) because GSS is a long lived fish (plus group of 21+).

Maturity by age used in the assessment for GSS.

AGE	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
Prop Mature	0.05	0.13	0.29	0.52	0.75	0.89	0.96	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

6.4.4.6 Catch, effort and research vessel data

Catch and effort data by haul for the commercial Faroese (1995-2019) and PFA fishery (2005-2008, 2012-2019) were available from Faroese logbooks and the PFA self sampling program. Catch from the Faroese trawlers logbook data account for more than 80% of the Faroese landings from 2005 and onwards, so 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 the Netherlands in area 5b6a.

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, WD 03).

In preparing for the WGDEEP 2020, two small errors have been detected in that analysis: 1) in the calculation of CPUE and 2) in the selection of hauls to be included (WGDEEP 2020, WD05).

During the development of the GLM model, the intention was to test different potential explanatory variables. For that reason, we had included the hour for shooting the haul (hset) as a factor.

This factor did not contribute significantly to the GLM and was left out in the final calculation. However, because the hset variable was included when calculating the catch per day and per rectangle, effectively, we were not calculating the catch per day, but rather the catch per haul, as the hset variable meant that few vessels would have the same hset when fishing in the same rectangle on the same day. This has been corrected in the analysis submitted to WGDEEP 2020.

The second issue was that only hauls were included north of 59.5 degrees latitude, as this was the area covered by the Faroe fleet. However, the PFA fleet carries out the main fishery south of 59.5 degrees. In the updated analysis the spatial selection statement was removed, thereby making substantially more hauls available for the CPUE calculation.

A comparison between the standardized CPUE as calculated during WKGSS 2020 and WGDEEP 2020 is shown in figure 6.4.13 and explanatory variables are shown in figure 6.4.14.

A single fleet analysis was carried out to assess the year trends in CPUE for the data by Faroese and PFA fisheries separately (figure 6.4.15) indicating the variability is substantially higher in the PFA series compared to the Faroese survey.

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.

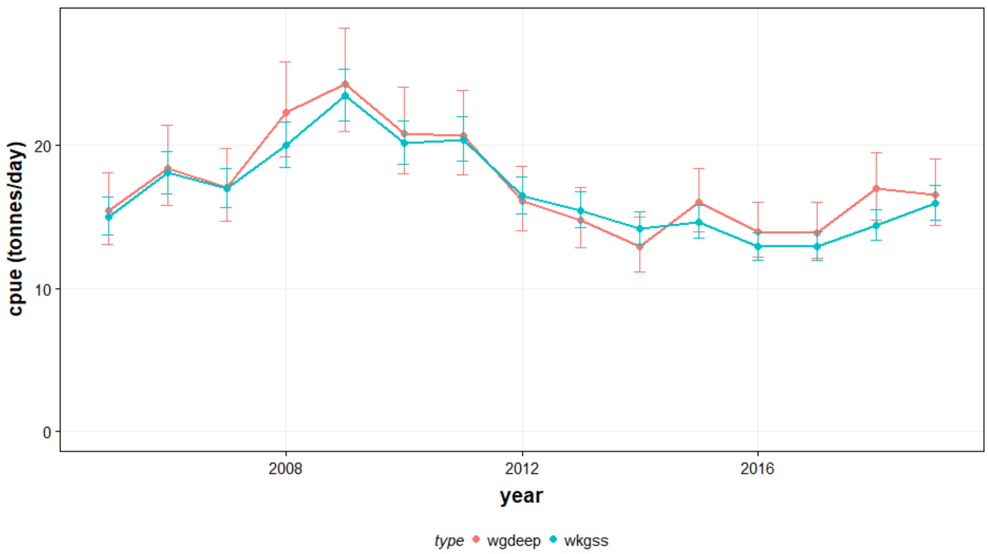


Figure 6.4.13. Greater silver smelt in 5b and 6a. Combined standardized cpue from Faroese and EU fisheries (WKDEEP 2020, WD05).

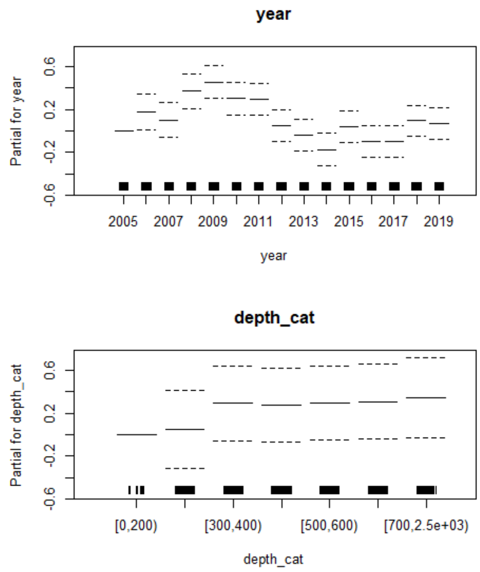


Figure 6.4.14. Greater silver smelt in 5b and 6a. Parameter estimates for explanatory variables (WGDEEP 2020, WD05).

Figure 6.4.15. Greater silver smelt in 5b and 6a. Standardized single-fleet analysis of Faroese and PFA fisheries.

Faroese groundfish trawl surveys (spring survey and summer survey)

Standardised catch rates from the Faroese summer groundfish survey is used to tune the assessment of greater silver smelt in 5.b and 6.a. Survey indices for greater silver smelt from the annual Faroese groundfish surveys on the Faroe Plateau in Division 5.b in spring (1994-2019, 100 stations) and summer (1996-2019, 200 stations) are shown in Figure 6.4.16. It has to be noted that these surveys have very few stations (<5) deeper than 500 m and are therefore only likely to 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 needs closer investigation before it can be used as a tuning series for greater silver smelt, because of large variation. The summer survey is used as a tuning series in the assessment (WKGSS, WD07).

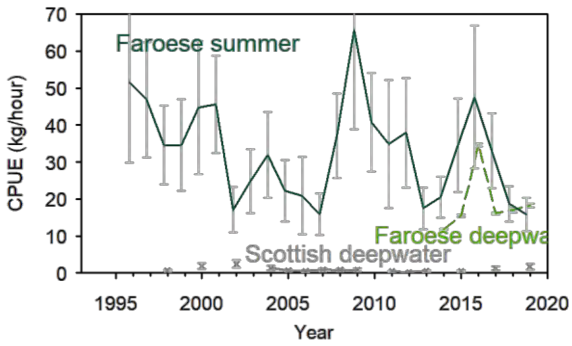


Figure 6.4.16. Survey indices with SE from the Faroese summer survey (1995–2019, dark green line), Scottish deepwater survey (1998-2019, grey line) and Faroese deepwater survey (2014–2019, green stippled line).

Faroese deepwater trawl survey

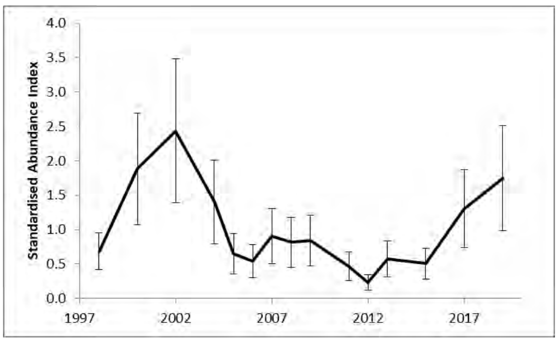
A Faroese deep-water trawl survey conducted in September has been conducted since 2014, covering the slope and banks including the fishing area for greater silver smelt in the Faroese EEZ (5.b and 6.a)(WGDEEP, 2019). A standardized index is presented in Figure 6.4.15. (WKGSS, WD07 and 10). The Faroese surveys are conducted by R/V Magnus Heinason.

Scottish deepwater trawl survey

The Scottish deepwater trawl survey (6.a) was explored at the benchmark in 2020 (WKGSS WD01). A regular trawl survey of the fish community in the deep waters to the northwest of Scotland has been undertaken irregularly since 1998 (Table below), using the MRV Scotia (Figure 6.4.16.) and showed that greater silver smelt are found at depths between 400m and 750m (Campbell, WD Nov. 2019). The CPUE was standardized (Figure 6.4.15.) and in the end this left 126 hauls, distributed across years as shown in the table below. The number of hauls per year where greater silver smelt is encountered is generally around 10.

Overview of the number of hauls with greater silver smelt in the Scottish deep water survey.

Year	1998	2000	2002	2004	2005	2006	2007	2008	2009	2011	2012	2013	2015	2017	2019
Hauls	10	11	12	11	5	11	6	8	8	7	7	7	8	9	6



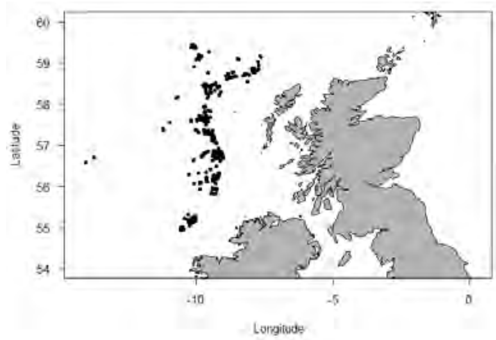


Figure 6.4.17 Greater silver smelt in 6.a. Location of hauls in the Scottish deepwater survey time series, 1988–2019 (above). Standardised abundance index of Greater Silver Smelt in Div. 6a (below) (Campbell, WD Nov. 2019).

6.4.5 Data analyses

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 6.4.4, 6.4.11, 6.4.18). 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 (Figure 6.4.18). 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 1995–2019, mean lengths in Dutch landings were mainly between 34 to 38 cm (Figures 6.4.6 and 6.4.7).

After 2003, the mean length of greater silver smelt from Faroese and Dutch trawlers landings was very similar, around 36–39 cm (Figure 6.4.18). The low mean lengths observed in the Dutch fishery (1996, 1999, 2002) are probably caused by the catch being a mixture of *Argentina silus* and *A. spyraena* or because the Dutch trawlers in these years fished in shallower waters than in other years or that the data are from discard not landings.

The mean lengths by age of greater silver smelt sampled in the Faroese and Dutch fishery are comparable (Figure 6.4.18), allowing the use of Faroese age–length data in an age-based assessment and to combine these from 2005 and onwards.

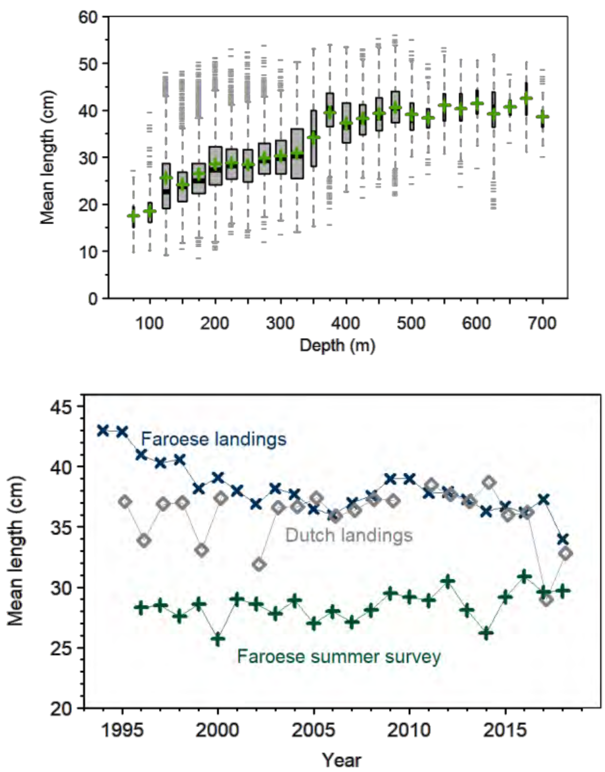


Figure 6.4.18. Greater silver smelt in 5.b and 6.a. Mean length at different depth interval (e.g. 100 is 100–124 m) from various surveys in Faroese area (upper). Comparison of mean length at year from Faroese- and Dutch landings and from the Faroese summer survey (lower).

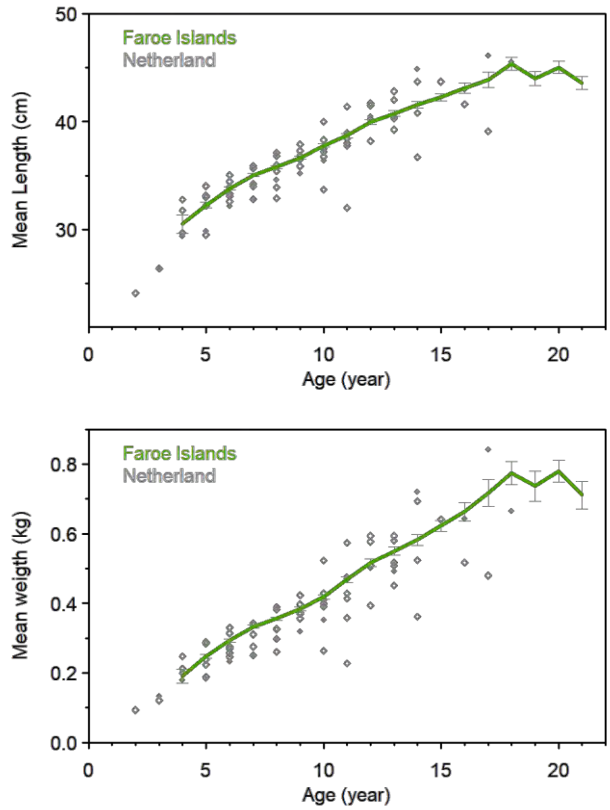


Figure 6.4.19. Greater silver smelt in 5.b and 6.a. Comparisons of greater silver smelt mean length-at-age (upper) and mean weight-at-age (lower) in the commercial Faroese fisheries (green line) and Dutch fisheries (grey symbols). Dutch data are from InterCatch and other sources.

Stock assessment

In the benchmark workshop on greater silver smelts (WKGSS 2020), 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. Catch data for 1995 to 2004 is derived from the Faroese sampling raised to the international catches. Catch data for 2005 until 2019 is derived from Inter-Catch whereby the age-based data is only contributed by Faroe Islands and the Netherlands. Maturity at age are set to same value for the whole period based on Faroese survey data. Natural mortality was set to 0.15 for all ages and years (WKGSS 2020)

Although the benchmark workshop has not been fully finalized and reviewed at the time of WGDEEP 2020, this section in the report is based on the agreed procedure at the benchmark meeting.

The age-disaggregated tuning series were the Faroese summer survey, ages 5 to 12 years (1997–2018) and the Faroese deepwater survey, ages 5 to 14 years (2014–2018).

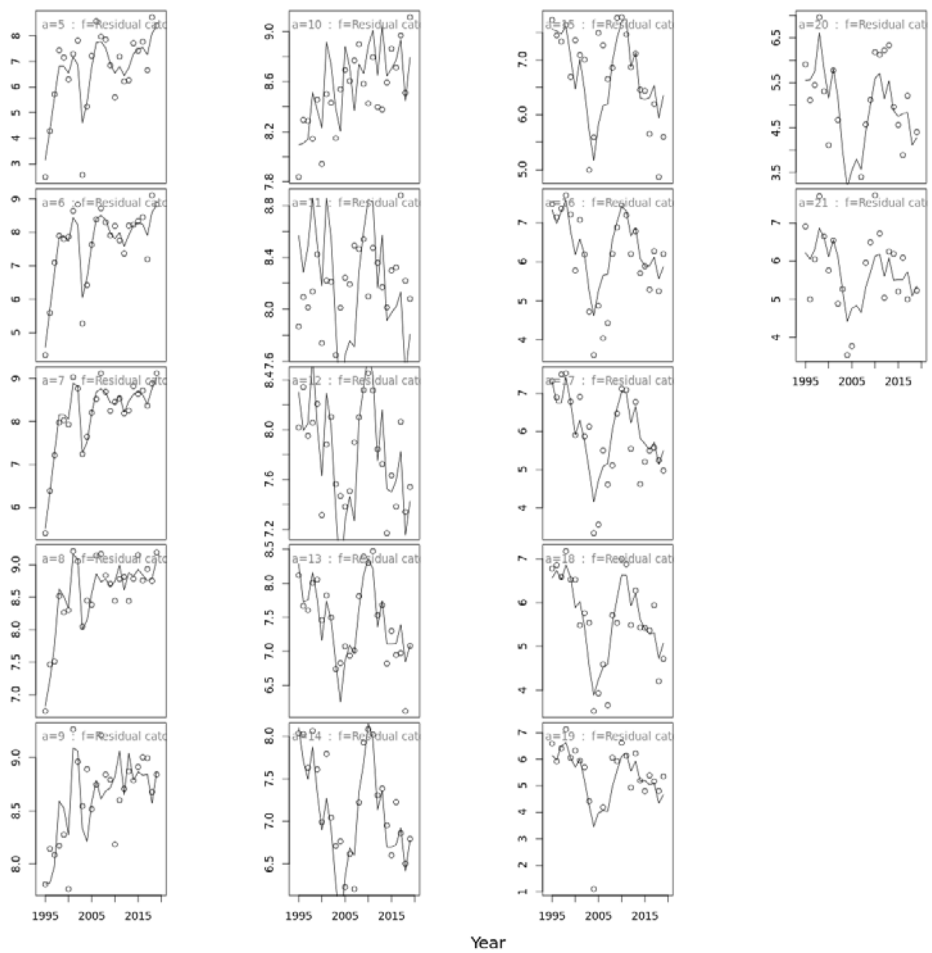
The Scottish deepwater survey (1998-2018, irregular) and the combined commercial Faroese and EU trawlers catch per unit effort (2005-2018) were used as biomass indices in the tuning of the assessment.

The selected 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. Results of the model as run by WGDEEP 2020 ("ARU _27.5b6a_WGDEEP2020_ @ stockassessment.org) is shown in the plots below:

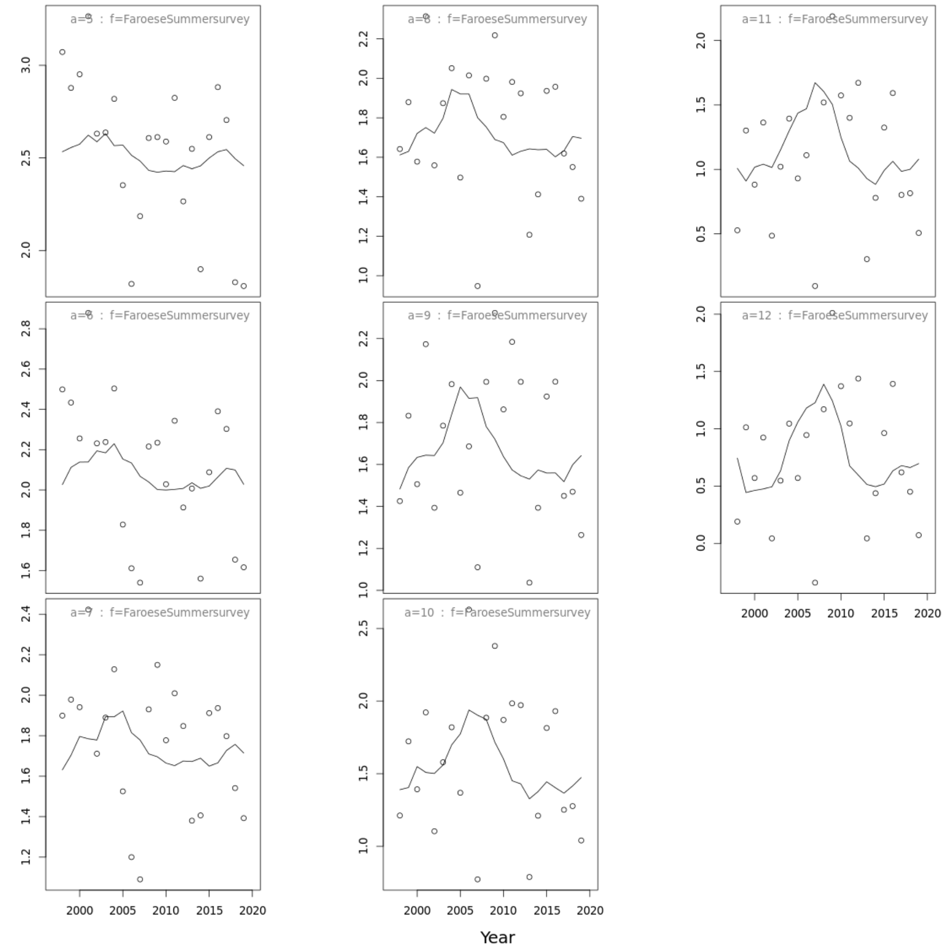
- Model fits to the data (7.4.20-7.4.23)
- Standardized one-step-ahead residuals (7.4.24)

- Leave-one-out analysis (7.4.25)
- Retrospective analysis (7.4.26)
- Estimated correlations between age groups for each fleet (7.4.27)
- SSB, F_{bar} and Recruitment (7.4.28)
- Model configurations (7.4.29)

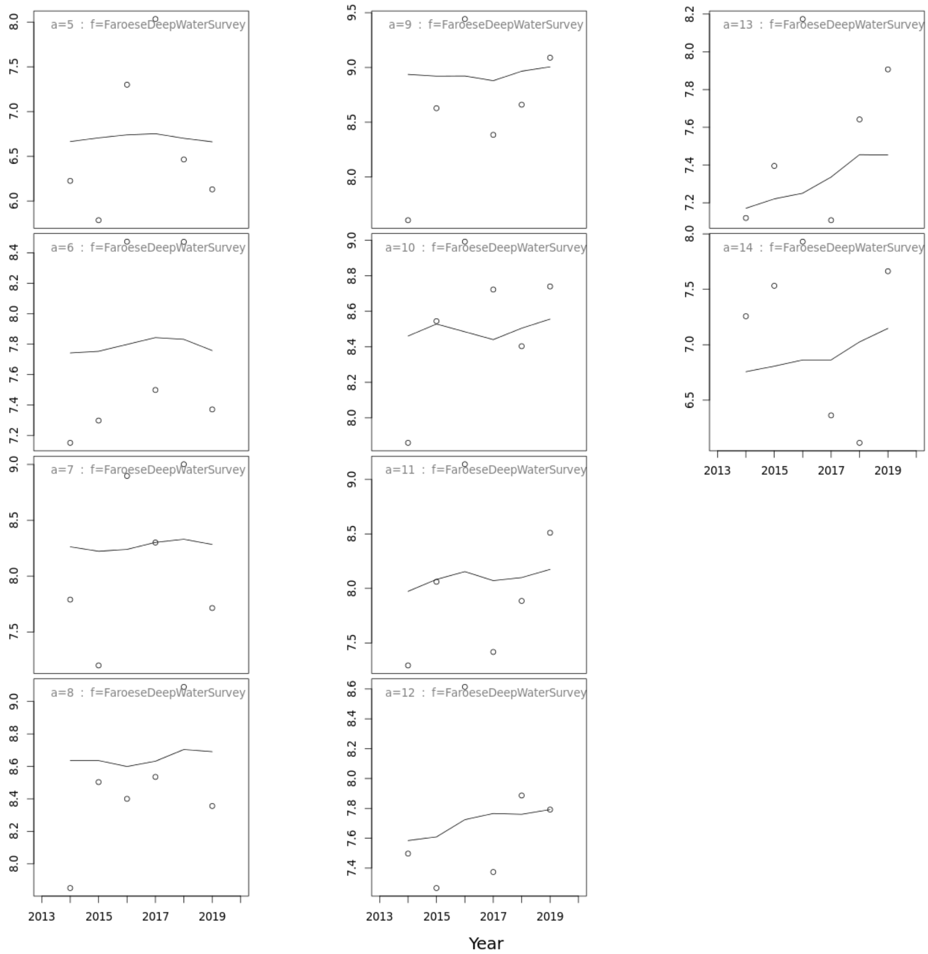
The leave one out analysis (figure 6.4.25) shows that the model is very sensitive to exclusion of the Faroese summer survey from the model fit. In order to minimize systematic year effects, the final SAM model included correlated errors across ages (Figure 6.4.27). Residuals were more randomly distributed after the correlated errors were taken into account.



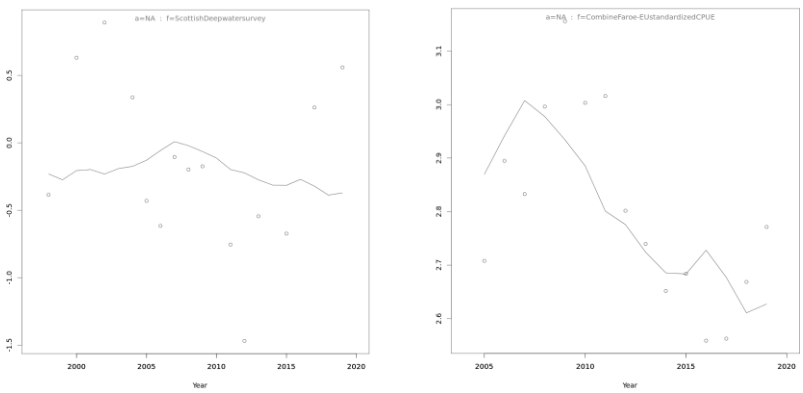
7.4.20. Greater silver smelt in 5.b and 6.a. Fit of the assessment model to the catches at age



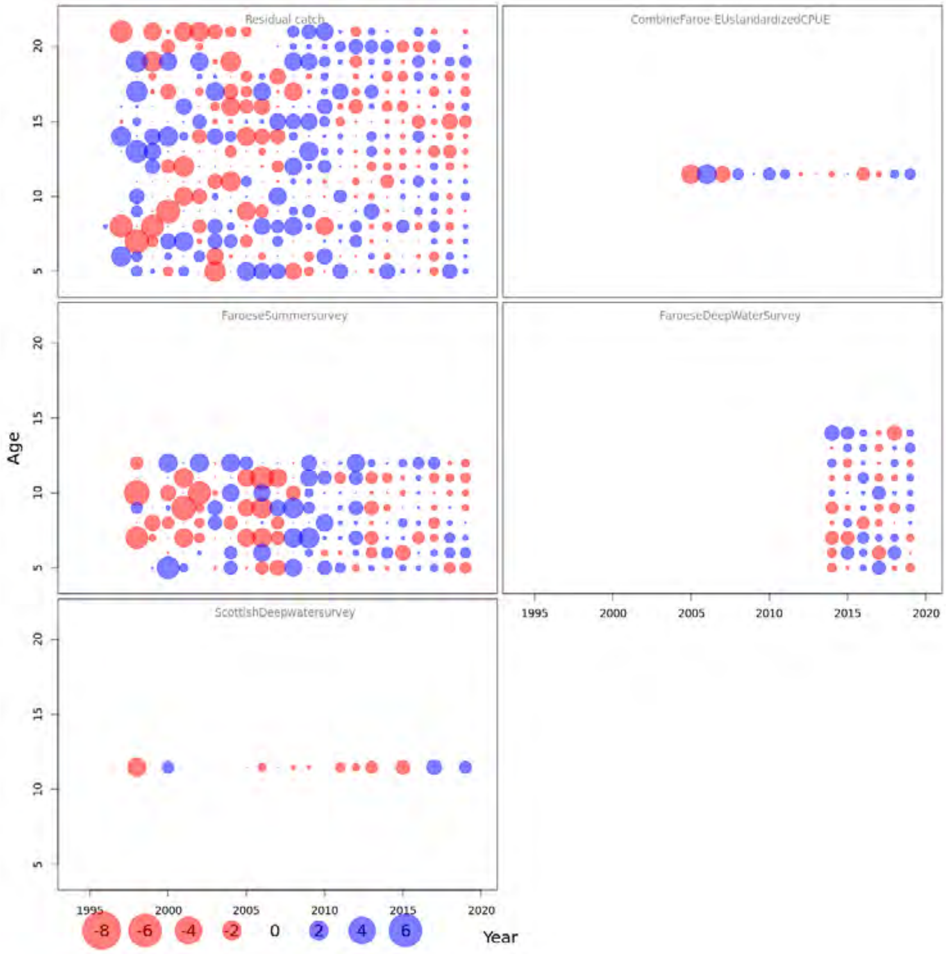
7.4.21. Greater silver smelt in 5.b and 6.a. Fit of the assessment model to the Faroese summer survey



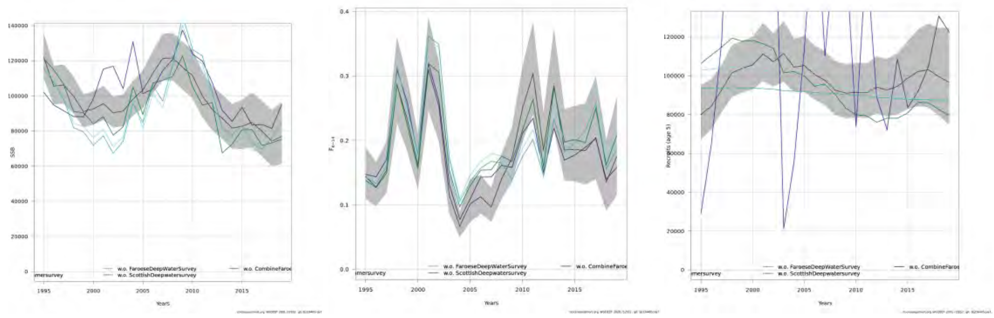
7.4.22. Greater silver smelt in 5.b and 6.a. Greater silver smelt in 5b and 6a. Fit of the assessment model to the Faroese deepwater survey



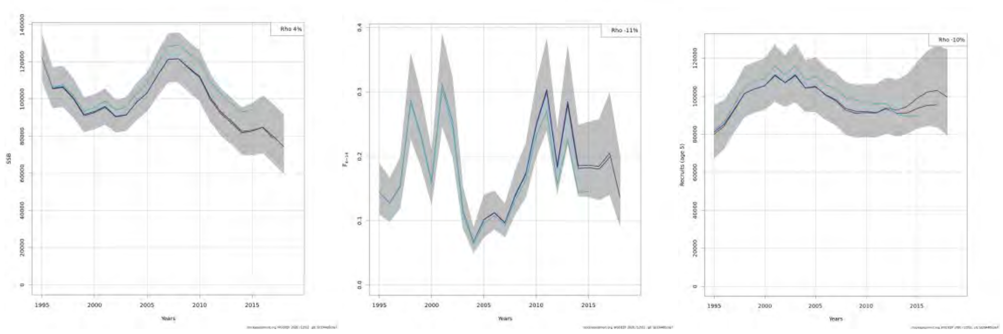
7.4.23**. Greater silver smelt in 5b and 6a. Fit of the assessment model to the Scottish deepwater survey (left) and the combined Faroese/EU CPUE (right).**



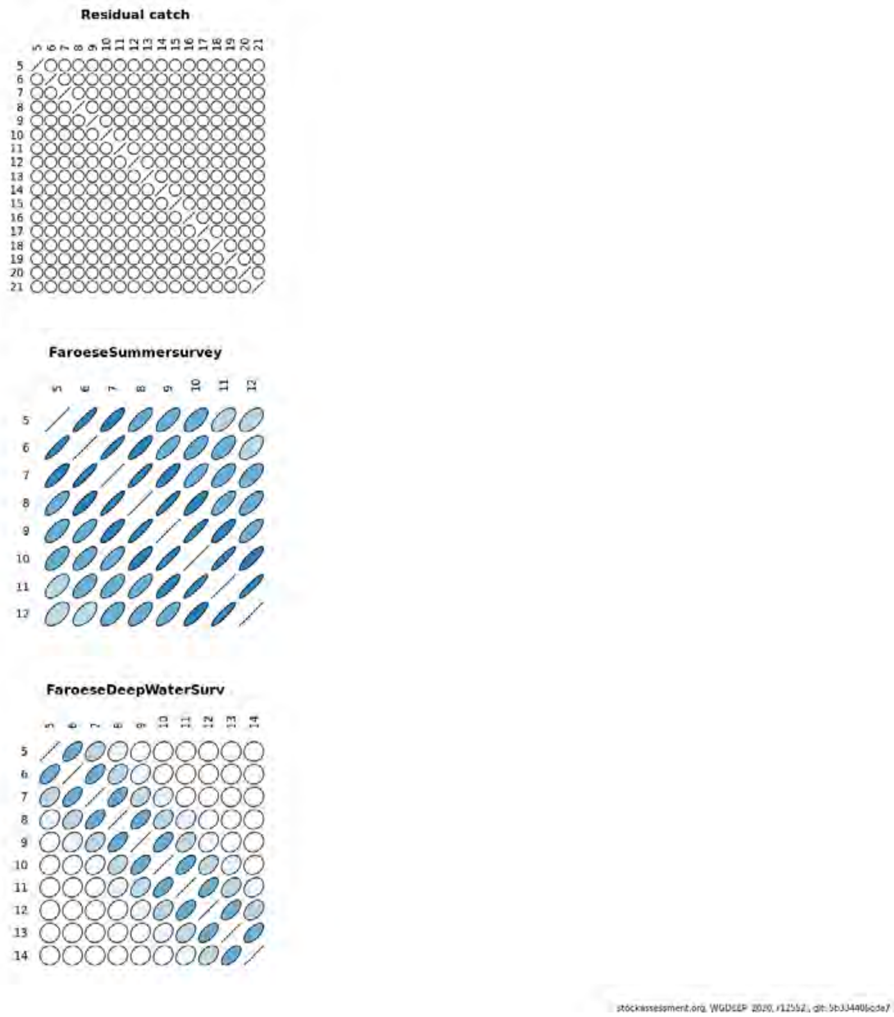
7.4.24. Greater silver smelt in 5b and 6a. Standardized one-step-ahead residuals from the SAM model.



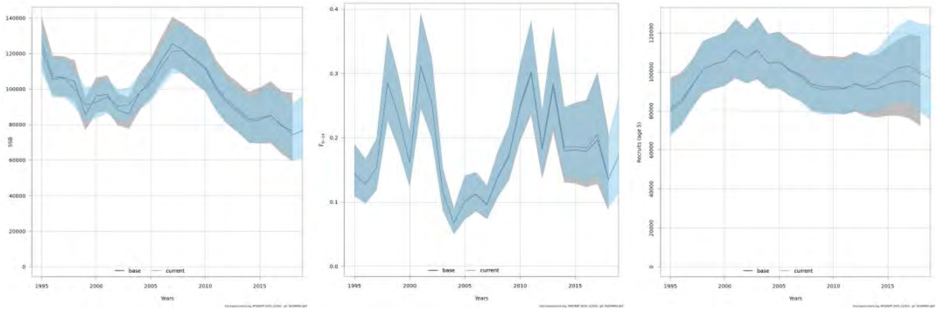
7.4.25. Greater silver smelt in 5b and 6a. Leave-one-out analysis of SSB (left), fishing mortality (middle) and recruitment (right).



7.4.26 Greater silver smelt in 5b and 6a. Retrospective analysis with 5 peels in SSB (left) and fishing mortality(middle) and recruitment (left).



7.4.27. Greater silver smelt in 5b and 6a. Estimated correlations between age groups for each fleet.



7.4.28. Greater silver smelt in 5.b and 6.a. Results from the SAM assessment. For 2019 is seems that the SSB is shifting slightly upwards.

	Model 1	Model 2
$minAge	5	5
$maxAge	21	21
$maxAgePlusGroup	1 0 0 0 0	1 0 0 0 0
$keyLogFsta		
catch	0 1 2 3 4 6 5 5 5 5 5 5 5 5 5 5 5	0 1 2 3 4 5 6 **7 8 9** 9 9 9 9 9 9 9
Faroese summer surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1	-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	-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	-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	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag	2	2
$keyLogFpar		
catch	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1	-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	0 1 2 3 4 **5** 6 6 -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	9 10 11 12 13 13 13 13 13 13 -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	7 -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	8 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyQpow	All -1	All -1
$keyVarF		
catch	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 **1 2 3** 3 3 3 3 3 3 3 3 3 3 3 3 3
Faroese summer surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1	-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	-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	-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	-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	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	**2 3 4** 4 4 4 4 4 4 4 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	6 6 6 6 **7 8** 8 8 -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	**9** 10 10 10 10 10 10 10 10 10 -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	0 -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	1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$obsCorStruct	"ID" "AR" "AR" "ID" "ID"	"ID" "AR" "AR" "ID" "ID"
$keyCorObs		
catch	NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA	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	0 0 0 0 0 0 0 -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 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 -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 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$stockRecruitmentModelCode	0	0
$noScaledYears	0	0
$keyScaledYears		
$keyParScaledYA		
$fbarRange	6-14	6-14
$keyBiomassTreat	-1 -1 -1 5 5	-1 -1 -1 5 5
$obsLikelihoodFlag	"LN" "LN" "LN" "LN" "LN"	"LN" "LN" "LN" "LN" "LN"
$fixVarToWeight	0	0
$fracMixF	0	0
$fracMixN	0	0
$fracMixObs	0 0 0 0 0	0 0 0 0 0
$constRecBreaks		

7.4.29. Greater silver smelt in 5.b and 6.a. Model configurations for the final selected model, with 23 parameters.

Table with parameter estimates of the model compared to the assessment carried out in WKGSS 2020.

Type	Description	estimate	stdev	low	high
Catchability	Far Summ Surv age 5	0.000138	0.1112	0.000111	0.000172
Catchability	Far Summ Surv age 6	0.000108	0.1103	8.7e-05	0.000135
Catchability	Far Summ Surv age 7	9.6e-05	0.1101	7.7e-05	0.000119
Catchability	Far Summ Surv age 8	0.000122	0.1105	9.8e-05	0.000152
Catchability	Far Summ Surv age 9	0.00016	0.1116	0.000128	2e-04
Catchability	Far Summ Surv age 10-12	0.00021	0.1139	0.000167	0.000264
Catchability	Far Deep Surv age 5	0.009426	0.2623	0.005578	0.01593
Catchability	Far Deep Surv age 6	0.03411	0.26	0.02028	0.05738
Catchability	Far Deep Surv age 7	0.07044	0.2556	0.04225	0.1174
Catchability	Far Deep Surv age 8	0.139	0.2438	0.08538	0.2264
Catchability	Far Deep Surv age 9-14	0.2656	0.2146	0.1729	0.4079
Catchability	Sco Deep Surv	5e-06	0.1697	4e-06	8e-06
Catchability	Comm CPUE	0.000114	0.0718	9.9e-05	0.000131
Observation SD	Catch age 5-21	0.5104	0.0426	0.4688	0.5558
Observation SD	Far Summ Surv age 5-12	0.4634	0.1259	0.3602	0.5961
Observation SD	Far Deep Surv age 5-14	0.5962	0.1434	0.4475	0.7943
Observation SD	Sco Deep Surv	0.6293	0.1839	0.4356	0.9091
Observation SD	Comm CPUE	0.1435	0.1971	0.09673	0.2128
Random walk SD	F age 5-21	0.6537	0.1418	0.4923	0.8682
Random walk SD	N age 5-21	0.06703	0.2792	0.03835	0.1172
x_itrans	par_rho	3.733	0.1724	2.644	5.27
x_transfIRARdist	par_0	0.124	0.2855	0.07006	0.2195
x_transfIRARdist	par_1	0.6554	0.3966	0.2965	1.449

Other details regarding the age based SAM stock assessment can be found in the Stock annex.

6.4.6 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 (2009-2018) and mean weights was based on 5 year averages. Stock numbers and selectivity were taken from the final year. It was noted that the settings of the short term forecast have not been fully described and analysed during the benchmark meeting, and could require some more scrutiny before the WGDEEP 2021.

The code to run the short term forecast is shown below. It uses two years to start the forecast: 2019 as the last data year and 2020 as the intermediate year (using an Fsq assumption).

```
library(stockassessment)
source("src/fixforecast.R")
load("run/model.RData")
FC<-list()
Ry<-2010:2019
set.seed(12345)
FC[[length(FC)+1]] <- forecastx(fit, fscale=c(1,1,1,1,1), rec.years=Ry,label="SQ all years", processNoiseF=
FALSE, addTSB=TRUE)

set.seed(12345)
FC[[length(FC)+1]] <- forecastx(fit, fscale=c(1,1,NA,NA,NA), fval=c(NA,NA,0.000001,0.000001, 0.000001), rec
.years=Ry, label="SQ then zero", processNoise=FALSE, addTSB=TRUE)
```

```
set.seed(12345)
FC[[length(FC)+1]] <- forecastx(fit, fscale=c(1,1,NA,NA,NA), fval=c(NA,NA,0.2,0.2, 0.2), rec.years=Ry, labe
l="SQ then Fpa=Fmsy", processNoise=FALSE, addTSB=TRUE)

set.seed(12345)
FC[[length(FC)+1]] <- forecastx(fit, fscale=c(1,1,NA,NA,NA), fval=c(NA,NA, 0.29,0.29, 0.29), rec.years=Ry,
label="SQ then Flim", processNoise=FALSE, addTSB=TRUE)

set.seed(12345)
FC[[length(FC)+1]] <- forecastx(fit, fscale=c(1,1,NA,NA,NA), fval=c(NA,NA,0.34,0.34, 0.34), rec.years=Ry, l
abel="SQ then F=0.34", processNoise=FALSE, addTSB=TRUE)


save(FC, file="run/forecast.RData")
```

Results of the forecast for 2020–2022 are shown in the text table below for five different scenarios.

scenario	year	fbar	fbar_range	catch	catch_range	ssb	ssb_range
Intermediate year	2020	0.18	0.12-0.26	17469	13570-21513	88046	66981-114681

scenario	year	fbar	fbar_range	catch	catch_range	ssb	ssb_range
SQ all years	2021	0.18	0.12-0.26	17114	13752-20523	86891	64489-115265
SQ all years	2022	0.18	0.12-0.26	16783	13872-19664	85293	62292-113663
SQ all years	2023	0.18	0.12-0.26	16531	13894-18858	83926	61573-112797
SQ then zero	2021	0				86891	64489-115265
SQ then zero	2022	0				100227	77218-128048
SQ then zero	2023	0				113507	91530-140540
SQ then Fpa=Fmsy	2021	0.2	0.13-0.30	19308	15568-23040	86891	64489-115265
SQ then Fpa=Fmsy	2022	0.2	0.13-0.30	18534	15414-21516	83392	60561-111772
SQ then Fpa=Fmsy	2023	0.2	0.13-0.30	17956	15290-20290	80454	58180-109640
SQ then Flim	2021	0.29	0.19-0.44	26784	21909-31737	86891	64489-115265
SQ then Flim	2022	0.29	0.19-0.44	23861	20539-27195	77239	54796-105210
SQ then Flim	2023	0.29	0.19-0.44	21845	19392-24124	69613	49069- 98019
SQ then F=0.34	2021	0.34	0.22-0.51	30583	25286-36181	86891	64489-115265
SQ then F=0.34	2022	0.34	0.22-0.51	26238	22786-29655	73859	51866-101888
SQ then F=0.34	2023	0.34	0.22-0.51	23345	20941-25640	64486	44176- 92913

6.4.7 Reference points

There were no accepted reference points for this stock unit prior to the benchmark meeting WKGSS 2020. The approach earlier was that this is a Category 3 stock, and hence the 3.2 rule was used to assess the stock.

At WKGSS 2020, new reference points were calculated according to ICES technical guidelines. 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. The PA reference points are used when assessing the state of stocks and their exploitation rate relative to the precautionary approach objectives. The MSY reference points are used in the advice rule applied by ICES to give advice consistent with the objective of achieving MSY.

ICES standard EqSim reference point analyses were done using the EqSim script. The results and settings for these simulations are summarized in the table below.

	$MSY_{Btrigger}$	5thPerc_SSB_{msy}	B_{pa}	B_{lim}	F_{pa}	F_{lim}	F_{p05}	$F_{msy\_unconstr}$	F_{msy}
Model 1	82999	68357.53	82999	59729.65	0.2	0.29	0.33	0.241241	0.2

6.4.8 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 in Chapter 7.4.4). 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.

There appears to be no agreement between the Faroe Islands and EU on the setting of an overall TAC for greater silver smelt in 5.b and 6.a. As a consequence, the sum of the quotas of the Faroe Islands and EU has exceeded the scientific ICES advice from 2016 onwards (Table in Chapter 6.4.4).

6.4.9 Tables

Table 6.4.1. Greater Silver Smelt 5.b and 6.a. WG estimates of landings in tonnes. * landings in 2019 are preliminary.

Greater silver smelt (*Argentina silus*) 5.b

Year	Faroes	France	Germany	Iceland	Ireland	Netherlands	Norway	Poland	UK(E&W)	UK (Scot)	Russia	TOTAL
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	12 286
1996	9495									3		9498
1997	8433											8433
1998	17 570											17 570
1999	8186	5							23	15		8229
2000	3713	64								247	1185	5209
2001	9572				1					94	414	10 081
2002	7058					5				144	264	7471

Year	Faroes	France	Germany	Iceland	Ireland	Netherlands	Norway	Poland	UK(E&W)	UK (Scot)	Russia	TOTAL
2003	6261					51				1	245	6558
2004	3441					1125				42	702	5310
2005	6939					15					59	7013
2006	12 524										35	12 559
2007	14 085					0.4	32				8	14 126
2008	14 930						3				19	14 952
2009	14 200										28	14 228
2010	15 567									40	2	15 609
2011	15 578										8	15 586
2012	9744										110	9854
2013	11 109										114	11 223
2014	9747		110								339	10 196
2015	13 025	0	40	132							115	13 312
2016	11 129		38	345		31				0	3	11 547
2017	9424		1	63		2					6	9496
2018	10114	0						1			150	10265
2019*	9193		2					4			87	9287

Table 6.4.1. (Continued).

Greater silver smelt (*Argentina silus*) 6.a

Year	Denmark	Faroes	France	Germany	Ireland	Netherlands	Norway	UK(E&W)	UK(Scot)	Poland	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
1995		483		284		3706			465				4938
1996				1384	295	3953							5632
1997				1496	1089	4684							7269
1998				464	405	4687							5556
1999				24	168	8026		5					8223
2000			19	403	3178	3389							6989
2001			7	189	5838	3655			4777				14466
2002			1	150	3035	4020		424	4136				11766
2003				126	1	1932			80				2039
2004			147	652	46	3707			507				5059

Year	Denmark	Faroes	France	Germany	Ireland	Netherlands	Norway	UK(E&W)	UK(Scot)	Poland	Russia	Spain	TOTAL
2005		103	10	125	18	5317			61				5634
2006		53		213		4628			3			1	4897
2007		254		589		6969	3					2	7817
2008		991		10		4156	3						5160
2009		3923		115	0.5	2488	83		6		36		6651
2010		3060				3143	3		20		11		6237
2011		3655			0.1	3050		2	2				6709
2012		2781	2	538	0.2	1785		5	5		1		5115
2013	388	3197		417	0	1430					13		5445
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		1973	8	1001		2763					18		5769
2019*		2980	17	953	6	4540			64	29	28	9	8626

Table 6.4.2. Greater silver smelt (*Argentina silus*) (5.b and 6.a).

Year	5.b	6.a	Total
1988	287	7924	8211
1989	227	20581	20808
1990	2888	6795	9683
1991	60	4726	4786
1992	1443	5531	6974
1993	1063	1069	2132
1994	960	7635	8595
1995	12286	4938	17224
1996	9498	5632	15130
1997	8433	7269	15702
1998	17570	5556	23126
1999	8229	8223	16452
2000	5209	6989	12198
2001	10081	14466	24547
2002	7471	11766	19237
2003	6558	2039	8597
2004	5310	5059	10369
2005	7013	5634	12647
2006	12559	4897	17456
2007	14126	7817	21943
2008	14952	5160	20112
2009	14228	6651	20879
2010	15609	6237	21846
2011	15586	6709	22295
2012	9854	5115	14969
2013	11223	5445	16668
2014	10196	5467	15663
2015	13312	4236	17548

Year	5.b	6.a	Total
2016	11547	4773	16320
2017	9496	7310	16806
2018	10265	5769	16033
2019*	9287	8626	17913

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 1966–2019. Landings increased until 2002 to 4662 tons then declined again to low levels of less than a ton in 2016. In 2017, 2018 and 2019 the landings were 8 t, 36 t and 8 t, respectively. Landings from 2006 until today have been less than 50 tons. The main landings have been from Subareas 6b and 7 where Ireland were fishing for some years between 2000 and 2003.

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 2019 and 2020 the EU TAC in Subareas 5, 6 and 7 are 4661 t and 3729 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 five last years are presented in Table 6.5.6. Discards are mainly from the Spanish fishery and from Subarea 7. The discards were very high compared to the landings. However, the discards since 2014 were reduced compared to the years before.

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.

6.5.5.2 Length compositions

The size compositions of *Argentinas* spp. from Porcupine survey since 2009 is presented in Figure 6.5.2.

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* (Figures 6.5.2, 6.5.3 and 6.5.4). 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. 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 (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 this last survey (Figure 6.5.3).

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 Comments on the assessment

Advice is given every second year for this stock and last advice applies for 2020 and 2021.

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, 6.5.3 and 6.5.4). 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.

6.5.8 Management considerations

The trends for Porcupine bank survey biomass indices for *Argentina* species have increased in 2015 and 2016 but are declining in 2017 onwards.

6.5.9 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

6.5.10 Tables and Figures

Table 6.5.1. Greater Silver Smelt in 6.b. WG estimates of landings in tonnes. *landings in 2019 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

Year	Faroes	Germany	Ireland	Netherlands	Scotland	Russia	Spain	TOTAL
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
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

Table 6.5.2. Greater Silver Smelt in 7. WG estimates of landings in tonnes. *landings in 2019 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
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

Year	France	Germany	Ireland	Netherlands	Scotland	Norway	Poland	Spain	UK E/W	TOTAL
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
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

Table 6.5.3. Greater Silver Smelt in 8. WG estimates of landings in tonnes. *landings in 2019 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

Year	Netherlands	Spain	Ireland	TOTAL
2010				0
2011	1			1
2012				0
2013				0
2014	1.1			1.1
2015				0
2016		0		0
2017		0		0
2018		3.9		3.9
2019*		1.6	0.5	2.1

Table 6.5.4. Greater Silver Smelt 9. WG estimates of landings in tonnes. *landings in 2019 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

Table 6.5.5. Greater Silver Smelt 12. WG estimates of landings in tonnes. *landings in 2019 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

Table 6.5.6. Discard data from 2015-2019 from Subarea 6b, 7-1012. *discards in 2019 are preliminary

Year	Spain				UK (Scotland)
	6b	7	8	9	6b
2015	0.7	28			0.5
2016		237	2	1	
2017	1.82	148.8			0.3
2018	2.9	97.9	1.8	0.8	10.3
2019*	5	146	0.2	0.1	0.29

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

6.5.11 Figures

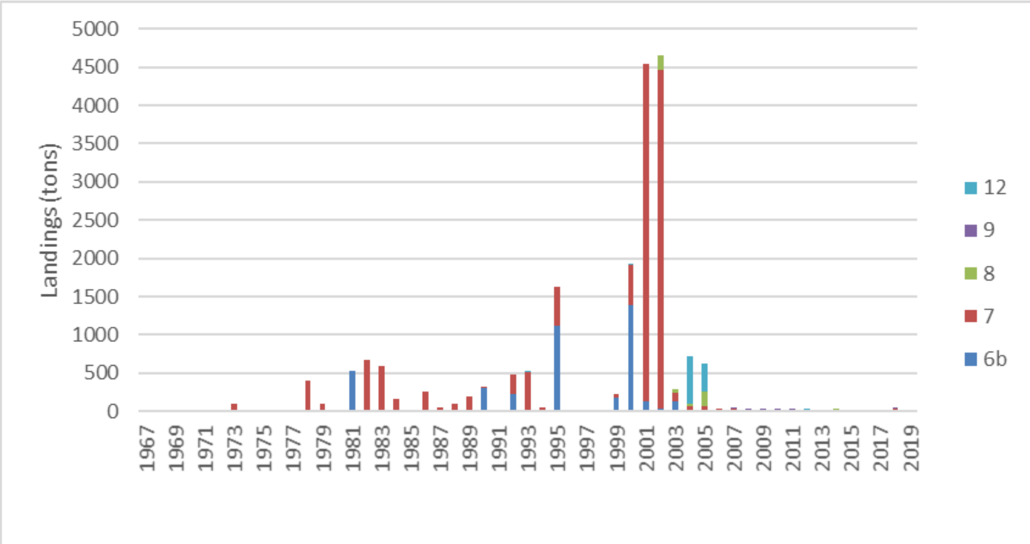


Figure 6.5.1. Total landings from 1966–2019 of greater silver smelt in 6.b, 7, 8, 9, 10 and 12.

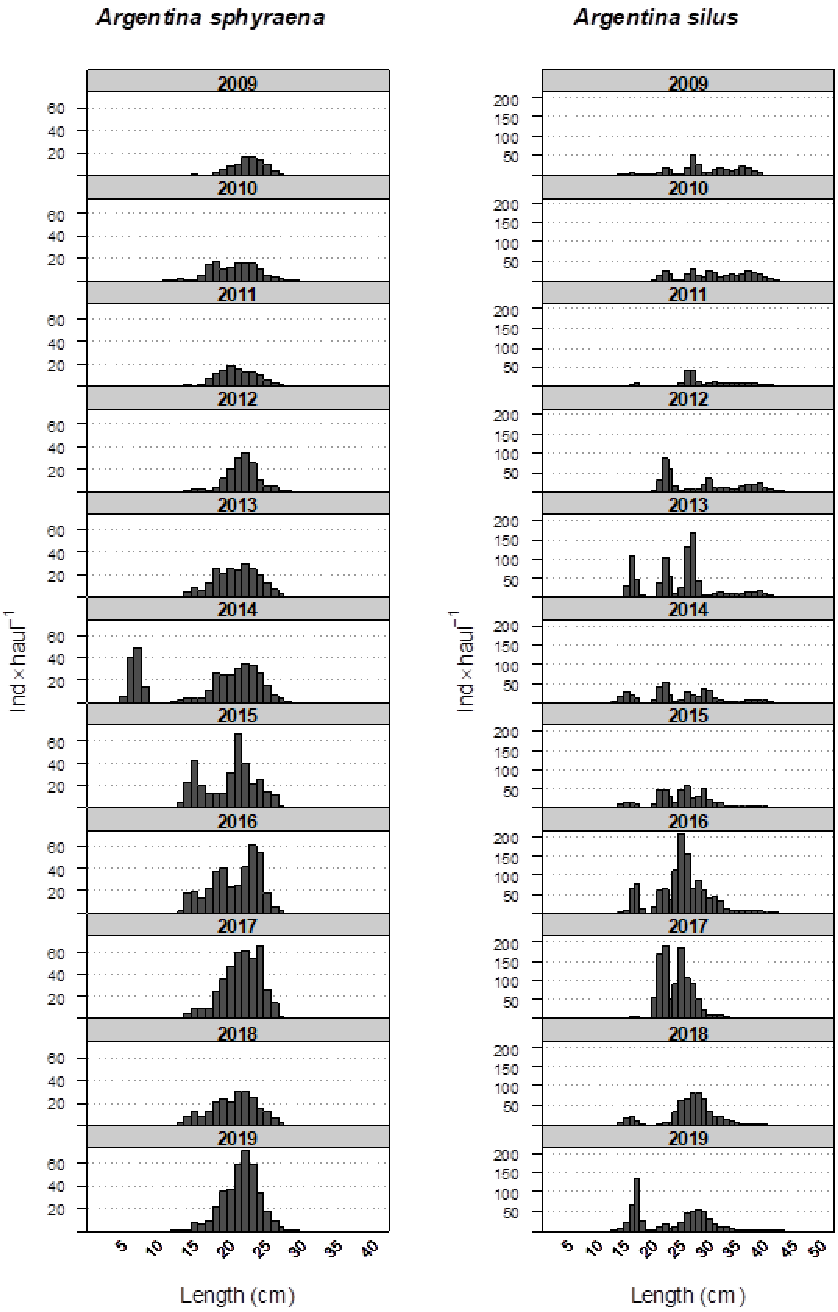


Figure 6.5.2. Mean stratified length distributions of *Argentina* spp. in Spanish Porcupine surveys from 2009–2019. Note different range in the y-axis values between species.

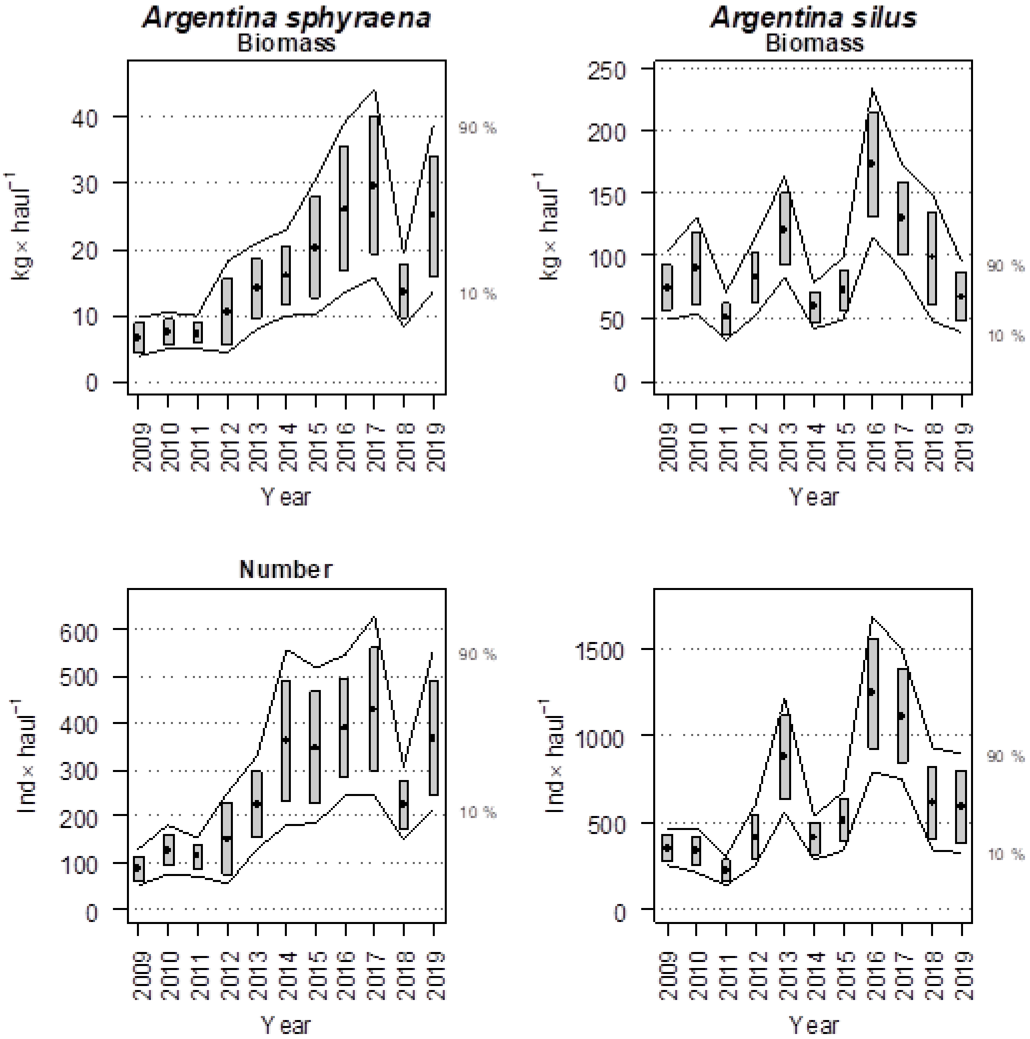


Figure 6.5.3. Evolution of *Argentina sphyraena* and *Argentina silus* biomass and abundance indices in Porcupine surveys (2009–2019). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a=0.80, bootstrap iterations=1000).

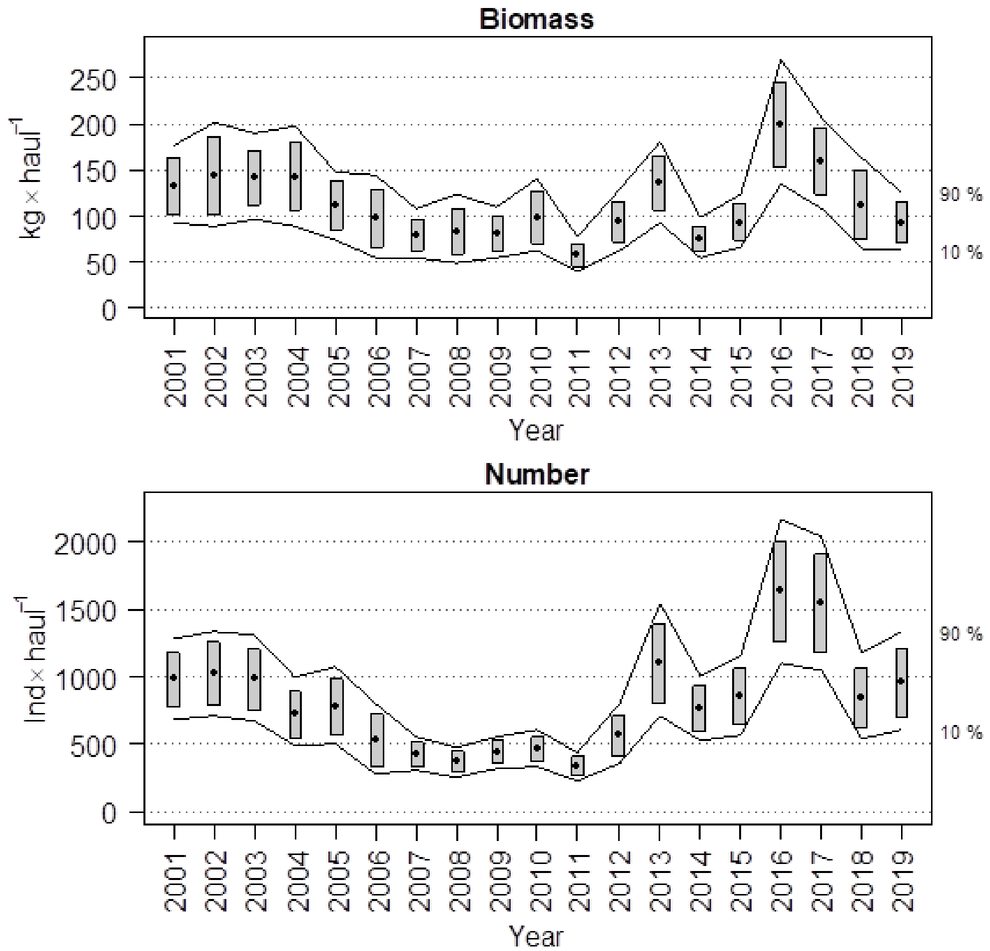


Figure 6.5.4. Evolution of *Argentina* spp. (mainly *Argentina silus*) biomass and abundance indices in Porcupine surveys (2001-2019). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000)

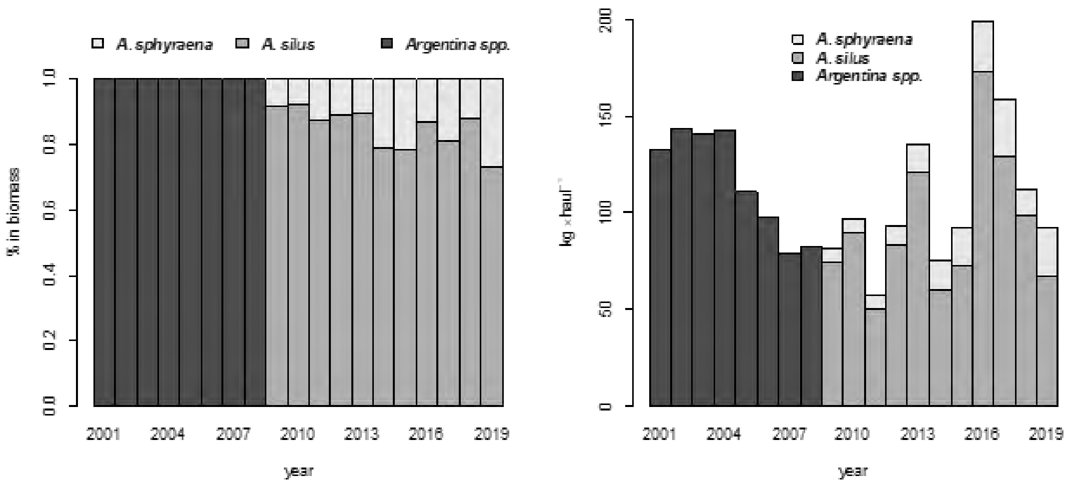


Figure 6.5.5. Share and abundance of *Argentine* species in Porcupine Bank surveys (2001–2019).

7 Orange roughy (*Hoplostethus atlanticus*) in the Northeast Atlantic

7.1 Stock description and management units

There is no information to determine the existence of separate populations of orange roughy in the North Atlantic.

The current ICES practice is to assume three assessment units:

- Subarea 6;
- Subarea 7;
- Orange roughy in all other areas.

Given the scarcity of spatial fisheries data, biological and genetics data, WGDEEP saw no reason to change this.

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 be separated 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.

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 Seamount. Irish vessels fished there for two years starting in 2001, but directed fisheries had ceased by 2006. No fishing and no catch was reported for years 2017-19. 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 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 2017-19.

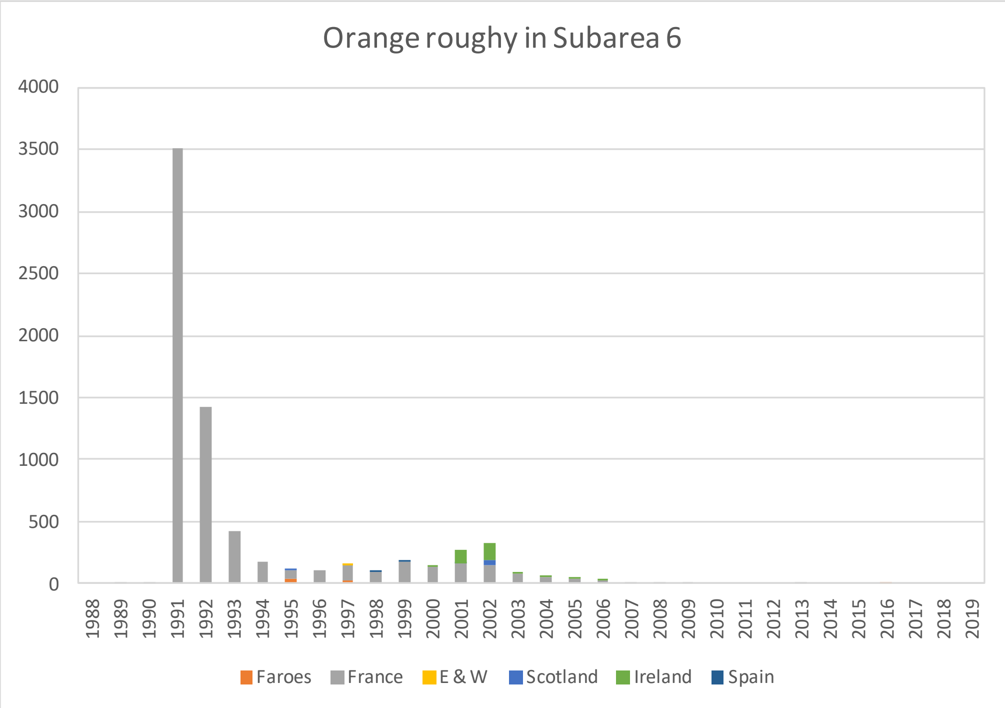


Figure 7.2.1. Time-series of orange roughy landings by country in ICES Subarea 6.

7.2.3 ICES Advice

The ICES advice was published in 2016 for 2017–2020. 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 2017–2020.

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. A zero TAC has been set for orange roughy in Subarea 6 since 2010.

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

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 and 2019 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 2020.

7.2.7 Management considerations

The fisheries for orange roughy in subareas 6 and 7 have now ceased and a zero EU TAC has been implemented since 2010. 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 recent 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.

7.2.8 Tables

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

Year	Faroes	France	E & W	Scotland	Ireland	Spain	Total
1994	-	179	-	-	-	-	179
1995	40	74	-	2	-	-	116
1996	0	116	-	0	-	-	116
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

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.

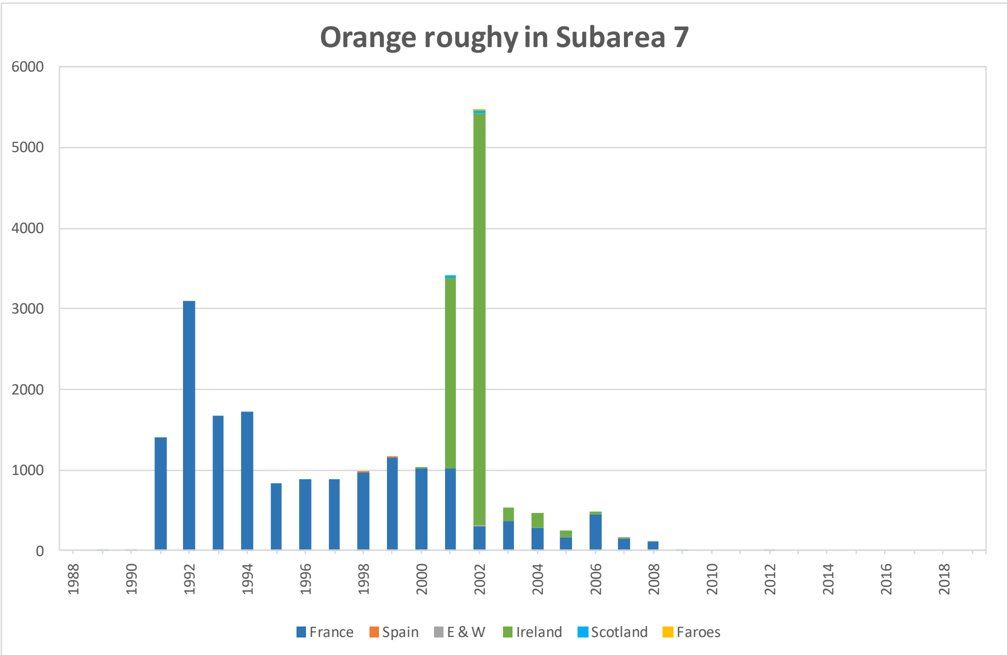


Figure 7.3.1. Time-series of orange roughy landings by country in ICES Subarea 7.

7.3.3 ICES Advice

The ICES advice was published in 2016 for 2017–2020. It applies to orange roughy in the North-east Atlantic and states that when the precautionary approach is applied, there should be zero catch in each of the years 2017–2020.

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

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
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 the landings data for orange roughy for the ICES areas as reported to ICES or as reported to the Working Group.

Landings 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.

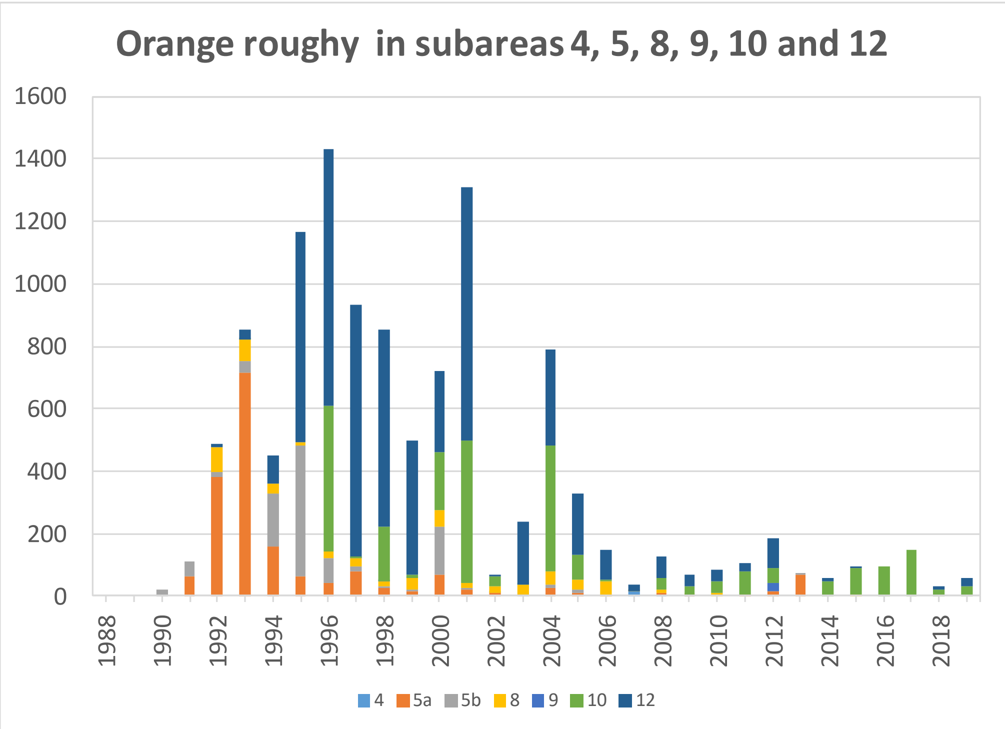


Figure 7.4.1. Time-series of orange roughy landings by subarea in all ICES areas (except subareas 6 and 7).

7.4.3 ICES Advice

The ICES advice was published in 2016 for 2017–2020. 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 2017–2020.

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

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.

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 gender 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 2020.

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 northeast 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

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7.4.9 Tables

Table 7.4.0a. Working Group estimates of landings 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
2012	16	16
2013	54	54
2014	0	0

Year	Iceland	Total
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0

Table 7.4.0b. Working Group estimates of landings 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
2006	0	0	0
2007	0	1	1
2008	0	<1	<1
2009	<1	2	2

Year	Faroes	France	Total
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

Table 7.4.0c. Working Group estimates of landings 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
2000	47	-	5	52
2001	20	-	-	20
2002	20	-	-	20
2003	31			31
2004	43			43

Year	France	Spain	E & W	Total
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

Table 7.4.0d. Working Group estimates of landings 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
1996	0	-	0
1997	0	1	1
1998	0	1	1
1999	0	1	1
2000	0	0	0
2001	0	0	0

Year	Portugal	Spain(1)	Total
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

Included in landings from Subarea 9 until 2002

Table 7.4.0e. Working Group estimates of landings of orange roughy, *Hoplostethus atlanticus*, in Subarea 10.

Year	Faroes	France	Norway	E & W	Portugal	Ireland	Total
1989	-	-	-	-	-		0
1990	-	-	-	-	-		0
1991	-	-	-	-	-		0
1992	-	-	-	-	-		0
1993	-	-	1	-	-		1
1994	-	-	-	-	-		0
1995	-	-	-	-	-		0
1996	470	1	-	-	-		471

Year	Faroes	France	Norway	E & W	Portugal	Ireland	Total
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
2019	31 (1)						31

(1) Landings 2014–2019 were from Division 10.b

Table 7.4.0f. Working Group estimates of landings 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

Year	Faroes	France	Iceland	Spain	E & W	Ireland	New Zealand	Russia	Total
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
2013	2								2
2014	11								11
2015	1								1
2016	0								0
2017	0								0
2018	9								9
2019	29								29

Table 7.4.0g. Orange roughy total international landings 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
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

Year	4	5.a	5.b	8	9	10	12	All areas
2017						150		150
2018						21	9	30
2019						31	29	60

7.4.10 Figures

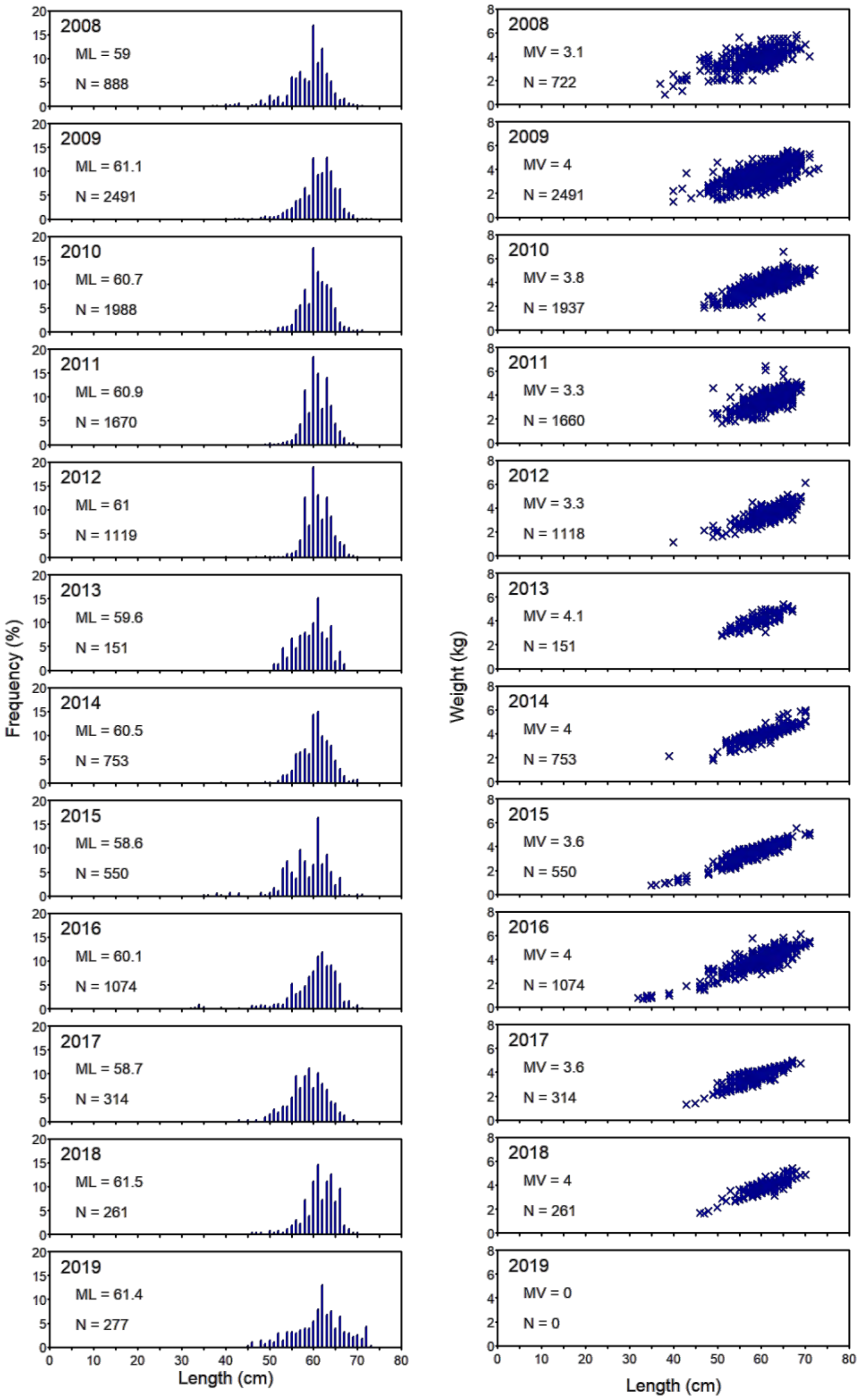


Figure 7.4.1. Length composition and length–weight relation of orange roughy in Faroese catches 2008–2019. There were no weight measurements of orange roughy in 2019.

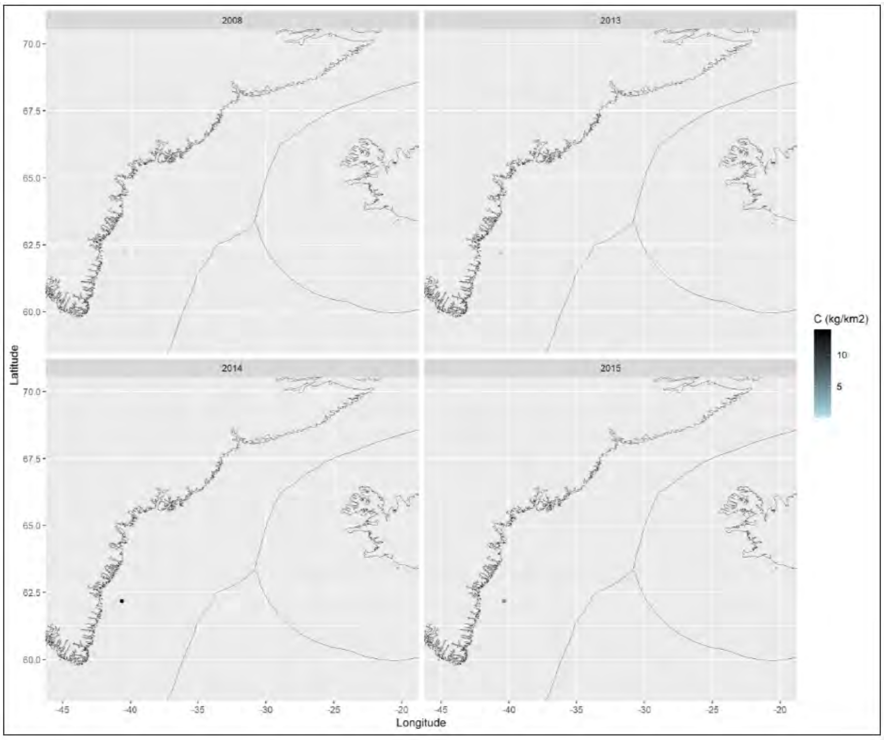


Figure 7.4.2. Distribution of survey catches of orange roughy at East Greenland in 1998–2016. No survey in 2001, 2017 and 2018.

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 seas (divisions 5.b and 12.b, subareas 6, 7);
- the Mid-Atlantic Ridge 'MAR' (divisions 10.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 5.b and 12.b, Subareas 6 and 7 (The Faroe-Hatton area, Celtic seas)

8.2.1 The fishery

The majority of landings of roundnose grenadier from this area are taken by bottom trawlers. To the west of the British Isles, in Divisions 5.b, 6.a, 5.b.2 and Subareas 7, French trawlers catch roundnose grenadier in a multispecies deep-water fishery. The Spanish trawling fleet operates further offshore along the western slope of the Hatton Bank in ICES Divisions 6.b.1 and 12.b.

8.2.2 Landings trends

Over the past two decades, landings from Division 5.b, have reached more than 3800 t in 1991 and more than 2000 t in 2001. Between these two periods, the landings were low (less than 700 t in 1994). After 2001, landings decreased to about 1000 t in 2002 but increased further to about 1840 t in 2005 and then decreased to 74 t in 2011. In 2019, the provisional landings in 5.b are 30 t. These landings are exclusively from French and Faroese trawlers (Table 8.2.0a).

In Subarea 6, the highest landings were observed in 2001 (close to 15 000 t) and have decreased progressively to around 513 t in 2018. Provisional landings are 202 t in 2019. Most of these landings are caught by French and Spanish trawlers (Table 8.2.0b), with small amounts from Scotland.

In Subarea 7, landings close to 2000 t were recorded in 1993–1994, recent annual landings are much lower (from 200-400 t/year in 2005–2007, to around 10 t in 2014-15). Only 2 t were reported in 2018 and provisional landings for 2019 are less than 1 t from France (Table 8.2.0c).

In ICES Division 12.b, the recent landings are exclusively from Spanish trawlers. After a peak to more than 12 700 t in 2004, reported landings have decreased to about 6377 t in 2009, 2900 t in 2011 and 992 t in 2014. In 2015 the landings went down to 363 t and then increased again slightly until the 632 t in 2016 and 1001 in 2017 and 2018. In 2019, provisional landings are around the 457 t (Table 8.2.0d).

There were significant Faroese landings in the mid-1990s, but this fishery disappeared in the 2000s and now amounts for a few t some years. French fisheries have landed up to 1700 t in 2004 but to almost no landings since 2007.

The landings data have been considered uncertain in Division 12.b for several years, because of the possibility of unreported landings in international waters, as well as the fact that some information were not reported by ICES areas. Those landings were allocated to divisions, and problematic data revised (for more information about these issues, see stock annex).

Official landings have been revised for 2018 and are preliminary for 2019.

8.2.3 ICES Advice

ICES advised in 2018 that when the precautionary approach was applied, catches should be no more than 3971 t in each of the years 2019 and 2020. If discard rates do not change from the average of 2015–2017, this implies landings of no more than 3693 t.

8.2.4 Management

TACs for EU vessels for deep-water species have been set since year 2003. These TACs are revised every second year. The EU TAC and national quotas from member countries apply to all vessels in EU EEZ and to EU vessels in international waters.

For Division 5.b and Subareas 6 and 7, a TAC was set at 2558 t for 2019 and 2558 t for 2020. The TAC since EC regulation 1367/2014 was a combined value for roundnose grenadier and roughhead grenadier (*Macrourus berglax*). For 2019 and 2020, this TAC set by EC regulation 2018/2025 is only for roundnose grenadier but with the following rule that "any bycatches for roughhead grenadier should be limited to 1% of each Member State's quota of roundnose grenadier and counted against that quota, in line with the scientific advice".

The rationale for this change is explained in the EC regulation: "According to the advice provided by ICES, limited on-board observations show that the percentage of roughhead grenadier has been less than 1% of the reported catches of roundnose grenadier. On the basis of those considerations, ICES advises that there should be no directed fisheries for roughhead grenadier and that bycatches should be counted against the TAC for roundnose grenadier in order to minimise the potential for species misreporting. ICES indicates that there are considerable differences, of more than an order of magnitude (more than ten times), between the relative proportions of roundnose and roughhead grenadier reported in the official landings and the observed catches and scientific surveys in the areas where the fishery for roughhead grenadier currently occurs. There are very limited data available for this species, and some of the reported landing data are considered by ICES to be species misreporting. As a consequence, it is not possible to establish an accurate historical record of catches of roughhead grenadier".

In Subareas 8, 9, 10, 12 and 14 the TAC was set at 2281 t in 2019 and 2281 t for 2020. This TAC covers areas with minor roundnose grenadier catches (8, 9 and 10), part of this assessment area (Division 12.b, the western slope of the Hatton bank) and the Mid-Atlantic Ridge (Divisions 12.a,c and Subarea 14). The main countries having quotas allocations under this TAC are Spain and Poland. Therefore these quota allocations are based upon historical landings in 12.b for Spain and in 12.a,c (Mid-Atlantic Ridge) for Poland.

The table below summarizes the TACs in the two management areas and landings in the assessment area.

	5.b, 6, 7		8, 9, 10, 12, 14		Total international Landings 5.b, 6, 7, 12.b	ICES predicted
estimates	**EU TAC**	**EU Landings**	**EU TAC**	**EU Landings 12.b**		**catch corresp. to advice**
2005	5253	5777	7190	8782	14558	-
2006	5253	4535***	7190	4361	8896***	-
2007	4600	3880***	6114	4258	8138***	< 6000
2008	4600	2980***	6114	2432	5412***	< 6000
2009	3910	2566***	5197	6377***	8943***	< 6000
2010	3324	1421***	5197	2910***	4332***	< 6000
2011	2924	790***	4573	2905***	3695***	< 6000
2012	2546	546***	3979	1343***	1889***	< 6000
2013	4297	760***	3581	991***	1752***	< 6000
2014	4297	558***	3223	988***	1546***	< 6000
2015**	4010	744***	3644	363***	707***	< 5433
2016**	4078	732***	3279	623***	1005***	< 5511
2017**	3052	633***	2623	1001	1634***	≤ 3897
2018**	3120	521	2099	998	1519	≤ 3971
2019*	2558	232	2281	457	689	≤ 3971
2020*	2558		2281			≤ 3971

*** provisional.**

**** combined TAC for roundnose grenadier and roughhead grenadier.**

***** Revised catches, updated in 2020**

After the introduction of TACs in 2003 and 2005, the reported landings have decreased.

In addition to TACs, further management measures applicable to EU fleets are a licensing system, fishing effort limits, the obligation to land the fish in designated harbours and a regulation for on-board observations according to Council Regulation (EC) No 2347/2002 of 16 December 2002. In Faroese waters, the catch of roundnose grenadier is subject to a minimum size of 40 cm total length.

The stock has been also affected by the EU regulation 2016/2336 establishing specific conditions for fishing for deep-sea stocks, establishing a ban for bottom trawling at depths > 800 m.

8.2.5 Data available

8.2.5.1 Landings and discards

Landings time-series data per ICES areas are presented in Table 8.2.0a-e.

Landings data by ICES areas were available from France, Norway and UK (England, Wales and Scotland) from 2005, and for Spain since 2010. Catch in Subarea 12 were allocated to Division 12.b (western Hatton bank) or 12.a,c (Mid-Atlantic Ridge) according to knowledge of the fisheries from WG members in years prior to 2010.

Catch and discards by haul were available from observer programmes from France and Spain.

French observer programme: Discards data are available routinely from France since 2004 through the Obsmer (observers at sea) program. The length distributions of discards from all these observations has been consistent and stable for the period 2004–2010 with about 30% of the weight and 50% of the number of roundnose grenadier caught being discarded, because of small size. This figure is higher than from previous sampling programme where the discarding rate in the French fisheries was estimated slightly above 20% in 1997–1998 (Allain *et al.*, 2003). These differences may have come from a combination of changes in the depth distribution of the fishing effort and a decrease in the abundance of larger fish as visible in the landings. Since then, the discard rate has been reduced to 12% of the weight of the catch (29% in number of individuals) in 2011 and 6% in weight in 2012 (24% in numbers). In 2013, discards accounts for 15% of the catch in weight and 32% in number. In 2014, discards accounts for 6% of the catch in weight and 16% in number. In 2015 and 2016, discards accounted for 5% of the catch in weight and 15 to 17% in number. In 2017, discards were 6% in weight and 15% in number. In 2018, discards accounted for 3% in weight and 8% in number. In 2019, reported discard rates are almost negligible, with around 0.7% in weight.

The reduction of discards is related to:

1. a change of depth of the French fleet towards shallower waters; and
2. attempts to avoid areas where discards are high.

<u>Spanish Observer programme (Hatton Bank):</u> discard data are available from the Spanish Observer Programme. For the period 2004–2015, observers have covered on average 15±10% (range 3–39%) of the fleet fishing days in Division 6.b, and 12±8% (range 2–33%) in Division 12.b. Discards data for 2011 were not presented as they are considered to be inaccurate but provided again for 2012 and onwards. Although occasionally the discards reached 26% of the total observed weight catch in the period 1996–2015, they are negligible in most sampled months. Annual average discards were around 7% (range 0–21%) in weight in both Divisions 6.b and 12.b (range 0–26%) for that period. These discards, however, correspond to undersized individuals.

In 2017, in area 6.b and 12.b, the discard rate is around 4.7% in weight (5.05% in 6.b and 4.6% in 12.b). In 2018, the discard rate is estimated to be around 2.5% (1.6% in 6.b and 3% in 12.b) , and around 0.32% in 2019 (0.39% in 6.b.1 and 0.26% in 12.b).

8.2.5.2 Length composition of the landings and discards

Length composition of landings and discards were available from France and Spain covering different periods and areas (Figures 8.2.1–8.2.5).

8.2.5.3 Age composition

No new data.

8.2.5.4 Weight-at-age

No new data.

8.2.5.5 Maturity and natural mortality

No new data.

8.2.5.6 Research vessel survey and cpue

Research vessel survey

Data were available from the Marine Scotland deep-water survey since the years 1998 and from stats squares 41E0 through 45E0. This survey operates now on a biannual basis therefore no survey was carried out in 2018. Last survey occurred in 2019.

Lpues from the French trawl fishery to the west of the British Isles

In 2020 no new information was presented as the fishing effort has been greatly reduced. Historical standardized LPUE information based haul by haul data from French skipper's personal tallybooks is included in the Stock annex.

Lpue from the Faroese commercial fleet

In 2020 no new information was presented as the fishing effort has been greatly reduced and more recent landings are at about 1t. Historical standardized LPUE information can be consulted in the stock annex.

CPUE from the Spanish commercial fleet.

CPUE series were calculated from commercial trawlers operating in 6.b.1 and 12.b areas, with effort being the total applied in each area in Kw-day, and the catches only those with any presence of roundnose grenadier in the total catch.

An updated revision of the available data for the period 2010-2019 was included for analysis. A general linear model (GLM) was used to standardize all the CPUE (kg/effort unit) series for the Spanish commercial fleet where the independent variables were the following: year, vessel and fishing area (6.b.1, 12.b). The dependent variable was the log-transformed kg per day measure for variable, which was back-transformed prior to use.

The standardized CPUE time series aims to serve as an approximation for the evolution of the stock in this period, but should be taken with caution, due to the limited number of years currently available and the fact that it only represents the area where the Spanish fleet has higher presence, and not the whole stock area. In addition, the continuous reduction of the effort applied to this stock by all the commercial fleets, could pose an added difficulty to improving the quality of this series in coming years.

8.2.6 Data analyses

Trends from length distribution and individual weight

For France, the modal discarded length has remained constant (Figures 8.2.1) at around 11 cm while the average pre-anal length of the individuals in the landings has decreased from 20.8 cm in 1990 to around 15.5 cm since 2011. There is an increasing trend in the landings since then. The mean pre-anal length for landings was around 15cm in 2018 and 2019 (Figure 8.2.4).

Modal length for landings in 12.b and 6.b1 shows some differences, being in general those from 12.b smaller (Figures 8.2.2 and 8.2.3). Size–frequency data provided by Spain for the period 2001–2019 in 6.b.1 and 12.b shows the modal length (PAFL) of landings to be closely similar between divisions with female being larger than male by around 2 cm (8.2.5). The modal length of discards is around 9.5 cm. Over the period 2001–2019, there is no apparent trend in size of discards.

However, for landed individuals, both the average size for male and female have decreased by 1 cm (from 15.5 cm to 14cm for females and 13.5 to 12.4 cm for males) until 2009. Over the period 2009–2019, in both 6.b.1 and 12.b, the mean length in landings has increased by two centimetres for both males and females in 2010–2014, with a tendency to decrease after 2015. Few discards data were available by the time of the working group. The difference of modes of the length distributions of landed catch between the Spanish fleet in Divisions 6 and 12.b and the French fleet is possibly because of different sorting habits in relation to different markets.

It is therefore important that length distribution of the landings and discards are provided to the working group by all fleets exploiting the stock.

Time-series of mean individual weight from the Marine Scotland Deepwater Science survey shows no clear trends because of big confidence intervals. Average weight is around 0.75 kg in 2017 and 0.5 kg in 2019 but with very wide confidence intervals in most of the cases (Figure 8.2.6).

Trends in abundance indices

Marine Scotland Deep-water Science survey (MSDSS)

The working group was provided this year with an update of the survey indices. There is an increasing trend of abundance over the period 2011–2013. Since 2015, there is however a decrease and the index was close to the long term average of the series. (Figure 8.2.7).

Lpue from the Faroese commercial fleet

In 2020 no new information was presented and the CPUE series available for the Faroese commercial fleet ended in 2014. The historical CPUE time series can be found in the stock annex.

CPUE from the Spanish commercial fleet in 12.b

CPUE indices based on revised catches for the period 2010-2019 were estimated for the Spanish fleet in order to include the 12.b landings into the assessment. The CPUE has declined from 2010 to 2014 with a peak in 2017 followed by a decline in 2018. Preliminary data shows and a slight increase in 2019(Figure 8.2.8). The general tendency of the total catches has been variable previous to 2010, with a general tendency to decrease since 2004, since there seems to be a change in the fishing habits, with a growing tendency for vessels to use this area as a stopover, either on the way out or on the way back, of other fishing grounds, mainly to the NAFO area.

Lpue from the French tallybooks

In 2020 no new information was presented. Stock annex includes the historical CPUE time series, which was available from 2010 to 2015.

Stock assessment

The advice on this stock is based on the framework for advice for ICES category 5 stocks for the entire stock since 2018.

In 2016, it was possible to provide advice on stock as category 1 advice for the part of the stock in subareas 6 and 7 and Division 5.b, but while the advice for the part of the stock occurring in Division 12.b was a catch-only assessment (category 5).

LPUE data from haul-by-haul data provided by French trawlers were used in previous assessments for subareas 6 and 7 and Division 5.b. The decrease in activity and number of boats now prevents the use of those indices in the assessment.

In 2020 an exploratory model using a new index (Marine Scotland Deepwater Survey) that was available up to 2019 was examined. However, this model formulation and the use of this survey as a biomass indicator have not been benchmarked.

Discard data are available back to 1996. Discards have not been included in the assessment as it was considered that sorting patterns of discards and landings in earlier years may have been different.

The ICES framework for category 5 stocks was applied for the 2021-2022 advice. ICES considers that a precautionary reduction of catches should be implemented unless there is sufficient data to access the current level of exploitation of the stock.

The precautionary buffer (20% reduction in landings) was applied in the 2016 advice and the available new data do not change the previous perception of the stock, so it is applied again in 2019. Therefore, ICES advises that when the precautionary approach is applied, catches should be no more than 3177 tonnes in each of the years 2021 and 2022. If discard rates do not change from the average of 2017–2019, this implies landings of no more than 3082 t.

ICES cannot assess the stock and exploitation status relative to MSY and PA reference points because the reference points are undefined.

This stock is classified as Category **1** in the NEAFC categorization of deep-sea species/stocks which implies that NEAFC requires stock-specific management measures since the entire or a significant proportion of the catch is taken in the NEAFC regulatory area.

Previous stock assessment issues

This stock has been benchmarked in 2010 and the assessment methodology based on the surplus production model has not been revised since then. At that time it was considered the assessment was considered to be of category 3. In 2012, this stock assessment was classified as category 1 due to development of short-term forecast.

Yet, some issues have not been resolved since the 2010 benchmark.

Discard time-series is available since 1996 and properly quantified since then. It is supposed from various exploratory runs that discard rates might have been higher at the beginning of the fishery. Because of this, discards have not been included in the past assessments and the impact of this is unknown. The reconstruction of a time-series of discard rates is required for the whole time-series. No new information has been available since then. Prior estimates of discards can only be addressed at the moment through assumptions to be tested.

Additionally, some issues have appeared since then:

- Estimates of r (intrinsic growth rates of the surplus production model) was possibly too high in regards of stock dynamics. This should be explored from modelling and data exploration. The lack of contrast between indices from observation and those predicted using estimates of r is a concern as trends from the model seem to increasingly differ over the years.
- A workaround to the problem above would be to use another model taking account additional information that are not currently taken account by the model such as length distributions and giving more value to recent information from survey indices.
- The French tallybooks, due to the decrease of effort and number of vessels in the deepwater French fisheries are no longer representative to derive abundance indices. The Marine Scotland Science Deep-water survey is available on a biannual basis in line with advisory years and a sufficient time-series has been integrated into the assessment over the

last years. However, comparisons with the French tallybooks showed some strong differences of biomass which leaves some doubt on biomass estimates. The reason for those differences have to be investigated.

- Spanish CPUE based on data from commercial fleet has been also calculated and tested as input for the assessment, combined with French and Scottish indices. The model shows discrepancies between the indices, with strong negative correlations between all of them.
- Multi Year Catch Curves are no longer available. Other indicator of stock status may be considered using for example, length or individual weight.

8.2.7 Management considerations

Previous simulations suggest that fishing mortality is below F_{MSY}.

8.2.8 Benchmark preparation

At this moment, there is no planned benchmark for this stock. In the current state, more work is needed to investigate what is the most appropriate approach to try to integrate the available information and develop a model that represents the dynamics of the stock.

8.2.9 Tables

Table 8.2.0a. Working Group estimates of landings (t) of roundnose grenadier from Division 5.b.

Year	Faroes	France	Nor way	Germ any	Russia/ USSR	UK (E+W)	UK (Scot)	TOTAL
1988				1				1
1989	20	181		5	52			258
1990	75	1470		4				1549
1991	22	2281	7	1				2311
1992	551	3259	1	6				3817
1993	339	1328		14				1681
1994	286	381		1				668
1995	405	818						1223
1996	93	983		2				1078
1997	53	1059						1112
1998	50	1617						1667
1999	104	1861	2			29		1996
2000	48	1699		1		43		1791
2001	84	1932						2016

Year	Faroes	France	Nor way	Germ any	Russia/ USSR	UK (E+W)	UK (Scot)	TOTAL
2002	176	774				81		1031
2003	490	1032				10		1532
2004	508	985	0	0	6	0	76	1575
2005	903	884	1	0	1	0	48	1837
2006	900	875	0	0	0	0	0	1775
2007	838	862	0	0	0	0	0	1700
2008	665	447	0	0	0	0	0	1112
2009	322	122	0	0	0	0	2	446
2010	229	381	0	0	0	0	1	611
2011	63	11	0	0	0	0	0	74
2012	16	28	0	0	0	0	0	44
2013	24	36	0	0	0	0	0	60
2014	33	44	0	0	0	0	0	77
2015	24	28	0	0	0	0	0	52
2016	30	7	0	0	0	0	0	38
2017	9	21	0	0	0	0	0	30
2018	0	6	0	0	0	0	0	6
2019*	19	11	0	0	0	0	0	30

***Provisional.**

Table 8.2.0b. Working Group estimates of landings (t) of roundnose grenadier from Subarea 6.

Year	Esto-nia	Faroes	France	Germany	Ireland	Lithuania	Norway	Poland	Russia	Spain	UK (E+W)	UK (Scot)	TOTAL
1988		27		4							1		32
1989		2	2211	3								2	2218
1990		29	5484	2									5515
1991			7297	7									7304
1992		99	6422	142			5				2	112	6782
1993		263	7940	1								1	8205
1994			5898	15	14							11	5938
1995			6329	2	59							82	6472
1996			5888									156	6044
1997		15	5795		4							218	6032
1998		13	5170				21			3			5207
1999			5637	3	1					1			5642
2000			7478		41		1			1002	1	433	8956
2001	680	11	5897	6	31	137	32	58	3	6942	21	955	14773
2002	821		7209		12	1817		932			6	741	11538
2003	52	32	4924		11	939		452	3			185	6598

Year	Esto-nia	Faroes	France	Germany	Ireland	Lithuania	Norway	Poland	Russia	Spain	UK (E+W)	UK (Scot)	TOTAL
2004	26	12	4574	0	8	961	0	13	72	1991	0	72	7729
2005	80	24	2897	0	17	92	1	0	71	468	0	44	3694
2006	34	25	1931	0	5	112	0	0	0	252	0	15	2374
2007	0	10	1552	0	2	31	0	0	0	354	0	4	1953
2008	0	6	1433	0	0	23	0	0	16	336	0	27	1841
2009	0	6	1090	0	0	0	0	0	0	279	0.3	15	1391
2010	0	13	1271	0	0	0	2	0	0	769**	1.2	23	2079**
2011	0	4	1112	0	0	0	0	0	0	682**	0	8	1806**
2012	0	0	1088	0	0	0	0	0	0	454**	2	0	1544**
2013	0	0	934	0	0	0	0	0	0	661**	6.2032	0	1601**
2014	0	0	630	0	0	0	0	0	0	471**	0	0	1101**
2015	0	0	364	0	0	0	0	0	0	282**	0	0	646**
2016	0	0	422	0	0	0	0	0	0	330**	0	5.368	757**
2017	0	0	99	0	0.5	0	0	0	0	496**	0	8	602**
2018	0	0	184	0	0	0	0	0	0	323	0	5.95	513
2019*	0	0	128	0	0	0	0	0	0	68	0	6	202

*** Provisional. ** Revised catches, updated in 2020.**

Table 8.2.0c. Working Group estimates of landings (t) of roundnose grenadier from Subarea 7.

Year	Faroes	France	Ireland	Spain	UK (Scot)	TOTAL
1988						0
1989		222				222
1990		215				215
1991		489				489
1992		1556				1556
1993		1916				1916
1994		1922				1922
1995		1295				1295
1996		1051				1051
1997		1033		5		1038
1998		1146		11		1157
1999		892		4		896
2000		859				859
2001		938	416			1354
2002	1	449	605		3	1058
2003		373	213		1	587
2004	0	248	320	0	0	568
2005	0	191	55	0	0	246
2006		248	138	0	0	386
2007		207	20	0	0	227
2008		27				27
2009		59				59
2010		41				41
2011		34				34
2012		48		0.18		48
2013		40				40
2014		11				11
2015		10				10

Year	Faroes	France	Ireland	Spain	UK (Scot)	TOTAL
2016		4				4
2017		0				0
2018	0	2	0	0	0	2
2019*		0.8				0.8

*** provisional.**

Table 8.2.0d. Working Group estimates of landings (t) of roundnose grenadier from Subarea 12.b

Year	Estonia	Faroes	France***	Germany	Iceland	Ireland	Lithuania	Spain	USSR/Russia	UK (E+W)	UK (Scotl.)	Norway	Total
1988													0
1989			0						52				52
1990			0										0
1991			14						158				172
1992			13										13
1993		263	26	39									328
1994		457	20	9									486
1995		359	285										644
1996		136	179		77			1136					1528
1997		138	111					1800					2049
1998		19	116					4262					4397
1999		29	287					8251	6				8573
2000		6	374	9				5791		9	6		6195
2001		2	159			3		5922			7	1	6094
2002			14				18	10045		1	2		10080
2003			539			1	31	11663			1		12235
2004		8	1 693				120	10880	91		4		12796

Year	Estonia	Faroes	France***	Germany	Iceland	Ireland	Lithuania	Spain	USSR/Russia	UK (E+W)	UK (Scotl.)	Norway	Total
2005	20	5	508				13	7804	81		350		8782
2006	27	1	85				6	4242					4361
2007	140	2	0				8	4108					4258
2008		0	0				3	2416	13				2432
2009								5335					5335
2010			1					2910**					2911**
2011		3						2905**					2908**
2012		9						1343**					1352**
2013								991**					991**
2014		3.6						988**					992**
2015								363**					363**
2016								632**					632**
2017								1001					1001
2018								998.53					999
2019*	0	3	0	0	0	0	0	454	0	0	0	0	457

*** Preliminary. ** Revised catches, updated in 2020.**

**** French landings reported in former ICES Subarea 12 allocated to 12.b.**

Table 8.2.0e. Working Group estimates of landings (t) of roundnose grenadier unallocated landings in 5.b, 6 and 12.

Year	Unallocated
1988	0
1989	0
1990	0
1991	0
1992	0
1993	0
1994	0
1995	0
1996	0
1997	0
1998	0
1999	0
2000	0
2001	208
2002	504
2003	952
2004	0
2005	0
2006	0
2007	0
2008	0
2009	0
2010	0
2011	0
2012	0**
2013	0**
2014	0**
2015	0

Year	Unallocated
2016	0
2017	0
2108	0
2019*	0

* Provisional. ** Revised catches, updated in 2020.

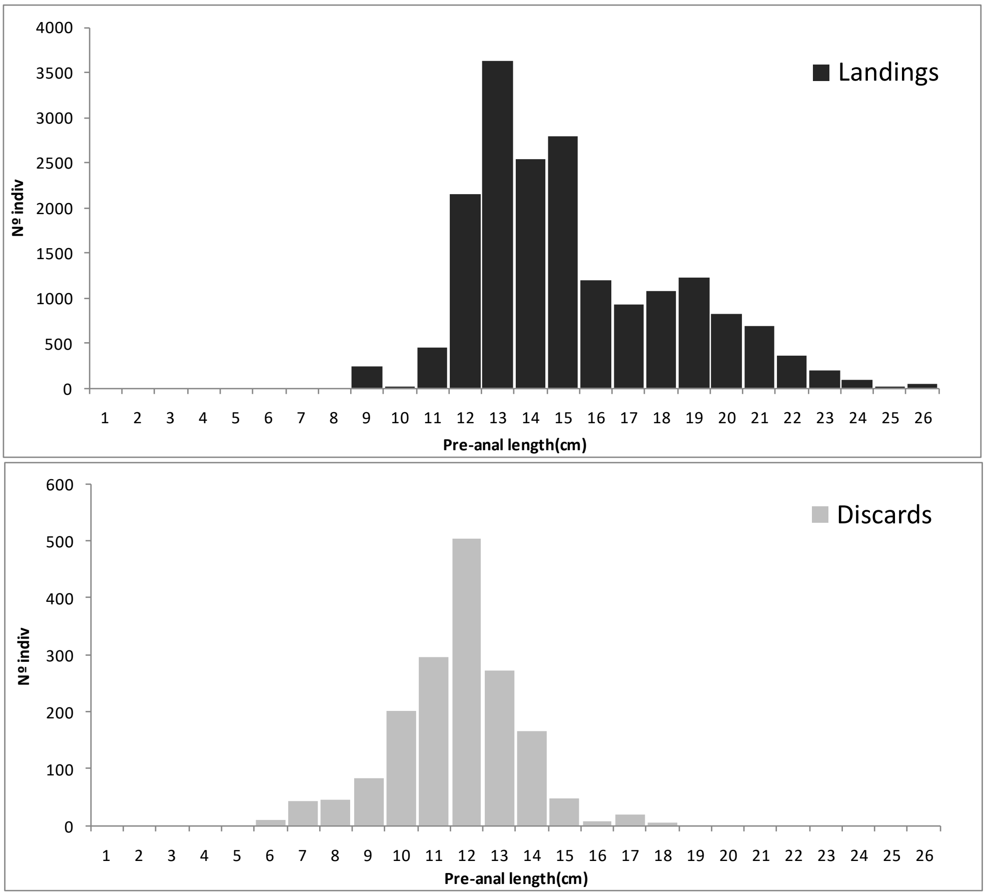
Table 8.2.0f. Working Group estimates of landings (t) of roundnose grenadier 5.b, 6, 7 and 12.b.

Year	5.b	6	7	12.b	Unallocated	5.b,6,7	Overall total
1988	1	32	0	0	0	33	33
1989	258	2218	222	52	0	2698	2750
1990	1549	5515	215	0	0	7279	7279
1991	2311	7304	489	172	0	10104	10276
1992	3817	6782	1556	13	0	12155	12168
1993	1681	8205	1916	328	0	11802	12130
1994	668	5938	1922	486	0	8528	9014
1995	1223	6472	1295	644	0	8990	9634
1996	1078	6044	1051	1528	0	8173	9701
1997	1112	6032	1038	2049	0	8182	10231
1998	1667	5207	1157	4397	0	8031	12428
1999	1996	5642	896	8573	0	8534	17107
2000	1791	8956	859	6195	0	11606	17801
2001	2016	14773	1354	6094	208	18143	24445
2002	1031	11538	1058	10080	504	13627	24210
2003	1532	6598	587	12235	952	8717	21904
2004	1575	7729	568	12796	0	9872	22668
2005	1837	3694	246	8782	0	5777	14559
2006	1775	2374	386	4361	0	4535	8896
2007	1700	1953	227	4258	0	3880	8138
2008	1112	1841	27	2432	0	2980	5411
2009	446	1391	59	5335	0	4046	9381

Year	5.b	6	7	12.b	Unallocated	5.b,6,7	Overall total
2010	611	2079**	41	2911**	0	2731**	5643**
2011	74	1805**	34	2907**	0	1914**	4822**
2012	44	1542**	48	1352**	0**	1634**	2986**
2013	60	1601**	40	991**	0**	1701**	2692**
2014	77	1100**	11	992**	0**	1188**	2180**
2015	52	646**	10	363**	0	708**	1071**
2016	38	777**	4	632**	0	819**	1452**
2017	30	603**	0	1001	0	633**	1634**
2018	6	513	2	998	0	521	1519
2019*	30	202	1	457	0	233	689

*** Preliminary. ** Revised catches, updated in 2020.**

8.2.10 Figures



Figures 8.2.1. Length distribution of the landings and discards of the French fleet in Division 5.b, 6, 7 based from on-board observations in 2019.

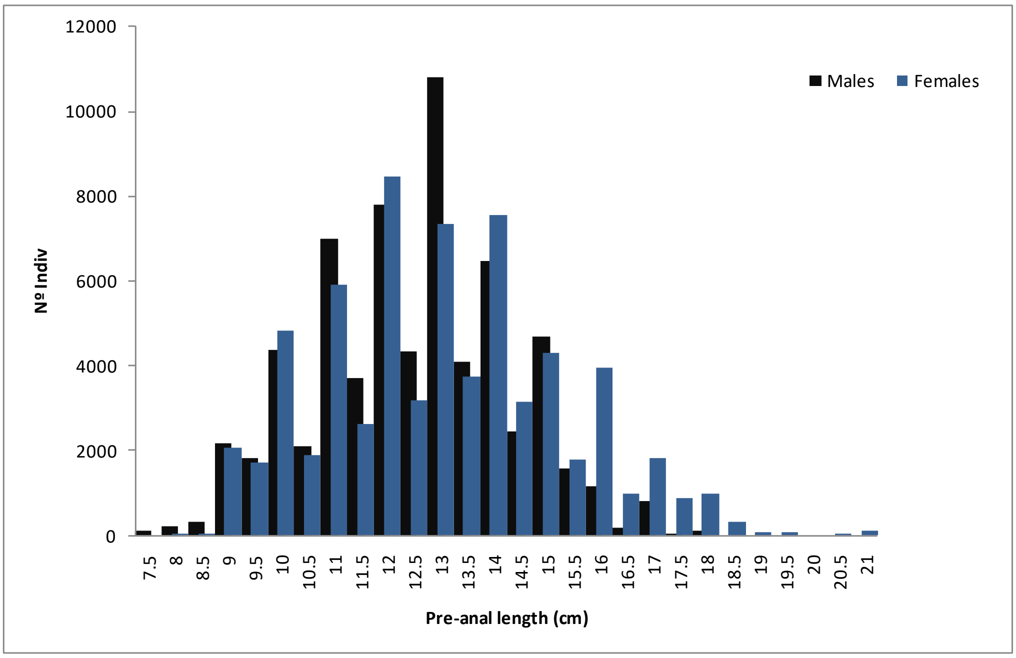


Figure 8.2.2. Length distribution of the landings of the Spanish fleet in Division 6.b.1 based from on-board observations in 2019.

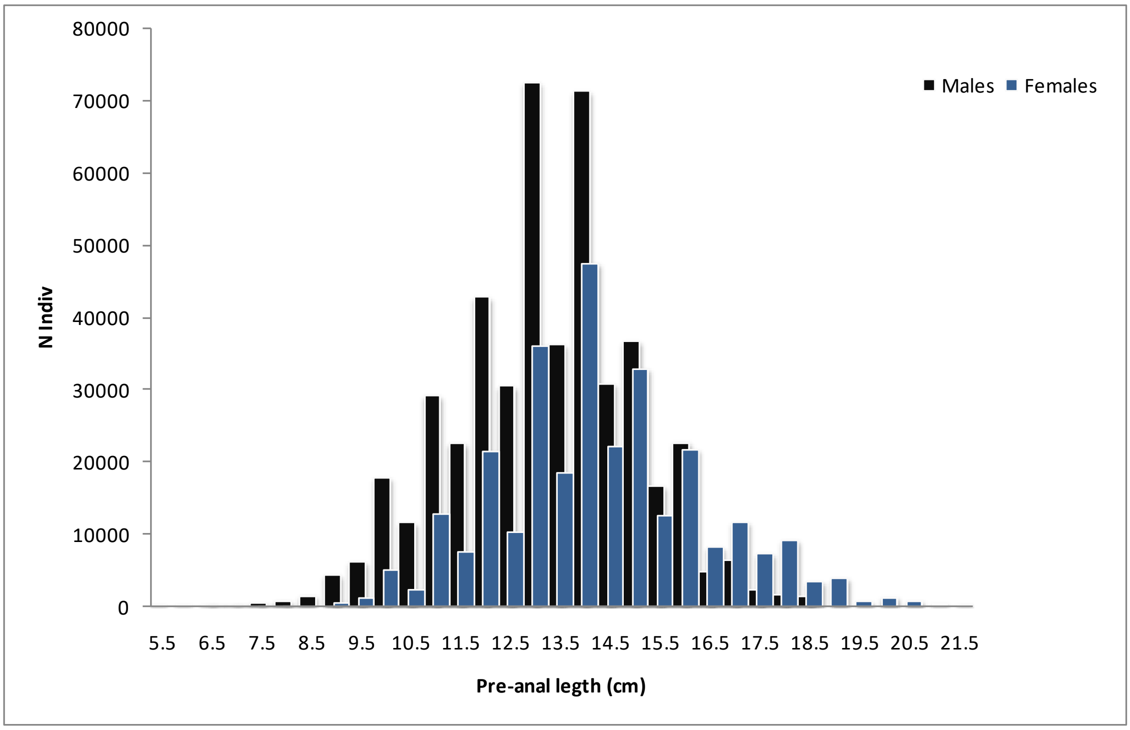


Figure 8.2.3. Length distribution of the landings of the Spanish fleet in Division 12.b based from on-board observations in 2019.

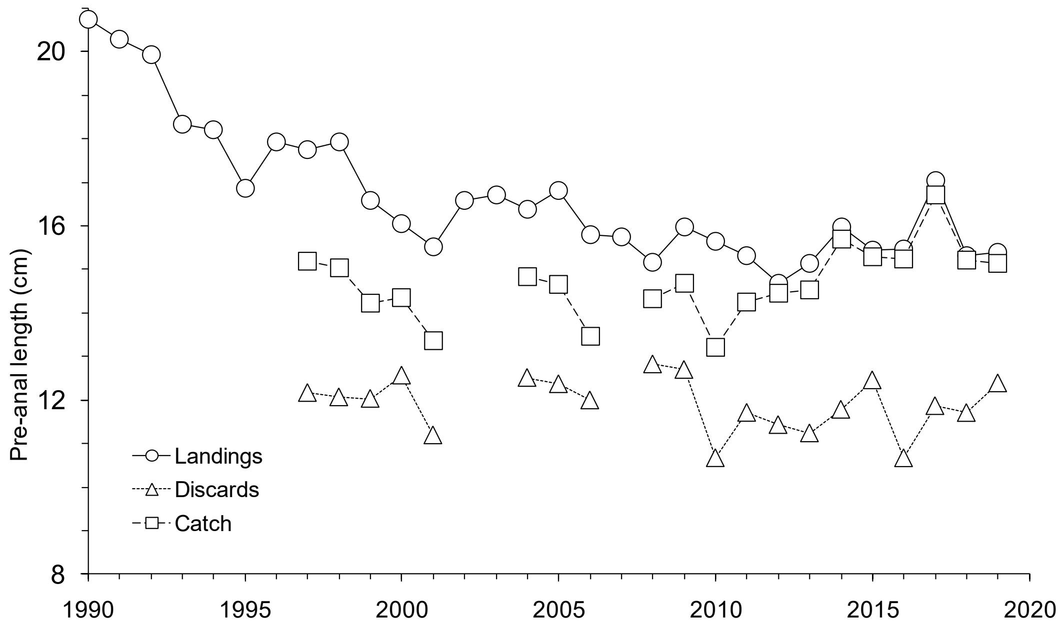


Figure 8.2.4. Evolution of the pre-anal length of roundnose grenadier in the French landings, catch and discards, 1990–2019.

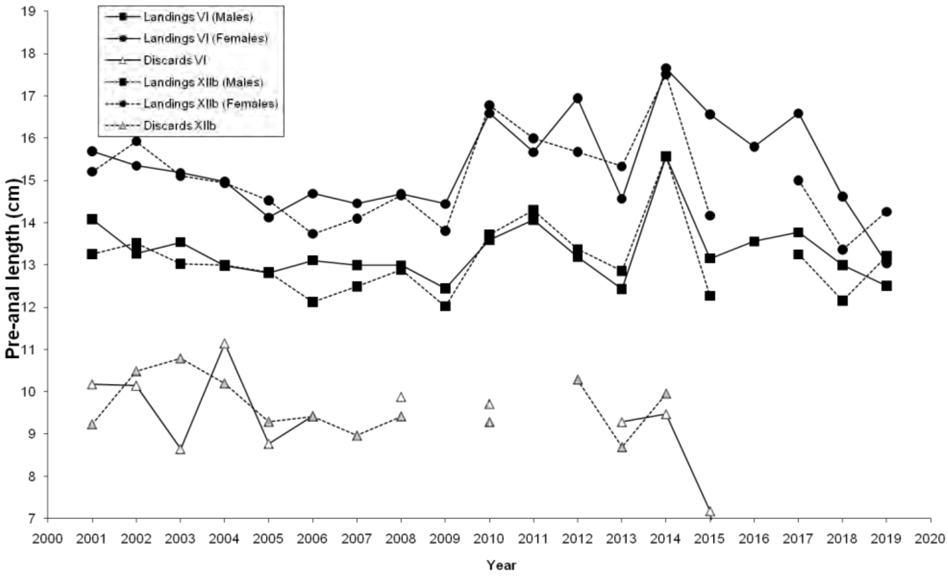


Figure 8.2.5. Evolution of the pre-anal length of roundnose grenadier in the Spanish landings and discards in Divisions 6.b and 12.b, 2001–2019.

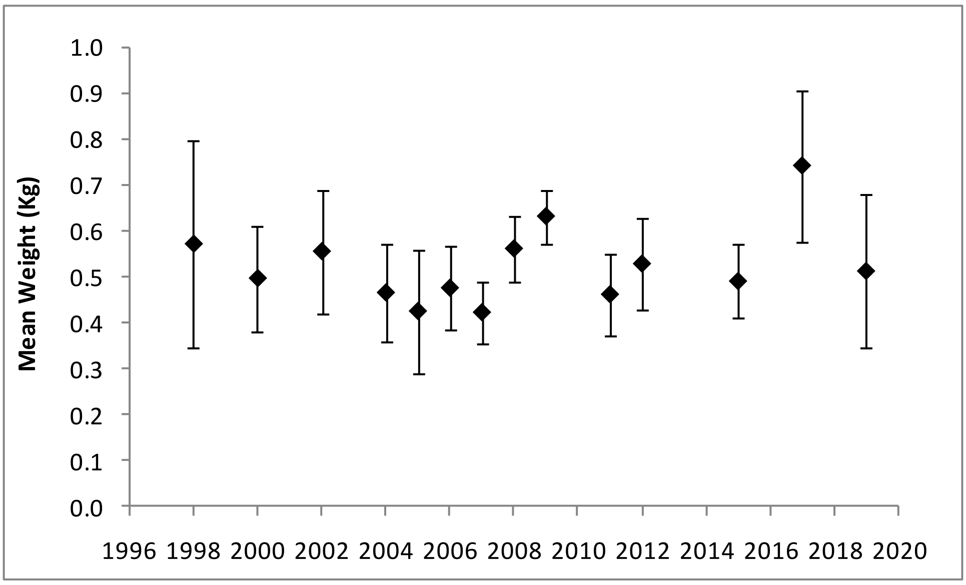


Figure 8.2.6. Mean individual weight of roundnose grenadier according to Marine Scotland deep-water science survey in 6.a.

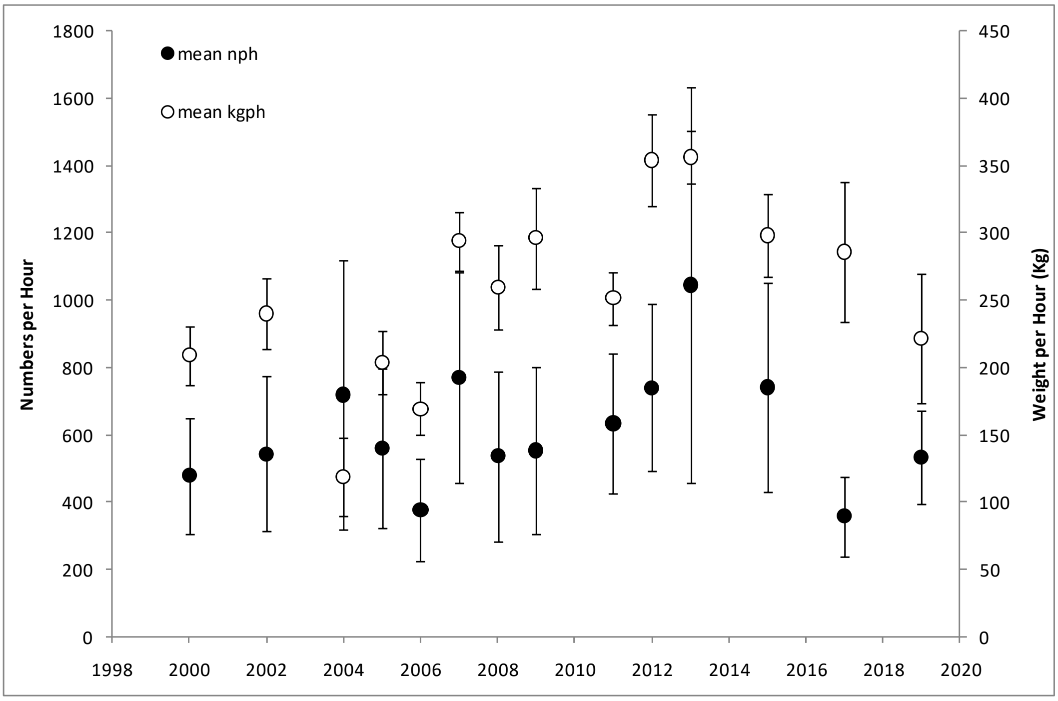


Figure 8.2.7. Abundance indices of roundnose grenadier according to Marine Scotland deep-water science survey in 6.a.

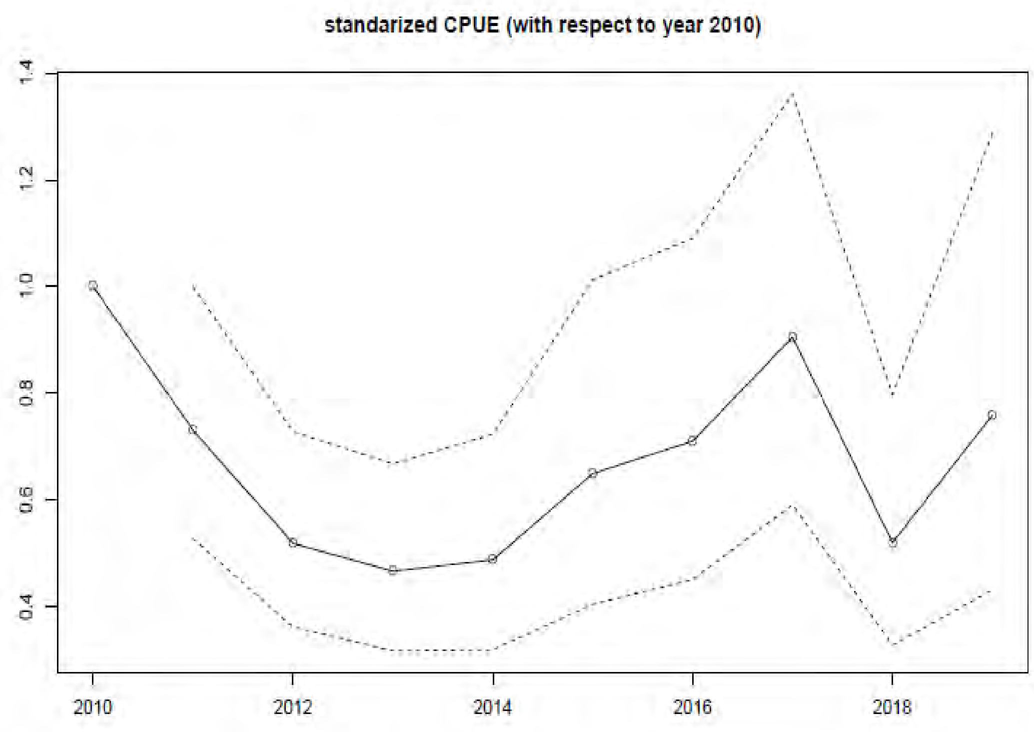


Figure 8.2.8. CPUE from the Spanish commercial fleet operating in 6.b.1 and 12.b. Dotted lines represent the confidence intervals.

