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 southwest of Ireland. The boarfish fishery is conducted primarily in shelf waters and the first landings were reported in 2001. Landings were at very low levels from 2001–2005. The main expansion period of the fishery was 2006–2010 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 advice for 2012. In 2018, ICES has been considering this stock for 8 years.

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 3.11). 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 2018 only data from these areas were utilized.

3.1 The fishery

3.1.1 Advice and management applicable from 2011 to 2018

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 to allow fishing using 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 FMSY (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 been continued since then.

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 has been 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 assessment run in 2018 confirms that the biomass is rather stable and at a low level.

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 text table below. The effect of this is that a quantity not exceeding the value indicated 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

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 (see section 3.15). The management plan was not fully evaluated by ICES. However, in 2013, ICES advised that Tier 1 of the plan can be considered precautionary if a Category 1 assessment is available.

A revised draft management strategy was proposed by the Pelagic AC in July 2015. This management strategy aims 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 that it follows the rationale for TAC setting enshrined in the ICES advice, but with additional caution.

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

3.1.2 The fishery in recent years

The first landings of boarfish were reported in 2001. Landings fluctuated between 100 and 700 t per year up to 2005 (Tables 3.1.2.1 & 3.1.2.2). In 2006 the landings began to increase considerably as a target fishery developed. Cumulative landings since 2001 are now over 500 000 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 typical pelagic pair trawl nets with mesh sizes ranging from 32 to 54 mm. Preliminary information suggests that only the smallest boarfish escape this gear.

From 2001 to 2006 only Ireland reported landings of boarfish. In 2007 UK-Scotland reported landings of 772 t. Scottish landings peaked at 9 241 t in 2010 and have declined since then with no fishery in 2015. Denmark joined the fishery in 2008 and landed 3 098 t. Danish landings increased to 39 805 t in 2010 but have declined considerably to only 29 t in 2015 and were null in 2016 and 2017. The vast majority of catches have come from ICES Division 27.7.j and 27.7.h (Figure 3.1.2.1 and Table 3.1.2.1). Since 2011 landings have been regulated by a TAC.

In 2014 and subsequent years, the TAC has not been caught. This is thought to be partly due to lesser availability of fishable aggregations, and partly due to economic and administrative reasons. According to the industry, fishable aggregations were not always available during the fishery. The season coincides with the mackerel and horse mackerel fisheries. 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 have been removed in Ireland, in an attempt to allow the specialist 6-7 vessels to 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 is below its 29 464 quota. Denmark took only 337 t, significantly under its national quota of 10 463 t. Scotland reported no boarfish landings. Table 3.1.2.2 shows that two thirds of the Irish landings were taken in ICES divisions 7.h and 8.a. Thirty-two Irish registered fishing vessels reported catches with the majority made in Q1 (7 143 t) and Q4 (8 711 t).

Previous to the development of the target fishery, boarfish was a discarded bycatch in pelagic fisheries for mackerel 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 are also discarded in whitefish fisheries, particularly by Spanish demersal trawlers (Table 3.1.2.3).

3.1.3 The fishery in 2017

In 2017 a total of 17 388 t of boarfish were caught (Table 3.1.2.1). Ireland continued to be the main participant landing 15 484 t but is 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. Table 3.1.2.2 shows that about 90% of the Irish landings were taken in ICES divisions 7.h and 8.a. Thirty-five Irish registered fishing vessels reported catches with almost the entirety made in Q1 (8 570 t) and Q4 (6 270 t).

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. Efforts are underway to develop a human consumption market and fishery for boarfish. 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 now seems unlikely.

3.1.6 Discards

Since 2003, the major sources of discards 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. 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 3.1.2.3 shows available data.

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

Discard data were included in the calculation of catch numbers at age. All discards were raised as one 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 number-at-age were prepared for Irish, Danish, Dutch, German 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 2017 allocations to unsampled metiers were made according to Table 3.2.1.3. In total 14 Irish and 4 Danish samples with the appropriate .5 cm length bin measurements were collected in 2017 (Table 3.2.1.4). These samples covered only the 4 most heavily fished areas out of a total of 16 (Table 3.2.1.5) and equated to one sample per 966 t landed. The samples comprised 1 440 fish measured for length frequency.

The results of the application of the ALK to commercial length-frequency data available for the years 2007-2017 to produce a proxy catch numbers-at-age are available in Table 3.2.1.6. Many old fish are still present in catches, though there appears to be a reduction of older ages since 2007. There have been no strong year classes with poor cohort tracking in the catch numbers. A high number of 2 year old are present in the 2015 data but this does not echo in the number of 3 year old fish in 2016. The modal age from 2007-2011 was 6 and in 2012-2017 it was 7. It should be noted that in WGWIDE 2011 and 2012 the +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 Hussy *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 un-sampled metiers in 2017. 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 onboard directly from the fish pump during fishing operations and are frozen until returning 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 0.5cm below for length frequency. Following standard protocols 5 fish per 0.5cm 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 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

A full description of the Boarfish Acoustic Survey (BFAS) which was initiated in July 2011 is given in the stock annex. This survey is run in conjunction with the Malin Shelf herring survey. These surveys are collectively known as the Western European Shelf Pelagic Acoustic Survey (WESPAS).

Change in abundance calculation method

Acoustic data collected during the WESPAS survey since 2016 were analysed using the StoX software package (ICES 2015a). This package was adopted for WGIPS coordinated surveys in 2016 and has been implemented for all international multi-vessel coordinated surveys within the group (IBWSS, IESSNS, IESSNS and HERAS). The Irish Marine Institute has adopted StoX as the primary abundance calculation tool for national and international acoustic survey data going forward as part of a transitional process initiated during WKEVAL (ICES 2015b). A detailed comparative review of the Irish national method and StoX was carried out on herring during WGIPS 2016 using HERAS and IBWSS data. A difference of 1% in the total herring biomass estimated by the national method compared to the StoX method for HERAS data was found. Abundances at age showed a greater difference which maybe more related to survey design for the 2015 data set. Regardless, the national abundance by age estimates were all contained within the uncertainty levels surrounding the StoX estimates (ICES 2016). The Irish national abundance is thus considered comparable with StoX going forward.

A description of the StoX application can be found at the following weblink: http://www.imr.no/forskning/prosjekter/stox/nb-no. Survey design and execution for the WESPAS survey adhere to guidelines laid out in the Manual for International Pelagic Surveys (IPS) (ICES 2015a).

Survey results 2018

The estimate of boarfish biomass from 2011 to 2018 is presented in Table 3.3.1.1 and the spatial distribution of the echotraces attributed to boarfish each year can be seen in Figure 3.3.1.1. In 2018, The WESPAS survey was carried out over a 42 day period beginning on the 09 June in the south (47°N) and working northwards to 59°N ending on 24 July. The survey direction was changed in 2017 from south to north to force containment in the southern area by aligning ourselves with the PELGAS survey. Spatial and temporal alignment has much improved with this move and the survey will be continued in this way in years to come. Overall the WESPAS survey provided continuous coverage from 47N° to 59N°over 42 days covering relating to an area coverage of almost 56, 403 nmi2 (boarfish strata) and transect mileage of over 5,200 nmi. In total 42 trawl stations were undertaken with 14 hauls containing boarfish providing 4,807 individual lengths, 2,234 weights and 945 otoliths for use during the analysis.

The 2018 estimate of biomass is 44,000t lower than observed in 2017 (230,000t in 2017, 186,000t in 2018). The low estimate in 2016 (70,000t) appears to be an outlier. Containment issues in 2016 were addressed and the survey has been conducted from south to north since 2017. The changes were implemented to increase the precision of the survey overall. Approximately 45% of the stock was observed in the southern survey area

(Celtic Sea, including Celtic Sea Deep and NW Bank areas). Boarfish were found further north than in previous years.

The age composition of the stock in 2018 is dominated by older age classes (> 7 years) with a peak at 10 year old fish. A second peak at 15+ years appears to be less in 2018 than in previous years. The numbers at age are variable across years, which may be a result of the fact that an age at length key is used.

The BFAS component of the WESPAS survey is still under development and adaptations have been necessary in an attempt to provide adequate coverage for these species. The survey currently provides an index for both the boarfish and Malin Shelf herring assessments, and in the future, this survey may provide a tuning index for western horse mackerel also. With this in mind, compromises are necessary. A visual comparison of boarfish distribution between years Figure 3.3.1.1 suggests that stock containment to the east, in the Celtic Sea shelf, was achieved in 2014 and possibly 2011 only.

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 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 also includes the spatial range of the Portuguese Groundfish Survey (1990–2011), however this survey is outside the current EC TAC area and was never in the assessment.

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 the main fishing grounds (Figure 3.1.2.1). Figure 3.3.2.3 shows the signal in abundance, increasing in the 1990s, declining again in the early 2000s, before increasing again.

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 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 estimated average across all rectangles within a year. To propagate the uncertainty, all survey index analyses were conducted in a Bayesian framework using MCMC sampling (Kery 2010). As WinBugs is no longer updated, the analyses were migrated from WinBUGS to JAGS in 2017. Indeed, JAGS has an almost identical language to WinBUGS and its outputs have been proven equivalent to the previous software (Plummer 2003; Spiegelhalter *et al.* 2003). In 2018, the assessment was reverted back to WinBUGS as it MCMC sampler appeared more efficient than that of JAGS. Still, the outputs derived from both software are highly similar.

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 small sample size and seasonal variation in weight and maturity stage.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
MW (g)	0.84	6.65	14.6	19.5	23.7	26.8	33.3	37.7	40	47.1	50.2	51.2	62.8	56.4	62.2

Age	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
MW (g)	68.9	50.5	86.7	77.9	64.6	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 assumes that M is the mortality that will reduce a population to 1% of its initial size over the lifespan of the stock. Based on a maximum age of 31, M is calculated as follows

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

Following this procedure M = 0.16 year^{-1}. M = 0.16 is considered a good estimate of natural mortality over the life span of this boarfish stock, as it is 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 is 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 is 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 are 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 is considered appropriate.

3.5 Recruitment

The IBTS data were explored as indices of abundance of 1 year old, and 1-5 years old as a composite recruitment index (Figures 3.5.1 & 3.5.2). The EVHOE 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 but declined to a low in 2003. However, this apparent dip in recruitment was not observed in the commercial catch-at-age data. The recruitment signal for ages 1-5 combined has been stable since 2004 with a small increase evident in 2015. The recruitment signal for 1 year old shows a more variable pattern with an increase in 2015 also evident (Figure 3.2.1.1). In 2016, almost all values for age 1 and combined ages 1-5 decreased compared to 2015. The decreases were rather important in the SPNGFS survey and led to historical lows for this survey.

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

The common ALK (Table 3.2.1.1) was applied to the IBTS number-at-length data. The length-frequency is presented in Table 3.3.2.1and 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 (Figures 3.5.1 & 3.5.2). 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.

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 (Figure 3.6.1.2). 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. The only exception is the EVHOE survey but its coverage was only partial year due its research vessel breakdown. 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 (Figures 3.6.1.2 & 3.6.1.3). 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 WCSGFS also displayed a negative correlation with the 2 Spanish surveys (SPPGFS and SPNGFS). The SPPGFS also displayed a negative correlations 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, we did not a-priori exclude any surveys 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 July 2011 and is now in its 8 year. The initial survey in 2011 collected data over 24 hours. Since 2012, acoustic data has been collected between the hours of 04:00 and 00:00. The 2011 data was reworked in 2015 to exclude the data between 00:00 and 04:00. A TS model of -66.2dB was developed in 2013 [Fässler *et al.* (2013); odonnell_implementation_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). The precision on the estimates has been good, with coefficients of variation in the range 11 to 21. An overall downward trend is evident in the first years while estimates have been more stables and rather low since 2014. No strong evidence exists for removing any of the survey points from the time series although 2016 may look like an outlier.

It should be noted that two acoustic surveys are conducted annually to the south of the southern limit of the dedicated Boarfish survey. In 2016 the PELACUS recorded an increase in biomass from 2015 although not of the order of the decrease seen further north. The Spanish PELGAS surveys recorded low levels of biomass, similar to that in 2015. Both these surveys take place 2-3 months prior to the boarfish survey.

3.6.3 Biomass dynamic model

In 2012 an exploratory biomass dynamic model was developed. This was a Bayesian state space surplus production model (Meyer & Millar 1999), incorporating the catch data, IBTS data, and acoustic biomass data. This assessment was then 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 again 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. The stock was moved from a category 1 assessment to a 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 did not change. Only the length of the time series used increase yearly. Details of this exploratory run used to calculate the DLS index are described below. Further model development work is undertaken since 2015 but did not lead to any change so far.

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

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

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 the estimation the biomass is scaled by the carrying capacity, denoting the scaled biomass $P_t = B_t / K$. 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 lognormally 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

$$\sigma^2_{\varepsilon,acoustic,t} = ln(CV^2_{acoustic,t} + 1)$$

Prior assumptions on the parameter distributions were:

- Intrinsic rate of population growth: $r \sim U(0.001, 2)$
- Natural logarithm of the carrying capacity: $ln(K) \sim U(ln(max(C), ln(10.sum(C)) = U(ln(144047), ln(4450407))$
- Proportion of carrying capacity in first year of assessment: $a \sim U[0.001, 1.0]$
- 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: 2011–2018

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 plenary 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. The reasons for this decision were: * it is 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 SPNGFS commences in 1991 such that running the assessment from 1991 onwards includes at least three surveys without relying, solely on the ECSGFS and WCSGFS, * surveys are internally weighted such that highly uncertain values receive lower weight.

Catches

2003–2018 time series

Priors

The final run assumes a strong prior $ln(q_{acoustic}) \sim N(1, 1/4)$ (mean 1, standard deviation 0.25), which has 95% of the density between 0.5 and 2. Given the short acoustic series (6 years) 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 2018 model run converged with good mixing of the chains and Rhat values lower than 1.1 indicating convergence (Figures 3.6.3.1 & 3.6.3.2). MCMC chain autocorrelation was rather high but was compensated by long MCMC chains providing representative samples of the parameter posteriors (Figure 3.6.3.3).

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 in the recent period from all fits. This could be indicative of stock expansion into this area at higher stock sizes and suggests that this index is 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.

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 2018 is estimated to be 284 770 t and it appears to be stable but low over the last 5 years. It is worth noting that the extremely low biomass estimate from the 2016 acoustic survey now appears considered as an outlier by the model. As a consequence the 2016 biomass estimate increased from 108 000 t last in 2016 to about 240 000 t in 2017 and 2018. Retrospective plots of TSB and F, presented in Figure 3.6.3.7, show that the perception of the stock is stable through time with the exception of 2013 prior to the inclusion of the lower biomass estimates of the acoustic surveys since 2014.

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 text 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 and has gradually reduced down to 0.15 in 2015 and 2016. In 2017, it increased up to 0.17. There was a weak correlation between catches and pseudo-cohort *F* ($r^2 = 0.48$). Recent *F* estimated this way is close to *FMSY* (0.149) and above *F0.1* (0.13).

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	0.2	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	0.2	75 409
2014	0.37	0.21	45 231
2015	0.31	0.15	17 766
2016	0.31	0.15	19315
2017	0.33	0.17	17388

3.6.5 State of the stock

According to this year assessment, total stock biomass appeared to increase 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, when it increased until 2012, followed by a sharp decline from 2013 to 2014. Since 2014, the abundance appear low but rather stable, fluctuating around 320 000 t. 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 may now be viewed as one of the most successful 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 now appears as an outlier and do no longer drive the stock abundance estimates to even lower values. The uncertainty surrounding the estimates of biomass the last years remain important with wide 95% credible interval (Table 3.6.5.1). This reflects 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. As more data accumulates from this survey, it is expected that the prior will become increasingly updated, and potentially less variable.

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).

Since 2017, MSY reference points have been developed for the boarfish stock and may be used to guide the advice. The ICES MSY framework specifies a target fishing mortality, FMSY (stock growth rate over 2), which, over the long term, maximises yield, and also a spawning biomass, MSY $B_{trigger}$ (stock carrying capacity over 4), below which target fishing mortality should be reduced linearly relative to the SSB $B_{trigger}$ ratio. In 2018, FMSY and MSY $B_{trigger}$ are estimated respectively equal to 0.185 (parameter r / 2) and 165 420 t (parameter K / 4). Throughout the history of the fishery, estimates of stock biomass have remained above $MSYB_{trigger}$. Fishing mortality (F) was greater than FMSY in 2009, 2010 and 2014, but has decreased since. In 2018, 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, an independent index of recruitment is available from groundfish surveys (Section 3.5). Observations from the survey recruitment of 1 year olds show strong negative trends since 2010 (Figure 3.5.1) and a weaker, but still negative, trend for ages 1-5 combined (Figure 3.5.2) for 2 out of 3 surveys. The trend within the IGFS is opposite.

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

It does not appear that boarfish is an important prey species in the NE Atlantic (Section 3.13). ICES (2007) considered that precautionary *F* targets (*Fpa*) should be consistent with F130 625 t based on the exploratory assessment in 2018).

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. In addition, the acoustic survey used (BFAS / WESPAS) is in a state of development at present and there are concerns that the acoustic survey may not be containing the stock sufficiently. 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 very 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 (WCSGFS for instance) may need to be revised.

Additional work to improve the surplus production model is undertaken since 2015 and will continue next year. A issue list has been provided and a benchmark is planned for 2020.

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 a good means of dealing with such data. The biomass dynamic model used in the stock assessment is based on the recent benchmarked assessment of megrim in Sub-divisions 4 and 6. The model was further developed by including acoustic survey biomass estimates. One drawback of the model is that it does not provide estimates of recruitment. However, an estimate of recruitment strength is available from the Spanish and French trawl surveys.

