6 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 and 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 2014, ICES is considering this stock for the fourth year.

An analysis of bottom trawl survey data suggests a continuity of distribution spanning ICES Subareas IV, VI, VII, VIII and IX (Figure 6.1). Isolated small occurrences appear in the North Sea (ICES Subarea IV) in some years indicating spill-over into this region. A hiatus in distribution was suggested between ICES Divisions VIIIc and IXa as boarfish were considered very rare in northern Portuguese waters but abundant further south (Cardador and Chaves, 2010), however it is unclear if this suggested hiatus represents a true stock separation. Based on these data, a single stock is considered to exist in ICES Subareas IV, VI, VII, VIII and IXa. This distribution is broader than the current EC TAC area: VI, VII and VIII and for the purposes of assessment in 2014 only data from these areas were utilised. A dedicated study on the stock structure of boarfish within the Northeast Atlantic and Mediterranean Sea commenced in October 2013, the results of which will feed into future assessments.

6.1 The Fishery

6.1.1 Advice and management applicable to 2011, 2012 and 2013

In 2011 a TAC was set for this species for the first time, covering ICES Subareas VI, VII and VIII. 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% ($F_{0.1}$, as an F_{msy} proxy). For 2013, the TAC was set at 82 000 t by the Council of the European Union.

For 2014, ICES advised that, based on F_{MSY} (0.23), catches of boarfish should not be more than 133 957t, or 127 509t when the average discard rate of the previous ten years

(6 448t) is taken into account. For 2014 the TAC was set at 127 509t by the Council of the European Union.

By-catch of boarfish in the horse mackerel pelagic fishery is regulated by a provision in the TAC for the latter species. This allows a certain percentage of boarfish, and other species, to be retained and deducted from the horse mackerel quota.

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 VIIg 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.

In August 2012 the Pelagic RAC proposed a long term management plan for boarfish. The management plan has not been 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.

Since 2011, there has been a provision for by-catch 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	2031	7779
2012	2148	7829
2013	1702	7799
2014	1392	5736

6.1.2 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 (Table 6.1.2.1). In 2006 the landings began to increase considerably as a target fishery developed. Cumulative landings since 2001 are now in excess of 380 000 t. The fishery targets dense shoals of boarfish from September to March. Catches are generally free from bycatch from September to February. From March onwards 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 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 less than 1 000 t. Scottish landings peaked at 9 241 t in 2010. Denmark joined the fishery in 2008 and landed 3 098 t. Danish landings then increased to 39 805 t in 2010. In all years the vast majority of catches have come from ICES Division VIIj (Figure 6.2 and Tables 6.1.2.2 and 6.1.2.3). Since 2011 landings have been regulated by TAC.

Previous to the development of the target fishery, boarfish was a discarded bycatch in pelagic fisheries for mackerel in ICES Subareas VII and VIII. 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 (Tables 6.1.2.1 and 6.1.2.4).

6.1.3 The fishery in 2013

In 2013 a total of 69 812 t of boarfish were landed (Tables 6.1.2.1, 6.1.2.2 and 6.1.2.3). Ireland continued to be the main participant (52 250 t), with Denmark taking 13 182 t and Scotland 4 380 t. Forty one Irish registered fishing vessels reported landings with the majority made in Q1 (25 884 t) and Q4 (19 339 t). The Q3 landings of 7 026 t were all made in September. Figure 6.2 shows the majority of the Irish catch was taken in ICES divisions VIIb, g, and j. Scottish pelagic vessels reported landings of boarfish in Q1 (2 547 t), Q3 (468 t) and Q4 (1 365 t) with the majority from VIIh (1 728 t) and VIIj (1 653 t). The 2013 Danish boarfish fishery occurred solely in Q1 in division VIIj (10 873 t), VIIIa (1 356 t), and VIIh (945 t) and was significantly (6 941 t) under quota. The number of Danish vessels participating in the fishery is unknown.

6.1.4 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.

6.1.5 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 Fuglafjørður, 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 are expected to increase with the development of a human consumption fishery

6.1.6 Discards

Discard data were available from Dutch and German pelagic freezer trawlers (van Overzee and van Helmond, 2014; areas not specified) and from Irish demersal fleets. No discard data from the Spanish demersal fleet was available before the 2014 working group meeting so an estimate (average of previous 10 years Spanish discards) was used in the assessment. Table 6.1.2.4 shows available data.

Discards were not obtained from UK or French freezer trawlers, though discard patterns in these fleets are likely to be similar to the Dutch fleet. 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. 46 t of boarfish were also discarded by the Portuguese bottom otter trawl fleet in ICES Division IXa in 2013 (Prista et al., 2014).

Discard data were included in the calculation of catch numbers at age. All discards were raised as one métier 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 will now be 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.

6.2 Biological composition of the catch

6.2.1 Catches in numbers-at-age

For 2013 catch number-at-age were prepared for Irish, Danish and Scottish landings using the ALK in table 6.2.1.1. This general ALK was constructed based on 814 aged fish from Irish, Danish and Scottish caught samples from 2012. Allocations to unsampled métiers were made according to table 6.2.1.2. In total 62 Irish and 14 Danish samples were collected in 2013, comprising 8 818 and 1 221 fish measured for length frequency, respectively. This equated to one sample per 919 t landed.

ALKs were applied to commercial length-frequency data available for the years 2007-2013 to produce a proxy catch numbers-at-age (Figure 6.2.1.1 and Table 6.2.1.3) (see the stock annex for a description of ALKs prior to 2012). It can be seen that many older 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 since the 2005 year class, with the possible exception of 2010, now at age 3, although it is too early to say for certain. The modal age from 2007-2011 was 6 and in 2012-2013 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 Hüssy *et al*. (2012a; 2012b). The age range is similar to the published growth information presented by White *et al*. (2011).

6.2.2 Quality of catch and biological data

Table 6.2.1.2 shows the number of samples available per year and allocations that were made to un-sampled métiers (Division*Quarter*Country). Length-frequencies of the international commercial landings by year are presented in Table 6.2.2.1.

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 (Table 6.2.1.2). There is no DCF funded sampling of the fishery and all Irish sampling is industry funded. 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 6kg 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. All fish in each sample are measured to the 0.5cm below for length frequency. Following standard protocols 5 fish per 0.5cm length class are randomly selected from each sample for biological data collection i.e. otolith extraction, measurement to the 1mm below and sex and maturity determination. To date all Irish sample and data processing has been conducted by one person and the quality and consistency can be ensured.

There is no sampling programme in place for Scottish catches.

6.3 Fishery Independent Information

6.3.1 Acoustic Surveys

The Boarfish Acoustic Survey (BFAS) series was initiated in July 2011 and is now in its fourth year. The 2011 survey, the first in the series, was conducted by Marine Institute scientists aboard the Irish pelagic RSW vessel FV "Felucca'' with a towed body system with a calibrated 38 kHz split beam transducer (O'Donnell *et al.*, 2012a). The survey was designed to extend the Malin Shelf Herring Acoustic Survey (MSHAS) conducted aboard the RV "Celtic Explorer" to the south, which increased the range of continuous coverage from approximately 58.5°N to 47.5°N (Figure 6.3.1.1). The 2011 BFAS operated on a 24 hour basis as it was an exploratory survey and the distribution and behaviour of boarfish during this time of year were unknown prior to the survey. The combined surveys resulted in a continuous coverage over 33 days, 90 000 nmi^2 and transect coverage over 4 500 nmi. 24 trawls were sampled and lengths, weights, maturity data, and otoliths of boarfish were collected. In 2011 the total biomass of boarfish in the survey area was estimated at 456 115 t. Estimates of boarfish biomass by category are presented in Table 6.6.4.1 and the spatial distribution of the echotraces attributed to boarfish in each year can be seen in Figure 6.3.1.1.

The text table below explains the categories used to report estimated biomass from all BFASs. Following standard acoustic survey protocols the Total Biomass estimate includes the '*Definitely*', '*Probably*' and '*Mixture*' categories but excludes the '*Possibly*' category.

Category	Definition
Definite	"Definitely" echotraces were identified on the basis of captures of boarfish from the fishing trawls which were sampled directly. Based on the directly sampled schools echotraces were also characterised as definitely boarfish which appeared very similar on the echogram i.e. large marks which showed as very high intensity (red), located high in the water column(day) and as strong circular schools.
Probably	"Probably" was attributed to smaller echotraces that had not been fished but which had similar characteristics to "definite" boarfish traces.
Mixture	"Mixture" was attributed to NASC values arising from all fish traces in which boarfish were contained, based on the presence of a proportion of boarfish in the catch or within the nearest trawl haul. Boarfish were often taken during trawling in mixed species layers during the hours of darkness.
Possibly	"Possibly" was attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite boarfish traces.

In 2012 the survey methodology was refined by switching to daylight only (04:00-00:00) surveying. This change in protocol was a result of the observation during the 2011 BFAS that boarfish shoals were observed to break up during the night (00:00-04:00) and could not be acoustically detected or quantified. The 2012 total biomass estimate was 863 446 t (O' Donnell *et al.*, 2012b; Table 6.6.4.1), with the increase partially attributable to the protocol change.

In July 2013 the BFAS series was continued, with the survey being conducted again aboard the FV "Felucca" (O'Donnell *et al.*, 2013). The survey used the same equipment and followed the same protocol as the 2012 survey and the survey track was broadly similar (Figure 6.3.1.1). In total 4,295nmi (nautical miles) of cruise track was undertaken by both vessels over 53 transects relating to a total area coverage of 57,020nmi^2. Transect spacing was set at 15nmi for the *Felucca* and 15 and 7.5nmi for the *Explorer* component. Coverage extended in coastal areas from the c.50m contour to the shelf slope (250m). The survey was carried out from 04:00–00:00 each day. In 2013 thirty three hauls were carried out during the survey, 19 of which contained boarfish. A total of 1,074 boarfish echotraces were identified during the survey. Of this 98% were categorised as '*Definitely*' boarfish, 1.6% as '*Probably*' and 0.3% '*Boarfish in a mixture*'. The total estimated biomass of the survey area was 423 158 t (Table 6.6.4.1).

As no species-specific target strength (TS) previously existed for boarfish, an industry funded project was conducted to model boarfish TS. Samples were collected during the 2011 survey and MRI scans were taken of the swim bladders from the observed size range of boarfish. 3D swimbladder dimensions of each fish sample were used as input to a KRM model. An estimated TS-L relationship of -65.98dB was derived based on model calculations. This TS was used in 2012 to produce biomass estimates for the 2012 and 2011 survey. In 2013 this TS was reviewed and revised to -66.2dB (Fässler *et al.*, 2013; O'Donnell, 2013). This new TS (-66.2dB) was applied to the 2013 survey data and retrospectively to the 2012 and 2011 BFAS survey data for use in the boarfish assessment.

The July 2014 BFAS again comprised acoustic and trawl data recorded from the FV "Felucca" and RV "Celtic Explorer" (Figure 6.3.1.1). Temporal and spatially coverage were almost identical to 2013 and the revised TS was used in the biomass calculation. Twenty one hauls were carried out during the survey, 11 of which contained boarfish. A total of 3 160 boarfish lengths, 1 102 length/weight measurements and 397 otolith were collected during the survey. The total estimated biomass was 187 779 t, 57% less than the 2013 BFAS estimate. Of this total estimate 71% were categorised as 'definitely' boarfish, 27% as 'probably' and 1.4% 'boarfish in a mixture' (Table 6.6.4.1). It should be noted that the higher percentage of '*Probably*' boarfish this year was mainly due to technical difficulties with the trawl gear that prevented sampling of some schools that had all the characterisitcs of '*Definitely*' boarfish. A full breakdown of school categorisation, abundance and biomass by ICES statistical rectangle is available in O'Donnell and Nolan (2014).

The large change in biomass observed between the surveys cannot be easily explained and is no doubt the result of multiple factors (O'Donnell *et al.*, 2013). Expected interannual variation between successive acoustic estimates is in part responsible. However, factors outside survey effects should also be considered including hydrographic conditions and prey availability. As boarfish continue to feed during spawning the availability of prey will also determine spatial distribution of schools locally and clusters of schools at larger scales. If conditions for spawning are not optimum then the prey availability will drive distribution. As the survey covered the same area using the same survey design and good trawl sampling was achieved it is methodologically a replicate of that performed in 2012. However, factors outside of the survey have no doubt influenced the distribution of the stock both in the large scale (how it was distributed over the greater survey area) and at the smaller scale (in terms of schooling behaviour). The latter being directly related to how available boarfish were to the acoustic recording equipment. As no bottom trawl was available during the survey it was not possible to target the seabed within the acoustic dead zone (ADZ) for presence/absence of boarfish. Unquantified sonar observations and off track investigations indicated that echosounder observations were indeed representative of aggregations present in the wider area. This raises the possibility that boarfish could have also been distributed within the ADZ and out of the range of echosounder and midwater trawl sampling.

It should be noted that the survey does not contain the stock fully, given that concentrations of boarfish are likely to be found southward of the survey area as evidenced by both IBTS data and information from the PELACUS survey on the northern Spanish Shelf (Carrera *et al.*, 2013). However, low abundances of boarfish were observed by the IFREMER PELGAS 2014 acoustic survey in the Bay of Biscay (May-June), particularly in northern Biscay (Pettigas *pers. comm.* reported in O'Donnell and Nolan, 2014). Carrera *et al.* (2014) recorded an increase in boarfish abundance on the northern Spanish Shelf but the same length frequency distribution was apparent in 2014 as in the same survey in 2013, just in much greater abundance. The more northern BFAS area is characterised by older, larger fish and if fish had moved south in 2014 it would likely result in a different size range in PELACUS 2014.

6.3.2 International bottom trawl survey (IBTS)

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

- EVHOE, French Celtic Sea and Biscay Survey, (Q4) 1997 to 2013
- IGFS, Irish Groundfish Survey, (Q4) 2003 to 2013
- WCSGFS, West of Scotland, (Q1 and Q4) 1986 to 2013 (no Q4 survey in 2010)
- SPPGFS, Spanish Porcupine Bank Survey, (Q3) 2001 to 2013
- SPNGFS, Spanish North Coast Survey, (Q3/Q4) 1991 to 2013
- 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 minute 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 6.3.2.2 for each survey. The spatial extent of each constituent survey of the IBTS is shown in Figures 6.3.2.1, 6.3.2.2a and 6.3.2.2b. These surveys cover the majority of the observed range of boarfish in the ICES Area (Figure 6.1). Figure 6.3.2.1 also includes the spatial range of the Portuguese Groundfish Survey (1990-2011), however this survey is outside the current EC TAC area and was not included in the index of abundance in 2014.

Anecdotal evidence from the fisheries indicates that from September to March boarfish are found on the shelf in dense shoals often in close proximity to the bottom. These shoals are particularly abundant around the banks in ICES Division VIIj in the Celtic Sea. Therefore boarfish are likely effectively sampled by the demersal gear of the IBTS despite being a pelagic species. However the shoaling nature of the species results in occasional large hauls.

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 6.3.2.3) correspond to the main fishing grounds (Figure 6.2). Figure 6.3.2.4 shows the signal in abundance, increasing in the 1990s, declining again in the early 2000s, before increasing again. These trends have been reported by (Farina *et al.*, 1997; Pinnegar *et al.*, 2002; Blanchard and Vandermeirsch, 2005). These authors used IBTS and other trawl survey data to show the increased abundance of the species in this area.

The preliminary results of a GAM modelling project of the IBTS data up to 2011, including the Portuguese data, are presented to illustrate the temporal and spatial distribution of boarfish in the ICES Area. A GAM based on the probability of occurrence of boarfish in a surveyed area was developed based on presence absence data from over 13,000 individual fishing hauls in 7 groundfish surveys over a 30 year period (Figures 6.3.2.2a, 6.3.2.2b, 6.3.2.5a and 6.3.2.5b). The GAM models clearly illustrate that boarfish are distributed on the shelf and have a wide area of distribution. In recent years (2003 onwards) there has been an increase in the northerly distribution of boarfish. The depth distribution profile of boarfish within these hauls was also calculated, which shows that boarfish have a depth distribution preference of approximately 100-300m and the probability of occurrence in deeper water decreases sharply (Figure 6.3.2.6). The proportion of each region over which boarfish were distributed per year was also investigated and shows an increasing trend over time (Figure 6.3.2.7). This indicates that the area of spread of boarfish within the surveyed area has increased during the period.

For subsequent surplus production modelling, 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 (Figure 6.3.2.8) 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 in WinBUGS (Spiegelhalter *et al.*, 2004; Kéry, 2010).

6.4 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	14.65	19.49	23.71	26.75	33.29	37.73	40.03	47.11	50.24	51.16	62.75	56.44	62.25
Age	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
MW g	68.86	50.52	86.69	77.94	64.56	63.52	75.02	86.05	71.01	76.97	84.42	79.38	-	67.60	52.77

Maturity-at-age was obtained from the ageing studies of Hüssy *et al.* (2012a; 2012b) 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= 0.19, see Section 6.6.3). Given that catches in 2007 were relatively low, this estimate of total mortality might be 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 may be 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 of Chapter 6, 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 6.6.3) a single value of M is considered appropriate.

6.5 Recruitment

The IBTS data were explored as indices of abundance of 1 year olds, and 1-5 year olds as a composite recruitment index (Figures 6.5.1 & 6.5.2). The EVHOE and SPNGFS surveys provide the best indices of recruitment as this is where the juveniles appear to be most abundant (Table 6.3.2.2). It appears that recruitment was high in the late 1990s but declined to a low in 2003, before increasing again. However, this apparent dip in recruitment was not observed in the commercial catch-at-age data (Figure 6.2.1.1). Recruitment has fluctuated in recent years with an overall slightly negative slope in the EVHOE and SPNGFS indices since 2010.

6.6 Assessment

In 2012, a new stock assessment method was tested. In 2013 this Bayesian state space surplus production model (BSP; Meyer and 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 the two estimates of biomass (and associated uncertainty) from the acoustic surveys in 2012 and 2013 (see stock annex for more details of the sensitivity runs). The model and settings from the final accepted run in 2013 were used once again in 2014.

6.6.1 Historical literature sources

In the Northeast Atlantic region it is suggested that boarfish have historically undergone fluctuations in abundance. It should be noted that these apparent fluctuations in abundance occurred during periods when fisheries and fishery independent sampling were less widespread that the present day. The primary distribution areas of boarfish, on the Celtic Sea shelf in winter and along the shelf edge in summer, were rarely if ever sampled during this time. Therefore, the observations of peaks in abundance are only related to inshore areas. There is no evidence that boarfish were not also abundant in offshore waters throughout these periods. A literature review of historical sources suggests increases in abundance in the following periods:

- 1840s to 1880s
- 1950s
- Mid 1980s to 1990s

From the 1840s to 1880s large abundances were periodically observed in the western English Channel (Day, 1880-1884; Couch, 1844; Cunningham, 1888). Gatcombe, writing in 1879, stated that they had become an extreme nuisance in trawl fisheries. In the early 1900s boarfish were noted for their sporadic occurrence in the English Channel and were scarce or absent for many years in the area around Plymouth where they had previously been abundant (Cooper, 1952). In the mid 1900s there was another apparent increase in abundance in the English Channel, which Cooper (1952) hypothesised was caused by a 'submarine eagre' that swept shoals of boarfish from submarine canyons in the southern edge of the Celtic Sea onto the continental shelf. There was no sound basis for this untested hypothesis and it is at odds with more reliable survey and fisheries data which indicates boarfish are a shelf species, which migrate to the shelf edge for spawning (see below).

Increases in abundance were observed in the Bay of Biscay, Galician continental shelf waters and the Celtic Sea between the 1980s and 2000 (Farina et al., 1997; Pinnegar *et al*., 2002; Blanchard and Vandermeirsch, 2005). Based on EVHOE data the relative abundance in the Bay of Biscay was reported to have increased from 0.3% in 1973 to 16% in 2000 resulting in boarfish becoming one of the dominant species in the fish community in this region (Blanchard and Vandermeirsch, 2005).

Based on the above information the external reviewers in 2012 noted the possibility that boarfish was a deep-water species that had undergone a shoreward range extension onto the shelf in the late 1980's. In 2013 this was deemed not to be the case; see stock annex for full descriptions of both arguments.

6.6.2 IBTS Data

The common ALK (Table 6.2.1.5) was applied to the number-at-length data. The length-frequency is presented in Table 6.3.2.2 and the age-structured index in Table 6.6.2.1 and Figure 6.6.2.1. 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 (see section 6.5 and Figures 6.5.1 & 6.5.2). It should be noted however that the IBTS data is measured to the 1.0cm not the 0.5cm. 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 6.3.2.8). More southern surveys, displayed a consistently higher proportion of positive tows (Figure 6.3.2.8). The variability of the data is reflected in the estimated mean CPUE indices (Figure 6.6.2.2). The West of Scotland survey index has been increasing since 2000 but is highly uncertain, whereas the estimate indices from the other series are typically less variable (Figure 6.6.2.2). The Spanish North Coast, EVHOE, and Irish Groundfish surveys display broadly consistent trend in periods of overlap. The Spanish Porcupine Bank Survey fluctuates with a peak in 2005, a decrease and a recent increase in the years 2009-2011. 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 6.6.2.2 and 6.6.2.3). The spatial extent of each survey is shown in Figures 6.3.2.1.

Diagnostics from the positive component of the delta-lognormal fits indicate relatively good agreement with a normal distribution on the natural logarithmic scale (Figure 6.6.2.4). 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 6.6.2.5). The WCSGFS also displayed positive correlation with most other surveys except for a weakly negative correlation with the SPNGFS survey. The SPPGFS and ECSFS displayed slightly negative correlations with EVHOE (Figure 6.6.2.5). 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 6.6.2.6). 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 certain surveys as explained in the section 6.6.5.

6.6.3 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 6.6.3.1). 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 $Z \approx M$ in 2007, the initial year of the expanded fishery, while F is negligible. F increased to a high of 0.26 in 2012 and has reduced to 0.19 in 2013. There was a weak correlation between catches and pseudo-cohort F ($r^2 = 0.54$). Recent F estimated in this way is above F_{MSY} (0.17) and $F_{0.1}$ (0.13).

Year	Z (7-14)	F (Z-M)	Catch (t)
2007	0.18	0.02	21 576
2008	0.32	0.16	34 751
2009	0.32	0.16	90 370
2010	0.32	0.16	144 047
2011	0.28	0.12	37 096
2012	0.42	0.26	87 355
2013	0.35	0.19	75 409

6.6.4 Biomass estimates from acoustic surveys

The Boarfish Acoustic Survey (BFAS) series was initiated in July 2011 and is now in its fourth year. Due to the change in survey protocol between the 2011 and 2012 acoustic surveys, the 2011 survey is not directly comparable with the others because data was collected during both day and night (24hrs). Three acoustic surveys are therefore appropriate for inclusion in the assessment model: 2012-2014. The revised modelled TS of -66.2dB (Fässler *et al.*, 2013; O'Donnell, 2013) was applied to the 2012 BFAS data to produce a new biomass estimate comparable to 2013 and 2014 (Table 6.6.4.1). This table also includes the CV for each estimate. Over the four years of the survey, biomass has been estimated in the range 187,779t to 863 446 t. The 2014 survey biomass estimate is 57% lower than that in 2013, which was in turn lower than that in 2012. The precision on the estimates has been good, with coefficients of variation in the range 10.7 to 16.7. In all model runs in 2014 the '*Total'* estimate of boarfish biomass was used for all years; see section 6.3.1 for more details and an explanation of the reported categories.

6.6.5 Biomass dynamic model

In 2012 an exploratory biomass dynamic model was developed. This was a Bayesian state space surplus production model (Meyer and 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. Details of the review and the associated changes can be found in the stock annex.

In 2014 the Bayesian state space surplus production model (Meyer and Millar, 1999) was again fit using the catch data, delta-lognormal estimated IBTS survey indices, and the acoustic survey estimates. The biomass dynamics are given by a difference form of a Schaefer biomass dynamic model:

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

where B_t is the biomass at time t, r is the intrinsic rate of population growth, K is the carrying capacity, and C_t is the catch, assumed known exactly. To assist 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:

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

where the logarithm of process deviations are assumed normal $u_t \sim \mathrm{N}(0, \sigma_u^2)$; σ_u^2 is the process error variance.