8.3 Roundnose grenadier (*Coryphaenoides rupestris*) in Division 3.a (Skagerrak)

8.3.1 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.

8.3.2 Landing trends

The total landings by all countries from 1988–2019 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 bycatches from other fisheries.

8.3.3 ICES Advice

The 2019 and 2020 advice for rng.3a was: "ICES advises that when the precautionary approach is applied, there should be zero catch in each of the years 2019 and 2020".

8.3.4 Management

The directed fishery for roundnose grenadier was stopped in April 2006 based on agreements between Norway and the EU, and has been prohibited since. 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 2018/2020, fixing for 2019 and 2020 the fishing opportunities for EU vessels for fish stocks of certain deep-sea fish species, a TAC was set to 50 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.

8.3.5 Data available

8.3.5.1 Landings and discards

Landings data are presented in Table 8.3.0. Discards are reported from both the Swedish and Danish fishery, but only Danish discards are noticeable for 2019 (Table 8.3.2). Danish discards were 0.5 t in 2019.

8.3.5.2 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.

8.3.5.3 Age composition

Age data are available from 1987 and from 2007-2019 (Table 8.3.3).

These age data are presented in Bergstad *et al*., 2014.

8.3.5.4 Bycatch effort and cpue

There is no new information on bycatch on this species.

Earlier, there has been estimated bycatch of roundnose grenadier in Norwegian shrimp fishery in ICES Division 4.a and 3.a (Figure 8.3.2). 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.

8.3.5.5 Survey indices

There is updated information on the survey indices from the shrimp survey (Table 8.3.4 and Figure 8.3.3). The indices are given as biomass (kg/h) and abundance (number/h). 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.

8.3.6 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 8.3.3). 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.

8.3.6.1 Trends in landings, effort and estimated bycatches

Collated information on landings and survey-based estimates of bycatch suggest that the removals of roundnose grenadier are now at low levels in Division 4.a and 3.a. Although the discards from the fishery in this area now is reported to be at the same level as the landings, the level on reported total catch is 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 are now insignificant and represent bycatches from other fisheries. The estimated bycatch of roundnose grenadier from the Norwegian shrimp fishery is shown to be at low levels (less than 100 tonnes /year) but since both the landings and survey catches are at very low levels now and the stock does not seem to recover. There is some concern that mortality from reported current bycatch levels are not fully accounted for. The application of sorting grids most probably reduces retained bycatch, but there is some uncertainty with regards to survival rates during passage of the grids for this species.

8.3.6.2 Size compositions

The recent length distributions from the Norwegian 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.

8.3.6.3 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, but show a small increase for 2020. 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.

8.3.6.4 Age data

The age frequency distributions from recent year 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.

8.3.6.5 Exploratory assessment

SPiCT was run on the landings data series (1988-2006) and the roundnose biomass index series from the Norwegian shrimp survey (1985-2019).

In an initial run, the entire landings series was used, disregarding the fact that a ban on directed fishing was introduced as of April 2006 and that bycatches have been small since then. Therefore, the landing series was shortened to only include the time period when there was a targeted fishery (1988-2006).

Six different runs were attempted using the input data selected. The results from the different runs are listed in Table 8.3.5. The first run was with program default values, the other five with different levels of the parameters n, alpha and beta; the parameters were fixed using priors. Fixing a parameter can be regarded as imposing a highly informative prior to the parameter and this reduced the credible intervals and produced better fits compared to the default values.

The selected option became run no. 5 (Table 8.3.5) and the output results and figures from this run are shown. The run no. 5 was selected because the credible intervals were small and, in contrast with run no 2, only two of the parameters were fixed. All the other runs show very high confidence intervals and were disregarded.

The diagnostic tests were all not significant and indicated that there was no un-modelled trend or extreme outlying observations in the data (Table 8.3.6).

Summary of the model is shown in Table 8.3.7. and Figure 8.3.4.

The model estimated reference points that are quite sensible based on what we know about the history of the stock and what is thought to be a sustainable level for this stock in this area. The B_{MSY}=14372 tonnes and F_{MSY}=0.1 seems reasonable and MSY=1916 tonnes is at a level of what the landings were before the target fishery expanded rapidly in the early 2000s.

The estimated catch related to MSY also show a reasonable development as the catch was estimated to be below MSY until 1998; when the fishery started to expand and developed into a targeted fishery (Figure 8.3.4). The relative fishing mortality was below F_{MSY} in the first years of the data series, then increased and has been above the F_{MSY} since. The Kobe plot shows the relationship between fishing mortality and biomass since the initial year (1985). The vertical dashed line at Bt=0 indicates the biomass level below which the stock has collapsed. The grey shaded banana-shaped area indicates 95% confidence region of the pair F_{MSY} and B_{MSY}. This plot shows that the stock is now at very low level.

Since the landing series was shortened to only include the period with expanding target fishing, it is worth noting that MSY=1916 tonnes may not be the sustainable level under recent and present conditions with very low survey indices for the stock, apparently low recruitment, and insignificant landings. This MSY relates better to the level that would have been sustainable if the targeted fishery had never expanded to a level which significantly reduced the stock, possibly to a level that impaired recruitment.

Since there are some uncertainties about the effect of shortening the landing series, the estimated reference points will not be included in the assessment this time. However, the results are interesting and it is recommended to further explore how to use the full landing series and still make the best fit to the model.

8.3.7 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.

8.3.8 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 1984–2020. However, this year indices show a small increase but still as low levels. Rejuvenation and growth of the population would at present seem unlikely due to low recruitment during the recent decade. Additionally, there is some uncertainty regarding the effect of the sorting grid in the shrimp fishery and this could be the source of an unknown mortality.

8.3.9 Tables

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

* **Preliminary data.**

Table 8.3.1. Summary of data on the bottom-trawl survey series, 1984-2019. 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
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

YEAR	Survey month	Vessel	IMR Gear code	Additional gear info.	No. trawls >300m	No. trawls >400m	No. trawls survey
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

*** 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 2014-2018.

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

Table 8.3.3. 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 8.3.4. Mean biomass index and mean abundance index from shrimp survey 1984-2020. 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.

	Number (n)	**) Mean biomass (kg/h**	**Standard error (2SE)**	**Mean abundance (n/h),**	**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

	Number (n)	) Mean biomass (kg/h	Standard error (2SE)	Mean abundance (n/h),	Standard error (2SE)
Year	n	(kg/h)	SE(kg/h)	(n/h)	SE(n/h)
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

Table 8.3.5. Results from the six different runs on SPICT with landings period (1988-2006) and survey biomass index (1985–2019). Stochastic reference points are used. cihigh and cilow are high and low confidence levels.

Landings period	1988-2006					
Index	1985-2019					
Run	1	2	3	4	5	6
Parameter settings						
n	mod.est	2	mod.est	2	2	2
Alfa	mod.est	1	1	mod.est	1	4
Beta	mod.est	1	1	mod.est	mod.est	1
Convergence	yes	yes	yes	yes	yes	yes
Parameter estimates						
Bmsy	88605	14419	29548	43151	14372	136664
cilow	29	3350	65	11	3130	46
cihigh	2,6*10^8	62000	1,3*10^7	1,7*10^8	65973	4,1*10^8
MSY	4600	1899	2810	4905	1916	13289
cilow	70	544	239	3	513	6
cihigh	300335	6623	32936	6,9*10^6	7149	3,1*10^7
Fmsy	0,005	0,137	0,092	0,114	0,139	0,097
cilow	0,5*10^-4	0,028	0,001	0,027	0,029	0,042
cihigh	4,517	0,657	6,969	0,579	0,672	2,245
K	399678	35204	141969	92957	35043	280476
cilow	20	6988	25	30	6549	94
cihigh	7,8*10^9	177348	8,0*10^8	2,8*10^8	187499	8,4*10^8
Diagnostics	OK	OK	OK	OK	OK	OK
Retrospective	negative	OK-	negative	negative	OK-	negative

Table 8.3.6. Results of the check of the OSA residuals for catch and index for normality (Shapiro), bias, autocorrelation (Ljung-Box). ns= non significant.

	Shapiro	Bias	LBox	Shapiro	Bias	LBox
Catch	0.1300	0.1244	0.6933	ns	ns	ns
Index	0.8128	0.5042	0.2676	ns	ns	ns

Table 8.3.7. Summary results from the model run no. 5.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 34.1800191
Euler time step (years):  1/16 or 0.0625
Nobs C: 19,  Nobs I1: 31

Priors
     logn  ~  dnorm[log(2), 0.001^2] (fixed)
 logalpha  ~  dnorm[log(1), 0.001^2] (fixed)
  logbeta  ~  dnorm[log(1), 2^2]

Model parameter estimates w 95% CI
           estimate        cilow        ciupp    log.est
 alpha  1.000001e+00    0.9980429 1.001963e+00  0.0000010
 beta   1.410358e+00    0.4028373 4.937749e+00  0.3438435
 r      3.264798e-01    0.0851997 1.251049e+00 -1.1193872
 rc     3.264799e-01    0.0851999 1.251048e+00 -1.1193869
 rold   3.264800e-01    0.0851998 1.251050e+00 -1.1193865
 m      2.860201e+03  965.0366291 8.477139e+03  7.9586472
 K      3.504291e+04 6549.3950358 1.874991e+05 10.4643285
 q      9.730200e-03    0.0023325 4.059090e-02 -4.6325227
 n      1.999999e+00    1.9960832 2.003923e+00  0.6931469
 sdb    3.146284e-01    0.2377783 4.163165e-01 -1.1563632
 sdf    2.169805e-01    0.0816695 5.764766e-01 -1.5279476
 sdi    3.146287e-01    0.2377791 4.163158e-01 -1.1563622
 sdc    3.060202e-01    0.1791096 5.228551e-01 -1.1841041

Deterministic reference points (Drp)
         estimate        cilow        ciupp   log.est
 Bmsyd 17521.45166 3274.6974503 9.374951e+04  9.771181
 Fmsyd     0.16324    0.0425999 6.255239e-01 -1.812534
 MSYd   2860.20101  965.0366291 8.477139e+03  7.958647
Stochastic reference points (Srp)
          estimate        cilow        ciupp   log.est rel.diff.Drp
 Bmsys 1.437200e+04 3130.8880143 65973.130931  9.573037   -0.2191377
 Fmsys 1.386877e-01    0.0285909     0.672742 -1.975531   -0.1770327
 MSYs  1.915894e+03  513.4386560  7149.149246  7.557940   -0.4928807

States w 95% CI (inp$msytype: s)
                    estimate        cilow        ciupp    log.est
 B_2019.00      1280.3943765 287.1613829 5709.0188889  7.1549234
 F_2019.00         0.3127764   0.0830971    1.1772866 -1.1622668
 B_2019.00/Bmsy    0.0890895   0.0129349    0.6136077 -2.4181140
 F_2019.00/Fmsy    2.2552568   0.7523179    6.7606837  0.8132638