3.11 Management considerations

As this stock is now placed in category 3, the ICES advice for 2018 is based on harvest control rules for data limited stocks (ICES 2017). Since the biomass estimate from the Bayesian model is considered reliable for trend 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.

ADG decided to use the advice given in 2017 and based on this framework for 2 years. This results in an advised catch of 21 830 t for 2019. More details can be found in last year report. The apparent stability of the assessment this year comforts this decision.

Although no longer 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 (ICES 2013) 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\&\#39 *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 includes 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.

2) Category 6: Category 6 - negligible landings stocks and stocks caught in minor amounts as bycatch

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

4) If the stock, estimated in the 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.

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

6) 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.

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

a) 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.

b) 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.

c) 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.

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Table 3.1.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Landings, discards and TAC by country by year (t), 2001–2017. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Years	Denmark	Germany	Ireland	The.Netherlands	UK.England	UK.Scotland	Unallocated	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			0.45		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			1284	19315	47637
2017	548		15485	182	0.13			1173	17388	27288

Table 3.1.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Landings by year (t), 2001–2017 (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Area	Denmark	Germany	Ireland	The.Netherlands	UKE	UKS	Total
2001	ALL			120				120
2002	ALL			91				91
2003	ALL			458				458
2003	6.a			65				65
2003	7.b			214				214
2003	7.j			179				179
2004	ALL			675				675
2004	6.a			292				292
2004	7.b			224				224
2004	8.d			38				38
2004	7.j			122				122
2005	ALL			165				165
2005	6.a			10				10
2005	7.b			105				105
2005	8.a			38				38
2005	7.j			12				12
2006	ALL			2772				2772
2006	6.a			21				21
2006	7.b			15				15
2006	7.g			375				375
2006	8.a			1				1
2006	7.j			2360				2360
2007	ALL			17615			772	18386
2007	5.b2			6				6
2007	6.a			93				93
2007	7.b			1259				1259
2007	7.g			120				120
2007	8.a			5				5
2007	7.j			16131			772	16903
2008	ALL			21584				21585
2008	6.a			28				28
2008	7.b			3				3
2008	7.g			184				184
2008	7.j			21370				21370
2009	ALL			68629				68629
2009	6.a			45				45
2009	7.b			73				73
2009	7.c			1				1
2009	7.g			4912				4912
2009	7.h			18225				18225
2009	7.j			45372				45372

Year	Area	Denmark	Germany	Ireland	The.Netherlands	UKE	UKS	Total
2010	ALL	39805		88457			9241	137503
2010	6.a			1349			10	1359
2010	6.aS			7				7
2010	7.b			2258				2258
2010	7.c			35			4	39
2010	7.e	2						2
2010	7.g	672		3649				4321
2010	7.h	1465		8453			1712	11629
2010	7.j	37667		72707			7515	117889
2011	ALL	7797		20685			2813	31295
2011	6.a			26				26
2011	7.b			274				274
2011	7.c			9				9
2011	7.g			811				811
2011	7.h	4155		8540			2813	15508
2011	8.a	18						18
2011	7.j	3624		11025				14648
2012	ALL	19888		55949			4884	80720
2012	6.a			125				125
2012	7.b	80		4501			838	5419
2012	7.c			108			907	1015
2012	7.g			616				616
2012	7.h	5837		10579			3139	19554
2012	8.a	1604		93				1697
2012	7.j	12366		39928				52294
2013	ALL	13182		52250			4380	69811
2013	6.a			538			15	553
2013	7.b			10405			100	10505
2013	7.e						883	883
2013	7.g			1808				1808
2013	7.h	955		11355			1728	14038
2013	8.a	1354		870				2224
2013	8.d			270				270
2013	7.j	10873		27003			1653	39529
2014	ALL	8758		34622			38	43418
2014	6.a			182			30	212
2014	7.b	12		3262				3274
2014	7.g			135				135
2014	7.h	4808		18389				23196
2014	8.a			119				119
2014	7.j	3886		12536			8	16429
2014	7.k	53						53
2015	ALL	29	5	16325	375	104		16837
2015	6.a	10		116		9		134
2015	7.b	8	4	2609		85		2706
2015	7.c			220				220

Year	Area	Denmark	Germany	Ireland	The.Netherlands	UKE	UKS	Total
2015	7.g			547				547
2015	7.h	5		8506				8510
2015	8.a	6	1	682				688
2015	7.j			3646		10		3655
2015	6				128			128
2015	7				33			33
2015	8				214			214
2016	ALL	337	7	17496	171	21		18031
2016	6.a			377	45			422
2016	7.b		5	1198	35	0.66		1239
2016	7.c				0.08			0.08
2016	7.e				0.02			0.02
2016	7.h	330		6771				7101
2016	7.j			1852	90	16		1959
2016	8.a	2	1	6173		5		6181
2016	8.b					0.11		0.11
2016	8.d	5		1124				1129
2017	ALL	548		15485	182	0.13		16215
2017	4.a				0.03			0.03
2017	6.a	37		907	34			979
2017	7.b			124	118			242
2017	7.c				20			20
2017	7.d	1						1
2017	7.e				0.08			0.08
2017	7.f					0.02		0.02
2017	7.g			1		0.02		1
2017	7.h	239		2961		0.09		3200
2017	7.j			33	9			43
2017	8.a	271		10543				10814
2017	8.d			915				915
ALL	ALL	90344	12	413378	727	126	22128	526711

Table 3.1.2.3. Boarfish in ICES Subareas 27.6, 7, 8. Discards of boarfish in demersal and non-target pelagic fisheries by year (t), 2003–2017. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Germany	Ireland	Netherlands	Spain	UK	Danemark	Lituania	Total
2003		119	1998	8812				10929
2004		60	837	3579				4476
2005		55	733	5007				5795
2006		22	411	3933				4366
2007		549	23	2617				3189
2008		920	738	8410				10068
2009		377	1258	5047				6682
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	1284
2017		640	146			386	1	1173

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	1	1													
8	1	1													
8		1													
8		1	1												
9		1	1												
10			1												
10			1												
10			2	10	3										
11			1	29	14	2	2								
12				9	21	21	18	2	2	1					
12				4	17	22	38	12	8						1
12					5	9	42	37	14	6	2		1	1	1
13					2	4	31	28	24	12	6	2	3	1	5
14					1	3	25	22	21	14	6	5	4	2	11
14							6	8	18	22	8	3	7	1	20
14						1	1	2	3	8	1	6	6	6	30
15							1	1		2	2	2	5	2	19
16										2				2	19
16															8
16															1
17															1
18															1
18															1
18															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	% landings covered by sampling programme	No. samples	No. measured	No. aged
2001	120	0	0	0	0
2002	91	0	0	0	0
2003	11 387	0	0	0	0
2004	5 151	0	0	0	0
2005	5 959	0	0	0	0
2006	7 137	0	0	0	0
2007	21 576	NA	3	217	0
2008	34 751	NA	1	152	0
2009	90 370	NA	9	1 475	0
2010	144 047	NA	95	10 675	403*
2011	37 096	NA	27	4 066	704
2012	87 355	NA	80 (68)***	9 656 (8 565)***	814**
2013	75 409	NA	76	9 392	0****
2014	43 418	NA	54	7 008	0****
2015	17 766	NA	32	3 356	0****
2016	18031	NA	27	3861	0****
2017	16215	NA	18	1140	0****

Table 3.2.1.3. Boarfish in ICES Subareas 5, 27.6, 7, 8. The allocation of Age length keys to unsampled metiers in 2017.

Country	Area	Quarter	landed	ALK
DK	7.d	1	1	IE_8.d_Q1 IE_8.a_Q1 IE_7.j_Q1 IE_7.h_Q1 DK_7.h_Q1 DK_8.a_Q1
DK	7.h	1	239	IE_7.h_Q1 DK_7.h_Q1
DK	8.a	1	271	IE_8.a_Q1 DK_8.a_Q1
IE	7.b	1	95	IE_7.j_Q1
IE	7.b	4	29	IE_7.h_Q4
IE	7.g	4	1	IE_7.h_Q3 IE_7.h_Q4
IE	7.h	1	188	IE_7.h_Q1 DK_7.h_Q1
IE	7.h	3	95	IE_7.h_Q3
IE	7.h	4	2678	IE_7.h_Q4
IE	7.j	1	33	IE_7.j_Q1
IE	8.a	1	7357	IE_8.a_Q1 DK_8.a_Q1
IE	8.a	3	50	IE_8.a_Q3
IE	8.a	4	3135	IE_8.a_Q4
IE	8.d	1	915	IE_8.d_Q1
NL	7.b	1	65	IE_7.j_Q1
NL	7.b	2	0.42	IE_7.j_Q1
NL	7.b	3	53	IE_7.j_Q1
NL	7.c	4	20	IE_7.h_Q4
NL	7.e	1	0.08	IE_8.a_Q1 IE_7.h_Q1 DK_7.h_Q1 DK_8.a_Q1
NL	7.j	1	0.01	IE_7.j_Q1
NL	7.j	2	1	IE_7.j_Q1
NL	7.j	3	8	IE_7.h_Q3 IE_7.h_Q4
UKE	7.f	2	0.02	IE_7.j_Q1 IE_7.h_Q1 IE_7.h_Q3 DK_7.h_Q1
UKE	7.g	2	0.02	IE_7.j_Q1 IE_7.h_Q1 IE_7.h_Q3 DK_7.h_Q1
UKE	7.h	2	0.09	IE_7.h_Q1 IE_7.h_Q3 DK_7.h_Q1

Table 3.2.1.4. Boarfish in ICES Subareas 27.6, 7, 8. Catch per country and corresponding number of samples collected in 2017.

Country	Official.catch	%.landings.covered	No.samples	No.measured	No.aged
DK	548		4	374	
ES	640				
IE	15631		14	766	
NL	182				
UKE	386				
UKS	1				
Total					

Table 3.2.1.5. Boarfish in ICES Subareas 27.6, 7, 8. Catch per area and corresponding number of samples collected in 2017.

Area	Official.catch	No.samples	No.measured	No.measured.per.1000t
27.4.a	0.03			
27.6.a	980			
27.6.b	5			
27.7.b	276			
27.7.c	81			
27.7.d	1			
27.7.e	371			
27.7.f	2			
27.7.g	4			
27.7.h	3363	7	452	134
27.8.a	10814	9	595	55
27.8.b	6			
27.8.c	208			
27.8.d	915	1	24	26
27.7.j	361	1	69	191
27.7.k	1			

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 2007–2017

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1			1575	2415		28	301		5556	218	1862
2	352	5488	15043	11229	2894	893	7148	695	116135	2385	4387
3	2114	21140	65744	72709	41913	5467	156680	49503	32248	10737	8830
4	40851	105575	338931	294382	28148	41278	58522	127520	16588	25114	34448
5	48915	141300	475619	567689	30116	110272	59797	93705	24564	20263	27266
6	62713	195339	543707	878363	175696	146582	68949	67275	26566	18025	21103
7	26132	104031	307333	522703	143967	492078	302967	193061	74115	61229	55189
8	29766	66570	172783	293719	107126	365840	250341	139124	52052	47573	38229
9	56075	53159	155477	276672	77861	271916	212318	121042	44615	42478	32258
10	44875	46893	130148	232122	60022	173486	160137	94225	34264	35150	25716
11	14019	15289	42521	78588	46079	69396	63025	36078	12999	13297	9560
12	32359	21178	61350	114600	40468	40968	41490	24895	9114	9132	7564
13	4848	11854	39609	59932	24352	58888	59380	36309	13362	13774	10922
14	16837	13570	31569	59060	19724	30277	30355	19064	7152	6682	5924
15+	109481	112947	196967	349320	157707	217260	239366	150688	59139	49589	40797

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 2007–2017.

TL (cm)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
4.5									14			14
5									878			878
5.5									515			515
6				156					810		765	1731
6.5				439					14		4607	5060
7				1090	522	56	52		513	417	5250	7900
7.5			1354	1574			551		10598	1684	12616	28377
8			677	375	1345	185	1419		80716	8685	11473	104875
8.5				1082		555	3592	1064	49508	6412	10115	72328
9			677	5382	851	555	7263	327	10219	7104	3874	36252
9.5		7473	17367	7883	7012	641	47509	4916	213	23065	14047	130126
10	9609	11209	54130	29410	33243	2791	94702	31649	1211	46010	32346	346310
10.5		52308	174796	130889	15848	6132	59833	71344	3865	39071	36242	590328
11	84555	63517	343283	361774	70615	24571	18359	108261	12226	14181	32445	1133787
11.5		59781	321637	655875	93487	81928	20938	82470	28142	18249	31589	1394096
12	44199	119561	297737	739025	189434	264888	98564	84288	41613	30975	33618	1943902
12.5		70990	207739	564347	114904	398772	204868	112826	42461	51110	41650	1809667
13	82633	52308	147965	353484	133539	419060	315063	172416	59990	57000	46495	1839953
13.5		29890	149314	246146	51235	307533	285688	153742	52625	58696	43121	1377990
14	117224	22418	105782	224611	50857	176710	210137	138549	50139	76872	45353	1218652
14.5		14945	71273	127711	25309	89726	105571	74059	28771	37755	39524	614644
15	65338	33627	47816	125463	25569	52791	62175	43347	16087	23137	21854	517204
15.5		11209	13082	81386	5473	25065	31122	22629	8572	7841	4932	211311
16	13452	11209	19397	24256	4181	13149	14990	7672	4331	625	1020	114282
16.5		3736	4061	6209	2280	2738	4918	2134	2081	128		28285
17		3736	677	1913	456	827	1109	1361	289			10368
17.5							407		23			430
18				283			296					579

TL (cm)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
18.5							592					592

Table 3.3.1.1. Boarfish in ICES Subareas 27.6. 7, 8. Acoustic survey abundance and biomass estimates from 2011–2018

	Abundance							
Age.(Yrs)	2011	2012	2013	2014	2015	2016	2017	2018
0	-	-	-	-	-	-	-	-
1	5	21.5	-	-	198.5	4.6	110.9	76.7
2	11.6	10.8	78	-	319.2	35.7	126.7	31.2
3	57.8	174.1	1842.9	15	16.6	45.5	344.6	115
4	187.4	64.8	696.4	98.2	34.3	43.6	367.3	68.3
5	436.7	95	381.6	102.3	80	6	156	106.7
6	1165.9	736.1	253.8	104.9	112	10	209	165.9
7	1184.2	973.8	1056.6	414.6	437.4	169	493.1	320.7
8	703.6	758.9	879.4	343.8	362.9	112.6	468.3	197.7
9	1094.5	848.6	800.9	341.9	353.5	117.6	397.2	293.4
10	1031.5	955.9	703.8	332.3	360	96.6	285.8	624.7
11	332.9	650.9	263.7	129.9	131.7	17	120.9	339.2
12	653.3	1099.7	202.9	104.9	113	32	82.1	264.1
13	336	857.2	296.6	166.4	174	48.7	74.4	198.4
14	385	655.8	169.8	88.5	108	18.3	220.4	116.5
15+	3519	6353.7	1464.3	855.1	1195	400.1	931	302.4
TSN ('000)	11104	14257	9091	3098	3996	1157	4387	3221
TSB (t)	670176	863446	439890	187779	232634	69690	230062	186252
SSB (t)	669392	861544	423158	187654	226659	69103		184624
CV	21.2	10.6	17.5	15.1	17	16.4	21.9	19.9

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

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SURVEY	YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.MATURE	TOTAL	TOTAL.MATURE
EVHOE	1997		5	11	7	17	197	2659	5020	3719	3598	4429	12065	16651	7198	3455	501	18	1			12	13	59548	47915
EVHOE	1998		1	4	26	76	2093	18283	8631	6125	5966	7095	11730	14078	9260	5076	934	8			1	11	13	89387	54148
EVHOE	1999			13	52	33	245	11177	26610	23947	6684	2899	4709	7868	6160	1353	267	7				10	12	92023	29947
EVHOE	2000		17	79	120	8	1504	26894	17674	9836	21967	16382	29585	36853	16522	5397	989	75				11	12	183903	127769
EVHOE	2001		1	45	687	489	913	21297	37171	13276	28355	31514	18309	12232	6471	3186	1270	81	4			10	12	175303	101422
EVHOE	2002		2	18	23	11	547	9631	29874	17777	13290	9470	9697	9751	6268	2484	641	37	1	1		10	12	109522	51639
EVHOE	2003			17	47	17	57	426	1655	7142	20018	24842	20989	21263	14494	7086	1550	36				12	12	119639	110277
EVHOE	2004			33	512	378	123	1248	1419	1307	1083	3102	7308	7224	6353	7866	3630	241	5			13	14	41833	36813
EVHOE	2005		2	93	975	1285	146	1100	2326	1229	1553	3183	13398	15758	9834	6010	1658	117	70			12	13	58738	51580
EVHOE	2006	1	26	112	79	75	15510	37566	10750	3622	2127	1521	1955	4131	3955	2535	921	94	2	12		8	13	84994	17253
EVHOE	2007		8	187	467	234	1503	22689	126065	64536	6341	6731	5431	6004	5911	4238	1409	118	11			9	12	251882	36193
EVHOE	2008		3	434	2807	827	5341	53189	247296	165392	163200	69382	38434	18390	17258	9178	3490	745	6	1		9	11	795371	320083
EVHOE	2009		6	128	194	72	1496	19769	35819	5264	3913	9556	12269	9402	10831	6720	775	38	1			10	13	116252	53505
EVHOE	2010		21	529	116	154	5755	46438	74986	27175	11952	37420	58313	34737	33774	14626	1561	249	8	1		10	12	347814	192641
EVHOE	2011		60	95	215	5	541	2247	8368	15256	33221	30237	50384	56559	36673	11867	3082	573	159	47		12	12	249590	222803
EVHOE	2012		9	145	584	137	2922	28865	26816	6124	11739	13606	22369	37135	44082	19963	4893	127	1			11	13	219516	153914
EVHOE	2013		3	48	91	10	306	2185	2165	2542	13649	9932	14987	37755	40524	20107	6918	666		2		13	13	151890	144540
EVHOE	2014		2	693	1386	508	84	1440	885	3074	8732	28586	39397	74122	69736	26871	3908	59	433			13	13	259915	251844
EVHOE	2015		5	183	5898	4143	607	19075	179269	119004	15765	18014	61575	62024	59904	21525	5487	541	429	8		10	13	573455	245271
EVHOE	2016	5	31	379	846	115	733	10284	14280	17251	42132	25304	68583	130633	131220	48538	11611	1358	26			13	13	503329	459405
EVHO	201		2	103	129	3	27	269	198	5												6		735	