The starting year biomass is given by aK, where α 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 ; $\varepsilon_t \sim N(0, \sigma^2_{\varepsilon,j,t})$; where $\sigma^2_{\varepsilon,j,t}$ is the index-specific measurement error variance $\mathrm{Var}(I_{j,t})$ 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 6.6.2.2) as opposed to estimating a measurement error within the assessment. The measurement error is obtained from:

$$\sigma^2_{\varepsilon,j,t} = \ln\left(1 + \frac{\mathrm{Var}(I_{j,t})}{\left(I_{j,t}\right)^2}\right)$$

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

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

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 10xsum C)=U(ln 144,047t, ln 4,450,407t)
- 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). Acoustic survey is discussed below when separate runs are described.
- Process error precision $1/\sigma^2_u$ ~Gamma(0.001,0.001)

Specifications

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 in 2014. (More details of the trial runs in 2013 can be found in the stock annex.)

Specifications for final 2013 and 2014 boarfish assessment model; $q_{acoustic}$ is the catchability of the acoustic survey, $I_{acoustic}$ is the acoustic index value used:

Acoustic survey

Years: 2012-2014

$I_{acoustic,year}$: 'Total' in tonnes (i.e. Definitely Boarfish + Probably Boarfish + Boarfish in a Mix)

$q_{acoustic}$: 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 years omitted from WCSGFS

First 9 years omitted from ECSGFS

- Discards: average of 2003-2013 (6 371t in 2014)

The final run assumes a strong prior ln $q_{acoustic} \sim N(1,1/4)$ (standard deviation of 1/4), which has 95% of the density between 0.5 and 2. Given the short acoustic series (3 years) it is not possible to estimate this parameter freely (using an uninformative prior) but assuming a strong prior removes the assumption of an absolute index from the acoustic survey and will be continually updated as data accrue.

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.

Run convergence

Parameters for the 2014 model run converged with good mixing of the chains and Rhat values lower than 1.1 indicating convergence (Figures 6.6.5.1, 6.6.5.2). MCMC chain autocorrelation was also low indicating good sampling of the parameter posteriors (Figures 6.6.5.3).

Diagnostic plots are provided in Figures 6.6.5.4 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 to 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 6.6.5.5 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 6.6.5.6, 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 6.6.5.1. F_{MSY} has been recalculated by the model (r/2) as 0.17, down from 0.23 in 2013. Biomass in 2014 is estimated to be 261 003 t, a decrease on the 2013 estimate of 653 668 t. Retrospective plots of TSB and F, presented in Figure 6.6.5.7, show that the model has revised the perception of the stock considerably with the addition of the new data. This revision is in large part due to the low biomass estimate of the 2014 acoustic survey. As the acoustic survey does not span the entire range of the stock, assuming its catchability and treating it as an absolute index is likely incorrect, hence the decision to use a strong prior on the acoustic survey catchability 2013. A free but strong prior, i.e. the acoustic survey is treated as a relative index but is strongly informed), allows the survey to cover <100% of the stock.

Review

ACOM ADGWIDE discussed some aspects of the assessment model as a basis for providing management advice in 2013, and details are available in the minutes of the advice drafting group. The working group provides feedback on these comments below.

ADGWIDE Comment	Response
Two acoustic survey data points and IBTS surveys. Model handles model uncertainty. Recent re-distribution of the stock appears to be the result of increasing abundance. However big decrease in acoustic estimate of abundance between 2012 and 2013. Final model uses strong prior on acoustic survey with q around 1.0.	A strong prior on the acoustic survey index centred on 1.0 is necessary to include this short survey index. As the number of years of the survey increases, the posterior for that catchability will update based on the accruing data. A strong prior allows for the inclusion of this important though short survey. This is somewhat similar to how ICES treated the egg survey in the mackerel assessment for many years. In the early years, the survey was treated as an absolute index (catchability "q" = 1) to allow it to fit. As the series extended this was changed to relative (q was allowed to be estimated). In new survey situations this is the only tenable approach.
Discussion about the validity of using Schaefer model. Reviewers and assessment audit both endorse use of the model. ADG questioned whether there was enough contrast in the catch, biomass and exploitation to properly parameterize production model. Also assumption that K is constant over time series may not be supported. However since reviewers have agreed with approach difficult to reject model.	The short series of catches is of concern. The acoustic survey, however, provides an anchor for the assessment, which would be very difficult to fit otherwise. Time-varying K would be very difficult to estimate given the shortness of the catch series and contrast in exploitation. Alternative formulations of production models, including Pella-Tomlinson could be trialled in future. The assessment as formulated makes the best use of the available data. The acoustic series, though short, is the main piece of information; the short catch series precludes many classical methods, though it does make the estimation of K less reliable; the trawl surveys are included though they would not be easily included in an age structured model, given their temporal asymmetry with the catch series.

Applicability of production model outputs for advice in the MSY context	The application of the HCR based on a production model estimate of BMSY is following the procedure used for several other stocks in the ICES area, including VIa megrim and IXa anglerfish. In these data limited stocks, a production model is used in the ICES MSY generic harvest control rule context.

6.6.6 State of the stock

According to the latest assessment total stock biomass appeared to increase from low levels from the early to mid 1990s (Figure 6.6.5.6). The stock fluctuated around this level until 2009. Biomass then greatly increased to a new level in 2010 and fluctuated around this elevated level until 2012. Since 2012 there has been a sharp decline in the estimated total stock biomass of boarfish in the North East Atlantic. This decline is exacerbated by the downward revision of the modelled perception of the stock with the addition of the latest year's catch and survey data (Figure 6.6.5.7 shows retrospective plots compared to the 2013 assessment). TSB in 2014 (261 003t) is still considerably higher than the proposed B_{lim} but has fallen below the proposed $B_{trigger}$ (Table 6.6.5.1; see section 6.9 for further information on reference points). The uncertainty surrounding the estimates of biomass in the final year are not as high as previous years but there is still a wide 95% credible interval (Table 6.6.5.2), this reflects the uncertainty in the survey indices, and short exploitation history of the stock and the fact that we treat the acoustic survey as a relative biomass index. As more data accumulates from this survey, we expect that the prior will become increasingly updated, and potentially less variable. Reflective of the uncertainty, short-term forecasts are presented with associated probabilities of crossing reference points for given levels of fishing mortality (see Section 6.7).

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 has increased since then in line with the larger TACs. In 2013 F was still below F_{msy}. 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 6.2.1.1).

Estimates of recruitment are not available from the stock assessment. However, an independent index of recruitment is available from groundfish surveys (section 6.5). Observations from the survey recruitment of 1 year olds show an overall slightly negative trend since 2010 (Figures 6.5.1 and 6.5.2).

6.7 Short term projections

A short term forecast was performed by projecting the model run forward by one year. However, as there is no recruitment estimate it is not possible to construct a traditional style catch forecast for management purposes. Instead, short term projections over a range of fishing mortality and catch options are provided on a risk based approach. An intermediate year catch constraint was applied (2014 TAC, 127 509 t + average discards of 6 371 t). The population is then projected forward within the assessment under a range of management objectives that included the yield at:

- F_{MSY} = 0.17 based on *r*/2 from model run (Table 6.6.5.1)
- $F_{MP} = B_{2014}\ (F_{MSY} / B_{trigger}) = 0.129$
- $F_{ICES\ HCR} = B_{2015}\ (F_{MSY} / B_{trigger}) = 0.132$
- $F_{0.1}$ = 0.13 based on yield-per-recruit analysis
- F_{lim} = 0.274 based on the F associated with a long-term biomass of *K*/5

(0.2 carrying capacity used for B_{lim})

- F_{pa} = exp(-1.645*CV(TSB_{2014}))*F_{lim} = exp(-1.645*0.381)* 0.367 = 0.146
- C_{2015} = 0 (zero catch option)
- C_{2015} = C_{2014}

Where F_{MP} is the F according to Rule 1.1b in the proposed management plan (section 6.14) and $F_{ICES\ HCR}$ is the reduced F according to the generic ICES harvest control rules.

A forward projection on the risk of the stock falling below B_{msy} ($B_{trigger}$), B_{lim} and fishing mortality exceeding F_{lim} are estimated. Fishing mortality for the fixed catch projections is calculated as -ln(1-C_{2015}/TSB_{2015}). Catch options are presented in Table 6.7.1.

Given that F (0.134) is below F_{MSY} (0.171) but mean total stock biomass in 2014 (261 003 t) is less than $B_{trigger}$ (347 063 t) but greater than B_{lim} (138 825 t) (Tables 6.6.5.1 and 6.6.5.2; section 6.9 for reference points), fishing at a reduced F is required. This reduced F is calculated as $B_{2015}\ (F_{MSY} / B_{trigger})$ and is consistent with the ICES MSY approach. It results in an advised catch of 33 875 t for 2015. There is a high level of uncertainty associated with this F and a wide 95% CI for the biomass in 2016, which is reflected in a 12.9% probability of falling below B_{lim} in 2016 (Table 6.7.1). Fishing at F_{lim} elevates this probability to 17.2%. However, we note that the probability of dropping below B_{lim} even at zero catch is 9.9%, again reflecting the uncertainty of the biomass trajectory.

6.7.1 Yield per Recruit

A yield per recruit analysis was conducted in 2011 (Minto *et al.*, WD 2011) and $F_{0.1}$ was estimated to be 0.13 whilst F_{max} was estimated in the range 0.23 to 0.33 (Figure 6.7.1.1). $F_{0.1}$ was considered to be well estimated (Figure 6.7.1.2). No new yield per recruit analyses were performed in 2012, 2013, or 2014.

6.8 Long term simulations

No long term simulations were conducted.

6.9 Precautionary and yield based reference points

6.9.1 Precautionary reference points

It does not appear that boarfish is an important prey species in the NE Atlantic (Section 6.12). ICES (1997) considered that precautionary F targets (F_{pa}) should be consistent with F<M for prey species, and F = M for non-prey species. This approach would ensure that fishing does not out-compete natural predators for their prey. This would suggest that a good candidate precautionary F_{pa} is $F = M = 0.16y^{-1}$. This is considered appropriate because boarfish is not an important prey in the NE Atlantic. B_{lim} may be defined from the stock size estimates available from the stock assessment. It is proposed that B_{lim} be set at 0.2* *K*, (0.2 * 694 127 t = 138 825 t), based on the results of model run (Table 6.6.5.1).

6.9.2 Yield based reference points

Yield per recruit analysis, following the method of Beverton and Holt (1957), found $F_{0.1}$ to be robustly estimated at 0.13 (ICES WGWIDE, 2011; Minto et al., WD 2011).

An estimate of F_{msy} is available from the stock assessment model as 0.171.

An estimate of B_{msy} is available from stock assessment model (347 063 t). This is proposed as a conservative basis for MSY $B_{trigger}$.

It should be noted that these values have changed since 2013. The new value is output from the surplus production model, which has revised the perception of the stock after the inclusion of the latest data.

6.10 Quality of the Assessment

This is the second year that a full stock assessment has been conducted for this stock. A considerable amount of data has been collected and analysed. The stock assessment method makes use of all available fisheries independent data, as well as landings and discard data too. Age data have been collected and analysed, but the time series is still too short to be useful for an age-based assessment of this long lived species.

The bottom trawl survey data are considered to be a good index of abundance given that boarfish aggregate on the bottom at this time of year. The trawl surveys record high abundances of the species, but with many zero hauls. The delta-log normal 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 Benchmark of megrim in Sub-divisions IV and VI. 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.

Boarfish cannot be considered a data poor stock, and the group considers that the stock assessment is a good indicator of stock status. However, in view of the new and developing nature of the fishery, uncertainty surrounding the final estimates, and considering that the biological information on the stock is constantly being updated, precaution is warranted when considering catch options for 2015.

6.11 Management Considerations

The available data suggests that this is still a large stock. Even accounting for the downward revision of the stock's perception (Figure 6.6.5.7), stock size in 2014 is estimated to be 261 003 t, though at this stage of the development of the assessment absolute estimates of stock size are uncertain. Trends in abundance over time indicate that the stock has increased from very low levels in the 1980s, to high levels in the 1990s. It declined somewhat in the early 2000s and recruitment weakened. The stock increased again in 2010 but has sharply declined from 2012-2014. Total stock biomass in 2014 is below the proposed $B_{trigger}$ (which equals B_{MSY}; Ssection 6.9).

Fishing mortality is estimated to have increased from a negligible rate in 2007 to a peak of 0.216 in 2010 and was 0.134 in 2013. This is lower than F_{MSY}. The large reduction in catch, resulting from the 2011 TAC (75% decrease in landings from 2010) reduced F considerably.

The management plan, proposed by the Pelagic RAC in 2012, has not been fully evaluated by ICES. However ICES advised in 2013 that the HCR in tier 1 of the plan can be considered in accordance with the precautionary approach if a Category 1 assessment is available (ICES, 2013). Though the ICES advice for 2015 will be based on the ICES generic HCR, the WG provides a catch option based on the proposed management plan. Applying tier 1.1b of the proposed plan implies catches in 2015 that are 2% lower than the ICES generic HCR. In order to be faithful to the precautionary approach and FAO guidelines on new and developing fisheries, it is appropriate to obey the signals from the assessment and other indicators and to reduce the catch.

Following the MSY approach implies reducing fishing mortality, where the reduced F from the generic ICES HCR is 0.132. On this basis, the proposed TAC in 2015 would be not more than 33 875 t. Various scenarios and the associated probabilities of attaining reference points are presented in Table 6.7.1.

6.12 Ecosystem considerations

The ecological role and significance of boarfish in the NE Atlantic is largely unknown. However, in the south-east 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 (Lopes *et al.*, 2006). 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 utilisation.

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; Morato *et al*., 2000; Morato *et al*., 2001; Barreiros *et al*., 2002; Morato *et al*., 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 and Tucker, 1974; Ellis *et al*., 1996,). However, this does not prove that they are currently not a prey item. A study of conger eel diet in Irish waters from 1998-1999 failed to find boarfish in the diet (O'Sullivan *et al.*, 2004). However, in Portuguese waters a recent study has found boarfish to be the most numerous species in the diet of conger eels (Xavier *et al*., 2010). It has been suggested that boarfish are an important component of the diet of hake (*Merluccius merluccius*), as they are sometimes caught together. However, a recent study of the diet of hake in the Celtic Sea and Bay of Biscay did not report any boarfish in the stomachs of hake caught during the 2001 EVHOE survey (Mahe *et al.*, 2007).

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

Boarfish are also an important component of the diet a number of sea birds in the Azores, most notably the common tern (*Sterna hirundo*) and Cory's shearwater (*Calonectris diomedea*) (Granadeiro *et al*., 1998; Granadeiro *et al*., 2002). This is surprising given that in the Mediterranean discarded boarfish were rejected by seabirds whereas in the Azores they were actively preyed on (Oro and 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 and Fernandes, 2001). However, the upper depth range of boarfish is within maximum diving depth recorded for auks (50 m) as recorded by Barrett and 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 6.3.2.2) 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; Granadeiro *et al*., 2002).

6.13 Changes in the environment

Studies are underway to investigate if the increase in abundance of boarfish in the 1990s and 2000s is related to changes in the environment. Blanchard and Vandermeirsch (2005) attributed the increase in abundance of boarfish in the EVHOE survey during this time to a concurrent increase in water temperature during the spawning season which may have enhanced recruitment.

The reproductive biology of the species goes some way to supporting and developing this theory. Evidence suggests that the boarfish is an asynchronous batch spawner with indeterminate fecundity (Farrell *et al*., 2012). Given suitable conditions (i.e. suitable temperature and abundant prey) boarfish are capable of spawning repeatedly over an extended period of time. In aquarium conditions, spawning has been observed daily for males and every 2-3 days for females over a period of nine consecutive months. Natural conditions are more variable and Farrell *et al.* (2012) indicated that spawning was restricted to the summer months with a peak in July. Spawning had ceased by September and remaining oocytes were resorbed at this time.

If conditions remain favourable for an extended period of time in a particular year then boarfish are likely to continue spawning, possibly leading to enhanced recruitment. Analysis of length at age data showed recruitment to have a positive correlation with adult growth the previous year for the Spanish north coast survey index only, and that complex climate related mechanisms are responsible for the boarfish stock expansion in the Northeast Atlantic (Coad et al. 2014).

6.14 Proposed management plan

A management plan has been proposed by the Pelagic RAC. This management plan has not yet been fully evaluated by ICES. However, ICES identifies that Tier 1 of the proposed plan coincides with the ICES generic approach to giving advice for data-rich situations. Given that a Category 1 assessment is now being used for advice, ICES recommends that Tier 1.1 of the plan be considered consistent with the PA and MSY approaches for as long as a Category 1 assessment is available (ICES, 2013). This plan is presented below.

The TAC setting rules 1.1-1.6 shall apply. Precedence is in decreasing order from Rule 1.1. These are shown in the table below. The decision year for TAC setting is the last year in the assessment, and not the TAC year.

Rule	Assessment	Uncertainty	Condition	Procedure
1.1.a	SSB and F	Low	SSB > Btrigger	Ftarget
1.1.b			SSB < Btrigger	SSB * (Ftarget / Btrigger)
1.2.a	SSB and F	Higher	SSB > Btrigger	Ftarget
1.2.b			SSB < Btrigger	SSB * (Ftarget / Btrigger) * G
1.3.a	F	Any	F < Ftarget	Reference TAC * G
1.3.b			F > Ftarget,	RTAC + (-RTAC / Flim-Fpa)*(F-Fpa) * G
1.4.a	U	Any	U > Upa, TAC =	Reference TAC * G
1.4.b			U < Upa, TAC =	U * (Reference TAC / Upa) * G
1.5.	Survey biomass	Any	TAC y,q3,4 = TACy+1, q1 =	ASB * 1-exp-F0.1_ * G * 0.62 ASB * 1-exp-F0.1_ * G * 0.38
1.6	None		No information on stock status and no risk of recruitment impairment	TAC = 33,000 t (interim management plan TAC)

SSB = Spawning stock biomass, F = Fishing mortality in units per year, U = Fisheries independent abundance index, from IBTS survey, C = Commercial catch in tonnes, TSB = Total stock biomass in tonnes

Notwithstanding Paragraph 1, if in the opinion of ICES, the stock is at risk of recruitment impairment, a TAC shall be based on advice given by ICES, and at a lower level than provided for in Paragraph 1, rules 1.1 to 1.6.

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

i) A closed season shall operate from 15th March to the 31st August. This is because it is known that herring and mackerel are present in these areas and may be caught with boarfish.

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

iii) If catches of other species covered by 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.

6.15 References

Arrizabalaga, H., Pereira, J. G., Royer, F., Galuardi, B., Goni, N., Artetxe, I., Arregi, I., et al. 2008. Bigeye tuna (*Thunnus obesus*) vertical movements in the Azores Islands determined with pop-up satellite archival tags. Fisheries Oceanography, 17: 74-83.

Barrett, R. T., and Furness, R. W. 1990. The prey and diving depths of seabirds on Hornøy, North Norway after a decrease in the Barents Sea capelin stocks. *Ornis Scandinavica*, 21: 179–186.

Barreiros, J. P., Santos, R. S. and de Borba, A. E. 2002. Food habits, schooling and predatory behaviour of the yellowmouth barracuda, *Sphyraena viridensis* (Perciformes : Sphyraenidae) in the Azores. Cybium, 26: 83-88.

Beverton, R. J. H. and Holt, S. J. (1957), On the Dynamics of Exploited Fish Populations, Fishery Investigations Series II Volume XIX, Ministry of Agriculture, Fisheries and Food

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

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

Brierley, A.S. and Fernandes, P.G. 2001. Diving depths of northern gannets: acoustic observations of *Sula Bassana* from an autonomous underwater vehicle. The Auk 118(2):529–534.

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

Carrera, P., Riveiro, I., Oñate, D., Miquel, J. & Iglesias, M. 2013. Multidisciplinary acoustic survey PELACUS0313: preliminary results on fish abundance estimates and distribution. Working document for the WGWIDE 27/08-02/09/2013, Copenhagen, Denmark.

Carrera, P., Riveiro, I., Oñate, D., Miquel, J. & Iglesias, M. 2014. Multidisciplinary acoustic survey PELACUS0314: preliminary results on fish abundance estimates and distribution. Presentation to WGWIDE 26/08-01/09/2014, Copenhagen, Denmark.

Clarke, M. R., Clarke, D. C., Martins, H. R. and Da Silva, H. M. 1995. The diet of the swordfish (*Xiphias gladius*) in Azorean waters. Arquipe´lago. Life and Marine Sciences 13 (A): 53-69.

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

Cooper, L. H. N. 1952. The boar fish, *Capros aper* (L.), as a possible biological indicator of water movement. Journal of the Marine Biological Association of the United kingdom, 31: 351-362.

Couch, R. Q. 1844. A Cornish fauna; being a compendium of the natural history of the county.

Cunningham, J. T. 1888. Notes and memoranda. Some notes on Plymouth fishes. Journal of the Marine Biological Association of the United kingdom, 2: 234-250.

Day, F. 1880-1884. The fishes of Great Britain and Ireland. London.

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

Farina, A. C., Freire, J. and González-Gurriarán, E. 1997. Demersal fish assemblages in the Galician continental shelf and upper slope (NW Spain): spatial structure and long-term changes. Estuarine, Coastal and Shelf Science, 44: 435-454.

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

Fässler, S.M.M., O'Donnell, C. & Jech, J.M. 2013. Boarfish (*Capros aper*) target strength modelled from magnetic resonance imaging (MRI) scans of its swimbladder. *ICES Journal of Marine Science*, doi:10.1093/icesjms/fst095.

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

Gatcombe, J. 1879. Boarfish off Plymouth. Zoologist, 3: 461-462.

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

Granadeiro, J. P., Monteiro, L. R., Silva, M. C. and Furness, R. W. 2002. Diet of Common Terns in the Azores, northeast Atlantic. Waterbirds, 25: 149-155.

Holden, M. J. and Tucker, R. N. 1974. The food of *Raja clavata* Linnaeus 1758, *Raja montagui* Fowler 1910, *Raja naevus* Muller and Henle 1841 and *Raja brachyura* Lafont 1873 in British waters. Journal du Coseil International pour l'Exploration de la Mer, 35: 189-193.

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

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

ICES. 2007. Report of the Workshop on Limit and Target Reference Points [WKREF], 29 January – 2 February 2007, Gdynia, Poland. Document Number. 89 pp.

ICES. 2013. Report of the ICES Advisory Committee 2013. ICES Advice, 2013. Book 9. Section 9.3.3.6

Kéry, M. 2010. Introduction to WinBUGS for Ecologists: A Bayesian Approach to Regression, ANOVA and Related Analyses. Academic Press, Burlington, MA, USA.

King, M., 1995. Fisheries Biology, Assessment and Management. Fishing News Book. 34p.

Lopes, M., Murta, A. G. and Cabral, H. N. 2006. The ecological significance of the zooplanktivores, snipefish *Macroramphosus* spp. and boarfish *Capros aper*, in the food web of the south-east North Atlantic. Journal of Fish Biology, 69: 363-378.

MacPherson, E. 1979. Estudio sobre el regimen alimentario de algunos peces en el Mediterraneo occidental. Miscelanea Zoologica, 5: 93-107.

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

Meyer, R. and Millar, R. B. (1999). BUGS in Bayesian stock assessments. Canadian Journal of Fisheries and Aquatic Science, 56, 1078—1086.

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

Morato, T., Encarnacion, S., Grós, M. P. and Menezes, G. 1999. Diets of forkbeard (*Phycis phycis*) and conger eel (*Conger conger*) off the Azores during spring of 1996 and 1997. Life and Marine Science, 17A: 51-64.

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

Morato, T., Sola, E., Gros, M. P. and Menezes, G. 2003. Diets of thornback ray (*Raja clavata*) and tope shark (*Galeorhinus galeus*) in the bottom longline fishery of the Azores, northeastern Atlantic. Fishery Bulletin, 101: 590-602.

