# 2 Spurdog in the Northeast Atlantic

## 2.1 Stock distribution

Spurdog or the piked dogfish, *Squalus acanthias* has a worldwide distribution in temperate and boreal waters, and occurs mainly in depths of 10–200 m. In the NE Atlantic, this species is found from Iceland and the Barents Sea southwards to the coast of Northwest Africa (McEachran and Branstetter, 1984).

WGEF considers that there is a single NE Atlantic stock ranging from the Barents Sea (Subarea 1) to the Bay of Biscay (Subarea 8), and that this is the most appropriate unit for assessment and management within ICES. Spurdog in Subarea 9 may be part of the NE Atlantic stock, but catches from this area are likely to consist of a mixture of *Squalus* species, with increasing numbers of *Squalus blainville* further south.

Genetic microsatellite analyses conducted by Verissimo *et al.* (2010) found no differences between east and west Atlantic spurdog. The authors suggested this could be accomplished by transatlantic migrations of a very limited number of individuals. Further information on the stock structure and migratory pattern of Northeast Atlantic spurdog can be found in the Stock Annex. Nonetheless, recent studies undertaken by Thorburn *et al*. (2018) suggest subpopulations across the UK.

## 2.2 The fishery

### 2.2.1 History of the fishery

Spurdog has a long history of exploitation in the Northeast Atlantic (Pawson *et al.*, 2009) and WGEF estimates of total landings are shown in Figure 2.1 and Table 2.1a. Spurdog has historically been exploited by France, Ireland, Norway and the UK (Table 2.2). The main fishing grounds for the NE Atlantic stock of spurdog are the North Sea (Subarea 4), West of Scotland (Division 6.a) and the Celtic Seas (Subarea 7) and, during the decade spanning the late 1980s to 1990s, the Norwegian Sea (Subarea 2) (Table 2.3). Outside these areas, landings have generally been low. In recent years the fishery has changed significantly in line with restrictive management measures, which have included more restrictive quota, a maximum landing length and bycatch regulations.

Further details of the historical development of the fishery are provided in the Stock Annex. Further general information on the mixed fisheries exploiting this stock and changes in effort can be found in ICES (2009a, b) and STECF (2009).

### 2.2.2 The fishery in 2021

The zero TAC for spurdog for EU vessels, introduced in 2011, has resulted in a major change in the magnitude and spatial distribution of reported landings. Between 2005 and 2017, landings declined across all ICES subareas, slightly increasing in 2018, 2019 and 2020.

Since 2011 the annual Norwegian landings, which land significantly more spurdog than other countries, have been fluctuating between 217–409 tonnes; with 367 tonnes in 2021.

In July 2016, an in-year amendment to EU quota regulations saw the introduction of a small TAC (270 t) for Union and international waters of subareas 1, 5–8, 10 and 12 (see Section 2.2.4). During

2018, 2019 and 2020, UK reported landings of 37, 52 and 79 tonnes spurdog, respectively. For UK, traditionally one of the major exploiters of the spurdog stock (prior to 2009), this was a major increase from a level close to zero that has been seen since the zero TAC was introduced in 2011. For other countries which landed spurdog, see Table 2.2.

Discard estimates are available from some countries from 2005 (Table 2.1b), and are highly variable across years and countries with between 20 and 4781 tonnes between 2005 and 2021; with the maximum of 4090 tonnes being reported by the UK England in 2017.

Commercial fishermen in various areas, including the southern North Sea, the Celtic Sea, and in the south- and mid-Norwegian coastal areas, continue to report that spurdog can be seasonally abundant on their fishing grounds.

### 2.2.3 ICES advice applicable

In 2020, ICES advised that "*when the MSY approach is applied, catches in 2023 and 2024 should be no more than 17 353 tonnes and 17 855 tonnes respectively. Any possible provision for the landing of bycatch should be part of a management plan, including close monitoring of the stock and fisheries*".

### 2.2.4 Management applicable

The following table summarises ICES advice and actual management applicable for NE Atlantic spurdog during 2001–2022.

| Year | Single-stock exploitation boundary (tonnes) | Basis | TAC (IIa(EC) and IV) (tonnes) | TAC IIIa , I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes) | TAC IIIa(EC) (tonnes) | TAC I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes) | WG landings (NE Atlantic stock) (tonnes) |
|---|---|---|---|---|---|---|---|
| 2000 | No advice | - | 9470 | | | | 15 890 |
| 2001 | No advice | - | 8870 | - | - | - | 16 693 (1) |
| 2002 | No advice | - | 7100 | - | - | - | 11 020 |
| 2003 | No advice | - | 5640 | - | - | - | 12 246 |
| 2004 | No advice | - | 4472 | - | - | - | 9365 |
| 2005 | No advice | - | 1136 | - | - | - | 7100 |
| 2006 | F=0 | Stock depleted and in danger of collapse | 1051 | - | - | - | 4015 |
| 2007 | F=0 | Stock depleted and in danger of collapse | 841 (2) | 2828 | - | - | 2917 |
| 2008 | No new advice | No new advice | 631 (2,3) | - | - | 2004 (2) | 1798 |
| 2009 | F=0 | Stock depleted and in danger of collapse | 316 (3,4) | - | 104 (4) | 1002 (4) | 1980 |
| 2010 | F=0 | Stock depleted and in danger of collapse | 0 (5) | | 0 (5) | 0 (5) | 892 |
| 2011 | F=0 | Stock depleted and in danger of collapse | 0 (6) | | 0 | 0 (6) | 435 |

| Year | Single-stock exploitation boundary (tonnes) | Basis | TAC (IIa(EC) and IV) (tonnes) | TAC IIIa , I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes) | TAC IIIa(EC) (tonnes) | TAC I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes) | WG landings (NE Atlantic stock) (tonnes) |
|---|---|---|---|---|---|---|---|
| 2012 | F=0 | Stock below possible reference points | 0 [(6)] | | 0 | 0 [(6)] | 453 |
| 2013 | F=0 | Stock below possible reference points | 0 | | 0 | 0 | 335 |
| 2014 | F=0 | Stock below possible reference points | 0 | | 0 | 0 | 383 |
| 2015 | F=0 | Stock below possible reference points | 0 | | 0 | 0 | 263 |
| 2016 | F=0 | Stock below possible reference points | 0 | | 0 | 0 (270[(7)]) | 373 |
| 2017 | F-0 | Stock below possible reference points | 0 | | 0 | 270[(7)] | 296 |
| 2018 | F-0 | Stock below possible reference points | 0 | | 0 | 270[(7)] | 363 |
| 2019 | F=0 | Stock below possible reference points | 0 | | 0 | 270[(7)] | 455 |
| 2020 | F=0 | Stock below possible reference points | 0 | | 0 | 270[(7)] | 526 |
| 2021 | F=0 | Stock below possible reference points | 0 | | 0 | 270[(7)] | 539 |
| 2022 | F=0 | Stock below possible reference points | 0 | | 0 | 270[(7)] | |

([1]) The WG estimate of landings in 2001 may include some misreported deep-sea sharks or other species. ([2]) Bycatch quota. These species shall not comprise more than 5% by live weight of the catch retained on board. ([3]) For Norway: including catches taken with longlines of tope shark (*G. galeus*), kitefin shark (*D. licha*), bird beak dogfish (*D. calcea*), leafscale gulper shark (*C. squamosus*), greater lantern shark (*E. princeps*), smooth lanternshark (*E. spinax*) and Portuguese dogfish (*C. coelolepis*). This quota may only be taken in zones IV, VI and VII. ([4]) A maximum landing size of 100 cm (total length) shall be respected. ([5])Bycatches are permitted up to 10% of the 2009 quotas established in Annex Ia to Regulation (EC) No. 43/2009 under the following conditions: catches taken with longlines of tope shark (*G. galeus*), kitefin shark (*D. licha*), bird beak dogfish (*D. calceus*), leafscale gulper shark (*C. squamosus*), greater lantern shark (*E. princeps*), smooth lantern shark (*E. pusillus*) and Portuguese dogfish (*C. coelolepis*) and spurdog (*S. acanthias*) are included (Does not apply to IIIa); a maximum landing size of 100 cm (total length) is respected; the bycatches comprise less than 10% of the total weight of marine organisms on board the fishing vessel. Catches not complying with these conditions or exceeding these quantities shall be promptly released to the extent practicable. ([6]) Catches taken with longlines of tope shark (*G. galeus*), kitefin shark (*D. licha*), bird beak dogfish (*D. calcea*), leafscale gulper shark (*C. squamosus*), greater lanternshark (*E. princeps*), smooth lanternshark (*E. pusillus*), Portuguese dogfish (*C. coelolepis*) and spurdog (*S acanthias*) are included. Catches of these species shall be promptly released unharmed to the extent practicable. ([7]) Spurdog shall not be targeted in the areas covered by this TAC. When accidentally caught in fisheries where spurdog is not subject to the landing obligation, specimens shall not be harmed and shall be released immediately, as required by Articles 12 (13 in 20180 and 41 (45 in 2018) of this Regulation. By derogation from Article 12 of this Regulation, a vessel engaged in the by-catch avoidance programme that has been positively assessed by the STECF may land not more than 2 tonnes per month of spurdog that is dead at the moment when the fishing gear is hauled on board. Member States participating in the by-catch avoidance programme shall ensure that the total annual landings of spurdog on the basis of this derogation do not exceed the above amounts. They shall communicate the list of participating vessels to the Commission before allowing any landings. Member States shall exchange information about avoidance areas.

In all EU regulated areas, a zero TAC for spurdog was retained for 2019. In July 2016, an in-year amendment to EU quota regulations (Council Regulation (EU) 2016/1252 of 28 July 2016) saw the introduction of a small TAC (270 t) for Union and international waters of subareas 1, 5–8, 10 and 12, with this TAC to be allocated to vessels participating in bycatch avoidance programmes. This regulation states that "*a vessel engaged in the by-catch avoidance programme that has been positively assessed by the STECF may land not more than 2 tonnes per month of picked dogfish that is dead at the moment when the fishing gear is hauled on board. Member States participating in the by-catch avoidance programme shall ensure that the total annual landings of picked dogfish on the basis of this derogation do not exceed the amounts indicated below. They shall communicate the list of participating vessels to the Commission before allowing any landings. Member States shall exchange information about avoidance areas*".

This derogation was not denoted for TAC areas for EU waters of 3.a or EU waters of 2.a and 4. In these areas, no EU landings were permitted.

In 2007, Norway introduced a general ban on target fisheries for spurdog in the Norwegian economic zone and in international waters of ICES subareas 1–14, with the exception of a limited fishery for small coastal vessels. Bycatch could be landed and sold as before. All directed fisheries were banned from 2011, although there is still a bycatch allowance. From October 2011, bycatch should not exceed 20% of total landings on a weekly basis. Since 4 June 2012, bycatch must not exceed 20% of total landings over the period 4 June–31 December 2012. From 1 January 2013, bycatch must not exceed 15% of total landings on a half calendar year basis. Live specimens can be released, whereas dead specimens must be landed. From 2011, the regulations also include recreational fisheries. Norway has a 70 cm minimum landing size (first introduced in 1964).

Since 1 January 2008, fishing for spurdog with nets and longlines in Swedish waters has been forbidden. In trawl fisheries, there is a minimum mesh size of 120 mm and the species may only be taken as a bycatch. In fisheries with hand-held gear only one spurdog was allowed to be caught and kept by the fisher during a 24-hour period.

Many of the mixed fisheries which caught spurdog in the North Sea, West of Scotland and Irish Sea are subject to effort restrictions under the cod long-term plan (EC 1342/2008).

## 2.3 Catch data

### 2.3.1 Landings

Total annual landings of NE Atlantic spurdog are given in Table 2.1a and illustrated in Figure 2.1. Preliminary estimates of landings for 2021 were 539 t.

### 2.3.2 Discards

Estimates of total amount of spurdog discarded are not routinely provided although some discard sampling does take place in several countries. Discards from some countries have been provided following the data.call for the WKNSEA benchmark 2021 (ICES, 2021) and also to the WGEF data.call in 2022. Total discards from 2005 can be found in Table 2.1b.

Data from Scottish observer trips in 2010 were made available to the WG. Over 1200 spurdog (raised to trip level and then summed across trips) were caught over 29 trips (across divisions 4.a and 6.a), but on no occasion were any retained.

At the 2010 WG, a working document was presented on the composition of Norwegian elasmobranch catches, which suggested significant numbers of spurdog were discarded.

Preliminary observations on the discard-retention patterns of spurdog as observed on UK (English) vessels were presented by Silva *et al.* (2013 WD; Figure 2.2).

No attempts to raise observed discard rates to fleet level have been undertaken as yet, and given the aggregating nature of spurdog, such analyses would need to be undertaken with care.

Further information on discards can be found in the Stock Annex.

### 2.3.3 Discard survival

Low mortality has been reported for spurdog caught by trawl when tow duration was < 1 h, with overall mortality of about 6% (Mandelman and Farrington, 2007; Rulifson, 2007), with higher levels of mortality (ca. 55%) reported for gillnet-caught spurdog (Rulifson, 2007).

Only limited data on at-vessel mortality are available for European waters (Bendall *et al.*, 2012), and there are no published data on post-release mortality.

### 2.3.4 Quality of the catch data

In addition to the problems associated with obtaining estimates of the historical total landings of spurdog, due to the use of generic dogfish landings categories, anecdotal information suggests that widespread misreporting by species may have contributed significantly to the uncertainties in the overall level of spurdog landings.

Underreporting may have occurred in certain ICES areas when vessels were trying to build up a track record of other species, for example deep-water species. It has also been suggested that over-reporting may have occurred in the case where other elasmobranch stocks with highly restrictive quotas have been recorded as spurdog. It is not possible to quantify the amount of under and over-reporting that may have occurred. The introduction of UK and Irish legislation requiring registration of all fish buyers and sellers should mean that such misreporting problems have declined since 2006.

It is not known whether the 5% bycatch ratio (implemented in 2008) or the maximum landing length (in 2009) led to misreporting (although the buyers and sellers legislation should deter this) or increased discarding.

Given the zero TAC in place, recent catch data are highly uncertain. Whilst data from discard observer programmes may allow catches to be estimated, the estimation of dead discards will be more problematic.

Some nations may now be reporting landings of spurdog under more generic codes (e.g. *Squalus* sp., Squalidae and Squaliformes) as well as for *Squalus acanthias*.

## 2.4 Commercial catch composition

### 2.4.1 Length composition

Sex disaggregated length–frequency samples are available from UK (E&W) for the years 1983–2001 and UK (Scotland) for 1991–2004 for all gears combined. The Scottish length–frequency distributions appear to be quite different from the length–frequency distributions obtained from the UK (E&W) landings, with a much larger proportion of small females being landed by the Scottish fleets. Figure 2.2a shows landings length–frequency distributions averaged over five-year intervals. The Scottish data have been raised to total Scottish reported landings of spurdog while the UK (E&W) data have only been raised to the landings from the sampled boats, a procedure which is likely to mean that the latter length frequencies are not representative of total removals by the UK (E&W) fleet. For this reason, the UK (E&W) length frequencies are assumed to be representative only of the landings by the target fleet from this country.

Discard length–frequency data were provided by the UK (Scotland) for 2010. Length frequencies raised to trip level and pooled over all trips and areas by gear type are shown in Figure 2.3. These have not been raised to fleet level.

Discard length–frequency data were provided by the UK (England) for four broad gear types (Figure 2.4). In general, beam trawlers caught relatively few spurdog, and these were comprised mostly of juveniles, gillnets catches were dominated by fish 60–90 cm TL and otter trawlers captured a broad length range. Data for larger fish sampled across the whole time-series were most extensive for gillnetters operating in the Celtic Seas (Silva *et al.,* 2013 WD). The discarding rates of commercial sized fish (80–100 cm TL) from these vessels increased from 7.5% (2002–2008) to 18.7% (2009–2010), whereas the proportion of fish > 100 cm LT discarded increased from 6.2% (2002–2008) to 34.1% (2009–2010), indicating an increased proportion of larger fish were discarded in line with the maximum landing length regulations that were in force during 2009–2010. The zero TAC with no bycatch allowance resulted in the discarding of all observed spurdog in 2011.

For the period from 2005 onwards, two gear groupings were selected as representing the two main types of fishing activity, namely “trawls & other” and “nets & hooks”. The length frequencies which formed the basis of the “trawls & other” fleet are shown in Figure 2.2b; these length frequencies were combined by first expressing them as proportions by length category (according to the established life-stage-based length bins used for spurdog), and then combining them by using weighted averaging using the relative contribution by nation to the fleet (Table 2.4 gives an example of these weights from ICES, 2022). For the “nets & hooks” fleet, length frequencies from gillnet and trammel nets were combined with equal weighting (Figure 2.2c)

## 2.4.2 Sex ratio

No recent data.

## 2.4.3 Quality of data

Length frequency samples prior to 2005 are only available for UK landings and these are aggregated into broader length categories and have been used in the previously presented assessments. Prior to 2005, no data were available from Norway, France or Ireland who are the other main exploiters of this stock. The availability of length data from 2005 onwards has improved following the Data Call associated with the 2021 benchmark (ICES, 2021).

From French on-board observation data, the occurrence of spurdog was calculated as the proportion of fishing operations (trawl haul or net set) with catch (discards, landings or both) of spurdog in areas where the species is observed regularly in French fisheries, namely Subarea 6 and divisions 7.b-c and 7.f-k from 2007–2015. Other areas, such as the Bay of Biscay (Subarea 8) where occurrences are rare in French Fisheries were excluded. Fishing operations were aggregated by DCF level 5 métier. The time-series of the proportion of fishing operations encountering spurdog is shown for the four top ranking métiers (Figure 2.40). No trend was observed in the two main métiers (OTB-DEF and OTT-DEF), with the two other métiers (with lower numbers of observed fishing operations) showing contrasting signals.

## 2.5 Commercial catch-effort data

No commercial CPUE data were available to the WG.

The outline of a Norwegian sentinel fishery on spurdog was presented to the 2012 WG (Albert and Vollen, 2012 WD). This potential provider of an abundance index series has not been initiated yet.

A UK Fishery Science Partnership (FSP) study carried out by CEFAS examined spurdog in the Irish Sea (Ellis *et al*., 2010), primarily to (a) evaluate the role of spurdog in longline fisheries and examine the catch rates and sizes of fish taken in a longline fishery; (b) provide biological samples so that more recent data on the length-at-maturity and fecundity can be calculated; and (c) tag and release a number of individuals to inform on the potential discard survivorship from longline fisheries. Survey stations were chosen by the fishermen participating in the survey.

This survey undertook studies on a commercial, inshore vessel that had traditionally longlined for spurdog during parts of the year. Four trips (nominally one in each quarter), each of four days, were undertaken over the course of the year. The spurdog caught were generally in good condition, although the bait stripper can damage the jaws, and those fish tagged and released were considered to be in a good state of health.

Large numbers of spurdog were caught during the first sampling trip, of which 217 were tagged with Petersen discs and released. The second sampling trip yielded few spurdog, although catches at that time of year are considered by fishermen to be sporadic. Spurdog were not observed on the first three days of the third trip, but reasonable numbers were captured on the last day, just off the Mull of Galloway. The fourth trip (spread over late October to early December, due to poor weather) yielded some reasonably large catches of spurdog from the grounds just off Anglesey.

## 2.6 Fishery-independent information

### 2.6.1 Availability of survey data

Fishery-independent survey data are available for most regions within the stock area. Beam trawl surveys are not considered appropriate for this species, due to the low catchability of spurdog in this gear type. The surveys coordinated by IBTS have higher catchability and the gears are considered suitable for this species. Spatial coverage of the North and Celtic Seas represents a large part of the stock range (Figure 2.5). For further details of these surveys and gears used see ICES (2010). A description of the current groundfish surveys can be found in the Stock Annex.

Norwegian data on spurdog from the Shrimp survey (NO-shrimp-Q1) and the Coastal survey (NOcoast-Aco-Q4) were presented to the WGEF in 2014 and 2018 (Vollen, 2014 WD). The survey coverage is shown in Figure 2.6, and general information on the surveys can be found in Table 2.5.

The annual shrimp survey (1998–2020) covers the Skagerrak and the northern parts of the North Sea north to 60°N. The timing of the survey changed from quarter 4 (1984–2003), via quarter 3 (2002–2004), to quarter 1 from 2005. Mesh size was not specified for the first years, 35 mm from 1989–1997, and 20 mm from 1998. Trawl time was one hour from 1984–1989, then 30 minutes for later years.

The coastal survey (1996–2020) yearly covers the areas from 62°N to the Russian border in the north in October–November. Only data south of 66°N were used, as very few spurdog were caught north of this latitude. Length data were available from 1999 onwards. A Campelen

Shrimp trawl with 40 mm mesh size was used from 1995–1998, whereas mesh size was 20 mm for later years. Trawl time was 20–30 minutes.

Spurdog catches in these surveys are not numerous. Number of stations with spurdog catches ranged from one to 35 per year in the shrimp survey; and from 0 to 8 per year in the coastal survey. The total number of spurdog caught ranged from one to 341 individuals per year in the shrimp survey, and from 0 to 106 individuals per year in the coastal survey (Table 2.5).

A new spurdog longline survey in Norwegian waters from 58 to 65 °N has started in October 2021 and will be performed annually for at least four more years. This survey is specifically designed for spurdog and covers its distribution area along the Norwegian coast;, especially in between the above mentioned two bottom trawl surveys, i.e. between 60 and 62 °N. The pilot survey consisted of 280 successful longline stations each with 180 hooks. Spurdog was caught between 20 and 300 m at 34% of stations (Vollen et al. 2022, survey report IMR; WD to be presented to ICES after 2nd survey year).

## 2.6.2 Length–frequency distributions

Length–frequency distributions (aggregated overall years) from the UK (E&W), Scottish and Irish groundfish surveys are shown in Figures 2.7–2.8.

The UK (E&W) groundfish survey length–frequency distribution (Figure 2.7a) consists of a high proportion of large females, although this is influenced by a single large catch of these individuals. Mature males are also taken regularly and juveniles often caught on the grounds in the north-western Irish Sea.

The Irish Q4 GFS also catches some large females (Figure 2.7b), but the majority of individuals (both males and females) are of intermediate size, in the range 50–80 cm.

The Scottish West coast groundfish surveys demonstrate an almost complete absence of large females in their catches (Figure 2.8). These surveys show a high proportion of large males and also a much higher proportion of small individuals, particularly in the Q1 survey. However, it should be noted that length frequency distributions exhibit high variability from year to year (not shown) with a small number of extremely large hauls dominating the length–frequency data.

In the UK FSP survey, the length range of spurdog caught was 49–116 cm (Figure 2.9), with catches in Q1 and Q3 being mainly large (> 90 cm) females. Catches in Q4 yielded a greater proportion of smaller fish. The sex ratio of fish caught was heavily skewed towards females, with more than 99% of the spurdog caught in Q1 female. Although more males were found in Q3 and Q4, females were still dominant, accounting for 87% and 79% of the spurdog catch, respectively. Numerically, between 16.5 and 41.9% of spurdog captured were > 100 cm, the Maximum Landing Length in force at the time.

In the Norwegian Shrimp and Coastal surveys, the length–frequency distribution was rather uniform overall years, with the length groups 60–85 cm being the most abundant (Figure 2.10).

Proportions by length category for the three combined survey indices included in the assessment are shown in Figure 2.11.

Previously presented length frequencies are displayed in the Stock Annex.

### 2.6.3 CPUE

Spurdog survey data are typically characterised by highly variable catch rates due to occasional large hauls and a significant proportion of zero catches.

Time-series plots of frequency of occurrence (proportion of non-zero hauls) for the Irish surveys are shown in Figure 2.12. This short time-series shows stability on the frequency of occurrence and on the catch rates. For UK surveys, previously presented data (either discontinued or not updated this year) have indicated a trend of decreasing occurrence and decreasing frequency of large catches with catch rates also decreasing (although highly variable) (Figures 2.16–2.17).

Time-series plots of frequency of occurrence (five year running mean) for both Norwegian surveys is shown for > 20 years in Figure 2.13; shrimp survey (1985–2018) and coastal survey (1995–2018). The frequency of occurrence declined for the Shrimp survey from late 1980s and reached a low in late 1990s. Since then, the Shrimp survey shows an increasing trend, whereas the Coastal survey shows a decreasing trend. With regards to average catch range, numbers are variable, but a decrease can be seen from the 1980s to the late 1990s for the Shrimp survey. For the Coastal survey, a peak could be seen around 2004, but it should be noted that results are generally based on very few stations.

Future studies of survey data could usefully examine surveys from other parts of the stock area, as well as sex-specific and juvenile abundance trends. In the absence of accurate catch data, fishery-independent trawl surveys will be increasingly important to monitor stock recovery.

### 2.6.4 Statistical modelling

Statistical modelling is carried out with the 'surveyIndex' R package (Berg, et al. 2014) using the delta-lognormal approach with the full model (for both the presence-absence and positive parts of the model) defined as follows:

$$g(\mu_i) = Year_i + Gear_i + U(Ship_i) + s_1(\mathrm{lon}_i, \mathrm{lat}_i) + s_2(\mathrm{depth}_i) + s_3(\mathrm{timeofday}_i) + \log(\mathrm{HaulDur}_i)$$

where g is the logit link function for the binomial model (1/0 response), and the lognormal for the positive observations (implemented by log-transforming the response variable and using a normal distribution with identity link function). The model includes an offset to account for the effects of haul duration. Further details of the modelling approach, including the final models used for each of the combined survey indices (Q1, Q3 and Q4) and the surveys included in these combined indices, can be found in the stock annex and the 2021 benchmark report (ICES 2021; see also WD1 to this benchmark report).

Figure 2.18 shows biomass maps for the three combined surveys, and Figure 2.19 the estimated biomass indices based on the delta-lognormal modelling approach, with 95% confidence bounds. For Q1, the estimated distribution map shows the highest biomass to be to the north and west of Scotland, with some indication of higher biomass in the coastal waters of Norway and the central North Sea (Figure 2.18), while the estimated index shows a steep decline at the start of the time series with a gradual increase since the mid-2000s (Figure 2.19). For Q3, the estimated distribution map shows areas of highest biomass to be in the central and northwestern North Sea, in addition to along the Swedish coastline (Figure 2.18), while the estimated index shows no obvious trend, although perhaps reaches a minimum in the early 2000s (Figure 2.19). For Q4, the estimated distribution map shows high biomass to the west of Scotland (similar to Q1), but also in the Irish Sea and to the south in the Celtic Sea (Figure 2.18), while the estimated index shows a significant and sharp increase since around 2010. (Figure 2.19).

## 2.7 Life-history information

Maturity and fecundity data were collected on the UK FSP surveys (Ellis et al, 2010). The largest immature female spurdog was 84 cm, with the smallest mature female 78 cm. The smallest mature and active female observed was 82 cm. All females ≥ 90 cm were mature and active. The observed uterine fecundity was 2–16 pups, and larger females produced more pups. In Q1, the embryos were either in the length range 11–12 cm or 14–18 cm, and no females exhibited signs of recently having given birth. In Q3, near-term pups were observed at lengths of 16–21 cm. During Q4, near-term and term pups of 19–24 cm were observed, and several females showed signs of recently having pupped. This further suggests that the Irish Sea may be an important region in which spurdog give birth during late autumn and early winter, although it is unclear if there are particular sites in the area that are important for pupping.

Collection of biological data for *S. acanthias* was possible as part of a Defra-funded project aiming to better understand the implications of elasmobranch bycatch in the southwest fisheries around the British Isles (Silva and Ellis, 2015 WD). A total of 1112 specimens were examined, including 805 males (53–92 cm LT) and 307 females (47–122 cm LT), as well as associated pups (n = 935, 98–296 mm LT). Conversion factors were calculated for the overall relationships between total length and total weight by sex and maturity stage and gutted weight by sex only.

Preliminary results suggested there may be no changes of length-at-maturity of females in comparison to earlier estimates of Holden and Meadows (1962), indicating that this life-history parameter may not have changed in relation to recent overexploitation. However, the maximum fecundity observed (n = 19 pups) reported in this recent study is higher than reported in earlier studies (e.g. Ford, 1921; Holden and Meadows, 1964; Gauld, 1979), and provides further support to the hypothesis that there has been a density-dependent increase in fecundity (see Ellis and Keable, 2008 and references therein).

Updated life history data have also been collected (Albert *et al*., 2019; see Section 2.14), which should be investigated for any update to the benchmark assessment.

The biological parameters currently used in the assessment can be found in the Stock Annex.

## 2.8 Exploratory assessments and previous analyses

### 2.8.1 Previous assessments

Exploratory assessments undertaken in 2006 included the use of a delta-lognormal GLM-standardized index of abundance and a population dynamic model. This has been updated at subsequent meetings. The results from these assessments indicate that spurdog abundance had declined, and that the decline was driven by high exploitation levels in the past, coupled with biological characteristics that make this species particularly vulnerable to such intense exploitation (ICES, 2006). More recent assessments have indicated that spurdog biomass is increasing again (e.g. ICES, 2020a).

### 2.8.2 Simulation of effects of maximum landing length regulations

Earlier demographic studies on elasmobranchs indicate that low fishing mortality on mature females may be beneficial to population growth rates (Cortés, 1999; Simpfendorfer, 1999). Hence, measures that afford protection to mature females may be an important element of a management plan for the species. As with many elasmobranchs, female spurdog attain a larger size than males, and larger females are more fecund.

Preliminary simulation studies of various Maximum Landing Length (MLL) scenarios were undertaken by ICES (2006) and suggested that there are strong potential benefits to the stock by protecting mature females. However, improved estimates of discard survivorship from various commercial gears are required to better examine the efficacy of such measures.

## 2.9 Stock assessment

### 2.9.1 Introduction

An initial benchmark assessment of the model was carried out in 2011. A summary of review comments and response to it were provided in Appendix 2a of the 2011 WGEF report (ICES, 2011), and is reproduced in an Appendix to the Stock Annex. The model is described in detail in the Stock Annex, and in De Oliveira *et al*. (2013).

In 2011, WGEF updated the model based on the benchmark assessment. Subsequent update assessments were carried out in 2014, 2016, 2018 and 2020. A second benchmark was held in early 2021 (ICES, 2021), and the assessment model presented here adopts the configuration approved during this benchmark in 2021.

### 2.9.2 Benchmark in 2021

#### 2.9.2.1 Summary of benchmark

In February 2021, a benchmark for spurdog was held as part of WKNSEA (ICES 2021).

The spurdog assessment is currently the only elasmobranch category 1 assessment, with an integrated age–length-based assessment that includes catch data back to 1905. Survey indices included in the assessment prior to the benchmark in 2021 only covered a relatively small part (primarily divisions 6.a and 4.a) of the entire stock distribution area. Therefore, one of the main aims of the benchmark was to improve spatial coverage by including a number of eligible surveys in the assessment. Furthermore, the inclusion of new fecundity data along with improved information on growth was on the issue list. Finally, inclusion of fleet-based data (including length distributions), and better catch information since 2010 was to be addressed and a data-call was set up to request this information. Four main topics were considered in this benchmark (i) catch data (landings, discards and commercial size and sex composition), (ii) survey indices (biomass indices and size and sex composition), (iii) biological parameters, and (iv) reference points.

Based on the discussion on spatial and temporal coverage of the various surveys in DATRAS and those made available as part of the data call, the workshop agreed to derive three separate biomass indices, one per quarter (Q1, Q3, Q4). Data extraction and manipulation made use of the 'DATRAS' R package while statistical modelling has been carried out using the 'surveyIndex' R package (Berg et al., 2014). It implements a GAM modelling framework allowing for a variety of different model assumptions including 'delta' models with lognormal and gamma distributions for positive observations. In addition to the survey indices (and estimated CVs), the number of individuals by sex (sample size) and proportion at length by year (and sex) were calculated for use in the stock assessment. Details on the input data, analysis and results are found in the WD by Dobby (2021). This results in the following indices to be used in the assessment:

- A modelled Q1 index by sex, based on four survey time-series: NO-shrimp, NS-IBTS, SWC-IBTS, SCOWCGFS [1985–present].
- Q3 index by sex, based on a single survey: NS-IBTS [1992–present]
- A modelled Q4 index by sex, based on five survey time-series: SWC-IBTS, SCOWCGFS, NIGFS, IE-IGFS, EVHOE [2003–present].

Fecundity data used to inform the model were improved from having two data years (1960, 2005) to include 14 data years covering the time period 1921–2020.

Commercial catch length data were requested as part of the data-call for the benchmark, and this resulted in the definition of two commercial fleet types from 2005 onwards ("nets & hooks" and "trawls & other"), with commercial proportions by length category data compiled from 2007 onwards and used to estimate the selectivity for these two fleet types. The commercial fleet types prior to 2005 were kept as before ("target" and "non-target"), with associated data (as before) to estimate selectivities for these. The model has therefore been extended to reflect four commercial selectivity types, as described above.

For reference points $B_{lim}$ was set to 20% of $B_0$ because the model goes back to 1905 when reporting of landings were relatively low and well before the high exploitation in the 1950s and onwards. For detailed descriptions, please see the benchmark report (ICES, 2021).

#### 2.9.2.2 Issues uncovered during WGEF 2022

When preparing data for the assessment presented below, some errors were discovered with input data preparation for the 2021 benchmark assessment. These are summarised as follows:

a. unraised sampling data were erroneously included when preparing the fishery length composition data for both the "nets & hooks" and "trawls & other" categories from 2007 onwards – these unraised data have now been removed;
b. when preparing the "trawls & other" fishery length composition data, a misalignment of years occurred due to missing years of data from Sweden, which meant that length compositions were incorrectly combined and allocated to the wrong years – this has now been corrected;
c. when preparing the discards data for 2007 onwards, a formatting issue in Excel meant that some discards data (e.g. for England and Wales) were omitted – these data have now been included.

In addition to these issues, there was an effort to update landings and discards data for elasmobranchs from 2005 onwards during the WKSHARK series of meetings (see e.g. ICES, 2020b). The decision from the 2021 benchmark was to use updated data from 2007 onwards, given information available at the time, but for the assessment presented below, updated landings and discards were included from 2005 onwards to be consistent with the work done within WKSHARK. However, length composition data used in the assessment were not updated to include 2005 and 2006, but these should be considered for inclusion during a future benchmark.

When preparing the discard data, it was clear that there were substantial gaps in the discard data for UK (England & Wales): there were no discard data for gillnets and trammel nets for the years 2011, 2013-2015, while surrounding years had anything from 683 t (2016) to 4472 t (2012). It was therefore decided to fill these gaps by allocating the average UK (England & Wales) discards for gillnets and trammel nets for the years 2010, 2012, 2016-19 (2425 t) to these missing years, and this was included in the assessment.

A comparison of selected results from the 2021 benchmark ("benchmark21") and a subsequent update to account for the issues mentioned above (corrections to input data, updated data for 2005 onwards, infilling for missing data: "update21") is given in Figures 2.20-2.22. Figure 2.20 indicates a markedly different likelihood profile for benchmark21 and update21 for the parameter $Q_{fec}$, which reflects the extent of density-dependence in the stock-recruit relationship, and hence productivity –update21 has a higher optimum $Q_{fec}$ value, indicating that the stock is more productive than previously thought. Figure 2.21 indicates the model fits to the survey index data, and these also show substantial differences. Finally, Figure 2.22 compares summary plots, including reference points, and these show quite a different perception, where during the benchmark the stock was still thought to be below the biomass reference points, but with subsequent updates, the perception is somewhat different, with the stock above biomass reference points. The basis for the assessment presented below is the update ("update21"); although $Q_{fec}$ is estimated, the other fecundity parameters ($a_{fec}$ and $b_{fec}$) are not, and the approach used was to set these to their update21 values (since that would have been the equivalent of the benchmark had there not been the data issues), and this is the approach adopted. Figure 2.23 shows the likelihood profile for $Q_{fec}$, $a_{fec}$, $b_{fec}$ and MSYR (the MSY rate) for the update21 assessment. The fixed values of $a_{fec}$ and $b_{fec}$ used in the assessment, taken from update21 (Figure 2.23), are given in Table 2.12b.

### 2.9.3 Life-history parameters and input data

Calculation of the life-history parameters $M_a$ (instantaneous natural mortality rate), $l_a^s$ (mean length-at-age for animals of sex $s$), $w_a^s$ (mean weight-at-age for animals of sex $s$), and $P_a''$ (proportion females of age $a$ that become pregnant each year) are summarised in Table 2.6, and described visually in Figure 2.24.

Landings data used in the assessment are given in Tables 2.7a and b. The assessment requires the definition of fleets with corresponding exploitation patterns, and the only information currently available to provide this comes from Scottish and English & Wales data for the period up to (and including) 2004 (Table 2.7a), and from Swedish, Scottish and Irish bottom trawl data, and England & Wales gillnet and trammel net data for the period 2005 onwards (Table 2.7b). Four fleets are therefore defined: two operating up to (and including) 2004 and allocated to landings data, namely a "non-target" fleet (Scottish data), and a "target" fleet (England & Wales data); two operating from 2005 onwards and allocated to catch data, namely a "trawls & other" fleet (Swedish, Scottish and Irish bottom trawl data), and a "nets & hooks" fleet (England & Wales gillnet and trammel net data). Several targeting scenarios were explored in order to show the sensitivity of model results to these allocations (ICES, 2011), and these results can be found in previous reports (e.g. ICES, 2020a). In order to take the model back to a virgin state, the average proportion of the first two fleets for 1980–1984 were used to split landings data prior to 1980.

Three abundance indices (biomass catch rate) were derived on the basis of applying a delta-lognormal GLM model to several surveys (following WKNSEA, 2021), and these are given in Table 2.8 along with the corresponding CVs. The proportions-by-length category data derived from these surveys, along with the actual sample sizes these data are based on, are given in Tables 2.9a-c separately for females and males.

