

21 Smooth-hounds in the Northeast Atlantic

21.1 Stock distribution

Three species of smooth-hound (*Triakidae*) occur in the ICES area.

Starry smooth-hound *Mustelus asterias*

This is the dominant smooth-hound in northern European waters. The development of molecular genetic identification techniques has allowed the reliable identification and discrimination of NE Atlantic *Mustelus* species (Farrell *et al.*, 2009). Subsequent studies involving the collection of 231 *Mustelus* from the Irish Sea, Bristol Channel, Celtic Sea and west of Ireland, identified all to be *M. asterias* (Farrell *et al.*, 2010a, b). Studies of *Mustelus* samples (n = 504) from the North Sea and English Channel (McCully Phillips and Ellis, 2015) also identified all specimens as *M. asterias*.

There are several on-going tag-and-release programmes for *M. asterias* (e.g., Burt *et al.*, 2013 WD). Sportvisserij Nederland, in conjunction with Wageningen Marine Research, have a tagging programme with anglers in the Dutch Delta (Brevé *et al.*, 2016, 2020). As of 2020, 3699 *M. asterias* have been tagged, and 220 recaptures have been reported (Brevé *et al.*, 2020). Recapture positions provide evidence of circannual migration, with fish spending the summer in the southern North Sea and overwintering in the English Channel and Bay of Biscay. The findings also suggest a degree of philopatry with individuals returning to their release locations on an annual basis (Brevé *et al.*, 2016, 2020). These behaviours are supported by electronic tagging studies conducted by Cefas (Griffiths *et al.*, 2020). Sex-based dispersal has also been described in these tagging studies, with females re-distributing over a wider spatial range than their male counterparts (Brevé *et al.*, 2020; Griffiths *et al.*, 2020). Cooperative large-scale analyses of all available tagging data are required to further understand population stock structure of *M. asterias* in the Northeast Atlantic. Tagging studies from the more southern parts of the distribution range could usefully be undertaken.

In the absence of more detailed studies on stock identity, WGEF considers there to be a single biological stock unit of *Mustelus asterias* in the continental shelf waters of ICES Subareas 4, 6–8. The southern limits of the stock are uncertain.

Common smooth-hound *Mustelus mustelus*

This species occurs along the west coast of Africa, Mediterranean Sea, and western Europe. It is believed to be the more common species in the southern parts of the ICES area; the northern limits of the stock are uncertain. In recent years, there have been no confirmed specimens in the northern parts of the ICES area and historical records, especially those north of the Bay of Biscay, are considered questionable. Separating *M. mustelus* from *M. asterias* based on the presence or absence of spots is considered unreliable (Compagno *et al.*, 2005; Farrell *et al.*, 2009), and information and data from northern Europe referring to *M. mustelus* likely refers to *M. asterias*.

Black-spotted smooth-hound *Mustelus punctulatus*

This species occurs in the Mediterranean Sea and off Northwest Africa (Quignard, 1972). Its northern limit is believed to be the southernmost part of ICES Division 9.a.

Generic issues

The species composition of smooth-hounds in Subareas 8–9 is unclear, and species/stocks in these areas likely extend into the northern part of the CECAF area and Mediterranean Sea. Given

species identification issues and that some species and/or stocks may extend beyond the ICES area, the identification of management unit(s) will need appropriate consideration.

Given the problems in separating *M. asterias* and *M. mustelus*, and that data for these two species are likely confounded, data in this chapter are generally combined at the genus level. Whilst assessments conducted by WGEF are based on *Mustelus asterias*, management advice should be applied at the genus level, therefore avoiding potential identification problems and their impacts on management and enforcement.

21.2 The fishery

21.2.1 History of the fishery

Smooth-hounds are a seasonal bycatch in trawl, gillnet, and longline fisheries. Though they are discarded in some fisheries, others land them as bycatch, depending on market demands. Some smooth-hounds may also be landed to supply bait for pot fisheries.

Smooth-hounds are also a relatively important species for recreational sea anglers and charter boat fishing in several areas, with anglers and angling clubs often having catch-and-release protocols, particularly in the Celtic and North Sea ecoregions.

21.2.2 The fishery in 2021

The impact of the COVID-19 pandemic on fishing activity remains unquantified, however, it is assumed based on national and/or local restrictions to have resulted in reduced fishing effort in 2020 and 2021 (ICES, 2021c).

Anecdotal information from the UK fishing industry suggests that increased landings of smooth-hounds in recent years are partly to supply market demand for ‘dogfish’, given the current restrictions on spurdog, *Squalus acanthias*. *M. asterias* is also of increasing importance to some inshore fisheries due to restricted quotas for traditional quota stocks. Anecdotal information from these inshore fisheries suggests that the local market value of *M. asterias* has increased beyond that of skates and rays.

21.2.3 ICES Advice applicable

ICES first provided advice for this stock in 2012 for 2013 and 2014 (which was reiterated for 2015), stating that “Based on ICES approach to data-limited stocks, ICES advises that catches should be reduced by 4%. Because the data for catches of smooth-hounds are not fully documented and considered highly unreliable (due to the historical use of generic landings categories), ICES is not in a position to quantify the result”.

In 2015, ICES advised that “when the precautionary approach is applied, landings should be no more than 3272 tonnes in each of the years 2016 and 2017”. This was based on a survey-based (Category 3) assessment, with a stock size indicator based on four survey indices.

In 2017, ICES advised that “when the precautionary approach is applied, landings should be no more than 3855 tonnes in each of the years 2018 and 2019. ICES cannot quantify the corresponding catches”. This was based on a survey-based (Category 3) assessment, with a stock size indicator based on three survey indices.

In 2019, ICES advised that “when the precautionary approach is applied, landings should be no more than 4626 tonnes in each of the years 2020 and 2021. ICES cannot quantify the corresponding catches”.

This was based on a survey-based (Category 3) assessment, with a stock size indicator based on three survey indices.

In 2021, ICES advised that “ICES advises that when the precautionary approach is applied, landings should be no more than 4441 tonnes in each of the years 2022 and 2023. ICES cannot quantify the corresponding catches”. This was based on a survey based (Category 3) assessment, with a stock size indicator based on five survey indices. Two additional surveys (FR-CGFS-Q4 and IE-IGFS-WI-BTS-Q4) were added in 2021 to increase the area covered within the stock unit.

21.2.4 Management applicable

There are no specific management measures for *Mustelus* spp. in the ICES area.

EC Council Regulations 850/98 for the “conservation of fishery resources through technical measures for the protection of juveniles of marine organisms” details the minimum mesh sizes that can be used to target fish. Although other dogfish (*Squalus acanthias* and *Scyliorhinus* spp.) can be targeted in fixed nets of 120–219 mm and >220 mm mesh size (in regions 1 and 2), *Mustelus* spp. are classified under “all other marine organisms”, and can only be targeted in fixed nets of >220 mm.

21.3 Catch data

21.3.1 Landings

No accurate estimates of catch are available for earlier years (Table 21.1; Figure 21.1). This is because many nations that landed smooth-hounds reported an unknown proportion of the landings to aggregated landings categories (e.g. ‘dogfish and hounds *nei*’).

ICES estimates, following WKSHARK2 (ICES, 2016a), indicate that landings have exceeded 3000 t since 2005 (Table 21.2). The main nations exploiting smooth-hounds are France and the UK. The English Channel and southern North Sea are important fishing grounds.

Although landings from Spain show a consistent decrease since 2015, this is mostly due to unavailable data from FAO areas 34 and 37, which represented on average ca. 11% and 30% of total landings reported to WGEF for this country during 2005–2014, respectively.

Landings data outside FAO area 27 that are currently reported to WGEF are negligible (ca. 0 to 2% between 2005–2021).

Landings from the Netherlands show an increase in 2019–2021 which may be partially linked to an increase in fishing effort by fly shoot (seine) fisheries.

Species-specific landings for the various species of *Mustelus* are not considered accurate, and data have been collated at genus level. These values are likely underestimates, as some nations still report some landings of ‘dogfish and hounds *nei*’.

21.3.2 Discards

Although discards data are available from various nations, data are limited for some nations and fisheries (Table 21.2). Seven countries reported preliminary estimates of discards for 2009–2021, however data show high inter-annual variability by country and thus, further data analysis should be undertaken before the data is used in the assessment (section 1.14 in ICES, 2021). Given the seasonality of catches in some areas, and that *M. asterias* is often taken by inshore vessels where observer data can be more sporadic, further studies to evaluate the most appropriate

methods of raising data from observer trips to fleet level are required if catches are to be estimated appropriately.

The collection of discards data in 2020 and 2021 was likely affected by COVID-19 national restrictions. Consequently, a decrease in the number of samples compared to previous years may be assumed, although the impact of this is yet to be quantified. As such discard data for both years should be viewed with caution.

A study has indicated that juvenile *M. asterias* are often discarded (Figure 21.2), although the survival of these discards has not been evaluated (Silva and Ellis, 2019). *M. asterias* taken by UK beam trawl and *Nephrops* trawl were composed primarily of juveniles and sub-adults (<70 cm L_T), and nearly all were discarded. Gillnet catches were comprised primarily of fish 70–110 cm L_T , with fish <60 cm L_T usually discarded. Otter trawl catches covered a broad length range, and *M. asterias* <60 cm L_T were usually discarded. The absence of full retention at length in these gears is likely linked to various factors (e.g., catch quality and local market value).

Silva and Ellis (2019) also noted that a greater proportion of *M. asterias* have been retained since landing opportunities for spurdog have become restrictive. In the years 2002–2009, the retention of *M. asterias* ≥ 70 cm L_T was 59% and 44% in gillnet and otter trawl fisheries, respectively. In the period 2010–2016, however, retention increased to 85% (gillnets) and 66% (otter trawl). In addition, length at retention for otter trawl dropped from 41 cm L_T (2002–2009) to 34 cm L_T (2010–2016). High rates of discarding (of smaller fish, <60 cm L_T) have also been observed in otter trawls, where *ca.* 63% and 71% of the total catches were discarded in the North Sea and Celtic Seas, respectively.

WKSARK3 undertook further exploratory analyses of discards data, noting similar discard-retention patterns to those described above. An analyses of discards data from Scottish fisheries was also presented (ICES, 2017).

21.3.3 Quality of catch data

Landings data have historically been of poor quality, as much of the landings data have been reported under generic landings categories. Most nations have made efforts to improve the recording of species in recent years.

Some northern European nations report more *M. mustelus* than *M. asterias* in official statistics, but WGEF combine these data, as *M. asterias* is the predominant and possibly the only species to occur around the British Isles.

Mustelus spp. are often taken in inshore fisheries, and landings data for vessels <10 m may not be complete.

M. asterias may be landed for bait in pot fisheries around the British Isles targeting whelk, and it is unclear whether such landings are reported consistently.

The availability of landings data from outside the ICES area (e.g., Mediterranean Sea) is limited, and the quality remains uncertain. In 2010, the European Commission collated landings data as an average across 2008–2010 and three species of *Mustelus* were represented in these data; *M. punctulatus* (269 t from Italy), *M. mustelus* (14 t combined from Italy, Spain, Malta, and Slovenia) and *M. asterias* (1 t from Malta) (ICES, 2012). WGEF has not yet considered potential catches/landings for waters off NW Africa.

Better estimates of discarding are required, with more robust estimates of discard survival also needed.

21.3.4 Discard survival

Discard survival is variable across this family (Ellis *et al.*, 2014 WD). Whilst quantitative data are limited in European waters, Fennessy (1994) reported at-vessel mortality of 29% for Arabian smooth-hound *Mustelus mosis* taken in a prawn trawl fishery. Mortality ranged from 57–93% for three triakid sharks taken in an Australian gillnet fishery, despite the soak times being <24 hours (Braccini *et al.*, 2012). High survival of triakids has also been reported in longline fisheries (Frick *et al.*, 2010a; Coelho *et al.*, 2012).

A UK research programme examining movements, behaviour, and discard survival through electronic tagging of *M. asterias* found that in terms of at-vessel mortality, the longline fleet had the greatest proportion of fish in a lively condition (91%; primarily large individuals due to the selectivity of the gear), whilst gillnets had the highest mortality (56%) of the gears studied (McCully Phillips *et al.*, 2019). Smaller individuals, which were caught mostly in beam trawls, were found to generally be in a poor condition (McCully Phillips *et al.*, 2019).

21.4 Commercial catch composition

Studies to better understand the composition of commercial catches by size and sex (and species where there is spatial overlap) are required. Given the potential for sex-based spatial segregation of *Mustelus*, as evidenced by sex-based dispersal of tagged fish (Brevé *et al.*, 2020; Griffiths *et al.*, 2020) as well as recent work on metazoan parasites (Gérard *et al.*, 2022), an appropriate level of monitoring would be required to fully understand commercial catch compositions over appropriate spatial and temporal scales.

21.4.1 Length composition of landings

In a UK study, 504 *M. asterias* samples (266 females; 238 males, Figure 21.3) were examined (McCully Phillips and Ellis, 2015), of which 286 (with a length range of 52–124 cm L_T) were landed by commercial vessels.

21.4.2 Length composition of discards

Silva and Ellis (2019) analysed the discard and retention patterns of *M. asterias* taken as bycatch in UK fisheries. Beam trawlers caught proportionally more juveniles (most records were of specimens of ca. 35–70 cm L_T), and discarding rates were high (95–99%). Gillnets were more selective for larger fish (most fish were 60–100 cm L_T), and typically only larger fish (>70 cm L_T) were retained.

21.4.3 Sex ratio of landings

Of 286 commercially landed samples of *M. asterias* from the southern North Sea and eastern English Channel in May–November (2012 – 2014), 155 were female and 131 were male (McCully Phillips, unpublished). Due to *M. asterias* aggregating by sex and size, the sex ratio (and length-frequency) is expected to vary over the year and between areas.

21.4.4 Quality of data

Mustelus length measurements may be collected as part of the concurrent sampling of the Data Collection Framework (DCF). These data should be made available for future analysis.

21.5 Commercial catch and effort data

There are no data available.

21.6 Fishery-independent information

21.6.1 Availability of survey data

Several fishery-independent surveys operate in the stock area. Smooth-hounds are often caught in GOV trawl and other otter trawl surveys in the area (Figure 21.4). For further details on trawl surveys in the stock area, see Section 15 (North Sea ecoregion), Section 18 (Celtic Seas) and Section 19 (Biscay-Iberia).

Larger individuals are not sampled effectively in beam-trawl surveys (because of low gear selectivity). For example, the UK western English Channel beam-trawl survey only occasionally records *M. asterias* >100 cm L_T (Silva *et al.*, 2020 WD; Figure 21.5).

Analyses of survey data need to be undertaken with care; smooth-hounds are relatively large-bodied fish (the maximum size of *M. asterias* is at least 124 cm (McCully-Phillips and Ellis, 2015), with other sources suggesting they may attain 133 or 140 cm L_T) and adults may be strong swimmers, and able to avoid capture. As the largest individuals may not be sampled effectively in some survey gears, survey data might not provide a representative sample of the population.

Given their aggregating nature, some surveys may have a large number of zero hauls and a few hauls with relatively large numbers, although this issue does not appear to be as pronounced as seen in spurdog.

Although two species of *Mustelus* are often reported in surveys, the discrimination of these species was usually based on the presence or absence of spots, which is not a reliable characteristic. WGEF consider that survey data for these two species should be combined in any analyses, and that *M. asterias* is likely to be the only, or main, species in the Celtic Seas and North Sea ecoregions.

More detailed investigations of data in DATRAS undertaken by WGEF in 2017 indicate that data for *Mustelus* spp. and *Galeorhinus galeus* (tope shark) may have been confounded. This is most evident for Danish survey data (see Section 21.6.3).

