10 Tope in the Northeast Atlantic

10.1 Stock distribution

WGEF considers there to be a single stock of tope (or school shark) *Galeorhinus galeus* in the ICES area. This stock is distributed from Scotland and southern Norway southwards to the coast of Northwest Africa and the Mediterranean Sea. The stock area covers ICES subareas 2–10 (where subareas 4 and 6–10 are important parts of the stock range, and subareas 2, 3 and 5 areas where tope tend to be an occasional vagrant). The stock extends into the northern part of the CECAF area and the Mediterranean Sea (Subareas I–III). The information used to identify the stock unit is summarized in the stock annex (ICES, 2009).

10.2 The fishery

10.2.1 History of the fishery

Currently there are no targeted commercial fisheries for tope in the NE Atlantic. Tope is discarded in some fisheries but landed as a bycatch in trawl, gillnet and longline fisheries, including demersal and pelagic static gears.

Tope is also an important target species for recreational sea angling in several areas, with anglers, angling clubs and charter boats often having catch and release protocols.

10.2.2 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 (ICES, 2021) and 2021.

10.2.3 ICES Advice applicable

ICES provided advice for this stock for the first time in 2012, stating "*Based on ICES approach to data-limited stocks, ICES advises that catches should be reduced by 20%. Because the data for catches of tope are not fully documented and considered unreliable (due to the historical use of generic landings categories), ICES is not in a position to quantify the result. Measures to identify pupping areas should be taken*".

In 2021, ICES advised that "*when the precautionary approach is applied, landings should be no more than 301 tonnes in each of the years 2022 and 2023. ICES cannot quantify the corresponding catches*".

10.2.4 Management applicable

In 2015, EC regulations for fishing opportunities first prohibited EU vessels from fishing for, retaining on board, transhipping or landing tope when captured on longlines in European Union waters of ICES Division 2.a and Subarea 4 and in Union and international waters of ICES subareas 1, 5–8, 12 and 14 (Council Regulation (EU) 2015/104). These prohibitions on longline-caught tope continue to apply in UK waters.

The UK's Department for Environment, Food and Rural Affairs (DEFRA) introduced a Statutory Instrument in 2008 (SI Number 2008/691, "The Tope (Prohibition of Fishing) Order") that banned fishing for tope other than by rod and line (with anglers fishing using rod and line from boats not allowed to land their catch) and established a tope bycatch limit of 45 kg per day in commercial fisheries. In Scotland, vessels are prohibited from fishing for tope other than by rod and line or hand-line, trans-shipment of tope caught by rod and line or hand-line (wherever caught), and landing tope (wherever caught) as per Statutory Instrument in 2012 (SI Number 2012/63, "The Sharks, Skates and Rays (Prohibition of Fishing, Trans-shipment and Landing) (Scotland) Order 2012").

10.3 Catch data

10.3.1 Landings

No accurate estimates of historical catch are available, as many nations that land tope report an unknown proportion of landings in aggregated landings categories (e.g. dogfish and hounds). In other cases, misidentification/misreporting of other species as tope may have taken place.

Reported species-specific landings, which commenced in 1978 for French fisheries, are given in Table 10.1, based on data collated by WGEF up to and including 2004. Prior to, and at WGEF 2016, landings from 2005–2015 were reassessed, and where possible, erroneous or generic species categories or figures were reassigned following WKSHARK2 (ICES, 2016a). The data supplied to WGEF are higher than previous data, although of a similar magnitude, and the reasons for these discrepancies are still to be investigated.

Recent estimated landings data from 2005–2021 for tope are shown by fishing area (Table 10.2) and by nation (Table 10.3), following the procedure from WKSHARK2. Overall, landings data appear relatively stable in recent years, although have decreased in 2019 and 2020 (Figure 10.1; Table 10.2; Table 10.3). The 2020 estimated landings were the lowest observed in the last decade, however, these should be viewed with care as the COVID-19 pandemic may have contributed to a reduction on fishing activity and thus, on reported landings. In 2021, estimated landings are at similar levels observed in 2016–2018.

France is one of the main nations landing tope, accounting for >75% since 2018 (2021: 77%), with the English Channel and Celtic Seas important fishing grounds. UK fisheries also land tope, although species-specific data are lacking for the earlier years, and reported landings have declined since precautionary management measures (trip limits of no more than 45 kg per day) were introduced.

Since 2001, Ireland, Portugal and Spain have also declared species-specific landings. However, it is believed that some of the Portuguese landings recorded as tope may also include unknown proportions of other sharks, including smooth-hounds and deep-water sharks. Portuguese tope landings for 2017 were examined by IPMA scientists and have been corrected in 2019, which explains values for this year to be less than declared previously. The main Portuguese landings of tope are recorded from areas around the Azores.

The introduction of management restrictions in 2015 applicable to Subarea 7 and 8 (see Section 10.2.4) may have, alongside with unavailable data from FAO areas 34 and 37, contributed to the decrease in 2015–2021 landings reported by Spain (Table 10.3).

Limited species-specific catch data for the Mediterranean Sea and off northwest Africa are available. The degree of possible misreporting or underreporting is not known.

10.3.2 Discards

Though some discard information is available from various nations, data are limited for most nations and fisheries.

Data analysis from the UK (E&W) observer programme (Silva and Ellis, 2019) suggested that the introduction of the Tope (Prohibition of Fishing) Order 2008, may have influenced the discard-retention patterns (Figure 10.2). This change was more evident on tope caught in drift and static gillnet fisheries where the proportion of discards increased from 11% (2002–2007) to 67% (2008–2016). No apparent change was observed by otter trawlers, with similar levels for both time periods (ca. 77%).

The small number of tope recorded in some discard observer programmes may be an artefact of limited coverage on those vessels that may encounter them, and the occasional and seasonal occurrence of tope in some areas. Sporadic records of tope in observer data indicate that appropriate methods of raising such discard data to fleet need to be evaluated if catch advice is to be developed.

In 2017, ICES held a workshop (WKSHARK3) to compile and refine catch and landings of elasmobranchs (ICES, 2017). National data were examined for UK (England), Ireland, France and Spain (Basque country) for two main gear categories: otter trawl and gillnet. Discard data were also provided as part of the 2017–2021 Data Call. However, data available were insufficient to draw a more comprehensive interpretation of any discard/retention patterns (see also Section 1.14).

10.3.3 Quality of catch data

Catch data are of poor quality, and biological data are not collected under the Data Collection Regulations. Some generic biological data are available (see Section 10.7).

10.3.4 Discard Survival

Ellis *et al.* (2014 WD; 2017) provided references for discard survival of shark species worldwide. Discard survival of members of the Triakidae family appears to be quite variable. Whilst quantitative data are limited in European waters, Fennessy (1994) reported at-vessel mortality (AVM) of 29% for Arabian smooth-hound *Mustelus mosis* taken in a prawn trawl fishery. AVM 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). Lower AVM of triakids has been reported in longline fisheries (Frick *et al*., 2010; Coelho *et al*., 2012). Investigations on post-release survival of mature and lively tope caught with automatic demersal longlines in the Great Australian Bight showed a high resilience to capture, precautious handling and release (Rogers *et al*., 2017).

10.4 Commercial catch composition

Tope is one of the main elasmobranch species caught by the Azorean bottom longline fleet (Morato *et al*., 2003) and was reported in 29% of the trips, representing up to 2% of the total catch landed along the studied period (Figure 10.3) (Santos *et al.* 2018 WD).

10.5 Commercial catch and effort data

Standardized CPUE series for tope from the Azorean bottom longline fleet (1990–2017) are shown in Figure 10.4 (see Table.10.4 in ICES, 2020; Santos *et al.* 2020 WD), with data no longer

available from 2018 onwards. The trends from the nominal and standardized index differed substantially; indeed, the nominal CPUE oscillated over time, with peaks in 1999, 2000 and 2017; while the standardized index gave a more stable trend since 1994. According to Ortiz (2017), it is not necessary that the nominal and standardized trends follow the same trend.

10.6 Fishery-independent information

10.6.1 Availability of survey data

Although several fishery-independent surveys operate in the stock area, data are limited for most of these. Analyses of catch data need to be undertaken with care, as tope is a relatively large-bodied species (up to 200 cm L_T in the NE Atlantic), and adults are strong swimmers that forage both in pelagic and demersal waters. Tope are not sampled effectively in beam trawl surveys (because of low gear selectivity). They are caught occasionally in GOV trawl and other (high-headline) otter trawl surveys in the North Sea and westerly waters, though survey data generally include a large number of zero hauls.