Predictions w 95% CI (inp$msytype: s)
                  prediction        cilow        ciupp    log.est
 B_2019.00      1280.3943765 287.1613829 5709.0188889  7.1549234
 F_2019.00         0.3127764   0.0830971    1.1772866 -1.1622668
 B_2019.00/Bmsy    0.0890895   0.0129349    0.6136077 -2.4181140
 F_2019.00/Fmsy    2.2552568   0.7523179    6.7606837  0.8132638
 Catch_2019.00   391.6850274 107.0073625 1433.7065883  5.9704580
 E(B_inf)                NaN          NA           NA        NaN
```

8.3.10 Figures

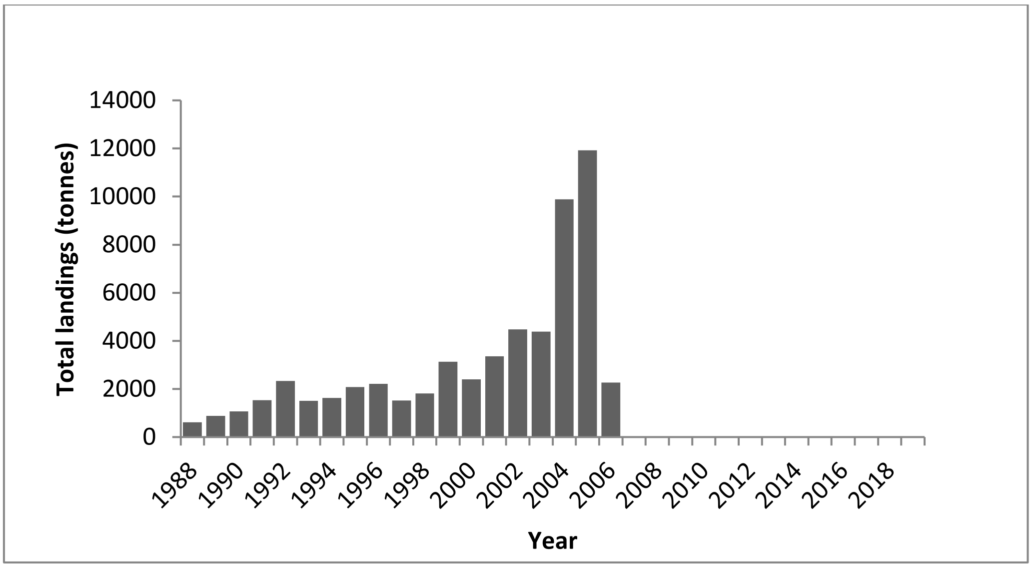


Figure 8.3.0. Landings of roundnose grenadier from Division 3.a. Landings from 2007–2019 are insignificant.

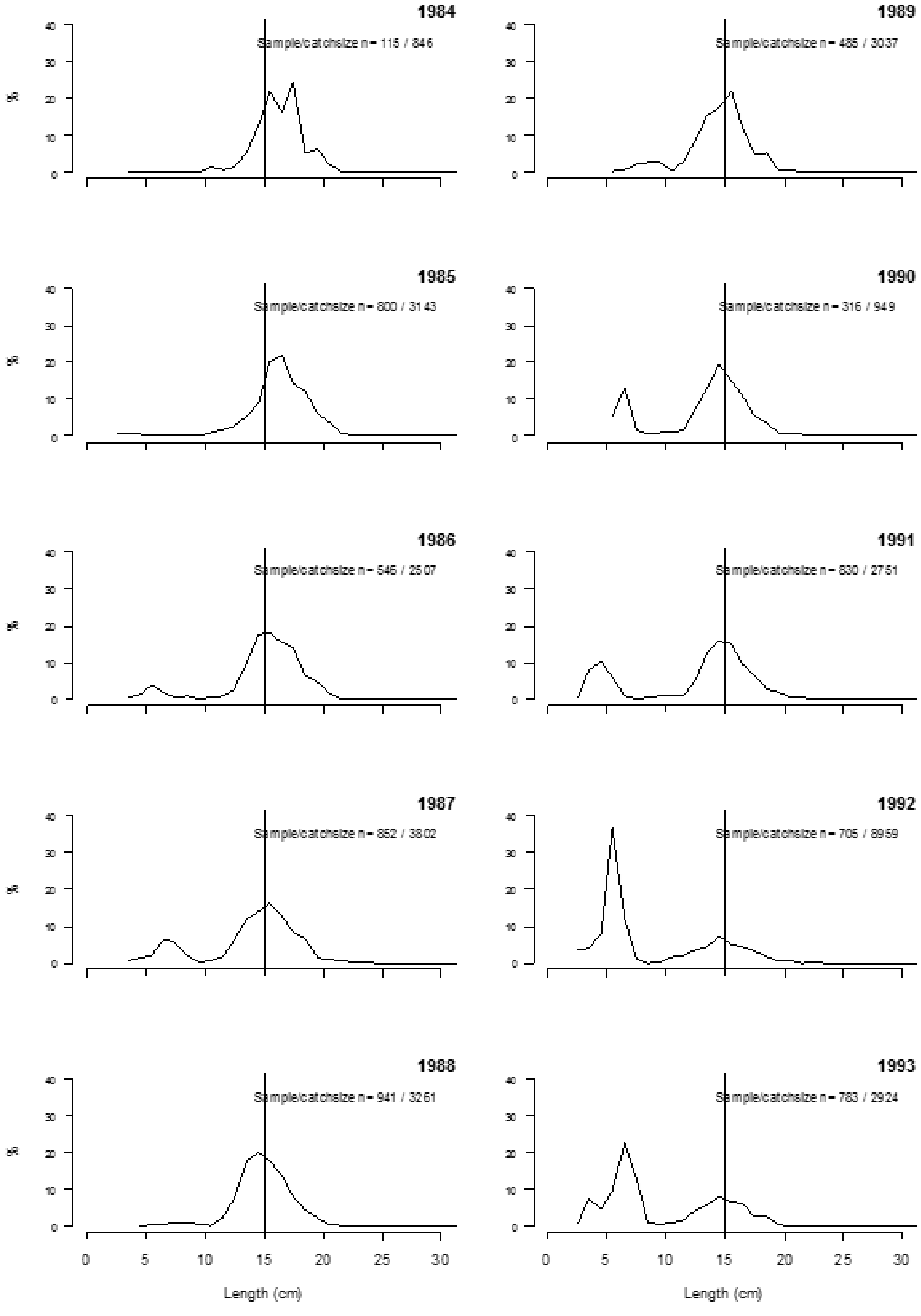


Figure 8.3.1. Length–frequency distributions for roundnose grenadier, 1984–2020. Data from Norwegian shrimp survey, all catches deeper than 300 m. Length is measured as pre-anal length in cm. The distributions are calculated as percent-number of fish in each cm length interval standardized to total catch number and trawling distance for each station each year.

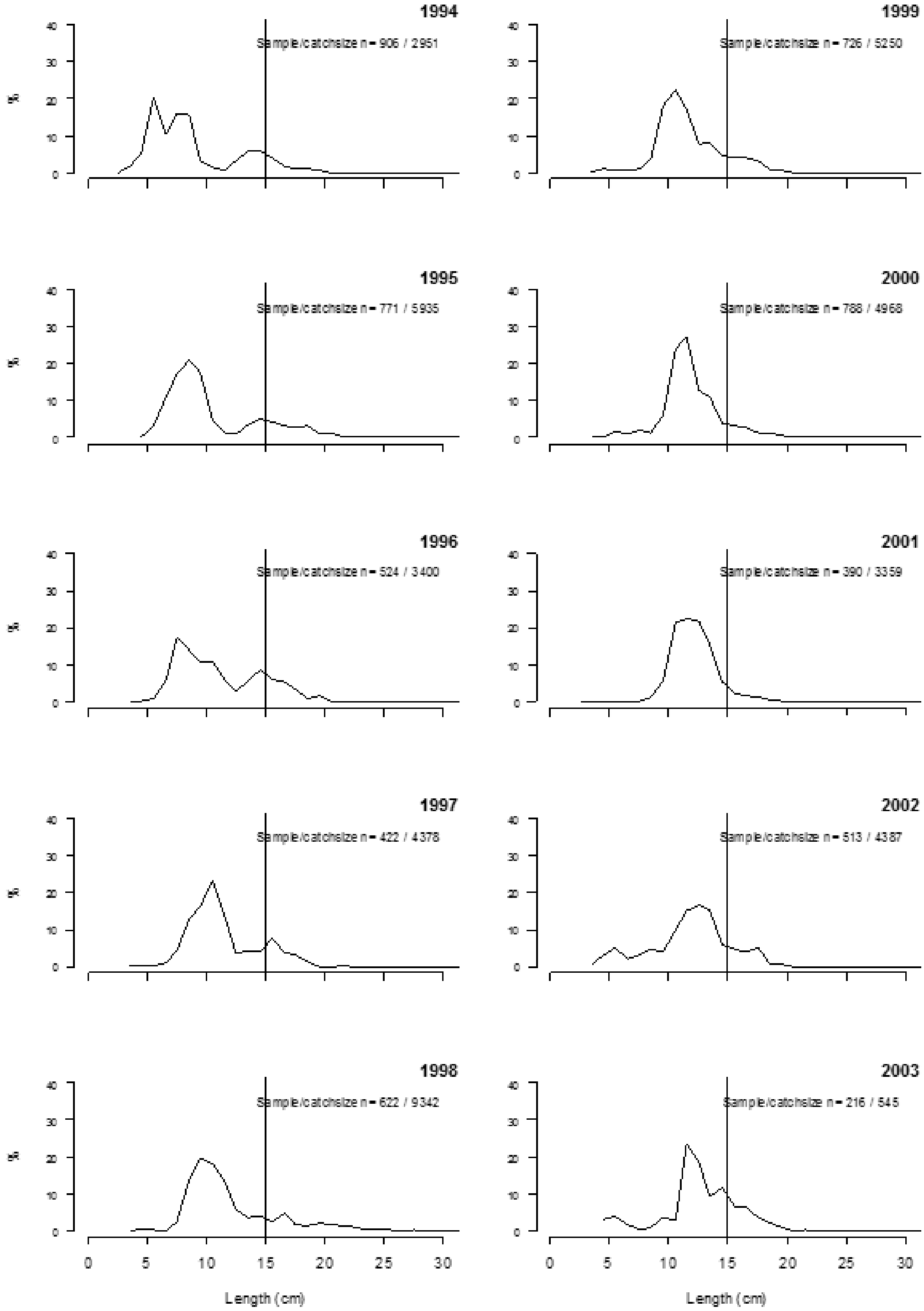


Figure 8.3.1. (Con't).

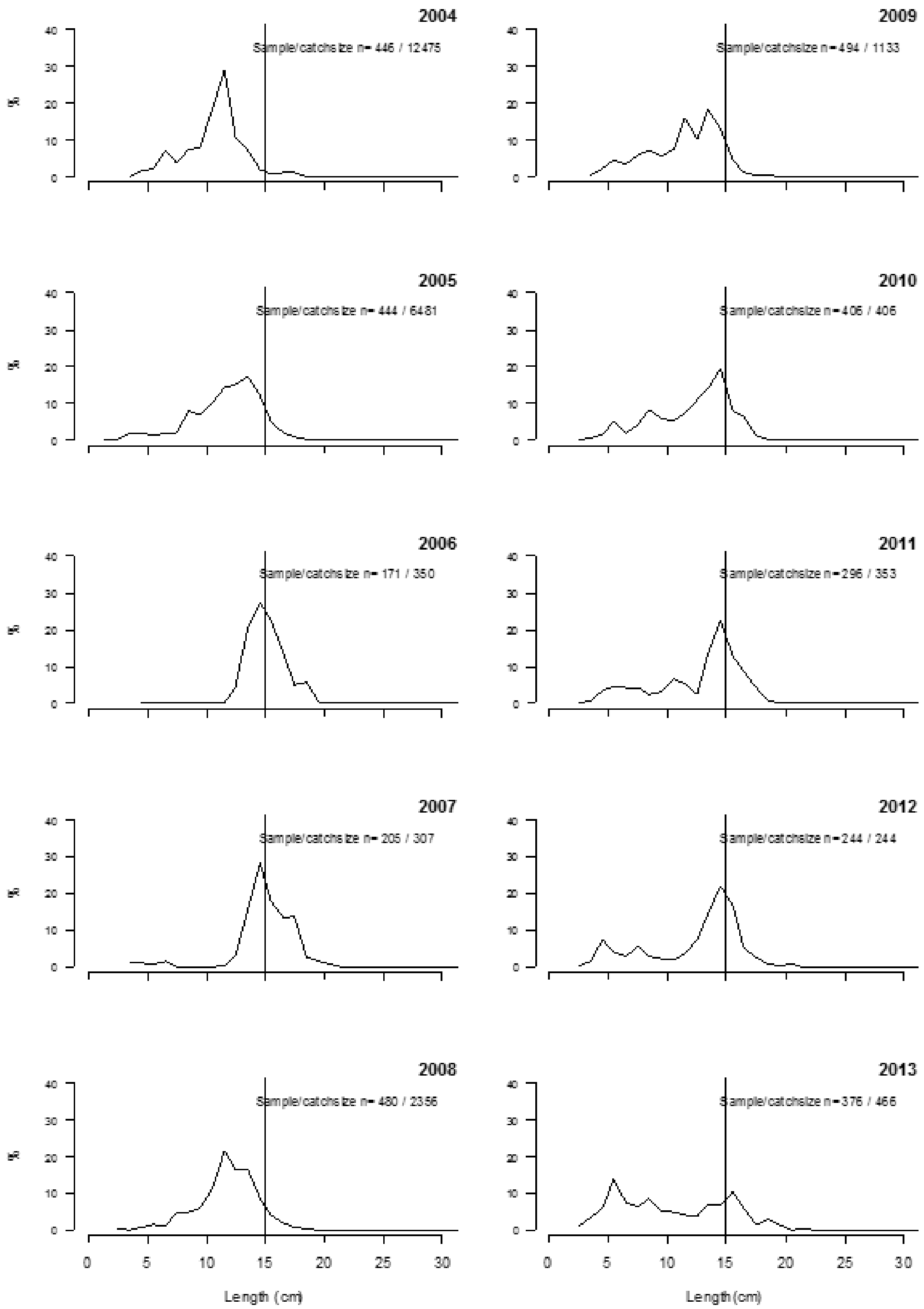


Figure 8.3.1. (Con't).

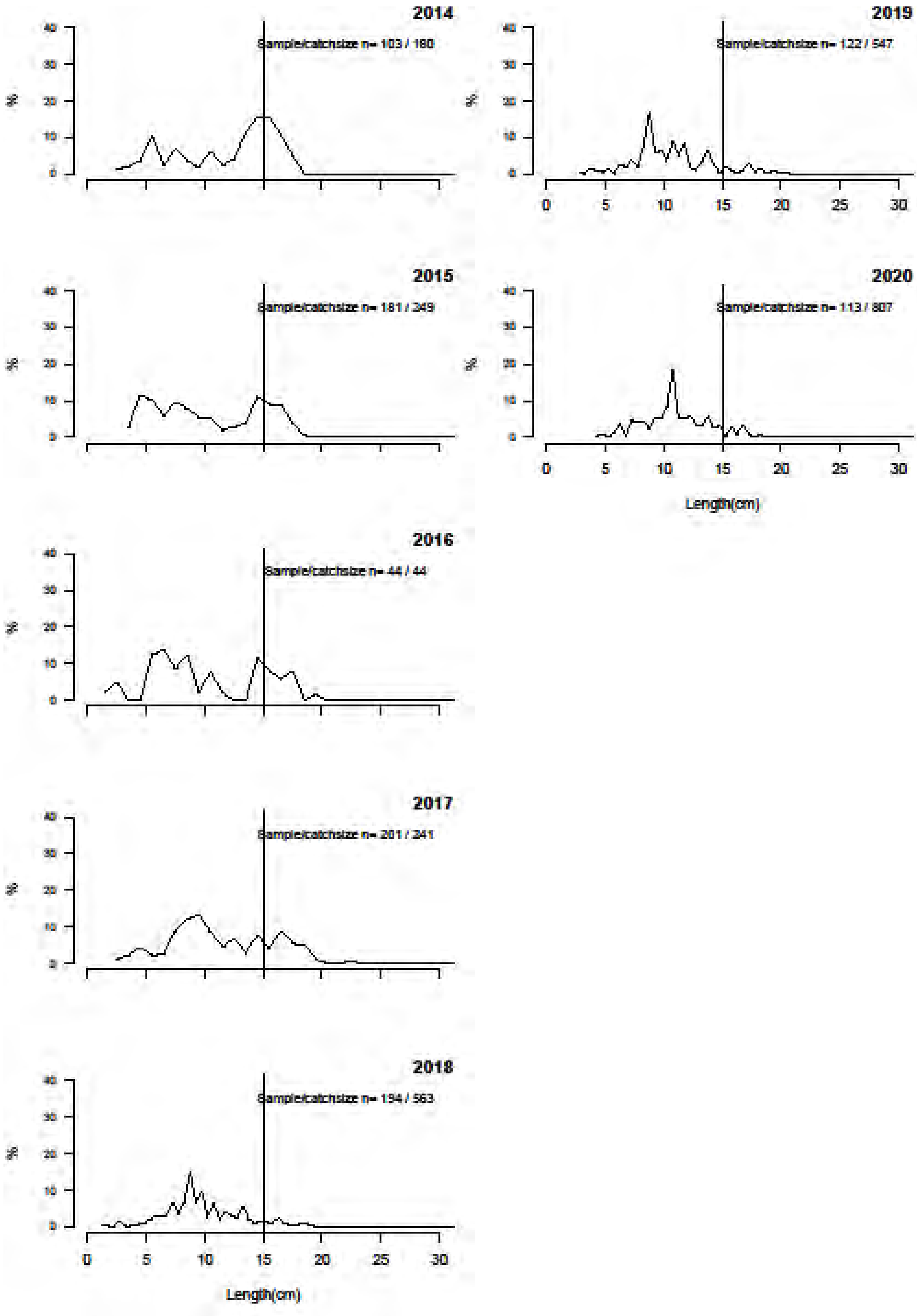


Figure 8.3.1. (Con't).

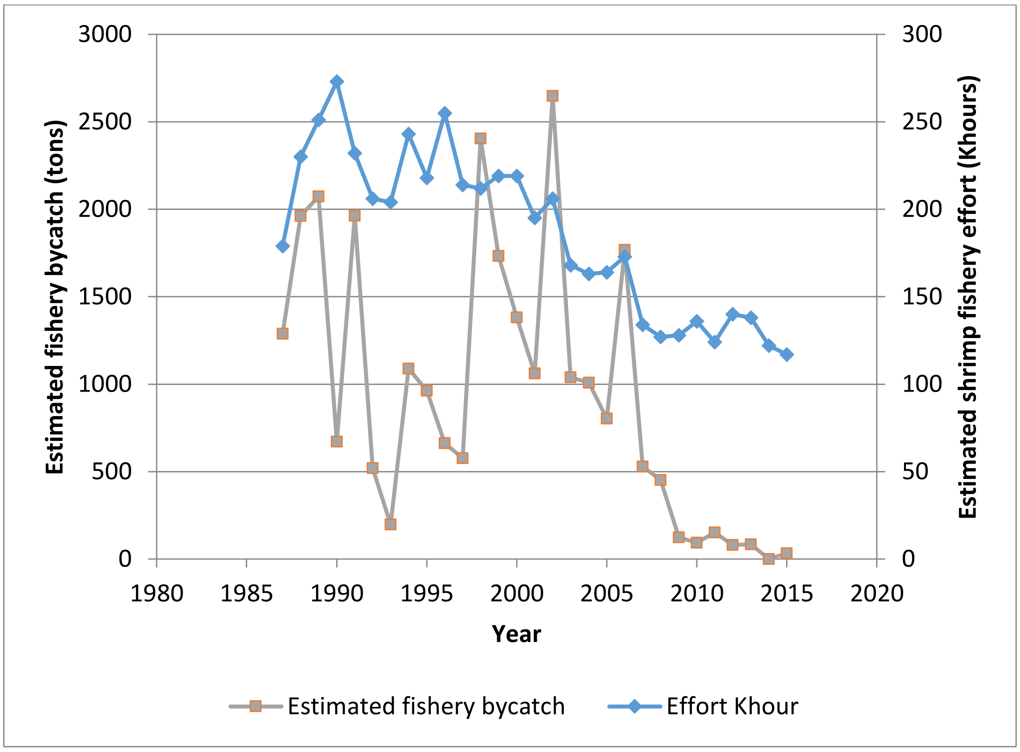
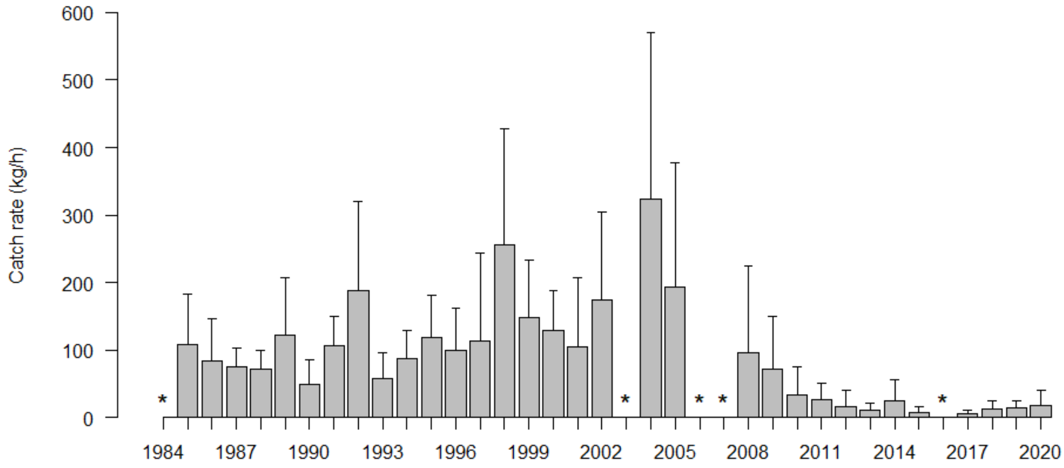


Figure 8.3.2. Estimated bycatch of roundnose grenadier in the Norwegian shrimp fishery in ICES Division 4.a and 3.a, and the estimated commercial shrimp fishery effort in the same area. See text for explanation.



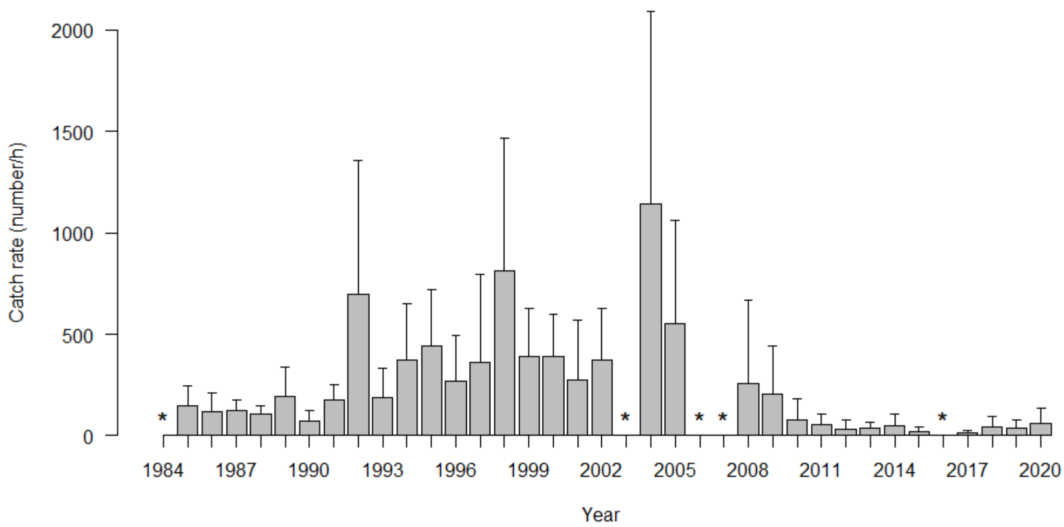


Figure 8.3.3. Survey catch rates in biomass (kg/h) and abundance (nos/h) of grenadier 1984–2020. Note: in 1984, 2003, 2006, and 2007 only a single or no trawls were made deeper than 400 m, thus the primary grenadier habitat was not sampled for those years. For 2016 data from the shrimp survey is regarded 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).

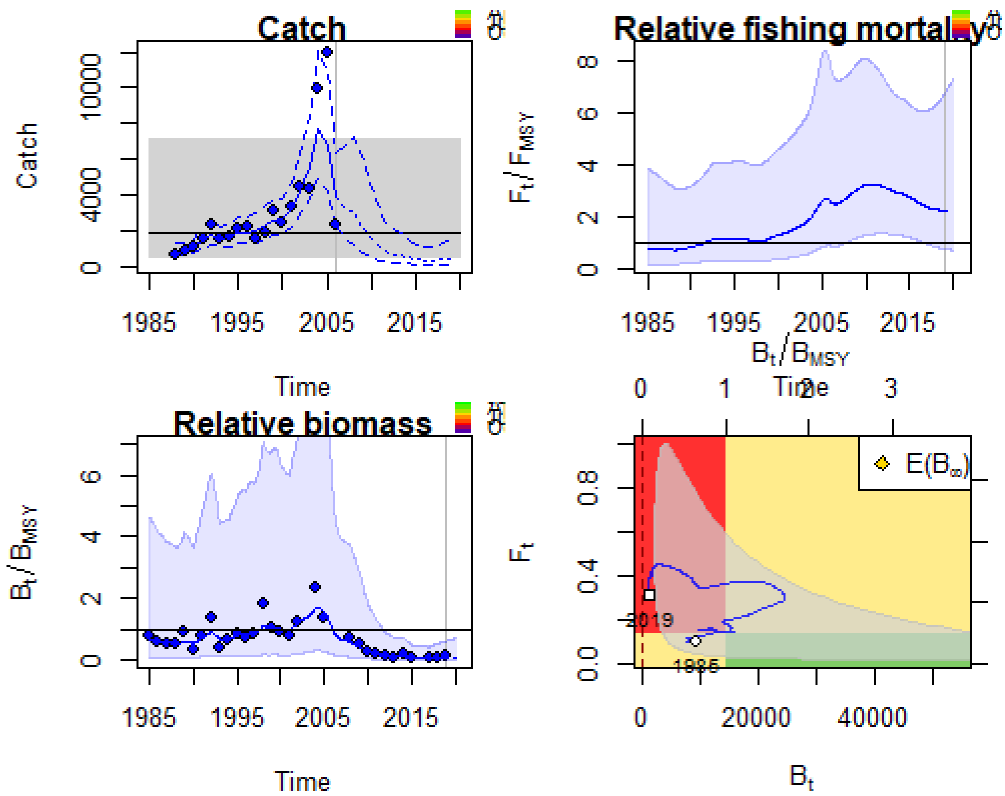


Figure 8.3.4. Upper panel left: Estimated catch (blue line) and observed catch (points). MSY is the black line and shaded grey area is 95% confidence interval of MSY. Upper panel right: Estimated relative fishing mortality (blue line) and shaded blue area is 95% confidence interval of relative fishing mortality. Lower panel left: Estimated relative biomass (blue line) and shaded blue area is 95% confidence interval of relative biomass. Lowe panel right: Kobe plot; development of biomass and fishing mortality since the initial year (1985). The vertical dashed line indicates the biomass level below which the stock has collapsed. The grey banana shaped area indicates the 95% confidence region of the pair F_{MSY} and B_{MSY}.

8.3.11 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.

8.4 Roundnose Grenadier (*Coryphaenoides rupestris*) in Divisions 10.b, 12.c and Subdivisions 5.a.1, 12.a.1, 14.b.1 (Oceanic Northeast Atlantic and northern Reykjanes Ridge)

8.4.1 The fishery

The fishery on the Northern Mid-Atlantic Ridge (MAR) started in 1973, when dense concentrations of roundnose grenadier were discovered by USSR exploratory trawlers. Roundnose grenadier aggregations may have occurred on 70 seamount peaks between 46–62°N, but only 30 of them were commercially important and subsequently exploited. Since the early 1990s, fisheries on MAR have been sporadic and much smaller in scale. USSR/Russian fleet has the maximum length of the history of fishery and took the greatest volume of landings. Since 2010, Russian fleets abandoned the fishery, which is almost exclusively exploited by Spain in recent years.

8.4.1.1 Landings trends

The highest annual catch (almost 30 000 t) was taken by the Soviet Union in 1975 (Figure 9.4.1, see Stock Annex for detailed information) and in subsequent years the Soviet catch varied from 2800 to 22 800 tonnes The fishery for grenadier declined after the dissolution of the Soviet Union in 1992. In the last 15 years, there has been a sporadic fishery by vessels from Russia (annual catch estimated at 200–3200 t), Poland (500–6700 t), Latvia (700–4300 t) and Lithuania (data on catch are not available). Grenadier has also been taken as bycatch in the Faroese orange roughy fishery and Spanish demersal multispecies fishery.

There is no information about target fishery of roundnose grenadier on the MAR in 2006 and 2007. In 2008 and 2009 Russian trawlers made attempts at fishing with pelagic and bottom trawls in the southern part of the Division 12.c. Total catches were 30 t and 12 t respectively including 13 t and 5 t of roundnose grenadier. In 2010, Russian trawler caught 73 t roundnose grenadier during a short-term fishery (two days) in the southern part of the Division 10.b.

In 2008, the Spanish fleet targeting redfish on the MAR reported landings of roundnose grenadier in 14.b.1 totalling 1722 tonnes. Since 2010, roundnose grenadier became a target species. In 2011 official landings in 14.b.1 increased to 2239 tonnes In subsequent years total estimated landings amounted to of 1860, 1790 and 2065 t in 2012, 2013 and 2014 respectively (Table 9.4.2). To these figures an unallocated catch in 14.b.1 of 1098 and 1015 t must be added in 2012 and 2014, respectively. The total estimated preliminary catch in 2014 consists of 3466 t including Spanish catch in 14.b.1, negligible Faroese and French bycatches in 10.a, 12.a and 14.b.1 and discards. Catches have been reported only by Spain since 2015. In 2015 total Spanish catch was declared as 862 t (533 and 329 tonnes in 14.b.1 and 12.a.1 respectively; Table 9.4.3). In 2016 the landings were estimated as 660 tonnes In 2017 and 2018, preliminary official landings were considerably low, not exceeding 84 tonnes In 2019 the landings increased to 215 tonnes, all in Division 12.a.1. (Table 9.4.1 and 9.4.3).

There has been uncertainty in the number of Spanish landings in 2015-2016, and previous report include different figures. Additionally, most landings of roundnose grenadier from the NEAFC Regulatory Area are caught in Division 12.b and 6.b.1, which are part of another stock (rng.27.5b6712b). The current report only includes data for 2019 based on preliminary official landings from InterCatch.

8.4.1.2 ICES Advice

ICES advice applicable to 2018 and 2019

"ICES advises that when the precautionary approach is applied, landings should be no more than 717 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches.".

8.4.1.3 Management

There is a TAC for the roundnose grenadier in Subareas 8, 9, 10, 12 and 14. It applies to European Union (EU) waters and EU vessels in international waters (See Section 9.1.2). The EU TAC combined ICES advices on catch for 2 stocks: the roundnose grenadier in divisions 10.b and 12.c, and in subdivisions 12.a.1, 14.b.1, and 5.a.1 and the roundnose grenadier in subareas 6 and 7, and divisions 5.b and 12.b. This allows for the realization of the full amount of TAC in any of these areas. For 2020, NEAFC recommendation (Rec. 5:2020) on the conservation and management of roundnose grenadier (*Coryphaenoides rupestris*) and other grenadiers in the NEAFC Regulatory Area (Divisions 10.b and 12.c, and Subdivisions 12.a.1 and 14.b.1) specifies:

1. *A total allowable catch limitation of 574 tonnes of roundnose grenadier is established.*
2. *No direct fisheries for roughhead grenadier and roughsnout grenadier should be authorised, and bycatches of these grenadiers as well as other grenadiers (Macrouridae) should be counted against the total allowable catch of roundnose grenadier specified in Point 1.*
3. *Contracting Parties shall submit all data on the relevant fishery to ICES, including catches, bycatches, discards and activity information. Catches should be reported by species. Unidentified grenadiers should be recorded as Macrouridae.*

8.4.2 Data available

8.4.2.1 Landings and discards

From earlier years data are WGDEEP estimates based on national submissions to ICES which are not fully included in InterCatch. Landings are given in Tables 9.4.1–9.4.3. The information on landings have been variable and at a considerably lower level down to insignificant in 2017 and 2018 but have increased to about 215 tonnes in 2019. Landings from the 1970s to the 1990s were reported to be mostly from pelagic trawling. In the 2000s there has been pelagic trawling in Division 14 and bottom trawling in Division 12. There were no discards of roundnose grenadier on Russian trawlers where smallest fish and waste were used for fishmeal processing. The information on discards is very limited. An assessment of discards was conducted in 2014, when the discards on Spanish target fishery estimated by scientific observers was at level of 386 tonnes (Tables 9.4.2). No discards have been reported from 2015–2019. Discards of roundnose grenadier in other fisheries have declined and this can be attributed to the decline of the deep-water fishery overall.

8.4.2.2 Length compositions

No new data on length compositions were presented.

8.4.2.3 Age compositions

No new data on age compositions were presented.

8.4.2.4 Weight-at-age

No new weight-at-age data are available.

8.4.2.5 Maturity and natural mortality

No new data on natural mortality are available.

8.4.2.6 Catch, effort and research vessel data

Catch and CPUE data are given in the Stock Annex. There are gaps in the CPUE time-series due to lack of catch statistics for 1973 and 1982 and absence of target fishery in 1994–1995 and 2006–2009 (data for some years cannot be used owing to short fishing periods). Effort data for each subareas and divisions are available for Russian fleet in 2003–2009. Effort data for Spanish fleet is available for 2010–2019, but information remains very uncertain.

8.4.3 Data analyses

Substantial landings were recorded in the 1970s and 1980s. Since then, landings have been variable and have decreased considerably to around 27 tonnes in 2018. Provisional landings are 215 tonnes in 2019. ICES cannot quantify the corresponding catches.

Since 2010 the official Spanish CPUE and effort data are available (see Stock Annex). The current effort is low compared to the effort developed by USSR vessels in the 1970s and the CPUE seems also low. Long-term comparison is debilitated by the lack of standardisation of fleet and vessel type. The Spanish CPUE in Subdivisions 14.b.1 were on maximum historical levels in 2011. In 2012–2013 the CPUE declined and was stable in 2014–2015. The time-series of the CPUE for Subdivisions 12.a.1 is very limited.

8.4.4 Stock assessment

The ICES framework for category 5 stocks was applied for the 2020-2023 advice (ICES, 2019). ICES considers that a precautionary reduction of catches should be implemented unless there is sufficient data to access the current level of exploitation of the stock.
The precautionary buffer (20% reduction in landings) was applied in the 2015 advice and the available new data (catch statistics) do not change the assessment of the stock. There is no data on abundance trends but in the absence of fishing, the stock is expected to rebuild from the past depletion state caused by exploitation before the 2000s. Therefore, ICES advises that when the precautionary approach is applied, landings should be no more than 717 tonnes in each of the years 2020 to 2023. ICES cannot assess the stock and exploitation status relative to MSY and PA reference points because the reference points are undefined.

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.

8.4.5 Biological reference points

No attempt was made to propose reference points for this stock.

8.4.6 Comments on the assessment

No analytical assessments were carried out.

8.4.7 Management considerations

Active roundnose grenadier fishery was resumed in 2010, but the current status is unknown due to insufficient data. The landings series is very limited and the CPUE data are very uncertain. The CPUE can be use as indicator of the state of stock in future.

8.4.8 References

ICES. 2019. Advice basis. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, section 1.2. https://doi.org/10.17895/ices.advice. 5757

Vinnichenko V., Khlivnoy V. 2008. New data on distribution of young roundnose grenadier (*Coryphaenoides rupestris*) in the North Atlantic Grenadiers of the world oceans: Biology, stock assessment and fisheries. American Fisheries Society, 2008. 119–124 pp.

8.4.9 Tables

Table 9.4.1. Working group estimates of catch for roundnose grenadier from Subareas 12.a.1 and 12.c, between 2012 and 2019 (data from 1973–2011 is shown in the Stock Annex)

Year	USSR/Russia	Poland	Latvia	Faroes	Spain	Lithuanian	Total
2012					864	4	868
2013					118		118
2014				4			4
2015					329		329
2016					289		289
2017[1]					16*		16
2018[1]					27*		27
2019[1]					215*		215

[1]–preliminary statistics. * Subareas 12.a.1 only

Table 9.4.2. Working group estimates of catch for roundnose grenadier from Subdivision 14.b.1.

Year	USSR/Russia	Spain	Unallocated	Discards	Total
1976	11				11

1982	153				153

1997	3361				3361
1998					
1999					

Year	USSR/Russia	Spain	Unallocated	Discards	Total
2000	5				5
2001	69				69
2002	4	235			239
2003		272			272
2004	201				201
2005					
2006					
2007		57			57
2008		1722			1722
2009					
2010		753			753
2011		2239			2239
2012		1860	1098		2958
2013		1790			1790
2014		2065	1015	386	3466
2015		533			533
2016		371			371
2017[1]		68			68
2018[1]	0	0	0	0	0
2019[1]	0	0	0	0	0

[1]–preliminary statistics.

Table 9.4.3. Working group estimates of catch of roundnose grenadier in Divisions 10.b, 12.c and Subdivisions 5.a.1, 12.a.1, 14.b.1, by area.

Year	5.a.1	10.b	12.a.1 and 12.c	14.b.1	Total
1973	820	0	226	0	1046
1974	12561	0	5874	0	18435
1975	0	0	29894	0	29894
1976	0	170	4545	11	4726
1977	0	0	9347	0	9347
1978	0	0	12310	0	12310

Year	5.a.1	10.b	12.a.1 and 12.c	14.b.1	Total
1979	0	0	6145	0	6145
1980	0	0	17419	0	17419
1981	0	0	2954	0	2954
1982	0	0	12472	153	12625
1983	0	0	10300	0	10300
1984	0	0	6637	0	6637
1985	0	0	5793	0	5793
1986	0	0	22842	0	22842
1987	0	0	10893	0	10893
1988	0	0	10606	0	10606
1989	0	0	9495	0	9495
1990	0	0	2838	0	2838
1991	0	0	7510	0	7510
1992	0	0	1979	0	1979
1993	0	249	2912	0	3161
1994	0	0	1132	0	1132
1995	0	0	359	0	359
1996	0	3	344	0	347
1997	0	1	6710	3361	10072
1998	0	1	7600	0	7601
1999	0	3	1151	0	1154
2000	0	0	2325	5	2330
2001	0	0	1716	69	1785
2002	0	0	737	239	976
2003	0	0	510	272	782
2004	0	1	444	201	646
2005	0	799	600	0	1399
2006	0	0	1	0	1
2007	0	0	2	57	59

Year	5.a.1	10.b	12.a.1 and 12.c	14.b.1	Total
2008	0	0	13	1722	1735
2009	0	0	5	0	5
2010	0	73	0	753	826
2011	0	0	0	2239	2239
2012	0	0	868	2958	3826
2013	0	0	118	1790	1908
2014	0	0	4	3466	3470
2015	0	0	329	533	862
2016	0	0	289	371	660
2017[1]	0	0	16*	68	84
2018[1]	0	0	27*	0	27
2019[1]	0	0	215*	0	215

[1]–preliminary statistics. * Subareas 12.a.1 only.

8.4.10 Figures

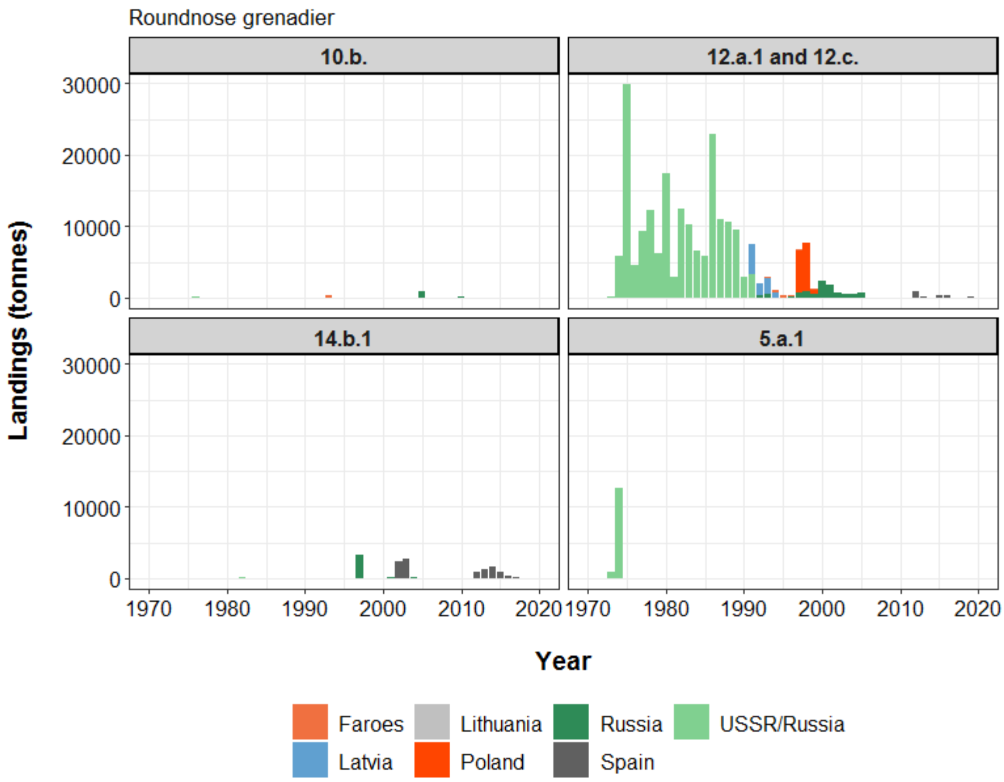


Figure 9.4.1. Landings of roundnose grenadier in ICES Divisions 10.b, 12.c and Subdivisions 5.a.1, 12.a.1, 14.b.1 in 1973–2019.

8.5 Roundnose grenadier (*Coryphaenoides rupestris*) in subareas 1, 2, 4, 8, and 9, Division 14.a, and in subdivisions 14.b.2 and 5.a.2 (Northeast Atlantic and Arctic Ocean)

8.5.1 The fishery

Areas of the main fisheries are covered in the other sections for roundnose grenadier. Landings of roundnose grenadier in subareas 1, 2, 4, 8, and 9, Division 14.a, and in subdivisions 14.b.2 and 5.a.2 are mostly small bycatch of trawl fisheries for other species.

8.5.2 Landings trends

Landing statistics by countries in the period 1990–2016 are presented in Tables 9.5.1–9.5.5.

In the Subareas 1 and 2 the catch of roundnose grenadier in 2016 comprised 4 t and was mainly taken as bycatch by Norwegian fleet. Moreover, insignificant catch of species was declared by France, from 1990 landings varied from 0 to 101 t (Table 9.5.1). The major contribution to the total catch was made by Norway. Roundnose grenadier was partly taken in mixed deep-water fisheries; directed local fisheries in Norwegian fjords for this species also exist. Earlier French landings, that reached 41 t, were assigned to this species however a recent revision of the data indicates that previous landings are more likely to correspond to roughhead grenadier, so there are no French landings for roundnose grenadier in subareas 1 and 2.

In Subarea 4, the catch of roundnose grenadier in 2016 was mainly taken by the French fleet and comprised 2 t. The vessels of Norway and Scotland also had negligible catches. During 1990–2012 total landings in this area varied between 0 and 372 t (Table 9.5.2). The main contribution to the total catch was made by the Danish fleet in 2004. Roundnose grenadier is caught as incidental bycatch in this area by Scottish and Norwegian vessels in insignificant amount as well. As detected for French landings of this species in Subareas 1 and 2, earlier landings of roundnose grenadier in Subarea 4 are likely to correspond to roughhead grenadier but 2014 landings are well assigned. Four tons in 2014 may correspond to catch of roundnose close to the Norwegian deep or to misreported roughhead along the slope of the northern North Sea.

During 1990–2016, the landings of roundnose grenadier within Icelandic waters (Division 5.a) varied 2 to 398 t and were caught by Iceland (Table 9.5.3). Maximum landings were registered in 1992–1997 when 198–398 t were caught annually as bycatch in mixed deep-water fisheries, but it should be noted that it can include other grenadier species till 1990. In recent years, roundnose grenadier landings from 16 to 81 t were taken in Icelandic waters as bycatch in trawl fisheries for Greenland halibut and redfish.

Roundnose grenadier landings in Subareas 8 and 9 during 1990–2014 were minor and amounted 0 to 28 t annually (Table 9.5.4).

Landings from Subdivision 14.b.2 (Greenland and Icelandic waters) in 1990–2016 varied from 1 to 126 t (Table 9.5.5). There is no directed fishery for roundnose grenadier in these areas. The majority of landings is taken as bycatch by Greenland, Germany and Norway during Greenland halibut bottom-trawl fisheries. In 2015 catch was 38 t that mainly was taken by Greenland.

In 2003–2005 unallocated landings were assigned to Subareas 1, 2, 4, 8, 9 and Division 5.a.2 and 14.b.2, the values were 208, 504, and 952 t respectively (Table 9.5.6).

8.5.3 ICES advice

ICES advice applicable to 2015

"The 2012 advice for this stock is biennial and valid for 2013 and 2014 (ICES, 2012). New data available do not change the perception of the stock. Therefore, the advice for this fishery in 2015 is the same as the advice for 2013: Based on the ICES approach for data-limited stocks, ICES advises that fisheries should not be allowed to expand from 120 t until there is evidence that this is sustainable."

ICES advice applicable to 2016 and 2017

"ICES advises that when the precautionary approach is applied, landings should be no more than 65 tonnes in each of the years 2016–2017. ICES cannot quantify the corresponding catches."

ICES advice applicable to 2018 and 2019

"ICES advises that when the precautionary approach is applied, landings should be no more than 65 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches."

ICES advice applicable to 2020 and 2023

"ICES advises that when the precautionary approach is applied, landings should be no more than 131 tonnes in each of the years from 2020 to 2023. ICES cannot quantify the corresponding catches."

8.5.4 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.

There is a TAC management of the roundnose grenadier fisheries in Subareas 1, 2, 4, 8, 9, Division 5.a and Subdivision 14.b.1 for European Community vessels. In eastern Greenland, main fishing operations are in Subdivision 14.b.2 and here, TAC of roundnose and roughead grenadier combined has been 1000 tonnes between 2010 and 2020.

8.5.5 Data available

8.5.5.1 Landings and discards

From earlier years data are WG estimates based on national submissions to ICES, which are not fully included in InterCatch.

Landings are given in Table 9.5.1–9.5.5. Estimated discards owing to bycatch in Spanish fisheries for demersal fish in 8 and 9 did not exceed 2 t in 2012, and 1 t in subsequent years. National catch statistics of Greenland were used to update catches in subarea 14.b.2 from 1999 to 2019. These 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. A potential misreporting is suspected for roundnose grenadier, as scientific surveys have revealed that roughhead grenadier is much more common than roundnose grenadier in ICES Subarea 14.b.2. – while roundnose grenadier is more abundant in reported catches from the same area (WGDEEP 2019: WD05 and WD06). Furthermore, the proportion of the catch from the longline fishery is very unlikely to be roundnose grenadier, since this species is unlikely to be caught by hooks (Hareide, 1995).

Landings of roundnose grenadier inside and outside the NEAFC Regulatory Area are provided in table 9.5.7.

There remains some uncertainty on historical landings and discards, which have not been always accurate or provided by all countries. Therefore, available data needs to be reviewed to provide robust estimations.

8.5.5.2 Length compositions

No new data.

8.5.5.3 Age compositions

No new data.

8.5.5.4 Weight-at-age

No new data.

8.5.5.5 Maturity and natural mortality

No new data.

8.5.5.6 Catch, effort and research vessel data

The Greenlandic annual bottom trawl survey is the main source for fishery-independent data for roundnose grenadier in subarea 14.b.2 (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 although no survey in 2001, 2017, 2018 and 2019 was carried out.

8.5.6 Data analyses

Catches of roundnose grenadier in Subarea 14.b.2 have been relatively stable between 1999 and 2019, ranging from 31 tonnes (2008) to 156 tonnes (2019). The majority of this is caught as bycatch by trawlers, whereas longlines contribute to a smaller proportion.

Length distribution data from surveys in Subarea 14.b.2 show varying modes between years. Typically, sizes between 3 cm to 10 cm dominates but no clear temporal pattern is evident (Fig. 9.5.1). In 2016, the highest indices of biomass and abundance were found at depths between 1001-1500 m (Table 9.5.8). The biomass index shows that for 1998 to 2016, the biomass generally decreased (from 3039 t in 1998 to 170 t in 2016) yet higher indices were estimated in some year, e.g. 2003 and 2012 (Fig. 9.5.2).

Biological reference points

There are no reference points for this stock.

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.

8.5.7 Comments on the assessment

No assessment.

8.5.8 Management considerations

This is a bycatch fishery and advice for other stocks and fisheries should take into account advice on this stock. Trends in landings may reflect changes in activity in other fisheries rather than in stock abundance. Most landings since 2000 are from divisions 5.a.2 and 14.b.2, and have been mostly stable. Landings from other areas were negligible since 2016. There are no reported catches inside the NEAFC regulatory area.

8.5.9 References

Hareide, N. 1995. Comparisons between longlining and trawling for deepwater species - selectivity, quality and catchability - a review. In Deep-Water Fisheries of the North Atlantic Ocean Slope (Hopper, A. G., ed.), pp. 227-234. Amsterdam: Kluwer Academic Publishers.

8.5.10 Tables

Table 9.5.1. Working group estimates of landings of roundnose grenadier from Subareas 1 and 2.

Year	Faroes	Denmark	Germany	Norway	Russia/USSR	Germany	UK (E+W)	France	TOTAL
1990			2		12	3			17
1991			3	28					31
1992		1		29					30
1993				2					2
1994			12						12
1995									0
1996									0
1997	1			100					101
1998				87	13				100
1999				44	2				46
2000									0
2001							2		2
2002				11	1				12
2003				4					4
2004				27					27
2005				12					12
2006				6	2				8
2007				11	1				12

Year	Faroes	Denmark	Germany	Norway	Russia/USSR	Germany	UK (E+W)	France	TOTAL
2008				10					10
2009				8					8
2010				17	6				23
2011				16					16
2012				5					5
2013				17					17
2014				4					4
2015				11					11
2016				2				0	2
2017				4				< 1	4
2018				21				< 1	21
2019*				35					35

*** Preliminary data.**

Table 9.5.2. Working group estimates of landings of roundnose grenadier from Subarea 4.

Year	Germany	Norway	UK (Scot)	Denmark	France	TOTAL
1990	2					2
1991	4					4
1992			4	1		5
1993	4					4
1994	2			25		27
1995	1		15			16
1996			5	7		12
1997			10			10
1998						0
1999		5				5
2000						0
2001				17		17
2002		1	26			27
2003		1	11			12

Year	Germany	Norway	UK (Scot)	Denmark	France	TOTAL
2004			1	371		372
2005		2				2
2006		4				4
2007		1				1
2008						0
2009						0
2010		2	0			2
2011		0	0			0
2012		1				1
2013						0
2014					3	3
2015		1	< 1		1	2
2016		0	0		1	1
2017		< 1			< 1	< 1
2018		< 0.5			< 1	< 1
2019*		< 0.5				< 0.5

***Preliminary data.**

Table 9.5.3. Working group estimates of landings of roundnose grenadier from Division 5.a.2.

Year	Faroes	Iceland**	Norway	UK (E+W)	Denmarck	Greenland	TOTAL
1990		7					7
1991		48					48
1992		210					210
1993		276					276
1994		210					210
1995		398					398
1996	1	139					140
1997		198					198
1998		120					120
1999		129					129

Year	Faroes	Iceland**	Norway	UK (E+W)	Denmarck	Greenland	TOTAL
2000		54					54
2001		40					40
2002		60					60
2003		57					57
2004		181					181
2005		76					76
2006		62					62
2007	1	13	2				16
2008		29					29
2009		46					46
2010		59					59
2011		62					62
2012	0	80					80
2013		84					84
2014		36					36
2015		22			2		24
2016		52					52
2017						2	2
2018		28					28
2019*		15					15

*** Preliminary data. ** includes other grenadiers from 1990 to 1996.**

Table 9.5.4. Working group estimates of landings of roundnose grenadier from Subareas 8 and 9.

Year	France	Spain	TOTAL
1990	5		5
1991	1		1
1992	12		12
1993	18		18
1994	5		5
1995			0

Year	France	Spain	TOTAL
1996	1		1
1997			0
1998	1	19	20
1999	9	7	16
2000	4		4
2001	7		7
2002	3		3
2003	2		2
2004	2		2
2005	8		8
2006	27	1	28
2007	10		10
2008	8		8
2009	1		1
2010	1		1
2011	1		1
2012	0		0
2013	0		0
2014	0		0
2015	1		1
2016	0	0	0
2017	0	0	0
2018	0	0	0
2019*		0	

*** Preliminary data.**

Table 9.5.5. Working group estimates of landings of roundnose grenadier from Division 14.a and Subdivision 14.b.2.

Year	Faroes	Germany	Greenland	Iceland	Norway	UK (E+ W)	UK (Scot)	Russia	Estonia	TOTAL
1990		45	1			1				47
1991		23	4			2				29

Year	Faroes	Germany	Greenland	Iceland	Norway	UK (E+ W)	UK (Scot)	Russia	Estonia	TOTAL
1992		19	1	4	6		1			31
1993		4	18	4						26
1994		10	5							15
1995		13	14							27
1996		6	19							25
1997	6	34	12		7					59
1998	1	116	3		6					126
1999		105	138		19					262
2000		41	107		5					153
2001		11	80		7	2	72			172
2002		25	61		15	1	1			103
2003			70		5	1				76
2004		27	110							137
2005			69		6	1				76
2006		35	79		17					131
2007	1		43		1					45
2008			31					12		43
2009			45		2					47
2010		33	61		7					101
2011		32	138		4					174
2012			126		1					127
2013			129		2					131
2014	0		100		7				4**	111
2015			179							179
2016			79							79
2017			119							119
2018		59	157		1					217
2019*			156		1					157

*** Preliminary data. ** Estonian landings in 2014 not reflected in ICES catch statistics.**

Table 9.5.6. Working group estimates of landings of roundnose grenadier from 1, 2, 4, 5.a.2, 8, 9, 14.a and 14.b.2.

Year	1+2	4	5.a.2	8+9	14.b.2	14.a	Unallocated	Total
1990	17	2	7	5	47		0	78
1991	31	4	48	1	29		0	113
1992	30	5	210	12	31		0	288
1993	2	4	276	18	26		0	326
1994	12	27	210	5	15		0	269
1995	0	16	398	0	27		0	441
1996	0	12	140	1	25		0	178
1997	101	10	198	0	57		0	366
1998	100	0	120	20	126		0	366
1999	46	5	129	16	262		0	458
2000	0	0	54	4	153		0	211
2001	2	17	40	7	172		208	238
2002	12	27	60	3	103		504	205
2003	4	12	57	2	76		952	151
2004	27	372	181	2	137		0	719
2005	12	2	76	7	76		0	173
2006	8	4	62	28	131		0	233
2007	12	1	16	10	45		0	84
2008	10	0	29	8	43		0	90
2009	8	0	46	1	47			102
2010	23	2	59	1	101			186
2011	16	0	62	1	174			253
2012	5	1	80	0	127			213
2013	17	0	84	0	131			232
2014	4	3	36	0	111			154
2015	11	2	22	1	179			216
2016	2	1	0	0	79	2		84
2017	4	< 1	2		119			125
2018	21	< 1	28	0	217	2		268

Year	1+2	4	5.a.2	8+9	14.b.2	14.a	Unallocated	Total
2019*	35	< 0.5	0	0	157			192

*** Preliminary data.**

Table 9.5.7. Roundnose 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 (%)
2017	0	125	125	0
2018	0	268	268	0
2019	0	192	192	0

Table 9.5.8 Biomass (t) and abundance (in numbers) with SE of roundnose 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	0.0000	0.0	0.0	0.0	0	0
Q2	401-600	1246	5	0.0000	0.0	0.0	0.0	0	0
	601-800	1475	7	0.0000	0.0	0.0	0.0	0	0
	801-1000	1988	10	0.0015	3.1	2.2	4.9	9839	6566
	1001-1500	6689	7	0.0193	128.9	43.2	45.8	306453	107017
Q3	401-600	9830	11	0.0000	0.0	0.0	0.0	0	0
	601-800	3788	14	0.0000	0.0	0.0	0.0	0	0
	801-1000	755	6	0.0000	0.0	0.0	0.0	0	0
Q5	401-600	1819	3	0.0000	0.0	0.0	0.0	0	0
	601-800	257	6	0.0000	0.0	0.0	0.0	0	0
	801-1200	256	5	0.0214	5.5	2.1	384.2	98206	41556
	1201-1400	986	9	0.0311	30.6	15.7	109.0	107419	55057
	1401-1500	615	5	0.0035	2.1	1.3	13.2	8132	5020
All		36679	100	0.0046	170.2	46.0	14.5	530050	128000

8.5.11 Figures

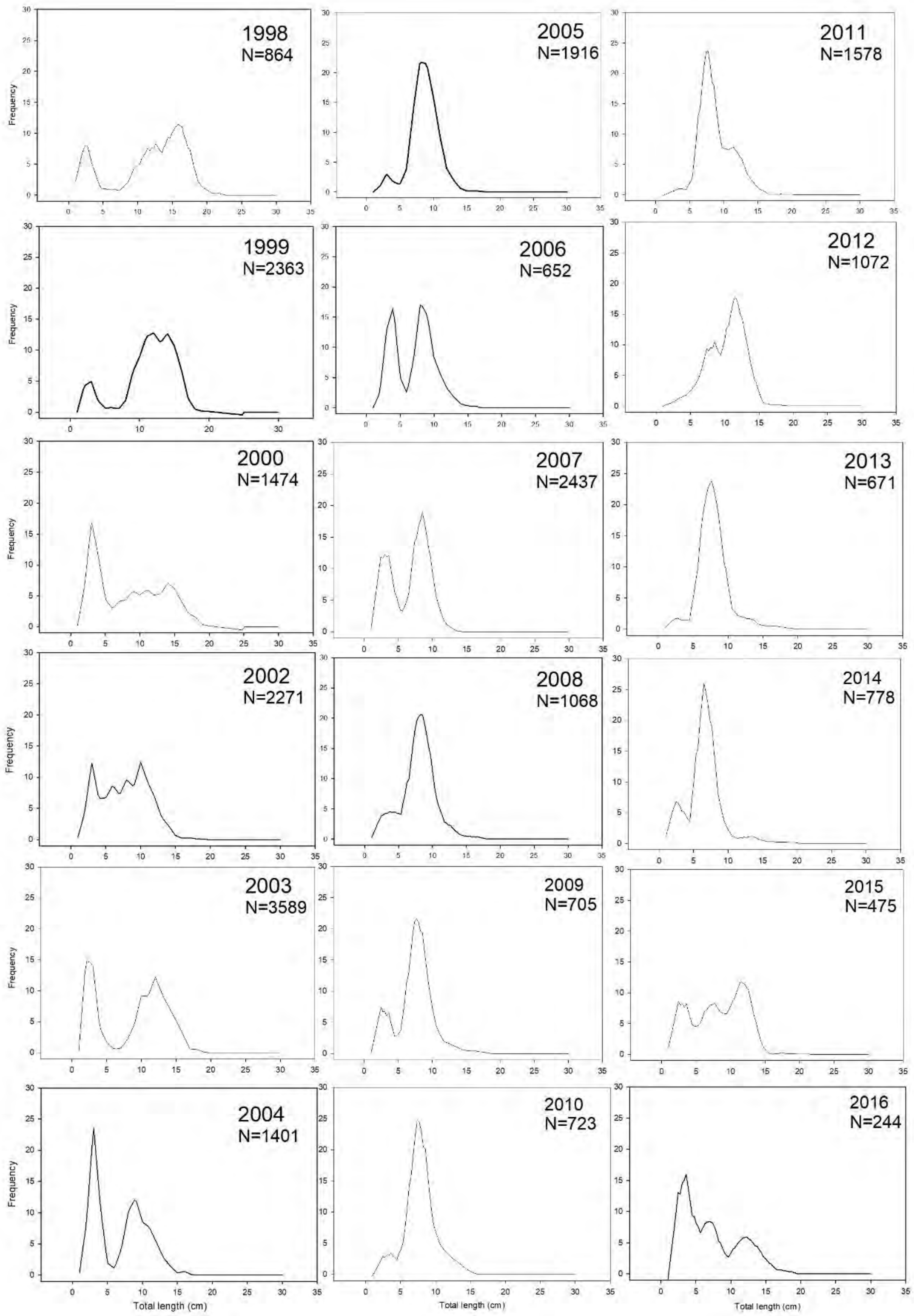


Figure 9.5.1. Length frequency distribution of roundnose grenadier for years 1998-2016 in ICES subarea 14b2. No survey in 2001, 2017, 2018 and 2019.

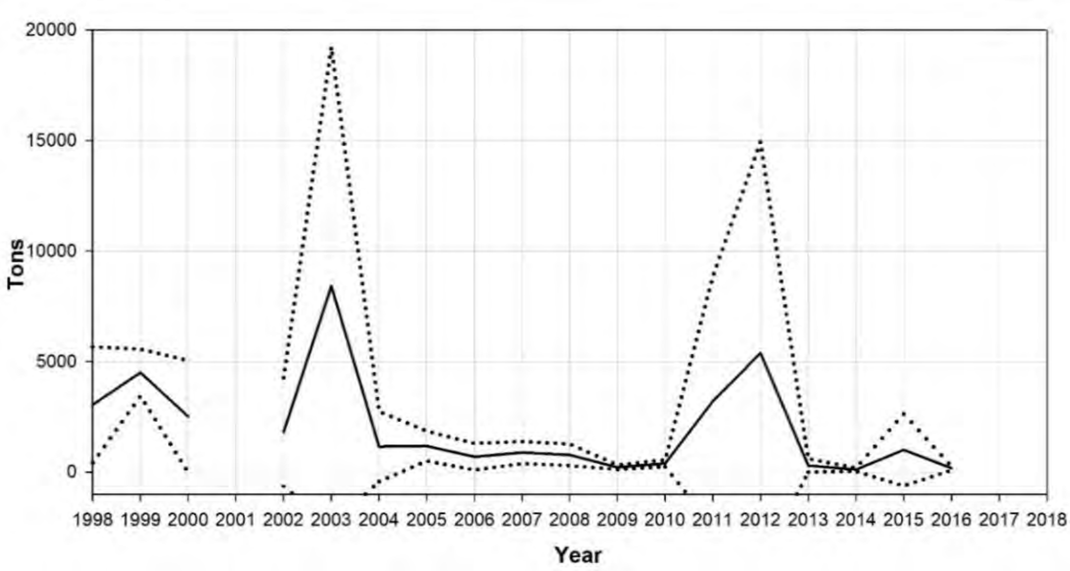


Figure 9.5.2. Total biomass of roundnose grenadier (solid line) in ICES subarea 14b2 plotted with +/- 2*SE. No survey in 2001, 2017, 2018 and 2019.

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.

The stock structure in the whole Northeast Atlantic is still uncertain. Nevertheless, the available information supports the assumption of a single stock from Faroese waters and the west of the British Isles down to Portugal (Farias *et al.*, 2013). The links with other areas such as ICES Subarea 27.10 is less clear, as in this subarea two different species *A. carbo* and *A. intermedius* coexist (Besugo *et al.*, 2014 WD).

Prior to the 2014 Benchmark Workshop on Deep-sea Stocks (ICES, 2015), WGDEEP has considered three assessment units for black scabbardfish (ICES, 2011):

i) Northern (divisions 27.5.b. and 27.12.b and subareas 27.6 and 27.7);

ii) Southern (subareas 27.8 and 27.9);

iii) Other areas (divisions 27.3.a and 27.5.a and subareas 27.1, 27.2, 27.4, 27.10, and 27.14).

The Northern component comprises the black scabbardfish exploited mainly by trawlers while the Southern component by deep-water longliners from Division 27.9.a. In the other areas, the species is exploited by both longliners and trawlers, but till 2010 the overall landings from those areas were globally much lower than at the other two management units.

In recent years, fishing activity in ICES Division 27.5.a has been regular, with landings rounding about 300 ton per year although with a decrease since 2017. To guarantee the consistency of the underlying assumption of a unique stock in NE Atlantic and since there are no evidences against this assumption, in 2016, WGDEEP agreed to include ICES Division 27.5.a in the Northern component.

Furthermore, based on the linkage between the Northern and Southern management units, WKDEEP 2014 concluded that despite the management advice is provided for each of the two management units, the advice should be given by considering the status of bsf.27.nea stock as a whole. The reason for the maintenance of two distinct units when management purposes are considered is related to the fact that the stock is subjected to two main distinct exploitation regimes (different fishing gears and exploited size ranges of the species).

All evidences available support the existence of one single stock doing a clockwise migration within these areas. A dynamic population model was developed for assessing the stock by considering the two components: Northern and Southern. The model was benchmarked at WKDEEP 2014 (ICES, 2015).

The link between the Northern and Southern components and the other areas, excluding ICES Division 27.5.a, is less clear. The component "Other areas" is treated separately from Northern and Southern components.

The present report is structured maintaining the initial separation between units, except for topics related with the stock assessment and the advice.

9.2 Black scabbardfish (*Aphanopus carbo*) in divisions 27.5.b and 27.12.b and subareas 27.6 and 27.7

In this section, fisheries, landings trends, and applicable management are presented for divisions 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 and 27.5.a.

ICES Division 27.5.a initially included in "Other areas" has, since 2016, been included in the Northern Component both for stock assessment analyses and for management considerations.

9.2.1 The fishery

In 2020 there was no updated information on the fisheries taking place in the Northern Component area. As a consequence of the EU Regulation 2016/2336 of 14 December 2016 that bans fishing with bottom trawls at a depth below 800 metres, the fishing effort from European deep-water trawl fisheries is null.

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 (Figure 9.2.1). 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 to1000 m and the trawling hours varies from 6 to 8h, but may last less if the species is very abundant (Ofstad, 2019 WD).

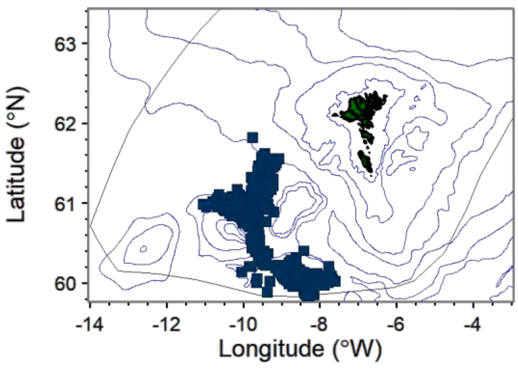


Figure 9.2.1. bsf.27.nea Northern component. Faroese main fishing grounds of black scabbardfish in Subarea 27.5.b (fishing hauls in which the species contributed with more than 50% of the total catch are represented by the dark squares). (Source: Ofstad, 2019 WD)

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 27.5.b and Subareas 27.6, 27.7 and 27.12 show a markedly increasing trend from 1999 to 2002 followed by a decreasing until 2005 (Figure 9.2.2). The peak in landings was registered in 2002 and refers mainly to landings in ICES divisions 27.6 and 27.7. The 2002 peak appears to be majorly driven as a response to the EU TAC management (Figure

9.2.2). From 2009 until 2016, landings have been stable, fluctuating around about 3000 Ton per year. Since 2017, there was a slight decrease.

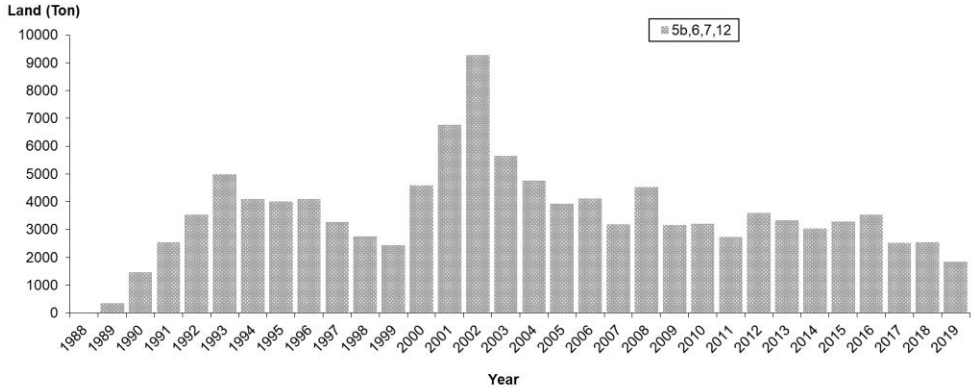


Figure 9.2.2. bsf.27.nea Northern component annual landings time-series for ICES Division 27.5.b and Subareas 27.6 plus 27.7 and 27.12.

In earlier years, French landings represented more than 75% of the Northern component total landings, but in 2002 and 2006 they just represented about 50%. From 2009 to 2012, the relative importance of French landings, particularly at ICES Subarea 27.6, augmented, decreased until 2015 and increased until 2017 to decrease again from 2017 to 2019. During that period, Spanish landings of black scabbardfish followed an inverse trend to those of French landings, but also decreasing in 2019, whereas Faroese landings increased from 2017 to 2019, which resulted on increase in their relative contribution (Figure 9.2.3).

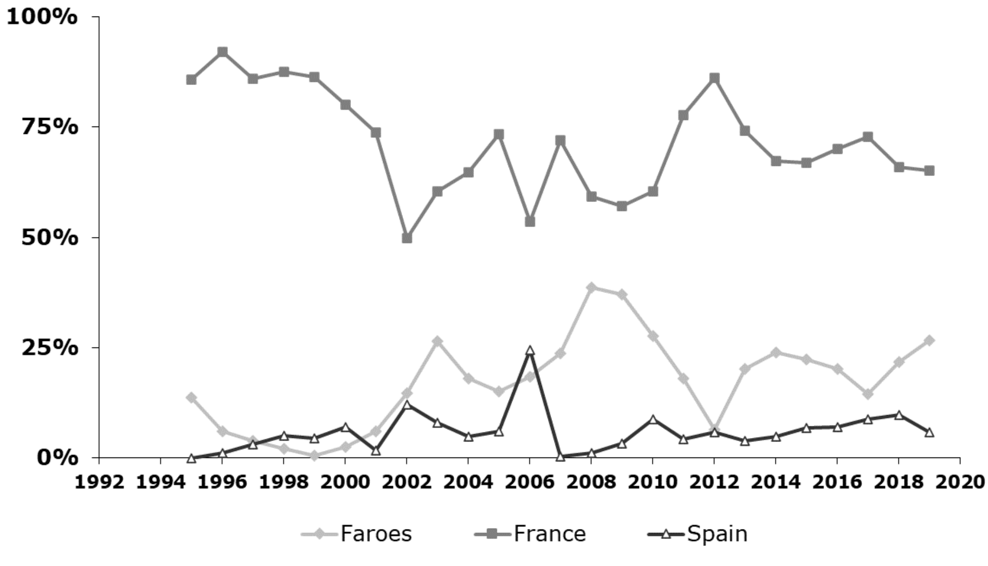


Figure 9.2.3 bsf.27.nea Northern component French, Spanish and Faroese relative contribution to the annual landings for the Northern component.

9.2.3 ICES Advice

The latest ICES advice for 2019 and 2020 was: "*ICES advises that when the precautionary approach is applied, catches should be no more than 5914 tonnes in each of the years 2019 and 2020.*

Distributed by area this corresponds to annual catches of no more than 2812 tonnes in subareas 6 and 7 and divisions 5.b and 12.b, annual catches of no more than 2735 tonnes in Subarea 8 and Division 9.a, and annual catches of no more than 367 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 2019, 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, "No fishing authorisation shall be issued for the purpose of fishing with bottom trawls at a depth below 800 metres", since 2017 black scabbardfish catches from trawl fishing grounds deeper than 800 meters are null for EU vessels.

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 2020.

Year	EU TAC 27.5, 27.6, 27.7 & 27.12	Landings 27.5.b, 27.6, 27.7 and 27.12
2006	3042	4127
2007	3042	3192
2008	3042	4532
2009	2738	3160
2010	2547	3202
2011	2356	2733
2012	2179	3592
2013	3051	3332
2014	3966	3048
2015	3649	3291
2016	3357	3545
2017	2954	2530
2018	2600	2545
2019	2470	1839
2020	2470	

9.2.5 Data available

9.2.5.1 Landings and discards

In 2020, updated landing data were made available for the major fishing countries operating in ICES Division 27.5.b and subareas 27.6, 27.7, and 27.12 (Table 9.2.2) and for ICES Division 27.5.a (Table 9.4.2c).

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 has 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.).

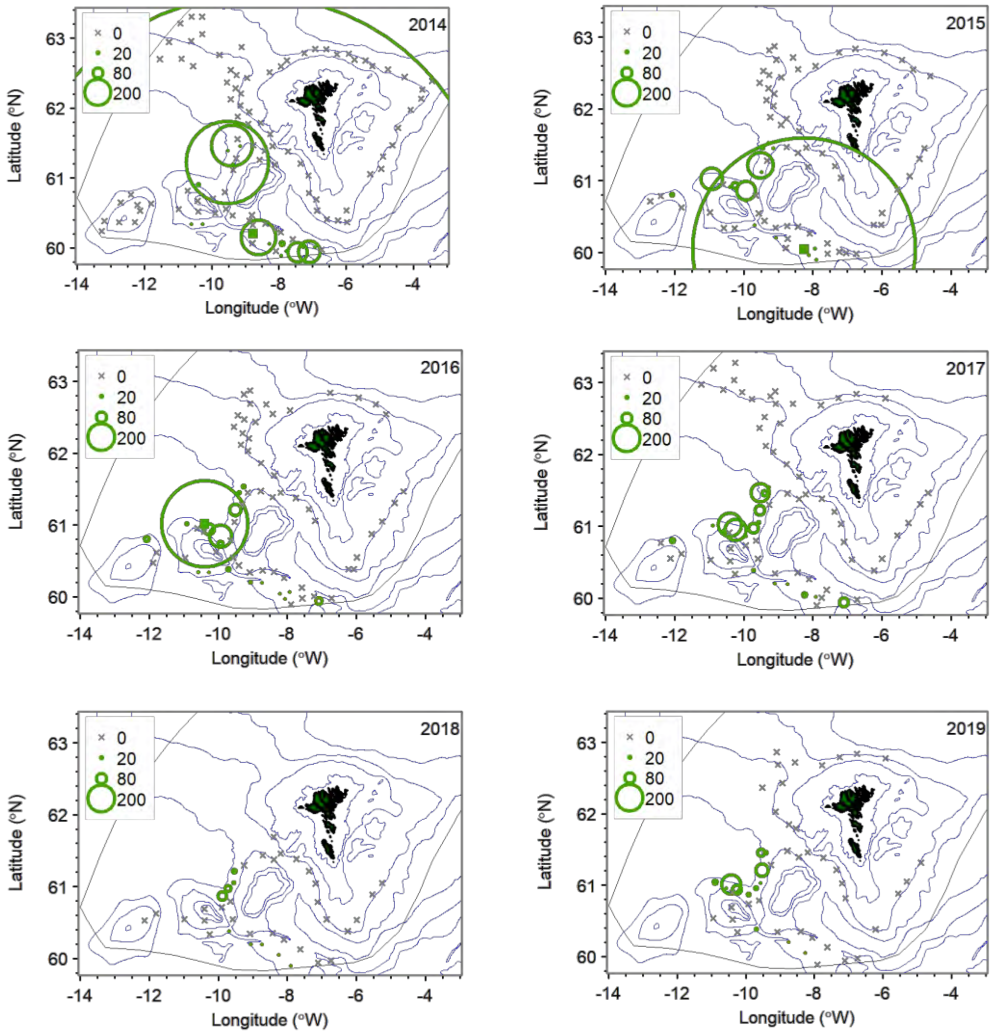
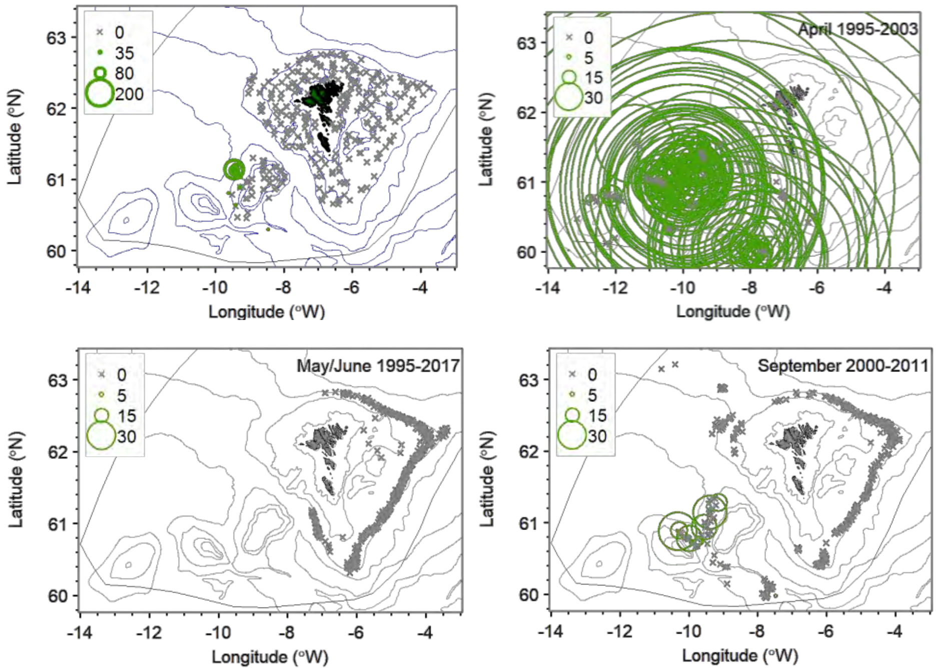


Figure 9.2.3. bsf.27.nea Northern component. Spatial distribution of CPUE (kg/h) from the deep-water surveys in 2014-2019. The green squares show the position of the largest catch. (Source: Ofstad, 2019, WD; 2020, pers. comm).

Figure 9.2.4.



bsf.27.nea Northern component. Spatial distribution, CPUE (kg/h), from different surveys. Annual groundfish 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.). Those oceanographic conditions are registered at the oceanic Faroese waters (Figure 9.2.6.).

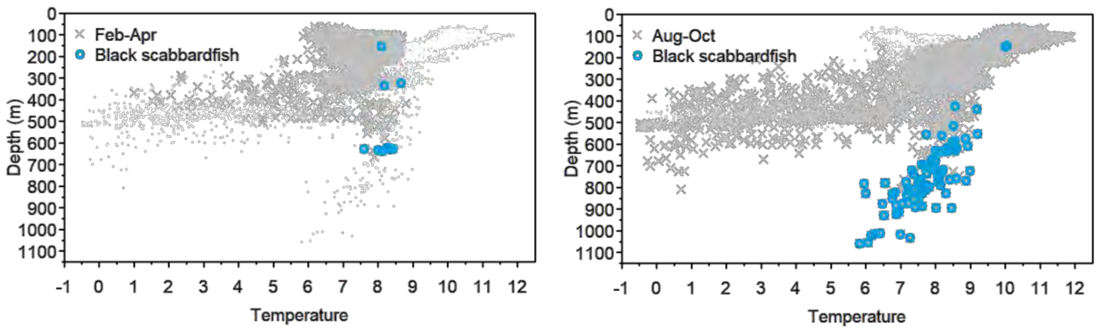


Figure 9.2.5. bsf.27.nea Northern component. Temperature and depth distribution of black scabbardfish (blue dots) and catch with no black scabbardfish (grey crosses) in February-April (left) and August-October (right). (Source: Ofstad, 2019, WD)

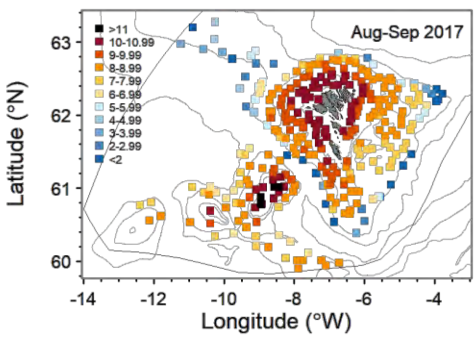


Figure 9.2.6. Temperature and depth distribution in Faroese waters August-September 2017. (Source: Ofstad, 2019, WD)

9.2.5.3 Length compositions

The annual length frequency distributions, based on French on-board observer data, for the period 2004-2019 are presented in Figure 9.2.7. Apart from a slight increase in the mean length in the latter 5 years, no major other differences were noted.

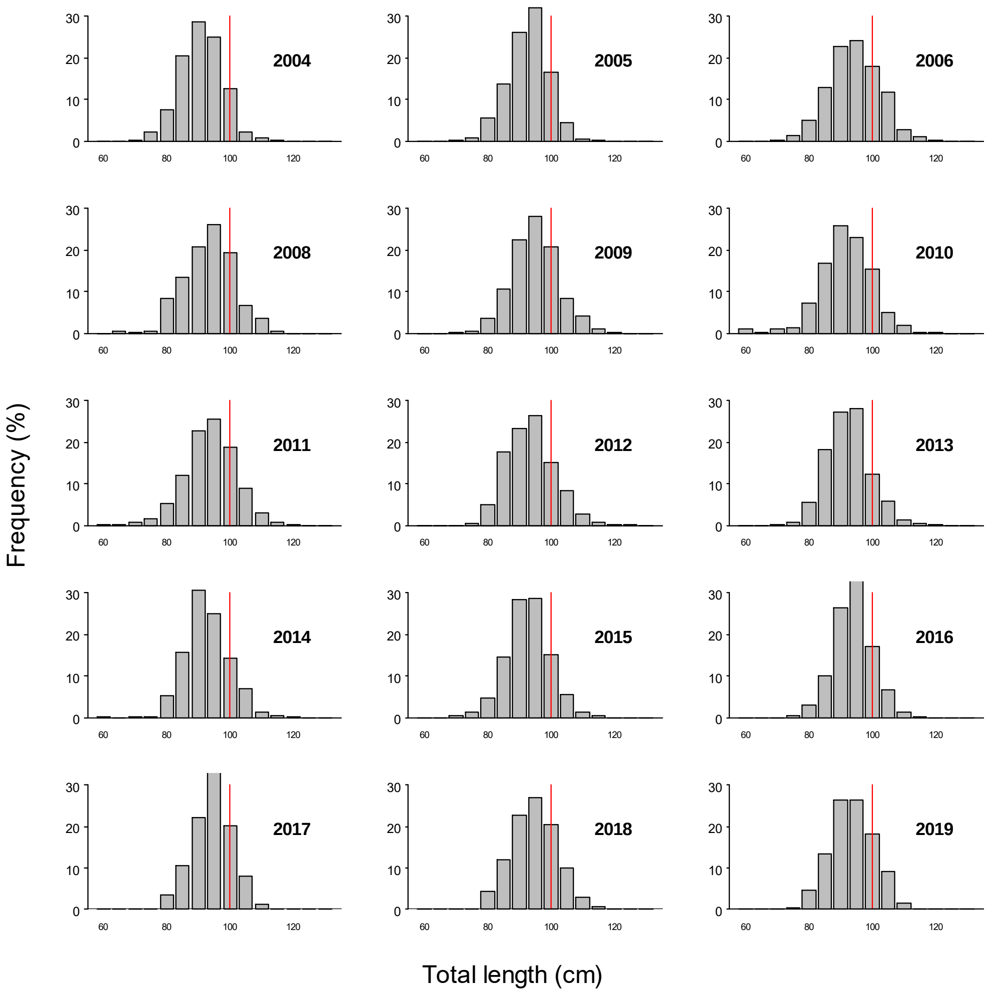


Figure 9.2.7. bsf.27.nea Northern component. Annual frequency length distribution of black scabbardfish based on French observer data collected on-board commercial vessels (2004–2019). The red vertical line indicates the length of 1st maturity of the species.

For the period 2004–2019, the temporal evolution of the mean length by quarter shows no trend (Figure 9.2.8), which supports the stability on the length structure of the exploited population along the whole period.

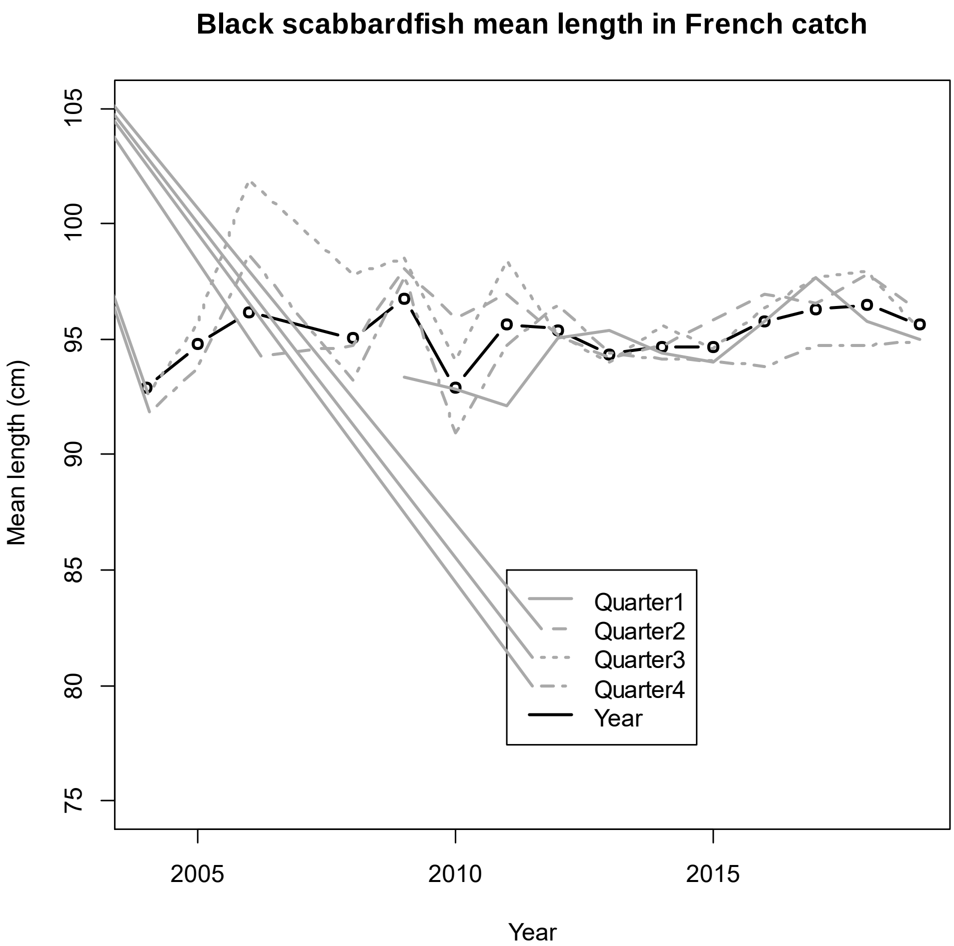


Figure 9.2.8. bsf.27.nea Northern component. Mean length estimates of black scabbardfish by quarter for the period 2004-2019. Data were collected under the French on-board observer program.

For the period 2014–2019, 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 (Figure 9.2.9).

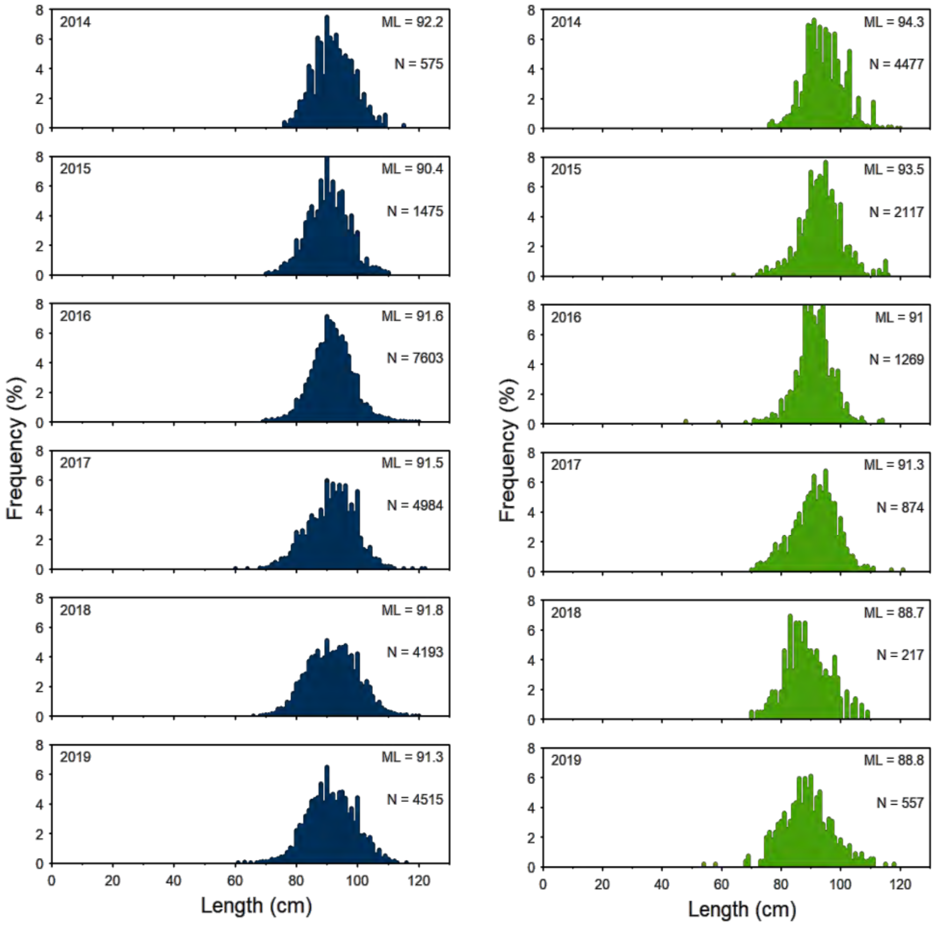
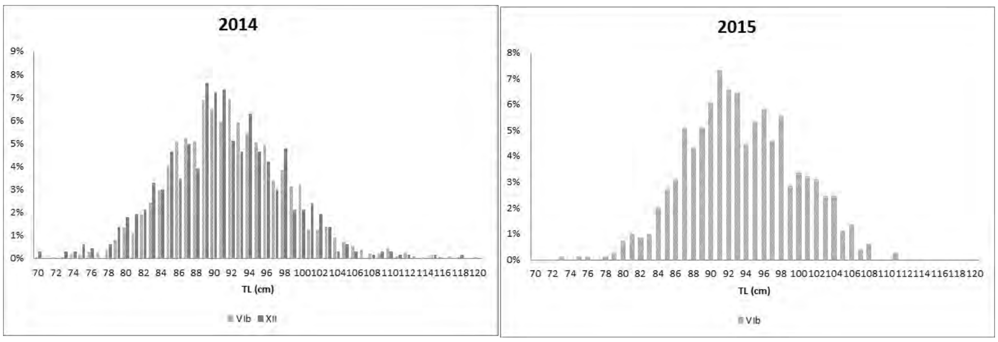


Figure 9.2.9. bsf.27.nea Northern component. Length-frequency distribution from the landings (left) and the deep-water survey (right) in 2014-2019. (Source: Ofstad, 2020, pers. comm.)

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). The range of the length frequency distributions are similar in the two geographic areas and fishing fleets. In the two areas and years, specimens with total length smaller than 103 cm predominate.



a) b)

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 2000–2019 are presented in Figure 9.2.11.

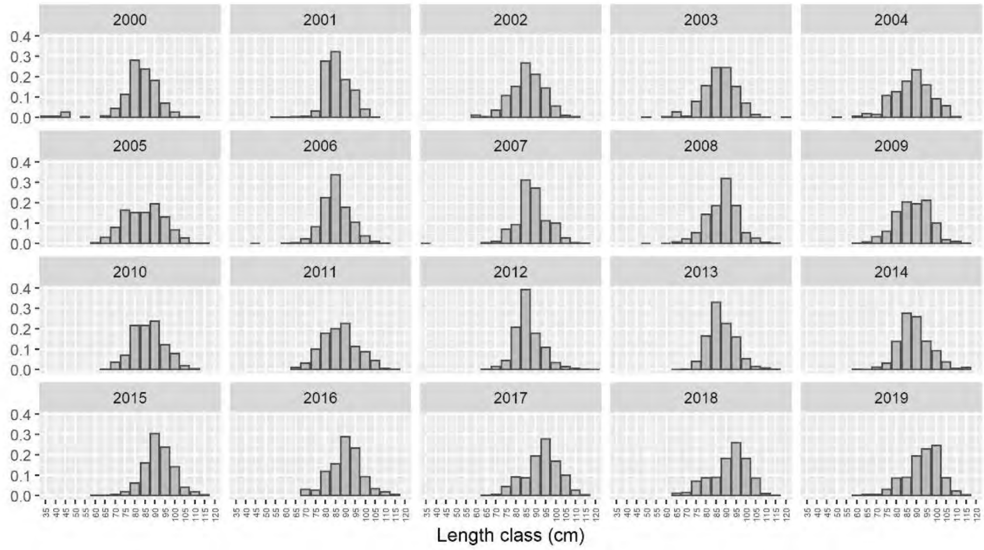


Figure 9.2.11. bsf.27.nea Northern component. Black scabbardfish in Division 27.5.a: length distribution from the Icelandic Autumn survey, from 2000 to 2019.

The length data available for the Northern component suggests a similar length structure of the exploited population between the different fishing fleets. The French length data is the longest time series 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).

Table 9.2.2 presents the total catch in weight (ton) and in number by length class, C2 and C3, for the period 1999-2019 by six-month time period, 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 1998–2019 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.

The trends in the abundance or biomass in recent years are consistent with both the Scottish and Icelandic surveys. Comparing the whole time-series, the recent abundance and biomass are at much higher levels.

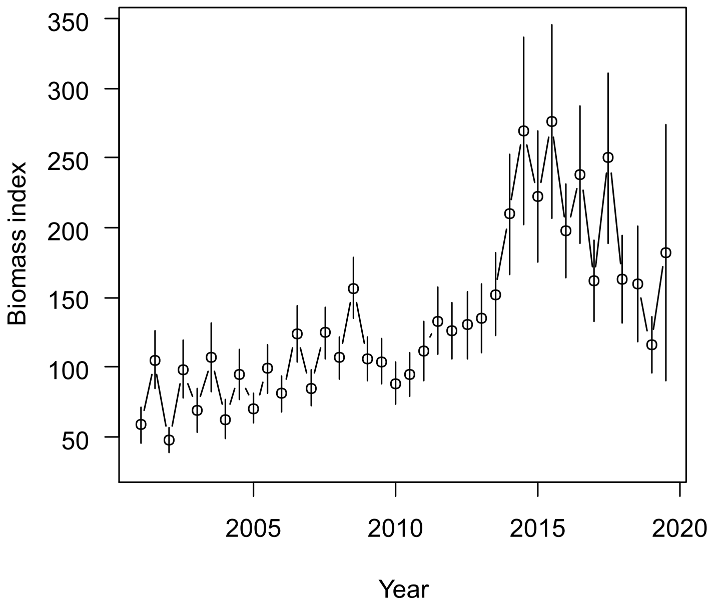


Figure 9.2.12. bsf.27.nea Northern component. CPUE by new semesters, i.e., SEM1= months 3-8 of the year and SEM2=month 9-12 of the year, plus months 1 and 2 of the next year.

For the period 2006 to 2019, 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.

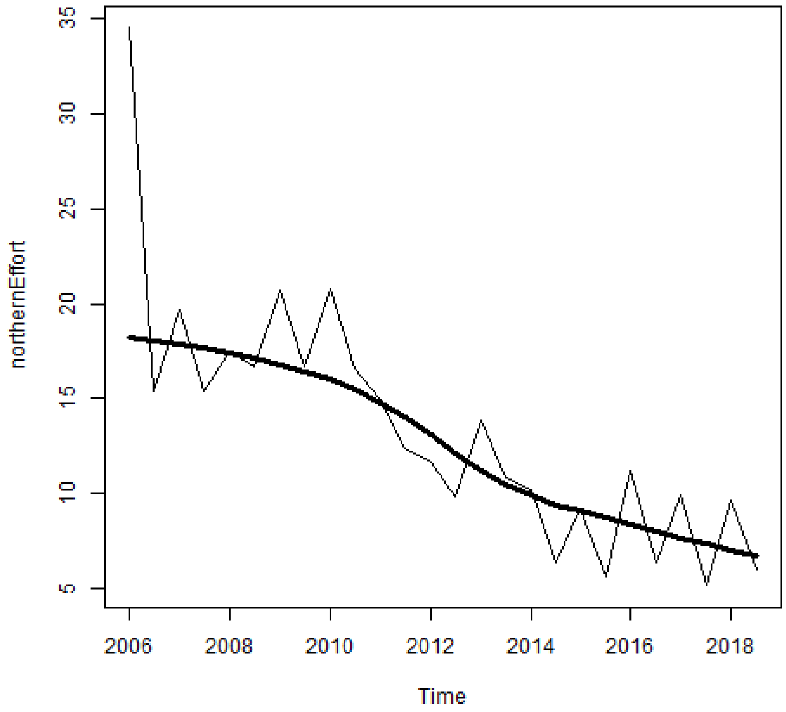


Figure 9.2.13. bsf.27.nea Northern component. Standardised effort by new semesters, i.e., SEM1= months 3-8 of the year and SEM2=month 9-12 of the year, plus months 1 and 2 of the next year.

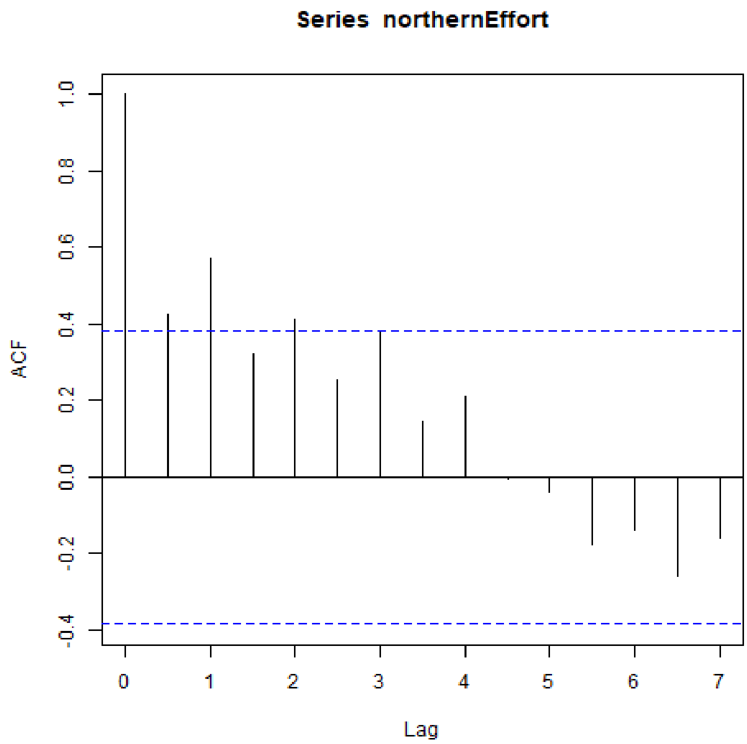


Figure 9.2.14. bsf.27.nea Northern component. Standardised fishing effort time series autocorrelation.

Scottish research survey data have been provided to WGDEEP. The 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.

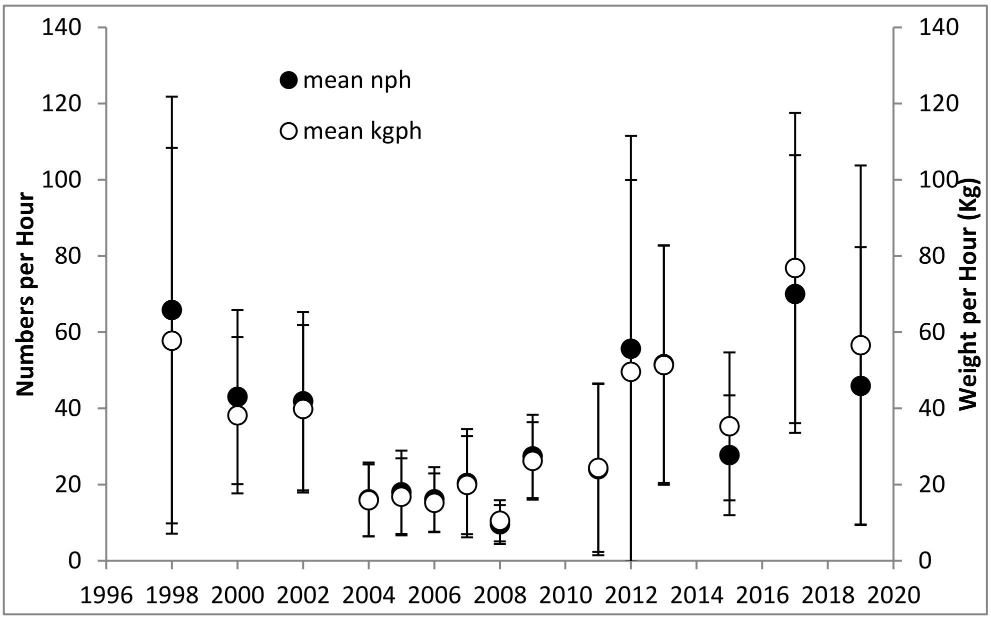


Figure 9.2.15. bsf.27.nea Northern component. Annual biomass and abundance indices of black scabbardfish estimated for depths deeper than 500 m and shallower than 1600 m, from 1998 to 2019. Seamounts/Rockall not included. (Source: Campbell, 2020, pers. comm.)

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 (Figure 9.2.16). Black scabbardfish abundance index from Icelandic Autumn survey shows an overall decreasing trend since 2011 however at higher levels than those registered at the beginning of the series (Figure 9.2.17).

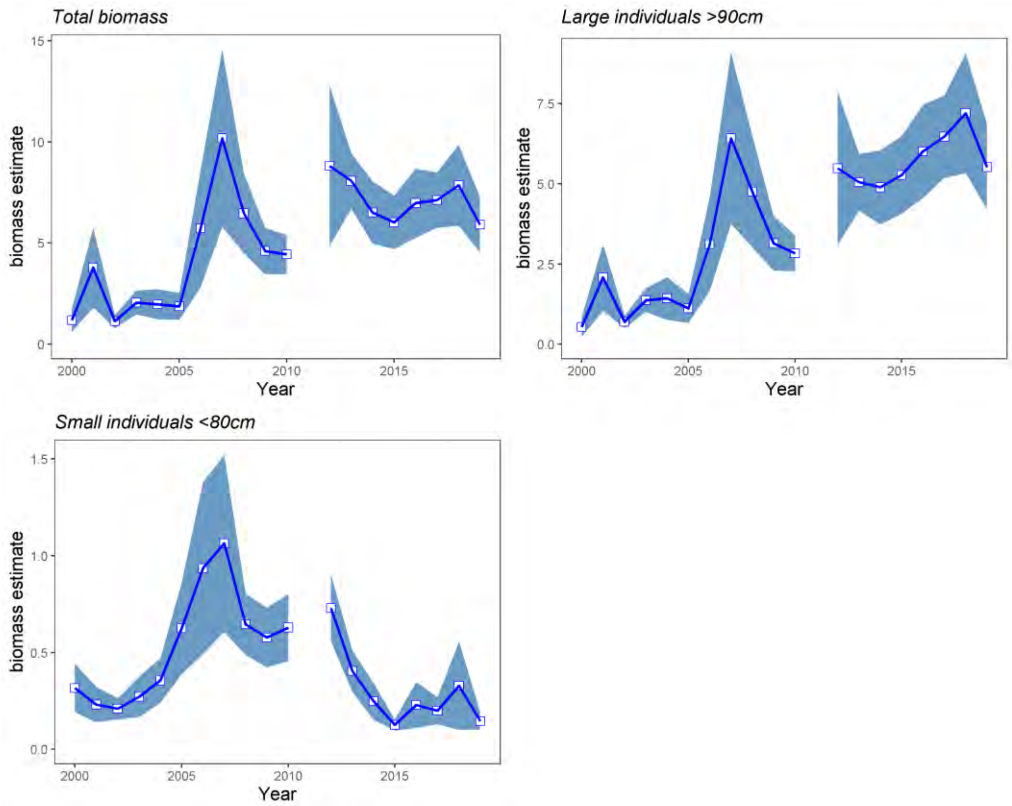


Figure 9.2.16. bsf.27.nea Northern component. Black scabbardfish biomass index with 95% confidence interval from the Icelandic Autumn survey from 2000 to 2019 for all sizes (Total biomass, upper left); specimens larger than 90 cm (Large individuals >90 cm, upper right); specimens smaller than 80 cm (Small individuals <80 cm, lower left).

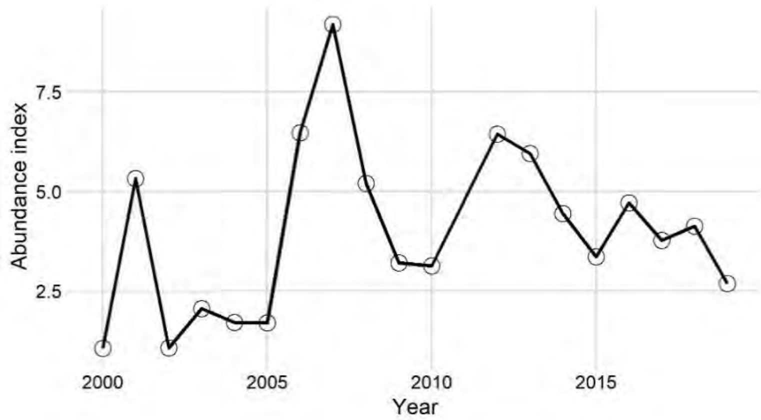


Figure 9.2.17. bsf.27.nea Northern component. Abundance of black scabbardfish from Icelandic Autumn survey from 2000 to 2019.

Faroese commercial CPUE, between 2000 and 2019, 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. In recent years CPUE values are at the levels observed at the beginning of the fishery.

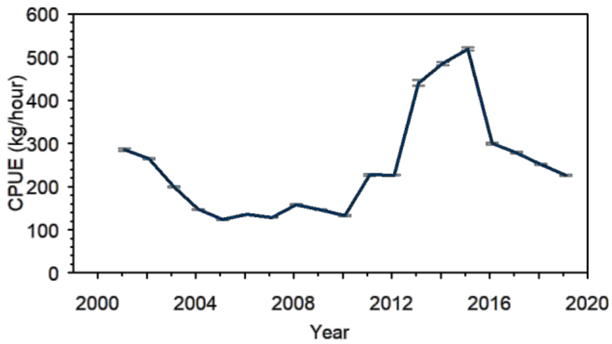


Figure 9.2.18. bsf.27.nea Northern component. Standardised CPUE (kg/hour) from Faroese commercial trawlers (> 1000 HK). Criteria: black scabbardfish >30% of total catch and effort > 2 hours per haul. (Source: Ofstad, 2019 WD)

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.

<u>**Stock assessment and model settings**</u>

Abundances of black scabbardfish at the Northern and Southern components are estimates based on two Bayesian state-space models. Under each model two separated processes run simultaneously but not independently since the migration from Northern to the Southern component is taken into account when fitting the model for the Southern component.

Model outputs provide posterior distributions of the stochastic state processes parameters associated with the species life cycle and with the migration processes. The prior distributions of those parameters are defined in a way that each of them incorporates the information available both on the biology and the fishery. More details on the definition of the prior distributions and on the model are described in the Stock annex.

In each model an observational process is included. The observation processes consist of the Catch in number by semester.

Model adequacy

The quality of the model fitting is evaluated for each model separately. For the Northern component, the **C2** and **C3** length groups catch estimates in semester *s* (that are equal to the median of the posterior distributions of those state process vector components in the **s** semester) are compared with the corresponding observational catch values. For the Southern model, the catch estimates in semester **s** are obtained in the same way as for the Northern component and these are compared with the corresponding observational catch values.

The evaluation of the model's adequacy based on the expected deviance estimates (Northern component 1442.38 and Southern component 1303.57) together and the credible intervals (intervals in the domain of the posterior probability distributions) indicate a good fitting (Figure 9.2.19).

The catch estimates (posterior medians) of C2 and C3 length classes combined and the corresponding observed catch in Northern and Southern components show a good adjustment. For both components, the range of the 95% credible intervals are relatively narrow, particularly for the semesters at the end of the studied period (Figure 9.2.19).

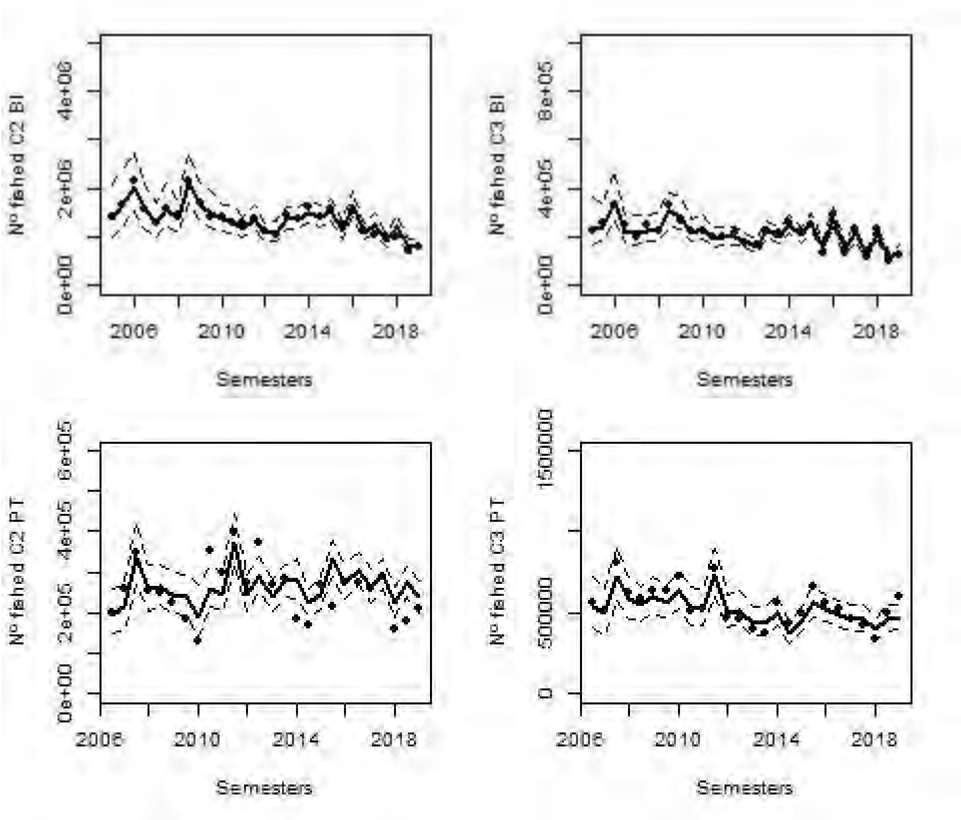


Figure 9.2.19. bsf.27.nea. Estimated catches (solid line) and 95% credible intervals (dashed lines), for Northern component C2 length group (upper left), C3 length group (upper right) and Southern component C2 length group (lower left) and C3 length group (lower right). Observed catches are represented by black dots.

The time-series of the estimates of the total abundance in the Northern component for the C2 and C3 length groups show that, in recent years, the abundance is consistently at higher levels when compared to the beginning of the series (Figure 9.2.20).

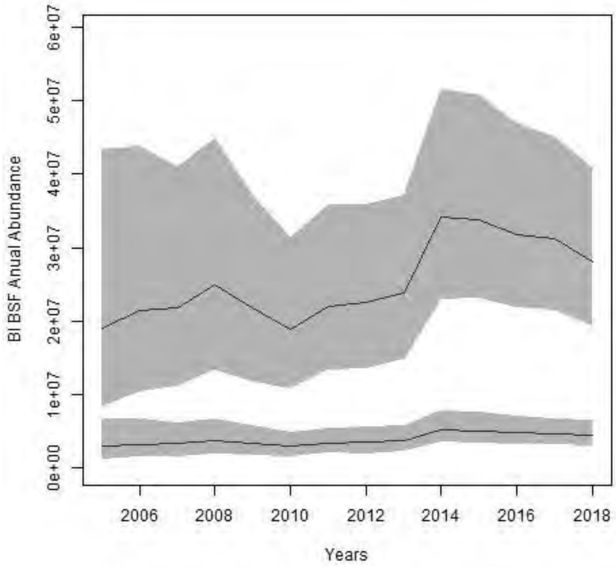


Figure 9.2.20. bsf.27.nea Northern component. Estimated black scabbardfish annual abundances for C2 (upper) and C3 (lower) length groups with the 95% credible intervals.

The temporal evolution of the total abundance in the Southern component for the C2 and C3 length group is presented in Figure 9.2.21.

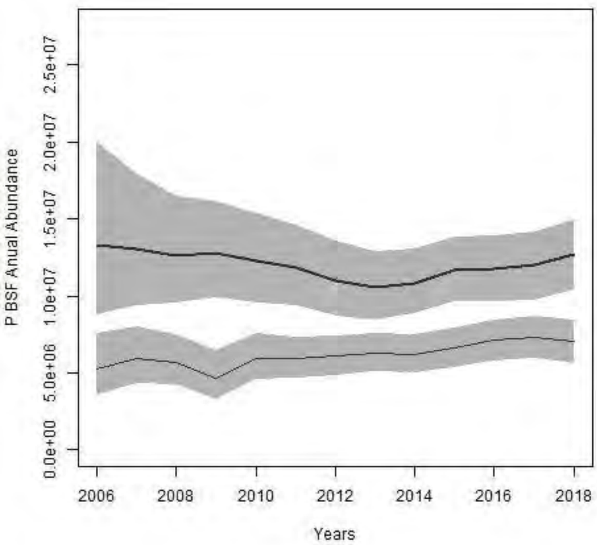


Figure 9.2.21. bsf.27.nea Southern component. Estimated black scabbardfish abundances for C2 (lower) and C3 (upper) length groups with 95% credible intervals.

For the two stock components and for both C2 and C3 length groups the credible intervals are wider at the beginning of the time series narrowing by the end of the time series, more markedly in C3 group in the Southern component (Figures 9.2.20 and 9.2.21).

The temporal evolution of the estimates of the total abundance of black scabbardfish suggests a downward trend in the Northern component, although at higher levels than at the beginning of the series, and an upward trend in the Southern component (Figure 9.2.22).

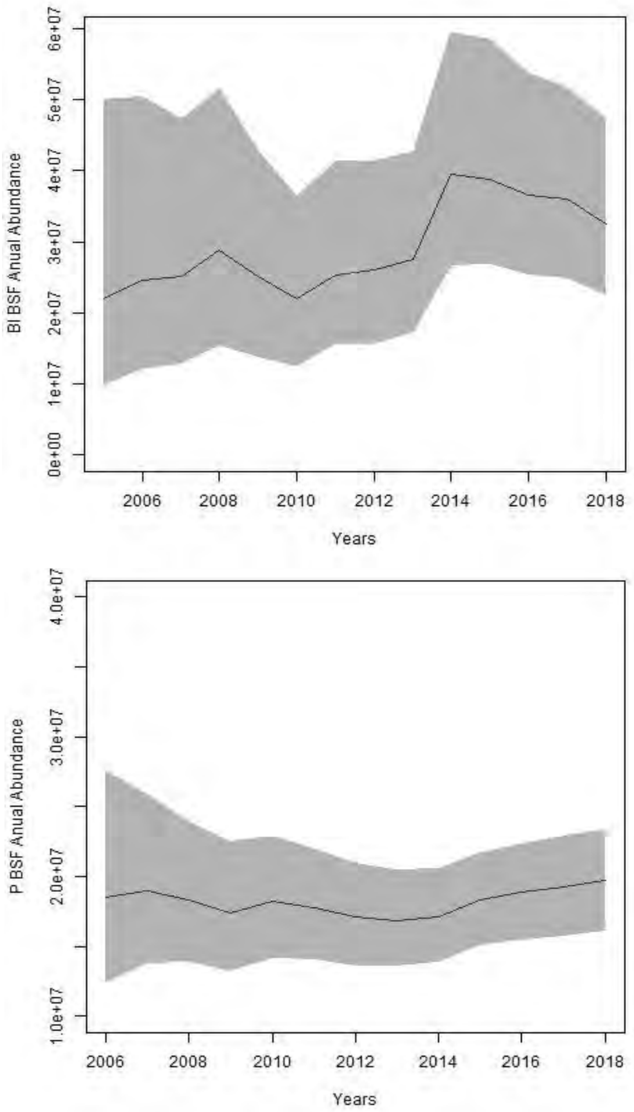


Figure 9.2.22. bsf.27.nea Northern (upper) and Southern (lower) components. Estimated black scabbardfish annual abundances with 95% credible intervals.

The posterior distributions for all the parameters of the Northern and Southern components are presented in Figures 9.2.23 and 9.2.24, respectively.

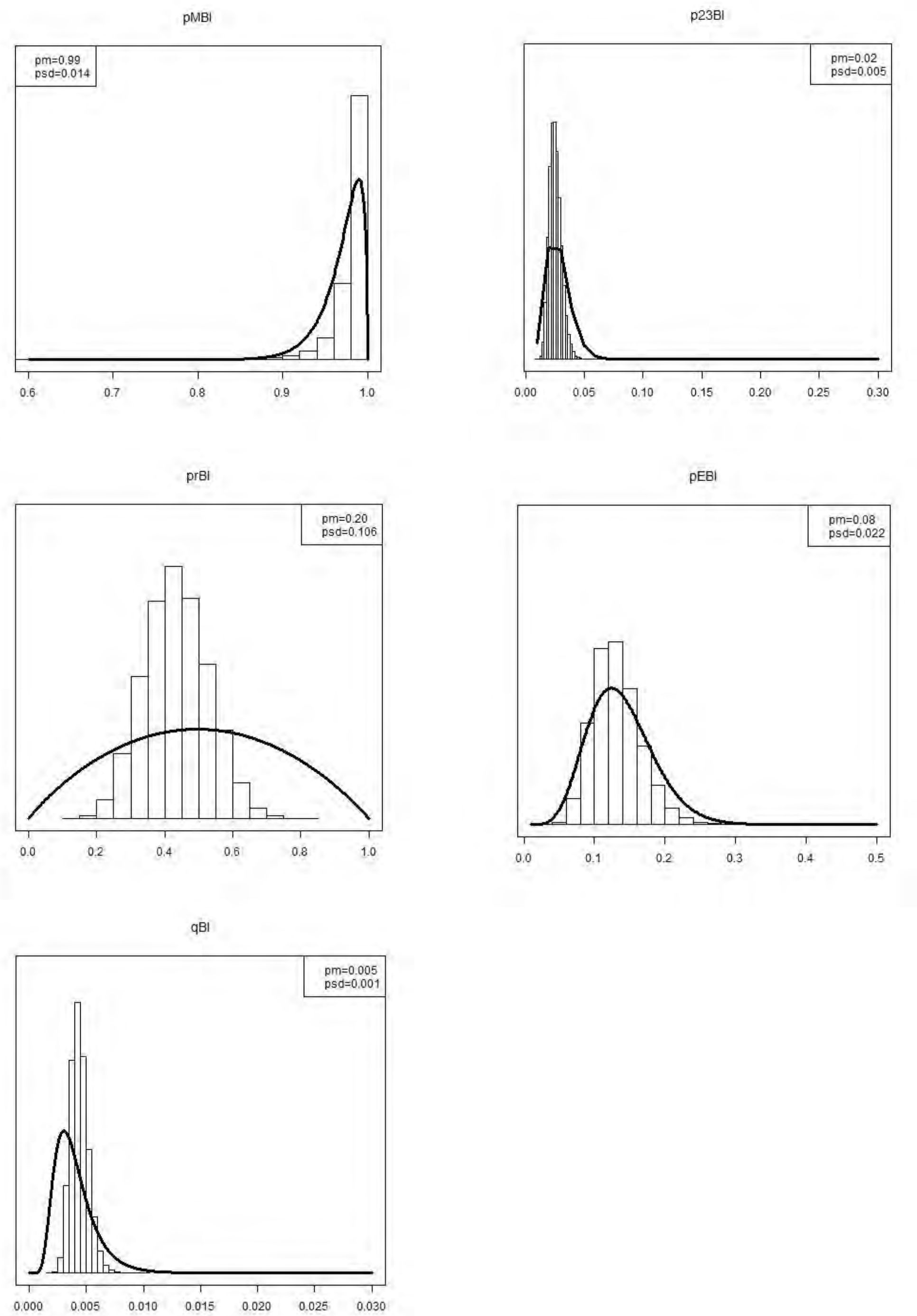


Figure 9.2.23. bsf.27.nea Northern component. Prior (thick line) and posterior distributions (histogram) for parameters of the Northern component. pMBI is the probability of surviving to natural mortality; p23BI is the probability of a specimen from the Northern component transiting from C2 to C3 during one semester. prBI is the probability of a specimen entering the length group C2 in the Northern component during the second semester; pEBI is the probability of a specimen belonging to length group C2 or C3 leaving the Northern component in the first semester; qBI is the probability of catchability in the Northern component.

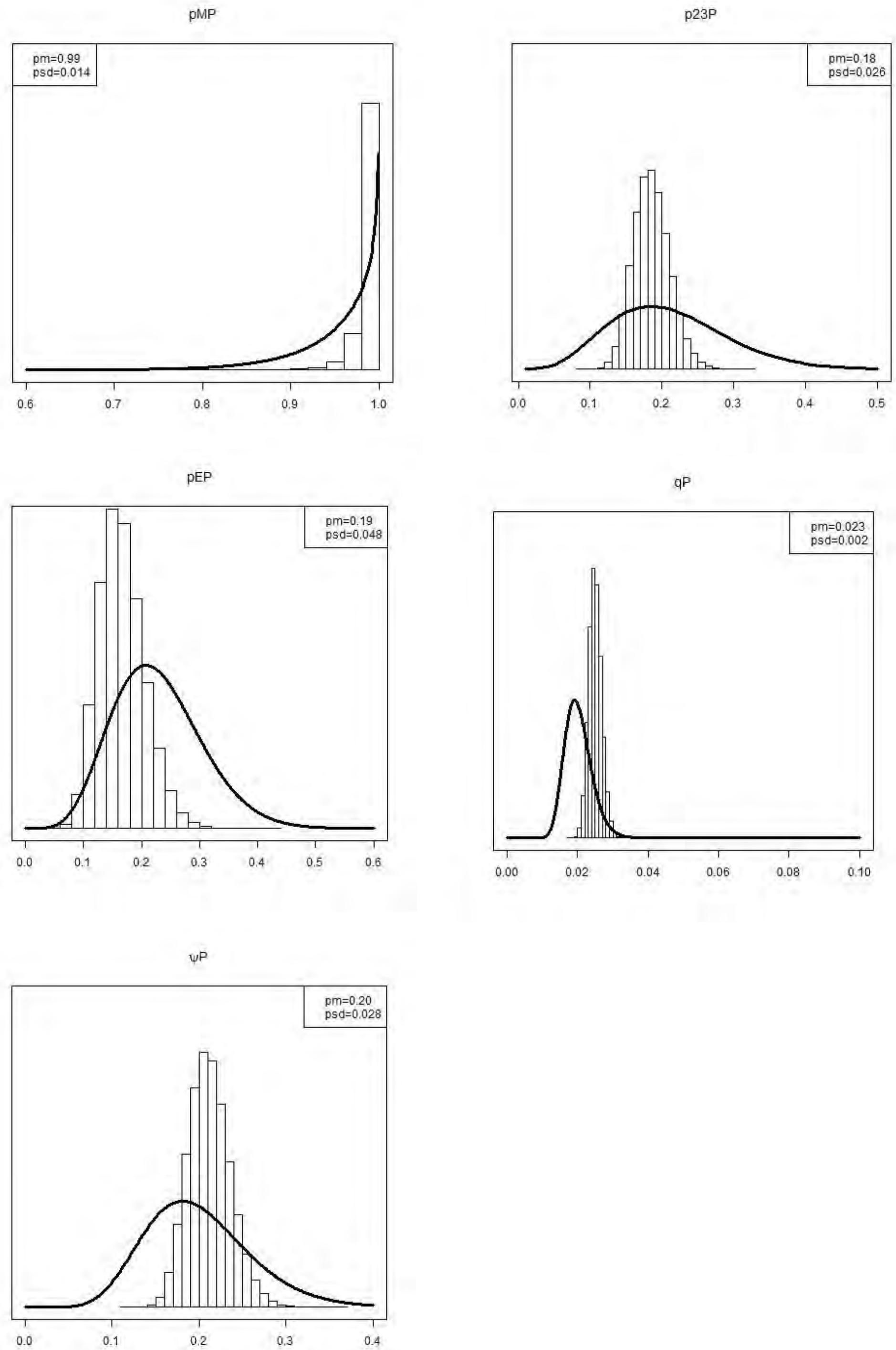


Figure 9.2.24. bsf.27.nea Southern component. Prior (thick line) and posterior distributions (histogram) for parameters of the Southern component. pMP is the probability of surviving to natural mortality; p23P is the probability of a specimen from the Southern component transiting from C2 to C3 during one semester; pEP is the probability of a specimen belonging to length group C3 leaving the Southern component in the first semester; qP is the probability of catchability in the Southern component.

All the priori distributions adopted for the parameters had a quite large coefficient of variation. These high values were included as precautionary measures to guarantee the introduction of uncertainty on their values. For most of the parameters' posterior distributions (Figures 9.2.23 and 9.2.24) it is evident that the observational data provided information to update the priori distributions. The posterior distributions have a narrow range.

HCR from WKDEEP 2014

At the WKDEEP 2014 and in view of the admitted linkage between the Northern and Southern components, it was agreed that the status of the stock as a whole in the NE Atlantic should be considered when giving management advice for either fishery component. However, it has also been agreed that given the presumed sequential nature of the exploitation pattern, management should also take into consideration trends occurring in the separate areas.

A harvest control rule was adopted in WKDEEP 2014 so that the catches in the two components are updated based on each component total abundance trends for the most recent five years. The harvest control rule simply specifies that catch advice should only increase when the abundance trends for the two components are increasing. If either is stable or decreasing, the advised catch for each of the two components should be adjusted according to the rate of change in the one showing the decrease.

The HCR adopted at 2014 Benchmark involves the estimation the trend of stock abundance by area and the selection of the one with the lowest value. The trend of abundance time series refers to the five most recent years. For each area, the trend corresponds to the slope that results from the adjustment of a linear regression to abundance estimates at a given year (Y) versus abundance estimate at the previous year (Y-1). Finally, the catch advice for the following two years corresponds to the product of the selected trend value and the total catch of the latest year.

The 2018 AGDEEP analysed the HCR under different trend scenarios and concluded that in some unlikely scenarios there is a potential flaw in the HCR. To account to this potential flaw of the HCR, in WGDEEP 2020, the trend of the stock is the slope of the linear regression adjusted to the abundance estimates of the five most recent years, scaled by dividing annual estimates by the mean abundance of those five years.

The trend estimates for each component are presented in Table 9.2.3. Following the HCR adopted, with selection of the minimum slope, the catches in the two components should be reduced by 4.76%.

Table 9.2.3. bsf.27.nea. Slope estimates of the regressions for the Northern and Southern components.

	Northern component	Southern component
Annual	0.9524	1.0309

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 2019. 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 results obtained are presented in Table 9.2.4.

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 2019 (Table 9.2.4).

Table 9.2.4. bsf.27.nea Northern and Southern components. LBI screening method ratios between 2014 and 2019.

	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	0.63	0.90	0.73	1.00	0.75	4%	0.94	1.13
2015	0.66	0.92	0.73	0.93	0.75	4%	0.95	1.11
2016	0.76	0.93	0.73	0.97	0.75	3%	0.95	1.02
2017	0.62	0.93	0.71	0.97	0.74	2%	0.95	1.16
2018	0.67	0.92	0.72	1.02	0.74	3%	0.95	1.10
2019	0.74	0.95	0.73	1.01	0.75	4%	0.97	1.06

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.

9.2.8 Tables

Table 9.2.2a. 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				
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**	0	1	**725**
	27.5.b.1	**27.5.b.2**	**27.5.b**	**27.5.b**	**27.5.b.1**	**27.5.b**				
2016			712	52						**765**
2017	285	14		112			0			**412**
2018	324	229		41			-			**594**
2019	395	93		52						**540**
***STATLAND data from 1988 to 2011.**										
****STATLAND data.**										

Table 9.2.2b. 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**
2006	8	0		1009				**1017**
2007	0		0	9			0	**9**

Year	Faroes	France	Scotland	Spain	Germany*	E&W&NI	Ireland	Total
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**
***STATLAND data from 1988 to 2011.**								

Table 9.2.2b. 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**
2000							**0**
2001							**0**

YEAR	Iceland*	Poland*	Russia**	Lithuania*	Estonia	Unallocated	Total
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**

***STATLAND data from 1988 to 2011.**

****STATLAND data.**

Table 9.2.2c. 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.b**	**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**
1992		2998	113	3		-		-	-			**3113**
1993		2857	87		62	-		-	-			**3006**
1994		2331	55			15		2	-			**2403**

Year	France				Faroes		Ireland		Scotland	Spain		Total
	27.6	27.6.a	27.6.b	27.6.a	27	27.6.b	27.6.a	27.6.a	27.6.b	27.6.a	27.6.b	
1995		2598	15			3		14	4			**2634**
1996		2980	1			2		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	0		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**

Table 9.2.1c. Continued.

Year	Germany*	Netherlands **			Lithuania**	Estonia**	Poland**	Russia**	Unallocated	Total
	27.6.a	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	-	-		-	-	-	-		**30**
1995	-	-	-		-	-	-	-		**0**
1996	-	-	-		-	-	-	-		**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.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**

***STATLAND data from 1988 to 2011.**

****STATLAND data.**

Table 9.2.2d. 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**
2007	-	-	2	7	0	4	168	7	0	52	17	-	-		**257**

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	
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**

Table 9.2.2e. 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**
2000	59	40	**99**
2001	68	37	**105**

Year	Ireland	E&W&NI	Total
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**

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).

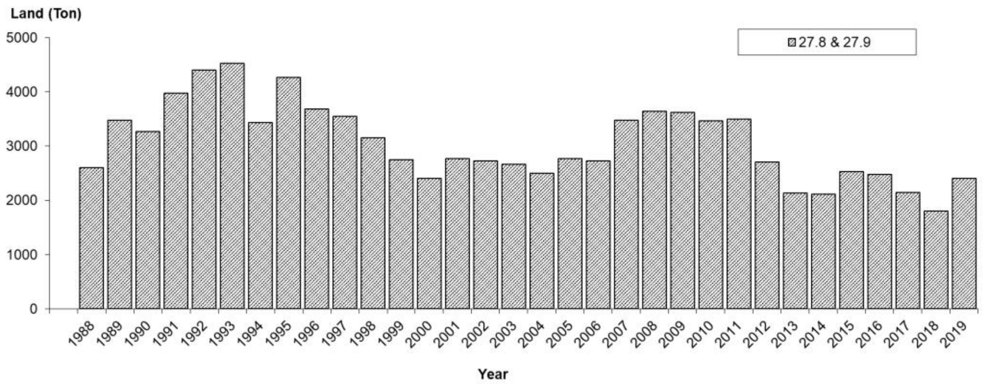


Figure 9.3.1. bsf.27.nea Southern component. Annual landings for ICES Subarea 27.8 and Division 27.9.a.

9.3.3 ICES Advice

The latest ICES advice for 2019 and 2020 was: "*ICES advises that when the precautionary approach is applied, catches should be no more than 5914 tonnes in each of the years 2019 and 2020.*
Distributed by area this corresponds to annual catches of no more than 2812 tonnes in subareas 6 and 7 and divisions 5.b and 12.b, annual catches of no more than 2735 tonnes in Subarea 8 and Division 9.a, and annual catches of no more than 367 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 2019.

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	1737	14
2019	2832	2305	0
2020	2832		

*** 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, 2020, pers. comm.).

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 2019 are presented in Figure 9.3.2.

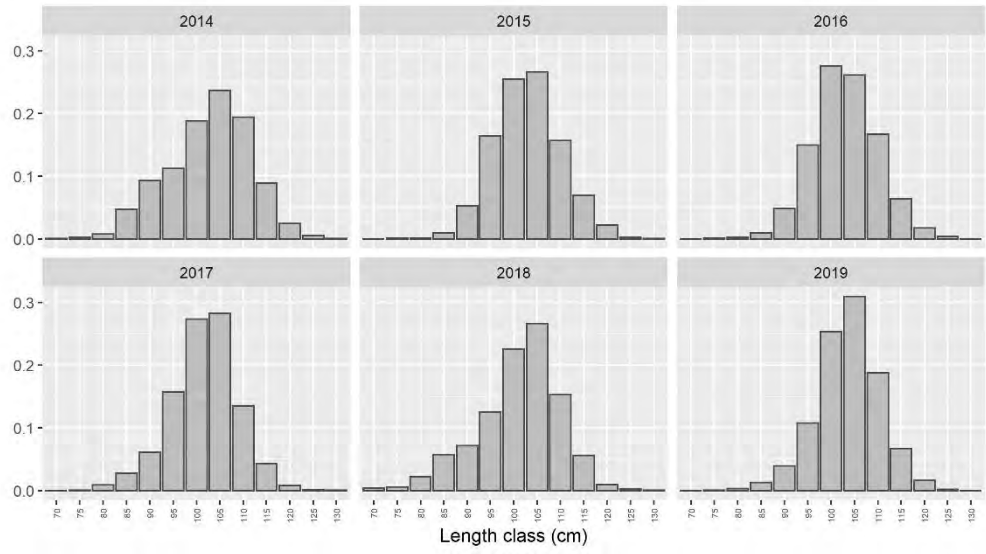


Figure 9.3.2. bsf.27.nea Southern component. Length–frequency distribution of black scabbardfish exploited by the deep-water longline fishery for ICES Division 27.9.a, from 2014 to 2019.

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). 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 congenera 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 9.3.2). 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.

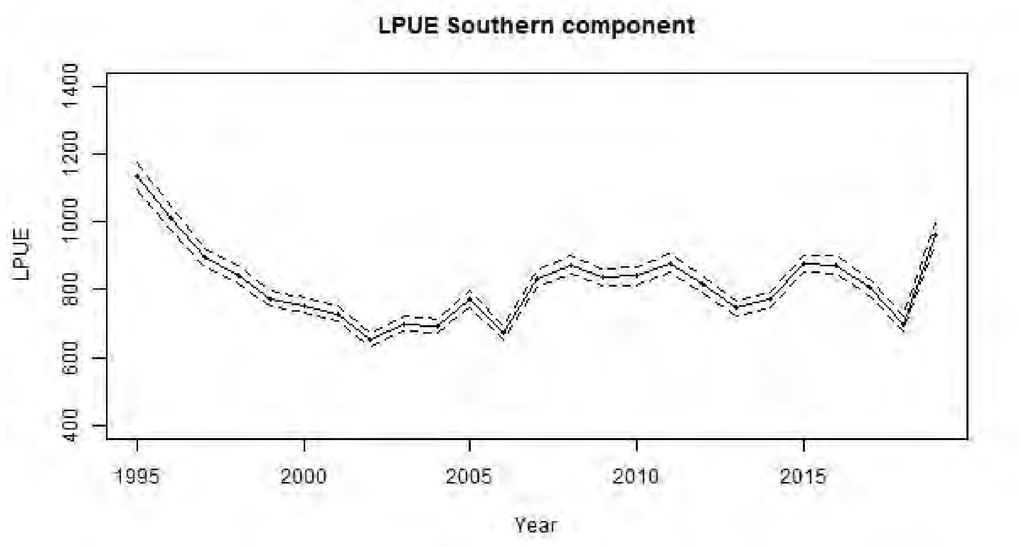


Figure 9.3.2. bsf.27.nea Southern component. Standardised Portuguese CPUE.

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 9.3.3) and the autocorrelation in this data is not significant (Figure 9.3.4). 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.

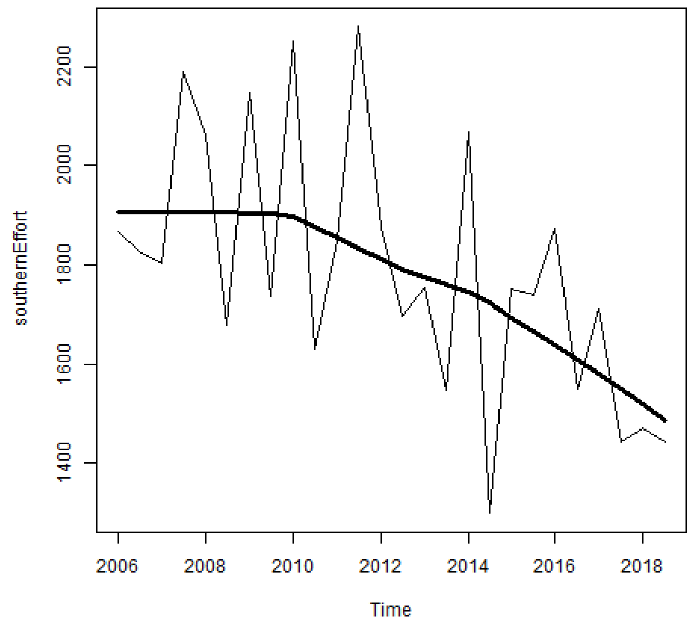


Figure 9.3.3. bsf.27.nea Southern component. Standardised effort by new semesters, i.e., SEM1= months 3-8 of the year and SEM2=month 9-12 of the year, plus months 1 and 2 of the next year.

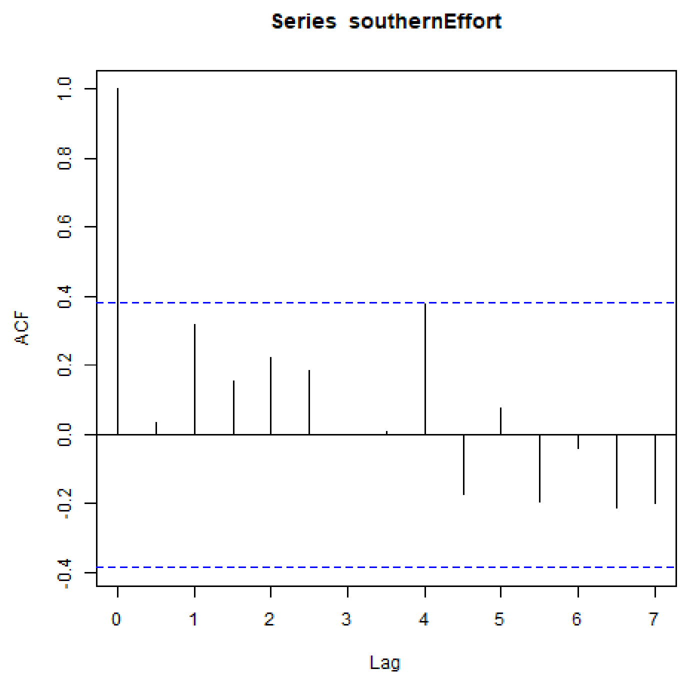


Figure 9.3.4. bsf.27.nea Southern component. Standardised fishing effort time series autocorrelation.

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 27.6 and 27.7 and divisions 27.5.b and 27.12.b, plus Division 27.5.a on one hand; 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
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

Year	Portugal	France	Spain	Total
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

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
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

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	
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
2019		12	5		8		45	15	0	22		108

9.4 Black scabbardfish (*Aphanopus carbo*) in other areas (27.1, 27.2, 27.3.a, 27.4, 27.10, 27.5.a, 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.

In recent years, fishing activity on black scabbardfish in ICES Division 27.5.a has been regular, with landings rounding about 300 ton *per* year. 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).

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. Since 2010, Icelandic landings in ICES Division 27.5.a have increased, being stable around 300 t in recent years. The 111 tonnes reported in 2010 in ICES Subarea 27.14 are considered as misreporting.

9.4.3 ICES Advice

The latest ICES advice for 2019 and 2020 was: "*ICES advises that when the precautionary approach is applied, catches should be no more than 5914 tonnes in each of the years 2019 and 2020.*

Distributed by area this corresponds to annual catches of no more than 2812 tonnes in subareas 6 and 7 and divisions 5.b and 12.b, annual catches of no more than 2735 tonnes in Subarea 8 and Division 9.a, and annual catches of no more than 367 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, 2013, and 2014, 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 2019.

YEAR	EU TAC 27.1, 27.2, 27.3, and 27.4	EU Landings 27.2, 27.3, 27.4, 27.5.a, 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	-	

*** TACs and landings for subarea X are included in Table 9.3.4.**

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.

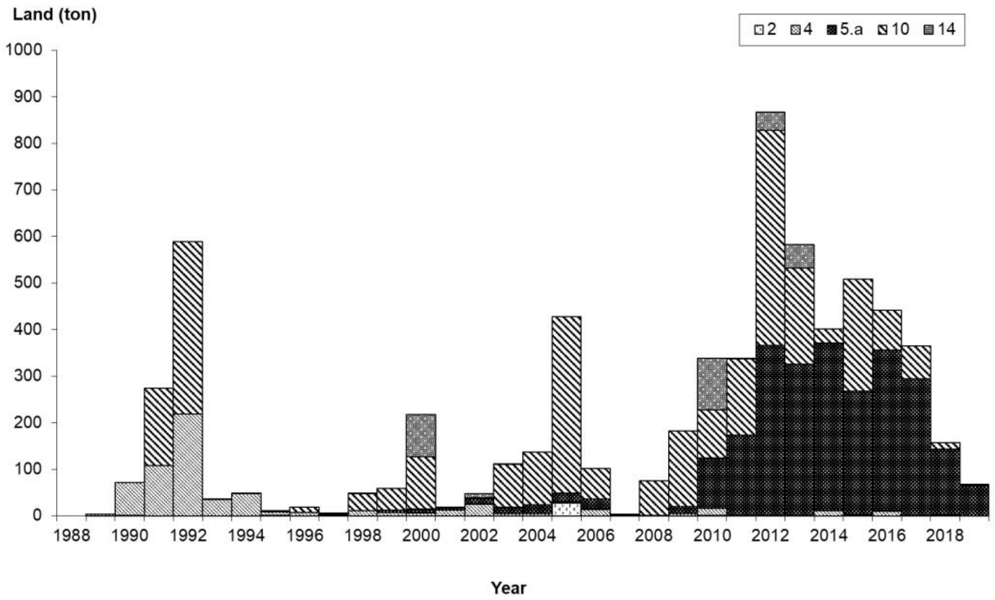


Figure 9.4.1. Annual landings for black scabbardfish in ICES subareas 27.2, 27.4, 27.10, and 27.14, and Division 27.5.a, between 1988 and 2019.

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).

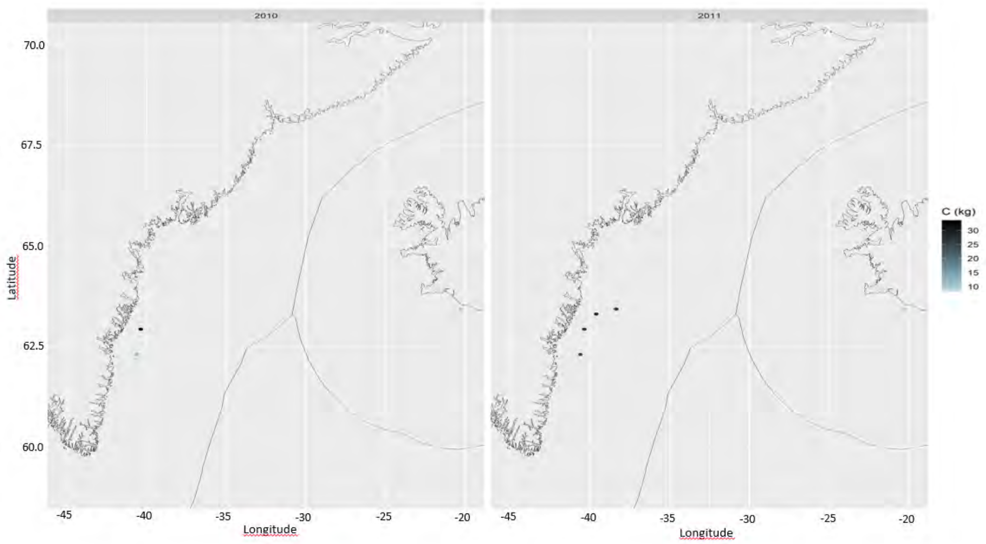


Figure 9.4.2. bsf.27.nea Black scabbardfish in 14. Distribution of commercial catches of black scabbard fish (in Kg) in East Greenland from 2010 and 2011. (Source: Nielsen *et al.*, 2019b WD)

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

See Section 9.2.4.6 where the Icelandic (ICES Division 27.5.a) series of biomass indices for all sizes (Total biomass) and for specimens larger than 90 cm and 110 cm are shown along with abundance of black scabbardfish smaller than 80 cm from the Icelandic Autumn survey provided by Iceland.

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)

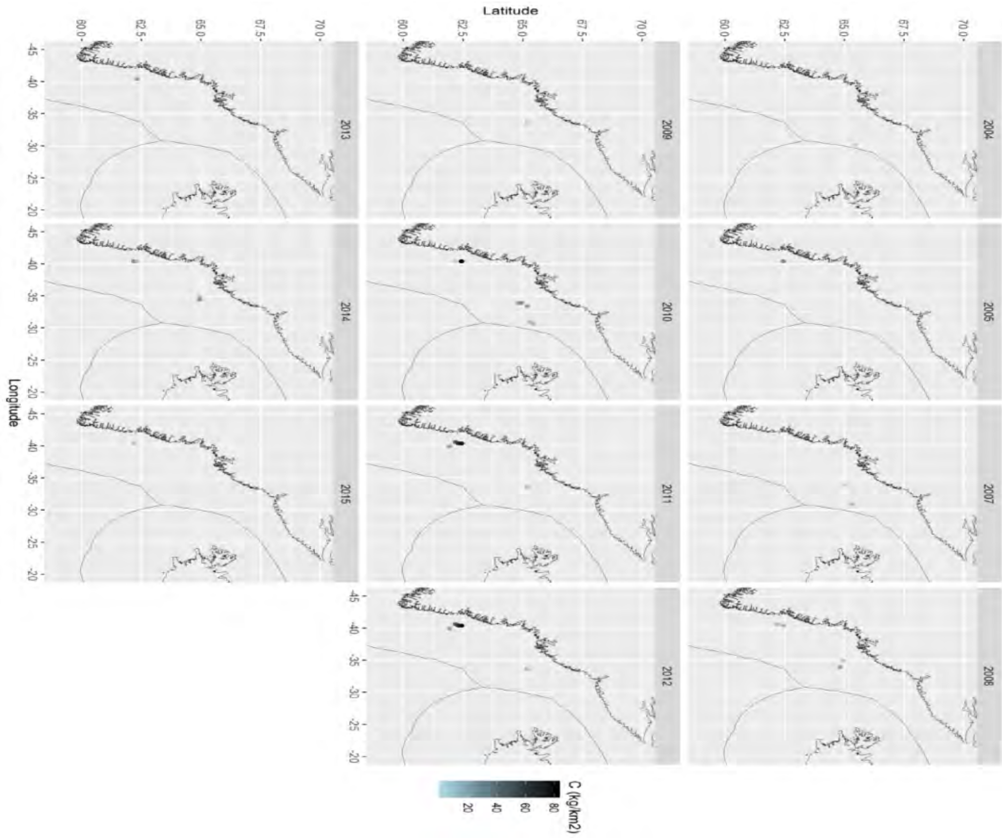


Figure 9.4.3. bsf.27.nea Black scabbardfish in Subarea 27.14. Distribution of survey catches of black scabbard fish at East Greenland (ICES Division 27.14.b) in 1998-2016. No survey in 2001, 2017, and 2018. (Source: Nielsen *et al.*, 2019a WD)

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).

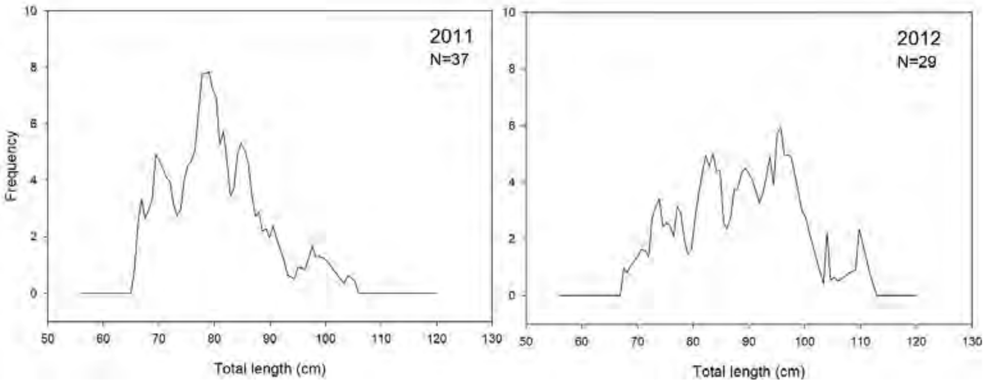


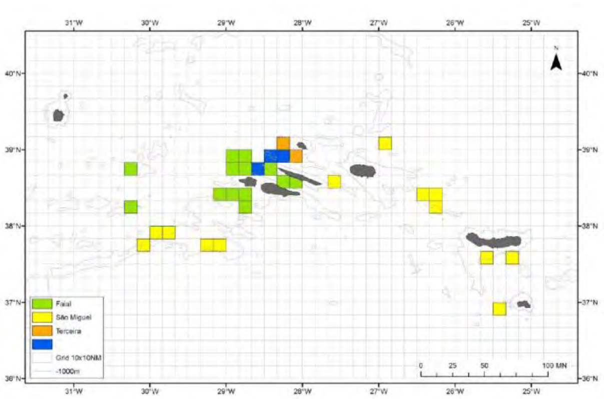
Figure 9.4.4 bsf.27.nea Black scabbardfish in Subarea 27.14. Length distribution of black scabbardfish at East Greenland (ICES Division 27.14.b) for 2011 and 2012. Survey years with n<20 are not shown. No survey in 2001, 2017 and 2018. (Source: Nielsen *et al.*, 2019a WD)

9.4.6 Data analyses

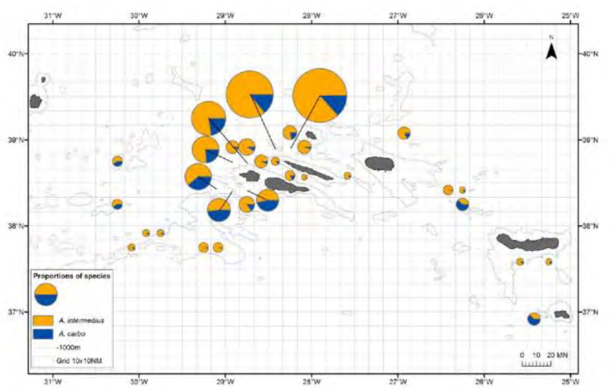
In Subarea 27.10, the commercial interest for the exploitation of black scabbardfish has varied over time, but apart from the data presented from the Faroese exploratory survey in 2008, the data available are only landings.

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

Excluding ICES Division 27.5.a, and 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. In face of this evidence, ICES Division 27.5.a data was included in the Northern component.

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

Year	France	Faroes 27.2.a	Iceland* 27.2.a.2	France 27.3.a	Total
2009	-	-			0
2010	0	-			0
2011	-	-			0
2012					0
2013	-	-			0
2014	-	-			0
2015	-	-			0
2016	-	-		0	0
2017	-	-		-	0
2018	-	.	13	-	13
2019					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
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

***STATLAND data**

****Preliminary catch statistics.**

Table 9.4.2c. Black scabbardfish other areas: 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
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

Year	Iceland	Faroes	Total
2016	346		346
2017	294		294
2018	142		142
2019	65		65

Table 9.4.2d. 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

Year	Faroes	Portugal	France	Ireland	Total
2011	25	139			164
2012	4	458			462
2013		206			206
2014	30	-			30
2015	234	7			240
2016	50	36			86
2017	7	63			70
2018	-	14			14
2019	3				3

Table 9.4.2e. Black scabbardfish other areas: Subarea 27.14. Working Group estimates of landings.

Year	Faroes	Spain	Greenland	Unallocated	Total
	27.14		27.14.b		
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

Year	Faroes 27.14	Spain	Greenland 27.14.b	Unallocated	Total
2005	0		0		0
2006			0		0
2007	0		0		0
2008	0		0		0
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

9.4.10 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.

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).

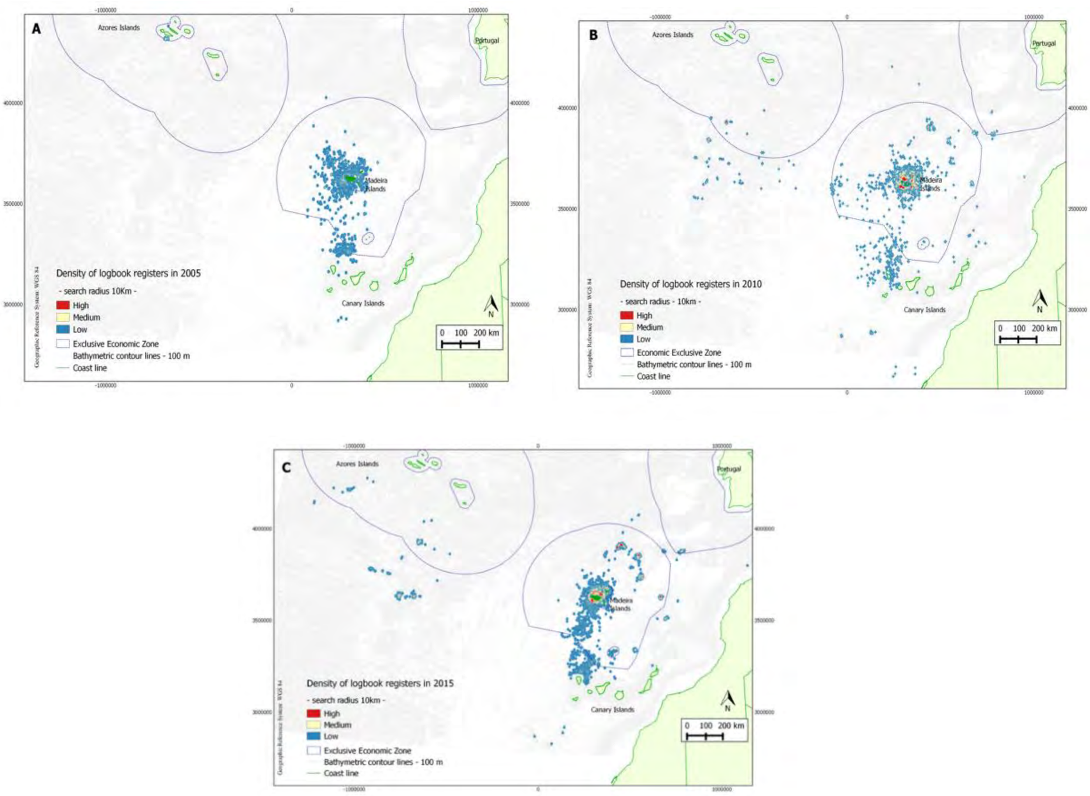


Figure 9.5.1. bsf CECAF area. Density plots illustrating the geographical distribution of the fishing sets with catches in 2005 (A), 2010 (B) and 2015 (C) (Delgado *et al.*, 2018).

Catches in CECAF 34 area were updated with fishery data from Madeiran longliners landings from 1990 to 2019. These catches are recorded by the Regional Fisheries Department of Madeira (Figure 9.5.2). CECAF catches have been decreasing after the 1998 peak, but a slight increase was observed since 2012 (landings in 2019 were around 2263 tons).

The EU TAC and total catches for CECAF 34 area from 2005 to 2019 are presented in Table 9.5.1.

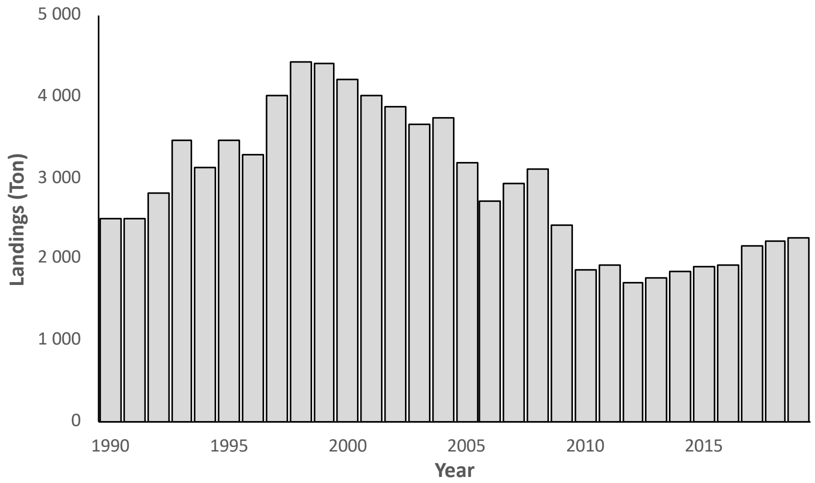


Figure 9.5.2. bsf CECAF 34. Time-series of annual Portuguese landings at CECAF area.

Table 10.5.1. bsf. Black scabbardfish TACs and total landings in CECAF 34 area between 2005 and 2019.

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

Following the methodology adopted at WGDEEP 2016 (ICES, 2016), standardised annual catch estimates for the period from 1990 to 2019 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.

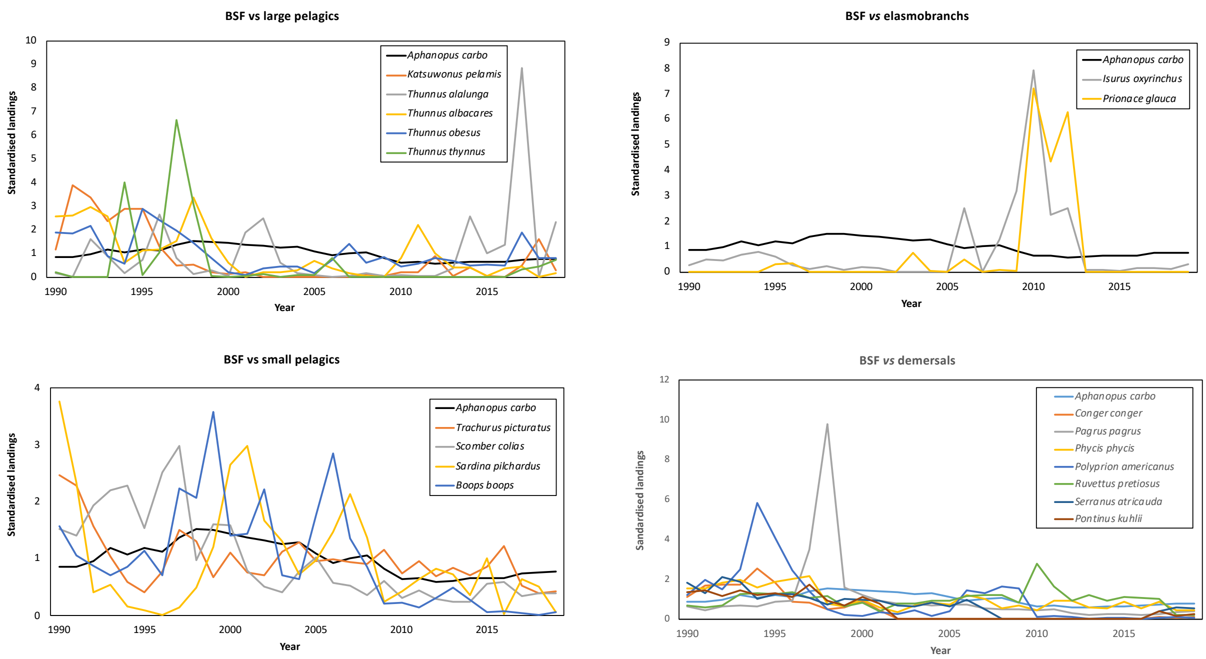


Figure 9.5.3. bsf CECAF area. Trends in standardised landings of black scabbardfish and the 19 other top ranked species in Madeiran landings.

For the period 2009–2019, the total length frequency distributions of the exploited population caught by the Madeiran longline fleet show no changes on the mean length (Figure 9.5.4).

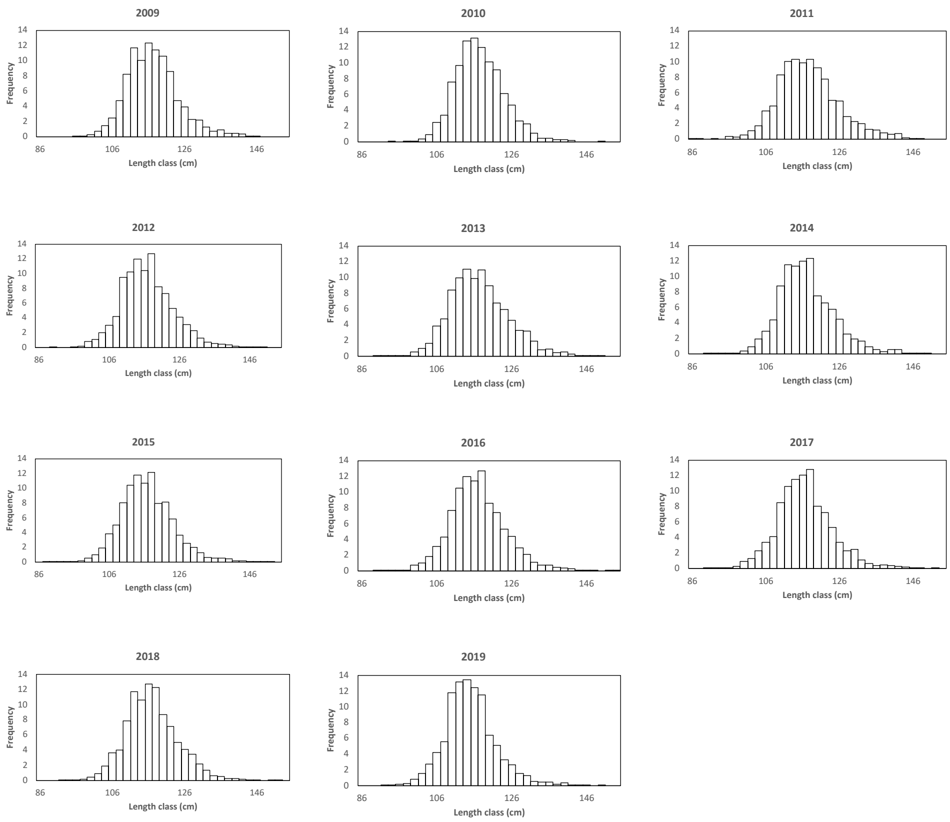


Figure 9.5.4. bsf CECAF. Annual length–frequency distribution of specimens landed by the Portuguese longliners operating along CECAF area.