Morato, T., Solà, E., Grós, M. P. and Menezes, G. 2001. Feeding habits of two congener species of seabreams, *Pagellus bogaraveo* and *Pagellus acarne* off the Azores (northeastern Atlantic) during sprong of 1996 and 1997. Bulletin of Marine Science, 69: 1073-1087.

O'Donnell, C. 2013. On the implementation of a modelled TS relationship for boarfish (*Capros aper)* abundance estimates. Working Document. ICES WGWIDE, Copenhagen, Denmark, 27 August-2 September 2013.

O'Donnell, C. & Nolan, C. (2014). Boarfish acoustic survey cruise report. 10 -31 July 2014. FEAS Survey Series: 2013/03.

O'Donnell, C., Farrell, E.D., Nolan, C. & Campbell, A. (2013). Boarfish acoustic survey cruise report. 10 -31 July 2013. FEAS Survey Series: 2013/03.

O'Donnell, C., Farrell, E.D., Saunders, S. & Campbell, A. (2012a). The abundance of boarfish (*Capros aper*) along the western shelf estimated using hydro-acoustics. *Irish Fisheries Investigations*, 23.

O'Donnell, C., Farrell, E.D., Nolan, C. & Campbell, A. (2012b). Boarfish acoustic survey cruise report. 09 -26 July 2012. FSS Survey Series: 2012/03.

O'Sullivan, S., Moriarty, C. and Davenport, A. 2004. Analysis of the stomach contents of the European conger eel *Conger conger* in Irish waters. Journal of the Marine Biological Association of the United Kingdom, 84: 823-826.

Oro, D. and Ruiz, X. 1997. Exploitation of trawler discards by breeding seabirds in the northwestern Mediterranean: Differences between the ebro delta and the balearic islands areas. ICES Journal of Marine Science, 54: 695-707.

Pinnegar, J. K., Jennings, S., O'Brien, C. M. and Polunin, N. V. C. 2002. Long-term changes in the trophic level of the Celtic Sea fish community and fish market price distribution. Journal of Applied Ecology, 39: 377-390.

Prista, N., Fernandes, A. C., Gonçalves, P., Ana Maria Costa, A. M. and Silva, A. 2014. Update on the discards of WGWIDE species by the Portuguese bottom otter trawl fleet operating in the Portuguese ICES Division IXa. Working Document for the ICES WGWIDE, Copenhagen, 26 August – 1 September 2014.

Spiegelhalter, D., Thomas, A., Best, N. and Lunn, D. 2004. WinBUGS User Manual. MRC Biostatistics Unit, Cambridge, UK, 2nd ed.

Stefánsson, G. (1996). Analysis of groundfish survey abundance data: combining the GLM and delta approaches. ICES Journal of Marine Science, 53, 577—588.

van Overzee, H.M.J. and van Helmond, A.T.M. 2014. Estimates of discarded boarfish by Dutch pelagic freezer trawler fishery in 2003-2013. Working Document for the ICES WGWIDE, Copenhagen, 26 August – 1 September 2014.

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

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

Table 6.1.2.1. Boarfish in Subareas VI, VII, VIII. Landings, discards and TAC by year (t), 2001–2013. (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	Ireland	Denmark	Scotland	Total landings	Estimated Discards	Total Catch incl. Discards	TAC
2001	120	0	0	120	NA	120	-
2002	91	0	0	91	NA	91	-
2003	458	0	0	458	10929	11387	-
2004	675	0	0	675	4476	5151	-
2005	165	0	0	165	5795	5959	-
2006	2772	0	0	2772	4365	7137	-
2007	17615	0	772	18387	3189	21576	-
2008	21585	3098	0.45	24683	10068	34751	-
2009	68629	15059	0	83688	6682	90370	-
2010	88457	39805	9241	137503	6544	144047	-
2011	20685	7797	2813	31295	5802	37096	33000
2012	55949	19888	4884	80720	6634	87355	82000
2013	52250	13182	4380	69812	5598	75409	82000

Table 6.1.2.2 Boarfish in ICES Subareas VI, VII, VIII. Landings by year (t), 2001–2013 and Subarea where available. (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.

	Denmark	Ireland	Scotland	Total
2001	0	120	0	120
2002	0	91	0	91
2003	0	458	0	458
VI		65		65
VII		393		393
2004	0	675	0	675
VI		292		292
VII		345		345
VIII		38		38
2005	0	165	0	165
VI		10		10
VII		117		117
VIII		38		38
2006	0	2772	0	2772
VI		21		21
VII		2750		2750
VIII		1		1
2007	0	17615	772	18386
V		6		6
VI		93		93
VII		17510	772	18282
VIII		5		5
2008	3098	21584	0	24683
VI		28	0	28
VII		21557		21557
2009	15059	68629	0	83688
VI		45		45
VII		68584		68584
2010	39805	88457	9241	137503
VI		1355	10	1365
VII	39805	87101	9231	136138
2011	7797	20685	2813	31295
VI		26		26
VII	7779	20659	2813	31251
VIII	18			
2012	19888	55949	4884	80720
VI		125		125
VII	18283	55731	4884	78898
VIII	1604	93		1697
2013	13182	52250	4380	69811
VI		538	15	553
VII	11828	50572	4365	66764
VIII	1354	1140		2494
Total	**98829**	**329449**	**22090**	**450367**

Table 6.1.2.3. Boarfish in ICES Areas VI, VII, VIII. Landings by year (t), 2001–2013 and subarea where available. (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	Denmark	Ireland	Scotland	Total
2001	0	120	0	120
2002	0	91	0	91
2003	0	458		458
VIa		65		65
VIIb		214		214
VIIj		179		179
2004	0	675	0	675
VIa		292		292
VIIb		224		224
VIIId		38		38
VIIj		122		122
2005	0	165	0	165
VIa		10		10
VIIb		105		105
VIIIa		38		38
VIIj		12		12
2006	0	2772	0	2772
VIa		21		21
VIIb		15		15
VIIg		375		375
VIIIa		1		1
VIIj		2360		2360
2007	0	17615	772	18386
Vb2		6		6
VIa		93		93
VIIb		1259		1259
VIIg		120		120
VIIIa		5		5
VIIj		16131	772	16903
2008	3098	21584	0	24683
VIa		28	0	28
VIIb		3		3
VIIg		184		184
VIIj		21370		21370
2009	15059	68629	0	83688
VIa		45		45
VIIb		73		73
VIIc		1		1
VIIg		4912		4912
VIIh		18225		18225
VIIj		45372		45372

Table 6.1.2.3 continued.

Year	Denmark	Ireland	Scotland	Total
2010	39805	88457	9241	137503
VIa		1349	10	1359
VIaS		7		7
VIIb		2258		2258
VIIc		35	4	39
VIIe	2			2
VIIg	672	3649		4321
VIIh	1465	8453	1712	11629
VIIj	37667	72707	7515	117889
2011	7797	20685	2813	31295
VIa		26		26
VIIb		274		274
VIIc		9		9
VIIg		811		811
VIIh	4155	8540	2813	15508
VIIIa	18			18
VIIj	3624	11025		14648
2012	19888	55949	4884	80720
VIa		125		125
VIIb	80	4501	838	5419
VIIc		108	907	1015
VIIg		616		616
VIIh	5837	10579	3139	19554
VIIIa	1604	93		1697
VIIj	12366	39928		52294
2013	13182	52250	4380	69811
VIa		538	15	553
VIIb		10405	100	10505
VIIe			883	883
VIIg		1808		1808
VIIh	955	11355	1728	14038
VIIIa	1354	870		2224
VIIId		270		270
VIIj	10873	27003	1653	39529
Total	98829	329449	22090	450367

Table 6.1.2.4. Boarfish in ICES Areas VI, VII, VIII. Discards of boarfish in demersal and non-target pelagic fisheries by year (t), 2003–2013. (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	Total
2003		119	1998	8812	10929
2004		60	837	3579	4476
2005		55	733	5007	5795
2006		22	411	3933	4365
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

***No Spanish discard data received prior to WG. Estimated (mean 2003-2012)**

Table 6.2.1.1. Boarfish in ICES Subareas VI, VII, VIII. 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													
7.5	1	1													
8		1													
8.5		1	1												
9		1	1												
9.5			1												
10			1												
10.5			2	10	3										
11			1	29	14	2	2								
11.5				9	21	21	18	2	2	1					
12				4	17	22	38	12	8						1
12.5					5	9	42	37	14	6	2		1	1	1
13					2	4	31	28	24	12	6	2	3	1	5
13.5					1	3	25	22	21	14	6	5	4	2	11
14							6	8	18	22	8	3	7	1	20
14.5						1	1	2	3	8	1	6	6	6	30
15							1	1		2	2	2	5	2	19
15.5										2				2	19
16															8
16.5															1
17															1
17.5															1
18															1
18.5															1

Table 6.2.1.2. Boarfish in ICES Subareas VI, VII, VIII. Sampling intensity by country of commercial landings.

			DK				IRL				SCT			
Year	Q	Area	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated
2007	1	VIa					12	0	0	VIIj_Q2 and VIa_Q4				
	1	VIIIa					5	0	0	VIIj_Q2 and VIa_Q4				
	1	VIIj					5253	0	0	VIIj_Q2 and VIa_Q4	772	0	0	Irish 2007 combined
	2	VIIg					120	0	0	VIIj_Q2 and VIa_Q4				
	2	VIIj					4130	2	197	VIIj_Q2 and VIa_Q4				
	3	VIIb					0	0	0	VIIj_Q2 and VIa_Q4				
	4	Vb2					6	0	0	VIIj_Q2 and VIa_Q4				
	4	VIa					82	1	20	VIIj_Q2 and VIa_Q4				
	4	VIIb					1259	0	0	VIIj_Q2 and VIa_Q4				
	4	VIIj					6748	0	0	VIIj_Q2 and VIa_Q4				
	Total		0	0	0		17615	3	217		772	0	0	
2008	1	VIa					5	0	0	VIIj_Q4				
	1	VIIg					184	0	0	VIIj_Q4				
	1	VIIj					5041	0	0	VIIj_Q4				
	2	VIIj					46	0	0	VIIj_Q4				
	3	VIIj					4067	0	0	VIIj_Q4				
	4	VIa					23	0	0	VIIj_Q4	0.5	0	0	Irish 2008 combined
	4	VIIb					3	0	0	VIIj_Q4				
	4	VIIj					12216	1	152	VIIj_Q4				
	Total		3098	0	0		21584	1	152		0.5	0	0	
2009	1	VIIb					55	0	0	VIIj_Q3				
	1	VIIg					2979	0	0	VIIj_Q3				
	1	VIIh					1971	0	0	VIIj_Q3				
	1	VIIj					10901	2	359	VIIj_Q3				
	2	VIIg					1933	0	0	VIIj_Q3				
	2	VIIh					3169	0	0	VIIj_Q3				
	2	VIIj					2727	0	0	VIIj_Q3				
	3	VIIh					10378	0	0	VIIj_Q3				
	3	VIIj					11423	1	175					
	4	VIa					45	0	0	VIIj_Q4				
	4	VIIb					18	0	0	VIIj_Q4				
	4	VIIh					2707	0	0	VIIj_Q4				
	4	VIIj					20321	6	941					
	Total		15059	0	0		68629	9	1475		0	0	0	
2010	1	VIa									10	0	0	Irish 2010 VIIb_Q1
	1	VIIb					1069	1	102					
	1	VIIg	577	1	77		2392	0	0	VIIj_Q1				
	1	VIIh	1079	0	0	VIIg+VIIj_Q1	326	1	94					
	1	VIIj	32422	2	193		34466	12	1447		2504	0	0	Irish 2010 VIIj_Q1
	2	VIIh					102	0	0	VIIh_Q3				
	2	VIIj	344	0	0	VIIj_Q1								
	3	VIIg					338	0	0	VIIh_Q3				
	3	VIIh	377	0	0	VIIh_Q4	5540	8	1316		548	0	0	Irish 2010 VIIh_Q3
	3	VIIj	2660	0	0	VIIj_Q4	11531	31	3275		2171	0	0	Irish 2010 VIIj_Q3
	4	VIa					1355	1	117					
	4	VIIb					1189	0	0	VIIj_Q4				
	4	VIIc					35	0	0	VIIj_Q4	4	0	0	Irish 2010 VIIj_Q4
	4	VIIe	2	0	0	VIIh_Q4								
	4	VIIg	94	0	0	VIIh+VIIj_Q4	920	0	0	VIIh_Q4				
	4	VIIh	9	3	384		2484	6	715		1165	0	0	Irish 2010 VIIh_Q4
	4	VIIj	2241	2	217		26710	27	2738		2840	0	0	Irish 2010 VIIj_Q4
	Total		39805	8	871		88457	87	9804		9241	0	0	

Table 6.2.1.2 continued.

			DK				IRL				SCT			
Year	Q	Area	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated
2011	1	VIIb					39	0	0	VIIj_Q4				
	1	VIIh	32	0	0	VIIh_Q4								
	1	VIIIa	18	0	0	VIIh_Q4								
	1	VIIj	1	0	0	VIIj_Q4	38	0	0	VIIj_Q4				
	2	VIIb					1	0	0	VIIj_Q4				
	3	VIIh					820	0	0	VIIh_Q4	434	0	0	Irish 2011 VIIh_Q4
	3	VIIj					1092	0	0	VIIj_Q4				
	4	VIa					26	0	0	VIIj_Q4				
	4	VIIb					235	0	0	VIIj_Q4				
	4	VIIc					9	0	0	VIIj_Q4				
	4	VIIg					811	0	0	VIIj_Q4				
	4	VIIh	4123	11	1347		7720	3	319		2379	0	0	Irish 2011 VIIh_Q4
	4	VIIj	3623	5	611		9894	8	1789					
	Total		7797	16	1958		20685	11	2108		2813	0	0	
2012	1	VIIb					4365	3	339					
	1	VIIg					616	0	0	IRL_Q3_VIIh				
	1	VIIh	3789	1	150	IRL_Q3_VIIh	1005	0	0	IRL_Q3_VIIh				
	1	VIIj	11403	3	102	IRL_Q1_VIIj	27812	42	4987					
	1	VIIIa	1330	2	214	IRL_Q3_VIIh								
	2	VIIh	208	0	0	IRL_Q3_VIIh								
	3	VIIb					49	0	0	IRL_Q1_VIIb				
	3	VIIh					3176	5	682		1537	0	0	IRL_Q3_VIIh
	3	VIIj					834	2	341					
	4	VIa					125	1	96					
	4	VIIb	80	0	0	IRL_Q1_VIIb	87	0	0	IRL_Q1_VIIb	838	0	0	IRL_Q1_VIIb
	4	VIIc					108	0	0	IRL_Q1_VIIb	907	0	0	IRL_Q1_VIIb
	4	VIIh	1840	4	445	IRL_Q4_VIIh	6398	7	945		1602	0	0	IRL_Q4_VIIh
	4	VIIIa	274	0	0	IRL_Q4_VIIj	93	0	0	IRL_Q4_VIIh				
	4	VIIj	963	2	180	IRL_Q4_VIIj	11281	8	1175					
Total			19888	12	1091		55949	68	8565		4884	0	0	
2013	1	VIa					370	0	0	IRL_Q1_VIIb	15	0	0	IRL_Q1_VIIb
	1	VIIb					8314	15	2037		100	0	0	IRL_Q1_VIIb
	1	VIIe									883	0	0	IRL_Q1_VIIh
	1	VIIg					1443	0	0	IRL_Q1_VIIh				
	1	VIIh	955	0	0	IRL_Q1_VIIh	1319	1	113		828	0	0	IRL_Q1_VIIh
	1	VIIIa	1354	3	369		100	1	147					
	1	VIIj	10873	11	852		14338	21	2984		721	0	0	IRL_Q1_VIIj
	3	VIIb					11	0	0	IRL_Q4_VIIb				
	3	VIIg					46	0	0	IRL_Q3_VIIh				
	3	VIIh					2307	3	480					
	3	VIIIa					770	0	0	IRL_Q3_VIIh				
	3	VIIj					3892	2	436		468	0	0	IRL_Q3_VIIj
	4	VIa					167.262	1	123					
	4	VIIb					2080	2	198					
	4	VIIg					320	0	0	IRL_Q4_VIIh				
	4	VIIh					7729	10	1467		901	0	0	IRL_Q4_VIIh
	4	VIIId					270	0	0	IRL_Q4_VIIh				
	4	VIIj					8773	6	833		464	0	0	IRLQ4_VIIj
Total			13182	14	1221		52250	62	8818		4380	0	0	

Table 6.2.1.3. Boarfish in ICES Subareas VI, VII, VIII. Proxy catch numbers-at-age of the international catches (raised numbers in '000s) for the years 2007-2013.

	2007	2008	2009	2010	2011	2012	2013
1	0	0	1575	2415	0	28	301
2	352	5488	15043	11229	2894	893	7148
3	2114	21140	65744	72709	41913	5467	156680
4	40851	105575	338931	294382	28148	41278	58522
5	48915	141300	475619	567689	30116	110272	59797
6	62713	195339	543707	878363	175696	146582	68949
7	26132	104031	307333	522703	143967	492078	302967
8	29766	66570	172783	293719	107126	365840	250341
9	56075	53159	155477	276672	77861	271916	212318
10	44875	46893	130148	232122	60022	173486	160137
11	14019	15289	42521	78588	46079	69396	63025
12	32359	21178	61350	114600	40468	40968	41490
13	4848	11854	39609	59932	24352	58888	59380
14	16837	13570	31569	59060	19724	30277	30355
15+	109481	112947	196967	349320	157707	217260	239366

Table 6.2.2.1. Boarfish in ICES Subareas VI, VII, VIII. Length-frequency distributions of the international catches (raised numbers in '000s) for the years 2007-2013.

TL (cm)	2007	2008	2009	2010	2011	2012	2013	Total
6	0	0	0	156	0	0	0	156
6.5	0	0	0	439	0	0	0	439
7	0	0	0	1090	522	56	52	1719
7.5	0	0	1354	1574	0	0	551	3479
8	0	0	677	375	1345	185	1419	4000
8.5	0	0	0	1082	0	555	3592	5229
9	0	0	677	5382	851	555	7263	14727
9.5	0	7473	17367	7883	7012	641	47509	87884
10	9609	11209	54130	29410	33243	2791	94702	235094
10.5	0	52308	174796	130889	15848	6132	59833	439807
11	84555	63517	343283	361774	70615	24571	18359	966675
11.5	0	59781	321637	655875	93487	81928	20938	1233646
12	44199	119561	297737	739025	189434	264888	98564	1753408
12.5	0	70990	207739	564347	114904	398772	204868	1561619
13	82633	52308	147965	353484	133539	419060	315063	1504052
13.5	0	29890	149314	246146	51235	307533	285688	1069806
14	117224	22418	105782	224611	50857	176710	210137	907739
14.5	0	14945	71273	127711	25309	89726	105571	434534
15	65338	33627	47816	125463	25569	52791	62175	412778
15.5	0	11209	13082	81386	5473	25065	31122	167337
16	13452	11209	19397	24256	4181	13149	14990	100634
16.5	0	3736	4061	6209	2280	2738	4918	23942
17	0	3736	677	1913	456	827	1109	8718
17.5	0	0	0	0	0	0	407	407
18	0	0	0	283	0	0	296	579
18.5	**0**	**0**	**0**	**0**	**0**	**0**	592	592

Table 6.3.2.2 Boarfish in ICES Subareas VI, VII, VIII. IBTS length-frequency data.