21.6.2 Survey trends

Updated survey data were examined by WGEF in 2021, as summarised below (see Section 21.9 for additional quantitative information).

IBTS-Q1 and IBTS-Q3

The IBTS surveys of the North Sea, undertaken in Q1 and Q3 by seven and six countries respectively, have a common time period of 30 years (1991–2020). These surveys were included in the 2021 assessment of the stock; both surveys catch relatively low numbers of *M. asterias*. The long-term trend in abundance of smooth-hounds has increased in both the Q1 and Q3 time-series (Figure 21.6). The survey trends were updated in 2021 for the whole time series and were averaged and treated as one following recommendations from WWSKATE (ICES, 2021b). Data presented for these surveys include all national data for Q1 and Q3 available on DATRAS, with the exception of Danish data for Q3 time-series described in Section 21.6.3.

EVHOE-WIBTS-Q4

This survey of ICES divisions 7.g–k and 8.a.b.d has a 23-year time-series of data (1997–2016, 2018–2020) and was included in the assessment of the stock in 2021 (see Section 21.9). The survey covers the south-western part of the stock area. Catch rates, though showing marked inter-annual variability, indicate a broadly increasing trend (Figure 21.7). The survey trends were updated for the whole time series in 2021; values may differ from previous results used in the 2019 assessment as the new estimates used data available on DATRAS following methodology presented at WSKATE (ICES, 2021b).

CGFS-Q4

This survey of ICES Division 7.d has a 24-year time-series of data (1997–2020) and was included in the 2021 assessment of the stock (see Section 21.9). The survey covers part of the stock area in the eastern English Channel. Catch rates indicate a broadly increasing trend despite intra-annual variability (Figure 21.7). Data considered for these estimations were based on data available on DATRAS, with calculations following methodology presented at WSKATE (ICES, 2021b).

This survey did not cover part of the survey grid in 2020 (ICES rectangles 29F1 and 30E9) and further analysis was conducted to better understand the potential impact on the assessment of this stock (see section 21.9).

IGFS-WIBTS-Q4

This survey of ICES divisions 6.a and 7.b.g.j has a 16-year time-series of data (2005–2020) and was included in the 2021 assessment of the stock (see Section 21.9). The survey covers the north-western part of the stock area. The increasing long-term trend in *M. asterias* is also evident in the Irish Groundfish Survey, although catch rates are generally low and more variable in recent years (2017–2020, Figure 21.10). This survey was previously used only as supporting information as it covers a shorter time-period compared to other surveys. However, following recommendations made by WSKATE to increase the spatial coverage of the stock size indicator, further analyses were undertaken to include this survey in the assessment.

BTS-UK(E&W)-Q3 (in 7.afg¹)

This survey of ICES divisions 7.a and 7.f.g has a 28-year time-series of data (1993–2020), and catches reasonable numbers of *M. asterias*, albeit mostly immature specimens. This survey was not used in the 2021 assessment of the stock as the assessment explicitly considers exploitable biomass (i.e., individuals ≥ 50 cm L_T).

The mean catch rate of this survey was derived from the catch rates from fixed stations (97 stations fished at least 24 years out of the 28-year time-series; Silva and Ellis, 2021 WD10). The temporal trend in CPUE (abundance and biomass for all individuals) indicates an increasing trend, although data indicate a decrease in 2018–2019. Both abundance and estimated biomass showed similar trends (Figure 21.9). Data are shown for 2020, however, these are considered not to be representative since these relate only to part of the survey area where this species is most abundant (ICES Division 7.f), and data for other parts of the survey area (where lower catches and more ‘nil hauls’ would be expected) are lacking (Silva and Ellis, 2021 WD). The reduction in survey coverage in 2020 to only locations within ICES Division 7.f was due to the COVID-19 pandemic, with a total of 65 fixed stations in ICES Division 7.a and 7.g being missed. While *M. asterias* is more commonly found in the Bristol Channel (7.f), there has been an increase in occurrence in the Irish Sea (7.a) in recent years (Silva and Ellis, 2021 WD).

¹ Only one fixed (prime) station is within ICES Division 7.g (Prime 501). Also referred as UK(E&W)–BTS–Q3.

BTS-Eng-Q3 (in 7.d and 4.c)

This survey of ICES divisions 7.d and 4.c has a 28-year time-series of data (1993–2020) and catches mostly juvenile *M. asterias*. This survey was not used in the 2021 assessment of the stock as the assessment explicitly considers exploitable biomass (i.e., individuals ≥ 50 cm L_T).

The mean catch rate of this survey was derived from the catch rates from fixed stations (78 stations, Silva and Ellis, 2020b WD). The temporal trend in CPUE (abundance and biomass for all individuals) indicates an increasing trend, although CPUE is lower and more variable than recorded in the beam trawl survey of the Irish Sea and Bristol Channel (Figure 21.9). Survey indices for the whole time series were updated following recommendations from WSKATE (ICES, 2021b).

UK-Q1SWBEAM²

The UK beam-trawl survey in the western English Channel (7.e: 2006–2013), and more recently extended to cover the Celtic Sea (2014–2019) also encounters *M. asterias* (Figure 21.8). Analyses of these data (for the period 2006–2019) noted that 1098 specimens had been caught (713 ≥ 50 cm L_T for exploitable biomass calculations) accounting for 5% of the elasmobranch catch by numbers; the observed length range was 26–117 cm L_T (Silva *et al.*, 2020 WD; Figure 21.5). In the western Channel (Division 7.e), the estimated total abundance and biomass showed similar trends, with peaks in 2009 and 2013–2014, and after a decrease in 2016, data indicate another increase in 2018–2019 (Figure 21.8; Silva *et al.*, 2020 WD). These results should be viewed as ‘qualitative assessments’, with further evaluations needed to better understand the utility of these trends for providing quantitative assessment and advice (Silva *et al.*, 2020 WD).

Other surveys also capture *M. asterias*. Previous analyses of the UK (Northern Ireland) western IBTS Q4 survey of the Irish Sea indicated increasing catch rates, but recent data have not been analysed.

Although smooth-hounds are not usually subject to additional biological sampling in trawl surveys, UK (England and Wales) and IGFS surveys tag and release *M. asterias*, and the individual weights and sex (all fish) and maturity (male fish only) are recorded prior to release (See Section 21.7.5).

21.6.3 Data quality

Exploratory analyses of DATRAS data (numbers at length data, 1992–2017) indicated that there might be some confounded data for *Mustelus* and *Galeorhinus*, which could be due to taxonomic or coding errors.

Exploratory data checks indicated the minimum and maximum recorded sizes of *Mustelus* spp. in IBTS-Q1 were 24 cm L_T and 129 cm L_T , respectively (1992–2017). While the record of 129 cm L_T is questionable, it is also potentially valid, given the range in reported L_{max} for the species. All nations recorded a minimum size of free-living pups that was greater than the length of the smallest neonates recorded by McCully Phillips and Ellis (2015), and are therefore within the accepted range.

Exploratory data checks indicated the minimum and maximum recorded sizes of *Mustelus* spp. in IBTS-Q3 were 22 cm L_T and 149 cm L_T , respectively (1992–2016). The minimum lengths observed by each nation (22–70 cm L_T) were within acceptable limits. During 1992–2016, most nations caught *Mustelus* spp. to a maximum length of 97–110 cm L_T , with one vessel (DAN) recording specimens larger than 110 cm L_T , with a maximum length of 149 cm L_T (Figure 21.11). These

² This survey may also be referred to as ‘Q1SWECOS’, ‘Q1SWBEAM’, ‘BTS-UK-Q1’ in other ICES-related documents.

data indicate that there seems to be inter-annual variation in the species of triakid sharks caught (for specimens >110 cm L_T; Figure 21.12), and suggest that DATRAS data for *Mustelus* and *Galeorhinus* are confounded for DAN. Further analyses of these data are required in order to determine whether it is a coding error or misidentification, and also to determine the extent of this issue. Similarly, some large catches linked to a single vessel would benefit from additional investigation.

For stock assessment purposes in 2021, IBTS-Q1 and IBTS-Q3 indices were both based on data held on DATRAS, with IBTS-Q1 including data from all countries, IBTS-Q3 excluded Danish data.

In 2021, the indices used in the assessment for EVHOE-WIBTS-Q4 were calculated using data currently available on DATRAS whereas in 2019, these were calculated using data held in the national database. The main differences between the two datasets relate to 2009 and 2010, as data currently on DATRAS show no *Mustelus* caught contrary to the national database. However, these discrepancies will not affect the ratio of the mean of the last two values (index A) and the mean of the five preceding values (index B) used in the assessment.

Although discussions during WSKATE highlighted the importance of using DATRAS datasets as opposed to national databases, discrepancies in species mapping remain in the historical data for the BTS-UK(E&W)-Q3 (in 7.afg) survey series on DATRAS (e.g. *Scyliorhinus stellaris*). Thus, to make calculations comparable across sharks and skate species (with the latter shown in Silva and Ellis, 2020a WD), survey indices for BTS-UK (E&W)-Q3 (in 7.afg) relate to national data (Silva and Ellis, 2021 WD).

In 2021, BTS-ENG-Q3 (in 7.d and 4.c) indices were calculated using DATRAS exchange data following recommendations from WSKATE. Indices provided to the WGEF in 2021 used a selection of fixed (prime) stations within DATRAS exchange data. The stations chosen for the calculations were the same as those held within national database (Silva and Ellis, 2020b WD; ICES, 2021b).

21.7 Life-history information

Biological data are not collected under EU-MAP, although some *ad hoc* data are collected on fishery-independent surveys and there are several published studies resulting from biological investigations of *Mustelus* spp. in European seas, including from the NE Atlantic (e.g., Farrell *et al.*, 2010a; McCully Phillips and Ellis, 2015) and Mediterranean Sea (e.g., Capapé, 1983; Saidi *et al.*, 2008).

21.7.1 Habitat

The spatial distribution of *Mustelus asterias* around the British Isles has been described by several authors (e.g., Brevé *et al.*, 2016; Griffiths *et al.*, 2020), with more detailed studies being undertaken on habitat utilization in the eastern English Channel (see Martin *et al.*, 2010; 2012).

21.7.2 Spawning, parturition and nursery grounds

Mustelus asterias pups are taken in trawl surveys (including beam trawl surveys), and such data may assist in the preliminary identification of pupping and primary nursery grounds. Most of the records for *M. asterias* pups recorded in UK beam-trawl surveys are from the southern North Sea, English Channel (including near the Solent) and Bristol Channel (Ellis *et al.*, 2005). Studies on other species of smooth-hound have shown high site fidelity of immature individuals to nursery grounds (Espinoza *et al.*, 2011).

Recent biological studies have indicated that full-term pups of *M. asterias* range in size from 205–329 mm L_T and that pup size is positively correlated with maternal length (McCully Phillips and Ellis, 2015; Figure 21.13). The smallest free-swimming neonate reported by this study was 24 cm L_T .

Parturition of *M. asterias* occurred in February in the western English Channel and June–July in the eastern English Channel and southern North Sea (Figure 21.14), indicating either protracted spawning or asynchronous parturition for the stock (McCully Phillips and Ellis, 2015).

21.7.3 Age and growth

Mustelus asterias

Farrell *et al.* (2010a) studied age and growth in the Celtic Seas ecoregion. Growth parameters for males ($n = 106$) were $L_\infty = 103.7$ cm L_T , $L_0 = 38.1$ cm and $k = 0.195$ year⁻¹. Growth parameters for females ($n = 114$) were $L_\infty = 123.5$ cm L_T , $L_0 = 34.9$ cm and $k = 0.146$ year⁻¹. Estimates of longevity were 13 years and 18.3 years for males and females, respectively. The lengths-at-age for *M. asterias* based on these growth parameters are given in Table 21.3.

An analysis of samples collected in waters around the British Isles between 2009–2019 provides preliminary estimates of $L_\infty = 94.6$ cm for males ($n = 159$, $L_T = 24$ –100 cm ages 0–14) and $L_\infty = 130.1$ cm for females ($n = 163$, $L_T = 28$ –124 cm ages 0–17) (Ellis *et al.*, 2019 WD), although it should be noted that this study had more fish at age 0. Further work is required to evaluate the estimated ages, and in terms of stock assessment modelling, the results of Farrell *et al.* (2010a) should still be used.

Mustelus mustelus

Age and growth have been reported for South African waters, with males and females estimated to mature at 6–9 and 12–15 years, respectively (Goosen and Smale, 1997). The maximum age reported in this study was 24 years.

21.7.4 Reproductive biology

Mustelus asterias

Studies in the Celtic Seas ecoregion indicated that the total length (and age) at 50% maturity for male and females was 78 cm L_T (4–5 years) and 87 cm L_T (six years), respectively (Farrell *et al.*, 2010b). A subsequent study in the southern North Sea and English Channel, estimated 50% maturity for males at 70.4 cm L_T (smallest mature = 65 cm; largest immature = 74 cm) and females at 81.9 cm L_T (smallest mature = 69 cm; largest immature = 87 cm) (McCully Phillips and Ellis, 2015; Figure 21.15). An analysis of samples collected between 2009–2019 by fishery-independent trawl surveys conducted by Cefas in waters around the British Isles estimated 50% maturity for males at 73.5 cm L_T (smallest mature = 64 cm; largest immature = 99 cm), with 100% maturity attained at ca. 90 cm, and females at 85.4 cm L_T (smallest mature = 75 cm; largest immature = 91 cm), with 100% maturity attained at ca. 92 cm (Ellis *et al.*, 2019 WD).

The smallest mature female that Farrell *et al.* (2010b) reported was 83 cm; considerably larger than the smallest females (69 cm and 75 cm L_T ; summarised above) recorded by McCully Phillips and Ellis (2015) and Ellis *et al.* (2019 WD). This is interesting because the studies use slightly different maturity keys; Farrell *et al.* (2010b) assigning a female to be mature when oocytes were present, yellow, and countable at >3 mm in diameter, whereas the Cefas maturity keys (Table II of McCully Phillips and Ellis, 2015), which are comparable to those keys developed within ICES, assigned a female as mature when the oocytes are slightly larger (>5 mm).

Estimates of fecundity range from 8–27 (ovarian fecundity) and 6–18 (embryonic fecundity), with a gestation period of about twelve months (Farrell *et al.*, 2010b). There may also be a resting period of a year between pregnancies, giving a two-year reproductive period. Mature female specimens sampled by McCully Phillips and Ellis (2015) included seventeen late gravid females with term pups (uterine fecundity 4–20), which were found to have numerous yolk-filled follicles ($n = 6\text{--}22$; follicle diameters 6–10 mm). Further studies, including more samples of fish from winter and spring are required to better gauge the reproductive period.

The number of mature follicles ranged from 0–28 in the mature females (McCully Phillips and Ellis, 2015). These will not all necessarily develop into embryos, however, and estimates of ovarian fecundity are known to exceed estimates of uterine fecundity. The size-spectra of the mature follicles (within mature females) ranged from 4.1 mm (mid-term gravid female) to 20.7 mm (mature female).

The uterine fecundity increased with total length and ranged from 4–20 (McCully Phillips and Ellis, 2015), which exceeded the maximum uterine fecundity (18) found by Farrell *et al.* (2010b). That said, Farrell *et al.* (2010b) did state that their values may be underestimated due to females aborting pups on capture. The female identified with a fecundity of 20 was found with full-term pups. Furthermore, there were also positive linear relationships identified between maternal length and average pup length and weight (Figure 21.13; McCully Phillips and Ellis, 2015).

