3 Northeast Atlantic boarfish (*Capros aper*)

The boarfish (*Capros aper*, Linnaeus) is a deep bodied, laterally compressed, pelagic shoaling species distributed from Norway to Senegal, including the Mediterranean, Azores, Canaries, Madeira and Great Meteor Seamount (Blanchard & Vandermeirsch 2005).

Boarfish is targeted in a pelagic trawl fishery for fish meal, to the south and southwest of Ireland and Northern Biscay. The boarfish fishery is conducted in shelf waters with the first landings reported in 2001. Landings were at very low levels from 2001-2005. The main expansion period of the fishery took place between 2006 and2010 when unrestricted landings increased from 2 772 t to 137 503 t. A restrictive TAC of 33 000 t was implemented in 2011. In 2011, ICES was asked by the European Commission to provide catch advice for 2012 for the first time.

An analysis of bottom trawl survey data suggests a continuity of distribution spanning ICES Subareas 27.4, 6, 7, 8 and 9 (Figure 3.1). Isolated occurrences appear in the North Sea (ICES Subarea 27.4) in some years indicating spill-over into this region. A hiatus in distribution was suggested between ICES Divisions 27.8.c and 9.a as boarfish were considered very rare in northern Portuguese waters but abundant further south (Cardador & Chaves 2010). Results from a dedicated genetic study on the stock structure of boarfish within the Northeast Atlantic and Mediterranean Sea suggests that this hiatus represents a true stock separation (Farrell *et al.* (2016); see section 3.12). Based on these data, a single stock is considered to exist in ICES Subareas 27.4, 6, 7, 8 and the northern part of 9.a. This distribution is slightly broader than the current EC TAC area (27.6, 7 and 8) and for the purposes of assessment in 2021 only data from these areas were utilized.

3.1 The fishery

3.1.1 Advice and management applicable from 2011 to 2021

In 2011 a TAC was set for this species for the first time, covering ICES Subareas 6, 7 and 8. This TAC was set at 33 000 t. Before 2010, the fishery was unregulated. In October 2010, the European Commission notified national authorities that under the terms of Annex 1 of Regulation 850/1998, industrial fisheries for this species should not proceed with mesh sizes of less than 100 mm. In 2011, the European Parliament voted to change Regulation 850/1998 allowing the fishery to use mesh sizes ranging from 32 to 54 mm.

For 2012, ICES advised that catches of boarfish should not increase, based on precautionary considerations. As supporting information, ICES noted that it would be cautious that landings did not increase above 82 000 t, the average over the period 2008-2010, during which the stock did not appear to be overexploited. In 2012 the TAC was set at 82 000 t by the Council of the European Union.

For 2013, ICES advised that catches of boarfish should not be more than 82 000 t. This was based on applying a harvest ratio of 12.2% (F0.1, as an F_{MSY} proxy). For 2013, the TAC was set at 82 000 t by the Council of the European Union.

For 2014, ICES advised that, based on F_{MSY} (0.23), catches of boarfish should not be more than 133 957 t, or 127 509 t when the average discard rate of the previous ten years (6 448 t) is taken into account. For 2014 the TAC was set at 133 957 t by the Council of the European Union. This advice was based on a Schaefer state space surplus production model (see section 3.6.3 for further details).

In 2014 there was concern about the use of the production model (see stock annex). ICES considered that the model was no longer suitable for providing category 1 advice and further model development was required. The model is still considered suitable for category 3 advice. The advised catch for 2015 of 53 296 t was based on the data limited stock HCR and an index calculated (method 3.1; ICES, 2012) using the total stock biomass trends from the model. Further work has been undertaken in 2015 to address the issues with the surplus production model and this work has continued since.

For 2016, ICES advised based on the precautionary approach that catches should be no more than 42 637 t.

For 2017, ICES advised based on the precautionary approach that catches should be no more than 27 288 t. For the first time, the precautionary buffer was applied resulting in a 36% reduction compared to the year before. The acoustic survey suggested that the stock abundance was at an historic low. In 2017, the Advice Drafting Group decided the advice of 21 830 proposed (20% reduction) would stand for 2 years. The update assessments in 2018 and 2019 confirmed that the biomass was rather stable and at a low level.

In 2019, advice of 19 152 t was issued for each of 2020 and 2021 on the basis of the precautionary approach.

Since 2011, there has been a provision for bycatch of boarfish (also whiting, haddock and mackerel) to be taken from the Western and North Sea horse mackerel EC quotas. These provisions are shown in the table below. The effect of this is that a quantity not exceeding the value of these 4 species combined may be landed legally and subtracted from quotas for horse mackerel.

Year	North Sea (t)	Western (t)
2011	2 031	7 779
2012	2 148	7 829
2013	1 702	7 799
2014	1 392	5 736
2015	583	4 202
2016	760	5 443
2017	912	4191
2018	759	5053
2019	759	5956
2020	688	3531
2021	701	3513

In 2010, an interim management plan was proposed by Ireland, which included a number of measures to mitigate potential bycatch of other TAC species in the boarfish fishery. A closed season from the 15th March to 31st August was proposed, as anecdotal evidence suggests that mackerel and boarfish are caught in mixed aggregations during this period. A closed season was proposed in ICES Division 7.g from 1st September to 31st October, in order to prevent catches of Celtic Sea herring, which is known to form feeding aggregations in this region at these times.

Finally, if catches of a species covered by a TAC, other than boarfish, amount to more than 5% of the total catch by day by ICES statistical rectangle, then fishing must cease in that rectangle for 5 days.

In August 2012 the Pelagic RAC proposed a long term management plan for boarfish. The management plan was not fully evaluated by ICES; however, in 2013 ICES advised that Tier 1 of the plan could be considered precautionary if a Category 1 assessment was available.

A revised draft management strategy was proposed by the Pelagic AC in July 2015. This management strategy aimed to achieve exploitation of boarfish in line with the precautionary approach to fisheries management, FAO guidelines for new and developing fisheries, and the ICES form of advice. ICES evaluated the plan and considered it to be precautionary, in that it followed the rationale for TAC setting enshrined in the ICES advice, but with additional caution.

The closed season, in the interim and revised management plans, have been enacted in legislation in Ireland, but not in other countries.

3.1.2 The fishery in recent years

Before the development of the fishery, boarfish was a discarded bycatch in the pelagic mackerel fishery in ICES Subareas 7 and 8. A study by Borges *et al.* (2008) found that boarfish may have accounted for as much as 5% of the total catch of Dutch pelagic freezer trawlers. Boarfish was also discarded in whitefish fisheries, particularly by Spanish demersal trawlers (Table 3.1.2.2).

The first landings of boarfish were reported in 2001. Landings fluctuated between 100 and 700 t per year up to 2005 (Table 3.1.2.1). In 2006, the landings began to increase considerably as a target fishery developed. Cumulative landings since 2001 exceed 600 000 t. The fishery targets dense shoals of boarfish from September to March. Catches are generally free from bycatch from September to February. From March onward a bycatch of mackerel can be found in the catches and the fishery generally ceases at this time. Information on the bycatch of other species in the boarfish fishery is sparse, though thought to be minimal. The fishery uses pelagic pair trawl nets with mesh sizes ranging from 32 to 54 mm. Preliminary information suggests that only the smallest boarfish escape this gear.

In 2014 and subsequent years, the full TAC has not been caught. This is thought to be partly due to a reduction in the availability of fishable aggregations, and partly due to economic and administrative reasons. Also, the Irish quota was allocated to individual boats, with non-specialist vessels receiving allocations that were not used. In 2015, Q3 and Q4 individual boat quotas were removed in Ireland, in an attempt to allow the specialist 6-7 vessels target the stock without (what the industry considers to be unnecessary) constraints. The same year, the Netherlands (375 t), UK England (104 t) and Germany (4 t) reported boarfish landings for the first time. These landings were mainly bycatch from freezer trawlers.

In 2016 a total of 19 315 t of boarfish were caught (Table 3.1.2.1). Ireland continued to be the main participant taking 17 496 t but was below its 29 464 t quota. Denmark took only 337 t, significantly under its national quota of 10 463 t. Scotland reported no boarfish landings. Tables 3.1.2.5 and 3.1.2.7 shows that two thirds of the Irish landings were taken in ICES divisions 7.h and 8.a respectively. Thirty-two Irish registered fishing vessels reported catches with the majority made in Q1 (7 143 t) and Q4 (8 711 t).

In 2017 a total of 17 388 t of boarfish were caught. Ireland continued to be the main participant landing 15 484 t but was almost 20% below its 18 858 quota. Denmark landed only 548 t, not even 10% of its national quota of 6 696 t. UK reported almost null boarfish landings. Discards accounted for 1 173 tonnes overall. About 90% of the Irish landings were taken in ICES divisions

7.h and 8.a (Tables 3.1.2.5 and 3.1.2.7). Thirty-five Irish registered fishing vessels reported catches with almost the entirety made in Q1 (8 570 t) and Q4 (6 270 t).

In 2018 a total of 11 286 t of boarfish were caught. This represented 55% of the 2018 quota of 20 380 t. Ireland continued to be the main participant landing 9 513 t (68% of its national quota). The Irish catch represented 85% of the total boarfish catch in 2018. Other countries reporting boarfish in 2018 were Denmark (94 t), The Netherlands (172 t), Spain (148t), UK England (0.085 t) and UK Scotland (0.229 t). Discards accounted for 1 359 t overall. Tables 3.1.2.5 and 3.1.2.7 shows that about 82% of the Irish landings were taken in ICES divisions 7.h and 8.a respectively.

A total of 11 312 t of boarfish was caught in 2019 (Table 3.1.2.1). This represents 52% of the 2019 quota of 21 830 t. The main participant in the fishery, Ireland, landed 9 910 t (75% of its national quota). The Irish catch represents 88% of the total boarfish catch in 2019. Other countries reporting boarfish catches in 2019 were Denmark (757 t), the Netherlands (317 t), England (19 t) and Spain (2.5 t). Discards accounted for 306 t overall. Tables 3.1.2.5 and 3.1.2.7 shows that about 87% of Irish landings were taken in ICES divisions 7.h and 8.a respectively.

3.1.3 The fishery in 2020

In 2020, the total catch was 15 649 t which represented 82% of the quota (19 152 t). Ireland was the main partaker in the fishery (14 666 t) and landed more than its national quota (13 234 t) for the first time since TAC and quota regulations were established. The Irish landings accounted for 94% of the total catch. The other countries reporting catches are Denmark (196 t), the Netherlands (416 t), England (62 t), Poland (109 t) and Spain (1 t). The total discards for this year were 198 t. The majority of landings were taken in ICES divisions 7.b and 7.h (Tables 3.1.2.4 and 3.1.2.5).

3.1.4 Regulations and their effects

In 2010, the fishery finished early when the European Commission notified member states that mesh sizes of less than 100 mm were illegal. However, in 2011, the European Parliament voted to change Regulation 850/1998 to allow fishing for boarfish using mesh sizes ranging from 32 to 54 mm. The TAC (33 000 t) that was introduced in 2011 significantly reduced landings.

3.1.5 Changes in fishing technology and fishing patterns

The expansion of the fishery in the mid-2000s was associated with developments in the pumping and processing technology for boarfish catches. These changes made it easier to pump boarfish ashore. To date the majority of boarfish landings by Danish, Irish and Scottish vessels have been made into Skagen, Denmark and Fuglafjorour, Faroe Islands to be processed into fishmeal. A small number of Irish vessels have landed into Killybegs and Castletownbere, Ireland. These landings into Irish ports were expected to increase in the future with the development of a human consumption fishery but this development now seems unlikely. This is due to the species' small size and difficulty being processed on conventional equipment.

3.1.6 Discards

It is to be expected that discarding occurred before 2003, particularly in demersal fisheries, however it is difficult to predict what the levels may have been.

Since 2003, the major sources of discard estimates are the Dutch pelagic freezer trawlers and both the Irish and Spanish demersal fleets. More sporadic discards are observed in German pelagic freezer trawlers and the UK demersal fleet. In 2016, Lithuania declared discards for the first time but hasn't since 2018. Discard estimates are not obtained from French freezer trawlers, though discard patterns in these fleets are likely to be similar to the Dutch fleet. Discard data from the Portuguese bottom otter trawl fleet in ICES Division 9.a are also available but are not included in the assessment as they are outside the TAC area. Table 3.1.2.2 show the total annual discards and estimates from the demersal and non-target fisheries respectively.

Discard data were included in the calculation of catch numbers at age. All discards were raised as a single metier using the same age length keys and sampling information as for the landed catches. In the absence of better sampling information on discards, this was considered the best approach. This placed the stock in Category A2 for the ICES Advice in October 2013: Discards 'topped up' onto landings calculations. With the introduction of the discard ban in 2015 this stock was placed in A4: Discards known, with discard ban in place in year +1. As such the advice will be given for catch in ICES Advice October 2014 and onwards.

3.2 Biological composition of the catch

3.2.1 Catches in numbers-at-age

Catch numbers-at-age were prepared from Irish, Danish, Dutch, Spanish, Polish and English landings using the ALK in Table 3.2.1.1 together with available samples from the fishery (Table 3.2.1.2). This general ALK was constructed based on 814 aged fish from Irish, Danish and Scottish caught samples from 2012 (see the stock annex for a description of ALKs prior to 2012). In 2020, allocations to unsampled metiers were made according to Table 3.2.1.3. In total, 10 samples with the appropriate 0.5 cm length bin measurements were collected. (Table 3.2.1.4). These samples covered the most heavily fished areas (Table 3.2.1.5) and equated to one sample per 290 t landed. The samples comprised 534 fish measured for length frequency.

The results of the application of the ALK to commercial length-frequency data (available for the years 2007-2020) produced proxy catch numbers-at-age values which are available in Table 3.2.1.6. In the last couple of years, there has been the appearance of strong year classes in the catch numbers. A high number of 1-4 year olds were present in the 2020 data. The modal age from 2007-2011 was 6 and in 2012-2018 it was 7. It should be noted that in WGWIDE 2011 and 2012 the plus group for boarfish was 20+. This was reduced to 15+ in WGWIDE 2013 due to potential inaccuracy of the age readings of older fish. Ageing was based on the method that has been validated for ages 0-7 by Hüssy *et al*. (2012a; b). The age range is similar to the published growth information presented by White *et al.* (2011).

3.2.2 Quality of catch and biological data

Table 3.2.1.3 shows allocations that were made to unsampled métiers in 2020. Length-frequencies of the international commercial landings by year are presented in Table 3.2.2.1.

Sampling in the early years of the fishery (2006-2009) was sparse as there was no dedicated sampling programme in place. The sampling programme was initiated in 2010 and good coverage of the landings has been achieved since then. Full details of the sampling programme in the earlier years are presented in the stock annex. Until 2017, boarfish was not included on the DCF list of species for sampling. Irish sampling comprises only samples from Irish registered vessels. Samples are collected on-board directly from the fish pump during fishing operations and are frozen until the vessel returns to port, which ensures high quality samples. Each sample consists of approximately 6 kg of boarfish. This equates to approximately 150 fish which, given the limited size range of boarfish, is sufficient for determining a representative length frequency. The established sampling target is one sample per 1 000 t of landings per ICES Division, which is also standard in other pelagic fisheries such as mackerel. Since 2017, all fish in each sample should be measured to the 0.5 cm below for length frequency. Following standard protocols 5 fish per 0.5 cm length class should be randomly selected from each sample for biological data collection *i.e.* otolith extraction, measurement to the 1mm below and sex and maturity determination. There is no sampling programme in place for Scottish catches.

The current surplus production model used to assess boarfish is considered an interim measure prior to the development of an aged-based assessment. In 2017, boarfish was included in the list of species to be sampled by the Data Collection Multi Annual Programme (DCMAP) which should provide estimates of catch at age and facilitate the future development of an age-based stock assessment method.

3.3 Fishery Independent Information

3.3.1 Acoustic Surveys

The Boarfish Acoustic Survey (BFAS) was first conducted in July 2011. The 2021 survey was carried out by the RV *Celtic Explorer* and run in conjunction with the Malin Shelf herring survey as the WESPAS survey (Western European Shelf Pelagic Acoustic Survey). The survey was carried out over a 42-day period beginning on the 9 June in the south (47°30N) and working northwards to 59°30N ending on 20 July.

Calculation of acoustic abundance
The StoX software package (Johnsen et. al., 2019) was used to calculate acoustic abundance from survey data (StoX V2.7 and R-StoX V1.11) and aggregated survey data are available for download at the ICES acoustic database (https://www.ices.dk/data/data-portals/Pages/acoustic.aspx). Survey design and execution of the WESPAS survey adhere to guidelines laid out in the Manual for International Pelagic Surveys (ICES, 2015).

Survey results 2021
The 2021 WESPAS survey provided continuous synoptic coverage from south to north over 42 days covering an area of over 50,552 nmi^2 (boarfish strata) and a transect mileage of over 4,986 nautical miles. In total, 65 trawl stations were undertaken during the survey. 35 hauls contained boarfish and provided 5,724 individual length measurements, 2,651 length and weight measurements and 1,474 otoliths.

Acoustic echotraces attributed to boarfish in 2021 are shown in Figure 3.3.1.1. Individual points represent the mean NASC over a 1nm transect distance. The 2021 estimate of total survey biomass of 444kt represents a slight increase over that observed in 2020 (399kt). The majority of the estimate (53%) is found in the Celtic Sea stratum with the Irish west coast contributing 33%, similar to the situation in 2020 (Figure 3.3.1.2.).

The Celtic Sea/Northern Biscay area was found to contained a high abundance of immature boarfish extending further northwards than observed in 2020 or previously. Mature fish were also present but in lower abundances than in previously. Immature boarfish represented 61% of the total abundance observed across the combined survey area, an increase from 59% observed in 2020.

The full time series of survey estimates of boarfish biomass is presented in Table 3.3.1.1.

The ALK developed in 2012 (during investigations to development the knowledgebase around boarfish) was used to estimate the survey abundance at age (otoliths are collected during the survey but are not currently aged), (Figure 3.3.1.3.). A plus group of 15+ is assumed and accounts for 23% of TSB and 6% of TSN. The contribution of 1-3 year olds represents over 33% of the TSB and 73% of TSN indicating strong recent recruitment. The previously observed strong year classes that are now 8-10-year-old fish are also present but in lower numbers than expected when compared to neighbouring year classes.

The 2021 stock estimate is dominated by the recently recruited year classes (2016-2020). The maturity ogive from the 2012 studies (see section 3.4) indicates that 79% of observed biomass in 2021 was mature (40% total abundance) compared to 90% biomass and 59% abundance in 2020. This year-on-year increase in the contribution of immature fish to the total stock estimate started in 2018 and has continued into 2021, indicating a continued positive trend of growth for the stock. Preliminary results from the PELGAS survey undertaken in the area south of the WESPAS grid during May indicates increased biomass of boarfish in northern Biscay, also with a significant contribution from immature ages in agreement with observations during WESPAS in the Celtic Sea (M. Doray, pers comm.). The current southern boundary of the WESPAS survey therefore does not ensure full containment of the stock such that the WESPAS estimate should be considered to be an underestimate.

3.3.2 International bottom trawl survey (IBTS) Indices Investigation

The western IBTS data and CEFAS English Celtic Sea Groundfish Survey were investigated for their use as abundance indices for boarfish for the first time in 2012. An index of abundance was constructed from the following surveys:

- EVHOE, French Celtic Sea and Biscay Survey, (Q4) 1997 to 2011
- IGFS, Irish Groundfish Survey, (Q4) 2003 to 2011
- WCSGFS, West of Scotland, (Q1 and Q4) 1986 to 2009 (survey design changed in 2010)
- SPPGFS, Spanish Porcupine Bank Survey, (Q3) 2001 to 2011
- SPNGFS, Spanish North Coast Survey, (Q3/Q4) 1991 to 2011
- ECSGFS, CEFAS English Celtic Sea Groundfish Survey, (Q4) 1982 to 2003

From the IBTS data, CPUE was computed as the number of boarfish per 30 min haul. The abundance of boarfish per year per ICES statistical rectangle (used for visualisation only) was then calculated by summing the boarfish in a given rectangle and dividing by the total number of hauls in that rectangle. Length frequencies are presented in Table 3.3.2.1 for each survey. These surveys cover the majority of the observed range of boarfish in the ICES Area (Figure 3.1). Figure 3.3.2.1 shows the haul positions for each of the 6 surveys analysed.

A detailed analysis of the IBTS data was carried out in 2012 to investigate the main areas of abundance of boarfish in these surveys. This analysis included GAM modelling based on the probability of occurrence of boarfish. The full details of this work are presented in the stock annex. The IBTS appears to give a relative index of abundance, with good resolution between periods of high and low abundance. The main centres of abundance in the survey (Figure 3.3.2.2) correspond to main fishing grounds (Figure 3.1.2.1). Figures 3.3.2.3a and b shows the signal in abundance and biomass, increasing gradually in the 1990s, slowly declining in the early 2000s, before increasing again with a strong increase in the most recent period. Much of this increase which is stronger in terms of abundance is due to increased recruitment since 2017. The low estimates for the 2017 survey are partly explained by issues with the execution of the EVHOE survey. Due to mechanical breakdown, the majority of the survey stations could not be completed. The missed stations would have covered the area in North Biscay typically associated with the highest catch rates of boarfish.

For subsequent surplus production modelling (see Section 3.6.3), biomass indices were extracted from each of the IBTS surveys using a delta-lognormal model (Stefánsson 1996). Many of the surveys exhibited a large proportion of zero tows with occasionally very large tows, hence the decision to explicitly model the probability of a non-zero tow and the mean of the positive tows. A delta-lognormal fit comprises fitting two generalized linear models (GLMs). The first model (binomial GLM) is used to obtain the proportion of non-zero tows and is fit to the data coded as 1 or 0 if the tow contained a positive or zero CPUE, respectively. The second model is fit to the positive only CPUE data using a lognormal GLM. Both GLMs were fit using ICES statistical rectangle and year as explanatory factor variables. Where the number of tows per rectangle was less than 5 over the entire series, they are grouped into an "others" rectangle. An index per rectangle and year is constructed, according to Stefánsson (1996), by the product of the estimated probability of a positive tow times the mean of the positive tows. The station indices are aggregated by taking the estimated average across all rectangles within a year. To propagate the uncertainty, all survey index analyses were conducted in a Bayesian framework using Markov chain Monte Carlo (MCMC) sampling (Kery 2010). The analyses were performed in WinBUGS from R with the R2WinBUGS package.