WCSGFS	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
1986								1													8.0		1	0
1987								1	1	2	1										9.7	10.2	4	3
1988				1																	4.0		1	0
1989							1														7.0		1	0
1990				1		1	1	2	24	55	50	43	12	1							10.7	11.1	188	160
1991						1	1	9	38	183	267	317	48	16							11.2	11.3	877	829
1992						1		10	39	468	1145	4001	1627	486							12.0	12.1	7775	7726
1993							4		3	9	60	155	73	16		1					12.0	12.1	319	313
1994									1	1	1			1							11.0	11.7	2	2
1995									8	37	194	294	398	199	22						12.5	12.5	1150	1143
1996				2		4	3				1	55	610	1575	304						13.8	13.8	2553	2544
1997			4			1	7	9	4	6	25	109	203	157	41	4					12.9	13.1	568	544
1998				1		1	5	2		1	2		3								8.8	11.8	15	6
1999			1			2	5	1	1		1	2	1								8.2	12.0	14	4
2000							2	2	39	110	216	288	183	93	46	6					12.0	12.1	983	940
2001		1						1	4	15	28	59	134	240	103	10	4				13.5	13.6	599	593
2002						1	8	2	1	82	742	3211	5601	5772	1497	167	1				13.2	13.3	17085	17073
2003			1				3	52		53	281	1473	3066	4895	3083	309	28				13.7	13.8	13244	13188
2004				1			2	2	43	82	743	4569	8600	9514	5693	948	84				13.6	13.6	30280	30232
2005		2					24	3	23	25	110	435	1085	1708	792	130	6				13.6	13.7	4343	4291
2006		1	2	1		1	4		10	218	232	452	1396	2853	2051	435	72				13.9	13.9	7726	7707
2007			2	2		2	1	3	21	159	780	2923	5194	6888	5283	1523	116				13.8	13.8	22897	22866
2008		1	1			16	37	36	187	468	1395	3213	9893	22758	18399	6288	575	71			14.1	14.2	63338	63060
2009			1			1		5	53	2443	2093	441	331	287	246	129	10				11.2	11.2	6038	5979
2010											530	1443	1384	1357	828	149	29				13.2	13.2	5720	5720
2011		1	4	1		1	5	254	1015	2034	7613	18918	14479	6445	2006	237	23				12.4	12.4	53034	51753
2012			1			1	2		103	9	1267	6545	26337	29361	27333	15857	1505	497			14.2	14.2	108817	108710
2013				1			1			1	143	3201	15282	11288	3935	858	6	1			13.5	13.5	34716	34714
SPPGFS	**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**
2001		2		2	2	4		88	10	104	266	323	1334	2259	460	81					13.3	13.5	4934	4827
2002									1	4	90	212	791	843	313	60					13.5	13.5	2314	2313
2003						1		3	15	22	21	62	268	426	249	51	2	1			13.8	13.8	1121	1102
2004		1				5	2		4	5	18	100	312	483	319	43	1				13.8	13.9	1293	1281
2005		1		1	6	1	18	10	9	14	7	101	530	935	705	226	18				14.0	14.2	2581	2536
2006			1	1	6	91	89	21	34	75	27	45	335	670	555	197	10	1			13.3	14.1	2158	1914
2007					3	4	9	15	12	9	27	25	72	151	144	26	4				13.4	13.9	501	458
2008		1				1	13	7	16	13	55	106	237	457	302	78	5				13.7	13.8	1292	1254
2009		6	5		2	7	8	1		1	154	318	924	1201	1172	324	7				13.9	14.0	4130	4101
2010	1			1	5	14	3	1	5	2	31	284	521	717	459	123	10				13.7	13.8	2178	2148
2011								3	16	18	5	147	671	792	429	122	13		2		13.8	13.8	2220	2200
2012				1	1			2	2	1	8	70	369	468	218	66	3				13.8	13.9	1208	1202
2013				1		7	22	6	9		1	42	435	889	480	141	12	1			14.0	14.1	2045	2000
IGFS	**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**
2003		1	32	22	7	22	129	172	879	2942	2322	1325	3822	4628	2898	896	163	38			12.7	13.0	20299	19035
2004		23	63	34	8	96	532	1431	369	344	410	2253	4320	4698	3966	1017	87	2	1		12.9	13.7	19654	17098
2005		8	59	52	20	203	1024	585	288	636	341	3463	11457	11348	7955	1744	382	2	1		13.4	13.7	39569	37330
2006	5	60	68	48	35	212	969	621	2046	4190	8044	7946	24208	42119	32168	12296	2454	532			13.7	13.9	138021	133957
2007	1	6	44	18	31	501	923	1251	1638	1166	2510	3581	8275	10740	7093	1934	92				12.9	13.5	39804	35391
2008			26	18	23	127	672	531	2095	13780	17664	19268	16980	19484	15953	8789	1747	76	1		12.8	12.9	117231	113741
2009		3	80	76	25	94	228	486	1000	1139	9081	7749	5138	6921	5592	1084	68	1			12.5	12.8	38763	36772
2010		6	42	3	18	199	272	463	920	393	7914	34236	28611	16063	8161	1974	433				12.8	12.9	99709	97784
2011		6	14	5	4	189	772	586	555	670	2578	20171	22082	10829	5298	2207	266	9	6		12.9	13.0	66247	64116
2012		7	36	20	10	131	271	378	702	2144	1183	11105	34010	22742	10906	3903	525	4			13.3	13.4	88077	86521
2013	1	3	9	9	20	127	352	340	1321	2833	3971	15572	51637	52868	20485	6560	492	20			13.5	13.5	156620	154439
EVHOE	**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**
1997		5	11	7	17	197	2659	5020	3719	3598	4429	12065	16651	7198	3455	501	18	1			11.8	12.7	59548	47915
1998		1	4	26	76	2093	18283	8631	6125	5966	7095	11730	14078	9260	5076	934	8			1	10.6	12.6	89387	54148
1999			13	52	33	245	11177	26610	23947	6684	2899	4709	7868	6160	1353	267	7				9.5	12.3	92023	29947
2000		17	79	120	8	1504	26894	17674	9836	21967	16382	29585	36853	16522	5397	989	75				10.8	12.2	183903	127769
2001		1	45	687	489	913	21297	37171	13276	28355	31514	18309	12232	6471	3186	1270	81	4			10.0	11.5	175303	101422
2002		2	18	23	11	547	9631	29874	17777	13290	9470	9697	9751	6268	2484	641	37	1	1		9.9	11.9	109522	51639
2003			17	47	17	57	426	1655	7142	20018	24842	20989	21263	14493	7086	1550	36				11.8	12.1	119639	110277
2004			33	512	378	123	1248	1419	1307	1083	3102	7308	7224	6353	7866	3630	241	5			12.7	13.5	41833	36813
2005		2	93	975	1285	146	1100	2326	1229	1553	3183	13398	15758	9834	6010	1658	117	70			12.3	13.1	58738	51580
2006	1	26	112	79	75	15510	37566	10750	3622	2127	1521	1955	4131	3955	2535	921	94	2	12		8.2	13.1	84994	17253
2007		8	187	467	234	1503	22689	126065	64536	6341	6731	5431	6004	5911	4238	1409	118	11			8.8	12.5	251882	36193
2008		3	434	2807	827	5341	53189	247297	165392	163200	69382	38434	18390	17258	9178	3490	745	6	1		9.3	11.1	795371	320083
2009		6	128	194	72	1496	19769	35819	5264	3913	9556	12269	9402	10831	6720	775	38	1			10.0	12.7	116252	53505
2010		21	529	116	154	5755	46438	74986	27175	11952	37420	58313	34737	33774	14626	1561	249	8	1		10.4	12.5	347814	192641
2011		60	95	215	5	541	2247	8368	15256	33221	30237	50384	56559	36673	11867	3082	573	159	47		12.0	12.4	249590	222803
2012		9	145	584	137	2922	28865	26816	6124	11739	13606	22369	37135	44082	19963	4893	127	1			11.4	13.1	219516	153914
2013		3	48	91	10	306	2185	2165	2542	13649	9932	14987	37755	40524	20107	6918	666		2		12.9	13.2	151890	144540
SPNGFS	**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**
1991		1			31	690	1311	313	49	9	6	7	7	4				6			7.0	12.7	2433	39
1992		57	38	9	178	3290	2743	282	48	10	8	69	162	390	779	246	95				8.2	14.7	8404	1760
1993		57	1206	488	97	3730	3753	421	105	54	7	4	8	3	2						6.0	10.8	9934	77
1994	1	40	33		342	4789	10162	8920	3195	53	106	20	9	12	1						7.4	11.1	27685	202
1995		84	108	4	342	3063	2157	220	84	65	58	105	105	90	20	4					6.7	12.4	6510	447
1996		218	537	143	245	4457	4449	267	820	722	82	145	126	219	96	39	2				7.0	11.6	12566	1431
1997	2	102	809	441	235	3458	6824	2189	1923	534	156	353	161	88	3						7.2	11.3	17277	1295
1998	3	2	7	4	49	1920	4685	1815	337	153	125	88	147	135	86	13	2	3			7.5	12.4	9573	752
1999		6	59	13	134	2736	3010	193	106	83	109	143	390	645	402	69					8.1	13.6	8098	1841
2000		7	3729	2046	17	554	1947	489	277	486	756	1252	999	1021	199	34	13				7.4	12.4	13827	4760
2001		68	4	1	153	3241	5085	659	225	206	205	236	692	407	120	22	9				7.7	12.7	11331	1896
2002		4	20		133	2333	2013	284	50	58	54	60	231	314	72	9					7.5	13.2	5634	798
2003		4	950	567	4	77	221	57	39	28	16	22	17	23	16	5	1				4.7	12.5	2047	128
2004		6	22	4	43	2289	3808	443	110	83	58	219	931	776	303	2	1				8.5	13.3	9097	2372
2005		16	451	25	9	754	1007	207	85	102	30	54	257	218	90	44	2				7.8	13.1	3349	797
2006		14	156	160	50	2238	8913	4507	175	94	9	36	229	419	169	9	2				7.4	13.5	17181	968
2007		49	40	1	111	3025	6620	1099	129	260	81	7	93	215	89	21	3				7.2	12.4	11843	768
2008	7	4	92	247	1	936	1561	1326	234	1483	304	537	11	833	201	186	11				9.2	11.9	7974	3566
2009	1	17	53	125	9	2582	3816	4105	119	250	45	142	59	819	120	17	1	1			7.8	13.1	12283	1456
2010		55	102	5	232	13090	22032	3169	1160	1056	89	82	179	1007	1981	518	9				7.5	13.6	44766	4920
2011		29	260	105	46	2805	5511	1278	148	340	145	100	144	591	724	134	3	1			7.9	13.5	12364	2182
2012		29	132	35	556	7550	7844	1364	88	53	59	170	1051	2394	1553	432	21				8.4	14.1	23331	5734
2013			2	11	126	2163	4664	854	302	609	251	61	110	123	140	64	7				7.6	11.7	9486	1364

Table 6.6.2.1. Boarfish in ICES Subareas VI, VII and VIII. IBTS length-frequency data converted to age-structured index by application of the 2010 common ALK rounded down to 1cm length classes.

All	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1997	9186	11460	5356	4603	4209	7331	6050	4331	4970	4375	1498	2491	1741	1248	635	1242	161	676	635	3814
1998	17475	19641	6886	6423	5693	7515	5791	3814	4860	4439	1481	2883	1654	1644	685	1240	236	917	685	4965
1999	11838	33029	20031	8826	3580	3421	2837	1990	2911	2552	804	1716	1045	1010	320	705	80	539	320	2435
2000	19340	29071	12974	18627	16220	19669	14950	10117	11553	9928	3345	5427	3955	2717	1310	2709	265	1470	1310	7757
2001	20344	44451	20694	25753	22184	16593	9665	4839	5137	4484	1492	2471	1545	1362	643	1109	175	824	643	4482
2002	10040	33131	18597	13158	9120	9171	6846	4380	6006	5313	1699	3476	2053	2046	696	1430	202	1115	696	5313
2003	840	4714	8356	20850	19443	18478	13092	7863	10801	10051	3279	7063	3662	4270	1598	2792	629	2439	1598	12890
2004	5958	5660	2092	2537	3567	8255	7560	5288	8479	8618	2871	6954	2968	4378	1924	2576	866	2794	1924	16191
2005	4201	4323	2012	2784	3836	9869	9393	6931	10296	9875	3269	7332	3684	4419	1814	2913	759	2642	1814	14728
2006	44120	35631	8054	7238	6703	8802	9417	6528	14774	15648	4994	14441	5398	9659	3847	4781	1967	6478	3847	37015
2007	24531	128029	67188	19124	7326	8707	7376	4824	8405	8454	2739	7014	2967	4520	1748	2495	799	2784	1748	15325
2008	43985	262478	172674	148047	91323	53729	31280	15702	23250	22959	7433	17778	7213	11602	5022	6177	2310	7992	5022	45589
2009	18107	42788	14748	10829	12257	14366	9760	5252	7847	7656	2476	5816	2443	3766	1259	2049	642	2128	1259	11324
2010	58552	98227	37475	25665	30828	52503	37174	21833	27440	24593	8035	15093	8215	8983	3253	6110	1257	4997	3253	25820
2011	8615	17617	17110	34003	34910	52378	39952	26259	31789	27728	9181	16113	10503	8764	3850	7350	1012	5048	3850	26631
2012	32050	40410	12771	13406	14205	27201	28554	21680	36693	35756	11588	28599	13608	17833	7714	10766	2944	11650	7714	64807
2013	6803	7520	5505	13956	13771	24883	28094	22103	38364	35844	11307	27931	14497	17316	6137	10616	2170	10230	6137	51394
EVHOE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**
1997	1876	6003	3741	3911	3938	7065	5867	4218	4832	4259	1461	2428	1699	1214	623	1215	159	659	623	3737
1998	12977	15997	6248	6247	5591	7435	5732	3777	4806	4386	1463	2843	1635	1619	676	1224	232	904	676	4888
1999	7576	31223	19915	8732	3499	3308	2715	1905	2720	2357	743	1540	975	893	285	647	62	474	285	2102
2000	17676	27730	12586	17986	15525	18740	14297	9737	11041	9490	3208	5160	3797	2556	1266	2604	253	1384	1266	7385
2001	14389	41313	20357	25467	21921	16211	9247	4525	4543	3951	1332	2057	1322	1098	578	959	153	684	578	3884
2002	6719	31728	18455	12784	8389	7115	4767	2851	3429	3018	994	1806	1123	1009	421	796	117	573	421	2964
2003	509	3993	7348	18371	17276	16113	10798	6270	7620	6852	2267	4294	2501	2456	1009	1838	326	1387	1009	7340
2004	1265	1976	1261	1722	2227	4124	3228	2061	2871	3058	1066	2426	939	1509	901	917	382	1142	901	7311
2005	2102	2603	1497	2098	3015	7160	5992	4177	5301	4873	1642	3144	1796	1776	833	1368	285	1065	833	6107
2006	35834	26593	4803	2199	1386	1489	1332	947	1521	1484	485	1170	557	725	311	445	125	464	311	2596
2007	16818	122140	65369	16986	4919	4316	2967	1715	2452	2392	788	1802	820	1124	484	678	204	715	484	4049
2008	41611	258758	168378	134061	77106	37738	18750	8277	9132	8183	2660	4868	2458	2992	1226	1876	492	1919	1226	10417
2009	13338	36829	12194	5626	5982	7788	5443	3054	4443	4230	1364	3079	1382	1965	618	1114	309	1064	618	5485
2010	33601	83903	35048	21678	23503	34210	23037	12643	16303	14519	4647	9008	4716	5551	1689	3457	690	2957	1689	14298
2011	2212	12471	14982	28729	26114	31844	23915	15535	19473	16964	5542	10176	6534	5663	2262	4513	597	3197	2262	16235
2012	20089	34348	11535	11098	10795	14979	13308	9004	15662	14714	4598	11467	5540	7325	2325	4142	920	4164	2325	20439
2013	1647	3695.1	3805.3	10388	9207	11385	11271	8299	14485	13797	4374	10961	5364	6893	2550	4068	981	4205	2550	21823
IGFS+WCSGFS+EVHOE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**
2003	636	4552	8306	20803	19406	18414	13013	7804	10668	9916	3237	6942	3612	4190	1573	2752	617	2393	1573	12654
2004	1685	3414	1912	2444	3481	8017	7255	5037	8031	8189	2735	6610	2796	4164	1860	2446	838	2683	1860	15644
2005	2930	3604	1895	2694	3773	9738	9200	6777	9949	9514	3154	7004	3553	4203	1731	2801	721	2505	1731	13978
2006	36687	28176	6830	7100	6633	8714	9277	6421	14479	15337	4898	14144	5288	9457	3779	4686	1933	6356	3779	36365
2007	17873	124020	66810	18929	7205	8648	7322	4790	8309	8353	2708	6917	2932	4453	1729	2464	788	2746	1729	15126
2008	42240	260577	172031	147113	90691	53328	31023	15587	22918	22641	7344	17496	7113	11395	4967	6101	2285	7861	4967	44972
2009	13607	37705	13658	10616	12063	14060	9426	5030	7283	7072	2296	5275	2243	3396	1141	1878	582	1909	1141	10185
2010	33976	84649	35967	24858	30441	52245	36921	21671	26982	23992	7828	14456	8055	8546	3060	5910	1145	4712	3060	24053
2011	2884	13954	16666	33742	34724	52174	39716	26089	31387	27290	9039	15699	10356	8486	3752	7213	958	4882	3752	25707
2012	20395	35049	12386	13340	14140	26984	28191	21406	35924	34955	11342	27840	13323	17314	7548	10525	2861	11338	7548	63197
2013	2021	4557.2	5053.5	13515	13490	24723	27933	21993	38084	35555	11218	27662	14393	17133	6074	10529	2140	10116	6074	50796
SPNGFS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**
1997	7306	5446	1609	681	249	203	121	67	69	56	18	22	18	11	4	11	0	6	4	23
1998	4493	3640	638	175	101	79	58	37	54	53	17	40	19	25	9	15	4	14	9	77
1999	4258	1802	116	93	80	112	121	85	191	195	61	175	70	117	35	58	18	65	35	333
2000	1661	1325	347	518	553	750	537	315	443	379	116	237	139	146	37	91	10	78	37	325
2001	5952	3099	308	205	161	197	190	148	199	175	58	114	77	62	25	53	6	34	25	169
2002	3315	1395	104	54	43	55	63	47	98	88	26	71	37	46	10	25	3	24	10	97
2003	203	155	38	26	16	14	10	5	9	9	3	7	3	4	2	2	1	3	2	15
2004	4267	2243	177	82	68	171	219	186	303	279	89	209	118	124	37	85	14	63	37	294
2005	1253	701	108	78	46	50	60	51	84	78	25	59	33	35	15	24	4	22	15	116
2006	7297	7378	1191	85	34	36	56	44	116	112	33	100	43	68	14	32	8	35	14	154
2007	6646	3990	367	180	106	37	30	18	55	54	16	50	20	35	8	15	4	20	8	92
2008	1736	1886	629	908	597	329	178	62	202	183	47	158	53	122	28	36	10	81	28	352
2009	4487	5077	1085	168	104	79	71	26	174	155	37	147	56	113	9	34	6	58	9	194
2010	24558	13572	1504	792	346	101	85	41	222	365	132	436	76	306	146	130	91	206	146	1347
2011	5730	3656	432	244	163	94	77	38	140	182	61	198	48	140	50	59	33	84	50	493
2012	11653	5359	383	62	55	160	276	202	620	657	201	638	228	441	140	198	73	266	140	1382
2013	4763	2947	446	439	276	110	59	30	44	49	17	44	16	28	15	16	7	21	15	132

Table 6.6.3.1. Boarfish in ICES Subareas VI, VII, VIII. 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	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013
	Raised numbers							ln (raised numbers)						
1	0	0	1575	2415	0	28	301	0	0	7	8	0	3	6
2	352	5488	15043	11229	2894	893	7148	6	9	10	9	8	7	9
3	2114	21140	65744	72709	41913	5467	156680	8	10	11	11	11	9	12
4	40851	105575	338931	294382	28148	41278	58522	11	12	13	13	10	11	11
5	48915	141300	475619	567689	30116	110272	59797	11	12	13	13	10	12	11
6	62713	195339	543707	878363	175696	146582	68949	11	12	13	14	12	12	11
7	26132	104031	307333	522703	143967	492078	302967	10	12	13	13	12	13	13
8	29766	66570	172783	293719	107126	365840	250341	10	11	12	13	12	13	12
9	56075	53159	155477	276672	77861	271916	212318	11	11	12	13	11	13	12
10	44875	46893	130148	232122	60022	173486	160137	11	11	12	12	11	12	12
11	14019	15289	42521	78588	46079	69396	63025	10	10	11	11	11	11	11
12	32359	21178	61350	114600	40468	40968	41490	10	10	11	12	11	11	11
13	4848	11854	39609	59932	24352	58888	59380	8	9	11	11	10	11	11
14	16837	13570	31569	59060	19724	30277	30355	10	10	10	11	10	10	10
15+	109481	112947	196967	349320	157707	217260	239366	12	12	12	13	12	12	12
Z (age 7-14)								0.18	0.32	0.32	0.32	0.28	0.42	0.35
F (Z-M), where M = 0.16								0.02	0.16	0.16	0.16	0.12	0.26	0.19
Catches (t)								21576	34751	90370	144047	36937	86414	75409
Correllation coefficient landings vs. F								0.54						

Table 6.6.4.1. Boarfish in ICES Subareas VI, VII, VIII. Acoustic survey biomass estimates for 2011 - 2014.

2011 *MFV Felucca* - 24 hour operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	7,049	393,893	86.4
Probably	1,134	62,222	13.6
Mixture	-	-	-
Total estimate	**8,183**	**456,115**	**100**
Possibly			
CV TSB	17.5	17.6	
SSB Estimate			
Definelty	7,019	393,312	86.4
Probably	1,126	62,063	13.6
Mixture	0	0	0.0
SSB estimate	**8,145**	**455,375**	**100**
Possibly	-	-	

2012 *MFV Father McKee* - daylight only (04:00 - 24:00) operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	11,684	708,019	82.0
Probably	2,072	123,723	14.3
Mixture	501	31,704	3.7
Total estimate	**14,257**	**863,446**	**100**
Possibly	16	1,017	
CV TSB	10.6	10.7	
SSB Estimate			
Definelty	11,615	706,582	82.0
Probably	2,050	123,286	14.3
Mixture	500	31,676	3.7
SSB estimate	**14,165**	**861,544**	**100**
Possibly	16	1,017	

2013 *MFV Felucca* - daylight only (04:00 - 24:00) operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	8,834	431,571	98.1
Probably	240	7,187	1.6
Mixture	17	1,139	0.3
Total estimate	**9,091**	**439,897**	**100**
Possibly	-	-	
CV TSB	17.5	16.7	
SSB Estimate			
Definelty	8,120	416,124	98.3
Probably	179	5,895	1.4
Mixture	17	1,139	0.3
SSB estimate	**8,316**	**423,158**	**100**
Possibly	-	-	

Biomass derived using a modelled boarfish TS-Length relationship (-66.2dB).

2014 *MFV Felucca* - daylight only (04:00 - 24:00) operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	2,227	133,713	71.2
Probably	830	51,461	27.4
Mixture	41	2,605	1.4
Total estimate	**3,098**	**187,779**	**100**
Possibly	-	-	
CV TSB	15.1	15.1	
SSB Estimate			
Definelty	2,223	133,600	71.2
Probably	829	51,449	27.4
Mixture	41	2,605	1.4
SSB estimate	**3,093**	**187,654**	**100**
Possibly	-	-	

Biomass derived using a modelled boarfish TS-Length relationship (-66.2dB).

Table 6.6.5.1. Boarfish in ICES Subareas VI, VII, VIII. Key parameter estimates from final run. CV(TSB_{2014}) is the coefficient of variation of the estimated total stock biomass in 2014. Posterior parameter distributions are provided in Figure 6.6.5.5.

Run	r	K	FMSY	BMSY	TSB2014	CV(TSB2014)
1	0.343	694127	0.171	347063	261003	0.381

Table 6.6.5.2. Boarfish in ICES Subareas VI, VII, VIII. Estimates of total stock biomass and F.

Year	Low TSB	Mean TSB	High TSB	Low F	Mean F	High F
1991	120302	242343	482648	0	0	0
1992	200600	385082	763798	0	0	0
1993	235500	464690	926990	0	0	0
1994	268602	538698	1084975	0	0	0
1995	237808	472397	942688	0	0	0
1996	249802	482913	969268	0	0	0
1997	213402	407993	797973	0	0	0
1998	292808	569625	1142000	0	0	0
1999	223405	433785	855868	0	0	0
2000	187600	361979	714373	0	0	0
2001	193602	364120	708700	0	0	0
2002	176200	327015	633300	0	0	0
2003	168002	309117	597243	0.019	0.042	0.07
2004	252300	469763	930195	0.006	0.012	0.021
2005	226802	421489	819848	0.007	0.016	0.027
2006	267700	490674	940488	0.008	0.016	0.027
2007	228205	419437	806883	0.027	0.059	0.099
2008	300802	547163	1045975	0.034	0.073	0.123
2009	303802	547028	1046975	0.09	0.204	0.353
2010	457102	830052	1587000	0.095	0.216	0.379
2011	355218	657557	1276975	0.029	0.065	0.11
2012	515808	873575	1650975	0.054	0.116	0.186
2013	379502	665634	1270975	0.061	0.134	0.222
2014	140800	261003	513893	-	-	-

Table 6.7.1. Boarfish in ICES Subareas VI, VII, VIII. Projection table. Basis: Catch (2014) = 133 880 thousand tonnes (EU TAC = 127 509 t and average discards 2003-2013 = 6 371 t). Note that for F projections, the fishing mortality is fixed and the credible intervals for catch (95% CI) represent the uncertainty in biomass; for fixed catch projections credible intervals on F represent the uncertainty in biomass. F_{MP} is based rule 1.1b of the proposed management plan. $F_{ICES\ HCR}$ is based on the generic ICES MSY harvest control rule.