A combined dataset on uterine fecundity, using data from Henderson *et al.* (2003), Farrell *et al.* (2010b), McCully Phillips and Ellis (2015) and additional samples collected during fishery-independent trawl surveys conducted by Cefas is given in Table 21.4 (Ellis *et al.*, 2019). Of the 74 early- to late-gravid females in this combined study, the uterine fecundity ranged from 2–20 (mean = 8.5) which is similar to the initial studies of subsets of this combined dataset (summarised above). Uterine fecundity (F) had a linear relationship with L_T , as described by the equation $F = 0.28390.L_T - 19.18583$ ($n = 74$; $r^2 = 0.4295$; Figure 21.16).

In the Mediterranean Sea, *Mustelus asterias* reach maturity at about 75 cm (males) and 96 cm (females), with estimates of fecundity ranging from 10–45 (ovarian fecundity) and 10–35 (uterine fecundity). Again, fecundity is found to increase with length (Capapé, 1983), although it is possible the higher fecundity in this study may relate to data being confounded with other species of smooth-hound.

Mustelus mustelus

Studies in the Mediterranean Sea have found that females matured at 107.5–123 cm L_T (50% maturity at 117.2 cm) and that males matured at 88–112 cm L_T (50% maturity at 97.1 cm) (Saidi *et al.*, 2008). This study also found that embryonic fecundity ranged from 4–18 embryos, with fecundity increasing with length. Further south off Senegal, the lengths at first (and 100%) maturity for *M. mustelus* were found to be 82 cm (95 cm), for males, and 95 cm (104 cm) for females (Capapé *et al.*, 2006). This study reported litters of 4–21 pups.

21.7.5 Movements and migrations

Mustelus asterias

Although the movements and migrations of *M. asterias* are not fully known, there have been relatively high numbers tagged and released during various elasmobranch research programmes (e.g., Burt *et al.*, 2013 WD, Ellis *et al.*, 2019 WD Figure 21.17). A tagging programme (2011–2014) undertaken by Sportvisserij Nederland, in conjunction with Wageningen Marine Research, involved anglers tagging *M. asterias* in the Dutch Delta. There were 2244 releases and 80 recaptures (Figure 21.18; Brevé *et al.*, 2016). Recapture positions indicated circannual migrations between summertime grounds in the southern North Sea and overwintering grounds in the

English Channel and Bay of Biscay, suggesting a degree of philopatry (Brevé *et al.*, 2016). This is an on-going tagging programme, and more recently Brevé *et al.* (2020) reported that during 2011–2019 a total of 3699 *M. asterias* were released, of which 220 recaptures were reported (ca. 5.9% return rate). The recent results support previous work from Brevé *et al.* (2016).

Cefas have tagged-and-released specimens of *M. asterias* from fishery-independent trawl surveys since 2003 (Burt *et al.*, 2013). In 2019, a total of 1613 (744 females and 868 males, one unsexed) had been tagged and released, of which 40 (2.48%) have been recaptured and details returned (Ellis *et al.*, 2019 WD). Results suggest that the species is wide ranging in northern European seas and displays seasonal migrations, which are likely related to its reproductive cycle (Figure 21.17; Ellis *et al.*, 2019 WD). An electronic tagging programme initiated by Cefas in 2017–2019 deployed 125 tags with a return rate of 14.4% to date. On a broad-scale, sex-biased dispersal, and potential metapopulation-like stock structuring either side of the UK continental shelf was seen along with clear diel variation in vertical activity and association with the seabed (Griffiths *et al.*, 2020).

21.7.6 Diet and role in ecosystem

Mustelus asterias is primarily carcinophagous (98.8% percentage of index of relative importance, %IRI), with the two main prey species being hermit crab *Pagurus bernhardus* (34% IRI) and flying crab *Liocarcinus holsatus* (15% IRI) in specimens from the Northeast Atlantic (McCully Phillips, *et al.*, 2020). Ontogenetic dietary preferences showed that smaller individuals [20–69 cm total length (L_T)] had a significantly lower diversity of prey than larger individuals (70–124 cm L_T) and similarly, specimens from the North Sea ecoregion had a lower diversity of prey types for a given sample size than fish from the Celtic Seas ecoregion (McCully Phillips, *et al.*, 2020). This study did not find any fish remains in the examination of 640 stomachs, however Ford (1921) and Ellis *et al.*, (1996) found that teleosts were only eaten occasionally by larger individuals. Larger individuals could be important predators of commercial crustaceans, feeding on velvet swimming crab *Necora puber* and small edible crab *Cancer pagurus* (McCully Phillips, *et al.*, 2020).

Other studies on the feeding habits of *Mustelus* also indicate a high proportion of crustaceans in the diet (Morte *et al.*, 1997; Jardas *et al.*, 2007; Santic *et al.*, 2007; Saidi *et al.*, 2009; Lipej *et al.*, 2011; Poiesz *et al.*, 2021; Biton-Porsmoguer 2022).

The trophic level of specimens from the Northeast Atlantic was calculated as 4.34 when species-level prey categories were used; a value higher than previously indicated by other studies (Cortés, (1999; 3.7), Cotter *et al.* (2008; 3.9), and Pinnegar *et al.* (2002; 4.0)). These differences are due to the high trophic levels of their preferred crustacean prey (McCully Phillips, *et al.*, 2020). These findings will have ramifications for food web and ecosystem modelling, with the role of this species potentially underestimated to date.

21.7.7 Conversion factors

The relationship between total length and weight in smooth-hounds sampled by McCully Phillips and Ellis (2015) are summarised by sex and maturity stage in Table 21.5 (see also figures 21.20 and 21.21).

The relationship for males differed slightly to that of females, largely driven by the larger maximum length of females and the weight of females about to give birth. Of note is the 119 cm outlier, which was a post-partum female with a very low body mass. Samples of the smaller size classes were obtained from scientific trawl surveys, while the larger individuals were commercially-landed specimens.

Recent data on overall length-weight relationships for male and female *M. asterias* caught between 2009–2019 by Cefas fishery-independent trawl surveys around the British Isles are illustrated in Figure 21.19.

21.8 Exploratory assessment models

21.8.1 Previous studies

No previous assessments of NE Atlantic smooth-hounds have been made. However, there have been assessment methods developed for the Australian species *Mustelus antarcticus* (e.g. Xiao and Walker, 2000; Pribac *et al.*, 2005) which could be applied to the European species when relevant data are available.

21.8.2 Data exploration and preliminary assessments

An analytical age-, sex-, and length-structured assessment model was explored for *M. asterias* following the approach of De Oliveira *et al.* (2013) for spurdog, however, further work is required.

21.9 Stock assessment

No quantitative stock assessment is available.

Since 2015, the stock of *M. asterias* in northern Europe was evaluated using trends from fishery-independent trawl surveys, as these are the longest time-series of standardised species-specific data available.

The biomass trends of the long-term time-series of five different surveys covering a large proportion of the species distribution range were used in the 2021 assessment (IBTS-Q1, IBTS-Q3, EVHOE-WIBTS-Q4, CGFS-Q4 and IGFS-WIBTS-Q4).

IBTS-Q1 and IBTS-Q3

Data from the two North Sea IBTS were used (see Section 15 for further details). These surveys sample the more northerly parts of the stock area. The biomass index of specimens ≥ 50 cm L_T of *Mustelus* spp. was used, though the GOV samples mostly larger fish (Figure 21.6). Data from Denmark were excluded in analyses for the IBTS-Q3, due to the suspicion that data for *Mustelus* and *Galeorhinus* were confounded (see Section 21.6.3). The temporal trends in abundance, total biomass, and exploitable biomass (specimens ≥ 50 cm L_T) all showed similar patterns (Figure 21.6).

EVHOE-WIBTS-Q4

A biomass index of specimens ≥ 50 cm L_T of *Mustelus* spp. from the EVHOE-IBTS-Q4, was included in the 2021 assessment. This survey covers more south-western parts of the stock area (divisions 8.a.b.d; Figure 21.7). Data were available for 1997–2020 (excluding 2017) and indicate an increasing total and exploitable biomass. The total biomass was calculated using the weight from on-board catch weight per species, as no individual weights were available for most years. Exploitable biomass (specimens > 50 cm L_T) was calculated using the length-weight relationship with $W_T = 0.0016 \cdot L_T^{3.1753}$.

CGFS-Q4

A biomass index of specimens ≥ 50 cm L_T of *Mustelus* spp. from the CGFS-Q4, was included in the 2021 assessment. This survey covers the eastern English Channel part of the stock area (Division 7.d; Figure 21.7). Data were available for 1997–2020 and indicate an increasing total and exploitable biomass. However, in 2020 the survey did not cover part of the survey grid (ICES rectangles 29F1 and 30E9). Consequently, four scenarios were run to evaluate the overall impact on the stock size indicator:

1. CGFS-Q4 time series excluded;
2. CGFS-Q4 included for the whole time series (1997–2020) and all available survey data;
3. CGFS-Q4 included for 1997–2019 with 2020 data excluded;
4. CGFS-Q4 included for the whole time series (1997–2020) excluding data from survey stations in ICES rectangles 29F1 and 30E9.

Results show that in all four scenarios there would be an increase in the stock size indicator. However, when excluding the CGFS-Q4 time series (scenario 1) the increase would be less pronounced compared to the other three scenarios (Table 21.6). The remaining scenarios show negligible impact on the overall stock size indicator thus, the EG agreed to use all data available for this survey time-series in the assessment (Table 21.6, Figure 21.25).

IGFS-WIBTS-Q4

Although the inclusion of this survey reduces the common time frame from 1997–2020 to 2005–2020, it covers the north-western parts of the stock area (divisions 6.a and 7.b.g.i) and was therefore used in 2021 assessment. The biomass index of specimens ≥ 50 cm L_T of *Mustelus* spp. was used, though the GOV samples mostly larger fish (Figure 21.6). Data indicate increasing total and exploitable biomass, though the variation is greater in recent years (Figure 21.10).

Summary

The stock size indicator is based on ‘exploitable biomass’ (individuals ≥ 50 cm total length). The inclusion of additional surveys such as the IGFS-WIBTS-Q4 truncates the common time period from 1997–2020 to 2005–2020, however, it does extend the spatial range. IBTS-Q1 and IBTS-Q3 were averaged prior to standardised to the long-term mean, and are therefore treated as a single survey following recommendations from WSKATE (ICES, 2021b). The remaining three survey indices were also standardised in relation to their long-term mean. The average of the four surveys was used to derive an annual index of stock size. In 2017, EHVOE-WIBTS-Q4 did not occur and the average for the annual index of stock size was based on the other surveys. All four surveys were given equal weighting. The mean index for the years 2019–2020 was 1.76, whilst the mean index for the preceding five years (2014–2018) was 1.42 (Figure 21.22; Table 21.7). CGFS-Q4 in 2020 was included in 2021 assessment as reduction in the survey area was found to have negligible impact on the index ratios (Table 21.6, Figure 21.25).

The BTS-UK (E&W)-Q3 and BTS-Eng-Q3 surveys primarily sample juvenile *M. asterias*, and so in 2021 were excluded from the assessment. However, data are informative for pup abundance (Figure 21.23), and thus it may be possible to develop an index of recruitment from such surveys in the future.

Further studies to better quantify differences between ‘total biomass’ and ‘exploitable biomass’ are still to be undertaken. Such work could usefully be appraised during a dedicated workshop for smooth-hounds *Mustelus* spp. and tope *Galeorhinus galeus* as recommended during WSKATE (ICES, 2021b). Furthermore, the suitability of statistical modelling to provide a single survey index and associated confidence intervals, similar to work developed for spurdog during the benchmark in 2021 (ICES, 2021a), could usefully be examined for *Mustelus*. This would allow

for the potential use of multiple surveys while accounting for potential differences (e.g., season, design, gear, depth, sex, length class).

21.10 Quality of the assessment

Commercial landings data are available for recent years but may be compromised by poor data quality. Whilst fishery-independent trawl surveys provide the best time-series information, such surveys may under-represent the largest size classes. It is unclear as to how recent increases in CPUE may relate to increased stock abundance and/or a possible northward shift in distribution.

The positions of survey hauls containing smooth-hounds in the EVHOE-WIBTS-Q4 survey were plotted over the 1997–2019 time-series (Figure 21.24). The number of stations catching smooth-hounds increased over the survey, but the distribution of the catches has remained constant, occurring north of 46°N. There was no evidence from this survey to support the theory of a northward shift in the distribution, which would support the suggestion that increasing catch rates reflect population growth.

21.11 Reference points

No reference points have been determined for this stock.

21.12 Conservation considerations

The most recent IUCN Red List Assessment for European marine fishes (Nieto *et al.*, 2015) upgraded all three *Mustelus* spp. to either Near Threatened (*M. asterias*) or Vulnerable (*M. mustelus* and *M. punctulatus*), identifying them as of increasing conservation interest. These species were listed previously as either Data Deficient or Least Concern (Gibson *et al.*, 2008).

21.13 Management considerations

Smooth-hounds appear to be increasing in relative abundance in trawl surveys, and in commercial landings data. Given the potential expansion in fisheries for smooth-hounds (which may reflect an increased abundance and/or an increase in fishing opportunities due to restrictions on *S. acanthias*), further studies to understand the dynamics, distribution and geographic boundaries of this stock are required.

Smooth-hounds taken by beam trawl are primarily juveniles and subadults (<70 cm L_T), and these are often discarded, as are smooth-hounds <50 cm L_T in otter trawl fisheries. Discard survival has not been quantified for many métiers, and survival is variable in this family (Ellis *et al.*, 2014 WD). Further studies on at-vessel mortality and post-release mortality, including of juveniles, are needed.

Survey data are available, and the quality of landings data is thought to be improving. Whilst there have been several recent biological investigations (Farrell *et al.*, 2010a, b; McCully Phillips and Ellis, 2015), there is still uncertainty in some key biological parameters, including the duration of the reproductive cycle.

Smooth-hounds are also an important target species in some areas for recreational fisheries; despite this there remains insufficient data to examine the relative economic importance of these fisheries, or the degree of mortality associated with recreational fisheries.

Other species of smooth-hound are targeted elsewhere in the world, including Australia/New Zealand and South America. Although smooth-hounds are generally quite productive stocks

(relative to some other elasmobranchs), evidence from these fisheries suggests that various management controls can be considered appropriate.

21.14 References

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Table 21.1. Smooth-hounds in the Northeast Atlantic. ICES estimated landings (t) for the period 1973–2021. Data from 1973–2014 are considered underestimates as some smooth-hounds are landed under generic landings categories. Data from 2005 onwards were revised following the 2016 Data Call (see ICES, 2016a); previous estimates are provided in brackets (2005–2014). Species-specific landings data are not available for the Mediterranean Sea and are limited for the north-west African waters. Blank = no data reported; 0 < 0.5 tonnes.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Belgium														
Germany														
Denmark														
Spain														
France	0	0	0	0	0	0	32	0	0	222	218	66	143	167
UK*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland														
Netherlands														
Portugal														
Total	0	0	0	0	0	0	32	0	0	222	218	66	143	167
	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
Belgium														
Germany														
Denmark														
Spain														
France	119	64	117	126	93	90	102	138	145	228	187	197		0
UK*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland														
Netherlands														
Portugal														
Total	119	64	117	126	93	90	102	138	145	228	187	197		0

*Data from 1973–2014 were previously separated into UK –E, W & NI and UK – Scotland (ICES, 2021c) but have been merged into UK.