When the indices were recalculated in 2021, (following a refresh of the input data from DATRAS and national data submitters), the following issues were encountered

- An error with the coding of the EVHOE 2018 data in DATRAS was corrected, revising upwards the estimates from 2018 for this survey
- The truncated EVHOE 2017 dataset was removed from the analysis. In previous years, this data was retained but, because the available data only corresponds to a small fraction of the total survey area (where boarfish are not usually encountered in significant quantities) a very low survey estimate resulted. It was considered appropriate to remove this data from the analysis. In future, explicit modelling of spatial and temporal correlations may permit this data to be considered again.
- An error in the analysis was discovered whereby hauls with more than one catch category were underrepresented as only a single catch category was included during the model fitting. Multiple catch categories are usually the result of splitting the catch into adult and juvenile portions and using an appropriate subsampling strategy for each. This issue is particularly relevant for the IGFS which, over the most recent 4 years has 2 catch categories for boarfish recorded for approximately 20% of hauls. The outcome is an increase in CPUE for these hauls and a subsequent increase in the survey index for the IGFS in recent years (2016 onwards).

3.4 Mean weights- at-age, maturity-at-age and natural mortality

Mean weight-at-age was obtained from the ageing studies of Hüssy *et al.* (2012b). These mean weights are presented in the text table below. The variation in weight-at-age is due to the small sample size and the seasonal variation in weight and maturity stage.

Age	0	1	2	3	4	5	6	7	8	9
Mean Weight (g)	0.84	6.65	14.6	19.5	23.7	26.8	33.3	37.7	40	47.1

Age	10	11	12	13	14	15	16	17	18	19
Mean Weight (g)	50.2	51.2	62.8	56.4	62.2	68.9	50.5	86.7	77.9	64.6

Age	20	21	22	23	24	25	26	27	28	29
Mean Weight (g)	63.5	75	86	71	77	84.4	79.4	-	67.6	52.8

Maturity-at-age was obtained from the ageing studies of Hüssy *et al.* (2012a; b) and the reproductive study by Farrell *et al.* (2012).

Age	0	1	2	3	4	5	6+
Prop mature	0	0	0.07	0.25	0.81	0.97	1

Natural mortality (M) was estimated over the life span of the stock using the method described by King (1995). This method assumed that M was the mortality that would reduce a population to 1% of its initial size over the lifespan of the stock. Based on a maximum age of 31, M was calculated as follows

$$M = -ln(0.01)/31$$

Following this procedure, M = 0.16 year^{-1}was considered a good estimate of natural mortality over the life span of the boarfish stock, as it was similar to the total mortality estimate from 2007, (Z = 0.18, see Section 3.6.5). Given that catches in 2007 were relatively low, this estimate of total mortality was considered a good estimate of natural mortality, assuming negligible fishing mortality in previous years.

Similarly, total mortality was estimated from age-structured IBTS data from 2003 to 2006 (years from which data was available for all areas). The total mortality was considered a good estimate of natural mortality as fishing mortality was assumed to be negligible during this period. Total mortality ranged from 0.09–0.2 with a mean of 0.16.

The special review in 2012 questioned the validity of a single estimate of M across the entire age range. If an age based assessment is possible in the future, age specific estimates of natural mortality will be required. However, the current estimate of M, which covers the whole age range, is considered appropriate in the context of the current situation where age data are used as an indicator approach, rather than as a full assessment method. Given that Z and F are also calculated over the entire (fully selected) range (Section 3.6.5) a single value of M was considered appropriate.

3.5 Recruitment

The common ALK (Table 3.2.1.1.) was applied to the IBTS number-at-length data. The length-frequency is presented in Table 3.3.2.1. and the age-structured index in Table 3.6.1.1. and Figure 3.6.1.1.

A cohort effect can be seen with those cohorts from the early 2000s appearing weak. This coincides with a decline in overall abundance in the early 2000s. From the mid-2000s onwards recruitment improved as observed in the abundance of 1-5 year olds in the EVHOE and Spanish northern shelf surveys (It should be noted however that the IBTS data is measured to the 1.0cm not the 0.5cm until 2015. Therefore, application of the common ALK to this data must be viewed with caution).

The EVHOE, IGFS and SPNGFS surveys provide the best indices of recruitment as this is where the juveniles appear to be most abundant (Table 3.3.2.1). It appears that recruitment was high in the late 1990s in the EVHOE survey with 2010 and 2015 also indicating above average recruitment. Particularly strong recruitment has been noted in each of 2018-2020, especially for the EVHOE survey but also the IGFS in 2020.

3.6 Exploratory assessment

In 2012, a new stock assessment method for Boarfish was tested. In 2013 this Bayesian state space surplus production model (BSP; Meyer & Millar (1999)) was further developed following reviewers' recommendations in 2012. Different applications of a Bayesian biomass dynamic model were run in 2013 incorporating combinations of catch data, abundance data from the groundfish surveys, and estimates of biomass (and associated uncertainty) from the acoustic surveys (see stock annex for more details of the sensitivity runs). The model and settings from the final accepted run in 2013 were used as the basis of ICES category 1 advice for catch in 2014. However, in 2014 there was concern about the use of the production model for a number of reasons and ICES considered this model as no longer suitable for providing category 1 advice. Since 2014, the assessment model has been used as a basis for trends for providing DLS advice (ICES category 3). ICES considers the current basis for the advice on this stock to be an interim measure prior to development of an age-based assessment.

3.6.1 IBTS data

Some of the IBTS CPUE indices displayed marked variability with a large proportion of zero tows and occasionally very large tows (*e.g*. West of Scotland survey, Figure B.4.7 stock annex). More southern surveys displayed a consistently higher proportion of positive tows. The variability of the data is reflected in the estimated mean CPUE indices (Figure 3.6.1.2). The West of Scotland survey index had been increasing between 2000 and 2009 but is uncertain, whereas the estimated indices from the other series are typically less variable. In 2014, four of the five current bottom trawl surveys experienced a sharp decline in CPUE, particularly the West of Scotland, the Spanish North Coast, the Spanish Porcupine and Irish Groundfish surveys. Both Spanish surveys remained low in 2015 whereas the latest IGFS and EVHOE surveys indicate an increase. In 2016, values were similar to those of the previous year for all surveys. In 2017, surveys suggest that the stock abundance increased compared to the year before although the EVHOE data is excluded from the analysis for this year. The CEFAS English Celtic Sea Groundfish Survey displays a steady increase from the mid-1980s to 2002 with a large but somewhat uncertain estimate in 2003. The spatial extent of each survey is shown in Figure 3.3.2.1.

Diagnostics from the positive component of the delta-lognormal fits indicate relatively good agreement with a normal distribution on the natural logarithmic scale (Figure 3.6.1.4). There is an indication of longer tails in some of the surveys (*e.g*. WCSGFS, SPPGFS).

Pair-wise correlation between the annual mean survey indices varied. The IGFS, EVHOE and SPNGFS displayed positive correlation (Figure 3.6.1.5). The updates described above with respect to data and analysis code corrections have resulted in increased correlation between the surveys most affected *i.e.* IGFS and EVHOE. The WCSGFS also displayed a negative correlation with the 2 Spanish surveys (SPPGFS and SPNGFS). The SPPGFS also displayed a negative correlation with EVHOE (Figure 3.6.1.5). Weighting the correlations by the sum of the pair-wise variances resulted in a largely similar correlation structure, though the WCSGFS and SPPGFS were more strongly correlated with the ECSGFS (Figure 3.6.1.6). Note that though some surveys displayed weak or no correlation, no surveys were excluded a-priori from the assessment. Sensitivity tests were conducted in 2013, which led to the exclusion of the surveys mentioned previously (see the stock annex).

3.6.2 Biomass estimates from acoustic surveys

The Boarfish Acoustic Survey (BFAS) series was initiated in 2011 in partnership with industry. The 2011 survey collected data over 24 hours. In 2012, the protocol was changed to exclude the hours between 00:00 and 04:00 as aggregations break up during the hours of darkness. The 2011 data was reworked in 2015 to exclude the data between 00:00 and 04:00. An acoustic target strength model of (-66.2dB) was developed in 2013 (Fässler *et al.* (2013)) and is applied to all surveys in the time series (Figure 3.3.1.1). Over the time series of the survey total biomass has been estimated in the range 863 kt (in 2012) to 70 kt (2016) with CV estimates ranging 0.11 to 0.31. Total biomass estimates declined sharply between 2012 and 2016 after which an increasing trend is seen. In the most recent surveys, the contribution of immature boarfish to the total estimate has been increasing such that the increase seen between 2020 and 2021 is largely due to juveniles. No substantial evidence exists for removing any of the survey points from the time series although 2016 may be considered an outlier (Table 3.3.1.1).

The PELACUS surveys is conducted annually in waters to the south of the boarfish (WESPAS) survey. In 2021 PELACUS recorded an increase in biomass on its most northerly transects (immediately south of the WESPAS southern limit) compared to 2019 (no survey was conducted in 2020), in broad agreement with increases noted on WESPAS. The PELACUS survey takes place approximately 1 month prior to the boarfish survey.

3.6.3 Biomass dynamic model

In 2012 an exploratory biomass dynamic model was developed for the assessment of boarfish. The model is a Bayesian state space surplus production model (Meyer & Millar 1999), incorporating the catch data, IBTS data, and acoustic biomass data. Following the initial development of the model, the assessment was peer-reviewed by two independent experts on behalf of ICES. In 2013 a new assessment was provided, which was based on the previous year's work and the reviewers' comments and formed the basis of a category 1 assessment. Details of the review and the associated changes can be found in the stock annex.

In 2014 the Bayesian state space surplus production model was fit using the catch data, delta-lognormal estimated IBTS survey indices, and the acoustic survey estimates. However, the inclusion of the low 2014 acoustic biomass estimate changed the perception on the stock, which raised concerns over the sensitivity and process error of the model and the stock assessment was moved from ICES category 1 to category 3 with the results of the surplus production model being used to calculate an index for the data limited stock approach.

Since 2014, the procedure used to run the model has not changed with annual updates to the input data only.

In the Bayesian state space surplus production model the biomass dynamics are given by a difference form of a Schaefer biomass dynamic model:

$$B_t = B_{t-1} + rB_{t-1}\left(1 - \frac{B_{t-1}}{K}\right) - C_{t-1}$$

where B_t is the biomass at time t, r is the intrinsic rate of population growth, K is the carrying capacity, and C_t is the catch, assumed known exactly. To assist estimation, the biomass is scaled by the carrying capacity, denoting the scaled biomass $P_t = B_t / K$. A lognormal error structure is assumed giving the scaled biomass dynamics (process) model:

$$P_t = (P_{t-1} + rP_{t-1}(1 - P_{t-1}) + \frac{C_{t-1}}{K})e^{\mu_t}$$

where the logarithm of process deviations are assumed normal $u_t = N(0, \sigma_2^{\mu})$ with σ_2^{μ} the process error variance.

The starting year biomass is given by aK, where a is the proportion of the carrying capacity in the first year. The biomass dynamics process is related to the observations on the indices through the measurement error equation:

$$I_{j,t} = q_j P_t K e^{\varepsilon_{j,t}}$$

where $I_{j,t}$ is the value of abundance index j in year t, q_j is survey-specific catchability, $B_t = P_t K$, and the measurement errors are assumed log-normally distributed with $u_t = N(0, \varepsilon_{e,j,t}^2)$ where $\varepsilon_{e,j,t}^2$ is the index-specific measurement error variance. $Var(I_{j,t})$ is obtained from the delta-lognormal survey fits. That is, the variance of the mean annual estimate per survey is inputted directly from the delta-lognormal fits (Figure 3.6.1.2) as opposed to estimating a measurement error within the assessment. The measurement error is obtained from:

$$\sigma_{e,j,t}^2 = ln(1 + \frac{Var(I_{j,t})}{(I_{j,t})^2})$$

For the acoustic survey, the CV of the survey was transformed into a lognormal variance via

$$\sigma_{\varepsilon,acoustic,t}^2 = ln(CV_{acoustic,t}^2 + 1)$$

Prior assumptions on the parameter distributions were:

- Intrinsic rate of population growth: *r ~ U(0.001, 2)*
- Natural logarithm of the carrying capacity: *ln(K) ~ U(ln(max(C), ln(10.sum(C)) = U(ln(144047), ln(4450407))*
- Proportion of carrying capacity in first year of assessment: *a ~ U[0.001, 1.0]*
- Natural logarithm of the survey-specific catchabilities $ln(q_i) \sim U(-16, 0)$ (for IBTS only). The acoustic survey prior is discussed below.
- Process error precision $\frac{1}{\sigma_u^2} \sim gamma(0.001, 0.001)$

Specification

During the 2013 WGWIDE meeting a number of different iterations of the model were run to discern the best parameters for the assessment. After four initial runs and four sensitivity runs the settings for the final run (run 2.2) were chosen. These settings are shown below and were used for the assessment model since 2014. (More details of the trial runs in 2013 can be found in the stock annex).

The specifications for the final boarfish assessment model runs are:

Acoustic survey

Years: 2011–2021

Index value ($I_{acoustic,y}$): 'total' in tonnes (i.e. Definitely Boarfish + Probably Boarfish + Boarfish in a Mix)

Catchability ($q_{acoustic}$): A free, but strong prior (i.e. the acoustic survey is treated as a relative index but is strongly informed, this allows the survey to cover <100% of the stock).

IBTS surveys

6 delta log normal indices (WCSGFS, SPPGFS, IGFS, ECSGFS, SPNGFS, EVHOE)

First 5 and last 7 (since 2017, because of change in survey design) years omitted from WCSGFS

First 9 years omitted from ECSGFS

Following discussion of the sensitivity runs in 2013, it was decided that the final run be based on a run that includes all surveys with the omission of the first 5 years of the WCSGFS and first 9 years of the ECSGFS as it was unclear whether boarfish were consistently recorded in the early part of the ECSGFS. The WCSGFS is thought to be at the northern extreme of the distribution and may not be an appropriate index for the whole stock. The initial data year was set at 1991 when 3 groundfish survey indices are available (SPNGFS, ECSGFS and WCSGFS). The survey indices are weighted such that highly uncertain values receive lower weight in the fitting.

Catches

2003–2020 time series

Priors

The final run assumes a strong prior for the acoustic survey catchability with $ln(q_{acoustic}) \sim N(1, 1/4)$ (mean 1, standard deviation 0.25), which has 95% of the density between 0.5 and 2. Given the relatively short acoustic series it is not possible to estimate this parameter freely (*i.e.* using an uninformative prior). The prescription of a strong prior removes the assumption of an absolute index from the acoustic survey. This assumption will be continually updated as additional data accrue.

Run convergence

Parameters for the 2021 model run converged with good mixing of the chains and Rhat values lower than 1.1 indicating convergence and acceptable autocorrelation (Figures 3.6.3.1-3).

Diagnostic plots are provided in Figure 3.6.3.4 showing residuals about the model fit. A fairly balanced residual pattern is evident. In some cases, outliers are apparent, for instance in the English survey in the final year (2003). However, these points are down weighted according to the inverse of their variance and hence do not contribute much to the model fit. The west of Scotland IBTS survey, located at the northern extreme of the stock distribution underestimates the stock in the early period (years) and overestimates it towards the end of the available time series. This could be indicative of stock expansion into this area at higher stock sizes and suggests that this index is perhaps not representative of the whole stock. Figure 3.6.3.5 shows the prior and posterior distributions of the parameters of the biomass dynamic model. The estimate of q is less than 1.0, leading to a higher estimate of final stock biomass than the acoustic survey result.

Results

Trajectories of observed and expected indices are shown in Figure 3.6.3.6, along with the stock size over time and a harvest ratio (total catch divided by estimated biomass). Parameter estimates from the model run are summarized in Table 3.6.3.1. Biomass in 2021 is estimated to be 497 kt, continuing the increasing trend in stock size since 2016. The extremely low biomass estimate from the 2016 acoustic survey appears to be largely considered as an outlier by the model. This is also the case for the high survey estimate in 2012 although the drop in biomass between these points is seen in a number of the input data series. Retrospective plots of TSB and F, presented in Figure 3.6.3.7, show that the perception of the stock is stable over the most recent 5 years.

3.6.4 Pseudo-cohort analysis

Pseudo-cohort analysis is a procedure where mortality is calculated by means of catch curves derived from catch-at-age from a single year. This is in contrast to cohort analysis, which is the basis of VPA-type assessments. In cohort analysis, mortality is calculated across the ages of a year class, not within a single year. Because only seven years of sampling data were available and owing to the large age range currently in the catches a cohort analysis would only yield information for a very limited age and year range. Therefore, pseudo-cohort analysis was performed to supplement the Bayesian state space model.

Pseudo-cohort Z estimates increased with the rapid expansion of the fishery but decreased in 2011 due to the introduction of the first boarfish TAC (Table 3.6.4.1). By subtracting M (= 0.16), an estimate of F was obtained for each year (ages 7-14). This series was revised to represent ages 7-14, rather than 6-14 as in previous years, because in 2013 age 6 boarfish were not fully selected, *i.e.* age 7 had higher abundance at age.

It can be seen from the table below that $Z = M$ in 2007, the initial year of the expanded fishery, while F is negligible. F increased to a high of 0.29 in 2012, gradually reduced to 0.15 in 2015/16 before increasing in the recent period. The estimate for 2020 is low although the majority of the fishery was conducted on juveniles given the strong recent recruitment with less information available from the older ages.

Year	Z (7-14)	F (Z-M)	Catch (t)
2007	0.17	0.01	21 576
2008	0.33	0.17	34 751
2009	0.36	0.20	90 370
2010	0.33	0.17	144 047
2011	0.29	0.13	37 096
2012	0.45	0.29	87 355
2013	0.36	0.20	75 409
2014	0.37	0.21	45 231
2015	0.31	0.15	17 766
2016	0.31	0.15	19 315
2017	0.33	0.17	17 388
2018	0.36	0.20	11 286
2019	0.37	0.21	11 313
2020	0.20	0.04	15649

3.6.5 State of the stock

The most recent year assessment indicates that total stock biomass increased from a low to average level from the early to mid-1990s (Figure 3.6.3.6). The stock fluctuated around this level until 2009, before increasing until 2012. A sharp decline is seen between 2013 and 2014. Since 2014, the abundance has increased although it remains below that from the previous high period. There was concern in 2014 that this decline was exaggerated by an unusually low acoustic biomass estimate that led to a downward revision in stock trajectory. However, the 2014 survey is considered satisfactory in terms of containment. The comparably low 2014 biomass estimate was supported by results of the 2015 survey. The 2016 biomass estimate, the lowest of the time series is considered likely an outlier and has little influence on stock abundance estimates. The 95% uncertainty bounds are relatively large reflecting the uncertainty in the survey indices, and short exploitation history of the stock and the treatment of the acoustic survey as a relative biomass index.

Catch data are available from 2001, the first year of commercial landings, and reasonably comprehensive discard data are available from 2003. Peak catches were recorded in 2010, when over 140 000 t were taken. Elevated fishing mortality was observed, associated with the highest recorded catch in 2010. Fishing mortality, expressed as a harvest ratio (catch divided by total biomass), was first recorded in 2003. Before that time, it is to be expected that some discarding took place, and there were some commercial landings. Fishing mortality increased measurably from 2006, reaching a peak in 2009-2010. F declined in 2011 as catches became regulated by the precautionary TAC but increased year on year until 2015 when reduced catches resulted in a reduction. The considerable catches in recent years do not appear to have significantly truncated the size or age structure of the stock and 15+ group fish are still abundant (Figure 3.2.1.1).

MSY reference points can be estimated from the production model assessment parameter values. In 2021, F_{MSY} (r/2) is estimated to be 0.17 and MSY $B_{trigger}$ (K/4) 160kt. Throughout the history of the fishery, estimates of total biomass have remained above MSY $B_{trigger}$. Fishing mortality (F) was briefly larger than the estimate of F_{MSY} between 2009 and 2010 and again in 2014, but has decreased since. In 2021, the stock is in the green area of the Kobe plot (Figure 3.6.6.1).

Estimates of recruitment are not available from the stock assessment. However, all available data sources (catch, acoustic survey and IBTS surveys) indicate above average recruitment since 2017. The 2021 acoustic survey recorded the largest proportion of juvenile biomass (<10cm, 4yo) in the time series and is comprised of a number of recent year classes.

3.7 Short Term Projections

As the assessment is exploratory, no short term projections were conducted.

3.8 Long term simulations

No long term simulations were conducted.

3.9 Candidate precautionary and yield based reference points

3.9.1 Yield per Recruit

A yield per recruit analysis was conducted in 2011 (Minto *et al.* 2011) and *F0.1* was estimated to be 0.13 whilst F_{MAX} was estimated in the range 0.23 to 0.33 (Figure 3.9.1.1). *F0.1* was considered to be well estimated (Figure 3.9.1.2). No new yield per recruit analyses were performed in subsequent years.

3.9.2 Precautionary reference points

No reference points have been defined for boarfish.

3.9.3 Other yield based reference points

Yield per recruit analysis, following the method of Beverton & Holt (1957), found *F0.1* to be robustly estimated at 0.13 (ICES 2011; Minto *et al.* 2011).

3.10 Quality of the assessment

ICES considers the current basis for the advice on this stock to be an interim measure prior to development of an age-based assessment. The acoustic survey has undergone several developments to improve its suitability with updates to methodology in 2012, a change in direction in 2017 and extension of transects at the boundaries to improve containment. The assessment was downgraded from Category 1 to Category 3 in 2014, and it has remained in this category since. The model is still considered suitable for category 3 advice, because it provides the best means of combining the available survey series. The assessment is sensitive to the acoustic series. In addition, a substantial part of the year to year variations in the stock abundance is linked to the process error. The use of some priors (like ratio to virgin biomass in the first year of the assessment) and survey (*e.g.* WCSGFS for instance) may require revision.

The bottom trawl survey data are considered to be a good index of abundance given that boarfish aggregate near the bottom at this time of year. The trawl surveys record high abundances of the species, but with many zero hauls. The delta-lognormal error structure used in the analyses is considered to be an appropriate means of dealing with such data. The biomass dynamic model used in the stock assessment is based on the assessment of megrim in Sub-divisions 4 and 6 with the model further developed by including acoustic survey biomass estimates. A drawback of the current assessment model is that it does not provide estimates of recruitment although estimates of recruitment strength are available from the Spanish and French bottom trawl surveys.