The discontinued UK (England and Wales) Q4 IBTS survey in the Celtic Seas ecoregion recorded small numbers of tope, which were tagged and released where possible (ICES, 2008). UK surveys in this area generally caught larger tope at the southern entrance to St George's Channel, and in 2011 several juveniles were caught in the Irish Sea.

Southern and western IBTS surveys may cover a large part of the stock range, and more detailed and updated analyses of these data are required.

The Western waters beam-trawl survey in the English Channel and Celtic Sea did not catch any tope (Silva *et al*., 2020 WD) which is known to occur in the area. However, tope occurs higher up in the water column and is rarely captured by beam trawls.

Data from the Azorean demersal spring bottom longline survey (ARQDAÇO(P)-Q1) were examined by Santos *et al.* (2020), where tope was frequently observed during 1995–2018.

10.6.2 Trends in survey abundance

Data for five trawl surveys were examined by WGEF, as summarised below.

IBTS-Q1: Data for the IBTS-Q1 in the North Sea showed a low abundance (and biomass) across countries over the time-series examined (1992–2020), with this survey excluded from further analysis.

IBTS-Q3: The mean CPUE (numbers and biomass) were calculated for the IBTS-Q3 in the North Sea IBTS for the years 1992–2020, with updated estimates provided in 2021 for the whole times series. During this period, there were large differences in abundance and biomass in earlier years compared to recent years (Figure 10.5). The frequency of occurrence for the years 1992–2016 has increased since 2002 (Figure 10.6), but such investigations are needed for the most recent years.

More detailed investigations of IBTS-Q3 data on DATRAS were undertaken by WGEF in 2017 in terms of the length and spatial distribution by nations (Figure 10.7 and 10.8). Length-frequency distributions indicate that data for *Galeorhinus galeus* and *Mustelus* spp. may have been confounded, with this most evident for Danish survey data (See Section 21.6). Data from DAN are included in the present analysis, but it is likely that larger tope have been attributed to *Mustelus* in some years, and so until further analyses of these data are undertaken, the temporal trends in catch rates are not based on a complete data set. Further analyses on the quality of these data are required.

Furthermore, WGEF note that the apparent 'peak' in tope in 1992 in driven by a single large catch at one station (*RV* Thalassa in 35F1, haul number 15 with CPUE of 182 ind/hr). Further examination of these data are required.

IGFS-WIBTS-Q4: Abundance and biomass estimates were calculated for all individuals for the time series 2005–2020 (Figure 10.9) and shows an increasing trend from 2012, with a slight decrease in 2017 and 2018, and a peak in 2020. This survey usually catches small numbers of tope, although one haul (40E2, Division 6.a) in 2006 yielded 59 specimens (Figure 10.9). The peak in 2020 relates to larger specimens (>80 cm total length) being caught in one single haul (33E3, 16 min tow, Division 7.a). Most tope caught are now tagged and released. Survey indices for the whole time series were updated with new estimates provided in 2019. The values have differed from the previous survey index as values are now scaled to the survey area rather than the ecoregion.

EVHOE-WIBTS-Q4: Swept area biomass estimates were calculated for total and exploitable biomass (individuals ≥50 cm total length) for the time series 1997–2020 (Figure 10.10) and fluctuate without trend. Abundance estimates were calculated for individuals <50 cm total length (Figure 10.10), which show that this GOV survey catches mostly larger specimens. New estimates were calculated using DATRAS contrary to previous estimates presented using national data. This survey did not occur in 2017.

The spatial distribution across the time-series (1997–2014) (Figure 10.4 in ICES, 2016b), showed similar locations reported during UK surveys, with the majority of individuals found at the entrance to St George's Channel and outer Bristol Channel.

ARQDAÇO(P)-Q1: Additional information on the Azorean demersal spring bottom longline survey ARQDAÇO(P)-Q1 on the relative abundance index for 1995–2018 is shown in Figure 10.11 (Santos *et al.*, 2020). However, abundance is highly variable over time, with no consistent trend and, this may relate to the gear used being of low catchability and to the survey sampling design.

WGEF consider that any trend analysis should be viewed with care, due to the low catchability on fishery-independent surveys. Given the low and variable catch rates, WGEF do not consider that catch rates are wholly appropriate for quantitative advice on stock status. The proportion of stations at which tope are captured may be an alternative metric for consideration and could be further investigated for more surveys covering the stock area.

10.6.3 Length distributions

In 2009, data were presented on length distributions found in the Celtic Seas ecoregion during fisheries-independent surveys conducted by England and Ireland in Q4 (Figure 10.7 in ICES, 2016b). Irish surveys recorded 145 tope (2003–2009), of which 110 (76%) were male. English surveys recorded 90 tope (56 (62%) males and 34 (38%) females). These specimens were 40–163 cm L_T. The length–frequency distributions found between the surveys were noticeably different, with more large males found in the Irish survey; 75% of the males were greater than 130 cm. The English surveys had a more evenly distributed length range.

Length distributions of tope caught in various UK surveys in 2004–2009 were analysed in 2016 (see Figure 10.8 in ICES 2016b). In the beam trawl survey (Figure 10.8a in ICES, 2016b), two peaks were observed, at 30–54 cm L_T and 70–84 cm L_T respectively. In the North Sea survey (Figure 10.8b in ICES, 2016b) a wide range (30–164 cm L_T) was observed, with a main peak at 30–44 cm L_T. Wide ranges were also observed in the Celtic Sea survey (44–164 cm L_T; Figure 10.8c in ICES, 2016b) and in the western IBTS survey (70–120 cm L_T; Figure 10.8d in ICES, 2016b).

In the Azorean demersal spring bottom longline survey ARQDAÇO(P)-Q1, records also show a wide length range of 25–185 cm L_T, with fish caught at depths up 650 m during 1995–2018. Smaller fish were caught in higher numbers in shallow waters, with an increase in length range observed in deeper waters while decreasing in abundance (Figure 10.12, Santos *et al.*, 2020).

10.6.3.1 Recreational length distributions

During 2009–2013, a Scottish recreational fishery in the Mull of Galloway recorded sex, length and weight of captured tope. While the number of tope tagged has declined, the number of mature fish of both sexes appears to have disproportionally declined (see Figure 10.11 in ICES, 2020). This area is thought to be a breeding ground for tope (James Thorburn, pers. comm., 2014), so the lack of mature animals is a cause for concern.

10.6.4 Tagging information

A total of 159 tope were tagged and released by CEFAS over the period 1961–2013, predominately in the Irish Sea and Celtic Sea (Figure 10.10 in ICES 2016b; Burt *et al.*, 2013). Fish were also tagged in the western English Channel and North Sea but in lower numbers (n = 9). Tope were tagged over a wide length range (41–162 cm L_T), the majority being males, with a male to female sex ratio of 1.5:1. A total of four tope were recaptured, and were, on average, at liberty for 1195 days, with a maximum recorded time at liberty of 2403 days. Over the period individual fish had travelled relatively large distances (112–368 km), and all had moved from one ICES division to another. For example, the fish that was at liberty the longest was released in Cardigan Bay (Division 7.a) in November 2003, was later captured in June 2010 just to the east of the Isle of Wight. It is also noted that a tag from a tope was returned to CEFAS from southern Spain, and although release information could not be located, it is thought it may have been tagged in the 1970s.

Mark and recapture data from 3 tagging programmes around the UK (Scottish Shark Tagging Program, the Glasgow Museum Tagging Program, the UK Shark Tagging Program) are available. From 2,043 tagged tope, 138 recapture records were analysed. Connectivity between UK waters and the Azores, the Canary Islands and the Mediterranean where shown (Thorburn *et al.*, 2019). Site fidelity and annual migrations were also suggested due to the closeness of tope recaptures to tagging sites throughout the year; however, seasonal patterns of movement are thought to be confounded by partial migration behaviour in the species (Thorburn *et al.*, 2019). Only mature individuals were found off the shelf and there is a relationship between maximum distance of recapture and body size in females with larger individuals undertaking the biggest movements into southerly regions, these are assumed to be in relation to parturition. There was no relationship between maximum distance and body size in males (Thorburn *et al.*, 2019). Electronic tag data from 4 tope from Scotland showed extensive summer use of shelf waters, but a movement into oceanic waters over winter months with tope diving to 826 m. PSAT tag track reconstruction showed a male tope moving from Scottish waters, around the North and west of Ireland to Porcupine Seabight. (Thorburn *et al.*, 2019).

