EMFF Operational Programme 2014-2020

Marine Biodiversity Scheme

The Biologically Sensitive Area:

A review of the basis and effectiveness

Lead Partner: APEM

Partners: Marine Institute

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APEM

Foras na Mara Marine Institute

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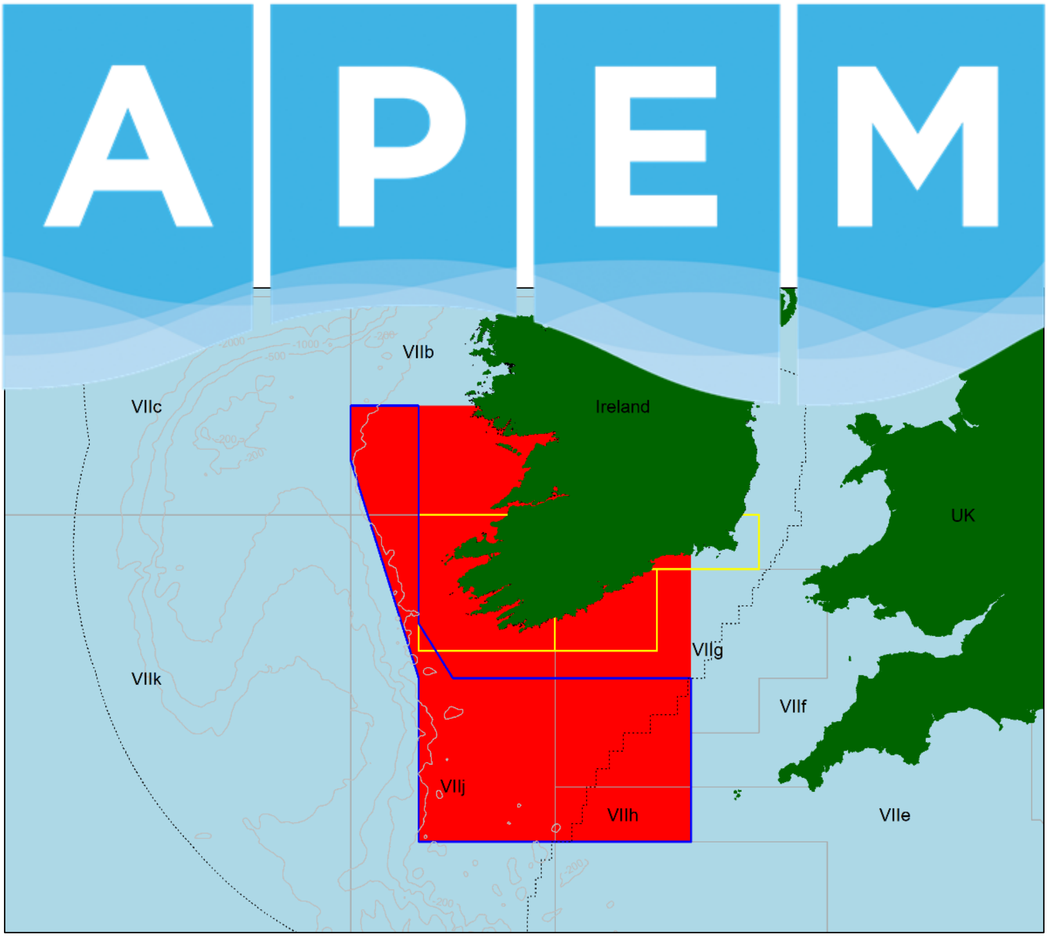

A review of the basis and effectiveness of the Biologically Sensitive Area

Marine institute

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February 2021

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2	12/02/2021	All	All	Full report draft	NT
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4	03/03/2021	All, resutls	All	Amending noted typos and figure legends	SD
5	12/03/2021	contents, resutls	multiple	Amending linked table and figure referencing	SD

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1. Executive summary

The Biologically Sensitive Area (BSA) designation is a multiuse area of protection to the south and west of Ireland. The BSA was established within a political context based on three core ideas, namely: (1) to prevent overfishing, (2) protect hake stocks and (3) protect spawning and nursery areas found in this area. The area was established in 2003 to limit fishing within the area, and replaced the previous larger 'Irish Box' which had surrounded Ireland.

Evidence supporting the presence of numerous commercial species spawning and/ or nursery areas within the BSA is present in the literature and fisheries independent survey data. These include mackerel, horse mackerel, herring, sprat, hake, anglerfish (white and black bellied), megrim, cod, whiting, haddock, saithe, ling, lemon sole, and *Nephrops*. In addition to reports of egg cases of vulnerable and threatened elasmobranchs. Information gathered by this report notes much of the hake spawning ground is to the west of the BSA along the 200m depth contour at the edge of the continental shelf. An area used by several species for spawning or as nursery grounds, including mackerel, horse mackerel, blue whiting, hake and anglerfish.