Table 2.10 lists the proportion-by-length-category data for the four commercial fleets considered in the assessment, along with the raised sample sizes or catch (see Table caption for details). Because these raised sample sizes/catch do not necessarily reflect the actual sample sizes the data are based on (as they have been raised to landings), these sample sizes have been ignored in the assessment (by setting $n_{pcom,j,y} = \bar{n}_{pcom,j}$ in equation 10b of the Stock Annex); a sensitivity test conducted in ICES (2010) showed a lack of sensitivity to this assumption.

The fecundity data (see Ellis and Keable, 2008, and the 2021 benchmark report, ICES, 2021, for sampling and other details) are given as pairs of values reflecting length of pregnant female and corresponding number of pups, and are listed in Tables 2.11a-n for the several periods (1921, 1960, 1978, 1987, 1988, 1997, 2005, 2010, 2014, 2016, 2017, 2018, 2019, 2020).

### 2.9.4 Summary of model runs in WGEF 2022

The starting point for the baseline assessment is the "update21" assessment, which is the equivalent of the 2021 benchmark assessment ("benchmark21"), but with updates to some of the input data to deal with corrections, updates, and missing data (see section 2.9.2.2). Furthermore, the values for the parameters $a_{fec}$ and $b_{fec}$ are taken from "update21" (Figure 2.23; see Table 2.12b), and the model fitted, including estimation of $Q_{fec}$.

| Category | Description | Figures | Tables |
|---|---|---|---|
| Base case run | Results for baseline assessment, including model fits and estimation. | 2.25-2.31 | 2.12–15 |
| Retrospective | A 6-year retrospective analysis, using the baseline assessment and omitting one year of data each time | 2.32 | |
| Projections | Projections under different harvest rate scenarios | 2.36 | |
| Comparison | Comparison of the baseline assessment with the previous assessment (WGEF 2020) and the "update21" assessment (equivalent of benchmark 2021 assessment, but with corrections, updates and infilling for missing data). | 2.37 | |
| **Sensitivity** | | | |
| $Q_{fec}$ | A comparison with an alternative $Q_{fec}$ values that fall within the 95% probability interval of Figure 2.23 | 2.33 | |
| Leave-out runs | A comparison of the baseline assessment with an assessment ("Q1 only") that omits the Q3 and Q4 survey indices, keeping only the Q1 index, along with likelihood profiles for the "Q1 only" assessment to highlight difference with the "update21" assessment profiles (Figure 2.23) on which the baseline assessment is based | 2.34-2.35 | |

## 2.9.5 Results for baseline assessment

### Model fits

Fecundity data available for several periods present an opportunity to estimate the extent of density-dependence in pup-production ($Q_{fec}$). However, estimating this parameter along with the fecundity parameters $a_{fec}$ and $b_{fec}$ was not possible because these parameters are confounded. The approach therefore was to plot the likelihood surface for a range of fixed $a_{fec}$ and $b_{fec}$ input values, while estimating $Q_{fec}$, and the results are shown in Figure 2.23 for the "update21" assessment. The likelihood profiles were not repeated for the baseline assessment because they result in unrealistically high $Q_{fec}$ values (optimum around 5, compared to around 3 from the "update21" assessment; results not shown), implying a highly productive resource, and likely resulting from conflicts in the underlying data. The periods of fecundity data are essential for the estimation of $Q_{fec}$, and further information that would help with the estimation of this parameter would be useful. Figure 2.23d indicates a near-linear relationship between $Q_{fec}$ and $MSYR$ (defined in terms of the biomass of all animals $\geq l^{f}_{mat00}$), so additional information about $MSYR$ levels typical for this species could be used for this purpose (but has not yet been attempted).

The value of $Q_{fec}$ estimated for the baseline assessment (3.060) corresponds to the optimum shown in Figures 2.23a and b for $a_{fec}$ and $b_{fec}$, respectively. Lower $Q_{fec}$ values correspond to lower productivity, and vice-versa, higher values to higher productivity.

Figure 2.25 shows the model fits to the Q1, Q3 and Q4 survey indices; the Q4 index shows a much steeper increase compared to the Q1 and Q3 indices, a sharp increase that the model struggles to deal with, and this is likely driving the perception of a more productive stock than previously thought. Figures 2.26 shows the model fits to the four sets of commercial proportion-by-length-category data (one for each commercial fleet), and to the three sets of survey proportion-by-length-category data (one for each survey index), the survey data fitted separately for females and males. Model fits to the survey index and commercial proportion data appear to be reasonable, with a close fit to the average proportion-by-length-category for the commercial fleets, but also with a poorer fit to the survey data, and some very high residuals.

The model fits to the fecundity data are shown in Figures 2.27, showing marked changes in fecundity over time, which is related to value estimated for $Q_{fec}$. Figures 2.28 compare the deterministic and stochastic modelled recruitment, and plot the estimated normalised recruitment residuals; the latter shows predominantly positive residuals, which is likely linked to the attempts of the model to fit to the steep increase in the Q4 survey index.

## Estimated parameters

Model estimates of the total number of pregnant females in the virgin population ($N_0^{f,preg}$), the extent of density-dependence in pup production ($Q_{fec}$), survey catchability for each survey ($q_{sur}$), and current (2022) total biomass levels relative to 1905 and 1955 ($B_{depl05}$ and $B_{depl55}$), are shown in Table 2.12a (for the "base case" and alternative $Q_{fec}$ estimates) together with estimates of precision. Estimates of the natural mortality parameter $M_{pup}$, the fecundity parameters $a_{fec}$ and $b_{fec}$, $B_0$, $B_{lim}$, MSY-related estimates ($HR_{MSY}$, $MSY$, $B_{MSY}$, MSY $B_{trigger}$ and $MSYR$), and other harvest rates of interest ($HR_{pa}$, $HR_{lim}$) are given in Table 2.12b. Table 2.13 provides a correlation matrix for some of the key estimable parameters (only the last five years of recruitment deviations are shown). Correlations between estimable parameters are generally low, apart from those associated with scale (strongly negative between $N_0^{f,preg}$ and $Q_{fec}$, and between $Q_{fec}$ and $q_{sur}$, and positive between $N_0^{f,preg}$ and $q_{sur}$) and among some selectivity parameters.

Estimated commercial- and selectivity-at-age patterns are shown in Figures 2.29, and reflect the differing proportions of animals of different size categories in the survey data when compared to the commercial catch data (e.g. a general tendency to select smaller animals in surveys and larger animals in commercial catches), and amongst the commercial fleets and surveys themselves (see also Figures 2.26). It should be noted that females grow to larger lengths than males, so that females are able to grow out of the second highest length category, whereas males, with an $L_\infty$ of < 85 cm (Table 2.6) are not able to do so (hence the commercial selectivity remains unchanged for the two largest length categories for males). The divergence of survey selectivity for females compared to males is a reflection of the separate selectivity parameters for females/males in the largest length category (70+ for surveys).

A plot of recruitment vs. the number of pregnant females in the population, effectively a stock–recruit plot, is given in plot b of Figure 2.28 together with the replacement line (the number of recruiting pups needed to replace the pregnant female population under no harvesting). This plot illustrates the importance of the $Q_{fec}$ parameter in the model: a $Q_{fec}$ parameter equal to 1 would imply the expected value of the stock–recruit point lies on the replacement line, which implies that the population is effectively incapable of replacing itself. A further exploration of the behaviour of $Q_y$ and $N_{pup,y}$ (equations 2a and b in the Stock Annex) is shown in Figure 2.30.

## Time-series trends

Model estimates of total biomass ($B_y$), recruitment ($R_y$) and mean fishing proportion ($HR_{5\text{-}30,y}$) are shown in Figure 2.31, together with approximate 95% probability intervals; observed annual catch ($C_y = \sum_j C_{j,y}$) is also shown. They indicate a strong decline in spurdog total biomass, particularly since the 1950s, to a low around the early- to mid-2000s (20% of pre-exploitation levels), which appears to be driven by relatively high exploitation levels, given the biological characteristics of spurdog. $HR_{5\text{-}30,y}$ appears to have declined in recent years, with $B_y$ increasing again to 45% of pre-exploitation levels in 2022 ($B_{depl05}$ in Table 2.12a). The fluctuations in recruitment towards the end of the time-series are driven by information in the proportion-by-length-category data. Table 2.14 provides a stock summary (recruitment, total biomass, catches and $HR_{5\text{-}30,y}$).

## 2.9.6 Retrospective analysis

A six year retrospective analysis (the baseline model was re-run, each time omitting a further year in the data) was performed, and is shown in Figure 2.32 for the total biomass ($B_y$), mean fishing proportion ($HR_{5\text{-}30,y}$) and recruitment ($R_y$). Mohn's rho values are given in the op right of each of these plots, and these are very low, although there are some retrospective lines that fall outside the probability intervals (black hashed lines) for the full data line (2021).

## 2.9.7 Sensitivity analyses

Two sets of sensitivity analyses were carried out, as listed in the text table above.

a) $Q_{fec}$

The $a_{fec}$ and $b_{fec}$ values that provided the optimum for the "update21" assessment ($Q_{fec}$=3.060; plots a-c in Figures 2.23) was selected for the baseline assessment. This sensitivity test compares it to the runs for which the $a_{fec}$ and $b_{fec}$ input values provide the lower bound of the 95% probability interval ($Q_{fec}$=2.275) and upper bound ($Q_{fec}$=3.803). Model results are fairly sensitive to these options (Figures 2.33, Tables 2.12a–b), which is unsurprising because $Q_{fec}$ reflects the productivity of the stock.

b) Leave-out runs

The leave-out runs tests the impact of only including the Q1 survey, to be similar to the assessment prior to the benchmark. Figure 2.34 indicates a large impact of including the Q3 and Q4 surveys (compare "include all" and "Q1 only"), with the "Q1 only" indicating only a very minor recovery in the stock in recent years, and "include all" showing a much stronger recovery. A big driver for this is the estimation of $Q_{fec}$, which is much lower for the former compared to the latter (compare Figure 2.35 to Figure 2.23).

## 2.9.8 Projections

The baseline assessment (see Tables 2.12) is used as a basis for future projections under a variety of catch options. These are based on:

- $HR_{MSY}$, which assumes a harvest rate set at that $HR_{MSY}$ = 0.043;
- Zero catch (for comparison purposes);
- $HR_{sq}$, which assumes a harvest rate set at the same harvest rate as 2021 (0.031) and that assumed for the intermediate year, 2022;
- $HR_{pa}$, which assumes a harvest rate set at $HR_{pa}$ = 0.049;
- $HR_{lim}$, which assumes a harvest rate set at $HR_{lim}$ = 0.067.

Results are given in Tables 2.15 , expressed as total biomass in future relative to the total biomass in 2022, and are illustrated in Figures 2.36. All scenarios result in increasing stock size, albeit at different rates, apart from fishing at $HR_{lim}$.

## 2.9.9 Conclusion

A benchmark for spurdog was held in 2021, during which there was a substantial improvement in data available for the assessment, including survey indices and associated length compositions covering a much larger area of the stock distribution, fecundity data spanning a much wider timeframe, fleet-based length data covering more countries than just the UK, and improved catch information since 2005. However, mistakes in the input data, subsequent updates to landings and discards data, including infilling for missing discards data (see Section 2.9.2.2) meant that the benchmark assessment had to be re-run, presented here as the "update21" assessment – as with the benchmark assessment, this assessment only uses data up to and including 2019. This was the basis for the baseline assessment put forward.

Sensitivity tests show the model to be sensitive to the range of $Q_{fec}$ values that fall within the 95% probability interval for corresponding fecundity parameters. The leave-out runs also highlight the influence of especially the Q4 survey index on the perception of productivity of the stock, leading to a substantially higher estimate of $Q_{fec}$ (and hence higher productivity) compared to past assessment. Summary plot of the final assessments (the baseline assessment), showing catches and estimates of recruitment, mean fishing proportion (with $HR_{MSY}$ = 0.043) and total biomass (with $B_{lim}$ = 240 569 t and $MSY\ B_{trigger}$ = 336 796 t), together with estimates of precision, are given in Figure 2.31 and Table 2.14.

Results from the current model confirm that spurdog abundance has declined, and that the decline is driven by high exploitation levels in the past, coupled with biological characteristics that make this species particularly vulnerable to such intense exploitation. The assessment also confirms that the stock is recovering from a low in the early- to mid-2000s, and is now well above $MSY\ B_{trigger}$.

A comparison with the 2020 assessment and with the "update21" assessment is provided in Figure 2.37 and shows an upward trend in recruitment and total biomass in recent years.

# 2.10 Quality of assessments

Whilst the current assessment model has been both benchmarked (ICES, 2011, 2021) and published (De Oliveira et al. 2013), there are a number of issues to consider regarding input data and the assessment mode itself, as summarised below.

## 2.10.1 Catch data

The WG has provided estimates of total landings of NE Atlantic spurdog, and from 2005 onwards estimates of discards, and has used these together with length frequency distributions in the assessment of this stock. However, there are still concerns over the quality of these data as a consequence of:

- uncertainty in the historical level of catches because of landings being reported by generic dogfish categories;
- uncertainty over the accuracy of the landings data because of species misreporting;
- missing discards data for some countries and métiers (e.g. for UK-England & Wales gillnets and trammel nets).

## 2.10.2 Survey data

Survey data are particularly important indicators of abundance trends in stocks. However, it should be highlighted that

- spurdog survey data are difficult to interpret because of the typically highly skewed distribution of catch-per-unit effort.
- annual survey length frequency distribution data (aggregated over all hauls) may be dominated by data from single large haul.

These problems have been dealt with by adopting appropriate statistical modelling approaches when analysing survey data (see above).

## 2.10.3 Biological information

As well as good commercial and survey data, the analytical assessments require good information on the biology of NE Atlantic spurdog. In particular, the WG would like to highlight the need for:

- updated and validated growth parameters, in particular for larger individuals;
- better estimates of natural mortality.

An area of future improvement for the spurdog model is including variation in the age-length relationship in the model. The lack of progress in this regard during the 2021 benchmark (given the need to focus on other areas considered of higher priority, such as the substantial improvement in the data now included in the model) meant that it was not possible to explore sensitivity to alternative growth parameterisations. This was because the alternative growth models proposed meant that there were no longer animals in the smallest length classes, leading to zero values which were not possible to deal with during this benchmark. The growth parameters used for the final model therefore remains the values used in the previous assessment and reported in Table 1 (see also De Oliveira et al., 2013).

## 2.10.4 Assessment

As with any stock assessment model, the exploratory assessment relies heavily on the underlying assumptions, particularly with regard to life-history parameters (e.g. natural mortality and growth), and on the quality and appropriateness of input data. The inclusion of several periods of fecundity data has provided valuable information that allows estimation of $Q_{fec}$, and projecting the model back in time is needed to allow fecundity data sets to be fitted. Nevertheless, the likelihood surface does not have a well-defined optimum, and additional information, such as on appropriate values of MSYR for a species such as spurdog, would help with this problem. Further refinements of the model are possible, such as including variation in growth. Selectivity curves also cover a range of gears over the entire catch history, and more appropriate assumptions (depending on available data) could be considered.

In summary, the model may be appropriate for providing an assessment of spurdog, though it could be further developed if the following data were available:

- Further refinements of selectivity parameters disaggregated by gear for the main fisheries (i.e. for various trawl, long line and gillnets);
- Improved estimates for biological data (e.g. growth parameters, reproductive biology and natural mortality);
- Information on likely values of MSYR for a species such as spurdog.

# 2.11 Reference points

The spurdog model is an integrated assessment model that includes a function that relates pup production to mature females, and it is therefore possible to estimate reference points (such as $B_{MSY}$) from within the model (in much the same way that is done for biomass dynamic models) without relying on an approach such as EqSim. Furthermore, the model commences in 1905, when reported landings were relatively low, and well before the period of high exploitation experienced from the 1950s onwards, and so the model is considered to provide a reasonably reliable estimate of $B_0$ (the virgin total biomass level). Reference points are directly based on assessment outputs, which means that reference points are updated every time the assessment is rerun. For the basis for current reference points, including the equations for how some of them are derived, please refer to the stock annex. For current estimates of reference points, please see Table 2.12b.

## 2.12 Conservation considerations

In 2007, the IUCN Red List of Threatened Species categorized spurdog globally as 'Vulnerable' (Finucci et al. 2020), although the most recent assessment of spurdog in European waters lists spurdog as 'Endangered' (Ellis et al. 2015; Nieto *et al*., 2015).

## 2.13 Management considerations

### Perception of state of stock

All analyses presented in previous reports of WGEF have indicated that the NE Atlantic stock of spurdog declined over the second half of the 20th century, but now appears to be increasing. The current stock size is thought to be ca. 45% of virgin biomass (Table 2.12a).

Although spurdog are less frequently caught in groundfish surveys than they were 20 years ago, there is some suggestion that spurdog are now being more frequently seen in survey hauls, and survey catch rates are starting to increase (Figure 2.25).

### Stock distribution

Spurdog in the ICES area are considered to be a single stock, ranging primarily from Subarea 1 to Subarea 8, although landings from the southern end of its range may also include other *Squalus* species.

### Biological considerations

Spurdog is a long-lived and slow growing species which has a high age-at-maturity and is particularly vulnerable to high levels of fishing mortality. Furthermore, females are thought to have restricted movement (Thorburn *et al*., 2015). Population productivity is low, with low fecundity and a protracted gestation period. In addition, they form size- and sex-specific shoals and therefore aggregations of large fish (i.e. mature females) are easily exploited by target longline and gillnet fisheries.

Updated age and growth studies are required. For Norwegian waters, see Albert *et al*., 2019 and Section 2.14.

### Fishery and technical considerations

Those fixed gear fisheries that capture spurdog should be reviewed to examine the catch composition, and those taking a large proportion of mature females should be strictly regulated.

During 2009 and 2010, a maximum landing length (MLL) was established in EC waters to deter targeting of mature females (see Section 2.10 of ICES, 2006 for simulations on MLL). Those fisheries taking spurdog that are lively may have problems measuring fish accurately, and investigations to determine an alternative measurement (e.g. pre-oral length) that has a high correlation with total length and is more easily measured on live fish are required. Dead spurdog may also be more easily stretched on measuring, and understanding such post-mortem changes is required to inform on any levels of tolerance, in terms of enforcement.

There is limited information on the distribution of gravid females with term pups and new-born spurdog pups, though they have been reported to occur in Scottish waters, in the Celtic Sea and off Ireland. The lack of accurate data on the location of pupping and nursery grounds, and their importance to the stock, precludes spatial management for this species at the present time.

# 2.14 Additional recent information

## 2.14.1 Developing an abundance index for spurdog in Norwegian waters

Input data to the assessment model have so far been restricted to the British sector, and data from other areas have been requested. In Norwegian waters, from where more than 80% of the current landings originate, there is no dedicated survey for spurdog, but data are recorded on all regular surveys, as well as by the Norwegian Reference fleet, and during official controls of commercial catches and landings. Two WDs were presented at 2016 WGEF meeting to indicate the potential for establishing one or several new tuning fleets in Norwegian waters to inform future assessments of this stock. An update was presented at 2020 WGEF.

Here are shown the updated trends from the Shrimp Survey in South-Norway (NO-shrimp-Q1, divisions 3.a and 4.a), the Coastal Survey in North-Norway (NOcoast-Aco-Q4, Division 2.a) and from samples from the commercial fleet in Norwegian waters. Details of the calculations were given in Albert and Vollen (2015 WD), Albert (2016 WD), Vollen and Albert (2016 WD), and Junge *et al*. (2020 WD).

The Shrimp Survey shows a rather clear pattern, with relatively high and fluctuating survey indices in the 1980s, low and decreasing values throughout the 1990s, reaching the lowest values in 2002, and then a return to high and variable values since 2003 (Figure 2.38; updated in Figure 2.14 and shown in strata in Figure 2.15). The Coastal Survey shows highly variable survey indices, with slight tendencies of higher values between 2000–2010 than in both the preceding and the following years (Figure 2.38). The percent of occurrence of spurdog in sampled catches from Norwegian commercial gillnetters shows an increasing trend throughout the most recent decade, and similar trends are also present from some other fleets (Figure 2.39).

All of these time series are crude estimates without proper stratification, and should only be regarded as preliminary indications of overall trends. Before the next benchmarking process of spurdog, more elaborated indices of abundance and composition should preferably be documented for this northern part of the distribution range.

## 2.14.2 Recent life-history information

The most recent update of biological data for *S. acanthias* in the Northeast Atlantic are from Norwegian waters (Albert *et al*., 2019). A total of 3948 bycaught individuals were sampled throughout the period from 2014–2018, within the ICES divisions 2.a, 4.a, and 3.a. Overall, females accounted for 56% of the samples, but the sex compositions of individual catches were highly skewed.

The sampled spurdog varied in length from 41 to 95 cm and 53 to 121 cm for males and females, respectively. The mean lengths of both males and females were larger in the northern area of the study.

The age composition was similar for both sexes, observed from the age of 3 up to the med-30s with dominance of individuals <15 years of age. Median age for both sexes was 11 years, with an interquartile range of 9–14 and 8–17 for females and males, respectively.

The youngest and smallest mature females were 7 years and 68 cm, while the oldest and largest immature ones were 26 years and 100 cm. Mean age of late gravid females was 15.3 years, with an interquartile range of 12–16 years; estimated 50% maturity was 9.5 years and 77.8 cm. For males, very few immatures were recorded making estimation of 50% maturity uncertain.

Near-term females had a range of 1–19 pups and a mean of 7.2 pups. Difference between left and right uteri was a maximum of two pups for 92% of the near-term females. Mean pup length of near-term females was 24 cm, with 10 and 90 percentiles of 19 and 27 cm, respectively. Both the number and mean size of pups of near-term females increased with maternal length.

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**Table 2.1a. Northeast Atlantic spurdog. WG estimates of total landings of NE Atlantic spurdog (1947–2021).**

| Year | Landings (tonnes) | Year | Landings (tonnes) | Year | Landings (tonnes) |
|---|---|---|---|---|---|
| 1905 | 7 248 | 1944 | 8 151 | 1983 | 37 046 |
| 1906 | 2 200 | 1945 | 6 776 | 1984 | 35 193 |
| 1907 | 1 428 | 1946 | 10 895 | 1985 | 38 674 |
| 1908 | 1 409 | 1947 | 16 893 | 1986 | 30 910 |
| 1909 | 2 022 | 1948 | 19 491 | 1987 | 42 355 |
| 1910 | 1 563 | 1949 | 23 010 | 1988 | 35 569 |
| 1911 | 1 957 | 1950 | 24 750 | 1989 | 30 278 |
| 1912 | 3 199 | 1951 | 35 301 | 1990 | 29 906 |
| 1913 | 4 050 | 1952 | 40 550 | 1991 | 29 562 |
| 1914 | 2 641 | 1953 | 38 206 | 1992 | 29 046 |
| 1915 | 2 602 | 1954 | 40 570 | 1993 | 25 636 |
| 1916 | 534 | 1955 | 43 127 | 1994 | 20 851 |
| 1917 | 339 | 1956 | 46 951 | 1995 | 21 318 |
| 1918 | 451 | 1957 | 45 570 | 1996 | 17 294 |
| 1919 | 2 659 | 1958 | 50 394 | 1997 | 15 347 |
| 1920 | 4 396 | 1959 | 47 394 | 1998 | 13 919 |
| 1921 | 5 321 | 1960 | 53 997 | 1999 | 12 384 |
| 1922 | 5 401 | 1961 | 57 721 | 2000 | 15 890 |
| 1923 | 5 655 | 1962 | 57 256 | 2001 | 16 693 |
| 1924 | 6 355 | 1963 | 62 288 | 2002 | 11 020 |
| 1925 | 6 719 | 1964 | 60 146 | 2003 | 12 246 |
| 1926 | 7 277 | 1965 | 49 336 | 2004 | 9 365 |
| 1927 | 8 395 | 1966 | 42 713 | 2005 | 7 101 |
| 1928 | 9 522 | 1967 | 44 116 | 2006 | 4 015 |
| 1929 | 9 320 | 1968 | 56 043 | 2007 | 2 917 |
| 1930 | 11 914 | 1969 | 52 074 | 2008 | 1 798 |
| 1931 | 11 838 | 1970 | 47 557 | 2009 | 1 980 |
| 1932 | 16 726 | 1971 | 45 653 | 2010 | 893 |
| 1933 | 20 244 | 1972 | 50 416 | 2011 | 435 |
| 1934 | 20 378 | 1973 | 49 412 | 2012 | 453 |
| 1935 | 22 266 | 1974 | 45 684 | 2013 | 336 |
| 1936 | 20 925 | 1975 | 44 119 | 2014 | 383 |
| 1937 | 23 930 | 1976 | 44 064 | 2015 | 263 |
| 1938 | 18 196 | 1977 | 42 252 | 2016 | 373 |
| 1939 | 20 119 | 1978 | 47 235 | 2017 | 296 |
| 1940 | 9 428 | 1979 | 38 201 | 2018 | 363 |
| 1941 | 8 740 | 1980 | 40 968 | 2019 | 455 |
| 1942 | 10 625 | 1981 | 39 961 | 2020 | 526 |
| 1943 | 8 181 | 1982 | 32 402 | 2021 | 539 |

**Table 2.1b. Northeast Atlantic spurdog. WG estimates of discards of NE Atlantic spurdog (2005–2021).**

| Year | Landings (tonnes) |
|---|---|
| 2005 | 20 |
| 2006 | 22 |
| 2007 | 34 |
| 2008 | 46 |
| 2009 | 96 |
| 2010 | 1523 |
| 2011 | 2597 |
| 2012 | 4757 |
| 2013 | 2939 |
| 2014 | 2915 |
| 2015 | 3016 |
| 2016 | 1580 |
| 2017 | 4781 |
| 2018 | 2371 |
| 2019 | 3165 |
| 2020 | 942 |
| 2021 | 639 |

**Table 2.2. Northeast Atlantic spurdog. WG estimates of total landings by nation (1980–2021); "-" = no data available, "." = zero catch, "+" = <0.5 tonnes Data from 2005 onwards revised during WKSHARK2. From 2005 Scottish landings data are combined with those from England and Wales, and presented as UK (combined).**

| Country | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belgium | 1097 | 1085 | 1110 | 1072 | 1139 | 920 | 1048 | 979 | 657 | 750 | 582 | 393 | 447 | 335 | 396 | 391 |
| Denmark | 1404 | 1418 | 1282 | 1533 | 1217 | 1628 | 1008 | 1395 | 1495 | 1086 | 1364 | 1246 | 799 | 486 | 212 | 146 |
| Faroe Islands | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 2 | 3 | 25 | 137 | 203 | 310 |
| France | 17 514 | 19 067 | 12 430 | 12 641 | 8356 | 8867 | 7022 | 11 174 | 7872 | 5993 | 4570 | 4370 | 4908 | 4831 | 3329 | 1978 |
| Germany | 43 | 42 | 39 | 25 | 8 | 22 | 41 | 48 | 27 | 24 | 26 | 6 | 55 | 8 | 21 | 100 |
| Iceland | 36 | 22 | 14 | 25 | 5 | 9 | 7 | 5 | 4 | 17 | 15 | 53 | 185 | 108 | 97 | 166 |
| Ireland | 108 | 476 | 1268 | 4658 | 6930 | 8791 | 5012 | 8706 | 5612 | 3063 | 1543 | 1036 | 1150 | 2167 | 3624 | 3056 |
| Netherlands | 217 | 268 | 183 | 315 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Norway | 5925 | 3941 | 3992 | 4659 | 4279 | 3487 | 2986 | 3614 | 4139 | 5329 | 8104 | 9633 | 7113 | 6945 | 4546 | 3940 |
| Poland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Portugal | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 3 | 2 | 128 | 188 | 250 | 323 | 190 | 256 |
| Russia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spain | 0 | 0 | 8 | 653 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sweden | 399 | 308 | 398 | 300 | 256 | 360 | 471 | 702 | 733 | 613 | 390 | 333 | 230 | 188 | 95 | 104 |
| UK (E&W) | 9229 | 9342 | 8024 | 6794 | 8046 | 7841 | 7047 | 7684 | 6952 | 5371 | 5414 | 3770 | 4207 | 3494 | 3462 | 2354 |
| UK (Sc) | 4994 | 3970 | 3654 | 4371 | 4957 | 6749 | 6267 | 8043 | 8075 | 8024 | 7768 | 8531 | 9677 | 6614 | 4676 | 8517 |
| Total | 40 968 | 39 961 | 32 402 | 37 046 | 35 193 | 38 674 | 30 910 | 42 355 | 35 569 | 30 278 | 29 906 | 29562 | 29046 | 25636 | 20851 | 21318 |

**Table 2.2 (continued). Northeast Atlantic spurdog. WG estimates of total landings by nation (1980–2021); "-" = no data available, "." = zero catch, "+" = <0.5 tonnes Data from 2005 onwards revised during WKSHARK2. From 2005 Scottish landings data are combined with those from England and Wales, and presented as UK (combined)**

| Country | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belgium | 430 | 443 | 382 | 354 | 400 | 410 | 23 | 11 | 13 | 21 | 17 | 11 | 12 | 7 | 1 | 0 | 0 | 0 | - | - |
| Denmark | 142 | 196 | 126 | 131 | 146 | 156 | 107 | 232 | 219 | 150 | 121 | 76 | 78 | 82 | 14 | 26 | 30 | 19 | 10 | 27 |
| Faroe Islands | 51 | 218 | 362 | 486 | 368 | 613 | 340 | 224 | 295 | 225 | 271 | 241 | 144 | 462 | 179 | 104 | - | - | - | - |
| France | 1607 | 1555 | 1286 | 998 | 4342 | 4304 | 2569 | 1705 | 1062 | 946 | 702 | 505 | 368 | 412 | 164 | 84 | 34 | 13 | 19 | 2 |
| Germany | 38 | 21 | 31 | 54 | 194 | 304 | 121 | 98 | 138 | 140 | 7 | 3 | 5 | 2 | 1 | 1 | 1 | 1 | 1 | + |
| Iceland | 156 | 106 | 80 | 57 | 107 | 199 | 276 | 200 | 142 | 76 | 82 | 43 | 68 | 102 | 62 | 53 | 51 | 6 | 19 | 8 |
| Ireland | 2305 | 2214 | 1164 | 904 | 905 | 1227 | 1214 | 1416 | 1076 | 1022 | 859 | 651 | 137 | 175 | 26 | 13 | 37 | 34 | 18 | 2 |
| Netherlands | 0 | 0 | 0 | 0 | 28 | 39 | 27 | 10 | 25 | 31 | 23 | 25 | 18 | 5 | 7 | 1 | 4 | 3 | 0 | 1 |
| Norway | 2748 | 1567 | 1293 | 1461 | 1643 | 1424 | 1091 | 1119 | 1054 | 1016 | 790 | 615 | 711 | 543 | 540 | 247 | 285 | 250 | 313 | 217 |
| Poland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Portugal | 120 | 100 | 46 | 21 | 2 | 3 | 4 | 4 | 9 | 5 | 9 | 10 | 4 | 3 | 2 | 3 | 2 | 2 | 1 | 2 |
| Russia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spain | 0 | 0 | 28 | 95 | 372 | 363 | 306 | 135 | 17 | 43 | 47 | 85 | 42 | 23 | 7 | 7 | 6 | 2 | 1 | 4 |
| Sweden | 154 | 196 | 140 | 114 | 123 | 238 | 0 | 275 | 244 | 169 | 147 | 93 | 75 | 80 | 5 | 0 | - | - | - | - |
| UK (combined)* | 2670 | 3066 | 4480 | 4461 | 3654 | 4516 | 2823 | 3109 | 1729 | 3481 | 1209 | 799 | 280 | 546 | 64 | 1 | 3 | 6 | 0 | - |
| UK (Sc)* | 6873 | 5665 | 4501 | 3248 | 3606 | 2897 | 2120 | 3708 | 3342 | | | | | | | | | | | |
| Total | 17 294 | 15 347 | 13 919 | 12 384 | 15 890 | 16 693 | 11 020 | 12 246 | 9365 | 7101 | 4015 | 2917 | 1798 | 1980 | 893 | 435 | 453 | 336 | 383 | 263 |

**Table 2.2 (continued). Northeast Atlantic spurdog. WG estimates of total landings by nation (1980–2021); "-" = no data available, "." = zero catch, "+" = <0.5 tonnes. Data from 2005 onwards revised during WKSHARK2. From 2005 Scottish landings data are combined with those from England and Wales, and presented as UK (combined).**

| Country | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Belgium | - | - | - | - | - | - |
| Denmark | 24 | 27 | 19 | 21 | 32 | 20 |
| Faroe Islands | - | - | - | - | - | - |
| France | 1 | 3 | 1 | - | - | - |
| Germany | 2 | + | 1 | + | - | + |
| Iceland | 8 | 4 | 2 | 1 | 3 | 1 |
| Ireland | 34 | 1 | 24 | 11 | 3 | - |
| Netherlands | 1 | 1 | 6 | + | + | - |
| Norway | 270 | 222 | 271 | 370 | 409 | 367 |
| Poland | - | - | - | - | - | - |
| Portugal | 1 | 1 | 1 | . | - | - |
| Russia | - | - | - | - | - | - |
| Spain | 1 | . | . | - | + | - |
| Sweden | + | + | + | + | - | + |
| UK (combined)* | 30 | 37 | 38 | 52 | 79 | 151 |
| UK (Sc)* | | | | | | - |
| Total | 373 | 296 | 363 | 455 | 526 | 539 |

**Table 2.3. Northeast Atlantic spurdog. WG estimates of landings by ICES Subarea (1980–2021). Data from 2005 onwards revised during WKSHARK2.**

| Subarea or Division | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baltic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 |
| 1 and 2 | 138 | 20 | 28 | 760 | 40 | 120 | 137 | 417 | 1559 | 2808 | 4296 | 6614 | 5063 | 5102 | 3124 | 2725 | 1853 | 582 |
| 3 and 4 | 20 544 | 16 181 | 11 965 | 11 572 | 10 557 | 11 136 | 8986 | 11 653 | 10 800 | 10 423 | 11 497 | 9264 | 10 505 | 6591 | 4360 | 7347 | 5299 | 4977 |
| 5 | 45 | 27 | 18 | 27 | 5 | 22 | 9 | 41 | 6 | 73 | 182 | 133 | 336 | 335 | 364 | 484 | 217 | 320 |
| 6 | 4590 | 4011 | 5052 | 7007 | 8491 | 12422 | 8107 | 9038 | 7517 | 6406 | 5407 | 6741 | 6268 | 5927 | 5622 | 5164 | 4168 | 3412 |
| 7.a | 2722 | 4013 | 4566 | 4001 | 6336 | 6774 | 6458 | 7305 | 5569 | 3389 | 2801 | 2527 | 2669 | 2700 | 2313 | 1185 | 1650 | 1534 |
| 7.b-c | 704 | 925 | 424 | 1777 | 2178 | 1699 | 1197 | 2401 | 1579 | 893 | 369 | 293 | 316 | 2009 | 1175 | 1004 | 603 | 450 |
| 7.d-f | 6693 | 8210 | 5989 | 4664 | 2450 | 1280 | 1644 | 2892 | 2120 | 1634 | 1339 | 1122 | 852 | 785 | 800 | 760 | 852 | 646 |
| 7.g-k | 4793 | 5479 | 3881 | 6924 | 4902 | 4965 | 3864 | 8106 | 6175 | 4477 | 3736 | 2495 | 2622 | 1745 | 2680 | 2034 | 2229 | 2984 |
| 8 | 739 | 1095 | 479 | 312 | 234 | 257 | 507 | 497 | 242 | 174 | 273 | 367 | 406 | 435 | 406 | 602 | 408 | 418 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 | 2 | 4 | 4 | 2 | 5 | 7 | 5 | 2 | 2 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 12 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 |
| Other or unspecified | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 12 | 10 |
| Total | 40 968 | 39 961 | 32 402 | 37 046 | 35 193 | 38 674 | 30 910 | 42 355 | 35 569 | 30 278 | 29 906 | 29 562 | 29 046 | 25 636 | 20 851 | 21 318 | 17 294 | 15 347 |

**Table 2.3 (continued) Northeast Atlantic spurdog. WG estimates of landings by ICES Subarea (1980–2021). Data from 2005 onwards revised during WKSHARK2.**

| Subarea or Division | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baltic | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 and 2 | 607 | 779 | 894 | 462 | 357 | 440 | 423 | 682 | 499 | 312 | 337 | 230 | 190 | 93 | 131 | 74 | 122 | 105 |
| 3 and 4 | 3895 | 2705 | 2475 | 2516 | 1904 | 2395 | 2163 | 1177 | 789 | 628 | 642 | 635 | 400 | 183 | 189 | 198 | 203 | 140 |
| 5 | 442 | 545 | 879 | 1406 | 808 | 583 | 677 | 244 | 204 | 161 | 86 | 103 | 63 | 53 | 51 | 6 | 28 | 8 |
| 6 | 2831 | 2715 | 5977 | 5624 | 3169 | 3398 | 2630 | 1581 | 830 | 619 | 169 | 263 | 69 | 3 | 1 | 0 | 0 | +0 |
| 7.a | 1771 | 2153 | 1599 | 1878 | 1529 | 2021 | 938 | 589 | 413 | 272 | 73 | 97 | 3 | 1 | 10 | 4 | 2 | + |
| 7.b-c | 854 | 1037 | 1028 | 816 | 527 | 588 | 432 | 332 | 268 | 299 | 48 | 97 | 7 | 1 | 1 | 0 | 0 | 0 |
| 7.d-f | 443 | 411 | 438 | 555 | 295 | 268 | 278 | 285 | 168 | 172 | 124 | 196 | 78 | 71 | 33 | 17 | 8 | + |
| 7.g-k | 2656 | 1822 | 2161 | 2846 | 2130 | 2339 | 1739 | 2005 | 746 | 386 | 245 | 288 | 63 | 14 | 29 | 30 | 16 | 2 |
| 8 | 308 | 171 | 405 | 469 | 269 | 134 | 56 | 138 | 87 | 58 | 70 | 65 | 15 | 12 | 3 | 3 | 2 | 2 |
| 9 | 2 | 3 | 19 | 8 | 11 | 5 | 14 | 5 | 10 | 11 | 5 | 6 | 5 | 5 | 5 | 3 | 2 | 6 |
| 10 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 104 | 22 | 14 | 41 | 22 | 74 | 12 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 63 | 0 | 0 | 0 | | | | | | | | | | | |
| Other or unspecified | 6 | 4 | 1 | 2 | 0 | 0 | 0 | 59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 13 919 | 12 384 | 15 890 | 16 693 | 11 020 | 12 246 | 9365 | 7101 | 4015 | 2917 | 1798 | 1980 | 893 | 435 | 453 | 336 | 383 | 263 |