SURVEY	YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.MATURE	TOTAL	TOTAL.MATURE
E	7																								
IGFS	2003		1	32	22	7	22	129	172	879	2942	2322	1326	3822	4628	2898	896	163	38			13	13	20299	19035
IGFS	2004		23	63	34	8	96	532	1431	369	344	410	2253	4320	4698	3966	1017	87	2	1		13	14	19654	17098
IGFS	2005		8	59	52	20	203	1024	585	288	636	341	3463	11457	11348	7955	1744	382	2	0.97		13	14	39569	37330
IGFS	2006	5	60	68	48	35	212	969	621	2046	4190	8044	7946	24208	42119	32168	12296	2454	532			14	14	138021	133957
IGFS	2007	1	6	44	18	31	501	923	1251	1638	1166	2510	3581	8275	10740	7093	1934	92				13	14	39804	35391
IGFS	2008			26	18	23	127	672	531	2095	13780	17664	19268	16980	19484	15953	8789	1747	76	1		13	13	117231	113741
IGFS	2009		3	80	76	25	94	228	486	1000	1139	9081	7749	5138	6921	5592	1084	68	1			12	13	38763	36772
IGFS	2010		6	42	3	18	199	272	463	920	393	7914	34236	28611	16063	8161	1974	433				13	13	99709	97784
IGFS	2011		6	14	5	4	189	772	586	555	670	2578	20171	22082	10829	5298	2207	266	9	6		13	13	66247	64116
IGFS	2012		7	36	20	10	131	271	378	702	2144	1183	11105	34010	22742	10906	3903	525	4			13	13	88077	86521
IGFS	2013	1	3	9	9	20	127	352	340	1320	2833	3971	15572	51637	52868	20485	6560	492	20			14	14	156620	154439
IGFS	2014		10	68	54	4	18	13	25	60	130	1127	3251	19125	23016	10355	2988	284	18			14	14	60547	60295
IGFS	2015		3	11	16	24	193	1008	3708	848	105	713	6314	29727	48221	33024	17350	1885	531			14	14	143681	137870
IGFS	2016	4	31	121	63	7	67	186	1515	4057	2891	1349	4110	32753	57753	40907	15527	3670	86			14	14	165097	159046
IGFS	2017		6	53	10169	689915	6406	1751	715	11818	21886	10164	11841	25588	42311	35049	17110	3299	369			7	14	888449	167616
SPNGFS	1991		1			31	690	1311	313	49	9	6	7	7	4				6			7	13	2433	39
SPNGFS	1992		57	38	9	178	3290	2743	282	48	10	8	69	162	390	779	246	95				8	15	8404	1760
SPNGFS	1993		57	1206	488	97	3730	3753	421	105	54	7	4	8	3	2						6	11	9934	77
SPNGFS	1994	1	40	33		342	4789	10162	8920	3195	53	106	20	9	12	1						7	11	27685	202
SPNGFS	1995		84	108	4	342	3063	2157	220	84	65	58	105	105	90	20	4					7	12	6510	447
SPNGFS	1996		218	537	143	245	4457	4449	267	820	722	82	145	126	219	96	39	2				7	12	12566	1431
SPNG	199	2	10	809	441	235	3458	6824	2189	1923	534	156	353	161	88	3						7	11	1727	1295

Survey	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.mature	Total	Total.mature
FS	7		2																					7	
SPNGFS	1998	3	2	7	4	49	1920	4685	1815	337	153	125	88	147	135	86	13	2	3			8	12	9573	752
SPNGFS	1999		6	59	13	134	2736	3010	193	106	83	109	143	390	645	402	69					8	14	8098	1841
SPNGFS	2000		7	3729	2046	17	554	1947	489	277	486	756	1252	999	1021	199	34	13				7	12	13827	4760
SPNGFS	2001		68	4	1	153	3241	5085	659	225	206	205	236	692	407	120	22	9				8	13	11331	1896
SPNGFS	2002		4	20		133	2333	2013	284	50	58	54	60	231	314	72	9					8	13	5634	798
SPNGFS	2003		4	950	567	4	77	221	57	39	28	16	22	17	23	16	5	1				5	12	2047	128
SPNGFS	2004		6	22	4	43	2289	3808	443	110	83	58	219	931	776	303	2	1				8	13	9097	2372
SPNGFS	2005		16	451	25	9	754	1007	207	85	102	30	54	257	218	90	44	2				8	13	3349	797
SPNGFS	2006		14	156	160	50	2238	8913	4507	175	94	9	36	229	419	169	9	2				7	14	17181	968
SPNGFS	2007		49	40	1	111	3025	6620	1099	129	260	81	7	93	215	89	21	3				7	12	11843	768
SPNGFS	2008	7	4	92	247	1	936	1561	1326	234	1483	304	537	11	833	201	186	11				9	12	7974	3566
SPNGFS	2009	1	17	53	125	9	2582	3816	4105	119	250	45	142	59	819	120	17	1	1			8	13	12283	1456
SPNGFS	2010		55	102	5	232	13090	22032	3169	1160	1056	89	82	179	1007	1981	518	9				8	14	44766	4920
SPNGFS	2011		29	260	105	46	2805	5511	1278	148	340	145	100	144	591	724	134	3	1			8	14	12364	2182
SPNGFS	2012		29	132	35	556	7550	7844	1364	88	53	59	170	1051	2394	1553	432	21				8	14	23331	5734
SPNGFS	2013			2	11	126	2163	4664	854	302	609	251	61	110	123	140	64	7				8	12	9486	1364
SPNGFS	2014		75	117	6	12	263	465	79	1083	1175	1174	1266	998	2444	3623	817	31	1			12	13	13630	11530
SPNGFS	2015		13	67	3	58	1889	4248	534	75	465	750	970	695	1173	1473	453	70	1			10	13	12937	6050
SPNGFS	2016		0.16	0.85	0.04	0.39	9	24	4	9	7	3	6	5	6	2	0.25	0.03				9	12	77	29
SPNGFS	2017	0.01	0.2	0.18	0.01	0.14	6	18	7	1	2	3	4	6	10	9	2	0.11	0.03			10	14	67	34
SPPGFS	2001		2		2	2	4		88	10	104	266	323	1334	2259	460	81					13	14	4934	4827
SPPGF	200									1	4	90	212	791	843	313	60					14	14	2314	2313

SURVEY	YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.MATURE	TOTAL	TOTAL.MATURE
S	2																								
SPPGFS	2003						1		3	15	22	21	62	268	426	249	51	2	1			14	14	1121	1102
SPPGFS	2004		1				5	2		4	5	18	100	312	483	319	43	1				14	14	1293	1281
SPPGFS	2005		1		1	6	1	18	10	9	14	7	101	530	935	705	226	18				14	14	2581	2536
SPPGFS	2006			1	1	6	91	89	21	34	75	27	45	335	670	555	197	10	1			13	14	2158	1914
SPPGFS	2007					3	4	9	15	12	9	27	25	72	151	144	26	4				13	14	501	458
SPPGFS	2008		1				1	13	7	16	13	55	106	237	457	302	78	5				14	14	1292	1254
SPPGFS	2009		6	5		2	7	8	1		1	154	318	924	1201	1172	324	7				14	14	4130	4101
SPPGFS	2010	1			1	5	14	3	1	5	2	31	284	521	717	459	123	10				14	14	2178	2148
SPPGFS	2011								3	16	18	5	147	671	792	429	122	13		2		14	14	2220	2200
SPPGFS	2012				1	1			2	2	1	8	70	369	468	218	66	3				14	14	1208	1202
SPPGFS	2013				1		7	22	6	9		1	42	435	889	480	141	12	1			14	14	2045	2000
SPPGFS	2014		10	9		1		3	17	62	11	6	85	2453	6703	3168	2115	162	82			14	14	14889	14787
SPPGFS	2015				2	1			1	1			32	300	471	316	151	43				14	14	1318	1313
SPPGFS	2016			0.04				0.02		0.16	0.06		0.1	2	4	3	1	0.25				14	14	11	11
SPPGFS	2017		1	0.35				0.2			0.02	0.35	0.52	3	10	10	5	0.33				14	15	31	29
WCSGFS	1986								0.5													8			
WCSGFS	1987								0.5	0.5	2	0.5										10	10	4	2
WCSGFS	1988				0.5																	4			
WCSGFS	1989							0.5														7			
WCSGFS	1990				1		0.5	1	2	24	54	50	43	12	1							11	11	188	160
WCSGFS	1991						1	0.5	8	38	183	266	316	48	16							11	11	876	829
WCSG	199						1		10	38	468	1145	4001	1626	486							12	12	7775	7726

Survey	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.mature	Total	Total.mature
FS	2																								
WCSGFS	1993							4		2	9	60	155	72	16		0.5					12	12	319	312
WCSGFS	1994									0.5	0.5	0.5			0.5							11	12	2	2
WCSGFS	1995									8	36	194	294	398	199	22						12	12	1150	1142
WCSGFS	1996				2		4	3				1	55	610	1574	304						14	14	2552	2544
WCSGFS	1997			4			0.5	6	9	4	6	25	108	203	157	40	4					13	13	568	544
WCSGFS	1998				1		1	5	2		1	2		3								9	12	15	6
WCSGFS	1999			1			2	5	1	1		1	2	1								8	12	14	4
WCSGFS	2000							2	2	39	110	216	288	182	92	46	6					12	12	983	940
WCSGFS	2001		1						1	4	15	28	59	134	240	103	10	4				14	14	599	593
WCSGFS	2002						1	8	2	1	82	742	3211	5601	5772	1497	167	1				13	13	17084	17072
WCSGFS	2003			1				3	52		53	281	1473	3066	4895	3083	309	28				14	14	13244	13188
WCSGFS	2004				1			2	2	43	82	743	4569	8600	9514	5692	948	84				14	14	30280	30232
WCSGFS	2005		2					24	3	23	25	110	435	1085	1708	792	130	6				14	14	4343	4291
WCSGFS	2006		1	2	1		1	4		10	218	232	452	1396	2852	2051	434	72				14	14	7726	7706
WCSGFS	2007			2	2		2	1	3	21	159	780	2923	5194	6888	5283	1523	116				14	14	22897	22866
WCSGFS	2008		1	1			16	37	36	187	468	1395	3213	9893	22758	18399	6288	575	71			14	14	63338	63060
WCSGFS	2009			1			1		4	52	2442	2093	440	331	287	246	129	10				11	11	6038	5978
WCSGFS	2010											530	1443	1384	1357	828	149	29				13	13	5720	5720
WCSGFS	2011		1	4	1		1	5	254	1015	2034	7613	18918	14478	6445	2006	236	23				12	12	53034	51753
WCSGFS	2012			1			1	2		103	9	1267	6545	26337	29361	27333	15857	1505	496			14	14	108817	108710
WCSGFS	2013				1			1			1	143	3201	15282	11288	3934	858	6	1			14	14	34716	34714
WCSG	201		48	457	386	48	3	7	63	21	98	876	1166	3026	3923	1093	1363	111	1			13	14	9558	94553

Survey	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.mature	Total	Total.mature
FS	4												8	7	6	3								7	
WCSGFS	2015			4	18	14	115	102	18	5			30	262	345	220	86	10	1		1	12	14	1230	955
WCSGFS	2016				1	2	49	1413	2439	2065	342	436	4088	24632	33254	14568	3484	508	102			14	14	87383	81414
WCSGFS	2017																								

Table 3.6.1.1. Boarfish in ICES Subareas 27.6, 7, 8. IBTS length-frequency data converted to age-structured index by application of the 2010 common ALK rounded down to 1cm length classes.

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
EVHOE	1997	23	1876	6003	3741	3911	3938	7065	5867	4218	4832	4259	1461	2428	1699	1214	623	1215	159	659	623	848	768	214	325	543	100	158	51	314	416
EVHOE	1998	31	12977	15997	6248	6247	5591	7435	5732	3777	4806	4386	1463	2843	1635	1619	676	1224	232	904	676	965	1042	327	476	752	187	231	93	461	353
EVHOE	1999	65	7576	31223	19915	8732	3499	3308	2715	1905	2720	2357	743	1540	975	893	285	647	62	474	285	477	509	91	246	317	53	61	27	123	197
EVHOE	2000	217	17676	27730	12586	17986	15525	18740	14297	973	11041	9490	3208	5160	3797	2556	1266	2604	253	1384	1266	1782	1538	374	714	1022	198	245	99	491	921
EVHOE	2001	733	14389	41313	20357	25467	21921	16211	9247	4525	4543	3951	1332	2057	1322	1098	578	959	153	684	578	780	710	304	456	508	254	147	129	290	306
EVHOE	2002	43	6719	31728	18455	12784	8389	7115	4767	2851	3429	3018	994	1806	1123	1009	421	796	117	573	421	617	625	192	324	429	128	113	65	227	244
EVHOE	2003	64	509	3993	7348	18371	17276	16113	10798	6270	7620	6852	2267	4294	2501	2456	1009	1838	326	1387	1009	1462	1557	491	763	1104	310	322	155	644	532
EVHOE	2004	545	1265	1976	1261	1722	2227	4124	3228	2061	2871	3058	1066	2426	939	1509	901	917	382	1142	901	1100	1160	817	925	962	726	360	366	715	181
EVHOE	2005	1070	2102	2603	1497	2098	3015	7160	5992	4177	5301	4873	1642	3144	1796	1776	833	1368	285	1065	833	1140	1184	486	639	877	332	308	201	546	394
EVHOE	2006	217	35834	26593	4803	2199	1386	1489	1332	947	1521	1484	485	1170	557	725	311	445	125	464	311	434	496	245	308	373	184	116	93	242	103
EVHOE	2007	661	16818	122140	65369	16986	4919	4316	2967	1715	2452	2392	788	1802	820	1124	484	678	204	715	484	668	778	381	467	594	282	198	146	385	150
EVHOE	2008	3244	41611	258758	168378	134061	77106	37738	18750	8277	9132	8183	2660	4868	2458	2992	1226	1876	492	1919	1226	1765	2062	1064	1237	1523	698	420	352	835	460
EVHOE	2009	327	13338	36829	12194	5626	5982	7788	5443	3054	4443	4230	1364	3079	1382	1965	618	1114	309	1064	618	956	1295	398	493	957	155	306	78	611	235
EVHOE	2010	666	33601	83903	35048	21678	23503	34210	23037	12643	16303	14519	4647	9008	4716	5551	1689	3457	690	2957	1689	2745	3490	920	1368	2435	312	669	160	1331	868
EVHOE	2011	370	2212	12471	14982	28729	26114	31844	23915	15535	19473	16964	5542	10176	6534	5663	2262	4513	597	3197	2262	3408	3486	1077	1762	2339	616	619	388	1126	1414
EVHOE	2012	738	20089	34348	11535	11098	10795	14979	13308	9004	15662	14714	4598	11467	5540	7325	2325	4142	920	4164	2325	3703	4595	1447	2356	3218	979	908	490	1815	928
EVHOE	2013	142	1647	3695	3805	10388	9207	11385	11271	8299	14485	13797	4374	10961	5364	6893	2550	4068	981	4205	2550	3816	4494	1872	2650	3228	1384	914	692	1830	944
EVHOE	2014	2081	1524	2365	3805	12988	17315	27692	24954	17460	27410	25016	7911	18266	9918	11160	3465	7107	1227	5977	3465	5644	6813	1636	2961	4634	782	1438	607	2443	1853
EVHOE	2015	6085	19233	175572	108367	35891	17618	33196	26770	17433	25562	22840	7208	15396	8396	9445	3078	5952	1033	5325	3078	4950	5809	1744	2969	3937	1097	1193	763	1965	1551
EVHOE	2016	1256	7360	21028	18355	32937	28679	43626	41581	30274	49797	45444	14238	33654	17999	20815	6633	12839	2342	11704	6633	10734	12885	3910	6423	8785	2322	2219	1174	4413	3266