3.11 Management considerations

As this stock is placed in category 3, the advice is based on harvest control rules for data limited stocks (ICES 2017). Since the biomass estimate from the Bayesian model is considered reliable for trends based assessment, an index can be calculated according to Method 3.1 of ICES (2012). The advice is based on a comparison of the average of the two most recent index values with the average of the three preceding values multiplied by the most recent catch. Table 3.6.5.1 shows the biomass estimates from the model from which the index was calculated.

Although not currently accepted as the basis for an analytic assessment, the surplus production model still provides the best unified view of this stock (Figure 3.6.3.6).

3.12 Stock structure

A dedicated study on the stock structure of boarfish within the Northeast Atlantic and Mediterranean Sea commenced in October 2013 in order to resolve outstanding questions regarding the stock structure of boarfish and the suitability of assessment data. Results (Farrell *et al.* 2016) indicated strong population structure across the distribution range of boarfish with 7-8 genetic populations identified (Figure 3.12.1).

The eastern Mediterranean (*MED*) samples comprised a single population and were distinct from all other samples. Similarly, the Azorean (*AZA*), Western Saharan (*MOR*) and Alboran (*ALM*) samples were distinct from all others. Of particular relevance to the assessment and management of the boarfish fishery is the identification and delineation of the population structure between southern Portuguese waters (*PTN2B-PTS*) and waters to the geographic north. A distinct and temporally stable mixing zone was evident in the waters around Cabo da Roca. The *PTN2A* sample appeared to be significantly different from all other samples however this sample was relatively small and was considered to represent a mixed sample rather than a true population.

No significant spatial or temporal population structure was found within the samples comprising the NEA population (Figure 3.12.1). A statistically significant but comparatively low level of genetic differentiation was found between this population and the northern Spanish shelf/northern Portuguese samples (NSA-PTN1). However, a high level of migration was revealed between these two populations and no barriers to gene flow were detected between them. Therefore, for the purposes of assessment and management these areas can be considered as one unit.

Analyses indicated a lack of significant immigration into this northeast Atlantic boarfish stock from populations to the south or from insular elements and the strong genetic differentiation among these regions indicate that the purported increases in abundance in the northeast Atlantic area are not the result of a recent influx from other regions. The increase in abundance is most likely the result of demographic processes within the northeast Atlantic stock (Blanchard & Vandermeirsch 2005; Coad *et al.* 2014).

Whilst the current assessment and management area constitutes the majority of the most northern population it should be extended into Northern Portuguese waters and repeated genetic monitoring of the stock in this region should be conducted to ensure the validity of this delineation. Based on analyses of IBTS data the biomass in this area is suspected to be small relative to the overall biomass in the TAC area.

3.13 Ecosystem considerations

The ecological role and significance of boarfish in the NE Atlantic is largely unknown. However, in the southeast North Atlantic, in Portuguese waters, they are considered to have an important position in the marine food web (Lopes *et al.* 2006). The diet has been investigated in the eastern Mediterranean, Portuguese waters and at Great Meteor Seamount and consists primarily of copepods, specifically *Calanus helgolandicus*, with some mysid shrimp and euphausiids (Macpherson 1979; Fock *et al.* 2002; Lopes *et al.* 2006). This contrasted with the morphologically similar species, the slender snipefish, *Macroramphosus gracilis* and the longspine snipefish, *M. scolopax*, whose diet comprised *Temora spp.*, copepods and mysid shrimps, respectively (Lopes *et al.* 2006). Despite the obvious potential for these species to feed on fish eggs and larvae, there was no evidence to support this conclusion in Portuguese waters and they were not considered predators of commercial fishes and thus their increase in abundance was unlikely to affect recruitment of commercial fish species. If the NE Atlantic population of boarfish is sufficiently large then there exists, the possibility of competition for food with other widely distributed planktivorous species.

Both seasonal and diurnal variations were observed in the diet of boarfish in all three regions. In the eastern Mediterranean and Portuguese waters, mysids become an important component of the diet in autumn, which correlates with their increased abundance in these regions at this time (Macpherson 1979; Lopes *et al.* 2006). Fock *et al.* (2002) found that boarfish at Great Meteor Seamount fed mainly on copepods and euphausiids diurnally and on decapods nocturnally, indicating habitat dependent resource utilization.

Boarfish appear an unlikely target of predation given their array of strong dorsal and anal fin spines and covering of ctenoid scales. However, there is evidence to suggest that they may be an important component of some species' diets. Most studies have focused in the Azores and few have mentioned the NE Atlantic, probably due to the relatively low abundance in the region until recent years. In the Azores, boarfish was found to be one of the most important prey items for tope (*Galeorhinus galeus*), thornback ray (*Raja clavata*), conger eel (*Conger conger*), forkbeard (*Phycis phycis*), bigeye tuna (*Thunnus obesus*), yellowmouth barracuda (*Sphyraena viridensis*), swordfish (*Xiphias gladius*), blackspot seabream (*Pagellus bogaraveo*), axillary seabream (*Pagellus acarne*) and blacktail comber (*Serranus atricauda*) (Clarke *et al.* 1995; Morato *et al.* 1999, 2000, 2001, 2003; Arrizabalaga *et al.* 2008). Many of these species also occur in the NE Atlantic shelf waters although it is unknown whether boarfish represent a significant component of the diet in this region.

In the NE Atlantic boarfish have not previously been recorded in the diets of tope or thornback ray (Holden & Tucker 1974; Ellis *et al.* 1996). However, this does not prove that they are currently not a prey item. A study of conger eel diet in Irish waters from 1998-1999 failed to find boarfish in the diet (O'Sullivan *et al.* 2004). However, in Portuguese waters a recent study has found boarfish to be the most numerous species in the diet of conger eels (Xavier *et al.* 2010). It has been suggested that boarfish are an important component of the diet of hake (*Merluccius merluccius*), as they are sometimes caught together. However, a recent study of the diet of hake in the Celtic Sea and Bay of Biscay did not report any boarfish in the stomachs of hake caught during the 2001 EVHOE survey (Mahe *et al.* 2007).

The conspicuous presence of boarfish in the diet of so many fish species in the Azores is perhaps more related to the lack of other available food sources than to the palatability of boarfish themselves. Given the large abundance in NE Atlantic shelf waters it is likely that they would have been recorded more frequently if they were a significant and important prey item.

Boarfish are also an important component of the diet a number of sea birds in the Azores, most notably the common tern (*Sterna hirundo*) (Granadeiro *et al.* 2002) and Cory's shearwater (*Calonectris diomedea*) (Granadeiro *et al.* 1998). This is surprising given that in the Mediterranean discarded boarfish were rejected by seabirds whereas in the Azores they were actively preyed on (Oro & Ruiz 1997). Cory's shearwaters are capable of diving up to 15 m whilst the common tern is a plunge-diver and may only reach 2-3 m. It is therefore surprising that boarfish are such a significant component of their diet given that it is generally considered a deeper water fish. In the Azores boarfish shoals are sometimes driven to the surface by horse mackerel and barracuda where they are also attacked by diving sea birds (J. Hart, CW Azores, pers. comm.). Anecdotal reports from the Irish fishery indicate that boarfish are rarely found in waters shallower than 40 m. This may suggest that they are outside the range of shearwaters and gannets, the latter having a mean diving depth of 19.7±7.5 m (Brierley & Fernandes 2001). However, the upper depth range of boarfish is within maximum diving depth recorded for auks (50 m) as recorded by Barrett & Furness (1990). Given their frequency in the diets of marine and bird life in the Azores, boarfish appear to be an important component of the marine ecosystem in that region. There is currently insufficient evidence to draw similar conclusions in the NE Atlantic.

The length-frequency distribution of boarfish may be important to consider. IBTS data shows an increase in mean total length with latitude (Table 3.3.2.1) and perhaps the smaller boarfish in the southern regions are more easily preyed upon. Length data of boarfish from stomach contents studies of both fish and sea birds in the Azores indicate that the boarfish found are generally < 10 cm (Granadeiro *et al.* 1998, 2002).

3.14 Proposed management plan

In 2015 the Pelagic Advisory Council submitted a revised draft management strategy for Northeast Atlantic boarfish. The EU has requested ICES to evaluate the following management plan:

This management strategy aims to achieve sustainable exploitation of boarfish in line with the precautionary approach to fisheries management, FAO guidelines for new and developing fisheries, and the ICES form of advice.

1) The TAC shall be set in accordance with the following procedure, depending on the ICES advice

a) If category 1 advice (stocks with quantitative assessments) is given based on a benchmarked assessment, the TAC shall be set following that advice.

b) If category 1 or 2 (qualitative assessments and forecasts) advice is given based on a non-benchmarked assessment the TAC shall be set following this advice.

c) Categories 3-6 are described below as follows:

i) Category 3: stocks for which survey-based assessments indicate trends. This category includes stocks with quantitative assessments and forecasts which for a variety of reasons are considered indicative of trends in fishing mortality, recruitment, and biomass.

ii) Category 4: stocks for which only reliable catch data are available. This category included stocks for which a time series of catch can be used to approximate MSY.

iii) Category 5: landings only stocks. This category includes stocks for which only landings data are available.

iv) Category 6: negligible landings stocks and stocks caught in minor amounts as bycatch.

2) Notwithstanding paragraph 1, if, in the opinion of ICES, the stock is at risk of recruitment impairment, a TAC may be set a lower level.

3) If the stock, estimated in either of the 2 years before the TAC is to be set, is at or below B_{lim} or any suitable proxy thereof, the TAC shall be set at 0 t.

4) The TAC shall not exceed 75,000 t in any year.

5) The TAC shall not be allowed to increase by more than 25% per year. However, there shall be no limit on the decrease in TAC.

6) Closed seasons, closed areas, and moving on procedures shall apply to all directed boarfish fisheries as follows:

i) A closed season shall operate from 31st March to 31st August. This is because it is known that herring and mackerel are present in these areas and may be caught with boarfish.

ii) A closed area shall be implemented inside the Irish 12-miles limit south of 52°30 from 12th February to 31st October, in order to prevent catches of Celtic Sea herring, known to form aggregations at these times.

iii) If catches of other species covered by a TAC amount to more than 5% of the total catch by day by ICES statistical rectangle, then all fishing must cease in that rectangle for 5 consecutive days.

3.15 References

Arrizabalaga, H., Pereira, J.G., Royer, F., Galuardi, B., Goñi, N., Artetxe, I., Arregi, I. & Lutcavage, M. 2008. Bigeye tuna (*thunnus obesus*) vertical movements in the Azores islands determined with pop-up satellite archival tags. *Fisheries Oceanography*, **17**, 74–83.

Barrett, R.T. & Furness, R.W. 1990. The prey and diving depths of seabirds on Hornøy, north Norway after a decrease in the Barents Sea capelin stocks. *Ornis Scandinavica (Scandinavian Journal of Ornithology)*, **21**, 179–186.

Beverton, R. & Holt, S. 1957. On the dynamics of exploited fish populations, fishery investigations series II volume XIX, ministry of agriculture. *Fisheries and Food*, **22**.

Blanchard, F. & Vandermeirsch, F. 2005. Warming and exponential abundance increase of the subtropical fish Capros aper in the Bay of Biscay (1973–2002). *Comptes Rendus Biologies*, **328**, 505–509.

Borges, L., Keeken, V., A, O., Helmond, V., M, A.T., Couperus, B. & Dickey-Collas, M. 2008. What do pelagic freezer-trawlers discard? *ICES Journal of Marine Science*, **65**, 605–611.

Brierley, A.S. & Fernandes, P.G. 2001. Diving depths of northern gannets: Acoustic observations of sula bassana from an autonomous underwater vehicle. *The Auk*, **118**, 529–534.

Cardador, F. & Chaves, C. 2010. Boarfish (*capros aper*) distribution and abundance in Portuguese continental waters (ICES div. IXa).

Clarke, M.R., Clarke, D.C., Martins, H.R. & Silva, H.M. 1995. The diet of swordfish (*xiphias gladius*) in Azorean waters. *ARQUIPÉLAGO. Life and Marine Sciences*, **13**, 53–69.

Coad, J.O., Hüssy, K., Farrell, E.D. & Clarke, M.W. 2014. The recent population expansion of boarfish, capros aper (linnaeus, 1758): Interactions of climate, growth and recruitment. *Journal of Applied Ichthyology*, **30**, 463–471.

Ellis, J.R., Pawson, M.G. & Shackley, S.E. 1996. The comparative feeding ecology of six species of shark and four species of ray (elasmobranchii) in the north-east Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, **76**, 89–106.

Farrell, E.D., Carlsson, J.E.L. & Carlsson, J. 2016. Next gen pop gen: Implementing a high-throughput approach to population genetics in boarfish (*capros aper*). *Open Science*, **3**, 160651.

Farrell, E.D., Hüssy, K., Coad, J.O., Clausen, L.W. & Clarke, M.W. 2012. Oocyte development and maturity classification of boarfish (*capros aper*) in the northeast Atlantic. *ICES Journal of Marine Science*, **69**, 498–507.

Fässler, S.M.M., O'Donnell, C. & Jech, J.M. 2013. Boarfish (*capros aper*) target strength modelled from magnetic resonance imaging (MRI) scans of its swimbladder. *ICES Journal of Marine Science*, **70**, 1451–1459.

Fock, H.O., Matthiessen, B., Zidowitz, H. & Westernhagen, H. v. 2002. Diel and habitat-dependent resource utilisation by deep-sea fishes at the great meteor seamount: Niche overlap and support for the sound scattering layer interception hypothesis. *Marine Ecology Progress Series*, **244**, 219–233.

Granadeiro, J.P., Monteiro, L.R. & Furness, R.W. 1998. Diet and feeding ecology of cory's shearwater calonectris diomedea in the Azores, north-east Atlantic. *Marine Ecology Progress Series*, **166**, 267–276

Granadeiro, J.P., Monteiro, L.R., Silva, M.C. & Furness, R.W. 2002. Diet of common terns in the Azores, northeast Atlantic. *Waterbirds: The International Journal of Waterbird Biology*, **25**, 149–155.

Holden, M.J. & Tucker, R.N. 1974. The food of raja clavata linnaeus 1758, raja montagui fowler 1910, raja naevus müller and henle 1841 and raja brachyura lafont 1873 in British waters. *ICES Journal of Marine Science*, **35**, 189–193.

Hüssy, K., Coad, J.O., Farrell, E.D., Clausen, L.A.W. & Clarke, M.W. 2012a. Age verification of boarfish (*capros aper*) in the northeast Atlantic. *ICES Journal of Marine Science*, **69**, 34–40.

Hüssy, K., Coad, J.O., Farrell, E.D., Clausen, L.W. & Clarke, M.W. 2012b. Sexual dimorphism in size, age, maturation, and growth characteristics of boarfish (*capros aper*) in the northeast Atlantic. *ICES Journal of Marine Science*, **69**, 1729–1735.

ICES. 2011. Report of the Working Group on Widely Distributed Stocks (WGWIDE). 23-29 August 2011, ICES HQ, Copenhagen, Denmark. ICES CM 2011/ACOM:15, 624 pp.

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp.

ICES. 2015. Manual for International Pelagic Surveys (IPS). Series of ICES Survey Protocols SISP 9 – IPS. 92 pp.

Johnsen, E., Totland, A., Skålevik, Å., Holmin, A., Dingsør, G., Fuglebakk, E. & Handegard, N. 2019. *StoX: An open source software for marine survey analyses*. *Methods in Ecology and Evolution*, **10**, 1523– 1528. https://doi .org/10.1111/2041-210X.13250

Kery, M. 2010. *Introduction to WinBUGS for ecologists: Bayesian approach to regression, ANOVA, mixed models and related analyses*, 1 edition. Academic Press, Amsterdam.

King, M. 1995. *Fisheries biology, assessment and management.* Oxford.

Lopes, M., Murta, A.G. & Cabral, H.N. 2006. The ecological significance of the zooplanktivores, snipefish macroramphosus spp. and boarfish capros aper, in the food web of the south-east north atlantic. *Journal of Fish Biology*, **69**, 363–378.

Macpherson, E. 1979. Estudio sobre el régimen alimentario de algunos peces en el mediterráneo occidental. *Miscellània Zoològica*, **5**, 93–107.

Mahe, K., Amara, R., Bryckaert, T., Kacher, M. & Brylinski, J.M. 2007. Ontogenetic and spatial variation in the diet of hake (*Merluccius merluccius*) in the Bay of Biscay and the Celtic Sea. *ICES Journal of Marine Science*, **64**, 1210–1219.

Meyer, R. & Millar, R.B. 1999. BUGS in Bayesian stock assessments. *Canadian Journal of Fisheries and Aquatic Sciences*, **56**, 1078–1087.

Minto, C., Clarke, M.W. & Farrell, E.D. 2011. Investigation of the yield- and biomass-per-recruit of the boarfish *capros aper*. Working document to WGWIDE 2011.

Morato, T., Santos, R.S. & Andrade, J.P. 2000. Feeding habits, seasonal and ontogenetic diet shift of blacktail comber, serranus atricauda (pisces: Serranidae), from the Azores, north-eastern Atlantic. *Fisheries Research*, **49**, 51–59.

Morato, T., Solà, E., Grós, M.P. & Menezes, G.M. 1999. Diets of forkbeard (phycis phycis) and conger eel (conger conger) off the Azores during spring of 1996 and 1997.

Morato, T., Solà, E., Grós, M.P. & Menezes, G. 2003. Diets of thornback ray (raja clavata) and tope shark (galeorhinus galeus) in the bottom longline fishery of the Azores, northeastern Atlantic. *Fishery Bulletin*, **101**, 590–602.

Morato, T., Solà, E., Grós, M.P. & Menezes, G. 2001. Feeding habits of two congener species of seabreams, pagellus bogaraveo and pagellus acarne, off the Azores (Northeastern Atlantic) during spring of 1996 and 1997. Bulletin of Marine Science, **69**, 1073–1087.

Oro, D. & Ruiz, X. 1997. Exploitation of trawler discards by breeding seabirds in the north-western Mediterranean: differences between the Ebro Delta and the Balearic Islands areas. *ICES Journal of Marine Science*, **54**, 695–707.

O'Sullivan, Moriarty, C. & Davenport, J. 2004. Analysis of the stomach contents of the European conger eel *Conger conger* in Irish waters. *Journal of the Marine Biological Association of the United Kingdom*, **84**, 823–826.

Plummer, M. 2003. JAGS: A program for analysis of Bayesian graphical models using Gibbs sampling. pp. 20–22.

Spiegelhalter, D., Thomas, A., Best, N. & Lunn, D. 2003. *WinBUGS user manual*. Version 1.4.

Stefánsson, G. 1996. Analysis of groundfish survey abundance data: Combining the GLM and delta approaches. *ICES Journal of Marine Science*, **53**, 577–588.

White, E., Minto, C., Nolan, C.P., King, E., Mullins, E. & Clarke, M. 2011. First estimates of age, growth, and maturity of boarfish (*Capros aper*): A species newly exploited in the Northeast Atlantic. *ICES Journal of Marine Science*, **68**, 61–66.

Xavier, J.C., Cherel, Y., Assis, C.A., Sendão, J. & Borges, T.C. 2010. Feeding ecology of conger eels (*Conger conger*) in north-east Atlantic waters. *Journal of the Marine Biological Association of the United Kingdom*, **90**, 493–501.