**Table 2.3 (continued) Northeast Atlantic spurdog. WG estimates of landings by ICES Subarea (1980–2021). Data from 2005 onwards revised during WKSHARK2.**

| Subarea or Division | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Baltic | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 and 2 | 150 | 127 | 164 | 183 | 280 | 277 |
| 3 and 4 | 165 | 123 | 128 | 208 | 156 | 110 |
| 5 | 8 | 4 | 2 | 0 | 3 | 1 |
| 6 | 5 | 1 | 3 | 0 | 5 | + |
| 7.a | 2 | 0 | + | + | + | - |
| 7.b-c | 3 | 0 | 0 | 0 | 0 | - |
| 7.d-f | 1 | 14 | 19 | 14 | 28 | 26 |
| 7.g-k | 36 | 24 | 45 | 49 | 53 | 125 |
| 8 | 1 | 1 | + | 0 | + | + |
| 9 | 2 | 1 | 1 | 0 | 0 | - |
| 10 | 0 | 0 | 0 | 0 | 0 | - |
| 12 | 0 | 0 | 0 | 0 | 0 | - |
| 14 | 0 | 0 | 1 | 0 | 0 | - |
| Other or unspecified | 0 | 0 | 0 | 0 | 0 | - |
| Total | 373 | 296 | 363 | 455 | 526 | 539 |

**Table 2.4. Northeast Atlantic spurdog. Relative proportion (by tonnage) of Swedish, Irish and British catches of spurdog taken by bottom trawls. These relative proportions are used as weights when combining the bottom trawl length composition data.**

| | Sweden | Ireland | GBR |
|---|---|---|---|
| **2007** | **7%** | **35%** | **57%** |
| **2008** | **14%** | **40%** | **46%** |
| **2009** | **7%** | **19%** | **74%** |
| **2010** | **7%** | **43%** | **51%** |
| **2011** | **6%** | **46%** | **48%** |
| **2012** | **10%** | **31%** | **59%** |
| **2013** | **12%** | **21%** | **67%** |
| **2014** | **28%** | **12%** | **59%** |
| **2015** | **4%** | **20%** | **76%** |
| **2016** | **6%** | **28%** | **66%** |
| **2017** | **21%** | **41%** | **37%** |
| **2018** | **2%** | **40%** | **59%** |
| **2019** | **9%** | **18%** | **73%** |
| **2020** | **0%** | **51%** | **49%** |
| **2021** | **0%** | **3%** | **97%** |
| **average** | **9%** | **30%** | **61%** |

**Table 2.5. Northeast Atlantic spurdog. Norwegian Shrimp and Coastal survey, 1984–2017. Month of survey, mean duration of tows, total number of stations, number of stations with spurdog, total number of spurdog caught, and mesh size used. Source: Vollen and Albert (2016 WD).**

| Year | Survey | Month of survey | Mean duration (h) | # of stations | # of stations with spurdog | # spurdogs caught | Mesh size | Survey | Month of survey | Mean duration (h) | # of stations | # of stations with spurdog | # spurdogs caught | Mesh shze |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | S | 10–11 | 0.96 | 59 | 10 | 67 | | | | | | | | |
| 1985 | S | 10–11 | 1.00 | 86 | 29 | 303 | | | | | | | | |
| 1986 | S | 10–11 | 0.96 | 57 | 26 | 341 | | | | | | | | |
| 1987 | S | 10–11 | 0.99 | 93 | 29 | 90 | | | | | | | | |
| 1988 | S | 10–11 | 0.97 | 102 | 29 | 87 | | | | | | | | |
| 1989 | S | 10–11 | 0.50 | 89 | 11 | 18 | 35 | | | | | | | |
| 1990 | S | 10–11 | 0.49 | 77 | 19 | 130 | 35 | | | | | | | |
| 1991 | S | 10–11 | 0.52 | 101 | 11 | 38 | 35 | | | | | | | |
| 1992 | S | 10–11 | 0.50 | 99 | 12 | 22 | 35 | | | | | | | |
| 1993 | S | 10–11 | 0.50 | 106 | 10 | 14 | 35 | | | | | | | |
| 1994 | S | 10–11 | 0.47 | 101 | 10 | 18 | 35 | | | | | | | |
| 1995 | S | 10–11 | 0.48 | 102 | 8 | 15 | 35 | C | 9–10 | 0.43 | 29 | 6 | 22 | 40 |
| 1996 | S | 10–11 | 0.50 | 103 | 4 | 15 | 35 | C | 9–10 | 0.45 | 22 | 5 | 9 | 40 |
| 1997 | S | 10–11 | 0.49 | 93 | 10 | 18 | 35 | C | 8–9 | 0.42 | 44 | 1 | 2 | 20 |
| 1998 | S | 10–11 | 0.49 | 95 | 9 | 14 | 20 | C | 10–11 | 0.47 | 33 | 8 | 106 | 20 |
| 1999 | S | 10–11 | 0.50 | 97 | 4 | 7 | 20 | C | 10–11 | 0.44 | 34 | 2 | 4 | 20 |
| 2000 | S | 10–11 | 0.50 | 98 | 5 | 18 | 20 | C | 10–11 | 0.47 | 28 | 6 | 12 | 20 |
| 2001 | S | 10–11 | 0.50 | 70 | 2 | 3 | 20 | C | 10–11 | 0.42 | 17 | 5 | 64 | 20 |
| 2002 | S | 10–11 | 0.50 | 77 | 1 | 1 | 20 | C | 10–11 | 0.46 | 37 | 4 | 43 | 20 |
| 2003 | S | 10–11 | 0.53 | 68 | 12 | 34 | 20 | C | 10–11 | 0.44 | 23 | 4 | 21 | 20 |
| 2004 | S | 5–6 | 0.50 | 60 | 7 | 48 | 20 | C | 10–11 | 0.37 | 33 | 5 | 104 | 20 |
| 2005 | S | 5–6 | 0.51 | 86 | 7 | 12 | 20 | C | 10–11 | 0.46 | 18 | 2 | 17 | 20 |
| 2006 | S | 1–2 | 0.49 | 43 | 9 | 33 | 20 | C | 10–11 | 0.30 | 34 | 8 | 52 | 20 |
| 2007 | S | 1–2 | 0.50 | 64 | 14 | 27 | 20 | C | 10–11 | 0.35 | 36 | 7 | 35 | 20 |
| 2008 | S | 1–2 | 0.51 | 73 | 13 | 52 | 20 | C | 10–11 | 0.56 | 7 | 0 | 0 | 20 |
| 2009 | S | 1–2 | 0.47 | 92 | 16 | 39 | 20 | C | 10–11 | 0.39 | 19 | 0 | 0 | 20 |
| 2010 | S | 1–2 | 0.47 | 95 | 20 | 34 | 20 | C | 10–11 | 0.36 | 26 | 3 | 25 | 20 |
| 2011 | S | 1–2 | 0.49 | 97 | 18 | 43 | 20 | C | 10–11 | 0.33 | 20 | 5 | 6 | 20 |
| 2012 | S | 1–2 | 0.47 | 63 | 14 | 71 | 20 | C | 10–11 | 0.36 | 31 | 5 | 9 | 20 |
| 2013 | S | 1–2 | 0.38 | 100 | 35 | 177 | 20 | C | 10 | 0.42 | 19 | 1 | 1 | 20 |
| 2014 | S | 1 | 0.47 | 68 | 18 | 99 | 20 | C | 10 | 0.39 | 30 | 3 | 4 | 20 |
| 2015 | S | 1 | 0.49 | 88 | 18 | 62 | 20 | C | 10-11 | 0.37 | 28 | 5 | 10 | 20 |
| 2016 | S | 1 | 0.50 | 105 | 19 | 51 | 20 | C | 10 | 0.37 | 27 | 2 | 37 | 20 |
| 2017 | S | 1 | 0.50 | 108 | 35 | 90 | 20 | C | 10-11 | 0.41 | 33 | 3 | 26 | 20 |

**Table 2.6. Northeast Atlantic spurdog. Description of life-history equations and parameters.**

| Parameters | Description/values | Sources |
|---|---|---|
| $M_a$ | Instantaneous natural mortality at age *a*: $M_a = \begin{cases} M_{pup} e^{-a \ln(M_{pup}/M_{adult})/a_{M1}} & a < a_{M1} \\ M_{adult} & a_{M1} \le a \le a_{M2} \\ M_{til} /[1+e^{-M_{gam}(a-(A+a_{M2})/2)}] & a > a_{M2} \end{cases}$ | |
| $a_{M1}$, $a_{M2}$ | 4, 30 | expert opinion |
| $M_{adult}$, $M_{til}$, $M_{gam}$ | 0.1, 0.3, 0.04621 | expert opinion |
| $M_{pup}$ | Calculated to satisfy balance equation | supplementary material of De Oliveira et al. 2013 |
| | | |
| $l_a^s$ | Mean length-at-age a for animals of sex *s* $l_a^s = L_\infty^s (1-e^{-\kappa^s (a-t_0^s)})$ | |
| $L_\infty^f$, $L_\infty^m$ | 110.66, 81.36 | average from literature |
| $\kappa^f$, $\kappa^m$ | 0.086, 0.17 | average from literature |
| $t_0^f$, $t_0^m$ | -3.306, -2.166 | average from literature |
| | | |
| $w_a^s$ | Mean weight at age *a* for animals of sex *s* $w_a^s = a^s (l_a^s)^{b^s}$ | |
| $a^f$, $b^f$ | 0.00108, 3.301 | Bedford *et al*. (1986) |
| $a^m$, $b^m$ | 0.00576, 2.89 | Coull *et al*. (1989) |
| | | |
| $l_{mat00}^f$ | Female length at first maturity 70 cm | average from literature |
| | | |
| $P_a''$ | Proportion females of age a that become pregnant each year $P_a'' = \dfrac{P_{\max}''}{1+\exp\left[-\ln(19)\dfrac{l_a^f - l_{mat50}^f}{l_{mat95}^f - l_{mat50}^f}\right]}$ where $P_{\max}''$ is the proportion very large females pregnant each year, and $l_{matx}^f$ the length at which *x*% of the maximum proportion of females are pregnant each year | |
| $P_{\max}''$ | 0.5 | average from literature |
| $l_{mat50}^f$, $l_{mat95}^f$ | 80 cm, 87 cm | average from literature |

**Table 2.7a. Northeast Atlantic spurdog. Landings used in the assessment (1905-2004), with the allocation to "Non-target" and "Target". Estimated Scottish selectivity (based on fits to proportions by length category data for the period 1991–2004) is assumed to represent "non-target" fisheries, and estimated England and Wales selectivity (based on fits to proportions by length category data for the period 1983–2001) "target" fisheries. The allocation to "Non-target" and "Target" shown below is based on categorising each nation as having fisheries that are "non-target", "target" or a mixture of these from 1980 onwards. An average for the period 1980–1984 is assumed for the "non-target"/"target" split prior to 1980, while all landings from 2008 onwards are assumed to come from "non-target" fisheries. Landings are used as catch in the assessment.**

| Year | Non-target | Target | Total | Year | Non-target | Target | Total | Year | Non-target | Target | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1905** | 3503 | 3745 | 7248 | **1939** | 9723 | 10396 | 20119 | **1973** | 23880 | 25532 | 49412 |
| **1906** | 1063 | 1137 | 2200 | **1940** | 4556 | 4872 | 9428 | **1974** | 22078 | 23606 | 45684 |
| **1907** | 690 | 738 | 1428 | **1941** | 4224 | 4516 | 8740 | **1975** | 21322 | 22797 | 44119 |
| **1908** | 681 | 728 | 1409 | **1942** | 5135 | 5490 | 10625 | **1976** | 21295 | 22769 | 44064 |
| **1909** | 977 | 1045 | 2022 | **1943** | 3954 | 4227 | 8181 | **1977** | 20420 | 21832 | 42252 |
| **1910** | 755 | 808 | 1563 | **1944** | 3939 | 4212 | 8151 | **1978** | 22828 | 24407 | 47235 |
| **1911** | 946 | 1011 | 1957 | **1945** | 3275 | 3501 | 6776 | **1979** | 18462 | 19739 | 38201 |
| **1912** | 1546 | 1653 | 3199 | **1946** | 5265 | 5630 | 10895 | **1980** | 20770 | 20198 | 40968 |
| **1913** | 1957 | 2093 | 4050 | **1947** | 8164 | 8729 | 16893 | **1981** | 20953 | 19009 | 39962 |
| **1914** | 1276 | 1365 | 2641 | **1948** | 9420 | 10071 | 19491 | **1982** | 16075 | 16327 | 32402 |
| **1915** | 1258 | 1344 | 2602 | **1949** | 11120 | 11890 | 23010 | **1983** | 17095 | 19951 | 37046 |
| **1916** | 258 | 276 | 534 | **1950** | 11961 | 12789 | 24750 | **1984** | 15047 | 20147 | 35194 |
| **1917** | 164 | 175 | 339 | **1951** | 17060 | 18241 | 35301 | **1985** | 17048 | 21626 | 38674 |
| **1918** | 218 | 233 | 451 | **1952** | 19597 | 20953 | 40550 | **1986** | 15138 | 15772 | 30910 |
| **1919** | 1285 | 1374 | 2659 | **1953** | 18464 | 19742 | 38206 | **1987** | 19558 | 22798 | 42356 |
| **1920** | 2125 | 2271 | 4396 | **1954** | 19607 | 20963 | 40570 | **1988** | 17292 | 18277 | 35569 |
| **1921** | 2572 | 2749 | 5321 | **1955** | 20843 | 22284 | 43127 | **1989** | 15355 | 14924 | 30279 |
| **1922** | 2610 | 2791 | 5401 | **1956** | 22691 | 24260 | 46951 | **1990** | 14390 | 15516 | 29906 |
| **1923** | 2733 | 2922 | 5655 | **1957** | 22023 | 23547 | 45570 | **1991** | 14034 | 15529 | 29563 |
| **1924** | 3071 | 3284 | 6355 | **1958** | 24355 | 26039 | 50394 | **1992** | 15711 | 13335 | 29046 |
| **1925** | 3247 | 3472 | 6719 | **1959** | 22905 | 24489 | 47394 | **1993** | 12268 | 13369 | 25637 |
| **1926** | 3517 | 3760 | 7277 | **1960** | 26096 | 27901 | 53997 | **1994** | 9238 | 11613 | 20851 |
| **1927** | 4057 | 4338 | 8395 | **1961** | 27896 | 29825 | 57721 | **1995** | 12104 | 9214 | 21318 |
| **1928** | 4602 | 4920 | 9522 | **1962** | 27671 | 29585 | 57256 | **1996** | 10026 | 7269 | 17295 |
| **1929** | 4504 | 4816 | 9320 | **1963** | 30103 | 32185 | 62288 | **1997** | 9158 | 6190 | 15348 |
| **1930** | 5758 | 6156 | 11914 | **1964** | 29068 | 31078 | 60146 | **1998** | 8509 | 5410 | 13919 |
| **1931** | 5721 | 6117 | 11838 | **1965** | 23843 | 25493 | 49336 | **1999** | 7233 | 5152 | 12385 |
| **1932** | 8083 | 8643 | 16726 | **1966** | 20642 | 22071 | 42713 | **2000** | 9283 | 6608 | 15891 |
| **1933** | 9784 | 10460 | 20244 | **1967** | 21320 | 22796 | 44116 | **2001** | 9513 | 7180 | 16693 |
| **1934** | 9848 | 10530 | 20378 | **1968** | 27085 | 28958 | 56043 | **2002** | 6169 | 5001 | 11170 |
| **1935** | 10761 | 11505 | 22266 | **1969** | 25166 | 26908 | 52074 | **2003** | 7167 | 5080 | 12247 |
| **1936** | 10113 | 10812 | 20925 | **1970** | 22983 | 24574 | 47557 | **2004** | 5718 | 3648 | 9366 |
| **1937** | 11565 | 12365 | 23930 | **1971** | 22063 | 23590 | 45653 | | | | |
| **1938** | 8794 | 9402 | 18196 | **1972** | 24365 | 26051 | 50416 | | | | |

**Table 2.7b. Northeast Atlantic spurdog. Catch from 2005 onwards used in the assessment, with the allocation to "Trawls & other" and "Nets & hooks". Estimated selectivity for "Trawls & other" is based on fits to proportions by length category data for available Scottish, Swedish and Irish bottom trawl data for the period 2007-present, and estimated selectivity for "Nets & hooks" is based on fits to proportions by length category data for available England and Wales gillnets and trammel nets data for the period 2007-present (although in this case, the year 2021 is omitted due to the lack of sufficient samples for that year). The allocation to "Trawls & other" and "Nets & hooks" shown below is based on assigning gears to these two broad categories for all landings and discards data. Note that infilling was required for the years 2011, 2013-2015 due to missing discards data for gillnets and trammel nets for England and Wales (average of 2010, 2012, 2016-2019 used for the missing years, equating to 2425 t discards added for England and Wales in each of the missing years), but this only affects "Nets & hooks".**

| Year | Trawls & other | Nets & hooks | Total |
|---|---|---|---|
| **2005** | 2890 | 4222 | 7112 |
| **2006** | 2186 | 1832 | 4018 |
| **2007** | 1562 | 1363 | 2925 |
| **2008** | 975 | 862 | 1837 |
| **2009** | 1203 | 861 | 2064 |
| **2010** | 675 | 1734 | 2409 |
| **2011** | 302 | 2722 | 3024 |
| **2012** | 399 | 4805 | 5204 |
| **2013** | 598 | 2672 | 3270 |
| **2014** | 536 | 2759 | 3295 |
| **2015** | 638 | 2635 | 3273 |
| **2016** | 984 | 967 | 1951 |
| **2017** | 726 | 4349 | 5075 |
| **2018** | 699 | 2034 | 2733 |
| **2019** | 795 | 2826 | 3621 |
| **2020** | 746 | 722 | 1468 |
| **2021** | 673 | 505 | 1178 |

**Table 2.8. Northeast Atlantic spurdog. Delta-lognormal GLM-standardised index of abundance (with associated CVs), based on combined indices for Q1, Q3 and Q4.**

| Year | Q1 index | CV | Q3 index | CV | Q4 index | CV |
|---|---|---|---|---|---|---|
| 1985 | 5902 | 0.22 | | | | |
| 1986 | 4124 | 0.21 | | | | |
| 1987 | 3518 | 0.23 | | | | |
| 1988 | 2690 | 0.24 | | | | |
| 1989 | 2704 | 0.25 | | | | |
| 1990 | 5014 | 0.24 | | | | |
| 1991 | 3423 | 0.23 | | | | |
| 1992 | 1045 | 0.29 | 1983 | 0.30 | | |
| 1993 | 1560 | 0.25 | 2092 | 0.30 | | |
| 1994 | 1856 | 0.25 | 434 | 0.38 | | |
| 1995 | 1758 | 0.30 | 340 | 0.48 | | |
| 1996 | 2308 | 0.28 | 765 | 0.43 | | |
| 1997 | 1187 | 0.32 | 3388 | 0.36 | | |
| 1998 | 1123 | 0.31 | 1349 | 0.34 | | |
| 1999 | 1990 | 0.29 | 1042 | 0.35 | | |
| 2000 | 607 | 0.38 | 567 | 0.45 | | |
| 2001 | 1728 | 0.30 | 894 | 0.50 | | |
| 2002 | 1464 | 0.30 | 260 | 0.56 | | |
| 2003 | 943 | 0.30 | 244 | 0.59 | 7151 | 0.13 |
| 2004 | 790 | 0.39 | 385 | 0.49 | 6027 | 0.13 |
| 2005 | 995 | 0.30 | 773 | 0.48 | 6506 | 0.13 |
| 2006 | 1372 | 0.30 | 381 | 0.47 | 6448 | 0.13 |
| 2007 | 1028 | 0.26 | 582 | 0.42 | 5507 | 0.12 |
| 2008 | 948 | 0.32 | 648 | 0.39 | 6230 | 0.13 |
| 2009 | 436 | 0.33 | 1522 | 0.44 | 5137 | 0.15 |
| 2010 | 519 | 0.28 | 861 | 0.38 | 7300 | 0.22 |
| 2011 | 1146 | 0.29 | 1331 | 0.38 | 5850 | 0.15 |
| 2012 | 722 | 0.33 | 885 | 0.38 | 9487 | 0.14 |
| 2013 | 1976 | 0.25 | 594 | 0.40 | 6080 | 0.17 |
| 2014 | 1761 | 0.24 | 782 | 0.42 | 9608 | 0.13 |
| 2015 | 683 | 0.30 | 1819 | 0.31 | 10024 | 0.13 |
| 2016 | 1714 | 0.27 | 1372 | 0.33 | 18939 | 0.12 |
| 2017 | 1969 | 0.23 | 918 | 0.31 | 25587 | 0.13 |
| 2018 | 1610 | 0.26 | 1035 | 0.34 | 17194 | 0.12 |
| 2019 | 1576 | 0.25 | 642 | 0.32 | 24875 | 0.10 |
| 2020 | 2235 | 0.23 | 842 | 0.28 | 30142 | 0.10 |
| 2021 | 2695 | 0.22 | 1324 | 0.29 | 40510 | 0.09 |

**Table 2.9a. Northeast Atlantic spurdog. Scottish survey proportions-by-length category for females (top) and males (bottom) for the Q1 combined index, with the actual sample sizes given in the second column.**

| | $n_{psur,y}$ | 16–31 | 32–54 | 55–69 | 70+ |
|---|---|---|---|---|---|
| *Females* | | | | | |
| 1985 | 244 | 0.0721 | 0.1934 | 0.0930 | 0.0352 |
| 1986 | 212 | 0.0406 | 0.0657 | 0.1546 | 0.1315 |
| 1987 | 101 | 0.0304 | 0.0761 | 0.1167 | 0.0439 |
| 1988 | 1894 | 0.0012 | 0.5886 | 0.0032 | 0.0010 |
| 1989 | 351 | 0.0466 | 0.3616 | 0.0150 | 0.0451 |
| 1990 | 516 | 0.0278 | 0.2170 | 0.1250 | 0.0176 |
| 1991 | 963 | 0.0992 | 0.2044 | 0.0495 | 0.0103 |
| 1992 | 119 | 0.1233 | 0.2651 | 0.0437 | 0.0271 |
| 1993 | 84 | 0.0923 | 0.2935 | 0.0730 | 0.0430 |
| 1994 | 1606 | 0.0287 | 0.3199 | 0.0215 | 0.0093 |
| 1995 | 2210 | 0.2164 | 0.2731 | 0.0041 | 0.0032 |
| 1996 | 174 | 0.0718 | 0.2656 | 0.0635 | 0.0263 |
| 1997 | 16 | 0.1013 | 0.2025 | 0.1013 | 0.0253 |
| 1998 | 216 | 0.0662 | 0.3080 | 0.0728 | 0.0372 |
| 1999 | 134 | 0.0894 | 0.2336 | 0.0547 | 0.0615 |
| 2000 | 33 | 0.0787 | 0.3148 | 0.0197 | 0.0787 |
| 2001 | 43 | 0.0123 | 0.2441 | 0.0862 | 0.0615 |
| 2002 | 54 | 0.0609 | 0.2348 | 0.1304 | 0.1566 |
| 2003 | 189 | 0.0277 | 0.3117 | 0.0554 | 0.0492 |
| 2004 | 24 | 0.0426 | 0.2340 | 0.0851 | 0.0639 |
| 2005 | 39 | 0.1250 | 0.2059 | 0.0882 | 0.0588 |
| 2006 | 39 | 0.0795 | 0.1324 | 0.1192 | 0.1457 |
| 2007 | 71 | 0.1124 | 0.2469 | 0.0787 | 0.1181 |
| 2008 | 135 | 0.1229 | 0.2610 | 0.0330 | 0.0454 |
| 2009 | 163 | 0.0968 | 0.3226 | 0.0183 | 0.0244 |
| 2010 | 3491 | 0.0087 | 0.3560 | 0.1972 | 0.0013 |
| 2011 | 171 | 0.0399 | 0.1835 | 0.0830 | 0.0751 |
| 2012 | 723 | 0.0136 | 0.3334 | 0.0088 | 0.0039 |
| 2013 | 129 | 0.0907 | 0.1782 | 0.1044 | 0.0925 |
| 2014 | 431 | 0.0347 | 0.1385 | 0.1071 | 0.0224 |
| 2015 | 74 | 0.0754 | 0.2439 | 0.0526 | 0.0311 |
| 2016 | 198 | 0.1018 | 0.1925 | 0.0762 | 0.1384 |
| 2017 | 686 | 0.0847 | 0.2982 | 0.0295 | 0.0331 |
| 2018 | 139 | 0.0614 | 0.2714 | 0.1089 | 0.0639 |
| 2019 | 549 | 0.0676 | 0.3174 | 0.0796 | 0.0676 |
| 2020 | 326 | 0.1514 | 0.1456 | 0.0691 | 0.1651 |
| 2021 | 1690 | 0.0335 | 0.0892 | 0.2763 | 0.3838 |

| | $n_{psur,y}$ | 16–31 | 32–54 | 55–69 | 70+ |
|---|---|---|---|---|---|
| *Males* | | | | | |
| 1985 | 1841 | 0.0432 | 0.1324 | 0.1909 | 0.2398 |
| 1986 | 654 | 0.0288 | 0.0957 | 0.3372 | 0.1458 |
| 1987 | 714 | 0.0406 | 0.0457 | 0.1316 | 0.5149 |
| 1988 | 1135 | 0.0010 | 0.3948 | 0.0082 | 0.0021 |
| 1989 | 431 | 0.0489 | 0.3917 | 0.0391 | 0.0520 |
| 1990 | 978 | 0.0427 | 0.1541 | 0.2111 | 0.2048 |
| 1991 | 1445 | 0.0787 | 0.2017 | 0.2168 | 0.1394 |
| 1992 | 127 | 0.1477 | 0.1808 | 0.0407 | 0.1717 |
| 1993 | 71 | 0.0959 | 0.2691 | 0.0344 | 0.0988 |
| 1994 | 2380 | 0.0268 | 0.5444 | 0.0184 | 0.0311 |
| 1995 | 1857 | 0.1588 | 0.3405 | 0.0026 | 0.0013 |
| 1996 | 218 | 0.0657 | 0.3734 | 0.0942 | 0.0394 |
| 1997 | 22 | 0.1899 | 0.1266 | 0.0759 | 0.1772 |
| 1998 | 219 | 0.0355 | 0.3431 | 0.0692 | 0.0680 |
| 1999 | 200 | 0.1401 | 0.2683 | 0.0479 | 0.1045 |
| 2000 | 36 | 0.0393 | 0.2525 | 0.0787 | 0.1377 |
| 2001 | 92 | 0.0246 | 0.1538 | 0.1087 | 0.3087 |
| 2002 | 36 | 0.0783 | 0.1696 | 0.0522 | 0.1174 |
| 2003 | 216 | 0.0216 | 0.3674 | 0.1259 | 0.0411 |
| 2004 | 32 | 0.0426 | 0.2340 | 0.0638 | 0.2341 |
| 2005 | 47 | 0.1250 | 0.1912 | 0.0588 | 0.1470 |
| 2006 | 57 | 0.0132 | 0.2252 | 0.1192 | 0.1655 |
| 2007 | 66 | 0.0675 | 0.1462 | 0.1162 | 0.1141 |
| 2008 | 146 | 0.1460 | 0.2653 | 0.0495 | 0.0770 |
| 2009 | 207 | 0.0897 | 0.3437 | 0.0308 | 0.0737 |
| 2010 | 2487 | 0.0063 | 0.2986 | 0.1150 | 0.0167 |
| 2011 | 309 | 0.0351 | 0.2135 | 0.2451 | 0.1248 |
| 2012 | 945 | 0.0248 | 0.5835 | 0.0128 | 0.0193 |
| 2013 | 196 | 0.1050 | 0.1513 | 0.1032 | 0.1747 |
| 2014 | 1084 | 0.0411 | 0.1774 | 0.3485 | 0.1302 |
| 2015 | 144 | 0.0590 | 0.2493 | 0.1059 | 0.1828 |
| 2016 | 215 | 0.0936 | 0.1813 | 0.1178 | 0.0984 |
| 2017 | 903 | 0.0877 | 0.3520 | 0.0534 | 0.0614 |
| 2018 | 231 | 0.0508 | 0.2128 | 0.1056 | 0.1252 |
| 2019 | 610 | 0.0541 | 0.2369 | 0.1003 | 0.0764 |
| 2020 | 435 | 0.1668 | 0.1148 | 0.0725 | 0.1148 |
| 2021 | 887 | 0.0293 | 0.0897 | 0.0559 | 0.0422 |

**Table 2.9b. Northeast Atlantic spurdog. Scottish survey proportions-by-length category for females (top) and males (bottom) for the Q3 combined index, with the actual sample sizes given in the second column.**

| | $n_{psur,y}$ | 16–31 | 32–54 | 55–69 | 70+ |
|---|---|---|---|---|---|
| *Females* | | | | | |
| 1992 | 32 | 0.00001 | 0.0118 | 0.1118 | 0.4824 |
| 1993 | 13 | 0.0294 | 0.0294 | 0.0882 | 0.3235 |
| 1994 | 15 | 0.0864 | 0.1481 | 0.0494 | 0.1975 |
| … | … | … | … | … | … |
| 2008 | 48 | 0.0685 | 0.2785 | 0.0183 | 0.0182 |
| 2009 | 28 | 0.0276 | 0.0552 | 0.1380 | 0.3671 |
| 2010 | 16 | 0.0303 | 0.2730 | 0.0910 | 0.00002 |
| 2011 | 47 | 0.0658 | 0.1343 | 0.0987 | 0.1534 |
| 2012 | 31 | 0.1177 | 0.0941 | 0.0244 | 0.1359 |
| 2013 | 52 | 0.0688 | 0.0854 | 0.0142 | 0.5124 |
| 2014 | 26 | 0.0046 | 0.0107 | 0.0076 | 0.0137 |
| 2015 | 53 | 0.0765 | 0.1756 | 0.1778 | 0.0810 |
| 2016 | 25 | 0.0882 | 0.1730 | 0.0799 | 0.1531 |
| 2017 | 92 | 0.0915 | 0.2063 | 0.0819 | 0.0546 |
| 2018 | 64 | 0.0210 | 0.0374 | 0.0187 | 0.1560 |
| 2019 | 51 | 0.0539 | 0.3695 | 0.0551 | 0.0368 |
| 2020 | 92 | 0.1072 | 0.2403 | 0.0277 | 0.0920 |
| 2021 | 208 | 0.0265 | 0.0718 | 0.1242 | 0.2376 |
| *Males* | | | | | |
| 1992 | 31 | 0.00001 | 0.0941 | 0.0588 | 0.2411 |
| 1993 | 19 | 0.00001 | 0.0882 | 0.1471 | 0.2941 |
| 1994 | 18 | 0.0494 | 0.2716 | 0.0741 | 0.1235 |
| … | … | … | … | … | … |
| 2008 | 71 | 0.0731 | 0.4201 | 0.0274 | 0.0959 |
| 2009 | 18 | 0.0276 | 0.0819 | 0.0267 | 0.2760 |
| 2010 | 25 | 0.0607 | 0.2118 | 0.1213 | 0.2118 |
| 2011 | 92 | 0.0658 | 0.1316 | 0.0987 | 0.2517 |
| 2012 | 56 | 0.1088 | 0.1314 | 0.1181 | 0.2697 |
| 2013 | 26 | 0.0488 | 0.0569 | 0.0712 | 0.1424 |
| 2014 | 725 | 0.0046 | 0.0122 | 0.0948 | 0.8517 |
| 2015 | 58 | 0.0720 | 0.1708 | 0.1351 | 0.1111 |
| 2016 | 34 | 0.0333 | 0.1065 | 0.0799 | 0.2862 |
| 2017 | 102 | 0.0819 | 0.2245 | 0.0546 | 0.2048 |
| 2018 | 302 | 0.0327 | 0.0491 | 0.0397 | 0.6452 |
| 2019 | 53 | 0.0613 | 0.2769 | 0.0546 | 0.0919 |
| 2020 | 85 | 0.1265 | 0.2543 | 0.0647 | 0.0872 |
| 2021 | 255 | 0.0198 | 0.0743 | 0.1064 | 0.3393 |

**Table 2.9c. Northeast Atlantic spurdog. Scottish survey proportions-by-length category for females (top) and males (bottom) for the Q4 combined index, with the actual sample sizes given in the second column.**

| | $n_{psur,y}$ | 16–31 | 32–54 | 55–69 | 70+ |
|---|---|---|---|---|---|
| *Females* | | | | | |
| 2003 | 266 | 0.0308 | 0.1273 | 0.0958 | 0.3883 |
| 2004 | 139 | 0.0083 | 0.1312 | 0.1240 | 0.2768 |
| 2005 | 611 | 0.0161 | 0.1193 | 0.3550 | 0.1340 |
| 2006 | 227 | 0.0403 | 0.1498 | 0.1032 | 0.3193 |
| 2007 | 213 | 0.0411 | 0.1706 | 0.1018 | 0.2493 |
| 2008 | 1247 | 0.0058 | 0.0273 | 0.0240 | 0.8685 |
| 2009 | 135 | 0.0181 | 0.1726 | 0.1498 | 0.1878 |
| 2010 | 386 | 0.0325 | 0.1685 | 0.0381 | 0.4706 |
| 2011 | 170 | 0.0224 | 0.1020 | 0.0704 | 0.1534 |
| 2012 | 1207 | 0.0234 | 0.0670 | 0.0448 | 0.6601 |
| 2013 | 399 | 0.0183 | 0.1314 | 0.1651 | 0.4121 |
| 2014 | 601 | 0.0622 | 0.2164 | 0.0530 | 0.2263 |
| 2015 | 302 | 0.0673 | 0.1489 | 0.0862 | 0.1924 |
| 2016 | 1469 | 0.0555 | 0.1795 | 0.1270 | 0.1671 |
| 2017 | 1090 | 0.0606 | 0.3157 | 0.0549 | 0.1139 |
| 2018 | 1761 | 0.0375 | 0.3582 | 0.0711 | 0.1058 |
| 2019 | 2319 | 0.0372 | 0.2077 | 0.0828 | 0.2354 |
| 2020 | 1743 | 0.0425 | 0.1890 | 0.1109 | 0.2149 |
| 2021 | 2564 | 0.0670 | 0.2131 | 0.0728 | 0.1841 |
| *Males* | | | | | |
| 2003 | 322 | 0.0668 | 0.1017 | 0.0810 | 0.1083 |
| 2004 | 261 | 0.0083 | 0.1494 | 0.1336 | 0.1686 |
| 2005 | 457 | 0.0221 | 0.0794 | 0.2021 | 0.0719 |
| 2006 | 221 | 0.0229 | 0.1178 | 0.1342 | 0.1125 |
| 2007 | 313 | 0.0178 | 0.1836 | 0.1154 | 0.1206 |
| 2008 | 332 | 0.0036 | 0.0280 | 0.0143 | 0.0285 |
| 2009 | 251 | 0.0331 | 0.1452 | 0.1023 | 0.1910 |
| 2010 | 268 | 0.0118 | 0.1554 | 0.0400 | 0.0830 |
| 2011 | 458 | 0.1189 | 0.1837 | 0.1541 | 0.1950 |
| 2012 | 593 | 0.0102 | 0.0682 | 0.0426 | 0.0838 |
| 2013 | 312 | 0.0133 | 0.0691 | 0.0755 | 0.1152 |
| 2014 | 619 | 0.0511 | 0.2332 | 0.0485 | 0.1092 |
| 2015 | 378 | 0.0416 | 0.1726 | 0.1079 | 0.1831 |
| 2016 | 1713 | 0.0504 | 0.1850 | 0.1172 | 0.1185 |
| 2017 | 1432 | 0.0336 | 0.2637 | 0.0528 | 0.1047 |
| 2018 | 1620 | 0.0218 | 0.2510 | 0.0668 | 0.0879 |
| 2019 | 2112 | 0.0303 | 0.2146 | 0.0701 | 0.1219 |
| 2020 | 1730 | 0.0420 | 0.1825 | 0.1096 | 0.1085 |
| 2021 | 2949 | 0.0683 | 0.1978 | 0.0728 | 0.1240 |