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
EVHOE	2017	234	187	263	50	0.91																									
IGFS	2003	55	126	517	930	2306	1858	1433	1244	842	1549	1545	494	1309	576	842	317	467	148	527	317	461	585	287	324	441	179	151	109	263	96
IGFS	2004	120	418	1422	594	396	484	1303	1341	993	1713	1773	589	1491	618	948	390	543	189	584	390	537	672	317	350	525	203	181	103	362	108
IGFS	2005	119	814	982	379	542	665	2302	2884	2364	4129	4140	1360	3431	1569	2142	822	1289	400	1283	822	1177	1509	689	703	1154	349	363	175	724	286
IGFS	2006	176	849	1572	1988	4719	5051	6885	7522	5179	12177	13018	4151	12178	4448	8189	3297	3989	1708	5570	3297	4613	6048	3673	3775	4731	2459	1728	1496	2924	605
IGFS	2007	68	1052	1866	1385	1605	1648	2625	2628	1855	3547	3577	1145	3059	1292	1987	723	1072	332	1196	723	1058	1335	553	722	999	387	322	193	645	207
IGFS	2008	44	588	1709	3445	12363	12597	13266	9219	5227	7773	7797	2576	6069	2491	3886	2028	2183	900	2996	2028	2637	3017	2303	2367	2408	1758	763	917	1451	424
IGFS	2009	158	267	776	1077	3174	4543	5513	3620	1839	2701	2706	886	2101	818	1373	491	727	261	802	491	707	954	390	433	738	217	255	109	508	128
IGFS	2010	51	374	747	902	3021	6590	17250	13258	8630	10098	8924	3002	5053	3150	2750	1284	2303	414	1616	1284	1786	1832	742	897	1331	395	371	197	742	715
IGFS	2011	25	641	951	598	1500	3223	10092	8433	5965	6989	6169	2095	3519	2333	1835	1014	1683	267	1165	1014	1352	1212	568	780	873	441	245	225	488	552
IGFS	2012	64	302	673	754	1774	2197	7201	8421	7104	10272	9476	3134	6741	3972	3834	1736	2907	548	2360	1736	2447	2518	1096	1491	1807	781	498	392	991	850
IGFS	2013	21	373	862	1243	3026	3903	10918	13284	10690	18929	17531	5483	13636	7177	8471	2878	5165	980	4941	2878	4530	5265	1784	2964	3613	1312	941	666	1862	1291
IGFS	2014	132	28	47	90	423	794	2958	4429	3697	7450	7127	2213	5965	2873	3818	1248	2146	499	2236	1248	1967	2437	883	1317	1717	598	480	308	941	478
IGFS	2015	30	815	3472	1377	516	943	4845	7454	5858	14016	14639	4623	13524	5243	9030	3979	4494	1690	6438	3979	5486	6393	3990	4977	4886	3470	1767	2001	3002	743
IGFS	2016	215	282	2400	2888	2682	1761	4458	7773	6173	16077	17088	5386	16240	6066	10938	4231	5302	2226	7389	4231	6036	8062	4880	4910	6258	3105	1902	1595	3719	819
IGFS	2017	10228	696697	6080	9322	16417	11347	9585	8818	5853	12738	13721	4436	12670	4564	8475	3944	4195	1923	6278	3944	5266	6490	4624	4744	5168	3422	1778	1896	3186	640
SPNGFS	1991	1	1402	881	102	15	6	5	3	2	2	2	0.62	0.98	0.78	0.5	0.18	0.48		0.25	0.18	0.3	0.25		0.12	0.12		3	3		0.18
SPNGFS	1992	104	4609	1830	95	17	13	41	53	35	103	156	57	175	37	120	64	56	45	94	64	76	114	98	61	102	49	35	25	71	4
SPNGFS	1993	1751	5508	2424	163	49	18	5	3	2	2	2	0.64	1	0.75	0.56	0.28	0.56	0.09	0.28	0.28	0.37	0.37	0.09	0.09	0.28		0.09		0.18	0.19
SPNGFS	1994	73	10576	12411	3845	643	57	35	17	5	5	4	1	3	1	2	0.27	0.88	0.05	0.82	0.27	0.66	0.87	0.05	0.39	0.48		0.05		0.09	0.22
SPNGFS	1995	196	4231	1526	107	66	51	64	48	30	41	35	11	22	13	13	4	9	0.9	7	4	7	7	1	4	5	0.83	0.9	0.41	2	3
SPN	19	89	670	290	584	553	254	109	66	38	72	67	20	53	23	36	11	17	5	22	11	18	23	9	15	16	8	4	4	9	3

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
GFS	96	7	7	8																											
SPNGFS	1997	1351	7306	5446	1609	681	249	203	121	67	69	56	18	22	18	11	4	11	0.14	6	4	7	6	0.14	3	3		0.14		0.27	4
SPNGFS	1998	13	4493	3640	638	175	101	79	58	37	54	53	17	40	19	25	9	15	4	14	9	13	17	6	7	12	3	5	3	8	4
SPNGFS	1999	79	4258	1802	116	93	80	112	121	85	191	195	61	175	70	117	35	58	18	65	35	55	77	25	34	57	14	18	7	37	10
SPNGFS	2000	5782	1661	1325	347	518	553	750	537	315	443	379	116	237	139	146	37	91	10	78	37	69	85	18	39	53	7	9	3	18	25
SPNGFS	2001	73	5952	3099	308	205	161	197	190	148	199	175	58	114	77	62	25	53	6	34	25	38	38	11	17	25	4	5	2	11	17
SPNGFS	2002	24	3315	1395	104	54	43	55	63	47	98	88	26	71	37	46	10	25	3	24	10	20	26	4	12	16	2	3	0.91	7	6
SPNGFS	2003	1521	203	155	38	26	16	14	10	5	9	9	3	7	3	4	2	2	0.83	3	2	2	3	2	2	2	1	0.73	0.5	1	0.42
SPNGFS	2004	32	4267	2243	177	82	68	171	219	186	303	279	89	209	118	124	37	85	14	63	37	61	76	14	25	52	0.4	14	0.2	28	23
SPNGFS	2005	492	1253	701	108	78	46	50	60	51	84	78	25	59	33	35	15	24	4	22	15	22	22	9	16	15	9	4	4	8	6
SPNGFS	2006	330	7297	7378	1191	85	34	36	56	44	116	112	33	100	43	68	14	32	8	35	14	27	42	9	15	29	2	8	0.9	15	6
SPNGFS	2007	90	6646	3990	367	180	106	37	30	18	55	54	16	50	20	35	8	15	4	20	8	15	22	7	11	15	4	4	2	8	2
SPNGFS	2008	343	1736	1886	629	908	597	329	178	62	202	183	47	158	53	122	28	36	10	81	28	54	73	32	63	47	37	9	19	18	0.28
SPNGFS	2009	195	4487	5077	1085	168	104	79	71	26	174	155	37	147	56	113	9	34	6	58	9	34	62	8	29	37	3	6	2	11	1
SPNGFS	2010	162	24558	13572	1504	792	346	101	85	41	222	365	132	436	76	306	146	130	91	206	146	178	245	146	135	213	104	90	52	180	4
SPNGFS	2011	393	5730	3656	432	244	163	94	77	38	140	182	61	198	48	140	50	59	33	84	50	68	103	48	45	85	27	33	14	66	4
SPNGFS	2012	196	11653	5359	383	62	55	160	276	202	620	657	201	638	228	441	140	198	73	266	140	215	295	122	161	220	86	71	43	141	26
SPNGFS	2013	13	4763	2947	446	439	276	110	59	30	44	49	17	44	16	28	15	16	7	21	15	19	22	16	17	18	13	6	6	13	3
SPNGFS	2014	198	542	611	767	1131	910	875	626	323	711	914	317	926	228	635	271	291	168	402	271	348	488	259	240	412	163	165	82	329	25
SPNGFS	2015	83	4207	2430	248	463	516	616	432	233	403	463	158	419	125	281	130	138	74	193	130	166	221	140	127	185	91	67	46	134	17
SPNGFS	2016	1	23	17	7	7	4	4	2	1	2	2	0.59	1	0.69	0.85	0.21	0.48	0.08	0.45	0.21	0.39	0.51	0.11	0.23	0.33	0.05	0.07	0.03	0.15	0.11
SPNGFS	2017	0.38	16	14	3	2	2	3	2	1	3	3	1	3	1	2	0.69	0.98	0.4	1	0.69	0.99	1	0.59	0.61	1	0.31	0.41	0.17	0.79	0.14
SPP	20	4	6	73	47	128	163	290	369	271	650	581	165	482	241	324	62	158	21	170	62	133	183	29	87	11	16	21	8	42	33

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
GFS	01																									2					
SPP GFS	2002		0.03	0.39	4	29	57	162	201	161	294	272	84	214	112	134	40	80	14	73	40	66	81	20	38	55	12	14	6	28	20
SPP GFS	2003		1	7	12	21	21	50	69	54	125	126	39	114	47	76	23	38	12	43	23	36	50	17	23	36	10	12	6	23	7
SPP GFS	2004	1	6	3	3	10	19	66	86	65	145	150	47	135	54	89	27	45	15	49	27	42	59	19	24	44	9	15	4	29	8
SPP GFS	2005	2	18	18	9	13	17	81	132	103	263	283	90	269	98	181	68	88	34	115	68	97	126	62	74	97	45	32	23	64	13
SPP GFS	2006	2	137	77	33	53	36	51	84	64	180	200	64	197	67	134	53	63	26	88	53	74	94	49	60	73	39	26	20	50	8
SPP GFS	2007		12	19	12	14	15	22	24	16	41	47	15	47	15	32	11	15	7	19	11	16	23	11	10	19	5	7	3	13	2
SPP GFS	2008	1	9	15	13	25	35	72	79	53	130	135	42	125	46	85	27	40	14	51	27	42	57	23	30	43	16	14	8	27	6
SPP GFS	2009	11	13	5	5	45	91	228	263	197	390	429	143	394	144	257	109	137	54	161	109	146	183	88	102	145	65	53	32	107	23
SPP GFS	2010	1	18	5	4	15	41	156	167	121	236	236	75	201	84	131	46	69	22	79	46	69	89	37	47	66	25	21	12	42	13
SPP GFS	2011		0.43	7	12	17	22	109	159	133	261	256	81	216	100	138	48	78	21	83	48	73	91	37	49	66	24	20	12	41	17
SPP GFS	2012	1	1	2	2	4	10	57	86	72	149	143	44	121	57	78	26	43	10	46	26	40	50	18	28	35	13	10	7	20	9
SPP GFS	2013	1	19	17	6	3	5	49	102	80	235	239	72	226	88	155	47	71	23	93	47	75	101	41	56	74	28	22	15	44	11
SPP GFS	2014	19	5	31	38	21	14	219	597	438	1632	1647	478	1602	603	1126	417	476	160	791	417	626	739	420	633	530	423	185	253	288	61
SPP GFS	2015	2	1	1	0.77	0.83	3	35	67	56	136	142	45	132	52	88	37	44	19	63	37	52	67	47	45	52	30	14	15	29	8
SPP GFS	2016	0.04	0.02	0.05	0.09	0.06	0.03	0.19	0.46	0.36	1	1	0.36	1	0.42	0.79	0.28	0.36	0.15	0.53	0.28	0.42	0.57	0.34	0.35	0.44	0.22	0.13	0.11	0.25	0.05
SPP GFS	2017	2	0.12	0.08	0.01	0.11	0.19	0.5	0.89	0.57	2	3	0.93	3	0.83	2	1	0.92	0.5	2	1	1	2	1	1	1	1	0.47	0.52	0.94	0.07
WCS GFS	1986			0.38	0.12																										
WCS GFS	1987		0.01	0.58	0.64	1	0.76	0.18	0.05	0.01																					
WCS GFS	1988	0.5																													
WCS GFS	1989		0.3	0.2																											
WCS GFS	1990	1	2	10	21	46	39	31	16	7	5	4	1	0.73	0.92	0.12	0.29	0.61		0.06	0.29	0.32	0.06		0.03	0.03					0.29
WCS	19		2	23	52	175	186	194	105	45	36	28	9	5	5	2	1	3		0.9	1	2	0.9		0.	0.					1

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
GFS	91																			7			7		48	48					
WCS GFS	1992		2	33	116	616	975	1952	1270	712	662	524	178	157	152	61	41	96		30	41	56	30		15	15					41
WCS GFS	1993		2	3	4	23	41	80	52	29	26	21	7	6	6	2	2	4		1	2	2	0.97	0.05	0.58	0.48	0.1		0.05		2
WCS GFS	1994		0.01	0.15	0.34	0.48	0.33	0.13	0.06	0.01	0.09	0.08	0.02	0.08	0.03	0.06		0.02		0.03		0.02	0.03		0.02	0.02					
WCS GFS	1995		0.2	3	15	74	113	189	151	103	121	101	33	54	42	27	11	27	0.98	13	11	17	14	0.98	6	8		0.98		2	10
WCS GFS	1996	2	5	2	0.03	1	6	67	153	112	391	353	95	318	144	224	29	93	14	112	29	78	126	14	49	77		14		28	15
WCS GFS	1997	4	4	11	6	12	22	63	62	47	69	60	19	40	25	23	7	17	2	12	7	12	13	2	6	9	0.8	2	0.4	4	5
WCS GFS	1998	1	4	4	0.67	1	1	0.72	0.65	0.56	0.45	0.38	0.15	0.15	0.22		0.08	0.15			0.08	0.08									0.08
WCS GFS	1999	1	5	3	0.8	0.47	0.58	1	0.7	0.4	0.31	0.25	0.09	0.05	0.08		0.02	0.05			0.02	0.02									0.02
WCS GFS	2000		2	16	41	124	142	179	116	65	68	59	20	30	19	16	7	14	2	8	7	10	10	3	4	7	1	2	0.6	4	5
WCS GFS	2001	1	0.11	2	5	17	21	40	44	30	70	67	20	58	25	39	9	19	5	21	9	17	25	7	10	18	2	5	1	9	3
WCS GFS	2002		6	8	35	291	631	1838	1814	1320	2184	1935	594	1386	781	858	225	528	68	446	225	405	497	85	214	317	33	68	17	136	140
WCS GFS	2003	1	2	42	28	127	272	867	971	691	1498	1519	476	1339	536	892	248	446	143	480	248	401	592	182	215	439	62	140	31	280	77
WCS GFS	2004	1	2	16	57	327	770	2590	2686	1983	3447	3359	1079	2693	1240	1707	569	986	267	957	569	866	1129	387	487	832	190	259	95	518	215
WCS GFS	2005	2	15	19	19	53	93	276	325	236	519	501	153	429	188	286	76	144	37	156	76	130	180	51	79	127	26	36	13	72	27
WCS GFS	2006	4	4	12	39	183	196	340	423	294	781	834	261	795	283	543	172	252	100	322	172	261	379	165	176	290	87	93	43	186	35
WCS GFS	2007	4	3	14	56	339	638	1707	1727	1220	2309	2385	775	2056	820	1341	522	715	252	835	522	738	934	439	520	719	305	240	152	480	130
WCS GFS	2008	2	41	110	208	689	989	2324	3054	2082	6013	6662	2108	6560	2164	4517	1712	2042	894	2945	1712	2424	3210	1695	1969	2499	1258	872	664	1673	247
WCS GFS	2009	1	2	100	387	1817	1538	759	363	137	139	136	46	95	43	58	32	37	12	43	32	41	42	28	35	33	26	11	13	22	8
WCS GFS	2010				17	160	347	785	626	398	580	549	179	394	189	245	87	149	41	140	87	130	166	64	72	123	30	38	15	75	35
WCS GFS	2011	6	31	531	1086	3514	5387	10238	7369	4589	4925	4157	1403	2004	1489	988	477	1016	93	520	477	678	590	124	249	388	47	91	24	182	362
WCS GFS	2012	1	5	28	97	469	1148	4804	6462	5298	9990	10765	3610	9632	3810	6155	3487	3477	1393	4814	3487	4404	4621	3430	4089	3703	3171	1491	1834	2485	658
WCS	20	1	0.6	0.43	5	101	381	242	337	300	467	422	136	306	185	176	64	129	17	971	64	999	106	26	52	71	17	17	86	35	38

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
GFS	13							0	8	3	0	8	1	4	2	9	7	6	9		7		4	7	4	2	2	9		8	2
WCS GFS	2014	891	56	60	67	509	1549	6999	8472	6502	12849	11622	3475	9135	4722	5898	1390	3236	508	3097	1390	2616	3468	678	1499	2242	273	497	137	994	757
WCS GFS	2015	22	173	73	7	2	3	31	57	49	106	109	34	97	41	63	25	34	11	41	25	36	44	23	28	33	17	11	9	20	8
WCS GFS	2016	1	945	2978	1730	751	680	3544	5695	4735	10264	9850	3016	8414	3926	5481	1626	2933	713	3140	1626	2666	3504	1214	1736	2465	697	713	399	1324	616
WCS GFS	2017	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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.

	Mean	SD	2.5	25	50	75	97.5
r	3.69e-01	1.91e-01	4.84e-02	2.28e-01	3.55e-01	4.89e-01	7.84e-01
K	6.62e+05	4.17e+05	3.09e+05	4.45e+05	5.50e+05	7.17e+05	1.78e+06
F_{MSY}	1.85e-01	9.53e-02	2.42e-02	1.14e-01	1.78e-01	2.45e-01	3.92e-01
B_{MSY}	1.65e+05	1.04e+05	7.72e+04	1.11e+05	1.38e+05	1.79e+05	4.44e+05
TSB	3.10e+05	1.86e+05	1.47e+05	2.17e+05	2.72e+05	3.49e+05	6.56e+05

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											Ln raised numbers										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	0	0	1575	2415	0	28	301	0	5556	218	1862	0	0	7	8	0	3	6	0	9	5	8
2	352	5488	15043	11229	2894	893	7148	695	116135	2385	4387	6	9	10	9	8	7	9	7	12	8	8
3	2114	21140	65744	72709	41913	5467	156680	49503	32248	10737	8830	8	10	11	11	11	9	12	11	10	9	9
4	40851	105575	338931	294382	28148	41278	58522	127520	16588	25114	34448	11	12	13	13	10	11	11	12	10	10	10
5	48915	141300	475619	567689	30116	110272	59797	93705	24564	20263	27266	11	12	13	13	10	12	11	11	10	10	10
6	62713	195339	543707	878363	175696	146582	68949	67275	26566	18025	21103	11	12	13	14	12	12	11	11	10	10	10
7	26132	104031	307333	522703	143967	492078	302967	193061	74115	61229	55189	10	12	13	13	12	13	13	12	11	11	11
8	29766	66570	172783	293719	107126	365840	250341	139124	52052	47573	38229	10	11	12	13	12	13	12	12	11	11	11
9	56075	53159	155477	276672	77861	271916	212318	121042	44615	42478	32258	11	11	12	13	11	13	12	12	11	11	10
10	44875	46893	130148	232122	60022	173486	160137	94225	34264	35150	25716	11	11	12	12	11	12	12	11	10	10	10
11	14019	15289	42521	78588	46079	69396	63025	36078	12999	13297	9560	10	10	11	11	11	11	11	10	9	9	9
12	32359	21178	61350	114600	40468	40968	41490	24895	9114	9132	7564	10	10	11	12	11	11	11	10	9	9	9
13	4848	11854	39609	59932	24352	58888	59380	36309	13362	13774	10922	8	9	11	11	10	11	11	10	10	10	9
14	16837	13570	31569	59060	19724	30277	30355	19064	7152	6682	5924	10	10	10	11	10	10	10	10	9	9	9
15+	109481	112947	196967	349320	157707	217260	239366	150688	59139	49589	40797	12	12	12	13	12	12	12	12	11	11	11
Z (age 7-14)												0.17	0.33	0.36	0.33	0.29	0.45	0.36	0.37	0.31	0.31	0.33
F (ZM), where 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
Catches (t)												21576	34751	90370	144047	37096	87355	75409	45231	17766	19315	17388
Correlation coefficient landings vs F.												0.46										

Table 3.6.5.1. Boarfish in ICES Subareas 27.6, 7, 8. Estimates of total stock biomass and F. 2018 catch data are not available thus the corresponding F estimate is not available.