The Irish Marine Sportfish Tagging Programme has tagged tope off the Irish coast since 1970. Four fish have been recaptured in the Mediterranean Sea (Inland Fisheries Ireland, pers comm. 2013; Fitzmaurice, 1994; cf. nicematin.com, 29 May 2013, "Le long périple d'un requin hâ, de l'Irlande à la Corse). A tope tagged on 30 July 2001 off Greystones (Ireland) as part of this programme, was caught on 9 May 2013 off Bastia, Corsica (Mediterranean Sea), showing a movement of 3900 km in twelve years. One tope tagged off Ireland was recaptured in May 2018, again off the west of Ireland, after 9046 days.

An ongoing tagging project of the German Thünen-Institute of Sea Fisheries (HTTP – Helgoland Tope Tagging Project) has been tagging tope in the southern North Sea (German Bight) around Helgoland Island during annual aggregations of mostly adult sharks in the summer months. As

of June 2022, 20 tope (16 females, 4 males, length range 103–164 cm L_T) have been tagged with Wildlifecomputers MiniPAT pop-up satellite archival tags and conventional tags. Preliminary results showed overwintering of the tope in the western English Channel and partial migration of both female and male specimens into oceanic habitats of the Northeast Atlantic, including long-distance, southward migrations of the female sharks towards the western part of the Strait of Gibraltar and as far south as Madeira. Tope that migrated into oceanic areas exhibited extensive diel vertical migratory behaviour, with a clear association with mesopelagic habitat features (deep scattering layers). The sharks followed the diel vertical migration of mesopelagic organisms staying at depths of around 500 m during daytime and ascending to surface layers during night time, while remaining in layers with highest densities of cephalopod prey (Schaber *et al*., 2022).

Long-distance migrations of tope from the Northeast Atlantic to the Mediterranean Sea have also been reported by Colloca *et al*. (2019), with two females tagged and released in the Irish Sea being recaptured by Sicilian artisanal fishers using trammel nets. One tope tagged off Luce Bay (West Scotland) in June 2009 was recaptured at a depth of 35 m off Talbot Bank (south-west coast of Sicily) in November 2014, after 1967 days. The second female tope at 153 cm total length tagged off Carlingford Bay (East Ireland) in June 2015, was recaptured at ca. 30 cm depth off Selinunte harbour (South Sicily) in April 2017, after 648 days.

10.7 Life-history information

Much biological information is available for tope in European seas and elsewhere in the world, which are summarized in the stock annex (ICES, 2009).

Genetic studies on five geographically isolated populations (Africa, Australia, North America, South America, Western Europe) showed that there is little to no gene flow between these populations, indicating a lack of population connectivity and mixing (Chabot and Allen, 2009; Chabot, 2015). A Northeast Atlantic and Mediterranean genetic study showed gene flow throughout the region but did observe unique haplotypes in some areas, with outlying genotypes observed in the Mediterranean (Thorburn, in prep). Further genetic assessment is recommended to explore connectivity with the Mediterranean.

The following relationships and ratios were calculated by Séret and Blaison (2010):

$L_T = 0.0119\ W^{2.7745}$ (n = 10; length range of 60–140 cm L_T; weight in g);
Live weight / eviscerated weight = 1.28 (s.d. 0.05);
Live weight / dressed weight (eviscerated, headed, skinned) = 2.81 (s.d. 0.13);
Smallest mature male = 110 cm L_T, smallest mature female 130 cm L_T, fitting with the ranges 120–135 and 134–140 cm L_T observed for other populations.

Additional data from French surveys were presented by Ramonet *et al.* (2012 WD).

The length-weight relationship from tope sampled on UK (E&W) surveys (Silva *et al.*, 2013) was used to convert individual numbers at length to biomass when assessing the North Sea IBTS survey index (Q1 and Q3).

$L_T = 0.0038\ W^{3.0331}$ (n = 43; length range of 39–155 cm L_T; weight in g)

10.7.1 Parturition and nursery grounds

Pups (24–45 cm L_T) are caught occasionally in groundfish surveys, and such data might be able to assist in the preliminary identification of general pupping and/or nursery areas (see Figure 10.5 of ICES, 2007). Most of the pup records in UK surveys are from the southern North Sea

(Division 4.c), though they have also been recorded in the northern Bristol Channel (Division 7.f). The updated locations of pups caught in fisheries-independent surveys across the ICES region could usefully be collated in the near future.

A recent study suggests the maximum depth associated with tope may be related to their body size, with specimens under 50 cm L_T being found in waters less than 50 m deep, suggesting small juvenile tope will be restricted to specific areas (Thorburn *et al.*, 2019). A combination of angler data and survey data showed areas where small tope (26–46 cm L_T) were found in the Southern North Sea, the Severn estuary, Cardigan bay and Liverpool bay (Figure 10.13; Thorburn *et al.*, 2019).

The lack of more precise 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.

10.8 Exploratory assessment models

Various assessment methods have been developed and applied to the South Australian tope stock (e.g. Punt and Walker, 1998; Punt *et al.*, 2000; Xiao and Walker, 2000).

A preliminary capture-recapture model was developed in 2015 using data from the Irish Marine Sportfish Tagging Programme (Bal *et al.*, 2015 WD). This approach was re-applied as an exploratory assessment by WGEF in 2016 including additional Irish tagging records from 2014 and 2015. The approach, results and a discussion of the current state of the model are summarized in the WGEF 2020 report (Figures 10.12–10.17 in ICES, 2020).

10.9 Stock assessment

Catch data (see Section 10.3) and survey data (see Section 10.6) are currently too limited to allow for a quantitative stock assessment of NE Atlantic tope. In the latest advice 2021, tope was still treated as a Category 5 stock, with advice based on recent estimated landings.

Whilst not used in quantitative advice, WGEF note that available survey trends indicate that catch numbers have been relatively stable or variable in recent years depending on the survey considered.

10.10 Quality of the assessment

The low catchability of tope in current surveys can lead to variability in catch rates. Trawl surveys are not designed to capture larger pelagic species like tope, and therefore survey catches may not accurately represent population size.

Current surveys do cover a large part of the stock area in northern European waters, but data for other areas are unavailable. The spatial and bathymetric distribution of tope may be influenced by the availability of pelagic prey as well as by far ranging migrations that could be conceivably related to reproduction, which may lead to further variability in catch rates in surveys.

In the absence of any other data sources, surveys with high headline trawls may be the most appropriate species-specific data currently available.

10.11 Reference points

No reference points have been proposed for this stock.

10.12 Conservation considerations

According to the latest IUCN Red List Assessments, tope is listed as Vulnerable in Europe (McCully *et al.*, 2015) and in the Mediterranean (McCully *et al.*, 2016), though listed globally as Critically Endangered (Walker *et al.*, 2020).

Tope have been added to Appendix II of the Convention of Migratory Species of Wild Animals (CMS) during the 13th Conference of Parties in February 2020 (CMS, 2020).

10.13 Management considerations

Tope is considered highly vulnerable to overexploitation, as this species has low population productivity, relatively low fecundity and a protracted reproductive cycle. Unmanaged targeted fisheries elsewhere in the world have resulted in stock collapse (e.g. off California and South America).

Tope is an important target species in recreational fisheries; though there are insufficient data to examine the relative economic importance of tope in the recreational angling sector, this may be high in some regions.

Tope is, or has been, a targeted species elsewhere in the world, including Australia/New Zealand, South America and California. Evidence from these fisheries (see stock annex and references cited therein) suggests that any targeted fisheries would need to be managed conservatively, exerting a low level of exploitation.

Australian fisheries managers have used a combination of legal minimum and maximum lengths, legal minimum and maximum gillnet mesh sizes, closed seasons and closed nursery areas. These technical measures may have less utility in the ICES area as tope is taken here mainly in mixed fisheries. Spatio-temporal measures would require further information on e.g. pupping and nursery grounds prior to assessing their suitability across the ICES area.

Following the publication of the GFCM (General Fisheries Commission for the Mediterranean) Report of the Workshop on Stock Assessment of selected species of Elasmobranchs in the GFCM area in 2011, WGEF believes that collaboration should continue between ICES and the GFCM. This will encourage the sharing of information and aid the better understanding of elasmobranch fisheries in the Mediterranean, where WGEF data for this region are often lacking.

10.14 References

Bal, G., Johnston G., Roche W., O'Reilly S., Green P., Fitzmaurice P. and Clarke M. 2015. Estimating the yearly size of the population of tope shark off the coast of Ireland. Working Document to ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, 2015; WD2015-18; 9 pp.