In CECAF 34 area, the fishing effort that corresponds to the total number of hooks per year shows a continuous decrease from 2000 to 2019. Such decreasing trend is in line with the reduction in the number of active vessels (Figure 9.5.5).

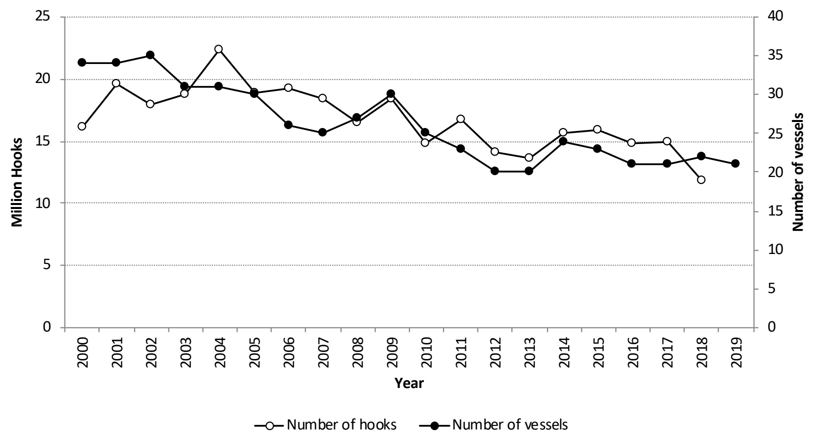


Figure 9.5.5. bsf CECAF 34 area. Time-series of the total annual effort estimated for the CECAF area (million hooks).

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.

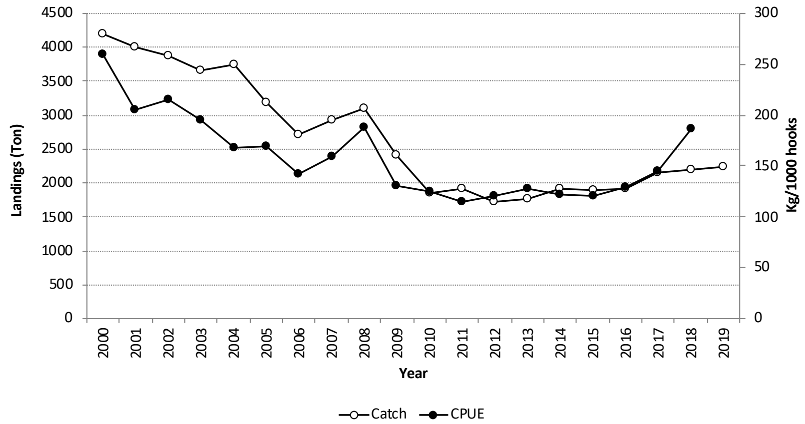


Figure 9.5.6. bsf CECAF 34 area. Time-series of landings per unit effort, nominal CPUE (kg/thousand hooks), in CECAF area.

For the period from 2008 to 2019, 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.

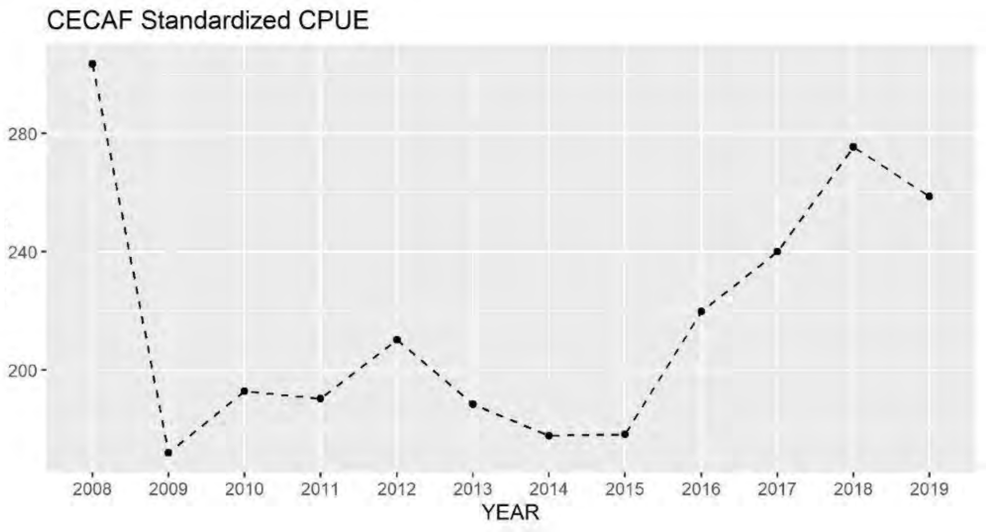


Figure 9.5.7. bsf.27.nea CECAF 34 area. Standardised CPUE (catch weight per fishing haul) from 2008 to 2019.

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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 less than 0.5% of total deep-water landings in the last five years, can be considered as bycatch.

10.2 Landings trends

Tables 10.0a–h 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 304 t in 2019 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 in 2016 and 2017, 3 and 5 t), and reaching 65 t in 2019 . Historically the main landings in 5.b come from France and Norway. However, in 2011 and 2012 the landings 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 2019. Landings reported in 2019 by all countries were 18 t. Traditionally, the most important landings in the Northeast Atlantic are recorded in 6 and 7 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 2019 the international reported landings were 1242 t, mainly by France (430 t) and Spain (498 t).

The main landings from subareas 8 and 9 come from Spanish fleets reaching 178 t in 2019. The average combined landings in the last ten years is 264 t. In 2010 landings were the lowest of the series mainly due to the reduction of landings reported by Spain.

Historically in Subarea 10 landings come only from Portugal. In 2107 for first time this country did not report any landing but in 2018 reached 14 t and again 0 landings in 2019. After a peak to 136 t in 1994 and 91 t in 2000 the average in this Subarea in the last ten years is 8.3 t. In 2014 for first time France reported 0.2 t in this subarea.

Although since 1991 many countries were involved in the fishery in Subarea 12 only in the period 2002–2009 Spain reported significant landings. 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

Biannual EU TACs for 2017 and 2018 and landings in the same years by ICES subarea are shown below. Landings in subareas 1, 2, 3 and 4 include Norwegian landings while only EU TACs are shown. In all subareas landings were lower than the EU TAC in this period.

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.

PHYCIS BLENNOIDES	EU TAC		TOTAL INTERNATIONAL LANDINGS	
Subarea	2018	2019	2018	2019
1, 2, 3, 4	29	no TAC	252	376
5, 6, 7	1928	no TAC	1276	1260
8, 9	254	no TAC	258	214
10, 12	52	no TAC	14	0
Total	2263	no TAC	1801	1850

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 2019 are shown in Table 10.1a for countries reporting landings to InterCatch and in Table 10.1b for Norway. The available discard estimates from 2013–2019 accounted 36%, 34%, 49%, 25%, 25%, 13% and 17% of the total catches respectively (Table 10.2a). In 2019 the main reported discards come from subareas 7 (67%), 6 (12%), and 4 (12 %). Length frequencies of commercial fleets available indicate 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 the situation is similar to 2016 and mostly of the discarded individuals are smaller than 33 cm (Figure 10.2a). Discards estimates should be considered with caution because (i) not all countries report discards and (ii) the method for estimating discards may not have been the same in all years. Discards may have been estimated by raising observed discards to total landings of the same species, to total landings of all species or to effort. Nevertheless, as a bycatch species available data suggest that this species is subject to significant discards and it would be useful to include request for consistent discards estimates from all countries in future data calls.

Series of Effort data (kWd) since 2014 of the Spanish, French, Swedish, 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 2009-2019, 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 (Moura and Figueiredo, 2020).

10.6.2 Length compositions

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 2019, 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 have been provided this year 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 2019 was presented (Figure 10.7).

10.6.5 Maturity and natural mortality

No new information of L_{mat}, L_{inf} and K was provided for the Spanish Data Call to the WG.

	Value	Reference	Comments
L_{mat}	53.89	CV=3.4%	both sex, n=960, years: 2015+2016+2017
Li_{nf}	91.46	CV=6.3%	both sex, n=1045, years: 2015+2016+2017
K	0.142	CV=10%	both sex, n=1045, years: 2015+2016+2017

10.6.6 Catch, effort and research vessel data

In 2018 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 2019 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 2019. 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 2019. 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 1990 to 2019 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 2019 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 2015. 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 2019 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 in 2019.

10.7 Data analyses

In the Spanish Groundfish Survey in the Porcupine bank the biomass and abundance of *P. blennoides* was slightly higher in this last survey, although the values remained among the lowest observed in the time series. The declining trend of the last four years has not yet been reverted (Figure 10.9). The spots of biomass were widely found in the south, west and east area, but scarcely in the north, as in previous years (Figure 10.17). Most specimens were from 26 cm to 39 cm this last survey (Figure 10.3) (Ruiz-Pico *et al.* 2020).

The EVHOE IBTS survey in Divisions 7.f,g,h,j and 8.a,b,d indicates an increase in biomass since 1996, with peaks in 2004, 2007 and 2012 and a decrease since 2013. However, landings have decreased from 2012 onwards since the most important peak was in 2011. Similarly, the 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 2019a slight recovery is recorded compared with values in 2016 and 2017 (Figure 10.10). The mean length has increased since the beginning of the series reaching the highest value in 2005 and 2016. No new data of length are available since 2016 (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 and 2019 a slight recovery in biomass is recorded compared with values in 2017. (Figure 10.11).

In Northern Spanish Shelf bottom-trawl survey in 2019, the biomass of *Phycis blennoides* in standard hauls (0.24 ± 0.07 Kg·haul^{-1}) decreased slightly, remaining among the lowest values of the time series. The abundance (1.01 ± 0.3 ind·haul^{-1}) suffered a collapse, reaching one of the lowest values in the time series. However, biomass and abundance of this species in hauls out the stratification, deeper than 500 m, grew sharply in 2019, matching the highest value of the historical series reached in 2014 (**Error! Reference source not found.**). It is important to highlight that 71% of the biomass of *Phycis blennoides* caught in the survey was found deeper than 500 m, with 40% of the hauls with this species carried out at that depth. In 2019, *P. blennoides* was caught between 152 m and 810.5 m and it was widespread in the sampling area (Figure 10. 18). Respecting length distribution, the small individuals (between 12 and 21 cm) of the two previous years were scarce in 2019 in standard hauls, whereas the abundance of larger individuals (around 30 cm) grew slightly. In additional deeper hauls, the mode matches that one in standard hauls; however, the largest individuals absent in the stratified area, ranged from 50 and 71cm (**Error! Reference source not found.**10.4) (Fernández-Zapico *et al*., 2020).

The NS-IBTS shows an increase on abundance since 1976. 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 (23.9 individuals/hour),in 2018 dropped again to 14.4 and increases in 2010 to 19.7.

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 2009,. In 2017 and 2019 an important increase of the biomass was recorded reaching the peak of the series with 35.1 kg/hour and 31.8 kg/hour respectively. The abundance shows the same profile of the biomass with an important increase in 2017 and (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 evidences 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 2020.

10.7.2 Comments on the assessment

No analytical assessment was presented in WGDEEP 2020.

10.8 Management considerations

As this 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 shows a decrease in biomass and abundance since 2017, and on the contrary, the French EVHOE shows an increase in biomass an abundance in 2018 and 2019. 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 26% in the biomass in last two years.

On the other hand, landings in all ecoregions has 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. The only exception is in subareas 1, 2, 3, and 4 in which the amounts landed have been historically above the TAC due to the landings of Norway which are not affected by the EU TAC regulation. According to the Council Regulation (EU) 2018/2025, the TACs for greater forkbeard in all ICES subareas was no longer set from 2019 onwards. It could be supposed that if the TAC for this stock was removed both landings and discards of greater forkbeard could increase. However, the landings reported in 2019 remained similar to those in 2018, the last year with TAC.. 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. Not all the countries involved in the fishery report data to InterCatch, and the discard cannot be quantified for the whole stock and are very variable from year to year. In the same sense, the commercial length frequencies are only partially available from some countries and areas and the historical series is short. According to the information available, reported discards are high and decreased in last years represented 36%, 34%, 49%, 25%, 13%, % and 17% of the annual catches from the period 2013–2019.

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

YEAR	1+2	3+4	5B	6+7	8+9	10	12	TOTAL
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
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

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

YEAR	NORWAY	FRANCE	RUSSIA	UK (SCOT)	UK (EWNI)	GERMANY	FAROE ISLANDS	TOTAL
1997	0							0
1998	0							0
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

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	TOTAL
1988	12	0	3	0				15
1989	12	0	0	0				12
1990	18	92	5	0				115

YEAR	FRANCE	NORWAY	UK (EWNI)	UK (SCOT)[1]	GERMANY	DENMARK	SWEDEN	TOTAL
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
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

[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
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

YEAR	FRANCE	NORWAY	UK(SCOT)[1]	UK(EWNI)	FAROE ISLANDS	RUSSIA	ICELAND	TOTAL
2016	7	3	0				3	13
2017	9		0					9
2018	5	7						12
2019	7	10						18

(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	IRE-LAND	NOR-WAY	SPAIN[1]	UK (EWNI)	UK (SCOT) [2]	GER-MANY	RUS-SIA	FAROE IS-LANDS	TO-TAL
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
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

YEAR	FRANCE	IRELAND	NORWAY	SPAIN[(1)]	UK (EWNI)	UK (SCOT) [(2)]	GERMANY	RUSSIA	FAROE ISLANDS	TOTAL
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

(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
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

YEAR	FRANCE	PORTUGAL	SPAIN[(1)]	UK(EWNI)	UK (SCOT)	TOTAL
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

(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

YEAR	PORTUGAL	FRANCE	TOTAL
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
2017			0
2018	14		14
2019			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

YEAR	FRANCE	UK(SCOT)[1]	NORWAY	UK(EWNI)	SPAIN[2]	RUSSIA	TOTAL
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
2011	0						0
2012	0						0
2013							0
2014	0						0
2015							0
2016							0
2017							0
2018					0		0
2019							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
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 2019.

Landings (t)	2019
Denmark	65
GNS_DEF	0.0
MIS_MIS	0.0
OTB_CRU	1.2
OTB_DEF	64.1
SDN_DEF	0.0
SSC_DEF	0.1
Ireland	18
OTB_DEF_100-119_0_0_all	17.2
OTB_DEF_70-99_0_0_all	1.0
TBB_DEF_70-99_0_0_all	0.0
Portugal	7
MIS_MIS_0_0_0	7.1
OTB	0.0
Spain	676
MIS_MIS_0_0_0_HC	2.7
OTB_DWS_100-129_0_0	0.0
OTB_DEF_70-99_0_0	10.3
OTB_DEF_>=55_0_0	52.1
PTB_MPD_>=55_0_0	1.3
LLS_DEF_0_0_0	412.7
OTB_DEF_100-119_0_0	153.9

Landings (t)	2019
GNS_DEF_>=100_0_0	7.0
OTB_MPD_>=55_0_0	8.3
GNS_DEF_60-79_0_0	5.5
GNS_DEF_80-99_0_0	2.5
OTB_MCD_>=55_0_0	6.5
OTB_DEF_>=70_0_0	10.7
GNS_DEF_120-219_0_0	0.5
PTB_DEF_>=70_0_0	0.2
OTB_MPD_>=70_0_0	0.7
GTR_DEF_60-79_0_0	0.9
LHM_DEF_0_0_0	0.1
Sweden	0
FPO_CRU_0_0_0_all	0.0
GNS_DEF_all_0_0_all	0.0
GTR_DEF_all_0_0_all	0.0
LLS_FIF_0_0_0_all	0.0
MIS_MIS_0_0_0_HC	0.0
MIS_MIS_0_0_0_IBC	0.0
OTB_CRU_32-69_0_0_all	0.0
OTB_CRU_32-69_2_22_all	0.0
OTB_CRU_70-89_2_35_all	0.0
OTB_CRU_90-119_0_0_all	0.0
OTB_DEF_>=120_0_0_all	0.0
SDN_DEF_>=120_0_0_all	0.0
UK (England)	13
GNS_DEF	0.8
LLS_DEF	0.0
MIS_MIS_0_0_0_HC	0.1
OTB_DEF	11.9

Landings (t)	2019
UK(Scotland)	98
LLS_DEF_0_0_0_all	7.4
MIS_MIS_0_0_0_HC	1.0
OTB_CRU_70-99_0_0_all	0.2
OTB_DEF_>=120_0_0_all	89.8
France	470
LLS_DEF	43.5
MIS_MIS_0_0_0	7.1
OTB_DEF_70-99_0_0	14.7
OTB_DEF_100-119_0_0	88.6
OTT-DWS	1.2
OTB_DWS_100-119_0_0_all	4.3
GNS_DEF_100-119_0_0_all	20.2
OTT_DEF_100-119_0_0	101.6
OTB_DEF_<16_0_0_all	0.9
OTT_DEF_>=70_0_0	7.3
OTB_DEF_>=70_0_0	0.7
OTT-DEF	0.0
OTB_DEF_>=120_0_0	94.2
OTB_DWS_>=120_0_0_all	85.4

Table 10.1b. Greater forkbeard *(Phycis blennoides*). Norwegian landings (t) by métier in 2019.

	Bottom trawl	Gillnets	Handlines	Longlines	Pelagic trawl	Traps
Norway	18.4	34.1	0.0	447.9	0.6	1.2

Table 10.2a. Greater forkbeard *(Phycis blennoides*). Reported discards (ton) of *P. blennoides* from 2013 to 2018.

ton	2013	2014	2015	2016	2017	2018	2019
DISCARDS	1185	1166	2068	677	513	263	366
LANDINGS	2143	2269	2175	2012	1503	1801	1850
CATCHES	3328	3435	4243	2689	2016	2064	2216

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 2013–2019.

year	Observation (kg/trip)	CPUE Estimate (Kg/trip)	Upper	Lower
2013	10.68	10.68	13.72	8.31
2014	12.31	11.82	15.4	9.07
2015	11.93	11.72	15.2	9.03
2016	10.76	10.37	13.42	8.01
2017	9.94	9.83	12.8	7.55
2018	12.46	12.13	15.9	9.3
2019	9.01	9.86	12.89	7.55

10.11 Figures

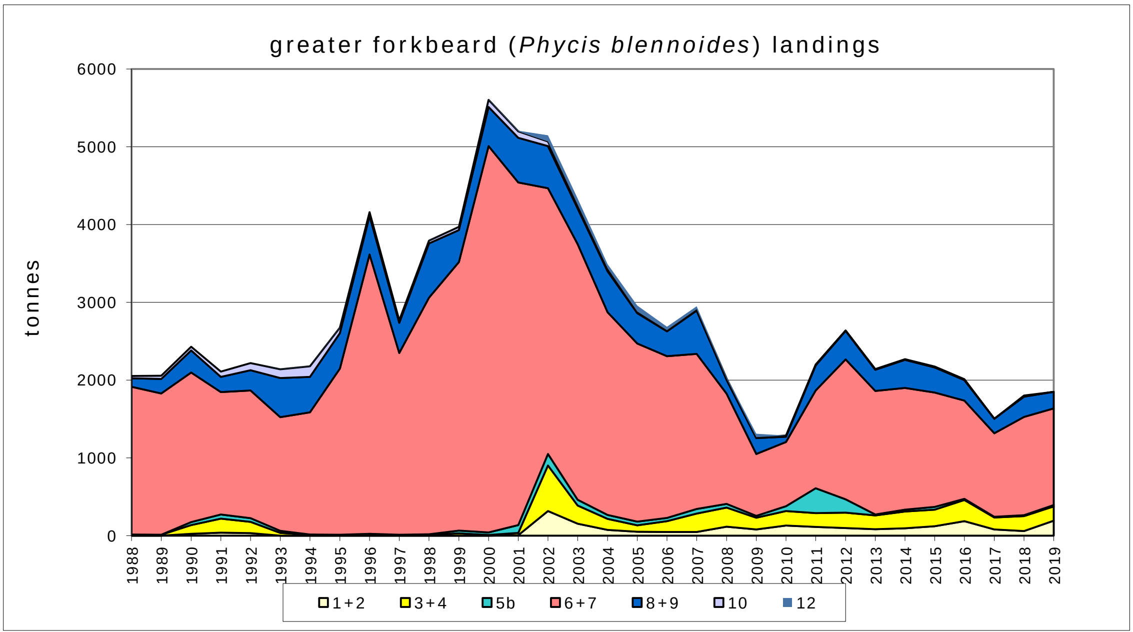
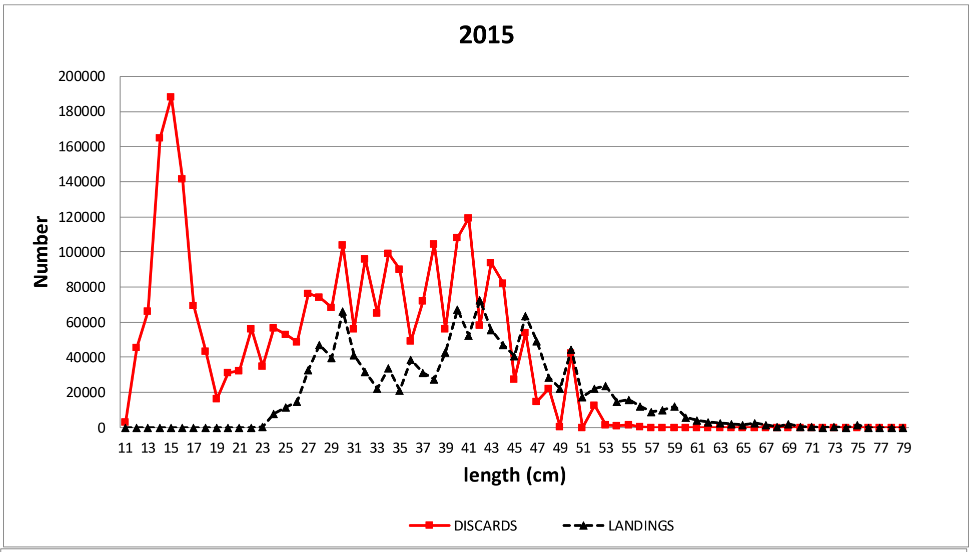
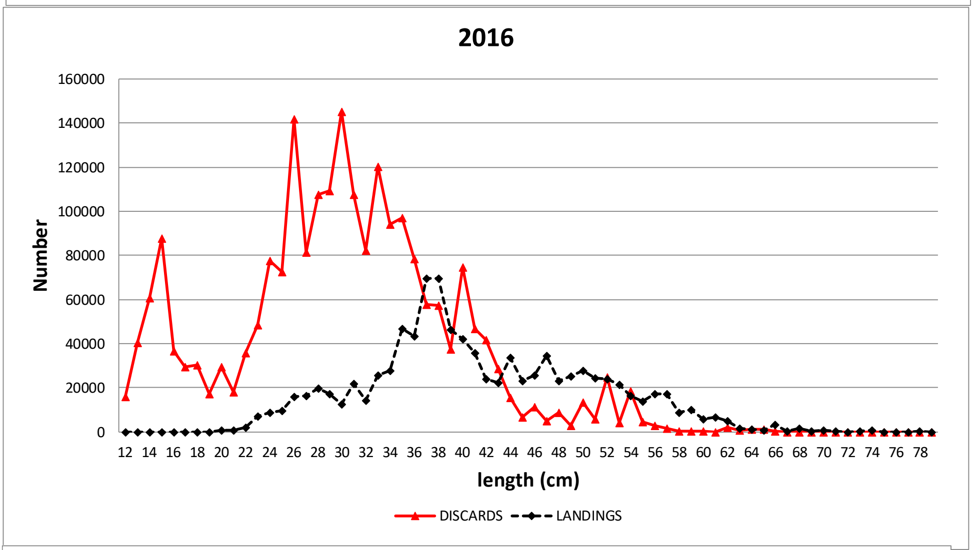
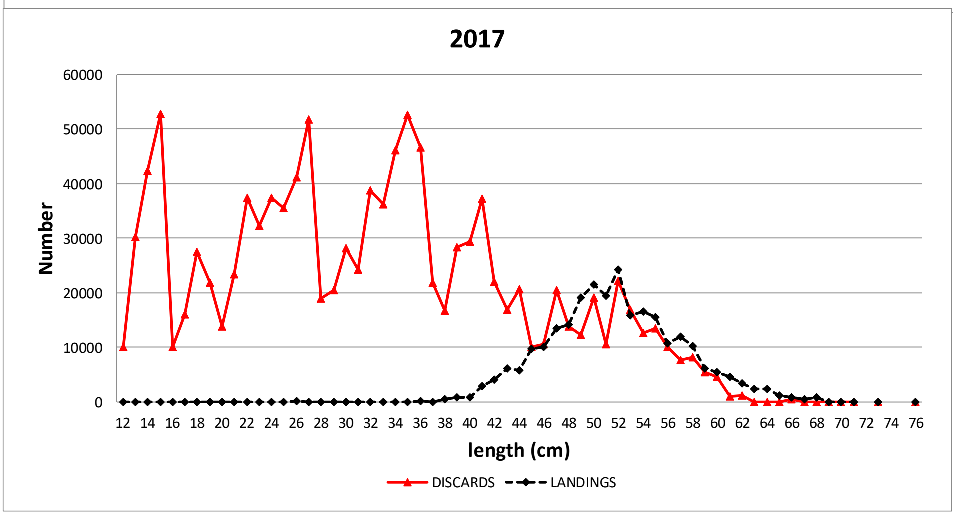


Figure 10.1. Greater forkbeard landing trends in all ICES subareas since 1988.


2015
Number
length (cm)
DISCARDS
LANDINGS


2016
Number
length (cm)
DISCARDS
LANDINGS


2017
Number
length (cm)
DISCARDS
LANDINGS

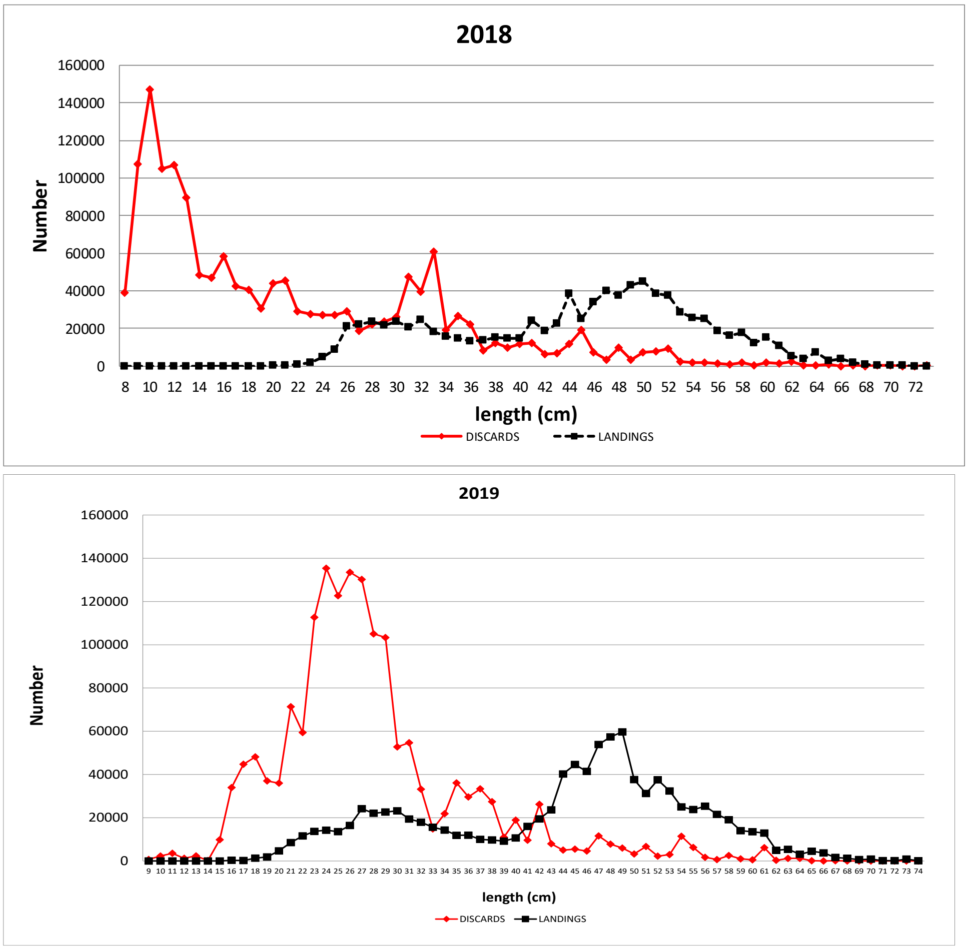


Figure 10.2a. Commercial length frequencies of the greater forkbeard landings and discards from 2015 to 2019 from France, Spain, Ireland, Portugal, Denmark, Sweden, UK (England), and UK (Scotland).

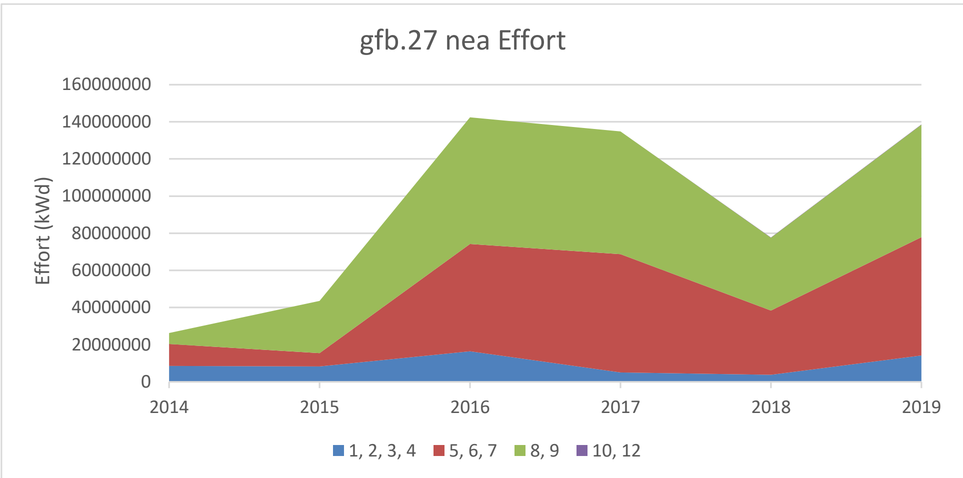


Figure 10.2b. Effort data (kWd) by stock units since 2014 of the Spanish, French, Swedish, UK (Scotland) and Irish fleets

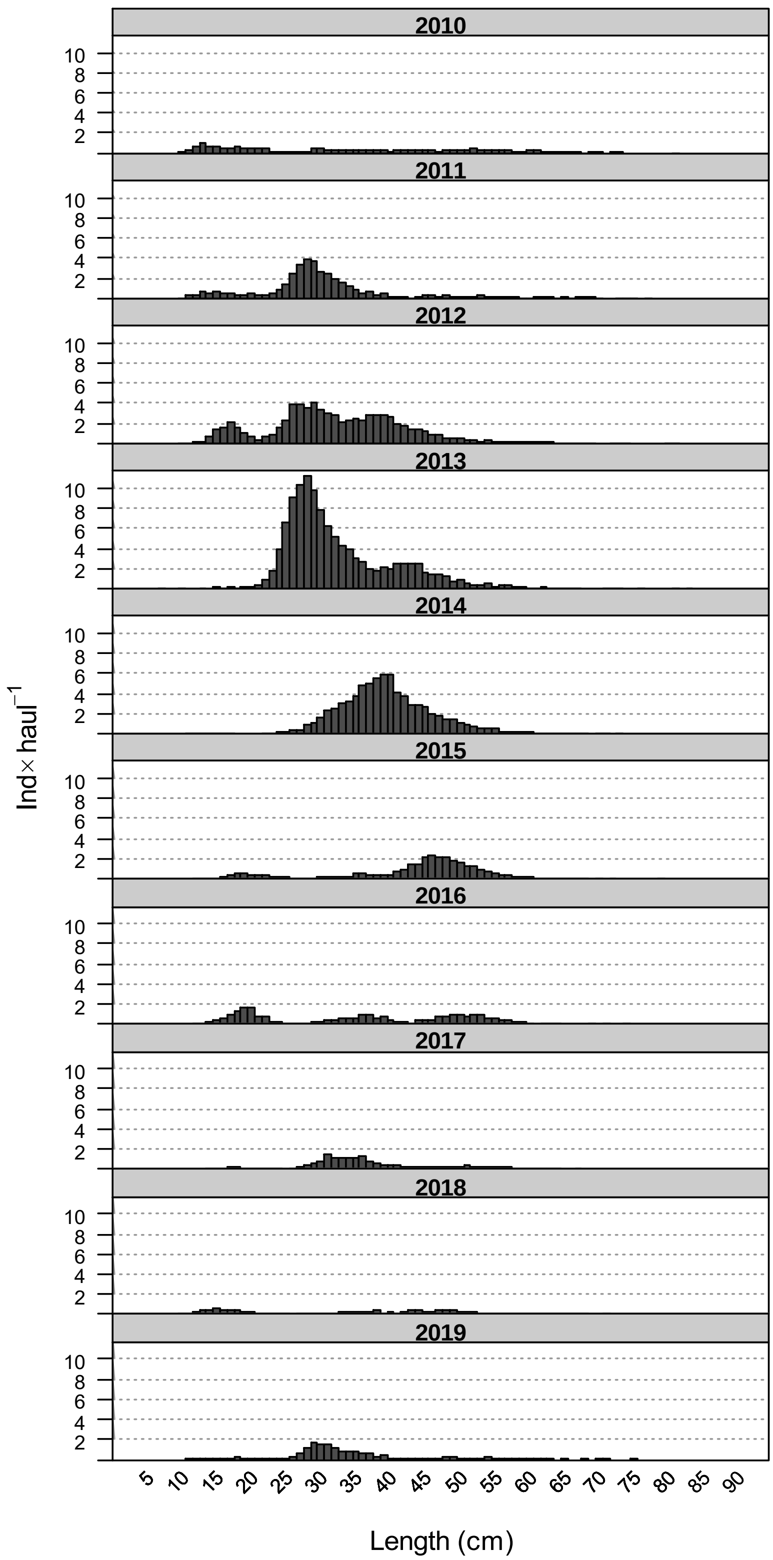


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Figure 10.3. Mean stratified length distributions of greater forkbeard (*P. blennoides*) in Porcupine survey (Divisions 7.c and 7.k) time-series (2009–2018).

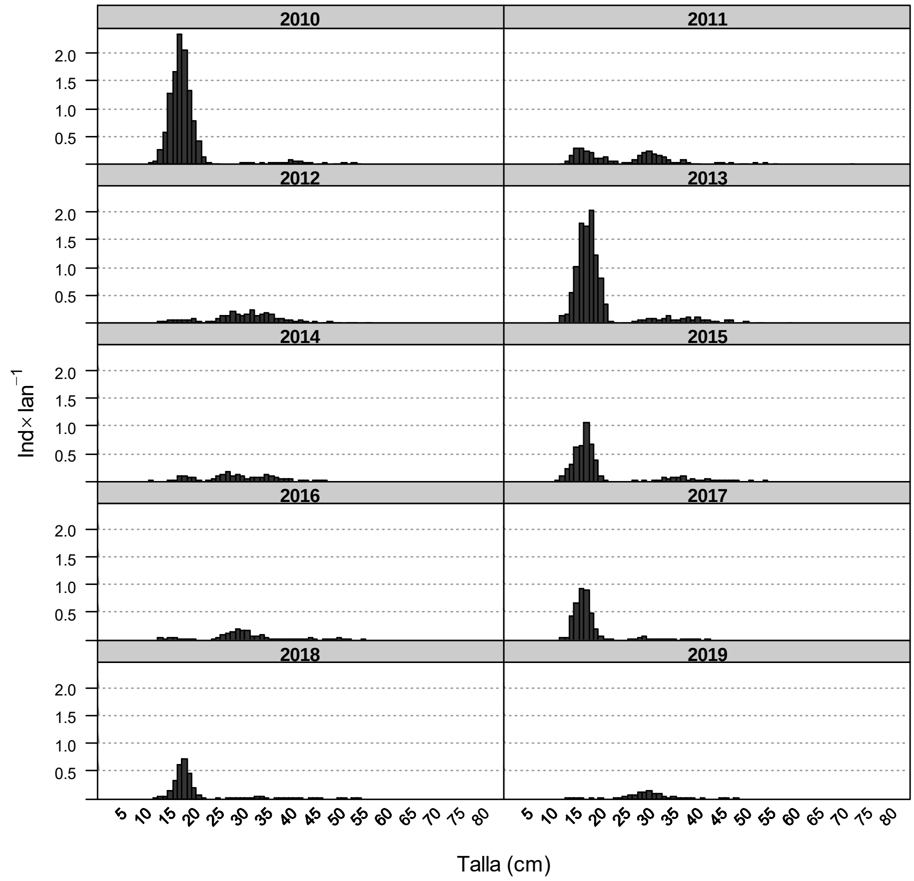

Figure 10. 4. Mean stratified length distributions of greater forkbeard (*P. blennoides*) in Northern Spanish Shelf survey (8.c and 9.a) in the period 2009–2018.

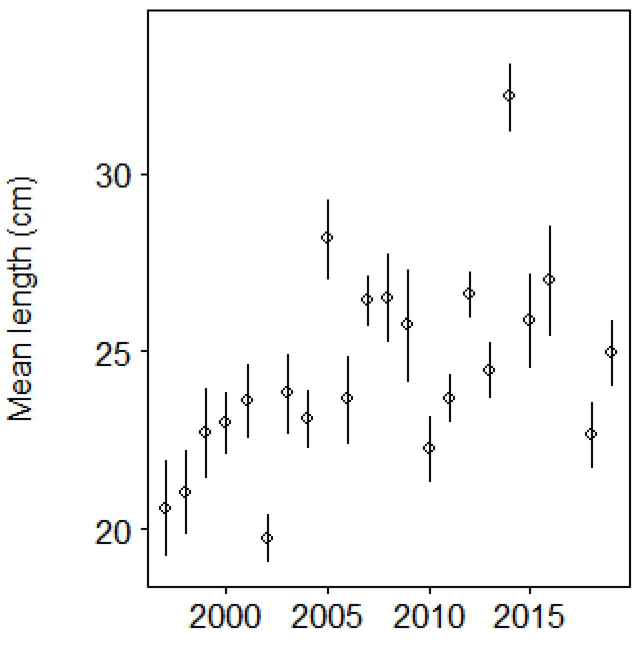

Figure 10. 5. Greater forkbeard series of mean length from the French IBTS survey Divisions 7.fghj and 8.abd until 2019.

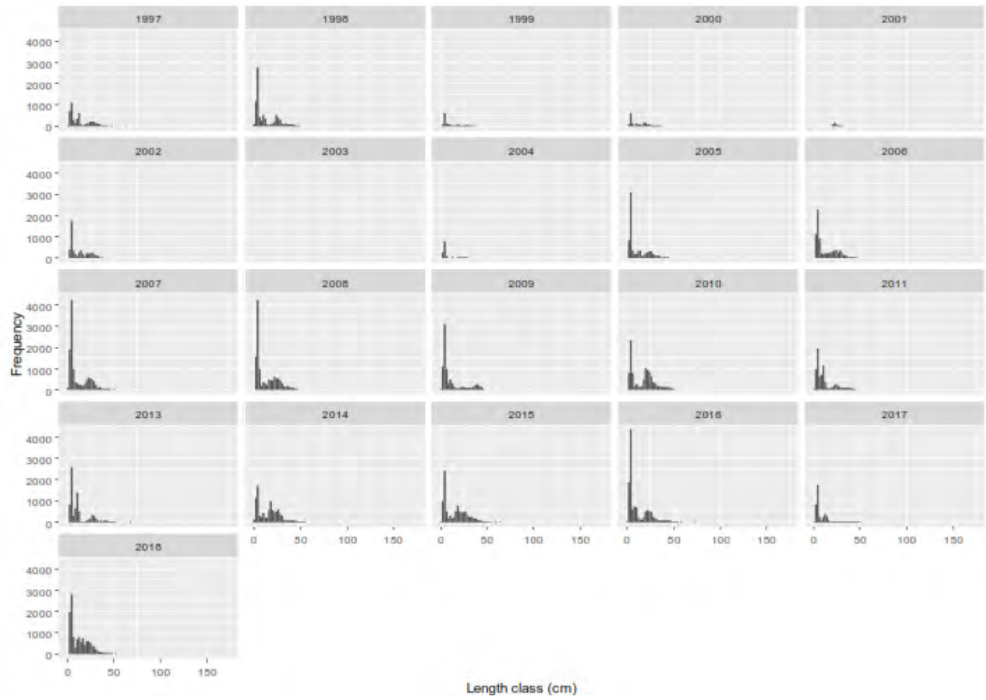

Figure 10.6a. Length frequency distribution of the greater forkbeard in the PT-CTS (UWTV (FU 28-29) until 2018.

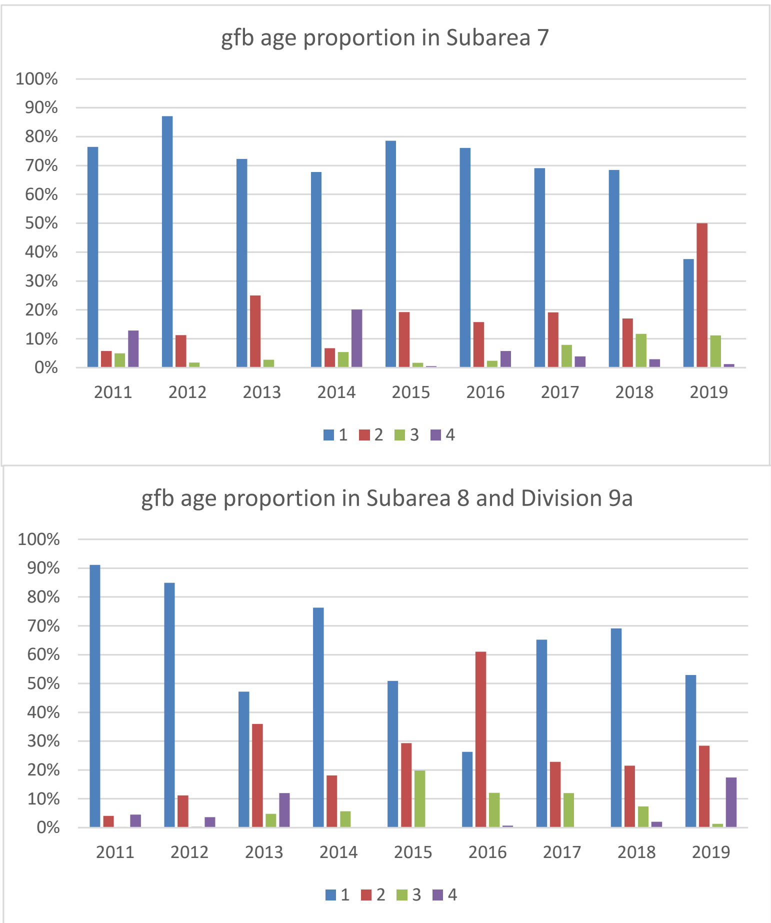

Figure 10.6b. . Age proportion of the Spanish commercial fleets since 2011 in subareas 7, 8 and Division 9a..

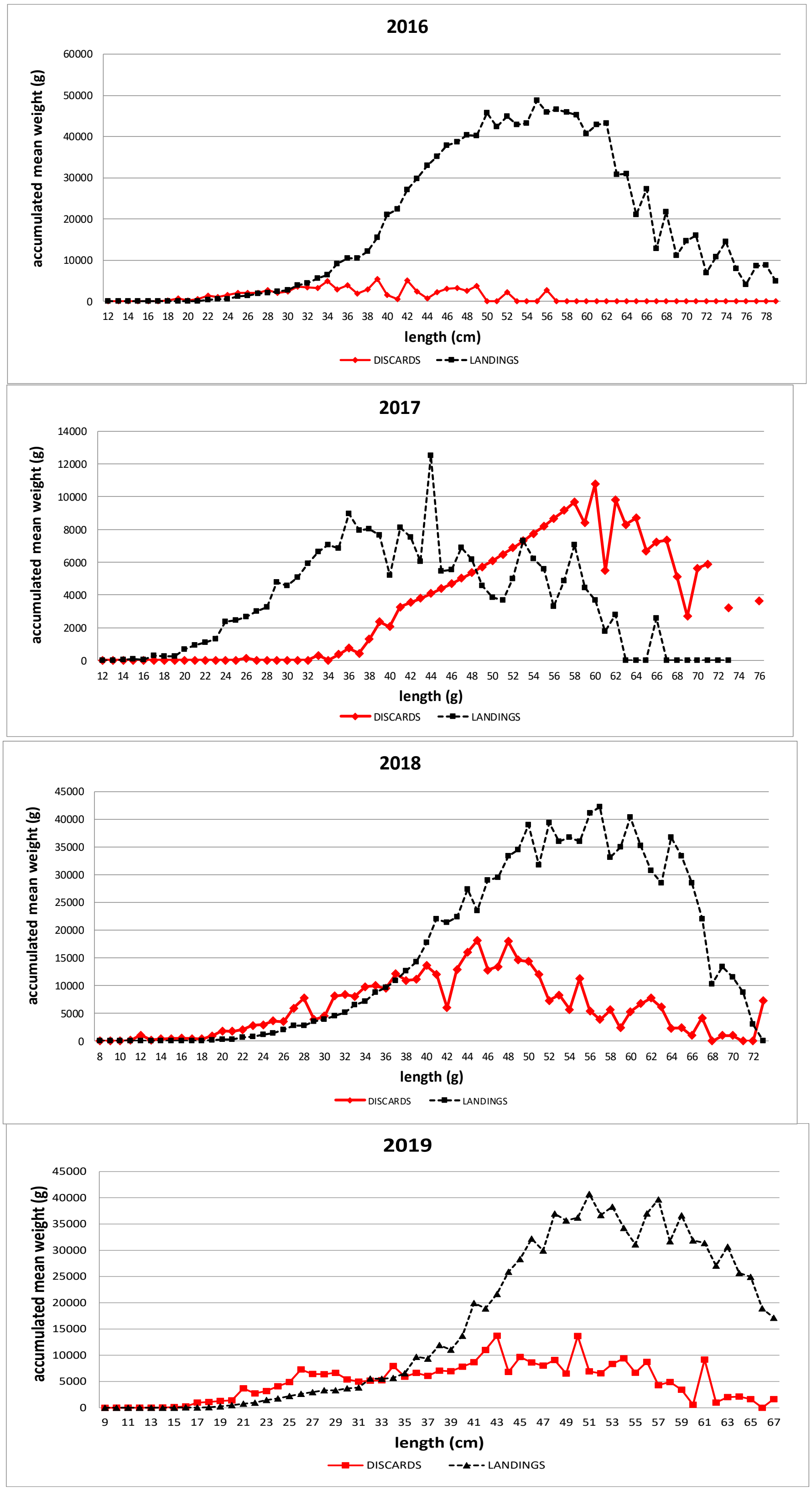

Figure 10.7 Accumulated mean weight at length of the international commercial landings and discards reported to Inter-Catch from 2016 to 2019.

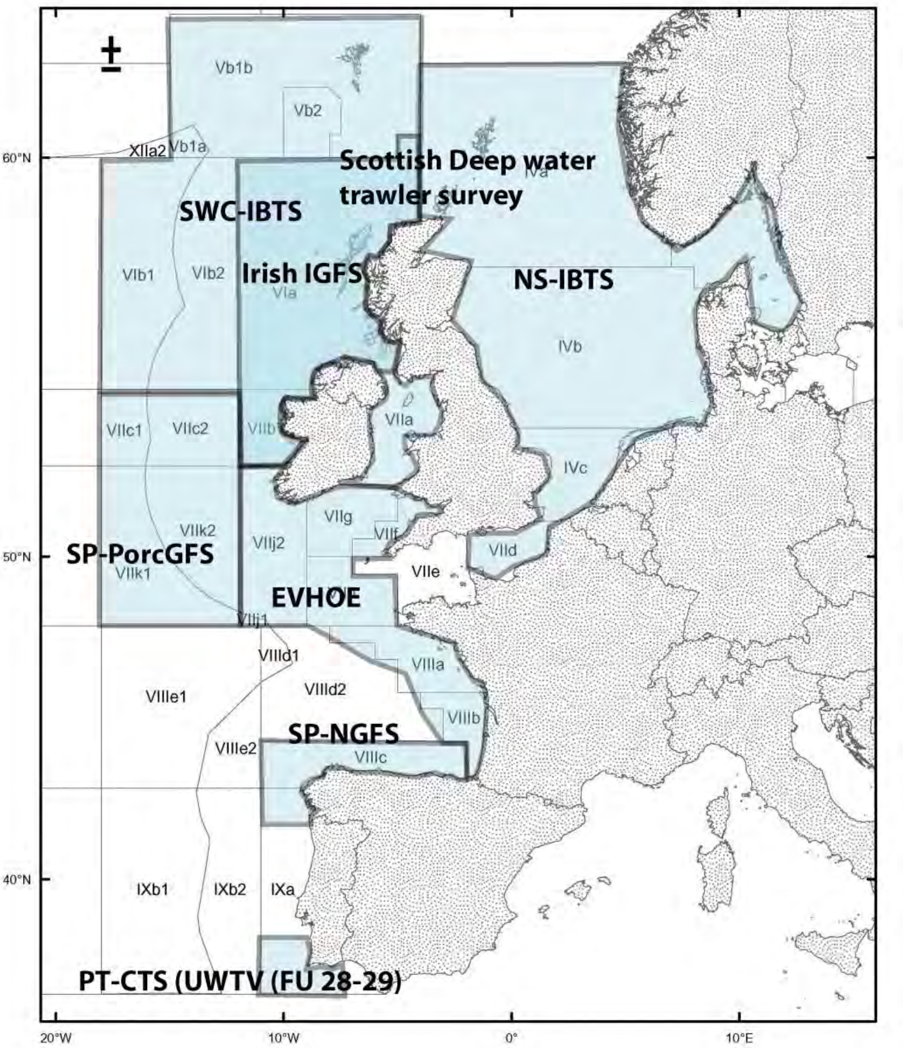

Figure 10.8. Map of the Divisions covered by the eight surveys used in the trend analysis of abundance and biomass of GFB.

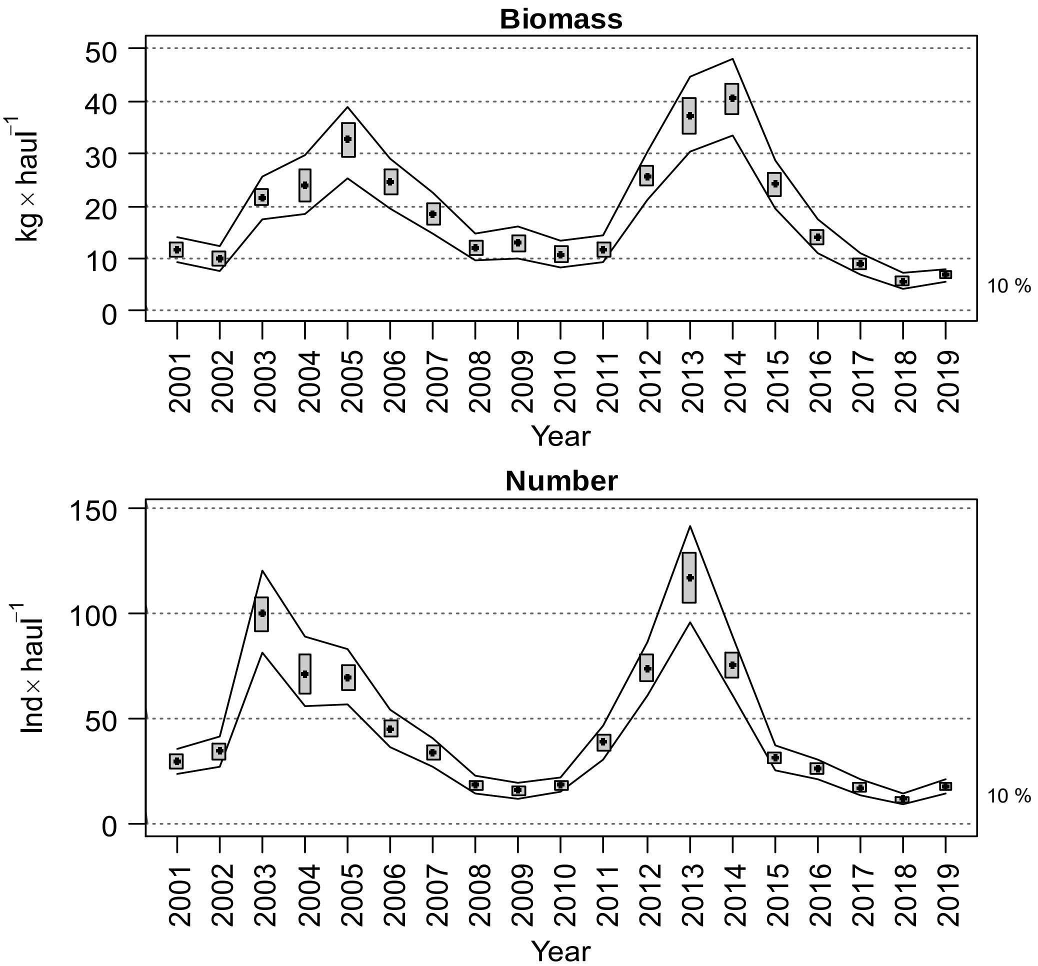

Figure 10.9. Evolution of *Phycis blennoides* biomass and abundance indices during Porcupine Survey time-series (2001–2019) in Divisions 7.c and 7.k. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000).

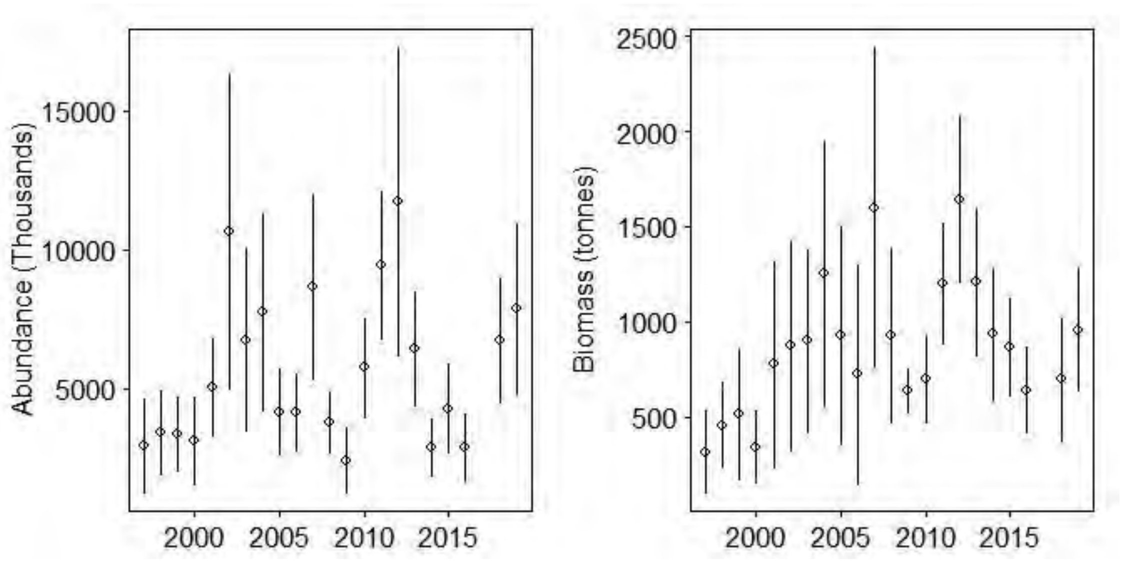

Figure 10.10. Greater forkbeard series of abundance and biomass of the French EVHOE IBTS survey in the Divisions 7.fghj and 8.abd combined until 2019.

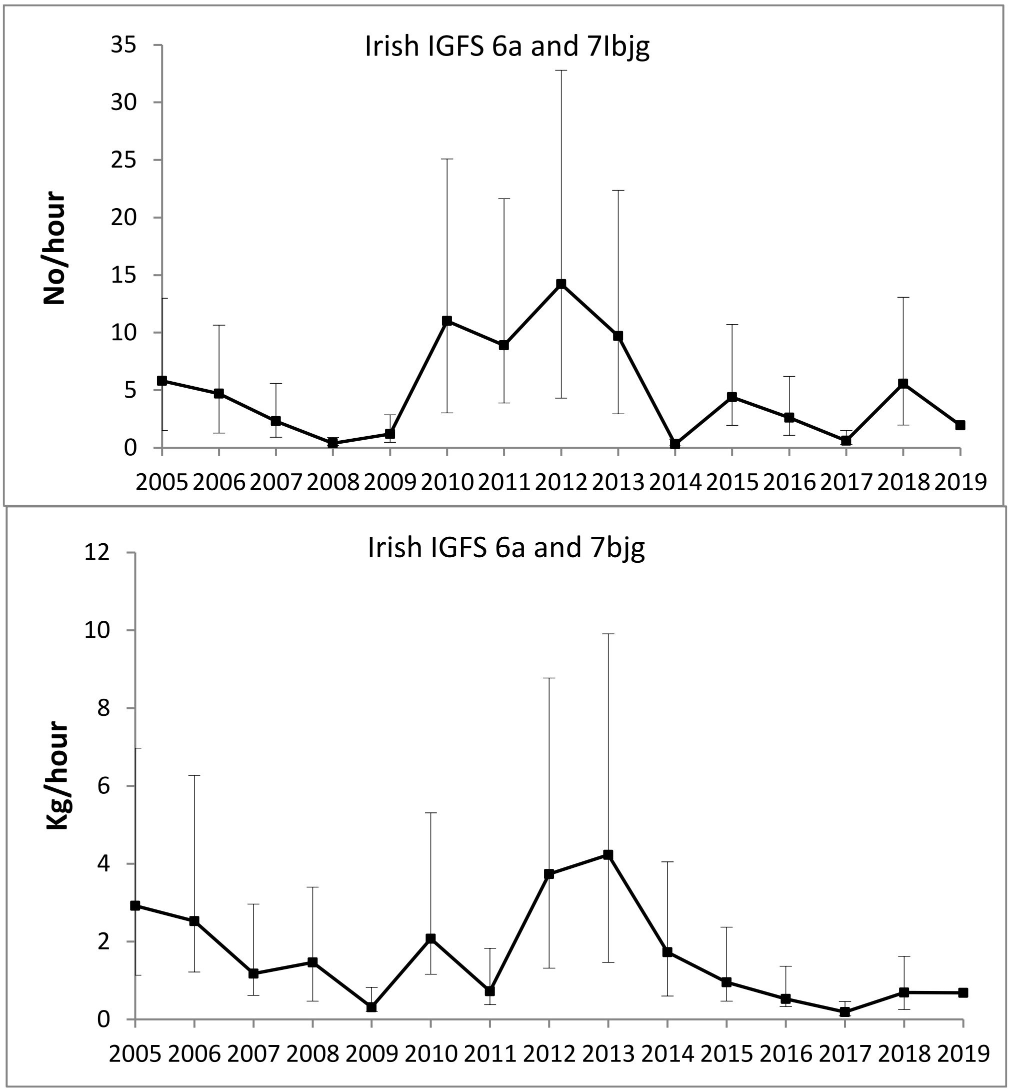

Figure 10.11. Abundance and biomass Indices (no. per hour and kg per hour) of Greater forkbeard total catches of the Irish IGFS Survey in the slope and shelf strata, 2005–2019.

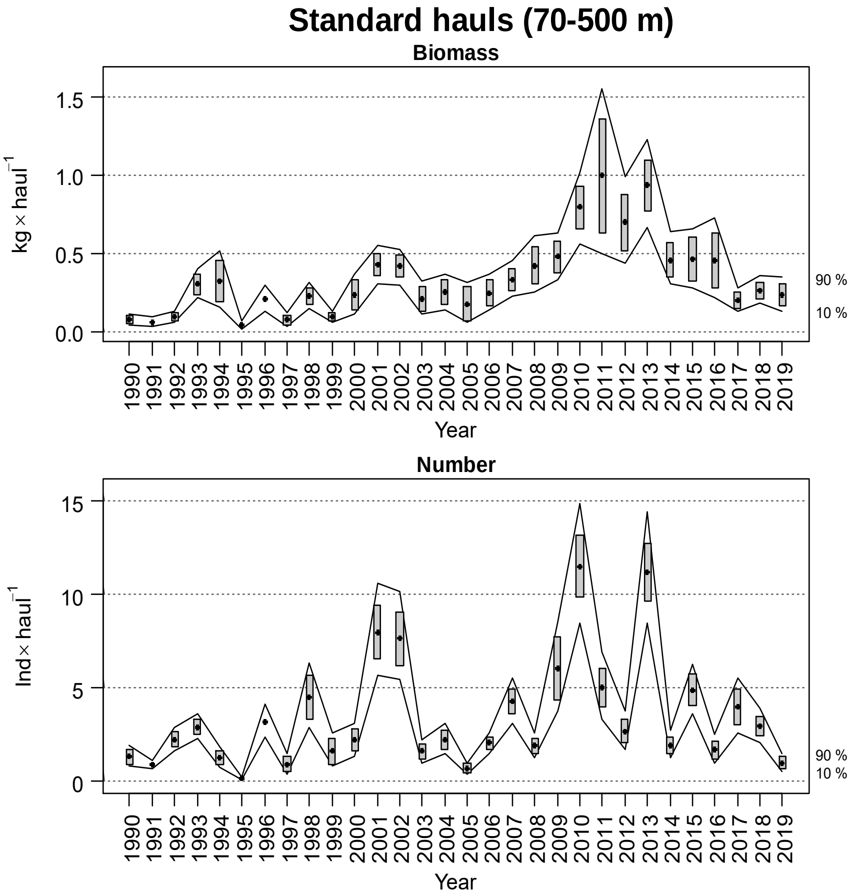

Figure 10.12. Changes in *Phycis blennoides* biomass and abundance indices (kg/tow and No/tow) during northern Spanish Shelf bottom-trawl survey time-series (1990–2019) in Divisions 9.a and 8.c.

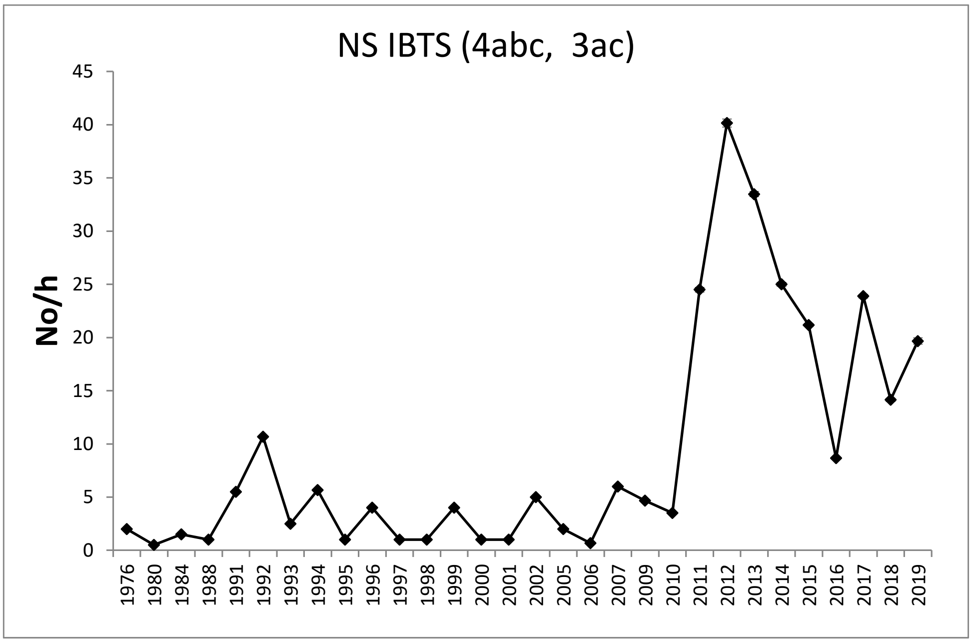

Figure 10.13. Greater forkbeard series of abundance (No/hour of the North Sea IBTS survey (NS-IBTS) until 2019 in Divisions 4.abc and 3.ac.

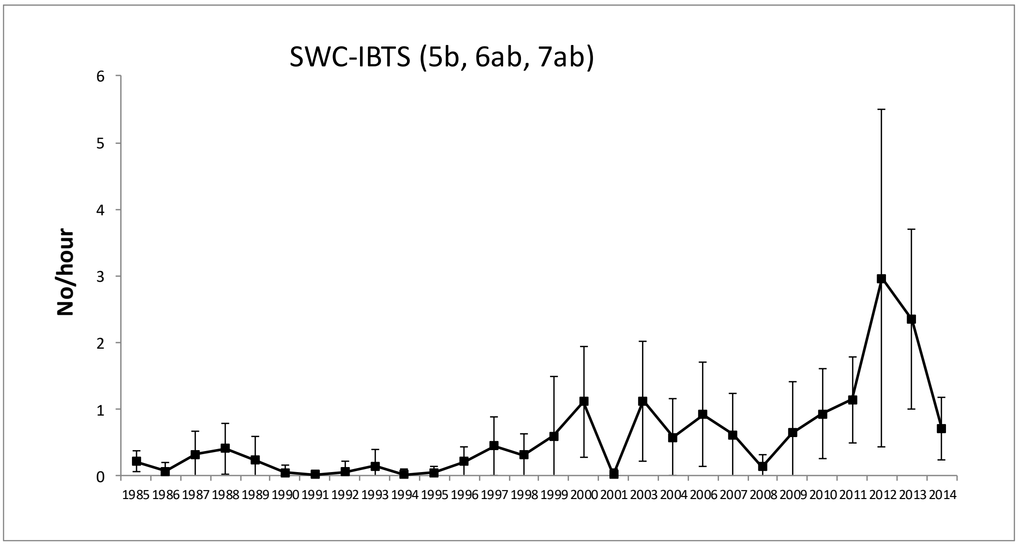

Figure 10.14. Greater forkbeard series of abundance (No/hour) of the Scottish Western Coast Groundfish IBTS survey (SWC-IBTS) until 2014 in Divisions 5.b, 6.ab and 7.ab.

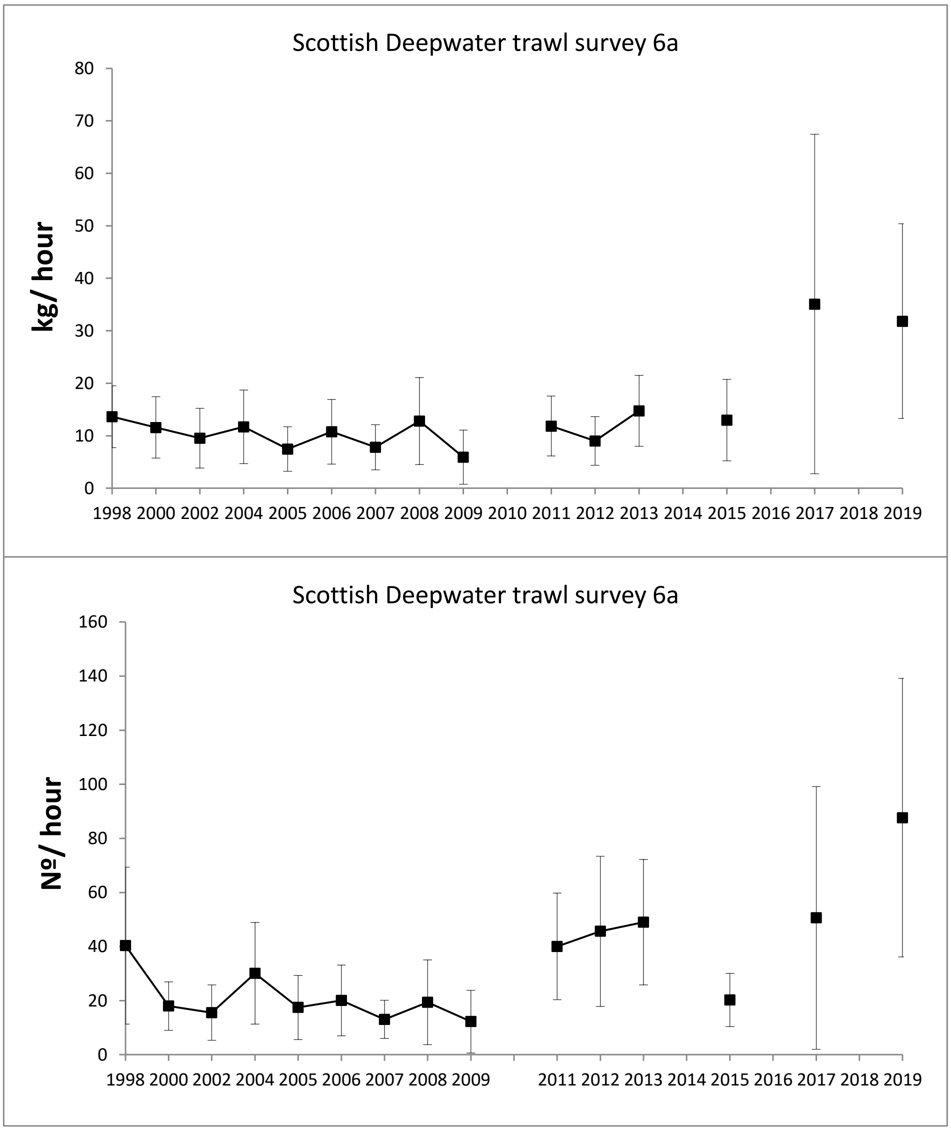

Figure 10.15. Greater forkbeard series of biomass (kg/hour) and abundance (Nº/hour) of the Scottish Deep-water trawl survey until 2017 in Division 6.a.

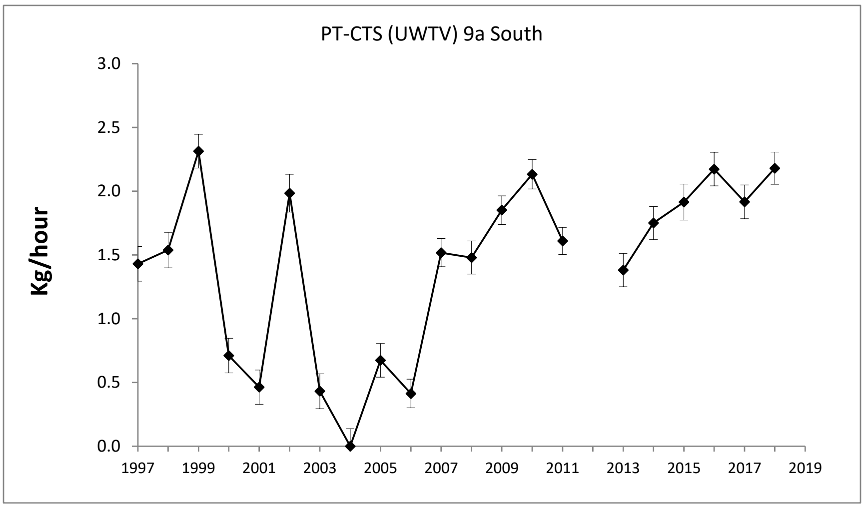

Figure 10.16. Greater forkbeard series of Standardized biomass index (kg.hour-1) of the Portuguese PT-CTS (UWTV (FU 28–29) survey until 2019 in the Division 9.a South. CPUE values estimated for the sector "Milfontes".

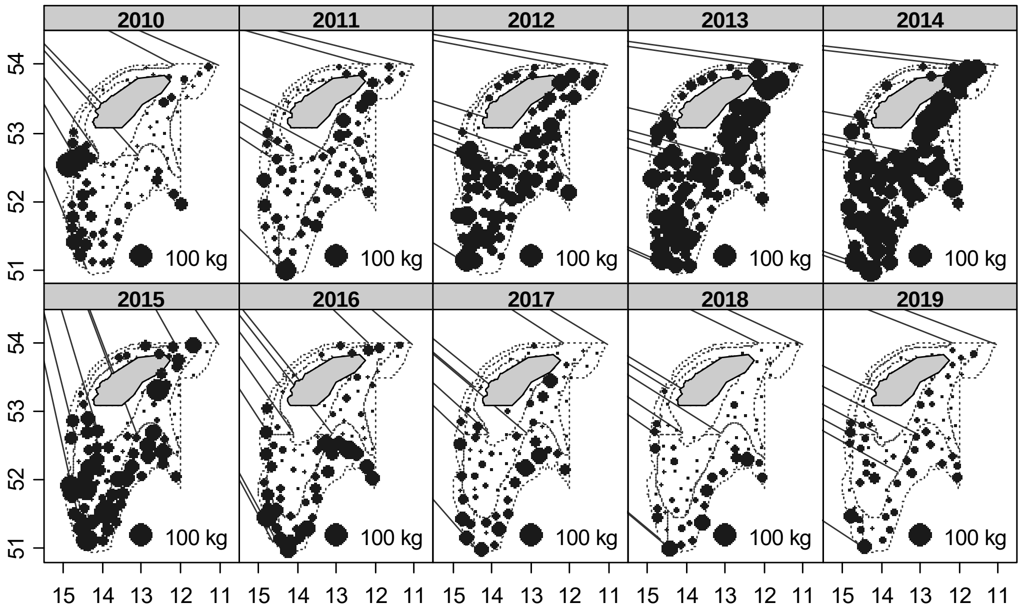

Figure 10.17. Geographic distribution of *Phycis blennoides* catches (kg/30 min haul) in Porcupine surveys between 2009 and 2019.

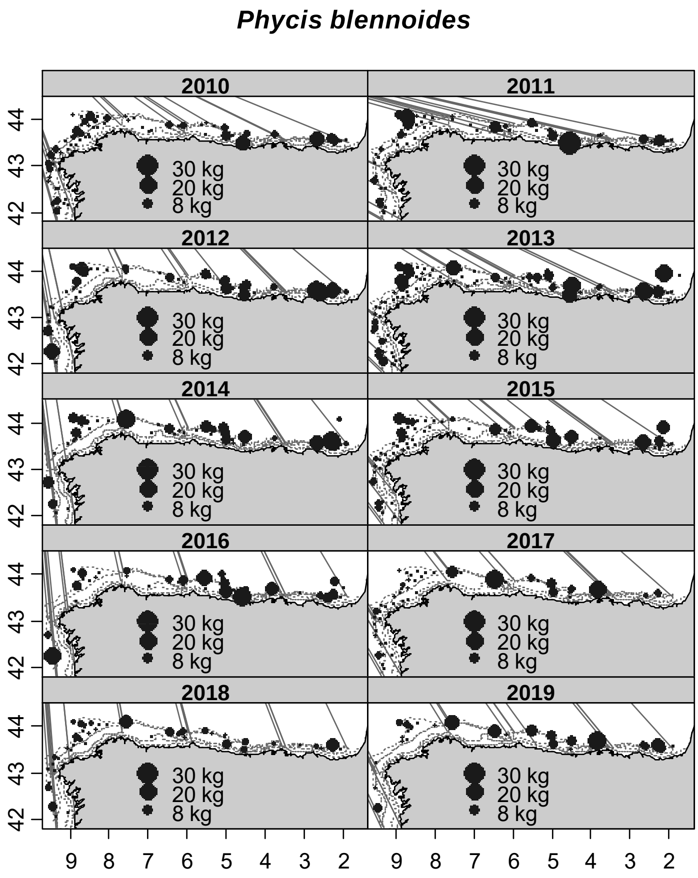

Figure 10.18. Catches in biomass of greater forkbeard on the Northern Spanish Shelf bottom-trawl surveys during the period: 2009–2019.

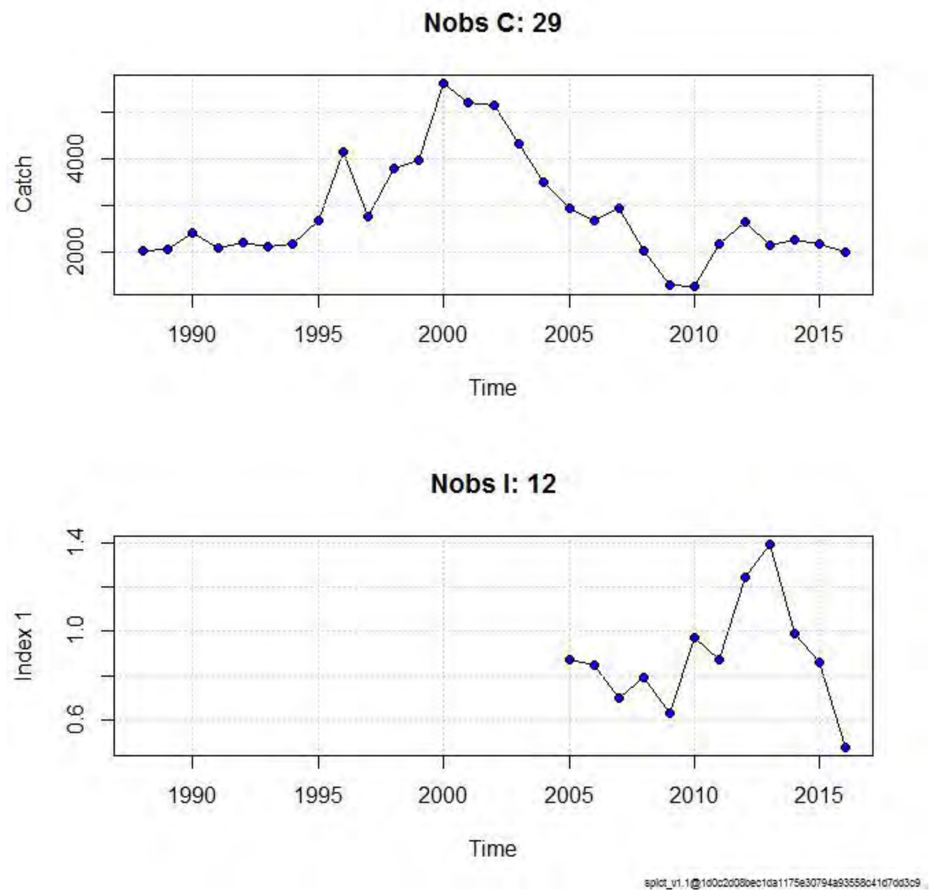

Figure 10.19. Inputs of the SPICT model used in the Greater Forkbeard stock.

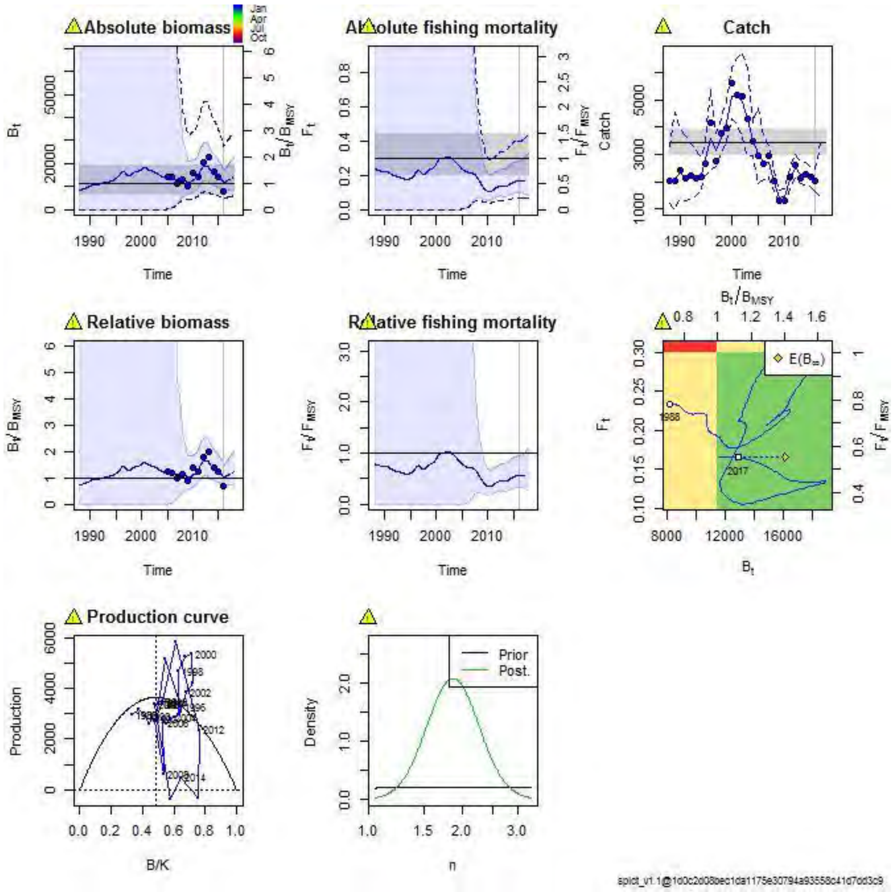

Figure 10.20. Results of the SPICT model for the Greater Forkbeard stock.

10.12 References

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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*) on the Northern Spanish Shelf Groundfish Survey. Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources Copenhagen, 24th April–1st May 2020. 19 pp.

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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 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 European fleets involved in this fishery.

There were Russian landings from a targeted fishery in the NEAFC area (ICES Subarea10.b) between 1993 and 2000 and some minor landings as bycatch in fisheries targeting other species since 2000. Since 2000 no target fisheries are taking place in Mid-Atlantic Ridge (NEAFC) area (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 (subareas 6, 7, 8 and 9), France (subareas 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).

11.2 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 12.1(a–g), 12.2 and 12.3 and Figures 11.1–11.5. Total landings stabilized since 2005, due to management measures introduced (TAC/quotas and effort regulation), being around 357 t between 2005 and 2019, with high landings during 2012 (605 t). Current catches are 294 t. Faroes reported a landing of 141 t for 2015, 48 t for 2016 and 5 t for 2019 from area 10.b.

11.3 ICES Advice

ICES advises that when the precautionary approach is applied, landings should be no more than 224 t in each of the years 2019 and 2020. ICES cannot quantify the corresponding catches.

11.4 Management

Fishing with trawl gears is forbidden in the Azorean EEZ (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).

Technical measures have been introduced in the Azores since 1998. During 2009 new measures were introduced, particularly to control the effort of longliners through restrictions on fishing area, minimum length, gear and effort. These measures were updated during 2015-2019. A net-work 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. There are NEAFC regulations of effort in the fisheries for deep-water species and closed areas to protect vulnerable habitats on the RA. (http://neafc.org/managing_fisheries/measures/current).

An EU TAC of 252 t for EC vessels is in force for the period 2019–2020 (see historical developments in table below).

Beryx **spp. TACs and total landings in recent years.**

Regulation	Species	Year	ICES Subarea	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	

11.5 Stock identity

No new information.

11.6 Data available

11.6.1 Landings and discards

Tables 12.1a–g, describe the alfonsinos landings by subarea and country. Discards results for the Azorean longliners were reported during 2014 (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). Longline discards of combined alfonsinos in 2018 were about 5.8% (8.6 t) of total landings. These discards are mostly a result of the management measures adopted such as TAC and minimum length.

11.6.2 Length compositions

Fishery length composition (LF, cm) of the landings from the Azores are shown for *Beryx splendens* in Figure 11.6 for 1991-2016, and for *Beryx decadatylus* in Figure 11.7 for the period 1993–2016. This information was not updated for the 2017, 2018 and 2019 because data were not available.

Azorean spring bottom longline survey length compositions (LF, cm) were updated (WD Medeiros-Leal *et al*., 2020) and are shown for both species in Figures 11.8 and 11.9.

Annual mean length from the Azorean survey for both species are presented in Figures 11.10 and 11.11. Annual mean length from Azorean fishery information was not presented because data was not available.

11.6.3 Age compositions

No new information

11.6.4 Weight-at-age

No new information.

11.6.5 Maturity, sex-ratio, length–weight and natural mortality

No new information was available to the working group. The DCF information was summarized in the 2010 WGDEEP report and there are no relevant changes on the biology of the species.

11.6.6 Catch, effort and research vessel data

Standardized fishery CPUE from the Azores was updated until 2017 (Table 11.5 and Figure 11.12), for both species (*Beryx splendens* and *Beryx decadactylus*) and combined (WD 10, 11 and 15 Santos *et al*., 2020). The information for 2018 and 2019 was not available.

Abundance indices from the Azorean longline survey were updated (WD 18 Medeiros-Leal *et al*., 2020) and are presented for the alfonsino (*Beryx splendens*) (Figure 11.13) and golden eye perch (*Beryx decadactylus*) (Figure 11.14).

11.7 Data analyses

Total landings declined in the late 1990s and since 2003 stabilized at about 357 t (for the two species combined), with a peak of 605 t in 2012 due to the landings reported by Spain for subareas 6–7 (Figure 11.4). Species-specific landings trends in the Azores fishery showed similar trends for both species (Figure 11.5).

Fishery length frequency distributions for *B. decadatylus* show a bimodal or trimodal distribution. Annually a well-defined mode is observed around 24 cm. The other two modes vary between years being centred on 32 cm and 42 cm during the 2012-2016 (Figure 11.7).

Survey length frequency distributions for *B. splendens* and *B. decadactylus* show that relatively small numbers of *B. decadactylus* are caught on the survey on the sampled depth strata (50–1200m) (Figures 11.8 and 11.9). For *B. splendens* a mode around 20–30 cm is observed and *B. decadactylus* show a bimodal distribution.

Survey mean length for *B. splendens*, shows an increase from 1995 (27 cm) to 1997 (32 cm) and maintained since 1999 around 27 cm fork length, with small decreases throughout the time series and returning to maintained of the 27 cm fork length (Figure 11.10). For *B. decadactylus* is observed a stable trend from 1995 around 34 cm, with a peak in 2013 (37 cm) and small decreases throughout the time series (Figure 11.11).

Survey abundance index for *B. splendens*, declined significantly between 1995 and 1997 and has remained at low levels with a small increase observed between 2010 and 2013 (Figure 11.13). For *B. decadactylus* a decrease is observed from 1995 to 1996, maintained thereafter until 2003 at low levels. It increased then from 2003 to 2007 and seems to present thereafter a decrease trend until 2019 but fluctuating along time (Figure 11.14).

The working group express concerns on the reliability of these indices as an indicator of North East Atlantic abundance due to the relatively small numbers of individuals caught in the survey each year particularly for *B. decadactylus.* The survey may not be designed to sample these highly mobile and aggregative species, particularly *B. decadactylus*. Therefore, the working group considers the approach taken in 2018, i.e. to base advice on catch history, to be appropriate.

11.8 Comments on the assessment

No assessment was performed.

11.9 Management considerations

As a consequence of the spatial distribution of the two alfonsinos species associated with seamounts, their life history and their aggregating behaviour, both are considered to be easily overexploited by trawl fishing and can only sustain low rates of exploitation. Population dynamics is uncertain while recent age estimates suggest high longevity (>50 years), other estimates suggest a longevity of ~15 years. Fisheries on such species should not be allowed to expand above current levels unless it can be demonstrated that such expansion is sustainable. To prevent wiping out entire subpopulations that have not yet been mapped and assessed, the exploitation of new seamounts should not be allowed.

11.10 References

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11.11 Tables

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
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	0

YEAR	FRANCE	TOTAL
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

***Preliminary.**

Table 11.1b. Alfonsinos (*Beryx* spp.) from Division 5.b.

YEAR	FAROES	FRANCE	TOTAL
1988			0
1989			0
1990		5	5
1991		0	0
1992		4	4
1993		0	0
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

YEAR	FAROES	FRANCE	TOTAL
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	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

YEAR	FRANCE	E & W	SPAIN	IRELAND	SCOTLAND	TOTAL
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
2017	7	0	11	0	0	18
2018	27	0.209	19	0	0	46
2019*	57		24	0	0	81

***Preliminary.**

Table 11.1d. Alfonsinos (*Beryx* spp.) from Subareas 8 and 9.

YEAR	FRANCE	PORTUGAL	SPAIN	E & W	TOTAL
1988					0
1989					0

YEAR	FRANCE	PORTUGAL	SPAIN	E & W	TOTAL
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
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

YEAR	FRANCE	PORTUGAL	SPAIN	E & W	TOTAL
2019*	5	10	55		70

*** 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
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

	10.a	10.b				
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

*** 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		
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

YEAR	FAROES	TOTAL
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

*** 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*			

YEAR	*B. splendens*	*B. decadactylus*	TOTAL
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
2017	41	78	119
2018	234	83	317
2019	90	146	236

*** No information.**

Table 11.2. 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

YEAR	4	5.b	6+7	8+9	10.a	10.b	12	TOTAL
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
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	138	5	0	294

***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
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

YEAR	*B. Splendens*	*B. Decadactylus*	TOTAL
2017	119	30	149
2018	107	50	157
2019*	92	46	138

***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

Table 11.5. Nominal and standardized CPUE series (kg 10^{-3} hooks scaled to the mean) for the alfonsinos *Beryx splendens, Beryx decadactylus* and species combined from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95%

	Beryx spp.				*Beryx splendens*				*Beryx decadactylus*			
Year	Nominal	Standardized	LCI	UCI	Nominal	Standardized	LCI	UCI	Nominal	Standardized	LCI	UCI
1990	0.88858	1.01788	1.02328	1.01455	0.00780	0.02174	-0.00952	0.03231	0.18517	0.80196	0.86827	0.76321
1991	1.28335	1.39501	1.38978	1.39823	1.09040	1.07641	0.68577	1.20853	1.53276	2.74415	2.71701	2.76000
1992	0.19790	0.94404	0.88902	0.97793	0.04519	0.13437	-0.05540	0.19855	0.06918	1.36391	1.36534	1.36308
1993	1.29870	1.41219	1.37210	1.43688	1.14860	1.80248	1.69060	1.84032	2.11198	1.62238	1.59983	1.63556
1994	1.51303	1.33281	1.25375	1.38151	1.28924	1.23628	0.98750	1.32042	2.64085	1.46520	1.42282	1.48996
1995	0.80899	1.36344	1.35885	1.36626	0.72808	0.70454	0.38409	0.81291	1.26918	1.88787	1.87955	1.89274
1996	2.68022	1.66349	1.53802	1.74078	2.83736	2.49318	2.42576	2.51598	2.63786	1.48883	1.37559	1.55500
1997	0.49677	1.07226	1.02031	1.10425	0.50323	0.61886	0.35936	0.70662	0.57244	0.63943	0.61829	0.65179
1998	0.74185	0.94910	0.95258	0.94695	0.79641	0.68633	0.58752	0.71974	0.68934	0.74647	0.74061	0.74990
1999	1.01107	0.93547	0.94454	0.92988	1.22798	1.03166	1.07263	1.01780	0.41411	0.47534	0.47100	0.47788
2000	0.99864	0.84177	0.85126	0.83592	1.14721	1.11093	1.22654	1.07184	0.65107	0.69189	0.68074	0.69841
2001	1.44902	0.80375	0.78905	0.81281	1.77759	1.16117	1.11023	1.17840	0.52830	0.55425	0.52910	0.56894
2002	1.50761	0.89355	0.85123	0.91961	1.80200	1.30173	1.30733	1.29984	0.71434	0.76695	0.70176	0.80505
2003	0.72029	0.51430	0.51740	0.51239	0.82756	0.71751	0.82501	0.68115	0.46920	0.51305	0.49447	0.52391
2004	0.86955	0.63412	0.62511	0.63967	1.01667	0.91099	0.99733	0.88179	0.50151	0.59975	0.57103	0.61652
2005	0.94313	0.83424	0.85538	0.82122	1.13684	1.15601	1.34282	1.09283	0.41809	0.50460	0.50865	0.50223
2006	1.15532	0.88184	0.88174	0.88191	1.22075	1.42348	1.72388	1.32188	1.12557	0.78357	0.76271	0.79575
2007	1.11872	0.80243	0.77460	0.81958	1.21581	1.71226	2.18708	1.55168	0.98497	0.67089	0.62021	0.70051
2008	1.10279	1.10794	1.10305	1.11095	1.15500	1.45328	1.70254	1.36899	1.13126	0.95661	0.93144	0.97132
2009	1.35098	1.24014	1.24078	1.23975	1.38954	2.11688	2.60988	1.95015	1.47940	1.04323	1.02350	1.05477
2010	1.09747	1.15964	1.20673	1.13063	1.06587	1.10574	1.19828	1.07445	1.43373	1.23508	1.29687	1.19897
2011	0.92180	1.33691	1.40818	1.29300	0.94226	1.03125	1.08371	1.01351	1.03099	1.21384	1.29364	1.16721
2012	1.33115	1.39439	1.47063	1.34742	1.37502	1.15698	1.19438	1.14433	1.43605	1.05451	1.12179	1.01519
2013	0.76766	1.10765	1.17803	1.06429	0.77691	0.65159	0.54630	0.68720	0.88733	0.86991	0.94094	0.82840
2014	0.39263	0.56864	0.61029	0.54299	0.33591	0.37920	0.23143	0.42918	0.68031	0.80229	0.86498	0.76566
2015	0.65790	0.63750	0.68282	0.60958	0.62744	0.28078	0.13610	0.32972	0.90190	1.01910	1.07928	0.98393
2016	0.44890	0.70078	0.73446	0.68003	0.33233	0.42548	0.38732	0.43838	0.96842	0.86337	0.88178	0.85262
2017	0.24598	0.45474	0.47703	0.44101	0.18101	0.09887	0.06152	0.11150	0.53469	0.62157	0.63879	0.61151

confidence bounds.

11.12 Figures

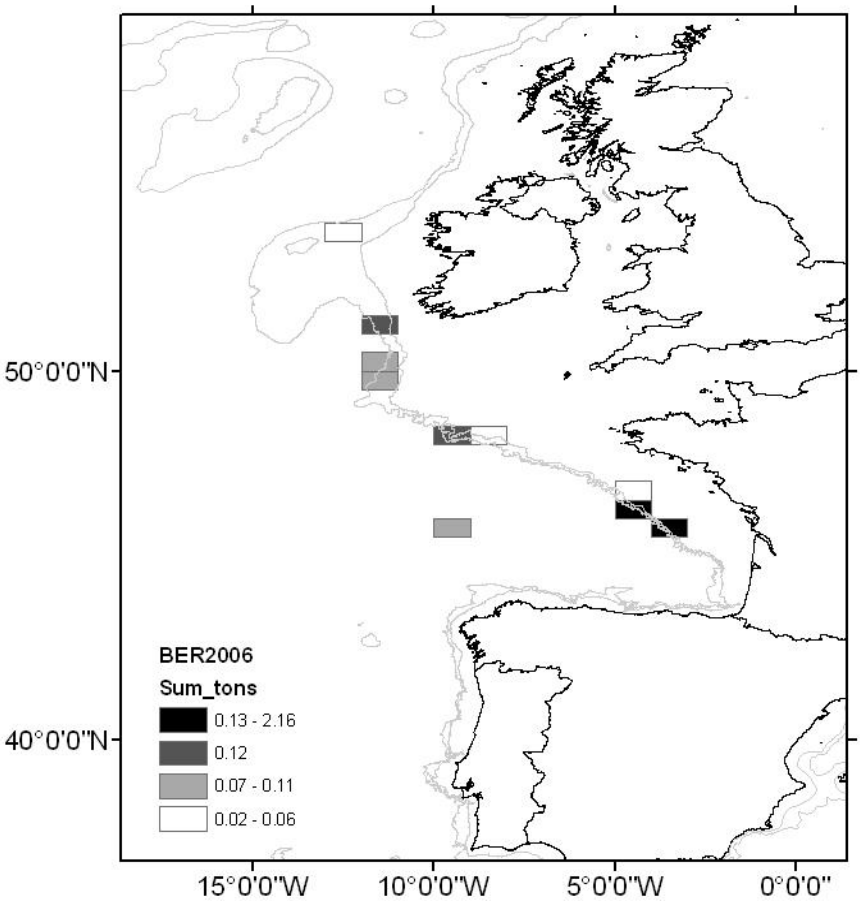

Figure 11.1. Catches of alfonsinos by French, Irish, UK (England and Wales and Scotland) and Icelandic vessels, 2006.

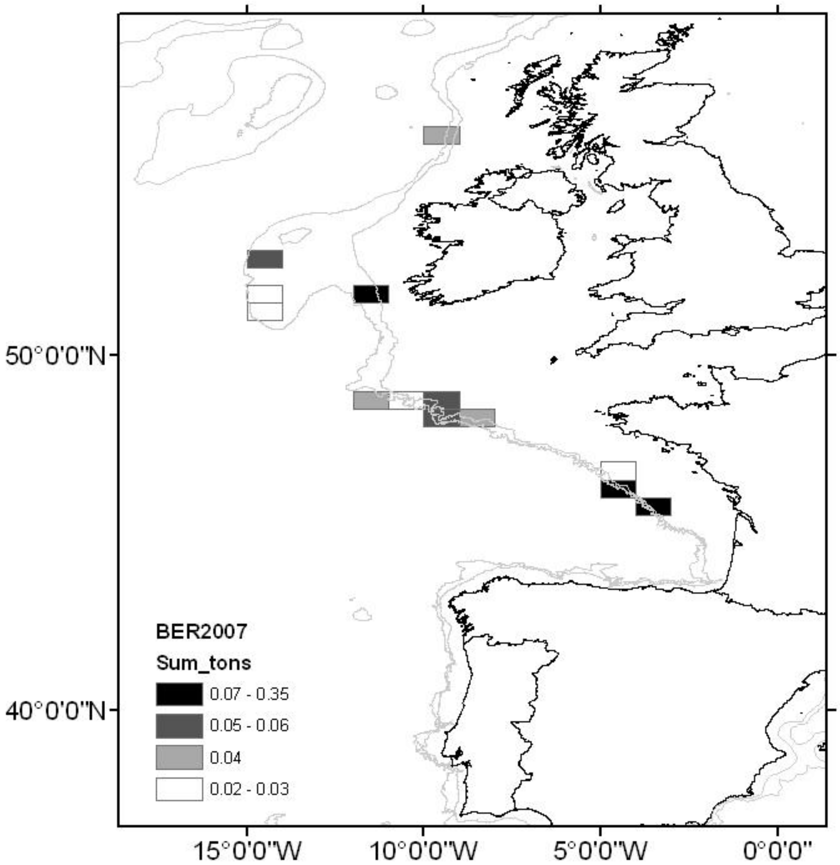

Figure 11.2. Catches of alfonsinos by French, Irish, UK (England and Wales and Scotland) and Icelandic vessels, 2007.

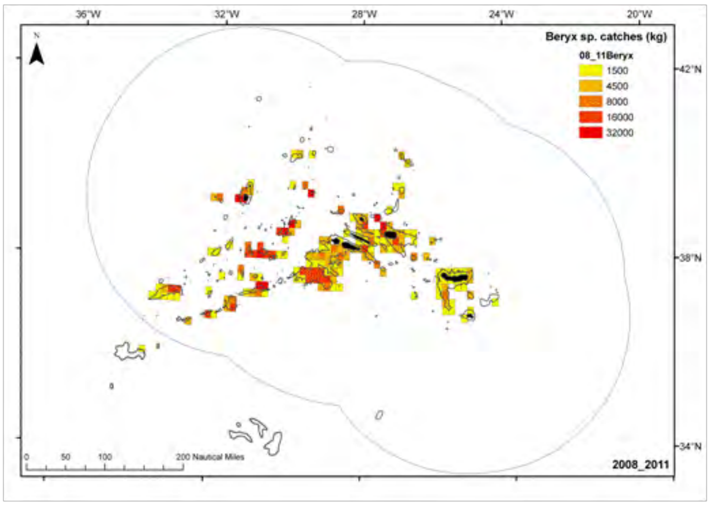

Figure 11.3. Catches of alfonsinos by Azores vessels, 2008–2011 (ICES, 10a2).

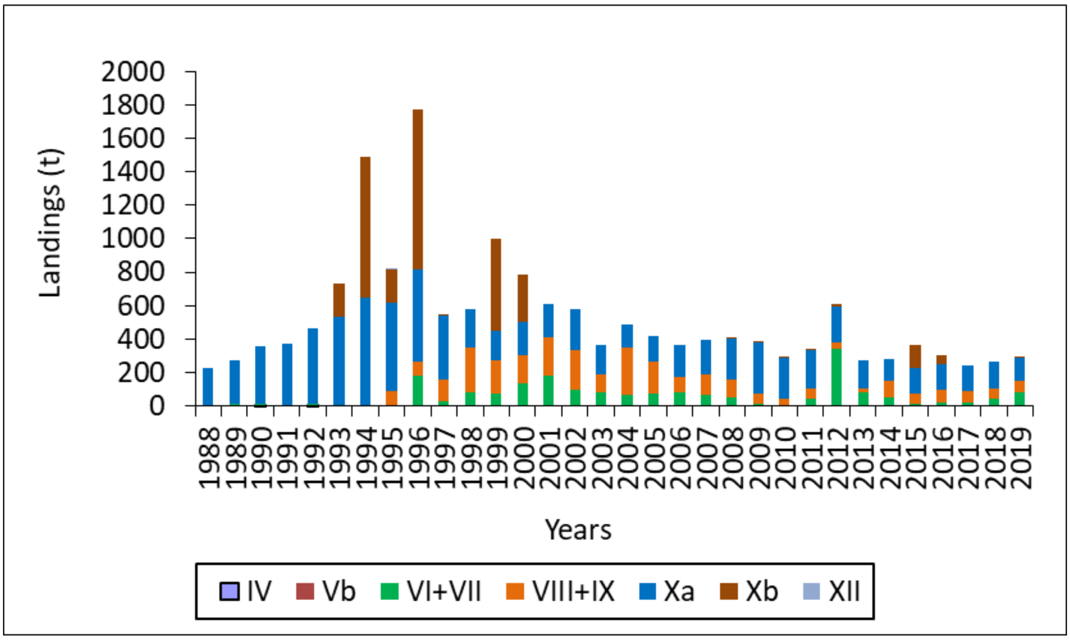

Figure 11.4. Reported landings for the alfonsinos, (*Beryx* spp), by ICES subarea/division.

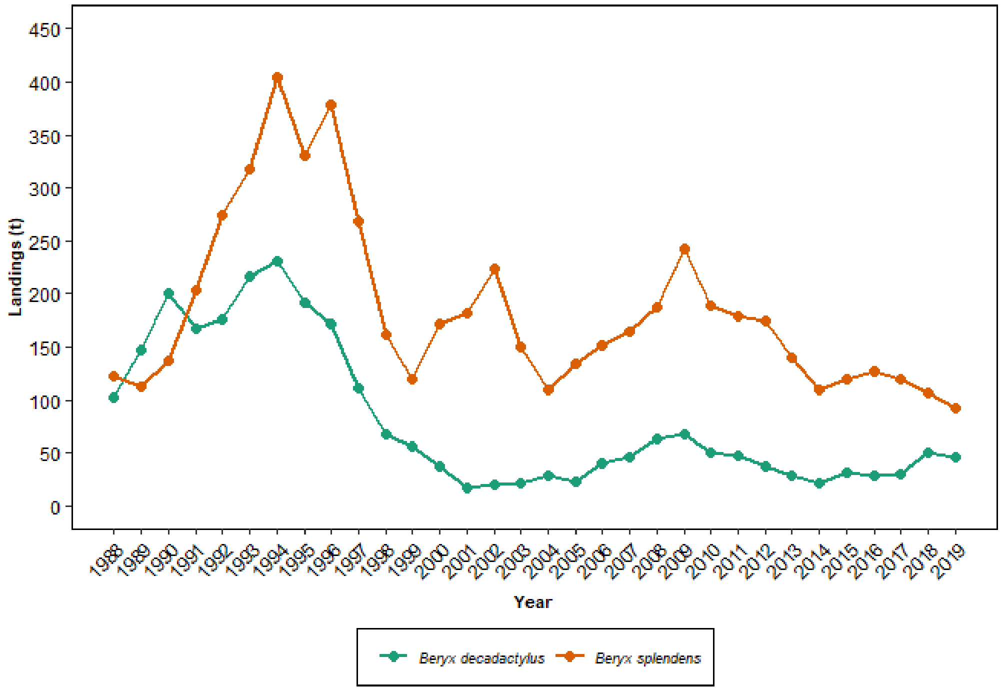

Figure 11.5. Landings of *Beryx splendens* and *B. decadactylus* in Azores (ICES 10a2).

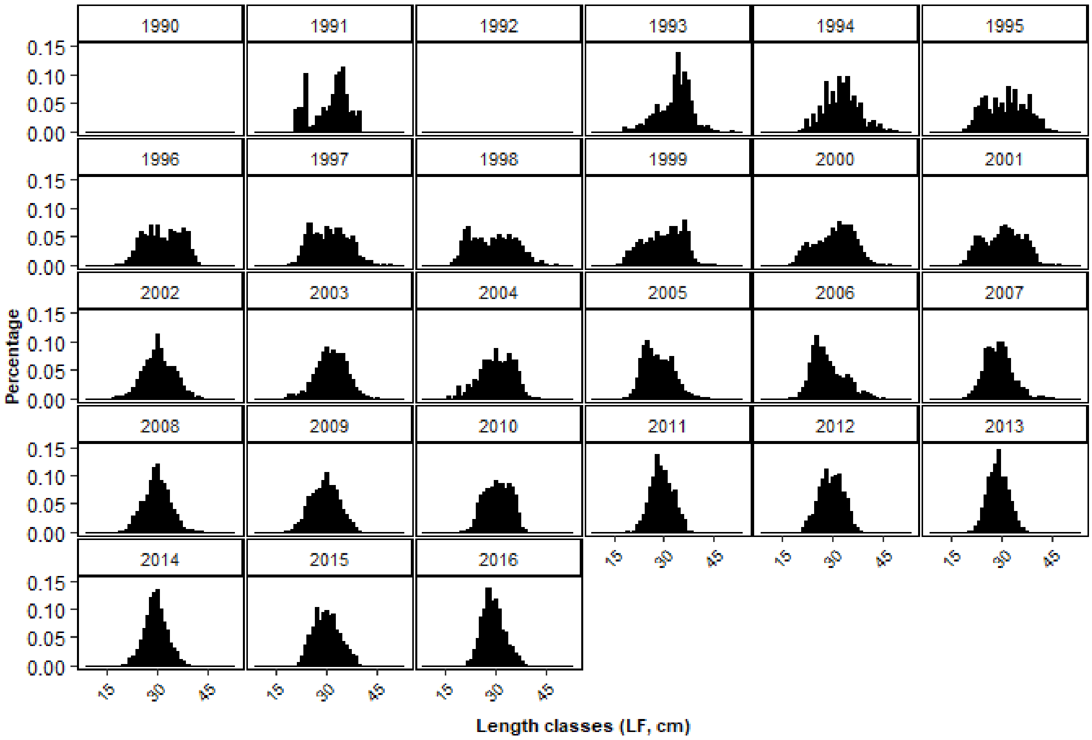

Figure 11.6. ***Beryx splendens*** **annual fishery length composition from the Azores (ICES 10a2).**

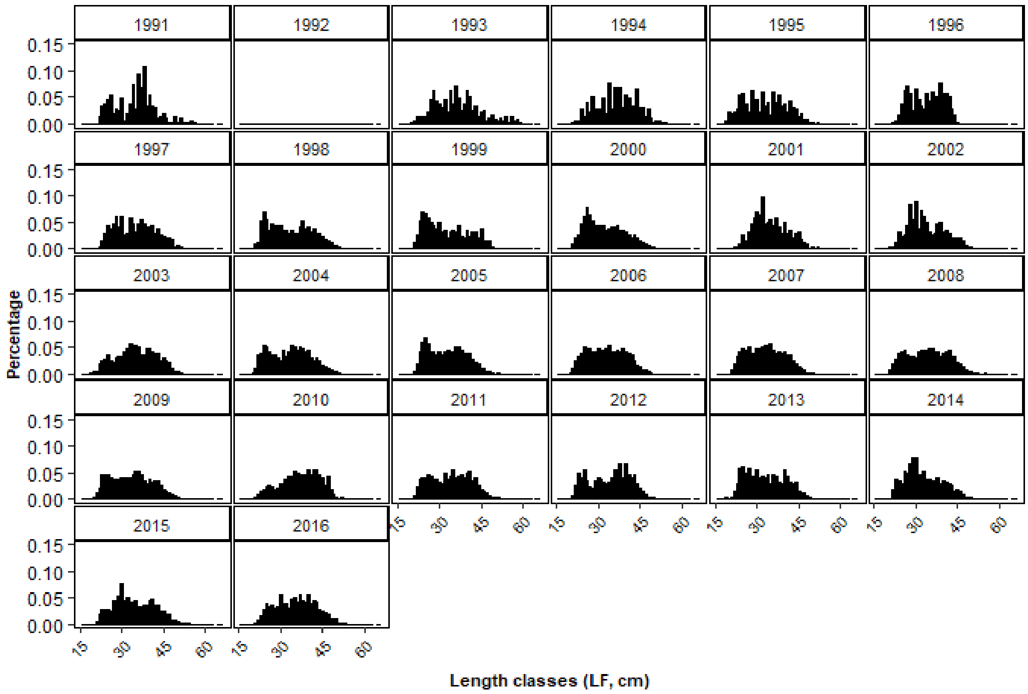

Figure 11.7. ***Beryx decadactylus*** **annual fishery length composition from the Azores (ICES 10a2).**

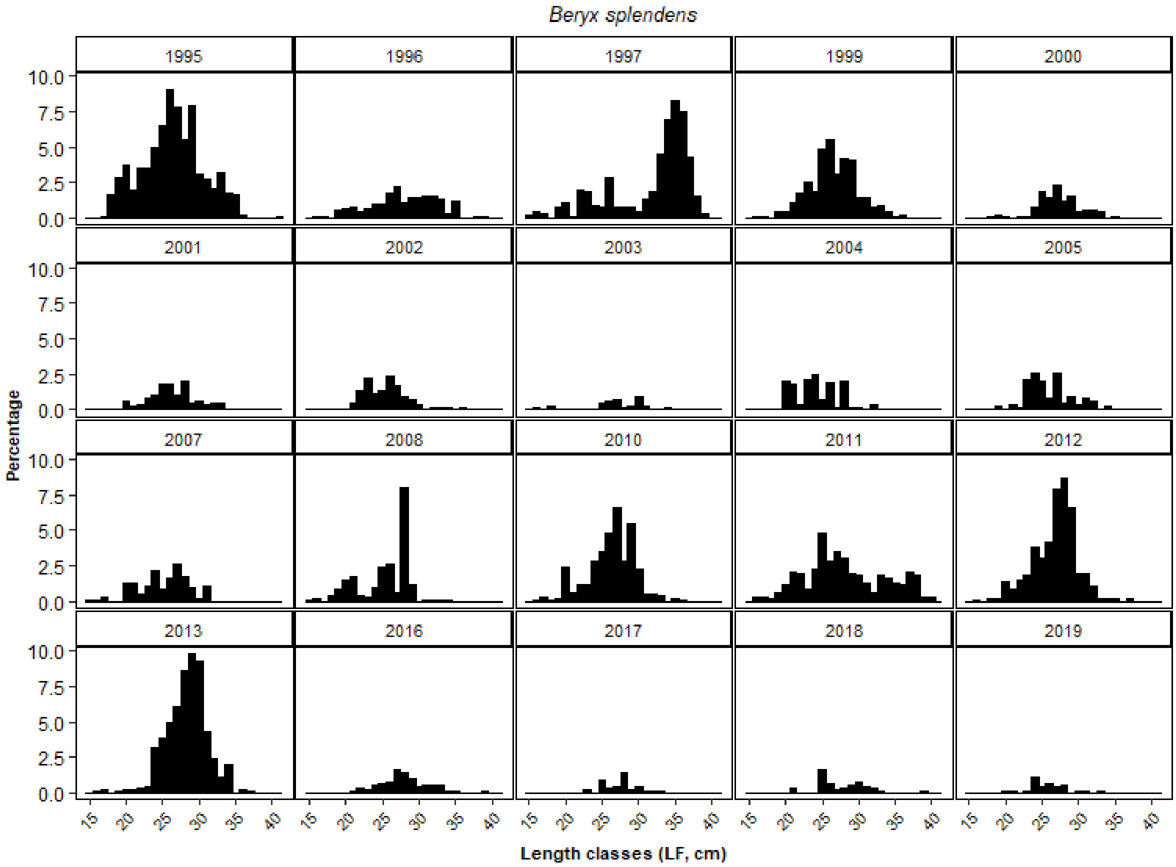

Figure 11.8. ***Beryx splendens*** **annual survey length compositions from the Azores (ICES Subarea 10a2).**

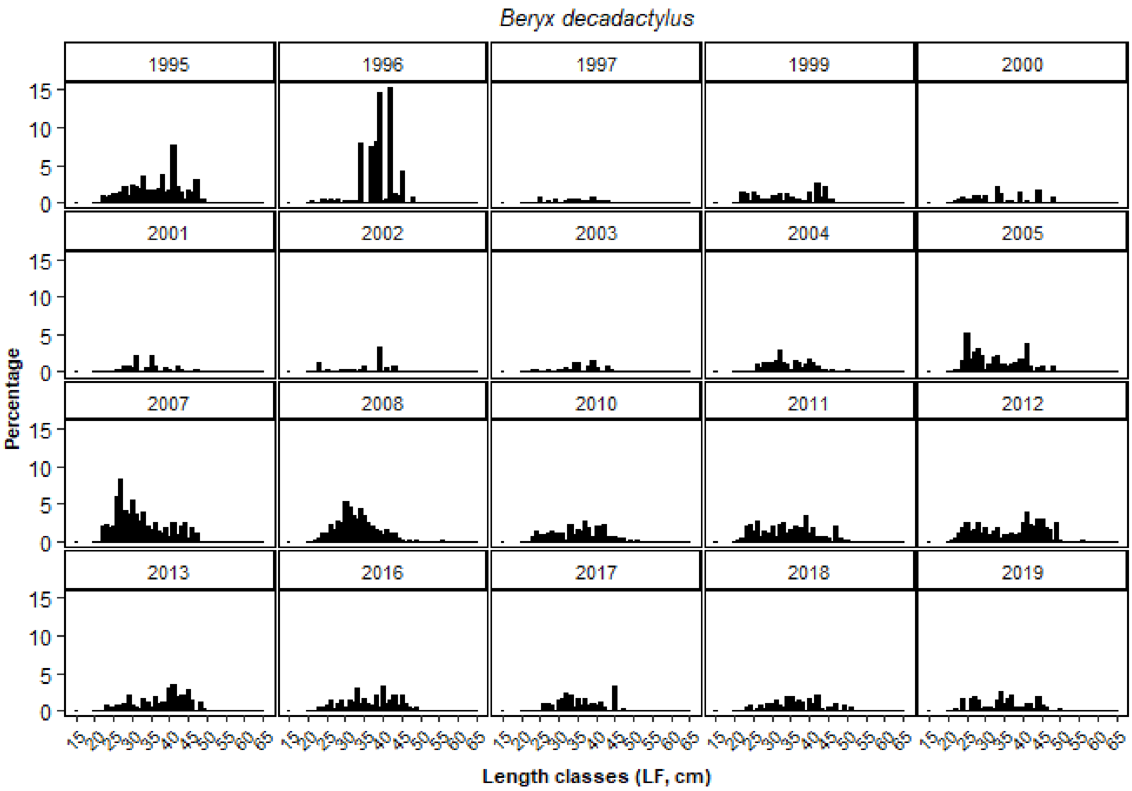

Figure 11.9. ***Beryx decadactylus*** **annual survey length compositions from the Azores (ICES 10a2).**

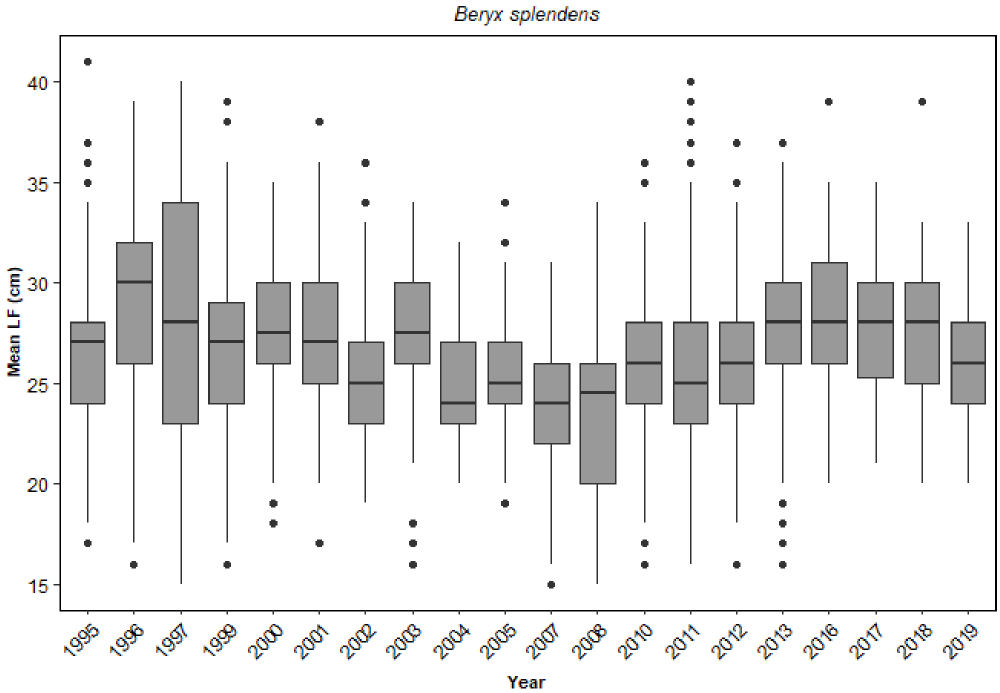

Figure 11.10. Survey annual mean length of *Beryx splendens* from the Azores (ICES 10a2).

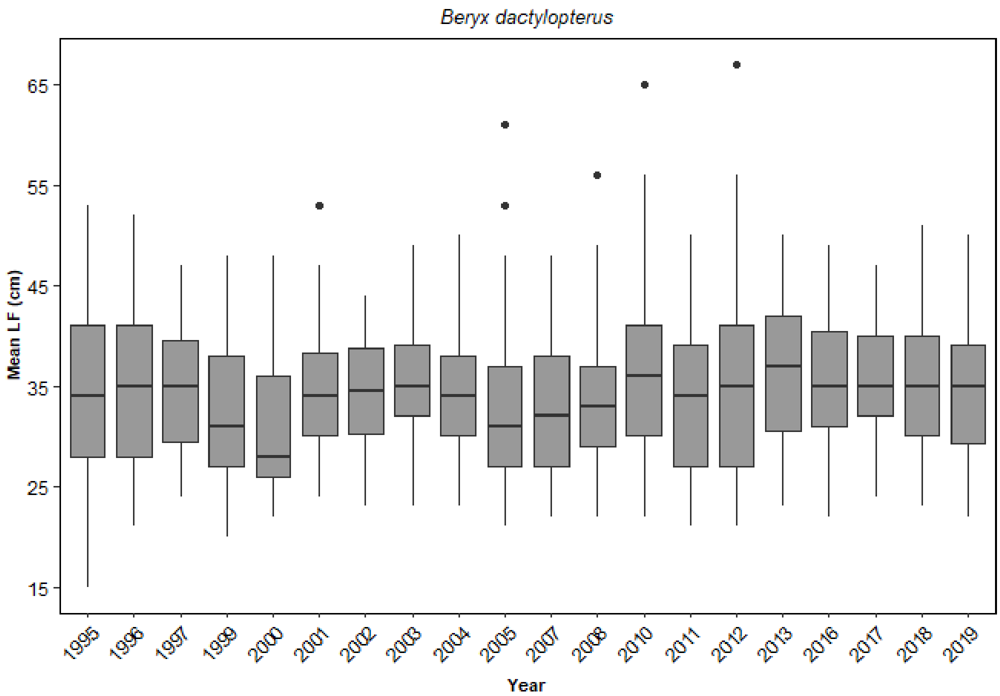

Figure 11.11. Survey annual mean length of *Beryx decadactylus* from the Azores (ICES 10a2).

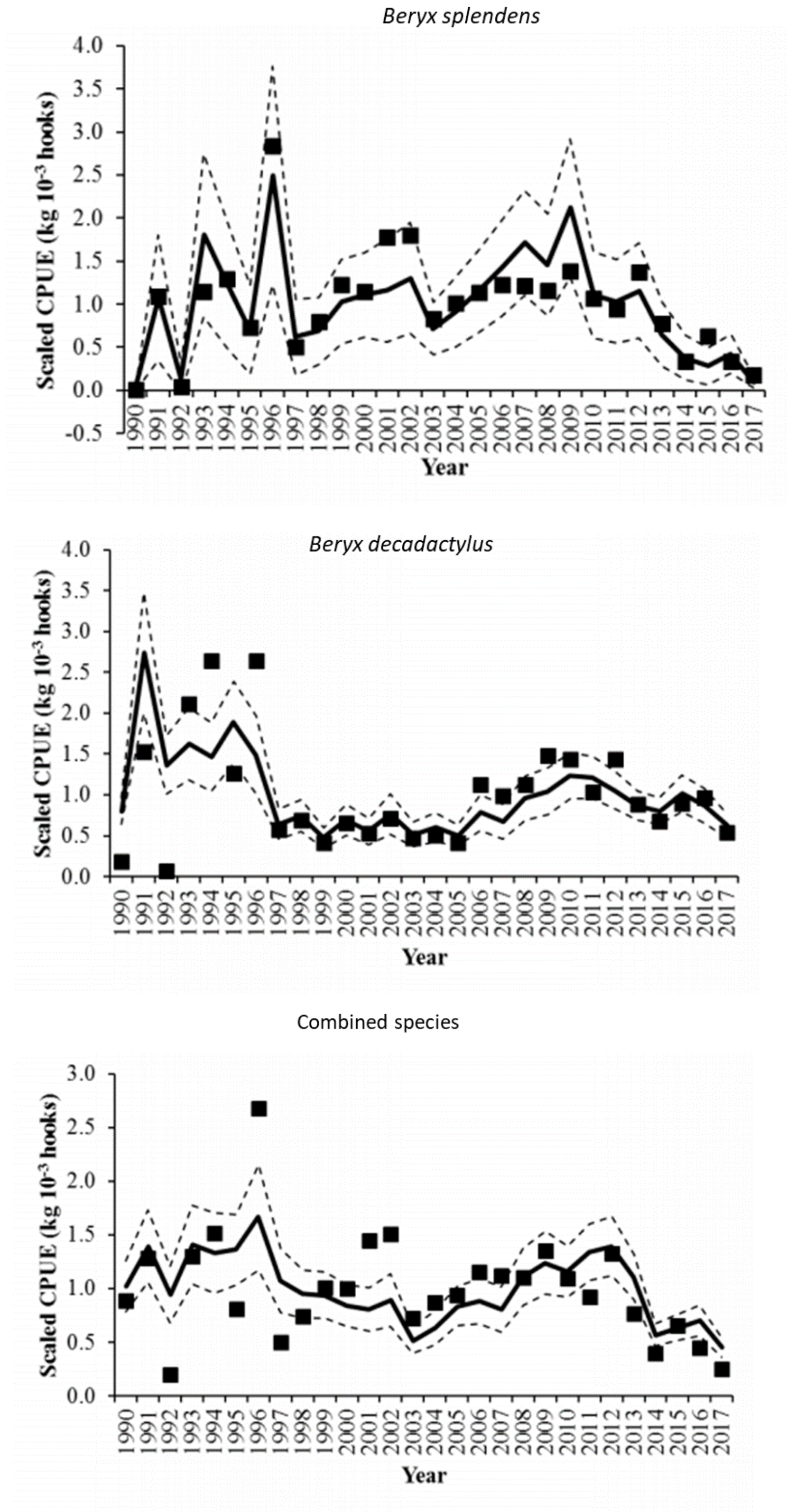

Figure 11.12. Standardized fishery cpue for alfonsinos by species and species combined from the Azorean bottom longline fishery (ICES 10a2).

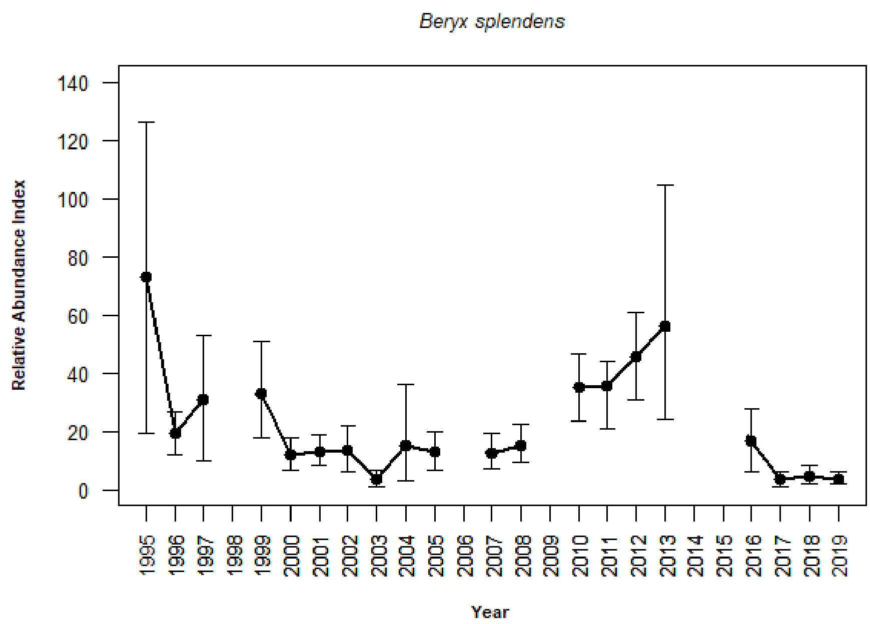

Figure 11.13. Annual bottom longline survey abundance index in number for the alfonsinos (*Beryx splendens*) from the Azores (ICES 10a2).

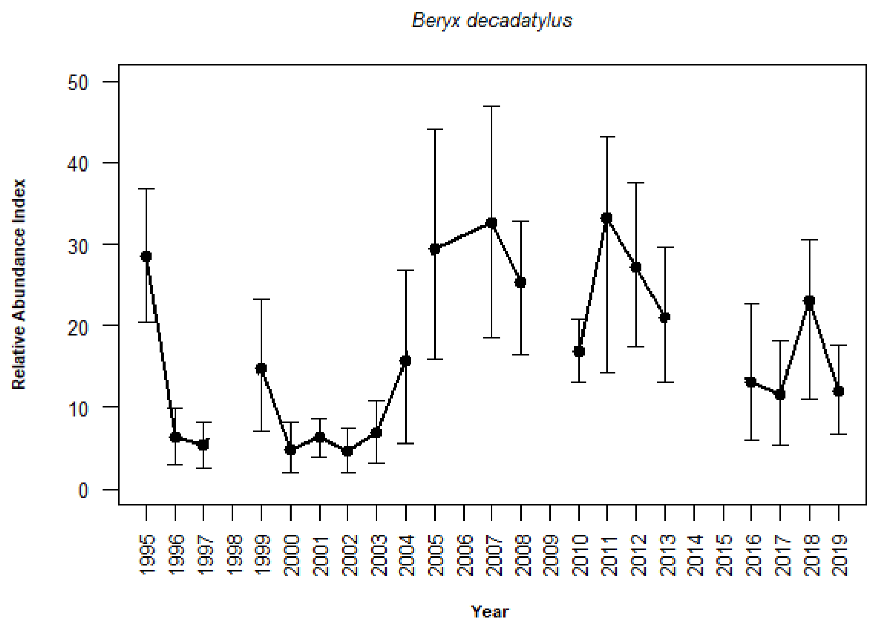

Figure 11.14. Annual bottom longline survey abundance index in number for *B. decadactylus* from the Azores (ICES 10a2).

12 Blackspot seabream (*Pagellus bogaraveo*)

12.1 Stocks description and management units

ICES considered three different components for this species: a) subareas 6, 7, and 8; b) Subarea 9, and c) Subarea 10 (Azores region).

The interrelationships of the blackspot seabream from Areas 6, 7, and 8, and the northern part of Area 9.a, and their migratory movements within these areas have been observed by tagging methods (Gueguen, 1974). However, there is no evidence of movement to the southern part of 9.a where the main current fishery currently occurs.

Studies show that there is 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. No genetic differentiation has been found on the Atlantic continental shelf, with small genetic differentiation between the Mediterranean Sea and the Atlantic reported (Stockley *et al*., 2005,).

ICES advice for Subarea 9 is based on the CPUE from the Spanish ("*voracera*") target fleet operating in the Strait of Gibraltar area, mostly out of Subarea 9. WGDEEP has raised concerns on the use of a biomass index that might not be representative of the entire Subarea stock abundance. Therefore, the EG has suggested to downgrade this stock to category 5 until it is benchmarked.

12.2 Blackspot seabream (*Pagellus bogaraveo*) 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 (1988–2019), 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). Since the 1980s, it has been mainly a bycatch of otter trawl, longline and gillnet fleets and only a few small-scale handliners have been targeting the species. Since 1988 the landings from Subarea 8 represent 67% and subareas 6 and 7, 33% of total accumulated landings. At present the blackspot seabream 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 is however part of the historical area of distribution of the species (Olivier, 1928; Desbrosses, 1932).

For these 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 parallel to the reduction of the TAC in following years from 350 t in 2013 and to 117 ton in 2019.

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 117 t in 2019. 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

Pagellus bogaraveo		
year	**TAC**	**landings**
2015	169	177
2016	160	164
2017	144	126
2018	130	133
2019	117	98

The Common Fisheries Policy states 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.

In Ireland and UK, there is no regulation applicable to recreational catches, however 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 2019a). 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 sub-areas 6, 7, 8 (MAPA 2019b).

12.2.5 Data available

12.2.5.1 Landings and discards

The Spanish, French and UK extended landing-series of *P. bogaraveo* in Northeast Atlantic were updated (Figure 12.2.1b). Landings in recent years dropped according to the continuous reduction of the biannual TAC since 2003.

Historically, discards are considered negligible and estimates are available since 2014 representing between 0.6%–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 was closed. 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 observation may occur as the species occurs at low abundance and other similar sparids species 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.

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) in a yield-per-recruit model 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). In French surveys, similar to the current western IBTS, from early 1980s when the stocks were already low it was still 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.

P. bogaraveo is a scarce species in the Northern Spanish Shelf Groundfish Survey. 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 (**Error! Reference source not found.**12.2.4). *P. bogaraveo* was only found in 2 hauls, mainly in the central area of the Cantabrian Sea (Figure 12.2.5). 94 specimens were caught in 2019 and ranged from 22 cm to 29 cm, with a mode in 25-26 cm (Figure 12.2.6) (Fernández-Zapico et al 2020).

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. 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.

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.

There are reports from fishers that the abundance of the blackspot seabream is increasing to the north of the Bay of Biscay, between 47 and 48°N. This latitude range is the main area where small catch of blackspot seabream has occurred in the 2000. When TACs were set from 2003, there were some conflicts between métiers in this area mainly with 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 on-board observations in French fisheries (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

Method

Acoustic survey

As part of the Bay of Biscay case study of the H2020 project Pandora, a six days acoustic survey was carried out to the west of Brittany, near Sein and Ouessant Islands (France 48°-48°30'N; about 5°West), an area where the species has always occurred (Figure 12.2.11). The two Islands are about 70 km apart.

The surveyed areas represent a small proportion of areas where the species is known to occur along the coast of Brittany. Some knowledge of the overall distribution of occurrence of blackspot seabream at the Brittany coast was also collected in Pandora from a survey of diving clubs, which members filled-in an on-line questionnaire on their sightings of blackspot seabream. This questionnaire showed that blackspot seabream is seen along the coast of Western and southern Brittany.

A few small areas were surveyed to the West and Southwest of Sein Island and around Ouessant Island using a portable acoustic transducer mounted on small-scale fishing boats (Figure 12.2.12ab). These areas were selected from information collected during a workshop with small-scale fishers for the west of Brittany. The transducer was mounted on the side of the vessels on a mobile pole and was lifted out during transit (Figure 12.2.12a) and lowered 50 cm under the sea surface during acoustic operations (Figure 2c). Data were recorded using an EK80 software and location was recorded from a portable GPS (Figure 12.2.12d).

During the survey, handline fishing was carried out to identify species detected by the acoustics. Shoal of pelagic species (mostly sardine in the surveyed area) can be easily distinguished from blackspot seabream, but for other species identification f**ishing wa**s required**. Fishing was done on several location were echo susceptible to be blackspot seabream were received.** The species **composition caught at these locations** was used to categorized the types of echos observed. Four echotypes where defined: (1) pure blackspot seabream, (2) blackspot seabream mixing with other species, (3) demersal species and (4) pelagic species. Some Target strength estimation was also made. Blackspot seabream **caught** were measured, weighed and samples of otoliths, scales, tissues for genetic studies, gonads for histology and stomach contents for identification of prey were collected.

Population dynamics model

An age-structured stock assessment model was further developed based on previous modelling (Lorance 2011) to accommodate the integration of the acoustic biomass estimate from 2019. The data were a reconstructed long term time series of landings, a historic catch-per-unit –effort time series, a short survey time series and the biomass estimate derived from the acoustic survey (Table 3). The developed model has the distinctive characteristic to estimate the spawning biomass of females, which is important for this species where sex change to female occurs at an average age of 6-8 years. Therefore, the biomass of spawning females declines more with fishing mortality than for other stocks.

Table 3 Data sets.

Data set	Years	Source
International landings (ICES area 6, 7, 8)	1956-2018	ICES catch statistics and reconstructed landings from Lorance (2011).
Landings-per-unit-effort (LPUE) for La Rochelle trawlers	1972-1977, 1982-1984	Lorance (2011)
Survey occurrence index	1980-1993, 1996, 1998, 2001	Lorance (2011)
Acoustic biomass estimate	2019	PANDORA project

Given the lack of age-structure data and scarceness of fisheries independent information several model runs were made making different assumptions regarding the proportion of total biomass in the Bay of Biscay represented by the acoustic survey.

Results

During the survey, blackspot seabream was by far the main catch (Figure 2d), other species caught included gurnards, ling, pollack and Ballan wrasse. More than 70% of blackspot seabream caught were larger than 40 cm, and less than 4 % were smaller than the current MCRS of 33 cm (Figure 12.2.13).

A preliminary biomass estimate of 100 t was estimated based on echotype 1 only. The details of the acoustics estimation and echotyping method are not given here. Owing to the length distribution, the 100 tonnes was considered to be fully mature fish. This amount do not represent the total biomass occurring near Brittany because the species occurs along larger part on the Brittany coast. Further the stock component along the French coast is probably much smaller than in the Cantabrian Sea (Division 8c), where roughly 80% of recent landings are caught. Therefore, the population dynamics model was run with several assumed scaling factors (5, 10, 50 and 100), by which this biomass estimate was multiplied (so to fit the model with SSB of 500, 1000, 5000 and 10 000 t in 2019, respectively). These scaling factor represent assumptions of multiplier between the SSB in the surveyed area and the stock SSB. Scaling factors lower than 5 can hardly be assumed, because this would imply that the small areas sampled represented more than 20% of the total stock biomass.

The stock is known to have collapsed in the 1980s. The model estimated that the collapse was caused by fishing mortality reaching values over 0.7 (Figure 12.2.14), driving the stock at low level in the mid-1980s. The scaling factors of the 2019 biomass estimate impact the stock trajectory from the 2000s only. Scaling factors of 50 and 100, result in estimating the stock to have rebuilt to levels similar to the early 1980s. This is not realistic because in these period the species was still caught in one quarter to one third of the hauls during the scientific survey in the Bay of Biscay. The rare catch events in the French EVHOE survey, less that one per year in the last five years, reflects that the current stock is smaller. With scaling factors of 5 and 10, the stock is estimated to be still at a low level but to have between doubled and quadrupled, respectively, since 2000-2002. Suggesting that the rebuilding is on-going. In recent years, the fishing mortality is estimated to decrease for all scaling factors owing declining catches (forced by the TAC) and the increasing biomass.

The stock dynamics can be understood as follows: in the 1970s-80s, the stock decreased and then collapsed because of fishing mortality well above possible MSY reference points for this species. Despite alerts on the obvious collapse, no management measures were introduced before the EU TAC in 2003. Before the TAC, it can be presumed that as soon as a few fish appeared somewhere they were landed owing to the high price of the species and the stock remained at a very low level. From 2003, the TAC has constrained the fishery. The increase can only be slow because of slow growth and late maturity of the species. Further the stock fell to levels well below any possibly MSY $B_{trigger}$, reference point, which implies that the SSB needs to rebuild before producing recruitments of similar abundance than before the collapse.

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

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12.2.11 Tables

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)	CHANNEL 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)	CHANNEL 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

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
2009	5	137	0	142

YEAR	FRANCE*	SPAIN	UK (E & W))	TOTAL
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

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
2003	40	89	129
2004	55	128	183

YEAR	6 AND 7*	8*	TOTAL
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

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

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 Out-side NEAFC RA (t)	Total Catches	Proportion of catch inside the NEAFC RA (%)	NEAFC RA areas where caught
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
20	50.2	1830	0.89

Table 12.2.5 Blackspot seabream in Subareas 6, 7 and 8. Source of the reconstructed landings of blackspot seabream in the Bay of Biscay.

Reference/Source [1] of reconstructed landings data for blackspot seabream in the Bay of Biscay	
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 1988–20198 WGDeep official data

12.2.12 Figures

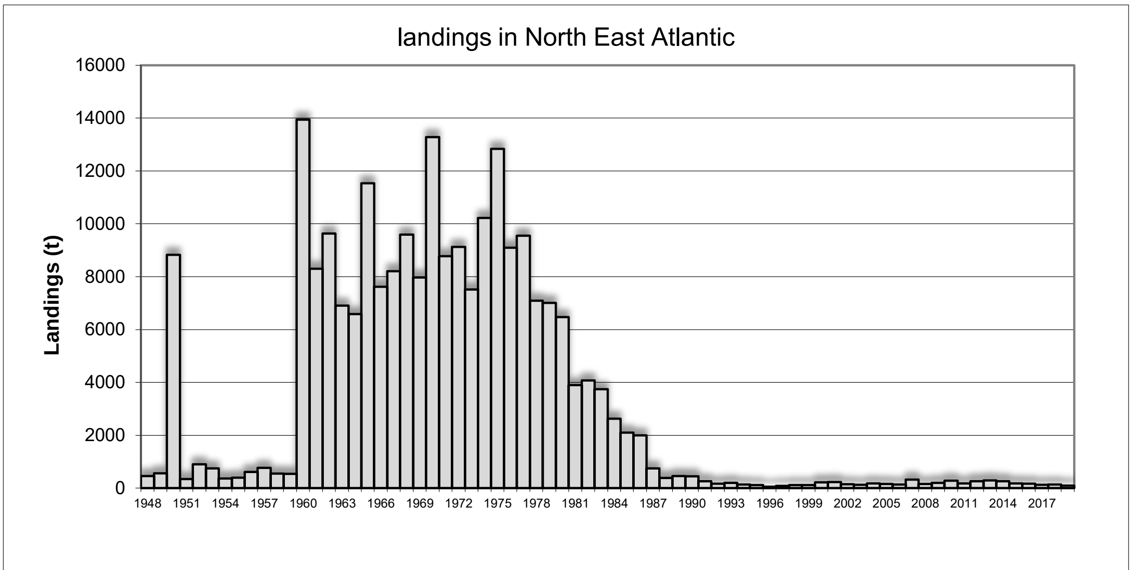


Figure 12.2.1b. Time-series of Blackspot seabream landings from 1948–2019 in Northeast Atlantic (Subareas 6, 7 and 8). Figure 12.2.1a.

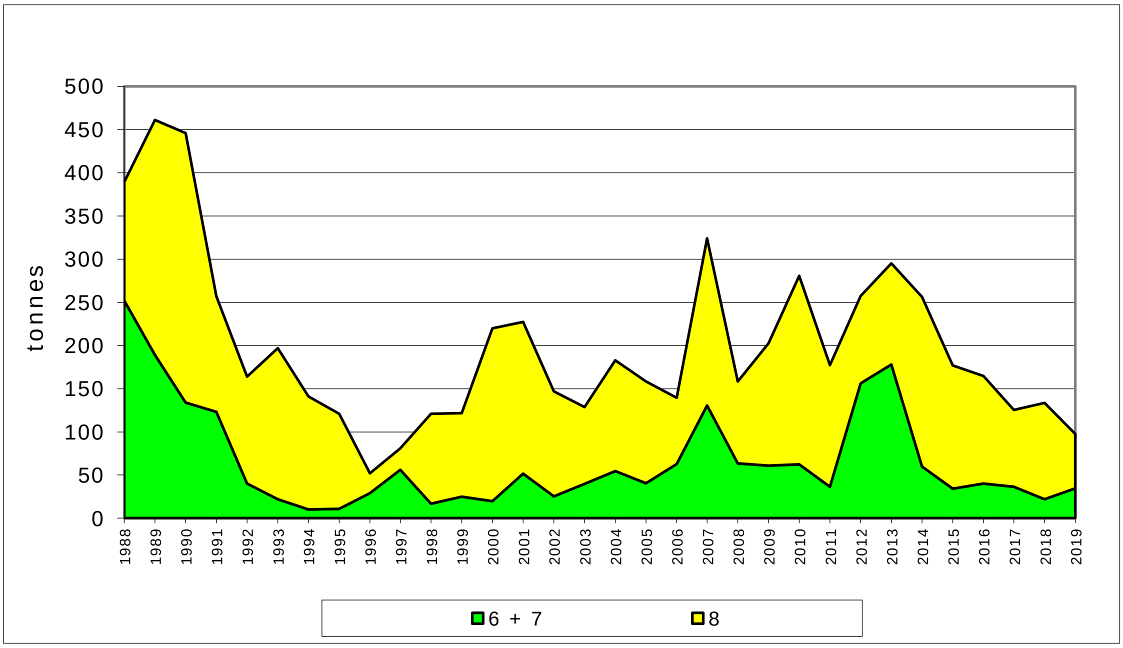
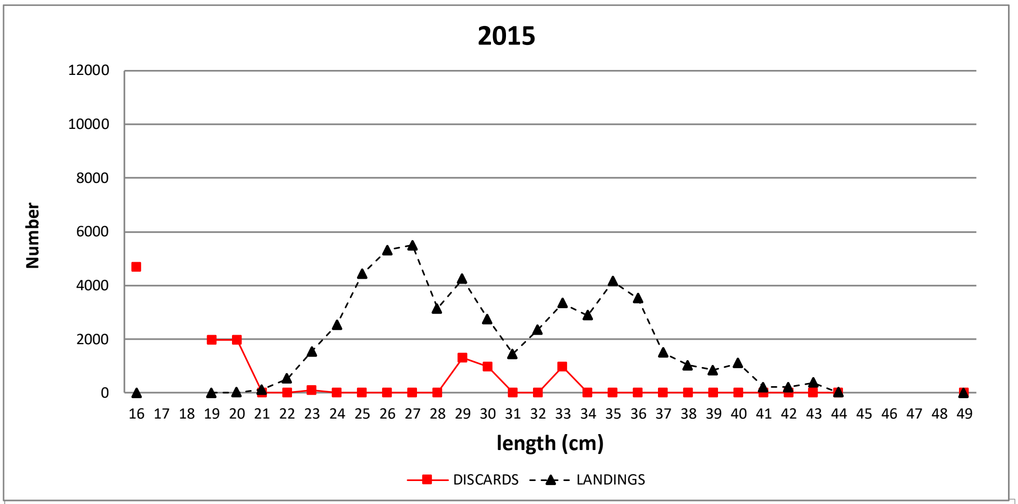
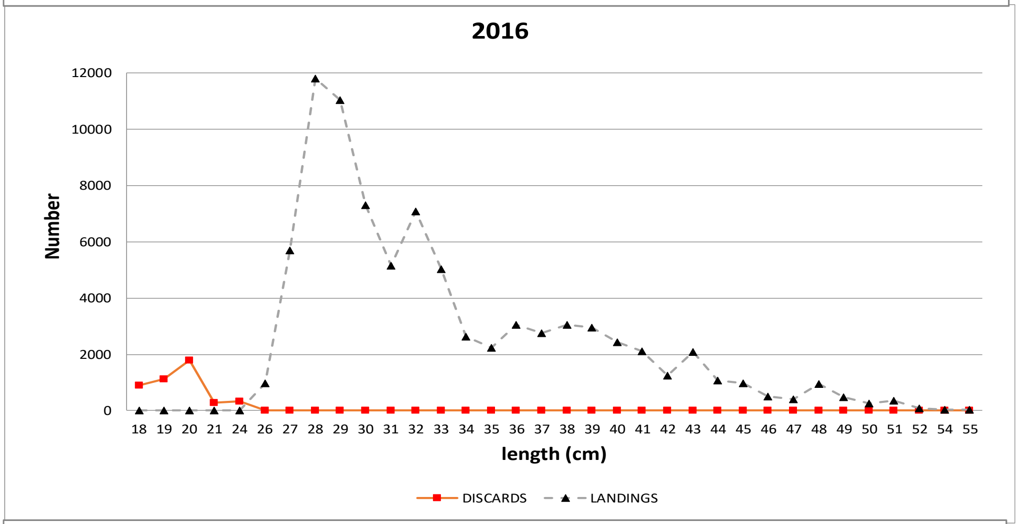
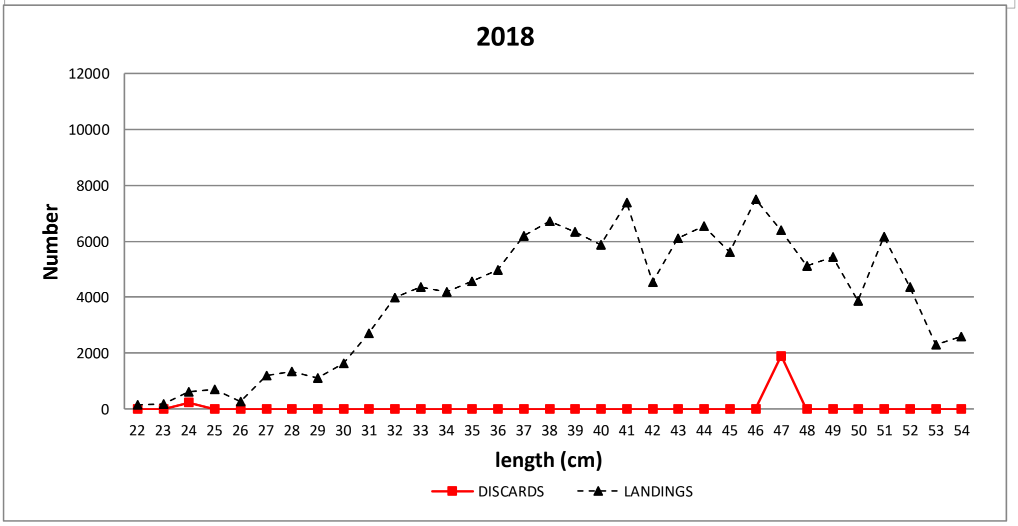


Figure 12.2.1b. Blackspot seabream landing trends in ICES Subareas 6 and 7 since 1988.


2015
Number
12000
10000
8000
6000
4000
2000
0
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
length (cm)
DISCARDS
LANDINGS


2016
Number
12000
10000
8000
6000
4000
2000
0
18 19 20 21 24 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 54 55
length (cm)
DISCARDS
LANDINGS


2018
Number
12000
10000
8000
6000
4000
2000
0
22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54
length (cm)
DISCARDS
LANDINGS

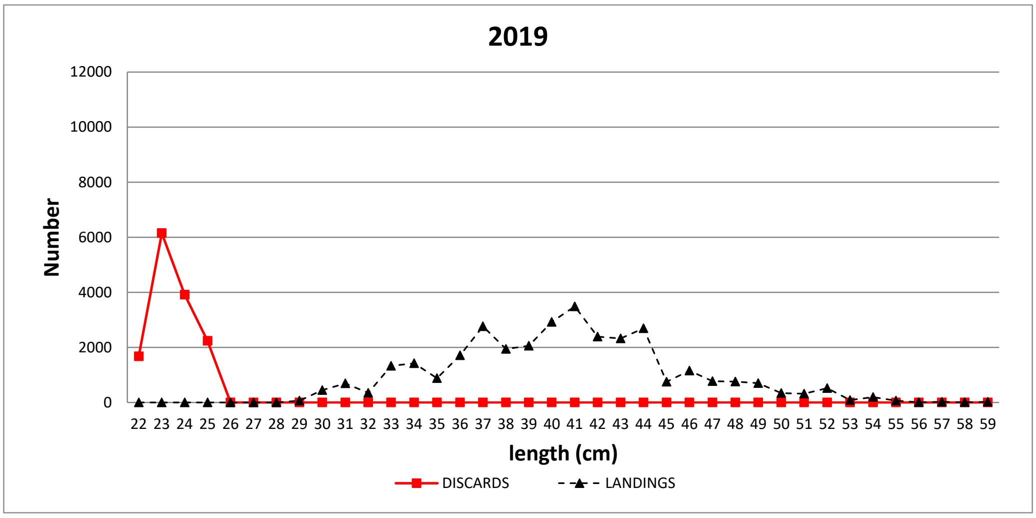


Figure 12.2.2. Length frequencies of the blackspot seabream in commercial catches, landings and discards since 2015, in Subareas 6, 7 and 8.

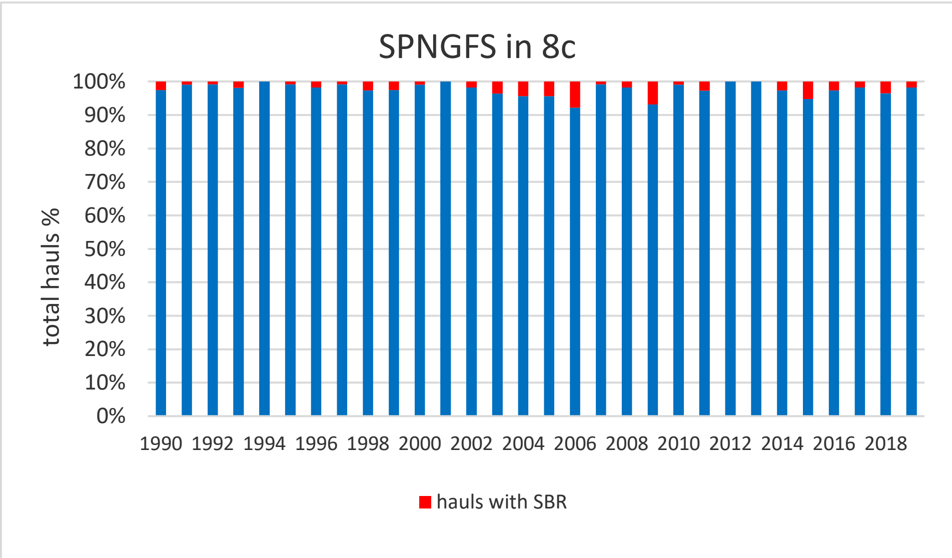


Figure 12.2.3. Occurrence (%) of the Blackspot seabream (*P. bogaraveo*) in Northern Spanish Shelf survey time-series (1990–2019).

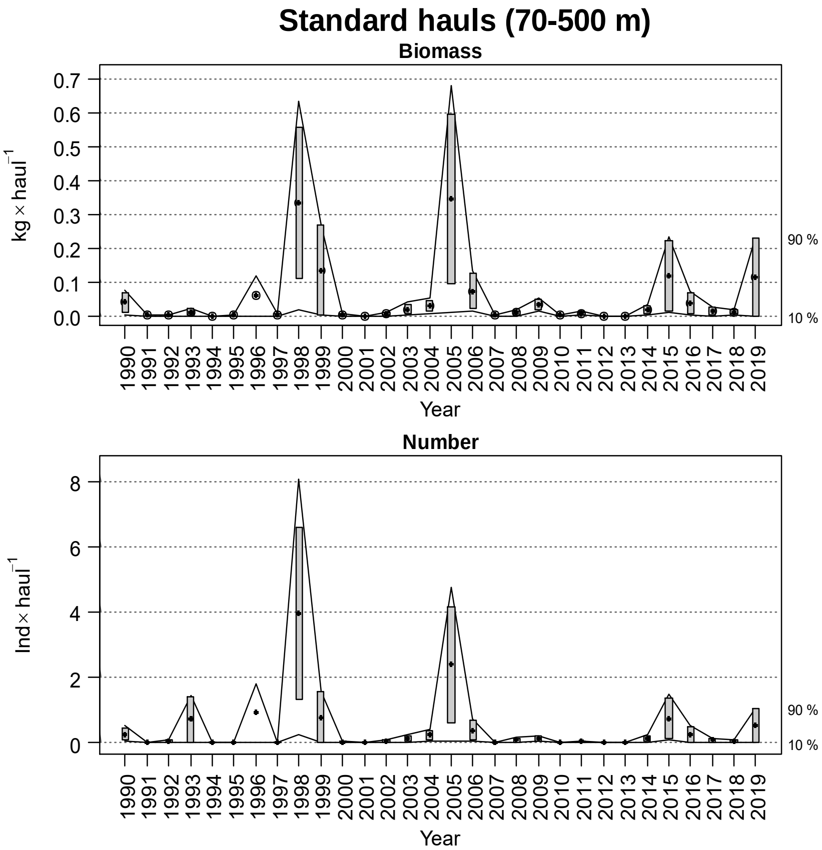


Figure 12.2.4. Evolution of Blackspot seabream (*P. bogaraveo*) mean stratified abundance in Northern Spanish Shelf survey time-series (1990–2019).

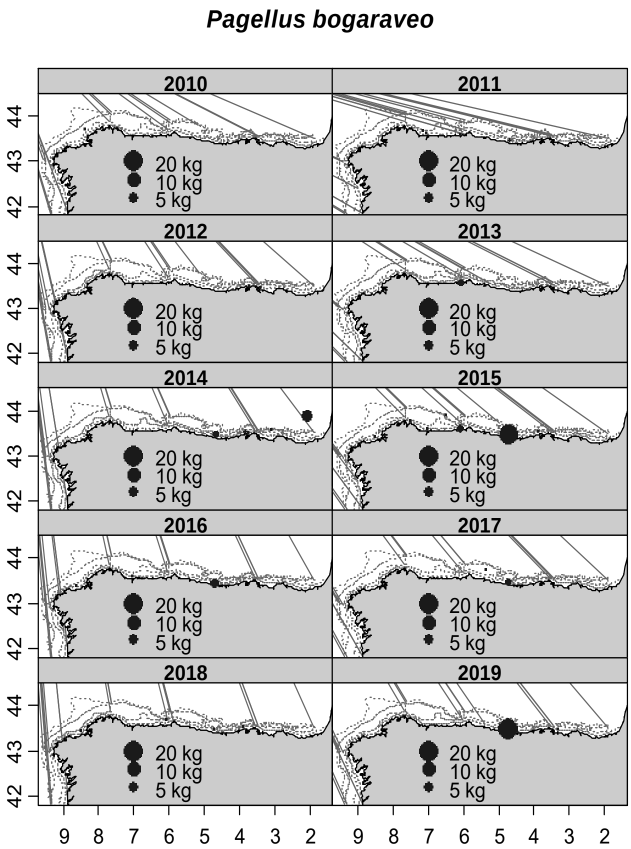


Figure 12.2.5. Catches in biomass of Blackspot seabream on the Northern Spanish Shelf bottom-trawl surveys, 2010–2019.

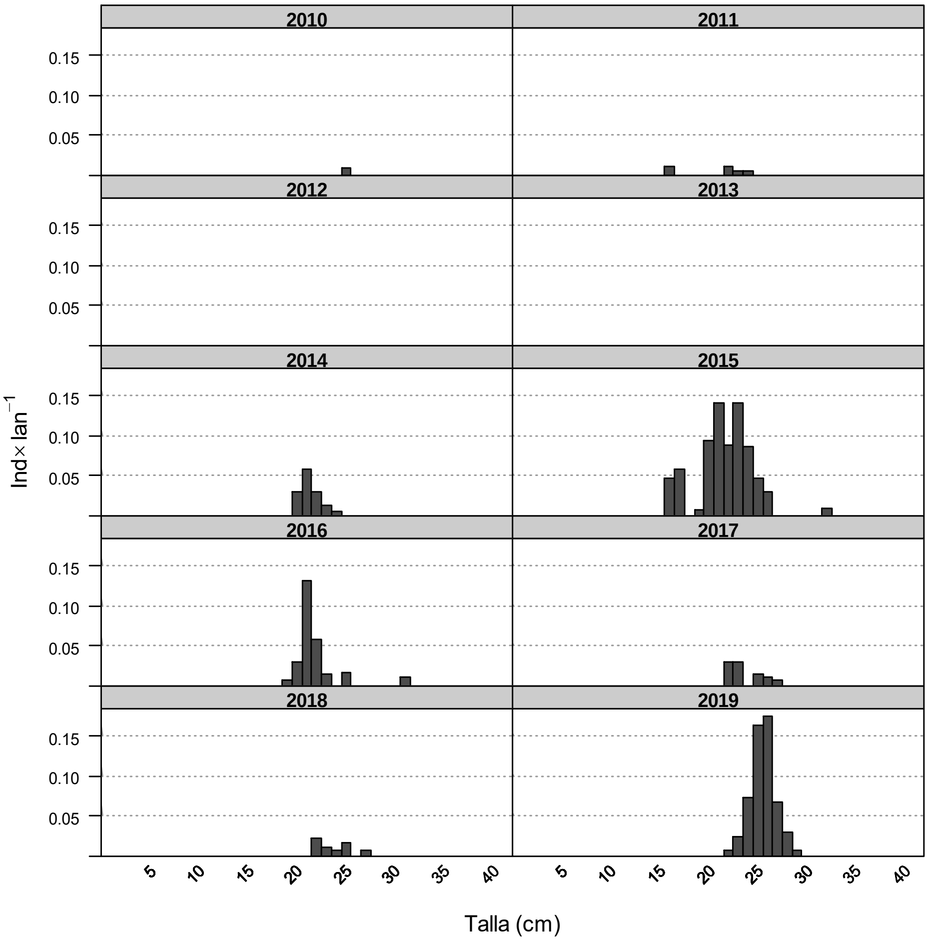


Figure 12.2.6. Mean stratified length distributions of Blackspot seabream (*P. bogaraveo*) in Northern Spanish Shelf surveys (2010–2019), no data before 2009.

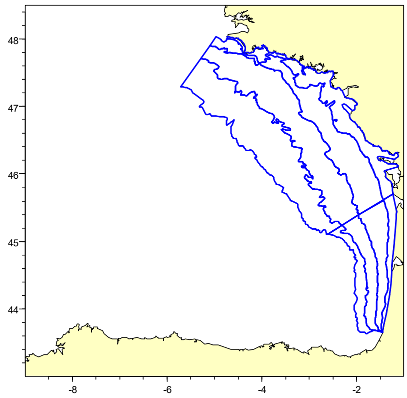


Figure 12.2.7. Strata covering the Bay of Biscay shelf, sampled in the current EVHOE survey and in two previous surveys in 1973 and 1976.

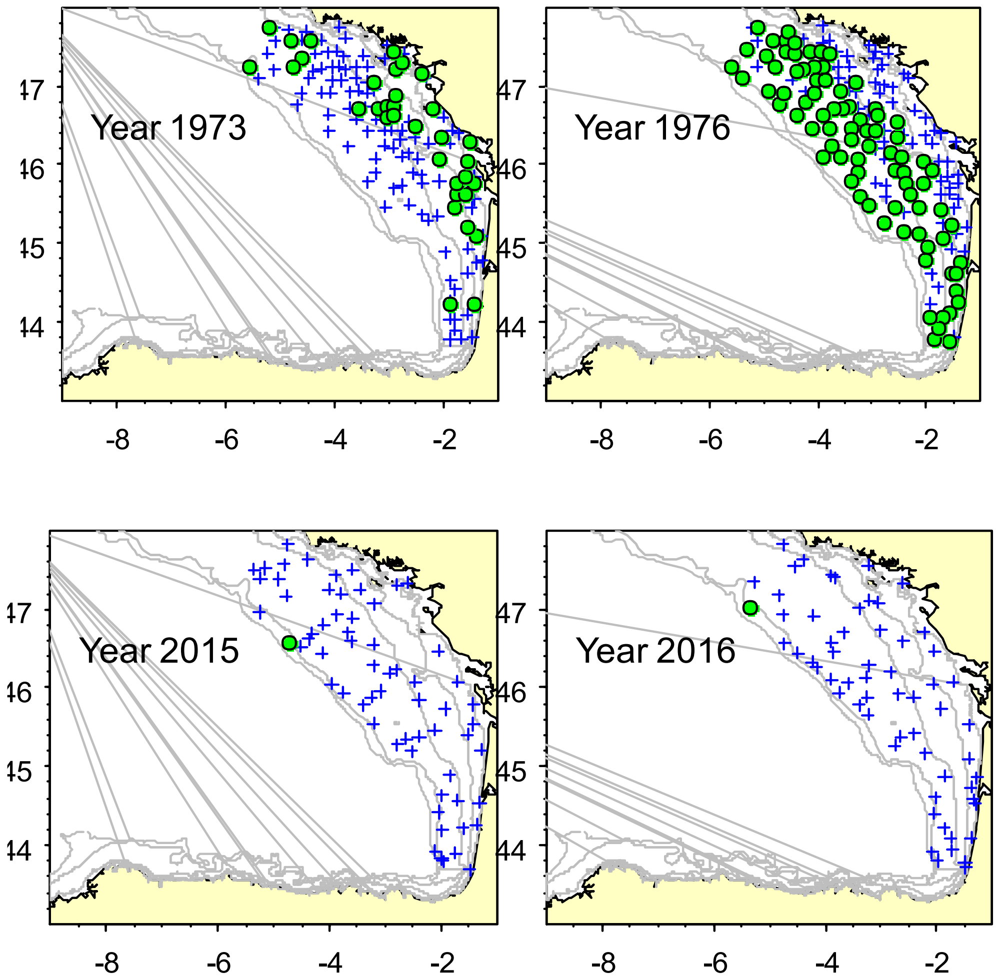


Figure 12.2.8. Occurrences of Blackspot seabream in surveys carried out in 1973 and 1976 and in the EVHOE survey in 2015 and 2016.

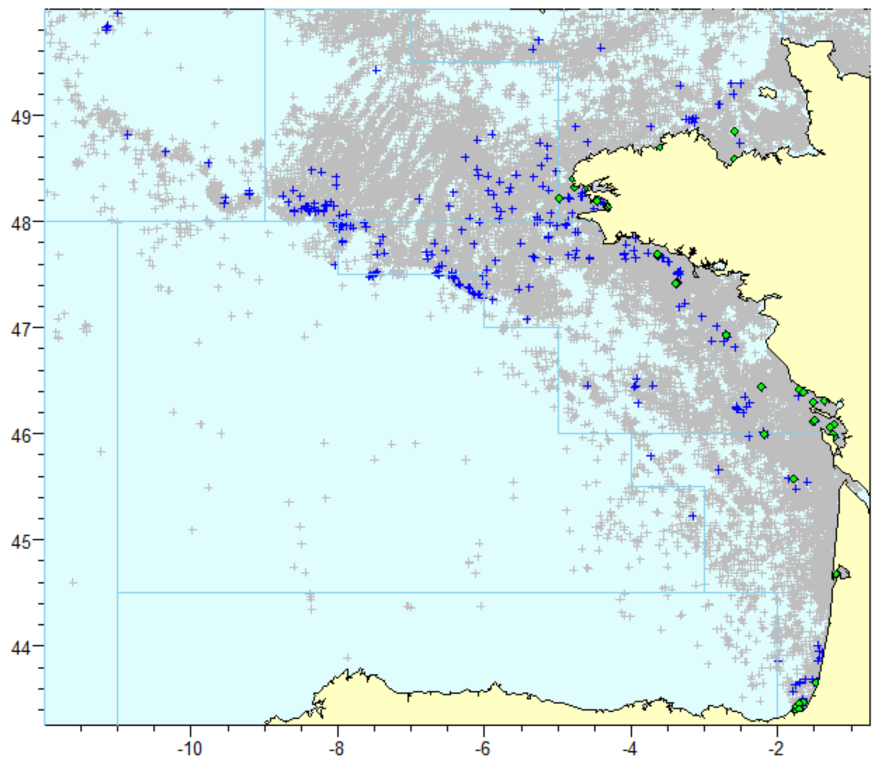


Figure 12.2.9. Geographical distribution on catch of the Blackspot seabream in French on-board observations 2010–2016 in the Bay of Biscay and southern Celtic Sea, all métiers. (Grey) all haul/sets observed, (Blue crosses) hauls with catch of blackspot seabream, (Green dots) hauls with catch of blackspot seabream <20 cm which species identification may be uncertain.

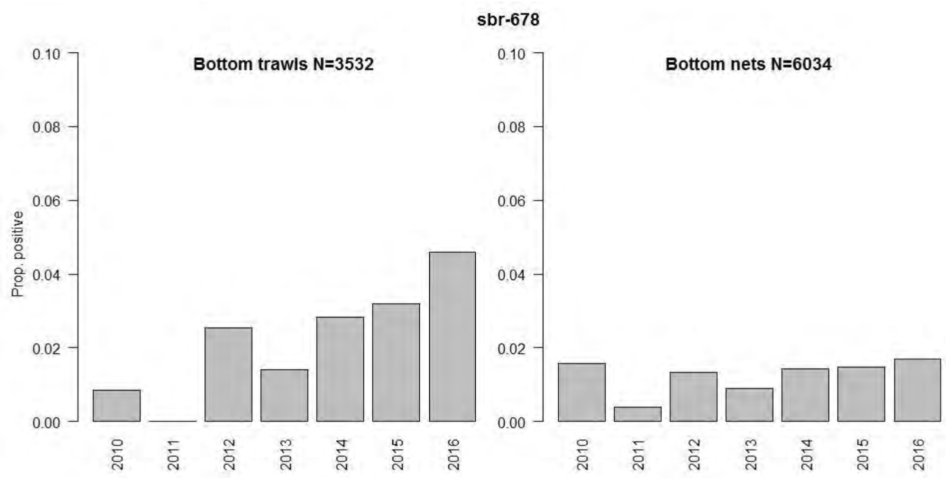


Figure 12.2.10. Proportion of fishing operations with catch of Blackspot seabream in bottom trawls (left) and bottom net (right) in French fisheries to the south of 49°N (ICES divisions 8.a–d and the southern part of 7.d and 7.h–k).

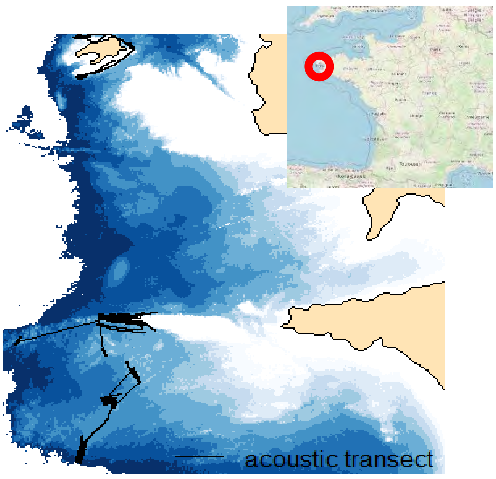


Figure 12.2.11. Surveyed areas and acoustics transits (black lines)

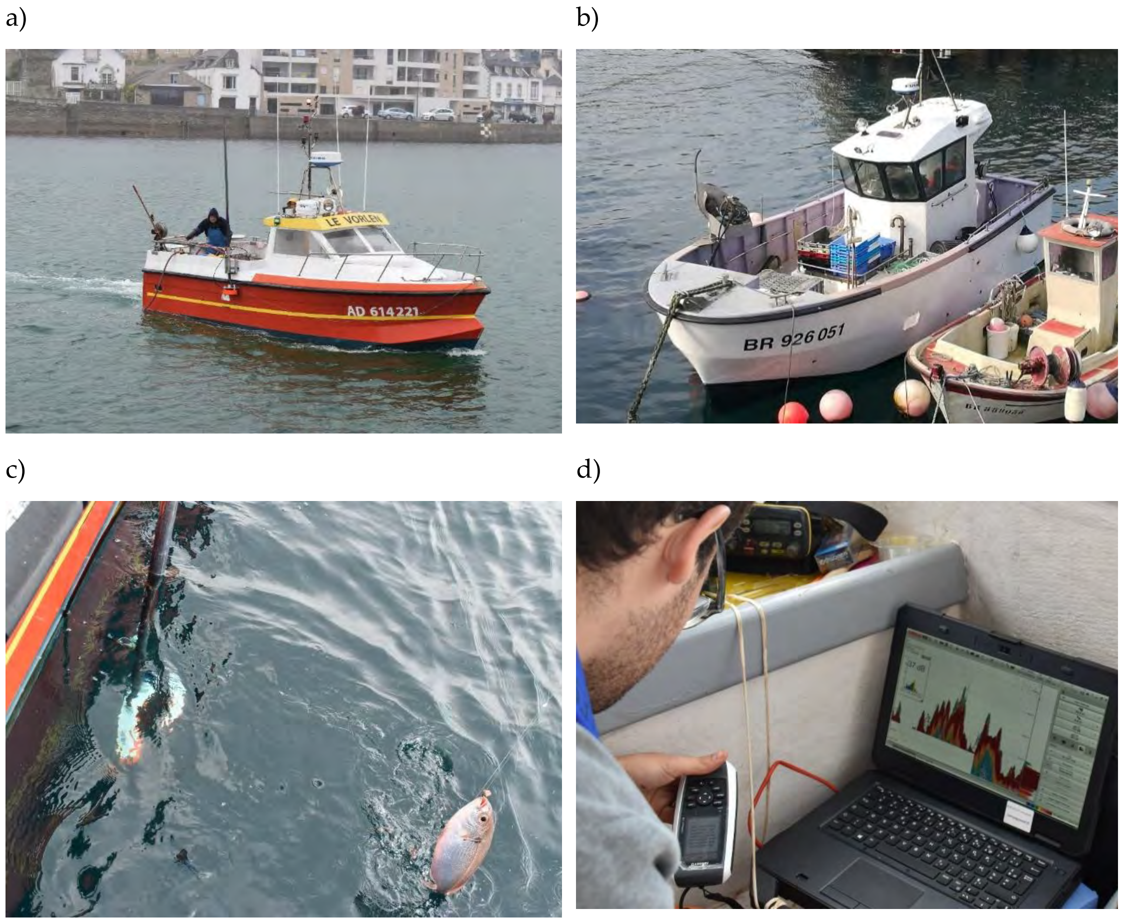


Figure 12.2.12. a) and b) Small-scale fishing vessels used for the acoustics survey, transducer lifted out of the water (a) and lower under the sea surface (c), d) data recording.

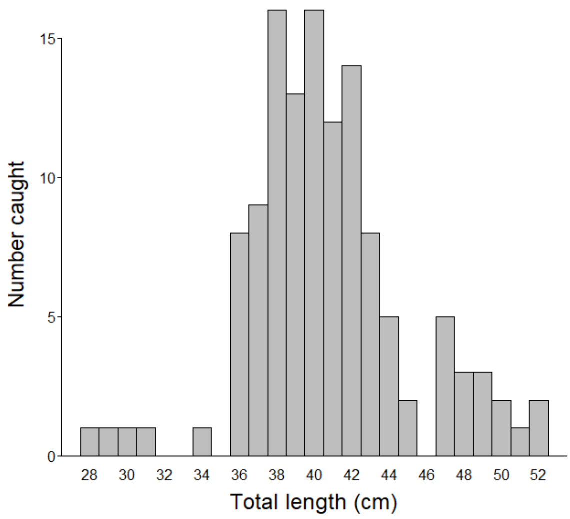


Figure 12.2.13. Length distribution of blackspot seabream caught during the acoustics survey.

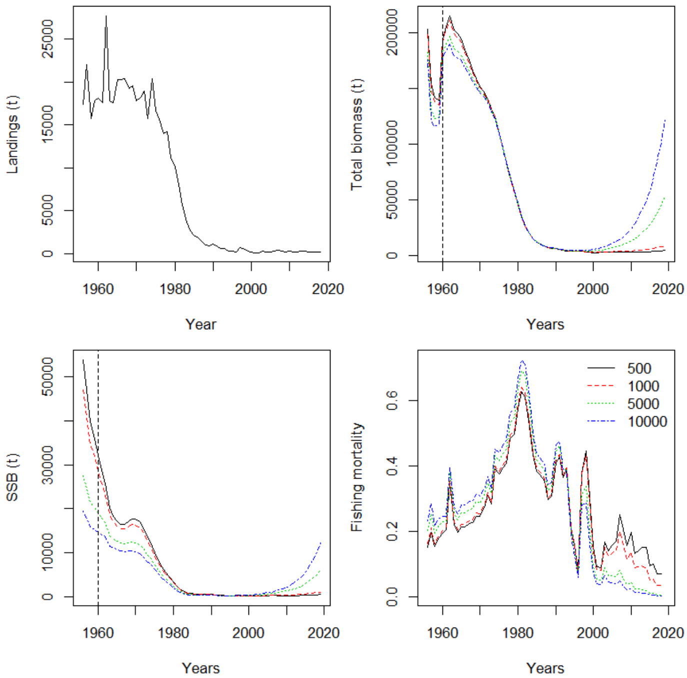


Figure 12.2.14. Time series of international landings and estimated biomasses and fishing mortality for blackspot sea-bream in the Bay of Biscay (ICES area 6, 7 and 8). SSB corresponds to females only. Colors represent runs for different scaling factors applied to the local acoustic survey biomass estimate obtained for a fishing area off Britany (France) in 2019.

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 Working Group (Gil *et al.*, WD 19 to the 2020 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 other 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 fleet is currently represent by about six vessels. 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 have been fishing 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 WG 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 2018 were also available from GFCM Subregional Committee on the Western Mediterranean meeting in 2019.

Detailed information from Portuguese fisheries has been updated to the Working Group by Farias and Figueiredo (). 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. Species landings are the second more relevant. The main landing ports (≈89% of the species mainland Portugal total landings) from North to South are: Matosinhos (Portuguese northwestern coast), Aveiro (Portuguese north western coast), Nazaré (Portuguese central western coast), Peniche (Portuguese central western coast), Sesimbra (Portuguese south western coast) and Sagres (Portuguese western Algarve coast).

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 in ICES 27.9. The species is mainly landed between December and March: this pattern could 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 (60 t) in 2019 (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 are supposed to be outside ICES Subarea 27.9 but 2019 landings are not available yet.

12.3.2 Advice

The ICES advice for 2019 and 2020 was "that when the precautionary approach is applied, catches should be no more than 149 tonnes in each of the years 2019 and 2020. All catches are assumed to be landed. ICES notes that the distribution of the stock extends outside Subarea 9. ICES recommends the establishment of a management plan that covers the entire stock distribution area."

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	2012–2013		2014–2015		2016–2017		2018–2019	
ICES Subarea	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings
9	780 – 780	295 –180	780 – 374	262 –153 (142*)	183 – 174	165 (77*) –130 (17*)	165 – 149	87 (8*) – 56 (4*)

***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.

Several tagging surveys (56 days at sea in 2001, 2002, 2004, 2006 and 2008) have been conducted in the Strait of Gibraltar area. A total of 4500 fish were tagged, of which 423 recaptures have been reported. No significant movements have been observed, although local migrations 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).

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, not only 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 but are not available in 2019, 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). For this species discards can be assumed to be zero or negligible for most assessment purposes and those that do occur are mainly related to catches of small individuals: therefore, for this stock, all catches are assumed to be landed at this moment.

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 (1983–2018). Figure 12.3.3 show the updated length distribution data (from Gil *et al.*, WD 19 to the 2020 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
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

Year	Mean	Std. Dev.	Median	Year	Mean	Std. Dev.	Median
2007	37.26	5.95	36	2019	37.27	4.21	37
2008	37.76	6.22	36				

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).

Farias and Figueiredo (WD 7 to the WGDEEP 2020) present length the frequency distribution by fishing segment (polyvalent and trawlers) from 2014 till 2019 landings in the port of Peniche (Figure 12.3.4). Differences in length distribution between the polyvalent the trawl segments might result from the fact that polyvalent fleet operate in deeper areas than trawlers, the former catch larger fish than the last.

12.3.5.3 Age compositions

Age and growth, based on otolith readings, were revised at the ICES WKAMDEEP2 meeting (September, 2018): A one-page template manual was first discussed and amended by the Group at the start of the meeting. Then this template was filled in for each species based on a demonstration of common practice by an expert reader of that species, followed by discussions in plenary. The finally agreed one-pagers are considered both necessary and sufficient as basis for a generic age reader of deepwater fish to be able to produce reasonably accurate and precise age estimates of each species. However, for this species the reading proved to be difficult, with low percentage of agreement (34.7) between the 12 participating age readers and high Coefficient of Variation (CV = 30.8), which is the consequence of low precision between the readers (i.e. difference of several years among readers for the same otolith). One of the reasons for these results might have been the inclusion of age readers with no or very limited experience. Restricting the comparisons to the two highest ranked readers for each species resulted in a reduction of CV to 15.7, close to the value that ICES (2013) considered more realistic and acceptable.

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 19 to the 2020 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 standardized CPUE estimated from VMS analysis shows the same trend.

Farias and Figueiredo (WD 7 to the WGDEEP 2020) identify two reference fleets landing at Peniche port: a total of 21 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 14 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 declining trend is clear in the target fishery of the Strait of Gibraltar (Figure 12.3.5). Landings declined significantly until 2013 which may be considered as an indication of a substantial reduction in exploitable biomass. Current CPUE levels may also be consistent with an overexploited population.

Even though the stock identity still unclear there is likely to be linkages between the Strait of Gibraltar populations and the populations in the southern and eastern area of Subarea 27.9. Certainly the Spanish "*voracera*" CPUE is probably more indicative of trends in the Strait of Gibraltar population than it is for the whole Subarea 27.9.

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 (Figure 12.3.6).

12.3.6 Management considerations

A TAC regime (149 t) was established for 2019 and 2020 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.

WGDEEP reiterates its advice of a need for a recovery plan for the Strait of Gibraltar fisheries: vital to its success is the involvement of non-EU countries (primarily Morocco).

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 seabream fisheries in the Alboran Sea, geographical subareas 1 - 3, for a two-year transition period). The 2019 Subregional Committee for the Western Mediterranean (SRC-WM) endorsed the advice on the status of blackspot seabream in the Strait of Gibraltar – based on a combination of two production models (SPiCT and BioDyn) and a Length Cohort Analysis (LCA), all producing compatible results – whereby the stock was considered in overexploitation and overexploited, with current fishing mortality estimated to be around twice F_{MSY} and biomass considered to be between 14 to 22 % B_{MSY}. The SRC-WM also suggested that the experts would continue pursuing the benchmark work on this species during the intersession to submit final results to the next 2020 SRC-WM (GFCM, 2019). 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. Therefore, it might not be appropriate to infer the stock status in all Division 9a from the CPUE from the Strait of Gibraltar.

12.3.7 Tables

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	19		374 (19*)
2002	111	248	37		259 (37*)
2003	142	329	24		471 (24*)
2004	183	297	34		480 (34*)
2005	129	365	39		494 (39*)
2006	104	440	74		544 (74*)

Year	Portugal	Spain	Morocco*	Unallocated	TOTAL
2007	185	407	90		592 (90*)
2008	158	443	77		601 (77*)
2009	124	594	99		718 (99*)
2010	105	379	107		484 (107*)
2011	74	259	136		333 (136*)
2012	143	60	122	92	295 (122*)
2013	90	91	92		181 (92*)
2014	59	203	118		262 (118*)
2015	66	87 (142**)	219		295 (219*)
2016	70	95 (77**)	159		242 (159*)
2017	69	61 (17**)	188		147 (188*)
2018	58	29 (8**)	72		95 (72*)
2019	36	20 (4**)	NA		60

***Morocco landings are available from the Subregional Committee on the Western Mediterranean 2019 meeting, which includes a benchmark workshop on blackspot seabream (GFCM SCR-WM 2019)**

****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 10 to the 2019 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	

Year	cpue	VMS cpue
1995	60	
1996	104	
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

12.3.8 Figures

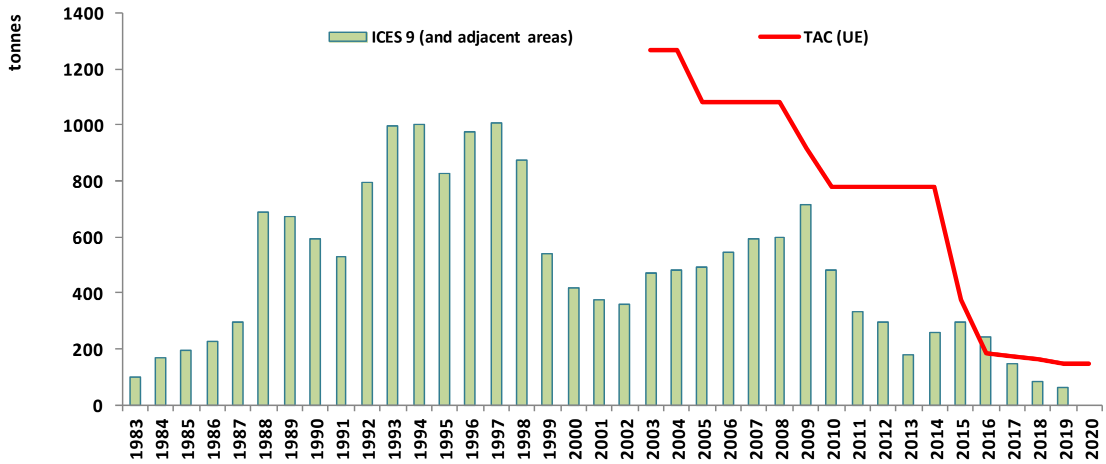


Figure 12.3.1. Blackspot seabream in ICES Subarea 27.9 (and adjacent waters): Total European landings (Morocco landings are not included) and EU TACs. Since 2015 landings from Strait of Gibraltar includes other areas (FAO 34.1.11 and FAO 37.1.1).

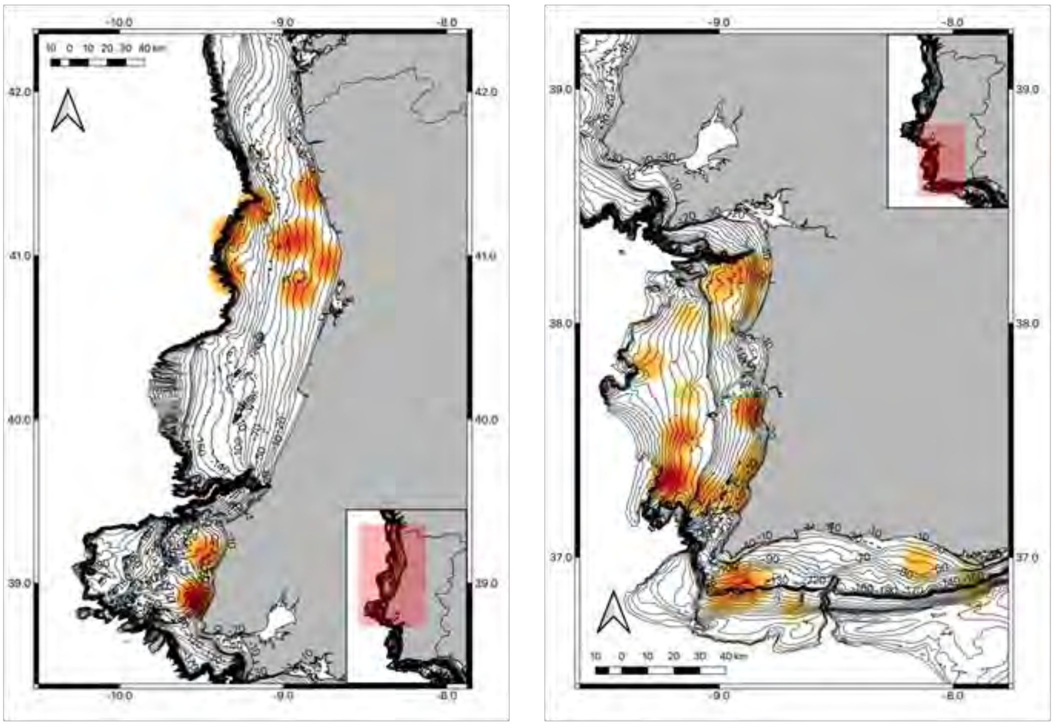


Figure 12.3.2. Blackspot seabream in ICES Subarea 9: Distribution *of Pagellus bogaraveo* along the Portuguese coast based on Portuguese surveys from the period between 1997-2011 and 2013-2017. The coloured blotches are hauls with *Pagellus bogaraveo* catches over 5 n.h-1. The colour intensity of the blotches reflects species occurrence (from Farias and Figueiredo, WD 14 to the 2019 WGDEEP).

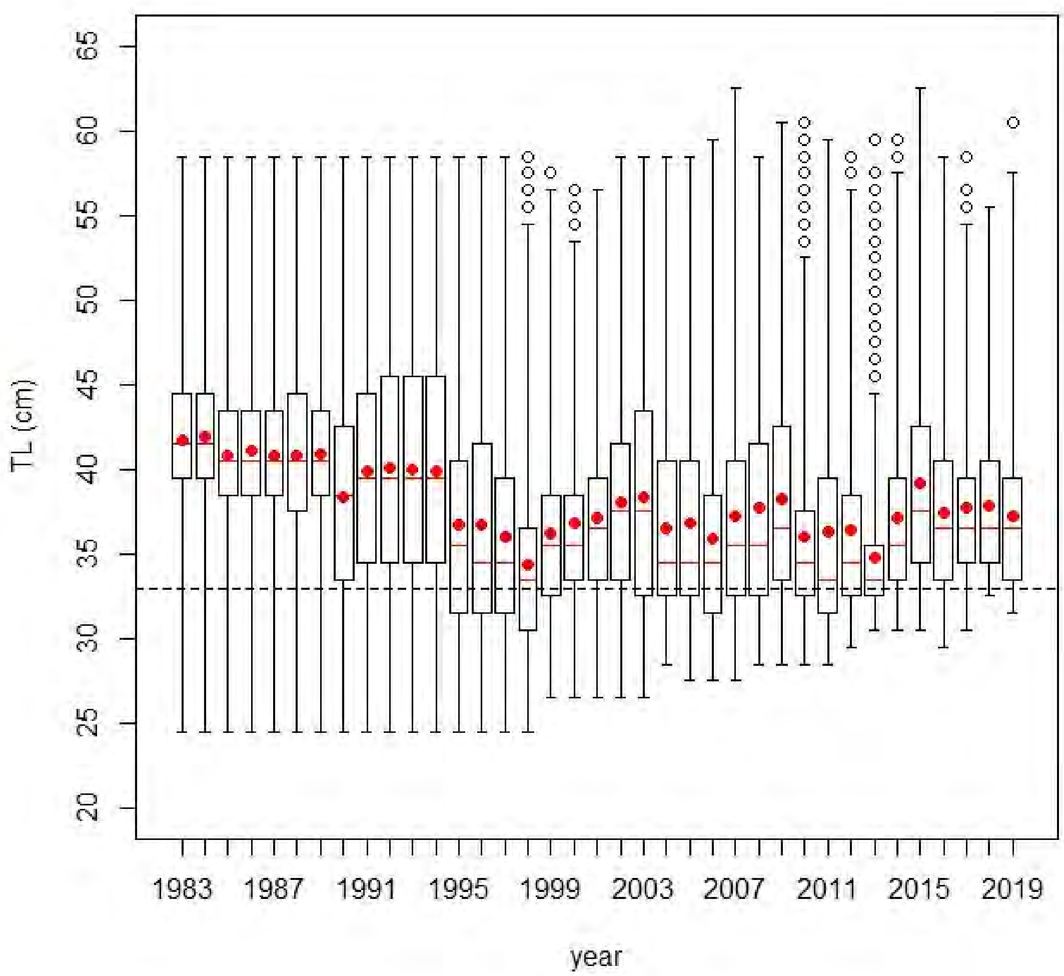


Figure 12.3.3. Spanish "*voracera*" blackspot seabream fishery of the Strait of Gibraltar: 1983–2019 (from Gil *et al.*, WD 19 to the 2020 WGDEEP). Dashed line (at 33 cm) represents the current minimum landing size for the species in Atlantic NE and Mediterranean European waters. Red dot are the mean value while red line represents the median.

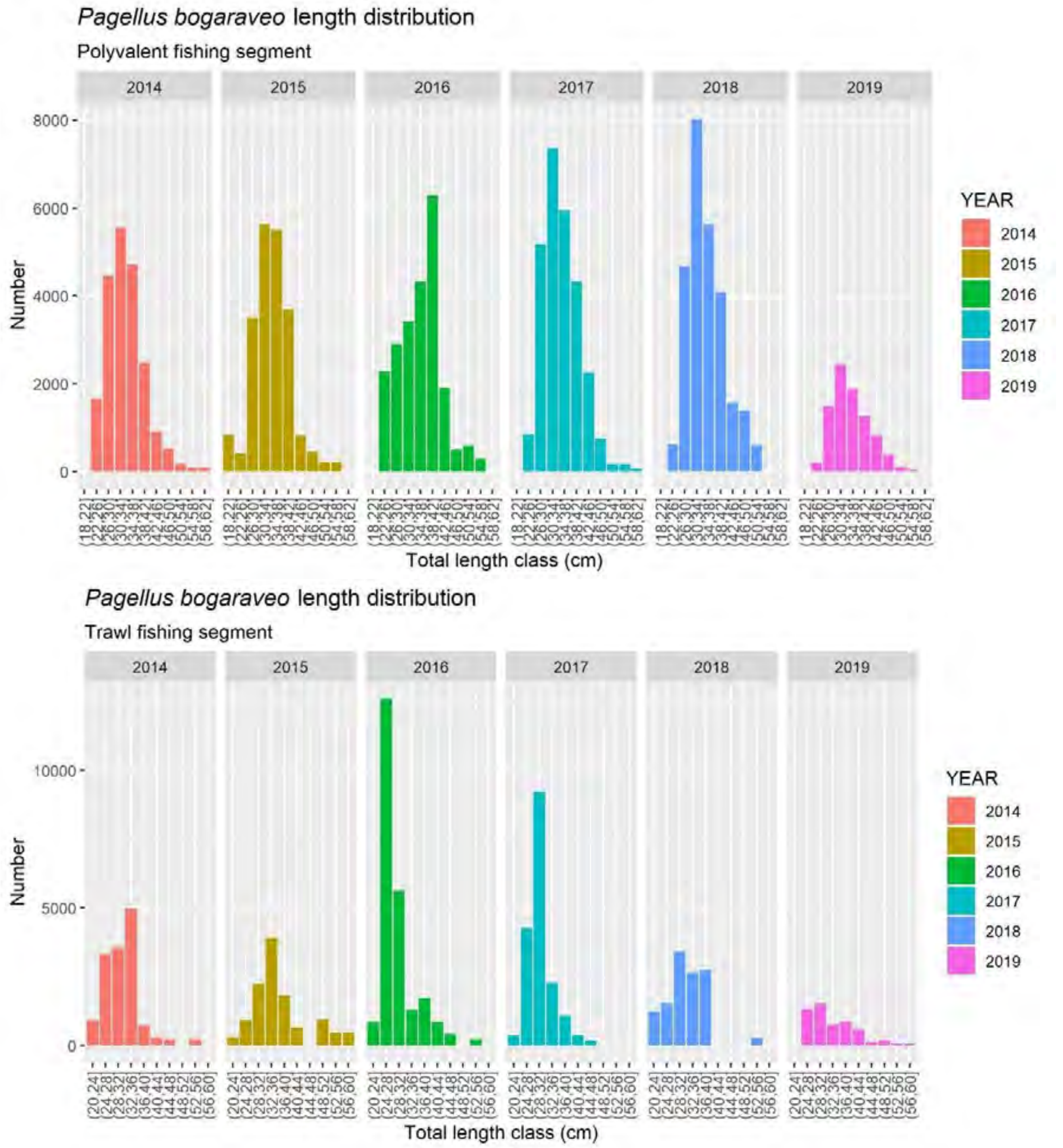


Figure 12.3.4. Peniche (Portugal) landing port: *Pagellus bogaraveo* length frequency distribution by fishing gear (polyvalent and trawl fleet) for the years 2014 to 2019 (from Farias and Figueiredo, WD 7 to the 2020 WGDEEP). Length classes are aggregated by 4 cms range (from 20-24 till 56-60).

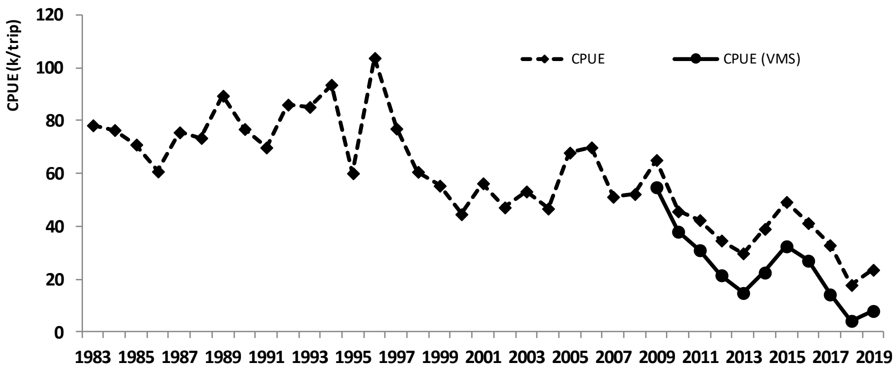


Figure 12.3.5. Blackspot seabream in ICES Subarea 27.9: Spanish "*voracera*" target fishery of the Strait of Gibraltar estimated CPUE, using sales sheets (dashed line: 1983-2018) and VMS data as unit of effort (solid line: 2009-2018) (from Gil *et al.*, WD 19 to the 2020 WGDEEP).

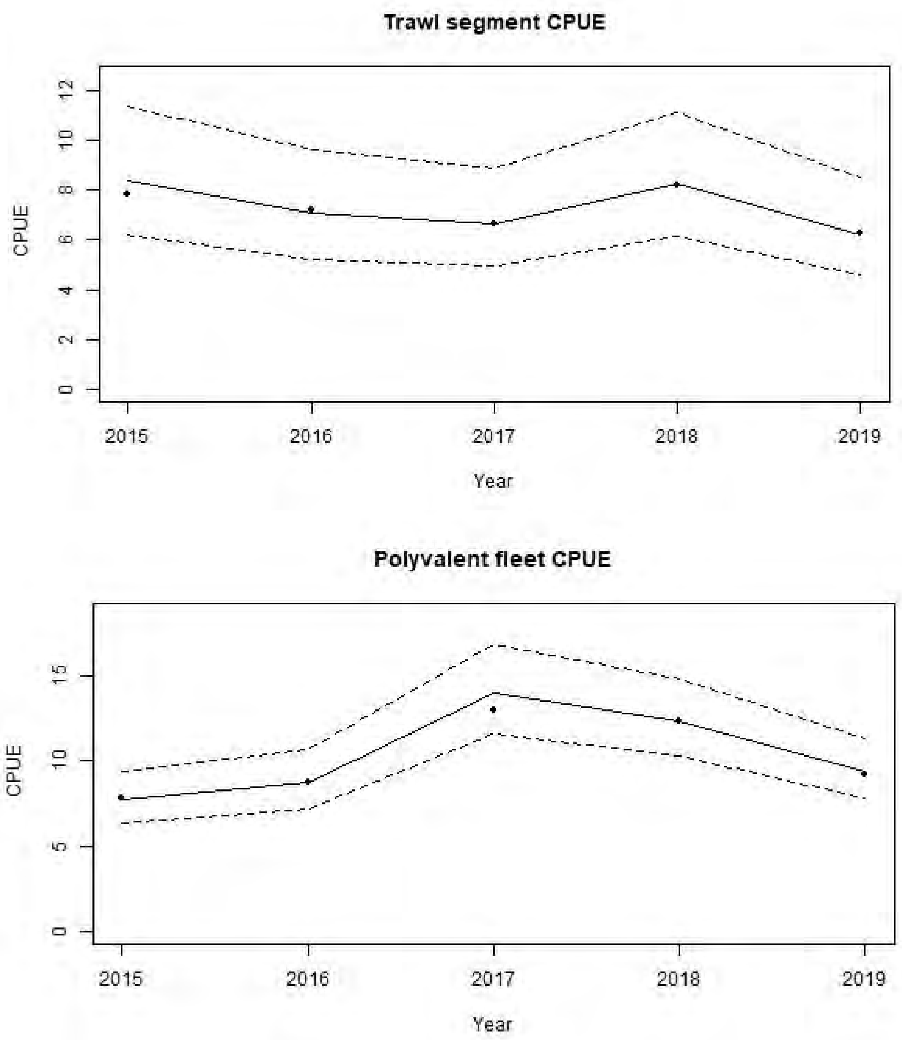


Figure 12.3.6. Blackspot seabream in ICES Subarea 27.9: Standardized annual estimates of CPUE by fleet segment (polyvalent and trawl) from the Peniche´s port reference fleets in 2015 - 2019 (from Farias and Figueiredo, WD 7 to the 2020 WGDEEP).

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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 Area 10.a.2), at least since the XVI century as part of the demersal fishery. The directed fishery is a hook and line fishery where two components of the fleet can be defined: 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), particularly made by the longline fleet as a consequence of 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.

12.4.2 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 12.4.1), 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 during that period, maintaining thereafter around this value due to the TAC introduced. In general, a continuous decrease has been observed since 2005. Currently the fishery is highly constrained by management measures. Landings of the last three years (2017, 2018 and 2019) were: 499t, 445t and 474t, respectively.

12.4.3 ICES Advice

ICES advised that when the precautionary approach is applied, catches should be no more than 553 tonnes in 2020 for area 10. All catches are assumed to be landed.

12.4.4 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 area 10 are 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		
EU TAC	678	507	517	517	576	553		
Landings	701	515	499	445	474			

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). For the 2006 the Regional 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 and bottom gillnets are forbidden in the Azores region.

For 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). A seamount (Condor) was also 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 limiting the fishing area for long-liners, updated the minimum landing size to 33 cm (Ordinance No. 120/2016) and introducing 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. Also at 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.