YEAR	TSB.2.5	TSB.50	TSB.97.5	F.2.5	F.50	F.97.5
1991	106692	207600	520907			
1992	176295	323600	794332			
1993	227100	411950	987700			
1994	269800	506750	1231000			
1995	218480	405650	981522			
1996	220597	412100	1005000			
1997	198397	355800	867045			
1998	264787	483650	1172025			
1999	197797	356500	866605			
2000	161397	293200	715922			
2001	177900	313800	765800			
2002	156300	276850	668782			
2003	138197	241700	578712	0.00	0.00	0.00
2004	200797	354250	843325	0.00	0.00	0.00
2005	193800	336700	807927	0.02	0.05	0.08
2006	226800	395400	947322	0.01	0.01	0.03
2007	188597	325550	775912	0.01	0.02	0.03
2008	235892	400800	955522	0.01	0.02	0.03
2009	238200	404750	940012	0.03	0.07	0.11
2010	368597	627600	1477000	0.04	0.09	0.15
2011	332500	566200	1355150	0.10	0.22	0.38
2012	494497	811700	1887000	0.10	0.23	0.39
2013	347592	584500	1390075	0.03	0.07	0.11
2014	156700	261350	621905	0.05	0.11	0.18
2015	185597	313200	742927	0.05	0.13	0.22
2016	124400	212700	499207	0.07	0.17	0.29
2017	224695	384250	907027	0.02	0.06	0.10
2018	146800	272500	655515	NA	NA	NA

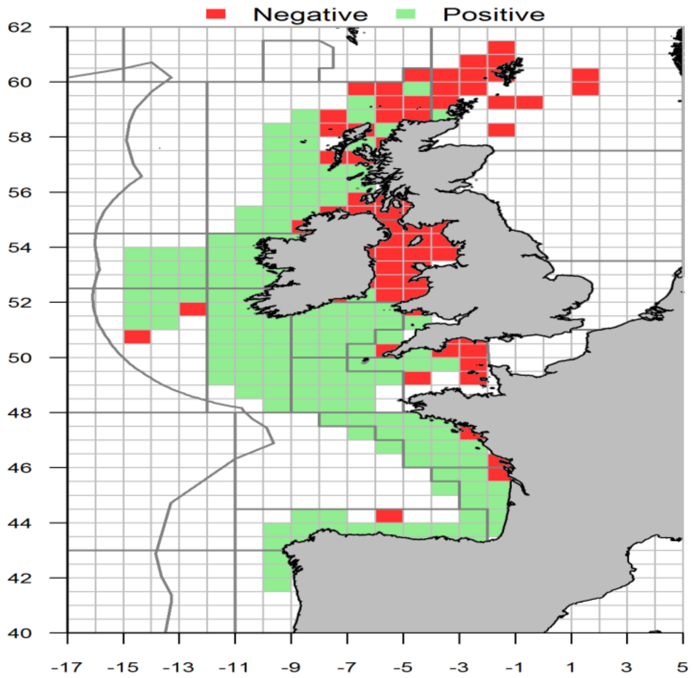


Figure 3.1. Boarfish in ICES Subareas 4, 27.6, 7, 8 and 9. Distribution of boarfish in the NE Atlantic area based on presence and absence in IBTS surveys (all years).

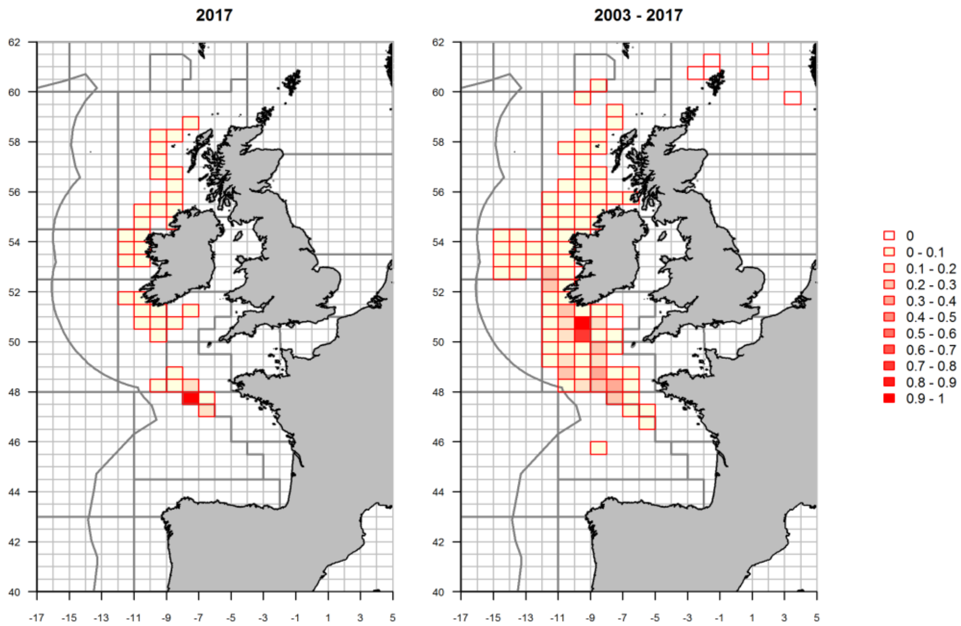


Figure 3.1.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Combined Irish boarfish landings 2003-2017 by ICES rectangle (Above). Irish boarfish landings 2017 by ICES rectangle (Below).

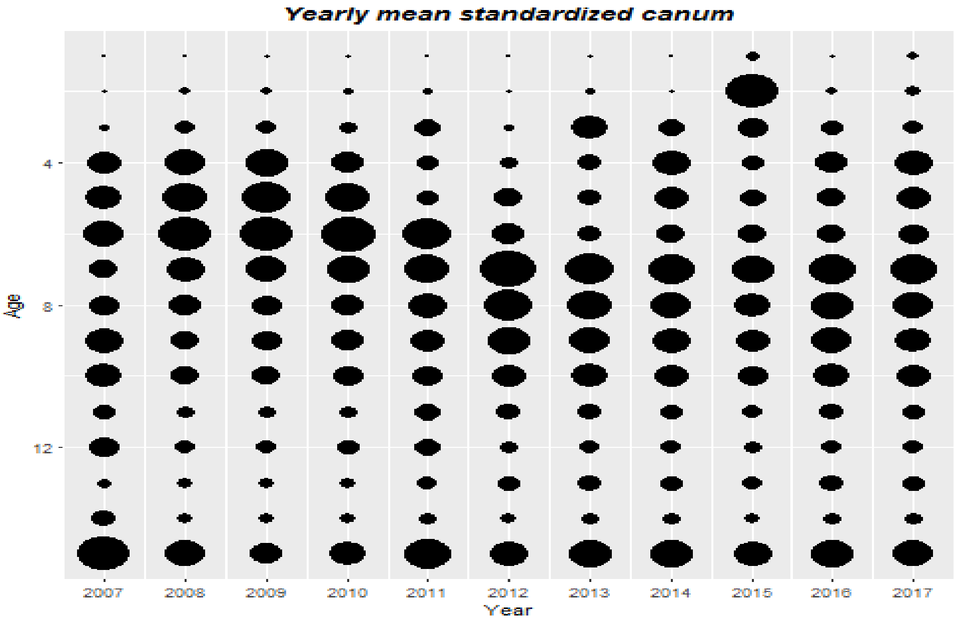


Figure 3.2.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Catch numbers-at-age standardised by yearly mean. 15+ is the plus group.

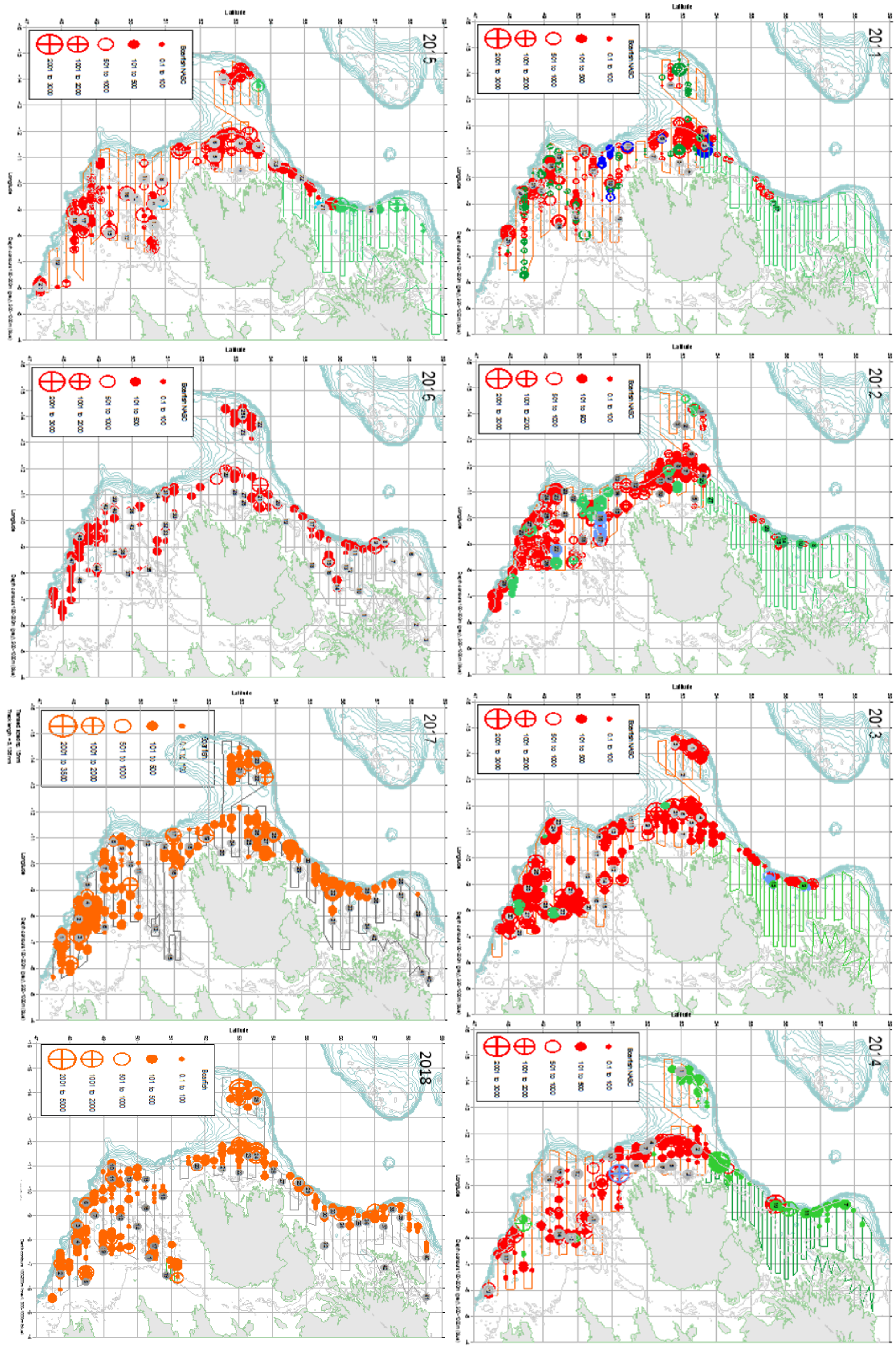


Figure 3.3.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey track and haul positions from acoustic survey 2011-2018. Red circles represent 'definitely' boarfish, green: 'probably boarfish', blue: 'boarfish mix' (all included in the biomass estimate).

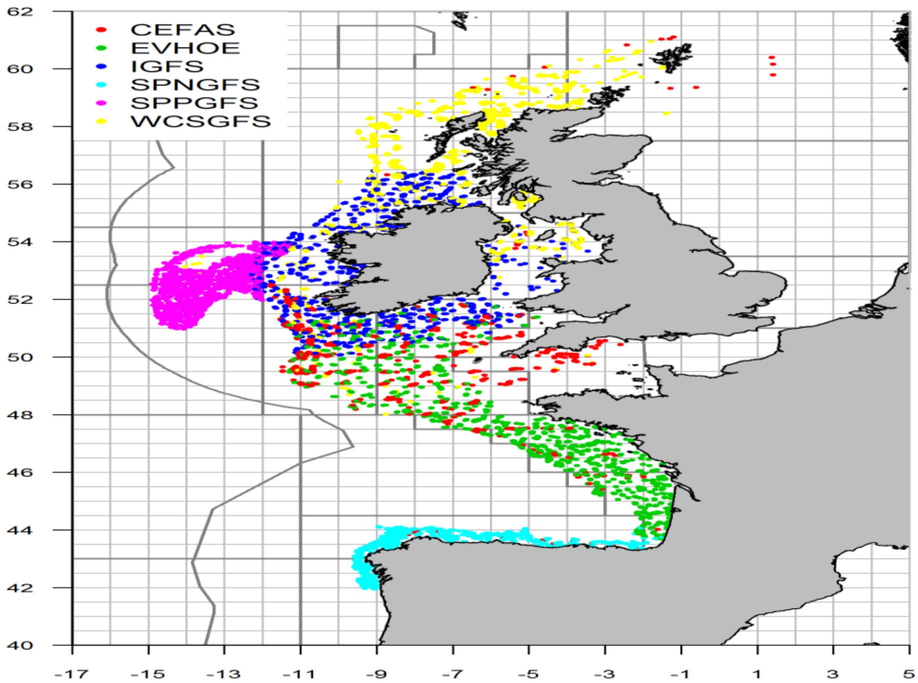


Figure 3.3.2.1. Boarfish in ICES Subareas 27.6, 7, 8. The haul positions of bottom trawl surveys analysed as an index for boarfish abundance. Note the Portuguese Groundfish survey included here was not included in the 2018 assessment.

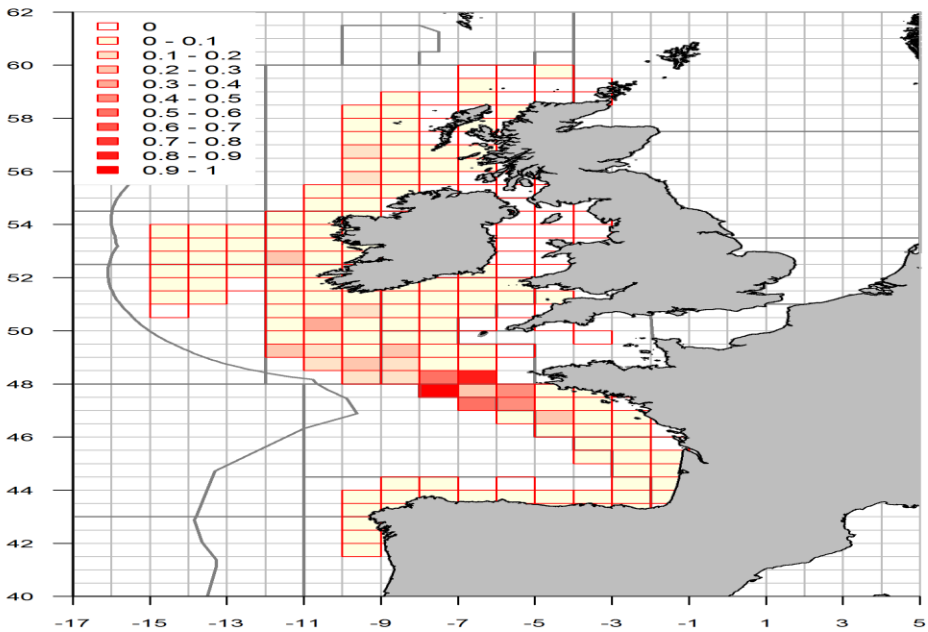


Figure 3.3.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Distribution of boarfish in the NE Atlantic showing proposed management area.