Braccini, M., Van Rijn, J., and Frick, L. 2012. High post-capture survival for sharks, rays and chimaeras discarded in the main shark fishery of Australia? *PloS One*, 7(2), e32547: 1–9.

Burt, G. J., Silva, J. F., McCully, S. R., Bendall, V. A. and Ellis, J. R. 2013. Summary results from opportunistic tagging programmes for smooth-hound *Mustelus* spp., greater-spotted dogfish *Scyliorhinus stellaris* and tope *Galeorhinus galeus* around the British Isles. Working Document to the Working Group on Elasmobranch Fishes, Lisbon, Portugal, 17–21 June 2013. 12 pp.

Chabot, C. L. 2015. Microsatellite loci confirm a lack of population connectivity among globally distributed populations of the tope shark *Galeorhinus galeus* (Triakidae). *Journal of Fish Biology*, 87: 371-385. doi:10.1111/jfb.12727

Chabot, C. L. and Allen, L. G. 2009. Global population structure of the tope (*Galeorhinus galeus*) inferred by mitochondrial control region sequence data. *Molecular Ecology*, 18: 545–552.

CMS. 2020. Convention on the Conservation of Migratory Species of Wild Animals, Notification to the Parties: Amendments to the Appendices of the Convention. Notification 2020/003. https://www.cms.int/sites/default/files/003_amendments%20to%20the%20appendices_0.pdf

Coelho, R., Fernandez-Carvalho, J., Lino, P.G. and Santos, M.N. 2012. An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. *Aquatic Living Resources*, 25: 311–319.

Colloca, F., Scannella, D., Geraci, M. L., Falsone, F., Batista, G., Vitale, S., Di Lorenzo, M. and Bovo, G. 2019. British sharks in Sicily: records of long-distance migration of tope shark (*Galeorhinus galeus*) from north-eastern Atlantic to Mediterranean Sea. *Mediterranean Marine Science*, 20(2): 309-313. https://doi.org/10.12681/mms.18121.

Ellis, J.R., McCully, S.R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 2014, 48 pp.

Ellis, J.R., McCully, S.R. and Poisson, F. 2017. A review of capture and post-release mortality of elasmobranchs. *Journal of Fish Biology*, 90: 653-722.

Fennessy, S.T. 1994. Incidental capture of elasmobranchs by commercial prawn trawlers in the Tugela Bank, Natal, South Africa. South African Journal of Marine Science, 14: 287–296.

Fitzmaurice, P. 1994. Tagging studies of blue sharks and tope off the Irish coast. In: S. L. Fowler and R. C. Earll (Eds.) Proceedings of the Second European Shark and Ray Workshop,15–16 February 1994, p. 17.

Frick, L.H., Reina, R.D. and Walker, T.I. 2010. Stress related changes and post-release survival of Port Jackson sharks (*Heterodontus portusjacksoni)* and gummy sharks (*Mustelus antarcticus)* following gill-net and longline capture in captivity. *Journal of Experimental Marine Biology and Ecology*, 385: 29–37.

ICES. 2007. Report of the Working Group on Elasmobranch Fishes. ICES CM 2007/ACFM:27.

ICES. 2008. Report of the International Bottom Trawl Survey Working Group (IBTSWG), 31 March–4 April 2008, Vigo, Spain. ICES CM 2008 RMC:02; 228 pp.

ICES. 2009. Report of the Joint Meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:16. 424 pp.

ICES. 2016a. Report of the Workshop to compile and refine catch and landings of elasmobranchs (WKSHARK2), 19–22 January 2016, Lisbon, Portugal. ICES CM 2016/ACOM:40, 69 pp.

ICES. 2016b. Report of the Working Group on Elasmobranch Fishes (WGEF), 15–24 June 2016, Lisbon, Portugal. ICES CM/ACOM:20. 26 pp.

ICES. 2017. Report of the Workshop to compile and refine catch and landings of elasmobranchs (WKSHARK3), 20–24 February 2017, Nantes, France. ICES CM 2017/ACOM:38. 119 pp.

ICES. 2020. Working Group on Elasmobranch Fishes (WGEF). ICES Scientific Reports. 2:77. 789 pp. http://doi.org/10.17895/ices.pub.7470.

ICES. 2021. Working Group on Elasmobranch Fishes (WGEF). ICES Scientific Reports. 3:59. 822 pp. https://doi.org/10.17895/ices.pub.8199

McCully, S., Dureuil, M. and Farrell, E. 2015. *Galeorhinus galeus*. *The IUCN Red List of Threatened Species* 2015: e.T39352A48938136. Downloaded on 24 June 2020.

McCully, S., Dureuil, M. and Farrell, E.D. 2016. *Galeorhinus galeus*. *The IUCN Red List of Threatened Species* 2016: e.T39352A16527949. Downloaded on 24 June 2020.

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

Ortiz, M. 2017. Standardized catch rates for simulated longline data SAM WG 2017. ICCAT Collective Volume of Scientifics Papers 74, 479–497.

Punt, A. E. and Walker, T. I. 1998. Stock assessment and risk analysis for the school shark (*Galeorhinus galeus*) off southern Australia. *Marine and Freshwater Research*, 49: 719–731.

Punt, A. E., Pribac, F., Walker, T. I., Taylor, B. L. and Prince, J. D. 2000. Stock assessment of school shark *Galeorhinus galeus* based on a spatially-explicit population dynamics model. *Marine and Freshwater Research*, 51: 205–220.

Ramonet M., Jung, A., Salaun M., Pawlowski, L., Bellail, R., Mahé, J-C., Poisson, F. and Biseau, A. 2012. Elasmobranch morphometric relationship and sexual maturity stages from EVHOE scientific survey in Northeast Atlantic Ocean from 2007 to 2011 campaigns. WGEF WD, June 2012, 26 pp.

Rogers, P.J., Knuckey, I., Hudson, R.J., Lowther, A.D. and Guida, L. 2017. Post-release survival, movement, and habitat use of school shark *Galeorhinus galeus* in the Great Australian Bight, southern Australia. *Fisheries Research*, 187: 188-198.

Santos, R., Medeiros-Leal, W. and Pinho, M. 2020 WD. Updated standardized CPUE for *Galeorhinus galeus* caught by bottom longline fleet in the Azores (ICES Subdivision 27.10.a.2), 1990-2017. Working Document to the Working Group on Elasmobranch Fisheries, June 16–25 2020, 11pp.

Santos, R V.S., Novoa-Pabon, A.M., da Silva, H.M., Pereira, J.G. and Pinho, M.R. 2018 WD. Standardized catch rates for tope (lsk.27.10a2) from the Azorean bottom longline fleet (1990-2016).

Santos, R., Novoa-Pabon, A., Silva, H. and Pinho, M. 2020. Elasmobranch species richness, fisheries, abundance and size composition in the Azores archipelago (NE Atlantic), *Marine Biology Research*, 16:2: 103-116. https://doi.org/10.1080/17451000.2020.1718713.

Schaber, M., Gastauer, S., Cisewski, B., Hielscher, N., Janke, M., Peña, M., Sakinan, S. and Thorburn, J. 2022. Extensive mesopelagic habitat use of a migratory continental shark species. *Scientific Reports*, 12 : 2074. https://doi.org/10.1038/s41598-022-05989-z

Séret, B. and Blaison A. 2010. Requins et raies des pêches françaises. Axe 2. Facteurs de conversion. Convention DPMA / IRD. Rapport, 31 pp.

Silva J. F., Ellis J. R. and Ayers R. A. 2013. Length-weight relationships of marine fish collected from around the British Isles. Sci. Ser. Tech. Rep., Cefas Lowestoft, 150: 109 pp.

Silva, J. F. and Ellis, J. R. 2019. Bycatch and discarding patterns of dogfish and sharks taken in English and Welsh commercial fisheries. *Journal of Fish Biology*, 94: 966–980. https://doi.org/10.1111/jfb.13899.

Silva, J. F., Ellis, J. R. and Kupschus, S. 2020. Demersal elasmobranchs in the western Channel (ICES Division 7.e) and Celtic Sea (ICES Divisions 7.f-j). Working Document to the ICES Working Group on Elasmobranch Fishes, June 16–25 2020; 40 pp.

Thorburn, J., Neat F., Burrett I., Henry, L., Bailey, D. M., Jones, C. S. and Noble L. R. 2019. Ontogenetic Variation in Movements and Depth Use, and Evidence of Partial Migration in a Benthopelagic Elasmobranch. Frontiers in Ecology and Evolution, 7 (353), 14 pp.