Table 21.1. Continued. Smooth-hounds in the Northeast Atlantic. ICES estimated landings (t) for the period 1973–2021. Data from 1973–2014 are considered underestimates as some smooth-hounds are landed under generic landings categories. Data from 2005 onwards were revised following the 2016 Data Call (see ICES, 2016a); previous estimates are provided in brackets (2005–2014). Species-specific landings data are not available for the Mediterranean Sea and are limited for the north-west African waters. Blank = no data reported; 0 < 0.5 tonnes.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Belgium														1	1
													(8)	(10)	(1)
Germany															
Denmark															
Spain**						112	134	138	200	297	129 (34)	106 (48)	120 (9)	80 (83)	70 (14)
France	306	377	585	589	682	2685 (767)	2722 (714)	2958 (908)	3403 (522)	3082 (926)	3204 (969)	3241 (706)	2821 (2695)	2942 (2955)	2836 (2825)
UK*	14	0	0	0	0	171 (0)	130 (0)	155 (0)	171 (115)	199 (133)	275 (161)	315 (919)	339 (337)	325 (323)	331 (647)
Ireland								0	1	0	0	0			0
Netherlands										4	9 (8)	3 (3)	23 (11)	26 (20)	24 (15)
Portugal						44	57	57	41	45	38	43 (35)	42 (42)	41 (41)	17 (187)
Total***	320	377	585	589	682	3013 (767)	3043	3308 (908)	3816 (637)	3628 (1059)	3655 (1172)	3709 (1712)	3345 (3101)	3415 (3433)	3280 (3690)

*Data from 1973–2014 were previously separated into UK –E, W & NI and UK – Scotland (ICES, 2021c) but have been merged into UK. **Data not available for Area 34 and 37 in 2015–2021; ***Includes negligible landings reported to Fishing Area 34 and 37 (ca. 0.0–2.4% of the total annual estimated landings).

Table 21.1. Continued. Smooth-hounds in the Northeast Atlantic. ICES estimated landings (t) for the period 1973–2021. Data from 1973-2014 are considered underestimates as some smooth-hounds are landed under generic landings categories. Data from 2005 onwards were revised following the 2016 Data Call (see ICES, 2016a); previous estimates are provided in brackets. Species-specific landings data are not available for the Mediterranean Sea and are limited for the north-west African waters. Blank = no data reported; 0 < 0.5 tonnes.

	2015	2016	2017	2018	2019	2020	2021
Belgium	1	3	2	1	1	3	4
Germany					1		
Denmark		0	0	1	0	0	
Spain**	42	40	43	38	30	41	28
France	2963	2855	2730	3136	2934	2665	3195
UK*	303	469	376	390	474	405	470
Ireland	0						0
Netherlands	24	22	22	34	74	91	62
Portugal	15	18	55	51	53	64	54
Total***	3349	3407	3228	3651	3567	3177	3814

Data not available for Area 34 and 37 in 2015–2021; *Includes negligible landings reported to Fishing Area 34 and 37 (ca. 0.0-2.4% of the total annual estimated landings).

Table 21.2. Smooth-hounds in the Northeast Atlantic. Preliminary discards estimates (t) by country for the period 2009–2021. Blank = no data reported; 0 < 0.5 tonnes.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Denmark	0	1	0		0	0	1	25	0	3	9	3	3
Spain											0		
France			441	204	308	508	320	510	874	284	464	357	319
UK	163	109	95	145	111	57	37	118	61	94	68	223	122
Ireland	26	39	33	56	31	29	15	119	43	27	6	36	
Netherlands			17	64	12	5	32	7	41	40	37	25	42
Portugal											0	0	
Total	189	149	586	469	462	599	405	779	1019	448	584	644	486

Table 21.3. Smooth-hounds in the Northeast Atlantic. Age-length key for *Mustelus asterias*, based on data given in Farrell *et al.* (2010a).

Age	Total length (cm)	
	Male	Female
0	38.1	34.9
1	49.7	46.9
2	59.3	57.3
3	67.2	66.3
4	73.6	74.1
5	79.0	80.8
6	83.3	86.6
7	86.9	91.6
8	89.9	95.9
9	92.4	99.7
10	94.4	102.9
11	96.0	105.7
12	97.4	108.1
13	98.5	110.2
14	99.4	112.0
15	100.2	113.6
16	100.8	114.9
17	101.3	116.1
18	101.7	117.1

Table 21.4 Smooth-hounds in the Northeast Atlantic. Fecundity at length data for *Mustelus asterias*, based on data given in Henderson *et al.* (2003), Farrell *et al.* (2010b), McCully Phillips and Ellis (2015) and Ellis *et al.* (2019 WD).

Source	Total length (cm)	Uterine fecundity	Maturity stage ³
Henderson <i>et al.</i> (2003)	87	10	D
	89	2	D
	109	10	D
Farrell <i>et al.</i> (2010)	83	6	
	90	8	
	91	7	
	92	4	
	94	7	
	97	6	
	97	9	
	100	9	
	103	14	
	104	7	
	106	7	
	106	11	
	108	10	
	111	18	
	112	9	
McCully Phillips & Ellis (2015)	80	4	D
	83	7	D
	86	10	E
	88	9	D
	90	7	D
	91	6	F
	92	6	D
	93	4	F
	96	14	F
	97	9	F
	97	5	E
	97	11	D
	98	10	F
	98	10	D
	101	7	F
	101	11	E
	101	10	F
	101	12	D
	102	11	F

³ Maturity stage as per described in McCully Phillips and Ellis, 2015.

Source	Total length (cm)	Uterine fecundity	Maturity stage ³
	103	12	F
	104	13	F
	105	17	F
	105	8	F
	106	11	F
	110	17	F
	115	12	F
	116	20	F
	116	15	E
	124	13	F
Cefas unpublished ⁴ in Ellis <i>et al.</i> (2019 WD)	101	5	F
Cefas (Ciro 2/02) in Ellis <i>et al.</i> (2019 WD)	88	4	D
	92	2	D
	93	2	D
	101	9	F
	111	14	F
Cefas trawl surveys (CEnd 2/13) in Ellis <i>et al.</i> (2019 WD)	93	4	F
	97	10	E
Cefas trawl surveys (CEnd 4/18) in Ellis <i>et al.</i> (2019 WD)	81	3	F
	85	5	F
	87	4	F
	88	4	F
	89	5	F
	89	5	F
	90	4	F
	90	6	F
	91	7	E
	93	8	F
	97	10	F
	99	9	F
	100	12	F
	101	4	F
Cefas trawl surveys (CEnd 3/19) in Ellis <i>et al.</i> (2019)	82	6	F
	99	10	F
	100	12	F
	100	9	E
	108	2	D

⁴ April 2019, 101 cm, 3671 g total weight

Table 21.5 Smooth-hounds in the Northeast Atlantic. Relationship between total length and weight in the smooth-hounds sampled by McCully Phillips and Ellis (2015)

Relationship $Y = ax^b$	Sex/Stage	a	b	r ²	n
Total weight to total length	All females	0.0014	3.2	0.992	248
	All males	0.0020	3.1	0.995	237
	Immature female (stage A/B)	0.0020	3.1245	0.994	170
	Immature male (stage A/B)	0.0014	3.2159	0.991	113
	Mature female (including early gravid) (stage C/D)	0.0021	3.1396	0.913	54
	Mature male (stage C/D)	0.0077	2.8084	0.938	123
	Mid-/late-term gravid females (stage E/F)	0.0002	3.7072	0.935	21
Gutted weight to total length	Sexes combined	0.0014	3.1580	0.995	484
	Female	0.0016	3.1	0.994	249
	Male	0.0014	3.2	0.996	235

Table 21.6 Smooth-hounds in the Northeast Atlantic. Index ratios based on the mean of the previous two years (Index A: 2019–2020) over the mean of the five preceding years (Index B: 2014 – 2018), depending on the fisheries-independent surveys and data considered. Note: Values as per ICES rounding rules. Option used in the assessment highlighted in bold.

Option	Time-series	Index A	Index B	Ratio A/B
As per advice in 2019 (IBTS-Q1, IBTS-Q3 and EHVOE-WIBTS-Q4)	1997–2020	2.5	1.73	1.43
Combined IBTS (Q1 and Q3) and EHVOE-WIBTS-Q4	1997–2020	2.4	1.88	1.30
Combined IBTS (Q1 and Q3), EHVOE-WIBTS-Q4 and IGFS-WIBTS-Q4	2005–2020	1.82	1.58	1.15
Combined IBTS (Q1 and Q3), EHVOE-WIBTS-Q4, IGFS-WIBTS-Q4 and CGFS-Q4 (incl 2020)	2005–2020	1.76	1.42	1.24
Combined IBTS (Q1 and Q3), EHVOE-WIBTS-Q4, IGFS-WIBTS-Q4 and CGFS-Q4 (excl 2020)	2005–2020	1.79	1.42	1.25
Combined IBTS (Q1 and Q3), EHVOE-WIBTS-Q4, IGFS-WIBTS-Q4 and CGFS-Q4 (excl ICES rectangles 29F1 and 30E9)	2005–2020	1.77	1.41	1.25

Table 21.7 Smooth-hounds in the Northeast Atlantic. Biomass indices for exploitable biomass (individuals of ≥ 50 cm total length) of starry smooth-hound derived from five surveys (average of NS-IBTS-Q1 and NS-IBTS-Q3, EVHOE-WIBTS-Q4, CGFS-Q4 and IGFS-WIBTS-Q4). The stock size indicator is the annual mean of the normalized surveys indices (2005–2020).

Year	NS-IBTS-Q1 Q3	EHVOE-WIBTS-Q4	CGFS-Q4	IGFS-WIBTS-Q4	Stock size indicator
2005	0.179	0.39	0.72	0.21	0.37
2006	0.52	0.196	1.00	0.26	0.49
2007	1.23	0.59	0.82	0.44	0.77
2008	0.62	1.23	1.01	0.37	0.81
2009	0.60	0.00	1.38	0.40	0.60
2010	0.69	0.00	0.82	0.75	0.57
2011	0.70	0.89	0.60	0.33	0.63
2012	0.74	0.84	0.75	0.61	0.73
2013	0.95	0.27	0.75	0.57	0.63
2014	1.24	1.14	0.57	1.02	0.99
2015	0.62	2.20	1.74	1.59	1.53
2016	0.86	1.99	1.09	2.20	1.54
2017	1.87	NA	0.97	2.50	1.79*
2018	1.08	1.79	0.67	1.41	1.24
2019	2.20	1.69	1.76	2.40	2.00
2020	1.86	1.85	1.34**	0.92	1.49

* In 2017, the stock size indicator does not include EHVOE-WIBTS-Q4 (Data not available).

** Only parts of the survey area covered during CGFS-Q4 though impact considered to be negligible for starry smooth-hound.

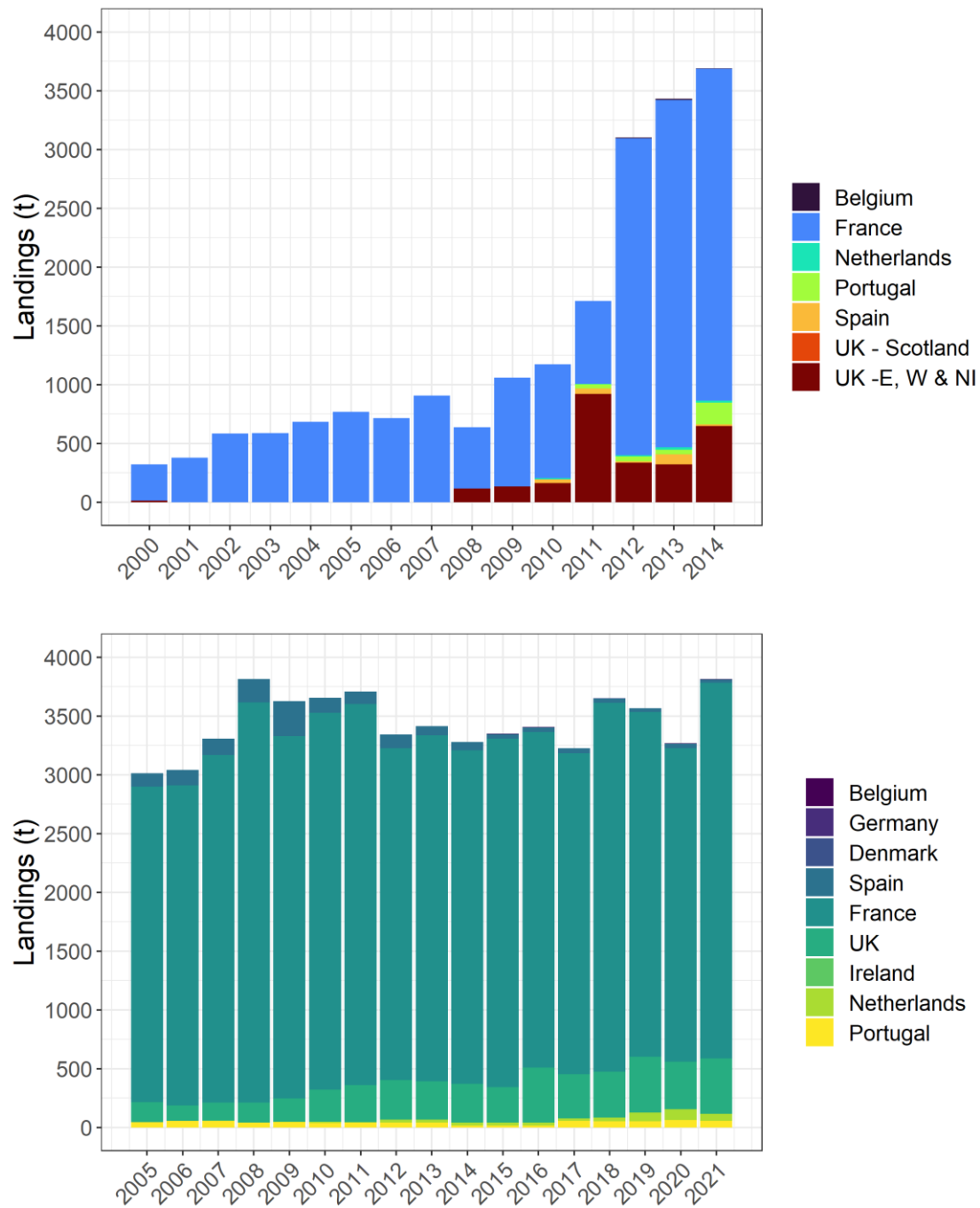


Figure 21.1. Smooth-hounds in the Northeast Atlantic. Earlier ICES estimates of overall *Mustelus* spp. landings by country (2000–2014; top) and revised ICES estimates (2005–2021; bottom). Data are considered underestimates.