**Table 2.10. Northeast Atlantic spurdog. Commercial proportions-by-length category (males and females combined), for each of the two fleets ("Non-target", "target", "Trawls & other", "Nets & hooks), with raised sample sizes given in the second column, except for "Trawls & other" which gives the combined catch tonnage (landings + discards) associated with Swedish, Scottish and Irish bottom trawl length compositions.**

| | $n_{pcom,j,y}$ | 16–54 | 55–69 | 70–84 | 85+ |
|---|---|---|---|---|---|
| *Non-target (Scottish) commercial proportions* | | | | | |
| 1991 | 6167824 | 0.0186 | 0.4014 | 0.5397 | 0.0404 |
| 1992 | 6104263 | 0.0172 | 0.1844 | 0.7713 | 0.0272 |
| 1993 | 4295057 | 0.0020 | 0.2637 | 0.7106 | 0.0236 |
| 1994 | 3257630 | 0.0301 | 0.3322 | 0.5857 | 0.0520 |
| 1995 | 5710863 | 0.0112 | 0.2700 | 0.6878 | 0.0309 |
| 1996 | 2372069 | 0.0069 | 0.4373 | 0.5416 | 0.0142 |
| 1997 | 3769327 | 0.0091 | 0.3297 | 0.5909 | 0.0702 |
| 1998 | 3021371 | 0.0330 | 0.4059 | 0.5286 | 0.0325 |
| 1999 | 1869109 | 0.0145 | 0.3508 | 0.5792 | 0.0556 |
| 2000 | 1856169 | 0.00001 | 0.1351 | 0.7683 | 0.0967 |
| 2001 | 1580296 | 0.0021 | 0.2426 | 0.7022 | 0.0531 |
| 2002 | 1264383 | 0.0529 | 0.3106 | 0.5180 | 0.1186 |
| 2003 | 1695860 | 0.0011 | 0.2673 | 0.5729 | 0.1587 |
| 2004 | 1688197 | 0.0106 | 0.2292 | 0.6893 | 0.0708 |
| *Target (England & Wales) commercial proportion* | | | | | |
| 1983 | 243794 | 0.0181 | 0.4010 | 0.4778 | 0.1030 |
| 1984 | 147964 | 0.0071 | 0.2940 | 0.4631 | 0.2359 |
| 1985 | 97418 | 0.0015 | 0.1679 | 0.6238 | 0.2068 |
| 1986 | 63890 | 0.0004 | 0.1110 | 0.6410 | 0.2476 |
| 1987 | 116136 | 0.0027 | 0.1729 | 0.5881 | 0.2362 |
| 1988 | 168995 | 0.0085 | 0.0973 | 0.5611 | 0.3332 |
| 1989 | 109139 | 0.0011 | 0.0817 | 0.5416 | 0.3757 |
| 1990 | 39426 | 0.0168 | 0.1349 | 0.5369 | 0.3115 |
| 1991 | 42902 | 0.0013 | 0.1039 | 0.5312 | 0.3637 |
| 1992 | 23024 | 0.0003 | 0.1136 | 0.4847 | 0.4013 |
| 1993 | 15855 | 0.0012 | 0.1741 | 0.4917 | 0.3331 |
| 1994 | 14279 | 0.0026 | 0.2547 | 0.3813 | 0.3614 |
| 1995 | 48515 | 0.0007 | 0.1939 | 0.4676 | 0.3378 |
| 1996 | 16254 | 0.0082 | 0.3258 | 0.4258 | 0.2402 |
| 1997 | 22149 | 0.0032 | 0.1323 | 0.4082 | 0.4563 |
| 1998 | 21026 | 0.0007 | 0.1075 | 0.4682 | 0.4236 |
| 1999 | 9596 | 0.0037 | 0.1521 | 0.5591 | 0.2851 |
| 2000 | 10185 | 0.0001 | 0.0729 | 0.4791 | 0.4480 |
| 2001 | 17404 | 0.0024 | 0.1112 | 0.4735 | 0.4128 |
| *Trawls & other (Swedish, Scottish and Irish bottom trawls) commercial proportion* | | | | | |
| 2007 | 288 | 0.0820 | 0.3020 | 0.4960 | 0.1200 |
| 2008 | 204 | 0.3310 | 0.1652 | 0.3852 | 0.1186 |

| | $n_{pcom,j,y}$ | 16–54 | 55–69 | 70–84 | 85+ |
|---|---|---|---|---|---|
| 2009 | 534 | 0.2118 | 0.1760 | 0.5050 | 0.1074 |
| 2010 | 404 | 0.1884 | 0.2028 | 0.4630 | 0.1456 |
| 2011 | 140 | 0.4566 | 0.2406 | 0.2440 | 0.0588 |
| 2012 | 316 | 0.7264 | 0.0514 | 0.1210 | 0.1010 |
| 2013 | 264 | 0.3764 | 0.3558 | 0.1602 | 0.1076 |
| 2014 | 446 | 0.1554 | 0.3448 | 0.4128 | 0.0870 |
| 2015 | 456 | 0.2336 | 0.3402 | 0.3596 | 0.0668 |
| 2016 | 212 | 0.5084 | 0.2288 | 0.1734 | 0.0892 |
| 2017 | 648 | 0.3818 | 0.2236 | 0.3270 | 0.0676 |
| 2018 | 564 | 0.4158 | 0.1584 | 0.3608 | 0.0650 |
| 2019 | 708 | 0.4262 | 0.2306 | 0.2724 | 0.0708 |
| 2020 | 358 | 0.0948 | 0.3430 | 0.4916 | 0.0706 |
| 2021 | 396 | 0.1658 | 0.4044 | 0.3680 | 0.0618 |
| *Nets & hooks (England & Wales gillnets and trammel nets) commercial proportion* | | | | | |
| 2007 | 187 | 0.00001 | 0.0838 | 0.5411 | 0.3751 |
| 2008 | 232 | 0.0092 | 0.1416 | 0.5585 | 0.2906 |
| 2009 | 2841 | 0.0041 | 0.0201 | 0.8979 | 0.0779 |
| 2010 | 514 | 0.0167 | 0.2994 | 0.5655 | 0.1183 |
| 2011 | 405 | 0.00001 | 0.1191 | 0.6006 | 0.2802 |
| 2012 | 796 | 0.00001 | 0.0148 | 0.8659 | 0.1192 |
| 2013 | 381 | 0.00001 | 0.0223 | 0.5456 | 0.4321 |
| 2014 | 305 | 0.0424 | 0.0214 | 0.2066 | 0.7296 |
| 2015 | 186 | 0.00001 | 0.1716 | 0.5764 | 0.2520 |
| 2016 | 5979 | 0.0011 | 0.0480 | 0.6472 | 0.3037 |
| 2017 | 1224 | 0.0045 | 0.0887 | 0.5272 | 0.3797 |
| 2018 | 2689 | 0.0106 | 0.1307 | 0.4225 | 0.4361 |
| 2019 | 967 | 0.0010 | 0.0468 | 0.5506 | 0.4015 |
| 2020 | 1002 | 0.0010 | 0.0459 | 0.4473 | 0.5058 |

**Table 2.11a. Northeast Atlantic spurdog. Fecundity data for 1921, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 81.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72 | 2 | 77 | 2 | 77 | 3 | 77 | 5 | 82 | 2 | 82 | 4 | 82 | 6 | 87 | 2 | 87 | 3 | 87 | 4 | 92 | 3 | 97 | 2 |
| 72 | 3 | 77 | 2 | 77 | 3 | 77 | 5 | 82 | 2 | 82 | 4 | 82 | 7 | 87 | 2 | 87 | 3 | 87 | 5 | 92 | 3 | 97 | 3 |
| 72 | 3 | 77 | 2 | 77 | 3 | 82 | 1 | 82 | 2 | 82 | 4 | 82 | 7 | 87 | 2 | 87 | 3 | 87 | 6 | 92 | 4 | 97 | 7 |
| 72 | 3 | 77 | 2 | 77 | 3 | 82 | 1 | 82 | 3 | 82 | 5 | 87 | 1 | 87 | 2 | 87 | 3 | 87 | 7 | 92 | 4 | 97 | 11 |
| 72 | 4 | 77 | 2 | 77 | 4 | 82 | 2 | 82 | 3 | 82 | 5 | 87 | 2 | 87 | 2 | 87 | 3 | 87 | 7 | 92 | 5 | | |
| 72 | 4 | 77 | 2 | 77 | 4 | 82 | 2 | 82 | 4 | 82 | 5 | 87 | 2 | 87 | 2 | 87 | 3 | 92 | 3 | 92 | 7 | | |
| 77 | 2 | 77 | 2 | 77 | 4 | 82 | 2 | 82 | 4 | 82 | 6 | 87 | 2 | 87 | 3 | 87 | 3 | 92 | 3 | 92 | 8 | | |

**Table 2.11b. Northeast Atlantic spurdog. Fecundity data for 1960 (Ellis and Keable, 2008), given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 783.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 73 | 3 | 84 | 4 | 86 | 3 | 87 | 7 | 88 | 3 | 89 | 4 | 90 | 1 | 91 | 7 | 93 | 3 | 94 | 5 | 96 | 10 | 101 | 11 |

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 73 | 3 | 84 | 6 | 86 | 3 | 87 | 8 | 88 | 5 | 89 | 4 | 90 | 3 | 91 | 8 | 93 | 4 | 94 | 5 | 96 | 10 | 101 | 7 |
| 75 | 3 | 84 | 6 | 86 | 3 | 87 | 9 | 88 | 5 | 89 | 5 | 90 | 3 | 91 | 8 | 93 | 5 | 94 | 6 | 96 | 7 | 102 | 5 |
| 77 | 3 | 84 | 3 | 86 | 4 | 87 | 2 | 88 | 6 | 89 | 7 | 90 | 5 | 91 | 3 | 93 | 5 | 94 | 6 | 96 | 7 | 102 | 10 |
| 78 | 3 | 84 | 3 | 86 | 4 | 87 | 5 | 88 | 6 | 89 | 8 | 90 | 6 | 91 | 4 | 93 | 5 | 94 | 7 | 96 | 8 | 102 | 3 |
| 79 | 2 | 84 | 4 | 86 | 4 | 87 | 5 | 88 | 6 | 89 | 8 | 90 | 8 | 91 | 4 | 93 | 5 | 94 | 8 | 97 | 4 | 103 | 14 |
| 79 | 3 | 84 | 4 | 86 | 4 | 87 | 5 | 88 | 7 | 89 | 5 | 90 | 5 | 91 | 7 | 93 | 5 | 94 | 8 | 97 | 4 | 103 | 9 |
| 79 | 4 | 84 | 4 | 86 | 5 | 87 | 5 | 88 | 8 | 89 | 6 | 90 | 6 | 91 | 4 | 93 | 6 | 94 | 8 | 97 | 7 | 103 | 15 |
| 79 | 4 | 84 | 5 | 86 | 5 | 87 | 6 | 88 | 6 | 89 | 6 | 90 | 6 | 91 | 5 | 93 | 8 | 94 | 9 | 97 | 2 | 103 | 9 |
| 79 | 3 | 84 | 6 | 86 | 5 | 87 | 5 | 88 | 6 | 89 | 8 | 90 | 7 | 91 | 7 | 93 | 9 | 94 | 9 | 97 | 3 | 103 | 15 |
| 80 | 4 | 84 | 6 | 86 | 5 | 87 | 5 | 88 | 8 | 90 | 1 | 90 | 7 | 91 | 7 | 93 | 5 | 94 | 9 | 97 | 3 | 105 | 11 |
| 80 | 3 | 84 | 4 | 86 | 6 | 87 | 6 | 88 | 9 | 90 | 2 | 90 | 9 | 91 | 8 | 93 | 5 | 94 | 11 | 97 | 3 | 110 | 8 |
| 80 | 4 | 84 | 4 | 86 | 2 | 87 | 7 | 89 | 3 | 90 | 3 | 90 | 10 | 92 | 2 | 93 | 5 | 94 | 3 | 97 | 4 | 117 | 9 |
| 80 | 5 | 84 | 6 | 86 | 3 | 87 | 7 | 89 | 3 | 90 | 3 | 91 | 2 | 92 | 4 | 93 | 6 | 94 | 3 | 97 | 4 | | |
| 80 | 2 | 84 | 6 | 86 | 4 | 87 | 7 | 89 | 4 | 90 | 3 | 91 | 3 | 92 | 5 | 93 | 6 | 94 | 8 | 97 | 4 | | |
| 80 | 3 | 84 | 6 | 86 | 4 | 87 | 8 | 89 | 4 | 90 | 3 | 91 | 4 | 92 | 7 | 93 | 6 | 94 | 9 | 97 | 5 | | |
| 80 | 3 | 84 | 6 | 86 | 5 | 87 | 9 | 89 | 4 | 90 | 5 | 91 | 5 | 92 | 2 | 93 | 8 | 94 | 9 | 97 | 6 | | |
| 80 | 5 | 84 | 3 | 86 | 5 | 88 | 2 | 89 | 6 | 90 | 5 | 91 | 5 | 92 | 2 | 93 | 9 | 94 | 9 | 97 | 6 | | |
| 81 | 1 | 84 | 4 | 86 | 5 | 88 | 2 | 89 | 2 | 90 | 5 | 91 | 6 | 92 | 2 | 93 | 9 | 94 | 11 | 97 | 7 | | |
| 81 | 3 | 84 | 4 | 86 | 5 | 88 | 2 | 89 | 2 | 90 | 6 | 91 | 6 | 92 | 2 | 93 | 4 | 95 | 3 | 97 | 3 | | |
| 81 | 3 | 84 | 4 | 86 | 6 | 88 | 4 | 89 | 3 | 90 | 7 | 91 | 7 | 92 | 2 | 93 | 6 | 95 | 6 | 97 | 5 | | |
| 81 | 3 | 84 | 6 | 86 | 6 | 88 | 4 | 89 | 3 | 90 | 1 | 91 | 2 | 92 | 2 | 93 | 6 | 95 | 6 | 97 | 6 | | |
| 81 | 6 | 84 | 6 | 86 | 7 | 88 | 5 | 89 | 3 | 90 | 2 | 91 | 2 | 92 | 3 | 93 | 6 | 95 | 8 | 97 | 7 | | |
| 81 | 3 | 84 | 6 | 86 | 5 | 88 | 5 | 89 | 3 | 90 | 2 | 91 | 2 | 92 | 3 | 93 | 7 | 95 | 3 | 97 | 4 | | |
| 81 | 3 | 84 | 6 | 86 | 6 | 88 | 5 | 89 | 3 | 90 | 3 | 91 | 2 | 92 | 3 | 93 | 9 | 95 | 4 | 97 | 6 | | |
| 82 | 3 | 85 | 3 | 86 | 7 | 88 | 5 | 89 | 3 | 90 | 3 | 91 | 2 | 92 | 3 | 93 | 9 | 95 | 4 | 97 | 8 | | |
| 82 | 4 | 85 | 3 | 86 | 7 | 88 | 6 | 89 | 4 | 90 | 3 | 91 | 3 | 92 | 3 | 93 | 9 | 95 | 4 | 97 | 9 | | |
| 82 | 4 | 85 | 4 | 86 | 7 | 88 | 1 | 89 | 4 | 90 | 3 | 91 | 3 | 92 | 4 | 93 | 9 | 95 | 5 | 97 | 9 | | |
| 82 | 4 | 85 | 5 | 86 | 8 | 88 | 2 | 89 | 4 | 90 | 4 | 91 | 4 | 92 | 4 | 93 | 9 | 95 | 7 | 97 | 4 | | |
| 82 | 5 | 85 | 5 | 86 | 1 | 88 | 3 | 89 | 4 | 90 | 4 | 91 | 4 | 92 | 5 | 93 | 10 | 95 | 7 | 97 | 6 | | |
| 82 | 6 | 85 | 5 | 86 | 2 | 88 | 3 | 89 | 4 | 90 | 4 | 91 | 4 | 92 | 5 | 93 | 11 | 95 | 7 | 97 | 7 | | |
| 82 | 1 | 85 | 5 | 86 | 2 | 88 | 3 | 89 | 4 | 90 | 4 | 91 | 4 | 92 | 6 | 93 | 1 | 95 | 9 | 97 | 7 | | |
| 82 | 4 | 85 | 5 | 86 | 3 | 88 | 3 | 89 | 4 | 90 | 4 | 91 | 4 | 92 | 6 | 93 | 4 | 95 | 6 | 97 | 9 | | |
| 82 | 4 | 85 | 7 | 86 | 4 | 88 | 3 | 89 | 4 | 90 | 4 | 91 | 4 | 92 | 6 | 93 | 7 | 95 | 9 | 97 | 6 | | |
| 82 | 6 | 85 | 1 | 86 | 5 | 88 | 3 | 89 | 4 | 90 | 5 | 91 | 4 | 92 | 6 | 93 | 4 | 95 | 7 | 97 | 8 | | |
| 82 | 6 | 85 | 3 | 86 | 6 | 88 | 4 | 89 | 4 | 90 | 5 | 91 | 5 | 92 | 7 | 93 | 6 | 95 | 8 | 97 | 9 | | |
| 82 | 5 | 85 | 3 | 86 | 7 | 88 | 4 | 89 | 5 | 90 | 5 | 91 | 5 | 92 | 7 | 93 | 6 | 95 | 10 | 98 | 1 | | |
| 82 | 6 | 85 | 3 | 86 | 7 | 88 | 4 | 89 | 5 | 90 | 5 | 91 | 5 | 92 | 8 | 93 | 6 | 95 | 11 | 98 | 5 | | |
| 82 | 5 | 85 | 4 | 86 | 7 | 88 | 4 | 89 | 5 | 90 | 5 | 91 | 5 | 92 | 9 | 93 | 7 | 95 | 11 | 98 | 6 | | |
| 82 | 6 | 85 | 4 | 86 | 8 | 88 | 5 | 89 | 5 | 90 | 6 | 91 | 6 | 92 | 4 | 93 | 9 | 95 | 11 | 98 | 9 | | |
| 82 | 5 | 85 | 4 | 87 | 2 | 88 | 5 | 89 | 5 | 90 | 6 | 91 | 6 | 92 | 5 | 93 | 9 | 95 | 4 | 98 | 9 | | |
| 83 | 3 | 85 | 5 | 87 | 3 | 88 | 5 | 89 | 5 | 90 | 6 | 91 | 6 | 92 | 6 | 93 | 9 | 95 | 7 | 98 | 8 | | |
| 83 | 2 | 85 | 5 | 87 | 4 | 88 | 5 | 89 | 6 | 90 | 8 | 91 | 6 | 92 | 6 | 93 | 9 | 95 | 8 | 98 | 8 | | |
| 83 | 2 | 85 | 3 | 87 | 5 | 88 | 5 | 89 | 6 | 90 | 9 | 91 | 6 | 92 | 6 | 93 | 10 | 95 | 11 | 98 | 9 | | |
| 83 | 3 | 85 | 4 | 87 | 6 | 88 | 5 | 89 | 6 | 90 | 4 | 91 | 7 | 92 | 7 | 93 | 11 | 95 | 11 | 98 | 12 | | |
| 83 | 4 | 85 | 4 | 87 | 3 | 88 | 5 | 89 | 6 | 90 | 4 | 91 | 7 | 92 | 8 | 94 | 5 | 95 | 11 | 98 | 8 | | |
| 83 | 5 | 85 | 5 | 87 | 4 | 88 | 5 | 89 | 6 | 90 | 4 | 91 | 7 | 92 | 6 | 94 | 6 | 96 | 4 | 98 | 8 | | |
| 83 | 4 | 85 | 5 | 87 | 4 | 88 | 6 | 89 | 6 | 90 | 5 | 91 | 7 | 92 | 6 | 94 | 6 | 96 | 4 | 98 | 9 | | |
| 83 | 4 | 85 | 5 | 87 | 4 | 88 | 6 | 89 | 7 | 90 | 5 | 91 | 4 | 92 | 7 | 94 | 6 | 96 | 9 | 99 | 6 | | |
| 83 | 5 | 85 | 6 | 87 | 5 | 88 | 6 | 89 | 4 | 90 | 5 | 91 | 4 | 92 | 10 | 94 | 7 | 96 | 4 | 99 | 6 | | |
| 83 | 5 | 85 | 6 | 87 | 5 | 88 | 6 | 89 | 4 | 90 | 6 | 91 | 4 | 92 | 3 | 94 | 9 | 96 | 5 | 99 | 8 | | |
| 83 | 5 | 85 | 6 | 87 | 5 | 88 | 6 | 89 | 4 | 90 | 6 | 91 | 4 | 92 | 3 | 94 | 3 | 96 | 5 | 99 | 4 | | |
| 83 | 6 | 85 | 7 | 87 | 7 | 88 | 6 | 89 | 4 | 90 | 6 | 91 | 4 | 92 | 4 | 94 | 3 | 96 | 5 | 99 | 8 | | |
| 83 | 4 | 85 | 4 | 87 | 3 | 88 | 4 | 89 | 4 | 90 | 6 | 91 | 5 | 92 | 5 | 94 | 3 | 96 | 5 | 99 | 15 | | |
| 83 | 4 | 85 | 5 | 87 | 4 | 88 | 5 | 89 | 4 | 90 | 7 | 91 | 6 | 92 | 6 | 94 | 4 | 96 | 6 | 99 | 8 | | |
| 83 | 4 | 85 | 7 | 87 | 5 | 88 | 5 | 89 | 5 | 90 | 7 | 91 | 6 | 92 | 6 | 94 | 4 | 96 | 6 | 100 | 6 | | |
| 83 | 6 | 85 | 8 | 87 | 5 | 88 | 5 | 89 | 5 | 90 | 7 | 91 | 6 | 92 | 7 | 94 | 4 | 96 | 6 | 100 | 9 | | |
| 83 | 4 | 85 | 3 | 87 | 5 | 88 | 6 | 89 | 6 | 90 | 7 | 91 | 6 | 92 | 7 | 94 | 5 | 96 | 6 | 100 | 10 | | |
| 83 | 4 | 85 | 4 | 87 | 6 | 88 | 6 | 89 | 6 | 90 | 9 | 91 | 6 | 92 | 7 | 94 | 5 | 96 | 8 | 100 | 14 | | |
| 83 | 4 | 85 | 5 | 87 | 6 | 88 | 6 | 89 | 6 | 90 | 9 | 91 | 7 | 92 | 10 | 94 | 5 | 96 | 5 | 100 | 7 | | |
| 83 | 6 | 85 | 6 | 87 | 7 | 88 | 5 | 89 | 6 | 90 | 5 | 91 | 7 | 92 | 6 | 94 | 6 | 96 | 5 | 100 | 10 | | |
| 84 | 3 | 85 | 7 | 87 | 7 | 88 | 5 | 89 | 7 | 90 | 6 | 91 | 7 | 93 | 1 | 94 | 6 | 96 | 6 | 100 | 14 | | |
| 84 | 3 | 85 | 4 | 87 | 7 | 88 | 6 | 89 | 3 | 90 | 6 | 91 | 8 | 93 | 4 | 94 | 6 | 96 | 6 | 101 | 4 | | |
| 84 | 3 | 86 | 2 | 87 | 5 | 88 | 6 | 89 | 5 | 90 | 6 | 91 | 8 | 93 | 5 | 94 | 7 | 96 | 8 | 101 | 6 | | |
| 84 | 4 | 86 | 3 | 87 | 5 | 88 | 6 | 89 | 6 | 90 | 7 | 91 | 8 | 93 | 6 | 94 | 7 | 96 | 8 | 101 | 6 | | |

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 84 | 6 | 86 | 3 | 87 | 5 | 88 | 6 | 89 | 6 | 90 | 7 | 91 | 8 | 93 | 7 | 94 | 7 | 96 | 7 | 101 | 10 | | |
| 84 | 3 | 86 | 4 | 87 | 6 | 88 | 7 | 89 | 8 | 90 | 8 | 91 | 4 | 93 | 8 | 94 | 7 | 96 | 7 | 101 | 7 | | |
| 84 | 3 | 86 | 5 | 87 | 6 | 88 | 8 | 89 | 8 | 90 | 9 | 91 | 5 | 93 | 1 | 94 | 7 | 96 | 8 | 101 | 9 | | |
| 84 | 3 | 86 | 2 | 87 | 7 | 88 | 8 | 89 | 3 | 90 | 10 | 91 | 7 | 93 | 2 | 94 | 8 | 96 | 10 | 101 | 11 | | |
| 84 | 4 | 86 | 2 | 87 | 7 | 88 | 9 | 89 | 3 | 90 | 1 | 91 | 7 | 93 | 2 | 94 | 4 | 96 | 10 | 101 | 9 | | |

**Table 2.11c. Northeast Atlantic spurdog. Fecundity data for 1978, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 58.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 74 | 4.9 | 78 | 5.9 | 83 | 6.9 | 86 | 6.1 | 88 | 7.1 | 91 | 6.4 | 93 | 9.6 | 96 | 10.4 | 99 | 9.7 | 101 | 12.6 | 104 | 12.9 | 107 | 13.2 |
| 75 | 5.9 | 79 | 4.1 | 84 | 6.7 | 86 | 7.4 | 89 | 5.2 | 91 | 9.2 | 94 | 9.4 | 97 | 10.3 | 99 | 11 | 102 | 11.5 | 104 | 13.1 | 108 | 12.9 |
| 76 | 5.9 | 80 | 7.9 | 84 | 7.5 | 87 | 5.8 | 89 | 7.1 | 92 | 7.2 | 94 | 9.5 | 97 | 10.7 | 100 | 9.9 | 102 | 12.4 | 105 | 13.2 | 108 | 13.9 |
| 77 | 5.9 | 81 | 6.9 | 85 | 6 | 87 | 7.5 | 90 | 7 | 92 | 10.9 | 95 | 11 | 98 | 10.4 | 100 | 11.7 | 103 | 11.2 | 106 | 12.9 | | |
| 78 | 3.9 | 82 | 6.3 | 85 | 7.4 | 88 | 6.5 | 90 | 8.6 | 93 | 8.6 | 96 | 7.3 | 98 | 10.5 | 101 | 11.5 | 103 | 12.2 | 106 | 14.2 | | |

**Table 2.11d. Northeast Atlantic spurdog. Fecundity data for 1987, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 126.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 71.5 | 5 | 75 | 4 | 76.5 | 5 | 77.5 | 5 | 79 | 4 | 80 | 7 | 82 | 5 | 84 | 9 | 86 | 5 | 88 | 7 | 91.5 | 9 | 101 | 17 |
| 72 | 4 | 95 | 4 | 95 | 8 | 95 | 11 | 79 | 5 | 80 | 9 | 82 | 6 | 84.5 | 5 | 86 | 8 | 88 | 7 | 92 | 6 | 101 | 17 |
| 72 | 5 | 95 | 4 | 95 | 8 | 96 | 4 | 79 | 5 | 80.5 | 5 | 82 | 6 | 84.5 | 8 | 86.5 | 4 | 89 | 7 | 92 | 9 | 101.5 | 12 |
| 72 | 6 | 95 | 5 | 95 | 8 | 96 | 4 | 79 | 6 | 80.5 | 6 | 82 | 7 | 85 | 2 | 86.5 | 7 | 89 | 8 | 92.5 | 6 | 105 | 12 |
| 72.5 | 4 | 95 | 6 | 95 | 9 | 96 | 4 | 79 | 6 | 81 | 4 | 82.5 | 5 | 85 | 4 | 87 | 2 | 89.5 | 6 | 92.5 | 11 | 106 | 14 |
| 72.5 | 6 | 95 | 6 | 95 | 9 | 96 | 5 | 79 | 7 | 81 | 5 | 82.5 | 8 | 85 | 5 | 87.5 | 4 | 89.5 | 7 | 93.5 | 8 | | |
| 73.5 | 4 | 95 | 6 | 95 | 10 | 96 | 5 | 79.5 | 4 | 81 | 6 | 82.5 | 8 | 85 | 10 | 87.5 | 6 | 90 | 4 | 94 | 10 | | |
| 73.5 | 5 | 95 | 7 | 95 | 11 | 96 | 5 | 79.5 | 6 | 81 | 8 | 83 | 5 | 85.5 | 4 | 87.5 | 8 | 90 | 6 | 94.5 | 8 | | |
| 73.5 | 6 | 95 | 7 | 95 | 11 | 96 | 5 | 80 | 3 | 81.5 | 3 | 83 | 7 | 85.5 | 7 | 88 | 5 | 90 | 7 | 94.5 | 10 | | |
| 74 | 4 | 95 | 7 | 95 | 11 | 96 | 5 | 80 | 5 | 81.5 | 6 | 83 | 8 | 85.5 | 8 | 88 | 6 | 91 | 6 | 99.5 | 13 | | |
| 74.5 | 5 | 95 | 7 | 95 | 11 | 96 | 5 | 80 | 6 | 82 | 4 | 83.5 | 7 | 86 | 4 | 88 | 6 | 91 | 8 | 100 | 11 | | |

**Table 2.11e. Northeast Atlantic spurdog. Fecundity data for 1988, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 25.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|
| 77 | 5 | 87 | 4 | 92 | 3 | 95 | 11 | 97 | 10 |
| 82 | 4 | 87 | 5 | 92 | 6 | 95 | 12 | 98 | 4 |
| 86 | 6 | 88 | 5 | 92 | 7 | 96 | 3 | 101 | 12 |
| 87 | 3 | 89 | 2 | 92 | 9 | 96 | 9 | 104 | 7 |
| 87 | 3 | 92 | 1 | 93 | 10 | 97 | 6 | 106 | 9 |

**Table 2.11f. Northeast Atlantic spurdog. Fecundity data for 1997, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 111.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72 | 6 | 79 | 4 | 82 | 4 | 84.5 | 5 | 87 | 5 | 87 | 7 | 92 | 4 | 92 | 7 | 93 | 4 | 97 | 7 | 102 | 5 | 108 | 15 |
| 77 | 1 | 79 | 5 | 82 | 5 | 84.5 | 7 | 87 | 5 | 87 | 7 | 92 | 4 | 92 | 7 | 93 | 7 | 97 | 8 | 102 | 8 | | |
| 77 | 3 | 80 | 4 | 82 | 5 | 86.5 | 5 | 87 | 5 | 87.5 | 6 | 92 | 4 | 92 | 7 | 94.5 | 5 | 97 | 9 | 102 | 8 | | |
| 77 | 3 | 80.5 | 5 | 82 | 5 | 87 | 1 | 87 | 5 | 88 | 5 | 92 | 5 | 92 | 8 | 94.5 | 7 | 97 | 9 | 102 | 9 | | |
| 77 | 4 | 82 | 1 | 82 | 6 | 87 | 2 | 87 | 5 | 89 | 6 | 92 | 5 | 92 | 8 | 95 | 7 | 97 | 9 | 102 | 10 | | |
| 77 | 4 | 82 | 2 | 82 | 6 | 87 | 4 | 87 | 6 | 90 | 5 | 92 | 5 | 92 | 8 | 95 | 8 | 97.5 | 8 | 102 | 10 | | |
| 77 | 4 | 82 | 3 | 82 | 6 | 87 | 4 | 87 | 6 | 90.5 | 9 | 92 | 6 | 92 | 8 | 97 | 4 | 97.5 | 10 | 102 | 13 | | |
| 77 | 5 | 82 | 4 | 82 | 6 | 87 | 5 | 87 | 6 | 91 | 9 | 92 | 6 | 92 | 10 | 97 | 5 | 98 | 9 | 106 | 12 | | |
| 77 | 6 | 82 | 4 | 82 | 9 | 87 | 5 | 87 | 6 | 91.5 | 8 | 92 | 6 | 92 | 11 | 97 | 6 | 100 | 11 | 106.5 | 10 | | |
| 77.5 | 5 | 82 | 4 | 84.5 | 3 | 87 | 5 | 87 | 6 | 92 | 3 | 92 | 7 | 92.5 | 6 | 97 | 7 | 100.5 | 7 | 107 | 8 | | |

**Table 2.11g. Northeast Atlantic spurdog. Fecundity data for 2005 (Ellis and Keable, 2008), given as length of pregnant female (l f) and number of pups (P'). Total number of samples is 179.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 84 | 6 | 92 | 5 | 94 | 11 | 97 | 7 | 98 | 11 | 100 | 7 | 101 | 10 | 102 | 13 | 103 | 14 | 105 | 11 | 107 | 12 | 109 | 15 |
| 87 | 8 | 92 | 8 | 95 | 7 | 97 | 8 | 98 | 12 | 100 | 8 | 101 | 12 | 102 | 13 | 103 | 15 | 105 | 12 | 107 | 12 | 109 | 16 |
| 89 | 3 | 92 | 8 | 95 | 9 | 97 | 8 | 98 | 12 | 100 | 9 | 101 | 13 | 102 | 13 | 103 | 16 | 105 | 13 | 107 | 12 | 109 | 18 |
| 89 | 5 | 92 | 9 | 95 | 10 | 97 | 12 | 98 | 12 | 100 | 9 | 101 | 13 | 102 | 13 | 103 | 16 | 105 | 15 | 107 | 15 | 110 | 10 |
| 89 | 5 | 92 | 9 | 95 | 11 | 97 | 12 | 98 | 12 | 100 | 9 | 101 | 14 | 102 | 15 | 104 | 11 | 105 | 15 | 107 | 16 | 110 | 13 |
| 89 | 6 | 93 | 3 | 96 | 7 | 97 | 12 | 98 | 12 | 100 | 10 | 101 | 14 | 102 | 16 | 104 | 12 | 105 | 15 | 107 | 17 | 110 | 15 |
| 89 | 6 | 93 | 4 | 96 | 7 | 97 | 14 | 98 | 13 | 100 | 11 | 101 | 17 | 102 | 17 | 104 | 13 | 105 | 16 | 108 | 12 | 111 | 19 |
| 89 | 8 | 93 | 5 | 96 | 10 | 97 | 14 | 98 | 13 | 100 | 12 | 102 | 3 | 102 | 17 | 104 | 14 | 105 | 16 | 108 | 13 | 112 | 12 |
| 90 | 4 | 93 | 9 | 96 | 10 | 98 | 5 | 98 | 16 | 100 | 12 | 102 | 5 | 103 | 11 | 104 | 14 | 105 | 17 | 108 | 14 | 112 | 16 |
| 90 | 7 | 93 | 11 | 96 | 11 | 98 | 7 | 99 | 8 | 100 | 12 | 102 | 10 | 103 | 11 | 104 | 14 | 105 | 19 | 108 | 14 | 112 | 17 |
| 90 | 9 | 94 | 5 | 96 | 11 | 98 | 7 | 99 | 10 | 100 | 14 | 102 | 12 | 103 | 11 | 104 | 14 | 106 | 7 | 108 | 16 | 113 | 15 |
| 90 | 9 | 94 | 6 | 97 | 5 | 98 | 7 | 99 | 11 | 101 | 6 | 102 | 12 | 103 | 11 | 104 | 15 | 106 | 14 | 108 | 16 | 113 | 21 |
| 91 | 6 | 94 | 8 | 97 | 6 | 98 | 8 | 99 | 11 | 101 | 9 | 102 | 12 | 103 | 13 | 104 | 17 | 106 | 16 | 109 | 10 | 114 | 14 |
| 91 | 6 | 94 | 9 | 97 | 7 | 98 | 10 | 99 | 11 | 101 | 10 | 102 | 13 | 103 | 14 | 105 | 5 | 106 | 16 | 109 | 13 | 116 | 16 |
| 92 | 3 | 94 | 9 | 97 | 7 | 98 | 10 | 99 | 12 | 101 | 10 | 102 | 13 | 103 | 14 | 105 | 8 | 107 | 11 | 109 | 13 | | |

**Table 2.11h. Northeast Atlantic spurdog. Fecundity data for 2010, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 1.**

| $l^f$ | P' |
|---|---|
| 98 | 10 |

**Table 2.11i. Northeast Atlantic spurdog. Fecundity data for 2014, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 109.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 86 | 3 | 93 | 8 | 98 | 2 | 100 | 4 | 102 | 6 | 103 | 5 | 104 | 4 | 105 | 16 | 107 | 11 | 109 | 12 | 111 | 13 |
| 89 | 7 | 94 | 6 | 98 | 3 | 100 | 6 | 102 | 7 | 103 | 7 | 104 | 10 | 106 | 1 | 107 | 12 | 109 | 12 | 111 | 17 |
| 90 | 7 | 94 | 7 | 98 | 4 | 100 | 7 | 102 | 8 | 103 | 8 | 104 | 11 | 106 | 5 | 107 | 15 | 109 | 14 | 111 | 19 |
| 90 | 7 | 95 | 7 | 98 | 8 | 100 | 11 | 102 | 10 | 103 | 10 | 104 | 14 | 106 | 8 | 107 | 15 | 109 | 17 | 113 | 17 |
| 91 | 2 | 95 | 7 | 98 | 9 | 101 | 6 | 102 | 11 | 103 | 10 | 104 | 15 | 106 | 8 | 108 | 5 | 110 | 4 | 114 | 15 |
| 91 | 4 | 96 | 2 | 98 | 9 | 101 | 8 | 102 | 12 | 103 | 11 | 104 | 16 | 107 | 2 | 108 | 8 | 110 | 12 | 115 | 12 |
| 92 | 3 | 96 | 8 | 98 | 10 | 101 | 9 | 102 | 13 | 103 | 12 | 104 | 17 | 107 | 3 | 108 | 8 | 110 | 13 | 116 | 7 |
| 92 | 5 | 97 | 8 | 99 | 8 | 101 | 11 | 102 | 15 | 103 | 12 | 105 | 8 | 107 | 4 | 108 | 13 | 111 | 1 | 116 | 7 |
| 92 | 6 | 97 | 11 | 99 | 12 | 101 | 14 | 103 | 2 | 103 | 12 | 105 | 12 | 107 | 10 | 109 | 2 | 111 | 7 | 122 | 14 |
| 92 | 6 | 98 | 1 | 99 | 12 | 102 | 3 | 103 | 4 | 103 | 15 | 105 | 14 | 107 | 11 | 109 | 11 | 111 | 10 | | |