Walker, T.I., Rigby, C.L., Pacoureau, N., Ellis, J., Kulka, D.W., Chiaramonte, G.E. and Herman, K. 2020. *Galeorhinus galeus*. *The IUCN Red List of Threatened Species* 2020: e.T39352A2907336..

Xiao, Y. and Walker, T. I. 2000. Demographic analysis of gummy shark (*Mustelus antarcticus*) and school shark (*Galeorhinus galeus*) off southern Australia by applying a generalized Lotka equation and its dual equation. *Canadian Journal of Fisheries and Aquatic Sciences*, 57: 214–222.

Table 10.1. Tope in the Northeast Atlantic. Reported species-specific landings (tonnes) for the period 1975–2004. These data are considered underestimates as some tope are landed under generic landings categories, and species-specific landings data are not available for the Mediterranean Sea and are limited for Northwest African waters.

ICES Area and Nation	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
ICES Division 3.a, 4																					
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
France	na	na	na	32	22	na	Na	26	26	13	31	13	14	18	12	17	16	10	11	12	8
Netherlands																					
Sweden	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	na	na	na	na	na	na	Na	8	10	31	36	94	28	22	18	14	21	15	15	19	25
UK (Scotland)																-	-	-	-	-	-
Subtotal	0	0	0	32	22	0	0	34	36	44	67	107	42	40	30	31	37	25	26	31	33
ICES Subarea 6–7																					
France	na	na	na	522	2076	na	Na	988	1580	346	339	1141	491	621	407	357	391	235	240	235	265
Ireland	na	na	na	na	na	na	Na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Netherlands																					
Spain	na	na	na	na	na	na	Na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Spain (Basque country)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	na	na	na	na	na	na	Na	63	51	28	23	21	21	21	55	45	47	53	48	49	38
UK (Scotland)																					
Subtotal				522	2076	0	0	1051	1631	374	362	1162	512	642	462	402	438	288	288	284	303
ICES Subarea 8																					
France	na	na	na	na	237	na	Na	na	63	119	52	103	97	66	39	34	38	34	40	54	44
Spain	na	na	na	na	na	na	Na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Spain (Basque country)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	-	-	-	+	+	+	+	+	+	+	+	1									0
UK Scotland																					
Subtotal				0	237	0	0	0	63	119	52	104	97	66	39	34	38	34	40	54	44

ICES Area and Nation	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
ICES Subarea 9																					
Spain	na	na	na	na	na	na	Na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Subtotal																					
ICES Subarea 10																					
Portugal	18	na	na	24	15	51	77	42	24	29	24	24	24	34	23	56	81	80	115	116	124
Subtotal	18			24	15	51	77	42	24	29	24	24	24	34	23	56	81	80	115	116	124
Other/Unknown																					
France	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
CECAF area																					
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL LANDINGS	**18**	**0**	**0**	**578**	**2350**	**51**	**77**	**1127**	**1754**	**567**	**505**	**1397**	**675**	**782**	**554**	**523**	**593**	**427**	**469**	**485**	**504**

Table 10.1. (continued). Tope in the Northeast Atlantic. Reported species-specific landings (tonnes) for the period 1975–2004. These data are considered underestimates as some tope are landed under generic landings categories, and species-specific landings data are not available for the Mediterranean Sea and are limited for Northwest African waters.

ICES Area and Nation	1996	1997	1998	1999	2000	2001	2002	2003	2004
ICES Division 3.a, 4									
Denmark	-	.	.	3	8	4	5	5	5
France	11	5	11		11	11	6	6	3
Netherlands									
Sweden	-	.	.	.	.	.	.	.	.
UK (E&W)	14	22	12	14	13	10	13	11	8
UK (Scotland)	-	.	.	.	.	.	.	.	.
Subtotal	25	27	23	17	32	25	24	22	16
ICES Subareas 6–7									
France	314	409	312		368	394	324	284	209
Ireland	na	na	na	na	na	4	1	6	4
Netherlands		.	.	.	.	.	.	.	.
Spain	na	na	na	na	na	+	242	3	na
Spain (Basque country)	-	.	.	.	.	+	+	3	15
UK (E&W)	39	34	41	62	98	72	60	55	65
UK (Scotland)									
Subtotal	353	443	353	62	466	470	627	351	293
ICES Subarea 8									
France	78	40	46	+	71	58	49	60	16
Spain	na	na	na	na	na	9	13	10	na
Spain (Basque country)	-	.	.	.	.	9	6	10	10
UK (E&W)	0	0	0	0		1		3	8
UK Scotland									
Subtotal	78	40	46	0	71	77	68	83	34

ICES Area and Nation	1996	1997	1998	1999	2000	2001	2002	2003	2004
ICES Subarea 9									
Spain	na	na	na	na	na	na	na	na	76
Subtotal									
ICES Subarea 10									
Portugal	80	104	128	129	142	82	77	69	51
Subtotal	80	104	128	129	142	82	77	69	51
Other/Unknown									
France	-	.	.	386	.	2	.	.	.
CECAF area									
Portugal	-	.	.	.	2	1	2	98	na
TOTAL LANDINGS	**536**	**615**	**551**	**593**	**713**	**656**	**798**	**622**	**394**

Table 10.2. Tope in the Northeast Atlantic. ICES estimates of tope landings (tonnes) by area 2005–2020 following WKSHARK2 (ICES, 2016a). Blank = no data reported; 0.0 < 0.1 tonnes.

Fishing Area	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
27.2	0.0	0.0	0.0	0.0		0.0	0.0		0.0		0.0			0.0	0.1	0.1	0.1
27.3	1.1	1.3	0.0	0.1		1.0	1.0			1.0	0.4	0.1	0.8	0.2	0.7	0.9	0.4
27.4	24.2	26.8	15.6	13.2	9.5	9.2	15.5	6.8	6.4	5.6	6.3	9.2	16.2	6.5	3.3	3.2	3.7
27.5b	0.0	0.0	0.5	0.1	0.0	0.0			0.0	0.0	0.0	0.0	0.0			0.0	
27.6	3.4	4.0	6.7	5.6	8.0	1.3	0.6	0.7	1.2	1.1	6.2	0.5	0.7	0.2	0.2	0.4	0.1
27.7	417.8	445.8	366.7	359.9	348.6	311.1	262.6	277.8	279.5	245.5	301.2	233.8	267.5	302.3	253.4	207.0	287.9
27.8	113.1	110.9	102.9	123.4	145.8	80.0	85.1	54.6	60.9	52.8	64.5	90.8	67.1	79.6	82.5	68.7	95.8
27.9	37.9	54.0	47.3	48.2	72.6	59.7	53.9	45.0	48.8	54.4	51.1	34.2	37.2	23.4	29.8	37.6	49.8
27.10	44.7	45.2	42.5	46.6	33.9	41.3	43.6	47.4	45.7	65.4	71.0	84.9	69.8	41.4	27.0	21.4	26.9
27.12			0.0				0.0			0.0	0.0						
27.14							0.0	0.0									
27/(unspecified, incl. BIL94B)	0.2	0.2	0.0	0.0		0.1	0.1	0.0		0.0							
34*	5.0	10.7	3.2	11.1	5.5	28.4	8.0	5.3	2.4	3.6	0.0	0.3	0.8	2.9	2.9	1.0	
37*/BIL95	20.3	16.3	15.6	12.8	25.9	32.4	41.2	28.4	38.4	33.0							
Total	**667.7**	**715.2**	**601.3**	**621.1**	**649.9**	**564.4**	**511.5**	**466.1**	**483.3**	**462.4**	**500.8**	**453.7**	**460.2**	**456.7**	**399.9**	**340.2**	**464.7**

*** Landings data from areas 34 and 37 are incomplete and not based on all nations fishing in those areas.**

Table 10.3. Tope in the Northeast Atlantic. ICES species-specific estimates of tope landings (tonnes) 2005–2020 following WKSHARK2 (ICES, 2016a). Blank = no data reported; 0.0 < 0.1 tonnes.