Projection	F_{2015}	F_{2015} 95% CI	Catch 2015	Catch 2015 95% CI	TSB_{2016}	TSB_{2016} 95% CI	Probability TSB_{2016}<$B_{trigger}$	Probability TSB_{2016}<B_{lim}
F_{lim}	0.274	-	65680	25780-200300	282115	77040-915400	0.777	0.172
F_{MSY}	0.171	-	43132	16930-131500	306969	87440-960100	0.712	0.145
F_{pa}	0.146	-	37305	14640-113800	310681	87190-983200	0.702	0.141
$F_{ICES\ HCR}$	0.132	-	33875	13300-103300	312637	88460-998100	0.700	0.129
$F_{0.1}$	0.13	-	33394	13110-101800	315563	87920-986300	0.703	0.128
F_{MP}	0.129	-	33154	13010-101100	318207	88450-992900	0.697	0.132
Zero catch	0	0-0	0	-	352984	98120-1095000	0.621	0.099
Status quo catch	0.671	-	133880	-	211826	5180-939000	0.867	0.511

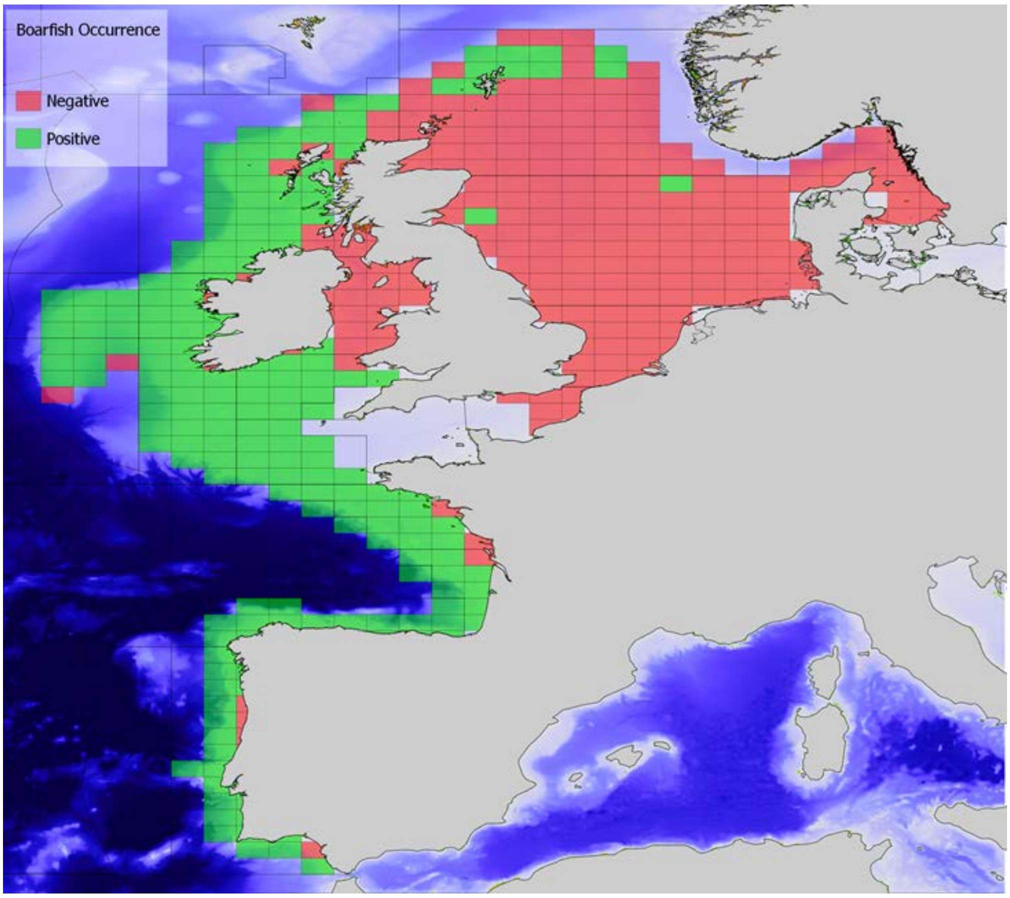
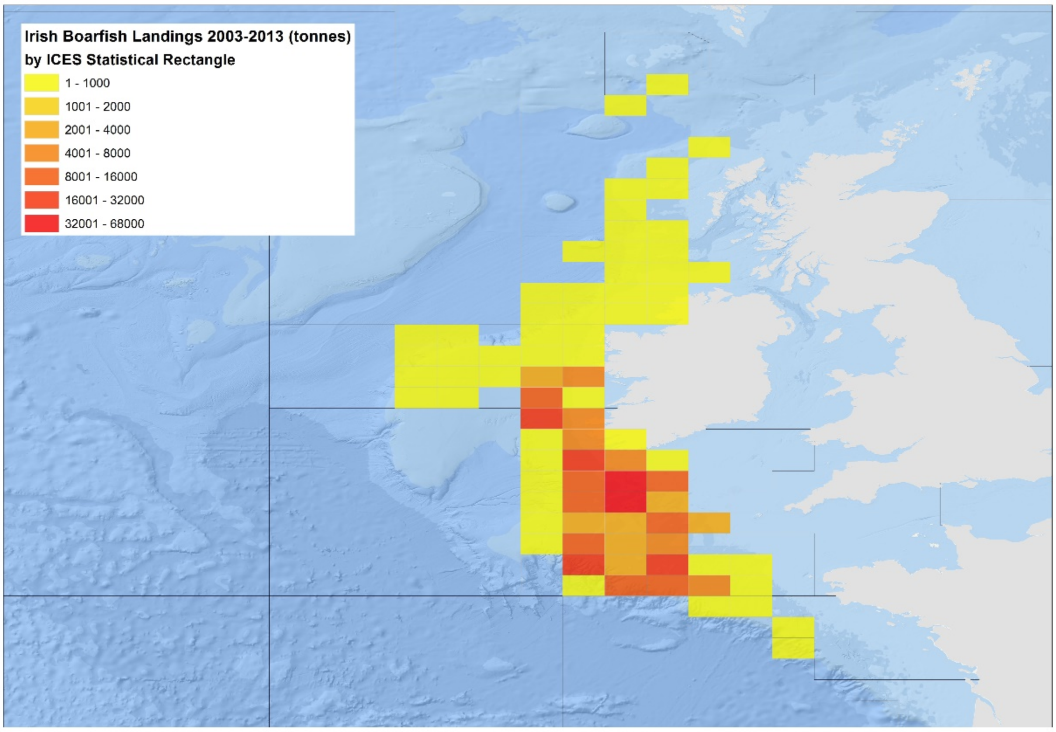


Figure 6.1. Boarfish in ICES Subareas VI, VII, VIII. Distribution of boarfish in the NE Atlantic area based on presence and absence in IBTS surveys (all years).



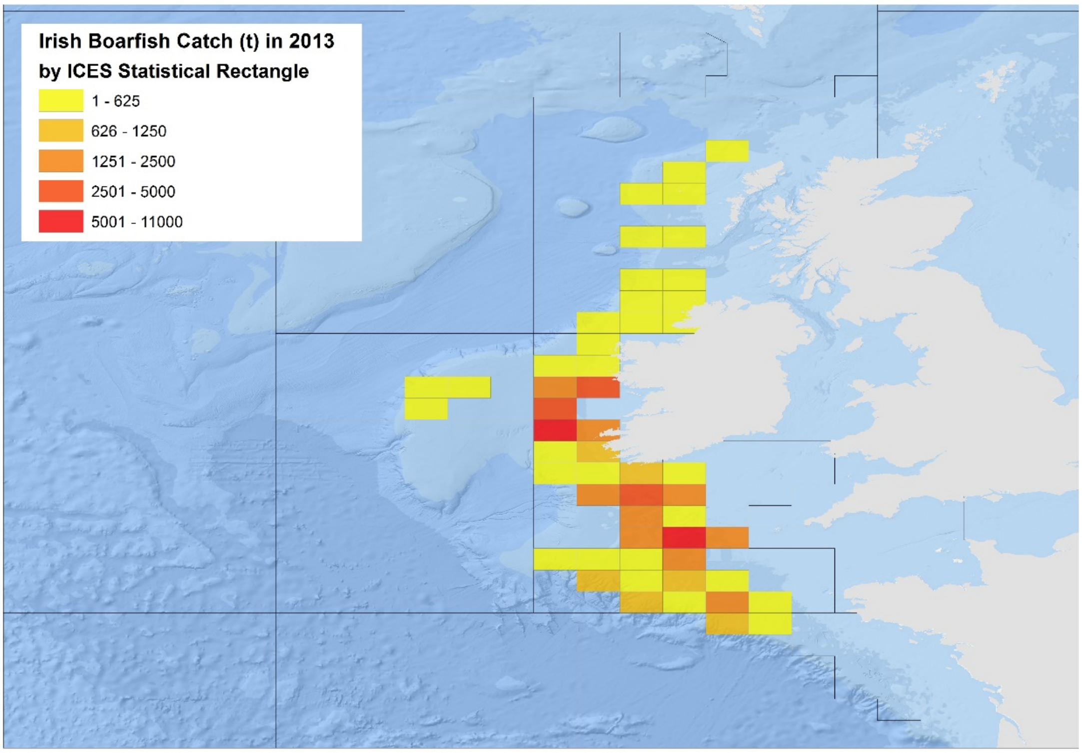


Figure 6.2. Boarfish in ICES Subareas VI, VII, VIII. Combined Irish boarfish landings 2003-2013 by ICES rectangle (Above). Irish boarfish landings 2013 by ICES rectangle (Below).

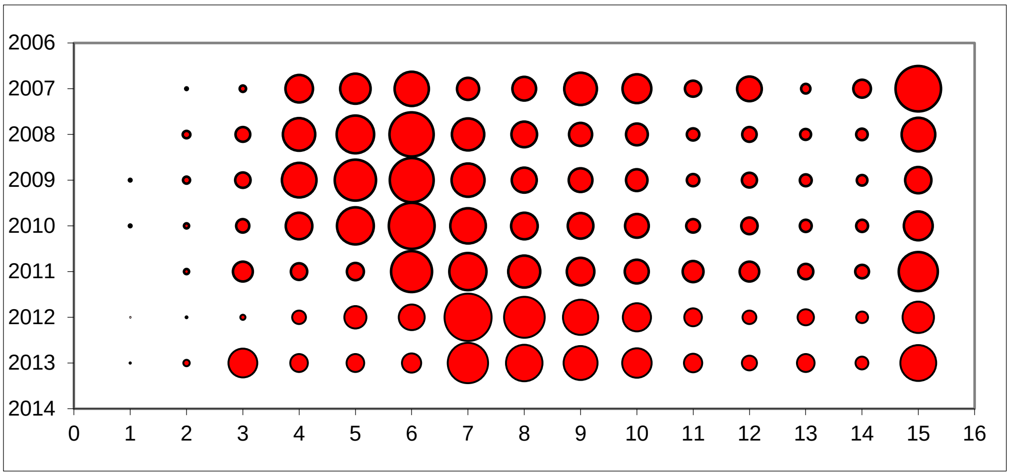


Figure 6.2.1.1. Boarfish in ICES Subareas VI, VII, VIII. Catch numbers-at-age standardised by yearly mean. 15+ is the plus group.

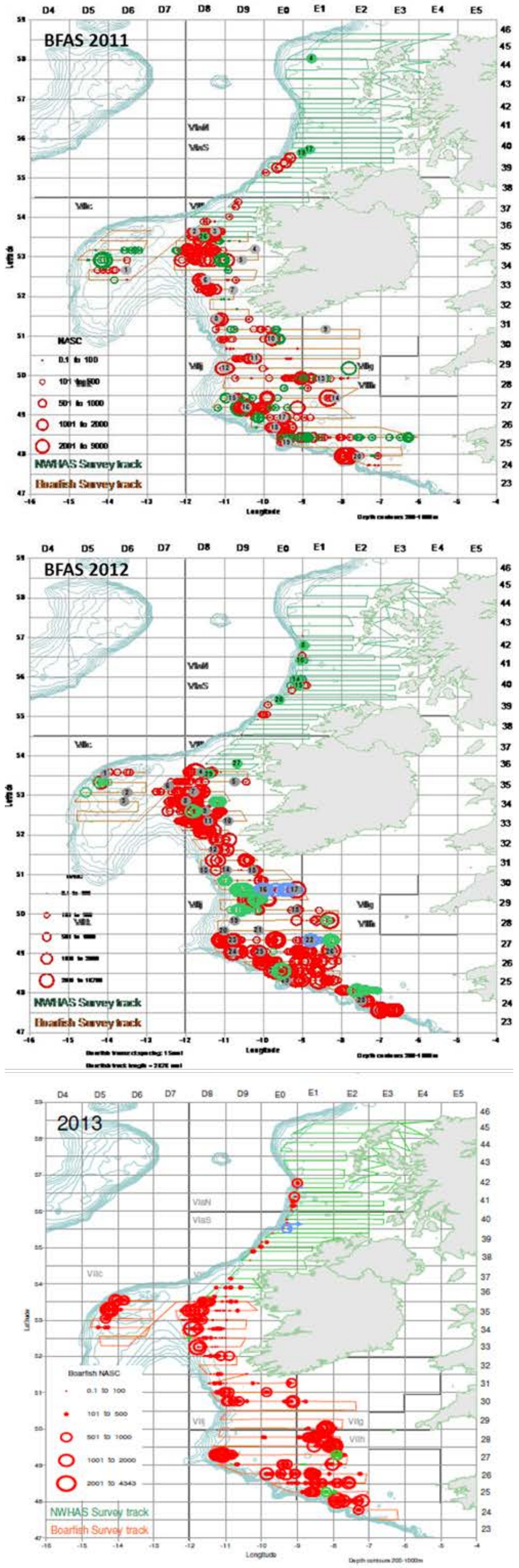


Figure 6.3.1.1a. Boarfish in ICES Subareas VI, VII, VIII. Boarfish acoustic survey track and haul positions from acoustic survey 2011-2013. Red circles represent 'definitely' boarfish, green: 'probably boarfish', blue: 'boarfish mix'.

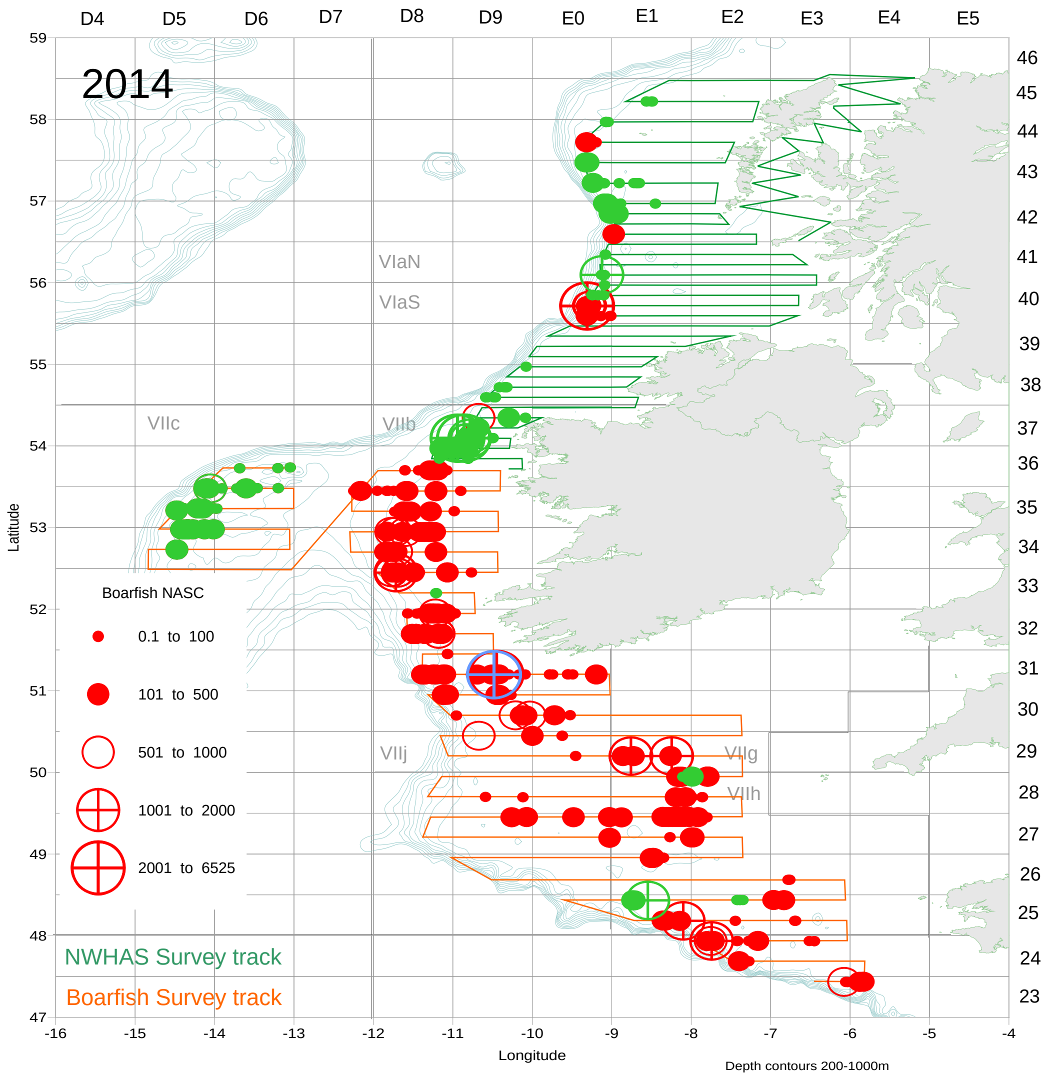


Figure 6.3.1.1b. Boarfish in ICES Subareas VI, VII, VIII. Boarfish acoustic survey track and haul positions from acoustic survey 2014. Red circles represent 'definitely' boarfish, green: 'probably boarfish', blue: 'boarfish mix'.

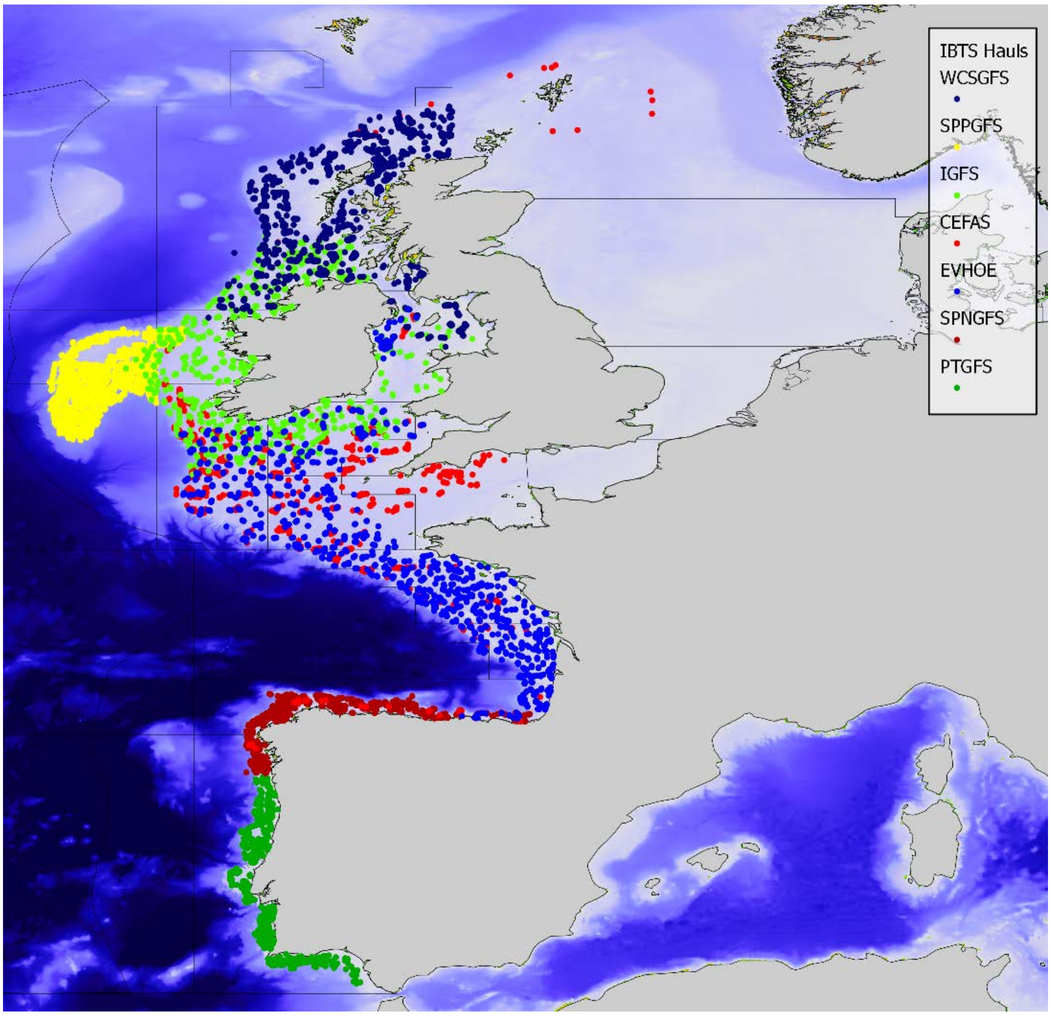


Figure 6.3.2.1. Boarfish in ICES Subareas VI, VII, VIII. The haul positions of bottom trawl surveys analysed as an index for boarfish abundance. Note the Portuguese Groundfish survey included here was not included in the 2014 assessment.

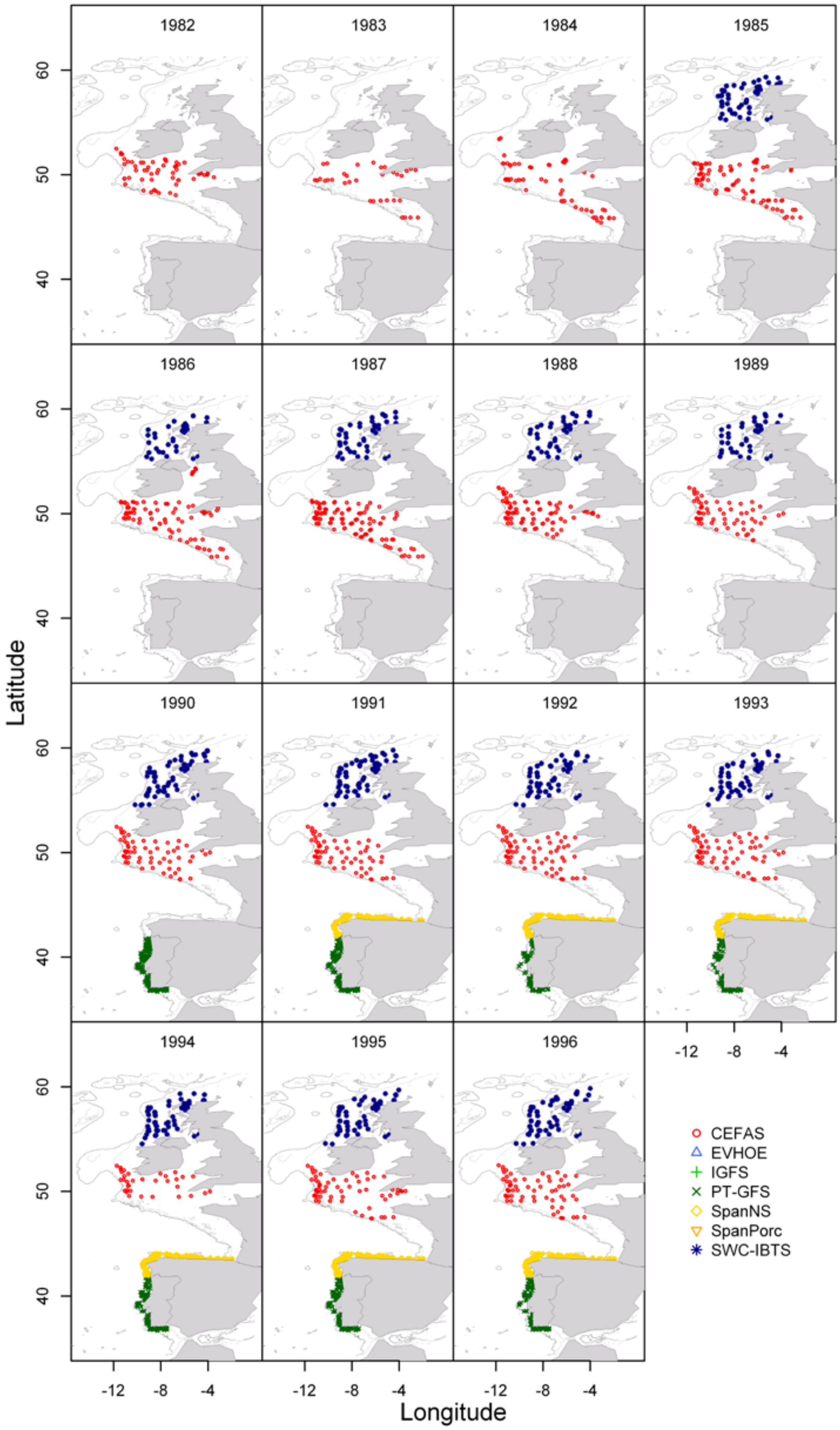


Figure 6.3.2.2a. Boarfish in ICES Subareas VI, VII, VIII. The haul positions of bottom trawl surveys by year analysed as part of the GAM modelling.