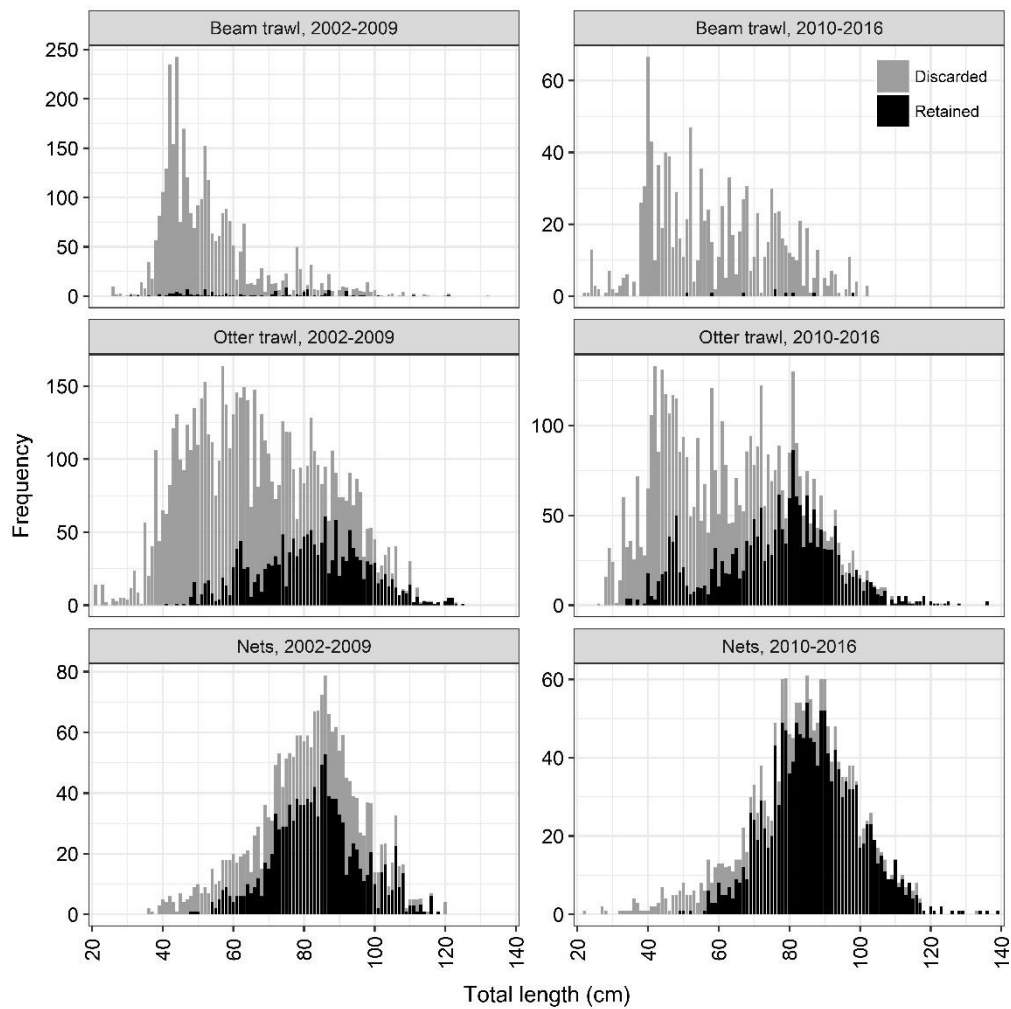


Figure 21.2. Smooth-hounds in the Northeast Atlantic. Length–frequency of discarded (pale grey) and retained (dark grey) starry smooth-hound *Mustelus asterias* caught by beam trawl, otter trawl and gillnets during the periods 2002–2009 and 2010–2016, as recorded in the Cefas observer programme. Data aggregated across North Sea and Celtic Seas ecoregions. (Source: Silva and Ellis, 2019).

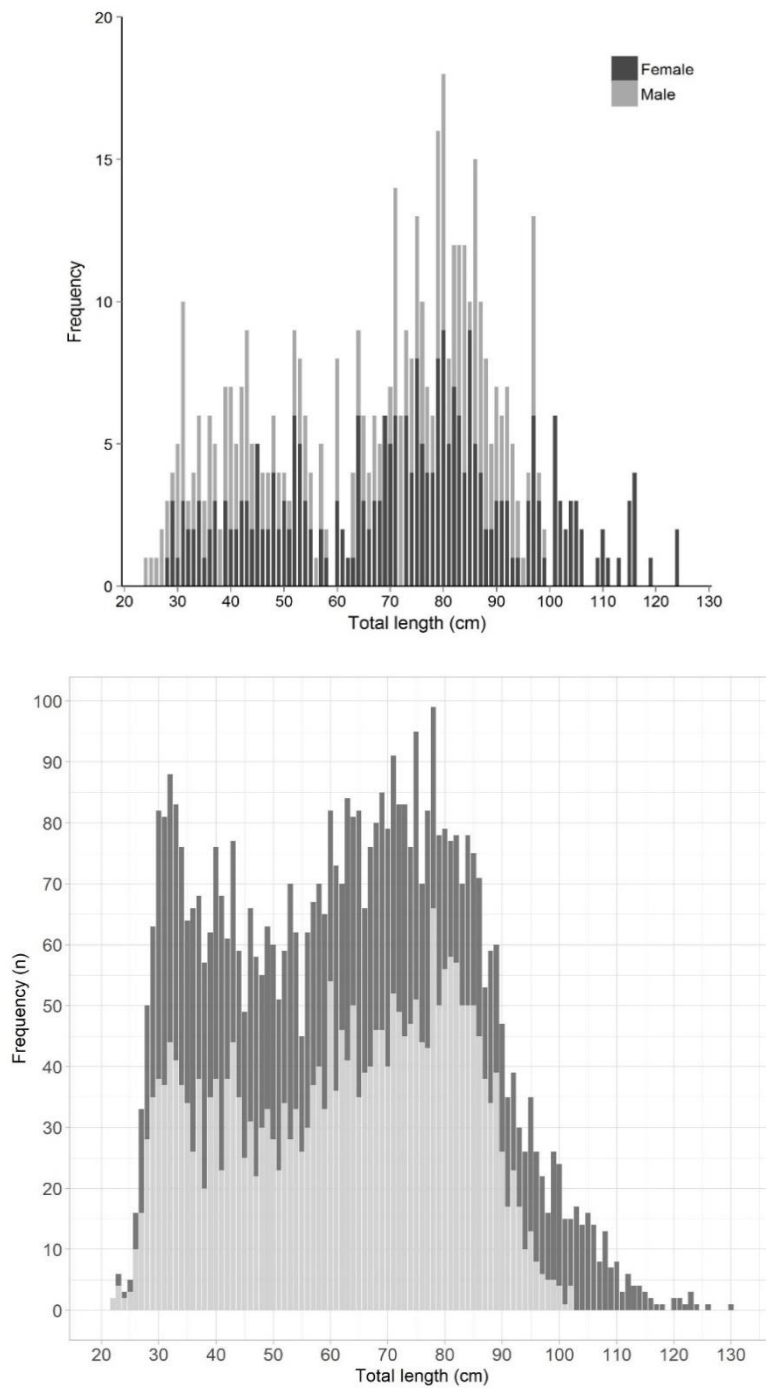


Figure 21.3. Smooth-hounds in the Northeast Atlantic. Number of starry smooth-hounds biologically sampled by length and sex (top; n = 504) from McCully Phillips and Ellis (2015) and (bottom; n = 4951) from Ellis *et al.* (2019 WD).

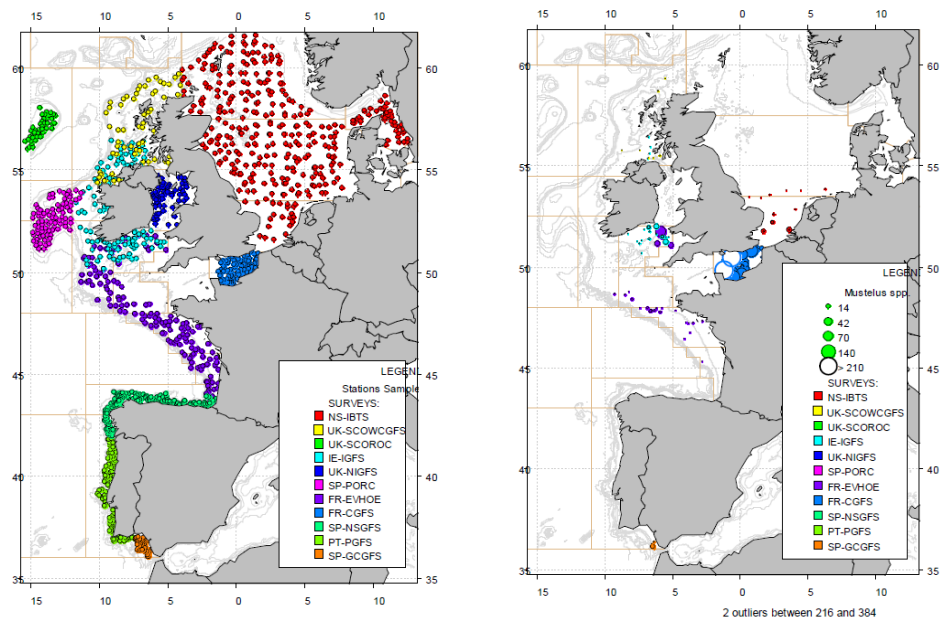


Figure 21.4. Smooth-hounds in the Northeast Atlantic. IBTS hauls undertaken in Q3 and Q4 2015 (left) and corresponding catches of *Mustelus* spp. (right). The catchability of the different gears used in the NE Atlantic surveys is not constant; therefore, the map does not reflect proportional abundance in all the areas but within each survey. Source: ICES (2016b).

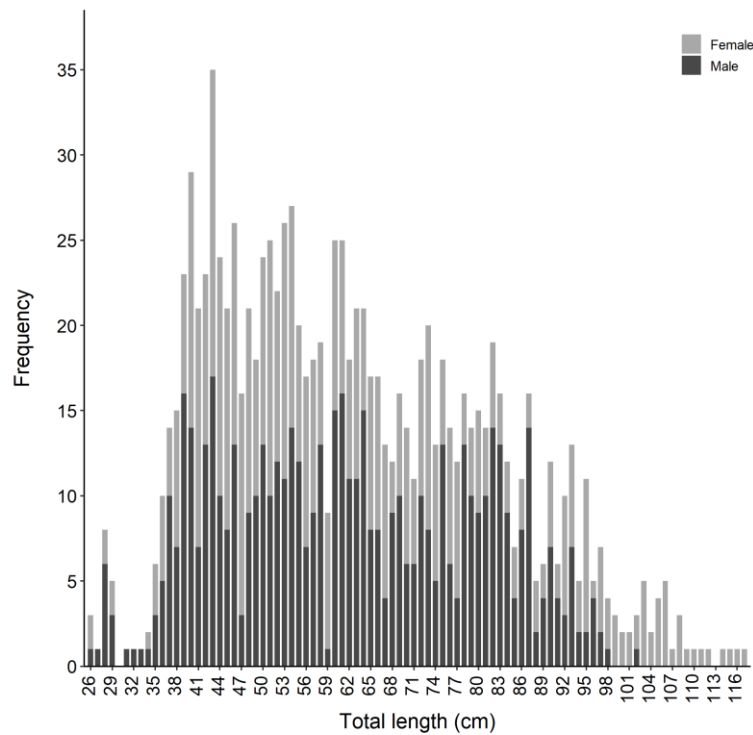


Figure 21.5. Smooth-hounds in the Northeast Atlantic. Length–frequency by sex of smooth-hounds *Mustelus* spp. encountered during the UK Western Channel Q1 Beam-trawl survey 2006–2019 (incorporating the Celtic Sea 2014–2019). Source: Silva *et al.* (2020 WD).

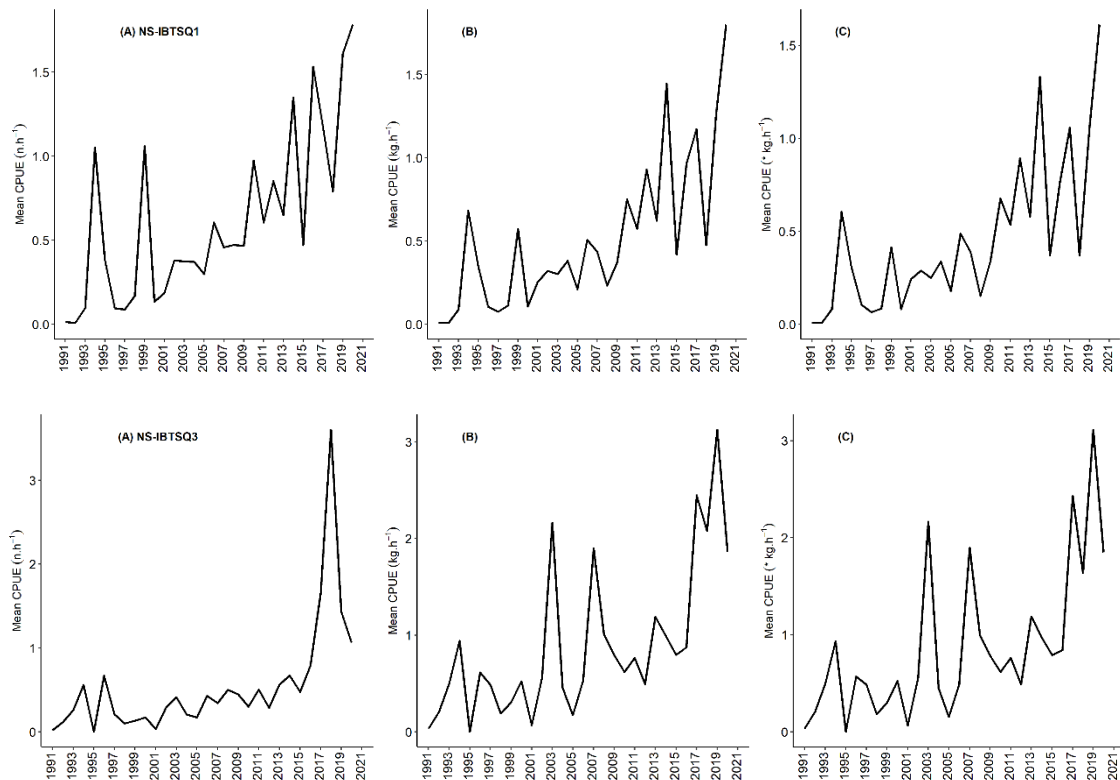


Figure 21.6. Smooth-hounds in the Northeast Atlantic. Survey indices (A - number per hour; B - estimated biomass per hour; and C - estimated exploitable biomass for individuals ≥ 50 cm total length) in IBTS-Q1 (top) and IBTS-Q3 (bottom) of the North Sea. Note: IBTS-Q3 excludes data for RV *Dana*. Updated survey index in 2021 for whole time series.

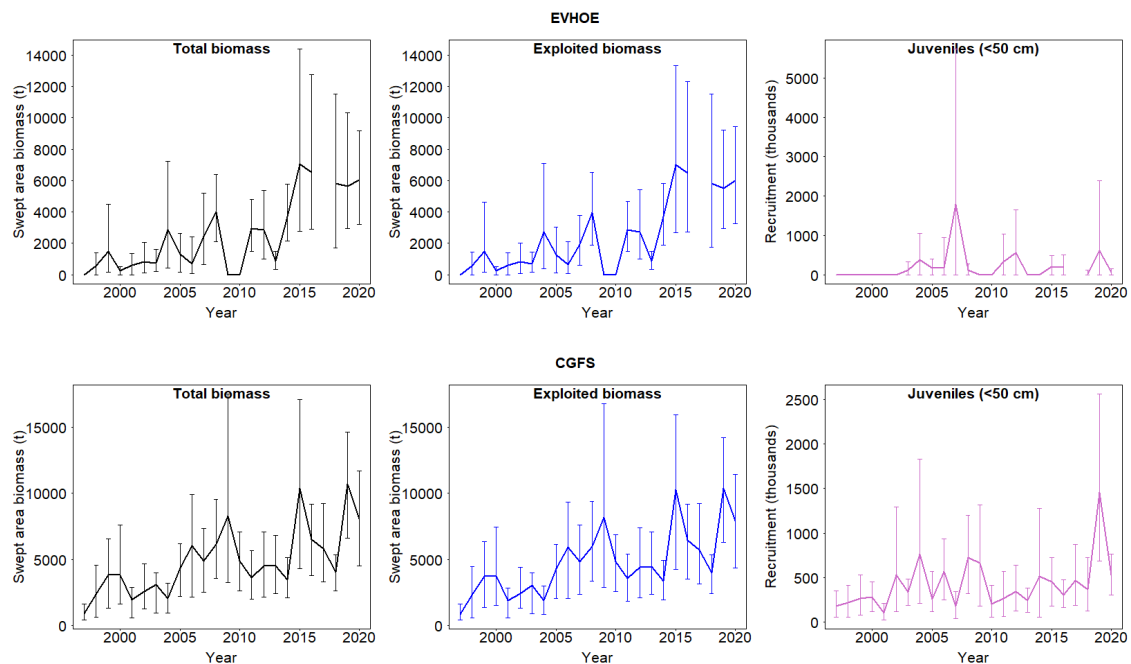


Figure 21.7. Smooth-hounds in the Northeast Atlantic. Swept area exploitable biomass index with 95% confidence intervals from the EVHOE-WIBTS-Q4 survey in divisions 7.g-j, 8.a.b.d (top) and CGFS-Q4 in Division 7.d (bottom). Note: EVHOE-WIBTS-Q4 indices updated in 2021 for whole time series, survey did not occur in 2017. Source: DATRAS.