12.4.5 Data available

12.4.5.1 Landings and discards

Total annual landings data are available since 1980. However, detailed and precise landing data are available for the assessment since 1990 (WD17 Medeiros-Leal *et al*., 2020). 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.

12.4.5.2 Length compositions

Fishery length composition from the landings is available for the period 1990-2016 (Figure 12.4.3). Data for 2017, 2018 and 2019 were not available.

Length compositions from survey (Figure 12.4.4) showed a mode around 25-31 cm and since 2016 have presented an increase for different length classes with a shift of modes to the following cohorts in the next two years (2017 and 2018). Larger individuals were observed during these last two years.

12.4.5.3 Age compositions

The information is available from the survey until 2019 but are not presented here because it is not relevant to the current assessment.

12.4.5.4 Weight-at-age

No new information was presented to the group because there are no relevant changes on the biology of the species.

12.4.5.5 Maturity, sex-ratio and natural mortality

Maturity and sex-ratio data were updated in accordance with the methods outlined in the stock annex. Natural mortality was reviewed in 2015 exploring several empirical methods for the M estimation. A mean value of M=0.3 was estimated but with a considerable uncertainty.

12.4.5.6 Catch, effort and research vessel data

Standardized fishery cpue was updated (WD13 Novoa-Pabon *et al.*, 2020) only until 2017 because fishery data was not available for 2018 and 2019 (Table 12.4.2 and Figure 12.4.2.).

Survey data were updated (WD18 Medeiros-Leal *et al.*, 2020) and are resumed on Table 12.4.3, Figure 12.4.5 and Figure 12.4.7.

12.4.6 Data analyses

The standardised fishery cpue has been variable (Table 12.4.2; Figure 12.4.2). In recent years, the cpue appears to have shown a declining trend from a high point in 2005 with current cpue around the lowest observed level. This coincides with a declining trend in landings (Figure 12.4.1) and survey abun-dance indices (Figure 12.4.5) over the same period, except for the last four year (2016-2019) for the survey case.

The Azorean bottom longline survey targeting *Pagellus bogaraveo* is reliable for abundance estimates, since the survey design is adapted to the stock behaviour covering most of the species habitat (with exception of seamounts around Mid-Atlantic Ridge) (Table 12.4.4). The survey time-series is not continuous because in 1998, 2006, 2009, 2014 and 2015 there was no survey. The annual values were computed using sampling statistical areas I-IV because area VI was not sampled in some years (1996 and 2008) (Figure 12.4.6). Survey indices from 1995 to 2019 show no trend with a high value every three years until 2005 and for the years of 2017, 2018 and 2019 (Figure 12.4.5). The 2017 and 2019 correspond to the year with the highest index value observed in the time series. These high values may be related with some sort of catchability variability (fish are more available to the gear in some years than in others) as a function of the feeding behaviour (bentho-pelagic), reproduction (protandric forming spawning aggregations) of the species, due to environmental effects or result of management measures. However, the survey abundance indices from 2010–2013 are in the range of lowest values and with a decrease trend. This period correspond to the lowest catch observed during the last 19 years being on average 60% of the precedent years (1995–2009) (Figure 12.4.1).

Survey abundance indices of mature and immature follow the same trend of the total abundance estimates (Figure 12.4.8). Mean length of the stock for the entire period (1995–2019) is 31 cm (Figure 12.4.9) and of mature stock around 37 cm LF (Figure 12.4.10) and immature about 25 cm LF (Figure 12.4.11). Mature fish mean length increased from 36 cm LF in 1995 to 41 cm LF in 2000 and decreased thereafter until 36 cm LF in 2013, with an increase for the 2016 and 2017, but decreasing again in 2018 and 2019. Variance of the estimates is high.

The stock is classified by ICES category 3 and the assessment is based on survey abundance index trends.. Survey data show an important increase in the relative abundance index for the last four years (2016-2019) relative to the previous period. The observed increase is consistent through all statistical survey areas (Figure 12.4.7). The lack of updated fishery abundance data to compare the observed trend makes it difficult to interpret the mean of this large increase; however, it may be a consequence of the severe management measures introduced, as e.g. minimum landing size, area restrictions and gear, limitations of the fisheries licence numbers, quotas by island and introduce of marine protected areas.

Catches in recent years are highly constrained by severe management measures.

Exploratory analysis

Length-based indicators

Length-base indicators reported from WKLIFEV were explored and for this exercise were used Azorean longline survey length compositions for pooled sexes from 1995–2019 (discards are assumed to be negligible). Main life-history parameters used are resumed in Table 12.4.4. Computations were performed using R software and the codes were available in the GitHub library of ICES.

Results from the analysis are shown in Figure 12.4.12 and Table 12.4.5. Results show that for immature conservation a substantial harvesting occurs before maturity (L_c and $L25\% << L_{mat}$). This was expected since the current relative exploitation pattern corresponds to a $L50\% \leq L_{mat}$. This L_{mat} value is already considered low (L_{mat} moved from 34 cm to 32 cm along time) being probably a response of the population to the fishing pressure.

For mature fraction of the population the results suggest that the large individuals are present but are scarce ($L_{max}<L_{inf}$). The L_{mat} (32 cm) is considerably lower than L_{opt} (38 cm) and the results of P_{mega} indicator clearly suggest that the mega spawners in the Azorean longline survey are lower than 30% throughout the analysed period.

The MSY proxy results show that exploitation is above the MSY level ($L_{mean}<L_{opt}$ and $L_{mean}<L_{F=M}$). Only in the period 1998–2001 and 2005–2010 the exploitation was considered at the sustainable levels close to MSY (Table 12.4.5 and Figure 12.4.12), because the effect of the suddenly increase of large individuals in the survey (see Figures 12.4.3 and 12.4.4).

Total mortality (Z)

Catch curve analysis was explored during 2015 (WD Pinho *et al.*, 2015) to estimate total fishing mortality (Z). An update was done for the current year. Annual fishery age compositions for the recent period (2014-2016) were used. Age–length compositions were computed by converting length to age using Age–Length Keys (ALK) from the survey age readings for the period 1995–2016. For 2014 was adopted the ALK of 2013 and for 2015 the ALK of 2016. Survey data were used because they cover a longer period than DCF data with age interpretation made by the same reader. A pseud cohort (equilibrium) approach was used, considering that the annual population structure is approximately the same as the cohort along life. ALK covers the age range between 1 and 15. Data from age 1 to 8 were used considering age 9 as a plus group because very few individuals are observed annually in the age range 9 to 15. Computation of the annual Z estimates was performed using FSA package in R software (Ogle et al., 2020). Current Z was estimated as a mean of the annual estimates. The natural mortality (M) was considered a constant value M = 0.2, and fishing mortality (F) was then estimated assuming that F = Z - M.

Results show that the mean total fishing mortality for the period 2014-2016 is around 0.6 (F=0.4) year^{-1} (Figure 12.4.13).

Yield-per-recruit

Length-based yield-per-recruit (YPR) formulation was used to explore the optimal fishing mortality for this species. All the computations were performed using fishing mortality varying between 0 and 2, step 0.01). Input data used in the YPR analysis are resumed in Table 12.4.4. Sex ratio and maturity by length were computed according the stock annex. A knife-edge approach was used. Results are resumed in Figure 12.4.14. The model is not able to estimate adequately fishing mortality correspondent to maximum sustainable yield (F_{max}) because the flat top nature of the YPR curve. $F_{0.1}$ reference point estimated is around the value of natural mortality ($F_{0.1}$=0.22ano^{-1}). The stock at the current fishing mortality (F_{curr}=0.4) is considered unsustainable at long-term.

Overall, the perception from the length base indicators is that the stock has been exploited unsustainably above the optimal and MSY levels.

SPICT

The SPICT production model was explored using all available information from ARQDAÇO survey (abundance indices in number and weight) from 1995 to 2019, landings for the period 1985–2019 and fishery nominal and standardized cpue for the period 1990–2017 (Figure 12.4.15). Several runs were explored with the different indices analysing different periods of years by excluding some points. When survey abundance indices are used, no convergence was obtained for any combination of data, probably due to high interannual variability observed in the survey indices. Convergence was only achieved when nominal cpue was used for the period of the 1990-2017.

The basic plots of the results using landings (1985–2017) and nominal cpue (1990–2017) are presented in Figures 12.4.16–12.4.19. The model results for this run suggest that the stock is overexploited over the entire time series. However, there are low contrast in the time series to properly estimate the parameters.

Comments on the explanatory analysis

Results from the methods used in the exploratory analysis seem to be all in agreement suggesting that the stock has been explored at or above the MSY level. However, it should be noted that this is a sex-changing fish and the methods used may not catch the resource dynamics. Therefore, the results must be interpreted with caution.

There are some data analyses that should be explored in future works, which can considerably improve the assessment:

- Review of the standardized fishery abundance indices and effort unit;
- Analyse the effects of factors such as competition, gear saturation and soak time on the survey data to better understand the reliability of the abundance indices for assessment;
- Analyse the reproductive biology of the Blackspot seabream clarifying aspects related to the maturity stages and sex transition phase.

12.4.7 References

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12.4.8 Tables

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

Year	Azores (10.a.2)	Total
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

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
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

YEAR	NOMINAL cpue	STANDARDIZED cpue	Lower CI	Upper CI
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
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

Year	Lower	Index	Upper
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

na = Not available.

Table 12.4.4. Input constant parameters used in Yield-per recruitment analysis for blackspot seabream *Pagellus bogaraveo* of the Azores (ICES area 10).

Parameters	Value	Definition	Obs.
L_{oo} (cm)	56,72	Asymptotic average maximum length	ICES, 2012
K (year-1)	0,13	Growth coefficient of the von Bertalanffy growth model	ICES, 2012
T_o (year-1)	-1,46	Hypothetical age at which the species has zero length	ICES, 2012
a=	0,0172	Condition factor parameter of length-weight relationship	Rosa *et al.,* 2006
b=	3,0273	Slope parameter of length–weight relationship	Rosa *et al.*, 2006
L_{max} (L_F, cm)	55	Maximum length usually observed on the population (not the max ever observed)	Pinho *et al.,* 2012
L_r (L_F,cm)	20	Length of recruitment to the fishing area	
Tr (year-1)	2	Age of recruitment to the fishing area	
L_{mat} (L_F, cm)	32,2	Length at size first maturity	
L_c (L_F, cm)	30	Length of first capture to the fishery (L50% from selectivity curve)	Sousa *et al.,* 1999
T_c (year-1)	4	Age of first capture to the fishery (age at L50%)	
M	0,2	Natural mortality	ICES, 2006
Zcurrent	0,63	Current total fishing mortality	
Fcurrent	0.43	Current fishing mortality	

Table 12.4.5. Traffic light indicators for blackspot seabream *Pagellus bogaraveo* from the Azorean spring bottom longline survey for the period 1995–2019 (ICES Area 10.a.2).

Year	Conservation				Optimizing Yield	MSY
	LC >1	L 25% >1	L max 5% >0.8	P mega >0.3	Lmean >0.9	Lmean ≥1
	Lc / Lmat (immatures)	L25%/ Lmat	$L_{max5\%}$ / L_{inf} (large individuals)	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
1995	0.75	0.75	0.84	0.12	0.79	0.97
1996	0.92	0.92	0.73	0.03	0.82	0.89
1997	0.92	0.92	0.82	0.08	0.85	0.92
1998	0.75	0.75	0.81	0.08	0.8	0.97
1999	0.58	0.75	0.87	0.2	0.82	1.14
2000	0.58	0.75	0.88	0.28	0.86	1.2
2001	0.75	0.75	0.86	0.15	0.82	1
2002	0.75	0.75	0.82	0.1	0.78	0.95
2003	0.75	0.92	0.79	0.06	0.78	0.95
2004	0.75	0.75	0.8	0.09	0.79	0.97
2005	0.92	0.92	0.84	0.21	0.92	1
2006	0.75	0.92	0.82	0.12	0.82	1
2007	0.75	0.92	0.81	0.11	0.83	1.01
2008	0.75	0.92	0.79	0.1	0.82	1
2009	0.75	0.92	0.8	0.11	0.83	1.01
2010	0.75	0.92	0.78	0.07	0.82	1
2011	0.75	0.75	0.78	0.05	0.79	0.96
2012	0.92	0.92	0.77	0.04	0.82	0.9
2013	0.75	0.92	0.79	0.06	0.79	0.96
2014	0.75	0.92	0.78	0.05	0.79	0.96
2015	0.92	0.92	0.78	0.05	0.83	0.91
2016	0.75	0.75	0.79	0.07	0.77	0.93
2017	0.83	0.83	0.85	0.1	0.87	0.96
2018	0.83	0.9	0.81	0.07	0.86	0.94
2019	0.77	0.83	0.79	0.04	0.81	0.96

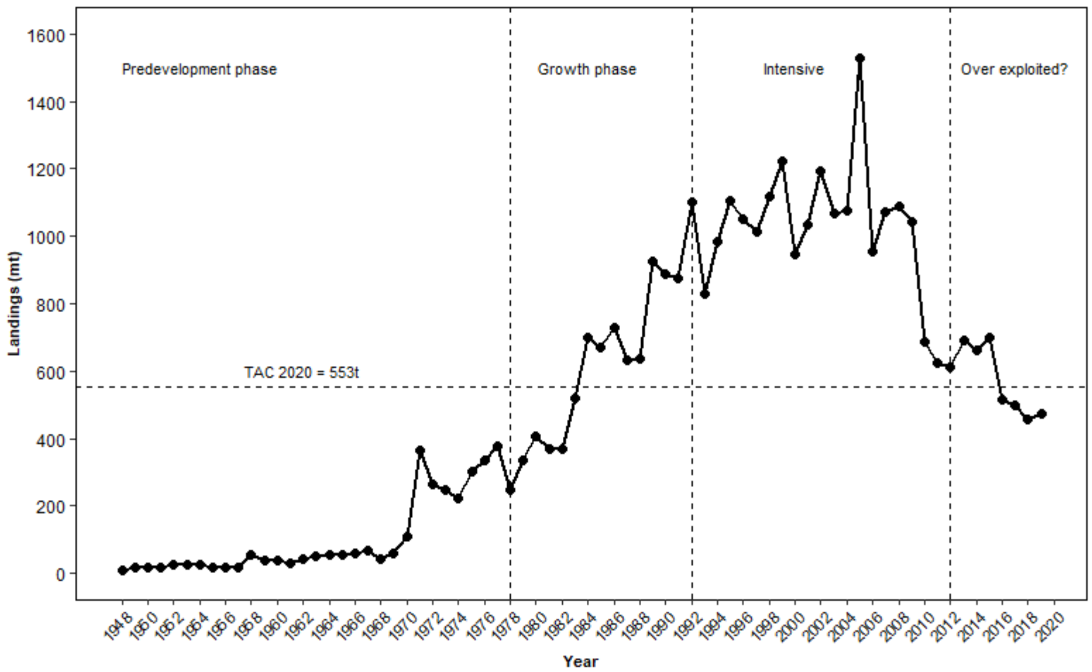

Figure 12.4.1. Historical landings of blackspot seabream *Pagellus bogaraveo* from the Azores (ICES Area 10.a.2).

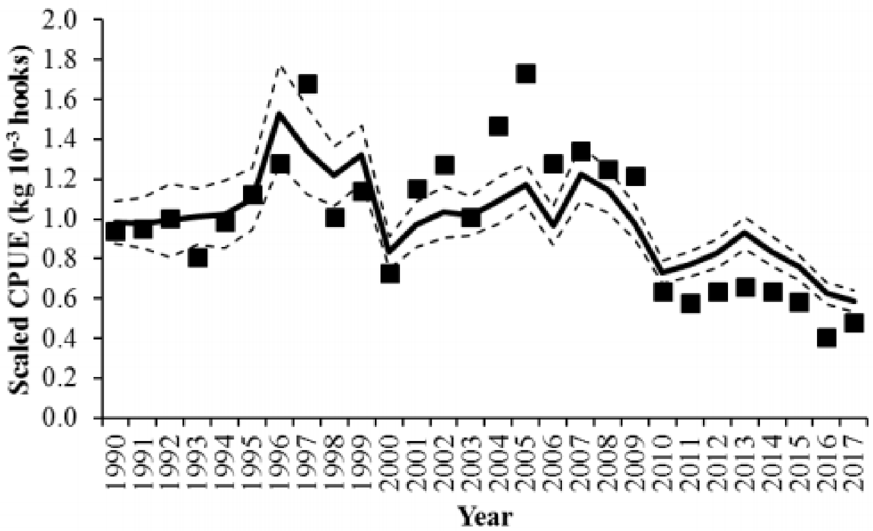

Figure 12.4.2. Nominal (■) and standardized (—) CPUE (kg 10^{-3} hooks) for blackspot seabream *Pagellus bogaraveo* from the Azorean bottom longline fishery, 1990–2017. Dotted lines represent 95% confidence intervals for the standardized CPUE.

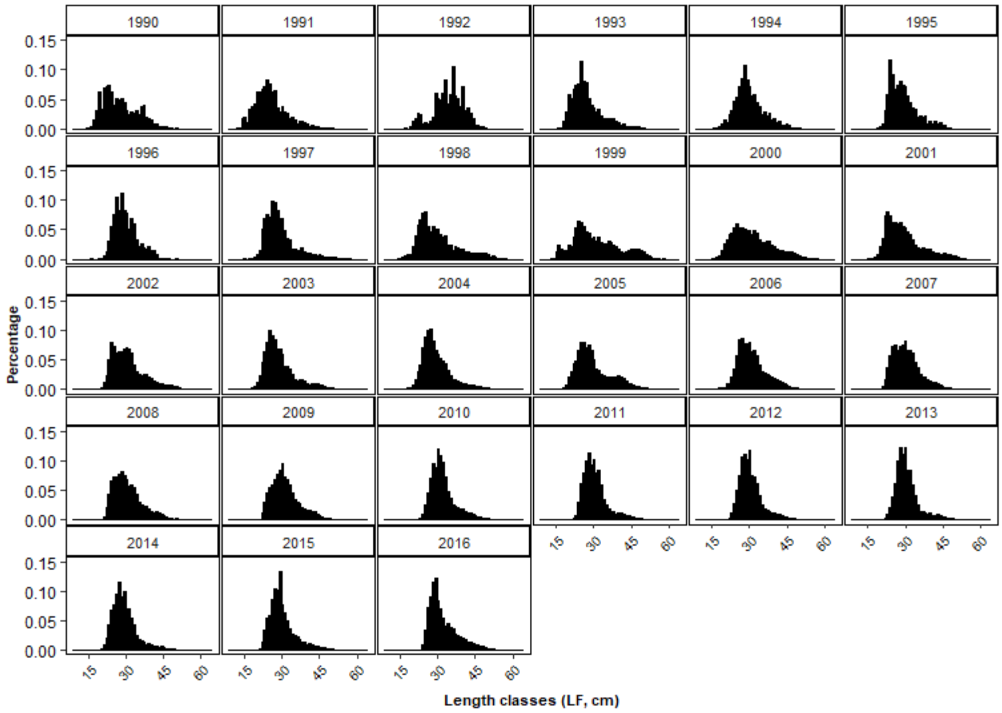

Figure 12.4.3. Annual fishery length composition of blackspot seabream *Pagellus bogaraveo* for the period 1995–2016 (ICES division 10.a.2).

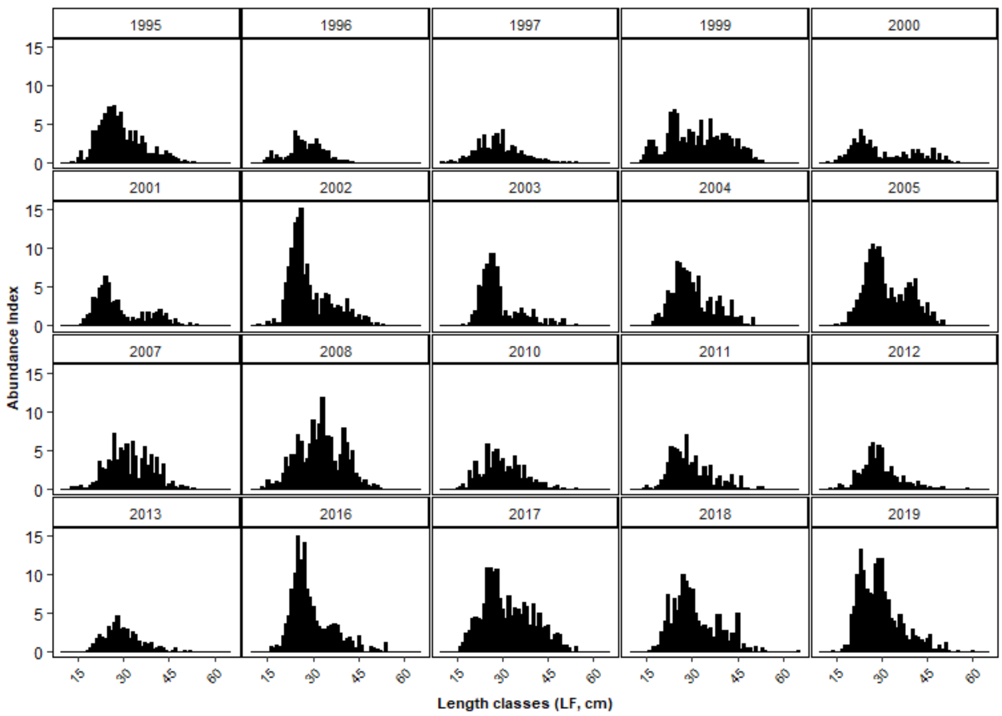

Figure 12.4.4. Annual length composition of blackspot seabream *Pagellus bogaraveo* from the Azorean spring bottom longline survey for the period 1995–2019 (ICES division 10.a.2).

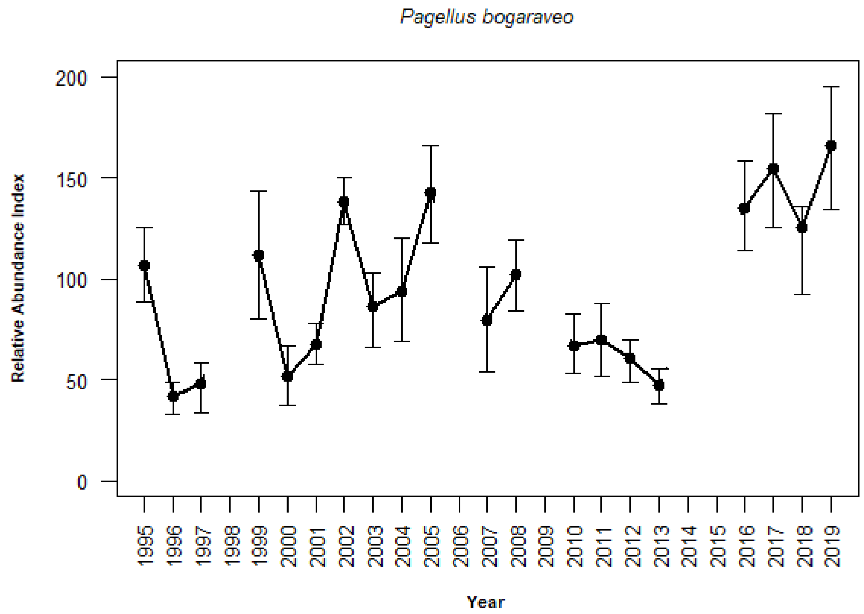

Figure 12.4.5. Annual abundance in number (Relative Population Number) of blackspot seabream *Pagellus bogaraveo* from surveys for the period 1995–2019 (ICES Area 10.a.2).

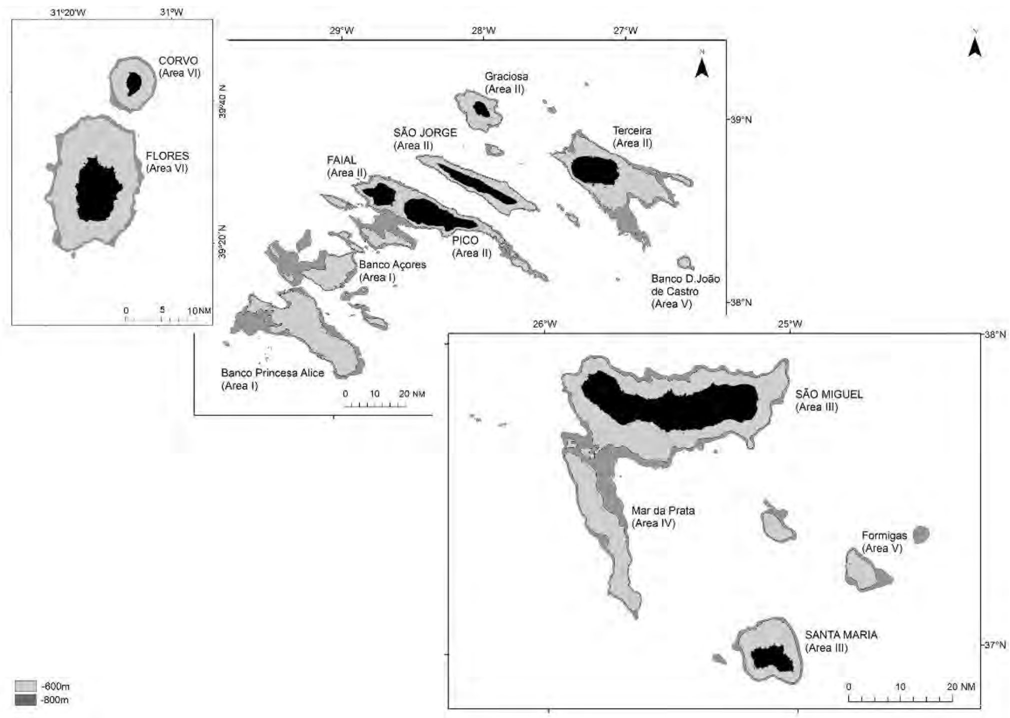

Figure 12.4.6. Statistical areas (I to VI) defined for the Azorean demersal bottom longline survey. Shadowed areas represent the 600 and 800 m isobaths.

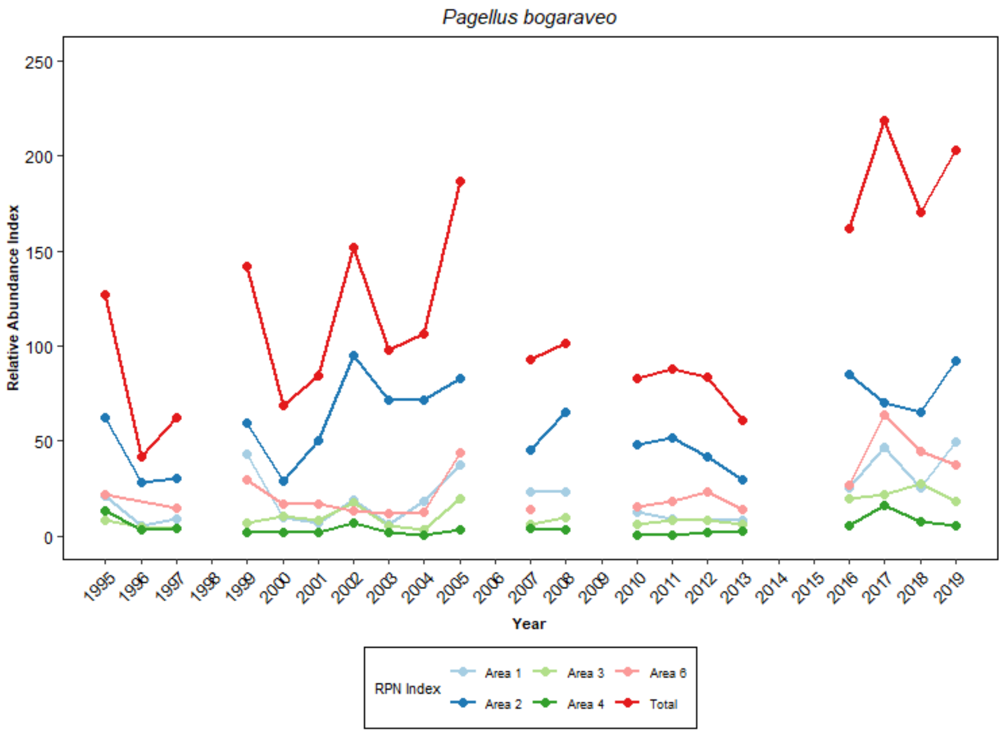

Figure 12.4.6. Annual abundance in number (Relative Population Number) of blackspot seabream *Pagellus bogaraveo* from surveys for the period 1995–2019, by sampling statistical areas (ICES Area 10.a.2).

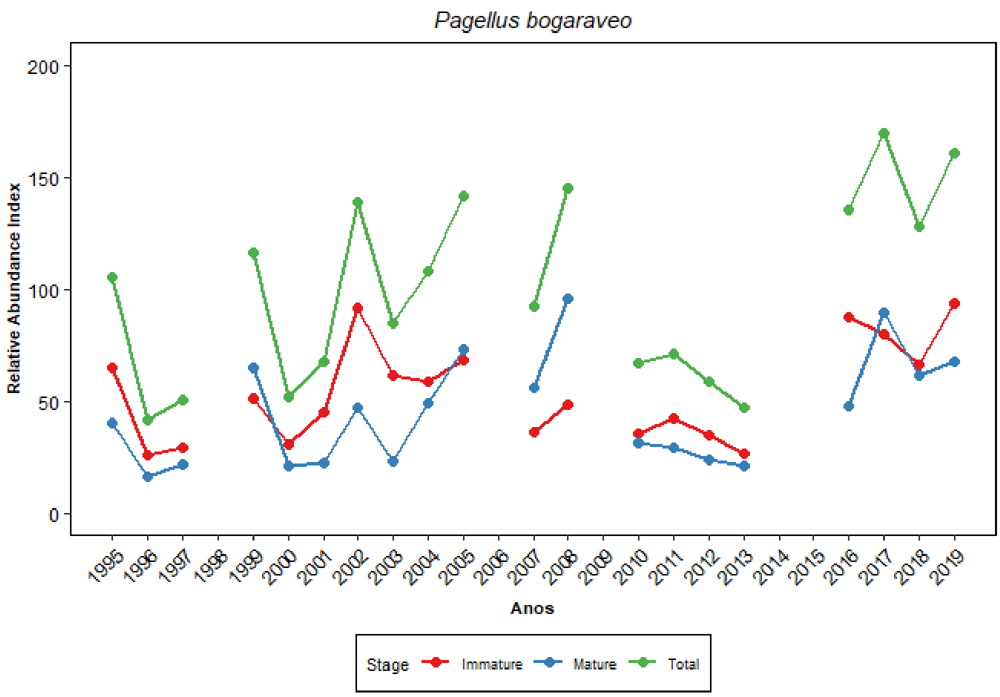

Figure 12.4.8. Survey abundance indices trends for mature, immature and total individuals of blackspot seabream *Pagellus bogaraveo* for the period 1995–2019 (ICES Area 10.a.2).

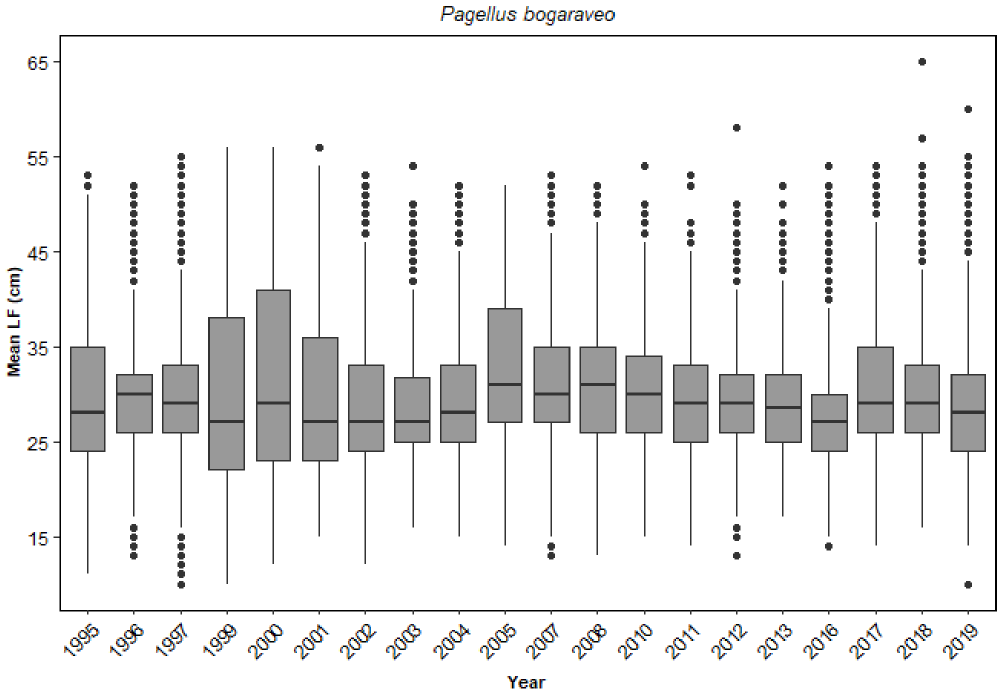

Figure 12.4.9. Annual mean length of blackspot seabream *Pagellus bogaraveo* from survey length compositions (1995–2019) (ICES Area 10.a.2).

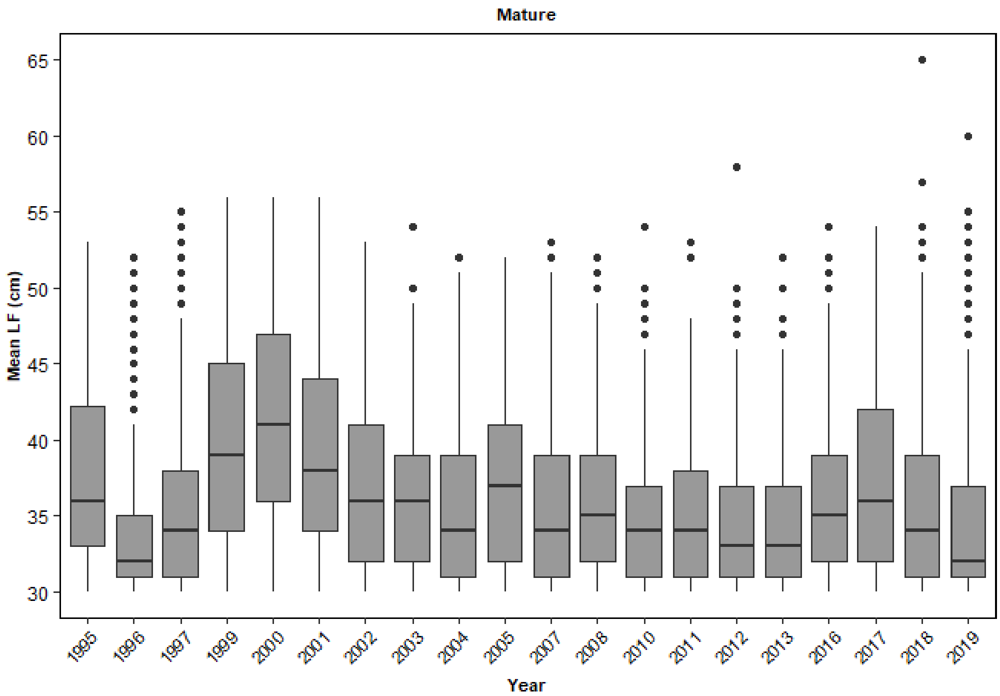

Figure 12.4.10. Annual mean length of mature individuals of blackspot seabream *Pagellus bogaraveo* from the Azorean longline survey (1995–2019).

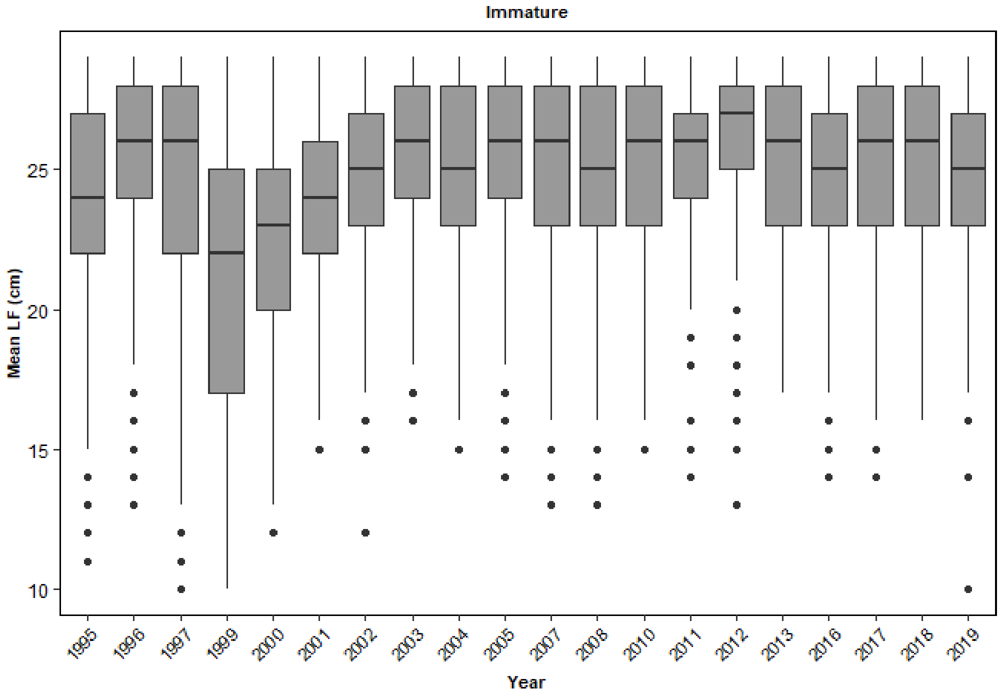

Figure 12.4.11. Annual mean length of immature individuals of blackspot seabream *Pagellus bogaraveo* from the Azorean longline survey (1995–2019).

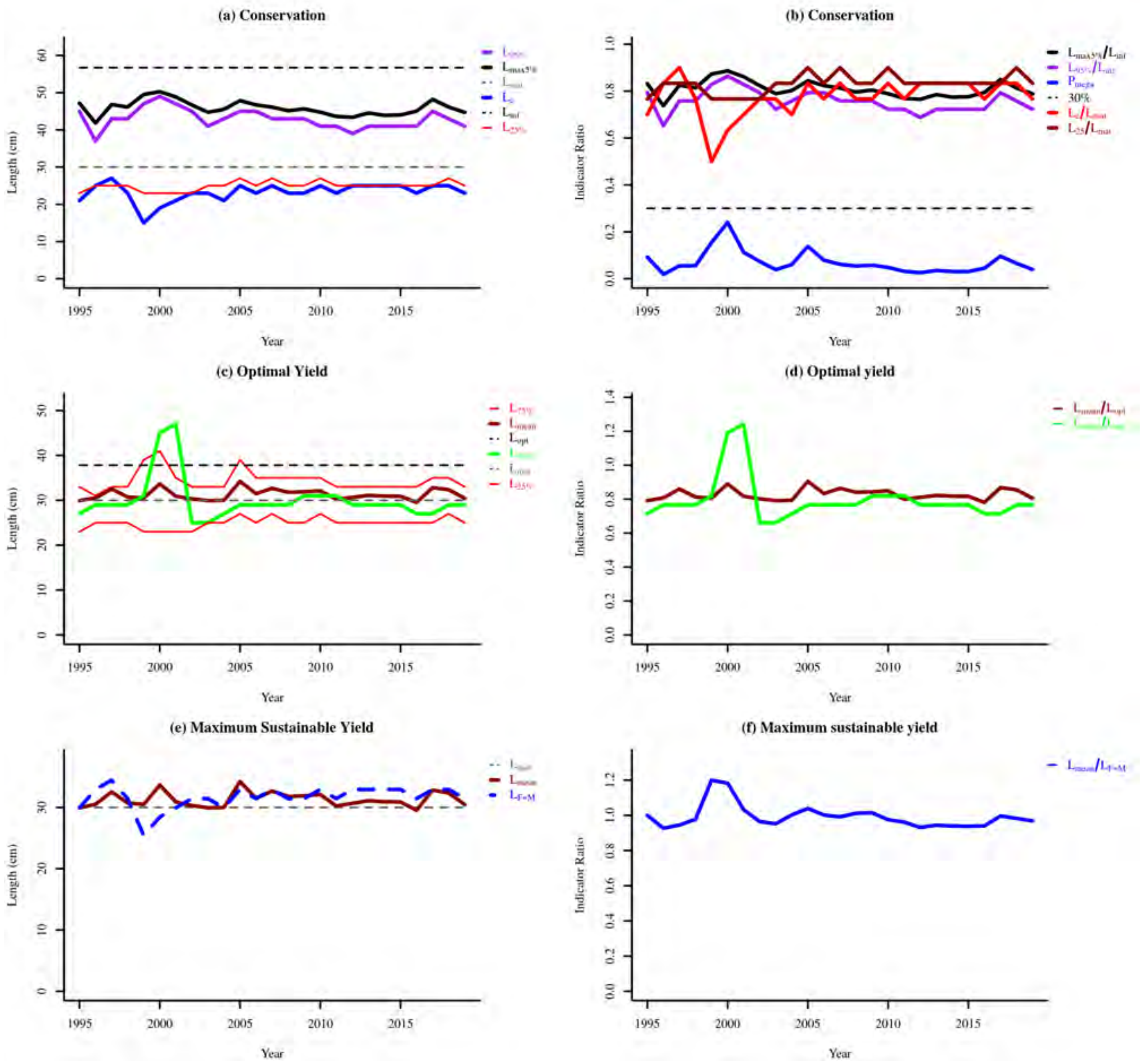

Figure 12.4.12. Indicator ratios and reference points for blackspot seabream *Pagellus bogaraveo* from the Azorean longline survey (1995-2019).

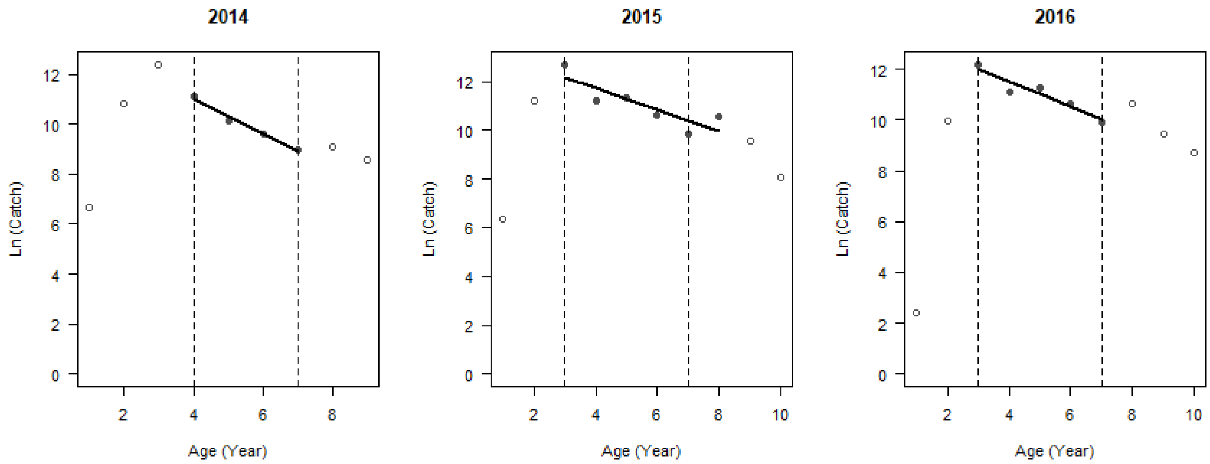

Figure 12.4.13. Catch curve of blackspot seabream *Pagellus bogaraveo* from the Azores (ICES division 10.a.2) based on the annual age structure of the population on the landings (pseud cohort approach). On the graph are identified, with dashed vertical lines, the point used for the analysis (interval of full recruited individuals for which mortality is considered constant). Solid line represent the regression line adjusted to the select points.

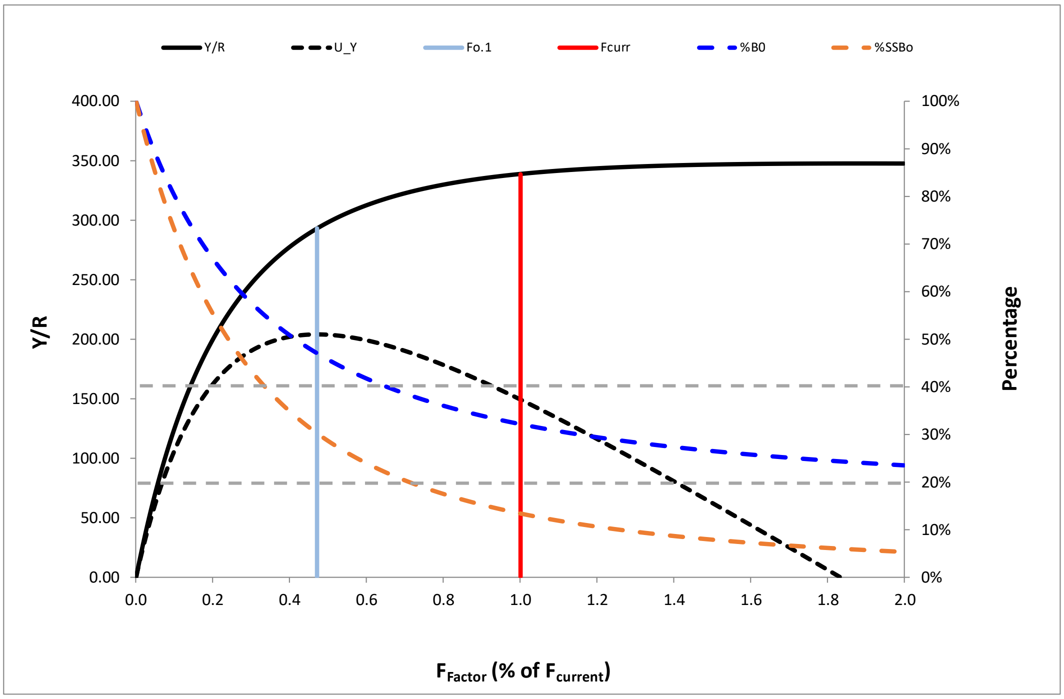

Figure 12.4.14. Yield-per-recruit analysis for the blackspot seabream *Pagellus bogaraveo* from the Azores (ICES division 10.a.2). Vertical red line is F_{curr} and vertical blue line is $F_{0.1}$. Black dashed line is the function used to estimate $F_{0.1}$. Blue and orange dashed lines are biomass and spawning biomass potential ratio, respectively. Horizontal grey dashed lines represent the lower (20%) and upper (40%) Spawning Potential Ratio levels.

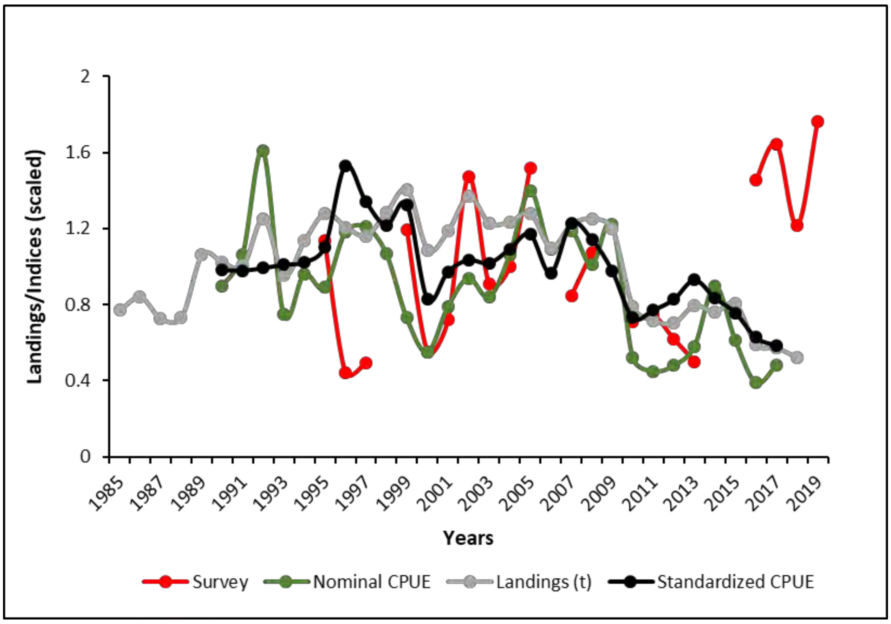

Figure 12.4.15. Evolution of blackspot seabream *Pagellus bogaraveo* landings, nominal and standardized cpue and survey index from the Azores (ICES 10.a.2).

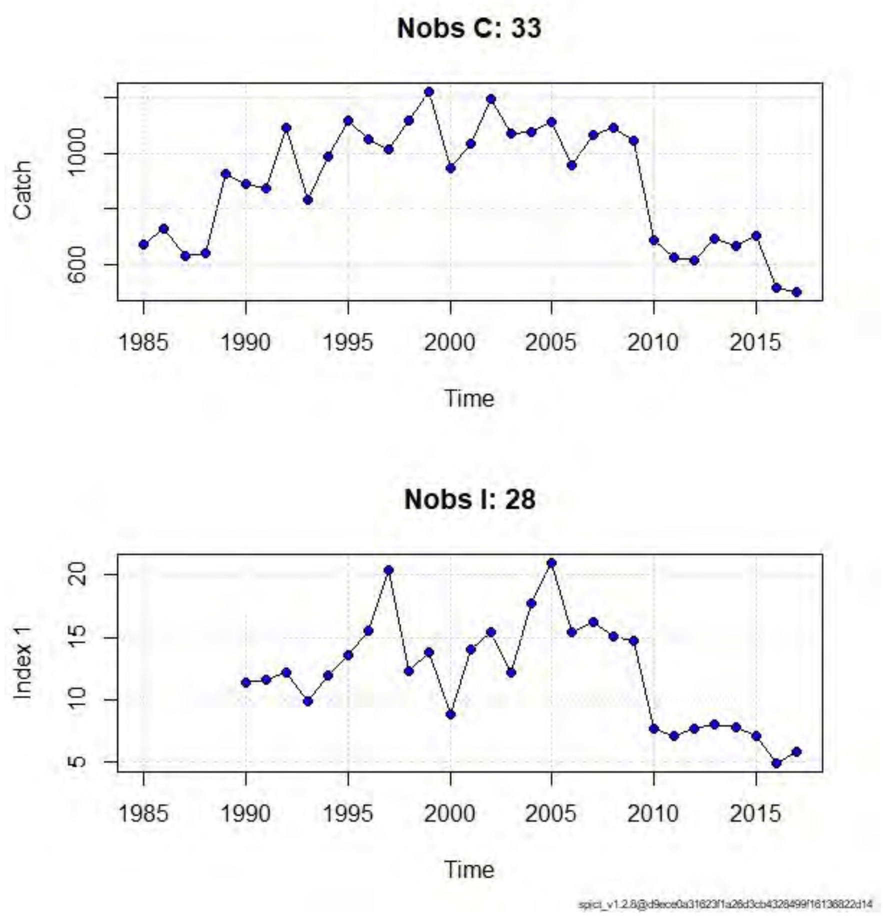

Figure 12.4.16. Input data used for SPICT modelling of blackspot seabream *Pagellus bogaraveo* from the Azores (ICES 10.a.2).

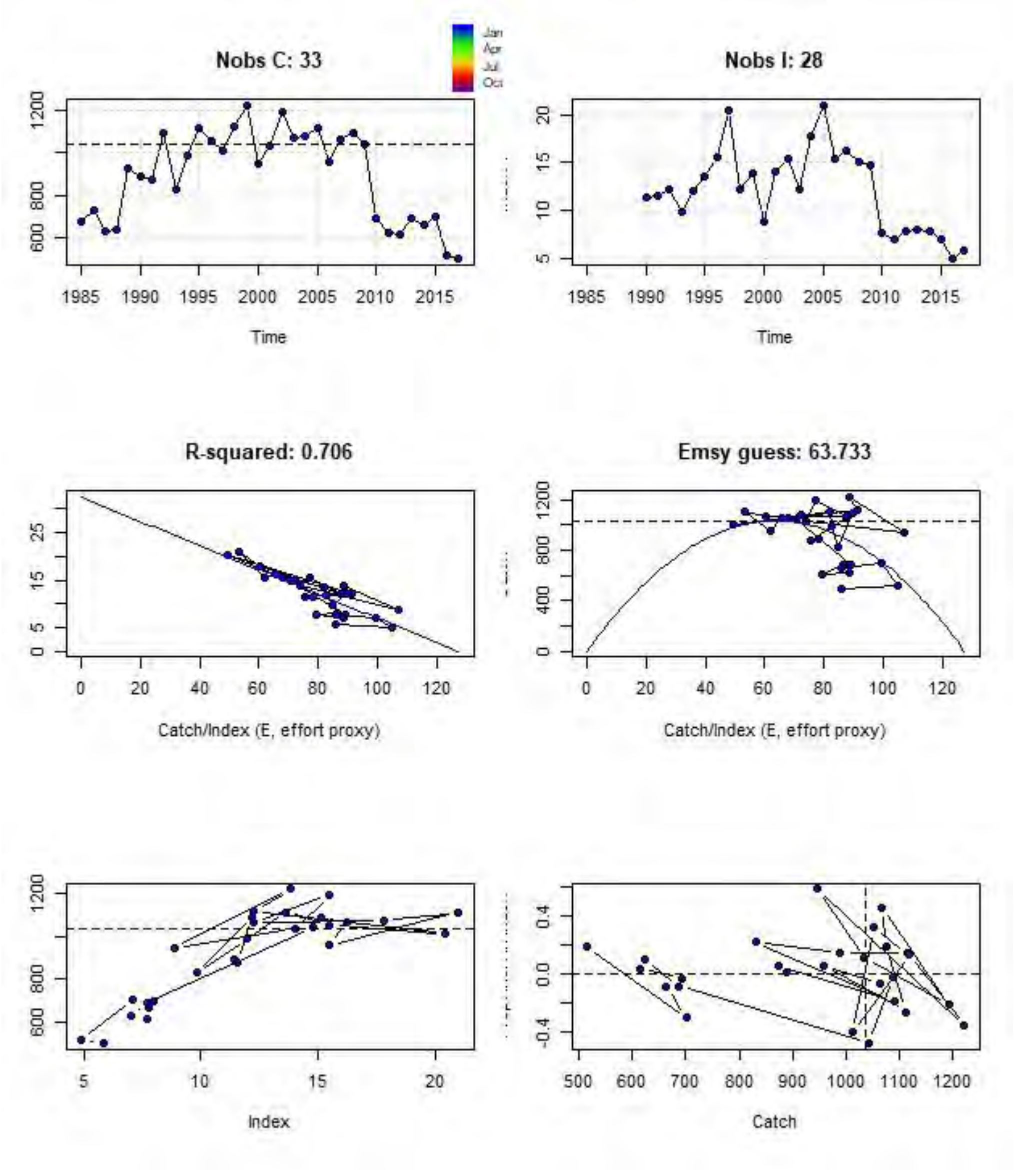

Figure 12.4.17. Advanced plot used for SPICT modelling of blackspot seabream *Pagellus bogaraveo* from the Azores (ICES 10.a.2).

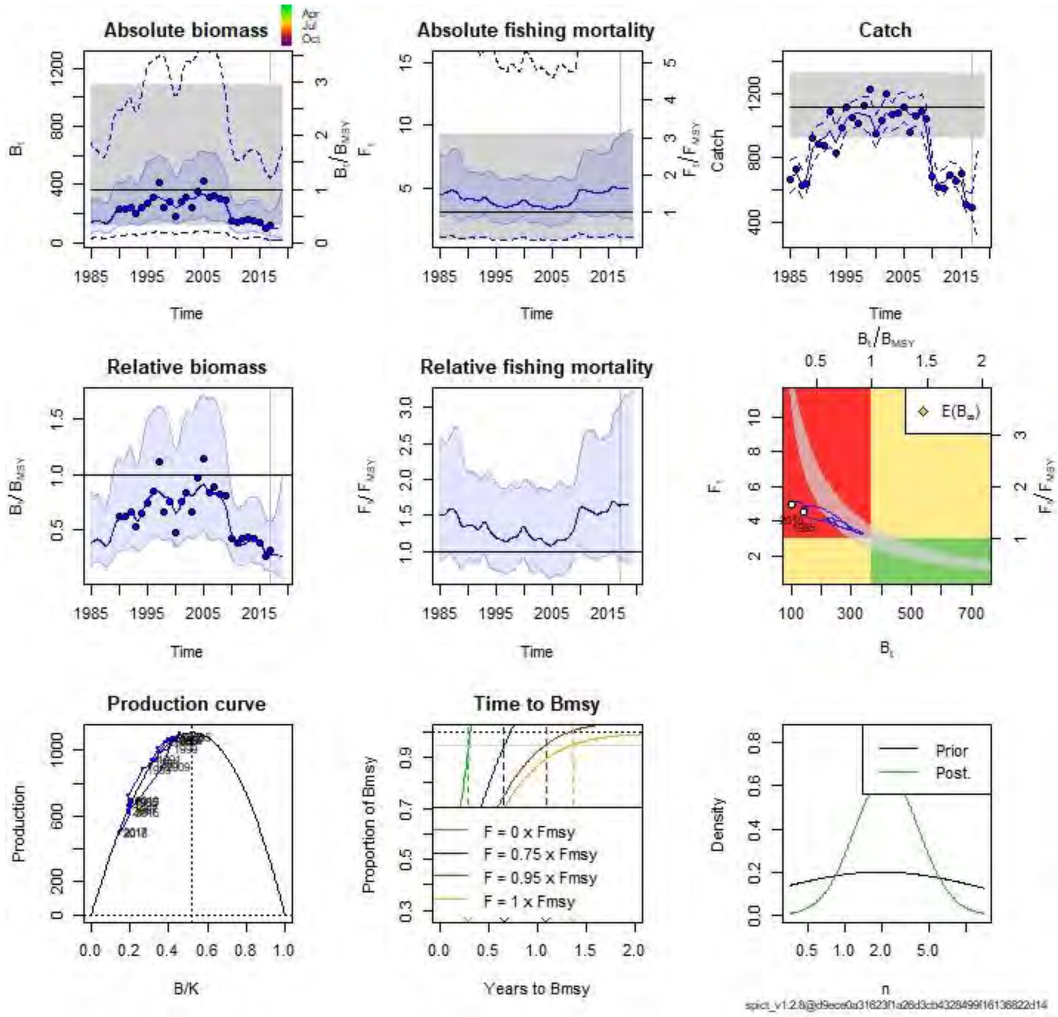

Figure 12.4.18. Basic results of SPICT model for the blackspot seabream *Pagellus bogaraveo* from the Azores (ICES, 10.a.2).

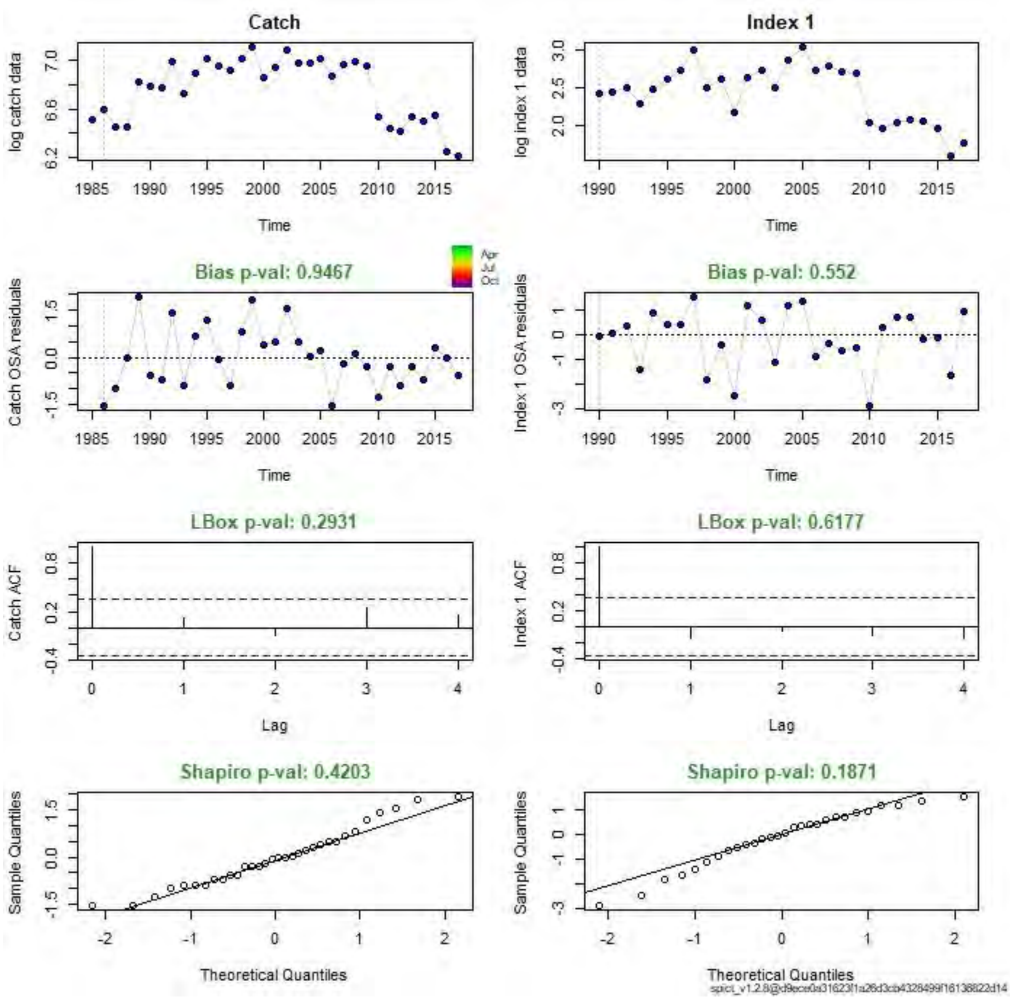

Figure 12.4.19. Residual results from SPICT model applied to the blackspot seabream *Pagellus bogaraveo* from the Azores (ICES, 10.a.2).

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 NEAFC requires measures stipulating that directed fisheries are not authorised and that bycatches should be minimised. 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.

13.2 The fishery

Roughhead grenadier has a low commercial value and the scarce landing data available correspond mostly to landed bycatch. However, 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 and onwards catches are strongly dominated by longliners. 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 143 tonnes in 2019. 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 only ICES advice on roughhead grenadier was published in 2015 and states that *"for the years 2016–2020 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."*

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 roughead 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 2020 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).

In 2018 and 2019, landings data were updated using data reported to InterCatch and preliminary catch statistics. National catch statistics of Greenland were used to update catches in Subarea 14.b.2 from 1999 to 2019. The latter 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 2019, a survey document has not been made available in 2020. 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. – a trend which is not supported by catches (WGDEEP 2020, WD02). 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, there was virtually no Russian directed fishery in the deep waters of the Northeast Atlantic. 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).

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).

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-II – 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 (Figure 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 (Figure 13.4).

13.8 Age composition

No new data available.

13.9 Weight-at-age

No new data available.

13.10 Maturity and natural mortality

No new data available.

13.11 Research vessel survey and cpue

13.11.1 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.

13.11.2 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.

13.12 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 (Figure 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 estimated index biomass were constant in east Greenland during 1998 to 2007, whereafter in increased by more than 50% most likely due to onset of night trawling in this time period. The estimated biomass appears constant from 2008 until 2016 (Figure 13.2).

13.13 Benchmark assessments

There has been no benchmark for this stock.

13.14 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 reality 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, making it unlikely that such quantities can have been caught.

There are no biological data (length or age composition, weight-at-age, maturity, mortality) that could be used to assess changes in stock status.

Recent 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).

Thus, no expansion of current fisheries should be permitted until enough data are collected from the exploited population to identify the stock and conduct an appropriate assessment.

13.15 References

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13.16 Tables

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
2014						

Year	Germany	Norway	Russia	France	Spain	TOTAL
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]		141	1	< 0.5	0	142

[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					
2010				< 0.5	
2011	2				2

Year	France	Ireland	Norway	UK (Scot.)	TOTAL
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				< 0.5
[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
2010	22		22
2011	21		21
2012	16		16

Year	Iceland	Norway	TOTAL
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
[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					
2012	2		1		3
2013	2				2
2014	< 0.5				
2015	1	+	0	0	1

Year	France	Norway	UK (Scot.)	Russia	TOTAL
2016					
2017	< 0.5	< 0.5			0.5
2018[1]	1	4	0	0	5
2019[1]	< 0.5	< 0.5			< 1
[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
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

Year	UK (E+W)	France	Norway	UK (SCO)	Spain	Ireland	Russia	Lithuania	TOTAL
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]		4	2	< 0.5	0	0			6

[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
2009	6		2826			2832
2010			580			580
2011			441			441
2012			526		4	530
2013			210			210
2014			164			164

Country	Norway	France	Spain	Russia	Lithuania	TOTAL
2015			53			53
2016	< 0.5		31			31
2017						0
2018[1]	0	0	0	0	0	0
2019[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)	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
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

Country	Greenland	Norway	Russia	Spain	UK (E+W)	TOTAL
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

[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	
2007				
2008	0.00		0.04	
2009			0.00	
2010			0.17	
2011				0.13
2012				
2013	1.00		1.00	1.00
2014				

Year	6.b	12.a	12.b	14.b
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

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

13.17 Figures

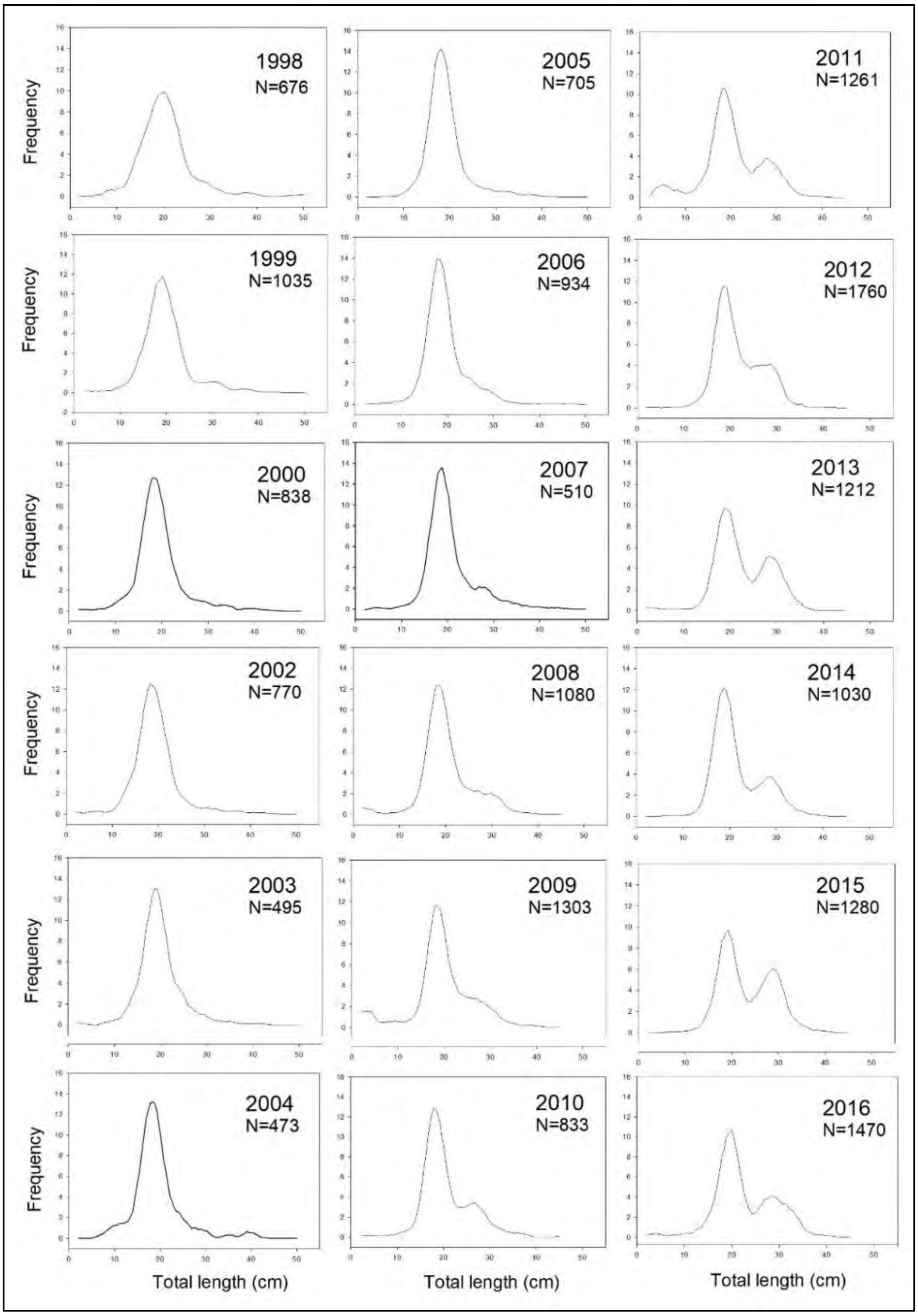

Figure 13.1. Length frequency distribution of roughhead grenadier for years 1998-2016 in ICES subarea 14b2 (east Greenland). No survey in 2001, 2017, 2018 and 2019.

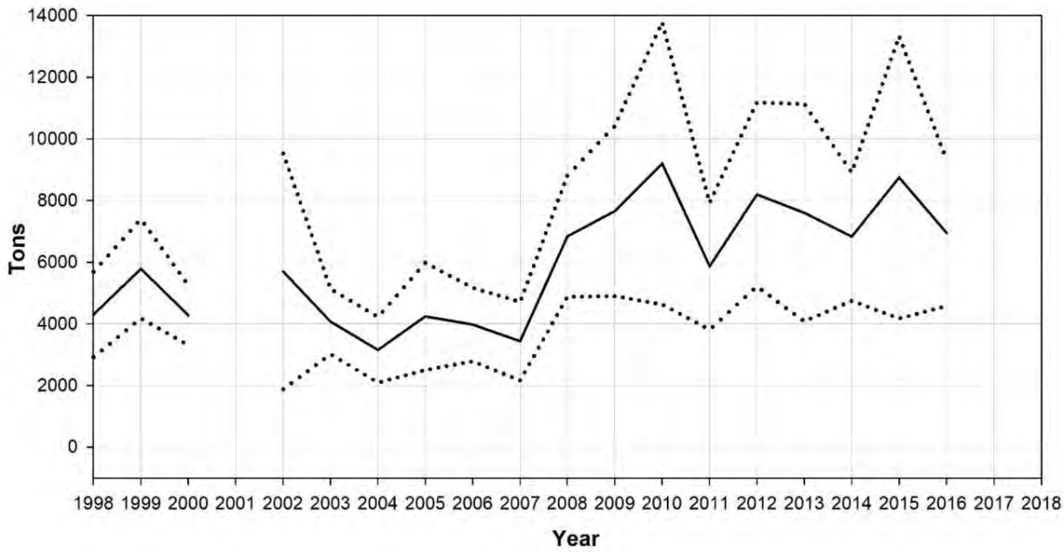

Figure 13.2. Estimated index biomass biomass (solid line) of roughhead grenadier in ICES 14.b.2 plotted with +/- 2*SE. No survey in 2001, 2017, 2018 and 2019.

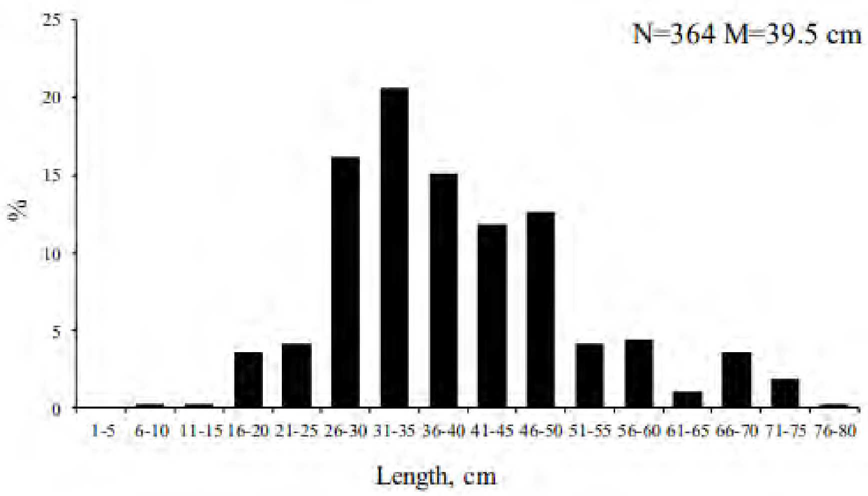

Figure 13.3. Length composition of roughhead grenadier in the Norwegian Sea (subareas 2a and 2b) in 2019.

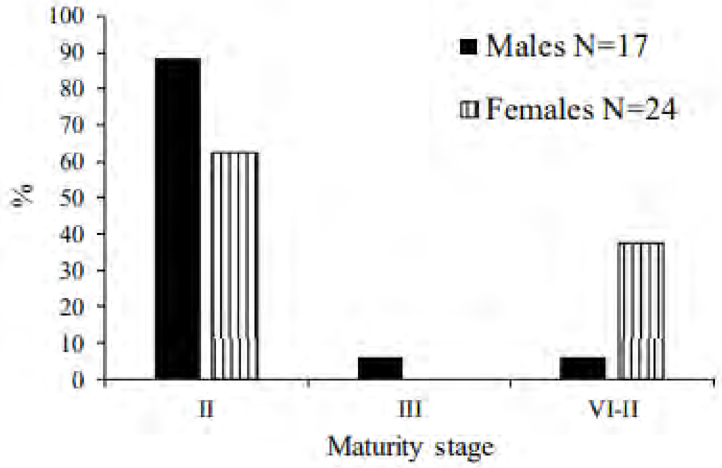

Figure 13.4. Maturity of roughhead grenadier in the Norwegian Sea (subareas 2a and 2b) in November-December 2019.

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 spelling 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 since 2014.

14.3 ICES Advice

The ICES advice for the years 2016–2020 is that "*there should be no directed fisheries for roughsnout grenadier, and bycatch should be counted against the TAC for roundnose grenadier to minimize the potential for species misreporting*."

In the future, *Trachyrincus scabrus* and *T. murrayi*, should be considered non-commercial species and should not be subject to ICES advice any more. Reported landings should be considered as 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 2018-2019 makes 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, make no mention of *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*HL0.402 (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). Scottish survey data for this species were not requested to Marine Scotland in 2020 because the species is not of commercial interest. 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-bord observations has increased, although the absolute quantity of small macrourids has not (Table 14.2).

14.10 Recommendation

As the roughsnout and roughnose grenadiers are non-commercial species and are not likely to become of commercial interest in the foreseeable future, WGDEEP recommends that these species are no longer considered by ICES in terms of stock assessment.

Reported landings of bycatch of these species should be considered misreporting of other species, most probably of the roundnose grenadier. WGDEEP recommends that the ICES Secretariat discusses the inclusion of these species in the MoUs with the relevant clients. There is no data and no interest in having this species of moderate size, minor (if any) commercial interest and no current conservation concern.

WGDEEP suggests that Roughsnout and roughnose grenadiers should not be subject of catch advice. For EU fleets, in term of management a simple way to treat these species would be to amend slightly the footnotes below the tables for the three TACs and quotas of roundnose grenadier as exemplified below for the TAC of roundnose grenadier in Union and international waters of 3 (RNG/03-):

"No directed fisheries of roughhead grenadier **and smaller Macrourid species** are permitted. Bycatches of roughhead grenadier (RHG/03-) **and any species of the family Macrouridae** shall be counted against this quota."

14.11 References

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14.12 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 Other deep-water species in the Northeast Atlantic

15.1 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.

15.1.1 Landings trends

Landings reported to ICES are presented in Tables 15.1–15.12, based on ICES catch statistics using historical nominal catches 1950-2010 and official nominal catches 2006-2017, downloaded from the ICES website in April 2020. 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 2018 and 2019 were not available as they were not included in preliminary catch statistics and were not reported to InterCatch either.

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.

15.1.2 ICES Advice

ICES has not previously given specific advice on the management of any of the stocks considered in this chapter.

15.1.3 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.

15.2 Stock identity

No information available.

15.3 Data available

15.3.1 Landings and discards

Landings for all these species are presented in Tables 15.1–15.9. In 2015, other deep-water species (OTH_COMB) were included in the data call for deep-water species, accompanied with a list of species for which landings data are required. The annual reporting of these species to WGDEEP has varied in quality and quantity. In some years and countries provided a single value for other species combined. Therefore, species-specific landings data are incomplete and time-series would need to be revised.

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 15.10–15.15. 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.

15.3.2 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 15.1 while Figure 15.2 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 15. 3. The cumulated length distribution of silver scabbardfish, common mora and wreckfish in Azorean surveys are presented in Figures 15.4, 15.5 and 15.6, respectively.

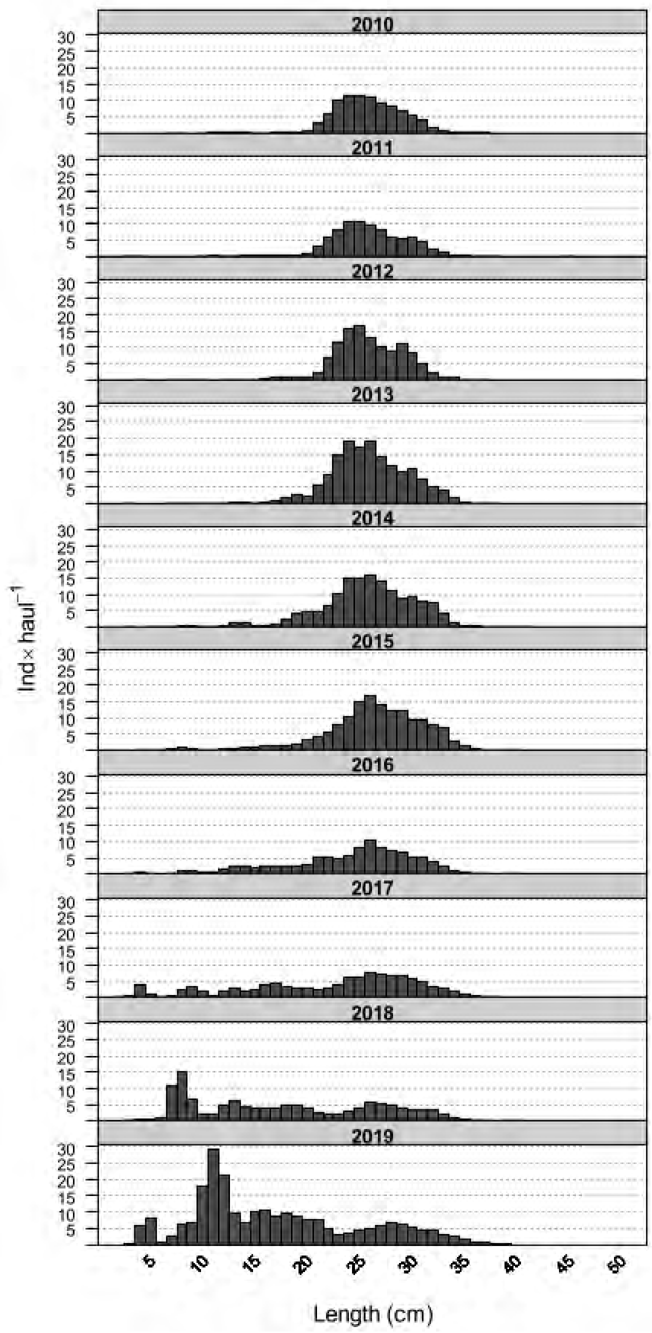

Figure 15.1. Mean stratified length distributions of *Helicolenus dactylopterus* in Porcupine surveys (2010-2019).

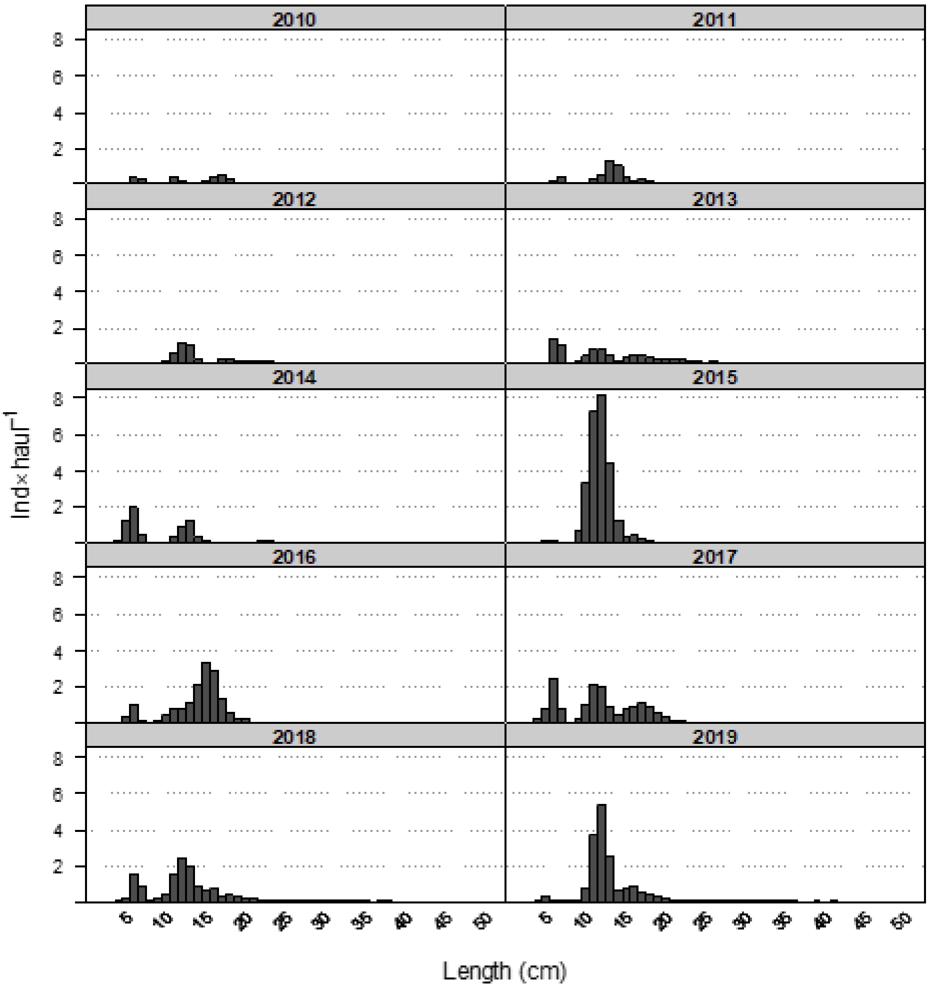

Figure 15.2. Mean stratified length distributions of bluemouth (*H. dactylopterus*) in Northern Spanish Shelf surveys (2010–2019).

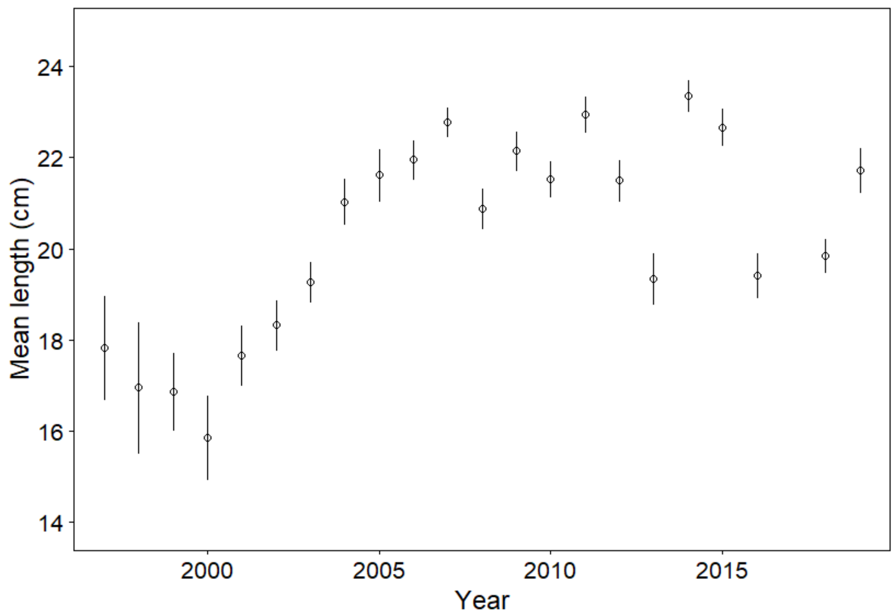

Figure 15.3 Mean length of *Helicolenus dactylopterus* in the French survey in Bay of Biscay and Celtic Sea (EVHOE) from 1997 to 2019 (no survey in 2017).

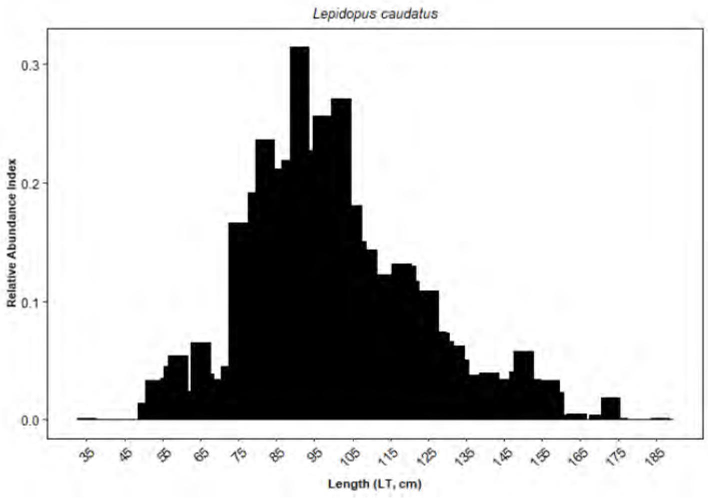

Figure 15.4. Mean length of *Lepidopus caudatus* in Azores bottom longline survey 1995–2016.

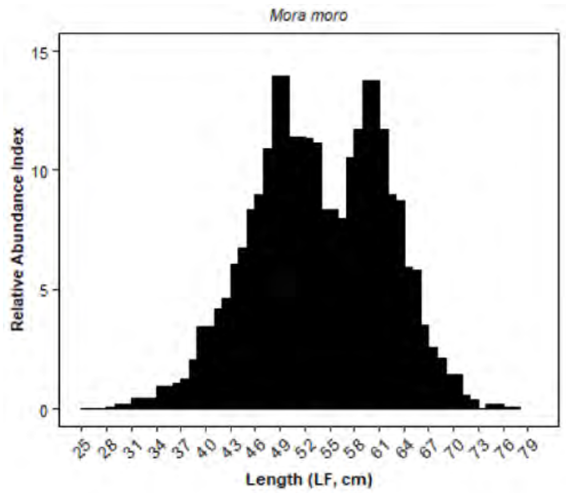

Figure 15.5. Mean length of *Mora moro* in Azores bottom longline survey 1995–2016.

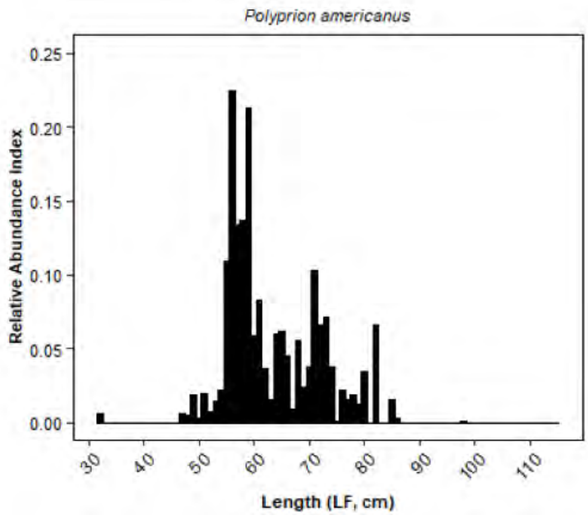

Figure 15.6. Mean length of *Polyprion americanus* in Azores bottom longline survey 1995–2016.

15.3.3 Age compositions

No new information.

15.3.4 Weight-at-age

No new information.

15.3.5 Maturity and natural mortality

No new information.

15.3.6 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 15.7–15.11.

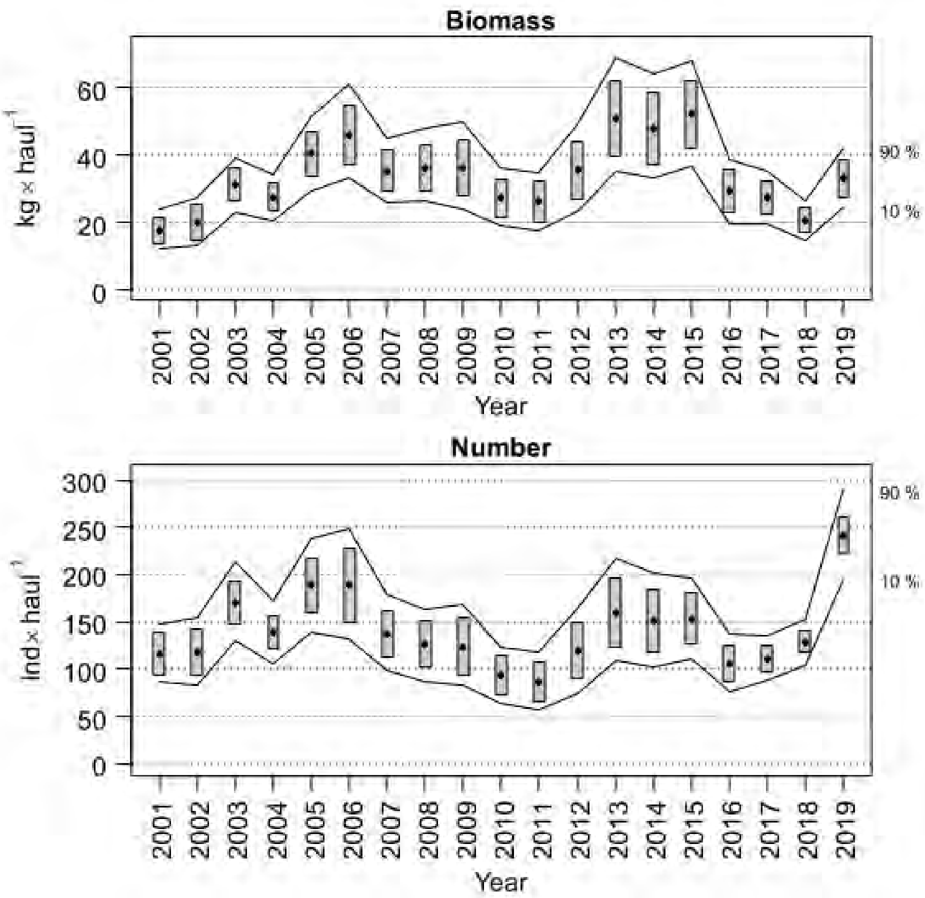

Figure 15.7. Trends of *Helicolenus dactylopterus* biomass and abundance indices during Porcupine Survey time-series (2001–2019). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

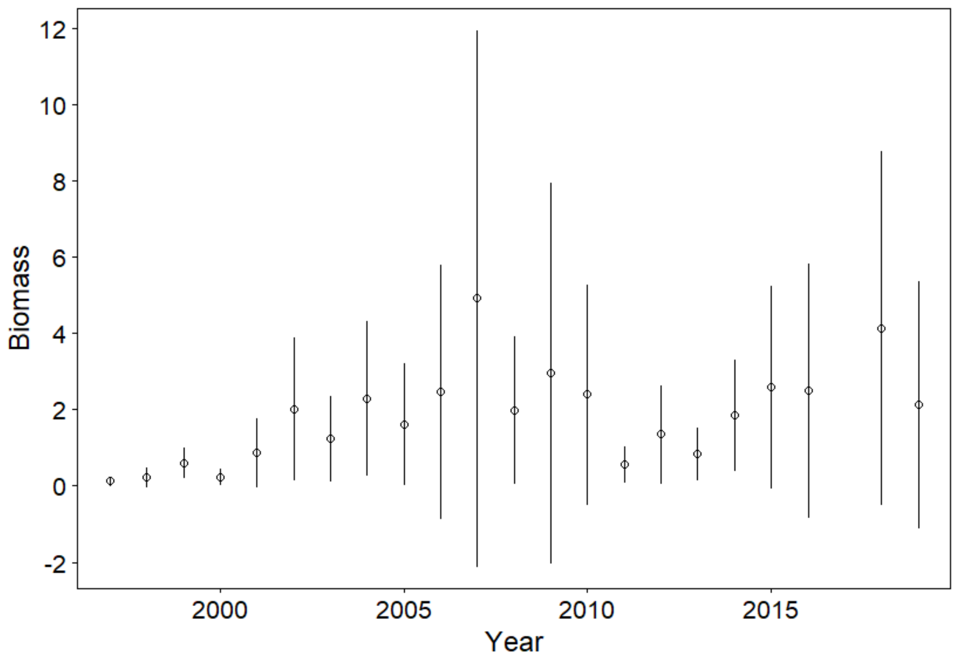

Figure 15.8. Survey biomass index from the French survey (EVHOE) for *Helicolenus dactylopterus*.

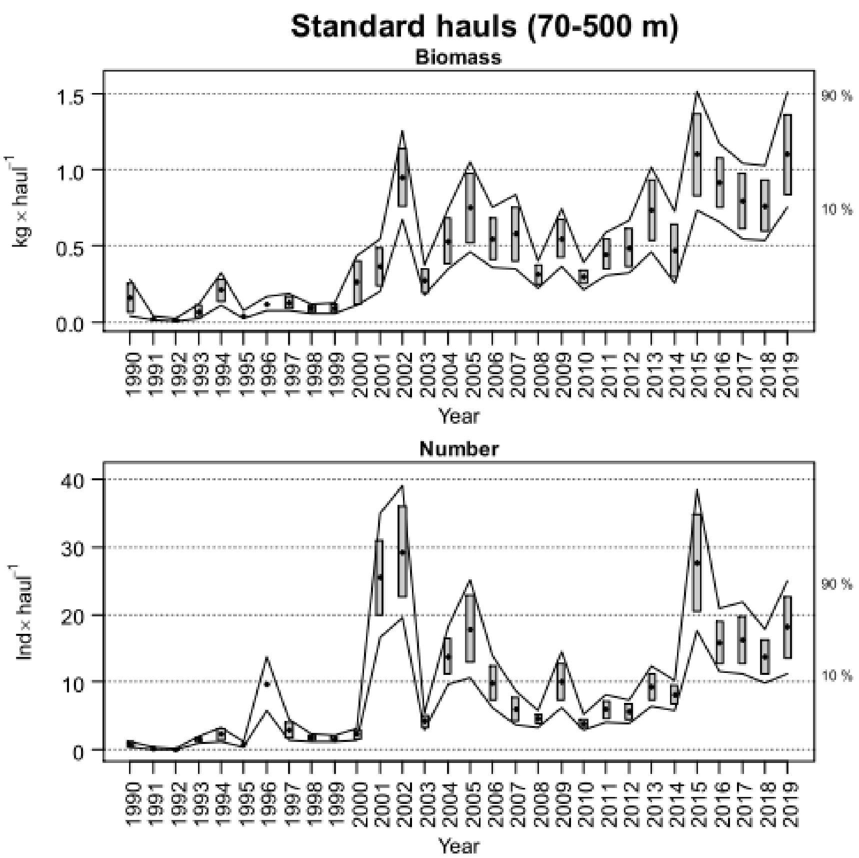

Figure 15.9. Evolution of *Helicolenus dactylopterus* mean stratified biomass and abundance in Northern Spanish Shelf surveys time-series (1990–2019). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000).

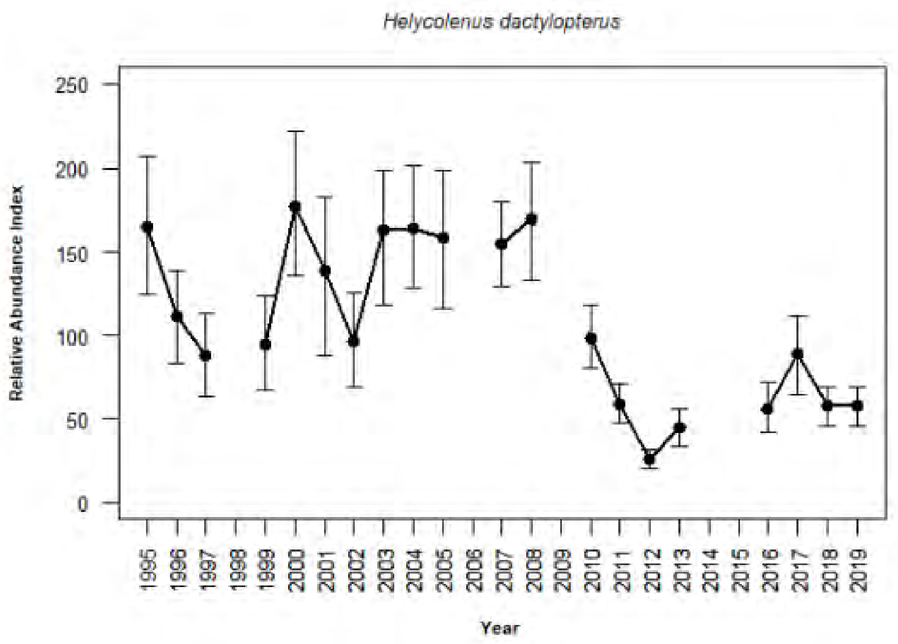

Figure 15.10. Annual bottom longline survey abundance index for *Helicolenus dactylopterus* in Azorean bottom longline surveys.

Abundance indices for silver scabbardfish, common mora and wreckfish from the Portuguese longline survey in the Azores Islands are given in Figures 15.11 to 15.13.

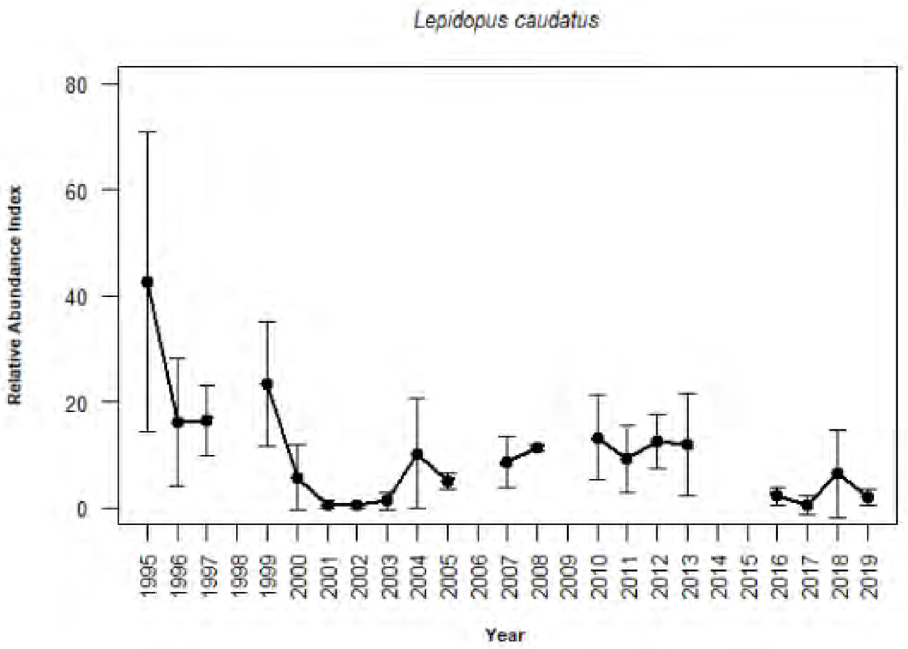

Figure 15.11. Annual bottom longline survey abundance index for *Lepidopus caudatus* in Azorean bottom longline surveys.

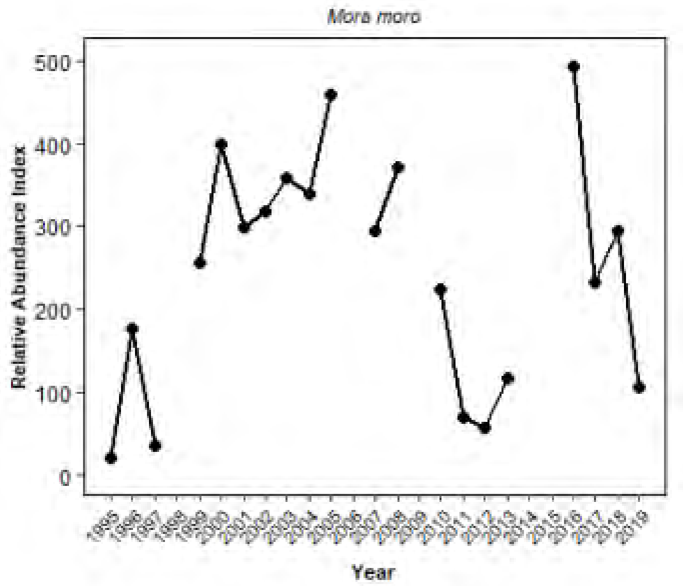

Figure 15.12. Annual bottom longline survey nominal cpue for *Mora moro* in Azorean bottom longline surveys.

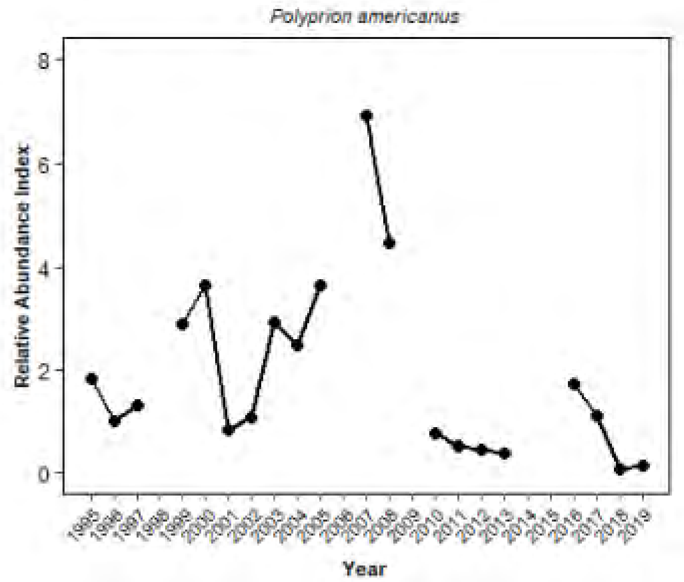

Figure 15.13. Annual bottom longline survey nominal cpue for *Polyprion americanus* in Azorean bottom longline surveys.

15.3.7 Data analysis

No new analyses were carried out in 2020. Updated surveys series from several species are included in working documents WD18, WD20, WD21.

15.3.8 Comments on the assessment

15.3.9 Management considerations

Currently no advice is required for these stocks.

Table 15.1. 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 15.3. 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 15.4. 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 15.5. 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 15.6. 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 15.7. 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 15.8. 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 15.9. 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 15.10. 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 15.11. 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 15.12. 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

16 Recommendations

As the stock of Roughsnout grenadier (*Trachyrincus scabrus*) (TSU) in the Northeast Atlantic (is considered to include catches of *T. scabrus* and *T. murrayi*). All three species are non-commercial and are not likely to become of commercial interest in the foreseeable future, it is recommended that these species are no longer considered by ICES in terms of stock assessment. Occasional catch of large individuals may only result in minor landings.

Significant reported landings of these species should be considered misreporting of other species, most probably of the roundnose grenadier. Therefore TSU should be removed from the MoU because there is no data to assess these species and there is no interest in having them in the MoU because they are of small size, have minor (if any) commercial interest and are not of conservation concern.

A catch advice for these species has no utility. In term of management a simple way to treat these species is to include a provision for any landings of any other macrourid species to be counted against the quotas for RNG. This should be done without increasing the TAC for roundnose grenadier.

This is already done for the roughhead grenadier, it should be extended to any macrourid species. All species should however be reported separately.

Annex 1: List of participants

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Annex 2: Resolutions

WGDEEP 2020 – Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources

This resolution was approved 1 October 2019

2019/2/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 by correspondence, 24 April–1 May 2020 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 2020.

f) Evaluate the stock status of stocks for the provision of biennial advice due in 2020.

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 8 May 2020 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

Due to the COVID-19 disruption that started early 2020, ACOM drafted a "spring 2020 approach" for recurring fishing opportunities advice. The generic Terms of Reference have been adjusted as described in the letter to ICES chairs below.

Chairs of Expert Groups

Our Ref: C 4.e/MDC/mo 13 March 2020

Subject: **Spring 2020 approach to advice production**

Dear Expert Group Chair,

I am writing this letter to keep you up to date about the approach of ACOM to the COVID-19 disruption. Many of our institutes now have travel bans and/or working from home policies. ACOM has developed a "spring 2020 approach" to this year's spring advice season. This letter covers the recurrent fishing opportunities advice. Any special request processes and non-fisheries advice will be dealt with separately. The expert groups effected are listed in Annex 1.

ACOM is encouraging all expert groups to keep working, and stick broadly to the time line, but clearly this needs to be through virtual meetings. ICES secretariat will support your efforts and make WebEx available. They will also produce a broad training document on WebEx. We know that the use of virtual meetings will result in an increased burden on the Chairs and members of the expert groups, therefore we have made changes to the generic terms of reference (see Annex 2 below) categorizing them as high, medium and low priority for this year's work. We also suggest that the expert group works virtually through smaller sub-groups, and only hold larger virtual meetings when necessary.

The requesters of advice have been informed that there will be disruption/change to the delivery of advice for the spring 2020 season.

ACOM will also change the way that ICES gives advice for the spring 2020 season. There will be three types of advice:

- **Standard advice** sheet (the advice sheet following the January 2020 guidelines)
- **Abbreviated advice** sheet (a shortened advice sheet)
- **Rollover advice** (the same advice as in 2019)

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The choice of which type of advice to apply to a stock is based on criteria determined by ACOM:

a. **Standard advice** - stocks with 2020 benchmarked methods
b. **Abbreviated advice** – most stocks, including management plan and MSY advice stocks, and some Cat 3 stocks. The abbreviated advice will contain the advice of the headline advice, catch scenario tables, plots and automated tables (last years' advice will be added as an annex to each sheet). The guidance for abbreviated advice is being written now and you should receive it in a few days.
c. **Rollover advice** – same as 2019 advice. This will be provided for stocks in the following categories:
    - zero TAC has been advised in recent years and no change likely,
    - category 3 or greater roll over advice, except if due to be reviewed in 2020
    - long lived stable stocks, with no strong trends in dynamics in recent years
    - some non-standard stocks (e.g. North Atlantic salmon)

We need to consult both you and the requesters of advice about which type of advice to apply to each stock. Today the ACOM criteria are being used by the secretariat to allocate advice types to stocks. This is the first version. We would like you to consider this list and comment if you think that the allocation needs changing. Please remember that the abbreviated advice is being developed to help your processes and also the ACOM processes during the disruption. The list of allocated advice type for each stock will hopefully be sent to you today or Monday. Please reply with your comments by 19th March so that we can start the dialogue with requesters. ACOM hopes that we could have a definitive list by 25th March. (This is too late for HAWG, so we suggest that HAWG use the list compiled in cooperation with Secretariat expecting requesters of advice to agree).

ACOM is recommending that for North Sea stocks with re-opening of advice in the autumn, the stock assessments be carried out in the spring but not the forecasts (postponed until early autumn). The advice would be delivered in the autumn of 2020.

You will shortly receive the first version of the **list of advice types allocated to stocks** and the **guidelines for abbreviated advice**. Please respond by 19th March with your comments on the first version of the list.
Your professional officer has been briefed about these changes. The changes are designed to reduce both expert group and ACOM workload. Lotte, your professional officer, the ACOM leadership and the FRSG Chair are available for further explanation.

Best regards

Mark

Mark Dickey-Collas
ACOM Chair

Annex 1. Expert groups associated with 2020 spring advice season

Herring Assessment Working Group for the Area South of 62°N
Working Group on North Atlantic Salmon*
Assessment Working Group on Baltic Salmon and Trout*
Baltic Fisheries Assessment Working Group
Arctic Fisheries Working Group
Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak
North-Western Working Group
Working Group on the Biology and Assessment of Deep-sea Fisheries Resources
Working Group for the Bay of Biscay and the Iberian Waters Ecoregion
Working Group for the Celtic Seas Ecoregion
Working Group on Southern Horse Mackerel, Anchovy, and Sardine
Working Group on Elasmobranch Fishes

* These groups already have different approaches.

Annex 2. Spring 2020 adapted generic terms of reference. [Agreed by ACOM 12 March 2020]

In light of the disruptions caused by COVID-19 in 2020, the generic terms of reference for the FRSG stock assessment groups have been re-prioritised. This applies to expert groups that feed into the spring advice season process[1]. ACOM is encouraging expert groups to use virtual meetings (e.g. WebEx) and subgroups to deliver the high priority terms of reference. See letter from the ACOM Chair to expert groups.

High Priority for spring 2020 advice season

c) Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant. **Check the list of the stocks to be done in detail and those to roll over.**
   - i) Input data and examination of data quality;
   - ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
   - iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.
   - v) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;
   - vi) The state of the stocks against relevant reference points;
   - vii) Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;
   - viii) Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines. Check list to confirm whether the stock requires a concise advice sheet or a traditional advice sheet.

f) Prepare the data calls for the next year update assessment and for planned data evaluation workshops;

j) Audit all data and methods used to produce stock assessments and projections.

[1] These do not apply to Assessment Working Group on Baltic Salmon and Trout and Working Group on North Atlantic Salmon.

Medium Priority for spring 2020 advice season

a) Consider and comment on Ecosystem and Fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:
   i) descriptions of ecosystem impacts of fisheries
   ii) descriptions of developments and recent changes to the fisheries
   iii) mixed fisheries considerations, and
   iv) emerging issues of relevance for the management of the fisheries;

e) Review progress on benchmark processes of relevance to the Expert Group; High for application;

Low Priority for spring 2020 advice season

c iv) Estimate MSY proxy reference points for the category 3 and 4 stocks

g) Identify research needs of relevance for the work of the Expert Group.

h) Review and update information regarding operational issues and research priorities and the Fisheries Resources Steering Group SharePoint site.

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice. ACOM would encourage expert groups to carry out this term of reference later in the year through a webex.

WGDEEP 2021– Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources

2020/2/FRSGXX **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 by correspondence, 22–28 April 2021 to:

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

h) Complete the development of Stock Annexes for all the stocks assessed by WGDEEP, based on the most recent agreed assessment.

i) 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.

j) Continue work on exploratory assessments for deep-water species.

k) Evaluate the stock status of stocks in Icelandic waters for the provision of annual advice in 2021.

l) 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 2020	aru27.5b6a
bli.27.5b67	Blue ling (*Molva dypterygia*) in subareas 6-7 and Division 5.b (Celtic Seas, English Channel, and Faroes grounds)	April 2020	bli.27.5b67
bsf-nea	Black scabbardfish (*Aphanopus carbo*) in subareas 1, 2, 4–8, 10, and 14, and divisions 3.a, 9.a, and 12.b (Northeast Atlantic and Arctic Ocean)	April 2020	bsf-nea
rng.27.3ab	Roundnose grenadier (*Coryphaenoides rupestris*) in Division 3.a (Skagerrak and Kattegat)	April 2020	rng.27.53a
rng.27.5b6712b	Roundnose grenadier (*Coryphaenoides rupestris*) in subareas 6-7, and in Divisions 5.b and 12.b (Celtic Seas and the English Channel, Faroes grounds, and western Hatton Bank)	April 2020	rng.27.5b6712b
sbr.27.9	Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)	April 2020	sbr.27.9
usk.27.6b	Tusk (*Brosme brosme*) in Division 6.b (Rockall)	April 2020	usk.27.6b

Faroese orange roughy fishery in ICES area 27.10 and 27.12.

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Faroe Islands continued the fishery for orange roughy (*Hoplostethus atlanticus*) in 2019 and the Faroese catches of orange roughy was in total 60.0 tons (Table 1).

Fisheries were undertaken in the period February-March 2019 in the traditional fishing area in ICES area 27.10 and 27.12 (NEAFC Regulatory Area). Orange roughy were mainly caught on seamounts north of the Azores (area 27.10b). In 2019, almost half of the catches were in area 27.12c and a small part in 27.12b. The fishery was carried out with one trawler (M/S Ran) which has many years' experience in the orange roughy fishery.

The logbook information was provided on a haul-by-haul basis. Trained crew members did the biological sampling and lengths, weight and gender of orange roughy were randomly taken from the catch. Around 2.0% of the Faroese landings of 60.0 tons in 2019 were sampled (277 fish). In 2019, only length measurements were taken of orange roughy, no gender or weight measurements. The length distribution of the catch was between 50-70 cm total length (Figure 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 at the same level in 2011-2018 as compared with the results from the experimental fishery in 1992-1998 (Table 2) (Thomsen, 1998).

Table 1. Catches (tons) of orange roughy from one Faroese trawler in the period 2013-2019 in ICES area 27.10 and 27.12.

Area/Year	2013	2014	2015	2016	2017	2018	2019
27.10		46.668	82.800	93.300	150.100	20.650	31.065
27.12	1.869	11.004	1.200			8.750	28.963
Total	1.869	57.672	84.000	93.300	150.100	29.400	60.028

Table 2. Mean length and weight of orange roughy. Comb.- combined data (Females + Males). * Thomsen, 1998.

Year	Area	Month	Average length (cm)			Average weight (kg)	
			Female	Male	Comb.	Female	Male
1992-1998*	Faroe Islands		61.4	58.6		4.4	3.7
1992-1998*	Hatton Bank		64.6	62.8		4.9	4.3
1992-1998*	Reykjanes ridge		58.9	56.4		3.6	3.0
1992-1998*	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		

Reference:

Thomsen, B. 1998. Faroese quest of orange roughy in the north Atlantic. ICES CM 1998/O:31.

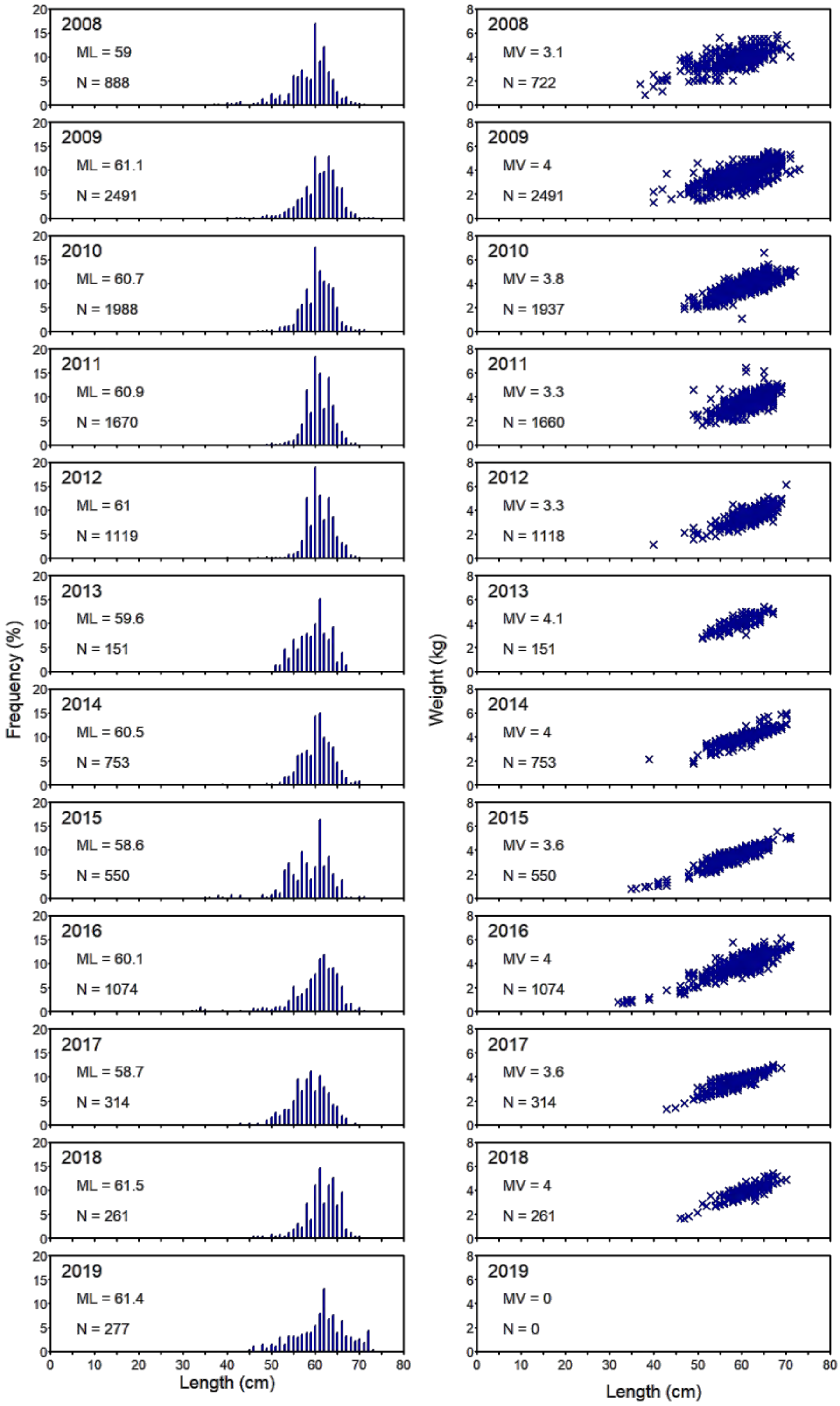

Figure 1. Length distribution (left) and length-weights (right) of orange roughy in 2008-2019. ML = mean length (cm), MV = mean weight (kg) and N = measured individuals.

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

By

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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 2019. 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=91.4 tons) throughout the evaluated time period (1999 to 2019) ranging from 30.9 tons (2008) to 156.4 tons (2019) (**Table 1, Fig. 1**). 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 2019, a survey document has not been made in 2020. However, from survey document from previous years (2019) it was established that roughhead grenadier 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. (**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, 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. There are no explanations for the drastic drop to only 1.0 tons in 2019, which has been reported by only a single vessel. Possibly, this is due to misidentification (see above).

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 (**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.

Blue ling (M*olva dypterygia*, BLI).

Catches of blue ling are relatively low and constant between 1999 to 2019 (annual mean catch =12.4 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 2019 (mean annual catch =674.6 tons) (**Table 1, Fig. 11**). 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. 7**). 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 2017-2019 (**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

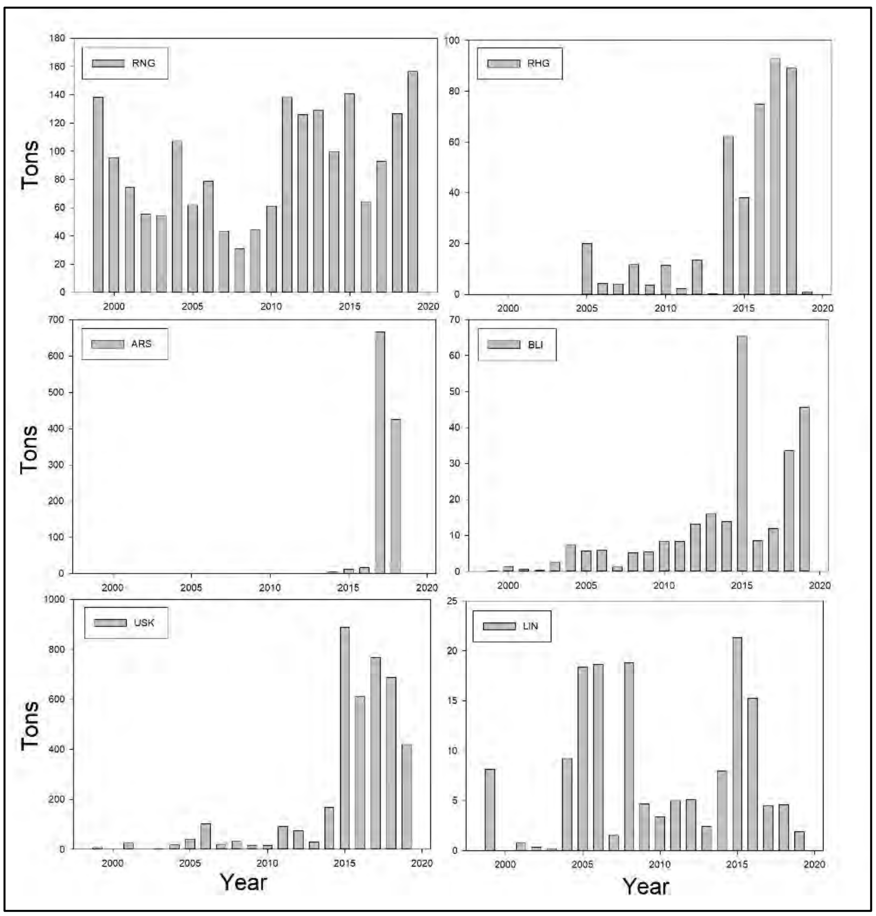

Fig. 1. Catches (trawl and longline combined) of roundnose grenadier (RNG), roughhead grenadier (RHG), greater silver smelt (ARS), blue ling (BLI), tusk (USK) and ling (LIN) from 1999 to 2019. Black scabbardfish can be seen in Table 1.

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 2019.

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

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 and IVa)

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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 37 years (1984-2020). 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 2014-2020.

Material and Methods

Data was collected from the annual *Pandalus borealis* shrimp survey performed by the Institute of Marine Research in the years 1984-2020 (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.

In a 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 in 2019 and 2020 remained low, but with a slight increase compared with 2017.

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 (2018-2020) contrasts with the pre-1990 distributions by having low proportions of large fish. The 2020 distribution is dominated with small fish but at low levels compared to the 1990's.

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_∞) for females is 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 2020 is one of the lowest during the time series.

Geographical distribution
The area sampled in a 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 1984-2020. Catches of roundnose grenadier are restricted to the Norwegian Deep north to 59°N and extend eastwards into the Skagerrak basin.

Commercial by-catch
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 a long term pattern of variation through the time series 1984-2020. 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 2020 abundance and biomass estimates were still at low levels.

The survey catch rates 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 1984-2020. 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 37 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 two 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. Our attempt to estimate by-catches suggests that current levels are minor, probably reflecting decreasing effort in the shrimp fishery and low grenadier abundance at relevant depths. However, our calculation misses a potentially important factor, i.e. the probable reduction in by-catch rates due to the introduction of sorting grids in the commercial trawls. Our estimates may thus be too high. On the other hand, we did not estimate Swedish and Danish by-catches that should be added to derive more accurate totals.

Skrive noe om data fra Intercatch og fordelingen mellom landinger og utkast fra svenske og danske data. Norske data rapporterer ikke utkast og landingstallene fra norske fiskerier er veldig lave (mye lavere enn det som rapporteres fra svenskeog danske fiskerier).

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 seems 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.

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Table 1. Summary of data on the bottom trawl survey series, 1984-2020. 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 2020 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

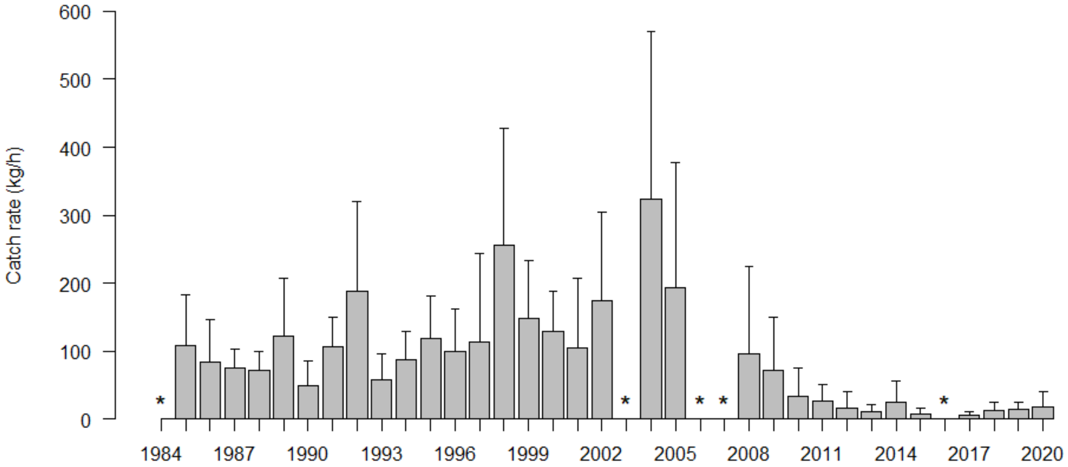
* Path width of the tow constrained by a 10 m rope connecting the warps, 200 m in front of otter boards. ** Path width of the tow constrained to a 15 m rope connecting the warps, 100 m in front of the otter boards. *** Same trawl and strapping but from 2019 there are inserted several floaters on the trawl to lighten the trawl (Nordsjørigging).

Table 2. Mean biomass index and mean abundance index from shrimp survey 1984-2020. 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 (SE)

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
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

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



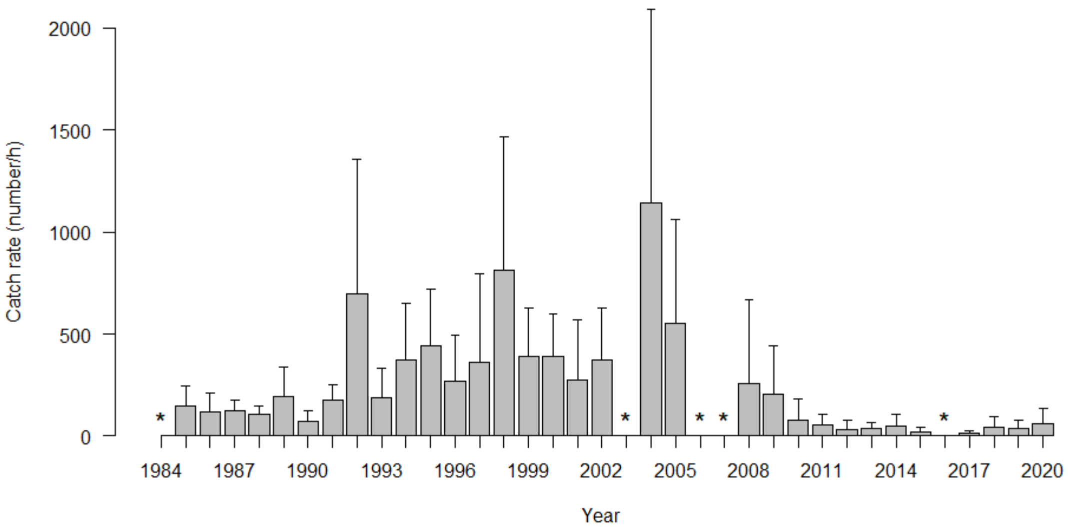


Figure 1. Standardized survey catches of grenadier, 1984-2020. Upper: Biomass (kg/h), Lower: Abundance (number/h). Standard error shown by lines on top of bar. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years were excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.

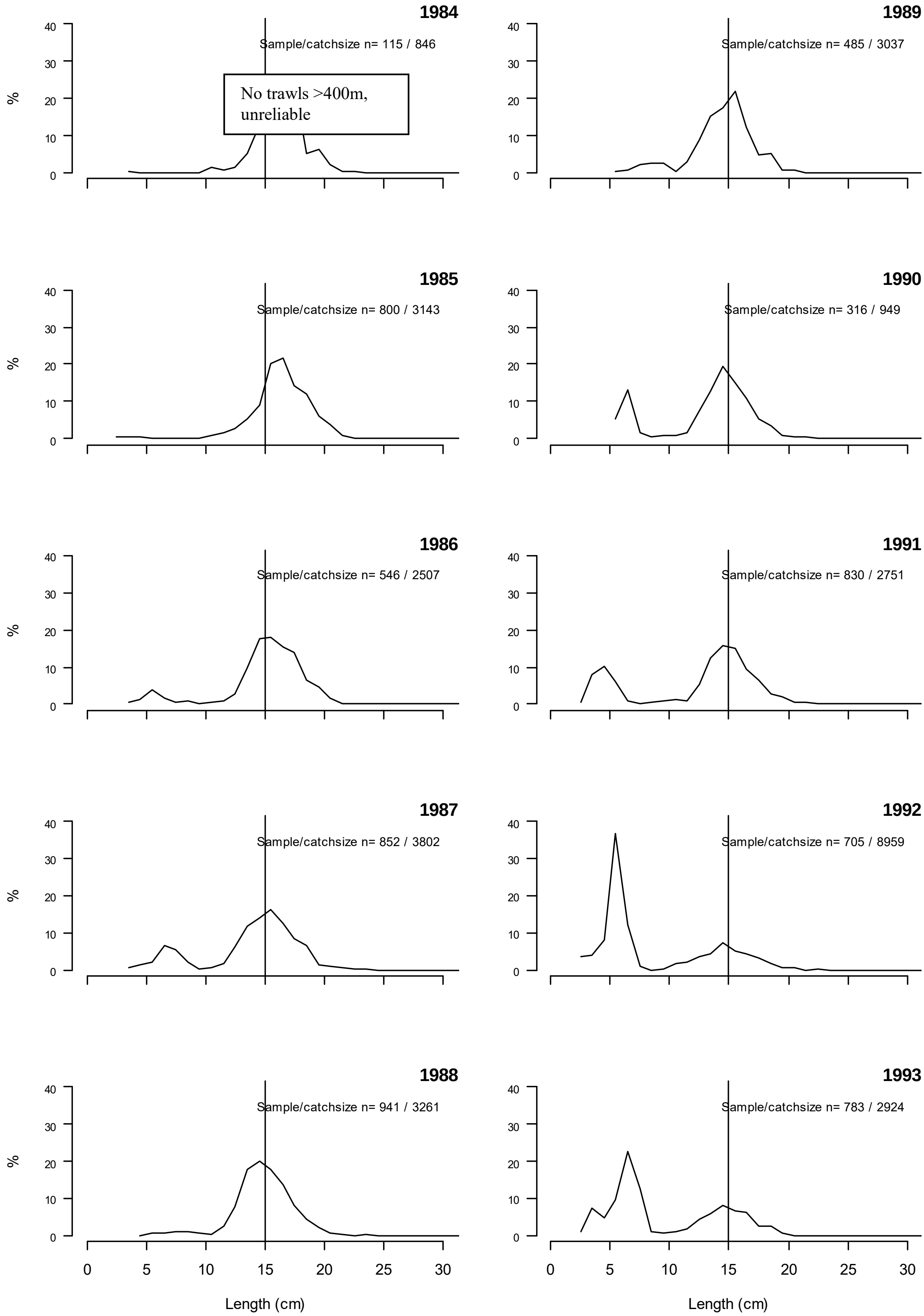


Figure 2. Length distributions of roundnose grenadier from annual *P. borealis* surveys, 1984-2020. Length is measured as PAL (cm). The length distributions are calculated as percentage number of fish in each centimetre length interval standardized to total catch number and trawling distance for each 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.

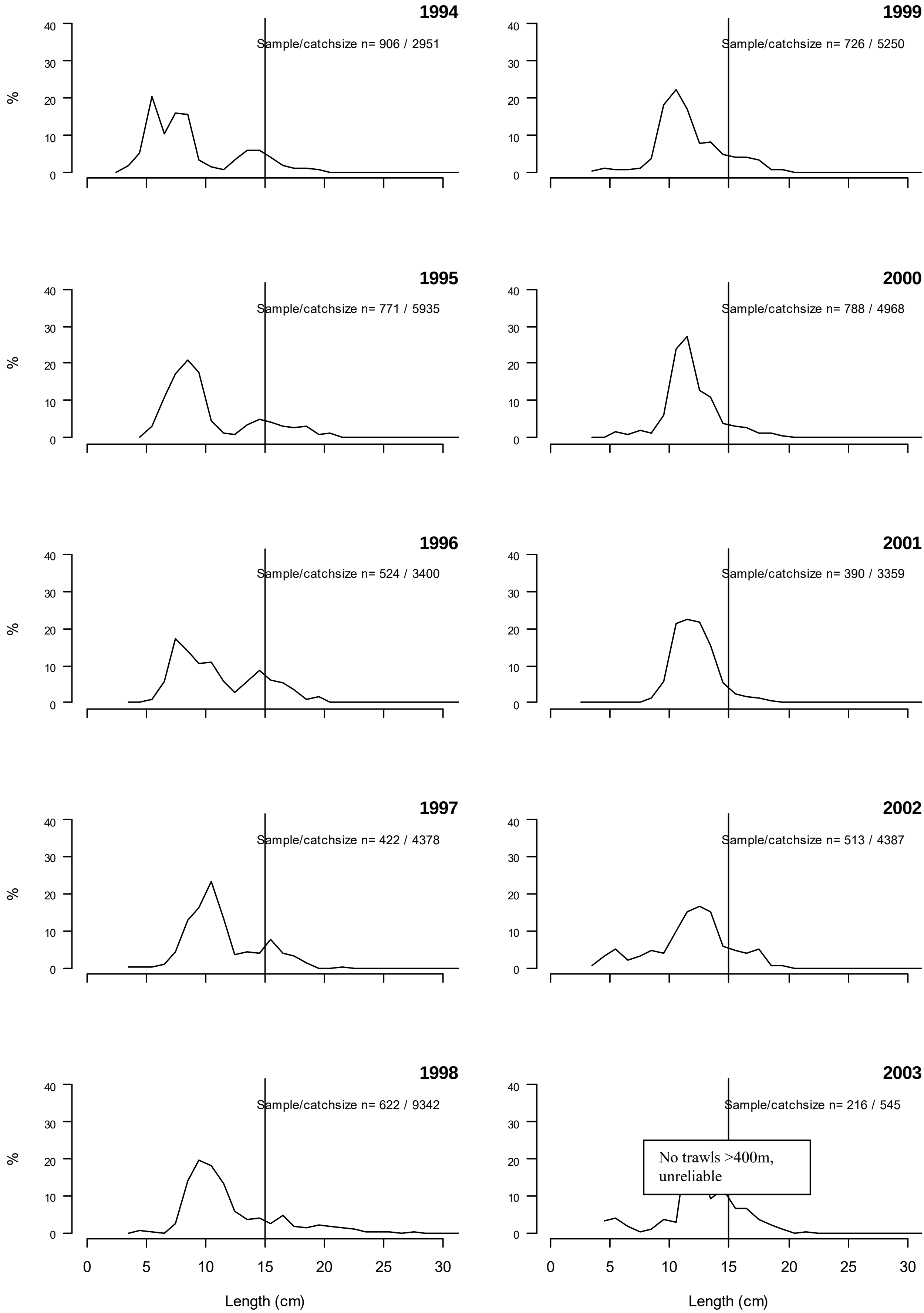
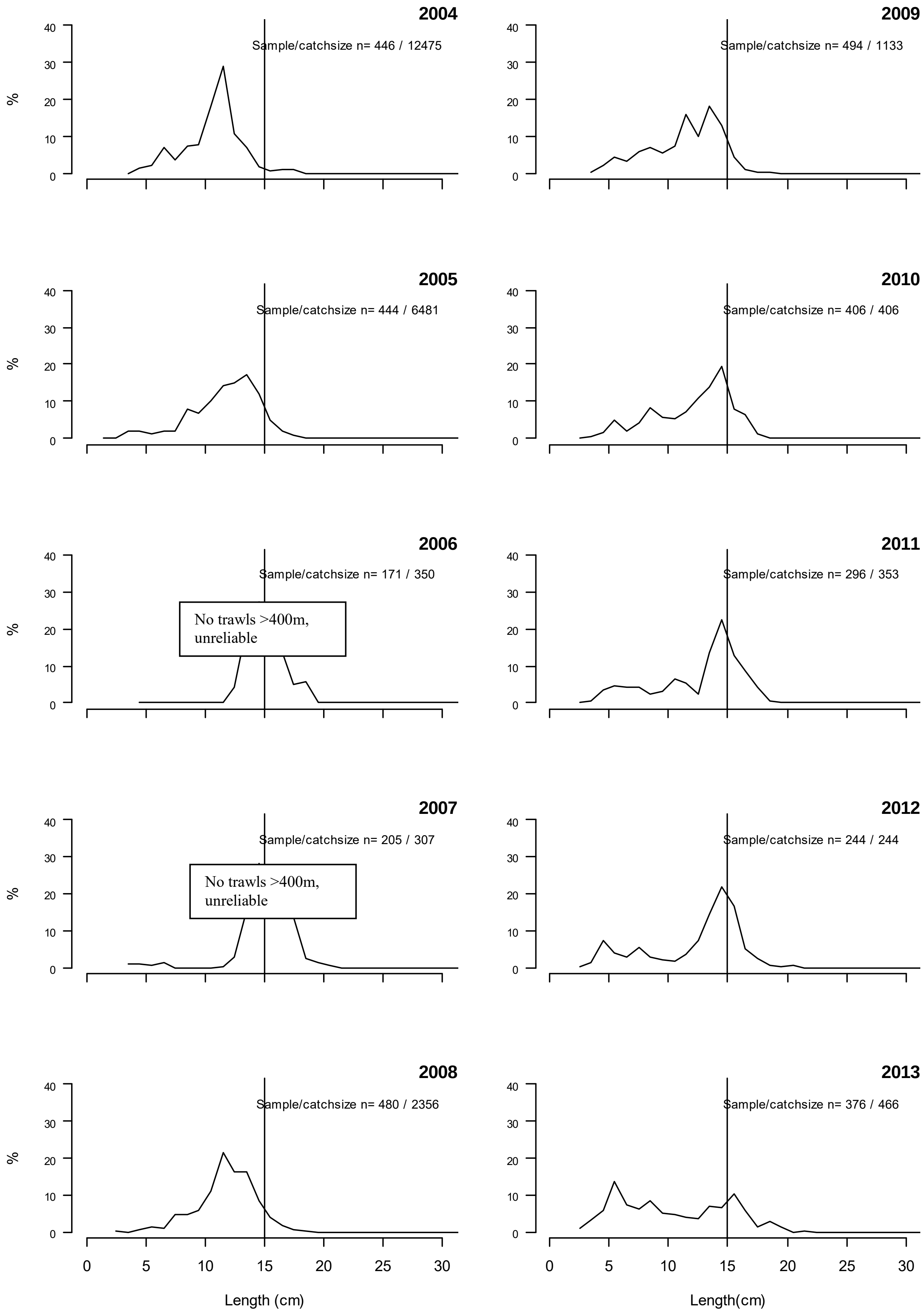


Figure 2 continued



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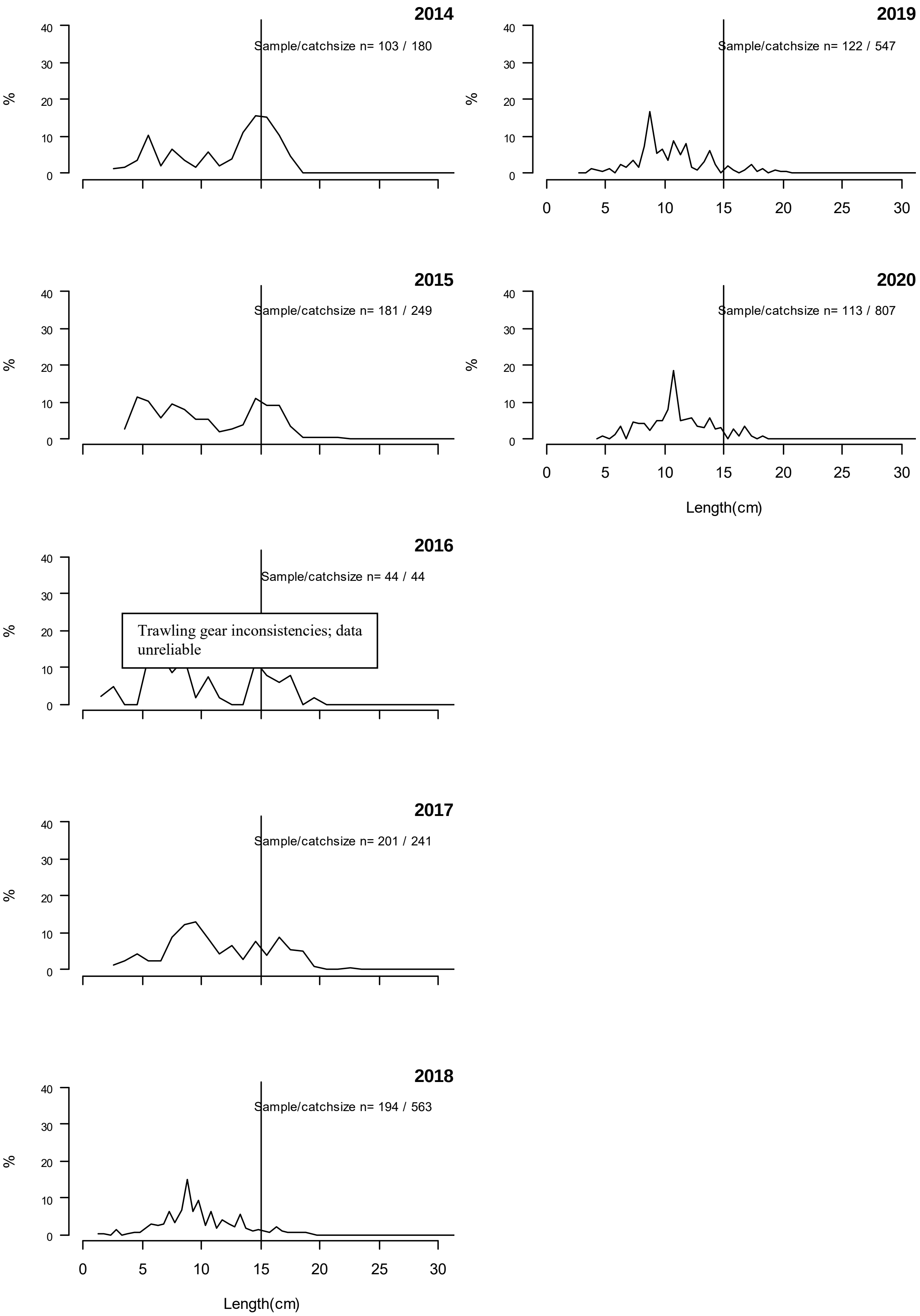


Figure 2. Continued

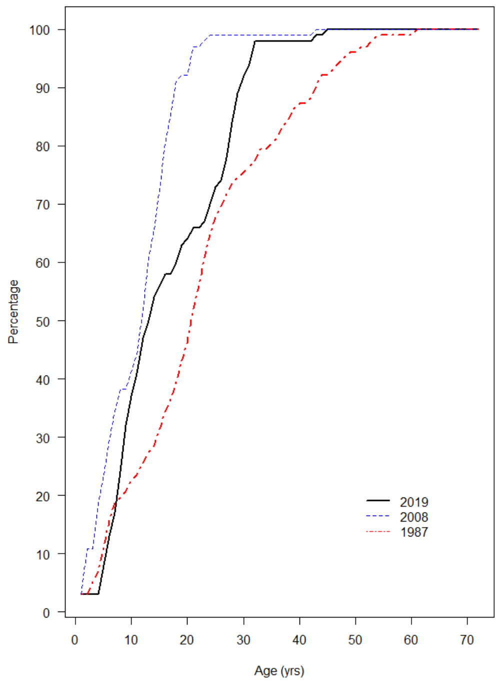


Figure 3. Cumulative age distributions of roundnose grenadier in the Skagerrak. Data from survey catches in Skagerrak in 1987, 2008 and 2019. The distribution from 1987 was modified from Bergstad (1990). Data from 2008 and 2019 was derived from the annual shrimp survey.

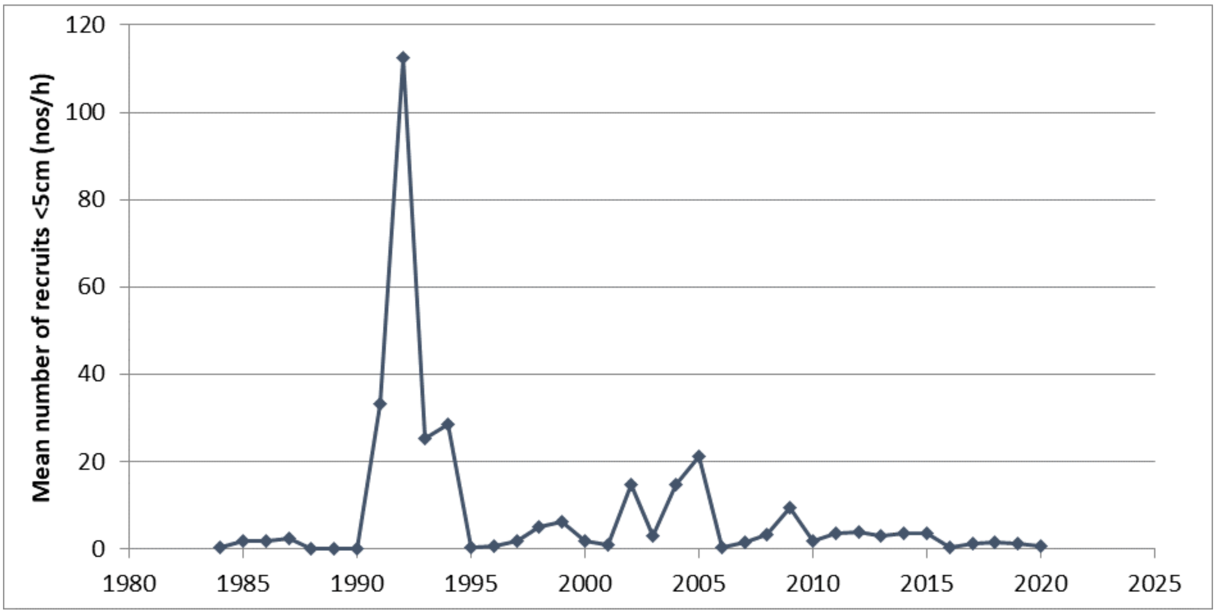


Figure 4. Mean catch rate of roundnose grenadier of PAL ≤ 5 cm, 1984-2020. Data from shrimp survey, trawls deeper than 300 m. *In 1984,2003,2006 and 2007, no trawls were made deeper than 400 m, and data from these years should be disregarded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.

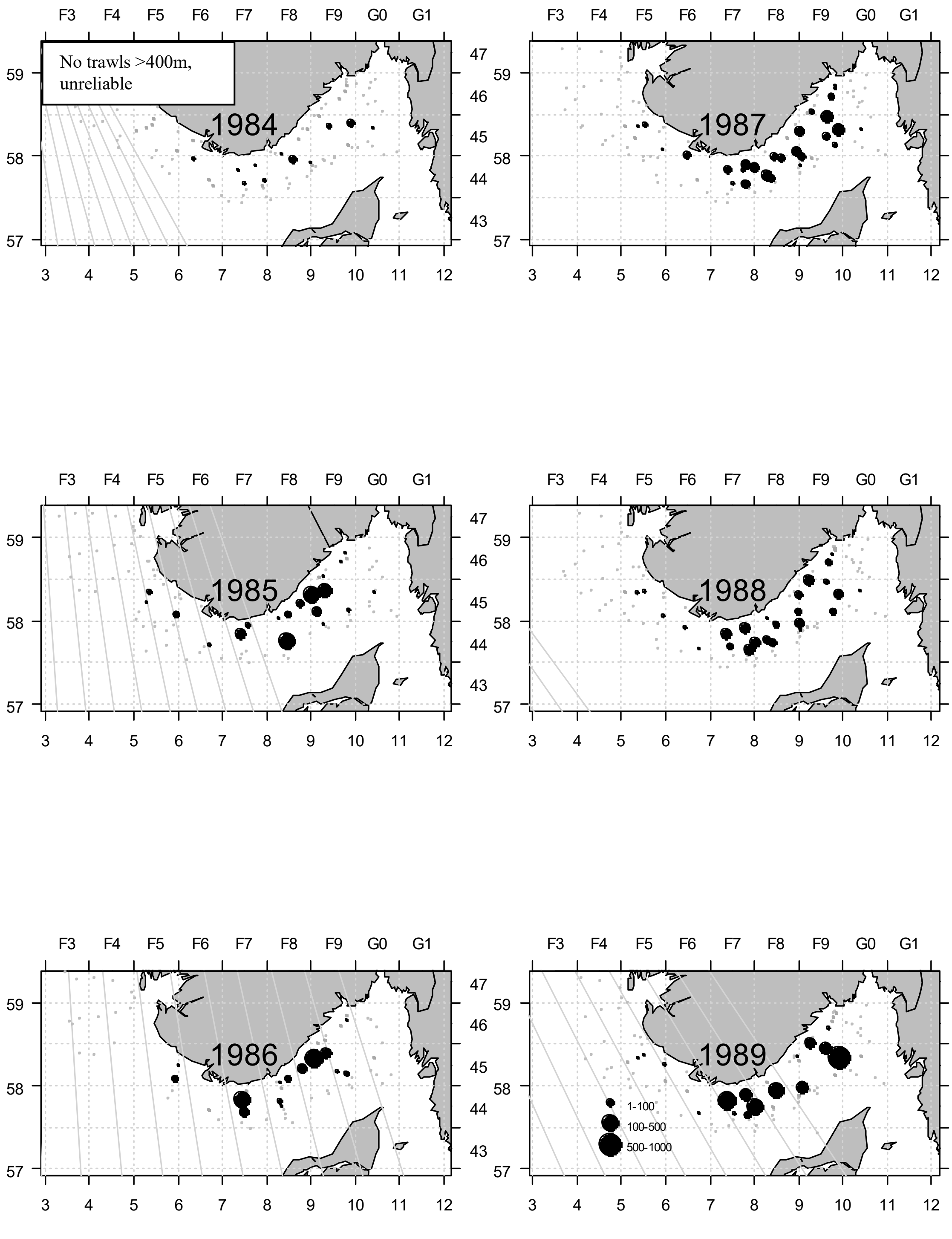


Figure 5. Geographical distribution of catches of roundnose grenadier (kg/h) from 1984-2020. Data from shrimp survey, trawls deeper than 300 m. Grey circles are trawls with no catch of grenadier. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those 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.

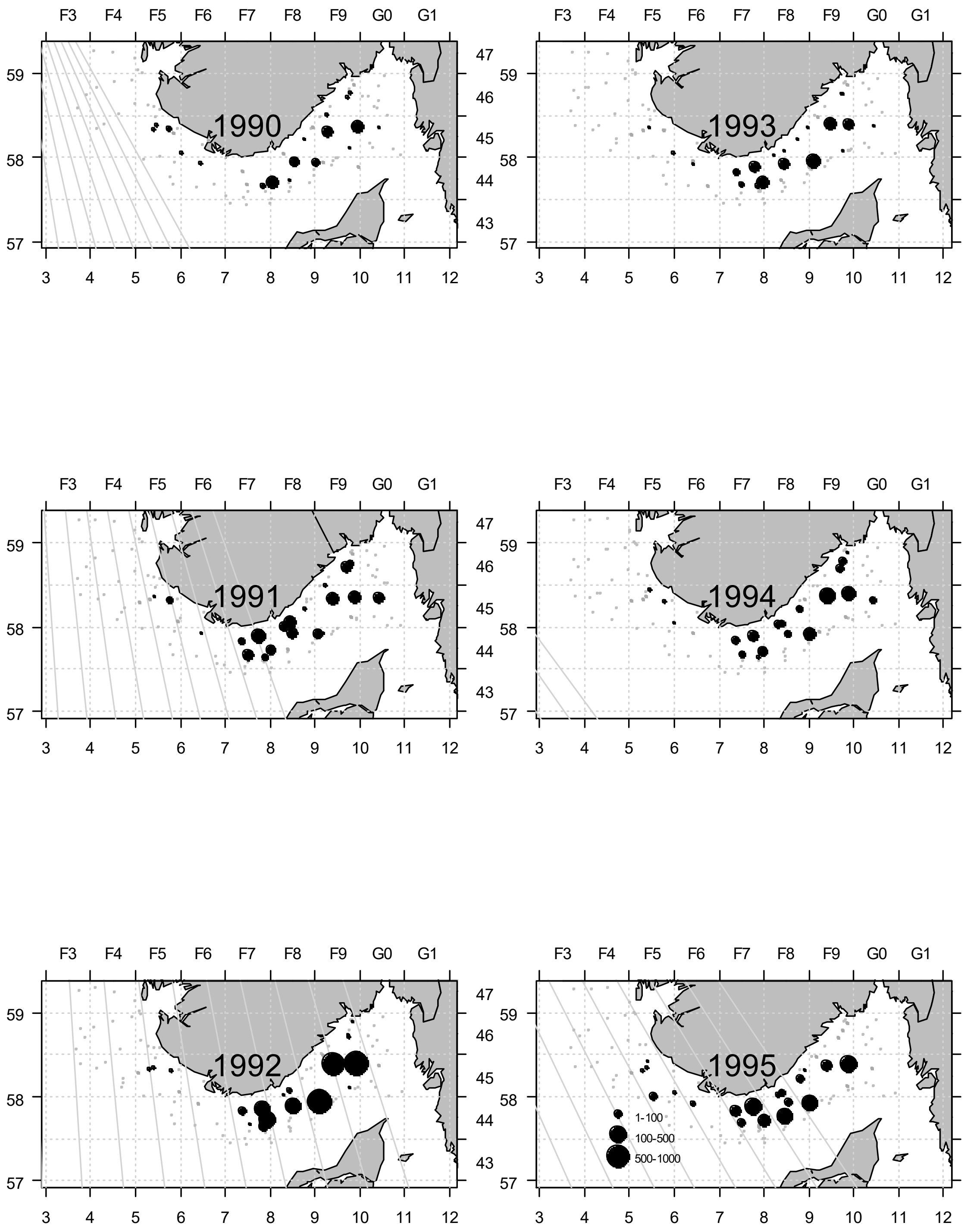
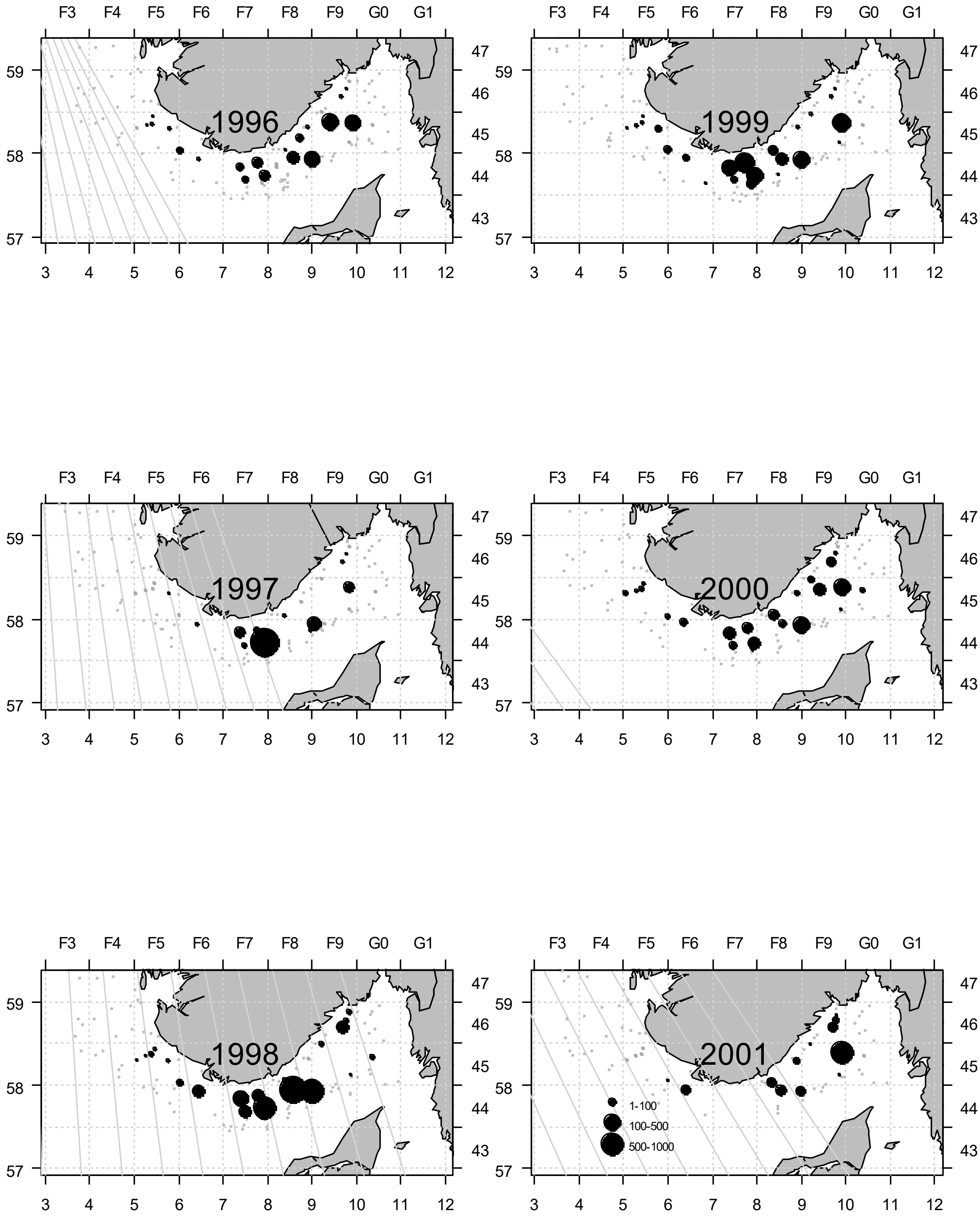


Figure 5 continued.



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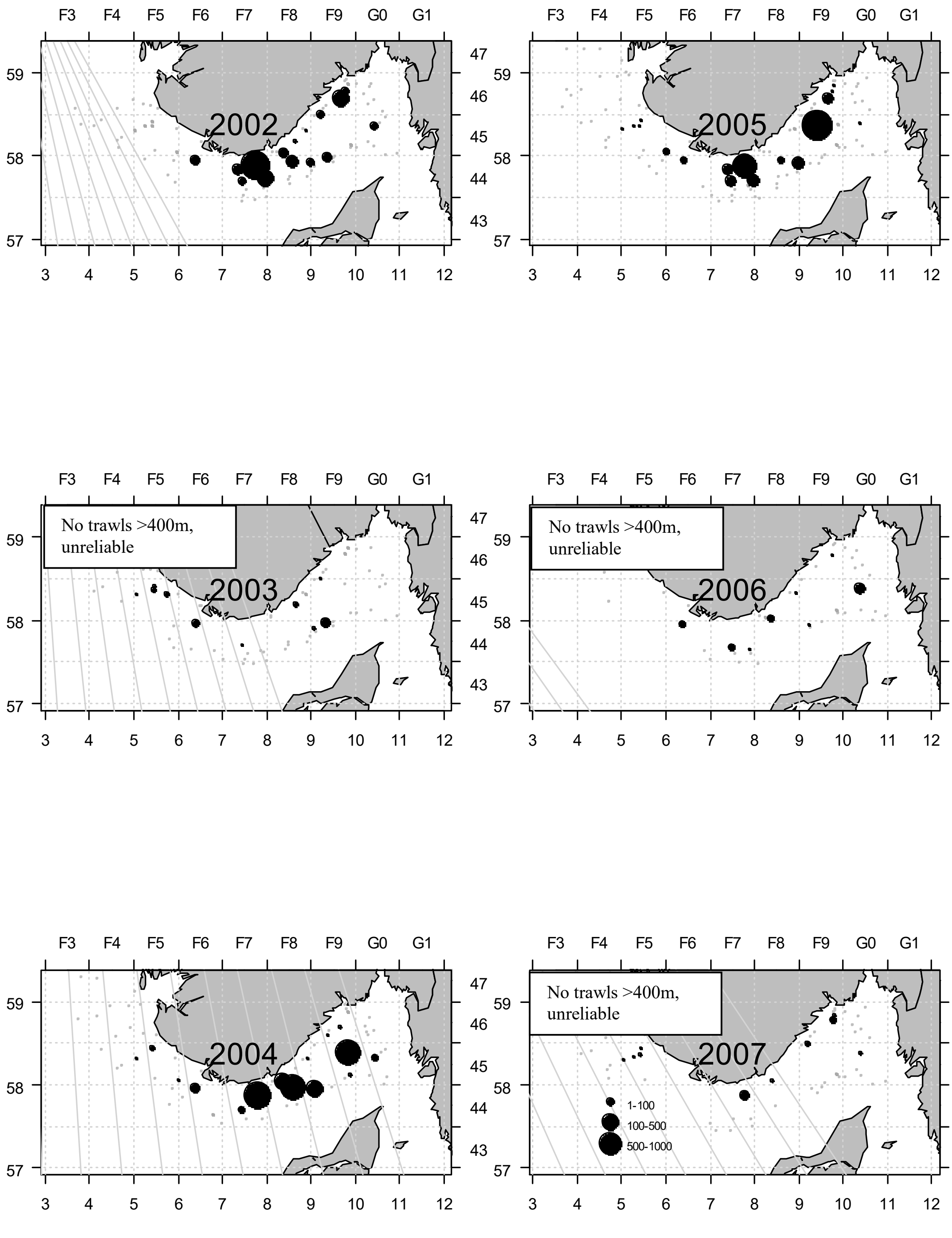

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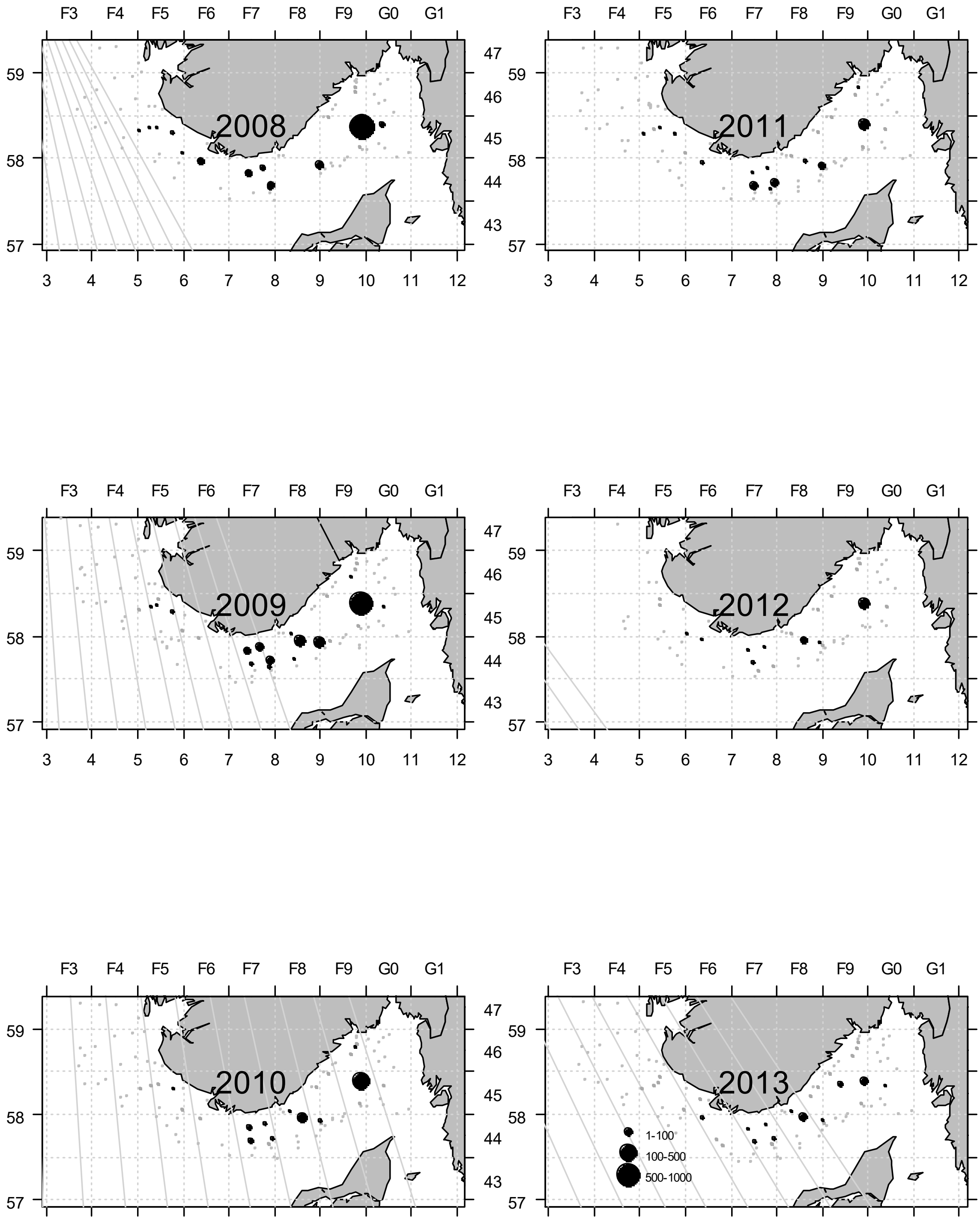

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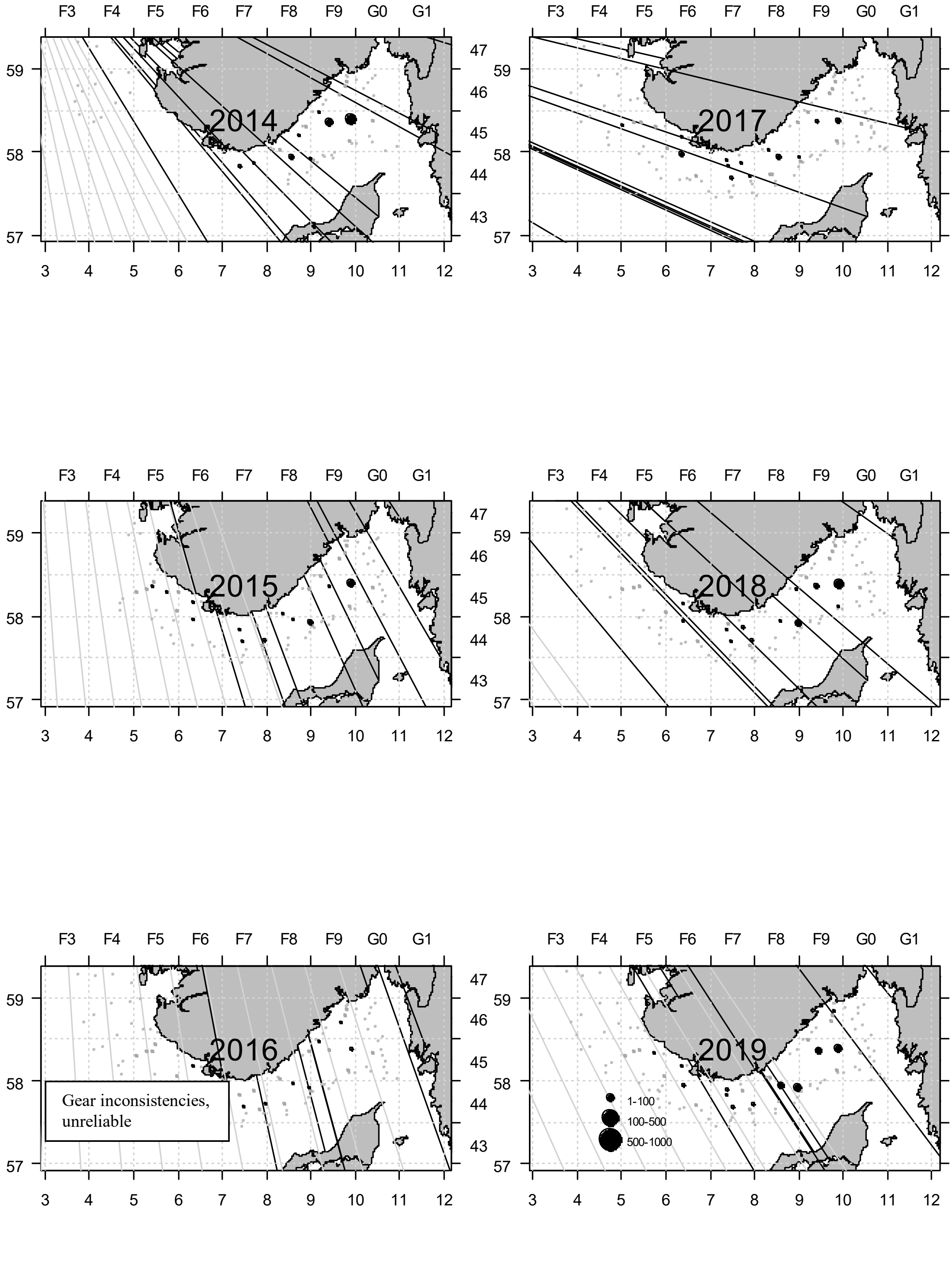

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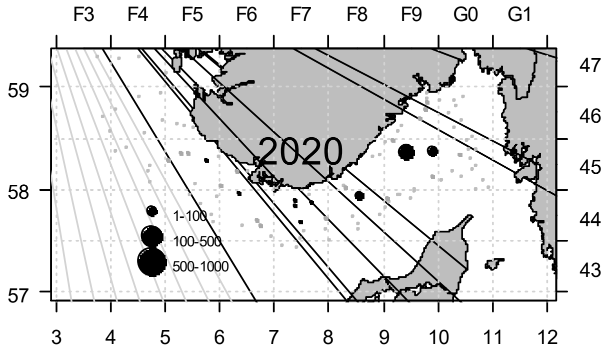

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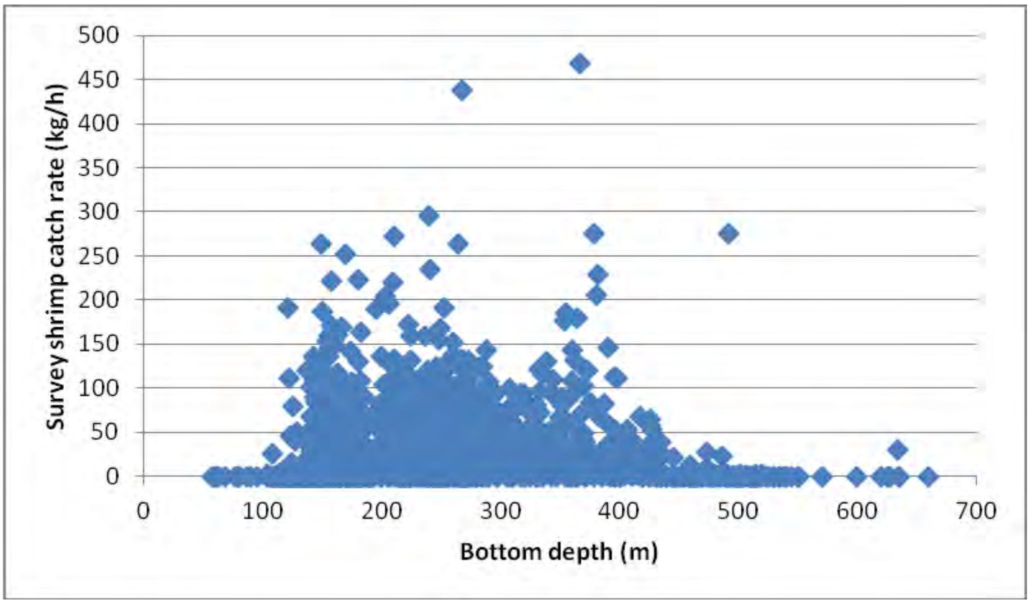

Figure 6. Depth distribution of deepwater shrimp (*Pandalus borealis*) as illustrated by catch rates in the Norwegian shrimp trawl survey, 1984-2013.

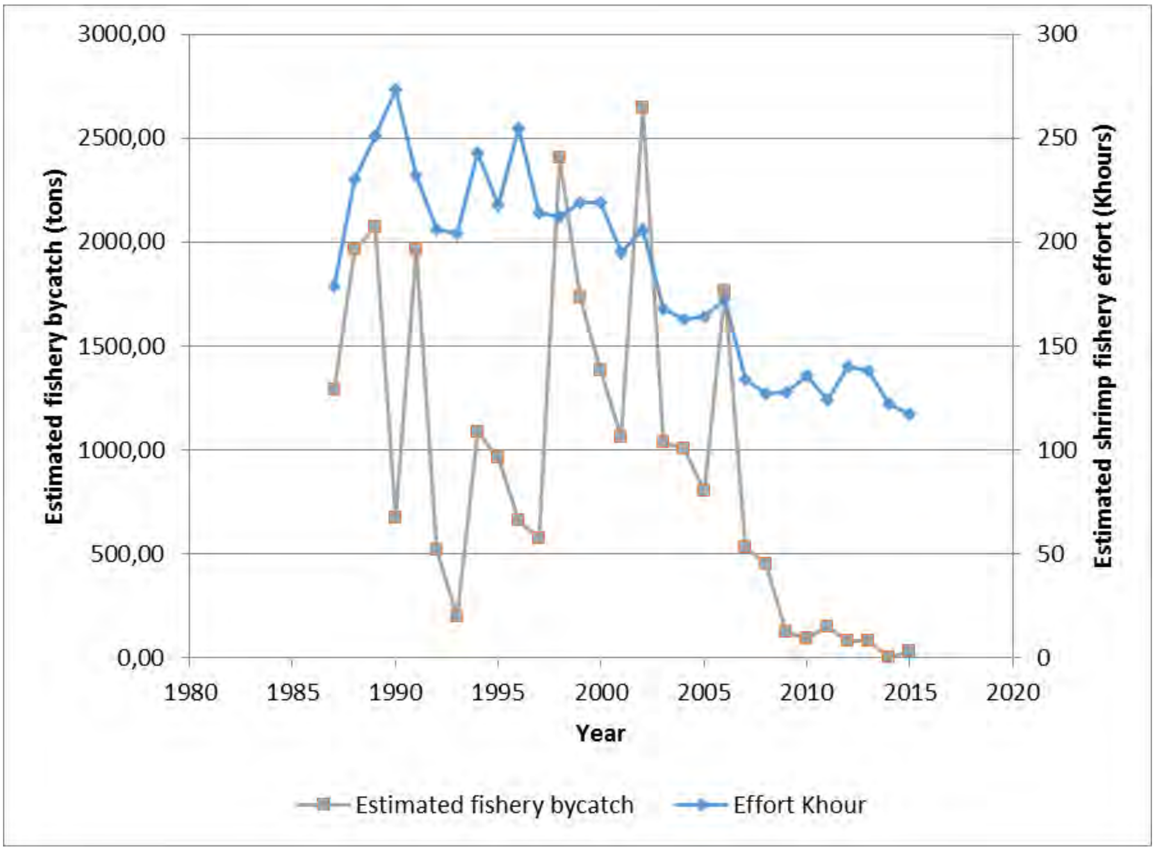

Figure 7. Estimated by-catch of roundnose grenadier in the Norwegian shrimp fishery in ICES Div. 3a and 4a, and the estimated commercial shrimp fishery effort in the same area. See text for explanation.

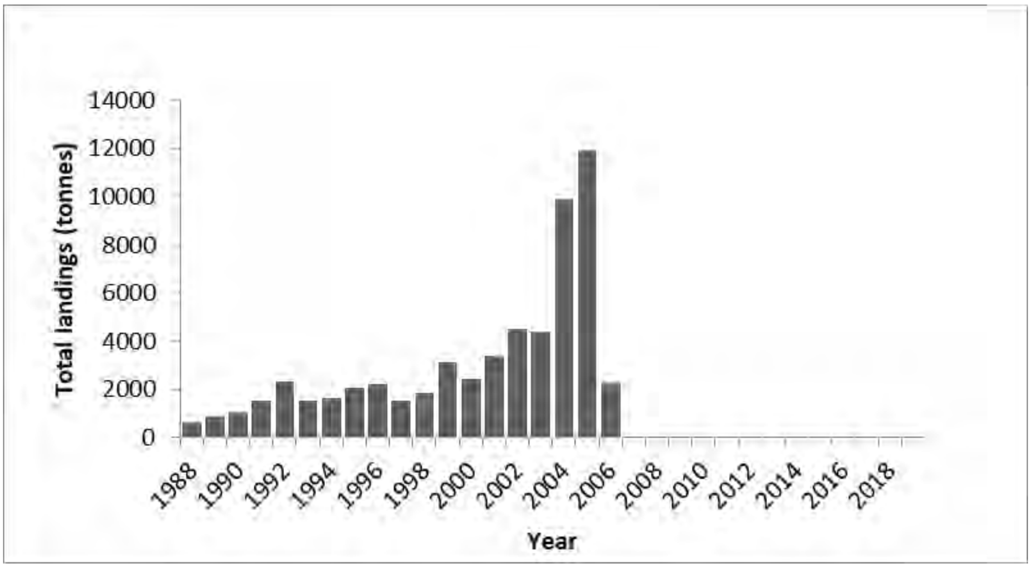

Figure 8. Total reported landings of roundnose grenadier in ICES Division 3a, 1988-2019. Landings from 2007 and later is very small and all less than 2 tons.

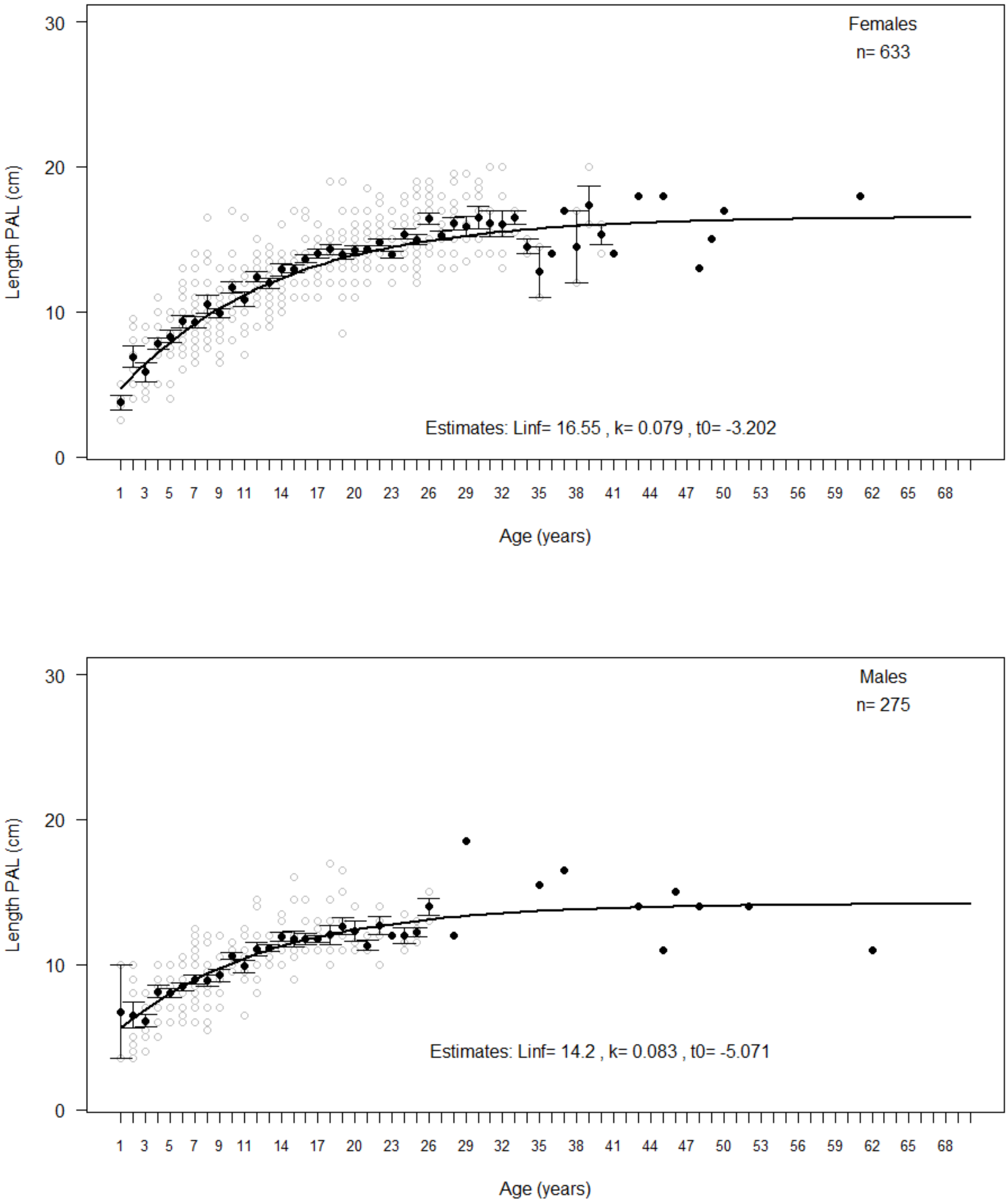

Figure 9. Length at age for female and male roundnose grenadier; data from Skagerrak 2008-2019. Mean values are estimated with ±SE where there is more than one value. Estimated von Bertalanffy growth curves with parameters for females and males.

Running SPiCT model on roundnose grenadier data from Skagerrak (ICES Division 3a)

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Introduction

This working document presents different scenarios on how to run SPiCT (Surplus Production model in Continous Time) (Pedersen, 2017) on roundnose grenadier data from Skagerrak (ICES Division 3a). Results from six different scenarios are presented. Landings data and a survey index are used as input data for the model. The model is runned as an R package (https://github.com/DTUAqua/spict).

Input data

Landings data reported annually to ICES from 1988-2019 and a survey biomass index from the shrimp survey in Skagerrak (No-Shrimp-Q1) (1984-2019) was used as input data for the model.
In an initial run, the entire landings series was used, disregarding the fact that a ban on directed fishing was introduced as of April 2006 and that bycatches have been small since then. (See WD 03 WGDEEP 2020). Therefore, the landing series was shortened to only include the time period when there was a targeted fishery (1988-2006).

Running the model

Six different scenarios were attempted using the input data selected. The results from the different runs are listed in Table 1. The first run was with default values, the other five with different levels of the parameters n, alpha and beta. Fixing these parameters reduced the confidence intervals and produced better fits compared to the default values.

The selected option became run no. 5 and the output results and figures from this run is shown below.

Figure 1 shows the input data from the landings and survey biomass index. These are the two data series used in the model. Landings are, as said above, from 1988-2006 reported to ICES (tonnes), and the survey index is from the annual shrimp survey in Skagerrak and North Sea given in kg/h.

The results from the model fit is shown in Table 2. Convergence 0 means that the model converged, hence plotting the results is advised.

The plots of the estimated catch, relative fishing mortality, relative biomass and Kobe plot is shown in Figure 2. Estimates for catch, relative fishing mortality and relative biomass are shown as blue lines versus points for the observed data. Confidence intervals (95%) are shown as shaded blue regions. Estimate of the reference points (MSY) are shown as black line, 95% confidence intervals are shown as shaded grey region. The Kobe plot shows the fishing mortality versus biomass.

The estimated catch was below MSY until 1998, then increased to above MSY until 2005. The relative fishing mortality was below Fmsy in the first years of the data series, then increased and has been above the Fmsy since. The relative biomass has been at or just below the Bmsy until early 2000´s, then increased to above Bmsy in 2005 and then decreased again to levels below Bmsy since 2007. The Kobe plot shows the relationship between fishing mortality and biomass since the initial year (1985). The vertical dashed line at Bt=0 indicates the biomass level below which the stock has collapsed. The grey shaded banana-shaped area indicates 95% confidence region of the pair Fmsy and Bmsy. This plot shows that the stock is now at very low levels.
The confidence intervals are for all plots quite large, indicating uncertainty in the model.

Before proceeding with the model, the model residuals were checked. The results from this OSA residuals check is shown in Figure 3. In this case, all checks were not significant and the assumptions for the model then seem to be satisfied.

Then the retrospective analysis was done and the plots are shown in Figure 4. The retrospective plots are reasonable although the confidence intervals are large which indicates large uncertainty in the model.

Results and Discussion

The model estimated reference points that are quite sensible based on what we know about the history of the stock and what is thought to be a sustainable level for this stock in this area. The Bmsy=14372 tonnes and Fmsy=0.1 seems reasonable and MSY=1916 tonnes is at a level of what the landings were before the target fishery expanded rapidly in the early 2000s.

The estimated catch related to MSY also show a reasonable development as the catch was estimated to be below MSY until 1998; when the fishery started to expand and developed into a targeted fishery.

Since the landing series was shortened to only include the period with expanding target fishing, it is worth noting that MSY=1916 tonnes may not be the sustainable level under recent and present conditions with very low survey indices for the stock, apparently low recruitment, and insignificant landings. This MSY relates better to the level that would have been sustainable if the targeted fishery had never expanded to a level which significantly reduced the stock, possibly to a level that impaired recruitment.

References

Hansen, H.Ø. and O.A. Bergstad (2020). Update on Norwegian fishery independent information on abundance, recruitment, size distribution and exploitation of roundnose grenadier (*Coryphaenoides rupestris)* in the Skagerrak and north-eastern North Sea (ICES Division 3a and 4a). ICES Working document, WGDEEP 2020.

Pedersen, M.W., and C.W. Berg (2017). "A stochastic surplus production model in continuous time." Fish and Fisheries 18 (2): 226–43. https://doi.org/10.1111/faf.12174.

Table 1. Results from the six different runs on SPICT with landings period (1988-2006) and survey biomass index (1985-2019). Stochastic reference points are used. cihigh and cilow are high and low confidence levels.

Landings period	1988-2006					
Index	1985-2019					
Run	**1**	**2**	**3**	**4**	**5**	**6**
Parameter settings						
n	mod.est	2	mod.est	2	2	2
Alfa	mod.est	1	1	mod.est	1	4
Beta	mod.est	1	1	mod.est	mod.est	1
Convergence	yes	yes	yes	yes	yes	yes
Parameter estimates						
Bmsy	88605	14419	29548	43151	14372	136664
cilow	29	3350	65	11	3130	46
cihigh	2,6*10^8	62000	1,3*10^7	1,7*10^8	65973	4,1*10^8
MSY	4600	1899	2810	4905	1916	13289
cilow	70	544	239	3	513	6
cihigh	300335	6623	32936	6,9*10^6	7149	3,1*10^7
Fmsy	0,005	0,137	0,092	0,114	0,139	0,097
cilow	0,5*10^-4	0,028	0,001	0,027	0,029	0,042
cihigh	4,517	0,657	6,969	0,579	0,672	2,245
K	399678	35204	141969	92957	35043	280476
cilow	20	6988	25	30	6549	94
cihigh	7,8*10^9	177348	8,0*10^8	2,8*10^8	187499	8,4*10^8
Diagnostics	OK	OK	OK	OK	OK	OK
Retrospective	negative	OK-	negative	negative	OK-	negative

Table 2. Summary results from the model run no. 5.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 34.1800191
Euler time step (years):  1/16 or 0.0625
Nobs C: 19,  Nobs I1: 31

Priors
     logn  ~  dnorm[log(2), 0.001^2] (fixed)
 logalpha  ~  dnorm[log(1), 0.001^2] (fixed)
  logbeta  ~  dnorm[log(1), 2^2]

Model parameter estimates w 95% CI
            estimate        cilow        ciupp    log.est
 alpha  1.000001e+00    0.9980429 1.001963e+00  0.0000010
 beta   1.410358e+00    0.4028373 4.937749e+00  0.3438435
 r      3.264798e-01    0.0851997 1.251049e+00 -1.1193872
 rc     3.264799e-01    0.0851999 1.251048e+00 -1.1193869
 rold   3.264800e-01    0.0851998 1.251050e+00 -1.1193865
 m      2.860201e+03  965.0366291 8.477139e+03  7.9586472
 K      3.504291e+04 6549.3950358 1.874991e+05 10.4643285
 q      9.730200e-03    0.0023325 4.059090e-02 -4.6325227
 n      1.999999e+00    1.9960832 2.003923e+00  0.6931469
 sdb    3.146284e-01    0.2377783 4.163165e-01 -1.1563632
 sdf    2.169805e-01    0.0816695 5.764766e-01 -1.5279476
 sdi    3.146287e-01    0.2377791 4.163158e-01 -1.1563622
 sdc    3.060202e-01    0.1791096 5.228551e-01 -1.1841041

Deterministic reference points (Drp)
          estimate        cilow        ciupp   log.est
 Bmsyd 17521.45166 3274.6974503 9.374951e+04  9.771181
 Fmsyd     0.16324    0.0425999 6.255239e-01 -1.812534
 MSYd   2860.20101  965.0366291 8.477139e+03  7.958647
Stochastic reference points (Srp)
           estimate        cilow        ciupp   log.est rel.diff.Drp
 Bmsys 1.437200e+04 3130.8880143 65973.130931  9.573037   -0.2191377
 Fmsys 1.386877e-01    0.0285909     0.672742 -1.975531   -0.1770327
 MSYs  1.915894e+03  513.4386560  7149.149246  7.557940   -0.4928807

States w 95% CI (inp$msytype: s)
                    estimate       cilow        ciupp    log.est
 B_2019.00      1280.3943765 287.1613829 5709.0188889  7.1549234
 F_2019.00         0.3127764   0.0830971    1.1772866 -1.1622668
 B_2019.00/Bmsy    0.0890895   0.0129349    0.6136077 -2.4181140
 F_2019.00/Fmsy    2.2552568   0.7523179    6.7606837  0.8132638

Predictions w 95% CI (inp$msytype: s)
                  prediction       cilow        ciupp    log.est
 B_2019.00      1280.3943765 287.1613829 5709.0188889  7.1549234
 F_2019.00         0.3127764   0.0830971    1.1772866 -1.1622668
 B_2019.00/Bmsy    0.0890895   0.0129349    0.6136077 -2.4181140
 F_2019.00/Fmsy    2.2552568   0.7523179    6.7606837  0.8132638
 Catch_2019.00   391.6850274 107.0073625 1433.7065883  5.9704580
 E(B_inf)                NaN          NA           NA        NaN
```