Nation	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Belgium												0.1	0.0	0.0	0.0	0.0	5.1
Denmark	7.0	6.0	2.0	3.0	2.0	2.0	3.0	1.0		3.0	1.4	0.9	2.2	1.8	1.2	1.6	0.6
France	347.8	383.2	301.9	365.1	353.8	319.7	291.4	282.5	308.9	261.1	349.8	302.7	312.9	355.8	319.6	257.6	359.7
Germany													0.4		0.0	0.1	0.1
Ireland	5.5	6.8	2.6	2.1	2.9	3.1	0.6	0.3									
Netherlands						2.1	17.7	24.8	11.2	11.4	5.8	8.2	18.7	11.6	0.5	0.4	0.6
Norway						0.1	0.2		0.0		0.0			0.0	0.1	0.1	0.0
Portugal	44.7	45.2	42.5	46.6	33.9	41.3	43.5	47.4	45.7	65.4	71.0	85.2	70.8	44.3	30.0	22.5	27.4
Spain	181.7	181.8	202.9	163.1	234.0	179.4	138.1	94.0	100.3	101.1	55.7	36.8	41.3	30.5	32.9	44.3	56.9
Sweden	0.1	0.3	0.0	0.1													
UK	80.8	91.9	49.4	41.1	23.3	16.8	17.0	16.1	17.1	20.4	17.0	19.8	13.8	12.6	15.6	13.6	14.1
Total	**667.7**	**715.2**	**601.3**	**621.1**	**649.9**	**564.4**	**511.5**	**466.1**	**483.3**	**462.4**	**500.8**	**453.7**	**460.2**	**456.7**	**399.9**	**340.2**	**464.7**

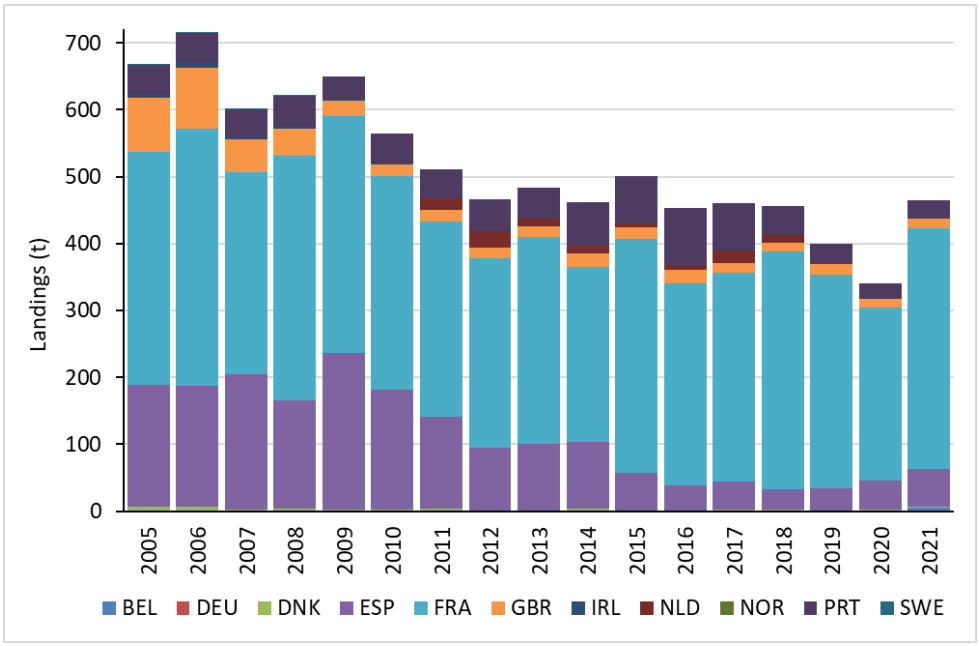

Figure 10.1. Tope in the Northeast Atlantic. ICES species-specific estimated landings by country for 2005–2021.

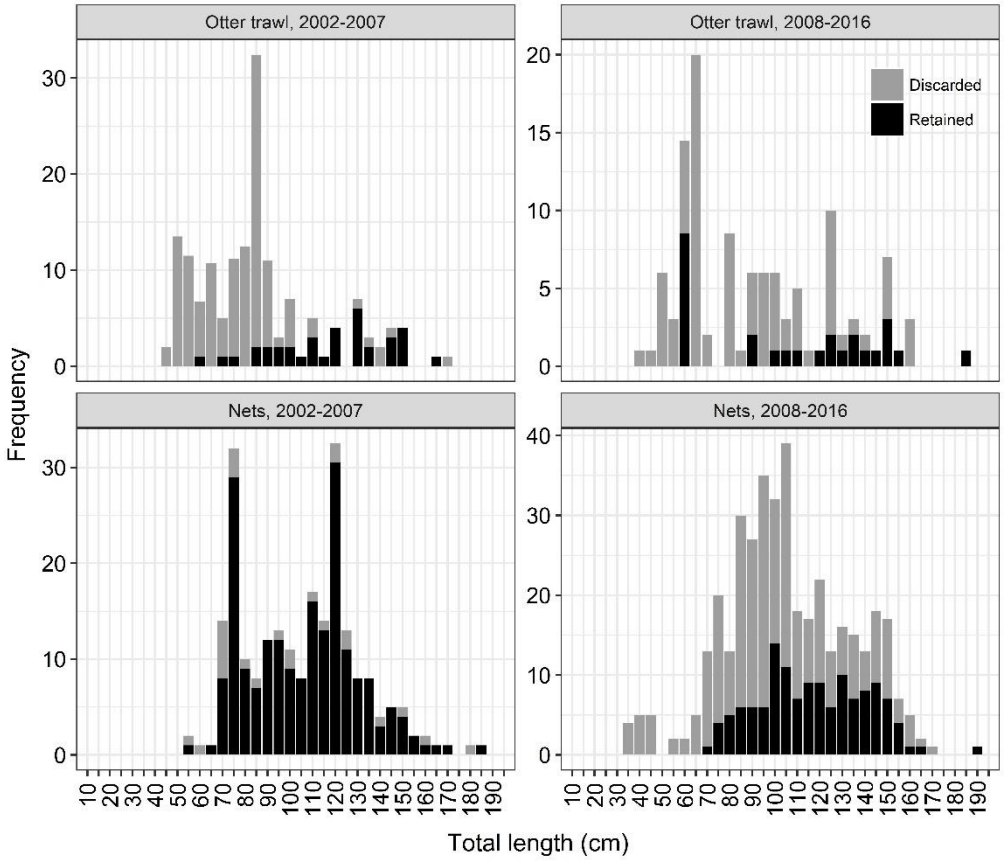

Figure 10.2. Tope in the Northeast Atlantic. Length–frequency of discarded and retained tope *Galeorhinus galeus* (5 cm length classes) caught by otter trawl and gill nets during the periods 2002–2007 and 2008–2016, as recorded in the Cefas observer programme. Source: Silva and Ellis (2019).

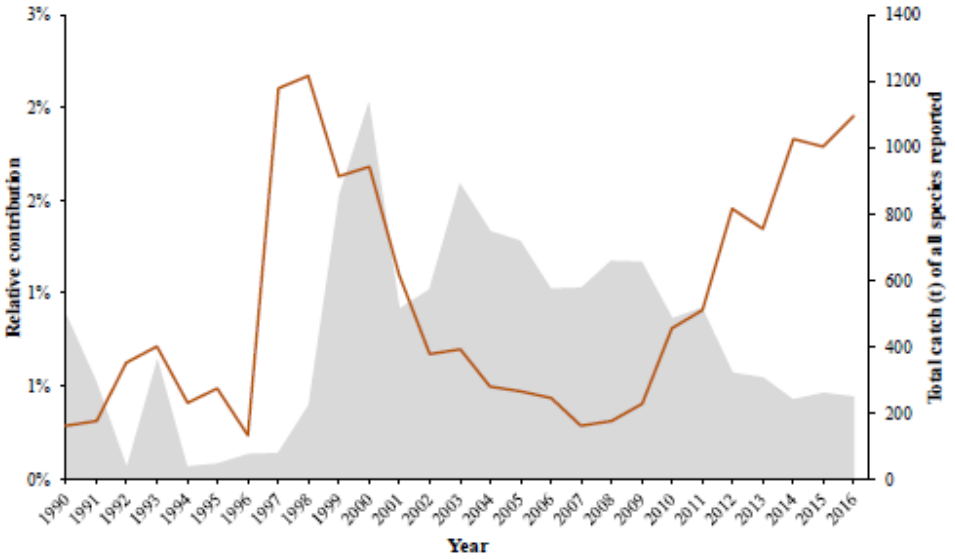

Figure 10.3. Tope in the Northeast Atlantic. Total catch of all species (■) and relative contribution of tope *Galeorhinus galeus* to all species (—) landed by the Azorean bottom longline fleet and sampled by the DCF inquiries.