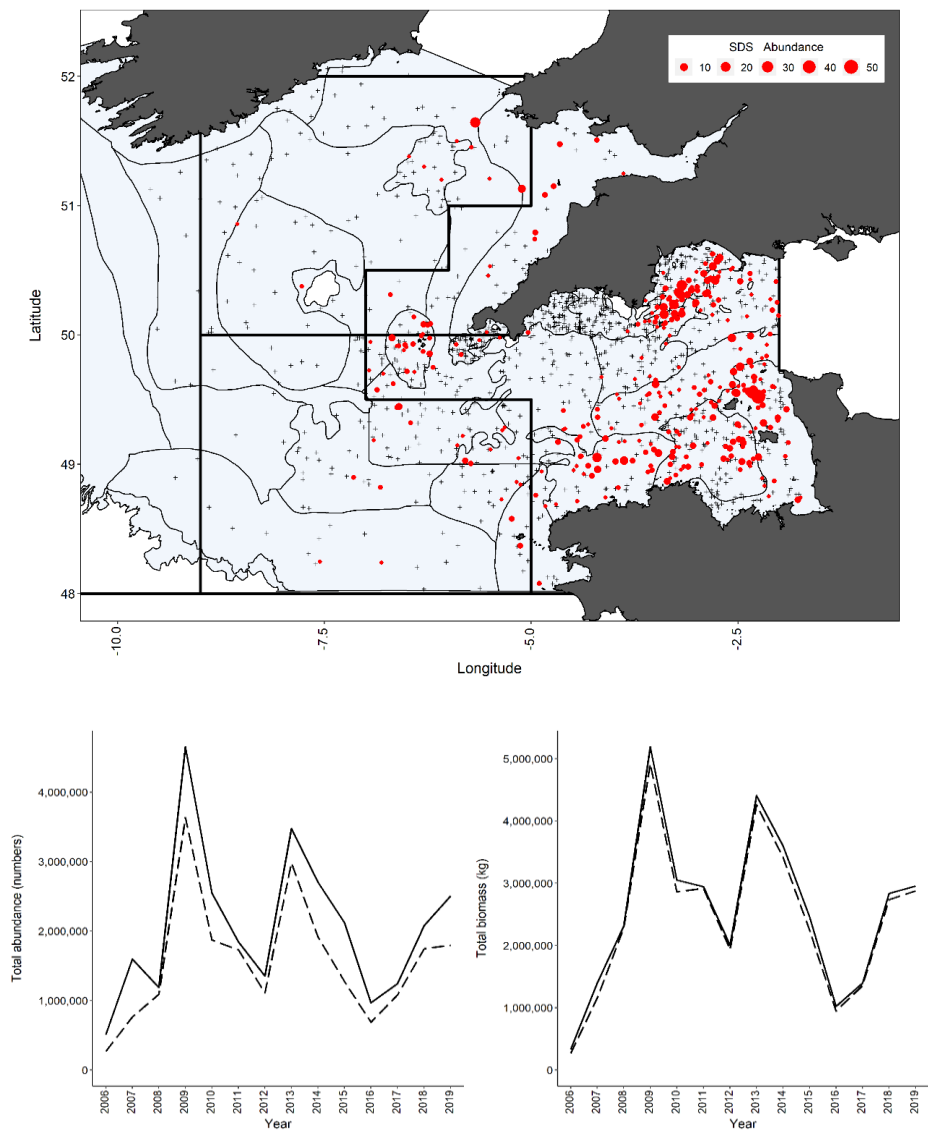


Figure 21.8. Smooth-hounds in the Northeast Atlantic. Survey grid of the UK-Q1SWBEAM survey (2006–2019) indicating the distribution and relative abundance of *Mustelus* spp. (top), and the total abundance (numbers in 7.e) and total biomass (kg in 7.e) for *Mustelus* spp (bottom). Continuous line relates to all specimens, dashed line relates to individuals ≥ 50 cm total length. Source: Silva *et al.* (2020 WD).

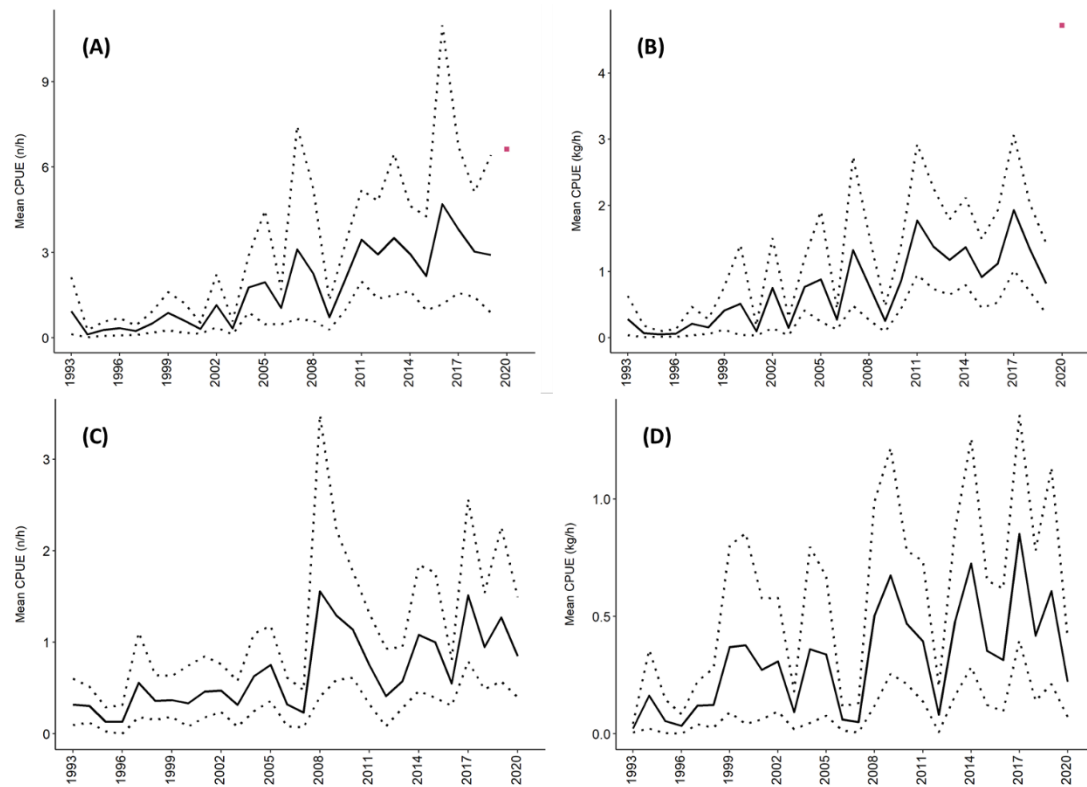


Figure 21.9. Smooth-hounds in the Northeast Atlantic. Survey indices and associated confidence intervals (number per hour for all individuals, estimated total biomass per hour and 95%CI) from BTS-UK (E&W)-Q3 in the Bristol Channel and Irish Sea (top, panel A and B) and BTS-Eng-Q3 in the eastern English Channel and southern North Sea (bottom, panel C and D). Note: 2020 value (top, panel A and B) shown as pink square without 95%CI should be viewed with caution (see Section 21.6.2). Survey indices were updated in 2021.

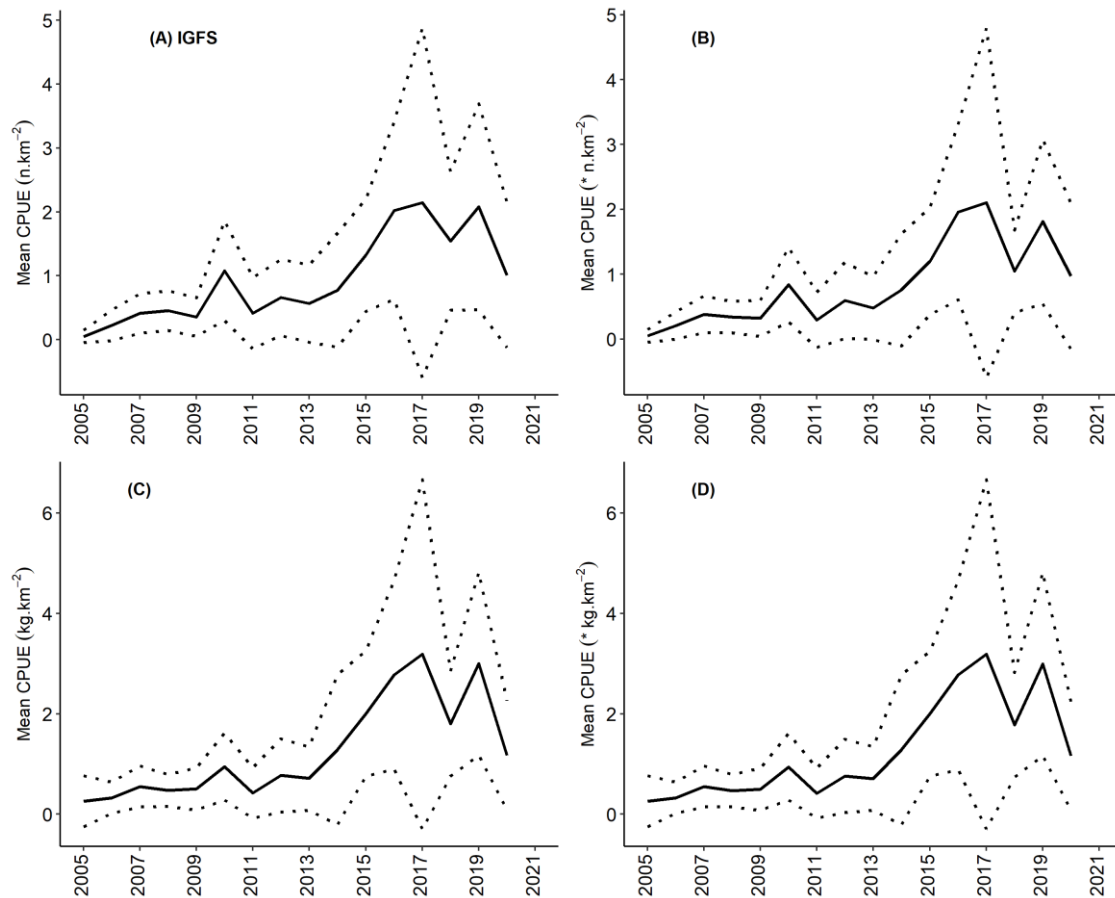


Figure 21.10. Smooth-hounds in the Northeast Atlantic. Survey indices and associated confidence intervals (95%CI) by (A) total abundance (n.km^{-2}), (B) total biomass (kg.km^{-2}), (C) abundance for individuals ≥ 50 cm total length ($*\text{n.km}^{-2}$) and (D) biomass for individuals ≥ 50 cm total length ($*\text{kg.km}^{-2}$) from the IGFS-WIBTS-Q4.

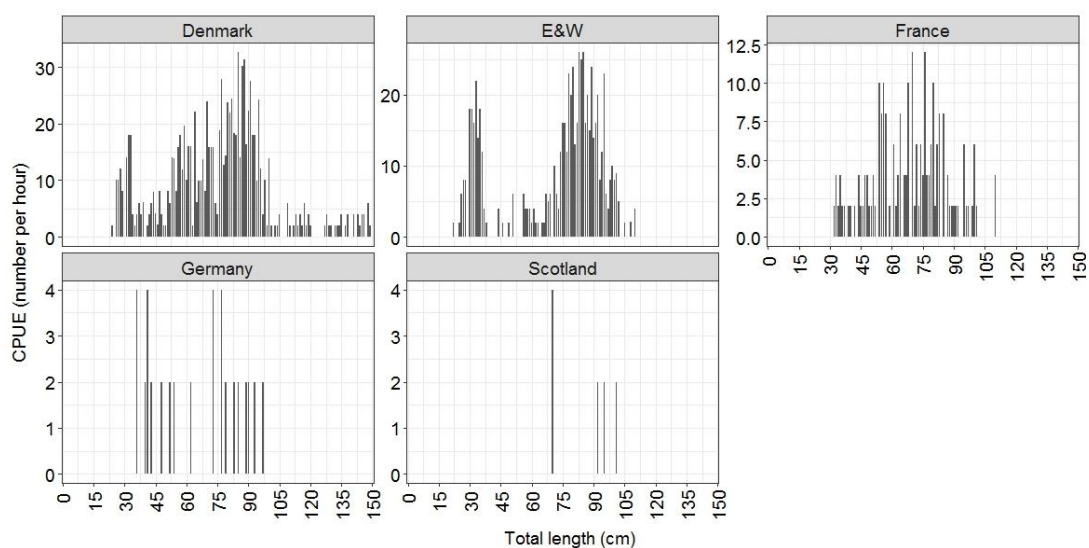


Figure 21.11. Smooth-hounds in the Northeast Atlantic. Length distributions of *Mustelus* spp. in the Q3-IBTS of the North Sea by nation during 1992–2016. Most nations record *Mustelus* spp. up to 110 cm, while Danish data (to 149 cm) suggests there may be misidentification with *Galeorhinus galeus* or coding errors.

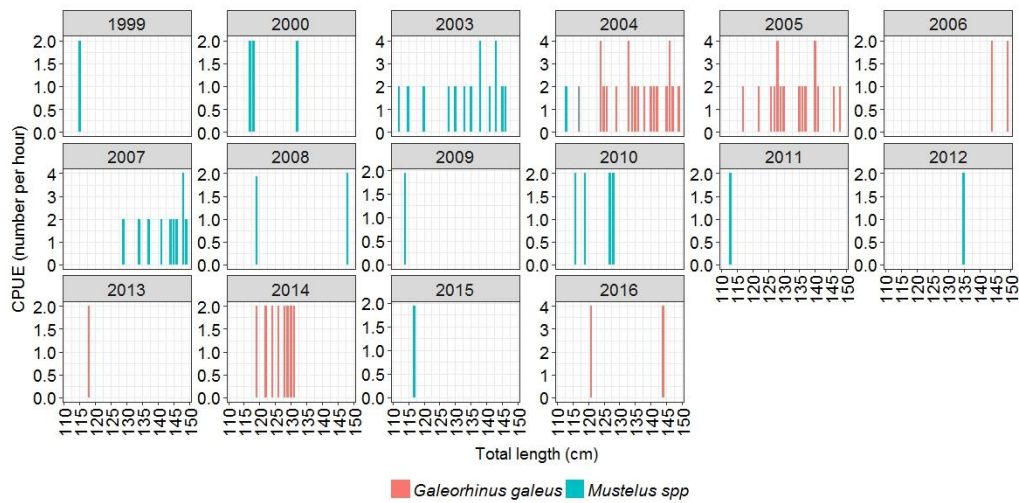


Figure 21.12. Smooth-hounds in the Northeast Atlantic. Length distributions of triakid sharks ≥ 110 cm as reported on DATRAS during IBTS-Q3 for the RV *Dana* (1992–2016). Large specimens of triakid sharks (i.e. *Mustelus* spp. or *Galeorhinus galeus*) are not usually captured in the same year, which suggests potential identification issues or coding errors.