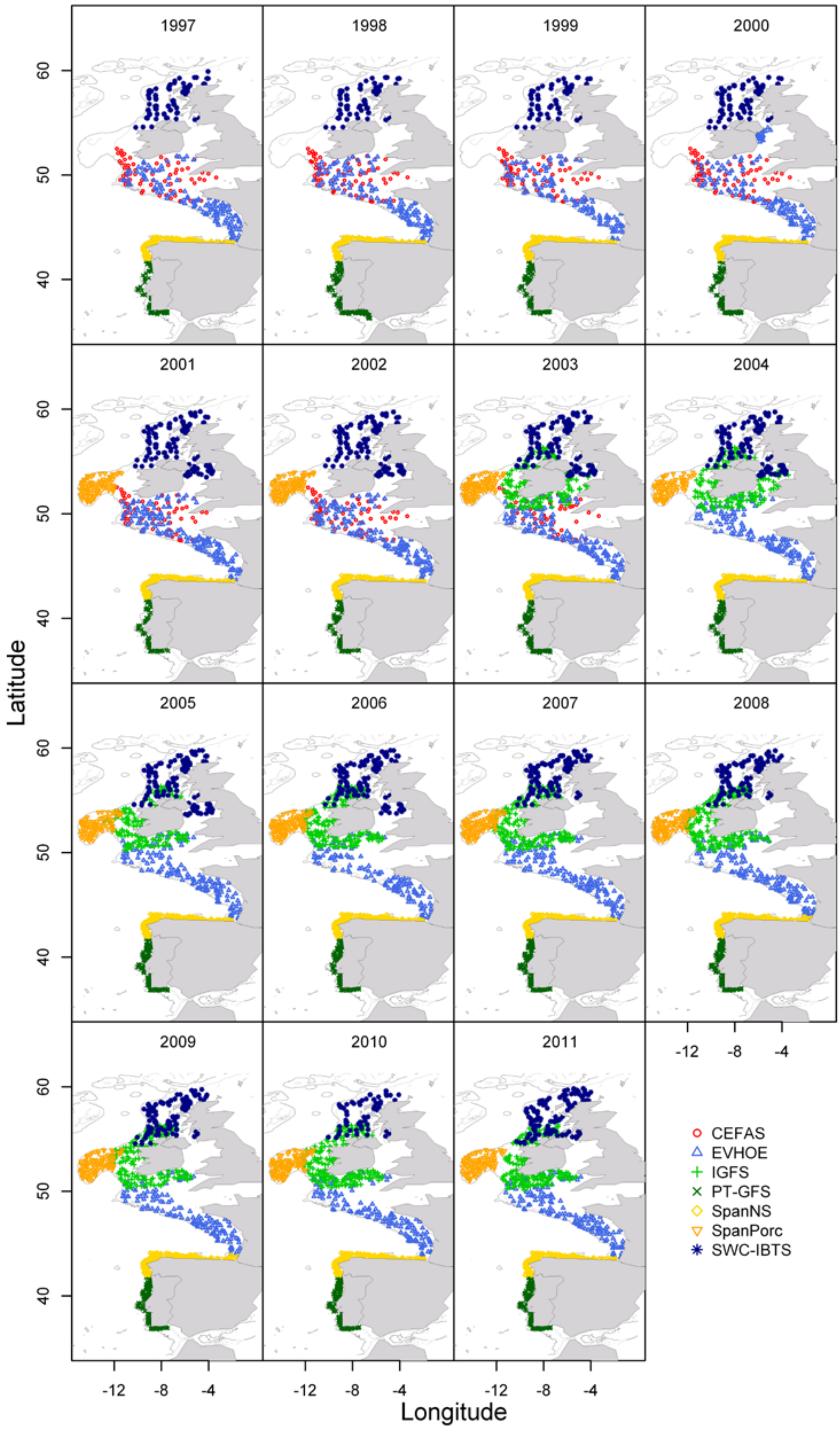


Figure 6.3.2.2b. Boarfish in ICES Subareas VI, VII, VIII. The haul positions of bottom trawl surveys by year analysed as part of the GAM modelling.

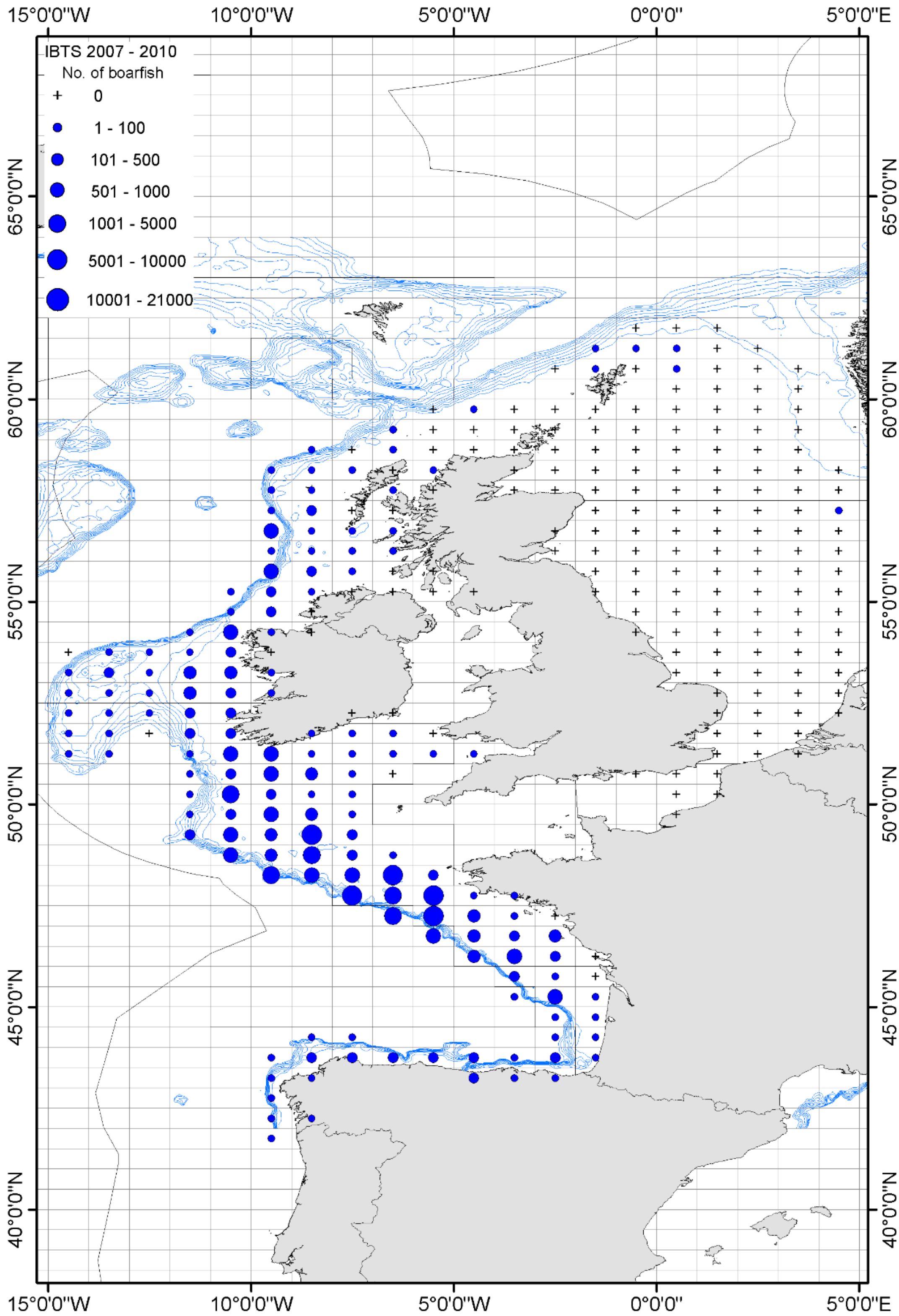


Figure 6.3.2.3. Boarfish in ICES Subareas VI, VII, VIII. Distribution of boarfish in the NE Atlantic showing proposed management area.

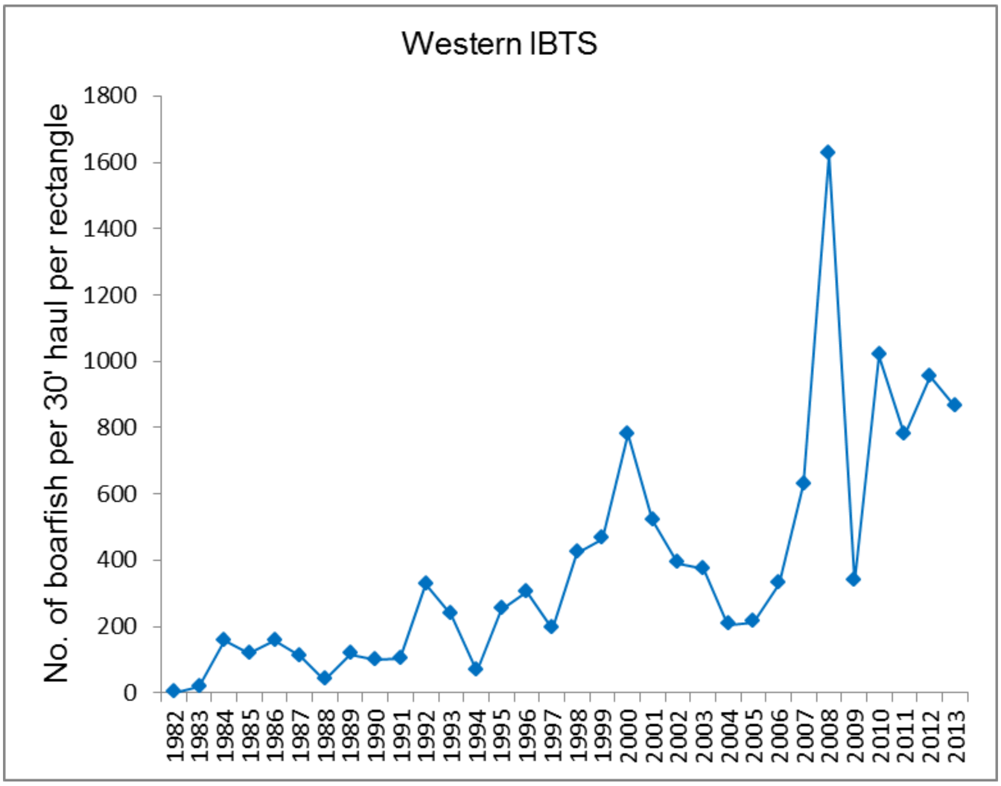


Figure 6.3.2.4. Boarfish in ICES Subareas VI, VII, VIII. CPUE in number per 30 minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2013.

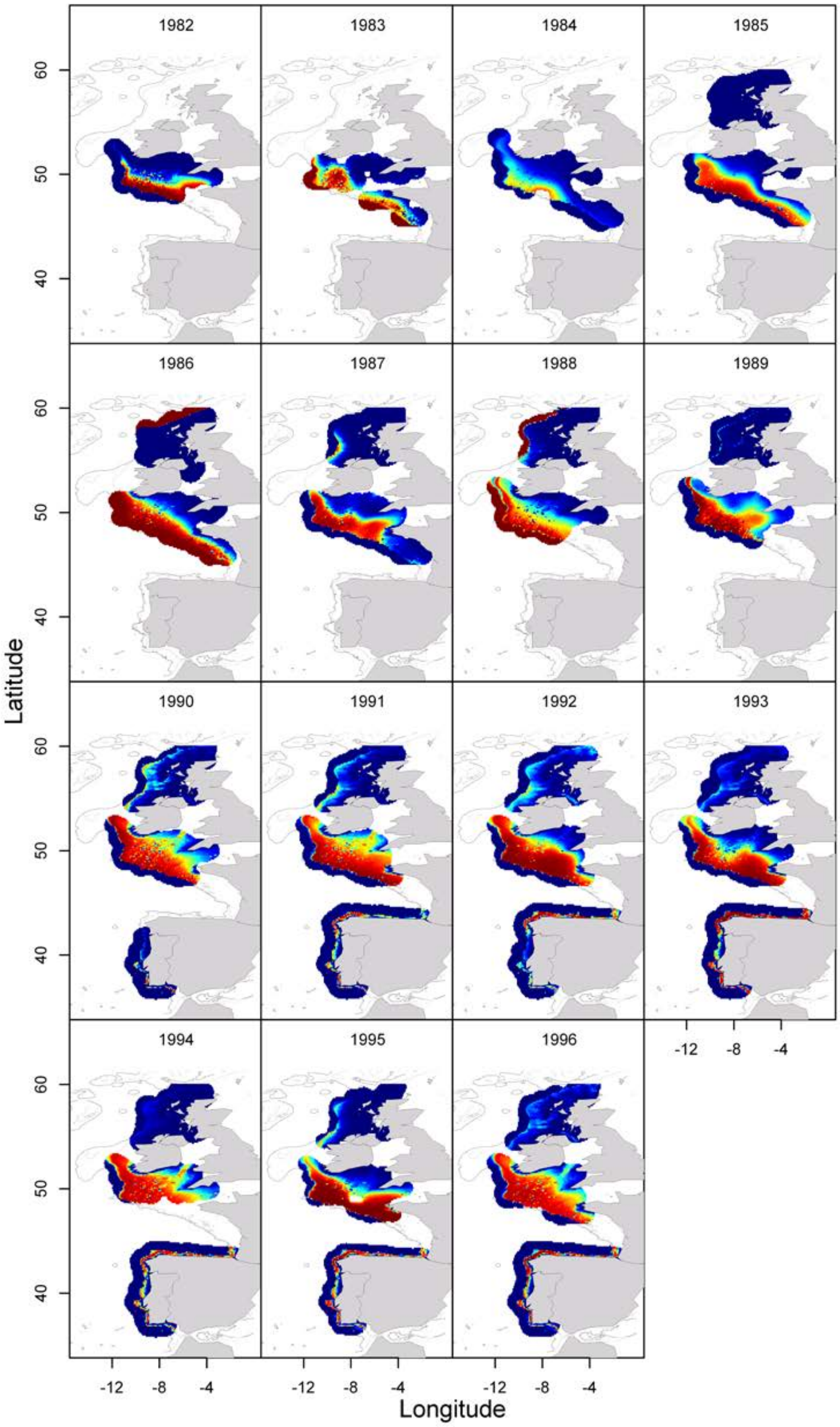


Figure 6.3.2.5a. Boarfish in ICES Subareas VI, VII, VIII. The occurrence GAM of the probability of occurrence of boarfish in a survey area 1982 – 1996. Red indicates definite occurrence and blue indicates absence.

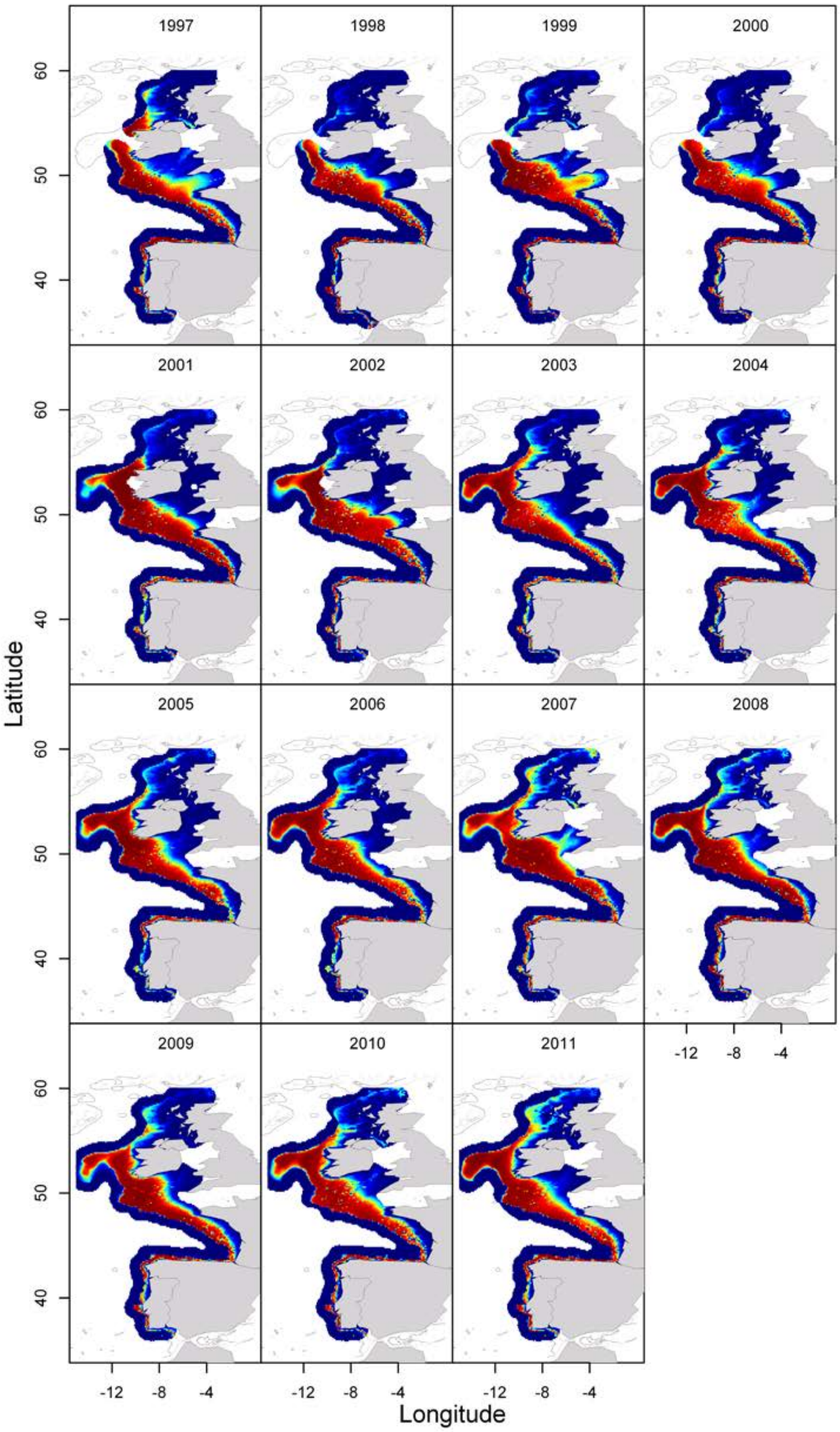


Figure 6.3.2.5b. Boarfish in ICES Subareas VI, VII, VIII. The occurrence GAM of the probability of occurrence of boarfish in a survey area 1997 – 2011. Red indicates definite occurrence and blue indicates absence.

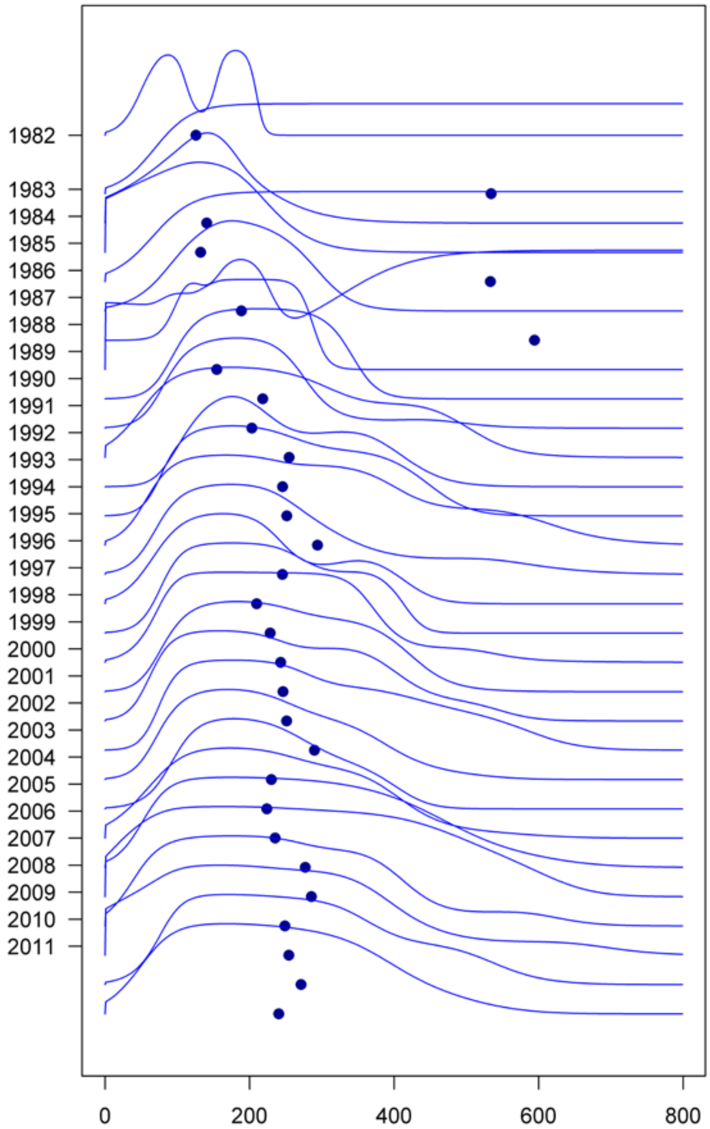


Figure 6.3.2.6. Boarfish in ICES Subareas VI, VII, VIII. The depth distribution profile of boarfish within the IBTS surveys.

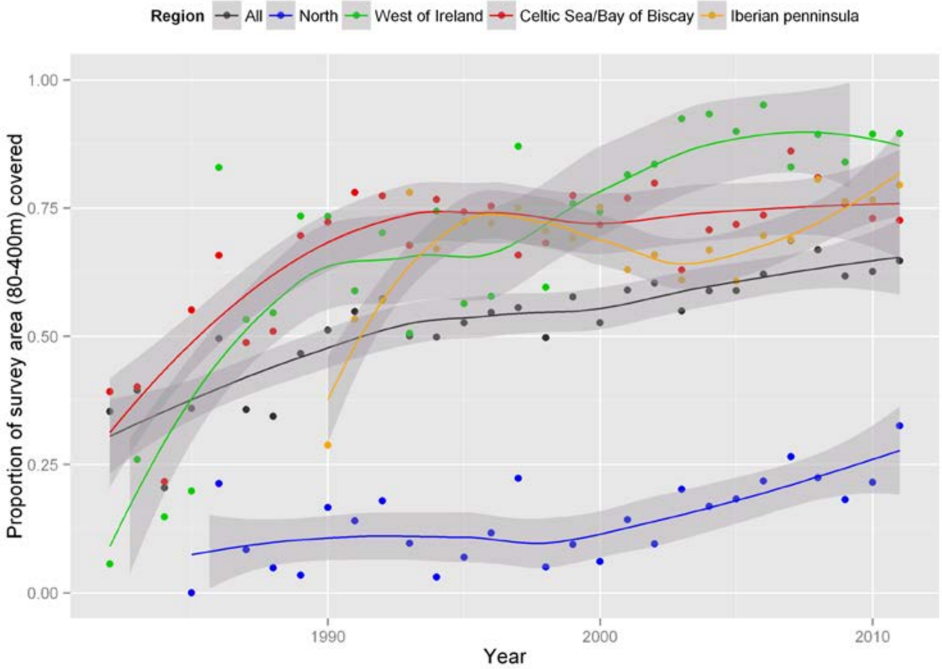


Figure 6.3.2.7. Boarfish in ICES Subareas VI, VII, VIII. The proportion of survey area covered by boarfish per region and per year.

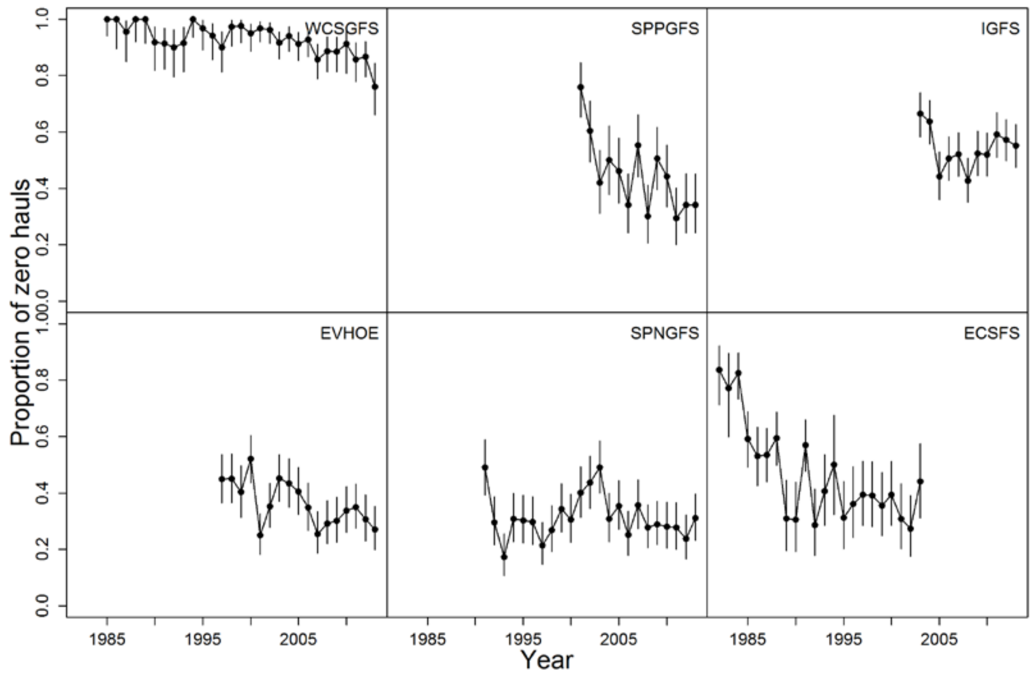


Figure 6.3.2.8. Boarfish in ICES Subareas VI, VII, VIII. The proportion of zero hauls per IBTS survey.