**Table 2.11j. Northeast Atlantic spurdog. Fecundity data for 2016, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 92.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 75 | 3 | 79 | 6 | 82 | 6 | 83 | 8 | 87 | 4 | 89 | 3 | 90 | 3 | 93 | 1 | 94 | 6 | 98 | 8 | 102 | 7 | 107 | 13 |
| 76 | 5 | 79 | 7 | 82 | 6 | 84 | 5 | 87 | 6 | 89 | 6 | 91 | 6 | 93 | 2 | 95 | 4 | 99 | 15 | 103 | 7 | 111 | 9 |
| 76 | 6 | 80 | 1 | 82 | 6 | 85 | 8 | 87 | 8 | 89 | 6 | 91 | 9 | 93 | 5 | 95 | 7 | 100 | 12 | 103 | 10 | 112 | 12 |
| 77 | 4 | 81 | 5 | 82 | 6 | 85 | 9 | 88 | 5 | 89 | 6 | 91 | 9 | 93 | 6 | 95 | 12 | 100 | 12 | 103 | 11 | 114 | 19 |
| 78 | 4 | 81 | 5 | 83 | 2 | 86 | 3 | 88 | 5 | 89 | 6 | 92 | 2 | 93 | 6 | 96 | 2 | 101 | 9 | 103 | 13 | | |
| 78 | 4 | 81 | 5 | 83 | 3 | 86 | 6 | 88 | 5 | 89 | 7 | 92 | 4 | 93 | 9 | 96 | 7 | 101 | 10 | 104 | 7 | | |
| 78 | 5 | 81 | 6 | 83 | 5 | 86 | 9 | 88 | 9 | 89 | 8 | 92 | 7 | 94 | 2 | 96 | 8 | 102 | 6 | 104 | 10 | | |
| 78 | 6 | 81 | 7 | 83 | 7 | 87 | 2 | 89 | 3 | 89 | 9 | 92 | 9 | 94 | 3 | 96 | 9 | 102 | 7 | 107 | 11 | | |

**Table 2.11k. Northeast Atlantic spurdog. Fecundity data for 2017, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 297.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72 | 3 | 79 | 4 | 83 | 4 | 85 | 6 | 87 | 4 | 88 | 9 | 91 | 4 | 93 | 6 | 95 | 10 | 97 | 10 | 100 | 8 | 107 | 9 |
| 72 | 4 | 79 | 6 | 83 | 5 | 85 | 6 | 87 | 4 | 89 | 2 | 91 | 5 | 93 | 6 | 95 | 11 | 97 | 10 | 100 | 9 | 107 | 11 |
| 73 | 2 | 80 | 2 | 83 | 6 | 85 | 8 | 87 | 4 | 89 | 5 | 91 | 5 | 93 | 6 | 95 | 11 | 97 | 11 | 100 | 9 | 107 | 12 |
| 73 | 4 | 80 | 5 | 83 | 7 | 85 | 9 | 87 | 5 | 89 | 5 | 91 | 6 | 93 | 7 | 95 | 12 | 97 | 13 | 100 | 11 | 107 | 13 |
| 75 | 3 | 80 | 5 | 84 | 3 | 86 | 3 | 87 | 5 | 89 | 6 | 91 | 6 | 93 | 7 | 95 | 15 | 97 | 13 | 100 | 13 | 108 | 1 |
| 75 | 5 | 80 | 5 | 84 | 3 | 86 | 3 | 87 | 5 | 89 | 6 | 91 | 7 | 93 | 8 | 96 | 3 | 98 | 2 | 101 | 5 | 108 | 7 |
| 75 | 5 | 80 | 5 | 84 | 4 | 86 | 3 | 87 | 6 | 89 | 6 | 91 | 7 | 93 | 9 | 96 | 4 | 98 | 5 | 101 | 7 | 108 | 10 |
| 75 | 7 | 81 | 2 | 84 | 4 | 86 | 3 | 87 | 6 | 89 | 6 | 91 | 7 | 93 | 9 | 96 | 4 | 98 | 5 | 101 | 7 | 108 | 14 |
| 76 | 3 | 81 | 3 | 84 | 4 | 86 | 4 | 87 | 6 | 89 | 6 | 91 | 7 | 93 | 13 | 96 | 6 | 98 | 5 | 101 | 7 | 108 | 14 |
| 76 | 3 | 81 | 4 | 84 | 5 | 86 | 4 | 87 | 7 | 89 | 8 | 91 | 7 | 94 | 6 | 96 | 7 | 98 | 7 | 101 | 10 | 108 | 14 |
| 76 | 4 | 81 | 4 | 84 | 5 | 86 | 5 | 88 | 2 | 89 | 8 | 91 | 7 | 94 | 6 | 96 | 7 | 98 | 8 | 101 | 14 | 108 | 15 |
| 77 | 1 | 81 | 5 | 84 | 5 | 86 | 5 | 88 | 3 | 89 | 8 | 91 | 7 | 94 | 6 | 96 | 7 | 98 | 10 | 102 | 5 | 109 | 6 |
| 77 | 3 | 81 | 7 | 84 | 5 | 86 | 6 | 88 | 4 | 89 | 10 | 91 | 8 | 94 | 6 | 96 | 7 | 98 | 11 | 102 | 7 | 110 | 1 |
| 77 | 3 | 82 | 3 | 84 | 5 | 86 | 6 | 88 | 4 | 90 | 3 | 91 | 8 | 94 | 7 | 96 | 7 | 98 | 14 | 102 | 10 | 110 | 12 |
| 77 | 4 | 82 | 3 | 84 | 6 | 86 | 6 | 88 | 4 | 90 | 5 | 91 | 9 | 94 | 8 | 96 | 9 | 98 | 14 | 102 | 12 | 110 | 13 |
| 77 | 4 | 82 | 5 | 84 | 6 | 86 | 7 | 88 | 5 | 90 | 5 | 92 | 2 | 94 | 8 | 96 | 9 | 99 | 7 | 102 | 13 | 112 | 12 |
| 77 | 5 | 82 | 5 | 84 | 6 | 86 | 7 | 88 | 5 | 90 | 5 | 92 | 3 | 94 | 8 | 96 | 9 | 99 | 8 | 102 | 14 | 112 | 13 |
| 77 | 6 | 82 | 5 | 84 | 6 | 86 | 8 | 88 | 5 | 90 | 6 | 92 | 3 | 94 | 12 | 96 | 10 | 99 | 9 | 103 | 12 | 112 | 15 |
| 78 | 4 | 82 | 5 | 84 | 7 | 87 | 2 | 88 | 6 | 90 | 6 | 92 | 5 | 95 | 4 | 96 | 11 | 99 | 9 | 105 | 12 | 112 | 16 |
| 78 | 5 | 82 | 5 | 84 | 7 | 87 | 3 | 88 | 6 | 90 | 6 | 92 | 6 | 95 | 5 | 97 | 6 | 99 | 10 | 105 | 12 | 113 | 3 |
| 78 | 5 | 83 | 2 | 84 | 7 | 87 | 3 | 88 | 6 | 90 | 6 | 92 | 7 | 95 | 7 | 97 | 6 | 99 | 10 | 105 | 12 | 113 | 19 |
| 79 | 2 | 83 | 3 | 84 | 8 | 87 | 4 | 88 | 6 | 90 | 6 | 92 | 8 | 95 | 8 | 97 | 6 | 99 | 12 | 105 | 13 | 121 | 14 |
| 79 | 3 | 83 | 3 | 85 | 3 | 87 | 4 | 88 | 7 | 90 | 8 | 92 | 8 | 95 | 8 | 97 | 8 | 100 | 7 | 105 | 16 | | |
| 79 | 4 | 83 | 3 | 85 | 4 | 87 | 4 | 88 | 8 | 90 | 9 | 92 | 9 | 95 | 8 | 97 | 8 | 100 | 8 | 106 | 11 | | |
| 79 | 4 | 83 | 4 | 85 | 5 | 87 | 4 | 88 | 9 | 90 | 13 | 92 | 9 | 95 | 10 | 97 | 9 | 100 | 8 | 106 | 14 | | |

**Table 2.11l. Northeast Atlantic spurdog. Fecundity data for 2018, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 43.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 | 4 | 85 | 3 | 89 | 6 | 90 | 6 | 91 | 9 | 93 | 8 | 94 | 10 | 99 | 6 | 101 | 10 |
| 81 | 5 | 85 | 6 | 89 | 7 | 91 | 6 | 92 | 3 | 93 | 8 | 95 | 7 | 99 | 7 | 102 | 10 |
| 82 | 5 | 86 | 5 | 89 | 8 | 91 | 6 | 92 | 7 | 93 | 9 | 96 | 7 | 100 | 7 | 112 | 13 |
| 84 | 2 | 86 | 5 | 90 | 5 | 91 | 7 | 92 | 9 | 94 | 6 | 97 | 11 | 100 | 9 | | |
| 84 | 6 | 87 | 6 | 90 | 6 | 91 | 8 | 93 | 5 | 94 | 9 | 99 | 2 | 100 | 11 | | |

**Table 2.11m. Northeast Atlantic spurdog. Fecundity data for 2019, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 25.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|
| 88 | 5 | 95 | 5 | 98 | 6 | 102 | 15 | 105 | 13 |
| 89 | 9 | 95 | 6 | 100 | 9 | 102 | 15 | 105 | 15 |
| 90 | 8 | 96 | 6 | 101 | 11 | 103 | 13 | 106 | 13 |
| 93 | 10 | 97 | 8 | 101 | 14 | 105 | 12 | 108 | 18 |
| 95 | 2 | 97 | 13 | 102 | 10 | 105 | 12 | 109 | 17 |

**Table 2.11n. Northeast Atlantic spurdog. Fecundity data for 2020, given as length of pregnant female ($l^f$) and number of pups (P'). Total number of samples is 26.**

| $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' | $l^f$ | P' |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 92 | 5 | 99 | 10 | 101 | 12 | 104 | 11 | 106 | 12 | 109 | 11 |
| 95 | 11 | 100 | 10 | 103 | 13 | 104 | 14 | 106 | 15 | | |
| 97 | 9 | 100 | 12 | 104 | 4 | 105 | 13 | 107 | 12 | | |
| 97 | 12 | 101 | 6 | 104 | 7 | 106 | 11 | 107 | 15 | | |
| 99 | 8 | 101 | 11 | 104 | 8 | 106 | 11 | 109 | 8 | | |

**Table 2.12a. Northeast Atlantic spurdog. Estimates of key model parameters, with associated Hessian-based estimates of precision (CV expressed as a percentage) for the baseline assessment, and two sensitivity tests for alternative estimates for $Q_{fec}$.**

| | $Q_{fec}$ = 3.060 Baseline assessment | | $Q_{fec}$ = 2.275 | | $Q_{fec}$ = 3.803 | |
|---|---|---|---|---|---|---|
| $N_0^{f,preg}$ | 71043 | 1.6% | 86609 | 1.3% | 61275 | 1.6% |
| $Q_{fec}$ | 3.060 | 2.0% | 2.275 | 1.6% | 3.803 | 1.7% |
| Q1 $q_{sur}$ | 0.0085 | 13% | 0.0089 | 14% | 0.0091 | 11% |
| Q3 $q_{sur}$ | 0.0067 | 12% | 0.0069 | 14% | 0.0074 | 10% |
| Q4 $q_{sur}$ | 0.0487 | 15% | 0.0498 | 16% | 0.0553 | 12% |
| $B_{depl05}$ | 0.449 | 14% | 0.313 | 15% | 0.514 | 11% |
| $B_{depl55}$ | 0.514 | 13% | 0.381 | 14% | 0.551 | 10% |

**Table 2.12b. Northeast Atlantic spurdog. Estimates of other estimates of interest for the baseline assessment, and two sensitivity tests for alternative estimates for $Q_{fec}$.**

| | $Q_{fec}$ = 3.060 Baseline assessment | $Q_{fec}$ = 2.275 | $Q_{fec}$ = 3.803 |
|---|---|---|---|
| $M_{pup}$ | 0.516 | 0.658 | 0.406 |
| $a_{fec}$ | -6.010 | -7.739 | -4.892 |
| $b_{fec}$ | 0.0969 | 0.1246 | 0.0790 |
| $B_{lim}$ | 240569 | 294960 | 206631 |
| $MSY\ B_{trigger}=B_{pa}$ | 336796 | 412944 | 289284 |
| $B_{MSY}$ | 847325 | 930757 | 797426 |
| $B_0$ | 1202840 | 1474800 | 1033160 |
| $HR_{msy}$ | 0.0430 | 0.0288 | 0.0549 |
| $HR_{pa}$ | 0.0485 | 0.0328 | 0.0617 |
| $HR_{lim}$ | 0.0670 | 0.0456 | 0.0845 |
| $MSY$ | 27677 | 21351 | 31941 |
| $MSYR$ | 0.0327 | 0.0229 | 0.0401 |
| $-\ln L_{tot}$ | 5079 | 5094 | 5071 |

**Table 2.13. Northeast Atlantic spurdog. Baseline assessment. Correlation matrix for some key estimable parameters for the base-case.**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 69 | 70 | 71 | 72 | 73 | 550 | 551 | 552 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | lnNfpreg0 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Sc1 | -0.17 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Sc1 | -0.03 | 0.01 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Sc1 | -0.04 | 0.00 | 0.00 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Sc1 | -0.01 | 0.00 | 0.00 | 0.01 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Sc2 | -0.48 | 0.36 | 0.01 | 0.01 | 0.00 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Sc2 | -0.23 | 0.03 | 0.08 | 0.01 | 0.00 | 0.08 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Sc2 | -0.04 | 0.00 | 0.00 | 0.76 | 0.01 | 0.00 | 0.007 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | Sc2 | -0.04 | 0.00 | 0.00 | 0.04 | 0.08 | 0.00 | 0.01 | 0.04 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Sc3 | -0.58 | 0.39 | 0.02 | 0.01 | 0.00 | 0.86 | 0.10 | 0.01 | 0.00 | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Sc3 | -0.47 | 0.08 | 0.10 | 0.02 | 0.00 | 0.21 | 0.53 | 0.01 | 0.01 | 0.26 | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | Sc3 | -0.04 | 0.01 | 0.00 | 0.78 | 0.01 | 0.02 | 0.01 | 0.77 | 0.03 | 0.02 | 0.02 | 1 | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Sc3 | -0.06 | 0.01 | 0.00 | 0.04 | 0.12 | 0.02 | 0.02 | 0.05 | 0.40 | 0.03 | 0.03 | 0.06 | 1 | | | | | | | | | | | | | | | | | | | | | |
| 14 | Ss1 | 0.09 | -0.02 | 0.00 | 0.01 | 0.00 | -0.06 | -0.04 | 0.00 | 0.00 | -0.06 | -0.06 | -0.01 | -0.02 | 1 | | | | | | | | | | | | | | | | | | | | |
| 15 | Ss1 | 0.02 | -0.01 | 0.00 | 0.01 | 0.00 | -0.02 | -0.01 | 0.00 | 0.00 | -0.02 | -0.01 | -0.01 | -0.02 | 0.02 | 1 | | | | | | | | | | | | | | | | | | | |
| 16 | Ss1 | 0.07 | -0.04 | -0.01 | 0.01 | 0.00 | -0.09 | -0.05 | 0.01 | 0.01 | -0.09 | -0.07 | 0.00 | 0.01 | 0.02 | 0.01 | 1 | | | | | | | | | | | | | | | | | | |
| 17 | Ss2 | 0.08 | -0.03 | -0.01 | 0.02 | 0.01 | -0.07 | -0.04 | 0.01 | 0.01 | -0.07 | -0.06 | -0.01 | -0.01 | 0.66 | 0.02 | 0.03 | 1 | | | | | | | | | | | | | | | | | |
| 18 | Ss2 | 0.01 | -0.01 | 0.00 | 0.03 | 0.01 | -0.02 | -0.01 | 0.00 | 0.00 | -0.02 | -0.02 | -0.01 | -0.03 | 0.02 | 0.23 | 0.01 | 0.03 | 1 | | | | | | | | | | | | | | | | |
| 19 | Ss2 | 0.09 | -0.05 | -0.01 | 0.01 | 0.01 | -0.12 | -0.06 | 0.02 | 0.03 | -0.12 | -0.09 | 0.01 | 0.02 | 0.02 | -0.01 | 0.59 | 0.03 | 0.00 | 1 | | | | | | | | | | | | | | | |
| 20 | Ss3 | 0.02 | -0.02 | 0.00 | 0.01 | 0.00 | -0.05 | -0.03 | 0.02 | 0.02 | -0.05 | -0.04 | 0.00 | 0.00 | 0.59 | 0.01 | 0.02 | 0.76 | 0.01 | 0.03 | 1 | | | | | | | | | | | | | | |
| 21 | Ss3 | 0.00 | -0.01 | 0.00 | 0.02 | 0.01 | -0.02 | -0.01 | 0.01 | 0.01 | -0.02 | -0.01 | -0.01 | -0.02 | 0.01 | 0.20 | 0.00 | 0.02 | 0.28 | 0.01 | 0.01 | 1 | | | | | | | | | | | | | |
| 22 | Ss3 | 0.09 | -0.04 | -0.01 | 0.00 | 0.00 | -0.12 | -0.06 | 0.02 | 0.03 | -0.11 | -0.08 | 0.02 | 0.04 | 0.01 | -0.03 | 0.52 | 0.02 | -0.04 | 0.70 | 0.03 | -0.02 | 1 | | | | | | | | | | | | |
| 23 | Ss4 | 0.08 | -0.01 | 0.00 | -0.01 | 0.00 | -0.04 | -0.02 | -0.02 | -0.01 | -0.04 | -0.03 | -0.02 | -0.02 | 0.43 | 0.00 | 0.01 | 0.54 | 0.00 | 0.01 | 0.48 | 0.00 | 0.01 | 1 | | | | | | | | | | | |
| 24 | Ss4 | 0.04 | -0.01 | 0.00 | -0.01 | 0.00 | -0.02 | -0.01 | -0.01 | -0.01 | -0.02 | -0.02 | -0.01 | -0.02 | 0.01 | 0.18 | 0.00 | 0.01 | 0.27 | 0.01 | 0.00 | 0.24 | 0.01 | 0.01 | 1 | | | | | | | | | | |
| 25 | Ss4 | 0.14 | -0.06 | -0.01 | 0.00 | 0.00 | -0.14 | -0.08 | -0.01 | 0.00 | -0.15 | -0.13 | -0.02 | -0.02 | 0.02 | 0.02 | 0.55 | 0.02 | 0.02 | 0.71 | 0.01 | 0.01 | 0.60 | 0.01 | 0.01 | 1 | | | | | | | | | |
| 26 | Qfec | -0.77 | 0.06 | 0.01 | 0.07 | 0.02 | 0.19 | 0.14 | 0.06 | 0.06 | 0.22 | 0.22 | 0.05 | 0.07 | -0.08 | -0.01 | -0.03 | -0.07 | 0.00 | -0.04 | 0.00 | 0.01 | -0.03 | -0.09 | -0.04 | -0.10 | 1 | | | | | | | | |
| 69 | epsRy | 0.03 | 0.00 | 0.00 | -0.05 | -0.02 | -0.01 | -0.01 | -0.01 | 0.00 | -0.01 | -0.01 | 0.00 | 0.00 | -0.04 | -0.05 | 0.00 | -0.03 | -0.08 | 0.01 | 0.00 | -0.02 | 0.03 | 0.00 | 0.00 | -0.02 | -0.04 | 1 | | | | | | | |
| 70 | epsRy | 0.02 | 0.00 | 0.00 | -0.05 | -0.01 | -0.01 | 0.00 | 0.00 | 0.00 | -0.01 | 0.00 | 0.00 | 0.00 | -0.01 | -0.08 | -0.02 | -0.03 | -0.06 | 0.01 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | -0.01 | -0.03 | -0.06 | 1 | | | | | | |
| 71 | epsRy | 0.01 | 0.00 | 0.00 | -0.04 | -0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.03 | -0.03 | -0.04 | -0.03 | -0.06 | 0.00 | 0.00 | -0.01 | 0.02 | 0.00 | 0.00 | -0.01 | -0.02 | -0.02 | -0.05 | 1 | | | | | |
| 72 | epsRy | 0.01 | 0.00 | 0.00 | -0.04 | -0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.02 | -0.05 | -0.03 | -0.03 | -0.06 | -0.01 | 0.00 | -0.01 | 0.02 | 0.00 | 0.00 | -0.01 | -0.01 | 0.01 | -0.02 | -0.01 | 1 | | | | |
| 73 | epsRy | 0.00 | 0.00 | 0.00 | -0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.07 | -0.09 | -0.05 | -0.01 | -0.02 | 0.00 | 0.00 | -0.01 | 0.02 | 0.00 | 0.00 | -0.01 | 0.00 | 0.02 | 0.02 | 0.03 | 0.03 | 1 | | | |
| 550 | qsur | 0.42 | -0.02 | -0.01 | -0.03 | -0.01 | -0.08 | -0.09 | -0.04 | -0.04 | -0.09 | -0.13 | -0.04 | -0.05 | 0.28 | 0.02 | 0.03 | 0.51 | 0.02 | 0.03 | 0.11 | 0.01 | 0.01 | -0.01 | 0.03 | 0.07 | -0.64 | -0.02 | -0.02 | -0.02 | -0.03 | -0.01 | 1 | | |
| 551 | qsur | 0.40 | 0.01 | 0.00 | -0.06 | -0.02 | 0.00 | -0.06 | -0.06 | -0.05 | -0.01 | -0.07 | -0.04 | -0.04 | 0.05 | -0.15 | 0.00 | 0.03 | -0.26 | 0.00 | -0.02 | -0.31 | 0.00 | 0.07 | -0.49 | 0.05 | -0.70 | 0.04 | 0.02 | 0.02 | 0.01 | 0.00 | 0.60 | 1 | |
| 552 | qsur | 0.54 | -0.04 | -0.01 | -0.06 | -0.02 | -0.13 | -0.13 | -0.08 | -0.07 | -0.16 | -0.19 | -0.06 | -0.09 | 0.08 | 0.02 | 0.11 | 0.06 | 0.02 | 0.11 | -0.01 | 0.01 | -0.01 | 0.09 | 0.04 | 0.44 | -0.78 | 0.00 | 0.00 | -0.01 | -0.01 | -0.02 | 0.65 | 0.71 | 1 |

**Table 2.14. Northeast Atlantic spurdog. Baseline assessment. Summary table of estimates: recruitment (thousands of pups), total biomass (t) and fishing proportion or harvest rate (with selectivity averaged over ages 5–30); and WG estimates of catch (t) used in the assessment. The final recruitment value is taken directly from the estimated stock-recruit relationship.**

| | R (thousand pups) | $B_{tot}$ (t) | Catch (t) | HR (5–30) |
|---|---|---|---|---|
| 1980 | 137718 | 498816 | 40968 | 0.1337 |
| 1981 | 121306 | 483609 | 39962 | 0.1342 |
| 1982 | 113371 | 468454 | 32402 | 0.1140 |
| 1983 | 109089 | 459689 | 37046 | 0.1339 |
| 1984 | 110993 | 445241 | 35194 | 0.1325 |
| 1985 | 101772 | 430989 | 38674 | 0.1482 |
| 1986 | 97316 | 411799 | 30910 | 0.1204 |
| 1987 | 100837 | 399484 | 42356 | 0.1704 |
| 1988 | 73235 | 373256 | 35569 | 0.1514 |
| 1989 | 74039 | 352864 | 30279 | 0.1329 |
| 1990 | 78548 | 337154 | 29906 | 0.1368 |
| 1991 | 91486 | 321947 | 29563 | 0.1401 |
| 1992 | 80651 | 306159 | 29046 | 0.1405 |
| 1993 | 74843 | 290122 | 25637 | 0.1340 |
| 1994 | 60804 | 276352 | 20851 | 0.1160 |
| 1995 | 83700 | 268383 | 21318 | 0.1171 |
| 1996 | 62109 | 258755 | 17295 | 0.0983 |
| 1997 | 66920 | 253052 | 15348 | 0.0890 |
| 1998 | 72474 | 249330 | 13919 | 0.0817 |
| 1999 | 80365 | 247340 | 12385 | 0.0738 |
| 2000 | 87511 | 247396 | 15891 | 0.0946 |
| 2001 | 73961 | 243309 | 16693 | 0.1022 |
| 2002 | 79729 | 238878 | 11170 | 0.0718 |
| 2003 | 79208 | 240236 | 12247 | 0.0779 |
| 2004 | 81926 | 240941 | 9366 | 0.0592 |
| 2005 | 87968 | 245140 | 7112 | 0.0404 |
| 2006 | 73198 | 250868 | 4018 | 0.0215 |
| 2007 | 77087 | 259705 | 2926 | 0.0150 |
| 2008 | 104080 | 271053 | 1837 | 0.0090 |
| 2009 | 136833 | 285741 | 2064 | 0.0094 |
| 2010 | 93159 | 298310 | 2409 | 0.0115 |
| 2011 | 142638 | 313429 | 3024 | 0.0145 |
| 2012 | 127135 | 328007 | 5204 | 0.0240 |
| 2013 | 120104 | 340781 | 3270 | 0.0142 |
| 2014 | 118944 | 356020 | 3295 | 0.0137 |
| 2015 | 186704 | 375667 | 3273 | 0.0131 |
| 2016 | 245802 | 400644 | 1951 | 0.0068 |

| | R (thousand pups) | $B_{tot}$ (t) | Catch (t) | HR (5–30) |
|---|---|---|---|---|
| 2017 | 167090 | 424577 | 5076 | 0.0186 |
| 2018 | 149075 | 445023 | 2733 | 0.0093 |
| 2019 | 144579 | 468062 | 3621 | 0.0118 |
| 2020 | 145486 | 490739 | 1468 | 0.0042 |
| 2021 | 145880 | 515588 | 1178 | 0.0031 |
| 2022 | 153816 | 540266 | | |

**Table 2.15. Northeast Atlantic spurdog. Baseline assessment. Assessment projections under different future catch options. Estimates of begin-year total biomass relative to the total biomass in 2022 are shown, assuming that the catch in 2022 is 1240 tons (status quo HR). Point estimates are given in the upper third of the table with corresponding lower and upper values (reflecting ±2 standard deviations) given in the middle and bottom third of the table. The "+x yrs" in the first column is relative to 2022 (so "+3 yrs" indicates 2025).**

| | Medium-term projections | | | | |
|---|---|---|---|---|---|
| | **HRmsy** | **zero** | **HRsq** | **HRpa** | **HRlim** |
| average catch* | 20296 | 0 | 2242 | 21747 | 25311 |
| **Point estimates** | | | | | |
| + 3 yrs | 1.07 | 1.13 | 1.13 | 1.06 | 1.03 |
| + 5 yrs | 1.09 | 1.22 | 1.21 | 1.07 | 1.01 |
| + 10 yrs | 1.13 | 1.45 | 1.43 | 1.10 | 0.98 |
| + 30 yrs | 1.31 | 2.26 | 2.19 | 1.20 | 0.87 |
| **Point estimates -2 standard deviations** | | | | | |
| + 3 yrs | 1.04 | 1.11 | 1.11 | 1.03 | 1.00 |
| + 5 yrs | 1.05 | 1.18 | 1.17 | 1.03 | 0.97 |
| + 10 yrs | 1.05 | 1.36 | 1.34 | 1.02 | 0.90 |
| + 30 yrs | 1.11 | 1.79 | 1.78 | 1.01 | 0.72 |
| **Point estimates +2 standard deviations** | | | | | |
| + 3 yrs | 1.09 | 1.16 | 1.15 | 1.08 | 1.06 |
| + 5 yrs | 1.13 | 1.26 | 1.25 | 1.11 | 1.06 |
| + 10 yrs | 1.21 | 1.54 | 1.51 | 1.18 | 1.06 |
| + 30 yrs | 1.50 | 2.74 | 2.61 | 1.38 | 1.03 |

*** "average catch" is the average for the projection period 2023–2051**

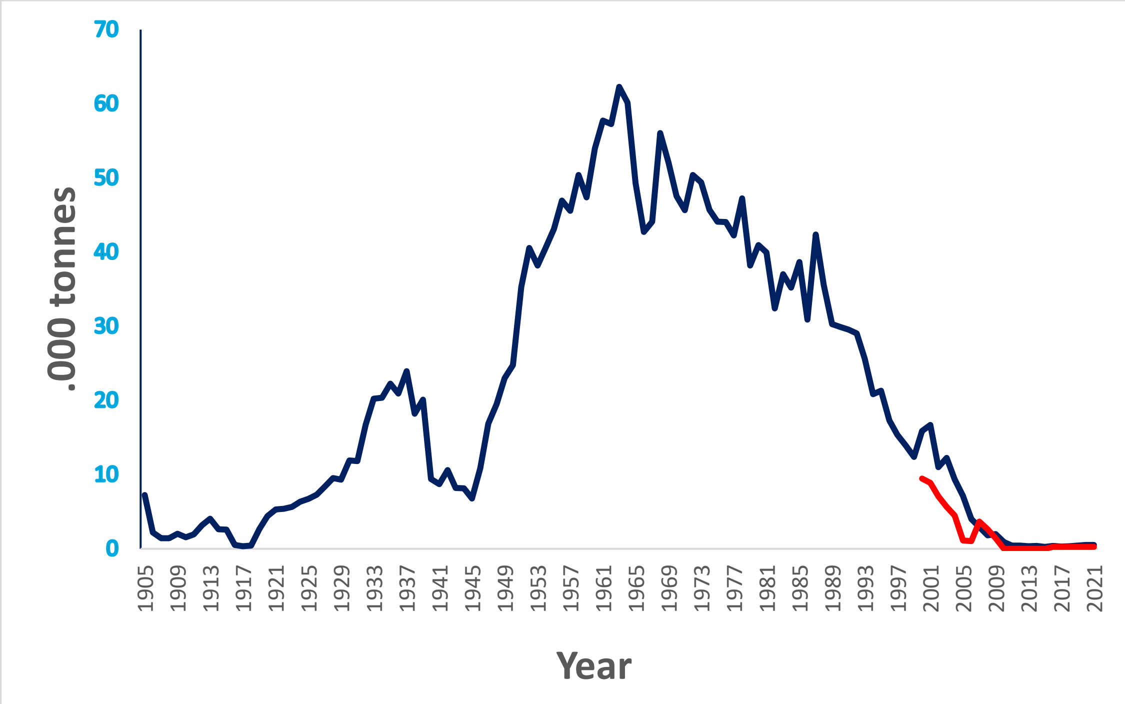



**Figure 2.1. Northeast Atlantic spurdog. WG estimates of total international landings of NE Atlantic spurdog (1903–2021, blue line) and TAC (red line). Restrictive management (e.g. through quotas and other measures) is only thought to have occurred since 2007.**

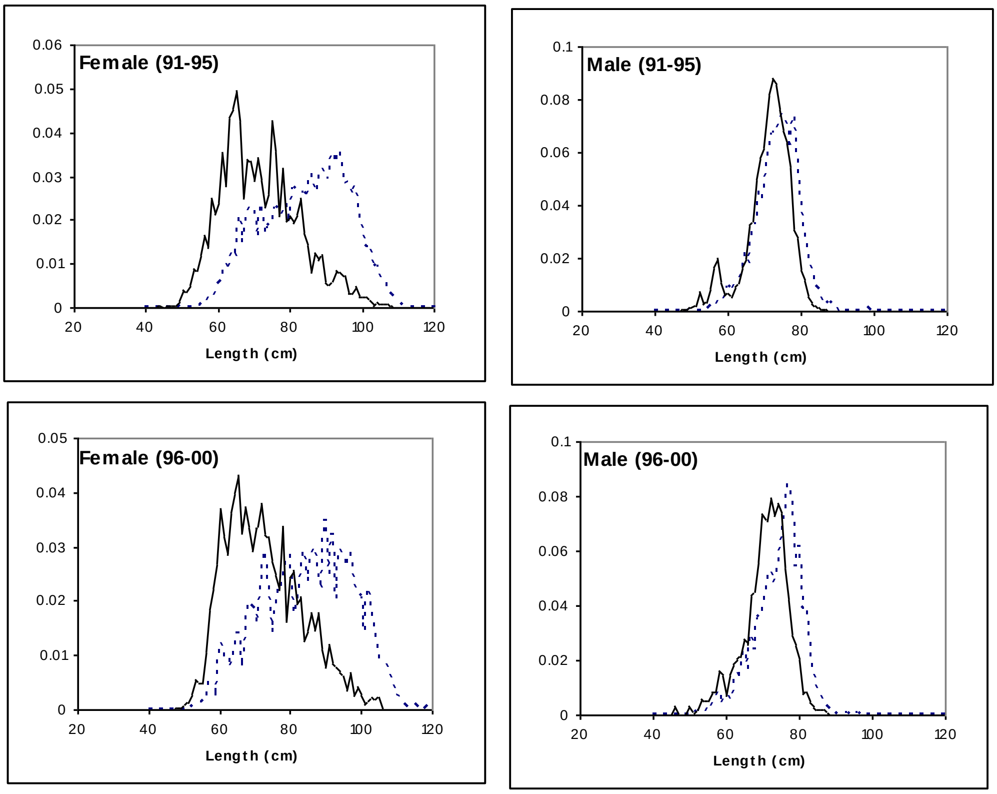



**Figure 2.2a. Northeast Atlantic spurdog. Comparison of length–frequency distributions (proportions) obtained from market sampling of Scottish (solid line) and UK (E&W) (dashed line) landings data. Data are sex-disaggregated, but averaged over five-year intervals.**

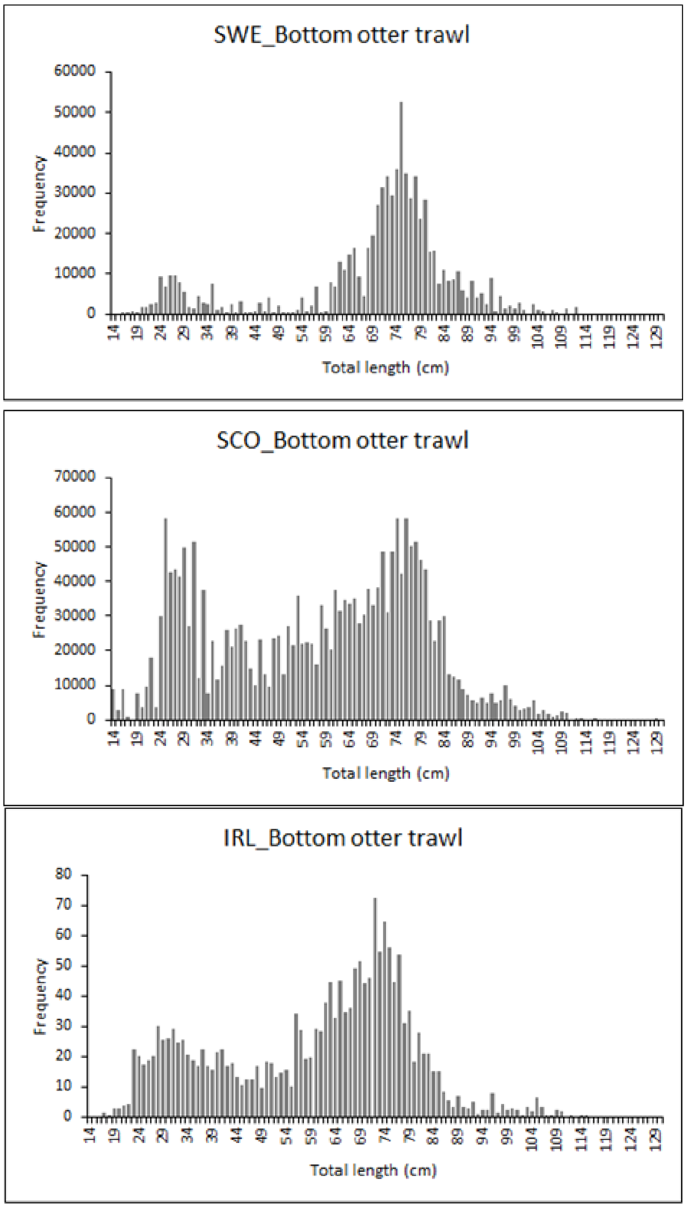



**Figure 2.2b. Northeast Atlantic spurdog. Length frequency information used as a basis for compiling the proportion by length category data for the "trawls & other" gear category.**

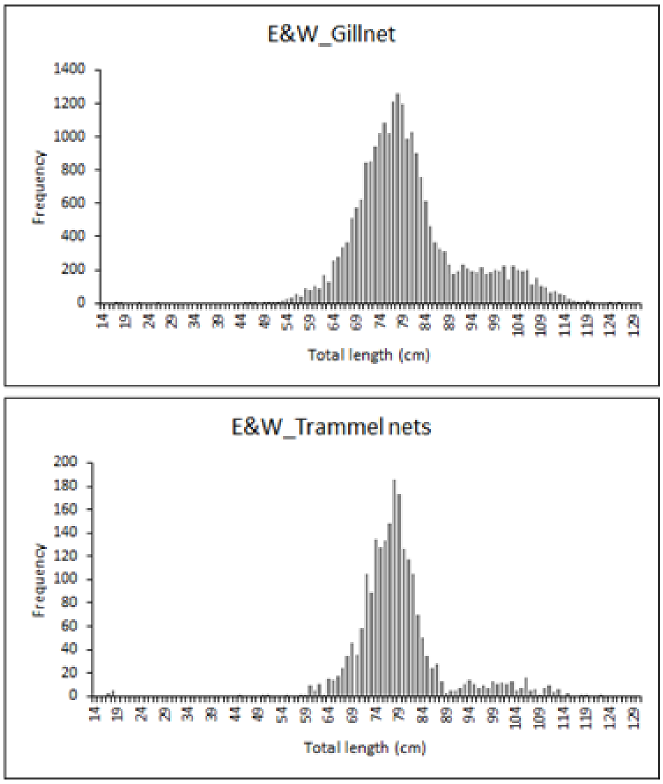



**Figure 2.2c. Northeast Atlantic spurdog. Length frequency information used as a basis for compiling the proportion by length category data for the “nets & hooks” gear category. These data were simply combined with equal weighting.**