3.16 Tables

Table 3.1.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Landings by country, total discards and TAC by year (t), 2001–2020. (Data provided by Working Group members)

	Denmark	Germany	Ireland	Netherlands	England	Poland	Scotland	Spain	Discards	Total	TAC
2001			120							120	
2002			91							91	
2003			458						10929	11387	
2004			675						4476	5151	
2005			165						5795	5959	
2006			2772						4365	7137	
2007			17615				772		3189	21576	
2008	3098		21585				0		10068	34751	
2009	15059		68629						6682	90370	
2010	39805		88457				9241		6544	144047	
2011	7797		20685				2813		5802	37096	33000
2012	19888		55949				4884		6634	87355	82000
2013	13182		52250				4380		5598	75409	82000
2014	8758		34622				38		1813	45231	133957
2015	29	4	16325	375	104				929	17766	53296
2016	337	7	17496	171	21				1283	19315	47637
2017	548		15485	182	0				1173	17388	27288
2018	94		9513	172	0		0	148	1359	11286	21830
2019	757		9910	318	19			3	306	11313	21830
2020	196		14666	416	62	109		1	198	15649	19152

0 = <0.5t

Table 3.1.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Discards in demersal and non-target pelagic fisheries by year (data provided by Working Group members)

Year	Denmark	Germany	Ireland	Netherlands	Spain	UK	Lithuania	Total
2003			119	1998	8812			10929
2004			60	837	3579			4476
2005			55	733	5007			10271
2006			22	411	3933			4366
2007			549	23	2617			3189
2008			920	738	8410			10068
2009			377	1258	5047			16750
2010			85	512	5947			6544
2011		49	107	185	5461			5802
2012			181	88	6365			6634
2013		22	47	11	5518			5598
2014		117	50	477	1119	50		1813
2015			7		921	1		929
2016		869	20	41	348	4	1	1283
2017	386		640	146			1	1173
2018	744		525	89			1	1359
2019			57		240	8		305

Year	Denmark	Germany	Ireland	Netherlands	Spain	UK	Lithuania	Total
2020			64		133	1		198
0 = <0.5t								

Table 3.1.2.3. Landings of boarfish in ICES Subareas 27.6

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark															37	67	172	10
England													9				9	7
Ireland	65	292	10	21	99*	28	45	1356	26	125	538	182	116	377	907	269	568	1222**
Netherlands													128	45	34	78	79	108
Scotland								10			15	30						
*6t in 5b, 0=0-0.5t																		
** 8t in 4a																		

Table 3.1.2.4 Landings of boarfish in ICES Subareas 27.7bc

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark											80	12	8	21				85
England													85	1			0	32
Germany													4	5				
Ireland	214	224	105	15	1259	3	74	2293	283	4609	10405	3262	2829	1198	124	163	241	6818

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Netherlands													33*	35	138	10	150	212
Scotland								4		1745	100							
*Division 7, 0=0-0.5t																		

Table 3.1.2.5 Landings of boarfish in ICES Divisions 7e-g

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark								674							1		1	0
England															0		6	
Ireland				375	120	184	4912	3649	811	616	1808	135	547		1	2		1
Netherlands														0	0	3	7	1
Scotland											883							
0=0-0.5t																		

Table 3.1.2.6 Landings of boarfish in ICES Subareas 27.7h-k

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark								39132	7779	18203	11828	8747	5	330	239	6	268	101
England													10	16	0	0	3	23
Ireland	179	122	12	2360	16131	21370	63597	81160	19565	50507	38358	30925	12152	8623	2994	3745	6222	6365
Netherlands														90	9	68	80	79

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Poland																		109
Scotland					772			9227	2813	3139	3381	8				0		
Spain																	0	0
0=0-0.5t																		

Table 3.1.2.7 Landings of boarfish in ICES Subarea 8

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark									18		1354		6	7	271		315	
England														5				
Germany													1	1				
Ireland		38	38	1	5					93	1140	119	682	7297	11458	5336	2876	283**
Netherlands													2014			14	0	17
Spain																148*	2	1
*94t in 9a, 0=0-0.5t																		
**14t in 12b																		

Table 3.2.1.1. Boarfish in ICES Subareas 27.6, 7, 8. General boarfish age length key produced from 2012 commercial samples. Figures highlighted in grey are estimated

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
7.25	1	1													
7.75	1	1													
8.25		1													
8.75		1	1												
9.25		1	1												
9.75			1												
10.25			1												
10.75			2	10	3										
11.25			1	29	14	2	2								
11.75				9	21	21	18	2	2	1					
12.25				4	17	22	38	12	8						1
12.75					5	9	42	37	14	6	2		1	1	1
13.25					2	4	31	28	24	12	6	2	3	1	5
13.75					1	3	25	22	21	14	6	5	4	2	11
14.25							6	8	18	22	8	3	7	1	20
14.75						1	1	2	3	8	1	6	6	6	30
15.25							1	1		2	2	2	5	2	19
15.75										2				2	19
16.25															8
16.75															1
17.25															1
17.75															1
18.25															1
18.75															1

Table 3.2.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Number of samples collected from the catch per year

Year	Landings	Percent landings covered by sampling	No. samples	No. measured	No. aged
2001	120	0	0	0	0
2002	91	0	0	0	0
2003	458	0	0	0	0
2004	675	0	0	0	0
2005	165	0	0	0	0
2006	2772	0	0	0	0
2007	18387	NA	3	217	0
2008	24683	NA	1	152	0
2009	83688	NA	9	1475	0
2010	137503	NA	95	10675	403*
2011	31295	NA	27	4066	704
2012	80720	NA	80(68)***	9656(8565)***	814**
2013	69812	NA	76	9392	0****
2014	43418	NA	54	7008	0****
2015	16837	NA	32	3356	0****
2016	18031	NA	27	3861	0****
2017	16215	NA	18	1140	0****
2018	9927	NA	12	556	0****
2019	11006	NA	8	371	0****
2020	15451	NA	10	534	0****

*** A common ALK was developed from fish collected from both commercial and survey samples. This comprehensive ALK was used to produce catch numbers at age data for pseudo-cohort analyses.**
**** A common ALK was developed from fish collected from Danish, Irish and Scottish commercial landings. This comprehensive ALK was used for all métiers to produce catch numbers-at-age for the pseudo-cohort analysis.**
Only aged fish measured to the 0.5cm were included in the ALK.
***** Only Irish collected samples were used for the length frequency, see stock annex.**
****** 2012 ALK was used.**

Table 3.2.1.3. Boarfish in ICES Subareas 5, 27.6, 7, 8. The allocation of Age length keys to unsampled metiers in 2020

Country	Area	Quarter	Landed	ALK
DK	7.b	4	18.693	IE_7.b_Q4
DK	7.e	4	0.001	IE_7.h_Q4
DK	7.h	4	68.013	IE_7.h_Q4
DK	7.j	1	22.409	IE_8.a_Q1
DK	7.j	4	10.377	IE_7.j_Q4
ES	7.j	2	0.012	IE_7.b_Q4 IE_7.h_Q4 IE_7.j_Q4
ES	7.j	3	0.028	IE_7.j_Q4
ES	8.c	4	1.021	IE_7.h_Q4 IE_7.j_Q4
IE	6.a	4	1,083.000	IE_6.a_Q4
IE	7.b	2	0.010	IE_7.b_Q4 IE_7.j_Q4
IE	7.b	4	6,676.000	IE_7.b_Q4
IE	7.c	4	2.364	IE_7.b_Q4
IE	7.g	2	0.311	IE_7.b_Q4 IE_7.h_Q4 IE_7.j_Q4
IE	7.g	3	0.119	IE_7.b_Q4 IE_7.h_Q4 IE_7.j_Q4
IE	7.g	4	0.162	IE_7.b_Q4 IE_7.h_Q4 IE_7.j_Q4
IE	7.h	1	189.000	IE_8.a_Q1
IE	7.h	4	4,954.000	IE_7.h_Q4
IE	7.j	1	41.710	IE_8.a_Q1
IE	7.j	2	0.825	IE_7.b_Q4 IE_7.h_Q4 IE_7.j_Q4
IE	7.j	3	56.670	IE_7.j_Q4
IE	7.j	4	1,123.000	IE_7.j_Q4
IE	8.a	1	268.600	IE_8.a_Q1
NL	6.a	3	1.690	IE_6.a_Q4
NL	6.a	4	73.440	IE_6.a_Q4
NL	7.b	2	2.240	IE_7.b_Q4 IE_7.j_Q4
NL	7.b	3	64.960	IE_7.b_Q4
NL	7.b	4	26.860	IE_7.b_Q4
NL	7.e	2	0.110	IE_8.a_Q1

Country	Area	Quarter	Landed	ALK
NL	7.f	4	0.390	IE_7.h_Q4 IE_7.j_Q4
NL	7.g	4	0.060	IE_7.b_Q4 IE_7.h_Q4 IE_7.j_Q4
NL	7.h	1	0.700	IE_8.a_Q1
NL	7.h	3	12.920	IE_7.h_Q4
NL	7.j	1	17.630	IE_8.a_Q1
NL	7.j	2	34.240	IE_7.b_Q4 IE_7.h_Q4 IE_7.j_Q4
NL	7.j	3	13.020	IE_7.j_Q4
NL	8.a	2	2.960	IE_8.a_Q1
NL	8.a	3	13.660	IE_7.h_Q4
PL	7.j	3	109.460	IE_7.j_Q4
UKE	7.d	3	0.003	IE_7.h_Q4 IE_7.j_Q4
UKE	7.j	1	22.935	IE_8.a_Q1

Table 3.2.1.4. Boarfish in ICES Subareas 27.6, 7, 8. Catch (landings and discards) per country and corresponding number of samples collected in 2020

Official catch	Country	No. samples	No. measured	No. aged
196	DK	0	0	0
134	ES	0	0	0
14738	IE	10	534	0
416	NL	0	0	0
109	PL	0	0	0
63	UKE	0	0	0
1	UKS	0	0	0

Table 3.2.1.5. Boarfish in ICES Subareas 27.6, 7, 8. Catch per area and corresponding number of samples collected in 2020

Area	Official catch	No. samples	No. measured	No. measured per 1000t
27.3.a	0.00	0	0	0.00
27.3.b	0.00	0	0	0.00
27.3.c	0.00	0	0	0.00
27.3.d	0.00	0	0	0.00

Area	Official catch	No. samples	No. measured	No. measured per 1000t
27.4.a	7.50	0	0	0.00
27.4.b	0.00	0	0	0.00
27.6.a	1,340.11	2	85	63.43
27.6.b	3.25	0	0	0.00
27.7.b	7,156.11	3	169	23.62
27.7.c	15.16	0	0	0.00
27.7.d	0.00	0	0	0.00
27.7.e	0.34	0	0	0.00
27.7.f	0.39	0	0	0.00
27.7.g	0.99	0	0	0.00
27.7.h	5,291.11	2	88	16.63
27.8.a	285.22	2	151	529.42
27.8.b	5.46	0	0	0.00
27.8.c	27.58	0	0	0.00
27.7.j	1,523.14	1	41	26.92
27.7.k	0.00	0	0	0.00

Table 3.2.1.6. Boarfish in ICES Subareas 27.6, 7, 8. Proxy catch numbers-at-age of the international catches (raised numbers in '000s) for the years 2007-2020

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0	0	1575	2415	0	28	301	0	5556	218	1862	314	17427	40397
2	352	5488	15043	11229	2894	893	7148	695	116135	2385	4387	1736	37620	57719
3	2114	21140	65744	72709	41913	5467	156680	49503	32248	10737	8830	2628	9737	37192
4	40851	105575	338931	294382	28148	41278	58522	127520	16588	25114	34448	13610	9944	26433
5	48915	141300	475619	567689	30116	110272	59797	93705	24564	20263	27266	15570	12682	10162
6	62713	195339	543707	878363	175696	146582	68949	67275	26566	18025	21103	14731	12716	2583
7	26132	104031	307333	522703	143967	492078	302967	193061	74115	61229	55189	38686	29513	9113
8	29766	66570	172783	293719	107126	365840	250341	139124	52052	47573	38229	26821	18819	7487
9	56075	53159	155477	276672	77861	271916	212318	121042	44615	42478	32258	23670	15875	7897
10	44875	46893	130148	232122	60022	173486	160137	94225	34264	35150	25716	19395	11359	8164
11	14019	15289	42521	78588	46079	69396	63025	36078	12999	13297	9560	7148	4272	3049
12	32359	21178	61350	114600	40468	40968	41490	24895	9114	9132	7564	5846	2937	2786
13	4848	11854	39609	59932	24352	58888	59380	36309	13362	13774	10922	8183	4256	4152
14	16837	13570	31569	59060	19724	30277	30355	19064	7152	6682	5924	4554	2156	2333
15+	109481	112947	196967	349320	157707	217260	239366	150688	59139	49589	40797	32130	14864	17663

Table 3.2.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Length-frequency distributions of the international catches (raised numbers in '000s) for the years 2007-2020

Length	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
4.5									14					
5.0									878					
5.5									515					2746
6.0				156					810		765		15868	37073
6.5				439					14		4607	203	70362	150810
7.0				1090	522	56	52		513	417	5250	405	80160	233347
7.5			1354	1574			551		10598	1684	12616	2635	85420	147915
8.0			677	375	1345	185	1419		80716	8685	11473	4703	115154	38949
8.5				1082		555	3592	1064	49508	6412	10115	3559	67471	43556
9.0			677	5382	851	555	7263	327	10219	7104	3874	6554	16504	101918
9.5		7473	17367	7883	7012	641	47509	4916	213	23065	14047	6196	3147	115103
10.0	9609	11209	54130	29410	33243	2791	94702	31649	1211	46010	32346	5559	9173	100550
10.5		52308	174796	130889	15848	6132	59833	71344	3865	39071	36242	4450	10144	55049
11.0	84555	63517	343283	361774	70615	24571	18359	108261	12226	14181	32445	17658	5796	9475
11.5		59781	321637	655875	93487	81928	20938	82470	28142	18249	31589	22826	22722	3172
12.0	44199	119561	297737	739025	189434	264888	98564	84288	41613	30975	33618	24070	22353	2396
12.5		70990	207739	564347	114904	398772	204868	112826	42461	51110	41650	24514	17521	3251

Length	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
13.0	82633	52308	147965	353484	133539	419060	315063	172416	59990	57000	46495	30665	28815	9494
13.5		29890	149314	246146	51235	307533	285688	153742	52625	58696	43121	38698	16688	13707
14.0	117224	22418	105782	224611	50857	176710	210137	138549	50139	76872	45353	34080	20053	16381
14.5		14945	71273	127711	25309	89726	105571	74059	28771	37755	39524	29908	13809	14913
15.0	65338	33627	47816	125463	25569	52791	62175	43347	16087	23137	21854	15561	5710	12563
15.5		11209	13082	81386	5473	25065	31122	22629	8572	7841	4932	5778	1513	4304
16.0	13452	11209	19397	24256	4181	13149	14990	7672	4331	625	1020	1948	143	1041
16.5		3736	4061	6209	2280	2738	4918	2134	2081	128		54	143	353
17.0		3736	677	1913	456	827	1109	1361	289					
17.5							407		23					353
18.0				283			296							
18.5									592					

Table 3.3.1.1. Boarfish in ICES Subareas 27.6. 7, 8. Acoustic survey abundance and biomass estimates

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0										1084	259
1	5	22			199	5	111	77	782	897	9523
2	12	11	78		319	36	127	31	389	1157	3392
3	58	174	1843	15	17	46	345	115	97	967	2955
4	187	65	696	98	34	44	367	68	93	113	1315
5	437	95	382	102	80	6	156	107	88	157	463
6	1166	736	254	105	112	10	209	166	106	183	150
7	1184	974	1057	415	437	169	493	321	446	913	953
8	704	759	879	344	363	113	463	198	183	885	207
9	1095	849	801	342	354	118	397	293	288	721	378
10	1032	956	704	332	360	97	286	625	290	331	249
11	333	651	264	130	132	17	121	339	50	81	151
12	653	1100	203	105	113	32	82	264	192	195	188
13	336	857	297	166	174	49	74	198	79	299	81
14	385	656	170	89	108	18	220	117	57	267	327
15+	3519	6354	1464	855	1195	400	931	302	759	1641	1213
TSN	11104	14257	9091	3098	3996	1157	4387	3221	3899	9888	21805
TSB	670176	863446	439890	187779	232634	69690	230062	186252	179156	399872	443777
SSB	669392	861544	423158	187654	226659	69103	218810	184624	169213	357871	351955
CV	21.2	10.6	17.5	15.1	17.0	19	21.9	19.9	25.4	34.8	31.0

Table 3.3.2.1. Boarfish in ICES Subareas 27.6, 7, 8. IBTS length-frequency data

EVHOE

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1997	0	5	12	7	17	195	2645	5006	3691	3570	4422	12054	16633	7200	3472	503	18	1	0	0
1998	0	1	4	25	70	2083	18263	8566	6117	5961	7082	11828	14363	9600	5261	971	8	0	0	1
1999	0	0	13	52	33	245	10949	25911	23235	6484	2818	4632	7780	6151	1357	268	8	0	0	0
2000	0	17	79	120	8	1508	26901	17725	9864	22076	16424	29584	36849	16508	5399	988	76	0	0	0
2001	0	1	45	687	490	916	21328	37173	13322	28492	31640	18378	12315	6507	3193	1272	81	4	0	0
2002	0	2	18	23	11	547	9634	29844	17728	13175	9280	9513	9615	6185	2458	642	37	1	1	0
2003	0	0	17	47	17	57	426	1663	7155	20073	24977	21358	21939	15004	7355	1599	35	0	0	0
2004	0	0	33	534	397	123	1248	1420	1308	1083	3102	7308	7224	6353	7866	3630	241	5	0	0
2005	0	2	94	964	1264	146	1097	2302	1225	1551	3182	13394	15782	9879	6012	1658	117	70	0	0
2006	1	26	111	77	74	15506	37545	10729	3611	2128	1518	1960	4165	4024	2601	940	93	2	12	0
2007	0	7	188	473	234	1511	22812	127331	65589	6442	6823	5477	6110	6003	4268	1411	118	11	0	0
2008	0	3	432	2795	823	5487	54355	256210	169633	163128	69199	38406	18310	17213	9157	3486	745	6	1	0
2009	0	6	128	194	69	1482	19663	35649	5260	3906	9562	12271	9402	10835	6722	775	39	1	0	0
2010	0	21	529	116	154	5774	46490	74999	27177	12168	37971	59369	38501	37683	15699	1555	248	8	1	0
2011	0	61	95	214	5	536	2232	8210	14905	32671	29788	50316	56963	36588	11723	3058	572	159	47	0
2012	0	9	146	594	142	2913	28823	26800	6124	11739	13607	22370	37138	44084	19963	4893	127	1	0	0
2013	0	3	48	92	10	305	2187	2141	2558	13769	9938	15006	37563	40266	20130	6888	686	0	3	0
2014	0	2	693	1386	508	84	1440	885	3074	8732	28586	39397	74122	69736	26871	3908	59	433	0	0
2015	0	5	183	5898	4143	607	19075	179269	119004	15765	18014	61575	62024	59904	21525	5487	541	429	8	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2016	5	31	379	846	115	733	10284	14280	17251	42132	25304	68583	130633	131220	48538	11611	1358	26	0	0
2018	0	14	4957	193861	173779	210	10910	76288	48343	29096	45773	85164	132174	157883	48603	14951	592	18	0	0
2019	2	997	6467	589	10688	531908	561517	329850	59733	4505	3418	8451	32547	61582	30031	7468	962	204	0	0
2020	3	283	1280	657	21381	408706	595107	142947	218153	421028	220190	54726	70612	97364	74415	30606	4736	1	0	0

IGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2003	0	1	33	22	7	22	129	172	879	2942	2322	1325	3823	4629	2898	896	163	38	0	0
2004	0	23	63	34	8	117	628	1444	423	397	464	2276	4325	4709	3972	1019	90	5	1	0
2005	0	8	59	52	20	203	1024	585	288	636	341	3463	11457	11348	7955	1744	382	2	1	0
2006	5	60	68	48	35	212	969	621	2046	4190	8044	7946	24208	42119	32168	12296	2454	532	0	0
2007	1	6	44	18	31	501	923	1251	1638	1166	2510	3581	8275	10740	7093	1934	92	0	0	0
2008	0	0	26	18	23	127	672	531	2095	13780	17664	19268	16980	19484	15953	8789	1747	76	1	0
2009	0	3	80	76	25	94	228	486	1000	1139	9081	7749	5138	6921	5592	1084	68	1	0	0
2010	0	6	42	3	18	199	272	463	920	393	7914	34236	28611	16063	8161	1974	433	0	0	0
2011	0	7	17	5	4	189	772	592	556	669	2600	20246	22121	10851	5319	2218	269	9	6	0
2012	0	7	36	20	10	130	271	378	702	2143	1183	11104	34005	22731	10905	3901	525	4	0	0
2013	1	3	9	9	20	127	352	340	1320	2833	3971	15572	51637	52868	20485	6560	492	20	0	0
2014	0	10	68	54	4	18	13	25	60	130	1127	3251	19125	23016	10355	2988	284	18	0	0
2015	0	3	11	16	24	193	1008	3708	848	105	713	6315	29727	48220	33024	17350	1885	531	0	0
2016	4	31	121	63	7	67	187	1515	4057	2891	1349	4111	32753	57753	40907	15527	3670	85	0	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2017	0	0	37	131	48	132	460	652	11411	20321	5909	5520	16426	33117	29972	15815	3194	369	0	0
2018	4	51	247	139	32	45	286	585	1194	6107	17005	15168	48895	61833	36519	10722	2030	63	0	0
2019	4	19	117	47	52	262	583	173	106	487	2677	4967	6863	12080	10480	5125	772	71	4	0
2020	9	388	233	21	16	1772	2052	13941	65121	24505	7709	17859	12157	17223	9125	2499	110	2	0	0

SPNGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1990	0	0	8	0	16	317	1817	2496	260	141	154	314	632	613	689	97	0	0	0	0
1991	0	1	0	0	31	690	1311	313	49	9	6	7	7	4	0	0	0	6	0	0
1992	0	57	38	9	178	3290	2743	282	48	10	8	69	162	390	779	246	95	0	0	0
1993	0	57	1206	488	97	3730	3753	421	105	54	7	4	8	3	2	0	0	0	0	0
1994	1	40	33	0	342	4789	10162	8920	3195	53	106	20	9	12	1	0	0	0	0	0
1995	0	84	108	4	342	3063	2157	220	84	65	58	105	105	90	20	4	0	0	0	0
1996	0	218	537	143	245	4457	4449	267	820	722	82	145	126	219	96	39	2	0	0	0
1997	2	102	809	441	235	3458	6824	2189	1923	534	156	353	161	88	3	0	0	0	0	0
1998	3	2	7	4	49	1920	4685	2217	337	153	125	88	147	135	86	13	2	3	0	0
1999	0	6	59	13	134	2736	3010	193	106	83	109	143	390	645	402	69	0	0	0	0
2000	0	7	3729	2046	17	554	1947	489	277	486	756	1252	999	1021	199	34	13	0	0	0
2001	0	68	4	1	153	3241	5085	659	225	206	205	236	692	407	120	22	9	0	0	0
2002	0	4	20	0	133	2333	2013	284	50	58	54	60	231	314	72	9	0	0	0	0
2003	0	4	950	567	4	77	221	57	39	28	16	22	17	23	16	5	1	0	0	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2004	0	6	22	4	43	2289	3808	443	110	83	58	219	931	776	303	2	1	0	0	0
2005	0	16	451	25	9	754	1007	207	85	102	30	54	257	218	90	44	2	0	0	0
2006	0	14	156	160	50	2238	8913	4507	175	94	9	36	229	419	169	9	2	0	0	0
2007	0	49	40	1	111	3025	6620	1099	129	260	81	7	93	215	89	21	3	0	0	0
2008	7	4	92	247	1	936	1561	1326	234	1483	304	537	11	833	201	186	11	0	0	0
2009	1	17	62	119	11	2587	3893	4070	119	250	45	142	59	819	120	17	1	1	0	0
2010	0	55	102	5	232	13090	22032	3169	1160	1056	89	82	179	1007	1981	518	9	0	0	0
2011	0	29	260	105	46	2805	5511	1278	148	340	145	100	144	591	724	134	3	1	0	0
2012	0	29	132	35	556	7550	7844	1364	88	53	59	170	1051	2394	1553	432	21	0	0	0
2013	0	0	2	11	126	2163	4664	854	302	609	251	61	113	134	156	81	8	0	0	0
2014	0	75	117	6	12	263	465	79	1083	1175	1174	1266	998	2444	3623	817	31	1	0	0
2015	0	13	67	3	58	1889	4248	534	75	465	750	970	695	1173	1473	453	70	1	0	0
2016	0	17	99	5	41	922	2423	473	925	746	346	548	452	561	169	22	4	0	0	0
2017	1	23	20	1	16	641	1947	755	134	165	285	405	579	967	936	177	13	3	0	0
2018	0	0	2	0	45	708	1635	258	43	99	230	605	1370	3324	3865	949	3	0	0	2
2019	0	12	2	1	259	4128	3887	379	18	83	273	329	717	4200	8402	2215	202	0	0	0
2020	0	8	33	2	33	1218	2123	525	387	314	75	225	705	2518	4751	1603	10	0	0	0

SPPGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2001	0	1	0	1	1	2	0	44	5	52	133	162	667	1129	230	40	0	0	0	0
2002	0	0	0	0	0	0	0	0	1	4	90	212	791	843	313	60	0	0	0	0
2003	0	0	0	0	0	1	0	3	15	22	21	62	268	426	249	51	2	1	0	0
2004	0	1	0	0	0	6	3	0	5	6	23	124	385	592	390	52	1	0	0	0
2005	0	1	0	1	8	1	20	11	10	16	8	118	628	1118	833	272	23	0	0	0
2006	0	0	1	1	8	120	118	26	43	95	34	58	431	863	716	252	13	1	0	0
2007	0	0	0	0	4	5	12	20	16	12	37	34	96	202	191	34	5	0	0	0
2008	0	1	0	0	0	1	17	10	23	19	79	156	349	666	442	113	7	0	0	0
2009	0	8	7	0	3	10	11	1	0	2	220	457	1333	1746	1698	474	11	0	0	0
2010	2	0	0	1	6	17	4	1	6	3	43	390	710	976	620	164	13	0	0	0
2011	0	0	0	0	0	0	0	4	20	22	6	180	815	960	522	151	17	0	2	0
2012	0	0	0	1	1	0	0	2	2	1	10	87	456	570	267	79	4	0	0	0
2013	0	0	0	1	0	8	24	7	10	0	1	48	500	1032	564	163	15	1	0	0
2014	0	10	9	0	1	0	3	17	62	11	6	85	2453	6703	3168	2115	162	82	0	0
2015	0	0	0	2	1	0	0	1	1	0	0	32	300	471	316	151	43	0	0	0
2016	0	0	3	0	0	0	1	0	13	7	0	9	157	336	220	84	19	0	0	0
2017	0	67	19	0	0	0	10	0	0	1	18	26	148	498	529	268	17	0	0	0
2018	0	2	1	0	0	0	1	0	0	0	0	37	1159	3574	2449	1131	159	0	0	0
2019	5	36	4	0	0	0	0	0	3	4	0	15	426	952	796	192	15	0	0	0
2020	0	5	1	0	0	4	1	1	2	4	0	26	250	616	851	661	111	0	0	1

WCSGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	3	2	0	3	24	42	62	172	210	1286	856	450	52	17	0	0	0	0
1991	0	0	0	2	0	31	138	80	183	644	683	848	226	89	12	1	2	4	0	0
1992	0	0	0	1	0	8	12	14	44	478	1160	4028	1674	502	5	0	0	0	0	0
1993	0	0	0	0	0	1	109	2	670	2078	1074	4904	2753	2882	28	2	0	0	0	0
1994	0	0	2	0	0	0	15	30	30	205	283	312	454	388	147	0	0	0	0	0
1995	8	12	18	4	2	10	40	30	94	162	640	1485	1770	1139	318	14	2	4	6	0
1996	0	0	0	4	0	10	48	27	49	48	64	188	920	1888	416	18	1	0	0	0
1997	0	0	4	0	0	1	17	42	120	64	116	249	436	301	91	8	4	0	0	0
1998	0	0	0	1	0	1	7	6	7	16	47	69	105	171	78	8	2	0	0	0
1999	0	0	1	0	0	2	6	8	189	221	312	458	346	221	69	0	0	0	0	0
2000	0	0	0	0	0	0	3	3	42	118	230	303	206	108	54	8	0	0	0	0
2001	0	1	0	0	0	0	0	1	12	27	54	90	233	414	242	80	15	1	0	0
2002	0	0	0	0	0	1	8	2	1	82	759	3243	5711	5896	1558	189	1	0	0	0
2003	0	0	1	0	0	0	3	52	9	107	326	1536	3294	5409	3553	413	37	0	0	0
2004	0	0	0	1	0	0	6	2	45	83	744	4576	8611	9526	5698	954	84	0	0	0
2005	0	2	0	0	0	9	38	15	30	31	113	442	1115	1747	818	141	9	3	2	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2006	0	1	2	1	0	2	9	4	22	256	311	508	1524	2964	2104	449	73	2	0	0
2007	0	0	3	2	0	8	14	65	118	182	795	2938	5220	6953	5332	1538	116	0	0	0
2008	0	1	3	0	0	16	37	38	200	482	1406	3218	9904	22777	18407	6293	575	71	0	0
2009	0	0	1	0	1	1	4	6	64	2460	2246	694	505	416	338	136	12	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	530	1443	1384	1357	828	149	29	0	0	0

Table 3.6.1.1. Boarfish in ICES Subareas 27.6, 7, 8. IBTS length-frequency data converted to age-structured indices by application of the 2012 common ALK rounded down to 1cm length classes

EVHOE

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1997	1323	5891	4835	3829	3369	3053	9614	6955	5556	3779	1521	973	1456	828	6235
1998	9132	16881	8109	6147	4527	3452	9545	6632	5452	4058	1597	1312	1733	1022	8419
1999	5474	30494	25366	5015	2592	1427	4373	3215	2887	2276	855	564	888	491	3675
2000	13450	28555	16758	19454	12310	8420	23424	16159	12783	8538	3354	1885	3099	1722	12485
2001	10664	39887	26874	27998	16428	8946	15285	7816	5688	3538	1301	863	1271	750	6396
2002	4817	30622	24313	11299	6215	3393	7688	4838	3852	2716	1035	726	1060	611	4928
2003	213	3707	9293	20716	13365	8409	18107	11109	8937	6448	2467	1932	2635	1547	12700
2004	624	2006	1574	1777	1923	1842	5376	3816	3078	2541	1075	1423	1434	932	11369
2005	549	2492	1901	2205	2758	2983	9853	7261	5865	4310	1727	1437	1869	1110	9951
2006	18772	27129	6395	1838	1086	692	2217	1683	1593	1407	557	586	688	416	4256
2007	11406	118156	87434	6252	3796	2250	4968	3140	2686	2208	861	923	1067	657	6591
2008	27177	254528	229646	124210	54539	19047	30818	15021	10954	7348	2618	2251	2934	1795	16959

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2009	9832	35351	16200	5643	4832	3830	8969	5783	4721	3809	1459	1524	1806	1110	9216
2010	23245	82303	45710	20517	19648	16749	39369	25075	19324	14156	5280	4343	5906	3511	26732
2011	1116	11557	19043	30617	20479	14495	39161	26846	21792	15613	5980	3928	6016	3404	27139
2012	14412	34320	15329	11984	8843	6877	21882	16580	15805	14165	5382	5221	6581	3893	34397
2013	1093	3373	5082	11975	7436	5156	18526	14722	14572	13248	5121	5049	6254	3703	35819
2014	720	2334	4216	15081	14776	13252	40953	30549	28568	24182	9208	7776	10517	6071	49039
2015	9537	168718	142196	16589	15129	14025	43805	31952	26892	21239	8025	6461	8982	5218	43843
2016	5142	20412	24368	35467	23775	18507	68150	53795	50979	44038	16743	14289	19326	11149	95082
2018	5455	72428	63489	33998	28889	24760	79148	59901	56898	49999	18526	15688	21690	12453	106474
2019	280759	520569	150645	4035	3104	2844	14950	13581	15700	16891	6358	7404	8669	5219	49538
2020	297553	465569	273832	332726	148543	51435	79125	38909	36296	32676	12326	15407	16693	10460	118335

IGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2003	64	472	1214	2586	1401	743	2065	1523	1556	1484	578	653	750	456	4672
2004	314	1418	842	434	493	543	2252	1838	1732	1603	653	802	864	541	5422
2005	512	998	509	567	717	908	4790	4166	4162	3867	1557	1730	1973	1201	11568
2006	484	1580	2423	5269	4211	3388	12623	10487	11436	12263	4853	6606	6952	4368	50651
2007	462	1842	1748	1576	1408	1235	4362	3474	3496	3378	1326	1557	1754	1076	10509
2008	336	1388	4302	14466	9811	6581	15265	9859	8231	6912	2728	3247	3553	2238	28119
2009	114	772	1117	3682	3665	2967	5991	3553	2883	2398	928	1136	1233	783	7266

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2010	136	752	906	3336	6161	7220	21721	15262	11417	7656	3025	2151	3055	1795	14845
2011	386	966	715	1598	3198	4038	13856	10232	7932	5384	2159	1453	2121	1224	10962
2012	136	622	1006	1911	2306	2843	13844	11639	10956	8966	3576	2903	3900	2242	21003
2013	176	843	1557	3292	3917	4545	21801	18670	19029	17278	6613	5870	7777	4484	40599
2014	6	43	82	492	927	1262	7300	6613	7255	7083	2717	2714	3384	1986	18529
2015	504	3259	1827	403	1251	1945	12476	11625	13072	13999	5512	7082	7697	4765	58017
2016	93	2456	3763	2302	1775	1846	13082	12553	14753	16394	6464	8634	9226	5742	65723
2017	230	4468	11683	14642	6277	2402	9024	7578	8395	9474	3824	5785	5766	3703	49915
2018	143	930	2275	9391	8194	6861	23782	19030	19873	19320	7511	8412	9756	5903	59025
2019	292	442	242	1229	1449	1419	4664	3618	3540	3626	1453	2058	2107	1346	16899
2020	1026	32027	52719	18043	8761	4356	11714	8061	6664	5578	2105	2193	2649	1618	14790

SPNGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1990	909	2660	1033	142	110	93	335	263	243	224	95	128	129	83	770
1991	656	880	138	8	4	2	6	3	3	2	1	0	1	0	8
1992	1371	1575	128	10	13	16	97	89	92	122	57	124	102	71	965
1993	1877	2192	220	36	13	2	5	3	2	2	1	0	1	0	3
1994	5081	12093	5114	66	43	23	28	9	7	5	1	1	1	1	5
1995	1079	1254	142	61	41	29	78	54	44	33	12	8	13	7	53
1996	2225	2676	772	479	175	40	109	77	70	65	24	25	31	18	181

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1997	3412	5512	2113	389	183	84	198	123	82	47	17	6	14	8	43
1998	2343	3933	993	137	76	41	96	64	58	49	19	19	23	14	125
1999	1505	1669	151	88	66	53	202	168	181	188	73	89	100	61	556
2000	973	1392	445	562	447	351	877	582	475	359	130	88	138	78	577
2001	2542	3057	410	197	130	93	311	237	219	170	66	43	66	36	286
2002	1006	1212	139	54	35	26	103	87	95	92	33	28	40	22	172
2003	110	162	50	23	12	7	16	11	9	8	3	3	4	2	25
2004	1904	2236	237	74	66	71	359	310	313	273	106	88	120	68	508
2005	504	670	145	74	36	21	99	85	86	76	30	25	34	19	191
2006	4457	7519	1636	62	27	14	93	89	106	114	42	46	56	33	268
2007	3310	4086	502	187	74	19	50	39	50	56	20	24	28	17	155
2008	781	1743	878	1031	419	134	290	185	174	186	60	69	89	53	594
2009	1947	4700	1483	173	75	31	113	100	138	174	56	59	81	46	363
2010	11016	13516	2029	689	234	34	167	157	182	283	134	313	253	178	2099
2011	2756	3657	590	260	117	46	134	106	121	158	67	127	114	77	791
2012	3922	4860	523	54	58	68	465	450	551	640	247	337	361	225	2268
2013	2332	3002	602	460	194	59	100	54	51	48	19	28	28	18	238
2014	232	646	978	1123	697	431	1071	739	675	751	325	610	539	367	3971
2015	2124	2505	322	542	409	300	726	482	406	388	162	260	245	163	1874
2016	1211	1835	917	584	300	157	397	267	226	184	67	55	77	45	347
2017	974	1522	374	199	161	129	397	301	291	298	121	178	178	115	1130

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2018	817	1004	135	145	163	171	810	719	786	945	398	690	641	424	4531
2019	1943	2202	156	143	137	120	669	645	749	1182	560	1325	1065	752	9058
2020	1062	1540	492	224	113	68	460	447	505	731	341	759	623	436	5435

SPPGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2001	0	31	29	77	73	68	300	262	304	308	110	94	135	76	596
2002	0	0	2	34	58	71	330	283	294	270	103	92	122	70	584
2003	0	7	15	21	20	21	115	105	117	123	48	57	65	39	366
2004	1	3	5	13	25	34	177	158	169	175	69	85	94	58	515
2005	10	21	14	14	25	38	264	251	288	319	126	172	182	114	1218
2006	59	91	56	71	39	28	184	176	209	242	97	142	145	92	1021
2007	6	25	20	20	18	15	54	46	50	58	23	36	36	23	230
2008	8	23	23	40	47	48	193	163	176	188	73	95	104	64	636
2009	6	7	3	78	127	147	639	540	550	561	232	325	329	210	2203
2010	2	5	5	22	61	85	379	317	313	301	118	138	156	96	930
2011	0	9	19	19	35	52	320	290	310	301	118	125	149	89	861
2012	0	2	3	5	18	28	176	161	177	174	67	68	84	50	466
2013	12	20	9	1	12	22	197	197	244	277	105	132	148	90	899
2014	2	33	49	11	45	89	992	1044	1403	1685	624	783	898	543	6669
2015	0	1	1	1	7	14	112	109	126	137	54	68	75	46	564

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2016	1	5	10	5	4	6	61	62	78	91	35	48	51	32	360
2017	5	5	0	7	10	12	80	80	100	132	54	96	90	59	786
2018	0	0	0	1	19	41	501	534	718	906	349	516	536	337	4050
2019	0	1	3	3	8	15	167	172	215	260	104	157	158	101	1040
2020	0	2	2	3	7	11	113	115	136	177	77	146	129	87	1519

WCSGFS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	12	61	90	197	233	248	736	509	363	224	85	38	74	41	261
1991	69	184	275	631	405	256	482	257	153	72	25	8	19	12	63
1992	6	30	133	733	849	840	2097	1321	823	409	155	41	112	63	301
1993	54	279	846	1723	1227	981	2777	1908	1446	1017	359	177	351	191	1165
1994	8	38	71	222	157	112	292	202	179	143	54	43	60	35	250
1995	20	71	109	328	387	385	1141	811	665	480	184	116	183	102	718
1996	24	59	51	53	58	67	398	375	458	490	174	160	222	126	953
1997	8	76	107	81	76	71	233	174	154	119	46	31	47	26	197
1998	4	10	10	26	25	22	68	52	52	50	19	20	24	15	121
1999	3	71	173	244	182	134	315	199	150	100	38	24	37	21	141

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2000	2	18	53	151	122	93	205	125	90	56	22	14	21	12	92
2001	0	5	14	35	33	30	122	103	112	118	45	55	62	38	397
2002	4	6	23	347	634	778	3010	2402	2269	1942	725	559	813	459	3480
2003	2	39	46	196	311	380	1730	1482	1545	1585	619	774	853	528	4647
2004	3	19	52	367	802	1054	4442	3641	3470	3148	1237	1315	1553	939	8289
2005	19	39	32	63	97	118	547	472	504	506	191	207	250	149	1307
2006	4	15	67	266	208	177	781	680	760	834	326	442	470	294	2900
2007	7	90	141	415	626	727	2893	2356	2285	2205	881	1104	1195	746	7600
2008	18	110	248	798	948	1026	5180	4696	5396	6246	2479	3677	3739	2381	26466
2009	2	27	524	2249	1182	537	771	336	263	187	68	70	81	51	531
2010	0	0	4	191	315	347	1030	738	612	492	192	191	231	140	1236

Table 3.6.3.1. Boarfish in ICES Subareas 27.6, 7, 8. Key parameter estimates from the exploratory Schaeffer state space surplus production model. Posterior parameter distributions are provided in Figure 3.6.3.5

Parameter	Mean	SD	2.5	25	50	75	97.5
r	0.35	0.17	0.06	0.22	0.34	0.46	0.71
K	639684	405965	302300	429500	531200	697700	1742000
F_{MSY}	0.17	0.09	0.03	0.11	0.17	0.23	0.36
B_{MSY}	159921	101491	75575	107375	132800	174425	435500
TSB	552960	253596	257500	390100	496700	646900	1176000

Table 3.6.4.1. Boarfish in ICES Subareas 27.6, 7, 8. Pseudo-cohort derived estimates of fishing mortality (F) and total mortality (Z), in comparison with total catch per year. Pearson correlation coefficient of F vs. catch (tonnes) indicated.

Age	Raised Numbers													
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0	0	1575	2415	0	28	301	0	5556	218	1862	314	17427	40397
2	352	5488	15043	11229	2894	893	7148	695	116135	2385	4387	1736	37620	57719
3	2114	21140	65744	72709	41913	5467	156680	49503	32248	10737	8830	2628	9737	37192
4	40851	105575	338931	294382	28148	41278	58522	127520	16588	25114	34448	13610	9944	26433
5	48915	141300	475619	567689	30116	110272	59797	93705	24564	20263	27266	15570	12682	10162
6	62713	195339	543707	878363	175696	146582	68949	67275	26566	18025	21103	14731	12716	2583
7	26132	104031	307333	522703	143967	492078	302967	193061	74115	61229	55189	38686	29513	9113
8	29766	66570	172783	293719	107126	365840	250341	139124	52052	47573	38229	26821	18819	7487
9	56075	53159	155477	276672	77861	271916	212318	121042	44615	42478	32258	23670	15875	7897
10	44875	46893	130148	232122	60022	173486	160137	94225	34264	35150	25716	19395	11359	8164
11	14019	15289	42521	78588	46079	69396	63025	36078	12999	13297	9560	7148	4272	3049
12	32359	21178	61350	114600	40468	40968	41490	24895	9114	9132	7564	5846	2937	2786
13	4848	11854	39609	59932	24352	58888	59380	36309	13362	13774	10922	8183	4256	4152
14	16837	13570	31569	59060	19724	30277	30355	19064	7152	6682	5924	4554	2164	2333
15+	109481	112947	196967	349320	157707	217260	239366	150688	59139	49589	40797	32130	14864	17663

Age	ln(Raised Numbers)													
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0	0	7	8	0	3	6	0	9	5	8	6	10	11
2	6	9	10	9	8	7	9	7	12	8	8	7	11	11
3	8	10	11	11	11	9	12	11	10	9	9	8	9	11
4	11	12	13	13	10	11	11	12	10	10	10	10	9	10
5	11	12	13	13	10	12	11	11	10	10	10	10	9	9
6	11	12	13	14	12	12	11	11	10	10	10	10	9	8
7	10	12	13	13	12	13	13	12	11	11	11	11	10	9
8	10	11	12	13	12	13	12	12	11	11	11	10	10	9
9	11	11	12	13	11	13	12	12	11	11	10	10	10	9
10	11	11	12	12	11	12	12	11	10	10	10	10	9	9
11	10	10	11	11	11	11	11	10	9	9	9	9	8	8
12	10	10	11	12	11	11	11	10	9	9	9	9	8	8
13	8	9	11	11	10	11	11	10	10	10	9	9	8	8
14	10	10	10	11	10	10	10	10	9	9	9	8	8	8
15+	12	12	12	13	12	12	12	12	11	11	11	10	10	10
Z (7-14)	0.17	0.33	0.36	0.33	0.29	0.45	0.36	0.37	0.31	0.31	0.33	0.36	0.37	0.20
F (M=0.16)	0.01	0.17	0.2	0.17	0.13	0.29	0.2	0.21	0.15	0.15	0.17	0.2	0.21	0.04

Age	ln(Raised Numbers)													
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Catches (t)	21576	34751	90370	144047	37096	87355	75409	45231	17766	19315	17388	11286	11313	15649
Corr coef landings vs F	0.33													

Table 3.6.5.1. Boarfish in ICES Subareas 27.6, 7, 8. Estimates of total stock biomass and F

Year	TSB.2.5	TSB.50	TSB.97.5	F2.5	F.50	F.97.5
1991	95660	183200	435600			
1992	156800	285100	659200			
1993	190900	346400	800495			
1994	225900	413300	961500			
1995	194000	355800	824795			
1996	196100	358200	836500			
1997	168900	302300	699895			
1998	224800	401000	925397			
1999	167200	299600	688992			
2000	144900	259700	599400			
2001	161300	283200	648600			
2002	138600	242600	555600			
2003	126500	220800	503195	0.02	0.05	0.09
2004	177600	309700	702097	0.01	0.02	0.03
2005	171100	298300	680895	0.01	0.02	0.03
2006	216200	371500	843897	0.01	0.02	0.03
2007	194200	337000	765000	0.03	0.06	0.11
2008	236600	407400	918500	0.04	0.09	0.15
2009	242000	411700	917397	0.10	0.22	0.37
2010	361700	613100	1377975	0.10	0.23	0.40
2011	317600	540000	1225000	0.03	0.07	0.12
2012	457100	753200	1678000	0.05	0.12	0.19
2013	308000	519600	1170000	0.06	0.15	0.24
2014	144500	243400	548897	0.08	0.19	0.31
2015	173000	292500	660195	0.03	0.06	0.10
2016	127200	217500	493600	0.04	0.09	0.15
2017	225300	384400	868895	0.02	0.05	0.08
2018	241900	410500	927200	0.01	0.03	0.05

Year	TSB.2.5	TSB.50	TSB.97.5	F2.5	F.50	F.97.5
2019	202502	345200	779700	0.01	0.03	0.06
2020	237100	408500	926100	0.02	0.04	0.07
2021	257500	496700	1176000			

3.17 Figures

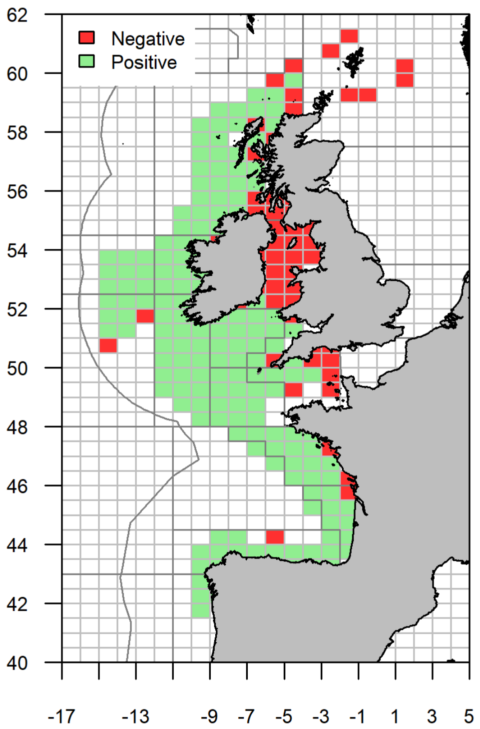

Figure 3.1. Boarfish in ICES Subareas 4, 27.6, 7, 8 and 9. Distribution of boarfish in the NE Atlantic area based on presence and absence in IBTS surveys (all years).