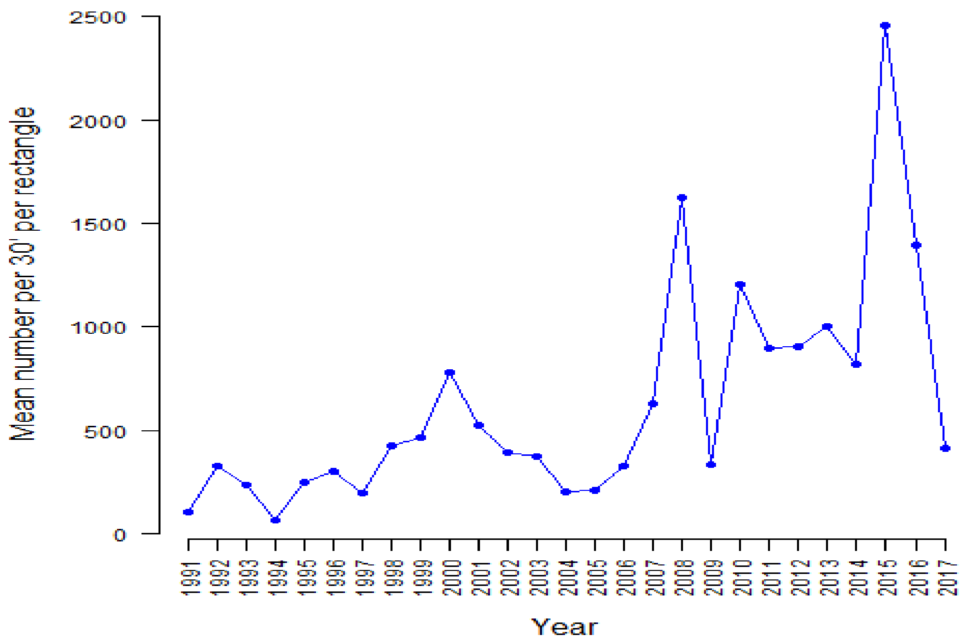


Figure 3.3.2.3. Boarfish in ICES Subareas 27.6, 7, 8. CPUE in number per 30 minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2017.

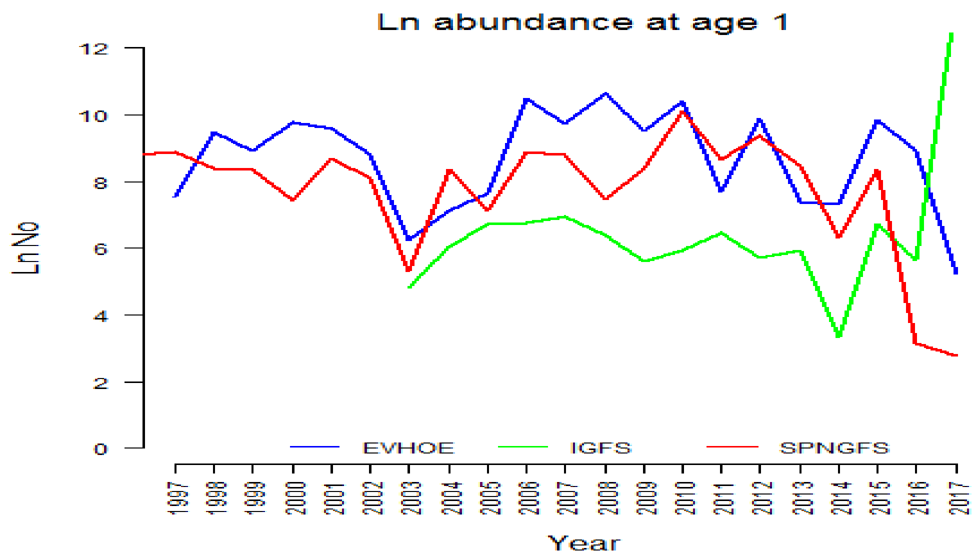


Figure 3.5.1. Boarfish in ICES Subareas 27.6, 7, 8. Recruitment-at-age 1, from various IBTS.

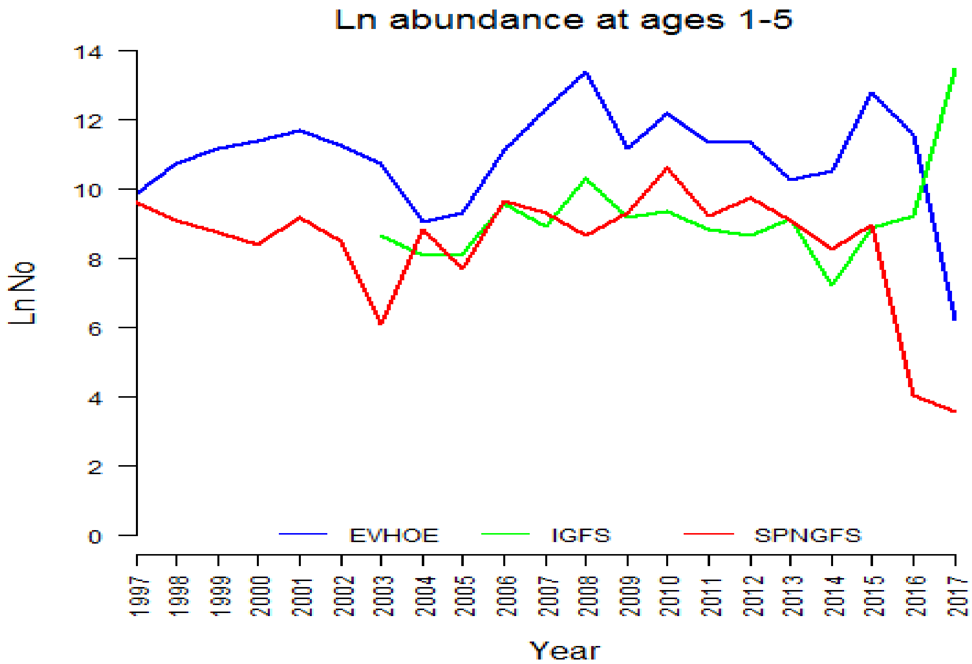


Figure 3.5.2. Boarfish in ICES Subareas 27.6, 7, 8. Recruitment-at-ages 1–5, from various IBTS.

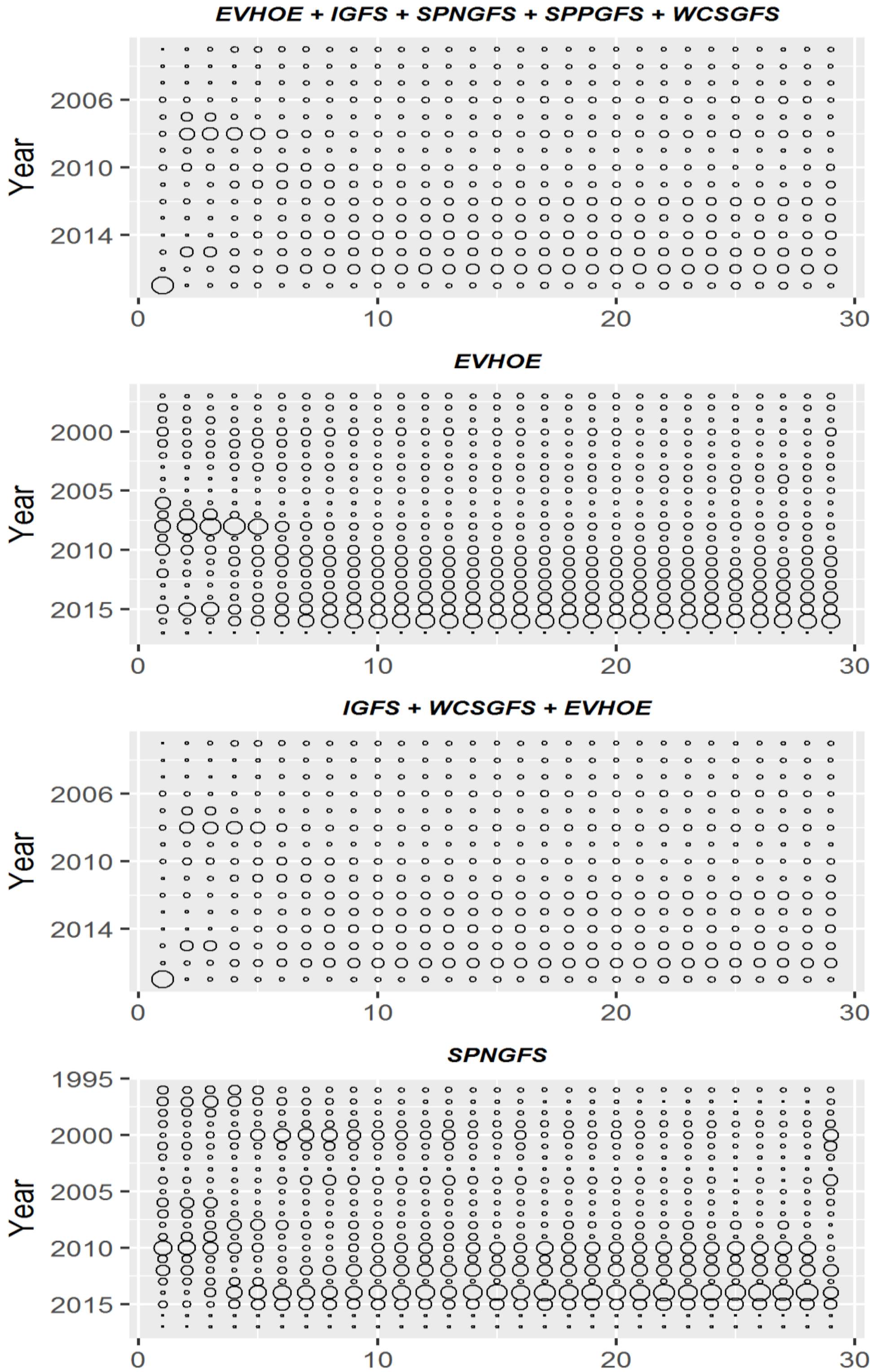


Figure 3.6.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Abundance-at-age in constituent western IBTS. Yearly mean standardised abundance-at-age.

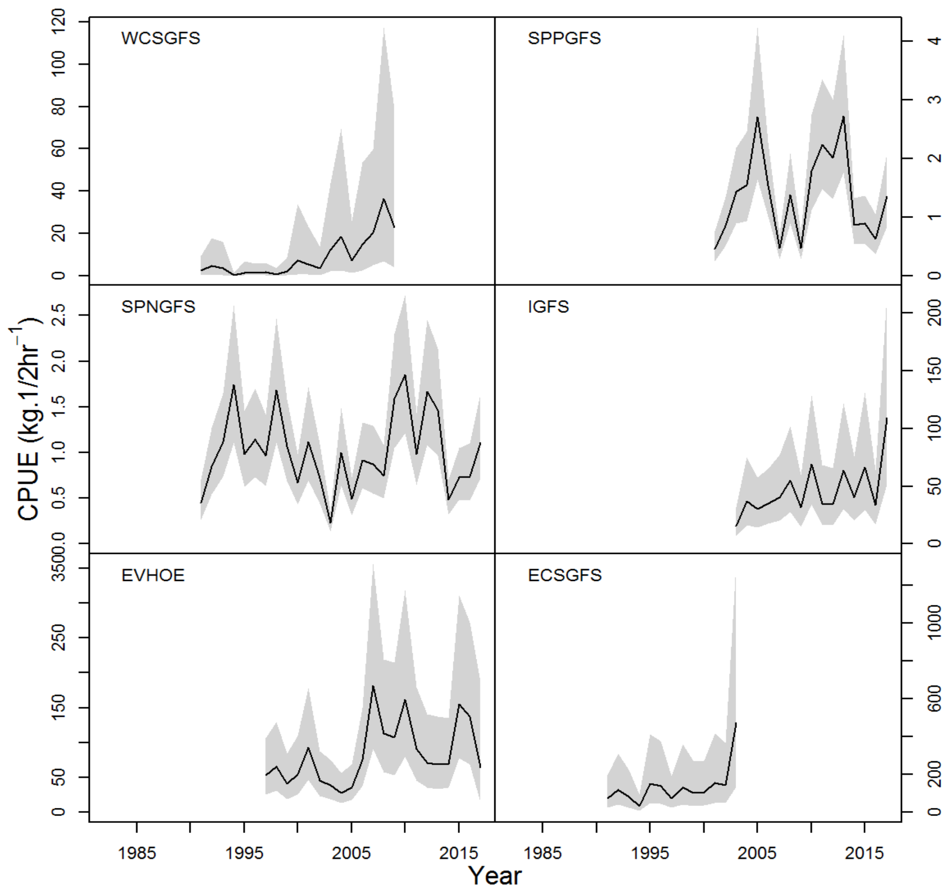


Figure 3.6.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish IBTS survey CPUE fitted delta-lognormal mean (solid line) and 95% credible intervals (grey region).

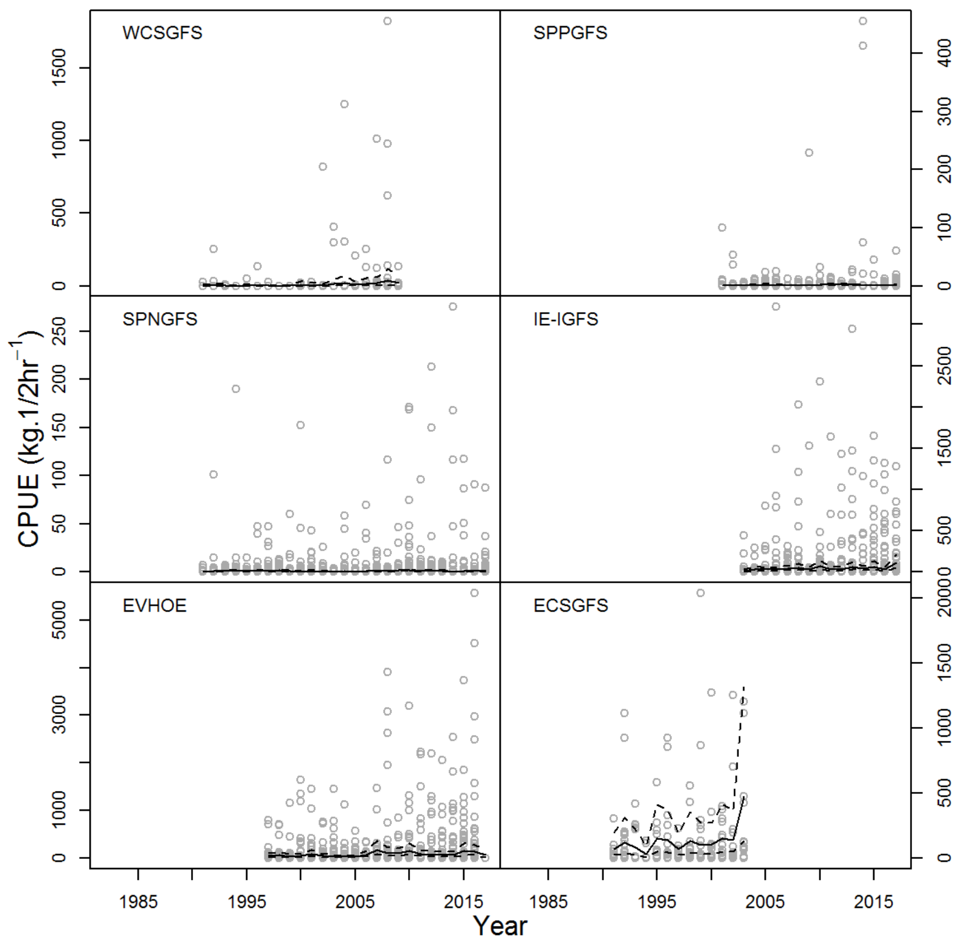


Figure 3.6.1.3. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish IBTS survey CPUE data (grey points) and fitted delta-lognormal mean (solid line) and 95% credible intervals (dashed lines).