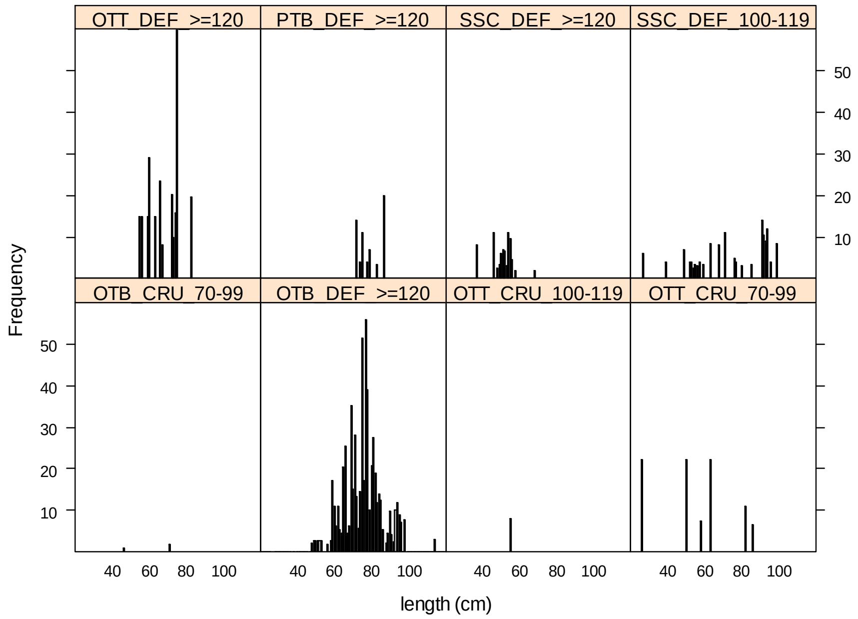



**Figure 2.3. Northeast Atlantic spurdog. Length distributions of spurdog caught on Scottish observer trips in 2010. Data are aggregated across trips for each gear category. Gear codes relate to gear type, target species and mesh size. OTT – Otter trawl twin; PTB – Pair trawl bottom; SSC – Scottish Seine; OTB – Otter trawl bottom; DEF – demersal fish; CRU – crustacean.**

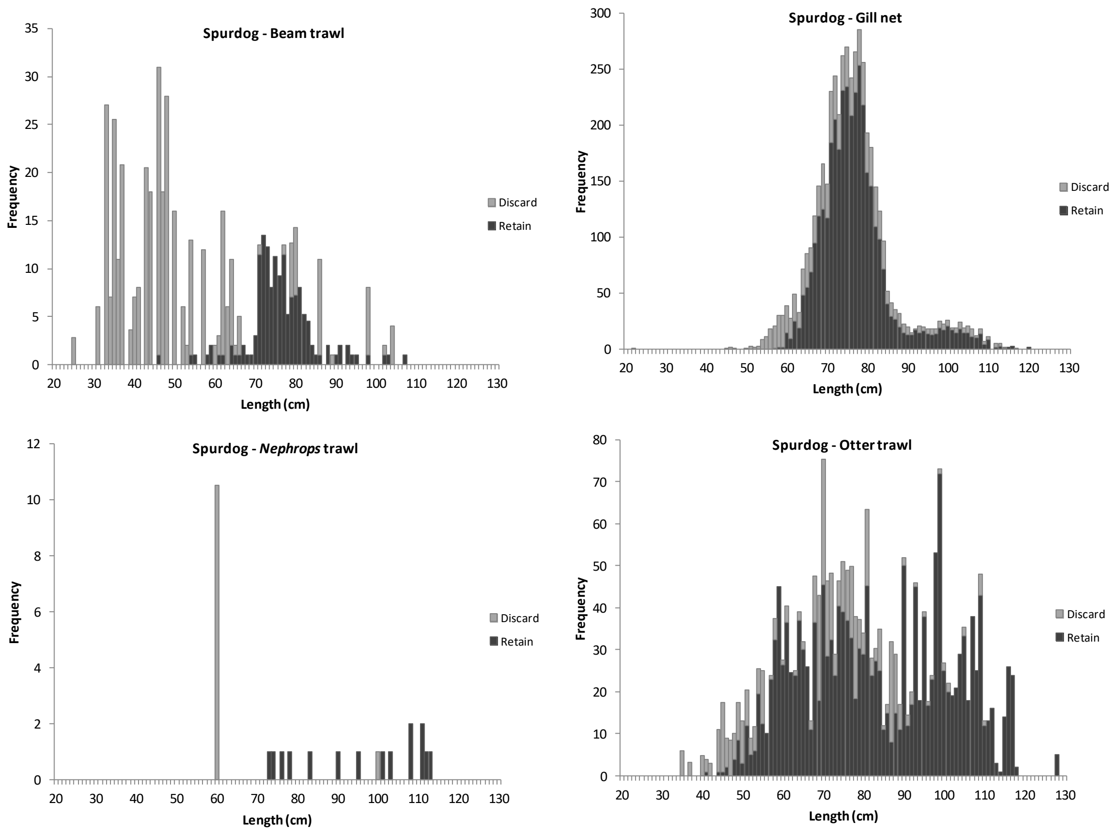



**Figure 2.4. Northeast Atlantic spurdog. Discard-retention patterns of spurdog taken in UK (English) vessels using beam trawl, gillnet, *Nephrops* trawl and otter trawl.**

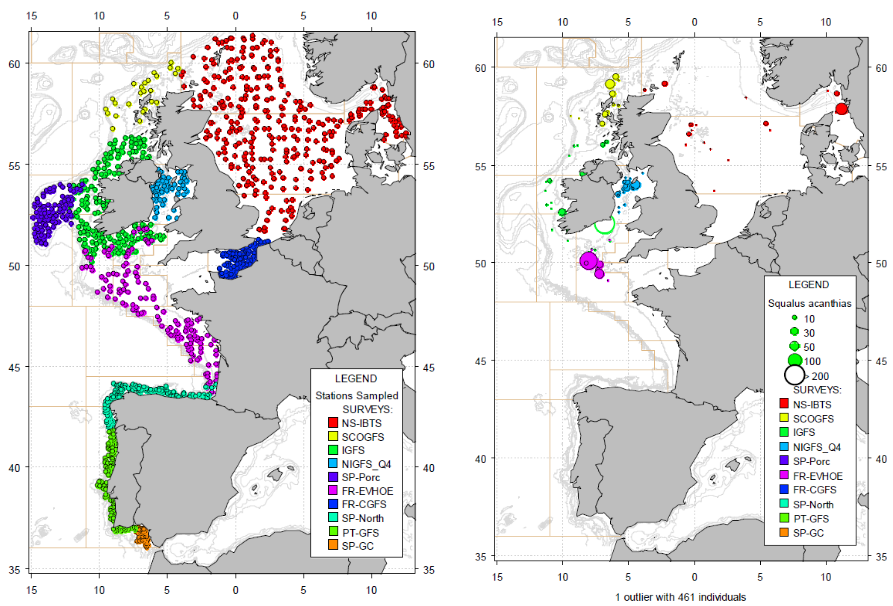



**Figure 2.5. Northeast Atlantic spurdog. Overall spatial coverage of the IBTS (left) all surveys combined and (right) captures of spurdog (number per hour, bottom) as reported in the 2013 summer/autumn IBTS. The catchability of the different gears used in the NE Atlantic surveys is not constant; therefore, the map does not reflect proportional abundance in all the areas but within each survey (From ICES, 2014).**

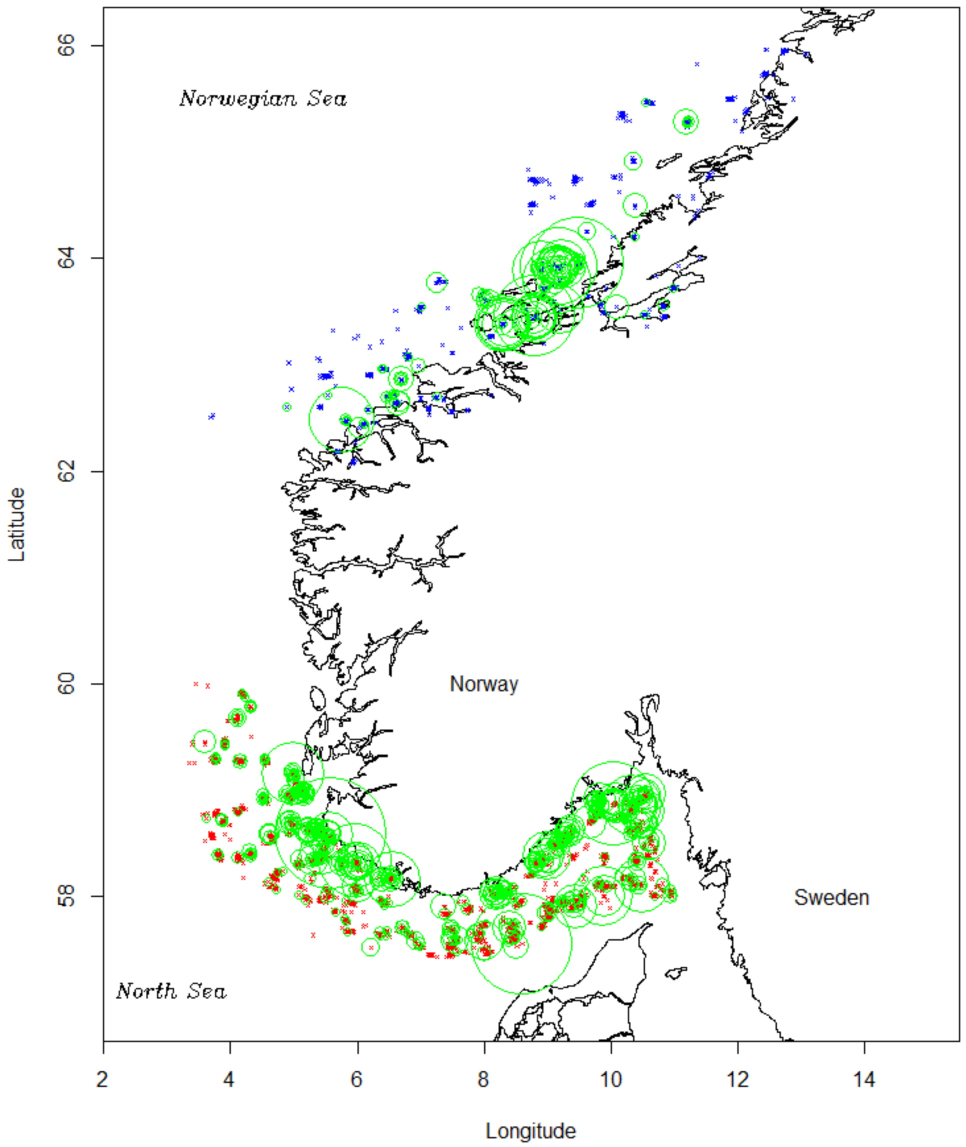



**Figure 2.6. Northeast Atlantic spurdog. Map of survey areas with stations 1996–2017/18 for Coastal survey (blue) and Shrimp survey (red) for area 58–66°North. Green circles indicate catches of spurdog; circle area is proportional to catch in number of individuals. Source: Vollen (2014 WD), plus additional data from 2014 onwards.**

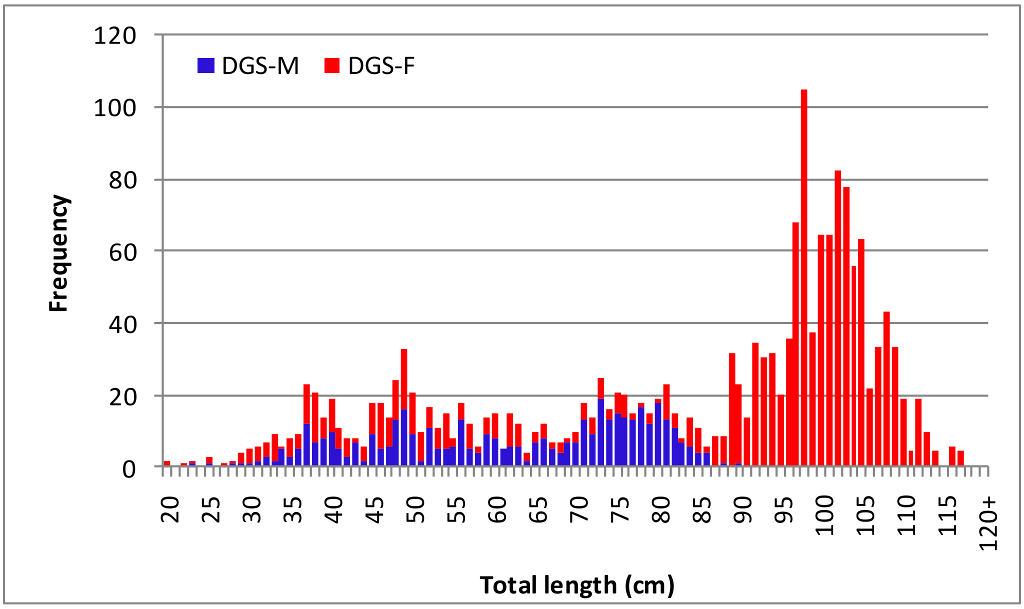



**Figure 2.7a. Northeast Atlantic spurdog. Length distribution of spurdog captured in the UK (England and Wales) westerly IBTS in Q4 (2004–2009, all valid and additional tows). Length distribution highly influenced by a single haul of large females.**

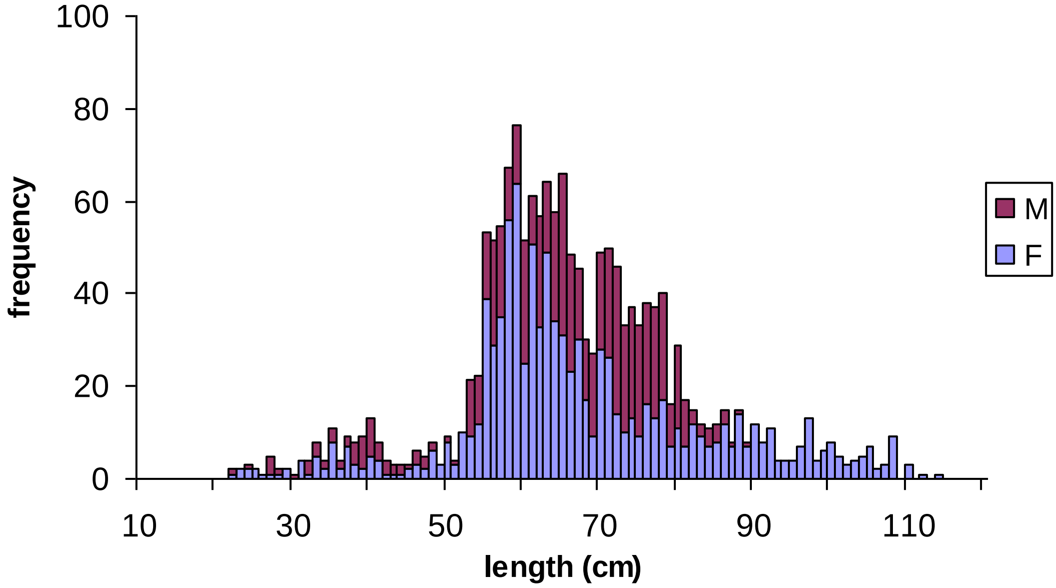



**Figure 2.7b. Northeast Atlantic spurdog. Length distribution of spurdog captured in the Irish Q3 Celtic Seas groundfish survey (2003–2009).**

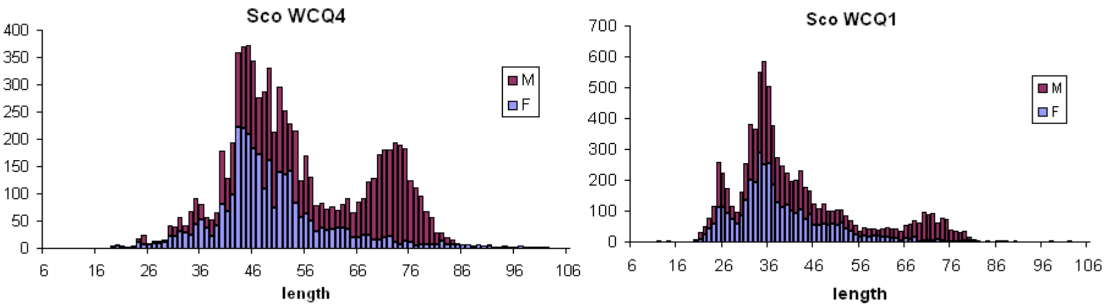



**Figure 2.8. Northeast Atlantic spurdog. Length distribution of spurdog captured in the Scottish Q1 and Q4 groundfish surveys (1990–2010). Length–frequency distributions highly influenced by a small number of hauls containing many small individuals.**

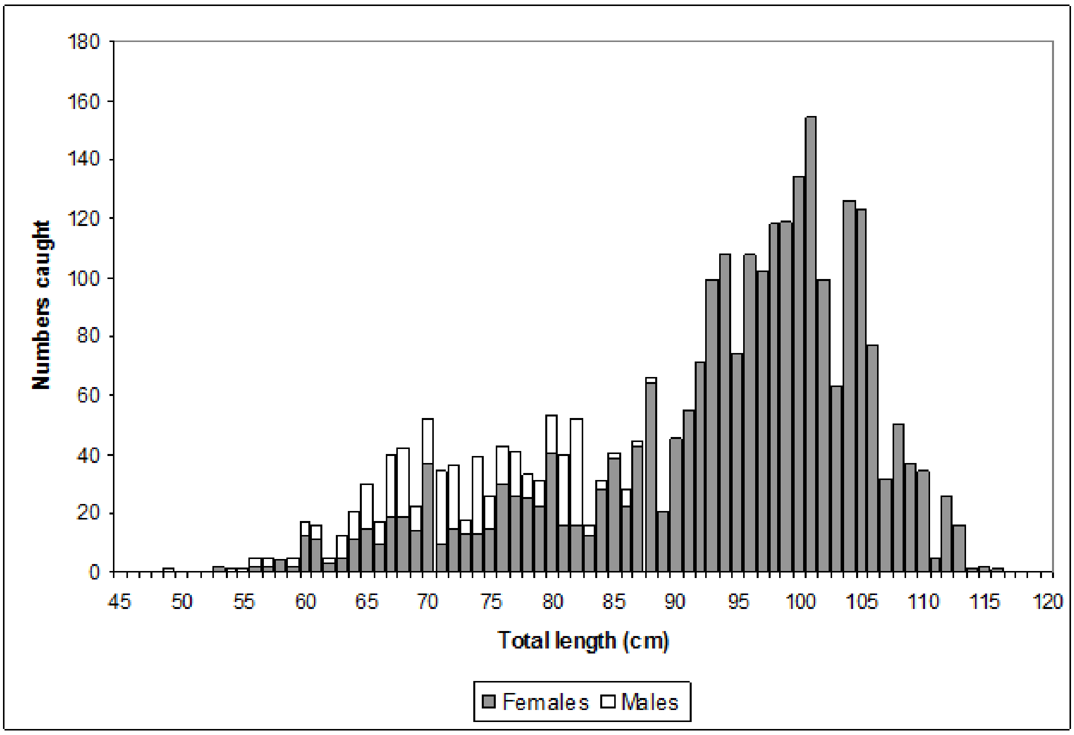



**Figure 2.9. Northeast Atlantic spurdog. Total length–frequency of male and female spurdog taken during the UK(E&W) FSP survey, raised for those catches that were sub-sampled (n = 2517 females and 356 males).**

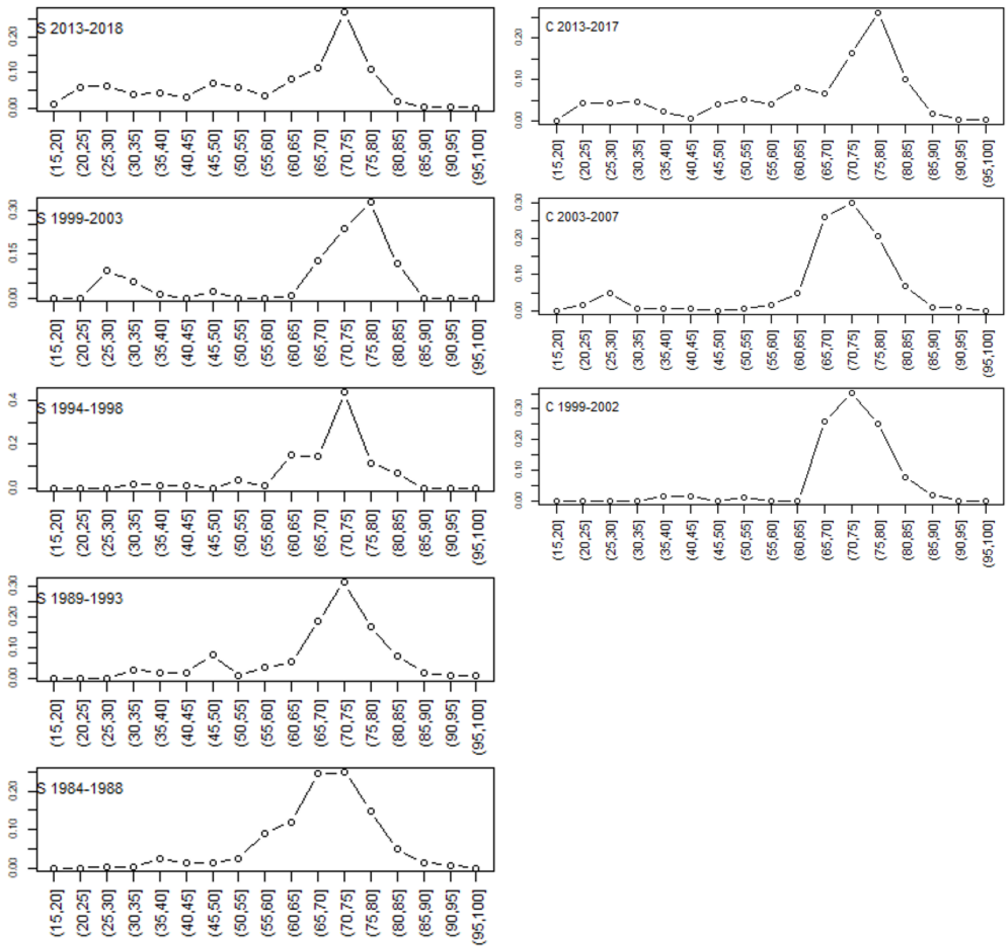



**Figure 2.10. Northeast Atlantic spurdog. Relative length–frequency distributions (5 cm length groups and five-year periods) for the Shrimp survey 1985–2018 (left) and Coastal survey 1999–2017 (right).**

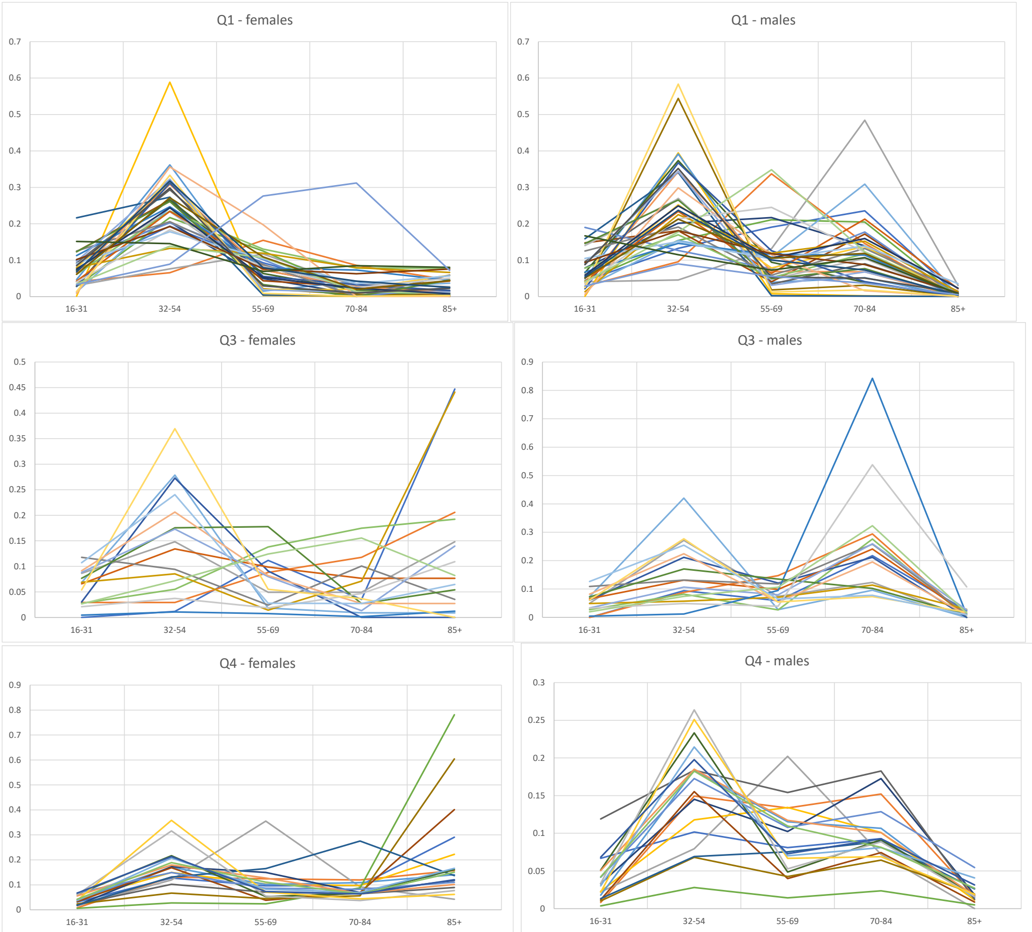



**Figure 2.11. Northeast Atlantic spurdog. Porportions by length-category for three combined survey indices (top row: Q1 1985-2021, middle row: Q2 1992-1994, 2008-2021, and bottom row: Q3 2003-2021) for females (left) and males (right).**

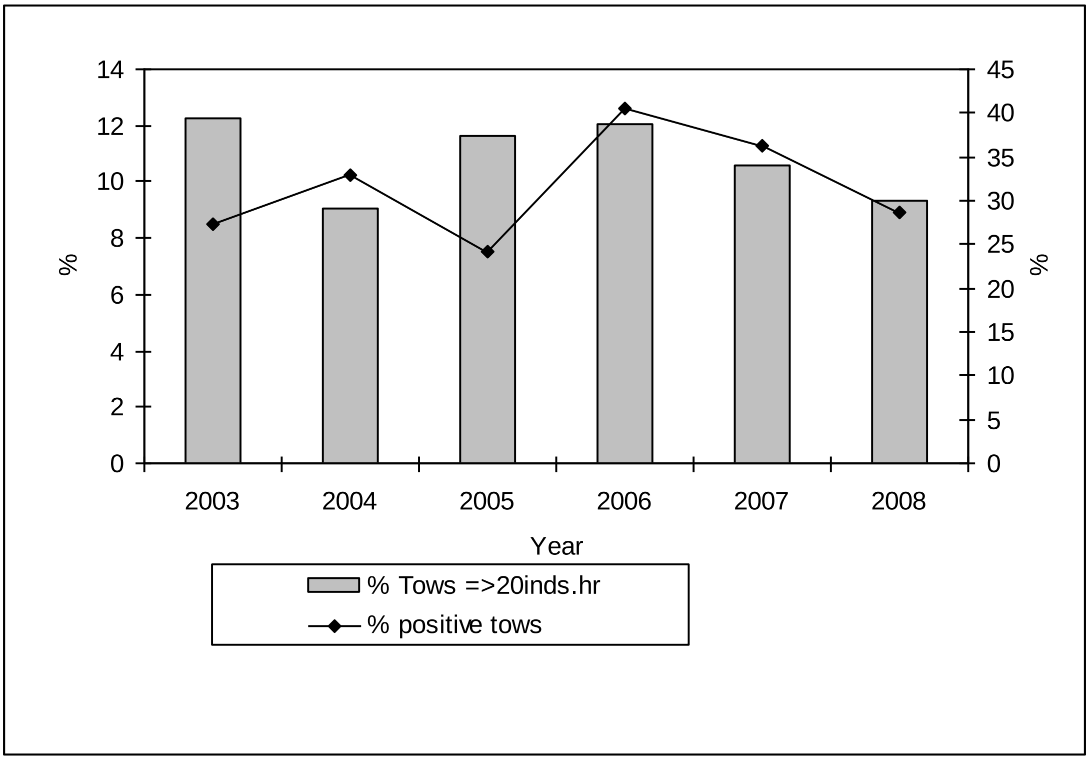



**Figure 2.12. Northeast Atlantic spurdog. Proportion of survey hauls in Irish Q3 groundfish survey 2003–2008, ICES Area 7, in which nominal CPUE was ≥ 20 per one hour tow, and percentage of tows in which spurdog occurred.**

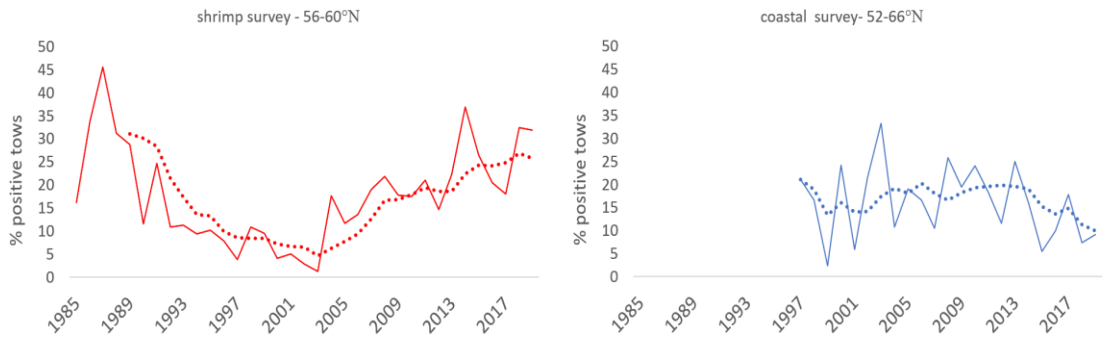



**Figure 2.13. Northeast Atlantic spurdog. Percentage of tows in shrimp (left) and coastal (right) survey in which spurdog occurred by year, with moving average (dotted, 5 yrs).**

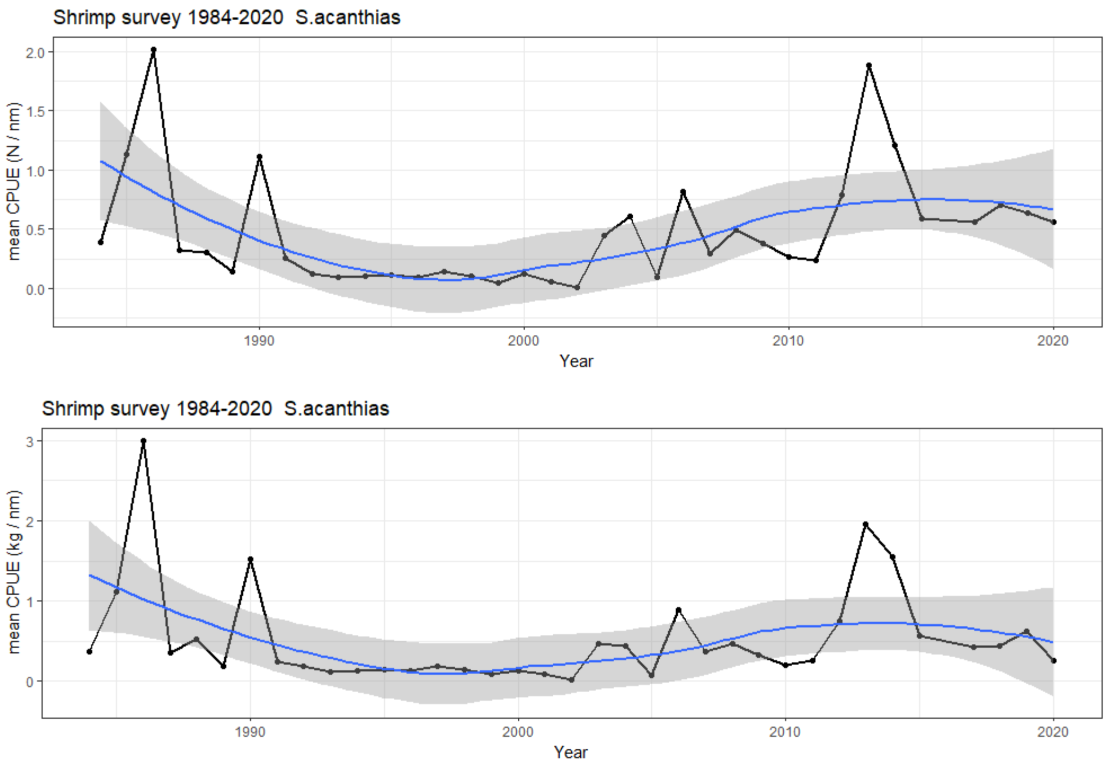



**Figure 2.14. Northeast Atlantic spurdog. Mean CPUE for numbers per nm (top) and biomass per nm (bottom) by year with smooth for shrimp survey 1984–2020 (Junge *et al*. (2020 WD)).**

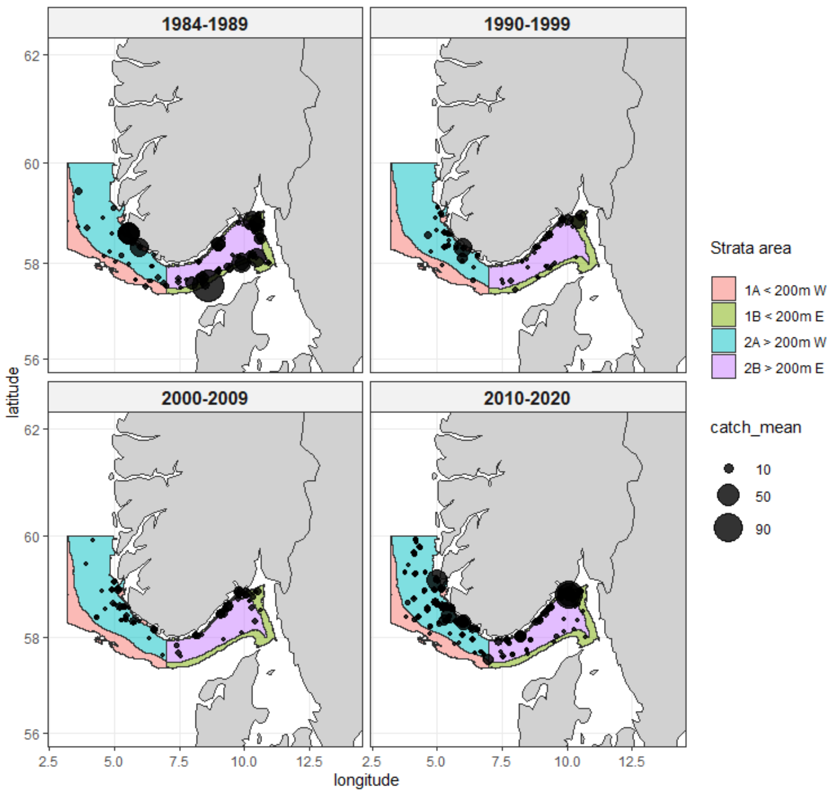
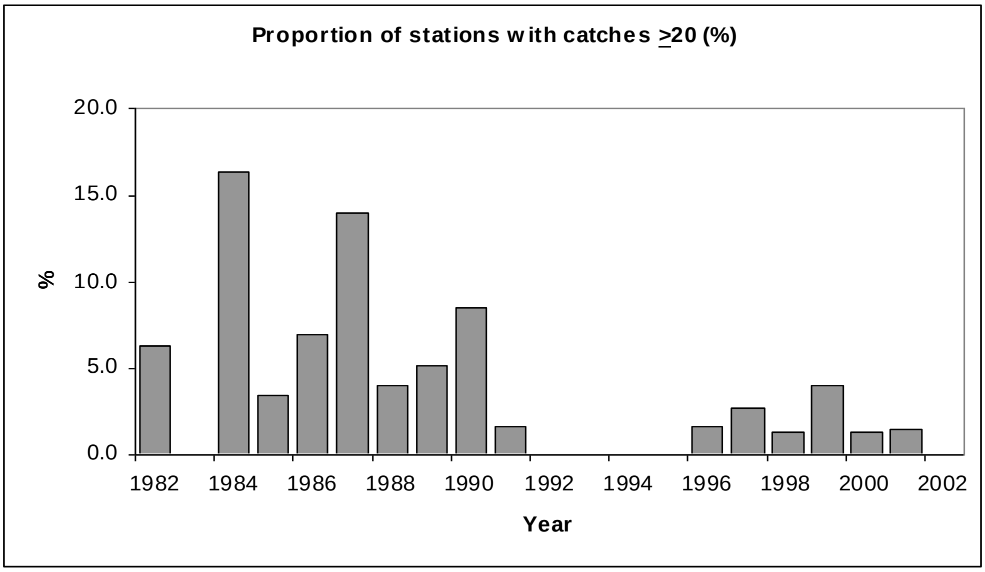



**Figure 2.15. Northeast Atlantic spurdog. Mean catch numbers per strata by decade for shrimp survey 1984–2020 (Junge *et al*. (2020 WD)).**