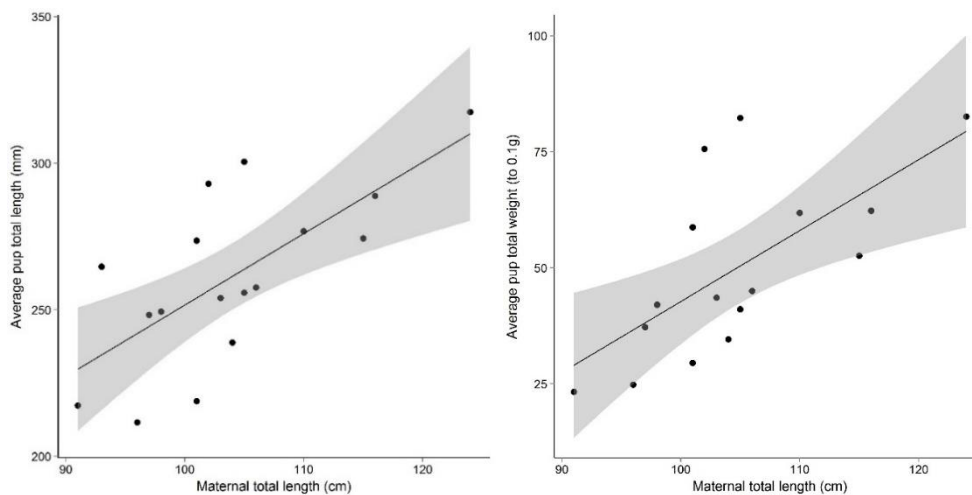


Figure 21.13. Smooth-hounds in the Northeast Atlantic. Relationship between maternal total length and average length and weight of term pups. Source: McCully Phillips and Ellis (2015).

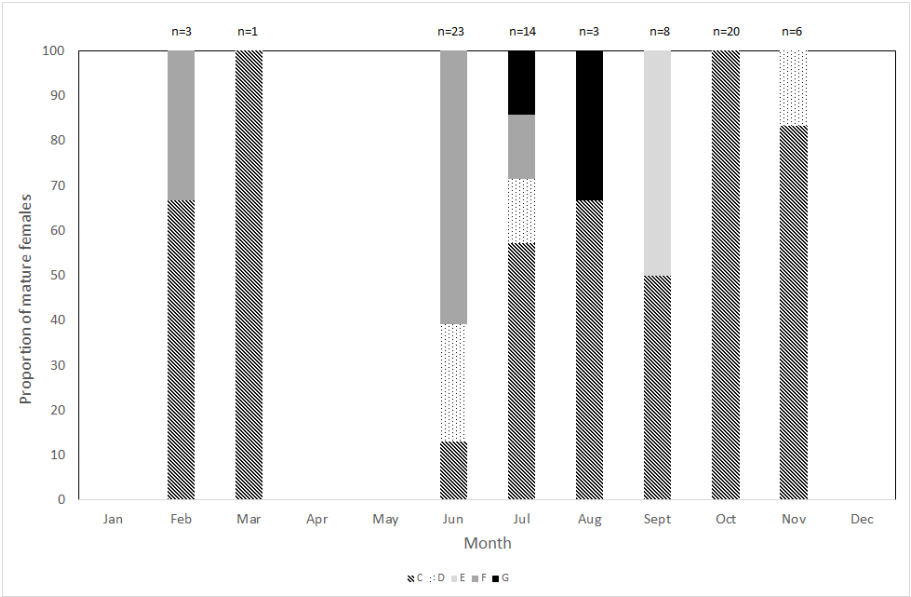


Figure 21.14. Smooth-hounds in the Northeast Atlantic. Percentage of mature females at each developmental stage (D: early gravid; E: mid-gravid; F: late gravid; G: post-partum) by month. Source: McCully Phillips and Ellis (2015).

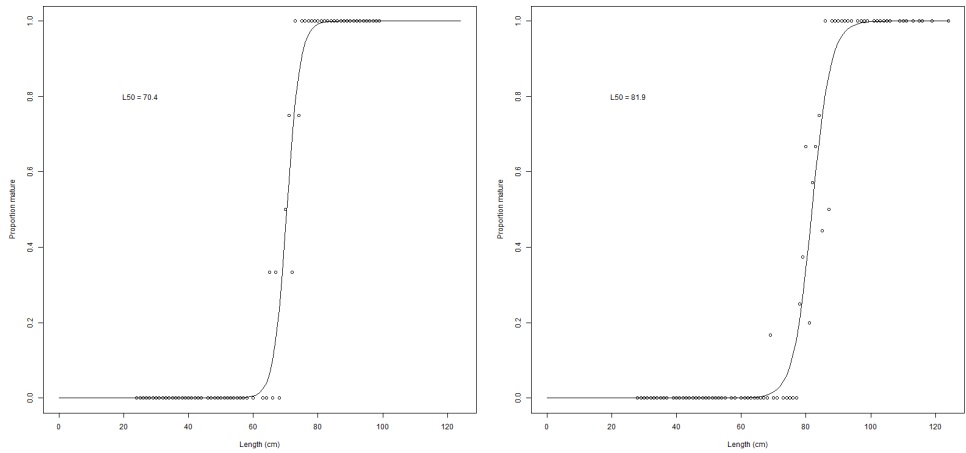


Figure 21.15. Smooth-hounds in the Northeast Atlantic. Maturity ogive for male (n = 237; $L_{50} = 70.4$ cm L_7) and female (n = 248; $L_{50} = 81.9$ cm L_7) *M. asterias*. Source: McCully Phillips and Ellis (2015).

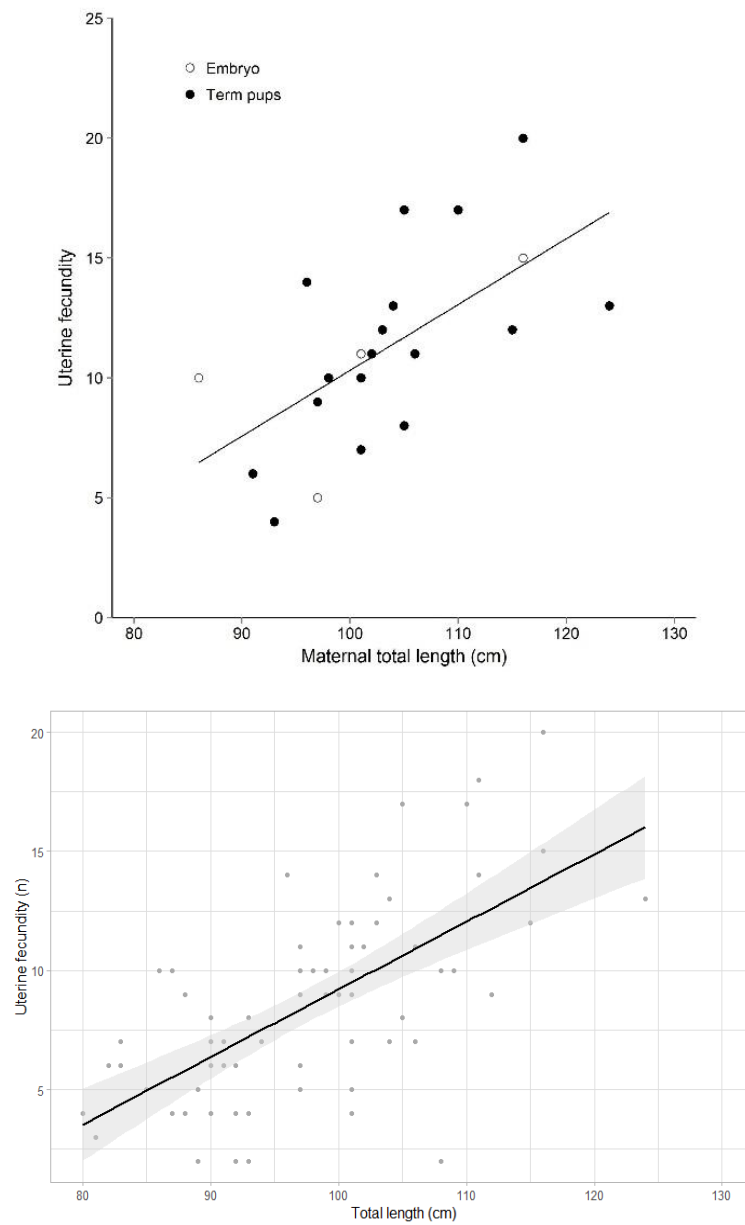


Figure 21.16. Smooth-hounds in the Northeast Atlantic. Relationship between maternal total length and uterine fecundity (top) from McCully Phillips and Ellis (2015) and (bottom) from Ellis *et al.* (2019 WD).

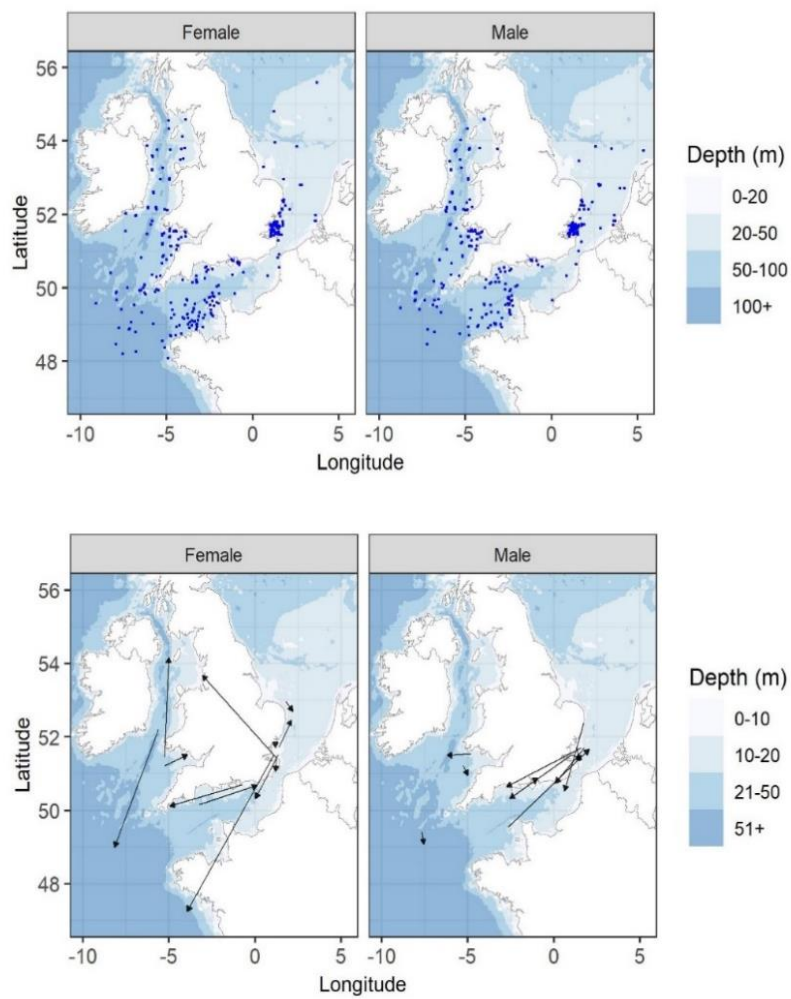


Figure 21.17. Smooth-hounds in the Northeast Atlantic. Tagging locations (top) and displacement vectors (bottom) for male and female *M. asterias*. Source: Ellis *et al.* (2019 WD).

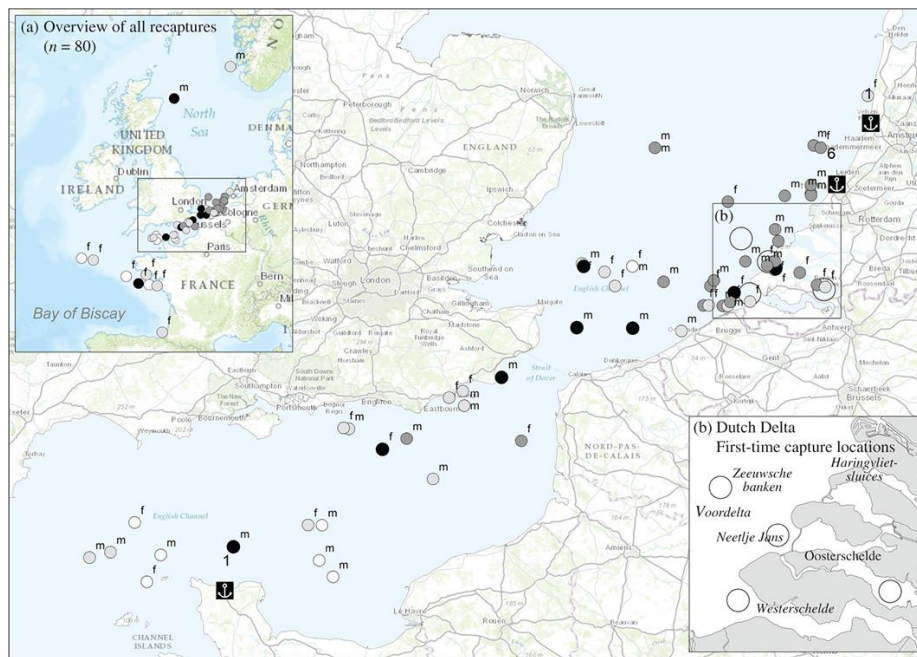


Figure 21.18. Smooth-hounds in the Northeast Atlantic. The main map shows the more detailed distribution of recaptures in the English Channel and southern North Sea. From three fish markets (indicated with anchors), eight tagged *M. asterias* were reported (numbers next to the anchors represent the number of sharks from each fish market) with unknown recapture location. Inset (a) shows the locations of recaptured *Mustelus asterias* ($n = 80$) reported by quarter for the years 2011–2014. Their distribution pattern indicates a circannual migration between the Dutch Delta (summer), the English Channel and Bay of Biscay (winter). Inset (b) shows the tag and release location with the main places fished indicated with open circles. Symbols: f = female; m = male; recaptures per quarter are shown for January to March (○), April to June (◐), July to September (◑) and October to December (●). Source: Brevé *et al.* (2016).