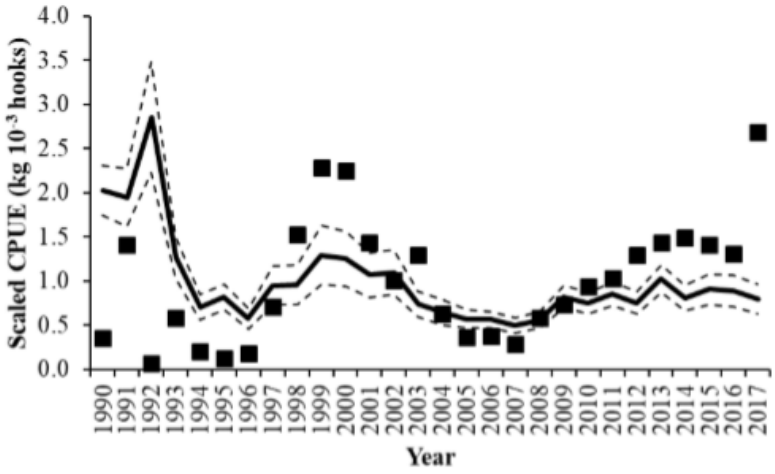

Figure 10.4. Tope in the Northeast Atlantic. Nominal (■) and standardized (—) CPUE (kg 10^{-3} hooks) for tope *Galeorhinus galeus* from the Azorean bottom longline fishery, 1990–2017. Dotted lines represent 95% confidence intervals for the standardized CPUE.

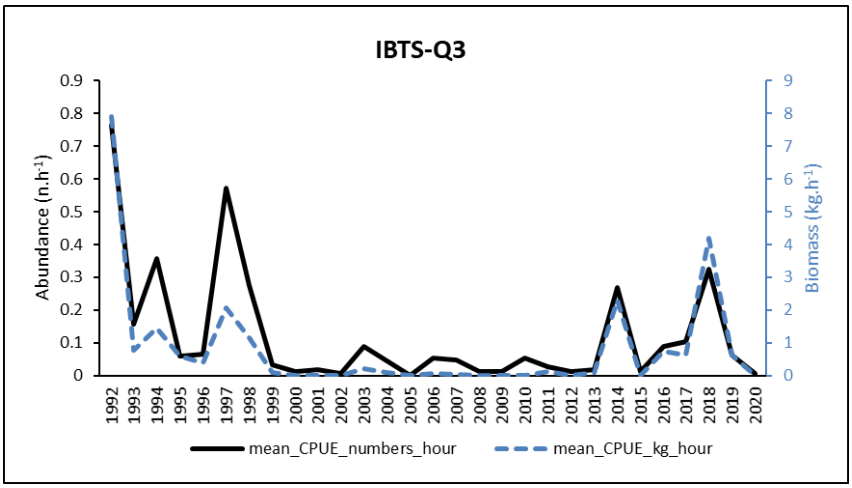

Figure 10.5. Tope in the Northeast Atlantic. Mean catch rate in terms of numbers (n.h^{-1}) and biomass (kg.h^{-1}) during the IBTS-Q3 of the North Sea (1992–2020). Note: The large catch in 1992 is largely due to a large catch reported in one haul, and these data should be verified. Some catches of tope are considered to have been reported as *Mustelus* on DATRAS, consequently this time-series does not provide a robust abundance trend.

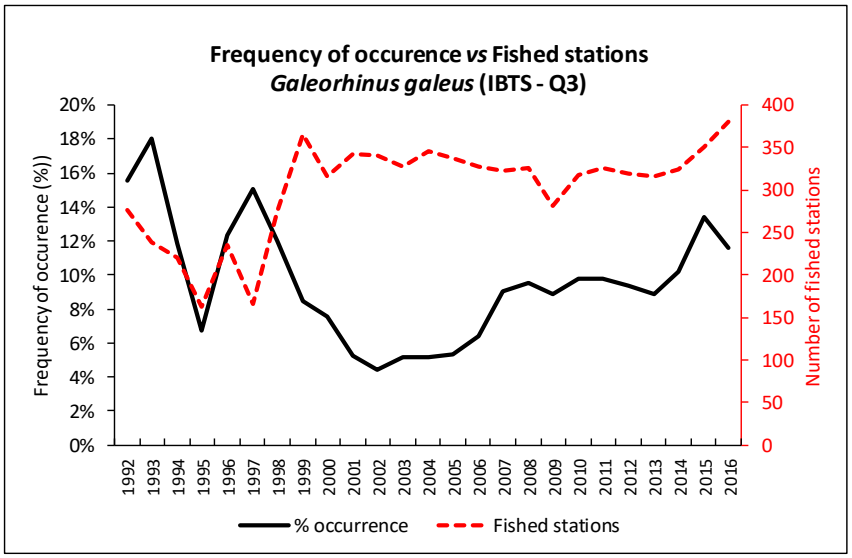

Figure 10.6. Tope in the Northeast Atlantic. Frequency of occurrence and number of fished stations in the IBTS-Q3 of the North Sea (1992–2016).

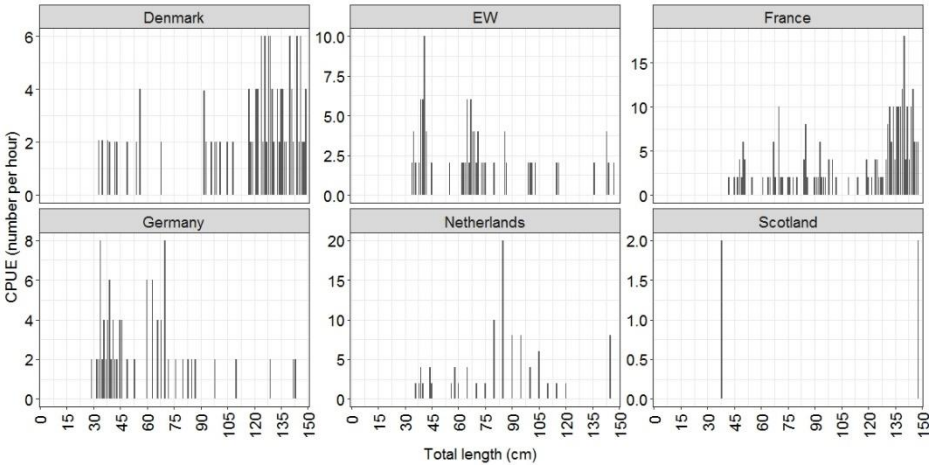

Figure 10.7. Tope in the Northeast Atlantic. Length-frequency distribution of tope by country in the IBTS-Q3 of the North Sea (1992–2016).

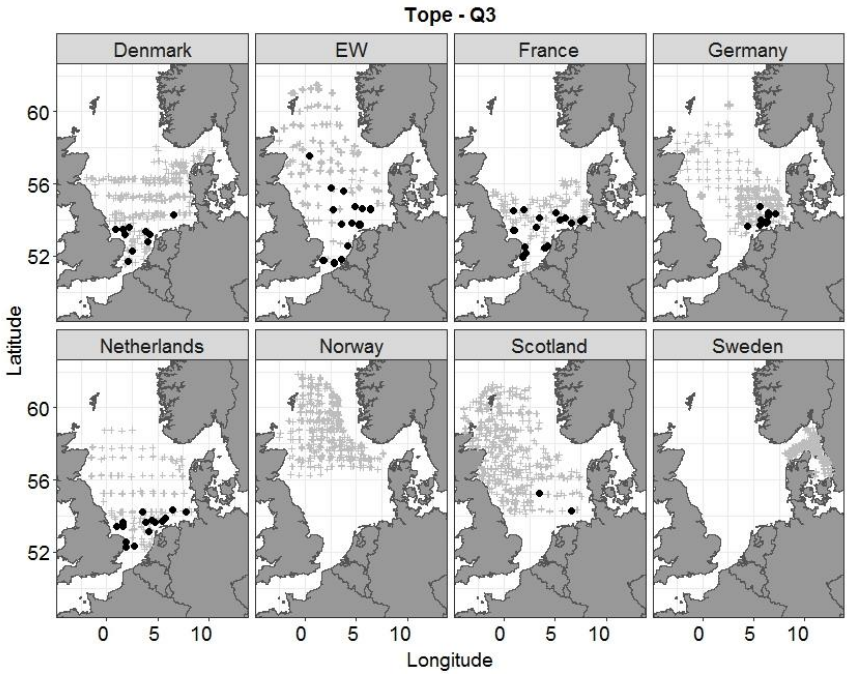

Figure 10.8. Tope in the Northeast Atlantic. Spatial distribution of tope by country in the IBTS-Q3 of the North Sea (1992–2016) (black dots = positive hauls; grey dots = negative hauls).