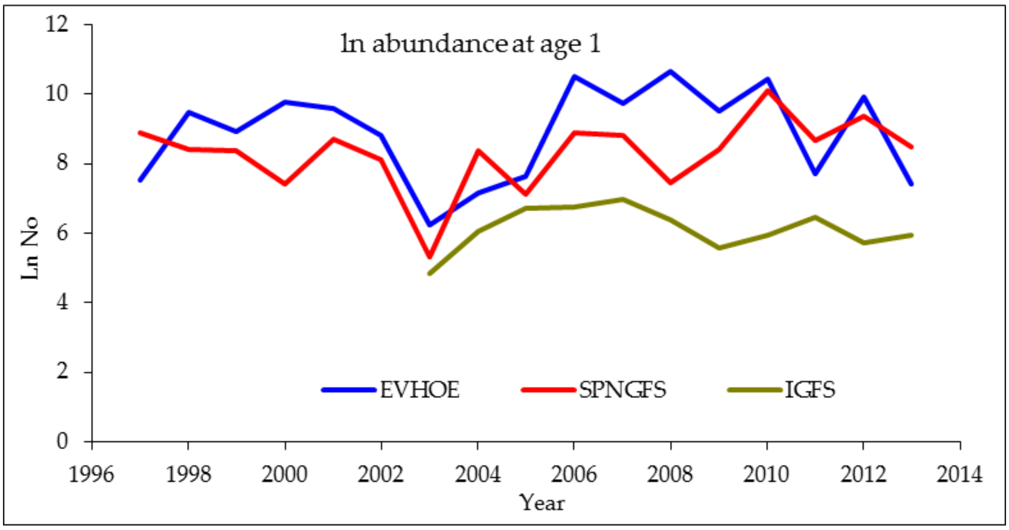


Figure 6.5.1. Boarfish in ICES Subareas VI, VII, VIII. Recruitment-at-age 1, from various IBTS.

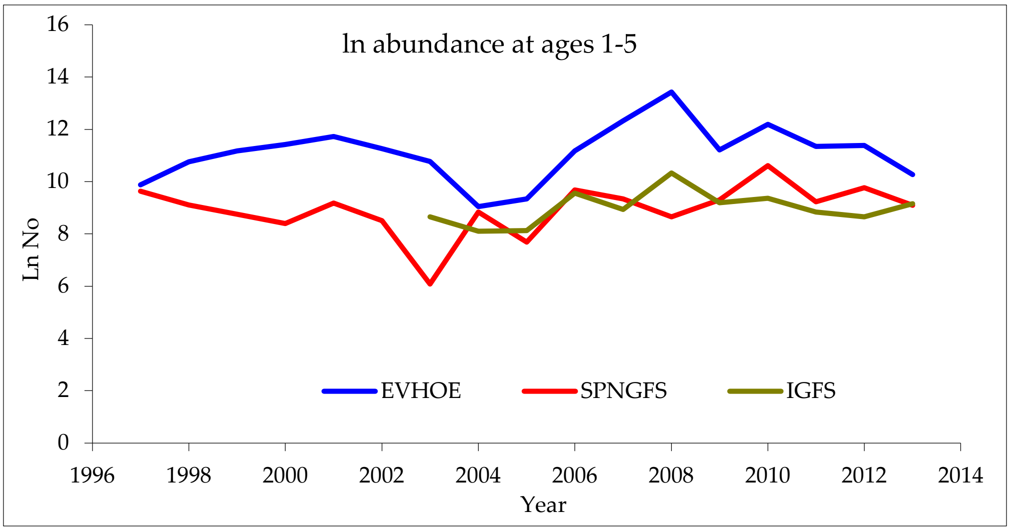


Figure 6.5.2. Boarfish in ICES Subareas VI, VII, VIII. Recruitment-at-ages 1-5, from various IBTS.

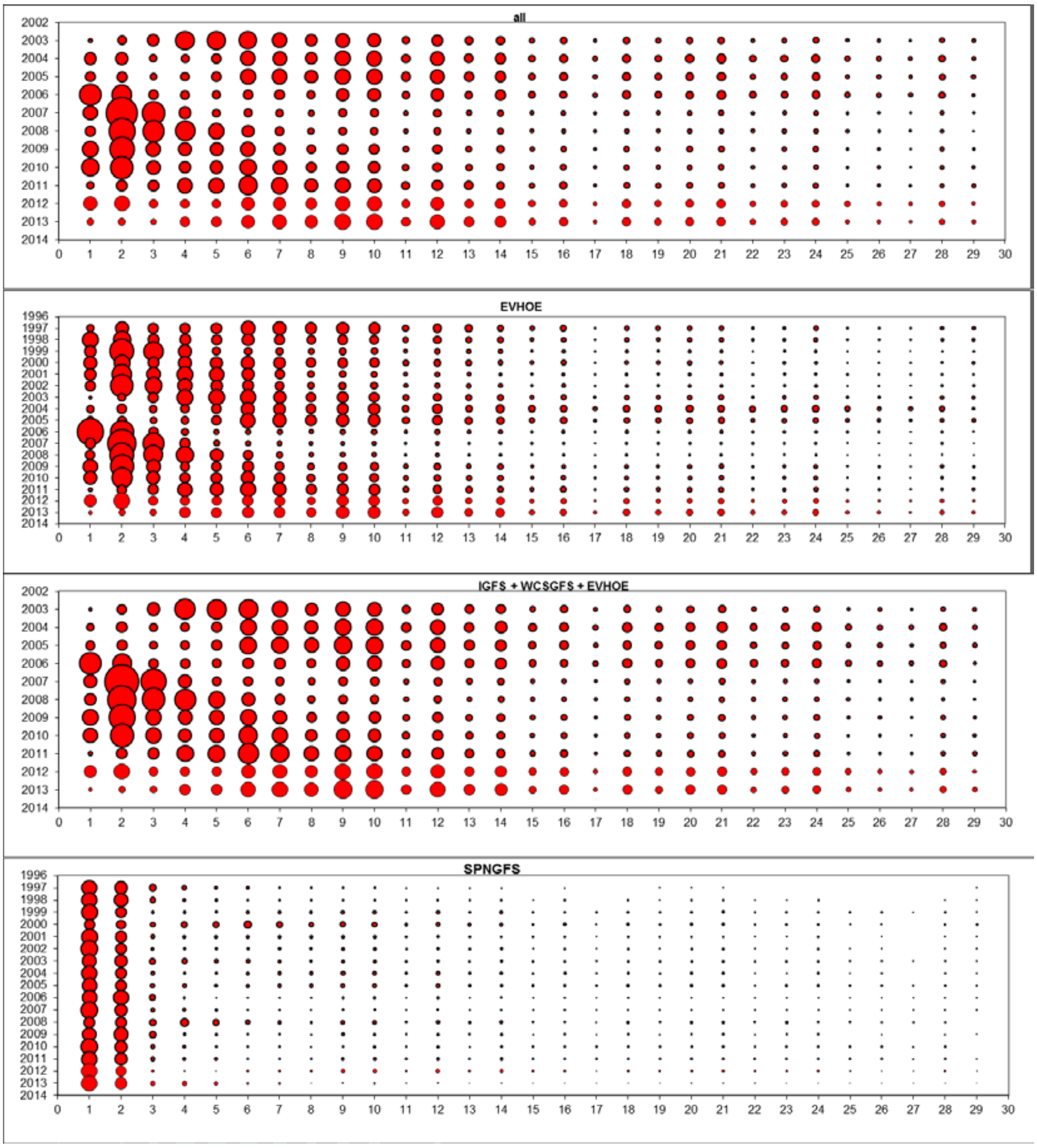


Figure 6.6.2.1. Boarfish in ICES Subareas VI, VII, VIII. Abundance-at-age in constituent western IBTS. Yearly mean standardised abundance-at-age.

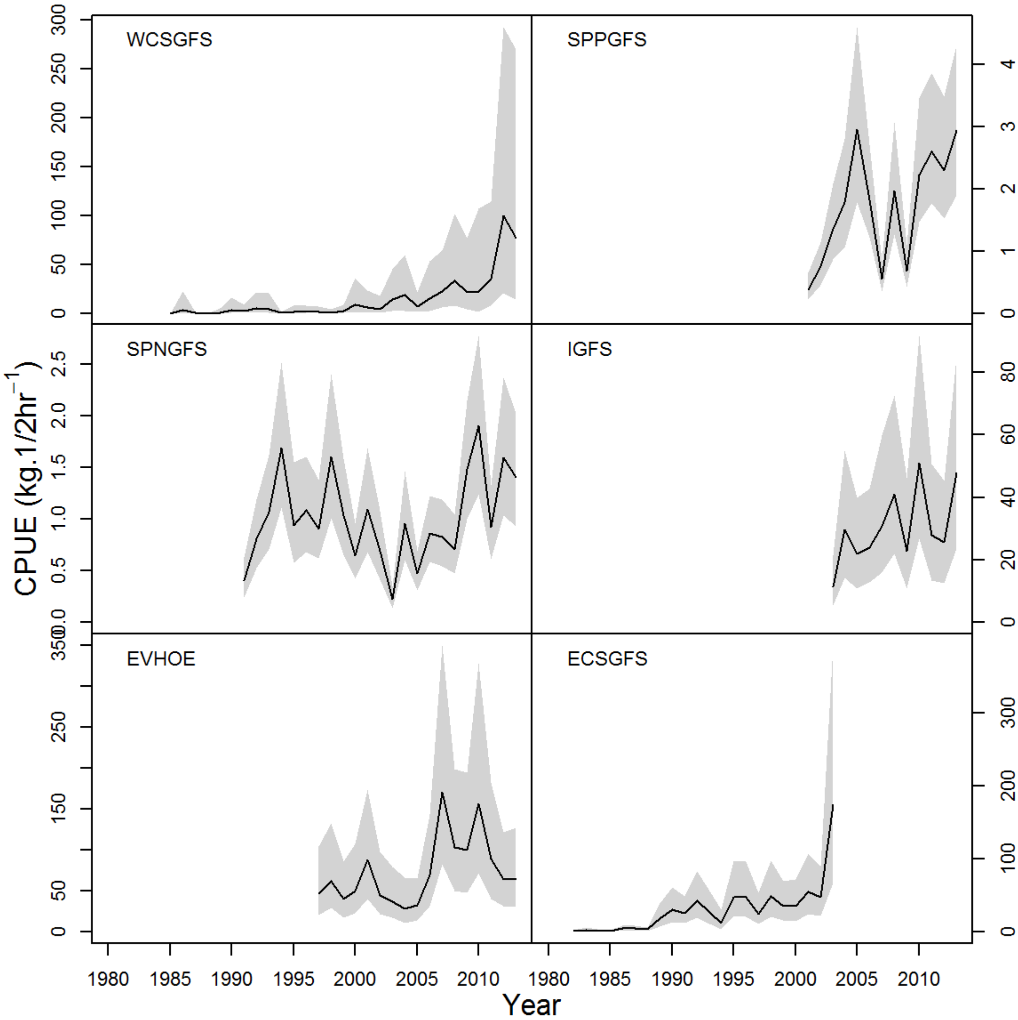


Figure 6.6.2.2. Boarfish in ICES Subareas VI, VII, VIII. Boarfish IBTS survey CPUE fitted delta-lognormal mean (solid line) and 95% credible intervals (grey region).

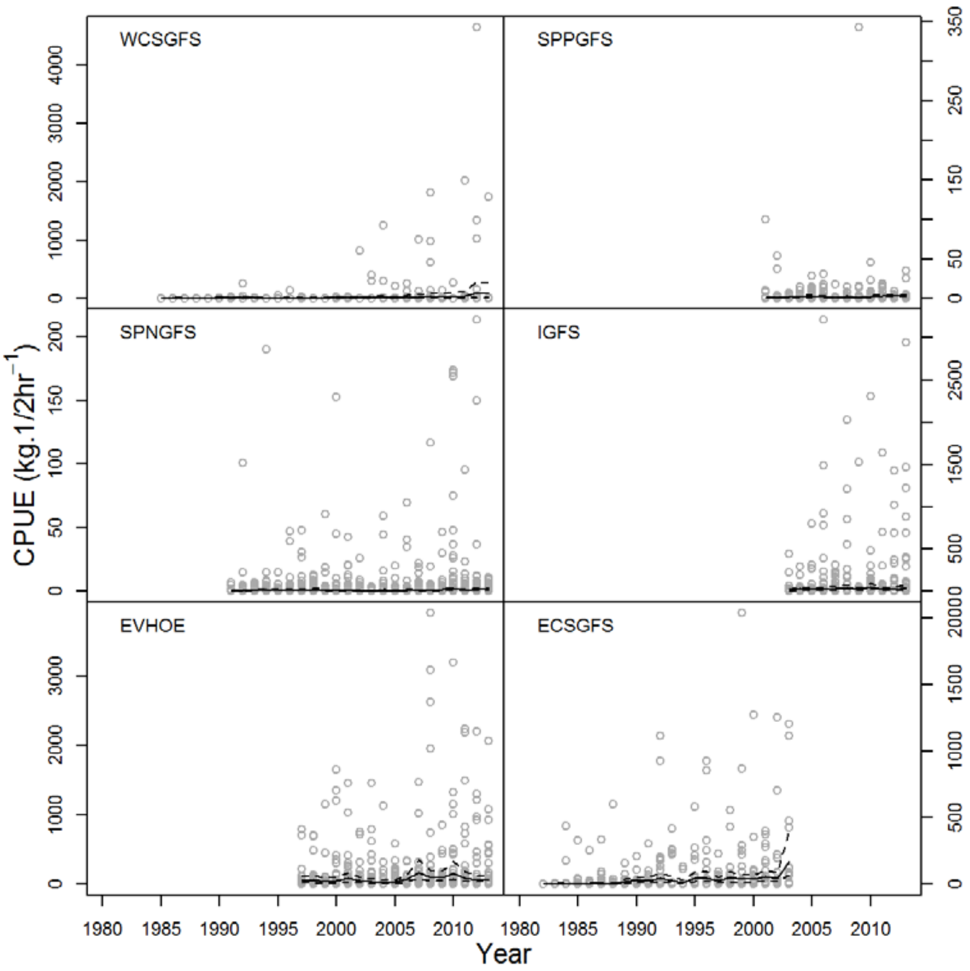


Figure 6.6.2.3. Boarfish in ICES Subareas VI, VII, VIII. Boarfish IBTS survey CPUE data (grey points) and fitted delta-lognormal mean (solid line) and 95% credible intervals (dashed lines).

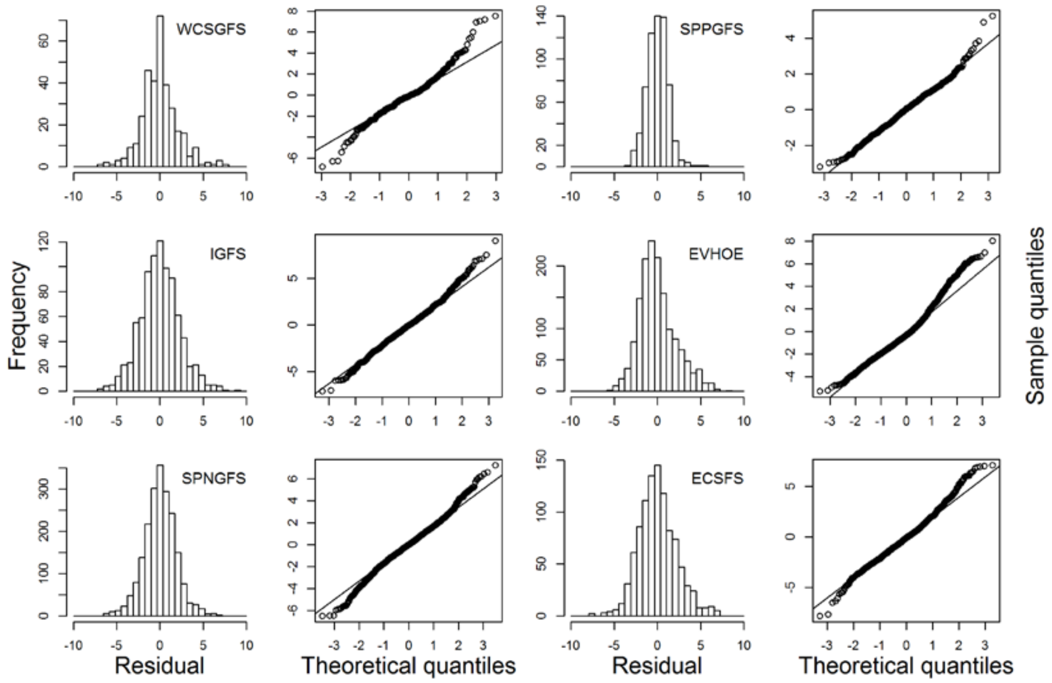


Figure 6.6.2.4. Boarfish in ICES Subareas VI, VII, VIII. Diagnostics from the positive component of the delta-lognormal fits.

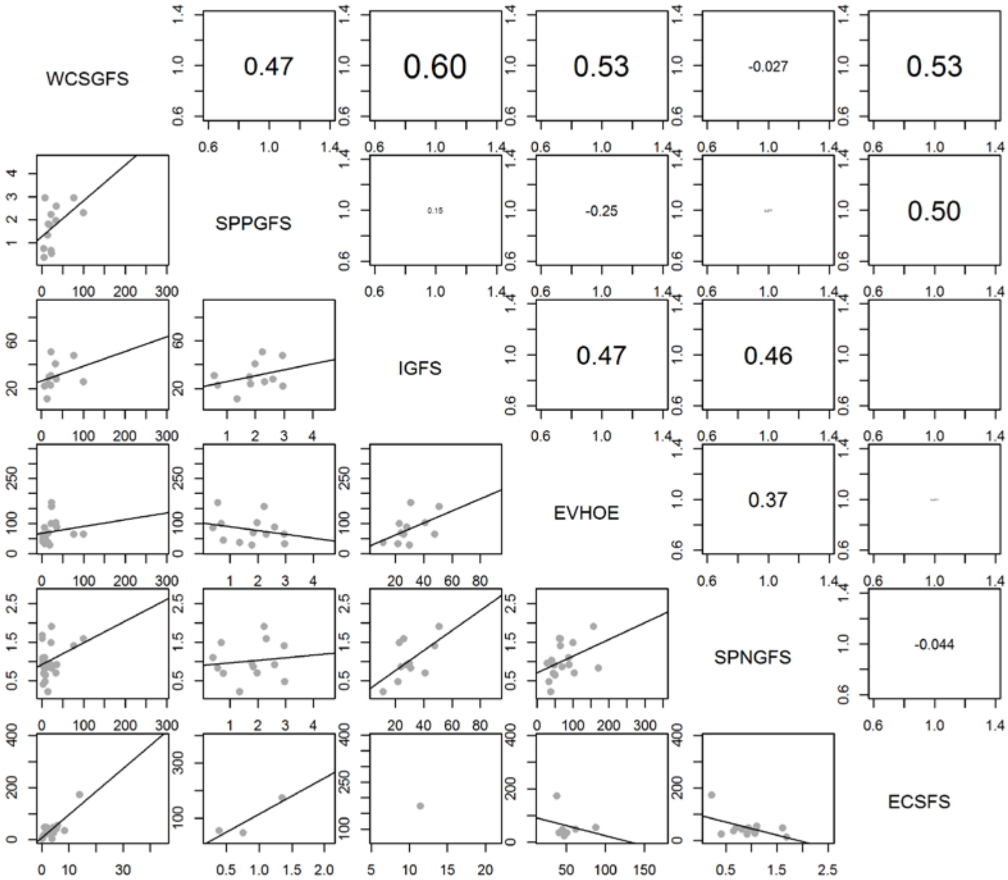


Figure 6.6.2.5. Boarfish in ICES Subareas VI, VII, VIII. Pair-wise correlation between the annual mean survey indices.

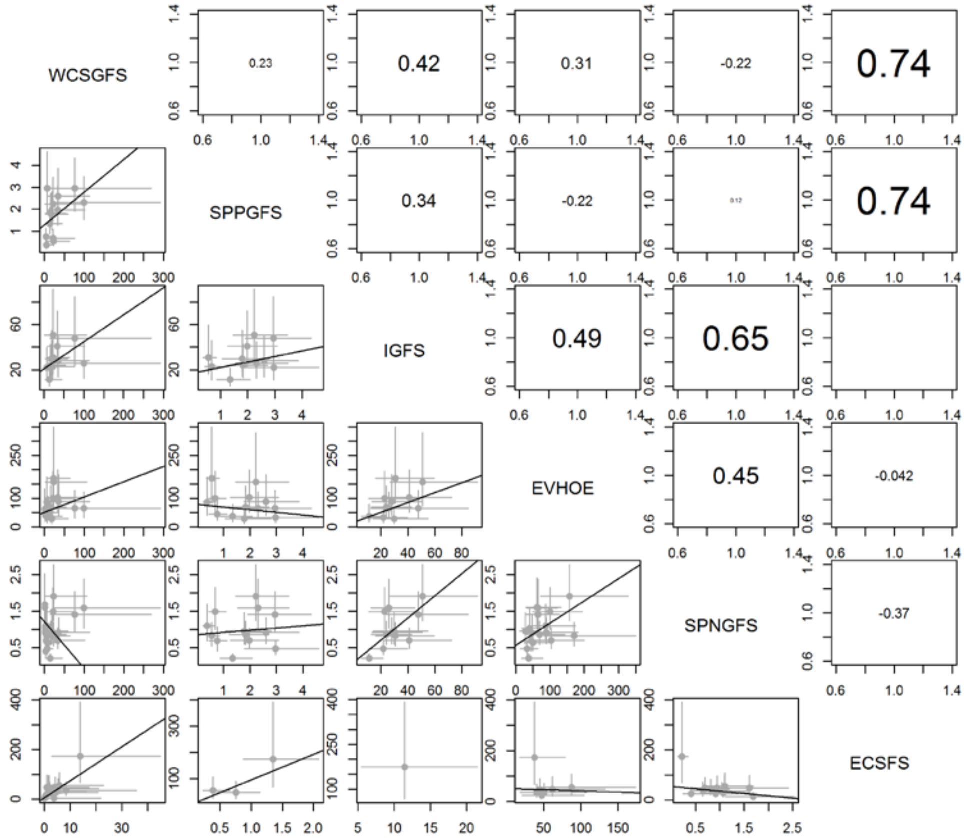


Figure 6.6.2.6. Boarfish in ICES Subareas VI, VII, VIII. Weighted correlation between the annual mean survey indices. Correlations are weighted by the sum of the pair-wise variances.