To protect the area from increasing commercial fishing, effort caps based on average levels between 1998 and 2002 were implemented in 2004 for demersal, shellfish and crustacean fishing under Council Regulation 1415/2004, often referred to as the Western Waters Regulations. A variety of additional regulations are active within the BSA, including total allowable catches (TACs), technical measures, closed seasons, and decommissioning schemes. Although each is implemented in isolation, they cumulative had positive impacts on the heath of some fish stocks within the area.

A greater number of stocks within the area are reported to be stainability exploited than in 2003. This includes the northern hake stock raised as one of the core purposes for the BSA. As well as species such as anglerfish and megrim. This is not the case for all stocks, and several commercially important stocks are still harvested unsustainably with reduced reproductive capacity. This includes cod, whiting, haddock, and several pelagic stocks. The BSA is therefore not helping to prevent overfishing for all stocks

Fishing effort estimated from STECF data between 2003 and 2016 (last year available in the time series) for the regulated fisheries indicated that when the regulation was introduced the effort ceilings were initially restrictive for some Member States. However, by 2016 effort had declined so much across the majority of Member States fisheries that the ceilings essentially became obsolete. This is reflected across the wider EU waters of ICES area VII and thus not due to effort displacement. One effort restriction has been noted as having remained limiting, effort restrictions within the edible and spider crab fishery. This effort limit is estimated to have been exceeded in most years with little evidence of a decline. Ireland, in particular, was responsible for fishing above this effort limit, and adjustments of the effort limits are regularly made through swaps. The effect of this on crab stocks is unknown due to data limitations, although there are indications of reduced catches in most recent years.

The cumulative impact of regulations present within the area are likely to be more effective than those specifically laid down for the BSA. It is hard to determine the effectiveness of the BSA due to the poorly defined objectives and purpose, as noted by previous reviews. However, given the apparent importance of the BSA area, the region should be protected. The report highlights a number of information gaps and future considerations as to how the BSA can be improved. The priority of which should be to define its purpose, develop management goals and objectives, and implement an appropriate monitoring program. In addition to the three initial factors guiding the development of the BSA, further aims should include: the protection of vulnerable species, particularly elasmobranchs, found in this area. An expansion along the western boundary of the BSA to encompass the main hake spawning ground which coincides with a particularly intensive area of fishing is recommended.

2. Introduction

In 2003, a Biologically Sensitive Area (BSA) to the south and west of Ireland was established, under Article 6 of Council Regulation 1954/2003 (EC, 2003b), replacing a previous, larger, protection area, the 'Irish Box' set up under the Iberian Act of Accession 1986 (EC, 1985). The BSA was established to limit fishing within the area following provision of powerful evidence of it being an area of high ecological importance containing important spawning and nursery grounds for exploited fish species in the Northeast Atlantic, particularly juvenile hake (EC, 2003b). However, the specific boundaries were formulated in a political context (ICES, 2009a). To protect the area from increasing commercial fishing, effort caps based on levels between 1998 and 2002 were implemented in 2004 for demersal, shellfish and crustacean fishing under Council Regulation 1415/2004 (EC, 2004b), often referred to as the Western Waters Regulations. Effort ceilings are not the only measure implemented within ICES Area VII, including catch limits, discarding restrictions, and technical measures regulating specific gear configurations, such as codend mesh sizes, each designed to aid commercially exploited species to reach sustainability and maintain Good Environmental Status (EC, 2001; EU, 2011; EU, 2013a; ICES, 2020t).

Acting on Article 6(3) of Council Regulation 1954/2003 (EC, 2003b), the Scientific, Technical and Economic Committee for Fisheries (STECF) began reviewing fishing effort within the BSA in 2009 via an expert working group on the evaluation of fishing effort regimes, deep sea, and western waters (STECF, 2009a), and continued in subsequent years. The utility, functioning and effectiveness of the BSA were considered inconclusive by this review in 2011 (STECF, 2011). The European Commission made a special request to ICES in 2009 relating to the impact of the "Irish Box" with the response focused on the BSA. The ICES advice gave a similar response to that of STECF, in that it was not possible "to draw conclusions on the usefulness of the BSA" and that should the BSA be retained "its objectives need to be clearly defined" (ICES, 2009a).

On December 2022, a report on the functioning of the current Common Fisheries Policy (CFP; EU, 2013) is due to be considered by the European Council and Parliament. As part of the CFP, the BSA will form part of this report. Ahead of this, a review of the utility, functioning and effectiveness of the BSA is required.

2.1 Project Background

The intention of this report is to review the basis and effectiveness of the BSA. This report focused on:

- the biological basis for the BSA;
- description of the effectiveness of the BSA to provide protection to the area;
- updating information on changes to the biological processes in the area; and
- gaps in the current knowledge and approach with possible mitigations to address such gaps; and
- recommendations for the future of the BSA.

3. Methods

3.1 Literature review

A review of literature was undertaken. Papers focusing on the BSA and the wider ICES Area VII were reviewed. Papers consisted of peer-reviewed scientific publications, council regulations, reports and grey literature. Papers were scored according to Perez-Dominguez *et al.,* (2016) scoring system.