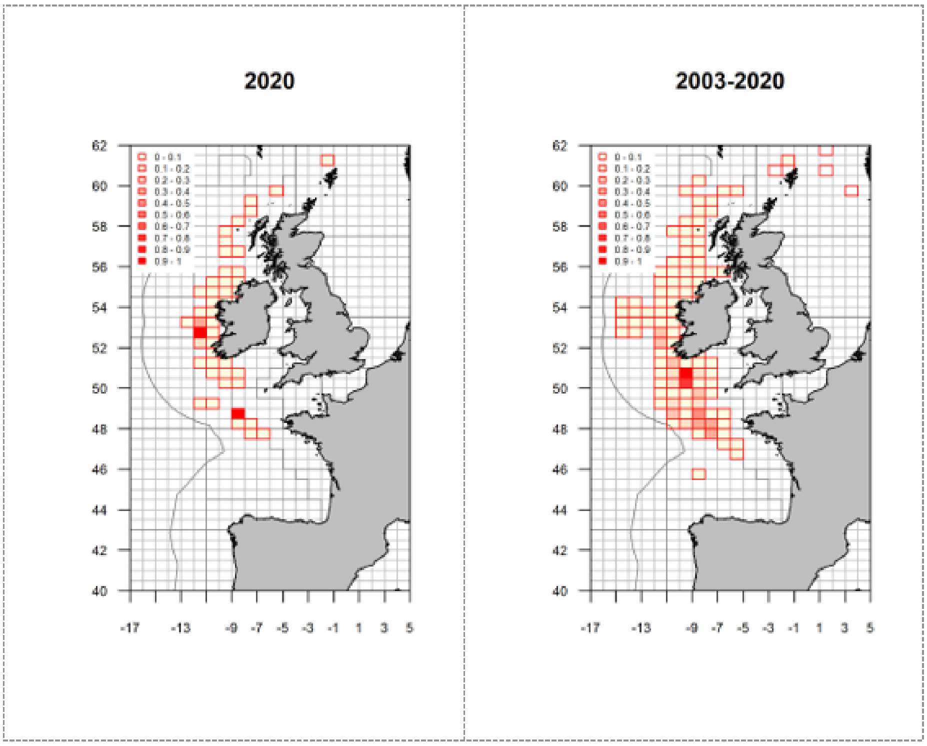

Figure 3.1.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Combined Irish boarfish landings 2003-2020 by ICES rectangle (Right). Irish boarfish landings 2020 by ICES rectangle (Left).

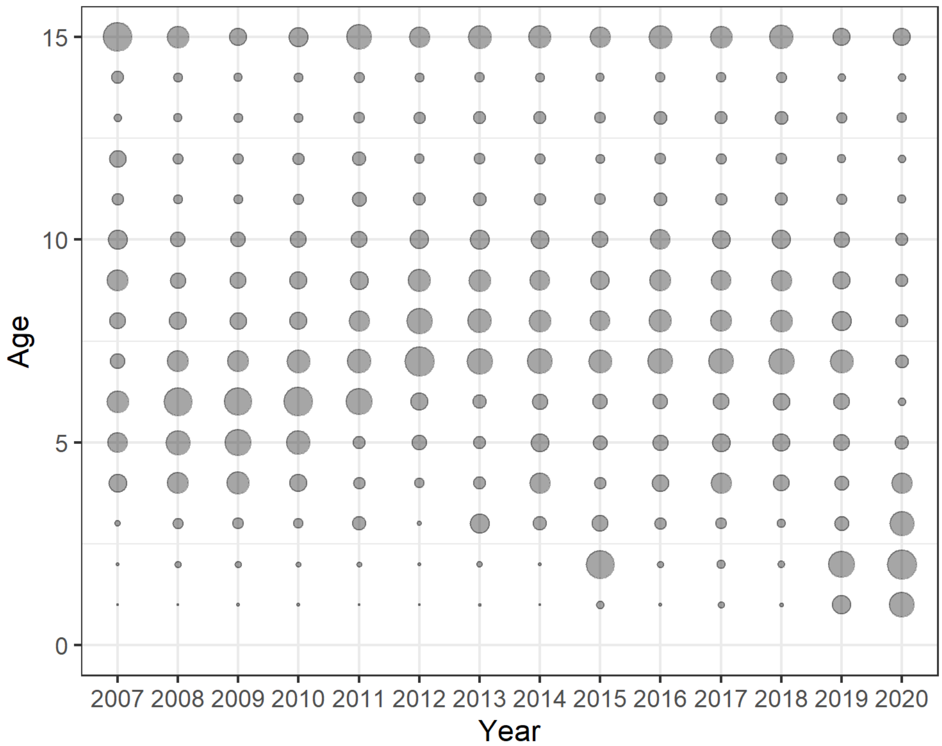

Figure 3.2.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Catch numbers-at-age standardised by yearly mean. 15+ is the plus group.

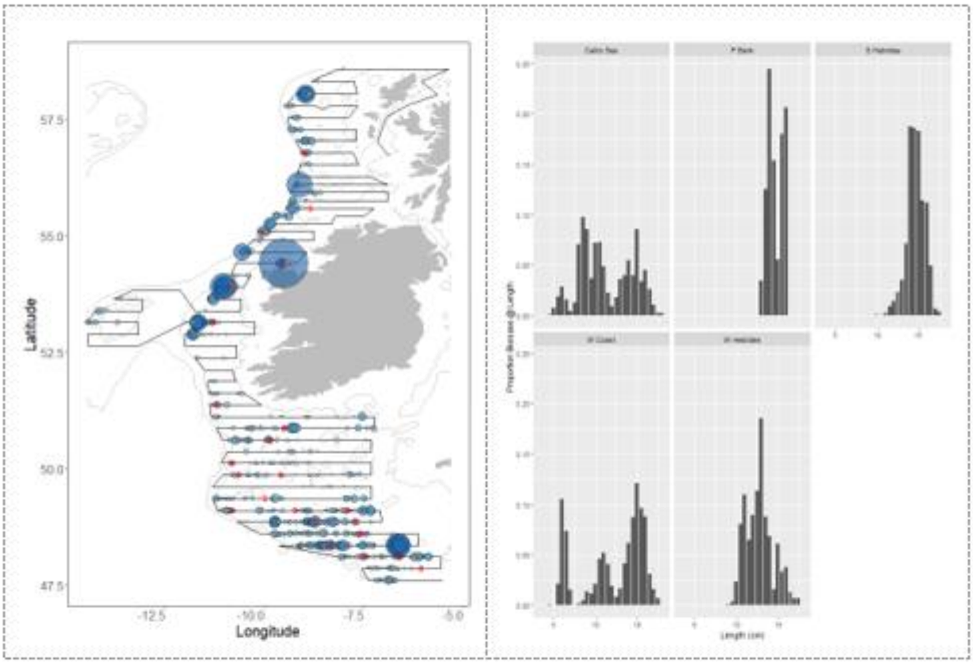

Figure 3.3.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey track and haul positions 2021 (left), estimates of biomass at length by stratum (right).

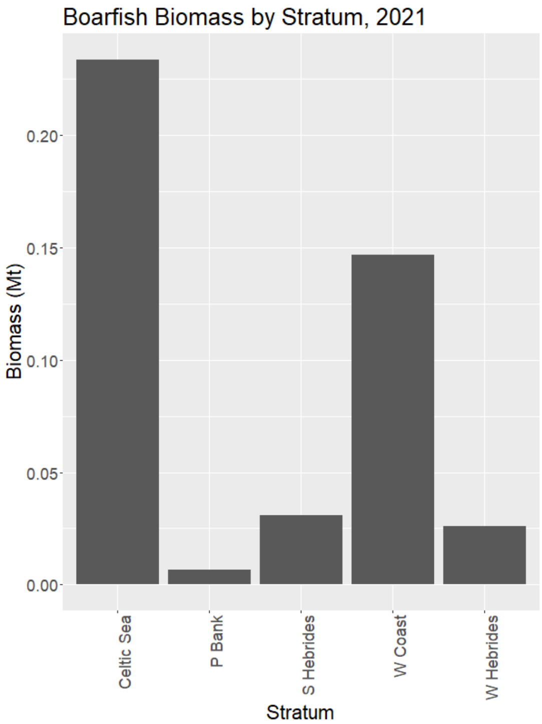

Figure 3.3.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey biomass estimate by stratum, 2021.

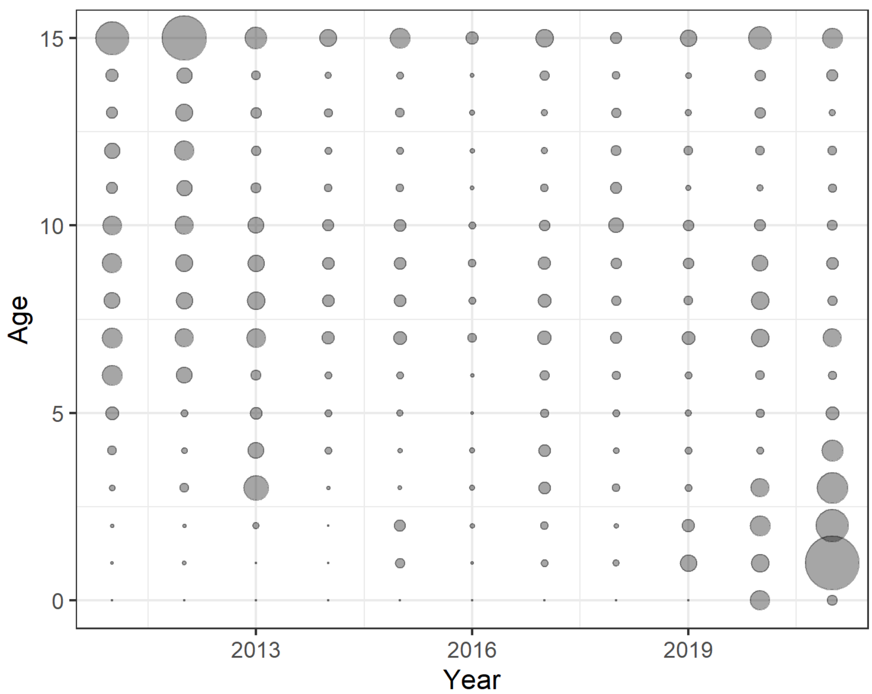

Figure 3.3.1.3. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey time series of acoustic estimates of abundance at age, 2011 - 2021.

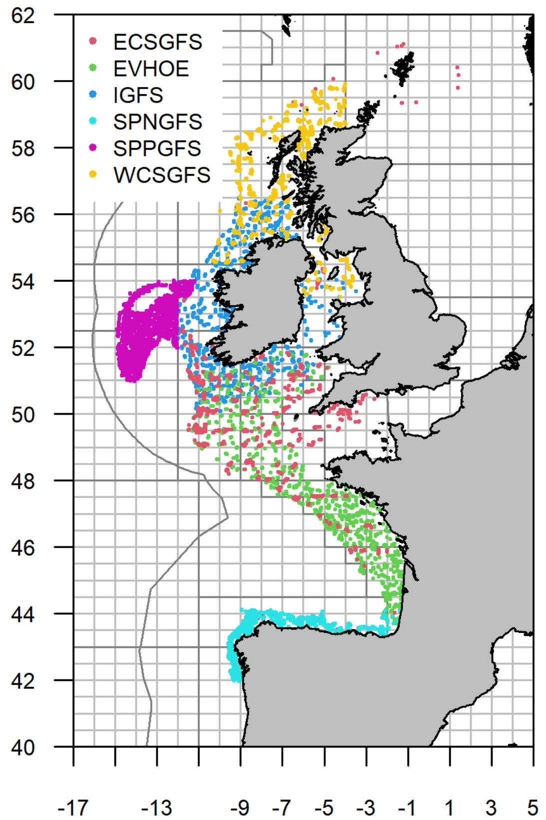

Figure 3.3.2.1. Boarfish in ICES Subareas 27.6, 7, 8. The haul positions of bottom trawl surveys analysed as an index for boarfish abundance.

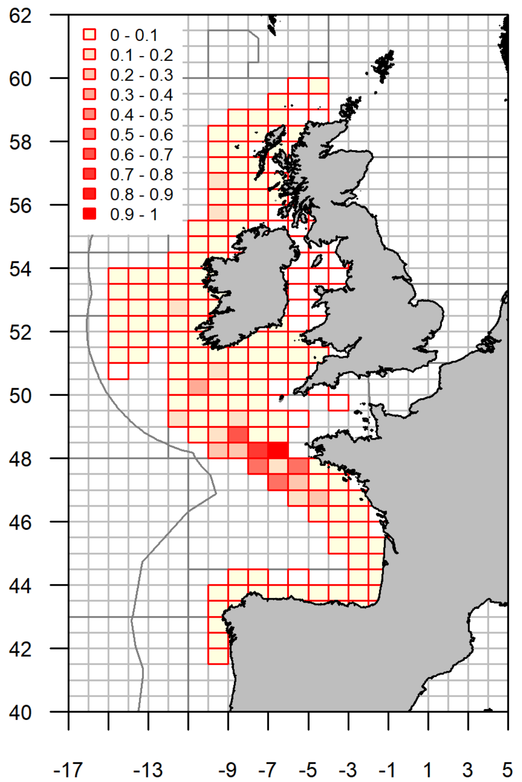

Figure 3.3.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Distribution of boarfish in the NE Atlantic from the 6 IBTS surveys.

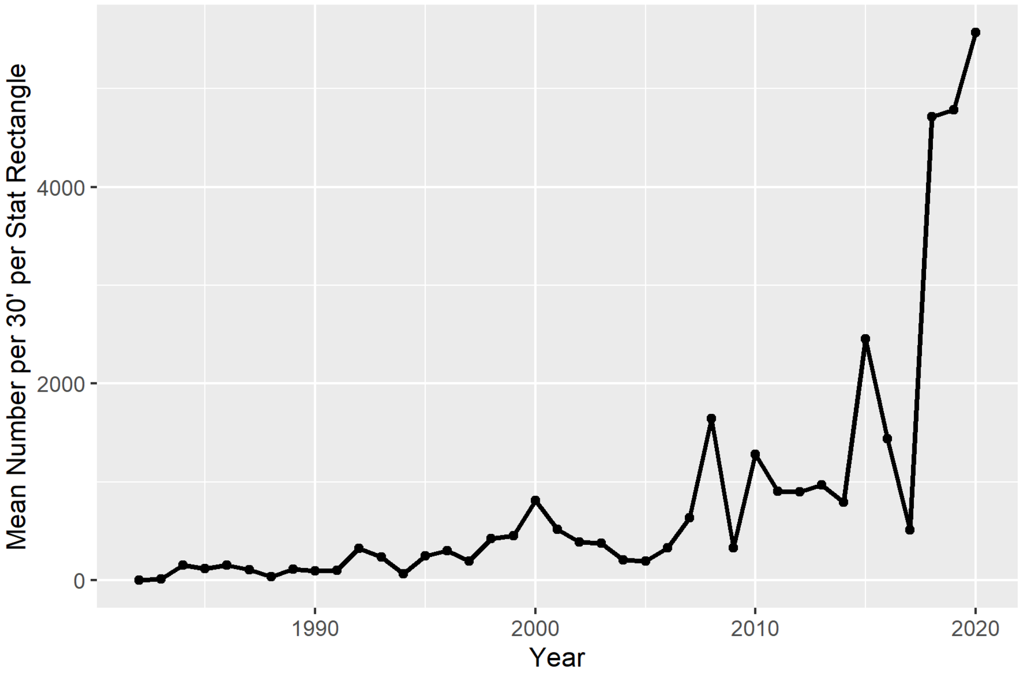

Figure 3.3.2.3a. Boarfish in ICES Subareas 27.6, 7, 8. CPUE in number per 30-minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2020.

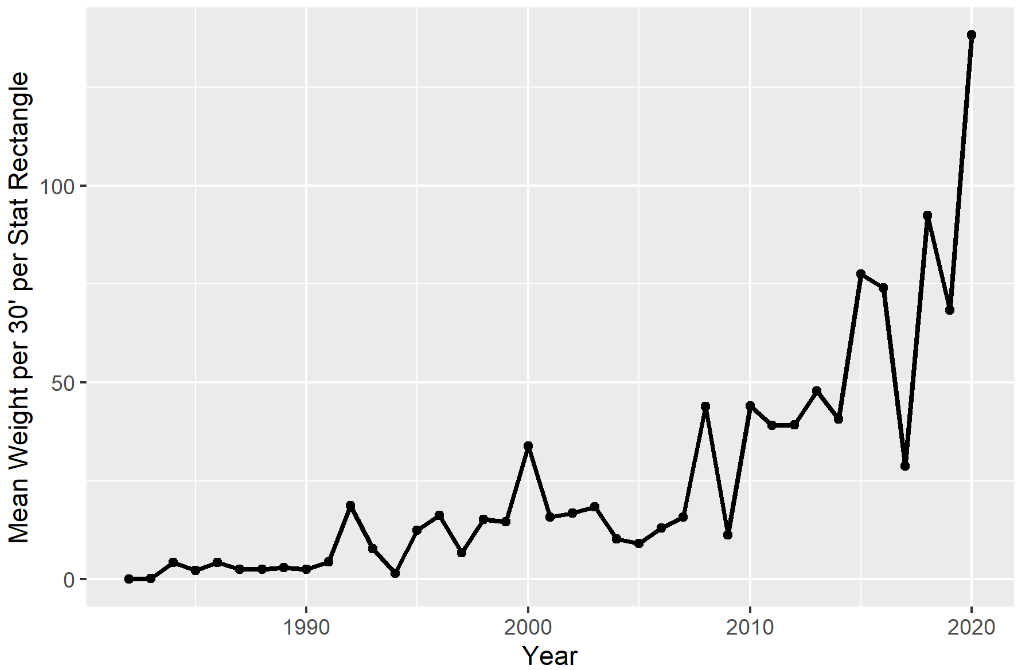

Figure 3.3.2.3b. Boarfish in ICES Subareas 27.6, 7, 8. CPUE in kg per 30-minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2020.

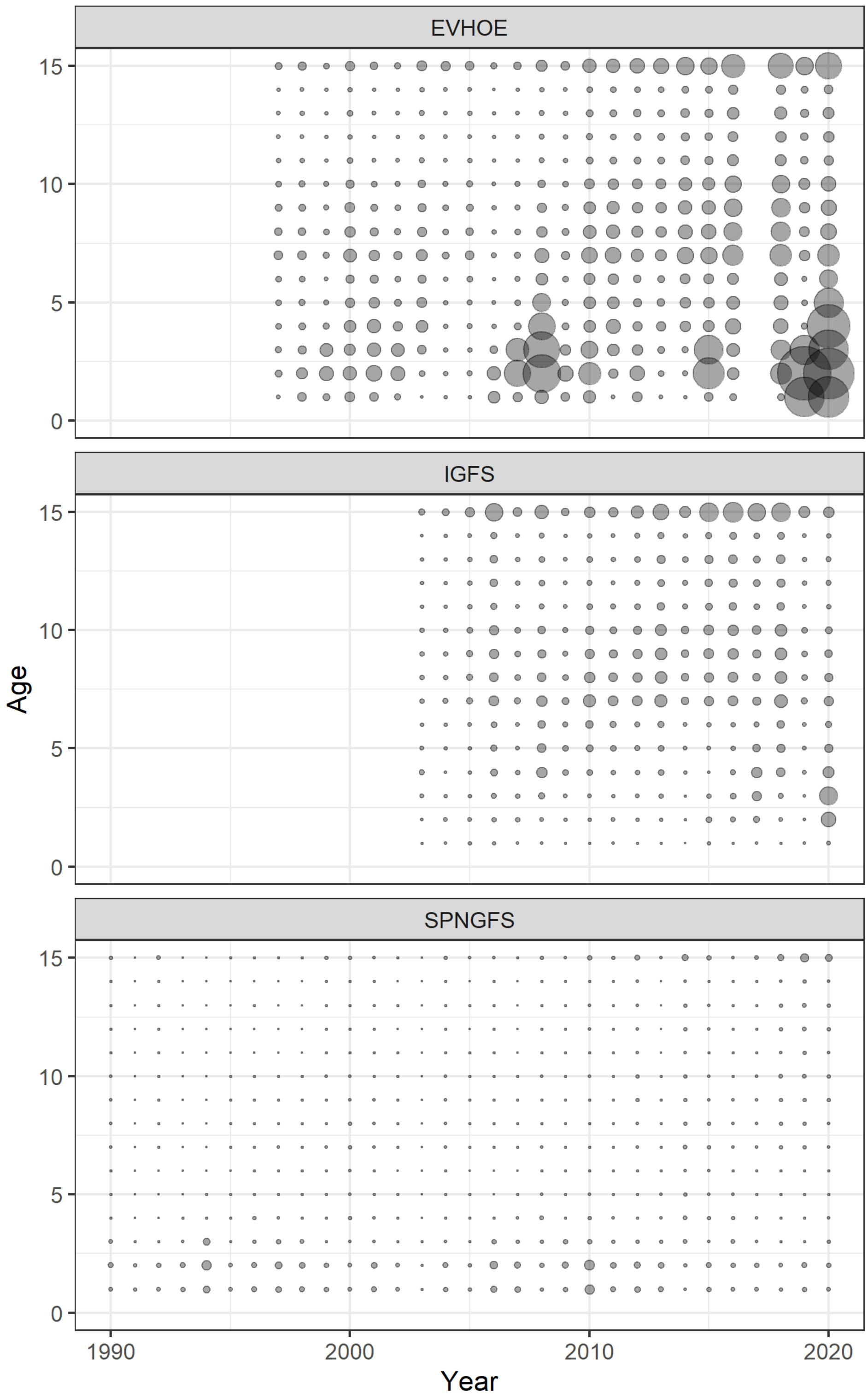

Figure 3.6.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Abundance-at-age in EVHOE, IGFS and SPNGFS surveys. Yearly mean standardised abundance –at-age.