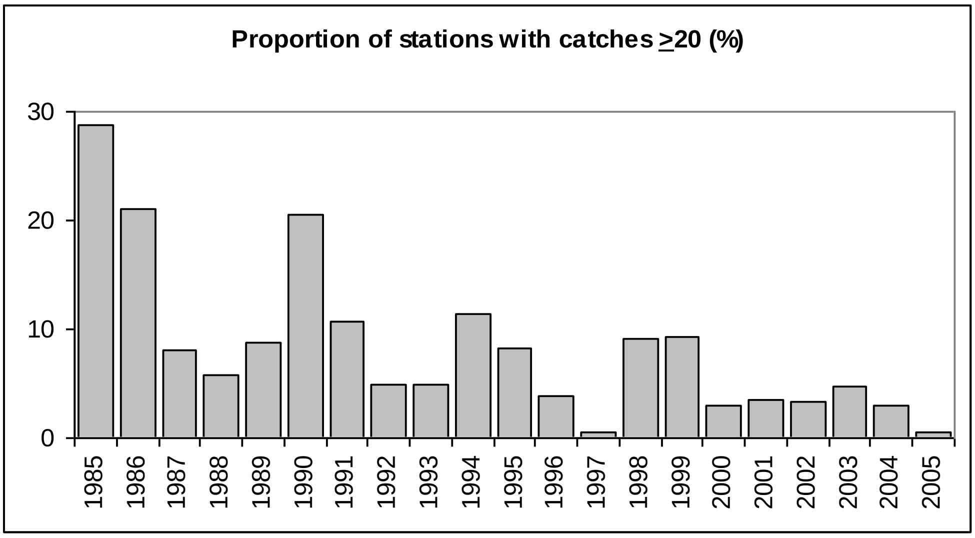
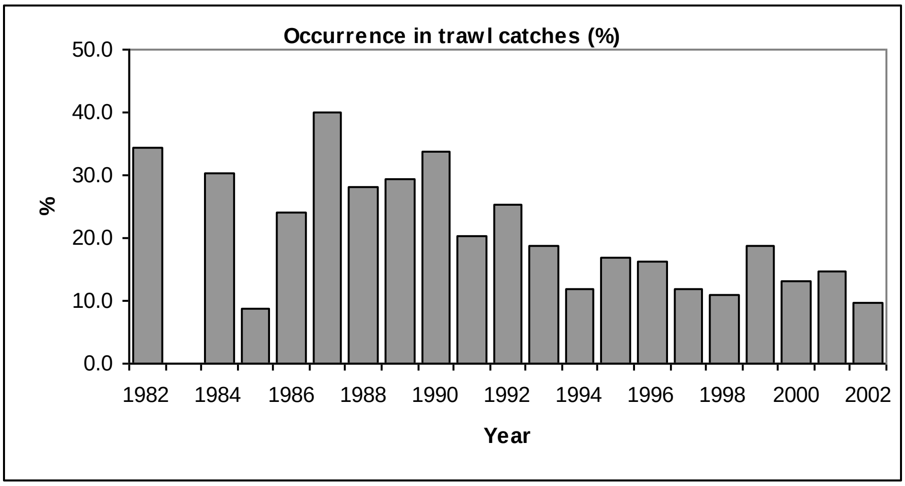




**Figure 2.16. Northeast Atlantic spurdog. Proportion of survey hauls in the English Celtic Sea groundfish survey (1982–2002, top) and Scottish west coast (6.a) survey (Q1, 1985–2005, bottom) in which CPUE was ≥ 20 ind. $h^{-1}$. (Source: ICES, 2006).**

a)




b)

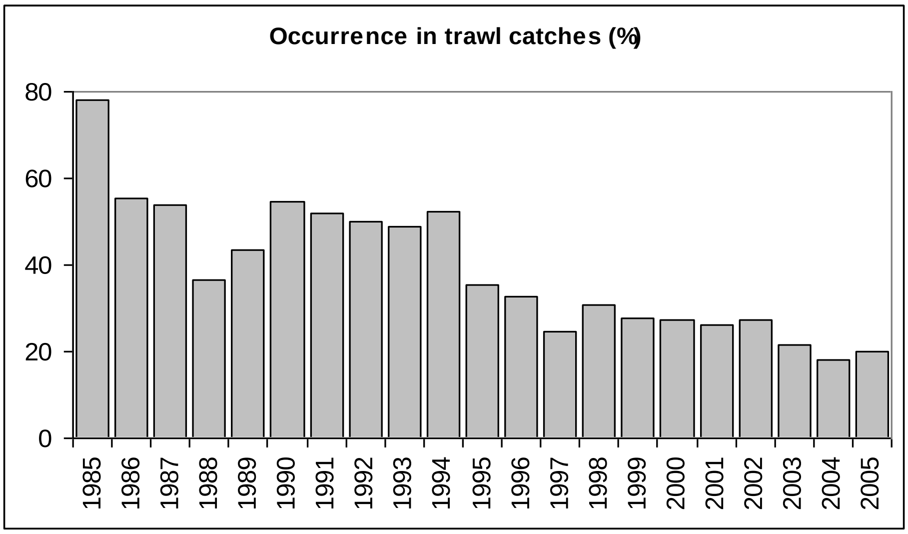



**Figure 2.17. Northeast Atlantic spurdog. Frequency of occurrence in survey hauls in a) the English Q1 Celtic Sea groundfish survey (1982–2002), and b) the Scottish west coast (6.a) survey (Q1, 1985–2005).**

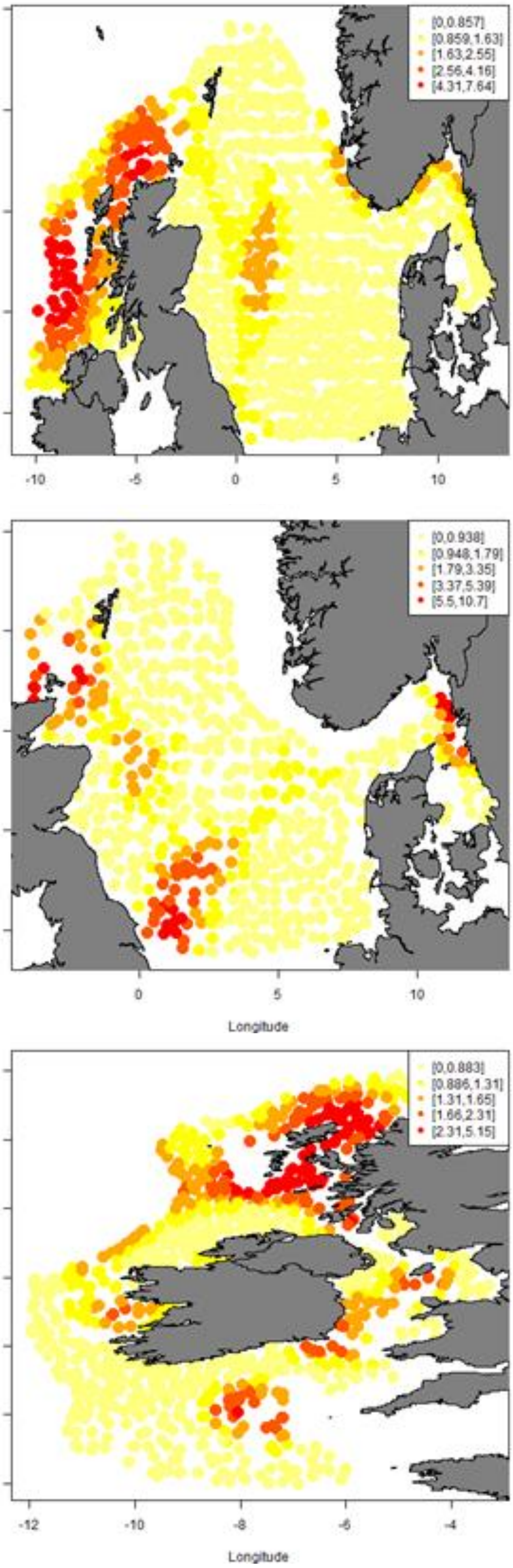



**Figure 2.18. Northeast Atlantic spurdog. Biomass maps (top-Q1, middle-Q3, bottom-Q4), where the biomass is predicted within each grid cell at the haul nearest to the centroid of the cell, using a delta-lognormal modelling approach.**

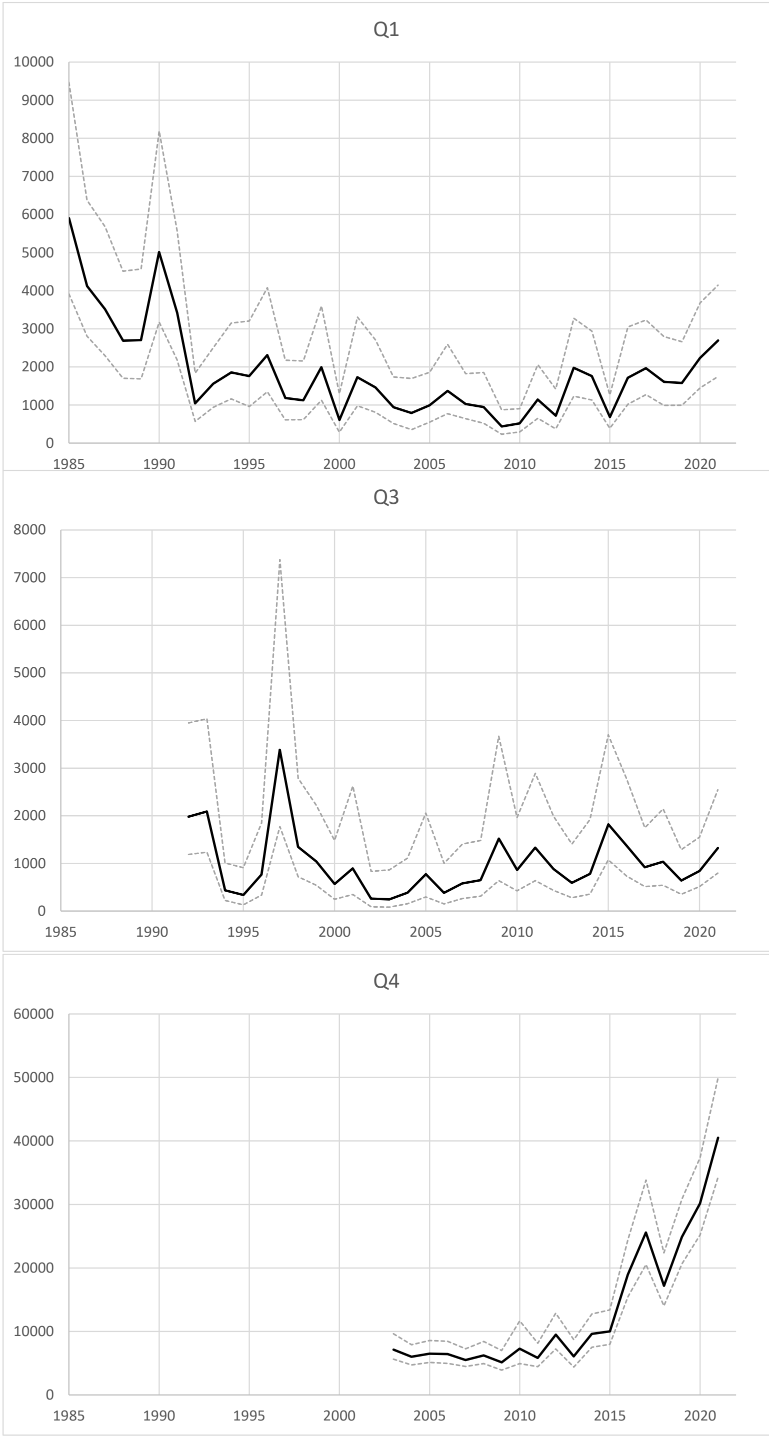



**Figure 2.19. Northeast Atlantic spurdog. Indices of biomass with 95% confidence bounds for the three combined survey indices (top-Q1, middle-Q3, bottom-Q4) estimated using a delta-lognormal modelling approach.**

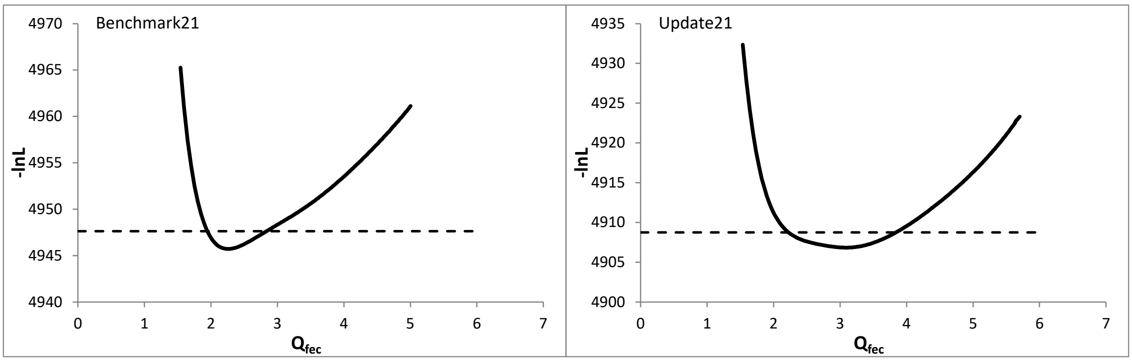



**Figure 2.20. Northeast Atlantic spurdog. Comparison of the likelihood profile on $Q_{fec}$ from the 2021 benchmark (left) and including corrections and updates for input data and infilling of missing discard data (right).**

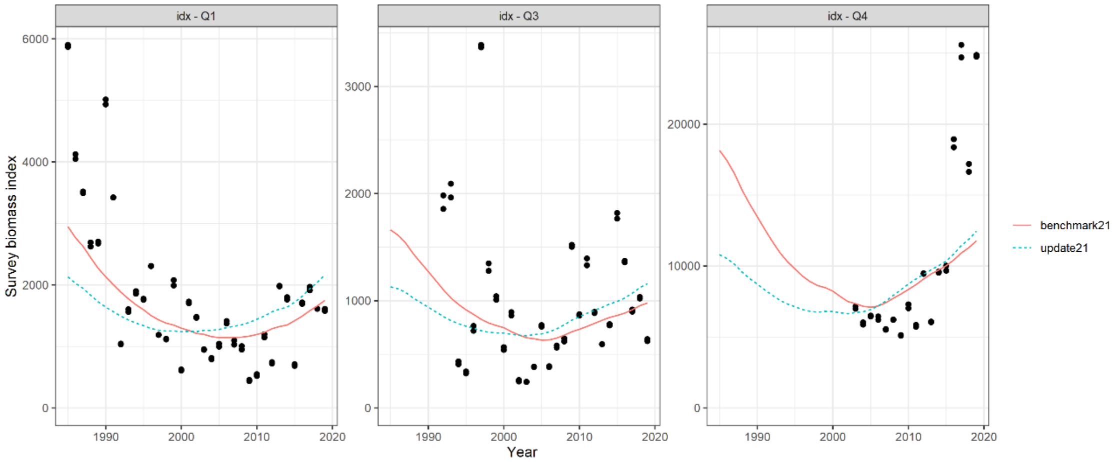
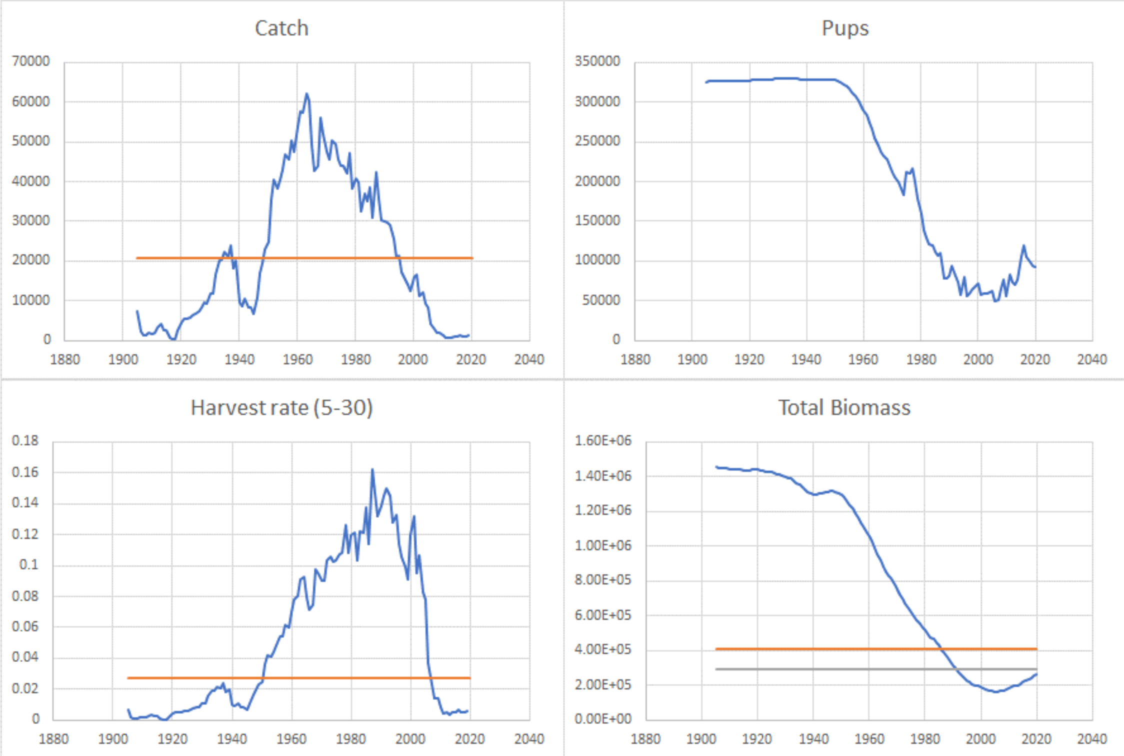



**Figure 2.21. Northeast Atlantic spurdog. Comparison of the fits to the survey indices from the 2021 benchmark (red solid lines) and including corrections and updates for input data and infilling of missing discard data (blue hashed lines).**

**(a) Benchmark21**




**(b) Update21**


**Figure 2.22. Northeast Atlantic spurdog. Comparison of summary plots from (a) the 2021 benchmark and (b) including corrections and updates for input data and infilling of missing discard data. MSY quantities are given (horizontal orange lines) for the Catch and Harvest rate plots, while for Total Biomass, both MSY $B_{trigger}$ (top horizontal orange line, and $B_{lim}$ (bottom horizontal grey line) are shown.**

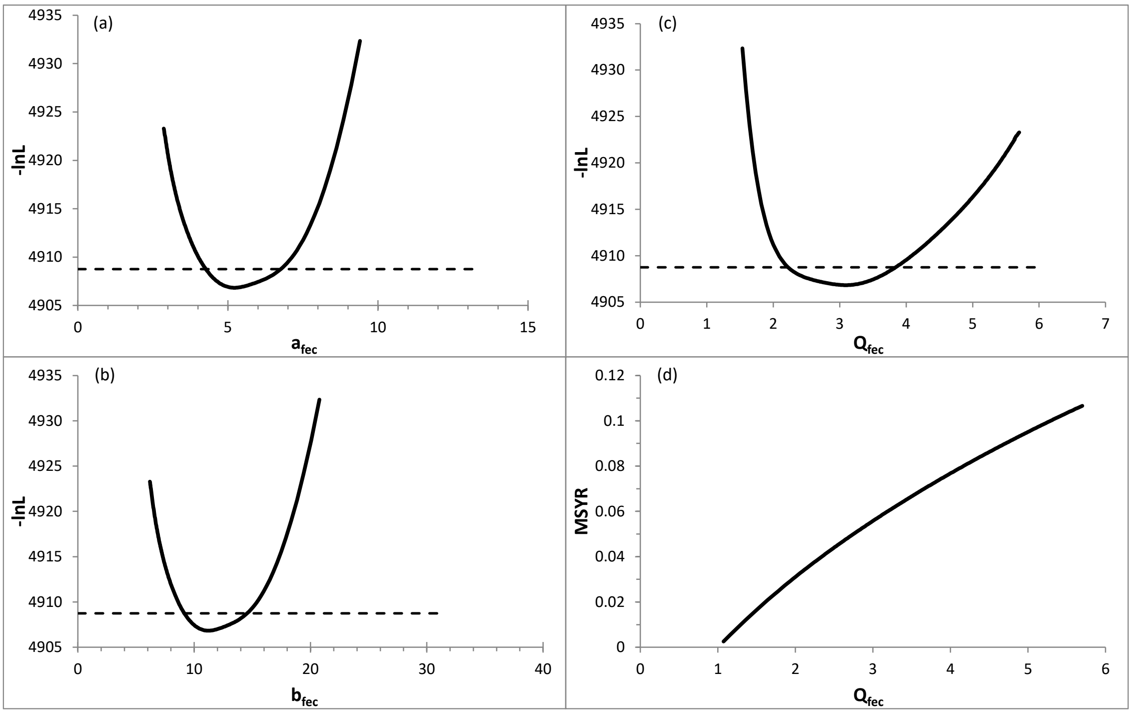



**Figure 2.23. Northeast Atlantic spurdog. "Update21" assessment negative log-likelihood (-ln*L*) for a range of (a) $a_{fec}$ and (b) $b_{fec}$ values, with (c) corresponding $Q_{fec}$. Plot (d) shows MSYR (MSY/$B_{MSY}$) vs. $Q_{fec}$. Using the likelihood ratio criterion, the hashed line in plots (a)–(c) indicate the minimum –ln*L* value + 1.92, corresponding to 95% probability intervals for the corresponding parameters for values below the line. Plot (c) is identical to the plot on the right of Figure 2.20.**

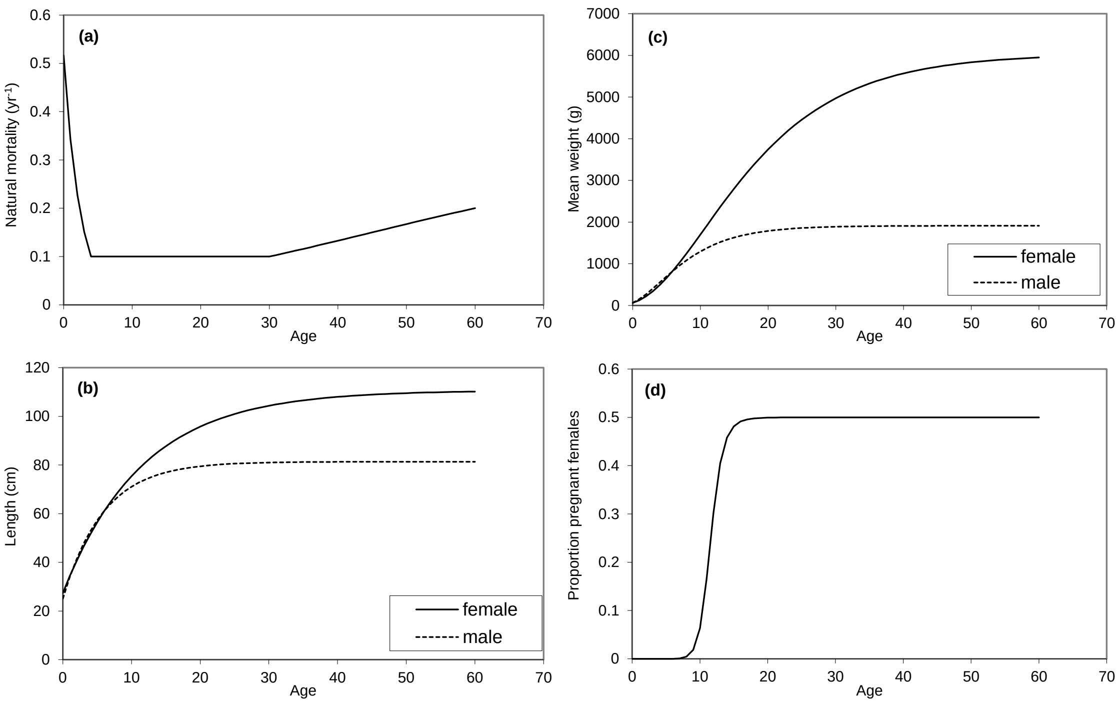



**Figure 2.24. Northeast Atlantic spurdog. A visual representation of the life-history parameters described in Table 2.6. [Note, the value of natural mortality-at-age 0 is a parameter derived from the assessment.]**

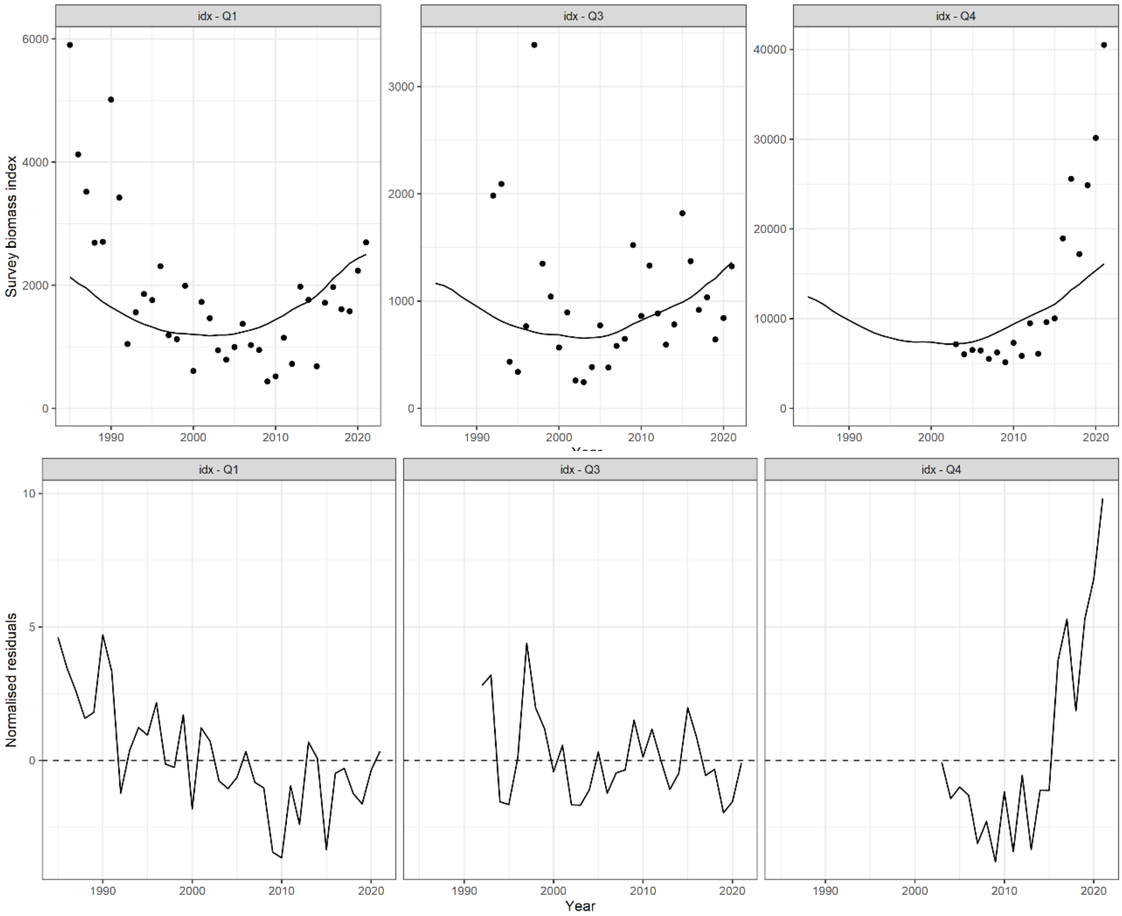



**Figure 2.25. Northeast Atlantic spurdog. Baseline assessment. Model fits to the three surveys indices (top panel), with normalised residuals ($\varepsilon_{sur,y}$ in Stock Annex equation 9b) (bottom).**

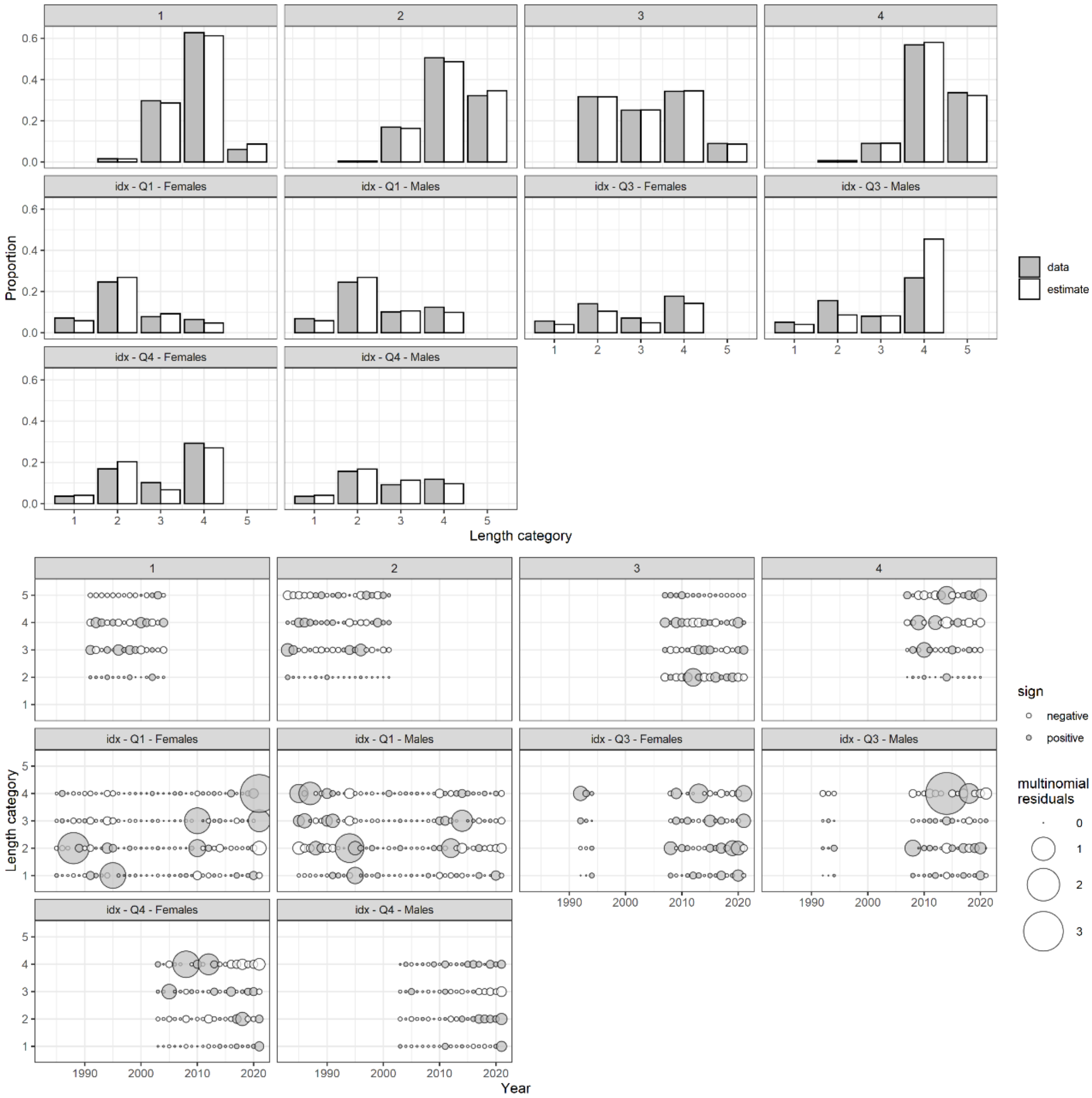
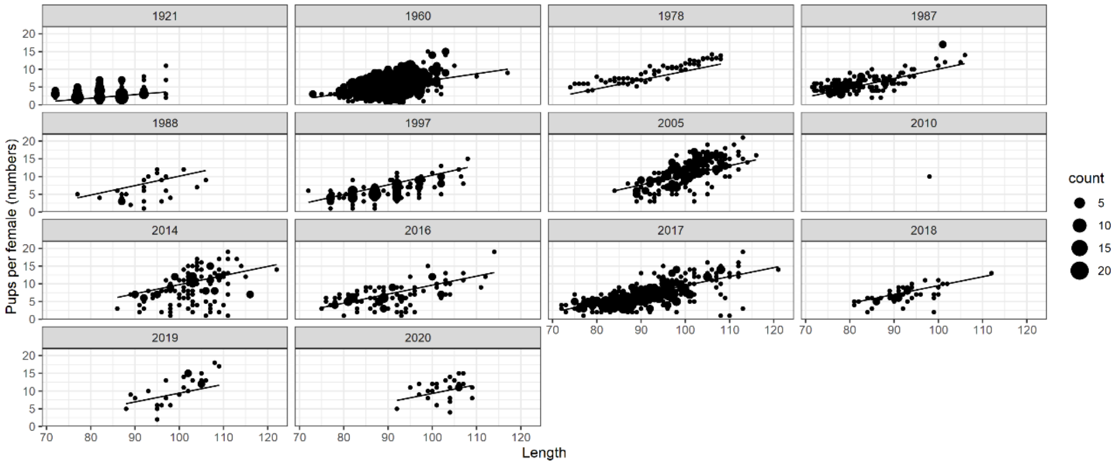



**Figure 2.26. Northeast Atlantic spurdog. Baseline assessment. Model fits (bar plots) and associated residuals (bubble plots) for the four commercial fleets (top row; 1="non-target", 2="target", 3="trawls & other", 4="nets & hooks") and three survey indices (second and third rows; by sex). The bar plots show proportions by length category averaged over the time period for which data are available, with the length category given along the horizontal axis. The bubble plots show multinomial residuals ($\varepsilon_{pcom,j,y,L}$ in Stock Annex equation 10b), with grey bubbles indicating positive residuals, bubble area being proportional to the size of the residual (see legend for reference), and length category indicated on the vertical axis. The length categories considered are, for the commercial data, 2: 16–54 cm; 3: 55–69 cm; 4: 70–84 cm; 5: 85+ cm, and for the surveys, 1: 16–31 cm; 2: 32–54 cm; 3: 55–69 cm; 4: 70+ cm.**

(a) Fits to fecundity data




(b) Normalised residuals

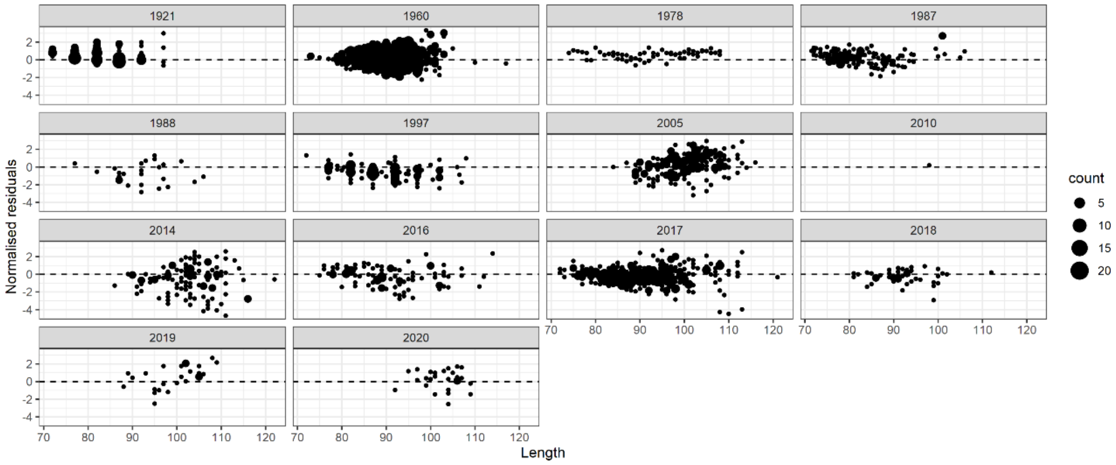



**Figure 2.27. Northeast Atlantic spurdog. Baseline assessment. Fit to fecundity data from several periods (a), with associated normalised residuals ($\varepsilon_{fec,k,y}$ in Stock Annex equation 11b) (b). For (a), the black lines reflect the model estimates for the given points. For all plots, the diameter of each point is proportional to $\sqrt{n}$, where $n$ is the number of samples with the same number of pups for a given length.**

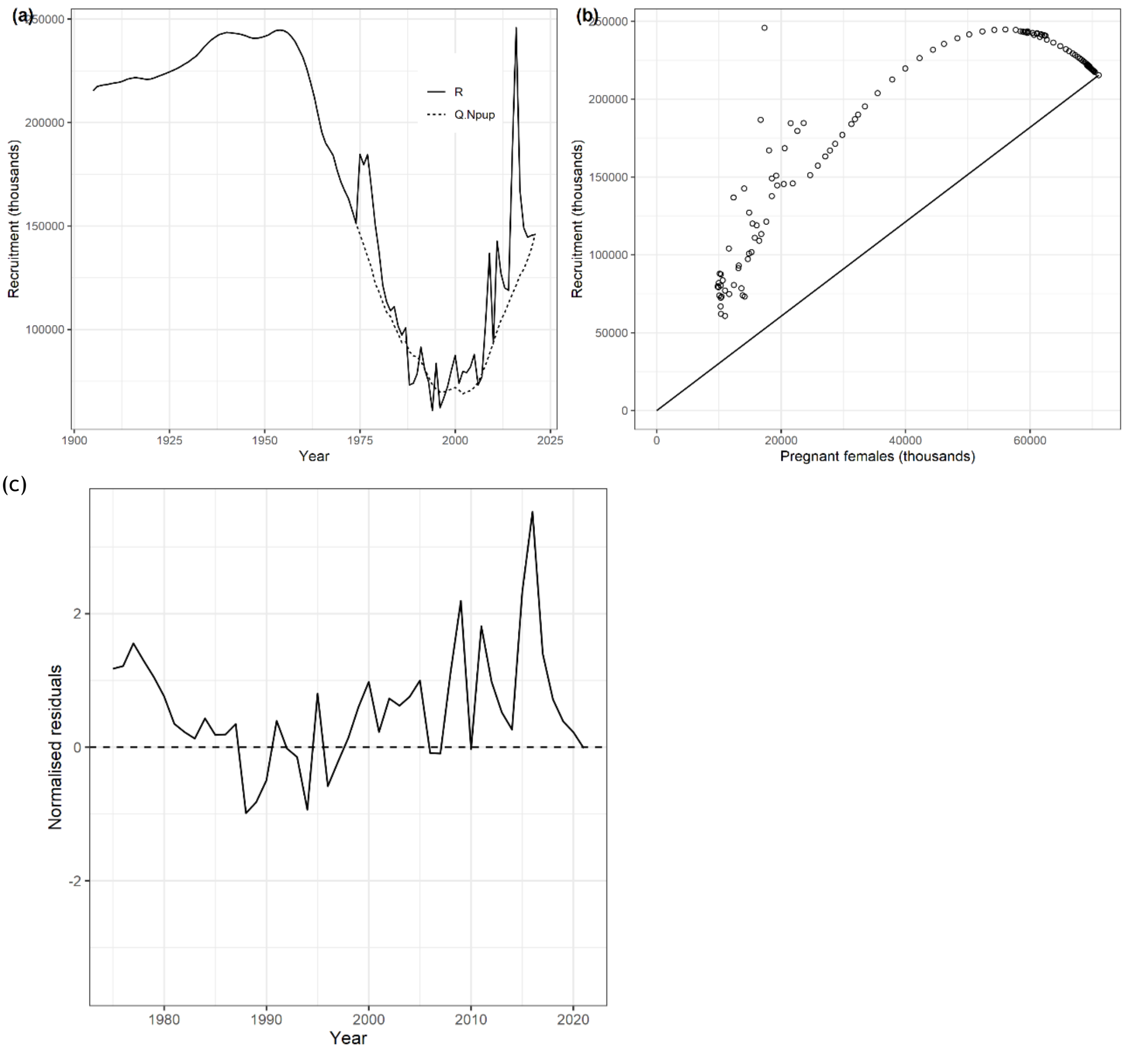



**Figure 2.28. Northeast Atlantic spurdog. Baseline assessment. (a) A comparison of the deterministic ($N_{pup}$) and stochastic (R) versions of recruitment (Stock Annex equations 2a–c) with (c) normalised residuals ($\varepsilon_{r,y}/\varepsilon_r$, where $\varepsilon_{r,y}$ are estimable parameters of the model); and (b) a plot of recruitment (R) vs. number of pregnant females (in thousands; open circles), together with the replacement line (number of recruiting pups needed to replace the pregnant female population under no harvesting).**