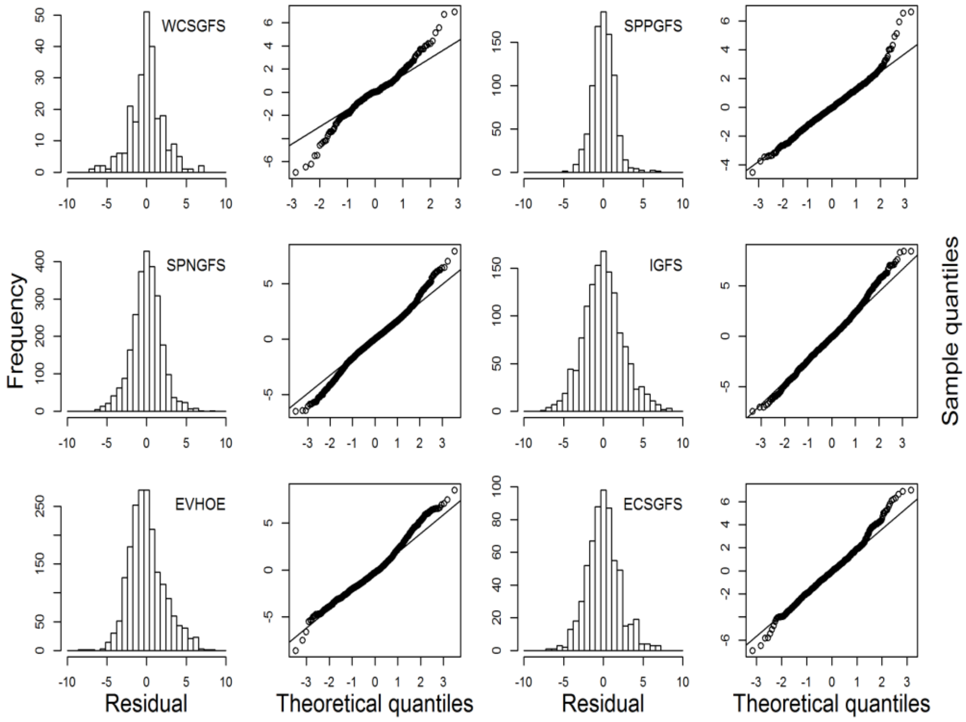


Figure 3.6.1.4. Boarfish in ICES Subareas 27.6, 7, 8. Diagnostics from the positive component of the delta-lognormal fits

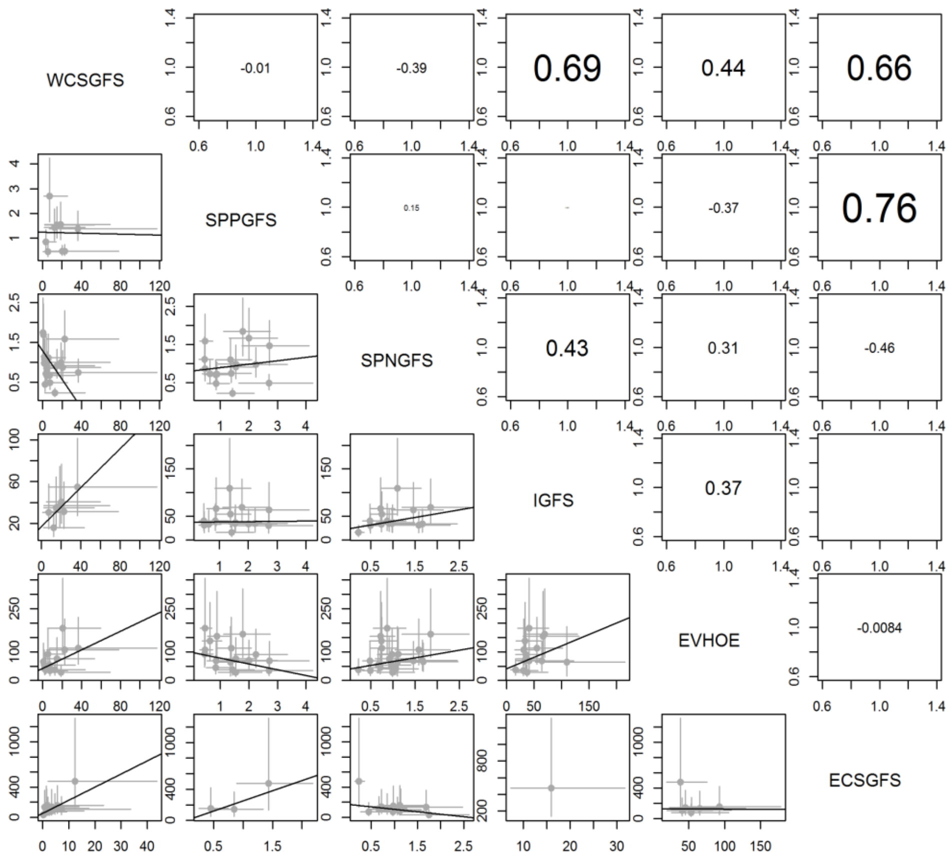


Figure 3.6.1.5. Boarfish in ICES Subareas 27.6, 7, 8. Pair-wise correlation between the annual mean survey indices.

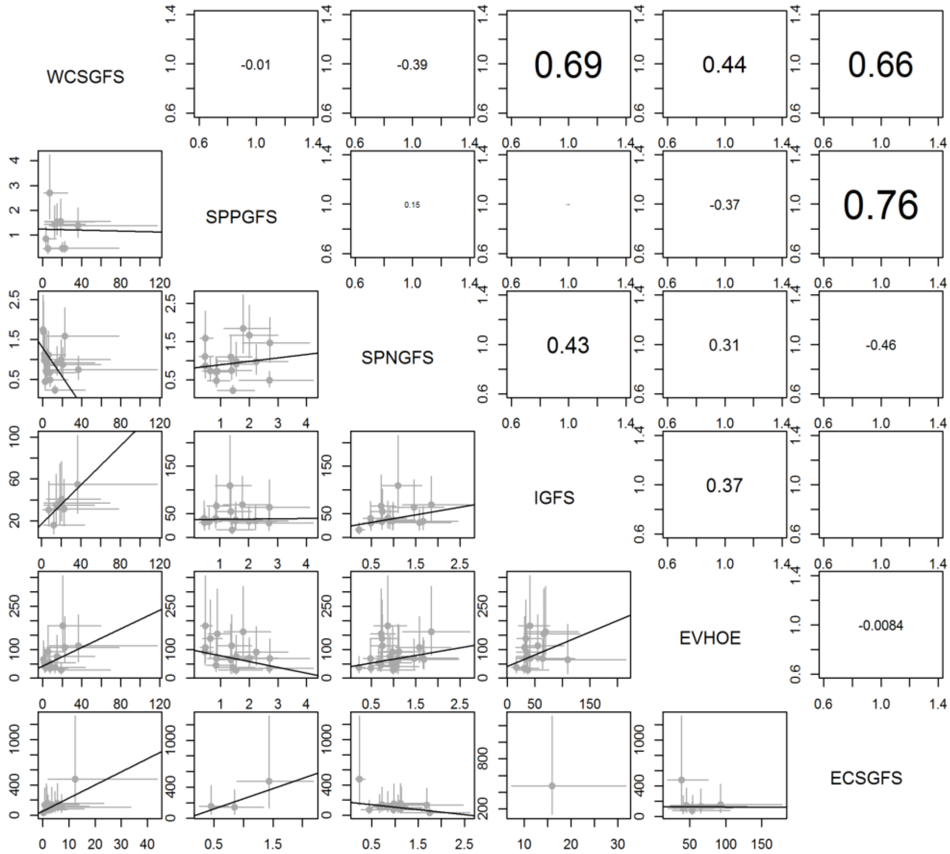
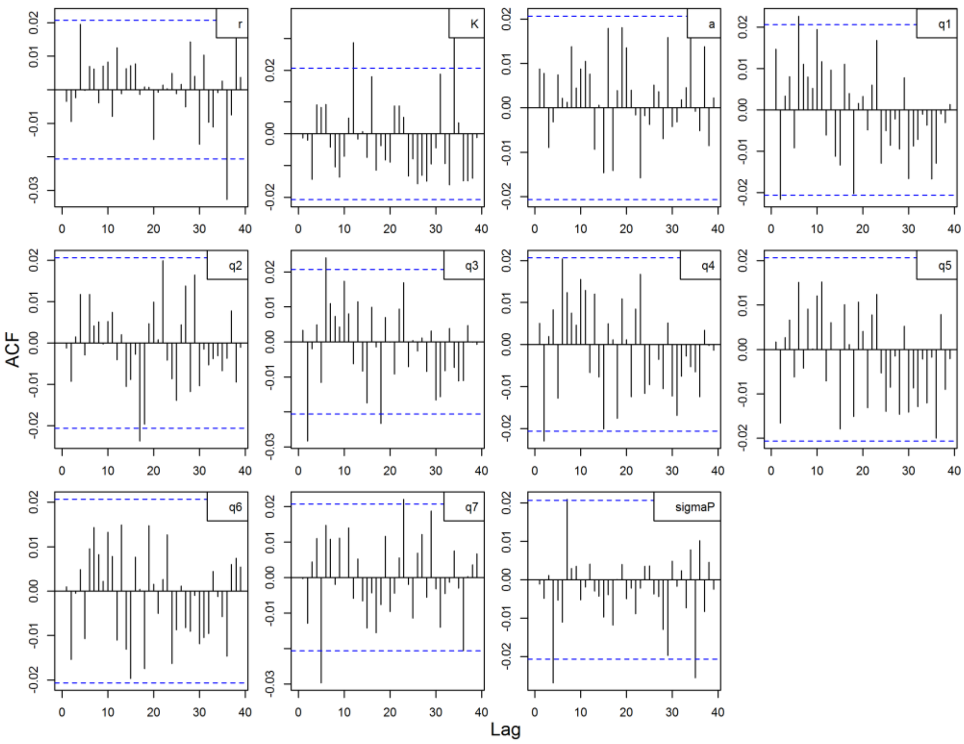


Figure 3.6.1.6. Boarfish in ICES Subareas 27.6, 7, 8. Weighted correlation between the annual mean survey indices. Correlations are weighted by the sum of the pair-wise variances.



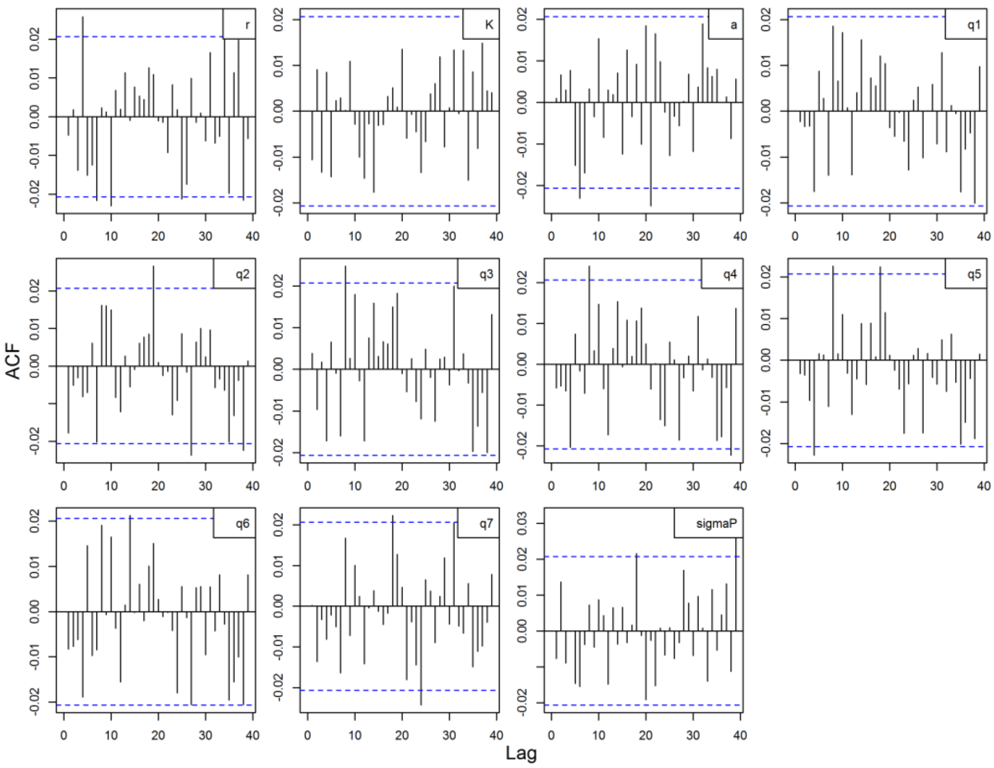


Figure 3.6.3.1. Boarfish in ICES Subareas 27.6, 7, 8. Parameters for final run converged with good mixing of the chains.

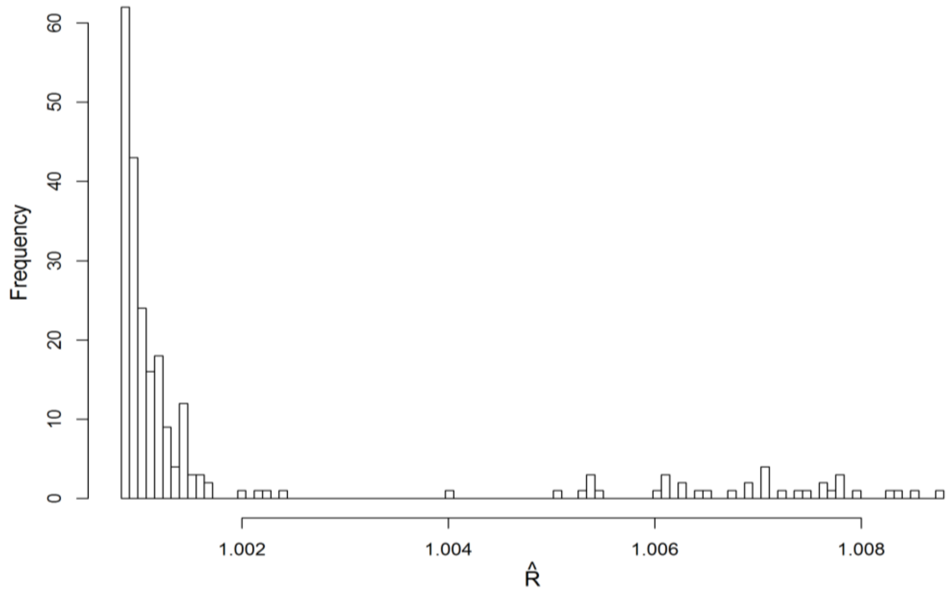


Figure 3.6.3.2. Boarfish in ICES Subareas 27.6, 7, 8. Rhat values lower than 1.1 indicating convergence.

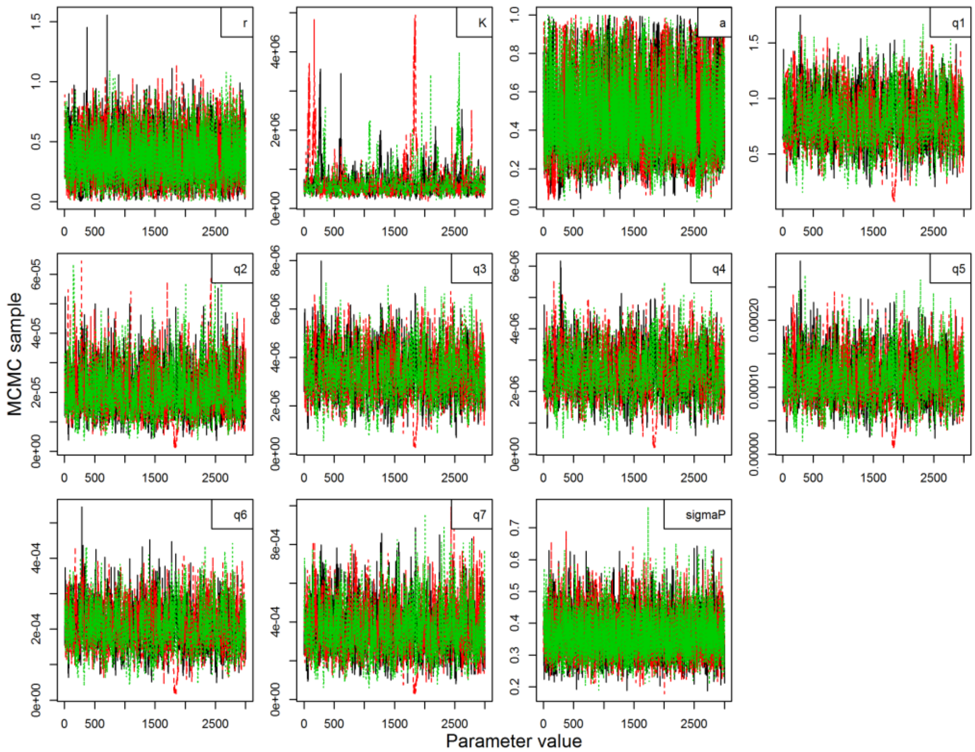


Figure 3.6.3.3. Boarfish in ICES Subareas 27.6, 7, 8. MCMC chain autocorrelation for final run.

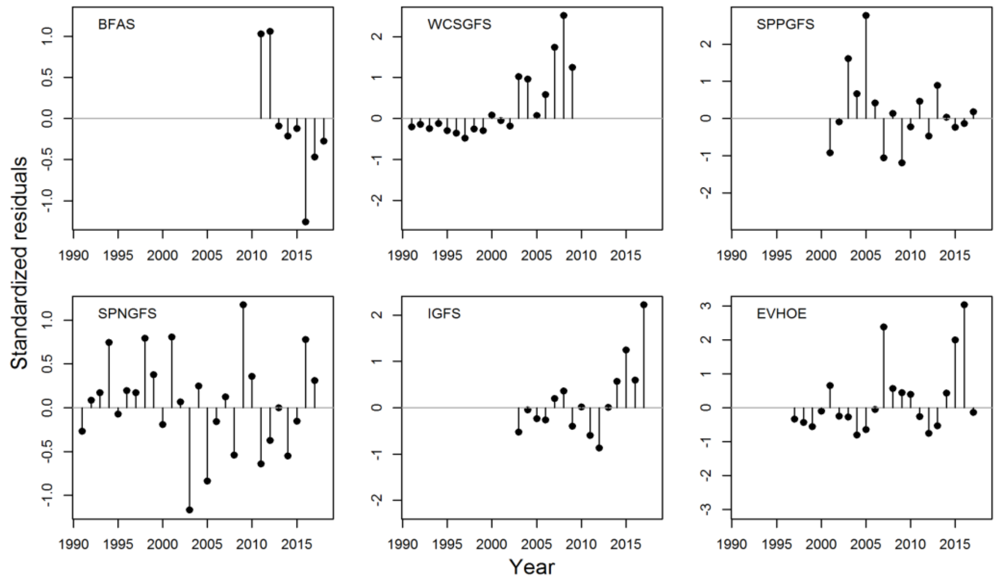


Figure 3.6.3.4. Boarfish in ICES Subareas 27.6, 7, 8. Residuals around the model fit for the final assessment run.