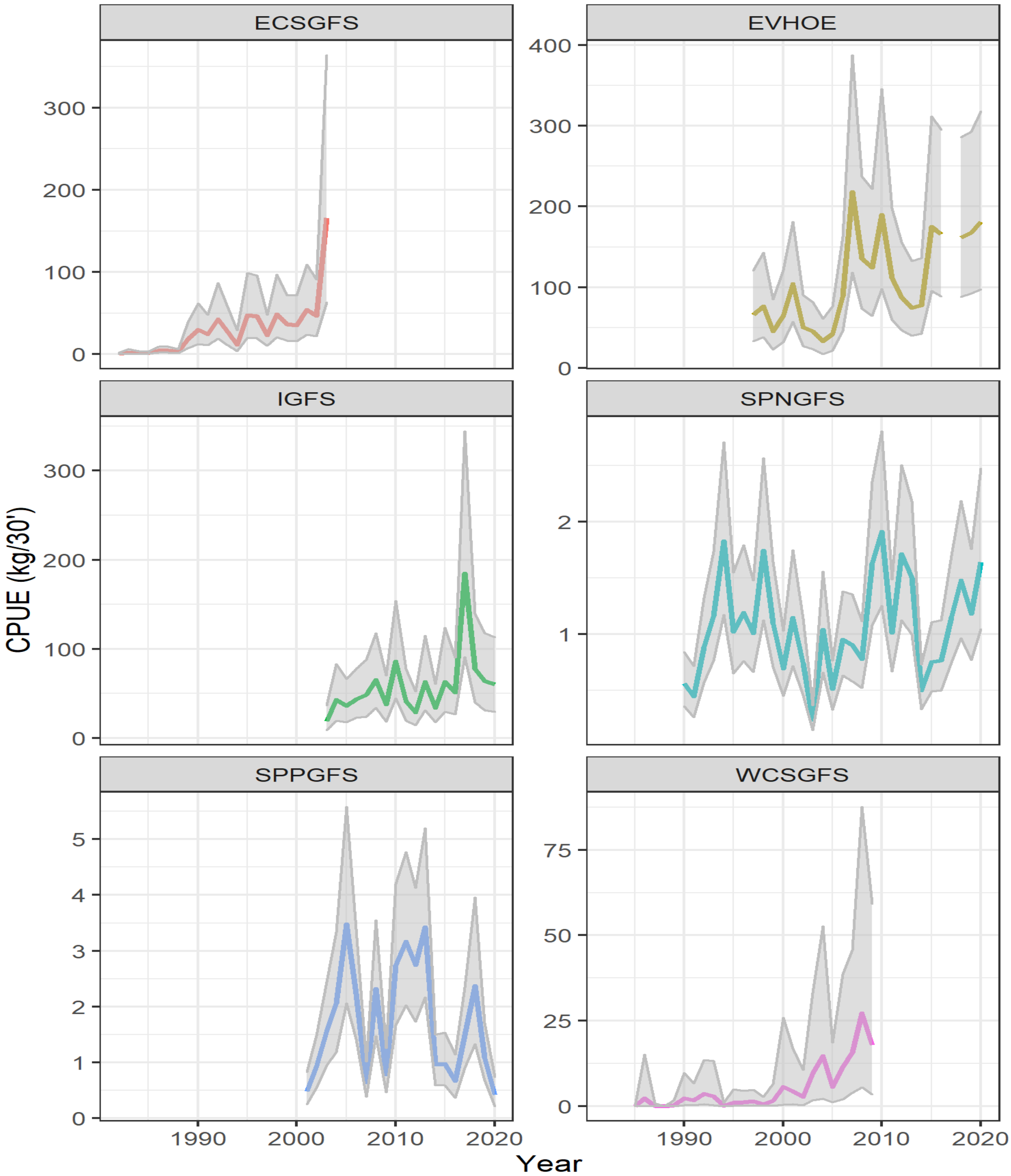

Figure 3.6.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish IBTS survey CPUE fitted delta-lognormal mean (solid line) and 95% credible intervals (grey region).

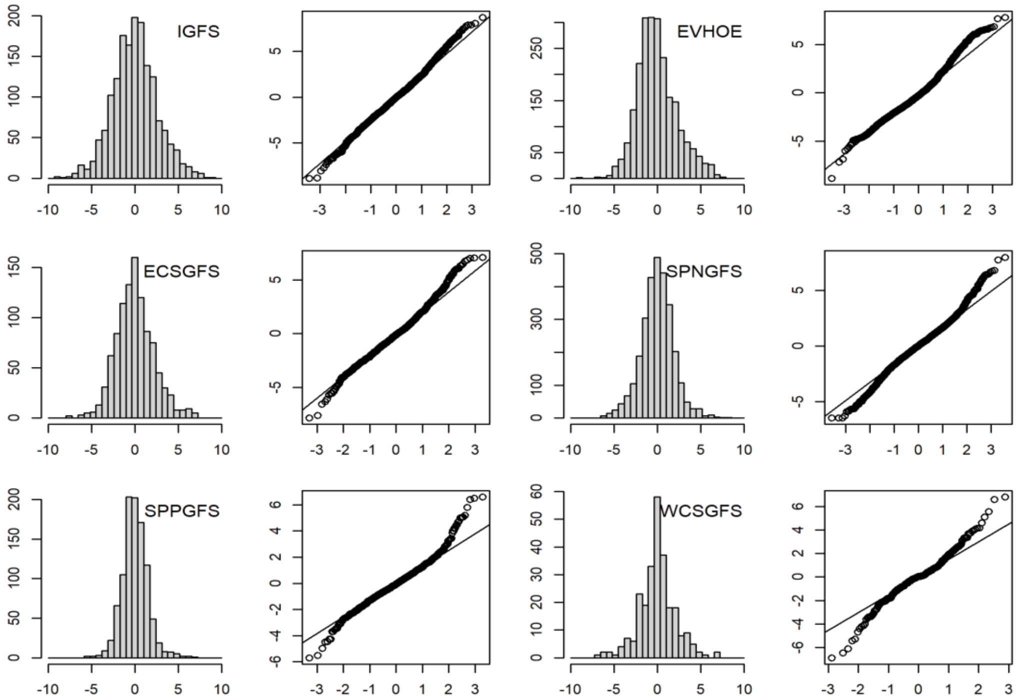

Figure 3.6.1.4. Boarfish in ICES Subareas 27.6, 7, 8. Diagnostics from the positive component of the delta-lognormal fits

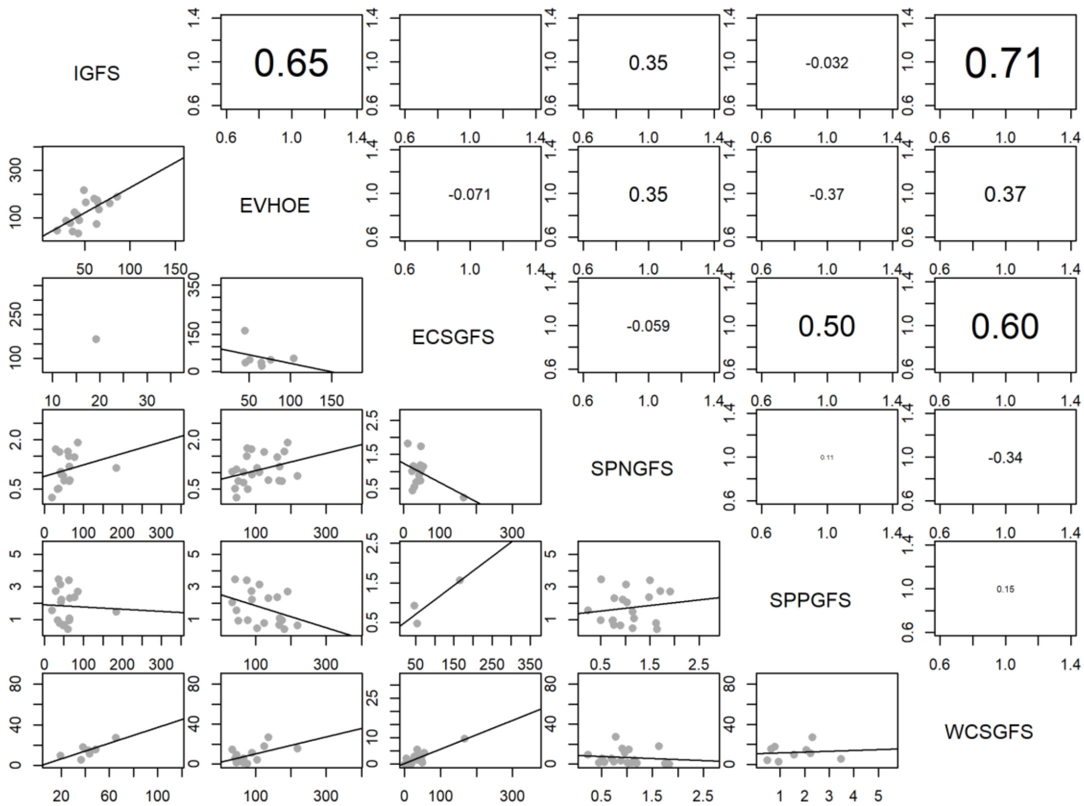

Figure 3.6.1.5. Boarfish in ICES Subareas 27.6, 7, 8. Pair-wise correlation between the annual mean survey indices.

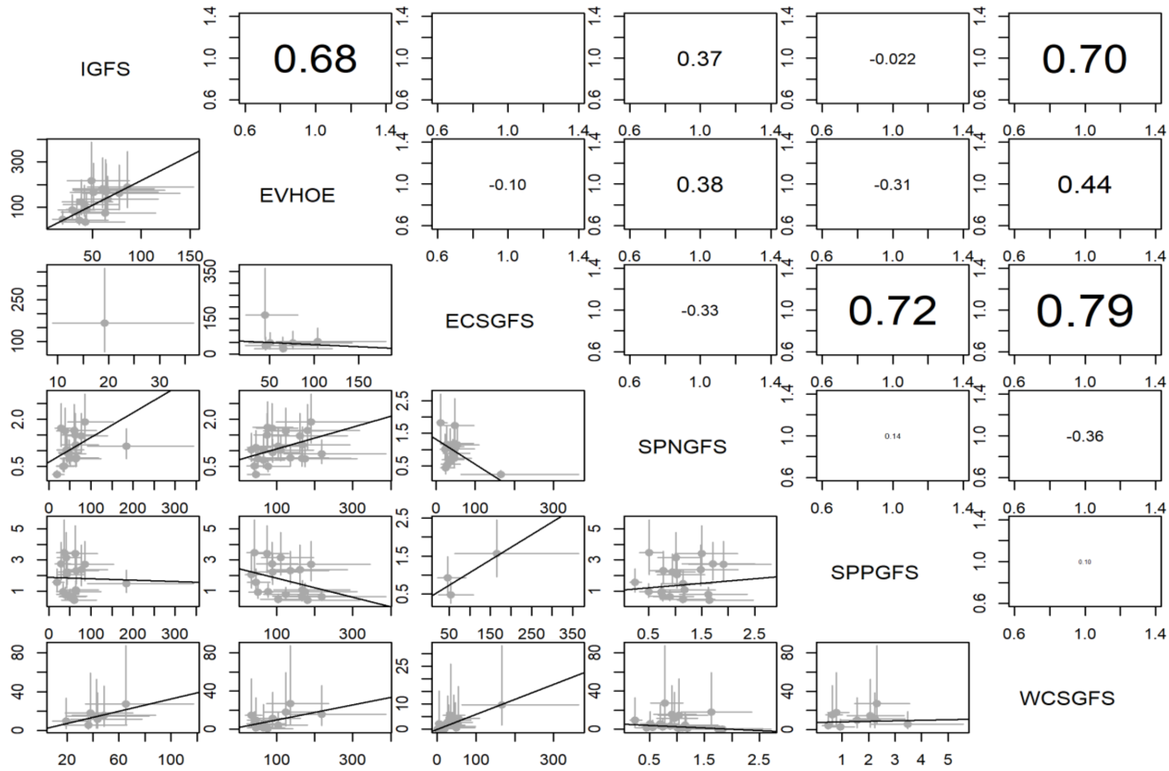

Figure 3.6.1.6. Boarfish in ICES Subareas 27.6, 7, 8. Weighted correlation between the annual mean survey indices. Correlations are weighted by the sum of the pair-wise variances.

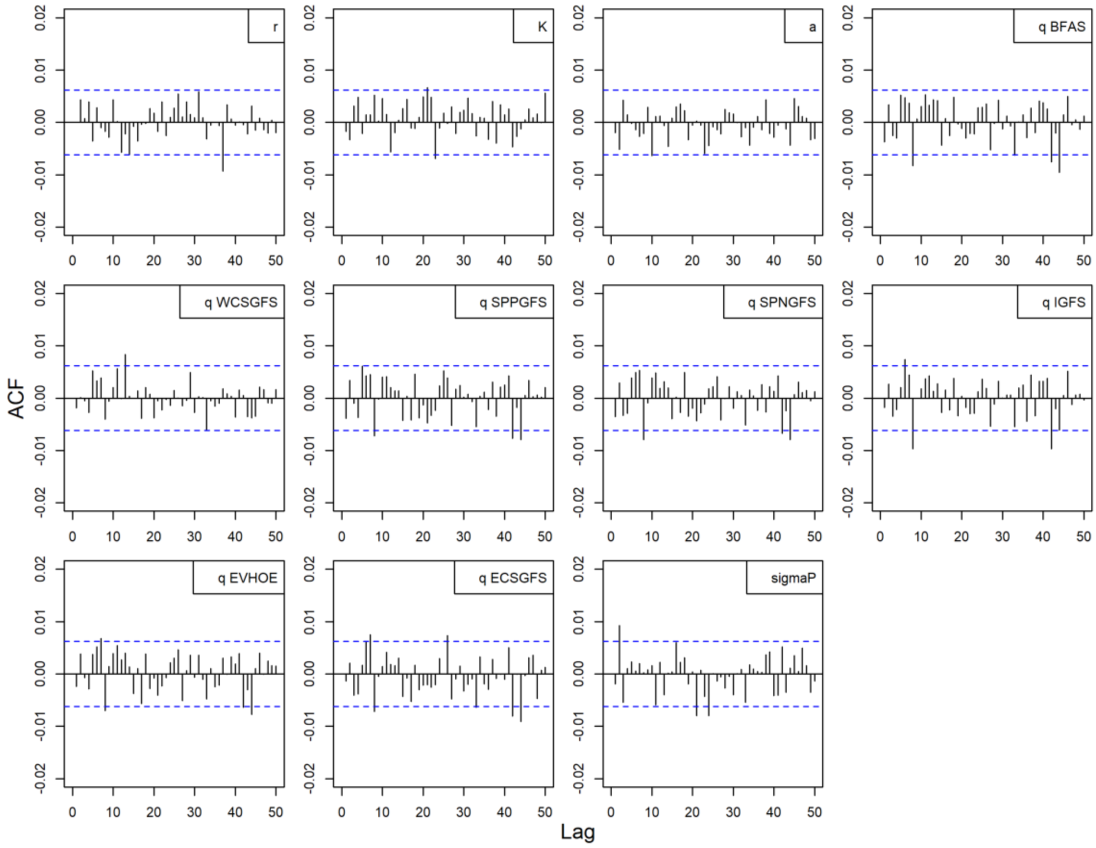

Figure 3.6.3.1. Boarfish in ICES Subareas 27.6, 7, 8. Parameters for final run converged with good mixing of the chains.

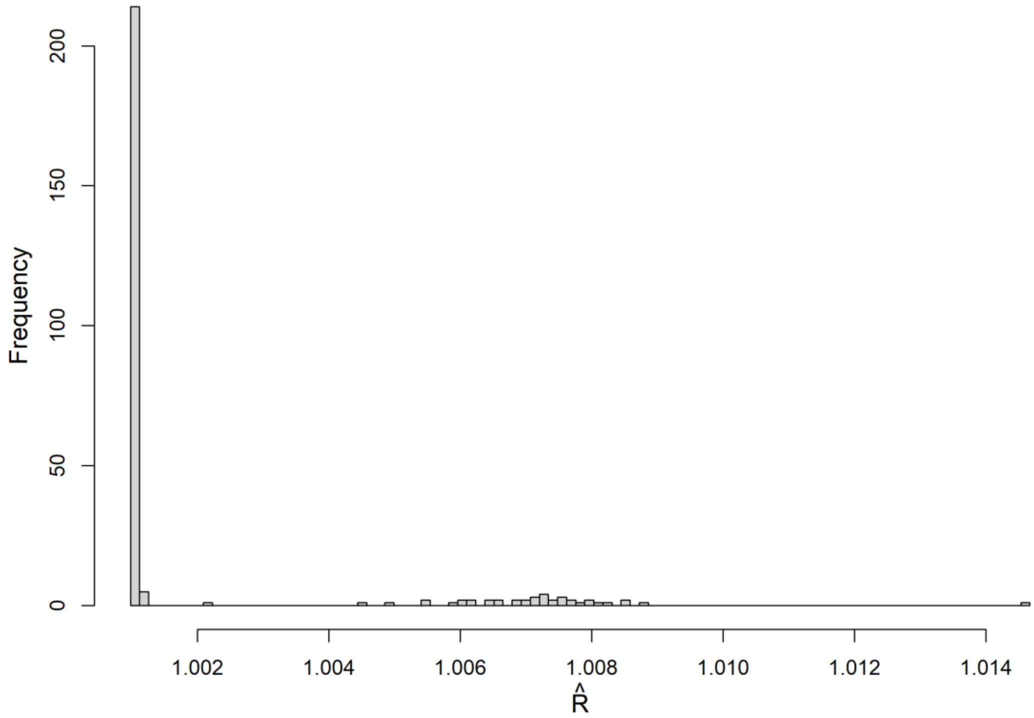

Figure 3.6.3.2. Boarfish in ICES Subareas 27.6, 7, 8. Rhat values lower than 1.01 indicating convergence.

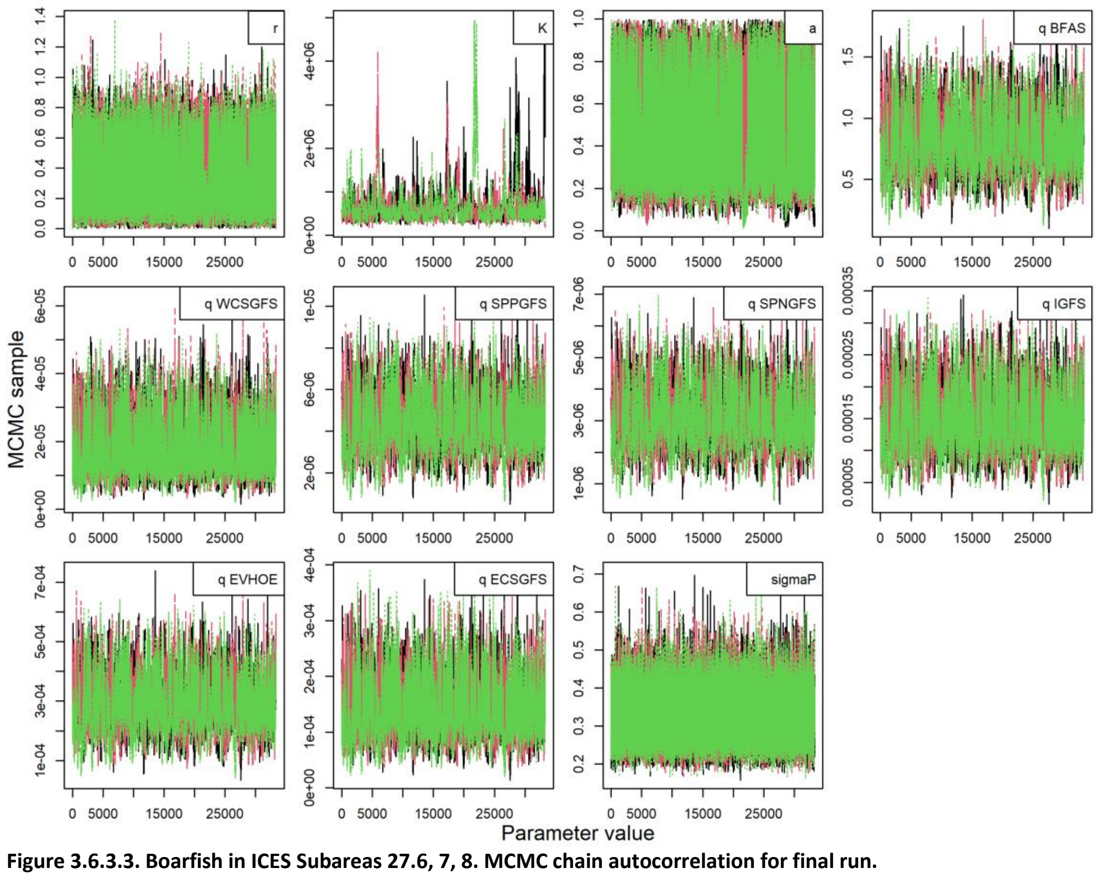

Figure 3.6.3.3. Boarfish in ICES Subareas 27.6, 7, 8. MCMC chain autocorrelation for final run.

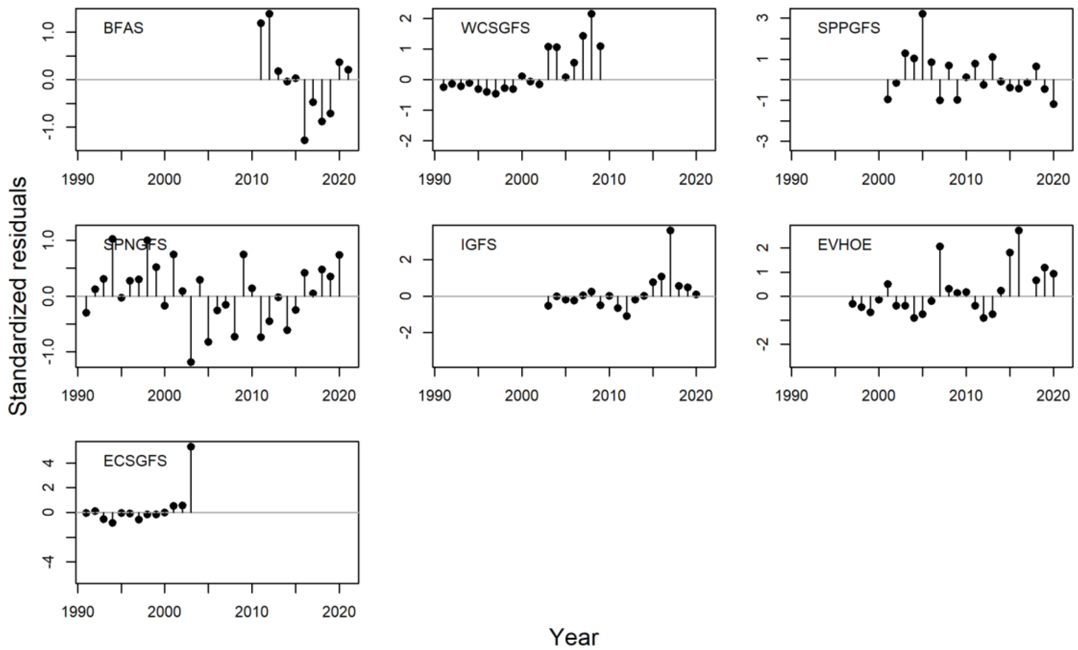

Figure 3.6.3.4. Boarfish in ICES Subareas 27.6, 7, 8. Residuals around the model fit for the final assessment run.