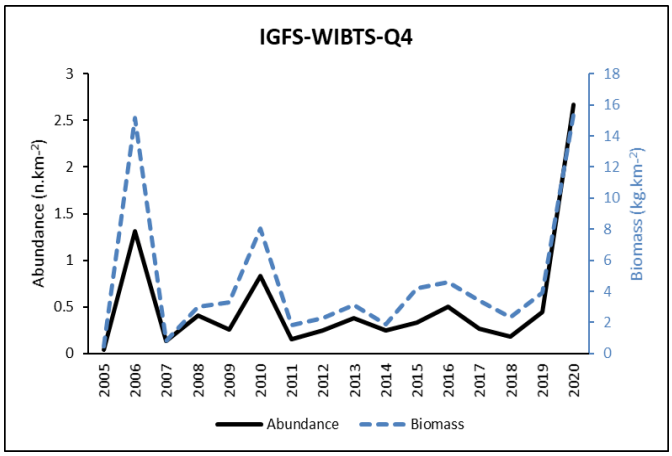

Figure 10.9. Tope in the Northeast Atlantic. Mean catch rate for in terms of abundance (n.km^{-2}) and biomass (kg.km^{-2}) for all individuals during the Irish Ground Fish Survey (IGFS-WIBTS-Q4) 2005–2020.

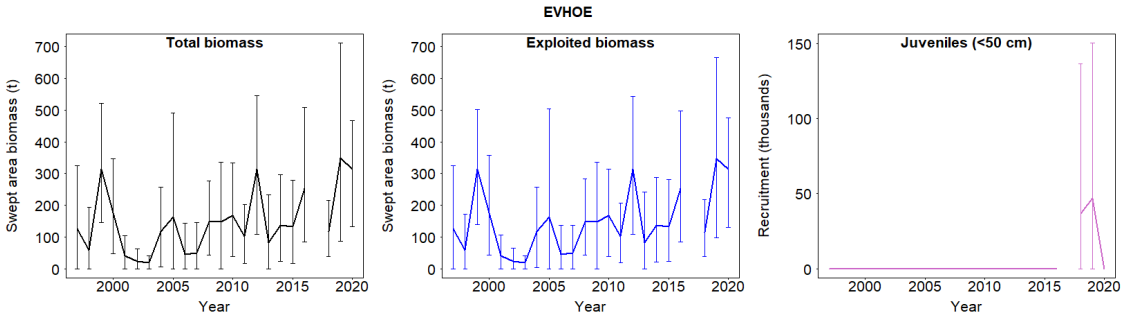

Figure 10.10. Tope in the Northeast Atlantic. Swept area biomass for total (t, all individuals) and exploitable biomass (t, individuals ≥50 cm total length) and, abundance in terms of numbers of juvenile fish (thousands, individuals <50 cm total length) during the EHVOE-WIBTS-Q4 (1997–2020). Associated confidence intervals (95% CI) calculated using bootstrap. Updated results in 2021 for whole time series.

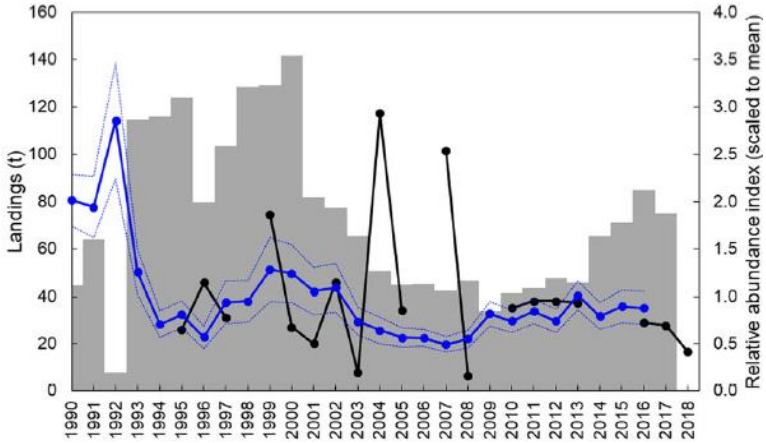

Figure 10.11. Tope in the Northeast Atlantic. Adapted from Santos *et al*. (2020). Landings (bars) and relative abundance index from the Azorean demersal spring bottom longline survey (black colour) and derived from commercial catch and effort (standardized CPUE) data (blue colour) in the Azores archipelago. Dotted lines represent 95% confidence intervals for the standardized CPUE. Note: Historical landings may differ from data in Table 10.1–10.3 so for ICES landings estimates used in advice please refer to Table 10.2 and 10.3.

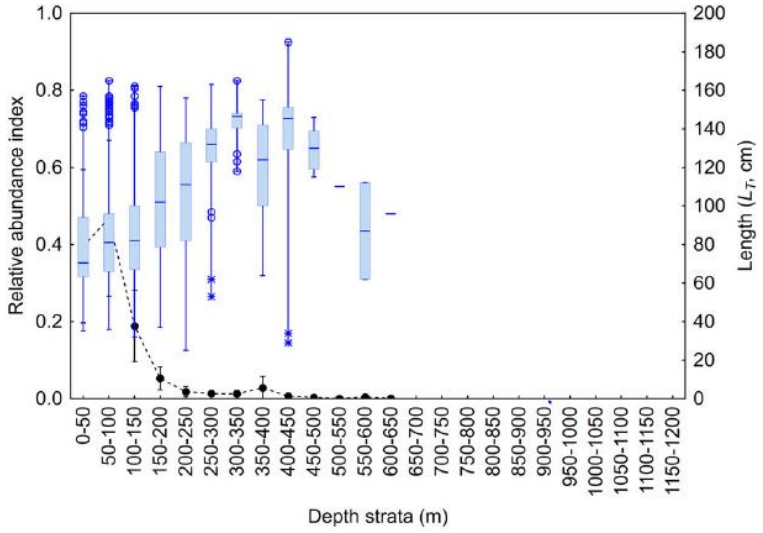

Figure 10.12. Tope in the Northeast Atlantic. Adapted from Santos *et al*. (2020). Relative abundance index (mean ± 0.95 confidence interval) and boxplot of length (L_T, cm) by stratum from the Azorean demersal spring bottom longline survey (1995–2018). Boxes show the quartiles (25–75%), horizontal lines inside each box show the median, and the limits are shown with whiskers. Empty-circle symbols identify outliers and asterisks are extreme outliers.

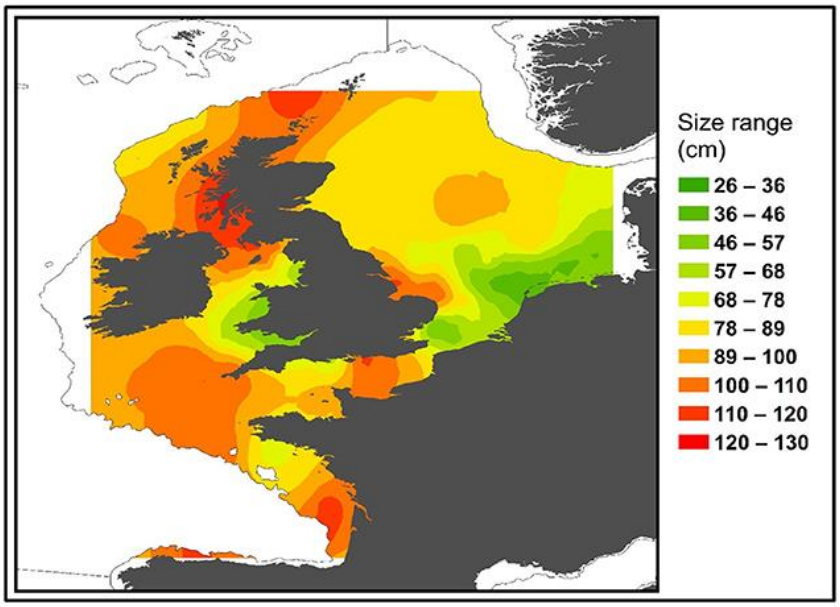

Figure 10.13. Tope in the Northeast Atlantic. Adapted from Thorburn *et al*. (2019). Distribution of all immature tope (max length = 130 cm L_T) based on mark and recapture and International Bottom Trawl Survey (IBTS) data sets. Colour represents smallest sized (based on L_T) animal predicted to occur in that area.