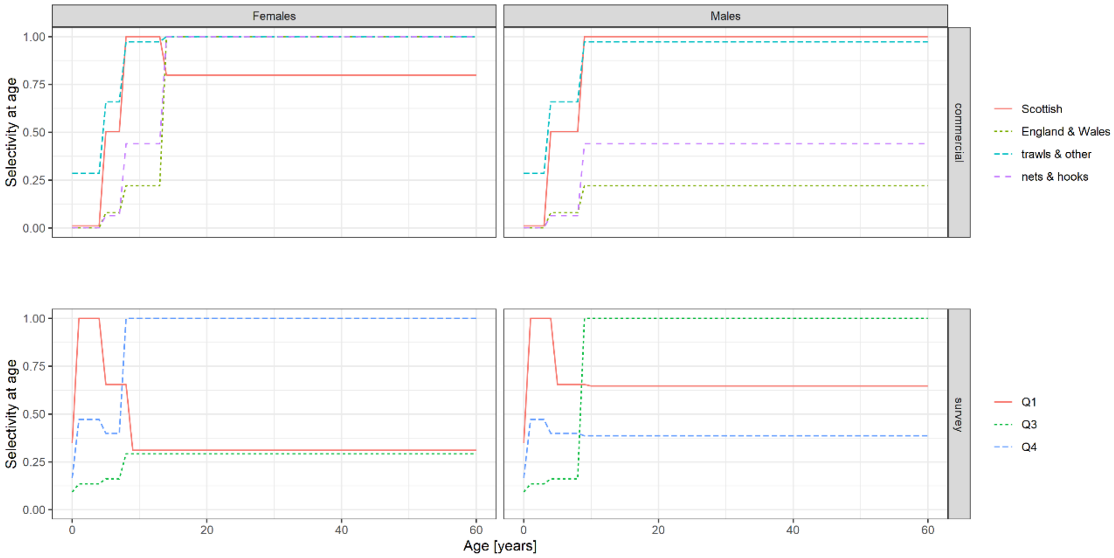



**Figure 2.29. Northeast Atlantic spurdog. Baseline assessment. Estimated selectivity-at-age curves for females (left plots) and males (right plots). The four commercial fleets considered (top row) have non-target (Scottish), target (England & Wales), "trawls & other", and "nets & hooks" selectivity, which differ by sex because of the life-history parameters for males and females (Table 2.6). The survey selectivity-at-age curves for the three indices are given in the bottom row.**

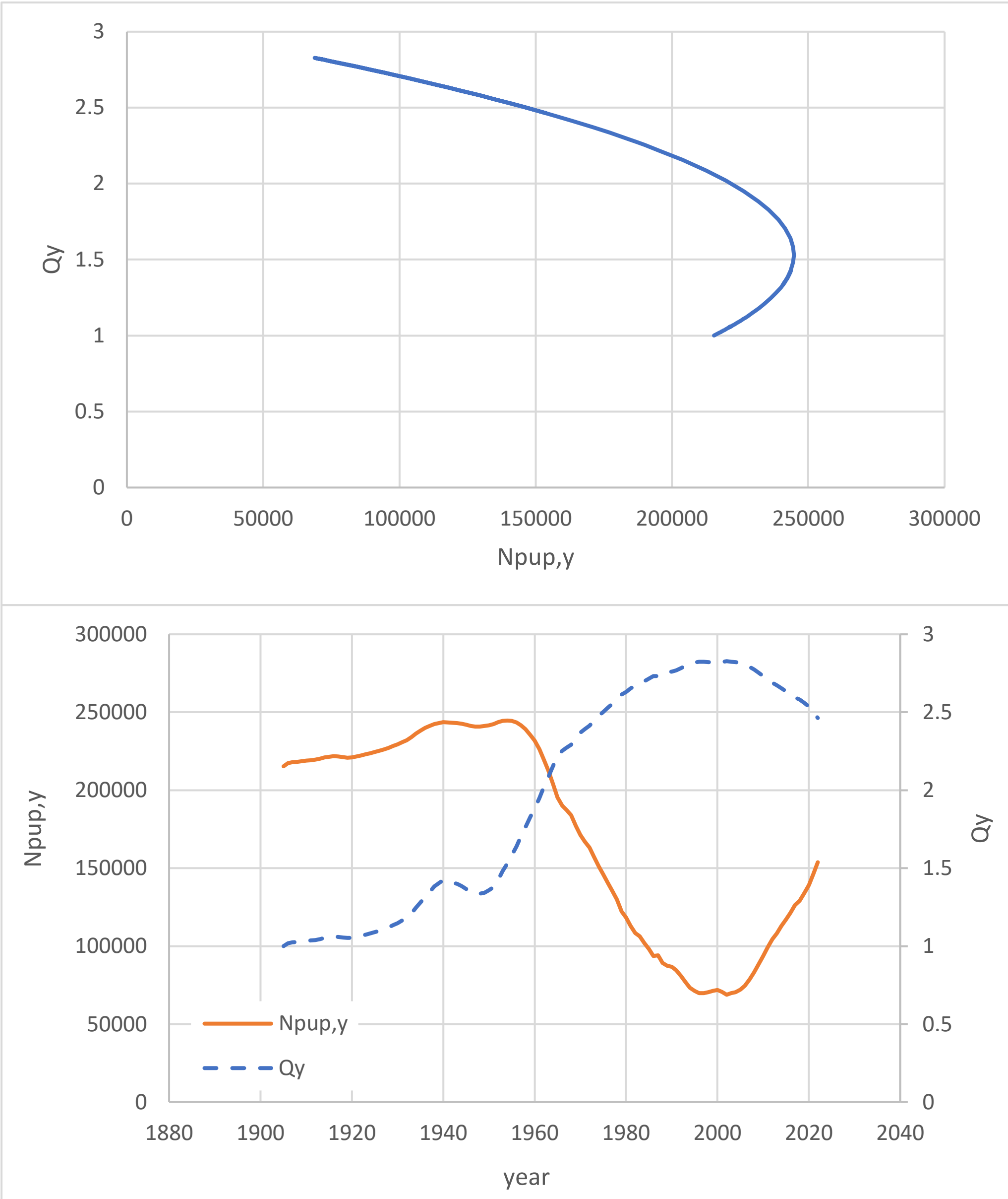



**Figure 2.30. Northeast Atlantic spurdog. Baseline assessment. A plot of the density-dependent factor $Q_y$ (Stock Annex equation 2b) against the number of pups $N_{pup,y}$ (top), and both plotted against time (bottom; orange line for $N_{pup,y}$, and blue hashed line for $Q_y$).**

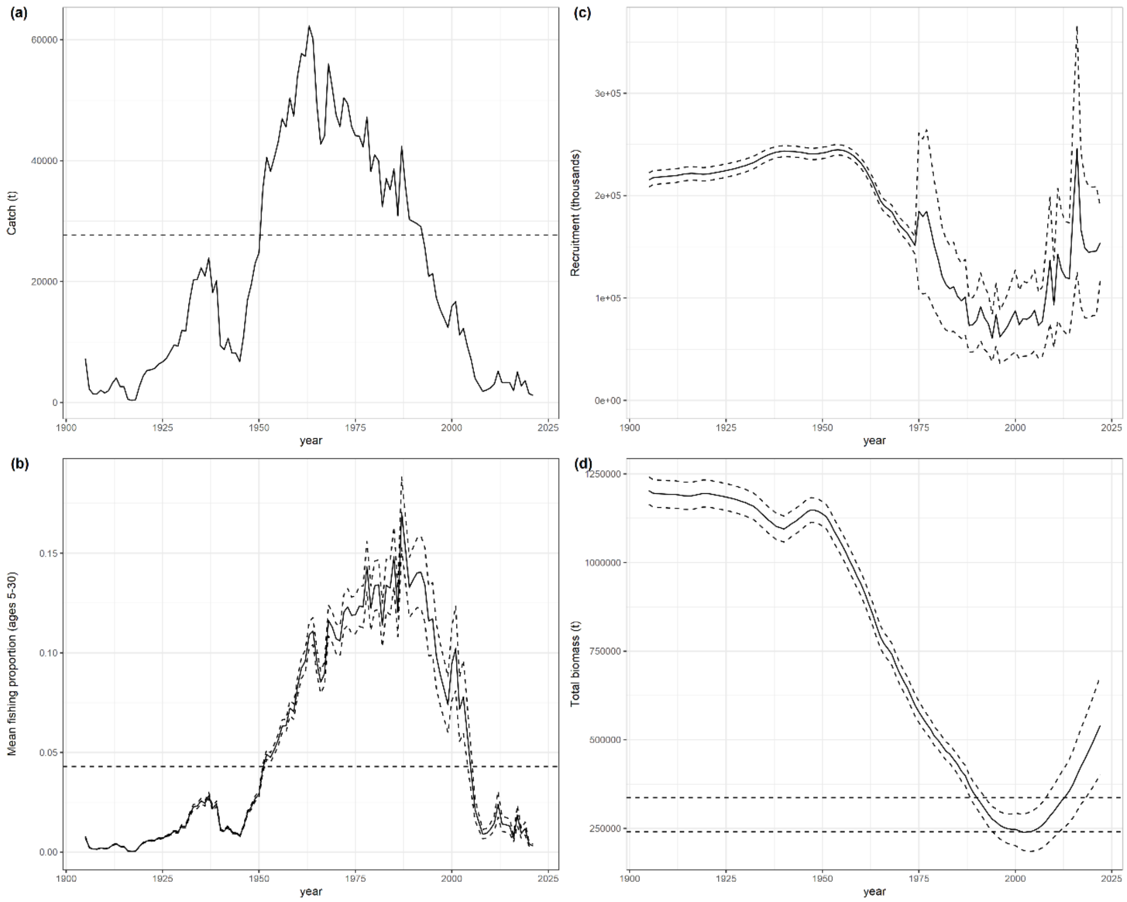



**Figure 2.31. Northeast Atlantic spurdog. Baseline assessment. Summary four-plot showing long-term trends in catch (tons; hashed horizontal line = *MSY*), recruitment (thousands of pups), mean fishing proportion (harvest rate, average over ages 5–30; hashed horizontal line = $HR_{MSY}$) and total biomass (tons; top hashed horizontal line = *MSY* $B_{trigger}$; bottom hashed horizontal line = $B_{lim}$). Hashed lines reflect estimates of precision (±2 standard deviations).**

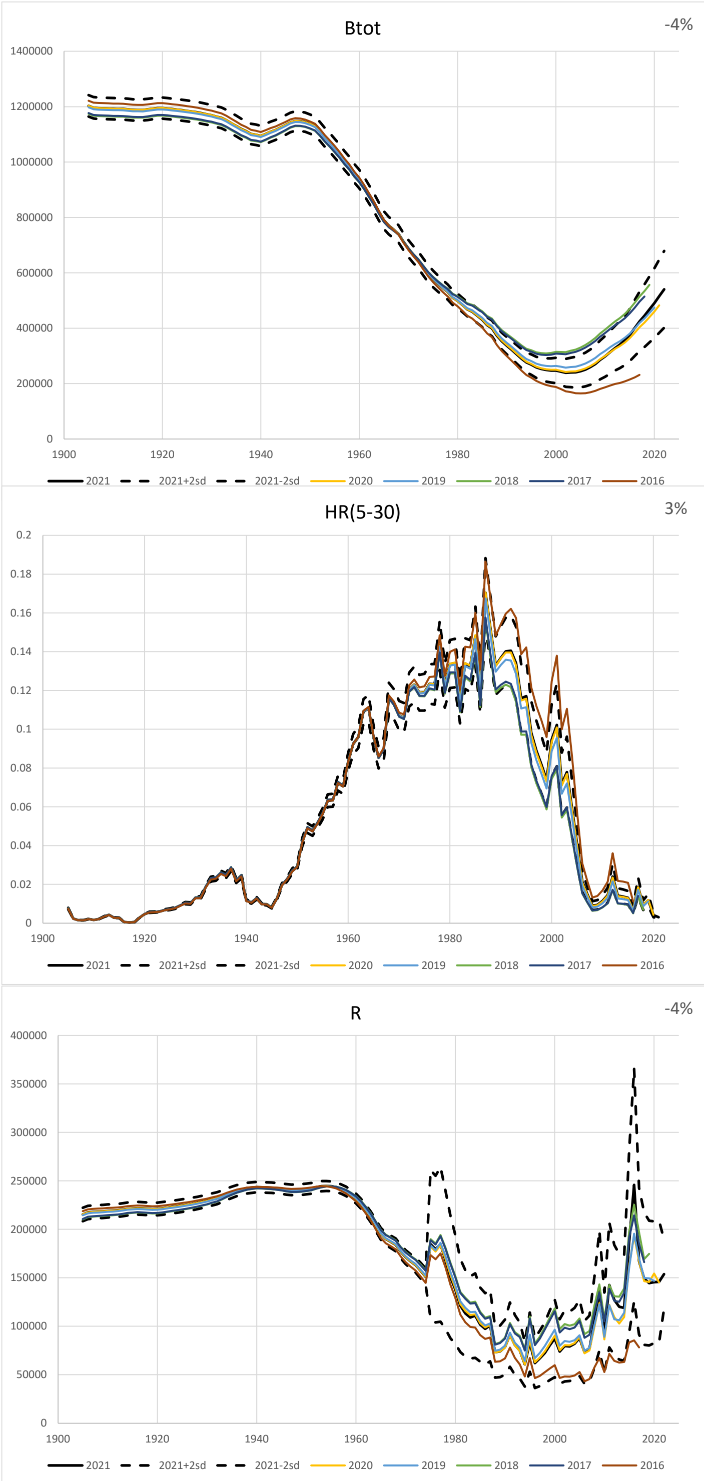



**Figure 2.32. Northeast Atlantic spurdog. Baseline assessment. Six-year retrospective plots (the model was re-run, each time omitting a further year in the data). Mohn's rho is given in the top-right of each plot, and confidence bounds (hashed black curves; ±2 sd) for the 2021 line (black curve).**

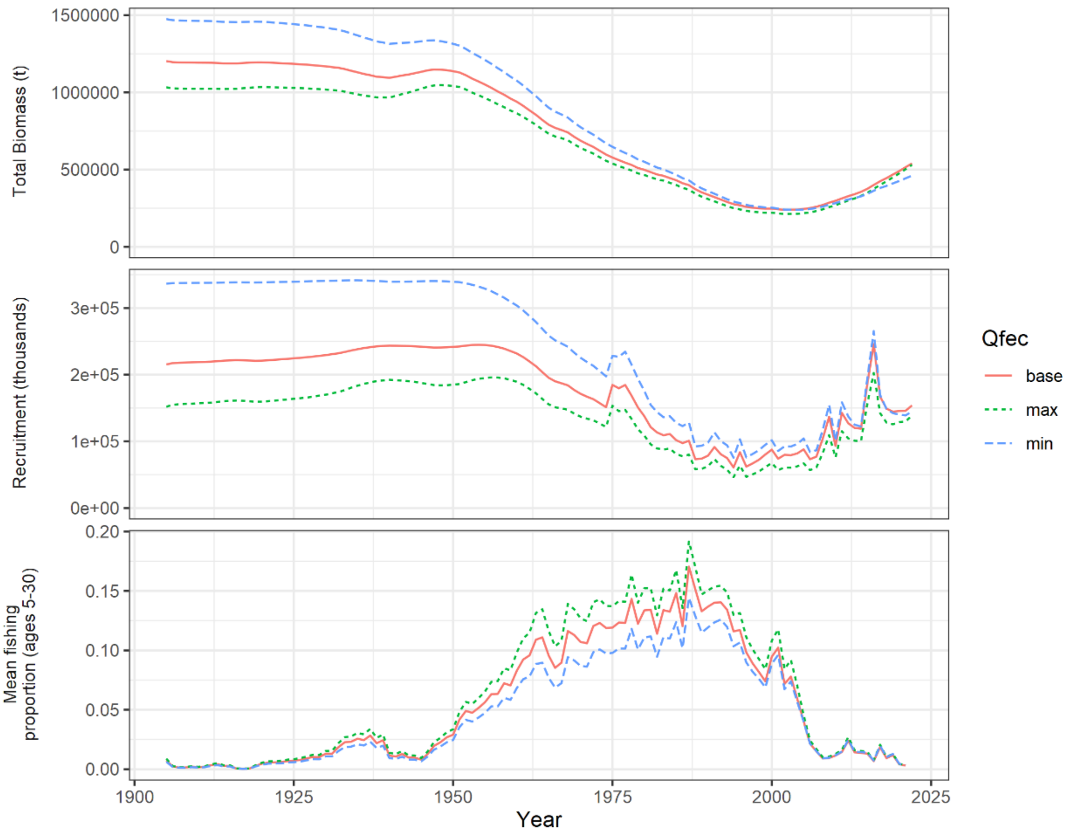



**Figure 2.33. Northeast Atlantic spurdog. A sensitivity analysis of the parameter that determines the extent of density-dependence in pup production ($Q_{fec}$). Three alternative values are considered, related to the optimum (in terms of lowest –ln*L*), smallest, and largest values for parameters $a_{fec}$ and $b_{fec}$ that are within the 95% probability intervals for the "update21" assessment (below the hashed lines in Figure 2.23). The estimated $Q_{fec}$ associated with these are base = 3.060 (baseline assessment), max = 3.803, min = 2.275, respectively.**

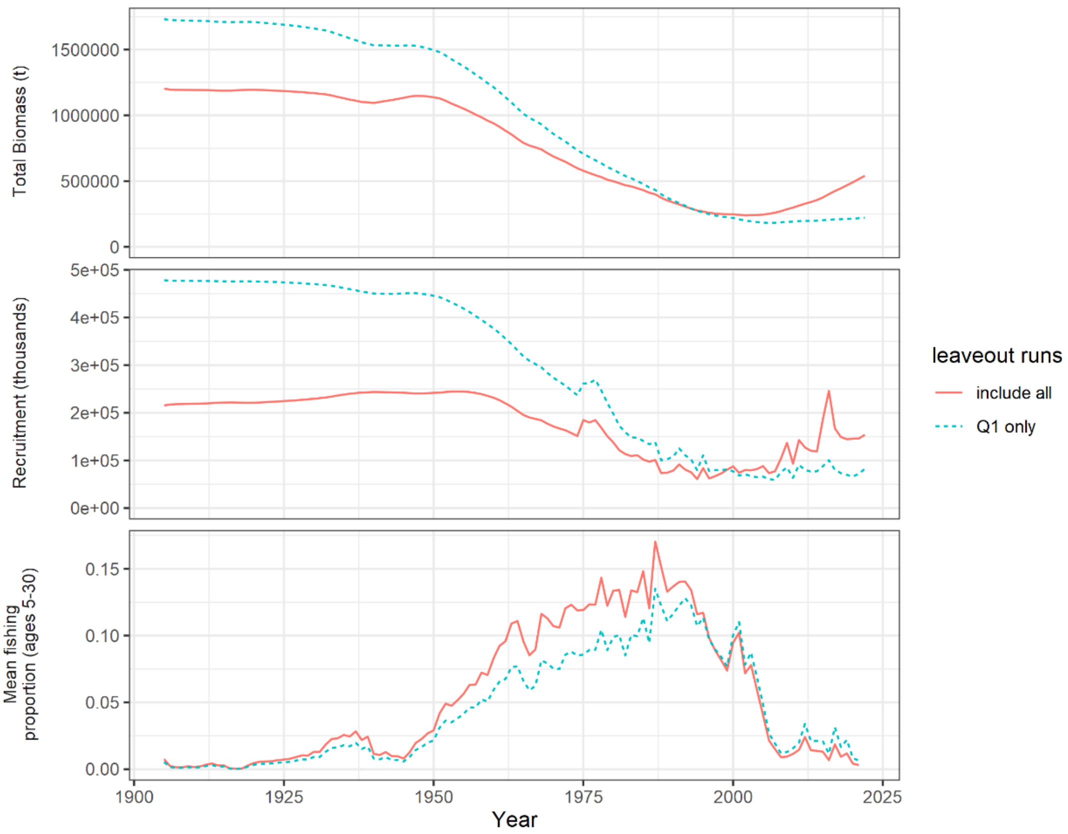



**Figure 2.34. Northeast Atlantic spurdog. A sensitivity analysis omitting all surveys indices except the Q1 index ("Q1 only") compared to the baseline assessment ("include all").**

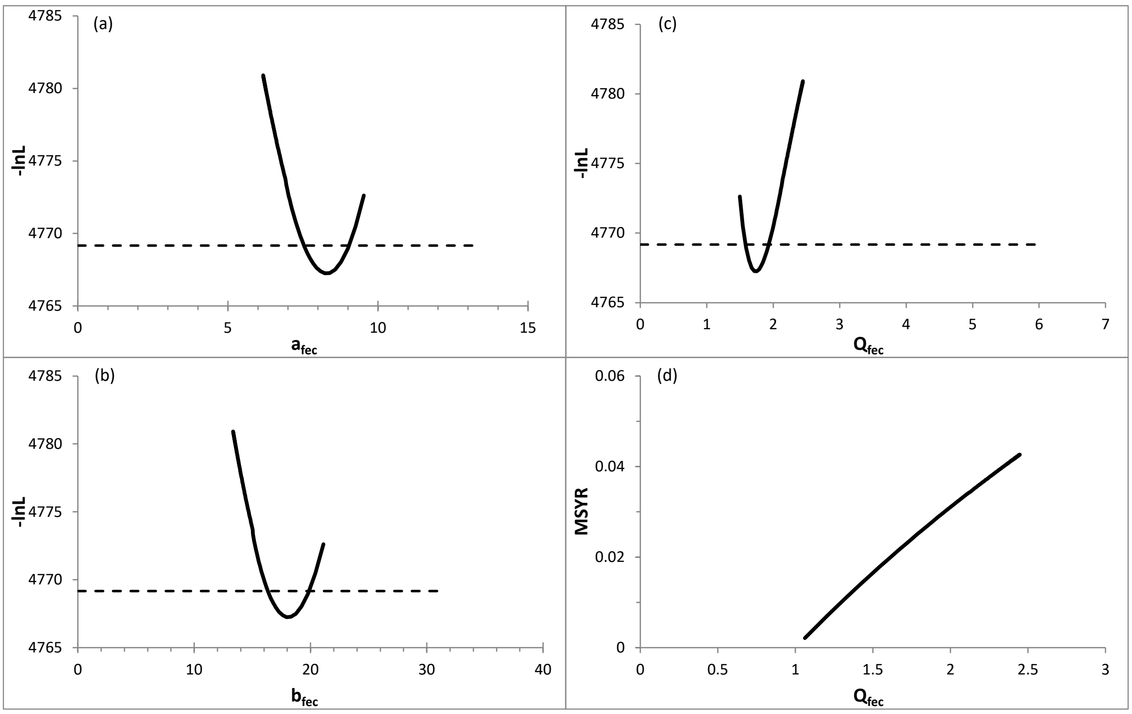



**Figure 2.35. Northeast Atlantic spurdog. Q1 only assessment. See caption to Figure 2.23 for relevant details.**

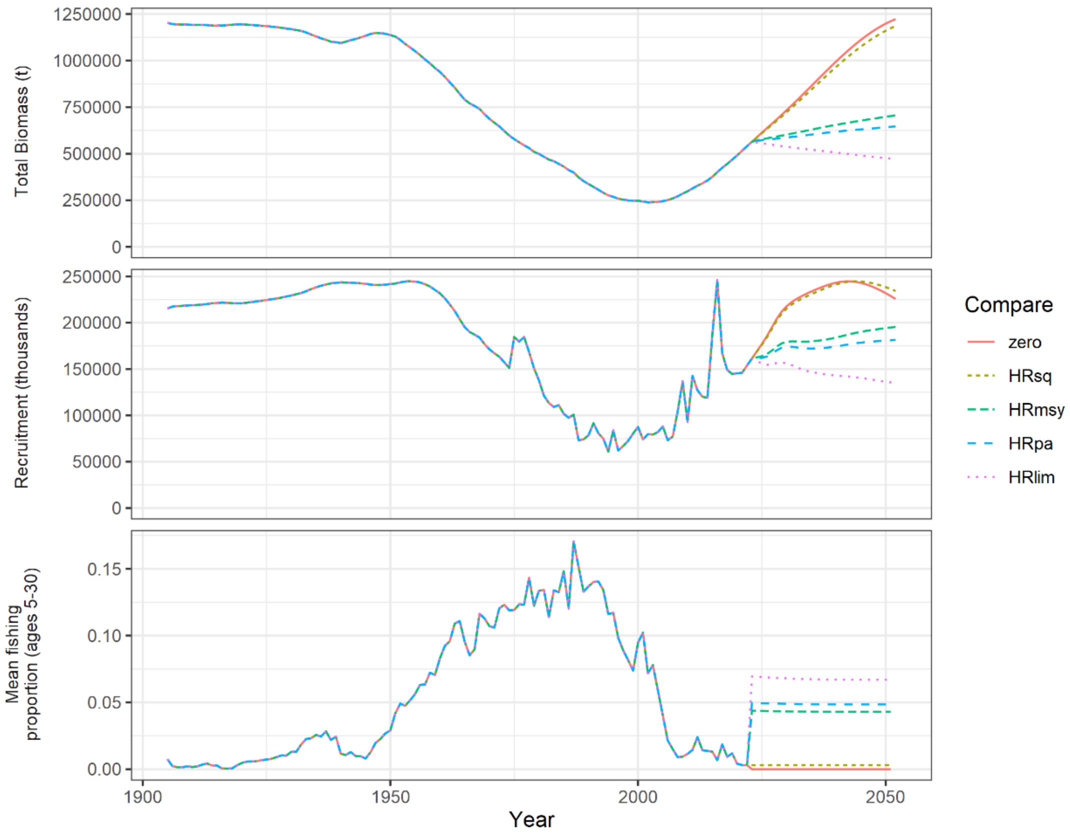



**Figure 2.36. Northeast Atlantic spurdog. Baseline assessment. 30-year projections for different levels of future catch, including zero catch for reference.**

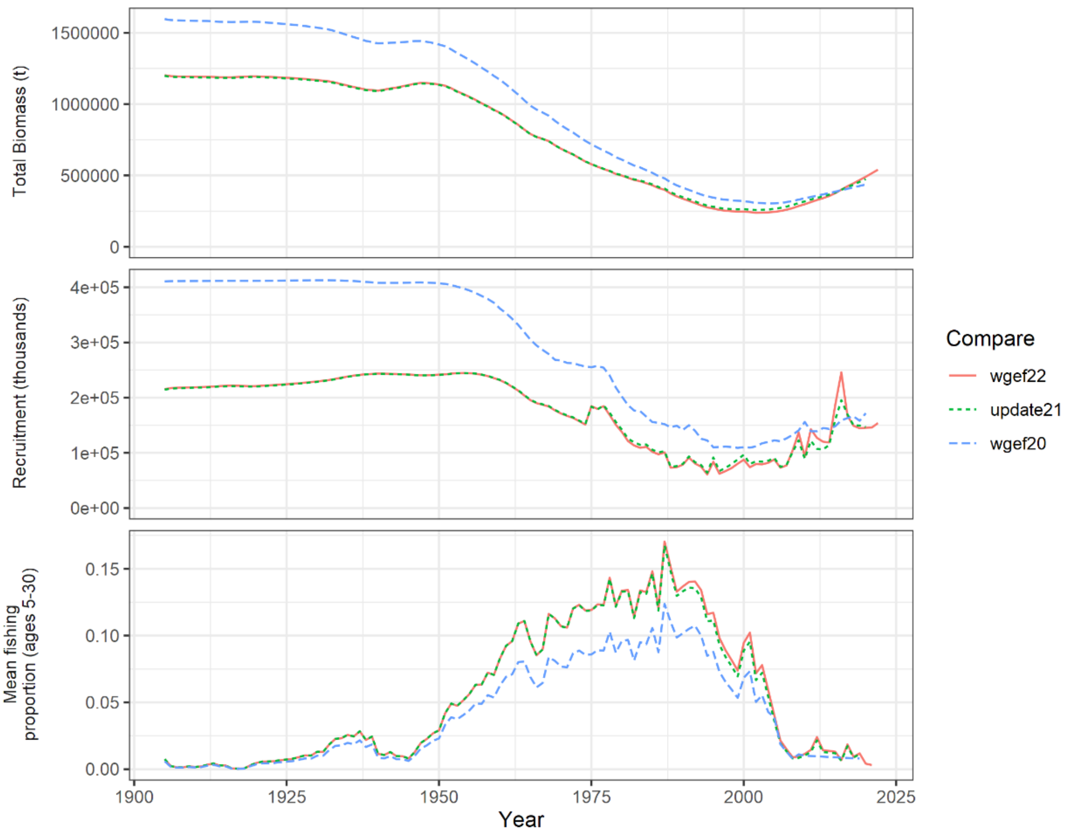



**Figure 2.37. Northeast Atlantic spurdog. Compare baseline assessment ("wgef22") with the assessment from WGEF (2020) ("wgef20") and the "update21" assessment (i.e. the 2021 benchmark assessment but with corrections and updates to input data, and infilling of missing data).**

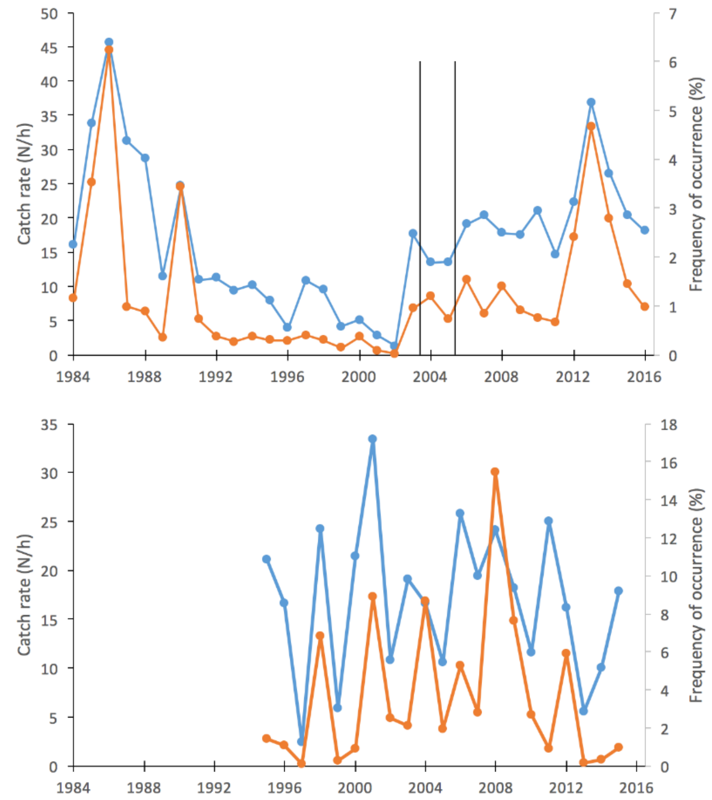



**Figure 2.38. Northeast Atlantic spurdog. Survey indices of spurdog in terms of catch rates (orange lines) and frequency of occurrence (blue lines) from the Norwegian Shrimp Survey in South-Norway (top panel) and the Norwegian Coastal Survey in North-Norway (bottom panel). The two vertical lines indicate changes in seasonal coverage of the shrimp survey, being in fourth quarter from 1984, in second quarter from 2004, and in first quarter from 2006.**

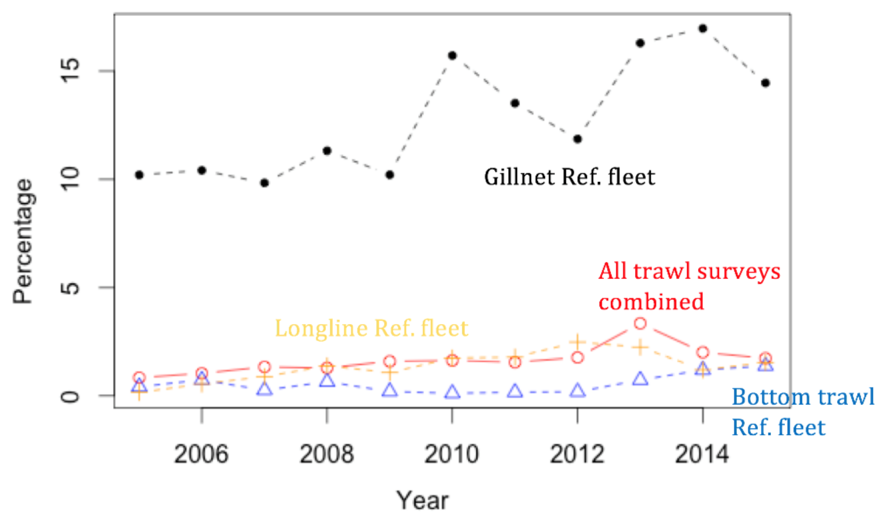



**Figure 2.39. Northeast Atlantic spurdog. Percentage occurrence of spurdog in sampled Norwegian commercial catches from each year and from each major fishery groups.**

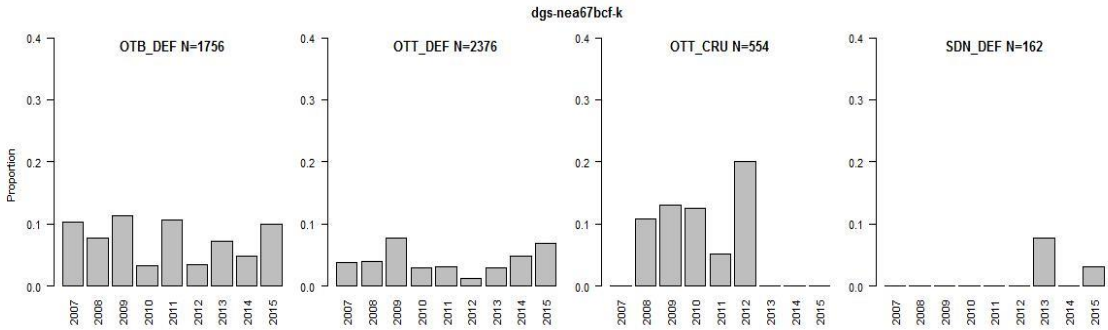



**Figure 2.40. Northeast Atlantic spurdog. Proportion of commercial hauls encountering spurdog in French fisheries (main level 5 métiers catching spurdog) in Subarea 6 and divisions 7.b–c and 7.f–k for the period 2007–2015. N: total number of fishing operations sampled for the métier.**

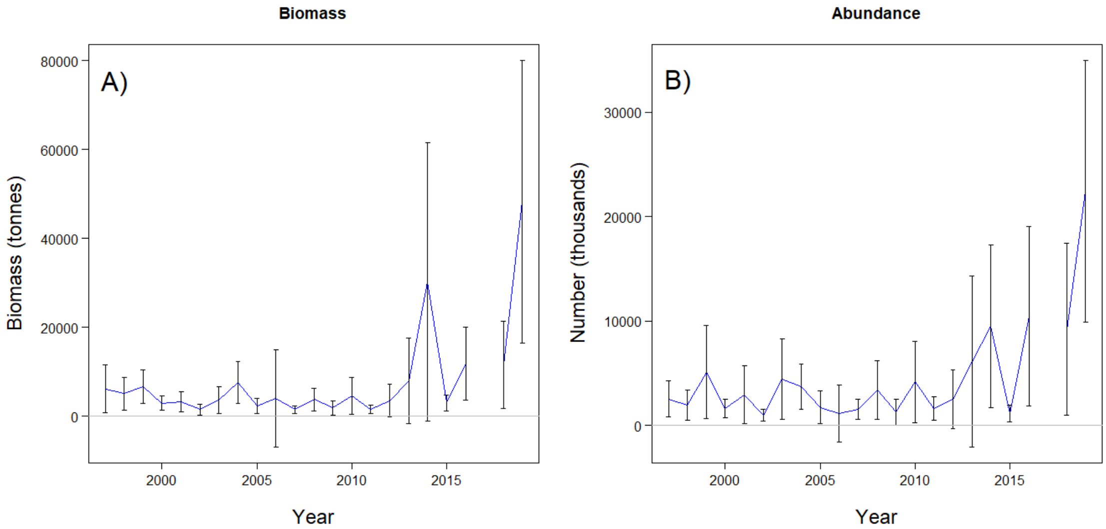



**Figure 2.41. Swept area biomass and abundance index of spurdog in the EVHOE (EVHOE-WIBTS-Q4) survey.**