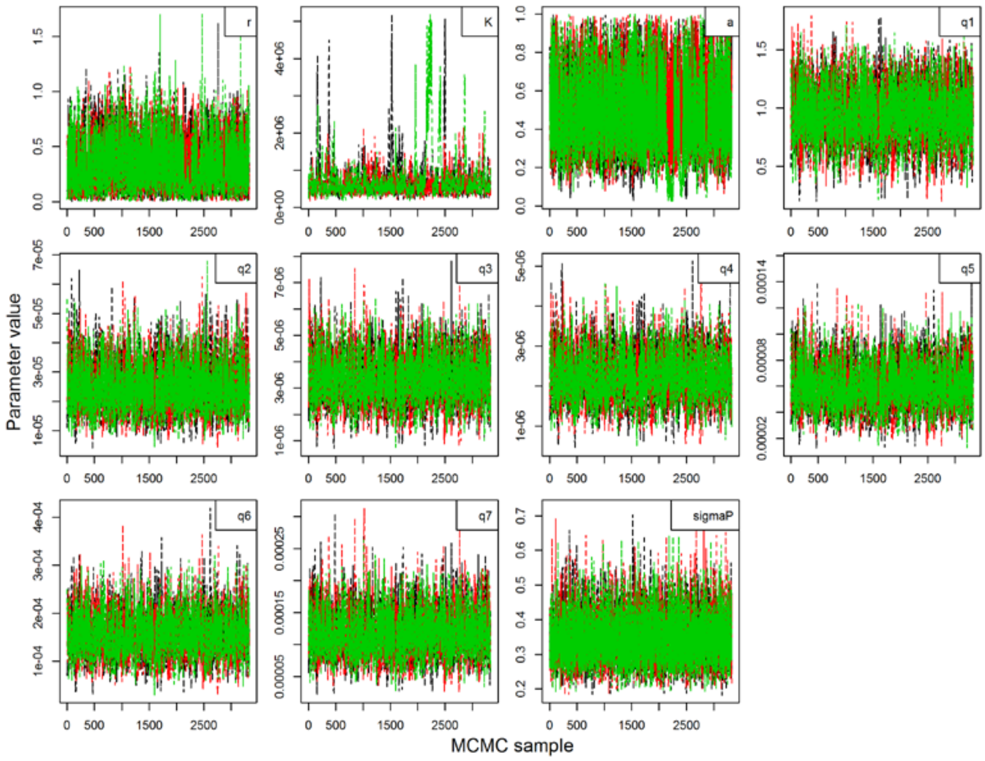


Figure 6.6.5.1. Boarfish in ICES Subareas VI, VII, VIII. Parameters for final run converged with good mixing of the chains.

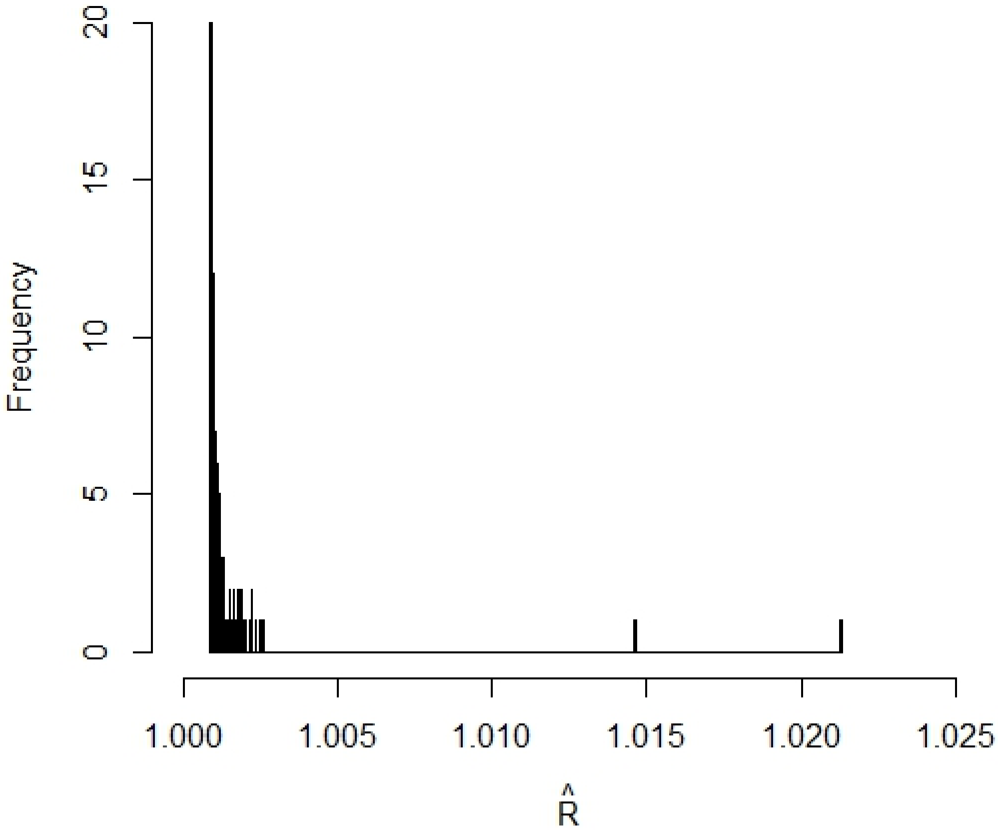


Figure 6.6.5.2. Boarfish in ICES Subareas VI, VII, VIII. Rhat values lower than 1.1 indicating convergence.

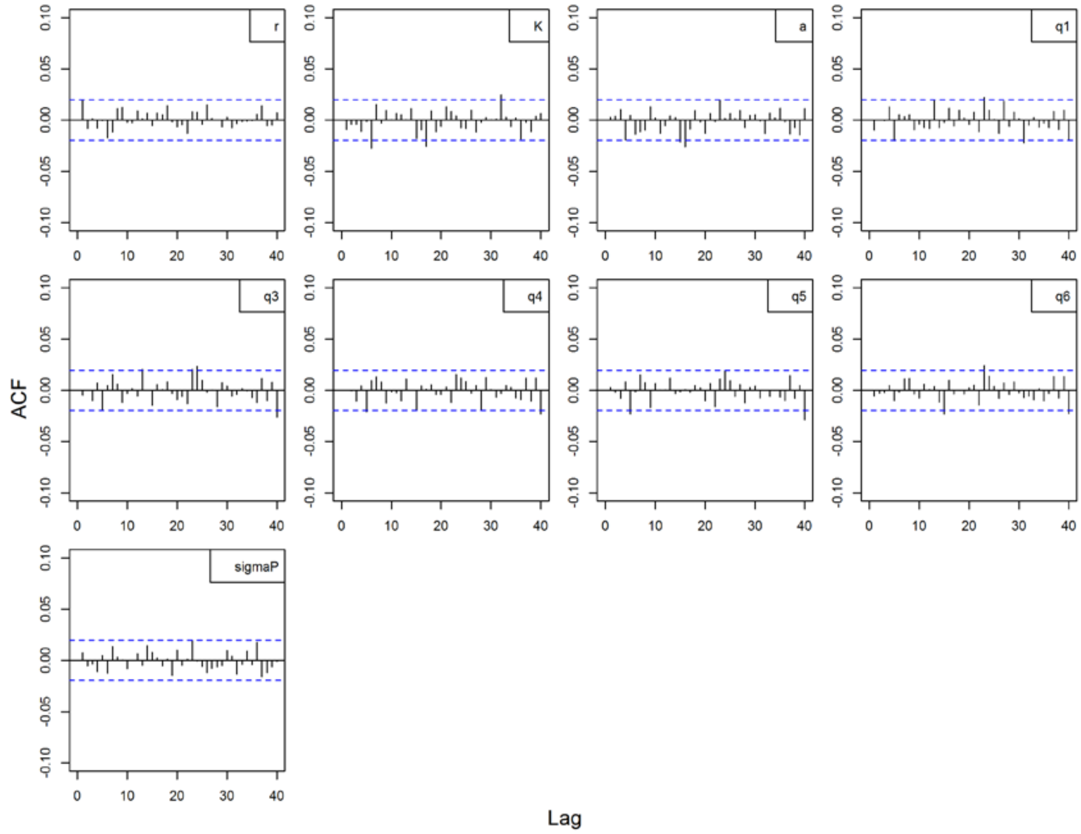


Figure 6.6.5.3. Boarfish in ICES Subareas VI, VII, VIII. MCMC chain autocorrelation for final run.

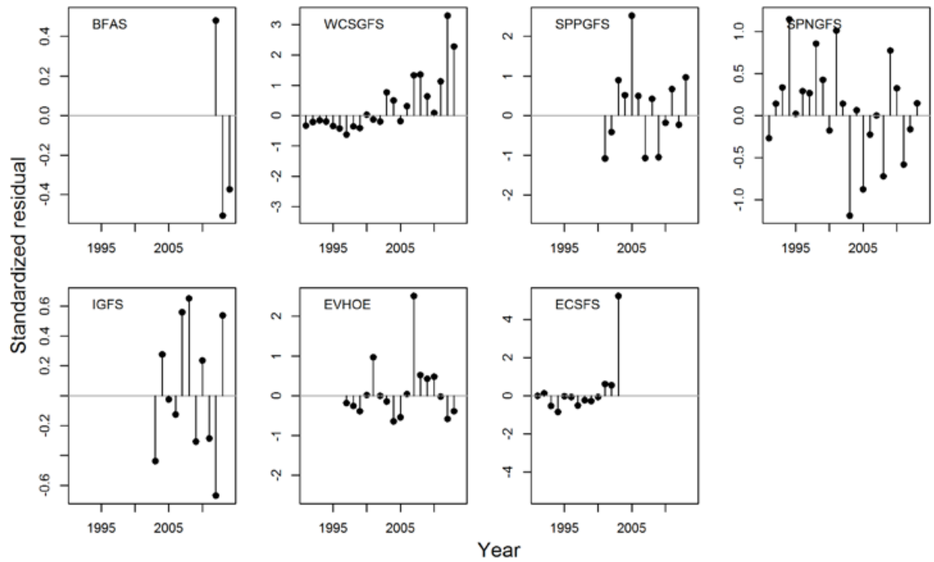


Figure 6.6.5.4. Boarfish in ICES Subareas VI, VII, VIII. Residuals around the model fit for the final assessment run.

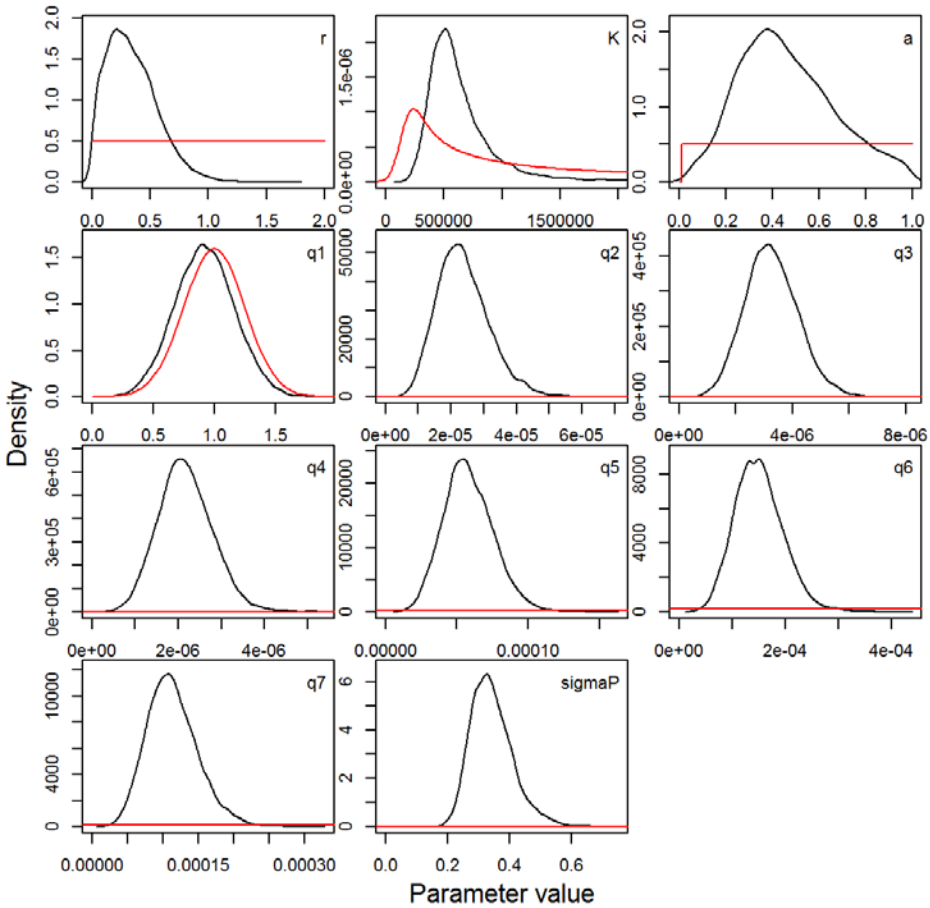


Figure 6.6.5.5. Boarfish in ICES Subareas VI, VII, VIII. Prior (red) and posterior (black) distributions of the parameters of the biomass dynamic model.

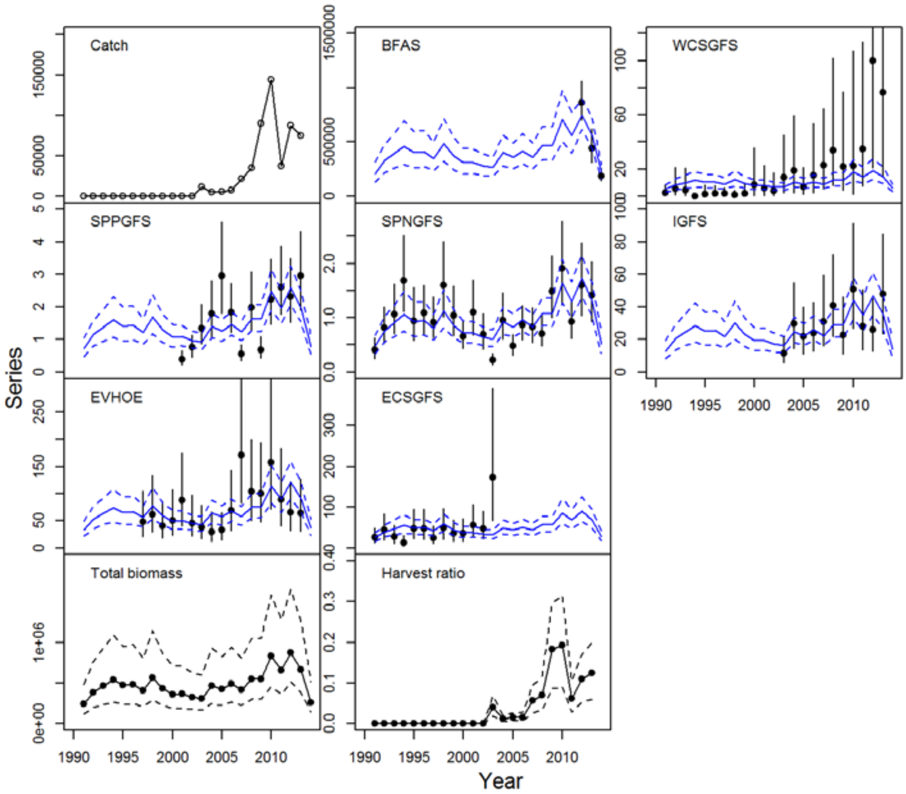


Figure 6.6.5.6. Boarfish in ICES Subareas VI, VII, VIII. Trajectories of observed and expected indices for the final assessment run. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

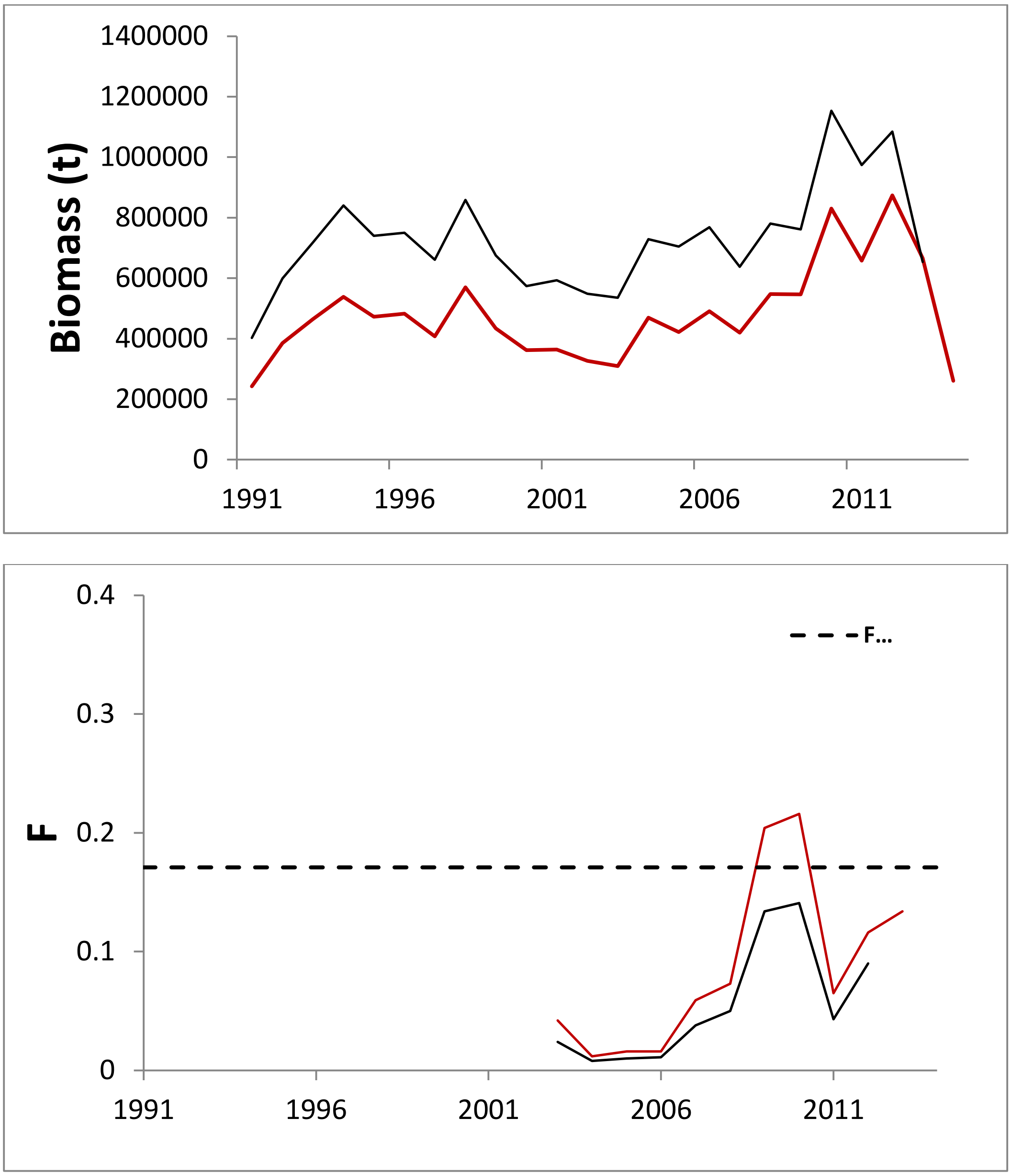


Figure 6.X.X.X. Boarfish in ICES Subareas VI, VII, VIII. Retrospective plot of total stock biomass (above) and fishing mortality (below) from the surplus production model in 2013 and 2014. Red line is current assessment.

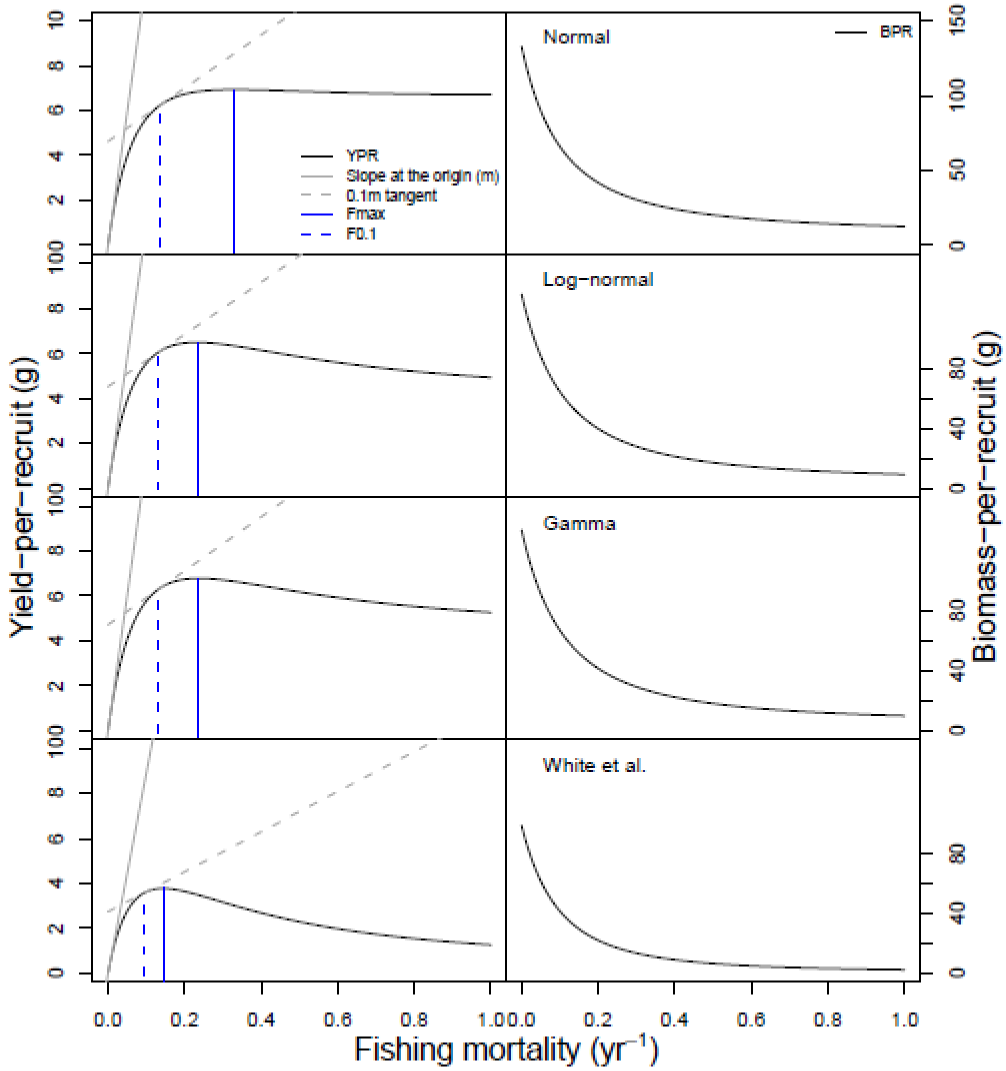


Figure 6.7.1.1. Boarfish in ICES Subareas VI, VII, VIII. Results of exploratory yield per recruit analysis. Beverton and Holt model applied to various fits of the VBGF and for comparison with the VBGF parameters provided by White *et al.* 2011.

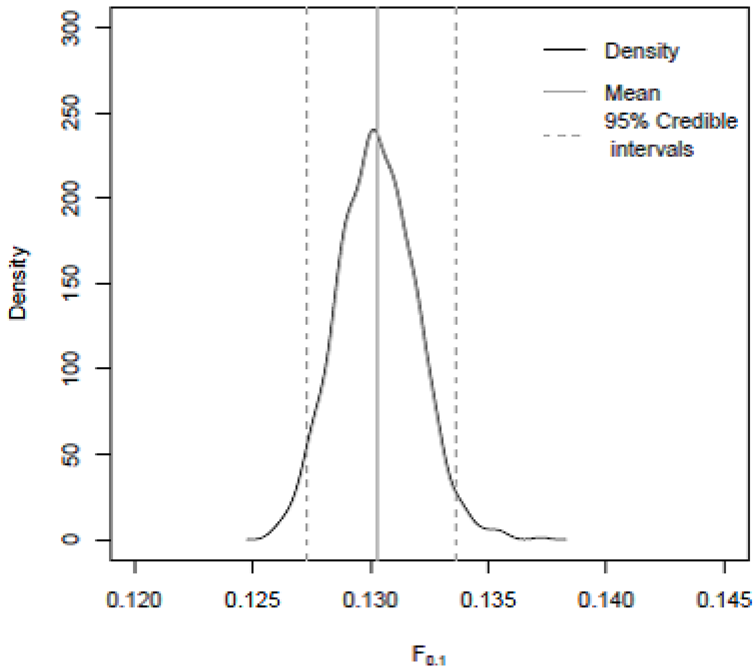


Figure 6.7.1.2. Boarfish in ICES Subareas VI, VII, VIII. Sensitivity of estimation of $F_{0.1}$.