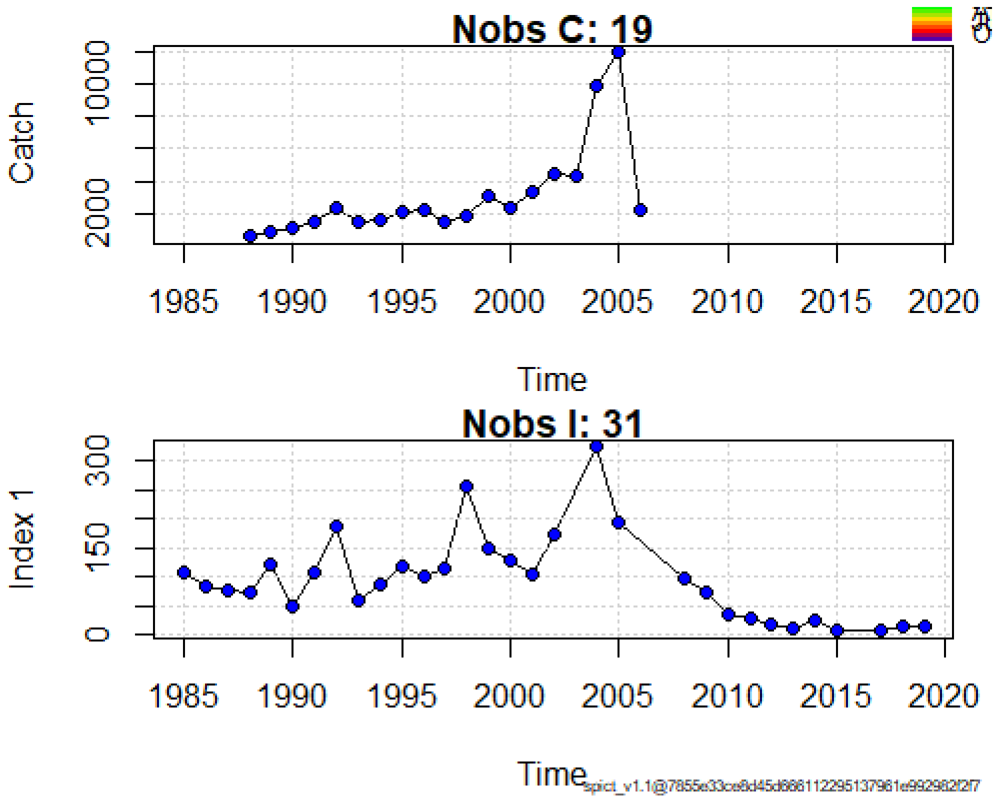

Figure 1. Input data to the model. Upper: Landings series from 1988-2006 reported to ICES working group. Lower: Survey biomass index from shrimp survey in Skagerrak 1985-2019 (excluded years 1984, 2003, 2006-07 and 2016).

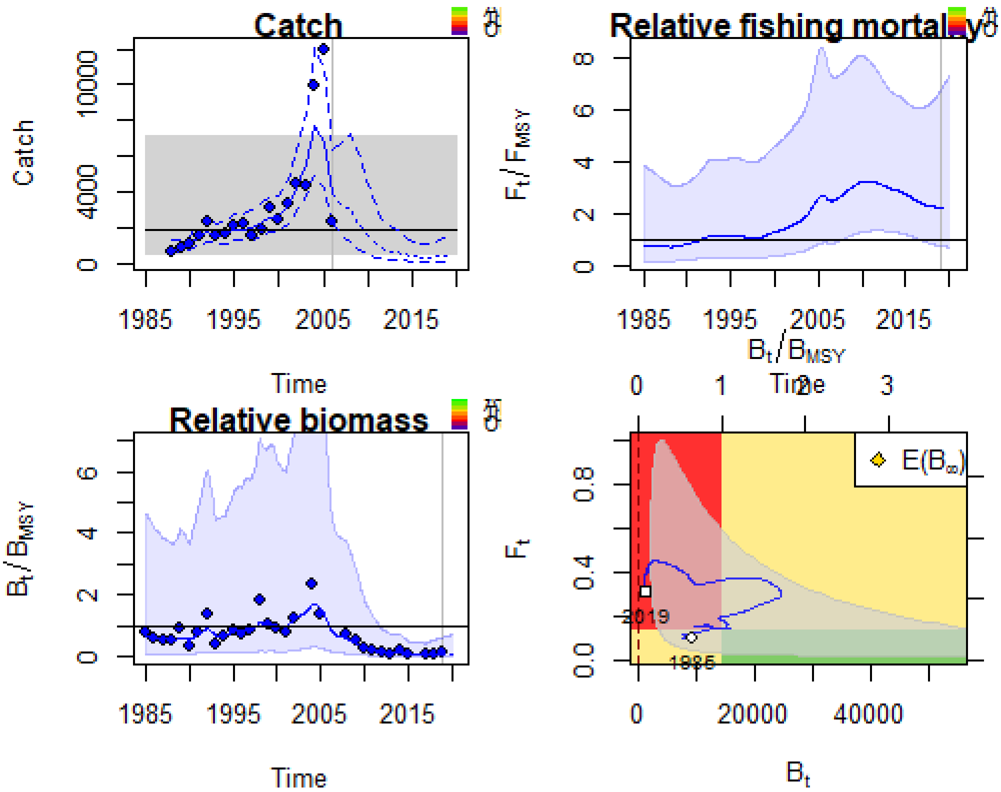

Figure 2. Upper panel left: Estimated catch (blue line) and observed catch (points). MSY is the black line and shaded grey area is 95% confidence interval of MSY. Upper panel right: Estimated relative fishing mortality (blue line) and shaded blue area is 95% confidence interval of relative fishing mortality. Lower panel left: Estimated relative biomass (blue line) and shaded blue area is 95% confidence interval of relative biomass. Lowe panel right: Kobe plot; development of biomass and fishing mortality since the initial year (1985). The vertical dashed line indicates the biomass level below which the stock has collapsed. The grey banana shaped area indicates the 95% confidence region of the pair Fmsy and Bmsy.

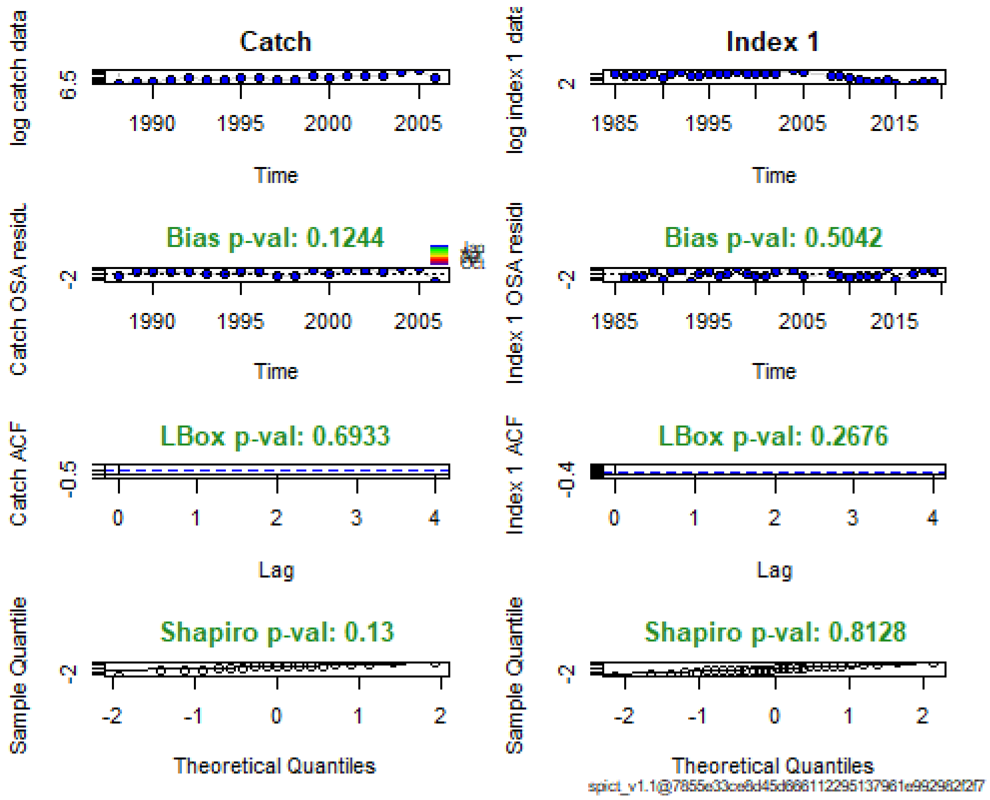

Figure 3. Diagnostic plots; the first column contains information related to the catch data, the second column relates to the index data. First row: Log of input data. Second row: OSA residuals with the p-value of a test for bias. Third row: Empirical autocorrelation of the residuals. Fourth row: Tests for normality of the residuals both as QQ-plot and with Shapiro test. Green headings mean that tests are not significant.

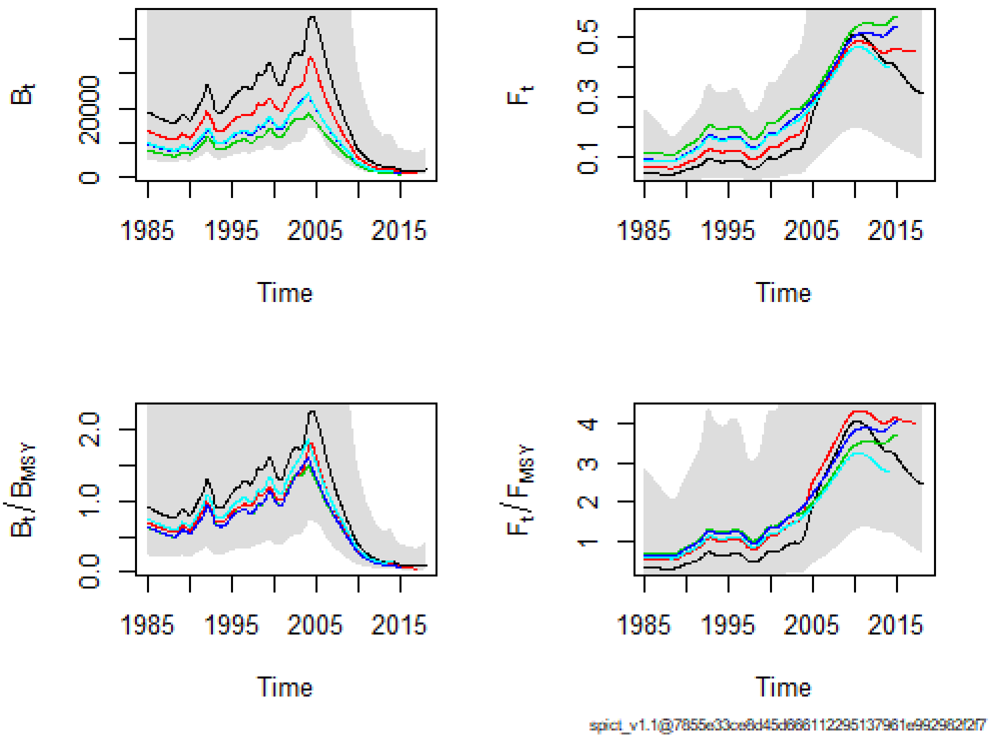

Figure 4. Retrospective plots; 5 scenarios with catch and index.

Correcting an error in the CPUE Standardizing of Greater silversmelt for WGDEEP 2020

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27/04/2020 (v2)

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, small errors were detected in the way CPUE was calculated and the selection of hauls to be included. 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). 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.

2 Issues

The CPUE standardization was based on a GLM model with CPUE against year, week and depth category. The calculation of CPUE was intended to be based on catch per day and per rectangle which was supposed to be achieved by summing the catches of all vessels in a certain rectangle, calculating the combined number of days spent by the vessels in the rectangle and dividing the catch by the number of days for that rectangle.

On checking the code to prepare for WGDEEP 2020, we discovered two issues in the code: 1) the calculation of CPUE and 2) the selection of hauls to be included.

1) Calculation of CPUE. Because we had initially planned to test different potential explanatory variables in the GLM model, we had included the hour for shooting the haul

(hset) as a factor. This factor did not contribute significantly to the GLM and was left out in the final calculation. However, because the hset variable was included when calculating the catch per day and per rectangle, effectively, we were not calculating the catch per day, but rather the catch per haul, as the hset variable meant that few vessels would have the same hset when fishing in the same rectangle on the same day.

2) Selection of hauls to be included. We discovered that only hauls were included north of 59.5 degrees latitude, as this was the area covered by the Faroe fleet. However, the PFA fleet carries out the main fishery south of 59.6 degrees. Due to the spatial selection process almost no hauls of the PFA fleet were included in the final calculation.

3 Results

The first issue is illustrated with the effort metrics used in the calculation for WKGSS 2020 and the new calculation for WGDEEP 2020 (figure 1).

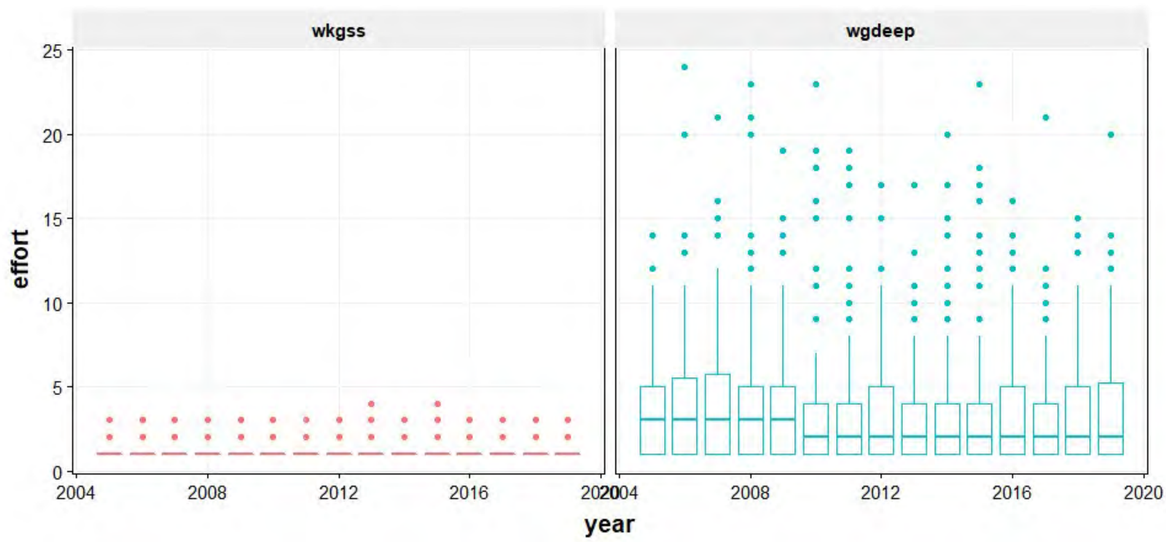


Figure 1: ARU.27.5b6a Effort (fishing days per rectangle) used for CPUE calculation

The ‘raw’ CPUE, based on the effort metrics in figure 1 is then calculated as shown below, whereby the WKGSS effort is effectively based on the catch per haul and the new effort of the catch per day.

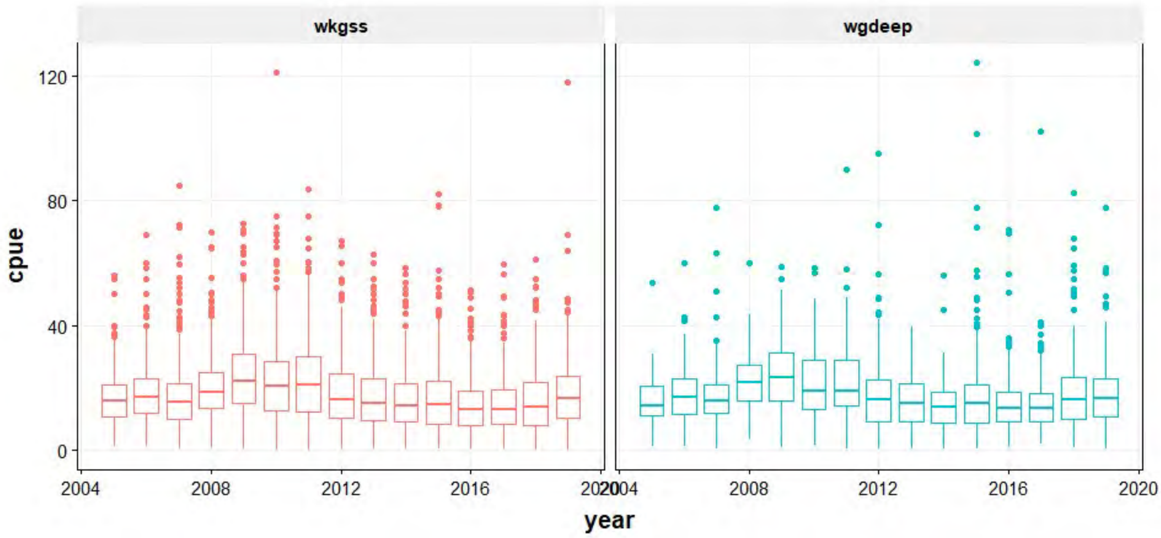


Figure 2: ARU.27.5b6a Catch per unit effort.

The second issue (selection of hauls to be included) is illustrated by the number of hauls by fleet and year in the figure below.

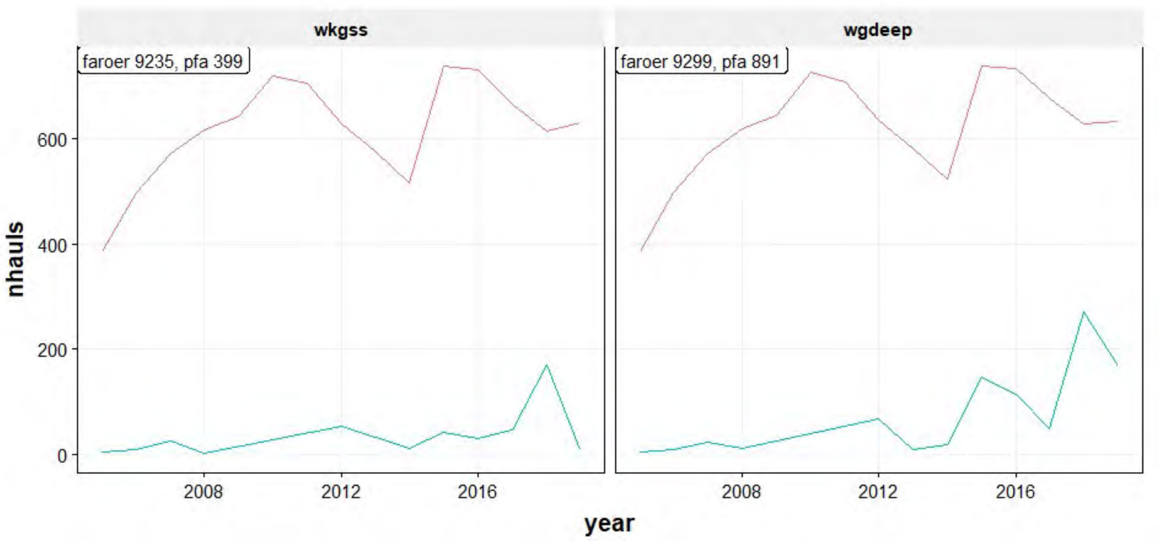


Figure 3: ARU.27.5b6a number of hauls used for the CPUE calculation.

For the years 2015-2019, below are the spatial distributions of the used number of hauls by fleet.

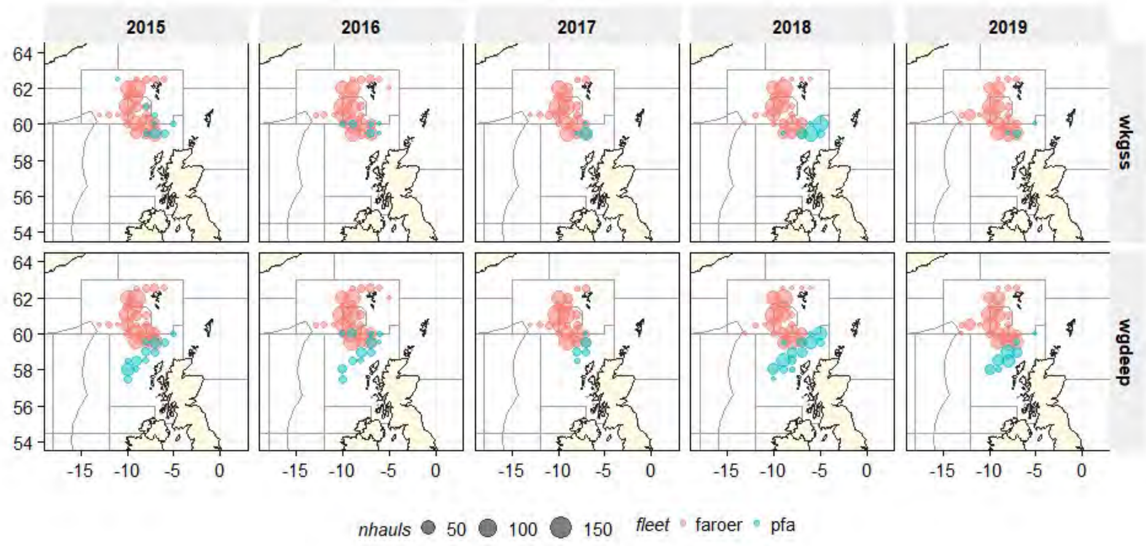


Figure 4: ARU.27.5b6a plot of the number of hauls by rectangle and day

New standardized CPUE index

We applied the same model for standardization of of CPUE: CPUE ~ year + week + depth, where CPUE is now actually 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. In addition we removed the constraint on only using hauls north of 59.5 degrees latitude. This follows the intended procedure explained in Quirijns and Pastoors (2020).

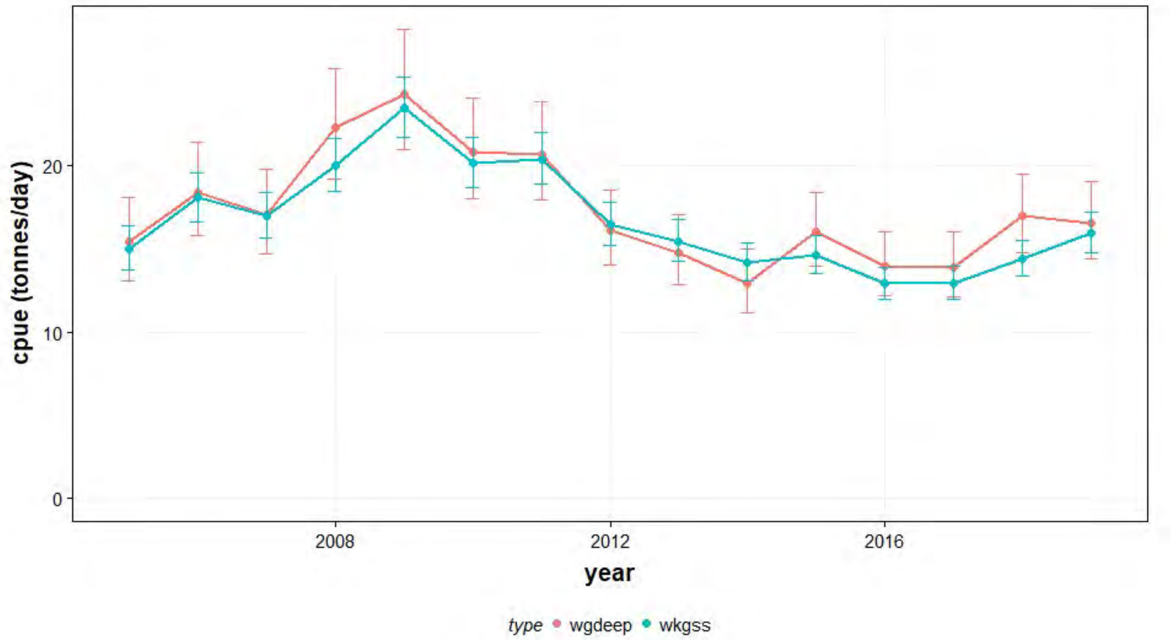
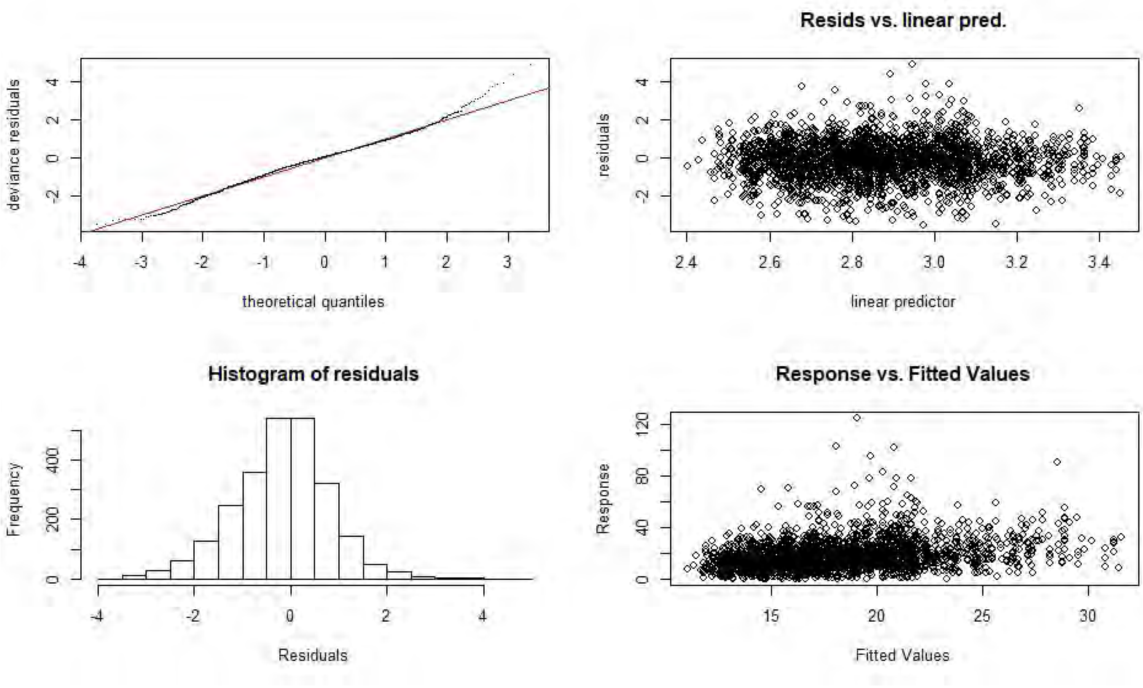


Figure 5: ARU.27.5b6a standardized CPUE (catch per rectangle and day), in comparison with WKGSS series




```
Method: UBRE   Optimizer: outer newton
Model required no smoothing parameter selectionModel rank =  40 / 40
```

Figure 6: ARU.27.5b6a standardized CPUE. Model diagnostics

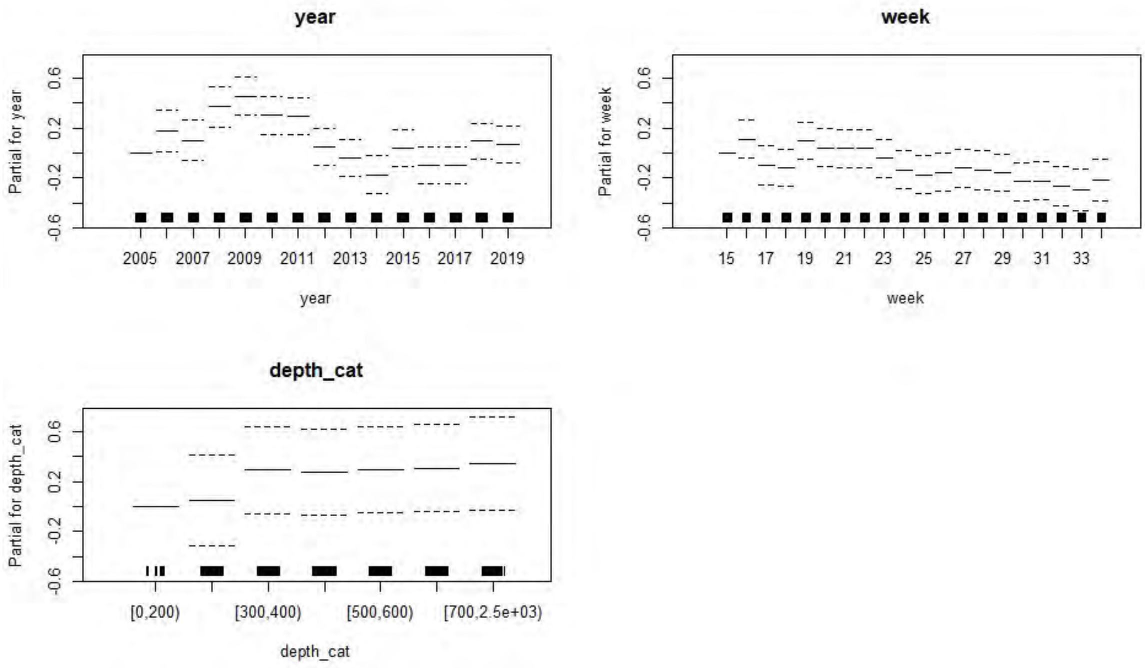


Figure 6: ARU.27.5b6a standardized CPUE. Estimates of explanatory variables.

year	cpue	lwr	upr
2005	15.42	13.1	18.15
2006	18.43	15.82	21.47
2007	17.08	14.74	19.79
2008	22.3	19.23	25.86
2009	24.35	21.03	28.2
2010	20.84	18.04	24.08
2011	20.7	17.98	23.83
2012	16.13	14.03	18.55
2013	14.8	12.84	17.07
2014	12.97	11.2	15.03
2015	16.05	13.99	18.42
2016	14.01	12.21	16.07
2017	13.93	12.1	16.04
2018	16.99	14.8	19.49
2019	16.57	14.42	19.04

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.

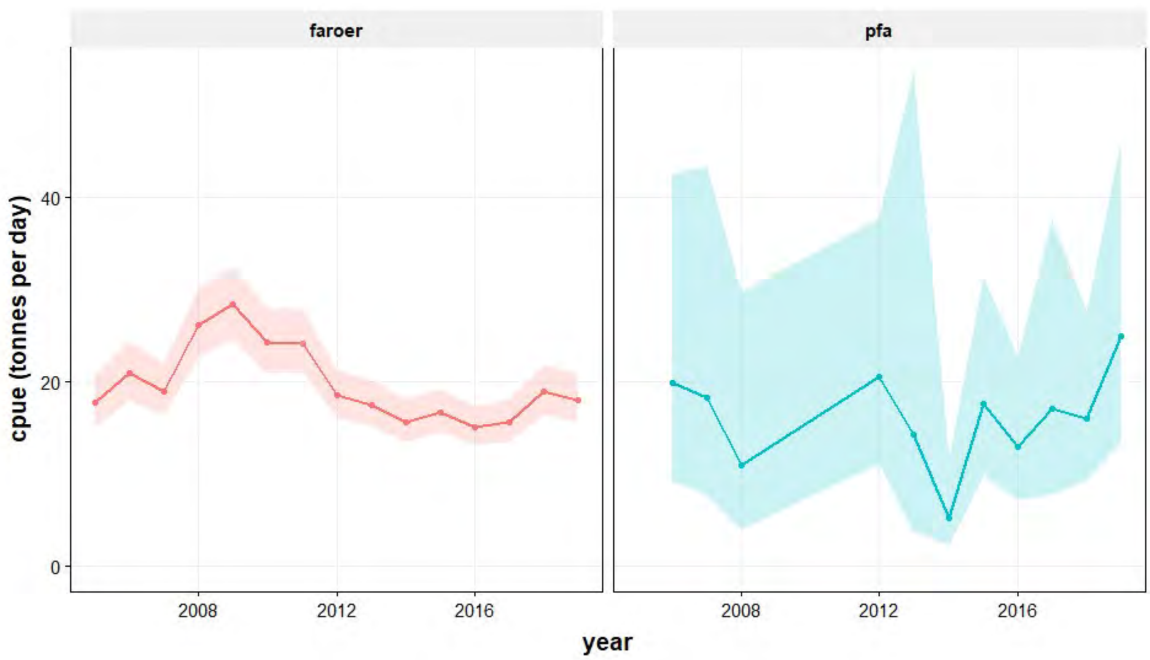


Figure 8: ARU.27.5b6a standardized single fleet CPUE (catch per rectangle and day)

4 Discussion

CPUE standardization using GLM procedures is a common way of dealing with CPUE information. We found that the data processing, prior to using it in the CPUE model, is perhaps a somewhat overlooked attribute of standardization. This is especially the case when the data formats of contributing data sets are in different shares and resolutions. Here we concluded that the checking how the subsetting of data is working, should have been better checked.

When using GLM modelling, a choice needs to be made between using the haul by haul information, which could use attributes related to the haul operation, or using aggregated data by area and period, which cannot use attributes that are related to the hauls.

Fortunately, the differences in CPUE trends between the analysis for WKGSS 2020 and WGDEEP 2020 are not very large so that the impact on the assessment is expected to be small.

5 References

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Updated standardized CPUE for *Beryx decadactylus* caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017

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ABSTRACT

Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2017. The CPUE of alfonsino was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. Once a final model was identified, model diagnostics were revised to identify potential departure from the GLMM assumptions. The index trends showed a peak in 1991, followed by a decreasing trend until 1997, and a more stable trend afterwards. Additional analyses are necessary to check if the zero-altered lognormal is the best error distribution model for standardization of alfonsino catch rates.

KEYWORDS

Alfonsino; demersal fisheries; CPUE; abundance; Azores; GLMM

Introduction

The Azorean fishery for demersal species has traditionally been a multispecific fishery, where several types of hooks and gears are used by the local fleet. The demersal fishing fleet consists mainly of small-scale boats (< 12 m length), mostly equipped with handlines and bottom longlines. The alfonsino (*Beryx decadactylus*) is one of the alfonsinos targeted by the Azorean bottom longline fleet, which also directs its effort to the other demersal fish species such as blackspot seabream (*Pagellus bogaraveo*), wreckfish (*Polyprion americanus*), blackbelly rosefish (*Helicolenus dactylopterus*), forkbeard (*Phycis phycis*), European conger (*Conger conger*) and splendid alfonsino (*Beryx splendens*) (Pinho and Menezes, 2005; Pinho *et al.*, 2015; Santos *et al.*, 2019).

Indices of abundance from commercial fisheries have been used to tune stock assessment models (Quinn and Deriso, 1999, Maunder and Punt, 2004), and their use have been strictly recommended by the International Council for the Exploration of the Sea (ICES) for stock advice. The utility of indices

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of abundance based on nominal catch rates can be improved by standardizing them to remove the impact of factors other than changes over time in stock biomass, usually by using statistical regression methods (Ortiz and Arocha, 2004).

This study updates the standardized catch rates for alfonsino captured by the Azorean bottom longline fleet up to 2017, revising the dataset and the available explanatory variables. Standardized catch rates were estimated using a Generalized Linear Mixed Model with random factor interactions particularly for the *Year* effect.

Material and methods

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAç), and was collected during the period of 1990–2017 as part of the mandate of the European Commission's Data Collection Framework (DCF). Sampling was designed to cover the main ports of the Azores and was performed by clerks who carried out standardized fishing inquiries (n = 9722) to the captains of the bottom longline vessels during the landings. Each record report included: the vessel identification, the dates of departure and return to the port and detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, fishing area and catch in weight for each species landed.

Factors considered in the analyses of the alfonsino catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: *São Miguel*, *Terceira* and *Faial*, which represent around 95% of the Azorean landings, and *Others*, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Pinho and Menezes, 2005; Menezes *et al*., 2006), and target (**Table 1**). The target was defined as the percentage of alfonsino catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of alfonsino caught per 1000 hooks. Records with missing effort data were excluded from the analysis.

Relative indices of abundance for the alfonsino species were estimated by Generalized Linear Modeling approach using a hurdle (delta) model (Lo *et al*., 1992; Ortiz and Arocha, 2004; Zuur and Ieno, 2016). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modeling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modeling the positive catch rates on successful trips.

Deviance tables were used to select the explanatory factors and interactions that explained most of the variability in the data (Ortiz and Arocha, 2004). The effect of each explanatory factor/interaction was evaluated according to 1) the percent of deviance explained by the addition of a specific factor/interaction to the model, and 2) the result of the Chi-squared (χ^2) test between two nested models. Only those factors and interactions that accounted for 5% or more of the variability were selected as explanatory variables.

After selecting the set of explanatory factors/interactions for each error distribution, all interactions that included the factor *Year* were treated as random interactions (Cooke, 1997). This process converted the basic models from generalized linear models into generalized linear mixed models (GLMMs). The significance of the random interactions was evaluated using the likelihood ratio test (Pinheiro and Bates, 2000), the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), where lower values indicated better model fitting. Once a final model was identified, model diagnostics were revised to identify potential departure from the GLMM assumptions or observations with large influence in the model results.

The indices of abundance were estimated as the product of the least squares means (LSmeans) of the factor *Year* from each of the two analyses that constitute a hurdle model, after back-transforming to the response scale. The variance estimation of the standardized index was calculated following Walter and Ortiz (2012) for two-stage CPUE estimators.

All the analyses were conducted using the software R-3.4.3 (R Core Team, 2017) with additional packages *lmtest* (Zeileis and Hothorn, 2002), *lattice* (Sarkar, 2008), *HLMdiag* (Loy and Hofmann, 2014), *lme4* (Bates *et al*., 2015) and *lsmeans* (Lenth, 2016).

Results and Discussion

Deviance tables for alfonsino from the DCF dataset analyses are presented in **Table 2**. For the proportion of positive catches; *Year*, *Vessel*, *Depth* and *Target* and the interactions *Year:Quarter* and *Year:Vessel* were the major factors that explained whether or not a set caught at least one fish. For the positive catches; the main factors *Year*, *Vessel* and *Target* and the interactions *Year:Quarter, Year:Vessel* and *Year:Port* were more significant. The *Year* interactions were considered as random effects and their statistical effect were evaluated using the AIC, BIC, and likelihood ratio test (**Table 3**).

Model diagnostics for the positive catches included plots for a check of the link function, the variance function, and the check for the error distribution of the model (**Fig. 1a-c**). All diagnostic plots showed no strong indication of departure from the expected or null pattern, and there was no observation with large influence in the model results (**Fig. 1d**). Thus, we can conclude that the model selected is not grossly wrong. However, additional analyses are necessary to check if the zero-altered lognormal is the best error distribution model for standardization of alfonsino catch rates.

Standardized CPUE series for alfonsino are shown in **Table 4** and **Fig. 2**. The index trends showed a peak in 1991, followed by a decreasing trend until 1997, and a more stable trend afterwards.

Acknowledgements

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TABLES

Table 1. Explanatory variables (main factors) used in the model formulations for standardized alfonsino catch rates.

Variable	Type	Observations
Year	Categorical (28)	Period: 1990-2017
Quarter	Categorical (4)	1: January-March
		2: April-June
		3: July-September
		4: October-December
Vessel	Categorical (5)	1: ≤ 10 m
		2: > 10 and ≤ 12 m
		3: > 12 and ≤ 18 m
		4: > 18 and ≤ 24 m
		5: > 24 and ≤ 40 m
Port	Categorical (4)	1: São Miguel
		2: Terceira
		3: Faial
		4: Others
Depth	Categorical (3)	1: shallow (< 200 m)
		2: intermediate (200-600 m)
		3: deep (> 600 m)
Target	Categorical (4)	1: 1st quartile (≤ 25%)
		2: 2nd quartile (> 25% and ≤ 50%)
		3: 3rd quartile (> 50% and ≤ 75%)
		4: 4th quartile (> 75%)

Table 2. Deviance analysis table of explanatory variables for the zero-altered lognormal model formulations for alfonsino catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Factors and interactions that accounted for 5% or more of the variability were highlighted and correspond to the selected explanatory variables.

Model structure	d.f.	Res Dev	Δ Dev.	% of Dev. exp.	*p*-value
Binomial (proportion of positive catches)					
Null		12340			
Year	27	11735	604.96	**13.1**	< 0.001
Year Quarter	3	11621	113.98	2.5	< 0.001
Year Quarter Vessel	4	10046.6	1574.44	**34.2**	< 0.001
Year Quarter Vessel Port	3	9951.7	94.87	2.1	< 0.001
Year Quarter Vessel Port Depth	2	9494.5	457.23	**9.9**	< 0.001
Year Quarter Vessel Port Depth Target	3	9124.5	370	**8.0**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	8343.4	781.08	**16.9**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	86	8035.8	307.67	**6.7**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	65	7857.9	177.85	3.9	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	52	7731.2	126.68	2.7	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	38	7731.2	0	0.0	1.000
Lognormal (positive catches)					
Null		6917.9			
Year	27	6216.9	701.02	**25.9**	< 0.001
Year Quarter	3	6138.6	78.32	2.9	< 0.001
Year Quarter Vessel	4	5801.2	337.39	**12.5**	< 0.001
Year Quarter Vessel Port	3	5769.1	32.03	1.2	< 0.001
Year Quarter Vessel Port Depth	2	5663	106.16	3.9	< 0.001
Year Quarter Vessel Port Depth Target	3	4983.4	679.62	**25.1**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	71	4770.9	212.5	**7.9**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	79	4487.9	282.98	**10.5**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	48	4343.6	144.3	**5.3**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	44	4257.8	85.77	3.2	0.058
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	37	4214.4	43.39	1.6	0.780

d.f.: degrees of freedom; Res. Dev.: residual deviance; Δ Dev.: change in deviance; % of Dev. exp.: percent of deviance explained; *p*-value: based on chi-squared (χ^2) distribution and used to determine the explanatory variables that contributed significantly ($p < 0.05$) to the deviance explained.

Table 3. Analyses of alternative zero-altered lognormal mixed model formulations for alfonsino catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Model structure	– 2 REM log likelihood	Akaike's information criterion	Bayesian information criterion	Likelihood ratio test	
Binomial (proportion of positive catches)					
Year Vessel Depth Target Quarter	9262.3	9342.3	9629.3		
Year Vessel Depth Target Quarter *Year:Quarter*	8825.9	8907.9	9202.1	436.3	< 0.001
Year Vessel Depth Target Quarter *Year:Quarter Year:Vessel* *	8713.9	8797.9	9099.3	112.0	< 0.001
Lognormal (positive catches)					
Year Vessel Target Quarter Port	10690.1	10774.0	11029.9		
Year Vessel Target Quarter Port *Year:Quarter*	10689.0	10775.0	11036.8	1.2	0.281
Year Vessel Target Quarter Port *Year:Quarter Year:Vessel* *	10662.4	10750.4	11018.3	26.6	< 0.001
Year Vessel Target Quarter Port *Year:Quarter Year:Vessel Year:Port*	10662.4	10752.4	11026.4	0.0	0.9644

The factors in normal typeface are treated as fixed effects and those in italics are random interactions.

* The final zero-altered lognormal mixed model.

Table 4. Nominal and standardized CPUE series (kg 10^{-3} hooks) for alfonsino (*Beryx decadactylus*) catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds. The values are scaled to mean.

Year	Nominal CPUE	Standardized CPUE	LCI	UCI
1990	0.19	0.80	0.64	0.96
1991	1.53	2.74	2.00	3.48
1992	0.07	1.36	1.01	1.72
1993	2.11	1.62	1.18	2.06
1994	2.64	1.47	1.05	1.88
1995	1.27	1.89	1.39	2.39
1996	2.64	1.49	1.01	1.96
1997	0.57	0.64	0.46	0.82
1998	0.69	0.75	0.55	0.95
1999	0.41	0.48	0.35	0.60
2000	0.65	0.69	0.50	0.88
2001	0.53	0.55	0.39	0.72
2002	0.71	0.77	0.52	1.02
2003	0.47	0.51	0.36	0.66
2004	0.50	0.60	0.42	0.78
2005	0.42	0.50	0.38	0.63
2006	1.13	0.78	0.56	1.00
2007	0.98	0.67	0.46	0.88
2008	1.13	0.96	0.69	1.23
2009	1.48	1.04	0.75	1.33
2010	1.43	1.24	0.96	1.51
2011	1.03	1.21	0.95	1.47
2012	1.44	1.05	0.83	1.28
2013	0.89	0.87	0.69	1.05
2014	0.68	0.80	0.64	0.97
2015	0.90	1.02	0.80	1.24
2016	0.97	0.86	0.65	1.08
2017	0.53	0.62	0.47	0.77

FIGURES

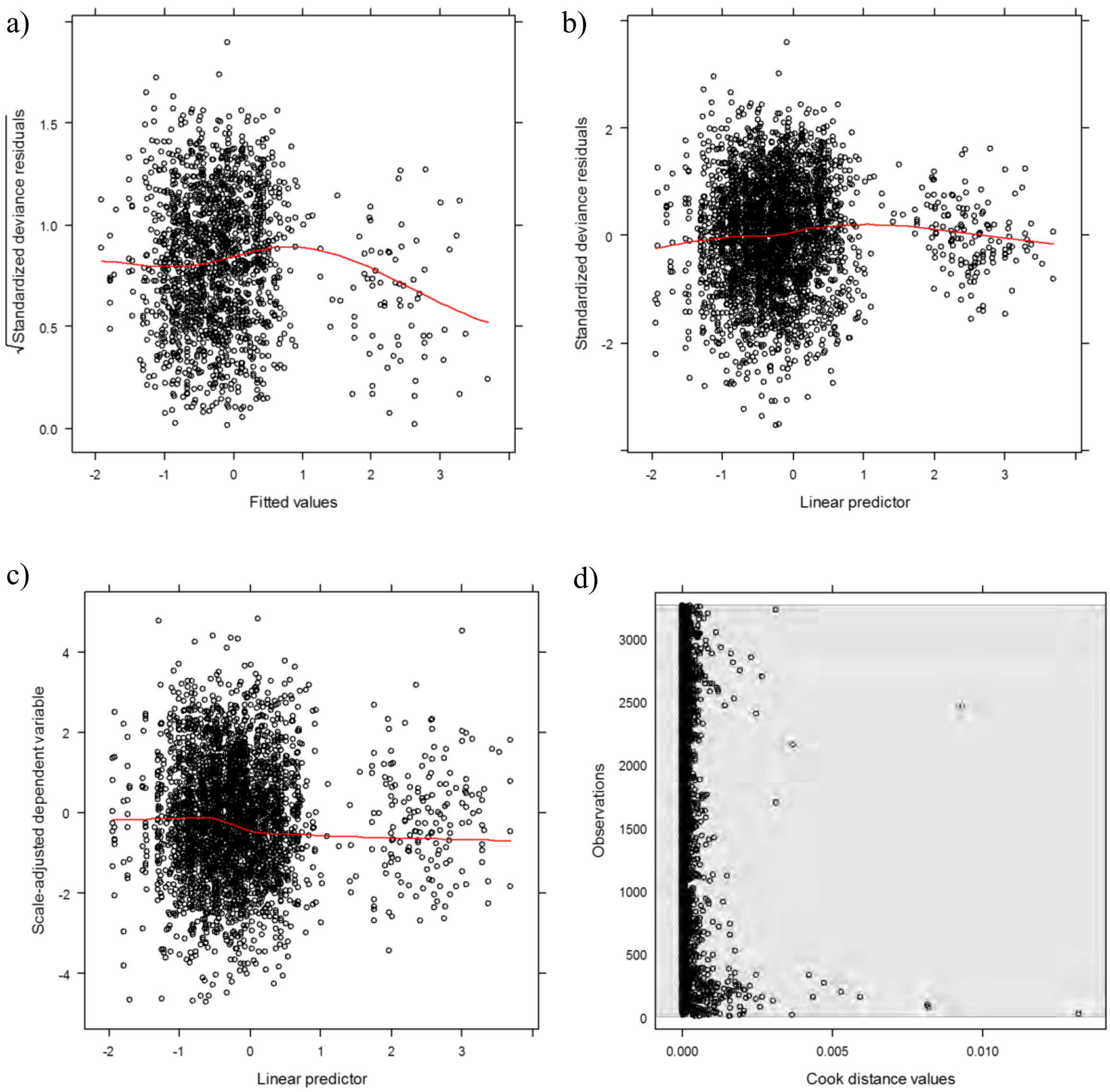

Fig. 1. Diagnostic plots for positive alfonsino (*Beryx decadactylus*) catch rates to check (a) the adequacy of the assumed variance function, (b) the assumed error distribution, (c) the link function selection, and (d) the influential observations. The null pattern is a no trend in the residuals (a), a distribution of residuals with mean zero and constant variance (b), a straight line (c), and no observation with Cook distance value greater than 1 (d). The red line is the loess smoother through the plotted values.

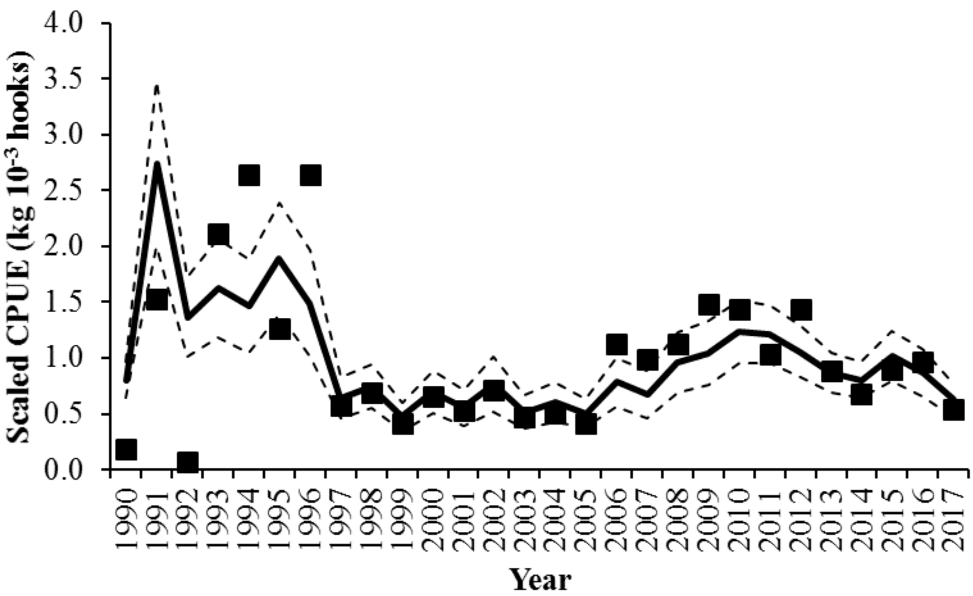

Fig. 2. Nominal (■) and standardized (▬) CPUE (kg 10^{-3} hooks) alfonsino (*Beryx decadactylus*) from the Azorean bottom longline fishery, 1990–2017. Dotted lines represent 95% confidence intervals for the standardized CPUE.

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

Régis V. S. Santos[1*], Wendell Medeiros-Leal[1], Ana M. Novoa-Pabon[1], Mario R. Pinho[1]

ABSTRACT

Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2017. The CPUE of alfonsinos was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. The standardized CPUE series showed an oscillation over time, with an increase up to 1996, followed by a decreasing trend overall with some recovery between 2003 and 2012, and a rapid decrease afterwards.

KEYWORDS

Alfonsinos; demersal fisheries; CPUE; abundance; Azores; GLMM

Introduction

The Azorean fishery for demersal species has traditionally been a multispecific fishery, where several types of hooks and gears are used by the local fleet. The demersal fishing fleet consists mainly of small-scale boats (< 12 m length), mostly equipped with handlines and bottom longlines. The alfonsinos (*Beryx splendens* and *B. decadactylus*) are one of the fish species targeted by the Azorean bottom longline fleet, which also directs its effort to the other demersal species such as blackspot seabream (*Pagellus bogaraveo*), wreckfish (*Polyprion americanus*), blackbelly rosefish (*Helicolenus dactylopterus*), forkbeard (*Phycis phycis*), and European conger (*Conger conger*) (Pinho and Menezes, 2005; Pinho *et al.*, 2015; Santos *et al.*, 2019).

Indices of abundance from commercial fisheries have been used to tune stock assessment models (Quinn and Deriso, 1999, Maunder and Punt, 2004), and their use have been strictly recommended by the International Council for the Exploration of the Sea (ICES) for stock advice. The utility of indices of abundance based on nominal catch rates can be improved by standardizing them to remove the

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impact of factors other than changes over time in stock biomass, usually by using statistical regression methods (Ortiz and Arocha, 2004).

This study updates the standardized catch rates for alfonsinos (*Beryx splendens* and *B. decadactylus* combined) captured by the Azorean bottom longline fleet up to 2017, revising the dataset and the available explanatory variables. Standardized catch rates were estimated using a Generalized Linear Mixed Model with random factor interactions particularly for the *Year* effect. The combined analysis of these species is justified by the catches of alfonsinos are reported under a single group (*Beryx* spp.) in ICES advice.

Material and methods

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAç), and was collected during the period of 1990–2017 as part of the mandate of the European Commission´s Data Collection Framework (DCF). Sampling was designed to cover the main ports of the Azores and was performed by clerks who carried out standardized fishing inquiries (n = 9722) to the captains of the bottom longline vessels during the landings. Each record report included: the vessel identification, the dates of departure and return to the port and detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, fishing area and catch in weight for each species landed.

Factors considered in the analyses of the alfonsinos catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: *São Miguel*, *Terceira* and *Faial*, which represent around 95% of the Azorean landings, and *Others*, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Pinho and Menezes, 2005; Menezes *et al*., 2006), and target (**Table 1**). The target was defined as the percentage of alfonsinos catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of alfonsinos caught per 1000 hooks. Records with missing effort data were excluded from the analysis.

Relative indices of abundance for the alfonsinos species were estimated by Generalized Linear Modeling approach using a hurdle (delta) model (Lo *et al*., 1992; Ortiz and Arocha, 2004; Zuur and Ieno, 2016). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modeling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modeling the positive catch rates on successful trips.

Deviance tables were used to select the explanatory factors and interactions that explained most of the variability in the data (Ortiz and Arocha, 2004). The effect of each explanatory factor/interaction was evaluated according to 1) the percent of deviance explained by the addition of a specific factor/interaction to the model, and 2) the result of the Chi-squared (χ^2) test between two nested models. Only those factors and interactions that accounted for 5% or more of the variability were selected as explanatory variables.

After selecting the set of explanatory factors/interactions for each error distribution, all interactions that included the factor *Year* were treated as random interactions (Cooke, 1997). This process converted the basic models from generalized linear models into generalized linear mixed models (GLMMs). The significance of the random interactions was evaluated using the likelihood ratio test (Pinheiro and Bates, 2000), the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), where lower values indicated better model fitting. Once a final model was identified, model diagnostics were revised to identify potential departure from the GLMM assumptions or observations with large influence in the model results.

The indices of abundance were estimated as the product of the least squares means (LSmeans) of the factor *Year* from each of the two analyses that constitute a hurdle model, after back-transforming to the response scale. The variance estimation of the standardized index was calculated following Walter and Ortiz (2012) for two-stage CPUE estimators.

All the analyses were conducted using the software R-3.4.3 (R Core Team, 2017) with additional packages *lmtest* (Zeileis and Hothorn, 2002), *lattice* (Sarkar, 2008), *influence.ME* (Nieuwenhuis *et al*., 2012), *lme4* (Bates *et al*., 2015) and *lsmeans* (Lenth, 2016).

Results and Discussion

Deviance tables for alfonsinos from the DCF dataset analyses are presented in **Table 2**. For the proportion of positive catches; *Year*, *Vessel*, *Depth* and *Target* and the interaction *Year:Quarter* were the major factors that explained whether or not a set caught at least one fish. For the positive catches; the main factors *Year* and *Target* and the interactions *Year:Quarter* and *Year:Vessel* were more significant. The *Year* interactions were considered as random effects and their statistical effect were evaluated using the AIC, BIC, and likelihood ratio test (**Table 3**).

Model diagnostics for the positive catches included plots for a check of the link function, the variance function, and the check for the error distribution of the model (**Fig. 1a-c**). All diagnostic plots showed no indication of departure from the expected or null pattern, and there was no observation with large influence in the model results (**Fig. 1d**). Thus, we can conclude that the model selected is not grossly wrong.

Standardized CPUE series for alfonsinos are shown in **Table 4** and **Fig. 4**. The index trends showed an oscillation over time, with an increase up to 1996, followed by a decreasing trend overall with some recovery between 2003 and 2012, and a rapid decrease afterwards.

Acknowledgements

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TABLES

Table 1. Explanatory variables (main factors) used in the model formulations for standardized alfonsinos catch rates.

Variable	Type	Observations
Year	Categorical (28)	Period: 1990-2017
Quarter	Categorical (4)	1: January-March
		2: April-June
		3: July-September
		4: October-December
Vessel	Categorical (5)	1: ≤ 10 m
		2: > 10 and ≤ 12 m
		3: > 12 and ≤ 18 m
		4: > 18 and ≤ 24 m
		5: > 24 and ≤ 40 m
Port	Categorical (4)	1: São Miguel
		2: Terceira
		3: Faial
		4: Others
Depth	Categorical (3)	1: shallow (< 200 m)
		2: intermediate (200-600 m)
		3: deep (> 600 m)
Target	Categorical (4)	1: 1st quartile (≤ 25%)
		2: 2nd quartile (> 25% and ≤ 50%)
		3: 3rd quartile (> 50% and ≤ 75%)
		4: 4th quartile (> 75%)

Table 2. Deviance analysis table of explanatory variables for the zero-altered lognormal model formulations for alfonsinos catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Factors and interactions that accounted for 5% or more of the variability were highlighted and correspond to the selected explanatory variables.

Model structure	d.f.	Res Dev	Δ Dev.	% of Dev. exp.	*p*-value
Binomial (proportion of positive catches)					
Null		13171.3			
Year	27	12661.9	493.1	**8.1**	< 0.001
Year Quarter	3	12481.5	169.0	2.8	< 0.001
Year Quarter Vessel	4	10601.7	1816.0	**29.8**	< 0.001
Year Quarter Vessel Port	3	10509.1	89.5	1.5	< 0.001
Year Quarter Vessel Port Depth	2	10082.9	1086.9	**17.8**	< 0.001
Year Quarter Vessel Port Depth Target	3	8739.6	1113.6	**18.3**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	7870.8	866.4	**14.2**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	86	7593.2	259.4	4.3	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	65	7400.3	144.8	2.4	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	52	7280.3	51.7	0.8	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	71	7280.3	0.0	0.0	1.000
Lognormal (positive catches)					
Null		10817.6			
Year	27	9648.9	1168.7	**21.1**	< 0.001
Year Quarter	3	9633.0	15.9	0.3	< 0.050
Year Quarter Vessel	4	9485.4	147.6	2.7	< 0.001
Year Quarter Vessel Port	3	9474.8	10.7	0.2	0.057
Year Quarter Vessel Port Depth	2	9458.1	16.6	0.3	< 0.010
Year Quarter Vessel Port Depth Target	3	6170.1	3288.0	**59.3**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	75	5900.4	269.7	**4.9**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	84	5629.3	271.1	**4.9**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	55	5498.1	131.2	2.4	< 0.010
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	51	5438.4	59.7	1.1	0.806
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	71	5268.5	169.9	3.1	< 0.001

d.f.: degrees of freedom; Res. Dev.: residual deviance; Δ Dev.: change in deviance; % of Dev. exp.: percent of deviance explained; *p*-value: based on chi-squared (χ^2) distribution and used to determine the explanatory variables that contributed significantly ($p < 0.05$) to the deviance explained.

Table 3. Analyses of alternative zero-altered lognormal mixed model formulations for alfonsinos catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Model structure	– 2 REM log likelihood	Akaike's information criterion	Bayesian information criterion	Likelihood ratio test	
Binomial (proportion of positive catches)					
Year Vessel Depth Target Quarter	8832.8	8912.8	9199.9		
Year Vessel Depth Target Quarter *Year:Quarter* *	8319.5	8401.5	8695.7	513.3	< 0.001
Lognormal (positive catches)					
Year Target Quarter Vessel	13755.4	13509.0	13430.6		
Year Target Quarter Vessel *Year:Quarter*	13412.8	13492.8	13745.9	17.7	< 0.001
Year Vessel Depth Target Quarter *Year:Quarter Year:Vessel* *	13395.0	13477.0	13736.5	17.8	< 0.001

The factors in normal typeface are treated as fixed effects and those in italics are random interactions.

* The final zero-altered lognormal mixed model.

Table 4. Nominal and standardized CPUE series (kg 10^{-3} hooks) for alfonsinos (*Beryx* spp.) catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds. The values are scaled to mean.

Year	Nominal CPUE	Standardized CPUE	LCI	UCI
1990	0.89	1.02	0.78	1.26
1991	1.28	1.40	1.06	1.73
1992	0.20	0.94	0.68	1.21
1993	1.30	1.41	1.05	1.78
1994	1.51	1.33	0.96	1.71
1995	0.81	1.36	1.04	1.69
1996	2.68	1.66	1.17	2.15
1997	0.50	1.07	0.78	1.37
1998	0.74	0.95	0.73	1.17
1999	1.01	0.94	0.72	1.15
2000	1.00	0.84	0.65	1.03
2001	1.45	0.80	0.60	1.01
2002	1.51	0.89	0.65	1.14
2003	0.72	0.51	0.39	0.63
2004	0.87	0.63	0.48	0.79
2005	0.94	0.83	0.65	1.02
2006	1.16	0.88	0.67	1.09
2007	1.12	0.80	0.59	1.01
2008	1.10	1.11	0.84	1.37
2009	1.35	1.24	0.95	1.53
2010	1.10	1.16	0.92	1.40
2011	0.92	1.34	1.07	1.60
2012	1.33	1.39	1.12	1.67
2013	0.77	1.11	0.90	1.32
2014	0.39	0.57	0.47	0.67
2015	0.66	0.64	0.52	0.75
2016	0.45	0.70	0.56	0.84
2017	0.25	0.45	0.36	0.55

FIGURES

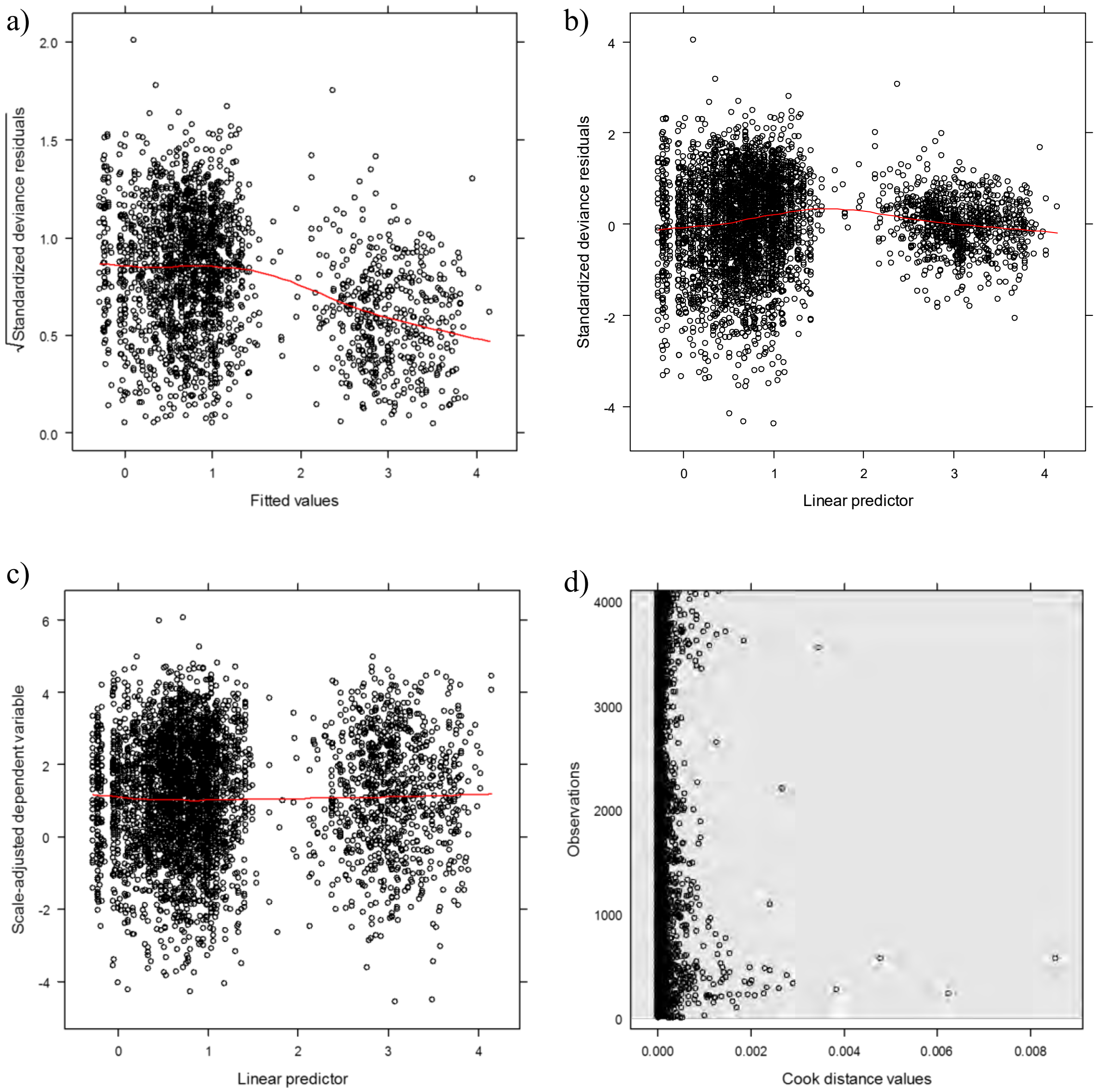

Fig. 1. Diagnostic plots for positive alfonsinos (*Beryx* spp.) catch rates to check (a) the adequacy of the assumed variance function, (b) the assumed error distribution, (c) the link function selection, and (d) the influential observations. The null pattern is a no trend in the residuals (a), a distribution of residuals with mean zero and constant variance (b), a straight line (c), and no observation with Cook distance value greater than 1 (d). The red line is the loess smoother through the plotted values.

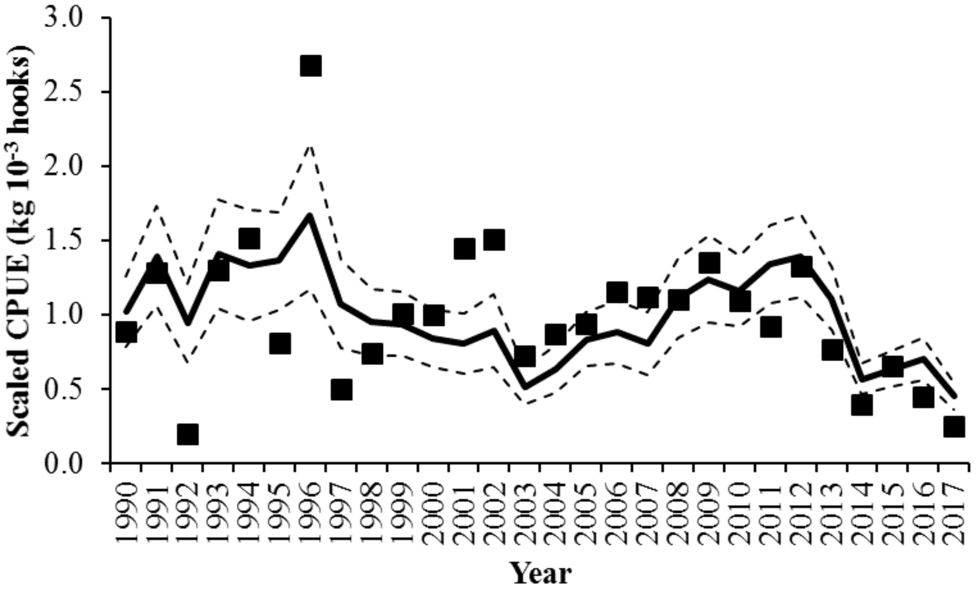

Fig. 2. Nominal (■) and standardized (**—**) CPUE (kg 10^{-3} hooks) for alfonsinos (*Beryx* spp.) from the Azorean bottom longline fishery, 1990–2016. Dotted lines represent 95% confidence intervals for the standardized CPUE.

Updated standardized CPUE for *Helicolenus dactylopterus* caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017

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Régis V. S. Santos[1*], Wendell Medeiros-Leal[1], Ana M. Novoa-Pabon[1], Mario R. Pinho[1]

ABSTRACT

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KEYWORDS

Blackbelly rosefish; demersal fisheries; CPUE; abundance; Azores; GLMM

Introduction

The Azorean fishery for demersal species has traditionally been a multispecific fishery, where several types of hooks and gears are used by the local fleet. The demersal fishing fleet consists mainly of small-scale boats (< 12 m length), mostly equipped with handlines and bottom longlines. The blackbelly rosefish (*Helicolenus dactylopterus*) is one of the species targeted by the Azorean bottom longline fleet (Santos *et al*., 2020), which also directs its effort to the other demersal species such as blackspot seabream (*Pagellus bogaraveo*), wreckfish (*Polyprion americanus*), forkbeard (*Phycis phycis*), European conger (*Conger conger*), and alfonsinos (*Beryx decadactylus* and *Beryx splendens*), (Pinho and Menezes, 2005; Pinho *et al*., 2015; Santos *et al*., 2019).