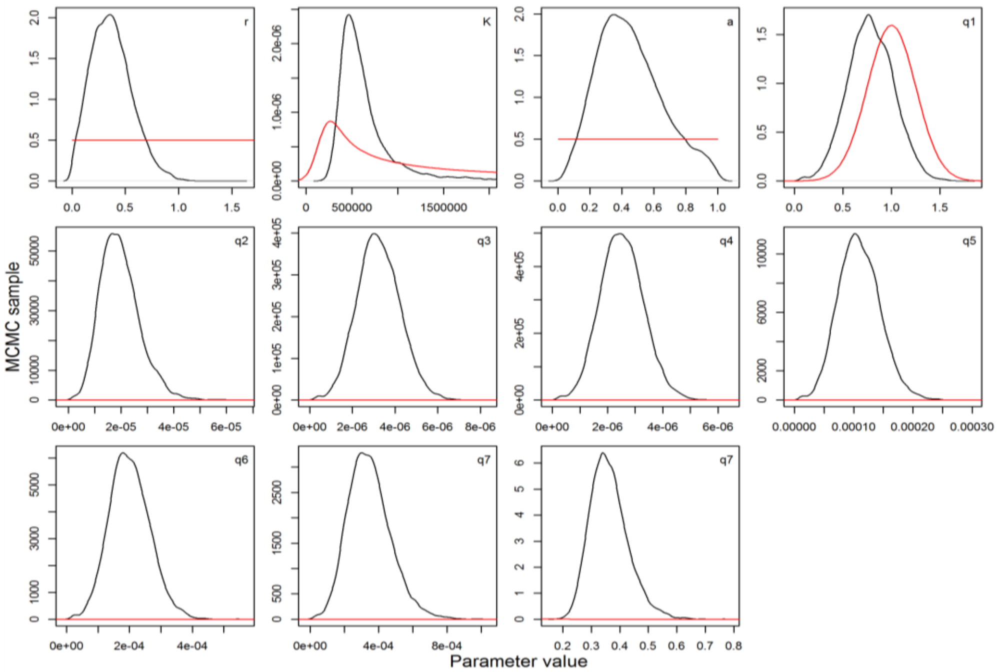


Figure 3.6.3.5. Boarfish in ICES Subareas 27.6, 7, 8. Prior (red) and posterior (black) distributions of the parameters of the biomass dynamic model.

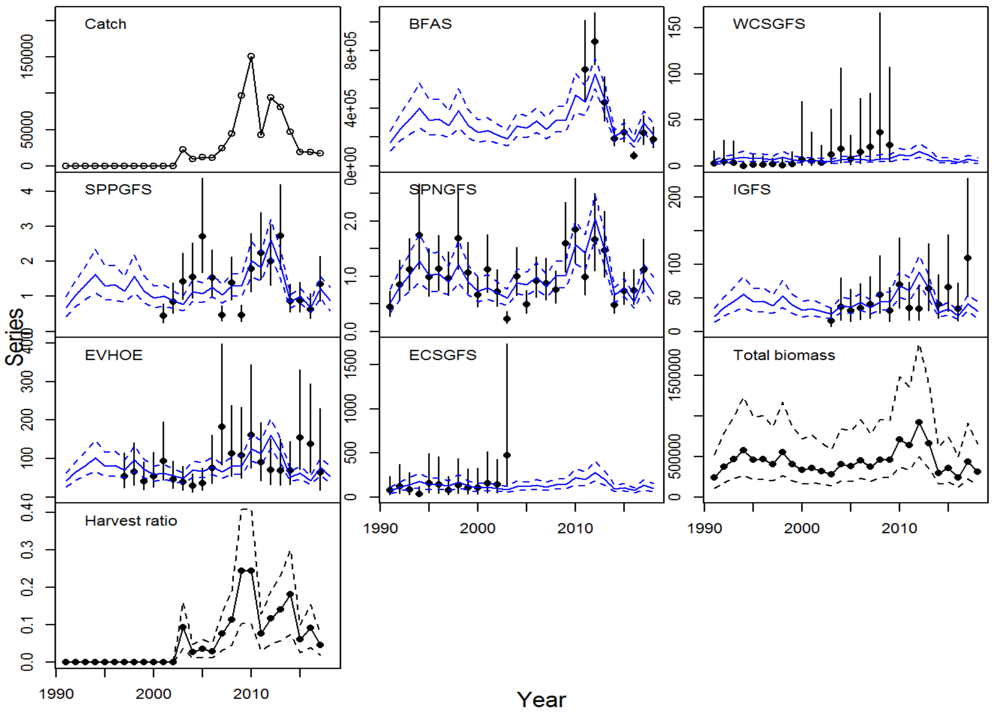


Figure 3.6.3.6. Boarfish in ICES Subareas 27.6, 7, 8. Trajectories of observed and expected indices for the final assessment run. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

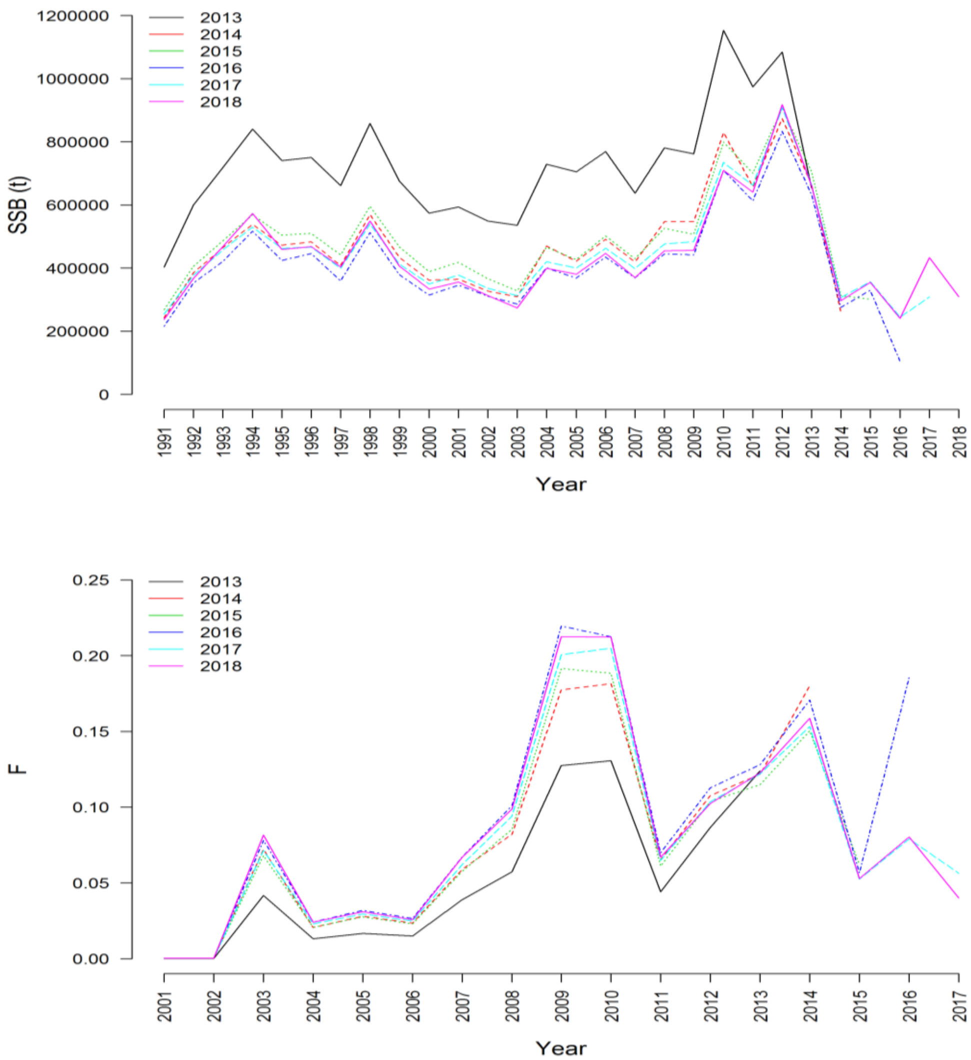


Figure 3.6.3.7. Boarfish in ICES Subareas 27.6, 7, 8. Retrospective plot of total stock biomass (above) and fishing mortality (below) from the surplus production model in 2013-2018. Heavy line is current assessment.

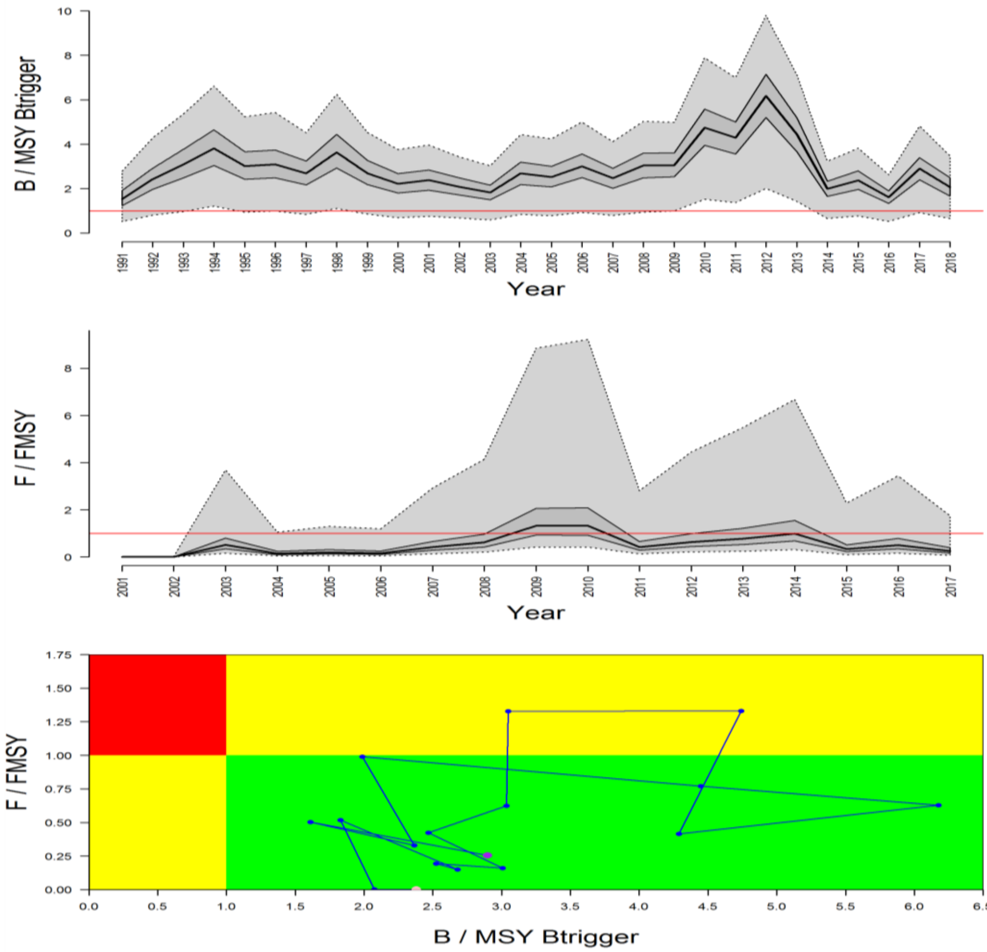


Figure 3.6.6.1. Boarfish in ICES Subareas 27.6, 7, 8. Ratios 'B / MSYBtrigger' and 'F / FMSY' through time and corresponding Kobe plot. Confidence intervals (50 and 95%) are given for the first two panels, the third displays median estimates only with the pink point representing the first point of the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

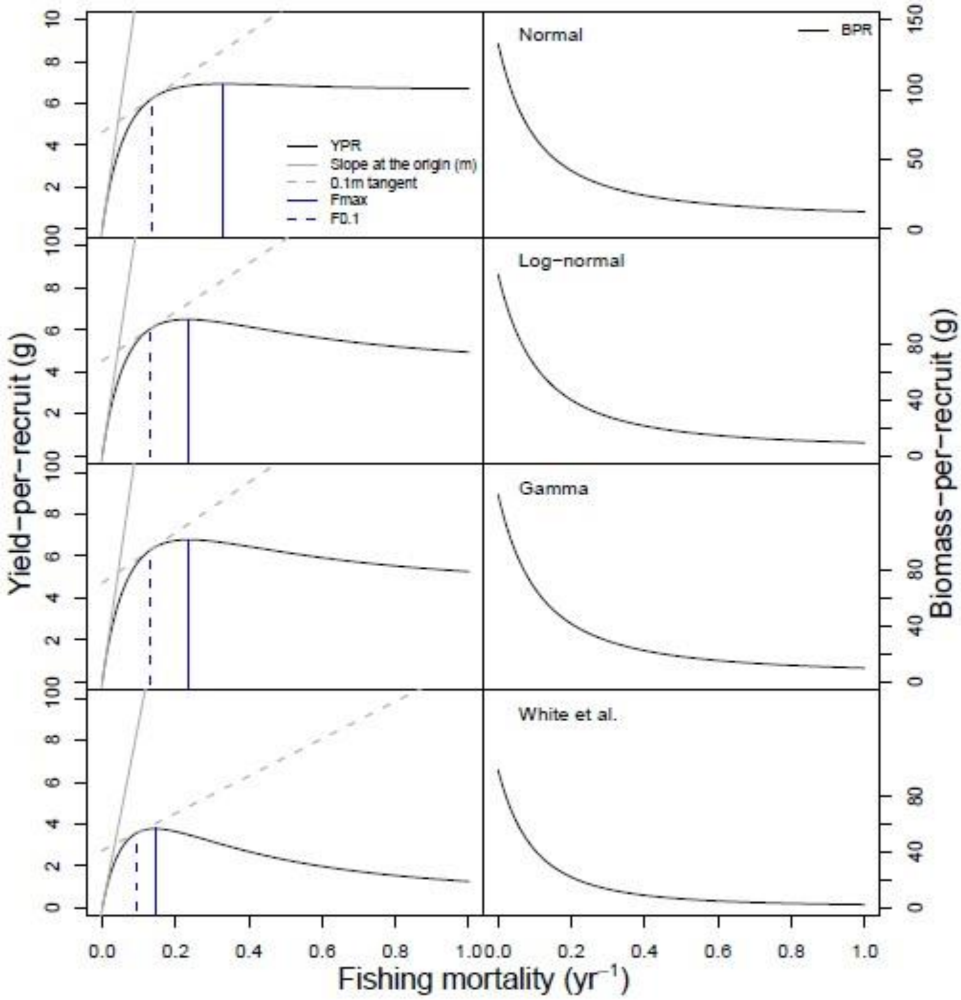


Figure 3.9.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Results of exploratory yield per recruit analysis. Beverton and Holt model applied to various fits of the VBGF and for comparison with the VBGF parameters provided by White *et al.* 2011.

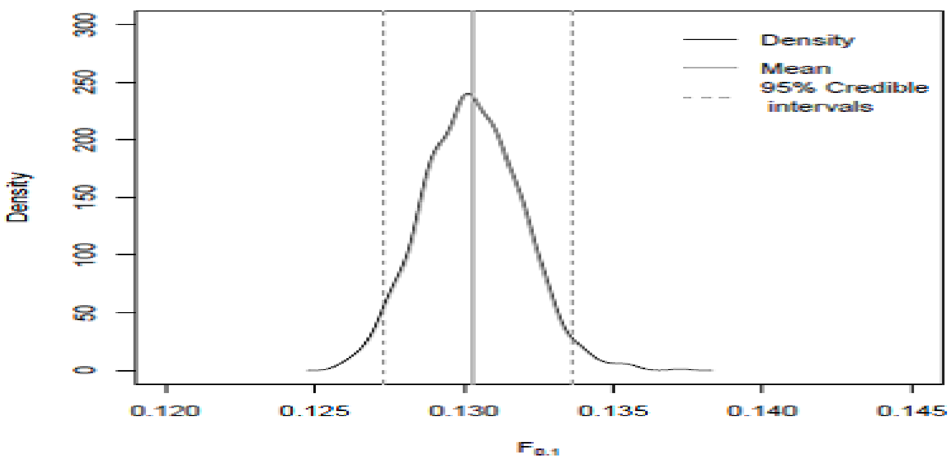


Figure 3.9.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Sensitivity of estimation of F0.1.

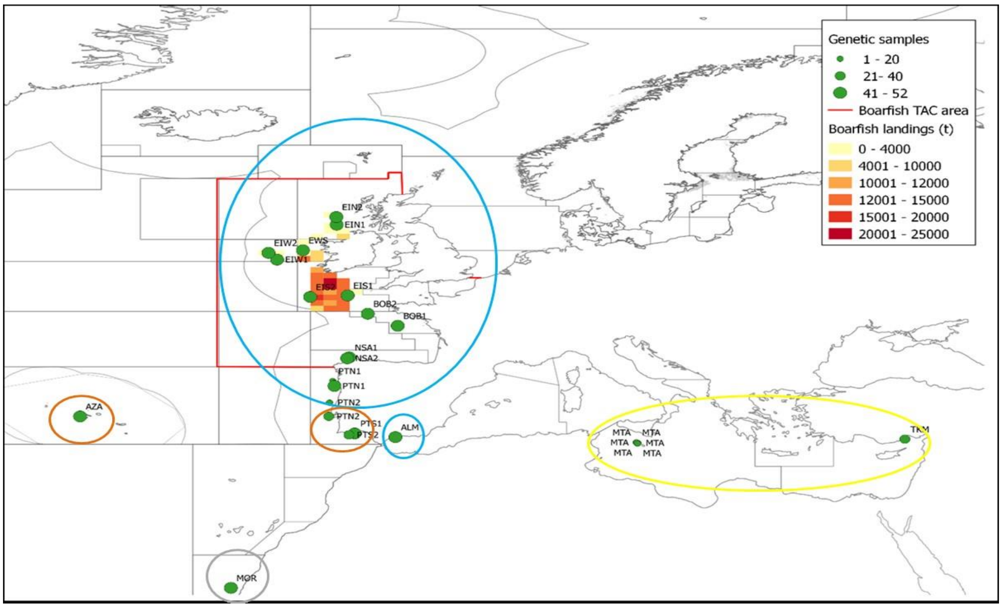


Figure 3.12.1. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish samples included in the genetic stock identification study are indicated in green. Population clusters identified by the STRUCTURE analyses are indicated by colour coded circles.