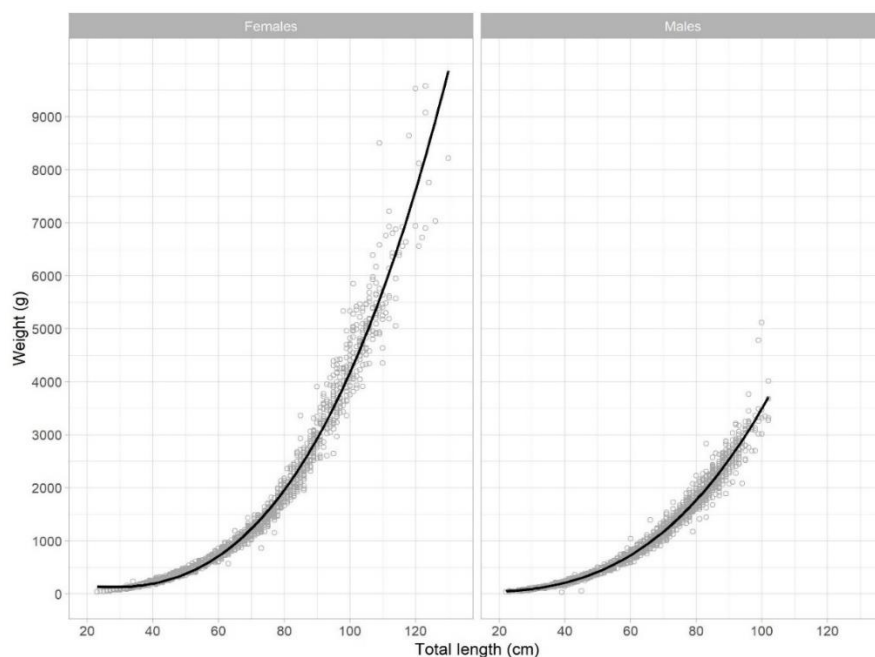


Figure 21.19. Smooth-hounds in the Northeast Atlantic. Length–weight relationships for female and male *M. asterias* caught in fishery-independent trawl surveys conducted by Cefas between 2009–2019. Relationships are described by the equations: females, $M_T = 0.002 T_L^{3.1}$ ($r^2 = 0.992$, $n = 2323$); males, $M_T = 0.003 T_L^{3.0}$ ($r^2 = 0.991$, $n = 2471$). M_T = Total weight (g), T_L = Total length (cm). Source: Ellis *et al.* (2019 WD).

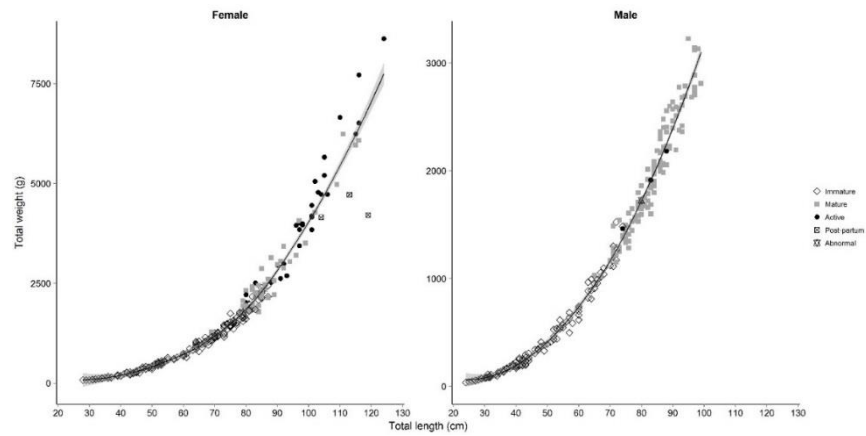


Figure 21.20. Smooth-hounds in the Northeast Atlantic. Length–weight relationship for female ($n = 248$) and male ($n = 237$) *M. asterias* by maturity stage (shaded region showing 95% confidence intervals). Source: McCully Phillips and Ellis (2015).

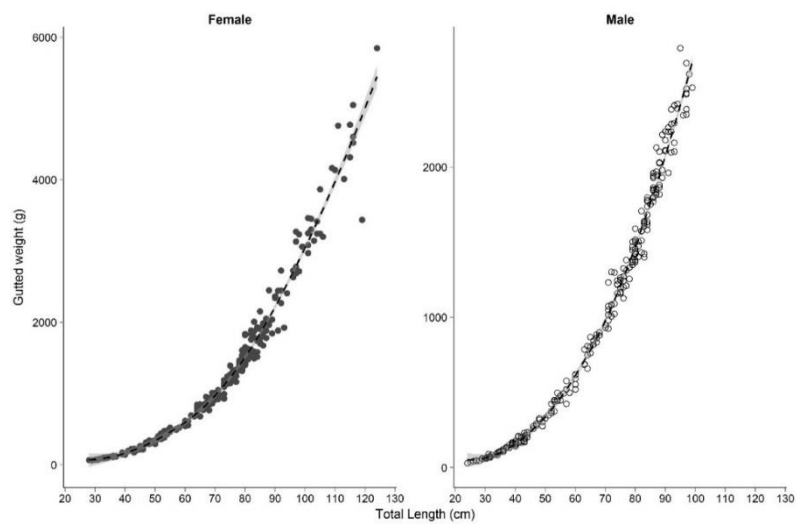


Figure 21.21. Smooth-hounds in the Northeast Atlantic. Total length to gutted weight relationship for female ($n = 249$) and male ($n = 235$) *M. asterias* (shaded region showing 95% confidence intervals). Source: McCully Phillips and Ellis (2015).

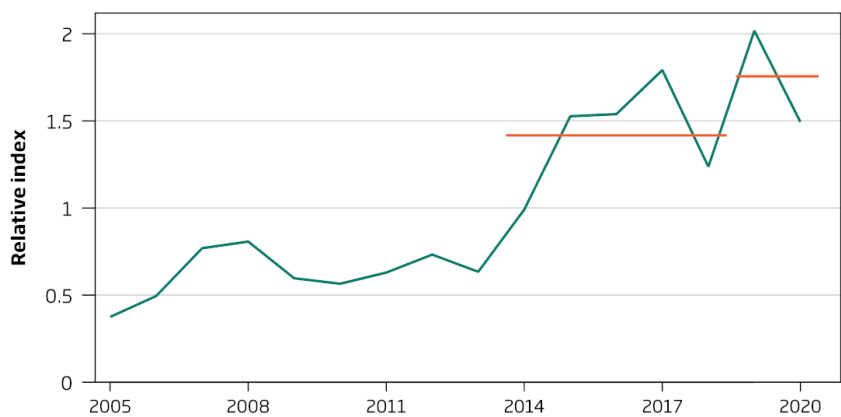


Figure 21.22. Smooth-hounds in the Northeast Atlantic. Stock size indicator is the mean normalized exploitable biomass index (individuals of ≥ 50 cm total length) of starry smooth-hound from the average of the two NS-IBTS surveys (NS-IBTS-Q1 and NS-IBTS-Q3), EVHOE-WIBTS-Q4, CGFS-Q4 and IGFS-WIBTS-Q4. The horizontal lines show the average of the most recent two-years (2019–2020) and the preceding five-years (2014–2018).

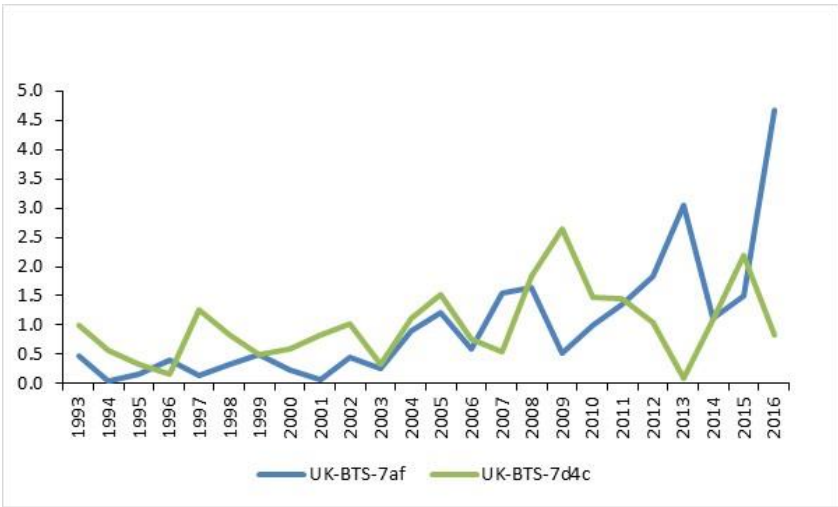


Figure 21.23. Smooth-hounds in the Northeast Atlantic. Annual catch rate of pups (<35 cm) in the BTS-UK (E&W)-Q3 (Bristol Channel and Irish Sea) and BTS-Eng-Q3 (eastern English Channel and southern North Sea) for the years 1993–2016, each standardised to the long-term mean for the survey.

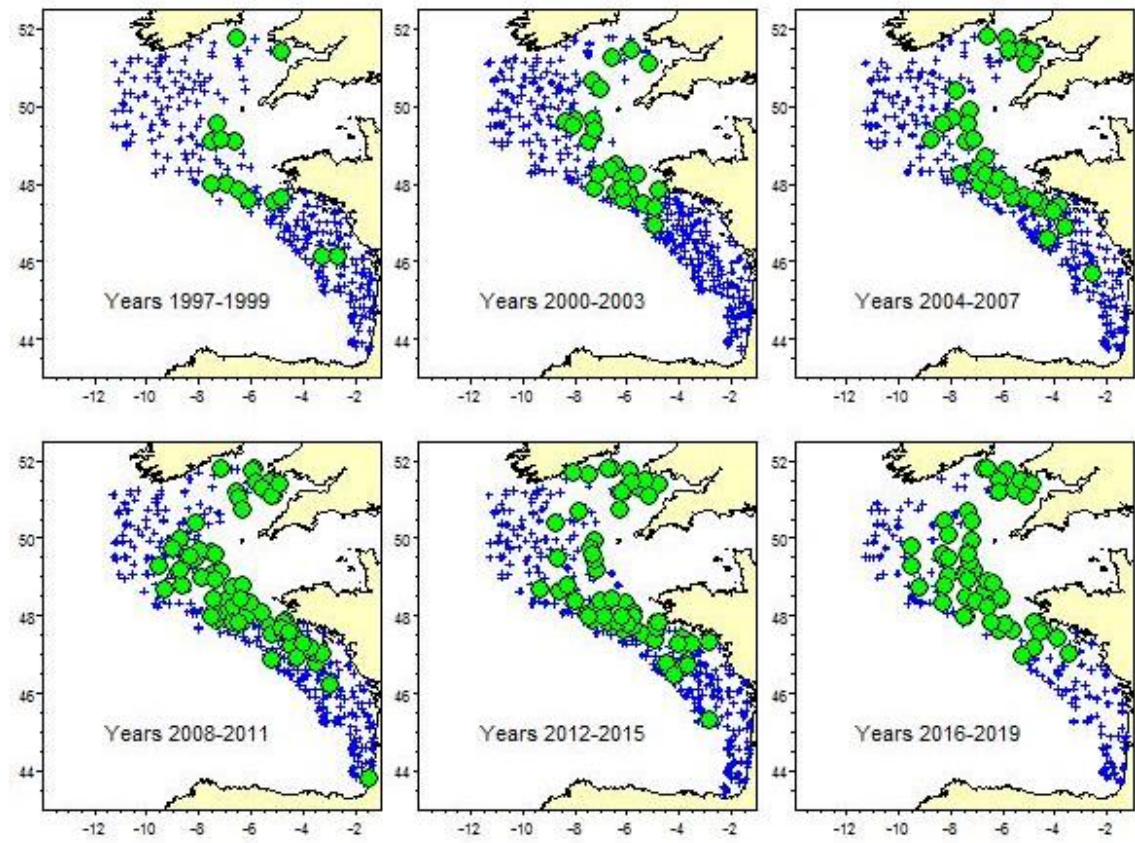


Figure 21.24. Smooth-hounds in the Northeast Atlantic. Distribution of occurrences of *Mustelus* spp. (green points) in the EVHOE-WIBTS-Q4 survey (1997–2019) by groups of 4 years. Source: National data (Ifremer).

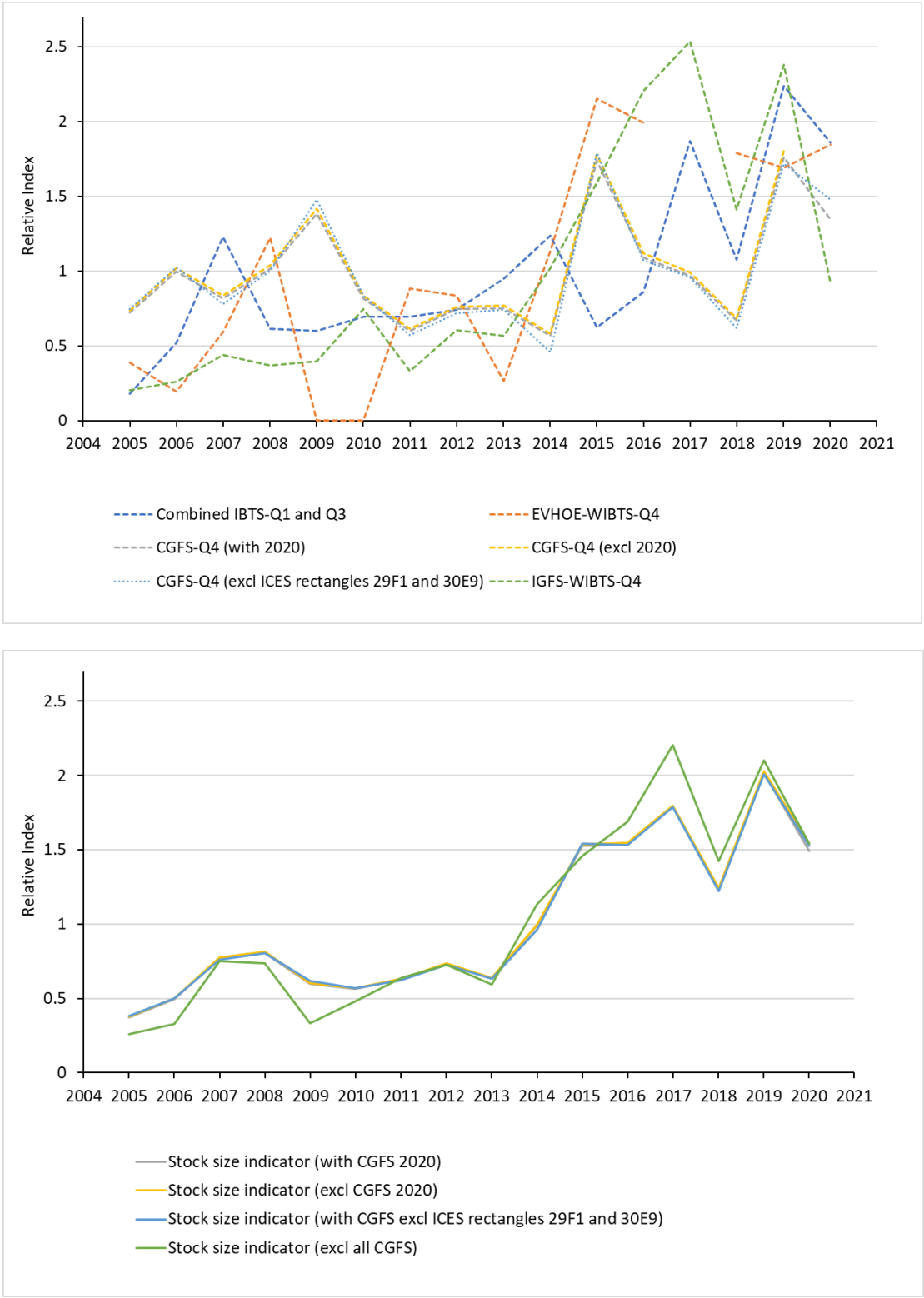


Figure 21.25. Smooth-hounds in the Northeast Atlantic. Normalized survey indices for starry smooth-hound (individuals ≥ 50 cm total length) for combined IBTS-Q1 and Q3, EVHOE-WIBTS-Q4, CGFS-Q4 (with 2020), CGFS-Q4 (excl. 2020), CGFS-Q4 (excl. ICES rectangles 29F1 and 30E9) and IGFS-WIBTS-Q4 (top), and different scenarios for stock size indicators for 2005–2020 (bottom).