Indices of abundance from commercial fisheries have been used to tune stock assessment models (Quinn and Deriso, 1999, Maunder and Punt, 2004), and their use have been strictly recommended by the International Council for the Exploration of the Sea (ICES) for stock advice. The utility of indices of abundance based on nominal catch rates can be improved by standardizing them to remove the impact of factors other than changes over time in stock biomass, usually by using statistical regression methods (Ortiz and Arocha, 2004).

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This study updates the standardized catch rates for blackbelly rosefish captured by the Azorean bottom longline fleet up to 2017, revising the dataset and the available explanatory variables. Standardized catch rates were estimated using a Generalized Linear Mixed Model with random factor interactions particularly for the *Year* effect.

Material and methods

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAç), and was collected during the period of 1990–2017 as part of the mandate of the European Commission's Data Collection Framework (DCF). Sampling was designed to cover the main ports of the Azores and was performed by clerks who carried out standardized fishing inquiries (n = 9722) to the captains of the bottom longline vessels during the landings. Each record report included: the vessel identification, the dates of departure and return to the port and detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, fishing area and catch in weight for each species landed.

Factors considered in the analyses of the blackbelly rosefish catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: *São Miguel*, *Terceira* and *Faial*, which represent around 95% of the Azorean landings, and *Others*, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Pinho and Menezes, 2005; Menezes *et al*., 2006), and target (**Table 1**).The target was defined as the percentage of blackbelly rosefish catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of blackbelly rosefish caught per 1000 hooks. Records with missing effort data were excluded from the analysis.

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Deviance tables were used to select the explanatory factors and interactions that explained most of the variability in the data (Ortiz and Arocha, 2004). The effect of each explanatory factor/interaction was evaluated according to 1) the percent of deviance explained by the addition of a specific factor/interaction to the model, and 2) the result of the Chi-squared (χ^2) test between two nested models. Only those factors and interactions that accounted for 5% or more of the variability were selected as explanatory variables.

After selecting the set of explanatory factors/interactions for each error distribution, all interactions that included the factor *Year* were treated as random interactions (Cooke, 1997). This process converted the basic models from generalized linear models into generalized linear mixed models (GLMMs). The significance of the random interactions was evaluated using the likelihood ratio test

(Pinheiro and Bates, 2000), the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), where lower values indicated better model fitting.

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Results and Discussion

Deviance tables for blackbelly rosefish from the DCF dataset analyses are presented in **Table 2**. For the proportion of positive catches; *Year*, *Vessel*, *Port*, *Depth* and *Target* and the interaction *Year:Vessel* were the major factors that explained whether or not a set caught at least one fish. For the positive catches; only the main factors *Year*, *Vessel* and *Target* were more significant. The *Year* interactions were considered as random effects in the hurdle model subcomponents, and their statistical effect were evaluated using the AIC, BIC, and likelihood ratio test (**Table 3**).

Model diagnostics for the positive catches included plots for a check of the link function, the variance function, and the check for the error distribution of the model (**Fig. 1a-c**). All diagnostic plots showed no indication of departure from the expected or null pattern, and there was no observation with large influence in the model results (**Fig. 1d**). Thus, we can conclude that the model selected is not grossly wrong.

Standardized CPUE series for blackbelly rosefish are shown in **Table 4** and **Fig. 2**. The index trends showed an oscillation over time, with a more stable trend since 2001.

Acknowledgements

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Table 1. Explanatory variables (main factors) used in the model formulations for standardized blackbelly rosefish catch rates.

Variable	Type	Observations
Year	Categorical (28)	Period: 1990-2017
Quarter	Categorical (4)	1: January-March
		2: April-June
		3: July-September
		4: October-December
Vessel	Categorical (5)	1: ≤ 10 m
		2: > 10 and ≤ 12 m
		3: > 12 and ≤ 18 m
		4: > 18 and ≤ 24 m
		5: > 24 and ≤ 40 m
Port	Categorical (4)	1: São Miguel
		2: Terceira
		3: Faial
		4: Others
Depth	Categorical (3)	1: shallow (< 200 m)
		2: intermediate (200-600 m)
		3: deep (> 600 m)
Target	Categorical (4)	1: 1st quartile (≤ 25%)
		2: 2nd quartile (> 25% and ≤ 50%)
		3: 3rd quartile (> 50% and ≤ 75%)
		4: 4th quartile (> 75%)

Table 2. Deviance analysis table of explanatory variables for the zero-altered lognormal model formulations for blackbelly rosefish catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Factors and interactions that accounted for 5% or more of the variability were highlighted and correspond to the selected explanatory variables.

Model structure	**d.f.**	**Res Dev**	**Δ Dev.**	**% of Dev. exp.**	***p*-value**
Binomial (proportion of positive catches)					
Null		11567.7			
Year	27	11237	330.73	**7.5**	< 0.001
Year Quarter	3	11230.9	6.12	0.1	0.106
Year Quarter Vessel	4	9862.3	1368.58	**31.2**	< 0.001
Year Quarter Vessel Port	3	9573.1	289.2	**6.6**	< 0.001
Year Quarter Vessel Port Depth	2	8952.8	620.32	**14.1**	< 0.001
Year Quarter Vessel Port Depth Target	3	8098.8	853.98	**19.5**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	7957.6	141.21	3.2	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	86	7540.9	416.64	**9.5**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	65	7372.3	168.67	3.8	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	52	7179.3	192.95	4.4	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	70	7179.3	0	0.0	1.000
Lognormal (positive catches)					
Null		11227.5			
Year	27	10775.1	452.4	**9.1**	< 0.001
Year Quarter	3	10600.2	174.9	3.5	< 0.001
Year Quarter Vessel	4	10359.7	240.5	**4.8**	< 0.001
Year Quarter Vessel Port	3	10313.1	46.6	0.9	< 0.001
Year Quarter Vessel Port Depth	2	10132.4	180.6	3.6	< 0.001
Year Quarter Vessel Port Depth Target	3	6920.6	3211.8	**64.5**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	6836.0	84.6	1.7	0.252
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	86	6641.8	194.2	3.9	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	59	6460.9	180.9	3.6	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	52	6335.2	125.6	2.5	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	70	6250.1	85.1	1.7	0.066

d.f.: degrees of freedom; Res. Dev.: residual deviance; Δ Dev.: change in deviance; % of Dev. exp.: percent of deviance explained; *p*-value: based on chi-squared (χ^2) distribution and used to determine the explanatory variables that contributed significantly ($p < 0.05$) to the deviance explained.

Table 3. Analyses of alternative zero-altered lognormal mixed model formulations for blackbelly rosefish catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Model structure	– 2 REM log likelihood	Akaike's information criterion	Bayesian information criterion	Likelihood ratio test	
Binomial (proportion of positive catches)					
Year Vessel Port Depth Target	8101.0	8181.0	8468.0		
Year Vessel Port Depth Target *Year:Vessel* *	7931.9	8013.9	8308.1	169.1	< 0.001
Lognormal (positive catches)					
Year Vessel Target *	19842.9	19915.0	20161.3		

The factors in normal typeface are treated as fixed effects and those in italics are random interactions.

* The final zero-altered lognormal mixed model.

Table 4. Nominal and standardized CPUE series (kg 10^{-3} hooks) for blackbelly rosefish (*Helicolenus dactylopterus*) catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds. The values are scaled to mean.

Year	Nominal CPUE	Standardized CPUE	LCI	UCI
1990	1.23	1.27	1.10	1.44
1991	1.27	1.15	0.97	1.33
1992	0.42	0.76	0.60	0.92
1993	1.26	1.19	0.99	1.39
1994	0.78	1.01	0.82	1.20
1995	0.52	1.05	0.87	1.22
1996	0.94	1.39	1.12	1.65
1997	0.62	1.00	0.81	1.19
1998	0.88	1.08	0.92	1.25
1999	1.64	1.48	1.27	1.68
2000	1.53	1.37	1.20	1.54
2001	1.15	0.93	0.79	1.07
2002	1.70	1.16	0.98	1.34
2003	1.31	1.09	0.95	1.23
2004	1.25	0.83	0.72	0.95
2005	0.78	0.71	0.63	0.80
2006	0.95	0.82	0.71	0.92
2007	1.08	0.87	0.75	1.00
2008	0.93	0.99	0.87	1.12
2009	0.77	0.81	0.71	0.90
2010	0.78	0.78	0.70	0.87
2011	0.65	0.83	0.74	0.92
2012	0.59	0.85	0.75	0.94
2013	0.83	1.01	0.89	1.12
2014	0.78	1.05	0.92	1.17
2015	0.79	0.85	0.76	0.95
2016	0.88	0.87	0.77	0.97
2017	1.68	0.81	0.71	0.90

FIGURES

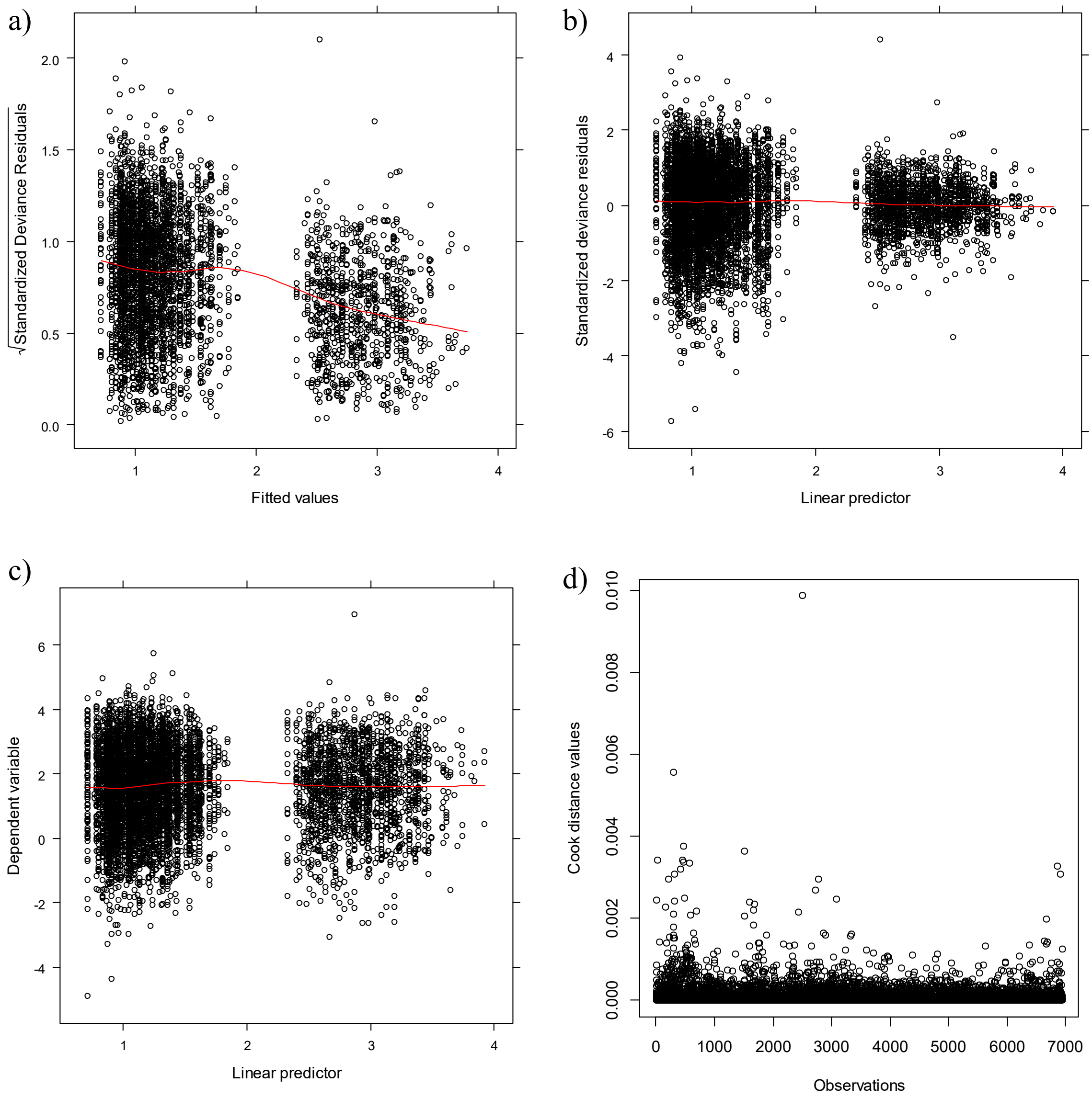

Fig. 1. Diagnostic plots for positive blackbelly rosefish (*Helicolenus dactylopterus*) catch rates to check (a) the adequacy of the assumed variance function, (b) the assumed error distribution, (c) the link function selection, and (d) the influential observations. The null pattern is a no trend in the residuals (a), a distribution of residuals with mean zero and constant variance (b), a straight line (c), and no observation with Cook distance value greater than 1 (d). The red line is the loess smoother through the plotted values.

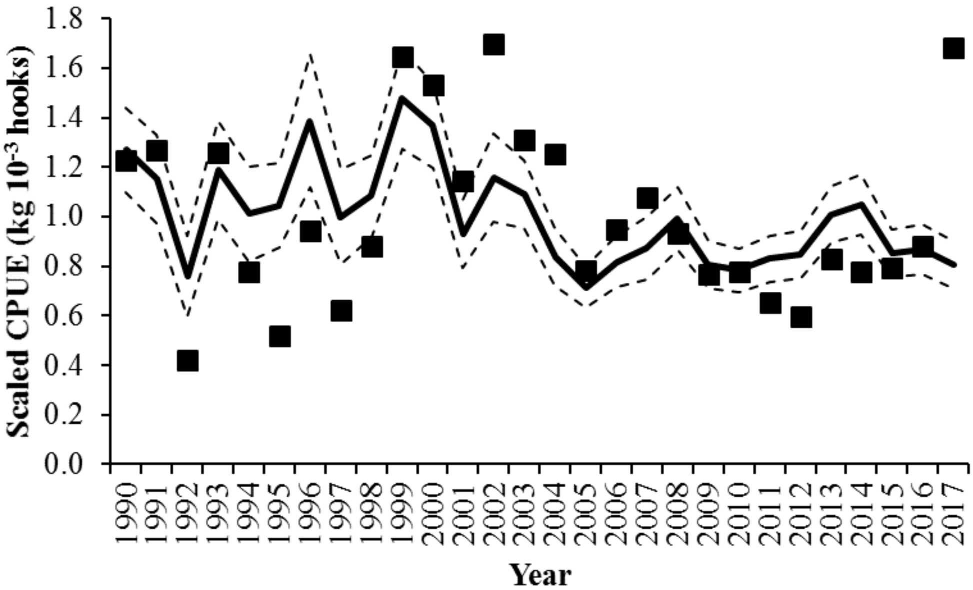

Fig. 2. Nominal (■) and standardized (▬) CPUE (kg 10^{-3} hooks) for blackbelly rosefish (*Helicolenus dactylopterus*) from the Azorean bottom longline fishery, 1990–2017. Dotted lines represent 95% confidence intervals for the standardized CPUE.

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

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ABSTRACT

Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2017. The CPUE of blackspot seabream was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. The standardized CPUE series showed an oscillation over time, with a general increasing trend until 1996, and a general decreasing behavior after this period.

KEYWORDS

Pagellus bogaraveo; demersal fisheries; CPUE; abundance; Azores; GLMM

Introduction

The Azorean fishery for demersal species has traditionally been a multispecific fishery, where several types of hooks and gears are used by the local fleet. The demersal fishing fleet consists mainly of small-scale boats (< 12 m length), mostly equipped with handlines and bottom longlines. The blackspot seabream (*Pagellus bogaraveo*) is the main species targeted by the Azorean bottom longline fleet, but the fishery also directs its effort to the other demersal species such as wreckfish (*Polyprion americanus*), blackbelly rosefish (*Helicolenus dactylopterus*), forkbeard (*Phycis phycis*), European conger (*Conger conger*) and alfonsinos (*Beryx splendens* and *Beryx decadactylus*) (Pinho and Menezes, 2005; Pinho *et al.*, 2015; Santos *et al.*, 2019).

Indices of abundance from commercial fisheries have been used to tune stock assessment models (Quinn and Deriso, 1999, Maunder and Punt, 2004), and their use have been strictly recommended by the International Council for the Exploration of the Sea (ICES) for stock advice. The utility of indices of abundance based on nominal catch rates can be improved by standardizing them to remove the

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impact of factors other than changes over time in stock biomass, usually by using statistical regression methods (Ortiz and Arocha, 2004).

This study updates the standardized catch rates for blackspot seabream captured by the Azorean bottom longline fleet up to 2017, revising the dataset and the available explanatory variables. Standardized catch rates were estimated using a Generalized Linear Mixed Model with random factor interactions particularly for the *Year* effect.

Material and methods

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAç), and was collected during the period of 1990–2017 as part of the mandate of the European Commission´s Data Collection Framework (DCF). Sampling was designed to cover the main ports of the Azores and was performed by clerks who carried out standardized fishing inquiries (n = 9722) to the captains of the bottom longline vessels during the landings. Each record report included: the vessel identification, the dates of departure and return to the port and detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, fishing area and catch in weight for each species landed.

Factors considered in the analyses of the blackspot seabream catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: *São Miguel*, *Terceira* and *Faial*, which represent around 95% of the Azorean landings, and *Others*, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Pinho and Menezes, 2005; Menezes *et al*., 2006), and target (**Table 1**). The target was defined as the percentage of blackspot seabream catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of blackspot seabream caught per 1000 hooks. Records with structural zeros (see Zuur *et al*., 2009) and missing effort data were excluded from the analysis.

Relative indices of abundance for the blackspot seabream species were estimated by Generalized Linear Modeling approach using a hurdle (delta) model (Lo *et al*., 1992; Ortiz and Arocha, 2004; Zuur and Ieno, 2016). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modeling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modeling the positive catch rates on successful trips.

Deviance tables were used to select the explanatory factors and interactions that explained most of the variability in the data (Ortiz and Arocha, 2004). The effect of each explanatory factor/interaction was evaluated according to 1) the percent of deviance explained by the addition of a specific factor/interaction to the model, and 2) the result of the Chi-squared (χ^2) test between two nested models. Only those factors and interactions that accounted for 5% or more of the variability were selected as explanatory variables.

After selecting the set of explanatory factors/interactions for each error distribution, all interactions that included the factor *Year* were treated as random interactions (Cooke, 1997). This process

converted the basic models from generalized linear models into generalized linear mixed models (GLMMs). The significance of the random interactions was evaluated using the likelihood ratio test (Pinheiro and Bates, 2000), the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), where lower values indicated better model fitting. Once a final model was identified, model diagnostics were revised to identify potential departure from the GLMM assumptions or observations with large influence in the model results.

The indices of abundance were estimated as the product of the least squares means (LSmeans) of the factor *Year* from each of the two analyses that constitute a hurdle model, after back-transforming to the response scale. The variance estimation of the standardized index was calculated following Walter and Ortiz (2012) for two-stage CPUE estimators.

All the analyses were conducted using the software R-3.4.3 (R Core Team, 2017) with additional packages *lmtest* (Zeileis and Hothorn, 2002), *lattice* (Sarkar, 2008), *lme4* (Bates *et al*., 2015) and *lsmeans* (Lenth, 2016).

Results and Discussion

Deviance tables for blackspot seabream from the DCF dataset analyses are presented in **Table 2**. For the proportion of positive cacthes; *Year*, *Vessel*, *Port*, and *Target* and the interactions *Year:Vessel*, and *Year:Port* were the major factors that explained whether or not a set caught at least one fish. For the positive catches, only the main factors: *Year*, *Vessel*, and *Target* were more significant. The *Year* interactions were considered as random effects and their statistical effect were evaluated using the AIC, BIC, and likelihood ratio test (**Table 3**).

Model diagnostics for the positive catches included plots for a check of the link function, the variance function, and the check for the error distribution of the model (**Fig. 1a-c**). All diagnostic plots showed no indication of departure from the expected or null pattern, and there was no observation with large influence in the model results (**Fig. 1d**). Thus, we can conclude that the model selected is not grossly wrong.

Standardized CPUE series for blackspot seabream are shown in **Table 4** and **Fig. 2**. The index trends showed an oscillation over time, with a general increasing trend until 1996, and a general decreasing behavior after this period. The trends from the nominal and standardized index differed markedly from 2002 onwards; indeed, the nominal CPUE (**Fig. 2**) showed a rather increasing trend until 2005, while the standardized index presented a less pronounced trend. According to Ortiz (2017), it is not necessary that the nominal and standardized trends follow the same trend. The standardized index for the *year* factor show in theory the trend of the population, while the nominal catch rates should represent the combined trends of all other factors and its interactions.

Acknowledgements

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		3: July-September
		4: October-December
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		2: > 10 and ≤ 12 m
		3: > 12 and ≤ 18 m
		4: > 18 and ≤ 24 m
		5: > 24 and ≤ 40 m
Port	Categorical (4)	1: São Miguel
		2: Terceira
		3: Faial
		4: Others
Depth	Categorical (3)	1: shallow (< 200 m)
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Model structure	d.f.	Res Dev	Δ Dev.	% of Dev. exp.	*p*-value
Binomial (proportion of positive catches)					
Null		9401.4			
Year	27	8998	403.34	**9.6**	< 0.001
Year Quarter	3	8983	15.06	0.4	< 0.010
Year Quarter Vessel	4	8278.6	704.38	**16.8**	< 0.001
Year Quarter Vessel Port	3	8050	228.58	**5.5**	< 0.001
Year Quarter Vessel Port Depth	2	7621.3	428.71	**10.2**	< 0.001
Year Quarter Vessel Port Depth Target	3	6111	1510.27	**36.1**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	5938.7	172.37	4.1	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	86	5588.5	350.14	**8.4**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	65	5315	273.56	**6.5**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	52	5213	101.93	2.4	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	81	5213	0	0.0	1.000
Lognormal (positive catches)					
Null		12966.9			
Year	27	11531.6	1435.3	**20.1**	< 0.001
Year Quarter	3	11256.2	275.4	3.9	< 0.001
Year Quarter Vessel	4	10847.0	409.3	**5.7**	< 0.001
Year Quarter Vessel Port	3	10686.8	160.2	2.2	< 0.001
Year Quarter Vessel Port Depth	2	10594.8	92.0	1.3	< 0.001
Year Quarter Vessel Port Depth Target	3	6469.0	4125.8	**57.9**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	6319.1	149.9	2.1	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	85	6169.6	149.5	2.1	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	61	6013.1	156.5	2.2	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	51	5932.5	80.5	1.1	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	81	5836.0	96.5	1.4	< 0.010

d.f.: degrees of freedom; Res. Dev.: residual deviance; Δ Dev.: change in deviance; % of Dev. exp.: percent of deviance explained; *p*-value: based on chi-squared (χ^2) distribution and used to determine the explanatory variables that contributed significantly ($p < 0.05$) to the deviance explained.

Table 3. Analyses of alternative zero-altered lognormal mixed model formulations for blackspot seabream catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Model structure	– 2 REM log likelihood	Akaike's information criterion	Bayesian information criterion	Likelihood ratio test	
Binomial (proportion of positive catches)					
Year Vessel Port Depth Target	6135.4	6215.4	6502.5		
Year Vessel Port Depth Target *Year:Vessel*	6030.0	6112.0	6406.2	105.5	< 0.001
Year Vessel Port Depth Target *Year:Vessel Year:Port* *	5932.5	6016.5	6317.9	97.5	< 0.001
Lognormal (positive catches)					
Year Vessel Target *	20890.48	20962.0	21213.5		

The factors in normal typeface are treated as fixed effects and those in italics are random interactions.

* The final zero-altered lognormal mixed model.

Table 4. Nominal and standardized CPUE series (kg 10^{-3} hooks) for blackspot seabream (*Pagellus bogaraveo*) catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds. The values are scaled to mean.

Year	Nominal CPUE	Standardized CPUE	LCI	UCI
1990	0.94	0.98	0.88	1.09
1991	0.95	0.98	0.85	1.11
1992	1.01	0.99	0.81	1.18
1993	0.81	1.01	0.87	1.15
1994	0.99	1.02	0.85	1.19
1995	1.12	1.10	0.94	1.26
1996	1.28	1.53	1.28	1.78
1997	1.68	1.34	1.13	1.56
1998	1.01	1.22	1.07	1.37
1999	1.14	1.32	1.18	1.47
2000	0.73	0.83	0.75	0.91
2001	1.16	0.97	0.86	1.09
2002	1.28	1.04	0.91	1.16
2003	1.01	1.02	0.92	1.12
2004	1.47	1.09	0.97	1.21
2005	1.73	1.17	1.07	1.27
2006	1.28	0.97	0.87	1.06
2007	1.34	1.23	1.09	1.37
2008	1.25	1.14	1.03	1.25
2009	1.22	0.98	0.89	1.07
2010	0.64	0.73	0.67	0.79
2011	0.58	0.77	0.71	0.83
2012	0.64	0.83	0.76	0.90
2013	0.66	0.93	0.85	1.01
2014	0.64	0.84	0.76	0.91
2015	0.58	0.76	0.69	0.82
2016	0.40	0.63	0.57	0.68
2017	0.48	0.59	0.53	0.64

FIGURES

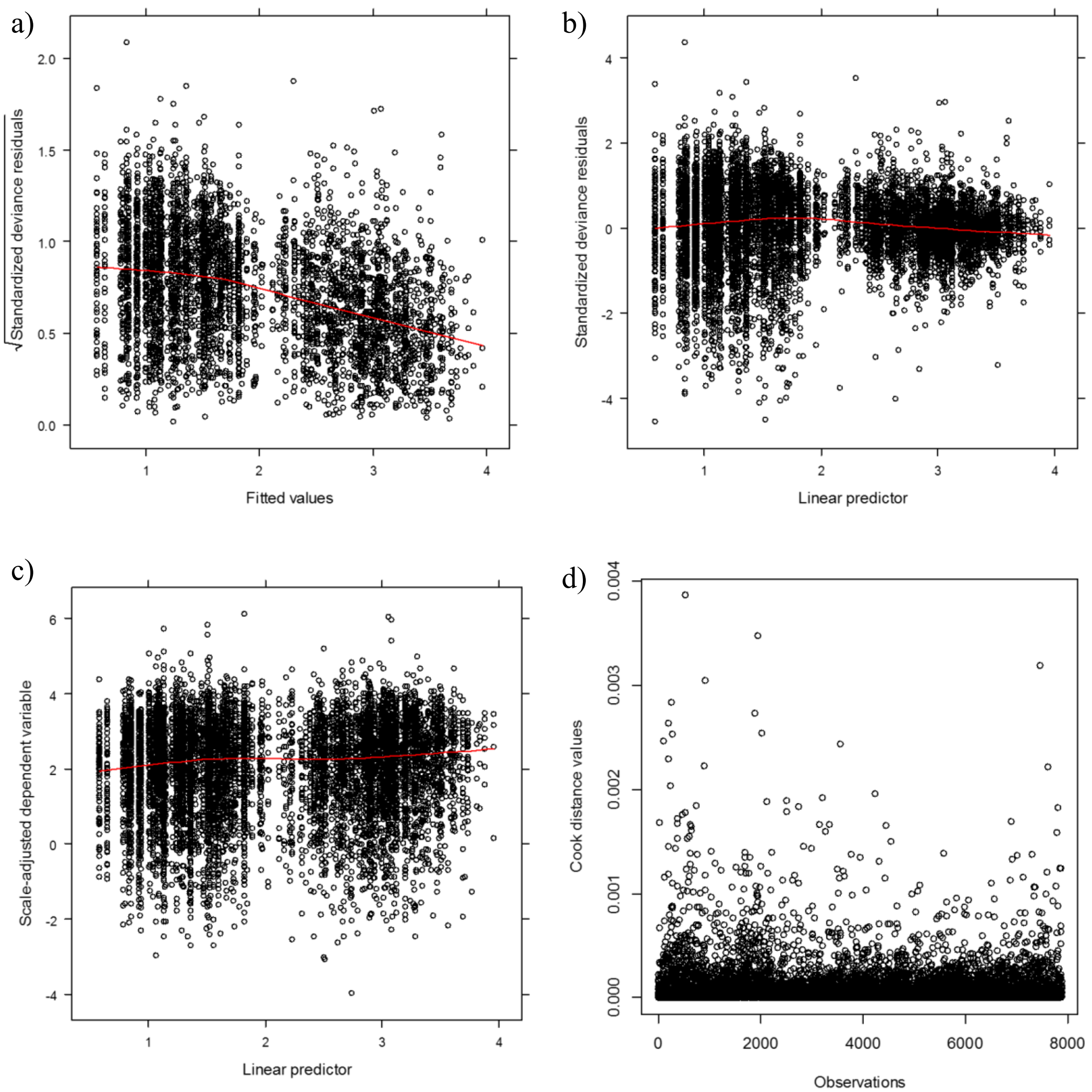

Fig. 1. Diagnostic plots for positive blackspot seabream (*Pagellus bogaraveo*) catch rates to check (a) the adequacy of the assumed variance function, (b) the assumed error distribution, (c) the link function selection, and (d) the influential observations. The null pattern is a no trend in the residuals (a), a distribution of residuals with mean zero and constant variance (b), a straight line (c), and no observation with Cook distance value greater than 1 (d). The red line is the loess smoother through the plotted values.

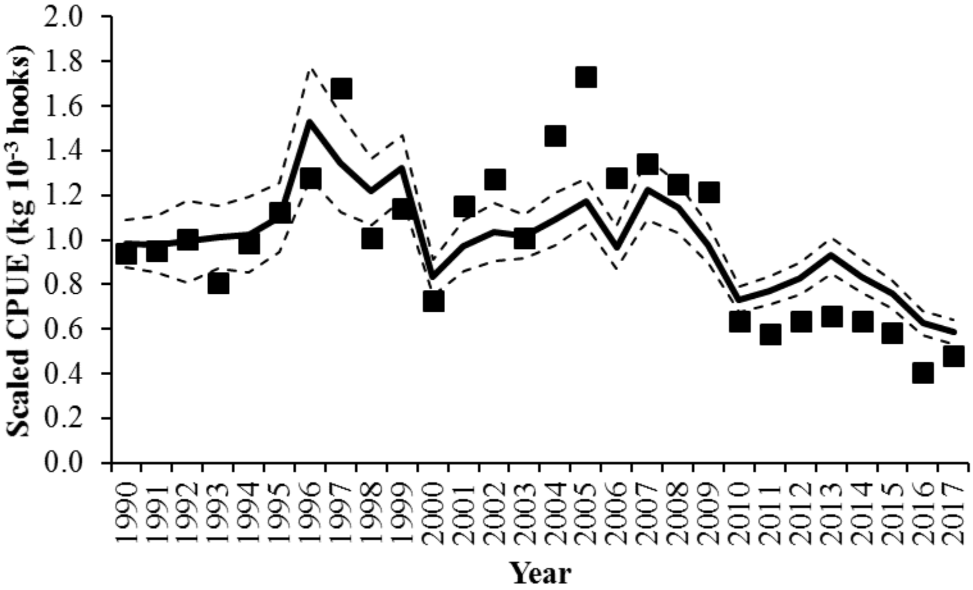

Fig. 2. Nominal (■) and standardized (▬) CPUE (kg 10^{-3} hooks) for blackspot seabream (*Pagellus bogaraveo*) from the Azorean bottom longline fishery, 1990–2017. Dotted lines represent 95% confidence intervals for the standardized CPUE.

Updated standardized CPUE for *Conger conger* caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017

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ABSTRACT

Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2017. The CPUE of European conger was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. The standardized CPUE series oscillated initially for 5 years, followed by a rapid increasing trend since 1996 with peaks in 1999–2000, and after by a rapid decrease until 2005, followed by a more stable trend afterwards.

KEYWORDS

European conger; demersal fisheries; CPUE; abundance; Azores; GLMM

Introduction

The Azorean fishery for demersal species has traditionally been a multispecific fishery, where several types of hooks and gears are used by the local fleet. The demersal fishing fleet consists mainly of small-scale boats (< 12 m length), mostly equipped with handlines and bottom longlines. The European conger (*Conger conger*) is one of the species targeted by the Azorean bottom longline fleet, which also directs its effort to the other demersal species such as blackspot seabream (*Pagellus bogaraveo*), wreckfish (*Polyprion americanus*), forkbeard (*Phycis phycis*), blackbelly rosefish (*Helicolenus dactylopterus*) and alfonsinos (*Beryx splendens* and *Beryx decadactylus*) (Pinho and Menezes, 2005; Pinho *et al.*, 2015; Santos *et al.*, 2019).

Indices of abundance from commercial fisheries have been used to tune stock assessment models (Quinn and Deriso, 1999, Maunder and Punt, 2004), and their use have been strictly recommended by the International Council for the Exploration of the Sea (ICES) for stock advice. The utility of indices of abundance based on nominal catch rates can be improved by standardizing them to remove the

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impact of factors other than changes over time in stock biomass, usually by using statistical regression methods (Ortiz and Arocha, 2004).

This study updates the standardized catch rates for European conger caught by the Azorean bottom longline fleet up to 2017, revising the dataset and the available explanatory variables. Standardized catch rates were estimated using a Generalized Linear Mixed Model with random factor interactions particularly for the *Year* effect.

Material and methods

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAç), and was collected during the period of 1990–2016 as part of the mandate of the European Commission´s Data Collection Framework (DCF). Sampling was designed to cover the main ports of the Azores and was performed by clerks who carried out standardized fishing inquiries (n = 9722) to the captains of the bottom longline vessels during the landings. Each record report included: the vessel identification, the dates of departure and return to the port and detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, fishing area and catch in weight for each species landed.

Factors considered in the analyses of the European conger catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: *São Miguel*, *Terceira* and *Faial*, which represent around 95% of the Azorean landings, and *Others*, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Pinho and Menezes, 2005; Menezes *et al*., 2006), and target (**Table 1**). The target was defined as the percentage of European conger catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of European conger caught per 1000 hooks. Records with missing effort data were excluded from the analysis.

Relative indices of abundance for the European conger species were estimated by Generalized Linear Modeling approach using a hurdle (delta) model (Lo *et al*., 1992; Ortiz and Arocha, 2004; Zuur and Ieno, 2016). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modeling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modeling the positive catch rates on successful trips.

Deviance tables were used to select the explanatory factors and interactions that explained most of the variability in the data (Ortiz and Arocha, 2004). The effect of each explanatory factor/interaction was evaluated according to 1) the percent of deviance explained by the addition of a specific factor/interaction to the model, and 2) the result of the Chi-squared (χ^2) test between two nested models. Only those factors and interactions that accounted for 5% or more of the variability were selected as explanatory variables.

After selecting the set of explanatory factors/interactions for each error distribution, all interactions that included the factor *Year* were treated as random interactions (Cooke, 1997). This process

converted the basic models from generalized linear models into generalized linear mixed models (GLMMs). The significance of the random interactions was evaluated using the likelihood ratio test (Pinheiro and Bates, 2000), the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), where lower values indicated better model fitting. Once a final model was identified, model diagnostics were revised to identify potential departure from the GLMM assumptions or observations with large influence in the model results.

The indices of abundance were estimated as the product of the least squares means (LSmeans) of the factor *Year* from each of the two analyses that constitute a hurdle model, after back-transforming to the response scale. The variance estimation of the standardized index was calculated following Walter and Ortiz (2012) for two-stage CPUE estimators.

All the analyses were conducted using the software R-3.4.3 (R Core Team, 2017) with additional packages *lmtest* (Zeileis and Hothorn, 2002), *lattice* (Sarkar, 2008), *lme4* (Bates *et al*., 2015) and *lsmeans* (Lenth, 2016).

Results and Discussion

Deviance tables for European conger from the DCF dataset analyses are presented in **Table 2**. For the proportion of positive catches; *Year*, *Vessel*, *Depth* and *Target* and the interactions *Year:Vessel* and *Year:Port* were the major factors that explained whether or not a set caught at least one fish. For the positive catches; only the main factors *Year* and *Target* were more significant. The *Year* interactions were considered as random effects in the hurdle model subcomponents, and their statistical effect were evaluated using the AIC, BIC, and likelihood ratio test (**Table 3**).

Model diagnostics for the positive catches included plots for a check of the link function, the variance function, and the check for the error distribution of the model (**Fig. 1a-c**). All diagnostic plots showed no indication of departure from the expected or null pattern, and there was no observation with large influence in the model results (**Fig. 1d**). Thus, we can conclude that the model selected is not grossly wrong.

Standardized CPUE series for European conger are shown in **Table 4** and **Fig. 4**. The index trends oscillated initially for 5 years, followed by a rapid increasing trend since 1996 with peaks in 1999–2000, and after by a rapid decrease until 2005, followed by a more stable trend afterwards.

Acknowledgements

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TABLES

Table 1. Explanatory variables (main factors) used in the model formulations for standardized European conger catch rates.

Variable	Type	Observations
Year	Categorical (28)	Period: 1990-2017
Quarter	Categorical (4)	1: January-March
		2: April-June
		3: July-September
		4: October-December
Vessel	Categorical (5)	1: ≤ 10 m
		2: > 10 and ≤ 12 m
		3: > 12 and ≤ 18 m
		4: > 18 and ≤ 24 m
		5: > 24 and ≤ 40 m
Port	Categorical (4)	1: São Miguel
		2: Terceira
		3: Faial
		4: Others
Depth	Categorical (3)	1: shallow (< 200 m)
		2: intermediate (200-600 m)
		3: deep (> 600 m)
Target	Categorical (4)	1: 1^{st} quartile (≤ 25%)
		2: 2^{nd} quartile (> 25% and ≤ 50%)
		3: 3^{rd} quartile (> 50% and ≤ 75%)
		4: 4^{th} quartile (> 75%)

Table 2. Deviance analysis table of explanatory variables for the zero-altered lognormal model formulations for European conger catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Factors and interactions that accounted for 5% or more of the variability were highlighted and correspond to the selected explanatory variables.

Model structure	**d.f.**	**Res Dev**	**Δ Dev.**	**% of Dev. exp.**	***p*-value**
Binomial (proportion of positive catches)					
Null		10204.6			
Year	27	9790.6	414.04	**15.0**	< 0.001
Year Quarter	3	9786.4	4.2	0.2	0.240
Year Quarter Vessel	4	9364	422.37	**15.4**	< 0.001
Year Quarter Vessel Port	3	9292.2	71.78	2.6	< 0.001
Year Quarter Vessel Port Depth	2	9152.8	139.44	**5.1**	< 0.001
Year Quarter Vessel Port Depth Target	3	8215.4	937.38	**34.1**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	8105.9	109.51	4.0	< 0.050
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	86	7762.1	343.82	**12.5**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	65	7556.5	205.57	**7.5**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	52	7453.4	103.14	3.7	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	66	7453.4	0	0.0	1.000
Lognormal (positive catches)					
Null		9926.9			
Year	27	9163.6	763.34	**17.6**	< 0.001
Year Quarter	3	9043.6	119.97	2.8	< 0.001
Year Quarter Vessel	4	9003.6	39.98	0.9	< 0.001
Year Quarter Vessel Port	3	8825.2	178.42	4.1	< 0.001
Year Quarter Vessel Port Depth	2	8784.7	40.50	0.9	< 0.001
Year Quarter Vessel Port Depth Target	3	6237.8	2546.88	**58.9**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	6113	124.81	2.9	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	85	5929.6	183.36	4.2	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	63	5776.3	153.33	3.5	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	51	5692.7	83.60	1.9	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	66	5601.2	91.48	2.1	< 0.001

d.f.: degrees of freedom; Res. Dev.: residual deviance; Δ Dev.: change in deviance; % of Dev. exp.: percent of deviance explained; *p*-value: based on chi-squared (χ^2) distribution and used to determine the explanatory variables that contributed significantly ($p < 0.05$) to the deviance explained.

Table 3. Analyses of alternative zero-altered lognormal mixed model formulations for European conger catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Model structure	– 2 REM log likelihood	Akaike's information criterion	Bayesian information criterion	Likelihood ratio test	
Binomial (proportion of positive catches)					
Year Vessel Depth Target Port	8220.5	8300.5	8587.5		
Year Vessel Depth Target Port *Year:Vessel*	8126.8	8208.8	8503.0	93.7	< 0.001
Year Vessel Depth Target Port *Year:Vessel Year:Port* *	8092.9	8176.9	8478.3	33.9	< 0.001
Lognormal (positive catches)					
Year Target *	20335.7	20400.0	20621.6		

The factors in normal typeface are treated as fixed effects and those in italics are random interactions.

* The final zero-altered lognormal mixed model.

Table 4. Nominal and standardized CPUE series (kg 10^{-3} hooks) for European conger (*Conger conger*) catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds. The values are scaled to mean.

Year	Nominal CPUE	Standardized CPUE	LCI	UCI
1990	0.90	1.18	1.03	1.33
1991	2.04	1.12	0.95	1.28
1992	0.50	0.71	0.57	0.85
1993	0.82	1.12	0.94	1.29
1994	0.54	0.91	0.75	1.07
1995	0.63	0.80	0.68	0.93
1996	0.77	0.82	0.67	0.96
1997	0.80	1.02	0.84	1.20
1998	0.86	1.06	0.91	1.21
1999	2.05	1.82	1.59	2.06
2000	2.11	1.74	1.54	1.95
2001	1.64	1.20	1.03	1.37
2002	1.57	1.15	0.99	1.32
2003	1.09	0.97	0.85	1.08
2004	0.84	0.99	0.86	1.12
2005	0.62	0.73	0.65	0.81
2006	0.92	0.80	0.70	0.89
2007	0.71	0.81	0.70	0.92
2008	0.71	0.90	0.79	1.00
2009	0.67	0.82	0.72	0.91
2010	0.77	0.83	0.74	0.91
2011	0.89	0.94	0.85	1.04
2012	0.89	0.92	0.82	1.02
2013	1.04	1.05	0.94	1.16
2014	0.95	1.01	0.91	1.12
2015	0.90	0.92	0.83	1.01
2016	0.88	0.87	0.78	0.96
2017	0.91	0.81	0.72	0.89

FIGURES

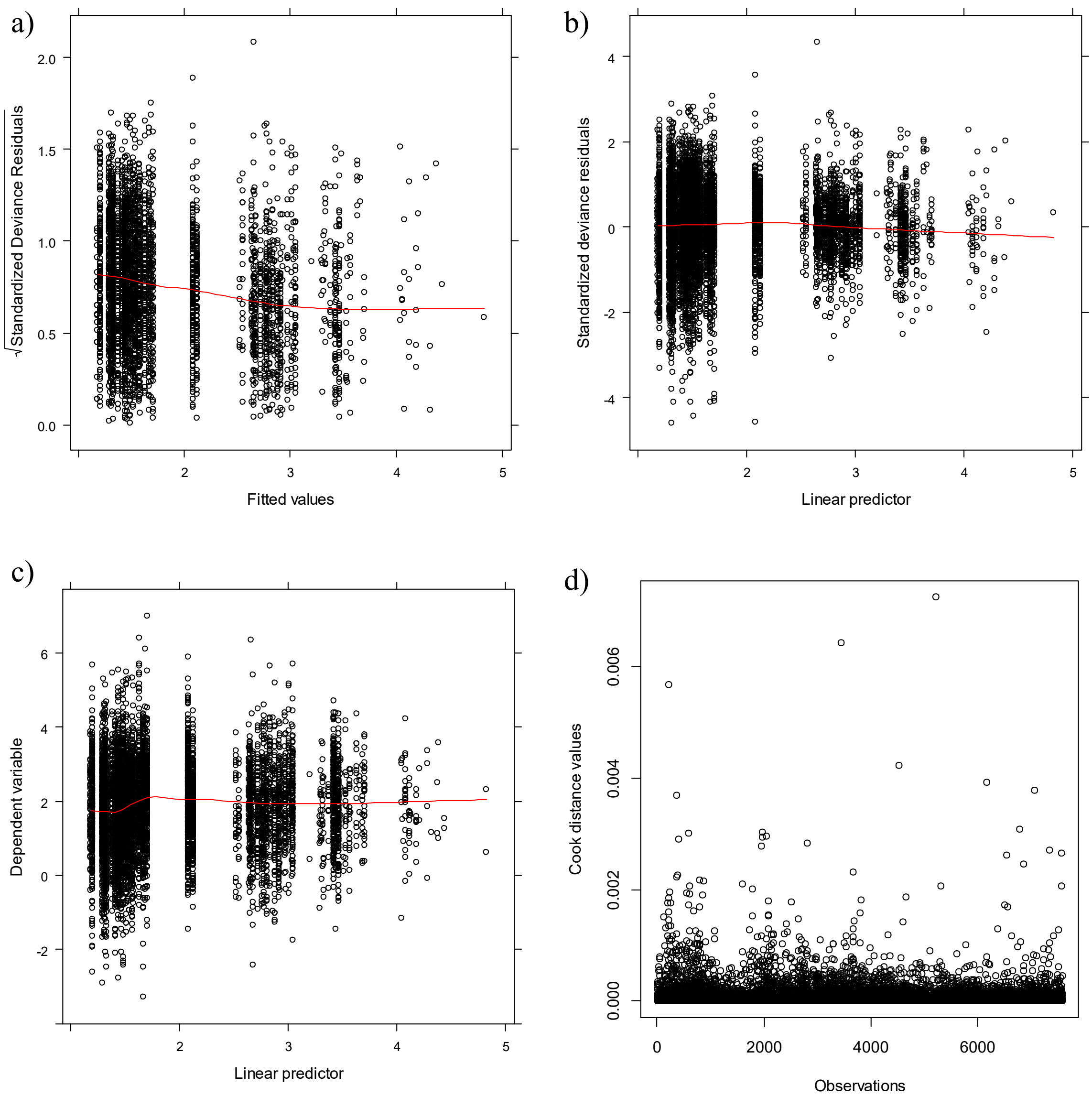

Fig. 3. Diagnostic plots for positive European conger (*Conger conger*) catch rates to check (a) the adequacy of the assumed variance function, (b) the assumed error distribution, (c) the link function selection, and (d) the influential observations. The null pattern is a no trend in the residuals (a), a distribution of residuals with mean zero and constant variance (b), a straight line (c), and no observation with Cook distance value greater than 1 (d). The red line is the loess smoother through the plotted values.

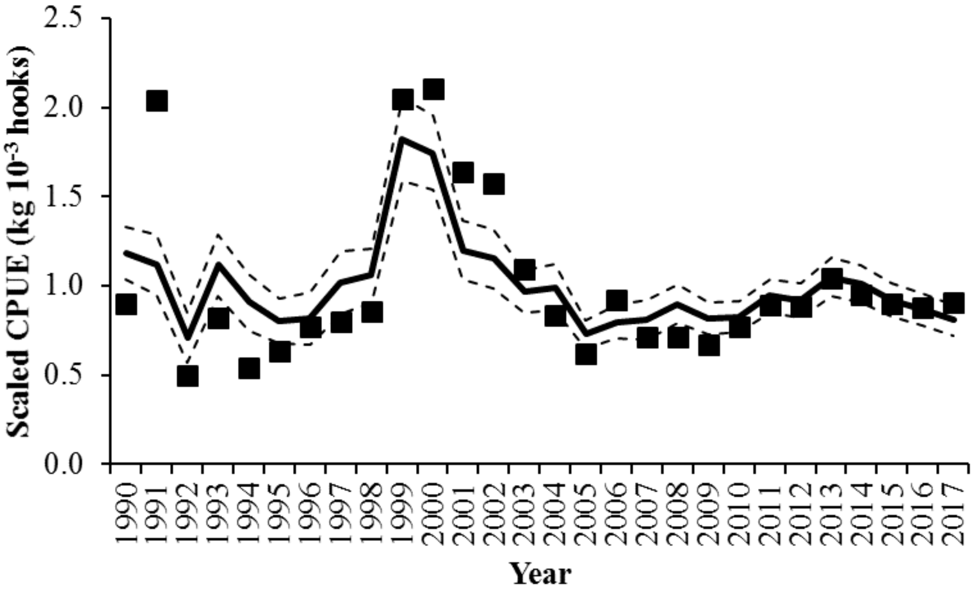

Fig. 4. Nominal (■) and standardized (▬) CPUE (kg 10^{-3} hooks) for European conger (*Conger conger*) from the Azorean bottom longline fishery, 1990–2017. Dotted lines represent 95% confidence intervals for the standardized CPUE.

Updated standardized CPUE for *Beryx splendens* caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017

Régis V. S. Santos[1*], Wendell Medeiros-Leal[1], Ana M. Novoa-Pabon[1], Mario R. Pinho[1]

ABSTRACT

Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2017. The CPUE of splendid alfonsino was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. The standardized CPUE series showed an oscillation over time, with a general decreasing behavior from the year 2009.

KEYWORDS

Splendid alfonsino; demersal fisheries; CPUE; abundance; Azores; GLMM

Introduction

The Azorean fishery for demersal species has traditionally been a multispecific fishery, where several types of hooks and gears are used by the local fleet. The demersal fishing fleet consists mainly of small-scale boats (< 12 m length), mostly equipped with handlines and bottom longlines. The splendid alfonsino (*Beryx splendens*) is one of the alfonsinos targeted by the Azorean bottom longline fleet, which also directs its effort to the other demersal fish species such as blackspot seabream (*Pagellus bogaraveo*), wreckfish (*Polyprion americanus*), blackbelly rosefish (*Helicolenus dactylopterus*), forkbeard (*Phycis phycis*), European conger (*Conger conger*) and alfonsino (*Beryx decadactylus*) (Pinho and Menezes, 2005; Pinho *et al.*, 2015; Santos *et al.*, 2019).

Indices of abundance from commercial fisheries have been used to tune stock assessment models (Quinn and Deriso, 1999, Maunder and Punt, 2004), and their use have been strictly recommended by the International Council for the Exploration of the Sea (ICES) for stock advice. The utility of indices of abundance based on nominal catch rates can be improved by standardizing them to remove the

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impact of factors other than changes over time in stock biomass, usually by using statistical regression methods (Ortiz and Arocha, 2004).

This study updates the standardized catch rates for splendid alfonsino captured by the Azorean bottom longline fleet up to 2017, revising the dataset and the available explanatory variables. Standardized catch rates were estimated using a Generalized Linear Mixed Model with random factor interactions particularly for the *Year* effect.

Material and methods

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAç), and was collected during the period of 1990–2017 as part of the mandate of the European Commission´s Data Collection Framework (DCF). Sampling was designed to cover the main ports of the Azores and was performed by clerks who carried out standardized fishing inquiries (n = 9722) to the captains of the bottom longline vessels during the landings. Each record report included: the vessel identification, the dates of departure and return to the port and detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, fishing area and catch in weight for each species landed.

Factors considered in the analyses of the splendid alfonsino catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: *São Miguel*, *Terceira* and *Faial*, which represent around 95% of the Azorean landings, and *Others*, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Pinho and Menezes, 2005; Menezes *et al*., 2006), and target (**Table 1**). The target was defined as the percentage of splendid alfonsino catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of splendid alfonsino caught per 1000 hooks. Records with missing effort data were excluded from the analysis.

Relative indices of abundance for the splendid alfonsino species were estimated by Generalized Linear Modeling approach using a hurdle (delta) model (Lo *et al*., 1992; Ortiz and Arocha, 2004; Zuur and Ieno, 2016). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modeling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modeling the positive catch rates on successful trips.

Deviance tables were used to select the explanatory factors and interactions that explained most of the variability in the data (Ortiz and Arocha, 2004). The effect of each explanatory factor/interaction was evaluated according to 1) the percent of deviance explained by the addition of a specific factor/interaction to the model, and 2) the result of the Chi-squared (χ^2) test between two nested models. Only those factors and interactions that accounted for 5% or more of the variability were selected as explanatory variables.

After selecting the set of explanatory factors/interactions for each error distribution, all interactions that included the factor *Year* were treated as random interactions (Cooke, 1997). This process

converted the basic models from generalized linear models into generalized linear mixed models (GLMMs). The significance of the random interactions was evaluated using the likelihood ratio test (Pinheiro and Bates, 2000), the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), where lower values indicated better model fitting. Once a final model was identified, model diagnostics were revised to identify potential departure from the GLMM assumptions or observations with large influence in the model results.

The indices of abundance were estimated as the product of the least squares means (LSmeans) of the factor *Year* from each of the two analyses that constitute a hurdle model, after back-transforming to the response scale. The variance estimation of the standardized index was calculated following Walter and Ortiz (2012) for two-stage CPUE estimators.

All the analyses were conducted using the software R-3.4.3 (R Core Team, 2017) with additional packages *lmtest* (Zeileis and Hothorn, 2002), *lattice* (Sarkar, 2008), *influence.ME* (Nieuwenhuis *et al*., 2012), *lme4* (Bates *et al*., 2015) and *lsmeans* (Lenth, 2016).

Results and Discussion

Deviance tables for splendid alfonsino from the DCF dataset analyses are presented in **Table 2**. For the proportion of positive catches; the interaction *Year:Depth* was the major factor that explained whether or not a set caught at least one fish. For the positive catches; the main factors *Year* and *Target* and the interaction *Year:Quarter* were more significant. The *Year* interactions were considered as random effects and their statistical effect were evaluated using the AIC, BIC, and likelihood ratio test (**Table 3**).

Model diagnostics for the positive catches included plots for a check of the link function, the variance function, and the check for the error distribution of the model (**Fig. 1a-c**). All diagnostic plots showed no indication of departure from the expected or null pattern, and there was no observation with large influence in the model results (**Fig. 2d**). Thus, we can conclude that the model selected is not grossly wrong.

Standardized CPUE series for splendid alfonsino are shown in **Table 4** and **Fig. 4**. The index trends showed an oscillation over time, with a general decreasing behavior from the year 2009.

Acknowledgements

This work is part of the PESCAz project (ref. MAR-01.03.02-FEAMP-0039) financed by the European Maritime and Fisheries Fund (EMFF) under the MAR2020 operational programme. RS was funded by the IMAR Instituto do Mar through a Post-doc fellowship (ref. IMAR/DEMERSAIS/001-2018). AN-P was funded by an FCT Ph.D. fellowship (ref. SFRH/BD/124720/2016).

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TABLES

Table 1. Explanatory variables (main factors) used in the model formulations for standardized splendid alfonsino catch rates.

Variable	Type	Observations
Year	Categorical (28)	Period: 1990-2017
Quarter	Categorical (4)	1: January-March
		2: April-June
		3: July-September
		4: October-December
Vessel	Categorical (5)	1: ≤ 10 m
		2: > 10 and ≤ 12 m
		3: > 12 and ≤ 18 m
		4: > 18 and ≤ 24 m
		5: > 24 and ≤ 40 m
Port	Categorical (4)	1: São Miguel
		2: Terceira
		3: Faial
		4: Others
Depth	Categorical (3)	1: shallow (< 200 m)
		2: intermediate (200-600 m)
		3: deep (> 600 m)
Target	Categorical (4)	1: 1st quartile (≤ 25%)
		2: 2nd quartile (> 25% and ≤ 50%)
		3: 3rd quartile (> 50% and ≤ 75%)
		4: 4th quartile (> 75%)

Table 2. Deviance analysis table of explanatory variables for the zero-altered lognormal model formulations for splendid alfonsino catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Factors and interactions that accounted for 5% or more of the variability were highlighted and correspond to the selected explanatory variables.

Model structure	**d.f.**	**Res Dev**	**Δ Dev.**	**% of Dev. exp.**	***p*-value**
Binomial (proportion of positive catches)					
Null		12074			
Year	27	11203	871.0	0.6	< 0.001
Year Quarter	3	10989	214.0	0.1	< 0.001
Year Quarter Vessel	4	9246	1744.0	1.2	< 0.001
Year Quarter Vessel Port	3	9232	13.0	0.0	< 0.010
Year Quarter Vessel Port Depth	2	9056	176.0	0.1	< 0.001
Year Quarter Vessel Port Depth Target	3	7940	1116.0	0.8	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	7044	895.0	0.6	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	86	6793	251.0	0.2	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	65	147202	0.0	0.0	1.000
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	53	6520	140683.0	**96.4**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	61	121972	0.0	0.0	1.000
Lognormal (positive catches)					
Null		7890.9			
Year	27	7221.3	669.56	**16.2**	< 0.001
Year Quarter	3	7188.2	33.13	0.8	< 0.001
Year Quarter Vessel	4	7094.6	93.57	2.3	< 0.001
Year Quarter Vessel Port	3	7039.5	55.16	1.3	< 0.001
Year Quarter Vessel Port Depth	2	7023.9	15.53	0.4	< 0.010
Year Quarter Vessel Port Depth Target	3	4422.2	2601.7	**62.9**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	70	4236	186.28	**4.5**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	76	4072.8	163.2	3.9	< 0.010
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	48	3967.5	105.25	2.5	< 0.010
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	41	3869.1	98.47	2.4	< 0.010
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	62	3757.7	111.39	2.7	0.054

d.f.: degrees of freedom; Res. Dev.: residual deviance; Δ Dev.: change in deviance; % of Dev. exp.: percent of deviance explained; *p*-value: based on chi-squared (χ^2) distribution and used to determine the explanatory variables that contributed significantly ($p < 0.05$) to the deviance explained.

Table 3. Analyses of alternative zero-altered lognormal mixed model formulations for splendid alfonsino catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Model structure	**– 2 REM log likelihood**	**Akaike's information criterion**	**Bayesian information criterion**	**Likelihood ratio test**	
Binomial (proportion of positive catches)					
Year Depth	10814.9	10875.0	11090.2		
Year Depth *Year:Depth* *	10747.2	10809.2	11031.7	67.7	< 0.001
Lognormal (positive catches)					
Year Target Quarter	9891.2	9961.2	10172.3		
Year Target Quarter *Year:Quarter* *	9887.9	9959.9	10177.0	3.4	0.067

The factors in normal typeface are treated as fixed effects and those in italics are random interactions.

* The final zero-altered lognormal mixed model.

Table 4. Nominal and standardized CPUE series (kg 10^{-3} hooks) for splendid alfonsino (*Beryx splendens*) catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds. The values are scaled to mean.

Year	Nominal CPUE	Standardized CPUE	LCI	UCI
1990	0.01	0.02	0.00	0.05
1991	1.09	1.08	0.35	1.81
1992	0.05	0.13	-0.03	0.30
1993	1.15	1.80	0.85	2.75
1994	1.29	1.24	0.50	1.97
1995	0.73	0.70	0.19	1.21
1996	2.84	2.49	1.23	3.76
1997	0.50	0.62	0.18	1.06
1998	0.80	0.69	0.30	1.08
1999	1.23	1.03	0.54	1.52
2000	1.15	1.11	0.62	1.60
2001	1.78	1.16	0.56	1.76
2002	1.80	1.30	0.66	1.94
2003	0.83	0.72	0.42	1.02
2004	1.02	0.91	0.50	1.32
2005	1.14	1.16	0.68	1.63
2006	1.22	1.42	0.87	1.98
2007	1.22	1.71	1.11	2.32
2008	1.15	1.45	0.86	2.05
2009	1.39	2.12	1.32	2.91
2010	1.07	1.11	0.61	1.61
2011	0.94	1.03	0.55	1.51
2012	1.38	1.16	0.60	1.71
2013	0.78	0.65	0.28	1.03
2014	0.34	0.38	0.12	0.64
2015	0.63	0.28	0.07	0.49
2016	0.33	0.43	0.20	0.66
2017	0.18	0.10	0.03	0.17

FIGURES

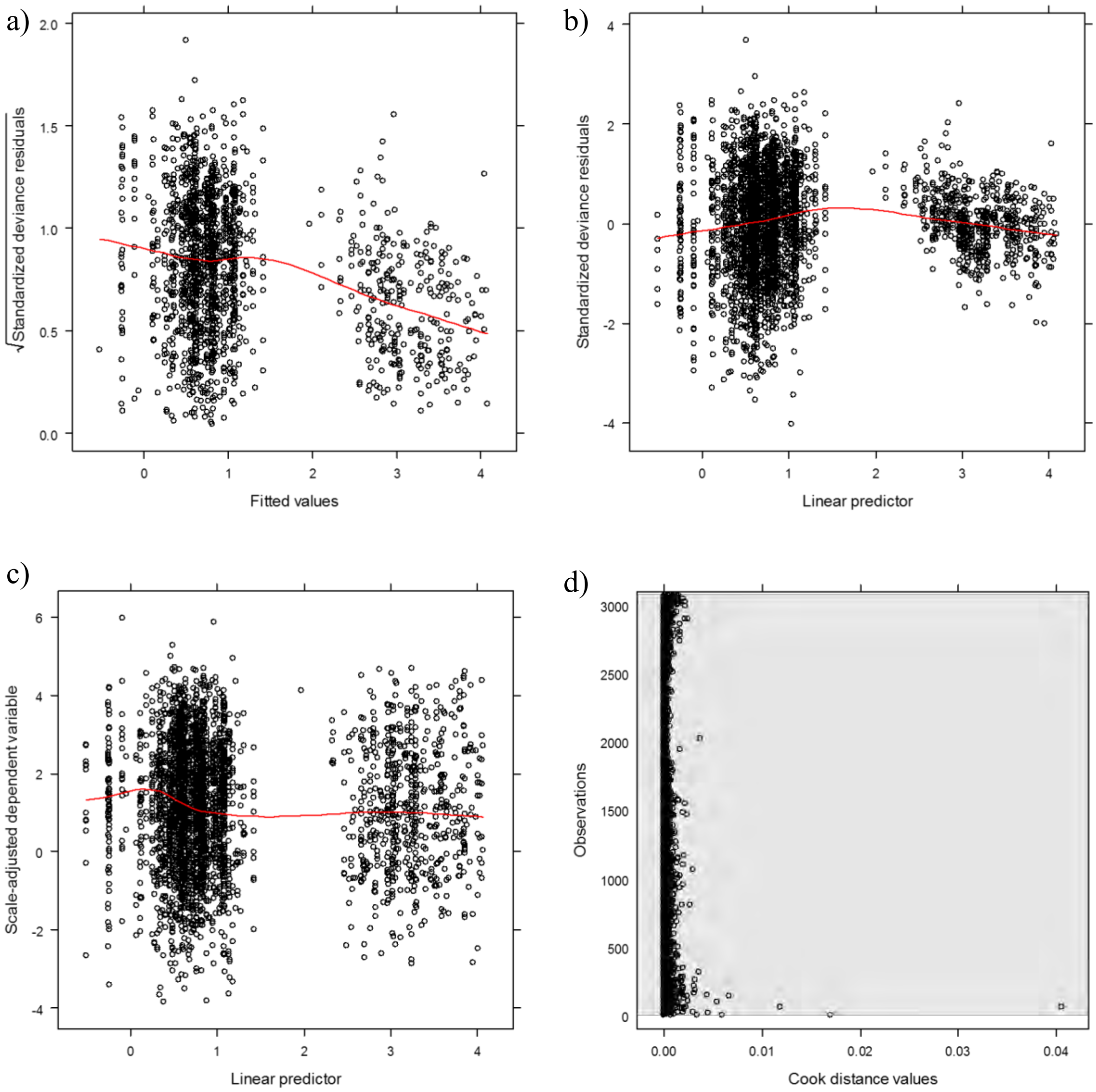

Fig. 1. Diagnostic plots for positive splendid alfonsino (*Beryx splendens*) catch rates to check (a) the adequacy of the assumed variance function, (b) the assumed error distribution, (c) the link function selection, and (d) the influential observations. The null pattern is a no trend in the residuals (a), a distribution of residuals with mean zero and constant variance (b), a straight line (c), and no observation with Cook distance value greater than 1 (d). The red line is the loess smoother through the plotted values.

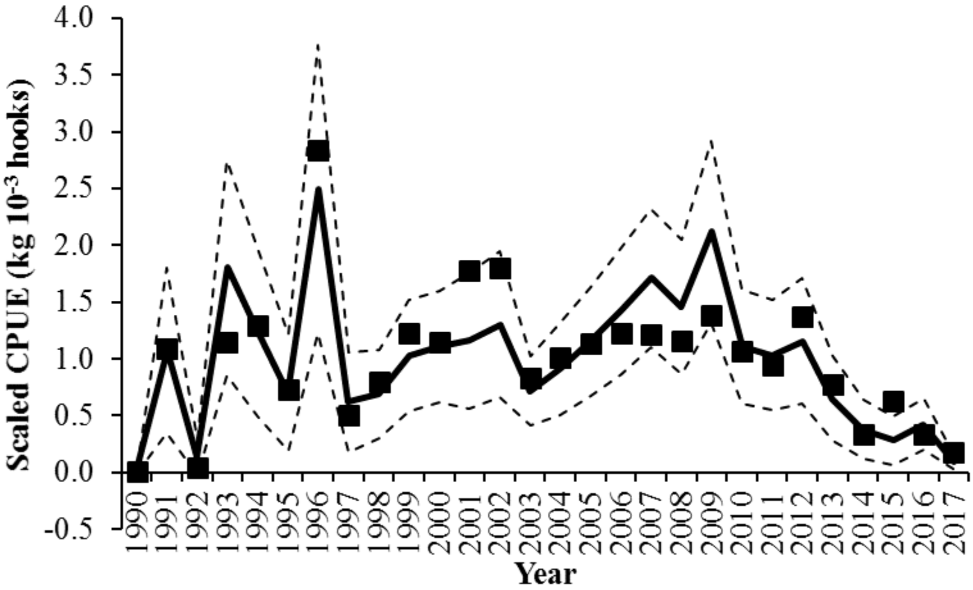

Fig. 2. Nominal (■) and standardized (▬) CPUE (kg 10^{-3} hooks) for splendid alfonsino (*Beryx splendens*) from the Azorean bottom longline fishery, 1990–2017. Dotted lines represent 95% confidence intervals for the standardized CPUE.

Updated standardized CPUE for *Polyprion americanus* caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017

Régis V. S. Santos[1*], Wendell Medeiros-Leal[1], Ana M. Novoa-Pabon[1], Mario R. Pinho[1]

ABSTRACT

Catch and effort information from the Azorean bottom longline fleet were collected by interviews to the captains during the landings. Sampling was designed to cover the main ports of the Azores archipelago and was performed during the period from 1990 to 2017. The CPUE of wreckfish was standardized by Generalized Linear Mixed Modeling approach using a hurdle model (Zero-altered Lognormal). The factors used in the model formulations were year, quarter, vessel, port of operation, depth of the hooks and target. Deviance analyses help to identify major factors and Year interactions. The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE showed an oscillation over time, with some peaks in 1992, 2000 and 2007, and a rapid decline after the latter; while the standardized index presented a more stable trend overall.

KEYWORDS

Wreckfish; demersal fisheries; CPUE; abundance; Azores; GLMM

Introduction

The Azorean fishery for demersal species has traditionally been a multispecific fishery, where several types of hooks and gears are used by the local fleet. The demersal fishing fleet consists mainly of small-scale boats (< 12 m length), mostly equipped with handlines and bottom longlines. The wreckfish (*Polyprion americanus*) is one of the species targeted by the Azorean bottom longline fleet, which also directs its effort to the other demersal fish species such as blackspot seabream (*Pagellus bogaraveo*), blackbelly rosefish (*Helicolenus dactylopterus*), forkbeard (*Phycis phycis*), European conger (*Conger conger*) and alfonsinos (*Beryx splendens* and *Beryx decadactylus*) (Pinho and Menezes, 2005; Pinho *et al.*, 2015; Santos *et al.*, 2019).

Indices of abundance from commercial fisheries have been used to tune stock assessment models (Quinn and Deriso, 1999, Maunder and Punt, 2004), and their use have been strictly recommended by the International Council for the Exploration of the Sea (ICES) for stock advice. The utility of indices

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of abundance based on nominal catch rates can be improved by standardizing them to remove the impact of factors other than changes over time in stock biomass, usually by using statistical regression methods (Ortiz and Arocha, 2004).

This study updates the standardized catch rates for wreckfish caught by the Azorean bottom longline fleet up to 2017, revising the dataset and the available explanatory variables. Standardized catch rates were estimated using a Generalized Linear Mixed Model with random factor interactions particularly for the Year effect.

Material and methods

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAç), and was collected during the period of 1990–2017 as part of the mandate of the European Commission´s Data Collection Framework (DCF). Sampling was designed to cover the main ports of the Azores and was performed by clerks who carried out standardized fishing inquiries (n = 9722) to the captains of the bottom longline vessels during the landings. Each record report included: the vessel identification, the dates of departure and return to the port and detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, fishing area and catch in weight for each species landed.

Factors considered in the analyses of the wreckfish catch rates included: year and quarter; vessel size, classified into 4 categories based on the European Union (EU) classification; port of operation, pooled by island into 4 categories: *São Miguel*, *Terceira* and *Faial*, which represent around 95% of the Azorean landings, and *Others*, that included all other islands; depth of the hooks, categorized by strata following the depth-aligned structure of the demersal fish assemblages off the Azores Archipelago (Pinho and Menezes, 2005; Menezes *et al*., 2006), and target (**Table 1**). The target was defined as the percentage of wreckfish catches related to the total catch, categorized into 4 categories using the quartiles. Fishing effort was reported in terms of the total number of hooks per trip and catch rates were calculated as kg of wreckfish caught per 1000 hooks. Records with structural zeros (see Zuur *et al*., 2009) and missing effort data were excluded from the analysis.

Relative indices of abundance for the wreckfish species were estimated by Generalized Linear Modeling approach using a hurdle (delta) model (Lo *et al*., 1992; Ortiz and Arocha, 2004; Zuur and Ieno, 2016). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modeling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modeling the positive catch rates on successful trips.

Deviance tables were used to select the explanatory factors and interactions that explained most of the variability in the data (Ortiz and Arocha, 2004). The effect of each explanatory factor/interaction was evaluated according to 1) the percent of deviance explained by the addition of a specific factor/interaction to the model, and 2) the result of the Chi-squared (χ^2) test between two nested models. Only those factors and interactions that accounted for 5% or more of the variability were selected as explanatory variables.

After selecting the set of explanatory factors/interactions for each error distribution, all interactions that included the factor *Year* were treated as random interactions (Cooke, 1997). This process converted the basic models from generalized linear models into generalized linear mixed models (GLMMs). The significance of the random interactions was evaluated using the likelihood ratio test (Pinheiro and Bates, 2000), the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), where lower values indicated better model fitting. Once a final model was identified, model diagnostics were revised to identify potential departure from the GLMM assumptions or observations with large influence in the model results.

The indices of abundance were estimated as the product of the least squares means (LSmeans) of the factor *Year* from each of the two analyses that constitute a hurdle model, after back-transforming to the response scale. The variance estimation of the standardized index was calculated following Walter and Ortiz (2012) for two-stage CPUE estimators.

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Results and Discussion

Deviance tables for wreckfish from the DCF dataset analyses are presented in **Table 2**. For the proportion of positive catches; *Year*, *Vessel*, *Depth* and *Target* were the major factors that explained whether or not a set caught at least one fish. For the positive catches; the main factors *Year*, *Quarter*, *Vessel* and *Target* and the interaction *Year:Vessel* were more significant. The *Year* interactions were considered as random effects in the hurdle model subcomponents, and their statistical effect were evaluated using the AIC, BIC, and likelihood ratio test (**Table 3**).

Model diagnostics for the positive catches included plots for a check of the link function, the variance function, and the check for the error distribution of the model (**Fig. 1a-c**). All diagnostic plots showed no indication of departure from the expected or null pattern, and there was no observation with large influence in the model results (**Fig. 1d**). Thus, we can conclude that the model selected is not grossly wrong.

Standardized CPUE series for wreckfish are shown in **Table 4** and **Fig. 2**. The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE showed an oscillation over time, with some peaks in 1992, 2000 and 2007, and a rapid decline after the latter; while the standardized index presented a more stable trend overall. According to Ortiz (2017), it is not necessary that the nominal and standardized trends follow the same trend. The standardized index for the *year* factor shows in theory the trend of the population, while the nominal catch rates should represent the combined trends of all other factors and its interactions.

Acknowledgements

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TABLES

Table 1. Explanatory variables (main factors) used in the model formulations for standardized wreckfish catch rates.

Variable	Type	Observations
Year	Categorical (28)	Period: 1990-2017
Quarter	Categorical (4)	1: January-March
		2: April-June
		3: July-September
		4: October-December
Vessel	Categorical (5)	1: ≤ 10 m
		2: > 10 and ≤ 12 m
		3: > 12 and ≤ 18 m
		4: > 18 and ≤ 24 m
		5: > 24 and ≤ 40 m
Port	Categorical (4)	1: São Miguel
		2: Terceira
		3: Faial
		4: Others
Depth	Categorical (3)	1: shallow (< 200 m)
		2: intermediate (200-600 m)
		3: deep (> 600 m)
Target	Categorical (4)	1: 1st quartile (≤ 25%)
		2: 2nd quartile (> 25% and ≤ 50%)
		3: 3rd quartile (> 50% and ≤ 75%)
		4: 4th quartile (> 75%)

Table 2. Deviance analysis table of explanatory variables for the zero-altered lognormal model formulations for wreckfish catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Factors and interactions that accounted for 5% or more of the variability were highlighted and correspond to the selected explanatory variables.

Model structure	d.f.	Res Dev	Δ Dev.	% of Dev. exp.	*p*-value
Binomial (proportion of positive catches)					
Null		13378			
Year	27	12345	1033.11	**19.7**	< 0.001
Year Quarter	3	12280	64.66	1.2	< 0.001
Year Quarter Vessel	4	9642	2638.38	**50.4**	< 0.001
Year Quarter Vessel Port	3	9510	131.79	2.5	< 0.001
Year Quarter Vessel Port Depth	2	9136	373.86	**7.1**	< 0.001
Year Quarter Vessel Port Depth Target	3	8661	474.99	**9.1**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	80	8483	177.81	3.4	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	86	8287	196.5	3.8	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	65	8146	141.19	2.7	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	52	174235	0	0.0	1.000
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	58	174740	0	0.0	1.000
Lognormal (positive catches)					
Null		10474.6			
Year	27	9857.1	617.5	**11.1**	< 0.001
Year Quarter	3	9311.1	546.0	**9.8**	< 0.001
Year Quarter Vessel	4	8388.6	922.5	**16.5**	< 0.001
Year Quarter Vessel Port	3	8351.7	36.9	0.7	< 0.001
Year Quarter Vessel Port Depth	2	8345.6	6.1	0.1	0.071
Year Quarter Vessel Port Depth Target	3	5667.6	2678.0	**48.0**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter	79	5524	143.6	2.6	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel	84	5253.5	270.5	**4.8**	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port	58	5117.2	136.3	2.4	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth	49	5001.6	115.6	2.1	< 0.001
Year Quarter Vessel Port Depth Target Year:Quarter Year:Vessel Year:Port Year:Depth Year:Target	58	4896.6	105.0	1.9	< 0.010

d.f.: degrees of freedom; Res. Dev.: residual deviance; Δ Dev.: change in deviance; % of Dev. exp.: percent of deviance explained; *p*-value: based on chi-squared (χ^2) distribution and used to determine the explanatory variables that contributed significantly ($p < 0.05$) to the deviance explained.

Table 3. Analyses of alternative zero-altered lognormal mixed model formulations for wreckfish catch rates (CPUE, kg 10^{-3} hooks) from the Azorean bottom longline fishery. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Model structure	– 2 REM log likelihood	Akaike's information criterion	Bayesian information criterion	Likelihood ratio test	
Binomial (proportion of positive catches)					
Year Vessel Depth Target *	8836.7	8910.7	9176.2		
Lognormal (positive catches)					
Year Quarter Vessel Target	14269.3	14347.0	14599.0		
Year Quarter Vessel Target *Year:Vessel* *	14234.3	14314.3	14572.4	35.0	< 0.001

The factors in normal typeface are treated as fixed effects and those in italics are random interactions.

* The final zero-altered lognormal mixed model.

Table 4. Nominal and standardized CPUE series (kg 10^{-3} hooks) for wreckfish (*Polyprion americanus*) catch rates from the Azorean bottom longline fishery. LCI and UCI indicate estimated 95% confidence bounds. The values are scaled to mean.

Year	Nominal CPUE	Standardized CPUE	LCI	UCI
1990	1.03	0.95	0.77	1.14
1991	0.46	0.76	0.61	0.92
1992	0.33	1.09	0.80	1.37
1993	0.72	1.20	0.93	1.47
1994	0.98	1.22	0.92	1.52
1995	0.22	0.77	0.61	0.94
1996	0.97	1.21	0.89	1.54
1997	0.25	0.80	0.59	1.01
1998	0.30	0.93	0.71	1.14
1999	0.89	1.16	0.91	1.41
2000	2.71	1.30	1.04	1.57
2001	1.76	0.98	0.77	1.19
2002	2.37	0.89	0.68	1.10
2003	1.19	1.03	0.80	1.26
2004	0.98	0.75	0.57	0.93
2005	0.96	0.99	0.79	1.19
2006	2.05	1.09	0.86	1.33
2007	3.26	1.10	0.85	1.36
2008	1.90	1.25	0.99	1.51
2009	1.24	1.03	0.83	1.24
2010	0.69	0.85	0.71	0.99
2011	0.71	0.98	0.81	1.14
2012	0.62	1.14	0.95	1.33
2013	0.46	1.04	0.86	1.23
2014	0.20	1.01	0.86	1.16
2015	0.26	0.86	0.73	0.99
2016	0.24	0.81	0.68	0.94
2017	0.26	0.77	0.65	0.90

FIGURES

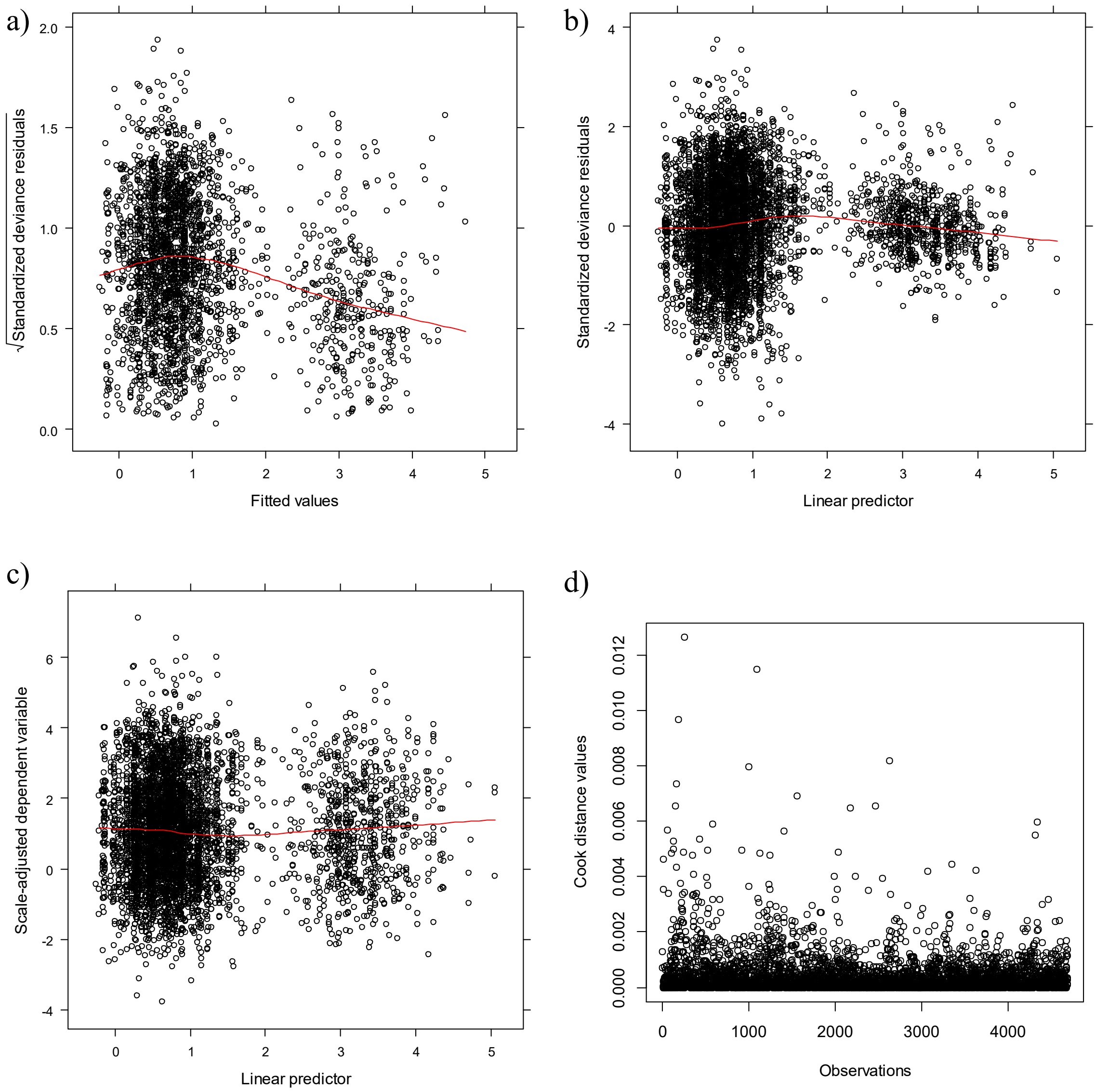

Fig. 3. Diagnostic plots for positive wreckfish (*Polyprion americanus*) catch rates to check (a) the adequacy of the assumed variance function, (b) the assumed error distribution, (c) the link function selection, and (d) the influential observations. The null pattern is a no trend in the residuals (a), a distribution of residuals with mean zero and constant variance (b), a straight line (c), and no observation with Cook distance value greater than 1 (d). The red line is the loess smoother through the plotted values.

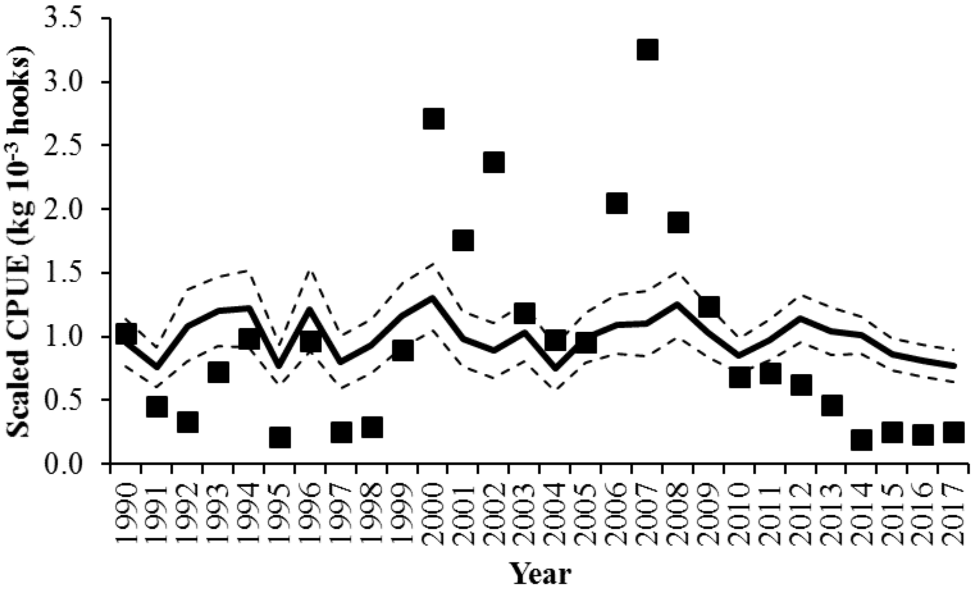

Fig. 4. Nominal (■) and standardized (▬) CPUE (kg 10^{-3} hooks) for wreckfish (*Polyprion americanus*) from the Azorean bottom longline fishery, 1990–2017. Dotted lines represent 95% confidence intervals for the standardized CPUE.

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 2018 for the *Aphanopus* spp. in CECAF fishing area 34, particularly 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 midwater drifting longline fishery in Madeira is being constructed for the period 2008-2019.

1. Introduction

The fishery for deep-water species carried out in the Madeira EEZ and international adjacent waters (CECAF 34.1.2. area), as a fundamental, irreplaceable value to the Madeira fisheries sector. In Madeira, exploited deep-water fish stocks are overwhelmingly dominated by two scabbardfish species: *Aphanopus carbo* and *Aphanopus intermedius*, 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 scabbardfish (off the Madeira archipelago represents one of the oldest continuous and intensive exploitation of a meso-bathypelagic fish species (Biscoito et al., 2011; Delgado et al., 2013).

Both scabbardfish 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).

1.1. Fishery in Madeira

In line with the European Data Collection Framework, the only métier developed by the Madeira fishing fleet targeting deep water species (LLD_DWF_0_0_0) comprises the very specialized Madeira fishery of the black and intermediate scabbard fish (*Aphanopus* spp.), exclusively performed with drifting longlines (**Figure 1**).

This fishery is known by its highly selective nature, concerning the by-catches 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.

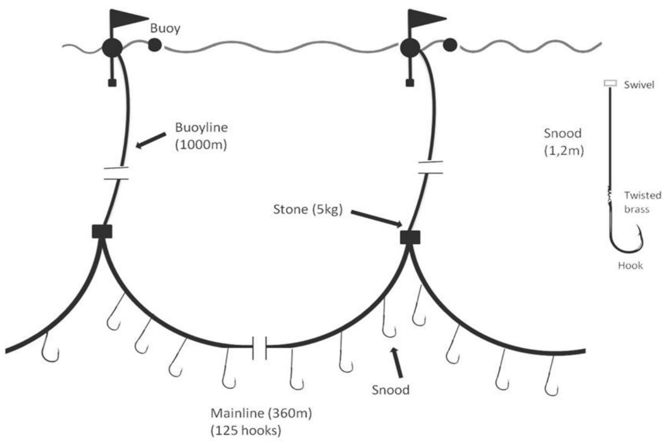

Figure 1 - Drifting long line used by the Madeira fishermen.

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 scabbardfish 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.

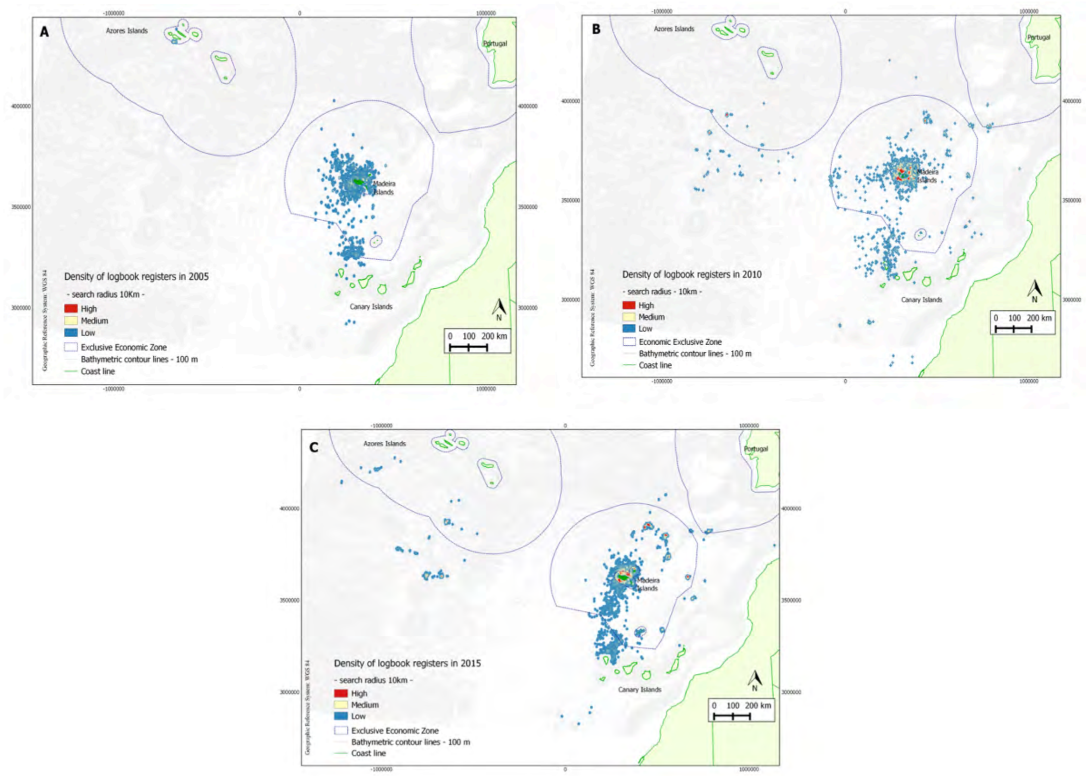

Figure 2 - Density plots illustrating the geographical distribution of the fishing sets with catches in 2005 (A), 2010 (B) and 2015 (C): density maps estimated with the software Quantum GIS 2.2, module "heatmap" covering a search radius of 10 Km (Delgado et al., 2018).

This 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. 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 (October–December). Migrations to areas less than12 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 drifting longline fishery (Vasconcelos et al., 2000).

There are three main aggregation areas identified off Madeira (**Figure 4**), where fishing events occurs during spawning: fishing grounds 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).

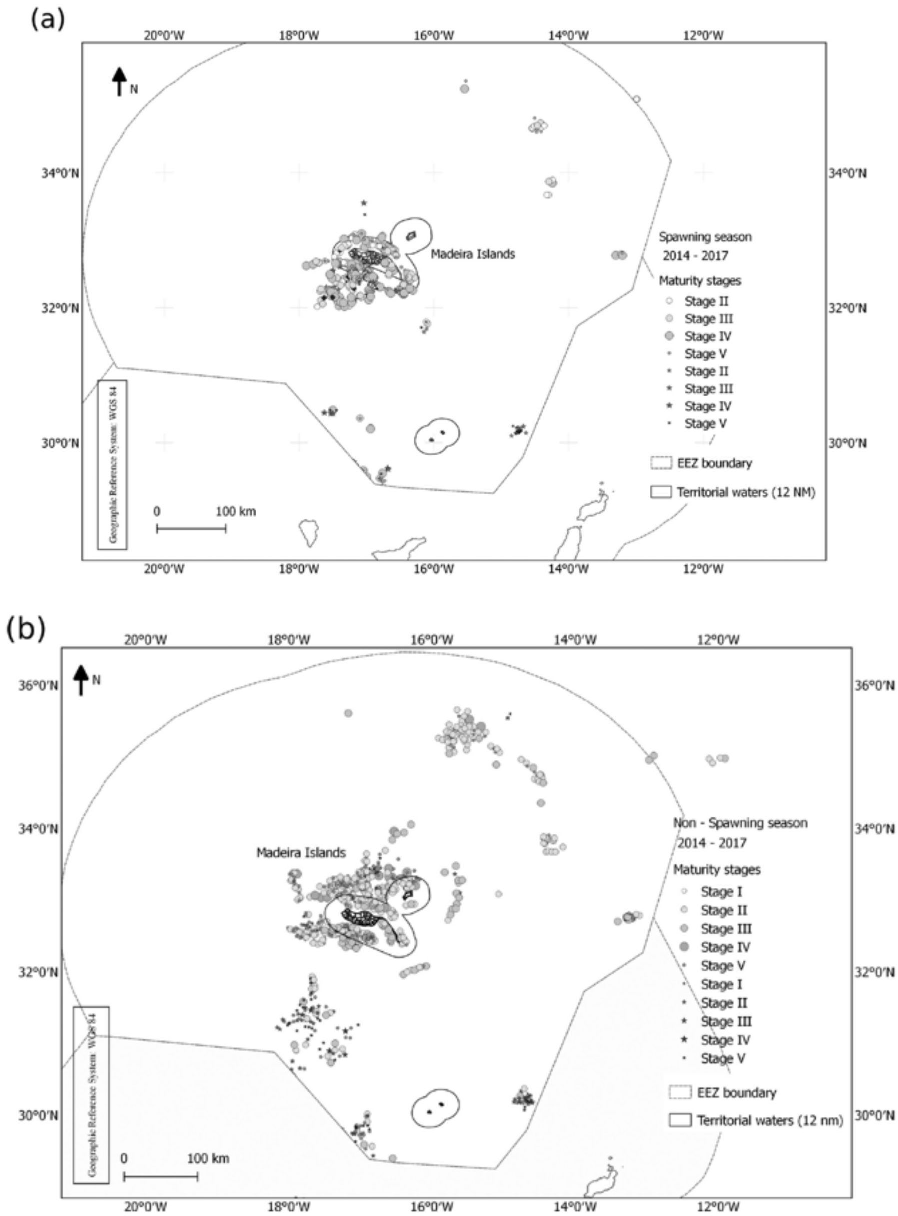

Figure 3 - Map showing both *Aphanopus* species distribution, *A. carbo* (grey circles) and *A. intermedius* (grey stars), during spawning (a) and nonspawning (b) seasons according to the distance from the coast (<12 and >12 nautical miles; 1 n.m. = 1.852 km) (Vasconcelos et al., 2020).

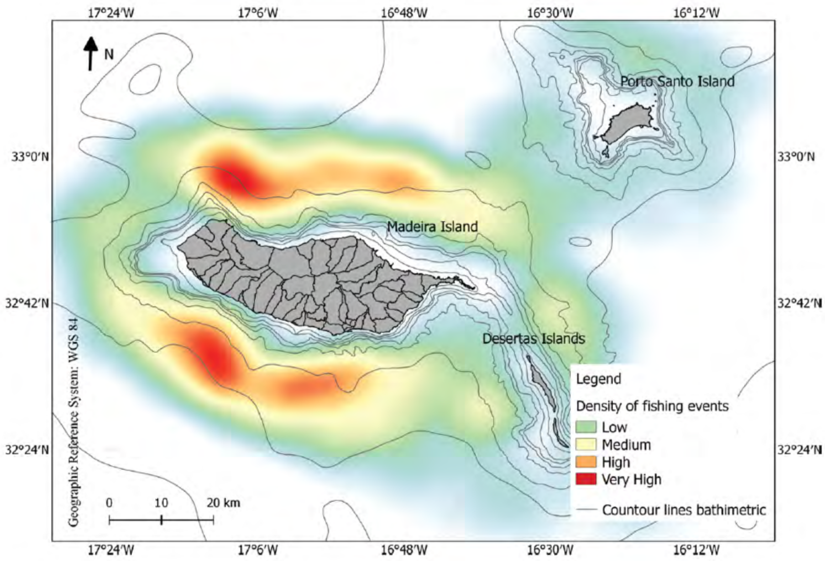

Figure 4 - Kernel density estimation plot showing the mean density values of the fishing events during the spawning season per compartment of 10 km × 10 km generated for the study area and for the period 2014–2017. Low: 1–10; Medium: 11–20; High: 21–30; and Very High: >31 fishing events (Vasconcelos et al., 2020).

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 2019.

2.1.2. Landings and mean price in Madeira archipelago by vessel segment

Portuguese landings of *Aphanopus* spp. in CECAF area 34 (in weight, ton, and value, euro) were analysed by year and by fishing vessel segment. Fishery dependent data were collected from commercial landings for the period between 2008 and 2019. The active flee at CECAF area is composed by the vessel segments VL0010, VL1012, VL1218 and VL1824.

2.2. Length distribution

Aphanopus spp. length sampling data available for Madeira were analysed yearly in the period between 2009 and 2019. Numbers-at-length were raised to the total landings.

2.3. CPUE

All landings from the commercial midwater 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 2019. From each fishing trip data on total weight landed of the species (in kg), vessel name and corresponding length segment, KW, number of days at sea, number of fishing days and fishing operations, and the total number of hooks is available. A trip is defined from the moment the vessel leaves the dock to when it arrives at the dock.

A standardized CPUE model based on daily landings of commercial midwater drifting longline fishery in Madeira is being constructed for the period 2008-2019.

3. Results and Discussion

3.1. Fishery dependent data

3.1.1. Landings and mean price in Madeira archipelago

The annual landings of black scabbardfish derived from Madeiran longliners for the period between 1990 and 2019 are presented in **Figure 5**. Annual landings have been decreasing since the 1998 peak, with a slight but constant recovery in the last eight years, wherein around 2263 tons were landed in 2019. EU has set TACs for both 2018 and 2019 for EU and international waters of CECAF 34.1.2 (BSF/C3412-) of 2189 ton. Between 2008 and 2019, the *Aphanopus* spp. total value in millions of euros (**Figure 6**), followed the same trend observed in the annual landings in terms of weight, with a slight increase in the last few years.

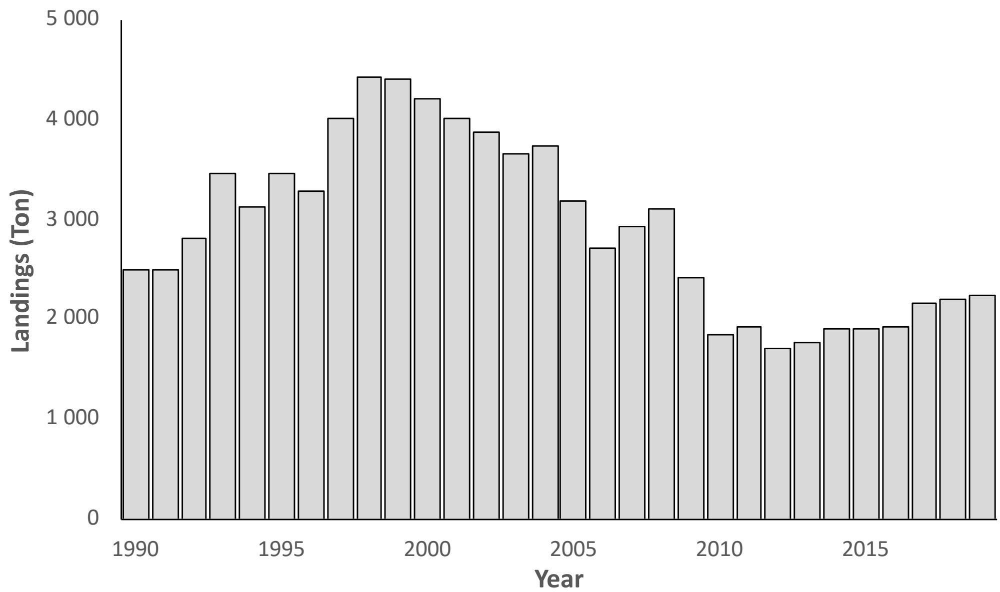

Figure 5 - Time-series of annual Portuguese landings at CECAF area.

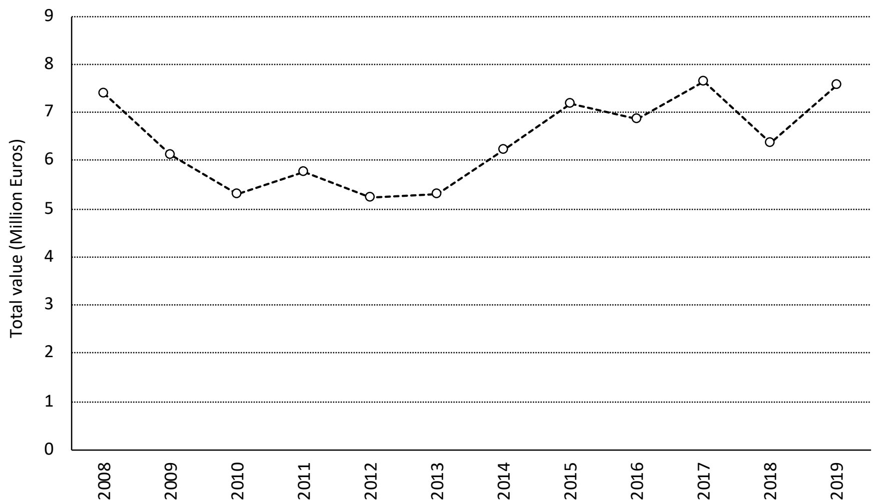

Figure 6 - *Aphanopus* spp. total value in millions of euros, between 2008 and 2019.

3.1.2. Landings and mean price in Madeira archipelago by vessel segment

The number of vessels in activity in Madeiran longline fleet has steadily decreased during the last two decades (**Figure 7**).

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 8),** mostly (52%) between 12 to 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.

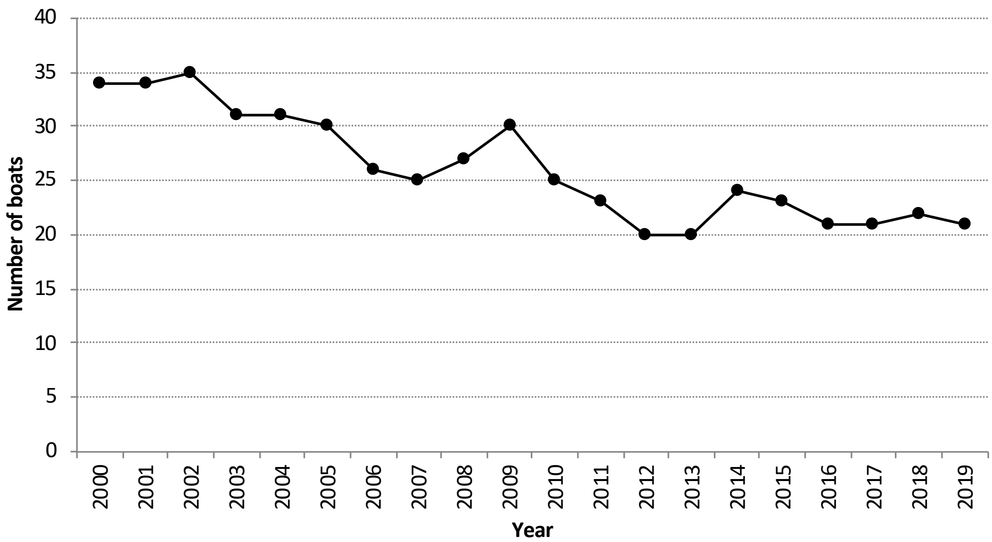

Figure 7 - Number of vessels active in the fishery at CECAF area between 2000 and 2019.

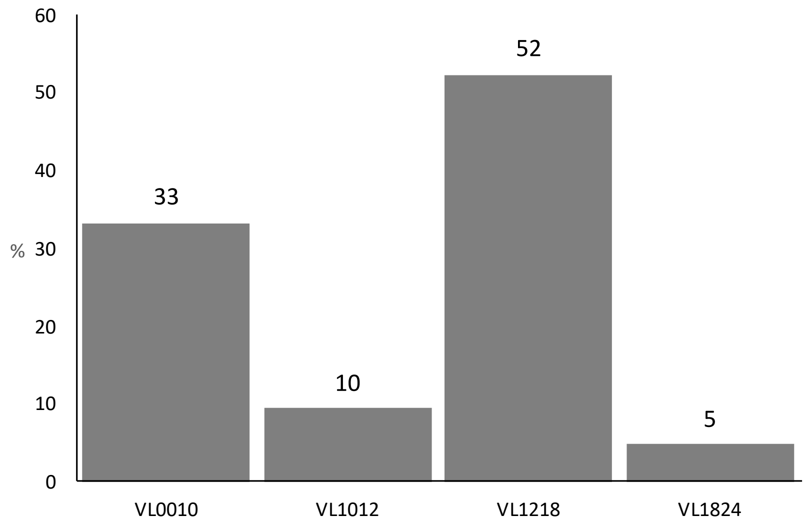

Figure 8 -Composition of the fleet active in 2019 at CECAF area per vessel length (n=21 vessels).

A time-series of annual Portuguese landings at CECAF area per vessel length is represented in **Figure 9**. The majority of the annual landings in Madeira are made by vessels of the length segments VL1218 and VL1824, wherein 82% of the total landings in 2019 were captured by VL1218.

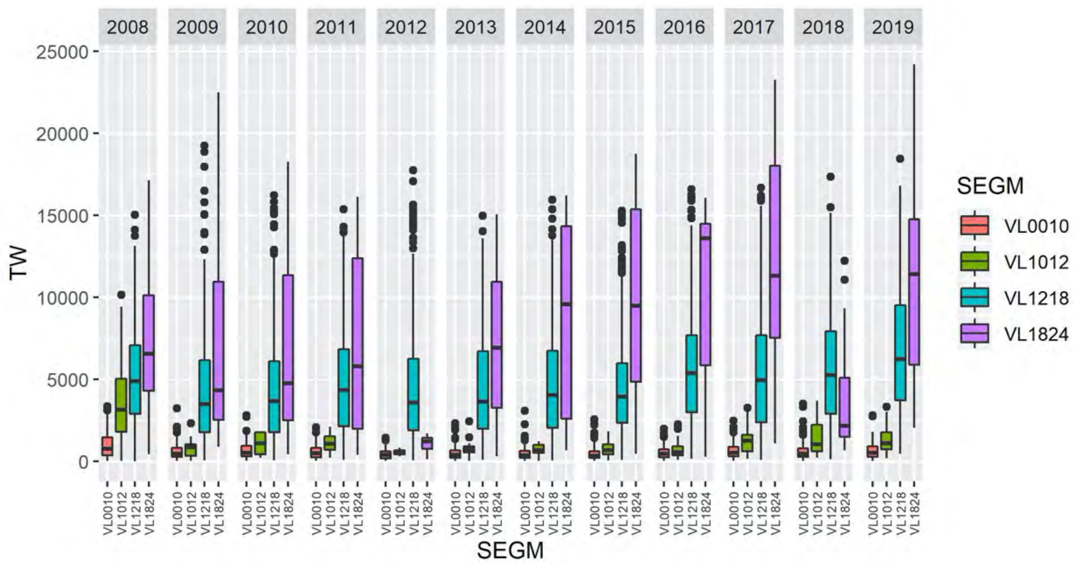

Figure 9 - Time-series of annual Portuguese landings at CECAF area per vessel segment.

The vessel segment VL1218 presented the highest landing values, followed by the vessel segment VL1824 (**Figure 10**). 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.

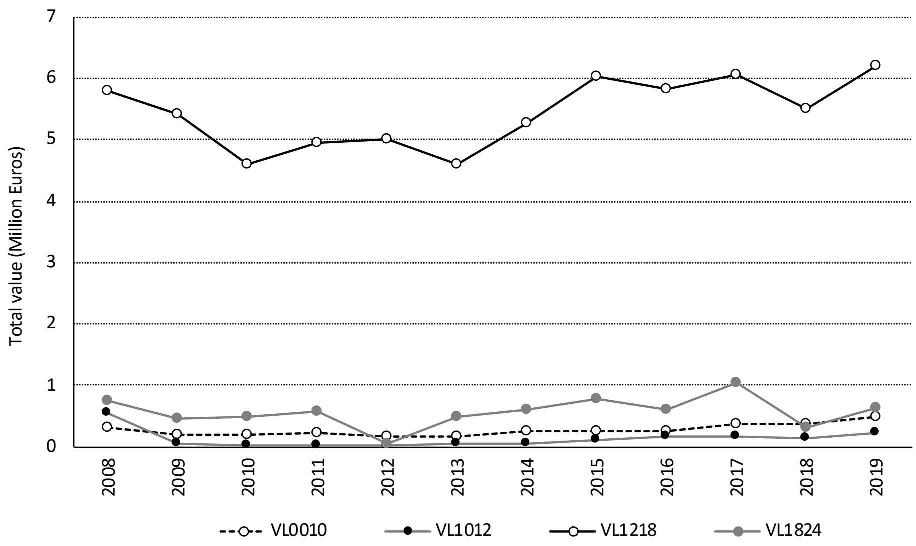

Figure 10 -*Aphanopus* spp. total value in millions of euros per vessel segment between 2008 and 2019.

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 2009–2019 are presented in **Figure 11**. The analysis of this figure indicates neither great changes on the length range between years nor on the mean length (around 117-118 cm total length, TL), with the exception of 2019 where the mean length observed was 115 cm TL. The smaller number of vessels sampled in 2019 for length frequency distribution analysis, may have influenced the estimated mean value.

3.3. CPUE

Regarding the fishing effort in total number of hooks accumulated per year (**Figure 12**), 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 (12 M).

The unstandardized CPUE had an overall decline along the analysed period (**Figure 13**). 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 from 2017.

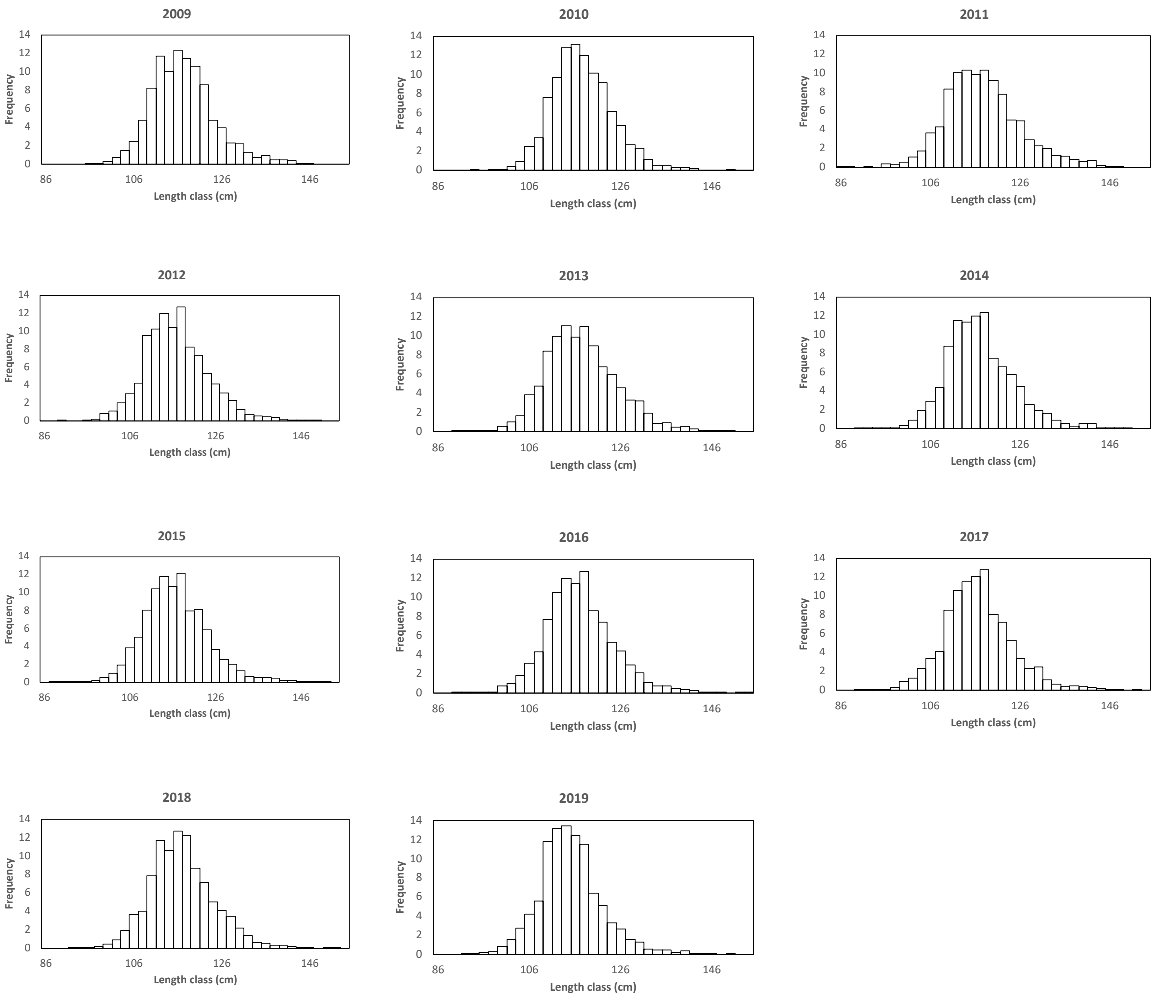

Figure 11 - Annual length–frequency distribution of specimens landed by the Portuguese longliners operating along CECAF area.

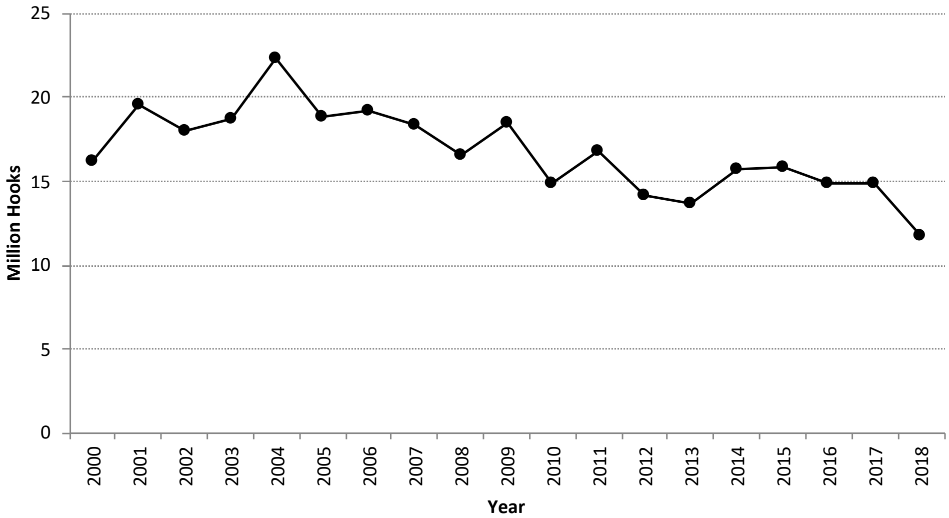

Figure 12 - Time-series of the total annual effort estimated for the CECAF area (million hooks).

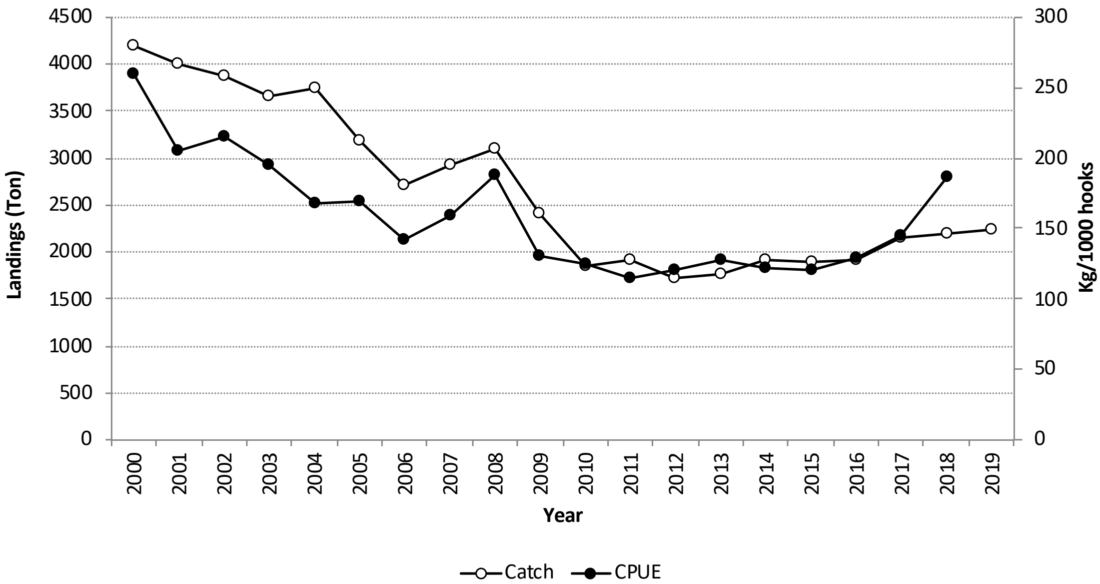

Figure 13 - Time-series of Landings per unit effort, CPUE unstandardized (kg / thousand hooks), in CECAF area.

A standardized CPUE model based on daily landings of commercial drifting longline fishery in CECAF 34 area is being developed for the period of 2008-2019. An exploratory data analysis showed a high correlation between the number of hooks and the number of hauls (**Figure 14**), but no other variable showed highly correlation with the number hooks per haul.

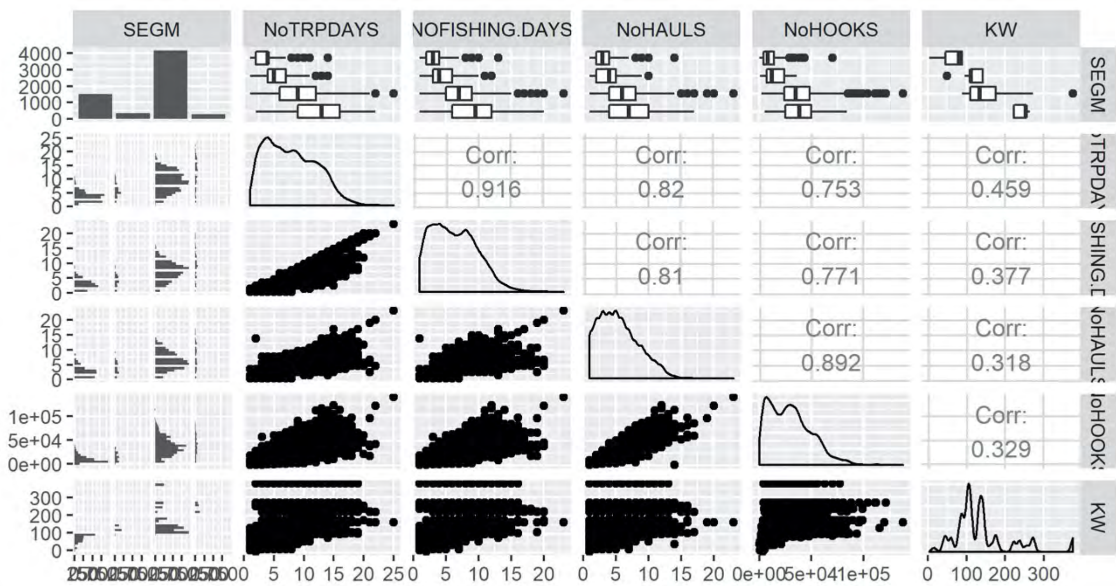

Figure 14 - Exploratory data analysis showing the correlation between the potential variables for the CPUE standardised model.

The exploratory standardised CPUE data analysis per year and by vessel segment (**Figure 15**) showed a recovery in the last four years, especially in the vessel segments smaller than 18 meters, which represents 95% of the Madeira drifting longline fleet. However, these are just preliminary results and further analysis will be performed.

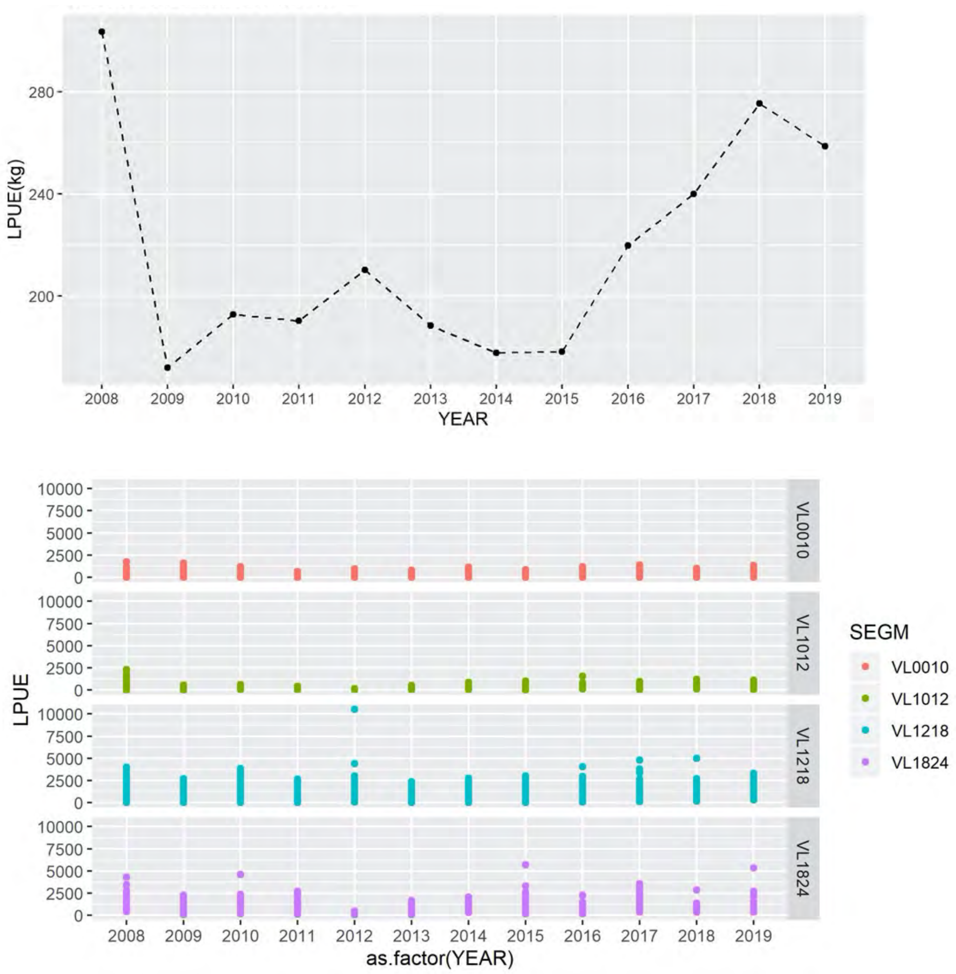

Figure 15 - Time-series of the standardized CPUE (kg/haul), per vessel segment (A) and all segments combined.

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Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources

24th April -1th May 2020

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 2013-2019. 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 (in 2019 no survey was performed). 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 the 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 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), it is observed a depth effect on specimen's size (Massutí et al., 1996): larger specimens occur deeper (>600 m deep) (Fig.1).

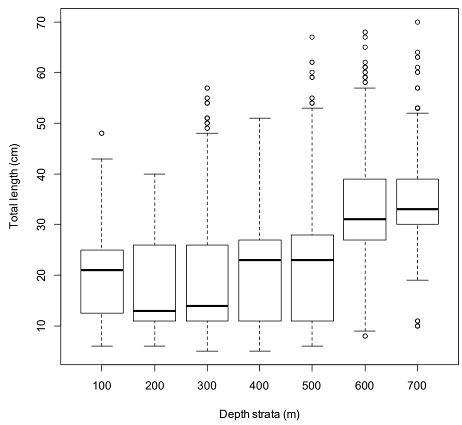

Figure 1. Inter-quartile total length range of *P. blennoides* by depth strata (m) caught during the Portuguese Crustacean Surveys/Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) undertaken between 1997 and 2016 (no survey was conducted in 2012).

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, depending on the targeted species and on the fishing grounds, deploy more than one fishing gear. 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*. Also, 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 the *Phycis* spp. landings corresponding to *P. blennoides* (~1 tonne in 2019) 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 since 2003. *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	0.198		8.85		4.13	1.69	172.00		0.0032		1.27	
2018	0.190		9.23		2.70	0.35	129.00				0.64	
2019	0.0174		7.12		2.03	0.313	133.00				1.34	

2.2. 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 2009-2019, 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 landing 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, 11 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 values (Fig. 2a) and of their transformed values (Fig. 2b) for the period 2013-2019. Figure 3 presents a skewness-kurtosis plot such as the one proposed by Cullen and Frey (1999) for the log-transformed empirical distribution. This plot is used as a tool to help the choice of distributions to fit to data. Values for common distributions are also displayed. While for some distributions they are just represented by a point on the plot, for others, areas of possible values are represented, consisting in lines (gamma and lognormal distributions for example) or larger areas (beta distribution, for example).

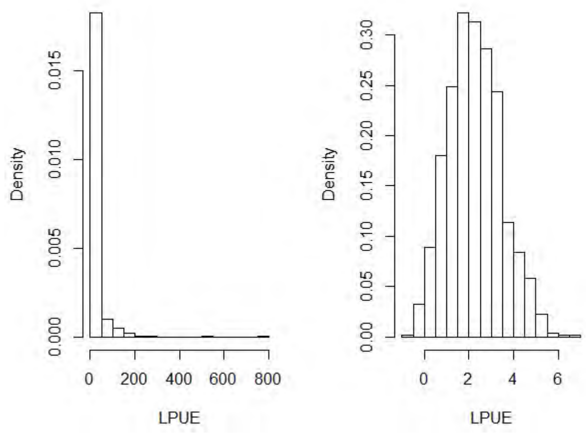

Figure 2. Reference fleet - histogram of the daily landing values (left) and of their log-transformed (right) for 2013-2019.

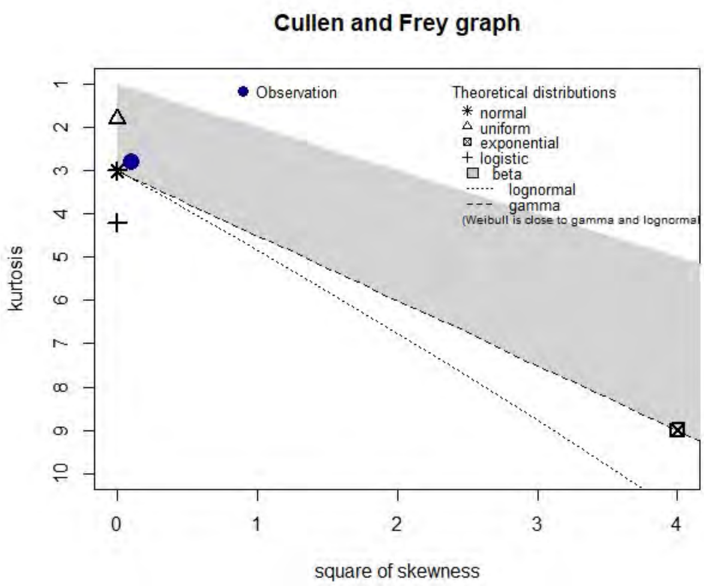

Figure 3. Reference fleet - skewness-kurtosis plot as proposed by Cullen and Frey (1999) for the log-transformed catch rate empirical distribution.

The normal distribution indicates a better adjustment to 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 fitfor log transformed CPUE. The variables considered in the selected model included the Month, Vessel code and Year. The graphical analysis of the residuals suggests inexistence of strong violations of model's assumptions (Fig. 4).