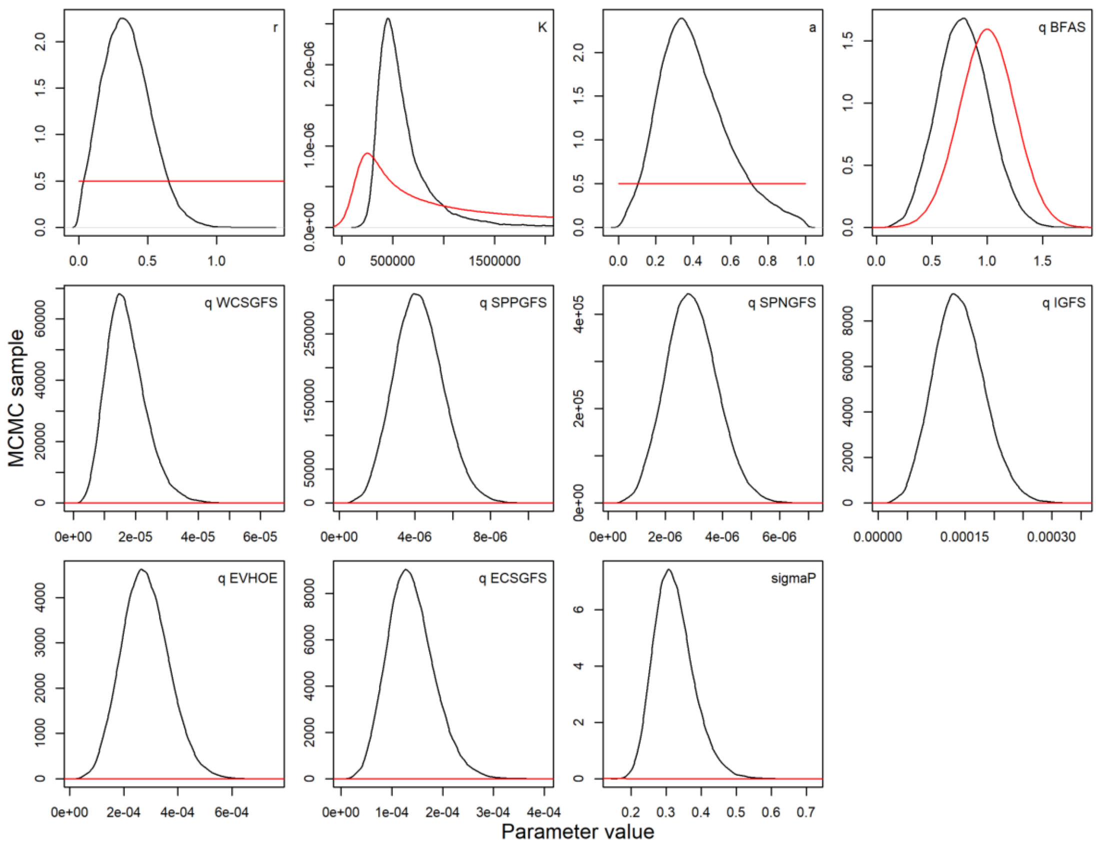

Figure 3.6.3.5. Boarfish in ICES Subareas 27.6, 7, 8. Prior (red) and posterior (black) distributions of the parameters of the biomass dynamic model.

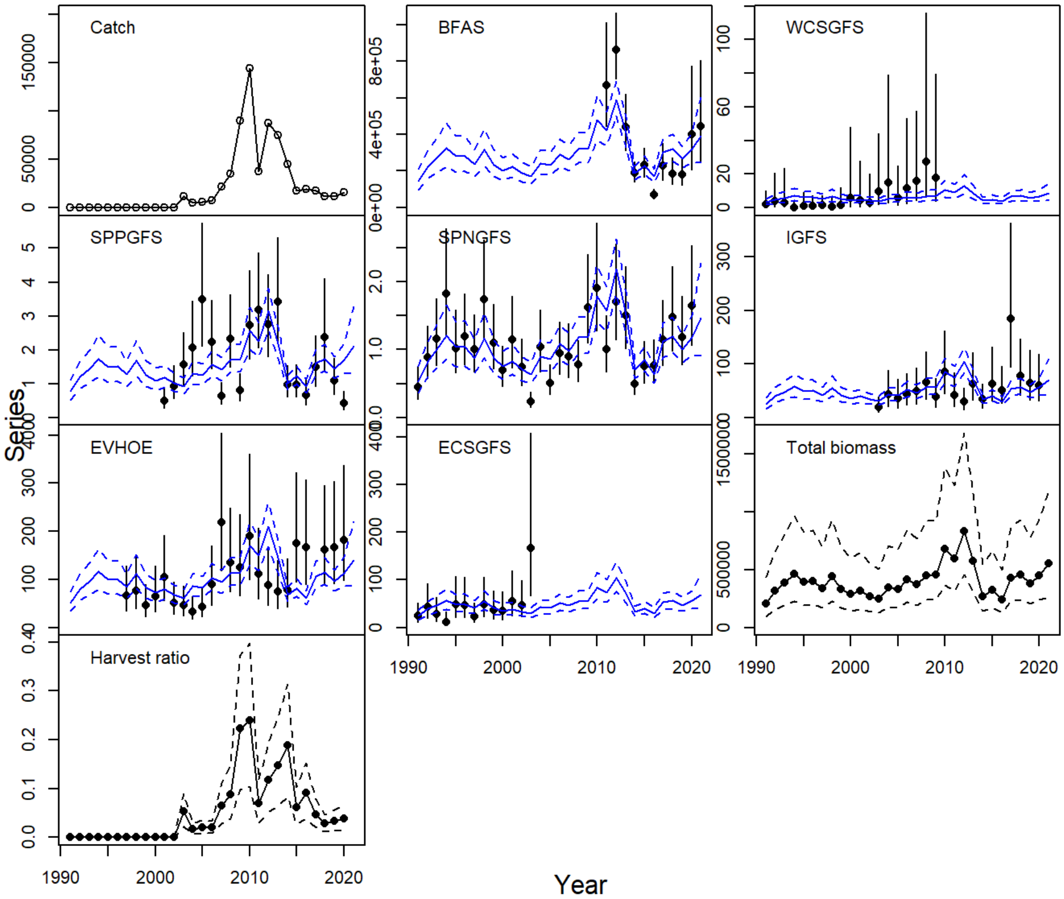

Figure 3.6.3.6. Boarfish in ICES Subareas 27.6, 7, 8. Trajectories of observed and expected indices for the final assessment run. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

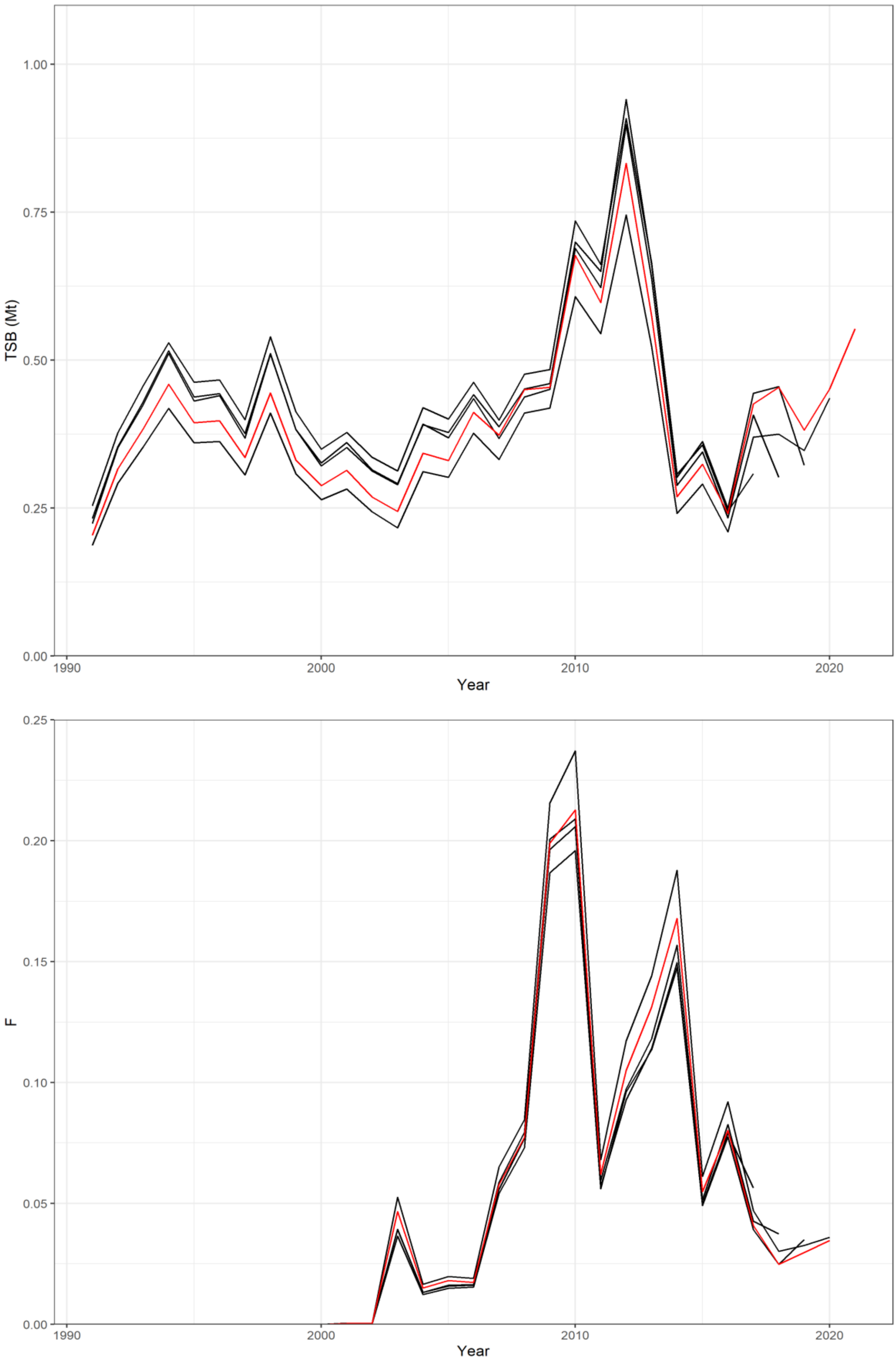

Figure 3.6.3.7. Boarfish in ICES Subareas 27.6, 7, 8. Retrospective plot of total stock biomass (above) and fishing mortality (below) from the surplus production model in 2013-2020.

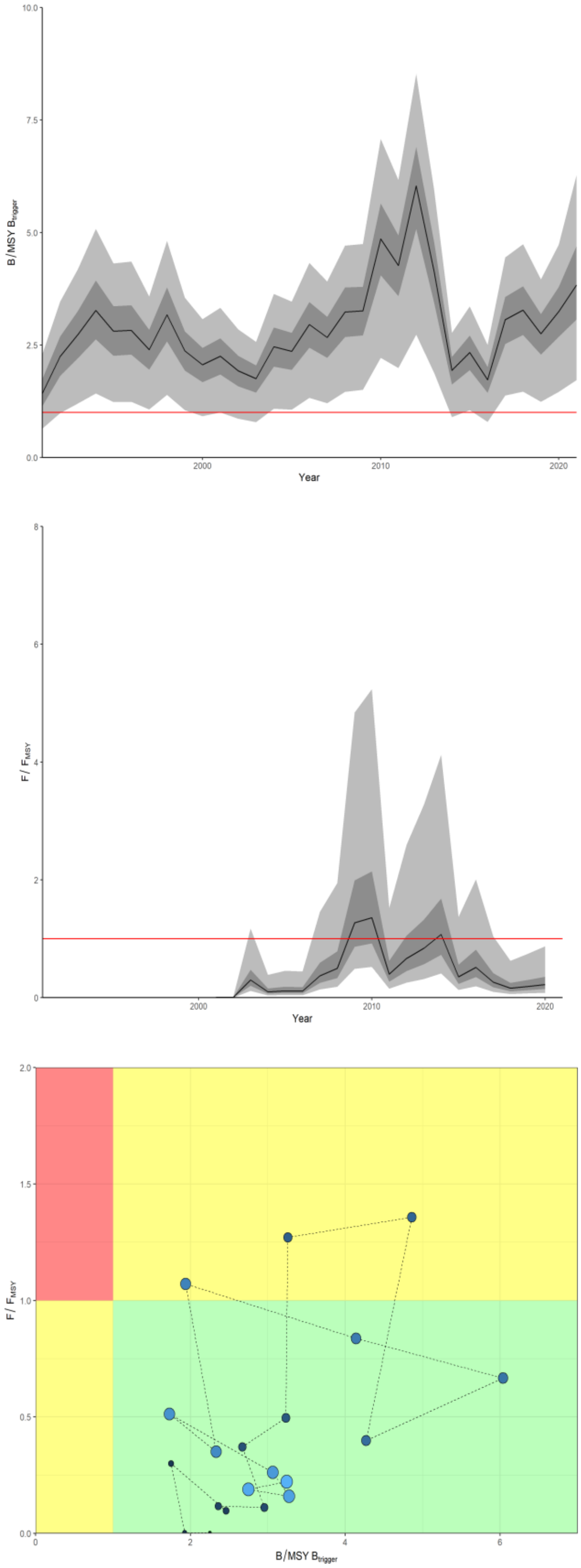

Figure 3.6.6.1. Boarfish in ICES Subareas 27.6, 7, 8. Ratios 'B / MSYBtrigger' and 'F / FMSY' through time and corresponding Kobe plot. Confidence intervals (50 and 95%) are given for the first two panels, the third displays median estimates only with the pink point representing the first point of the time series and the purple point the last.

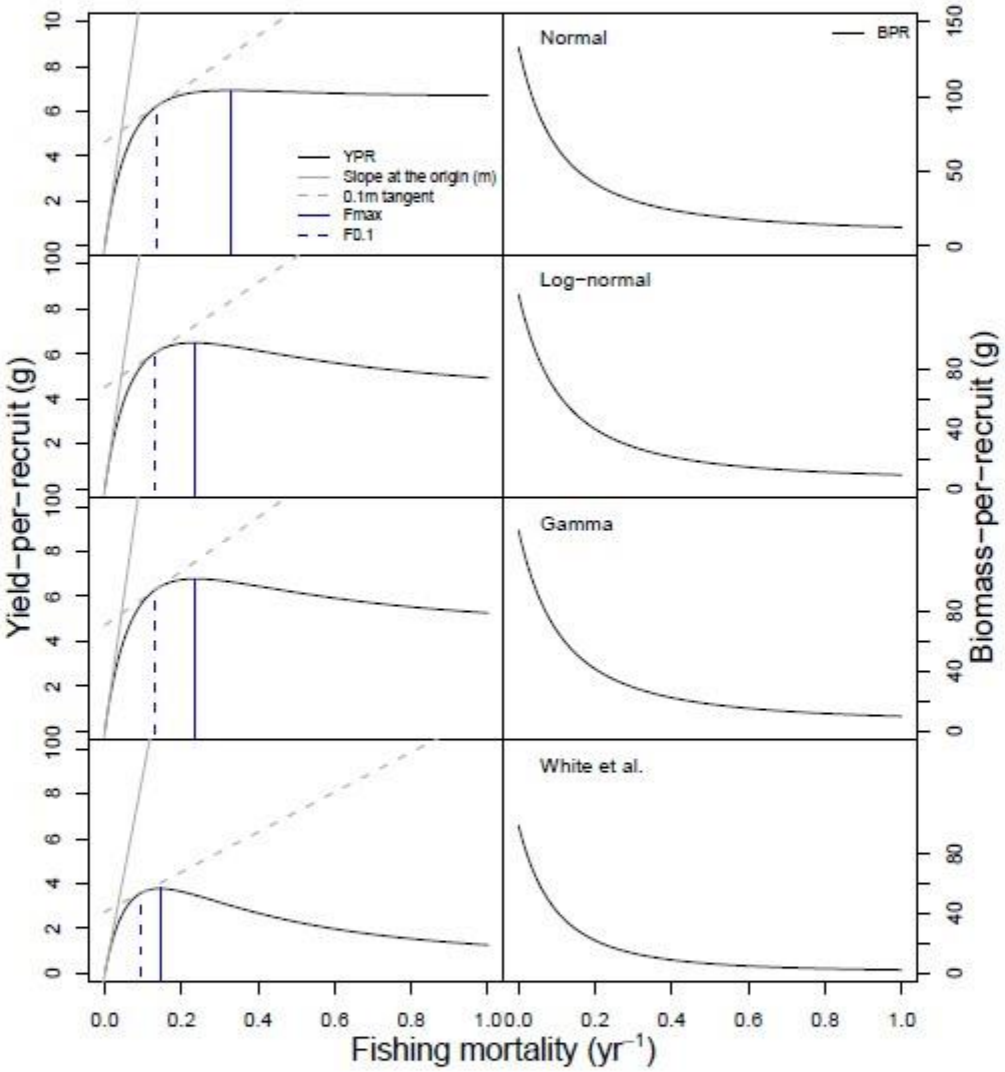

Figure 3.9.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Results of exploratory yield per recruit analysis. Beverton and Holt model applied to various fits of the VBGF and for comparison with the VBGF parameters provided by White *et al*. 2011.

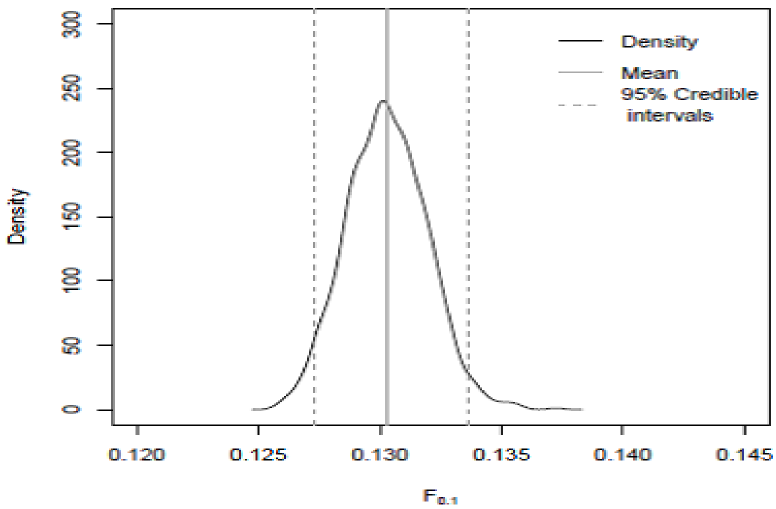

Figure 3.9.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Sensitivity of estimation of F0.1.

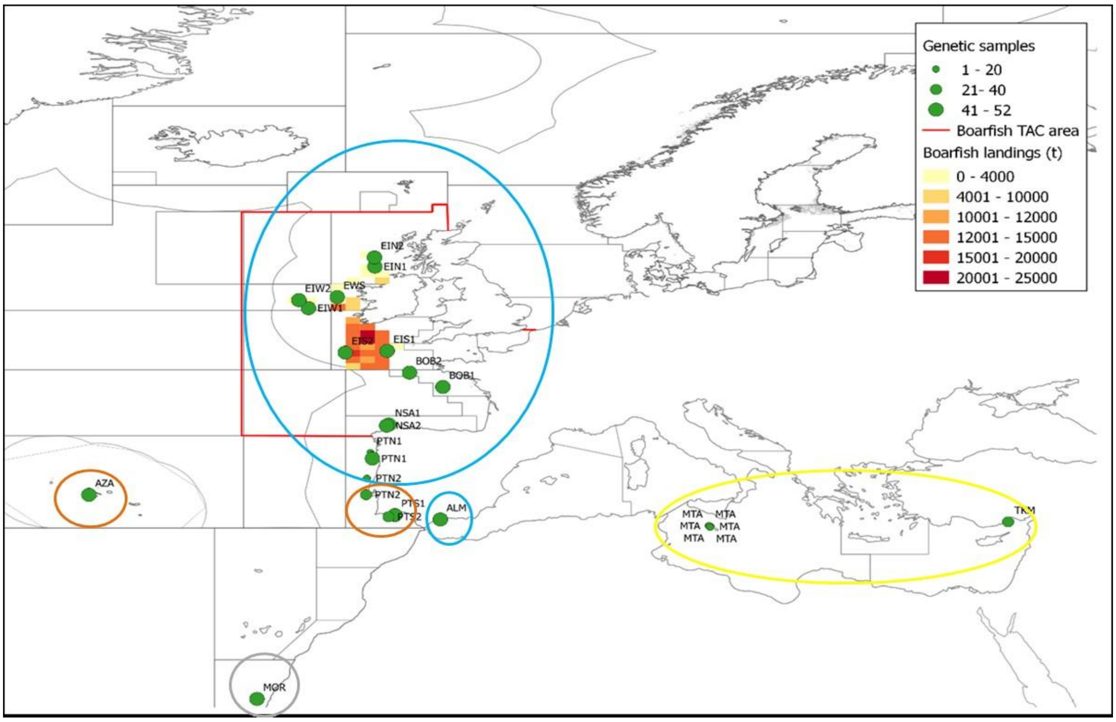

Figure 3.12.1. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish samples included in the genetic stock identification study are indicated in green. Population clusters identified by the STRUCTURE analyses are indicated by colour coded circles.