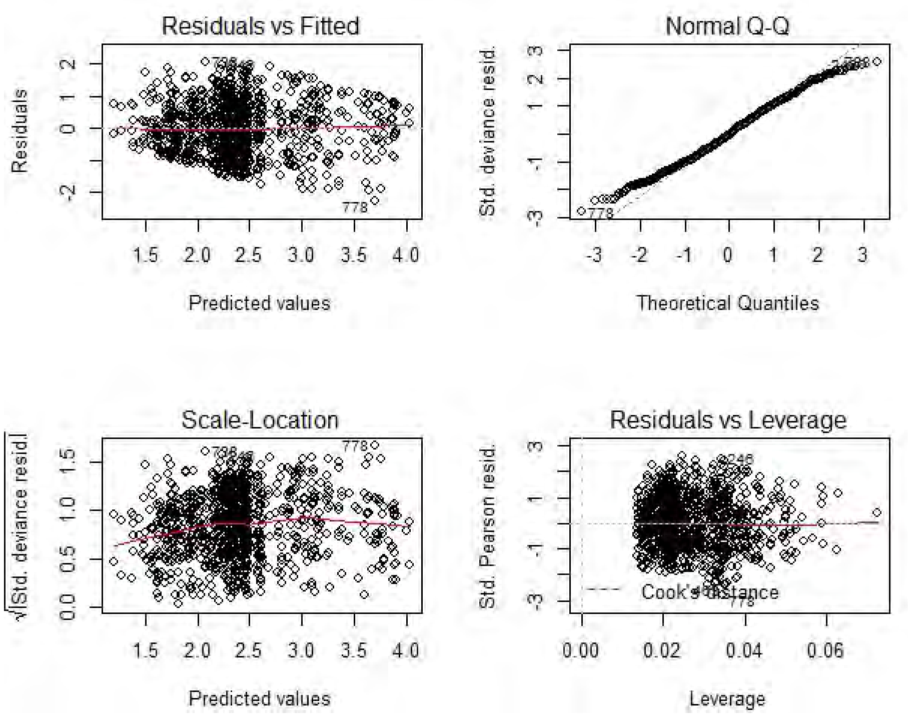

Figure 4. Reference fleet – residual analysis plot of the selected model

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 2013-2019. Estimated values on the original scale are presented in Table 2.

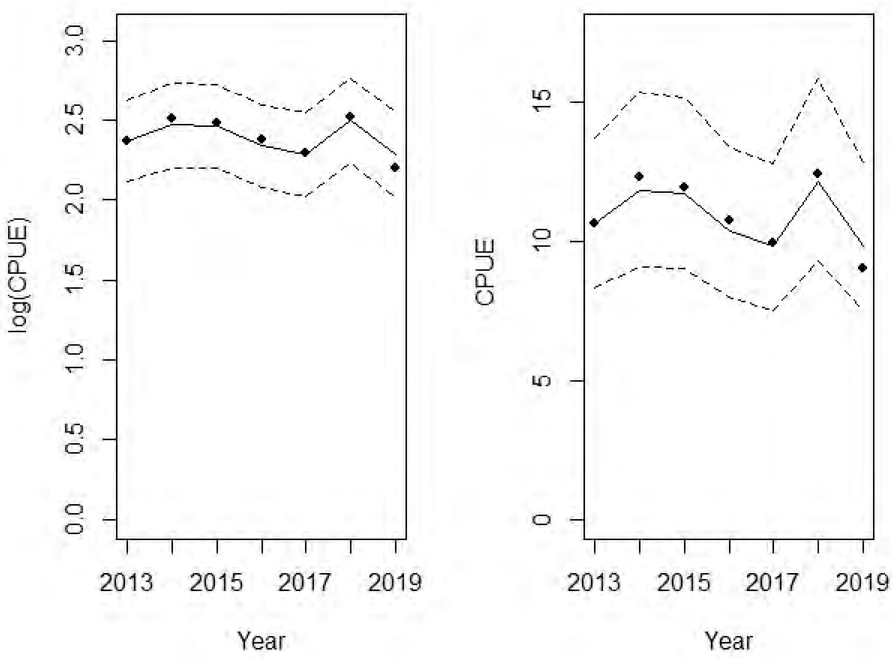

Figure 5. Reference fleet – CPUE (Kg/trip) estimates and 95% confidence intervals of log transformed catch rate and of values in on the original scale for the period 2013-2019. The black dots correspond to the observed mean annual catch rates.

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 2013-2019.

Year	Observation Kg/trip	CPUE estimate Kg/trip	Upper	Lower
2013	10.68	10.68	13.72	8.31
2014	12.31	11.82	15.40	9.07
2015	11.93	11.72	15.20	9.03
2016	10.76	10.37	13.42	8.01
2017	9.94	9.83	12.80	7.55
2018	12.46	12.16	15.90	9.30
2019	9.01	9.86	12.89	7.55

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 2019 (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). 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 2014-2019. However, due to the low number of samples available for 2018 this year was 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 Table 3. 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	**$\geq$ 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

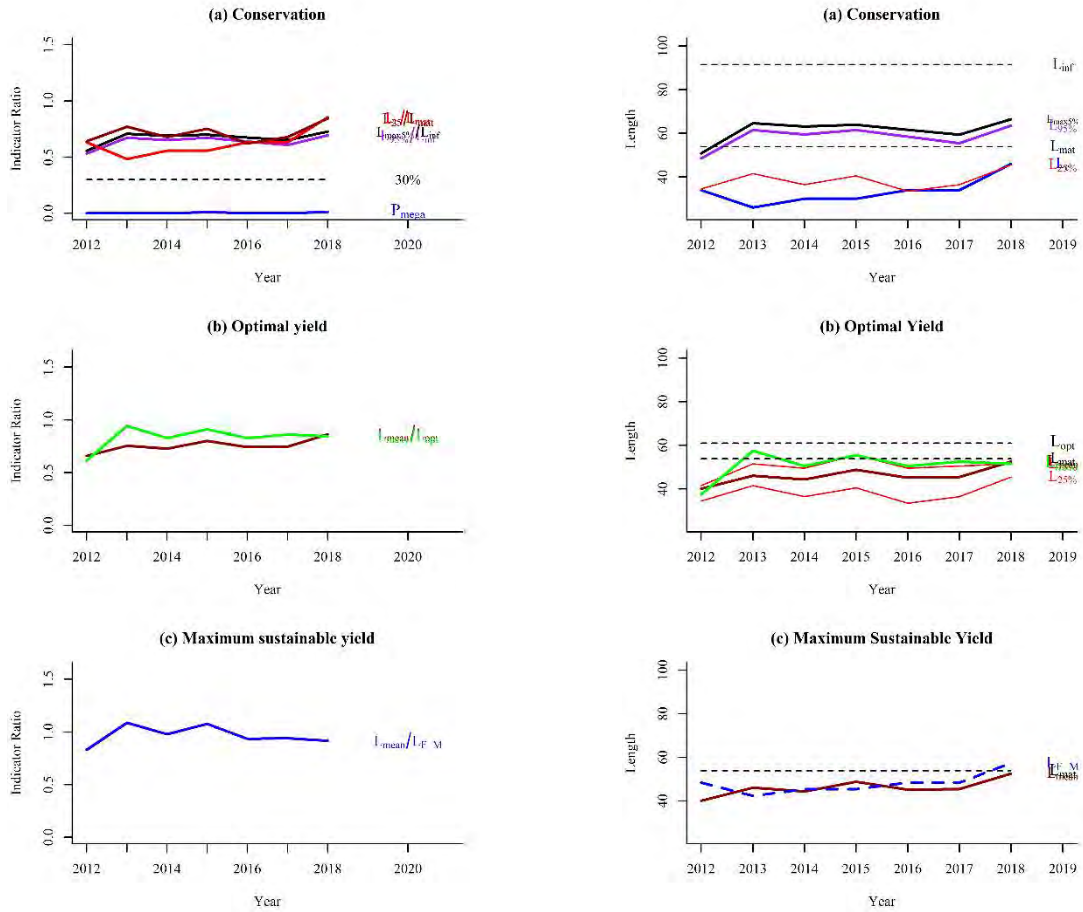

Figure 6. Results from LBI screening.

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 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. However, given the uncertainty in species identification (it is possible that misidentification problems with *Phycis phycis* have occurred in the past) at the beginning of the time series 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).

As a result of the initial exploratory analysis the sector Milfontes was selected to provide the standardized relative biomass index estimates. For analysed time series, this sector is the one that presents a good temporal sampling coverage and also because 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).

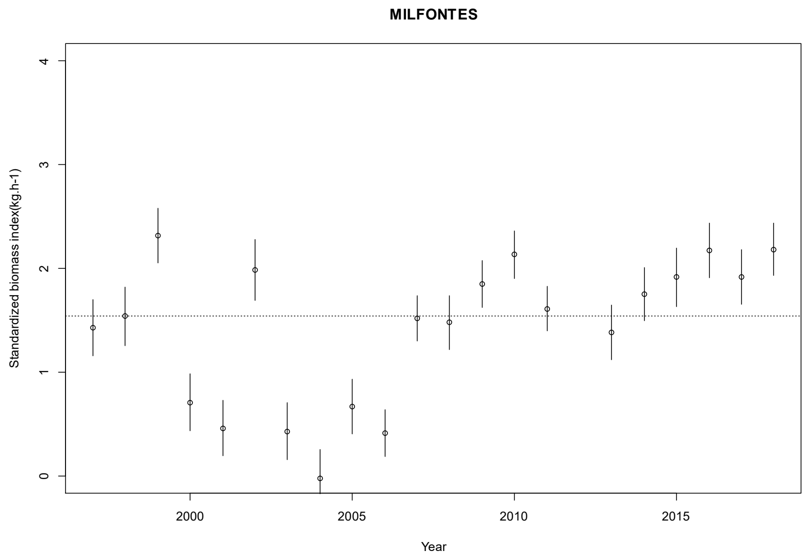

Figure 7. Standardized biomass index (kg.hour^{-1}) for the Portuguese Crustacean Surveys/Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) undertaken between 1997 and 2018. CPUE values estimated for the sector "Milfontes".

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 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.

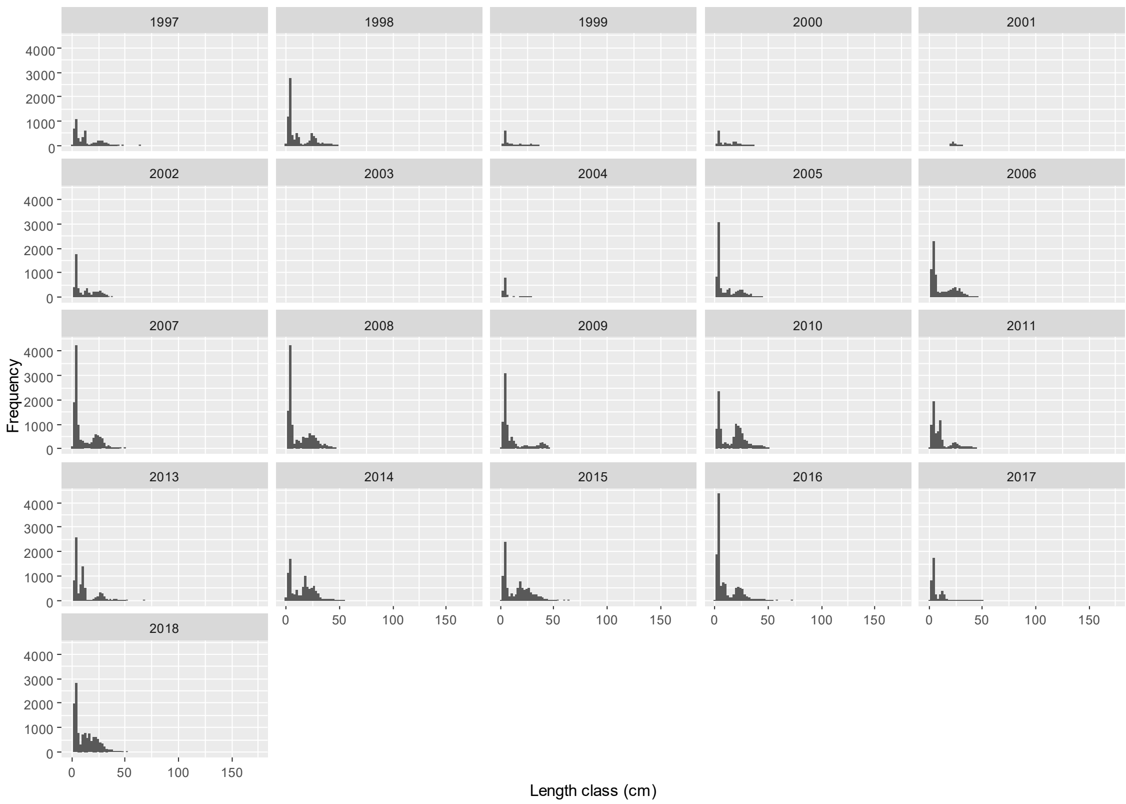

Figure 8. Length frequency distribution by year of the greater forkbeard in the PT-CTS (UWTV (FU 28-29))) survey.

4. Conclusions

The two standardized CPUE series, either based on commercial or research survey 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 a 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.

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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, ex-IPIMAR) 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).

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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) that 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:

$$\text{CPUE= Year+Sector+Depth -1}$$

Model´s adequacy was checked 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).

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Pagellus bogaraveo in the 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 and in the case of females the age of first maturity is about 8 years old (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).

Despite the poor knowledge on the species stock structure, ICES adopts, for management purposes, three management components: (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 mainland Portugal (ICES Division 27.9.a) between 2014 and 2019 (Table 1).

Table 1. *Pagellus bogaraveo* Total Allowable Catch (TAC) and Portuguese quota and official landings in ICES Subarea 27.9, between 2014 and 2019.

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

1.1. Fishery in Portugal mainland

In mainland Portugal, *P. bogaraveo* is mainly caught as by-catch of fisheries targeting other species. Peniche (Portuguese central western coast) is the most important landing port (landings between 1999 and 2019 represented nearly 50% of the Portuguese landings of the species in ICES Division 27.9.a). Highest landing values are registered between December and March.

Fishery data and information collected through enquiries made to Peniche skippers with experience on *P. bogaraveo* fishing (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 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.
Information on blackspot seabream collected from 1990 to 2018 (in 2019 no survey was performed) 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.

2. Methodology

1.1. Fishery dependent data

1.1.1. Landings and mean price in mainland 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 2019.

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, mainland 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 2019, by fishing segments (polyvalent and trawl) and by NUTS II (North, Centre, and Algarve).

1.1.3. Landings in the most important Portuguese mainland ports

Pagellus bogaraveo total landings in weight (ton) were analysed throughout the year, between 2009 and 2019, 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

A reference fleet for the polyvalent fishing segment and another for the trawl fishing segment were defined.

The criteria adopted for the selection of fishing vessels were: i) vessels with mean number of trips with positive landings of blackspot seabream by year greater than 9, between 2015 and 2019; and ii) vessels with mean number of months with positive landings of blackspot seabream by year greater than or equal to 6, between 2015 and 2019.

The previous data were restricted to landings in Peniche port because 70% of landings of the selected vessels took place in this port.

The criteria adopted for the selection of fishing vessels were: i) vessels with mean number of trips with positive landings of blackspot seabream by year greater than 9, between 2015 and 2019; and ii) vessels with mean number of months with positive landings of blackspot seabream by year greater than 5, between 2015 and 2019.

The previous data were restricted to landings in Peniche, which was the port were most of the landings (37%) of the selected vessels took place.

1.2.2. CPUE adjustment

Considering only the selected vessels for each fishing segment, data available at fishing trip level for each selected vessel 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 species 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 the 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 mainland were analysed by year in the period between 2014 and 2019. 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 mainland. 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 2019 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

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
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 mainland Portugal

In the period between 2009 and 2019, 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).

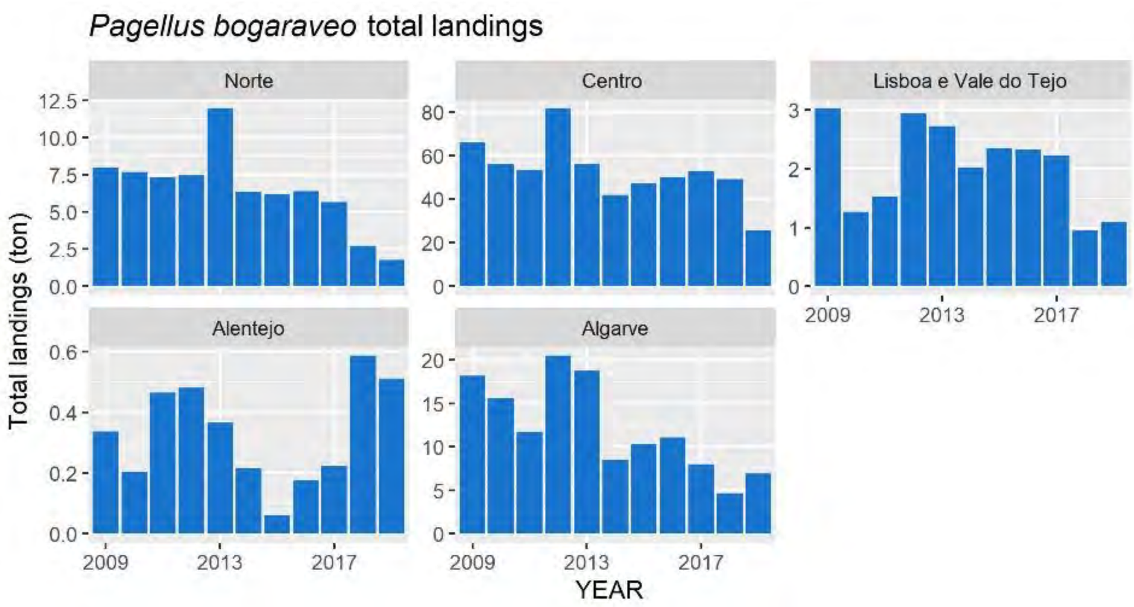

Figure 1. *Pagellus bogaraveo* total landings in tonnes in each NUTS II in Portugal mainland between 2009 and 2019.

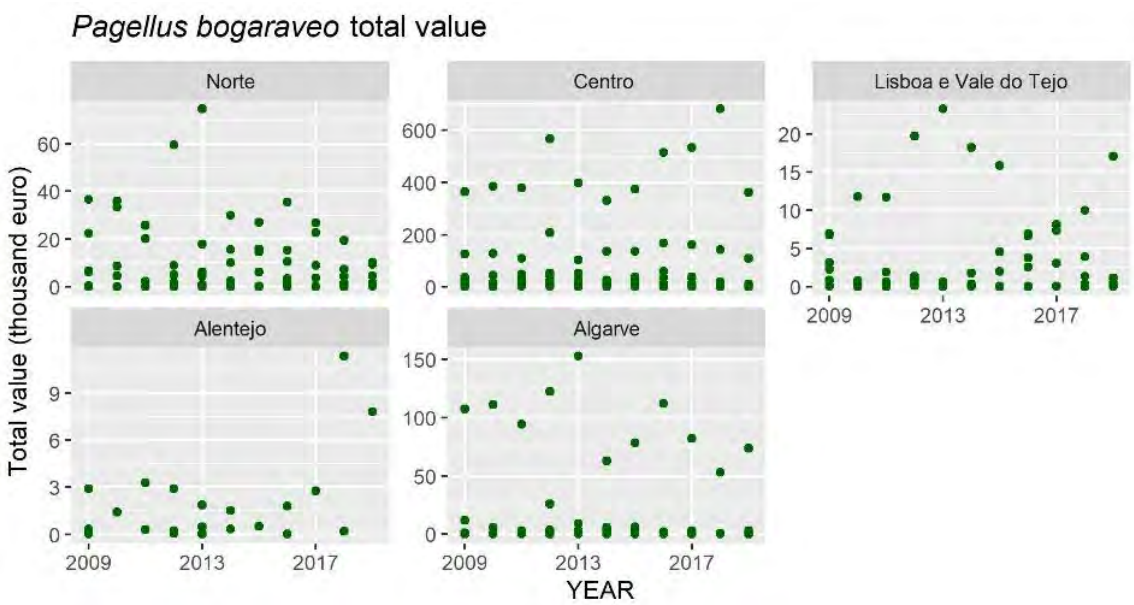

Figure 2. *Pagellus bogaraveo* total value in thousands of euros in each NUTS II in Portugal mainland between 2009 and 2019.

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, where the polyvalent represented around 60% of the species landings, the trawl segment represented nearly 40%, and the purse-seine fishery less than 1%.

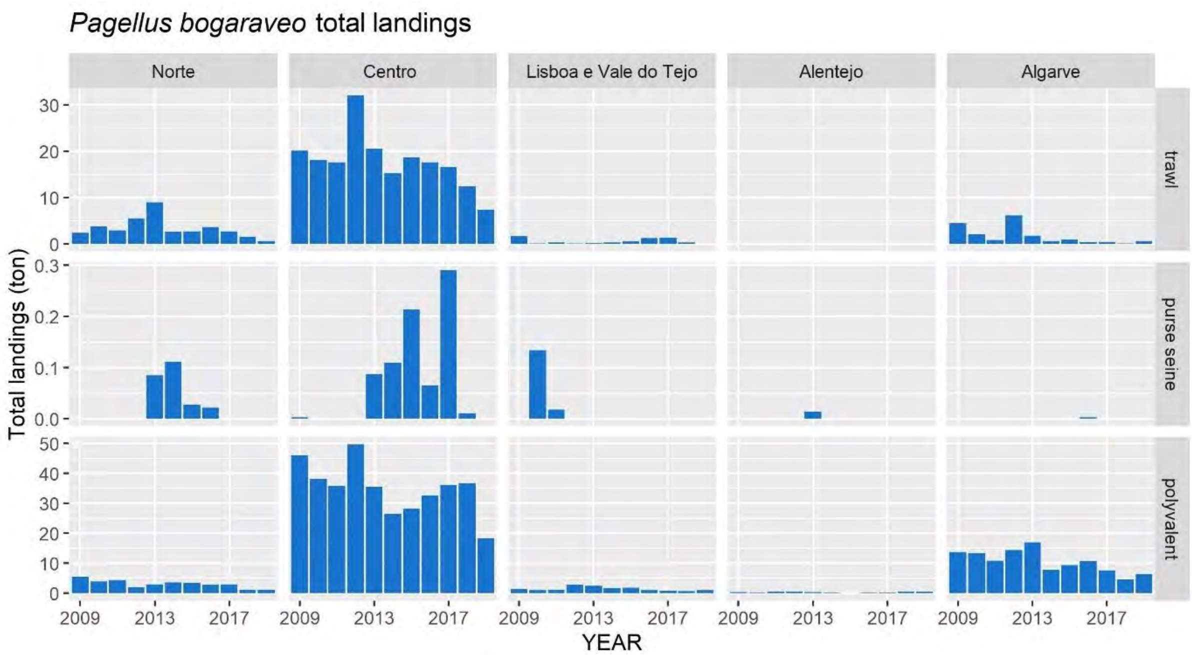

Figure 3. *Pagellus bogaraveo* total landings in tonnes by fishing segment (trawl, purse seine, and polyvalent) in each NUTS II in Portugal mainland between 2009 and 2019.

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, it was observed a decreasing trend in the number of vessels landing the species, which is probably associated to the continuous EU TAC reduction in Subarea 27.9 since 2004 (ICES, 2017a).

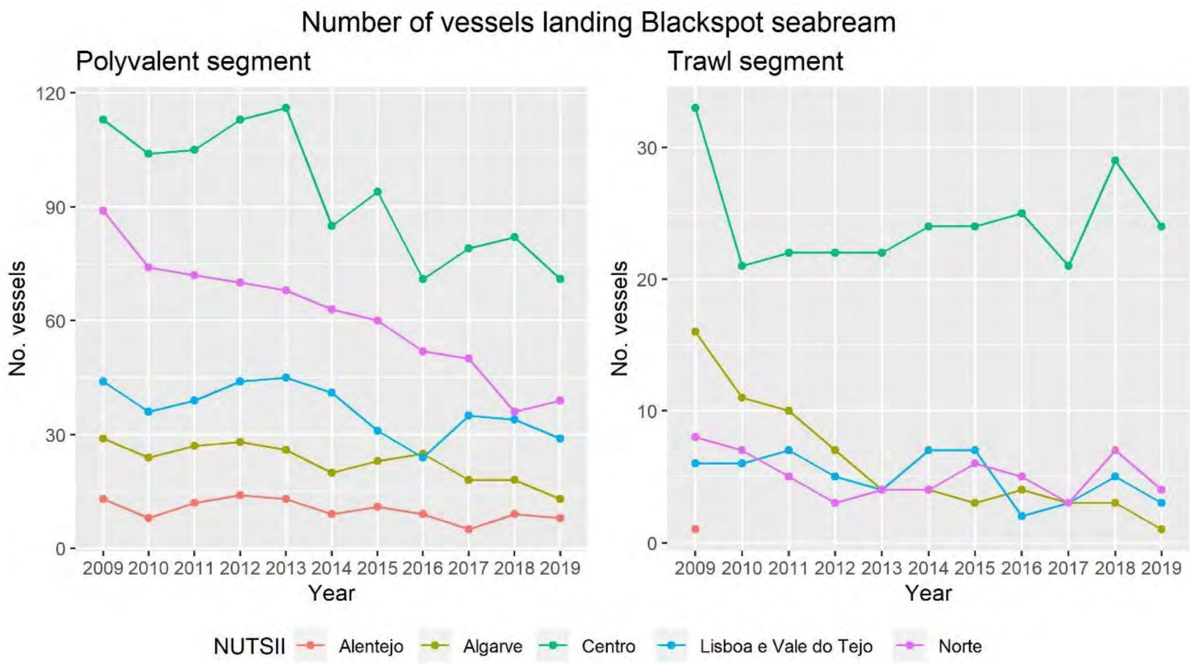

Figure 4. Number of vessels landing *Pagellus bogaraveo* in each NUTS II in Portugal mainland, by year and by fishing segment (polyvalent and trawl), from 2009 to 2019.

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 (Figure 5). In the North 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 2019, there was a decreasing trend in the species landings in the three considered NUTS II.

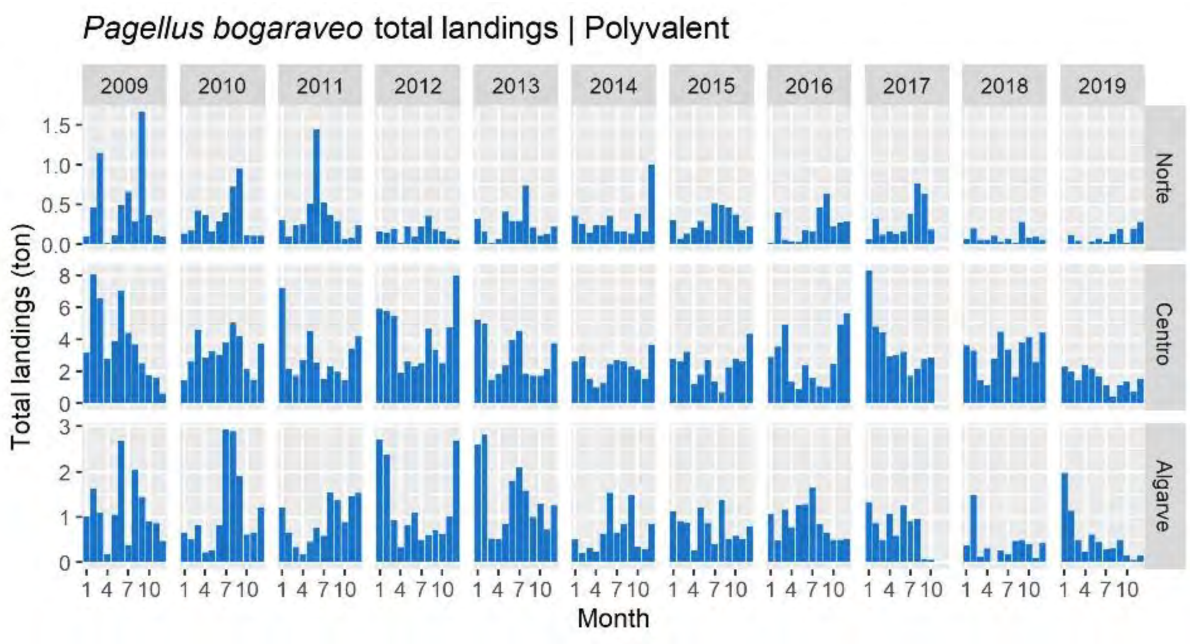

Figure 5. *Pagellus bogaraveo* landings (tons) from the polyvalent fleet by month and year at the three most important NUTS II in Portugal mainland, from 2009 to 2019.

The trawl fishing segment shows a sharp decrease in total landings by month from 2012-2013 to the 2019 (Figure 6). In the North and in the Centre, landings were also higher at the beginning and end of the year. In the South, landings occur mainly in the months in the middle of the year since 2013.

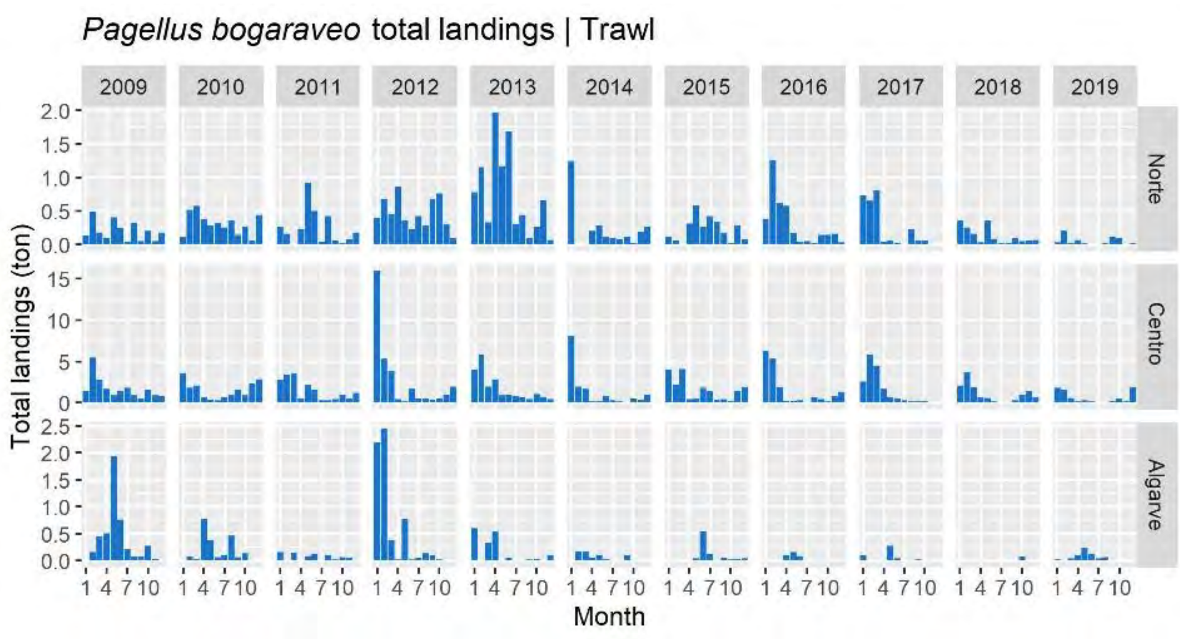

Figure 6. *Pagellus bogaraveo* landings (tons) from the trawl fleet by month and year at the three most important NUTS II in Portugal mainland, from 2009 to 2019.

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.

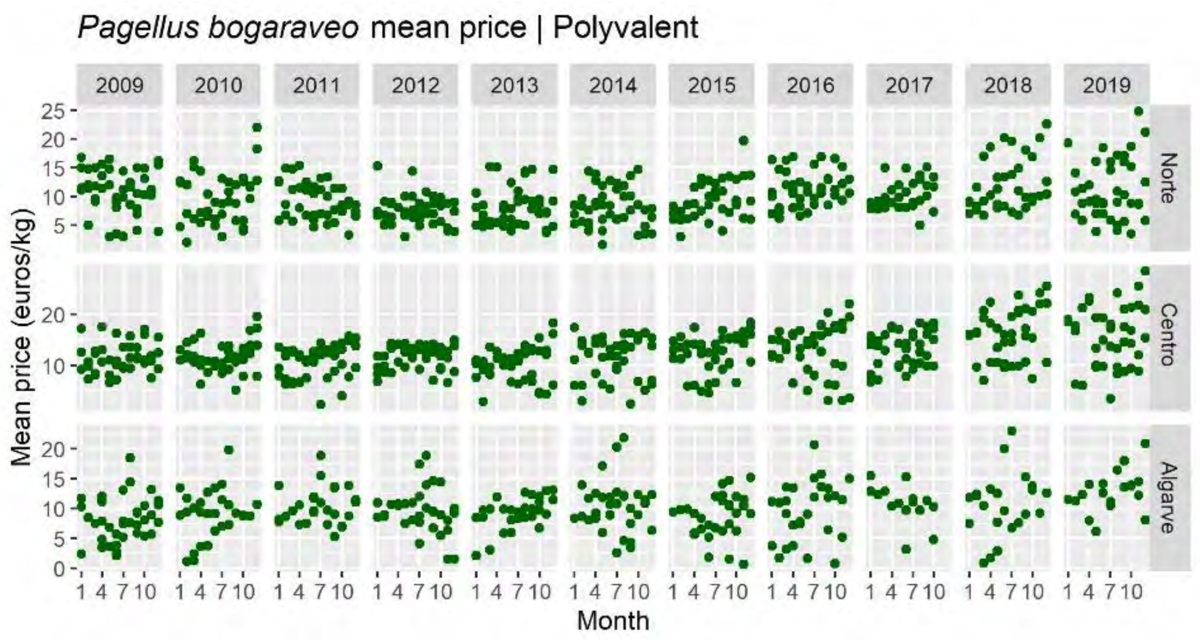

Figure 7. Mean price (in euro per Kg) of *Pagellus bogaraveo* landed by the polyvalent fishing segment along the months for the three main NUTS II in Portugal mainland between 2009 and 2019.

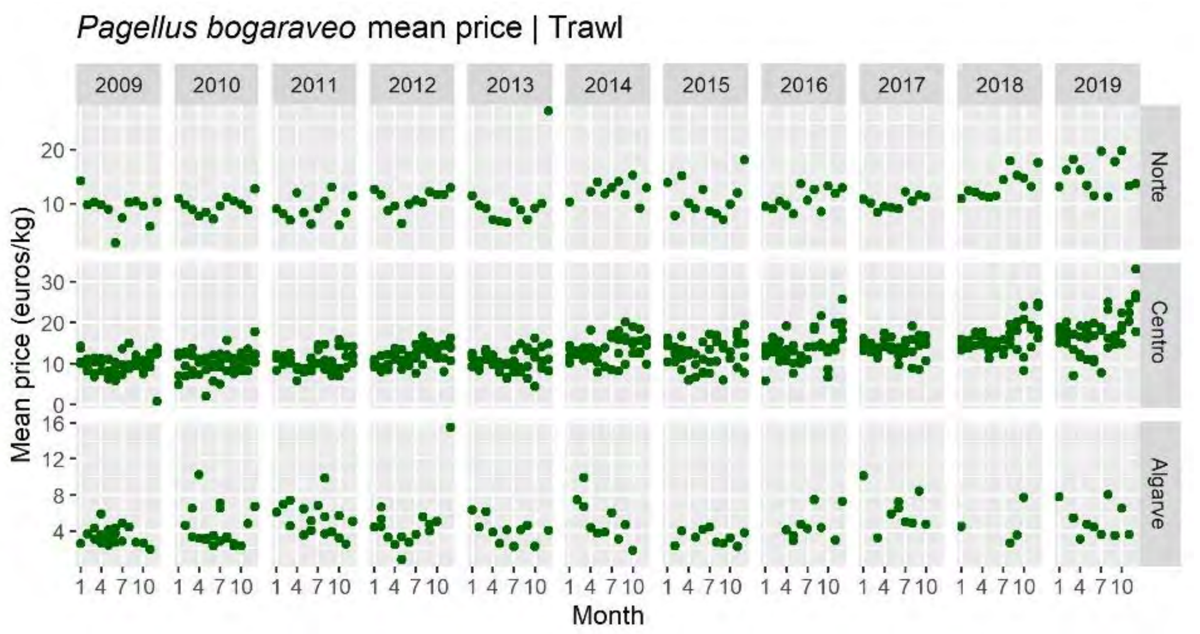

Figure 8. Mean price (in euro per Kg) of *Pagellus bogaraveo* landed by the trawl fishing segment along the months for the three main NUTS II in Portugal mainland between 2009 and 2019.

2.1.3. Landings in the most important Portuguese mainland 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 presented much higher landings than the other ports for both fishing segments. Extreme values were excluded from the plots for better visualization of data.

P. bogaraveo total landings by most important ports and by fleet segment are summarised in Annex 1.

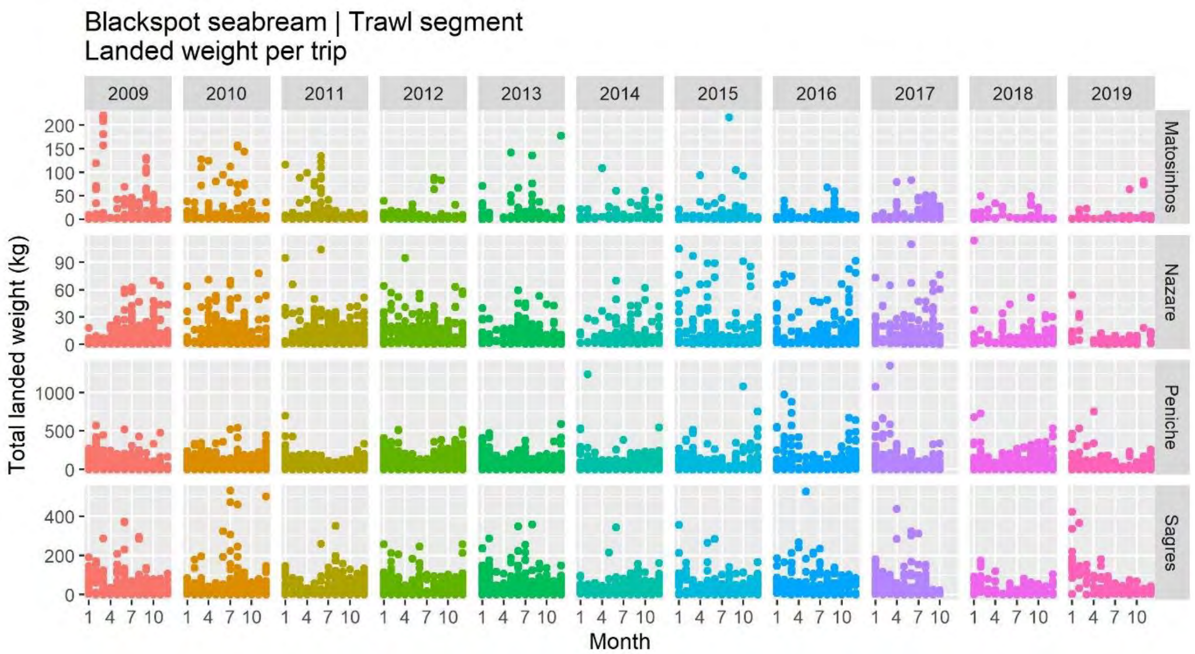

Figure 9. *Pagellus bogaraveo* total landed weight (kg) from the polyvalent fishing segment by month and year at the most important ports in Portugal mainland, from 2009 to 2019.

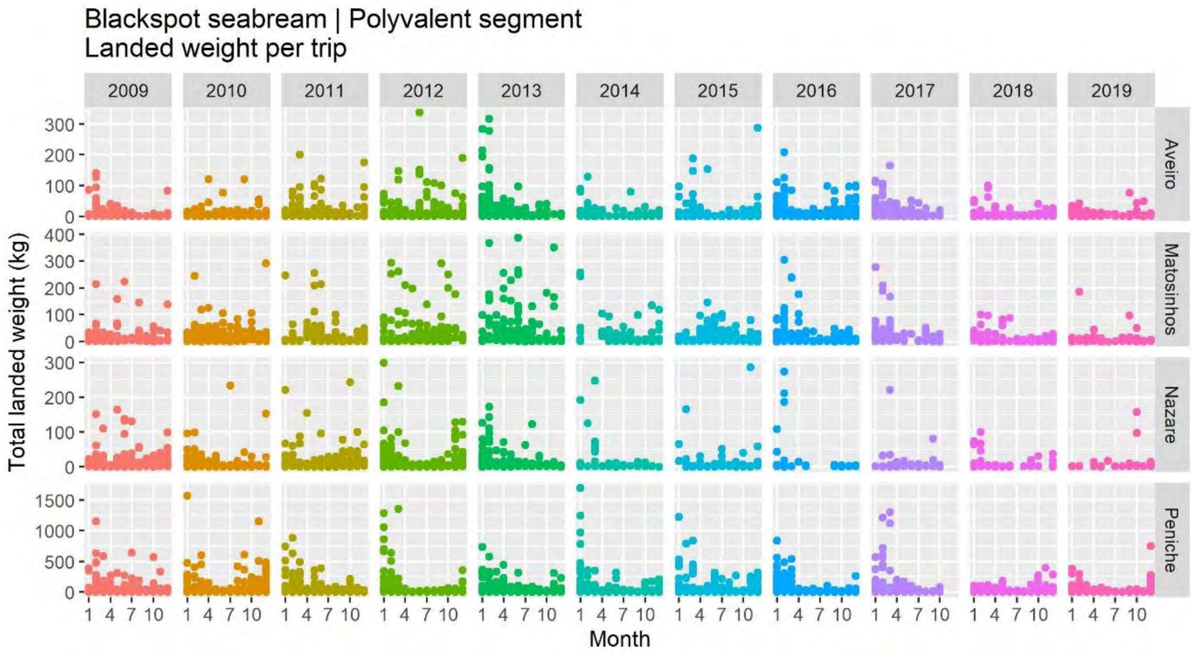

Figure 10. *Pagellus bogaraveo* total landed weight (kg) from the trawl fishing segment by month and year at the most important ports in Portugal mainland, from 2009 to 2019.

2.2. LPUE

2.2.1. Reference fleet

A total of 21 fishing vessels were selected for the polyvalent fleet landing in Peniche port and a total of 14 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 model was selected based on AIC and analysis of the residuals. 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 shows a decreasing trend since 2017.

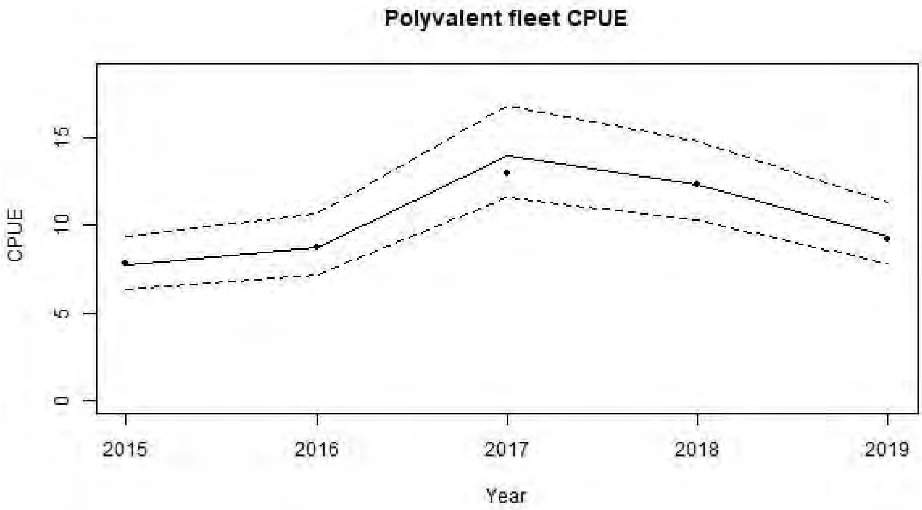

Figure 11. *Pagellus bogaraveo* Peniche polyvalent fishing segment reference Fleet. Standardized annual estimates of CPUE for the period from 2015 to 2019.

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	7.78	6.36	7.72	9.36
2016	8.75	7.19	8.75	10.64
2017	12.94	11.54	13.94	16.83
2018	12.33	10.25	12.33	14.82
2019	9.21	7.79	9.39	11.31

The analysis of the residuals of the fitted model is presented in Figure 12.

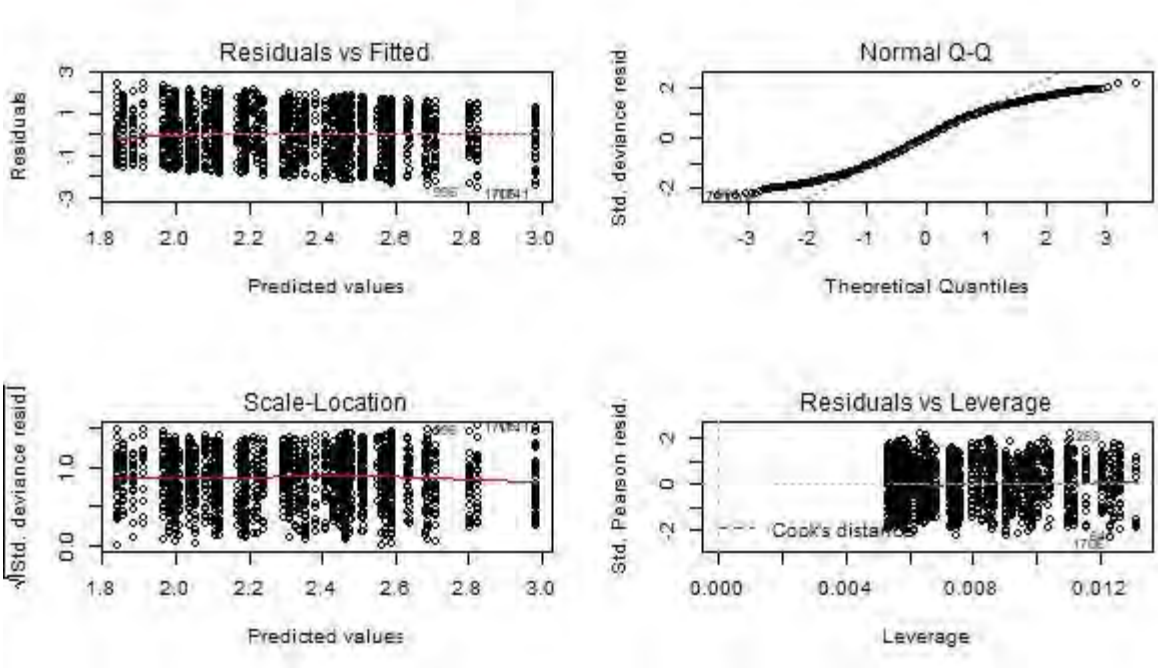

Figure 12. *Pagellus bogaraveo* Peniche polyvalent fishing segment reference fleet.

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 shows a decreasing trend since 2018.

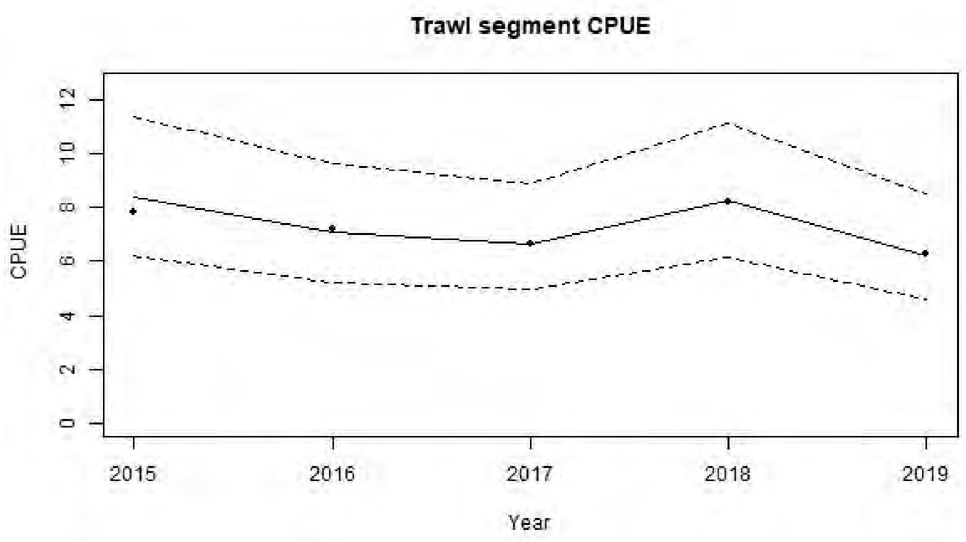

Figure 13. *Pagellus bogaraveo* Peniche trawl fishing segment reference Fleet. Standardized annual estimates of CPUE for the period from 2015 to 2019.

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	8.54	6.77	9.27	12.70
2016	7.47	5.36	7.36	10.12
2017	6.76	4.98	6.76	9.17
2018	8.25	6.08	8.31	11.35
2019	6.56	4.70	6.52	9.04

The analysis of the residuals of the fitted model is presented in Figure 14.

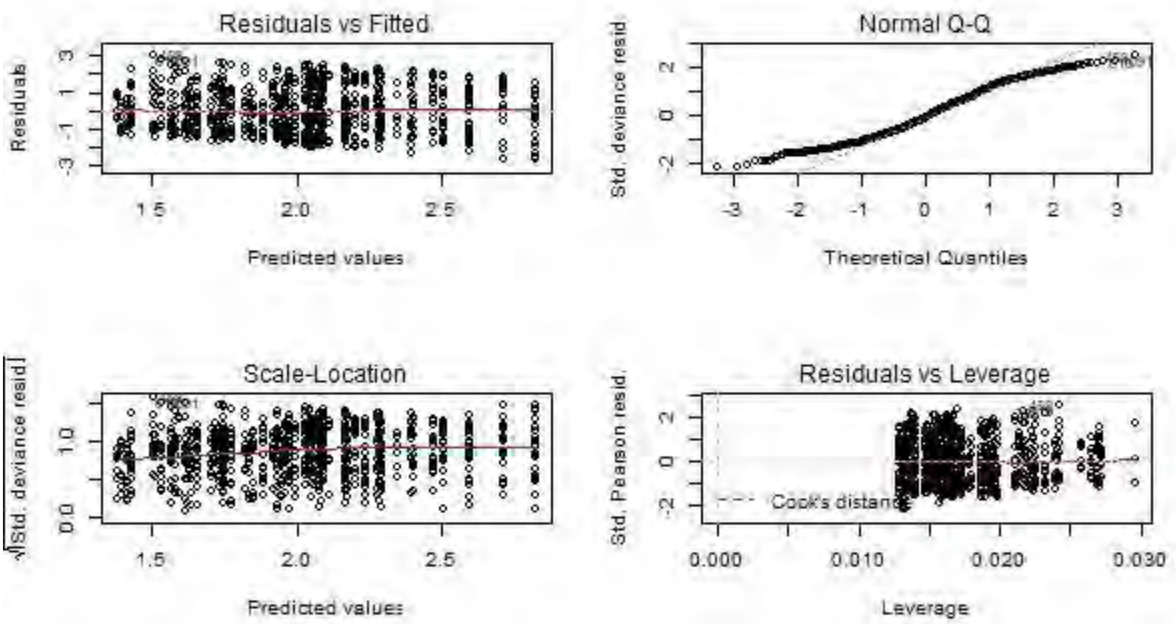

Figure 14. *Pagellus bogaraveo* Peniche trawl fishing segment reference fleet.

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 mainland by year in the period between 2014 and 2019.

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 because the species shows a very high survival rate (Serra-Pereira et al., 2019).

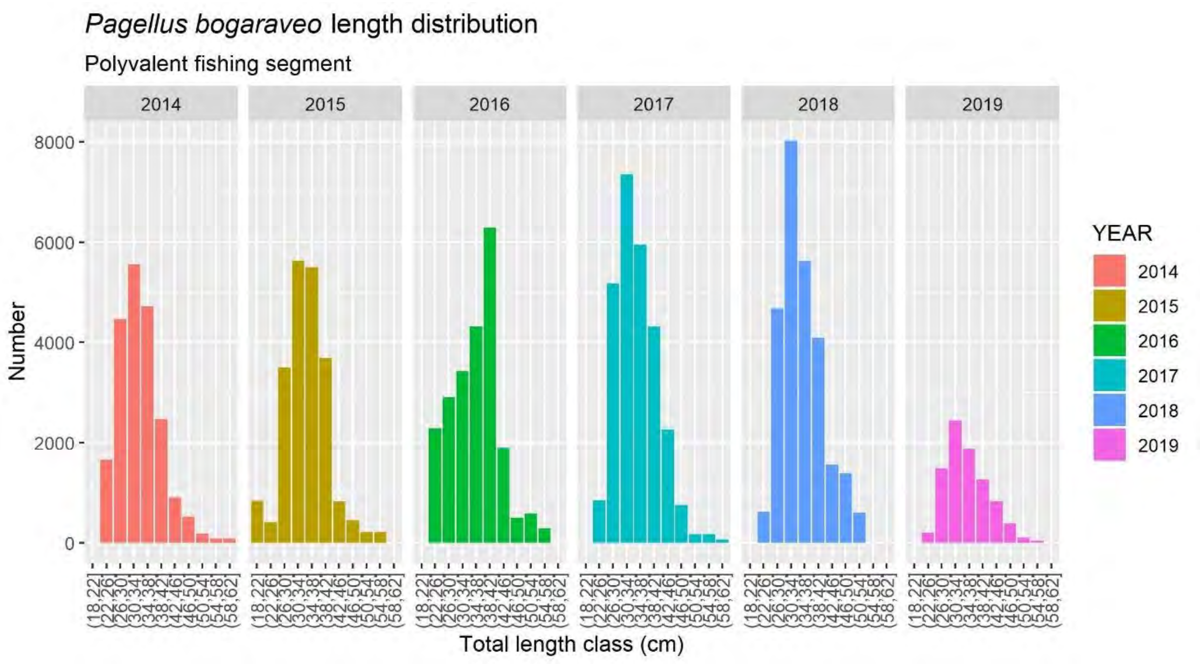

Figure 15. *Pagellus bogaraveo* extrapolated length frequency distributions for the polyvalent fishing segment for the years between 2015 and 2019. (4 cm total length classes)

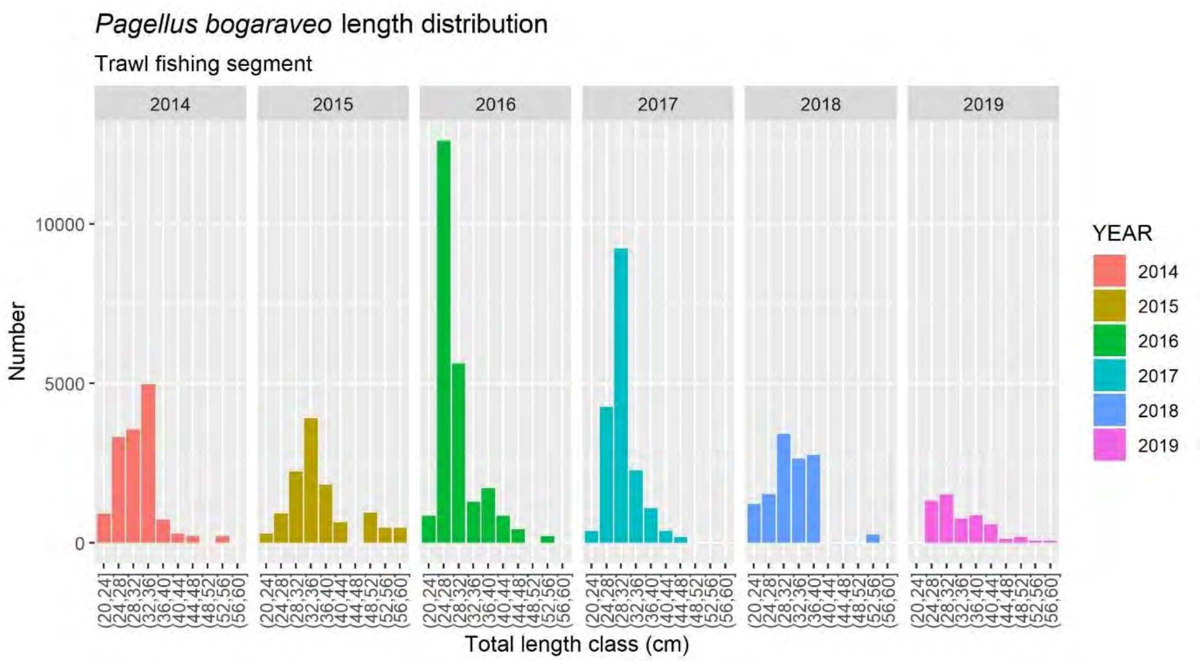

Figure 16. *Pagellus bogaraveo* extrapolated length frequency distributions for the trawl fishing segment for the years between 2015 and 2019. (4 cm total length classes)

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 than trawlers, the former catching larger fish than the last (Farias et al., 2018).

2.4. LBI

Results from the LBI screening method are shown in Tables 5 and 6 and Figure 17.

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

Table 6. *Pagellus bogaraveo* in ICES Division 27.9.a. Results from 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

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). For L_c/L_{mat} and $L_{25\%}/L_{mat}$ estimates these might be related with the fact that as *P. bogaraveo* is a protandric hermaphrodite and the L_{mat} assumed in the screening was that of females, which is above the MLS.

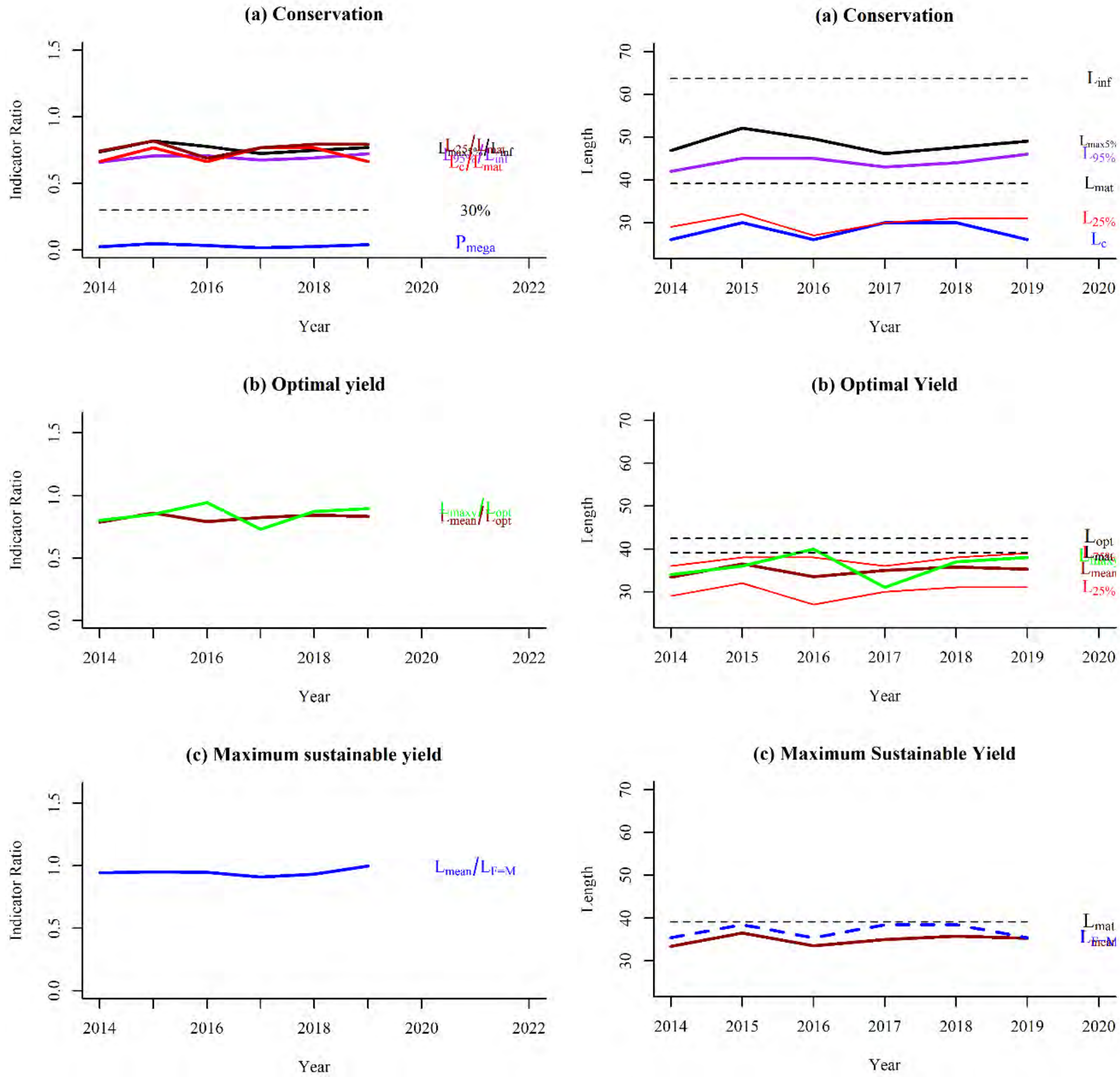

Figure 17. *Pagellus bogaraveo* in ICES Division 27.9.a. Results from LBI screening.

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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		Algarve
Year	Gear	Matosinhos	Aveiro	Nazare	Peniche	Sagres
2009	Polyvalent	4.24	0.06	3.42	41.98	13.47
	Trawl	2.43	1.43	2.69	15.32	-
2010	Polyvalent	2.64	0.09	3.83	33.65	13.33
	Trawl	3.73	1.12	1.47	14.50	0.00
2011	Polyvalent	2.27	0.52	3.92	31.09	10.63
	Trawl	2.90	3.03	2.32	11.43	-
2012	Polyvalent	1.03	0.53	3.99	44.85	13.88
	Trawl	5.56	3.63	5.33	21.29	-
2013	Polyvalent	1.55	0.74	2.60	32.05	16.70
	Trawl	8.91	4.79	3.34	10.89	-
2014	Polyvalent	1.05	0.36	1.80	24.36	6.89
	Trawl	2.62	1.09	1.11	12.61	-
2015	Polyvalent	1.32	0.55	2.82	24.88	8.65
	Trawl	2.70	1.99	1.38	14.30	-
2016	Polyvalent	0.86	0.34	2.28	29.87	10.45
	Trawl	3.62	3.68	0.95	12.26	-
2017	Polyvalent	1.73	0.55	2.43	33.04	7.35
	Trawl	2.71	2.78	0.57	12.09	-
2018	Polyvalent	0.54	0.20	1.02	35.40	4.50
	Trawl	1.58	1.07	0.60	9.66	-
2019	Polyvalent	0.49	0.31	0.49	17.35	6.25
	Trawl	0.63	0.58	0.35	6.08	-

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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 target fishery in the Strait of Gibraltar updating the documents presented in previous years with the information from 2019. So, data about landings, fishing effort, CPUEs and landings length frequencies are presented to its discussion within the 2020 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 and 2019). 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 and 2018). Finally, 2018 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) were updated with 2019 data.

Thus, the main objective of this paper is to provide to the 2020 ICES WGDEEP a summary of the available information of this deep-water fishery located in a very narrow place of the ICES area 9.

2. Material and methods

Fishery information from the sale sheets was gathered for the period 1983-2019: 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. In fact, last years Spanish Blackspot seabream landings available at InterCatch tool comprise three different areas: 27.9.a (ICES), 34.1.11 (CECAF) and 37.1.1 (GFCM).

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 and 2017 the signal fall again.

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 (2013-2019) 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
VMS	Landings (kg)	459,010	274,882	190,786	79,163	39,799	94,261	137,344	73,508	24,716	4,402	4,825
	No. sales	7,200	5,863	4,711	2,946	2,086	2,989	3,079	1,873	1,017	309	248
	Fishing days (trips)	8,373	7,238	6,160	3,686	2,695	4,191	4,234	2,724	1,740	1,046	607
	CPUE 1 (Landings/No. sales)	64	47	40	27	19	32	45	39	24	14	19
	CPUE 2 (Landings/Fishing days)	55	38	31	21	15	22	32	27	14	4	8
	Missing effort (%)	14	19	24	20	23	29	27	31	42	70	59
TOTAL	Landings (kg)	579,140	316,546	239,751	126,006	66,159	137,623	166,651	99,727	42,991	7,633	18,693
	No. sales	8,892	6,932	5,659	3,638	2,222	3,527	3,384	2,418	1,308	429	794
	CPUE 1 (Landings/No. sales)	65	46	42	35	30	39	49	41	33	18	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.

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). The 2019 SRC-WM suggested that the experts would continue pursuing the benchmark work on this species during the intersession, submitting the information to the WGSAD and/or perform any additional activity needed to submit final results to the next 2020 SRC-WM (GFCM, 2019).

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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.

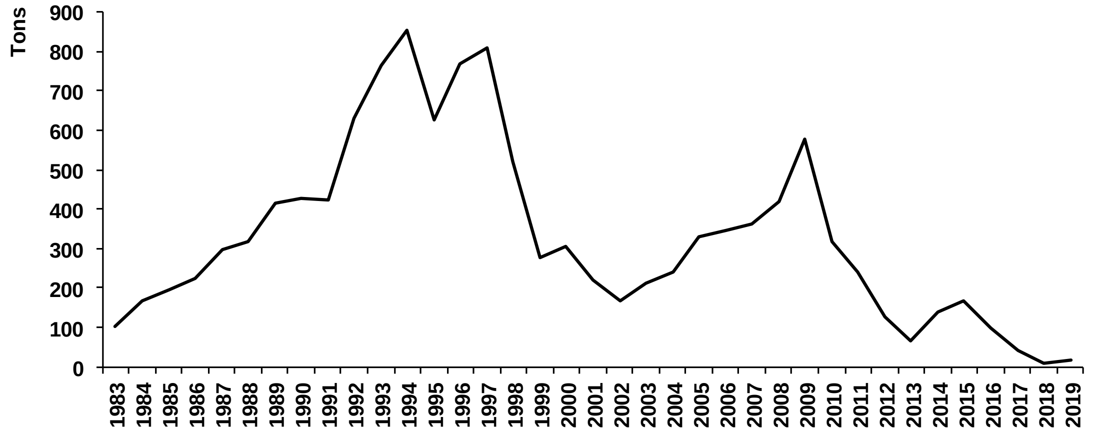

Figure 1. Blackspot seabream Spanish "*voracera*" fishery of the Strait of Gibraltar: total landings (1983-2017).

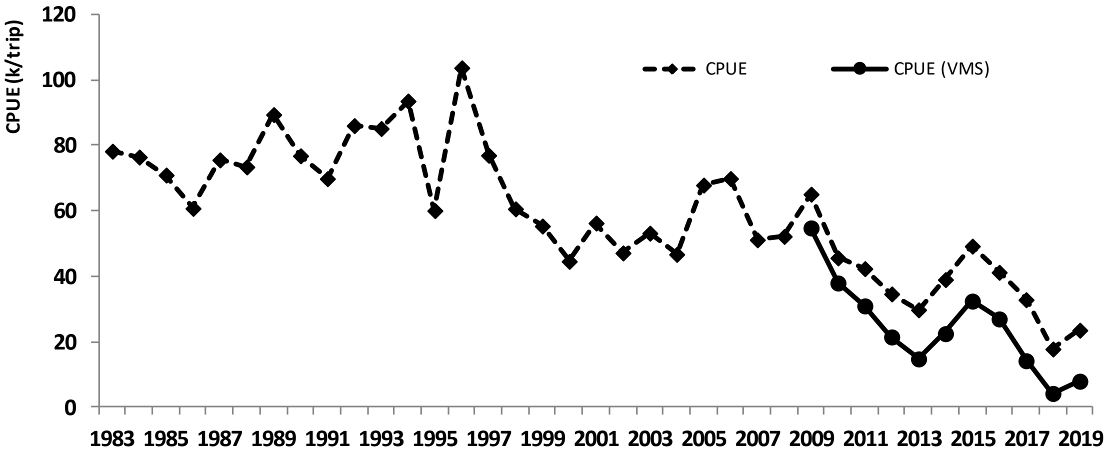

Figure 2. Blackspot seabream Spanish "*voracera*" fishery of the Strait of Gibraltar: nominal (sale sheets) CPUE (1983-2019) and standardized (VMS) CPUE (2009-2019).

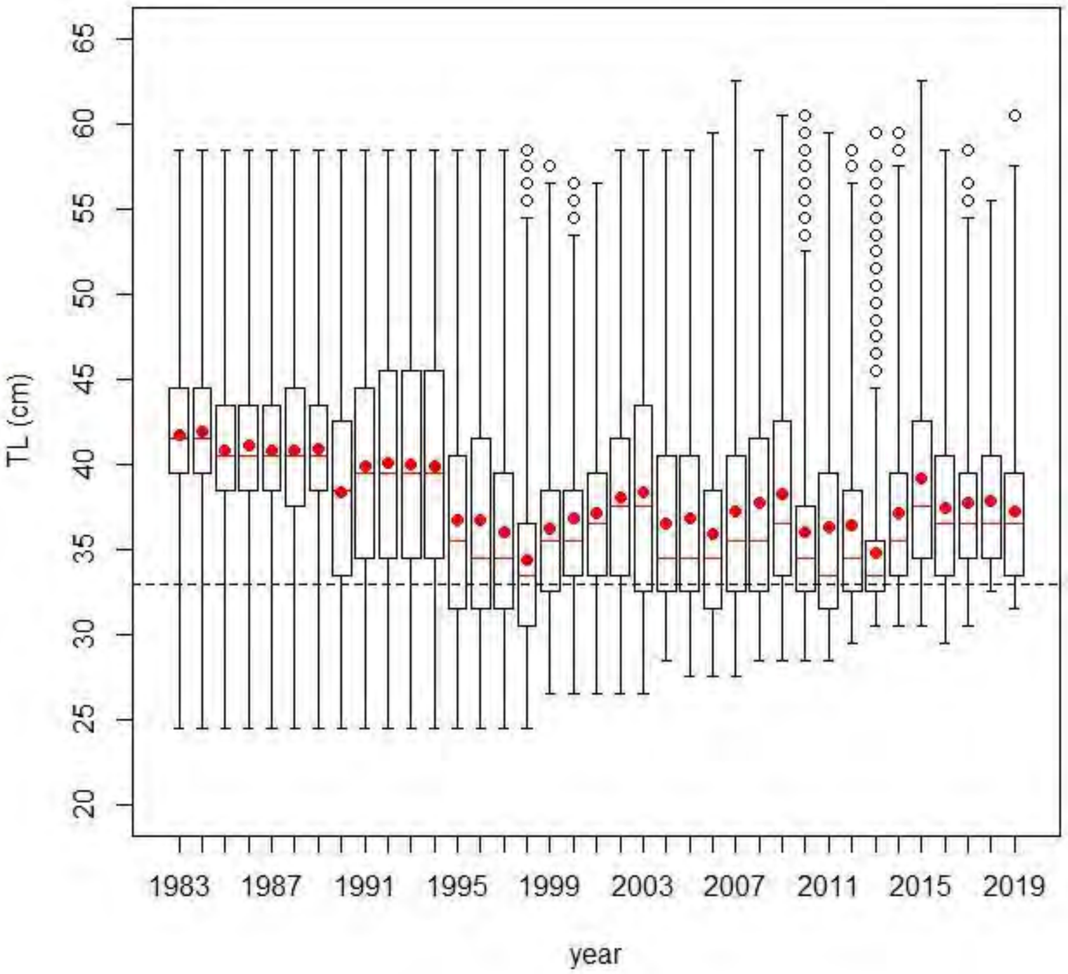

Figure 3. Blackspot seabream Spanish "*voracera*" fishery of the Strait of Gibraltar: landings length distribution descriptive statistics (red dot: mean value, red line: median value, box and whiskers: Interquartile Range plus Q_1-3IQR and Q_3+3IQR, circles: outliers).

Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources

24 April - 1 May 2020

Roundnose Grenadier (*Coryphaenoides rupestris*) in Division 5.b and 12.b, Subareas 6 and 7

Bruno Almón, Diana González and Fernando González

Instituto Español de Oceanografía

Issues in Catch Data

Several issues have been highlighted in previous years regarding the quality of Spanish official catch data, which has greatly hindered attempts to find an approach that could represent the actual trend of the stock. Different reports in previous years have been reflecting these issues in the appropriate sections *"Evidence of substantial mismatches between observer and official Spanish data of landings in Subarea 6 and Division 12.b were presented at WGDEEP in 2010. This has raised some concerns regarding possible misreporting between the different species of grenadiers (Coryphaenoidesrupestris, Macrourusberglax and Trachyrincusscabrus)"* (ICES, 2016, 2018), leading to a chronic situation in which the data is permanently considered as unreliable.

In order to try to solve this situation, a new approach that can help to improve the quality of the Spanish catch data has been applied resulting in an update of the catch series.

About the unreported data from 2012 to 2014.

Taking into account the problematic described above, a revision of the original Spanish catch data from 2010 to 2019 has been conducted.

We have focused first on data from 2012-2014, which were those with high "unallocated" Working Group estimates of landings of roundnose grenadier. The quantities included as "unallocated" were calculated at the moment by applying the CPUEs observed by Spanish scientific observers to the total effort of the Spanish commercial fleet, in each of the years 2012-2014. This was justified by discrepancies between observed and official data in the same areas and periods.

After the revision of original Spanish catch datasets from those years, some issues with these unallocated values have been found.

After retrieving the original IEO observers files from the source and analyzing them, the results showed that the information from those files didn't match those used to calculate the former IEO observers CPUE (/2014 Meeting Docs/Data/Spain_official_catch_1213.xls), so these extrapolated catches could be derived from an error in the initial input values. In addition to discrepancies in the total catch input values, calculations of the CPUE have been based on the use of "day" as effort unit, regardless of fishing power.

For that reason, a new approach is proposed here to estimate the Spanish catches in this period:

1- Given that in those years there was a suspicion that there might be a problem of misreporting catch in the area, and for that reason total catches of RNG would be higher than officially reported, we will take into account for the analysis the combined weight of the three species of grenadier (RNG, RHG and TSU) as official data. Both RHG and TSU are consider to have a very low presence based in the Spanish IEO observers reports in this area, therefore, catches of RNG could be assumed as the combined catches of the three species.

2- Very high unallocated values have been included so far into the assessments as a result of the extrapolation of Spanish observers CPUE to the total effort of the Spanish fleet. However, it seems like this calculations could contain errors in the input values as well as in the calculation process, which yield unreliable results. When calculating the CPUE with the updated observers catch values as input and Kw-day as effort unit, the new estimated Spanish total catches are very close to those on official logbooks data, especially when considering as official RNG catches, the combined catch of all grenadiers.

3- Assuming point 1 and 2, there is no justification for unreported extrapolations, so it could be deleted, and official Spanish catch series should be updated according with the proposed criteria.

4- In line with these assumptions, a reviewed version of the catch data series 2010-2019 applying the criteria explained above is presented for approval within the group and is provisionally included in 2020 advice and other relevant documents (Table 1).

Table 1. Previous and updated Spanish catch values for the period 2010-2019 and changes in overall total catches for all countries and areas.

Year	6 prev	6	12 prev	12.b	Unallocated	Overall total Prev	Overall total
2010	189	769	644	2911	0	4911	5643
2011	336	682	2268	2905	0	3146	4822
2012	258	454	1521	1343	0	9103	2986
2013	476	661	914	991	0	3835	2692
2014	129	471	829	988	0	2072	2180
2015	275	282	314	363	0	1015	1072
2016	298	330	599	632	0	1366	1452
2017	523	496	1001	1001	0	1662	1634
2018	323	323	998	998	0	1519	1519
2019*	68	68	457	457	0	689	689

Exploratory Analysis of Spanish series

In previous years, French tallybooks series from subarea 6, have been used as base for the assessment. Due to the decline of activity of this fleet and the low number of boats now involved, the series is no longer usable for the assessment. Therefore, the assessment has used since 2017 overall standardized abundances indices from Marine Scotland Science Deepwater Survey (2000–2017). These indices have been considered a suitable replacement because the data selection is made for the same area than for the French tallybook and the survey sampling is considered to be an independent source of information. However, part of the stock distribution area is not covered by these indices, especially the main area where the Spanish fleet operate.

The Bayesian Surplus Production model, Multiyear Catch Curve model and indices of abundance have been used for assessment until 2018 when the assessment method for this stock changed to catch only (category 5).

In order to generate additional information that could be applicable to the stock assessment, helping to fill the current information gaps, a basic standardized Spanish CPUE series (2010-2019) covering division 12.b and subdivision 6.b.1 have been calculated in 2020.

Standardized CPUE

In accordance with the current criteria about the grenadier species composition in the area, we have considered the sum of the three grenadier species catches of the Spanish commercial fleet to estimate a new indices of biomass (Kg/Kw-day).

Several glm models were used to standardized the RNG CPUE, all of them with a Normal link. In order to avoid ceros, we use the LCPUE = ln(cpue+mcpue) where mcpue is the 10% of the mean CPUE.

A number of combinations were tested and results analyzed with an ANOVA. The combinations explored included:

lm1: simplest of the models, LCPUE vs year

lm2: lm1 plus one more variable(vessel): LCPUE ~ year + vessel

lm3: lm2 plus one variable division: LCPUE ~ year + vessel + division

lm4: lm3 plus one variable (month): LCPUE ~ year + vessel + division + month

lm5: lm3 plus an interaction vessel:division: LCPUE ~ year + vessel + division + vessel:division

lm6: lm3 plus an interaction year:division: LCPUE ~ year + vessel + division + year:division

lm7: lm3 plus an interaction year:vessel: LCPUE ~ year + vessel + division + year:vessel

lm8: lm3 plus two interactions, year:vessel and year:division: LCPUE ~ year + vessel + division + year:vessel + year:division

From the ANOVA analysis, all variables in lm3 are highly significant. From lm4, the results show that month is not a significant variable, so it was dropped from the subsequent analysis. From lm5 analysis, we can conclude that the interaction vessel:division is not significant. From lm6, lm7 and lm8, we can say that the interactions year:vessel and year:division are both significant when trying to fit the LCPUE, but as we have few data (a total of 350 values for 9 years, 14 vessels and 2 divisions), lot of NAs are generating from the fits with interactions.

Best results were obtained from lm3, lm7 and lm8, with the following parameter summaries:

The ANOVA results for the three models are:

```
lm3 <- lm(LCPUE ~ year + vessel + division)
            Df  Sum Sq Mean Sq F value    Pr(>F)
year         9  21.371  2.3745  4.5088 1.370e-05 ***
vessel      12  52.226  4.3522  8.2639 1.491e-13 ***
division     1   7.530  7.5305 14.2989 0.0001867 ***
Residuals  314 165.366  0.5266

lm7 <- lm(LCPUE ~ year + vessel + division + year:vessel)
                  Df  Sum Sq Mean Sq F value    Pr(>F)
year               9  21.371  2.3745  5.4359 6.950e-07 ***
vessel            12  52.226  4.3522  9.9632 2.987e-16 ***
division           1   7.530  7.5305 17.2391 4.371e-05 ***
```

```
year:GRN$vessel    32  42.182  1.3182  3.0177 5.018e-07 ***
Residuals         282 123.184  0.4368

lm8 <- lm(LCPUE ~ year + vessel + division + year:vessel +
year:division)
                       Df  Sum Sq Mean Sq F value    Pr(>F)
GRN$year                9  21.371  2.3745  6.1115 7.815e-08 ***
GRN$vessel             12  52.226  4.3522 11.2016 < 2.2e-16 ***
GRN$division            1   7.530  7.5305 19.3819 1.537e-05 ***
GRN$year:GRN$vessel    32  42.182  1.3182  3.3927 2.384e-08 ***
GRN$year:GRN$division   9  17.116  1.9018  4.8947 4.310e-06 ***
Residuals             273 106.069  0.3885
```

The SE, R square and Akaike information were:

SE lm3: 0.7408   R2 lm3: 0.3604   - Simplest model

SE lm7: 0.6481   R2 lm7: 0.5586   - Few NA's, good results

SE lm8: 0.6164   R2 lm8: 0.6197   - Best results, but lot of NA's

AIC lm3: 764   AIC lm7: 729   AIC lm8:697

Coefficients of each fit were calculated in log scale, and then transformed to the original.

In order to examine the evolution and behavior of the fits over time, a plot combining all the three fits can be seen in Fig. 1. As a reference line in the plot, the mean CPUE by year has been included.

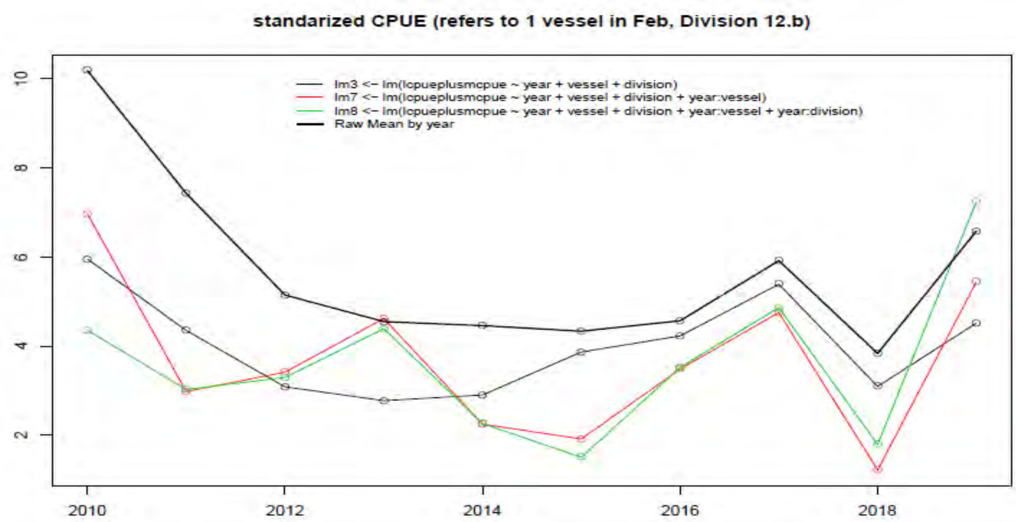

Fig1. Plot showing each of the selected coefficients trajectory along with the mean CPUE.

As a result of the model selection analysis, both lm7 and lm8 have been discarded, due to higher confidence intervals (Fig.2). Probably this is a consequence of the high number of NAs generated during the fit of lm7 and lm8. We think that the reliability of the data is not so good to introduce interactions at this moment in the model.

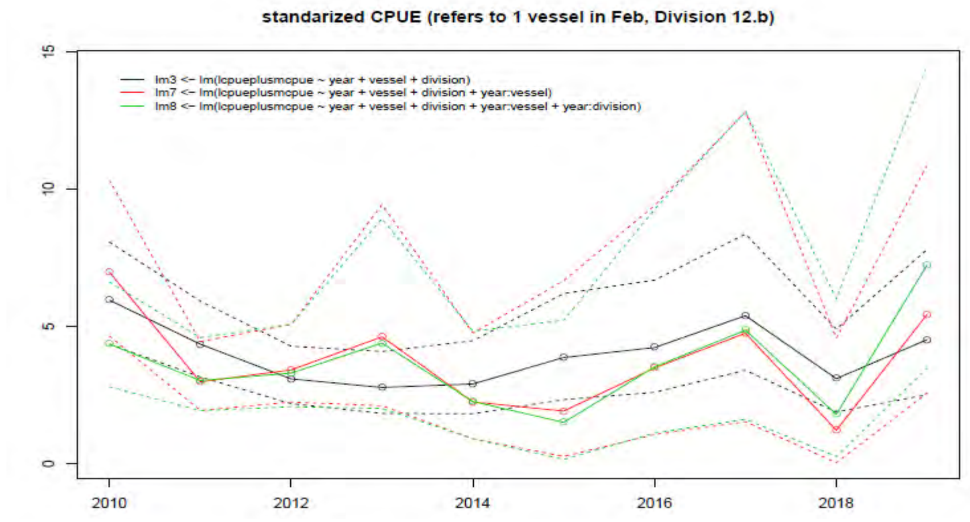

Fig 2. Plot for the fitted CPUE by year for the three models with confidence intervals .

Thus, lm3 model was selected as the more adequate, and this GLM model was used to standardize the CPUE (kg/effort unit) series for the Spanish commercial fleet, being the independent variables the following: year, vessel and fishing area (6.b.1, 12.b). The dependent variable was the log-transformed kg per effort unit measure, which was back-transformed prior to use. In Fig. 3 the plots of the residuals of lm3 model can be seen, both in general and by year.

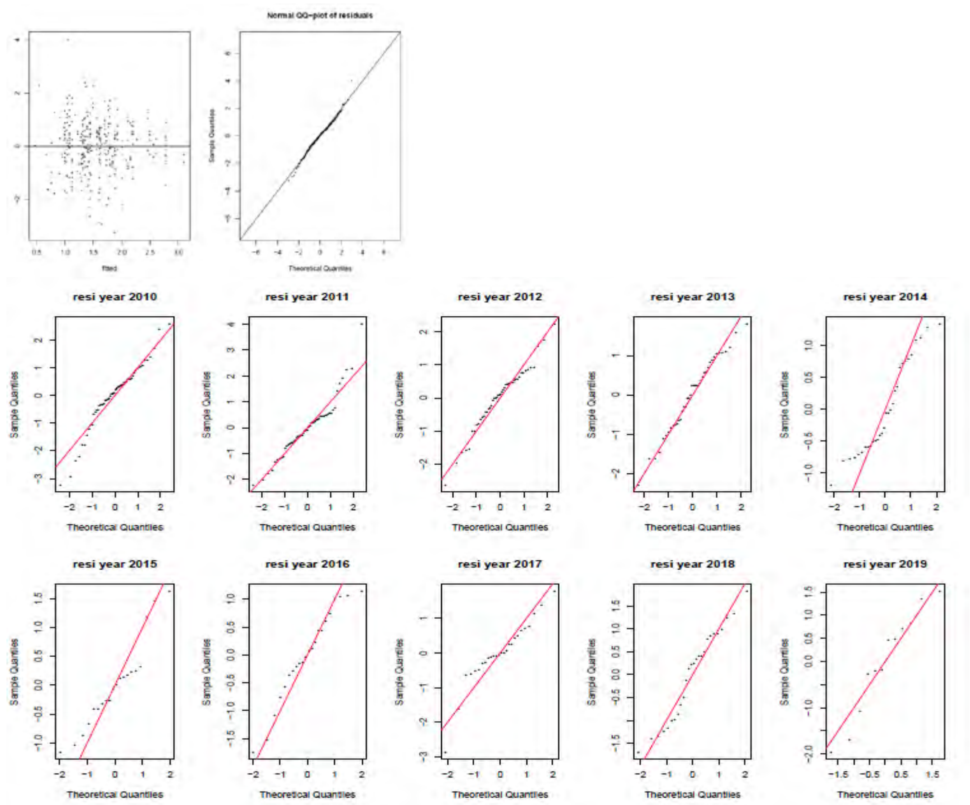

Fig 3. Plots of the lm3 model residuals: general and QQ plot by year.

Exploratory forecast analysis with ASPIC

The WKDEEP benchmark agreed in 2010 that "landings and effort data in Division 12.b should be included into the assessment if they become reliable. A separate assessment for Division 12.b should be carried out separately from the one for Division 5.b, and Subareas 6, 7" (ICES, 2010). The reference assessment was therefore limited to 5.b, 6, 7 and was capable of provide category 1 advice until 2018 where the assessment method changed to category 5. A full exploratory assessment including 12.b was also presented in 2018 (ICES, 2018), although the confidence of the full assessment was considered lower due, between other reasons, to the uncertainty of the catch series in 12.b .

An exploratory Schaefer surplus production model analysis using ASPIC was carried out with the new estimated catches series and the following indices of biomass: new Spanish standardized CPUE series, French standardized CPUE and Marine Scottish survey indices (Table 2).

Table 2. Overview of the model input data, including the revised overall landings series for the stock and the three indices. Colored cels are values interpolated with immediate neighboring years.

Year	Landingsl	French Index	Mar.Scot. Surv.	Spanish Index
1988	33	-	-	
1989	2750	-	-	
1990	7279	-	-	
1991	10276	-	-	
1992	12168	-	-	
1993	12130	-	-	
1994	9014	-	-	
1995	9634	-	-	
1996	9701	-	-	
1997	10231	-	-	
1998	12428	-	-	
1999	17107	-	-	
2000	17801	1	1	
2001	24445	1.093	1.135	
2002	24211	1.809	1.269	
2003	21904	0.399	1.258	
2004	22668	0.424	1.247	
2005	14559	0.387	1.14	
2006	8896	0.332	0.887	
2007	8138	0.465	1.251	
2008	5412	0.546	1.471	
2009	8273.1	0.493	1.288	
2010	5642.83	0.429	1.26	1
2011	4821.61	0.403	1.233	0.731
2012	2986.37	0.462	1.612	0.518
2013	2691.84	0.497	1.798	0.466
2014	2180.23	0.399	1.621	0.487
2015	1071.5	-	1.445	0.649
2016	1451.65	-	1.289	0.710
2017	1634.33	-	1.133	0.905
2018	1519	-		0.520
2019	689.275	-		0.759

A Stock Production Model Incorporating Covariates (ASPIC) is a non-equilibrium implementation of the well-known Schaefer surplus production model (1954, 1957). ASPIC also fits the generalized stock production model of Pella and Tomlinson (1969) using the alternative parameterization of Fletcher (1978) (Prager, 1994).

First approximations showed that there is a negative correlation between all the three indices, preventing the use of the combined set for calculations, neither a pairwise combination of any of them.

```
 1  French Index and Total Landings      |   1.000
                                         |      15
                                         |
 2  Mar. Scot. Survey                    |  -0.162   1.000
                                         |      15      18
                                         |
 3  Spanish CPUE Indices                 |  -0.362  -0.881   1.000
                                         |       5       8      10
 -----------------------------------------------------
                                                 1       2       3
```

The preliminary results obtained show that none of the available series of indices of biomass is very suitable for applying a production model. It is possible that these indices are not very representative of the trends in biomass of the stock in general (none of the indices covers the total distribution area of the stock) and that they are only representative of the variations that occur in small areas where they are carried out. And that the trends of these small areas are contradictory with the general trends of the stock.

Runs including only one of the series indicated that the index with which the most reasonable biological results are obtained is the Marine Scottish surveys. A summary of these results is presented below.

```
MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
------------------------------------------------------------------------------------------------
Parameter                                  Estimate   User/pgm guess   2nd guess  Estimated  User guess

B1/K      Starting relative biomass (in 2000)  7.403E-01    4.000E-01   5.893E-01        1          1
MSY       Maximum sustainable yield            3.790E+04    4.000E+04   7.431E+03        1          1
K         Maximum population size              3.255E+05    3.000E+05   4.458E+04        1          1
phi       Shape of production curve (Bmsy/K)   0.5000       0.5000      ----             0          1

--------- Catchability Coefficients by Data Series ---------------
q(1)      Mar. Scott. Surv and Total Landings  4.445E-06    1.000E-04   9.500E-03        1          1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
------------------------------------------------------------------------------------------------
Parameter                                  Estimate         Logistic formula       General formula

MSY       Maximum sustainable yield            3.790E+04                ----                  ----
Bmsy      Stock biomass giving MSY             1.628E+05                 K/2       K*n**(1/(1-n))
Fmsy      Fishing mortality rate at MSY        2.328E-01            MSY/Bmsy             MSY/Bmsy

n         Exponent in production function      2.0000                   ----                  ----
g         Fletcher's gamma                     4.000E+00                ----  [n**(n/(n-1))]/[n-1]

B./Bmsy   Ratio: B(2020)/Bmsy                  1.984E+00                ----                  ----
F./Fmsy   Ratio: F(2019)/Fmsy                  9.170E-03                ----                  ----
Fmsy/F.   Ratio: Fmsy/F(2019)                  1.091E+02                ----                  ----

Y.(Fmsy)  Approx. yield available at Fmsy in 2020  6.816E+04    MSY*B./Bmsy           MSY*B./Bmsy
          ...as proportion of MSY              1.799E+00                ----                  ----
Ye.       Equilibrium yield available in 2020  1.214E+03  4*MSY*(B/K-(B/K)**2)  g*MSY*(B/K-(B/K)**n)
          ...as proportion of MSY              3.205E-02                ----                  ----

--------- Fishing effort rate at MSY in units of each CE or CC series ---------
fmsy(1)   Mar. Scott. Surv and Total Landings  5.238E+04          Fmsy/q( 1)            Fmsy/q( 1)
TestRun RNG.5b6712b                                                                        Page 2
```

References

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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. 682 pp.

Prager, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fish. Bull. (U.S.) 92: 374–389.

Schaefer, M. B. 1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. Inter-Am. Trop. Tuna Comm. Bull. 2: 247–268.

Annex 5: Audits

Audit of (bli.nea)

Date: 30/04/2020
Auditor: Fróði B. Skúvadal

General

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type:** update of previous year.
2) **Assessment**: trends Category 1.
3) **Forecast**: short term forecast presented
4) **Assessment model**: Catch trends-based assessment
5) **Data issues:** no issues
6) **Consistency**: Consistent with previous
7) **Stock status**: Harvested sustainably
8) **Management Plan**: managed with MSY rule.
9) **General comments**

The report was well documented with updated data, revised and completed in 2020. The advice was drafted consistently with the correspondent chapter in the report.

Technical comments

Stock Annex needs to be updated.

Conclusions

The assessment has been performed correctly

Audit of (Rng 5b6712b)

Date: 30.04.2020
Auditor: Hege Øverbø Hansen

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

The advice is done according the Stock Annex.

For single stock summary sheet advice:

10) **Assessment type: update**
11) **Assessment**: Catch trends
12) **Forecast**: not presented
13) **Assessment model**:
14) **Data issues:** The data are available as described in the stock annex, the data used for the advice is well described and the data for the new exploratory assessment is well documented in the report.
15) **Consistency:**
16) **Stock status**: Fishing pressure and stock size is unknown.
17) **Management Plan**: There is no management plan for this stock.

General comments

This was all well documented sections to the report, stock annex and advice. This is a stock that has changed from cat.1 to cat. 5 and the history of the stock assessment and the transition into a new assessment is well described.

Technical comments

Stock Annex: In the A.1. Stock definition section: There is information from a study that found that stock structure is clearly evident in the outskirts of the distribution range (Canada and Norway) however, significant but weaker structure, is found among some pairwise samples in the central distribution areas like MAR, west of UK and Greenland (Knutsen *et al*. (2012). This reference could further document the stock definition for this species.

Conclusions

The assessment has been performed correctly

Audit of (rng.27.3.a)

Date: 30/05/2020

Auditor: Bruno Almón

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
    - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
    - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

The assessment is based on survey trend. The advice is based on the 2 over 3 rule.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

18) **Assessment type: update**
19) **Assessment**: survey trend based assessment
20) **Forecast**: not presented
21) **Assessment model**: survey trends
22) **Data issues:** The survey abundance index is missing for some of the years.
23) **Consistency**: Same as last year
24) **Stock status**: No reference points are established for the stock
25) **Management Plan**: None

General comments

Although the index are missing for some years, the survey is assumed to reflect the stock trend.

Technical comments

(Include comments on points where the draft report contains errors, is unclear and if the assessment is done according to the stock annex)

Conclusions

The assessment has been performed correctly.

Audit of Tusk (*Brosme brosme*) in 6.b

Date: 29.04.2020

Auditor: Anika Sonjudóttir

General

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

26) **Assessment type:** update
27) **Assessment**: No assessment
28) **Forecast**: Not presented
29) **Assessment model**: None
30) **Data issues:** No issues

31) **Consistency**: Consistent with last year
32) **Stock status**: Unknown
33) **Management Plan**: None

General comments

Well documented.

Technical comments

The stock Annex needs to be updated.

Conclusions

The assessment has been performed correctly.

Audit of Alfonsinos (*Beryx* spp.) in subareas 1–10, 12, and 14 (the Northeast Atlantic and adjacent waters) (alf.27.nea)

Date: 30th of April 2020

Auditor: Lise Heggebakken

General

The stock section is updated with the available datasets and the advice sheet is done according to the Stock Annex.

For single stock summary sheet advice:

34) **Assessment type:** Update
35) **Assessment**: No assessment (ICES category 5 stock).
36) **Forecast**: None
37) **Assessment model:** None
38) **Data issues:** The landing data for stock development are updated, while there are other time series in Stock Annex which have not been updated for a few years, due to no available data.
39) **Consistency:** Stock information has been updated where data is available. No new exploratory assessment has been presented.
40) **Stock status:** No reference points available.
41) **Management Plan**: No management plan for this stock.

General comments

The stock section was well updated with the available datasets.

Technical comments

In the advice sheet a minor comment regarding the sentence "**[Advised landings for 2019–2020]" whether this should be changed to "2021-2022.

Conclusions

The advice has been updated correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?YES
- Is the assessment according to the stock annex description?YES
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? No management plans.
- Have the data been used as specified in the stock annex? YES
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Not available.
- Is there any **major** reason to deviate from the standard procedure for this stock? NO
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? YES

Audit of Alfonsino in the North East Atlantic (alf.27.nea)

Date: April 29th, 2020

Auditor: Lionel Pawlowski

General

The stock section is properly documented with an update of the available datasets. The advice sheet is in line with the stock annex.

For single stock summary sheet advice:

42) **Assessment type:** **Update**
43) **Assessment**: No assessment (ICES category 5 stock).
44) **Forecast**: None
45) **Assessment model**: None
46) **Data issues:** Apart from the persistent lack of reliable indices, there is no deviation from previous years. Some times series have not been updated for a few years.
47) **Consistency**: Stock information has been updated as in previous years. No new exploratory assessment has been presented.
48) **Stock status**: Stock and exploitation status are currently unknown with no reference points available.
49) **Management Plan**: There is no management plan for this stock. ICES has previously based its advice on the precautionary approach based on recent catch levels.

General comments

The stock section is properly documented with an update of the available datasets.

Technical comments

I feel important to note that some of the times series have not been updated for several years because the information was not made available to the stock coordinator and members of WGDEEP. This lack of information adds difficulties to provide recent clues about the status of stock and to develop any sort of trend based assessment for this stock in addition to technical difficulties to develop an assessment due the bycatch nature and biology of this stock. Any attempt to benchmark this stock will probably require to compile extensively any missing information to provide some updated time series.

Conclusions

The section has been updated correctly considering the amount of available information and the advice does not exhibit any deviation from the information in the stock annex.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? YES
- Is the assessment according to the stock annex description? YES
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? N/A
- Have the data been used as specified in the stock annex? YES
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? N/A
- Is there any **major** reason to deviate from the standard procedure for this stock? NO
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? YES

Audit of bli.27.5b67

Date: 01.05.2020

Auditor: Pamela Woods

General

For single stock summary sheet advice:

1. Assessment type: update
2. Assessment: Category 1 statistical age-based assessment
3. Forecast: short-term projection under a variety of F options
4. Assessment model:
5. Data issues: Suitable data have been updated
6. Consistency: Consistent with previous years
7. Stock status: Harvested sustainably, SSB > MSY Btrigger, F < FMSY
8. Management Plan: Follows the ICES MSY advice rule

General comments

The catch scenarios seem excessive and perhaps could be reduced

Technical comments

None

Conclusions

The assessment has been performed correctly

Advice sheet audit report and check list

Working Group: WGDEEP **Stock Name: bsf.27.nea**

Date: 01.05.2020
Auditor: Fróði Skúvadal

General

For single stock summary sheet advice:

1) **Assessment type:** Bayesian state-space models
2) **Assessment**: analytical
3) **Forecast**: Short term provided
4) **Assessment model**: Bayesian state-space model
5) **Data issues:** No issues
6) **Consistency**: consistent
7) **Stock status**: likely to be stable, precautionary buffer applied for the first time, due to lack in increase in stock size, even if fishing effort is decreasing.
8) **Management Plan**: ICES is not aware of a management plan.

General comments
The assessment is clearly communicated as a category 3 stock. The advice sheet publication date needs to be updated.

Technical comments

Stock annex needs to be updated. Table 6 in advice sheet, there are three empty columns

Total abundance index (millions)	Total abundance index High	Total abundance index Low

Can they be deleted?

Conclusions
The assessment has been performed correctly.

Audit of greater forkbeard (*Phycis blennoides*) in all ecoregions gfb.27.nea

Date: 30.04.2020
Auditor: Erik Berg

General

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

50) **Assessment type: update**
51) **Assessment**: Trends from survey
52) **Forecast**: not presented
53) **Assessment model**: Precautionary approach (2/3 survey index)
54) **Data issues:** Many surveys covering small parts of the distribution area. All are given equal weigths in the combined index.
55) **Consistency**: Consistent with last report and advice
56) **Stock status**: Unknown
57) **Management Plan**: No management plan available
58) **General comments:** No other comments

Technical comments No comments

Conclusions: The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? **Yes**
- Is the assessment according to the stock annex description? **Yes**
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **Not relevant**
- Have the data been used as specified in the stock annex? **Yes**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Not relevant**
- Is there any **major** reason to deviate from the standard procedure for this stock? **No**
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

Audit of gfb.27.nea

Date: 30/04/2020
Auditor: Inês Farias

General

Data sets have been updated with available information.

For single stock summary sheet advice:

59) **Assessment type: update**

60) **Assessment**: trends

61) **Forecast**: not presented

62) **Assessment model**: Survey trends-based assessment.

63) **Data issues:** Discards estimates may have problems because (i) not all countries report discards and (ii) the method for estimating discards may not have been the same in all years. Neither the available surveys nor discard data cover yet the entire distributional stock, especially in subareas 1 and 2

64) **Consistency**: Advice is consistent with reported data.

65) **Stock status**: Unknown because the reference points are undefined.

66) **Management Plan**: ICES is not aware of any agreed precautionary management plan for greater forkbeard in this area.

General comments

This is a simple advice sheet was easy to follow and interpret. Data have been updated with available information. Minor formatting changes were made in this audit, following a previous audit.

Since the audits refer to abbreviated time sheets, the topics for the short description of the assessment could also be abbreviated.

Technical comments

According to the report, discards estimates should be considered with caution because (i) not all countries report discards and (ii) the method for estimating discards may not have been the same in all years. Further it is stressed out the need to include a request for consistent discards estimates from all countries in future data calls.

Conclusions

The assessment has been performed correctly. There is no reason to deviate from the standard procedure for this stock.

Audit of (Stock name)

Date: 30/04/2020

Auditor: Rui Vieira

General

Use bullet points and subheadings (Recommendations, General remarks, etc.) if needed

For single stock summary sheet advice:

67) **Assessment type:** update
68) **Assessment**: No assessment.
69) **Forecast**: presented / not presented
70) **Assessment model**: None
71) **Data issues:** No issues
72) **Consistency**: Consistent with previous years. No changes in the stock.
73) **Stock status**: Unknown
74) **Management Plan**: None. This stock is classified as Category 2 in the NEAFC categorization of deep-sea species/stocks which implies that NEAFC requires measures stipulating that directed fisheries are not authorised and that bycatches should be minimised.

General comments

Well written and easy to understand.

Technical comments

Stock annex was updated in 2019. No new information is available for the 2020 assessment. The analysis of available VMS-data would allow a better understanding of direct and indirect effects of fisheries in these stocks.

Conclusions

The assessment has been performed correctly.

Audit of Orange roughy in 27.nea

Date: 30.04.2020

Auditor: Anika Sonjudóttir

General

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

75) **Assessment type:** update
76) **Assessment**: No assessment

77) **Forecast**: Not presented
78) **Assessment model**: None
79) **Data issues:** No issues
80) **Consistency**: Consistent with previous years. No changes in the stock.
81) **Stock status**: Unknown.
82) **Management Plan**: None

General comments

Well documented.

Technical comments

The stock Annex needs to be updated.

Conclusions

The assessment has been performed correctly.

Audit of roughhead grenadier (*Macrourus berglax*) in the Northeast Atlantic. rhg.27.nea

Date: 30.04.2020
Auditor: Erik Berg

General

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

83) **Assessment type: update**
84) **Assessment**: No assessment
85) **Forecast**: not presented
86) **Assessment model**: Precautionary approach
87) **Data issues:** Population structure poorly known. Mixed grenadier fishery.
88) **Consistency**: Consistent with last report and advice
89) **Stock status**: Unknown
90) **Management Plan**: No management plan available
91) **General comments:** No other comments

Technical comments No comments

Conclusions: The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? **Yes**
- Is the assessment according to the stock annex description? **Yes**
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **Not relevant**
- Have the data been used as specified in the stock annex? **Yes**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Not relevant**
- Is there any **major** reason to deviate from the standard procedure for this stock? **No**
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

Audit of (Stock name)

Date: 01.05.2020
Auditor: Pascal Lorance

General

Data and text from the report section and the advice are consistent. The report well written, detailed and informative, relative to the amount of data available for the stock.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: trends (ICES category 6, catch only)
3) **Forecast**: not presented
4) **Assessment model**: None
5) **Data issues:** the stock is data limited, there are issues in species identification/reporting which are properly described in the report
6) **Consistency**: na
7) **Stock status**: na
8) **Management Plan**: None
9) **General comments**

Technical comments

There is a long and useful text in the section catch scenario of the advice, this could rather be "Issues relevant for the advice "

Conclusions

The assessment has been performed correctly

Audit of 8.2 Roundnose grenadier (Coryphaenoides rupestris) in Division 3.a

Date: 1/5/2020

Auditor: Martin Pastoors

General

This is a category 3.2 stock where the advice is based on a survey biomass index from the Norwegian shrimp survey. The stock increased in the late 1990s and early 2000s after a recruitment pulse in the early 1990s. This attracted a targetted fishery in 2003-2005. The decline in abundance after 2005–2006, as suggested by the Norwegian shrimp survey, probably reflects the combined effect of the targeted exploitation in 2003–2005 and low recruitment.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: presented
3) **Forecast**: not presented
4) **Assessment model**: survey trends (Norwegian shrimp survey)
5) **Data issues:** no data issues
6) **Consistency**: Same approach as previous advice (2018) when the stock was upgraded from category 6 (no assessment) to category 3.2. The advice has remained the same (zero)
7) **Stock status**: No reference points have been defined but the stock is at a low level.
8) **Management Plan**: No management plan

General comments

This is a well documented section that is easy to follow and interpret.

Technical comments

The main survey that is used in this assessment is the biomass index from the Norwegian shrimp survey, that provides a long time series. Although a plot of the survey is available in the report, the actual survey values are not in the report (they are in the advice document, but preferably they should be in the WG report as well). The timing of the survey has changed substantially over the course of the time series. A plot as shown in the example below could be used to highlight some of those changes in terms of the month of the survey and the number of deep stations by year.

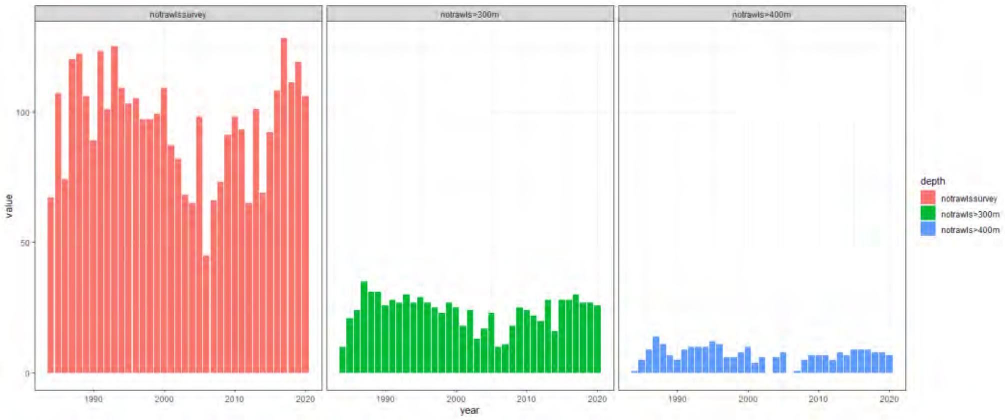
The exploratory runs with the Spict model have been carried out using a truncated time series of catches, because otherwise the model could not be fitted. However, by removing the next to zero catches in the years since 2006, you are effectively changing the overall information source for the model and allowing the model to fit better to the survey. This procedure would need to be well investigated and better described.

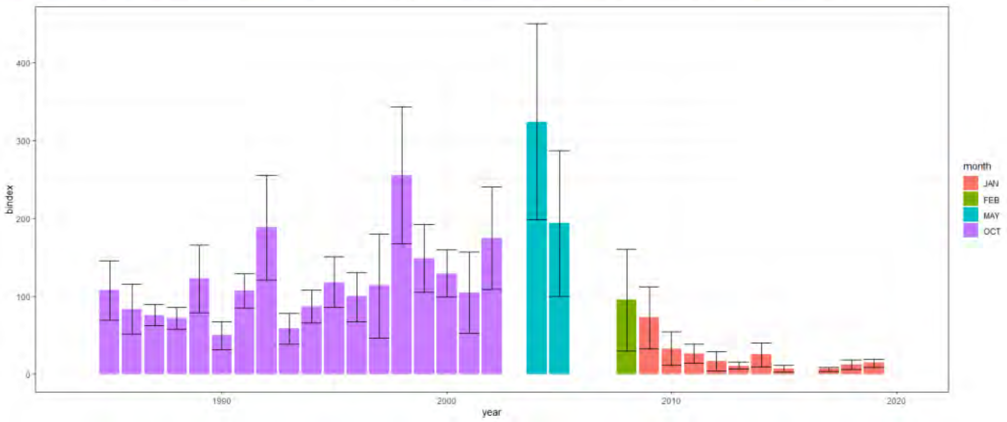
In addition, the Spict model selection process that lead to the selection of model 5 as the preferred option needs to be better underpinned. Preferably there is some sort of statistical evaluation of the different model options. The fact that the confidence intervals were low and that only 2 parameters were fixed does not provide sufficient argumentation that it is the better model configuration. Given the level analysis, I am not convinced that the Spict model results are informative on biological reference points.

Conclusions

The agreed assessment approach has been performed correctly.

The exploratory Spict assessments would require more in-depth analyses before they can be used.





Audit of Roundnose Grenadier (Coryphaenoides rupestris) in Division 5.b and 12.b, Subareas 6 and 7 (rng.27.5b6712b)

Date: 29 April 2020
Auditor: Martin Pastoors

General

Since 2018, Roundnose grenadier in 5b, 6, 7 12b is treated as a category 5 stock because the assessment method that was used before was no longer considered appropriate by the ADG. The recommended maximum catch according to the precautionary approach is substantially higher than recent catches. Catch time series have been revised for a number of years, due to potential misallocation of catches by species.

For single stock summary sheet advice:

92) **Assessment type: update**
93) **Assessment**: no assessment (catch only)
94) **Forecast**: not presented
95) **Assessment model**: No assessment. Previous assessment (Bayesian Biomass model) was discontinued from 2018 onwards. Stock annex has been updated to reflect this change.
96) **Data issues:** Catch data have been updated. A new analysis was performed on the combined catches of three grenadier species (roundnose grenadier, roughhead grenadier and roughsnout grenadier) thereby fixing some of the issues with previous catch data.
97) **Consistency**: Same as basis for the 2018 advice. Advised landings are lower because of application of the precautionary buffer.
98) **Stock status**: Unknown
99) **Management Plan**: No management plan exists.

General comments

The section was generally well documented and easy to follow.

Technical comments

The revision of the catch data is announced and executed in the report, but it is not completely clear what has been revised and how it has been revised. This also affects the landings table in the advice document.
The stock annex has been updated to reflect the new assessment procedure after the 2018 ADG.

Conclusions

The assessment has been performed correctly

Audit of sbr.27.6.8

Date: 30/04/2020
Auditor: Inês Farias

General

This stock has been depleted since the mid 1970's. At present the blackspot seabream catches in divisions 6, 7, and 8 are almost all bycatches of longline and otter trawl fleets from France, Ireland and Spain.

Data sets have been updated with available information.

For single stock summary sheet advice:

100) **Assessment type: update**

101) **Assessment**: There is no assessment for blackspot seabream in this area.

102) **Forecast**: not presented

103) **Assessment model**: There is no assessment for blackspot seabream in this area.

104) **Data issues:** No issues

105) **Consistency**: Advice is consistent with reported data.

106) **Stock status**: Unknown because the reference points are undefined.

107) **Management Plan**: ICES is not aware of any agreed precautionary management plan for blackspot seabream in this area.

General comments

This is a simple advice sheet was easy to follow and interpret. Data have been updated with available information. Minor formatting changes were made in this audit, following a previous audit.

Technical comments

Nothing to comment.

Conclusions

The assessment has been performed correctly

Audit of Blackspot seabream (*Pagellus bogaraveo*) in subareas 6, 7 and 8 (Celtic Seas and the English Channel, Bay of Biscay (sbr.27.6-8)

Date: 30th of April 2020

Auditor: Lise Heggebakken

General

The description of the stock and the development over time is in line with stock annex and updated with the available datasets.

For single stock summary sheet advice:

108) **Assessment type:** Update
109) **Assessment**: No assessment (ICES category 6 stock)
110) **Forecast**: None
111) **Assessment model**: None
112) **Data issues:** No issues concerning the available data, time series have been updated.
113) **Consistency:** Stock information has been updated for previous years. Exploratory assessment was presented at the WGDEEP.
114) **Stock status:** No reference points available.

115) **Management Plan**: In 2014 ICES recommended the establishment of a recovery plan for this stock. Apart from that, no management plan for this stock.

General comments

The stock section is well documented, with updated information of the available datasets.

Technical comments

No major changes in the advice sheet, only changing the sentence "ICES advise that when the precautionary approach is applied, there should be zero catch in each of the years 2020 and 2021" to be for years 2021 and 2022. A minor comment for the Stock Annex, the figure number 14.2.1 is wrong compared to the reference in the text.

Conclusions

The advice has been updated correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? YES
- Is the assessment according to the stock annex description? YES
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? In 2014 a recovery plan.
- Have the data been used as specified in the stock annex? YES
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Not available
- Is there any **major** reason to deviate from the standard procedure for this stock? NO
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? YES

Audit of sbr.27.9

Date: 01.05.2020

Auditor: Pamela Woods

General

For single stock summary sheet advice:

1. Assessment type: update

2. Assessment: Category 3.2 DLS approach using the 2 / 3 rule, with an option for change to Category 5

3. Forecast: none

4. Assessment model: none

5. Data issues: Suitable data have been updated

6. Consistency: Consistent with previous years

7. Stock status: Low status in relation to possible reference points could be added to advice sheet

8. Management Plan: The sheet adequately mentions the need for a management plan with international agreement between the EU and adjacent areas, but is vague regarding to whether the advice applies outside subarea 9

General comments

None

Technical comments

None

Conclusions

The assessment has been performed correctly

Audit of Blackspot sea bream in subarea 10 (sbr.27.10)

Date: April 30th, 2020

Auditor: Lionel Pawlowski

General

The stock section is properly documented with an update of the available datasets. The advice sheet is in line with the stock annex.

For single stock summary sheet advice:

116) **Assessment type:** **Update**
117) **Assessment**: Trend based assessment (ICES category 3 stock).
118) **Forecast**: None
119) **Assessment model**: ICES Survey trend based assessment based on Azorean Bottom longline survey
120) **Data issues:** None regarding the approach followed to deliver the advice.
121) **Consistency**: Stock information has been updated as in previous years.

122) **Stock status**: Stock and exploitation status are currently unknown with no reference points available.

123) **Management Plan**: There is no management plan for this stock. ICES has previously based its advice on the precautionary approach following Category 3 stock trend based assessment.

General comments

The stock section is properly documented with an update of the available datasets and ongoing DLS attempts to assess this stock.

Technical comments

Some exploratory assessments using various DLS approaches reflect the progressive availability of data and methods to assess this stock from both fishing and biological information. These combined approaches provide indications about the supposed state of the stock and how the assessments could be improved using additional data analysis.

Conclusions

The section has been updated correctly and the advice does not exhibit any deviation from the information in the stock annex.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? YES
- Is the assessment according to the stock annex description? YES
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? N/A
- Have the data been used as specified in the stock annex? YES
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? N/A
- Is there any **major** reason to deviate from the standard procedure for this stock? NO
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? YES

Audit of Blackspot sea bream (*Pagellus bogaraveo*) in Subarea 10 (Azores grounds)

Date: 30.04.2020

Auditor: Régis Santos

General

Assessment is based on the survey trend. The advice is based on the 2 over 3 rule.

For single stock summary sheet advice:

124) **Assessment type:** Update.
125) **Assessment**: Survey trends-based assessment.
126) **Forecast**: Not presented.
127) **Assessment model**: Survey trends.
128) **Data issues:** Data available is as described in stock annex. Discard rate is considered negligible.
129) **Consistency**: Consistent with previous years.
130) **Stock status**: No reference points are established for the stock.
131) **Management Plan**: None.

General comments

The report was well documented and updated data. The advice was drafted according to the Stock Annex.

Technical comments

Although the survey-derived abundance index is missing some years, the survey is reliable for abundance estimates and reflects the stock size trend. There is no reported fishery abundance data for this stock since 2017, making it difficult to compare with the observed survey trend and interpret its increase in recent years.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes.
- Is the assessment according to the stock annex description? Yes.
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Not applicable.
- Have the data been used as specified in the stock annex? Yes.
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Not applicable.
- Is there any **major** reason to deviate from the standard procedure for this stock? No.
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes.

Audit of Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

Date: 30 April 2020
Auditor: Joana Vasconcelos

General

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

132) **Assessment type: Update**
133) **Assessment**: No assessment / Trend-based assessment
134) **Forecast**: Not presented
135) **Assessment model**: None
136) **Data issues:** Data available as described in the stock annex and report draft.
137) **Consistency**: Consistent with the stock annex and report draft but with minor discrepancy in some landings values between documents. These minor comments were sent to the stock coordinator. Furthermore, in this 2021–2022 scientific advice, two options are presented based on: categorize this stock as ICES category 5 stock (Option a); and categorize this stock as ICES category 3 stock (Option b).
138) **Stock status**: Unknow / ICES cannot assess the stock and exploitation status relative to MSY and PA reference points because the reference points are undefined
139) **Management Plan**: Plan is not evaluated by ICES.

General comments

This was a well-documented, well ordered and considered section. It was easy to follow and interpret. Minor comments were sent to the stock coordinator.

Technical comments

No major comments apart from those sent to the stock coordinator.

Conclusions

The assessment has been performed correctly.

Audit of Roughsnout grenadier (*Trachyrincus scabrus*) in the Northeast Atlantic

Date: 3. May 2020
Auditor: Lise Helen Ofstad

General

Use bullet points and subheadings (Recommendations, General remarks, etc.) if needed

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

140) **Assessment type: Update**
141) **Assessment**: No assessment
142) **Forecast**: Not presented
143) **Assessment model**: No assessment.
144) **Data issues:** Very few years with landings. Landings in 2012 were delited and landings for 2006-2008 updated.
145) **Consistency**: Consistent with previous years. No changes in the stock.
146) **Stock status**: Unknow
147) **Management Plan**: None.

General comments

Well documented.

Technical comments

ICES stock advice: The years in the note should be corrected.

"Note: This advice sheet is abbreviated due to the Covid 19 disruption. The previous advice issued for ***2016-2020*** *is attached as Annex 1."*

Sources and references: The years in the note should be corrected.

"*Annex 1 to be added: Advice* ***2016-2020***

(This annex will have watermark added: "Advice provided in ***2016****")"*

Conclusions

The assessment has been performed correctly

Audit of Roughsnout grenadier (*Trachyrincus scabrus*) in the Northeast Atlantic

Date: 30 April 2020

Auditor: Joana Vasconcelos

General

Use bullet points and subheadings (Recommendations, General remarks, etc.) if needed

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

148) **Assessment type: Update**
149) **Assessment**: No assessment
150) **Forecast**: Not presented
151) **Assessment model**: No assessment.
152) **Data issues:** Landings data have been updated. The only data issue has already been reported by the stock coordinador, as the only available information is official landings between 2006 and 2008 and in the previous advice the available information were landings from 2012.
153) **Consistency**: Consistent with the report and data issues reported by stock coordinator.
154) **Stock status**: Unknow
155) **Management Plan**: There is no management plan for this species.

General comments

This was a well documented. It was easy to follow and interpret.

Technical comments

The section 15.3 Ices Advice in the draft report should be updated in accordance to the new advice sheet, as it is referring the years 2016-2020 instead of 2021-2024.

Conclusions

The assessment has been performed correctly

Audit of (Tusk (Brosme brosme) in Division 6.b (Rockall))

Date: 29.04.2020

Auditor: Erik Berg

11.1.1 Tusk (*Brosme brosme*) in Division 6.b (Rockall)

General

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

156) **Assessment type: update**
157) **Assessment**: Precautionary approach
158) **Forecast**: not presented
159) **Data issues:** CPUE from longliners available. However, the effort has probably decreased and is at present very low. Tusk is only taken as bycatch and thus the CPUE is probably not reliable as representative for stock fluctuation.

160) **Consistency**: Consistent with last advice and report
161) **Stock status**: Unknown
162) **Management Plan**: No management plan available
163) **General comments** No additional comments

Technical comments

No additional comments

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? **Yes**
- Is the assessment according to the stock annex description? **Yes**
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **Not relevant**
- Have the data been used as specified in the stock annex? **Yes**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Not relevant**
- Is there any **major** reason to deviate from the standard procedure for this stock? **No**
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

Advice sheet audit report and check list

Working Group: WGDEEP **Stock Name: bsf.27.nea**

Date: 30/04/2020
Auditor: Juan Gil Herrera

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
    - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
    - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

Use bullet points and subheadings (Recommendations, General remarks, etc.) if needed

For single stock summary sheet advice:

164) **Assessment type:** update
165) **Assessment**: ICES category 3
166) **Forecast**: not presented
167) **Assessment model**: Stage-structured state-space model with two life history stages and two ("BI": British Isles or North and "P": Portugal or South) spatial stock components, including unidirectional migration (southwards). Used to analyse trends in total abundance across data sources for a trends-based assessment, not to provide biomass estimates or reference points.
168) **Data issues:** The stock structure in the whole Northeast Atlantic is still uncertain.
169) **Consistency:** Results consistent similar in trends to 2018 assessment.
170) **Stock status**: Unknown.
171) **Management Plan:** ICES is not aware of any management plan.

General comments

Stock benchmarked in 2014.Although the model of stock dynamics is complex, the assessment is clearly communicated as a category 3 stock.

Available Stock Annex for both components are only the after benchmark one (2014). This was available in pdf by email during the 2020 WGDEEP. Thus, the 3 Stock Annexes by component remaining at the ICES sharepoint could be deleted and replace with an unique (and updated, if possible) Stock Annex for bsf NEA.

This is an Abbreviate Advice sheet, so there is less sections to review ☺

Technical comments

The assessment model combines data sources from two distant fisheries (North and South). From this model, abundance trends are inferred and used in a trends-based assessment. Auxiliary data (i.e. Icelandic, Faroese and Scottish surveys) are used qualitatively. Information from outside ICES areas (Madeira) are also available in the Report chapter.

Conclusions

The assessment has been performed in the same with previous year (2018) following the 2014 benchmark. The PA buffer was firstly applied because the stock size is not increasing consistently unless there is evidence of decreasing fishing effort.

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice?

Yes

Is the assessment according to the stock annex description?

Yes

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?

No management plan

Have the data been used as specified in the stock annex?

Yes

Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

No forecast

Is there any **major** reason to deviate from the standard procedure for this stock?

None

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Yes

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table. ☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☐ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☐ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Stock and exploitation status

☒ Compare with the previous year's advice sheet. The years in common should have the same status (symbol).

☒ Check if the labels for the years are correct. "Fishing pressure years" should be from 2017 to 2019 (as stock size) instead of 2016-2018.

☐ Compare the status table with the F and SSB plots they should show the same information.

☐ Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.

Catch options

Basis of catch scenarios table:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct,

Catch options table:

☐ The forecast should be re-run to ensure all values are correct.

☐ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☐ The wanted catch and SSB values should be given in tonnes (t);

☐ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☐ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☐ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☐ For all the options given in the table calculate the percentage of change in SSB and TAC.

☐ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options".

☐ Compare different catch options; higher F should result in lower SSB

☐ Check if SSB change is in line with F.

Basis of the advice

☐ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☐ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☐ Are the units in plots correct? Yes

☐ Are the titles in the plots correct including F (age range) recruitment (age).

☐ The red line correspond to the year of assessment (except F which is year of assessment -1)

☐ Each plot should have five lines.

☐ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☐ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☐ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☐ If there is no change from the previous year the table should be the same.

☐ Ensure there is no typos wrong acronyms for the surveys.

☐ Assessment type- check that the standard text is used.

Information from stakeholders

☐ If no information is available the standard sentence should be "There is no available information"

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☐ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☐ Ensure the legend of the table reflects the year for the data given in the table.

☐ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☐ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☐Ensure that the values for the last row are correct check against the preliminary landings (link to be added).

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☐ Check if the column names are correct mainly recruitment age and age range for F.

☐ If the stock is category 5 or 6 then it should read “There is no assessment for this stock”

Sources and references

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section.

Annex 6: WGDEEP 2020 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	0	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
bsf.27.nea										
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
lin.27.5b	3	3	1	0	0	0	0	0	0	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*
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	0	0	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	0	0	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

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*
usk.27.5a14	0	0	0	0	0	0	1	1	0
usk.27.6b	0	0	0	0	0	0	0	0	0

Stock code	Mixed fisheries			Climate
	Catch and bycatch of target species	*Bycatch of non-target species*	*Consideration of mixed fisheries advice*	*Consideration of changes due to climate variability/change*
alf.27.nea	1	1	0	0
aru.27.123a4	2	0	1	0
aru.27.5a14	0	1	0	0
aru.27.5b6a	1	1	0	0
aru.27.6b7-1012	0	0	0	0
bli.27.5a14	0	0	0	0
bli.27.5b67	0	0	0	0
bli.27.nea	1	0	0	0
bsf.27.nea	1	1	1	0
gfb.27.nea	0	1	0	0
lin.27.1-2	1	0	0	0
lin.27.3a4a6-91214	1	0	0	0
lin.27.5a	0	0	0	0
lin.27.5b	1	1	0	0
ory.27.nea	1	0	0	0
rhg.27.nea	1	0	0	0

Stock code	Mixed fisheries			Climate
	Catch and bycatch of target species	*Bycatch of non-target species*	*Consideration of mixed fisheries advice*	*Consideration of changes due to climate variability/change*
rng.27.1245a8914ab	1	0	0	0
rng.27.3a	0	0	0	0
rng.27.5a10b12ac14b	1	1	0	0
rng.27.5b6712b	1	1	1	0
sbr.27.10	1	0	0	0
sbr.27.6-8	1	1	0	0
sbr.27.9	1	0	0	1
tsu.27.nea	0	0	0	0
usk.27.1-2	1	1	0	0
usk.27.12ac	0	0	0	0
usk.27.3a45b6a7-912b	1	0	0	0
usk.27.5a14	0	0	0	0
usk.27.6b	1	1	0	0