3.2 Fish landings in Ireland

To identify the change in species landings within the BSA, the top 15 species landed (live weight) in ICES divisions VIIb, j, and g between 1999 to 2008 and 2009 to 2018 were compared. Data was obtained from ICES, Official Nominal Catches. Selected landings were grouped by species to allow accurate representation of catch quantities. To account for species which fall under similar catch quotas or where species may have been miss labelled (for instance landings recorded as *Nephropidae* and *Nephrops norvegicus*), species were entered at the genus level. It is important to note that countries may revise historic data at any time and therefore slight differences within the same dataset do occur over time.

3.3 Stock assessments

Recent stock health for species of interest within and around the BSA were examined in terms of available reference points (linked to maximum sustainable yield and precautionary limits) in comparison to spawning stock biomass (SSB) and fishing mortality (F). Information was compiled from ICES and ICCAT advice in addition to IUCN assessments based on Europe wide information (Nieto et al., 2015) and information from Clarke *et al.* (2016) based on Irish-wide assessment of elasmobranchs. Tables compare 2003 to the most recent information with trends provided graphically.

3.4 Length frequency

Length data of fish sampled from commercial catches as part of the Irish Data Collection Framework (EC, 2017) were provided by the Marine Institute. Individual length measurements were provided denoted as the retained (landed) and discarded (unwanted). These were unraised measured numbers. As such, length frequencies are presented as proportions to provide an indication of the length distributions being caught by the Irish fleet in ICES divisions VIIg and VIIj. Note that monkfish is the only represented species where a minimum landing weight was specified (EC, 1996). This has been converted to a length measurement using the length weight relationship: $W = a\ L^b$ where W is weight (g), L is total length (cm) and ‘a’ represent the intercept (0.0285) and ‘b’ the slope of the relationship (2.83) (Gerritsen, pers. com) giving a 32cm estimation. Minimum landing size / minimum conservation reference size (renamed with the introduction of the landings obligation) for all other species depicted are given in Council Regulation 850/1998 (EC, 1998).

3.5 Logbook fishing effort

In the BSA and wider EU waters of ICES Area VII, estimates of kilowatt (kW) fishing effort derived from European logbooks were used to compare trends in Member State fishing effort to fishery specific effort limits laid down in Council Regulation 1415/2004 (EC, 2004b). Council Regulation 1415/2004 states “For the calculation of fishing effort by vessel in a particular area, the activity is defined, for the vessel absent from port, as the number of days at sea by trip in the area, rounded up to the nearest whole number.” There are several methods of estimating fishing effort used by STECF, the primary review group assessing European effort management regime. Methods include (1) days-at-sea, (2) fishing days (or nominal effort) and (3) hours fished. Each method measures effort in a slightly different way: (1) days-at-sea includes days spent reaching a fishing ground but not actively fishing; (2) fishing days only count days on which fishing activity occurred and (3) hours fished, records only the hours reported as fishing within an area by logbooks. Methods 1 and 2 can both result in an over estimation when vessels are active in multiple areas on the same day, as this method will allocate effort to both areas.

For calculating effort, this report has used the second method fishing days as this method is considered to be the measure most accurately reflecting the definition given in the regulation. Furthermore, as vessels notify authorities when entering the ICES area VII and the BSA with the intention to fish, time spent steaming is unlikely to be counted against the allocation. Method 1, Days-at-sea, would likely result in an over estimation, particularly for nations such as Spain and France which would have longer steaming times to reach the BSA, especially compared to Irish vessels. While method 3, hours fished, would likely underestimate effort as it does not round to the nearest day.

Further information regarding effort estimation and submission can be found in the 2017 EWG FDI report (STECF, 2017b). For details and assumptions on how kW fishing effort data was generated by the STECF please refer to the report of the Expert Group on Fisheries Dependent Information where sections are dedicated to describing how Member States compiled effort estimates, how the Expert Group aggregated these data, and data limitations (STECF, 2017b).

Effort is regulated by fisheries, however effort data is not available with an associated target species. For the purposes of this report, estimated effort was scaled to demersal, scallop and crab fisheries per country over time using species composition of landings at the same aggregation level as that available for fishing effort (Member State, gear, year, quarter and ICES rectangle). Whereby, the proportion of landings associated with the target species of a regulated fishery was used to adjust effort to the same proportion. For example, if an aggregation contained landings of 40% crab,Crab-directed effort would be estimated to be 40% of the reported effort for the same aggregation. The following assumptions were made when adjusting effort:

1) Crab fishery effort (spider crabs and edible crabs) was generated from scaling pot gear effort to crab landings;
2) Scallop fishery estimated effort was generated based on beam trawl and dredge effort scaled to scallop landings;
3) Demersal fishery estimated effort was generated in two parts:
    a. All gillnet and demersal seine effort were assumed to originate from demersal species; and
    b. Effort by beam trawls, longlines and demersal trawls was scaled to remove effort used to catch scallop, crab and pelagic species (mackerel, horse

mackerel, herring, sprat, blue whiting, boarfish, and tunas), with effort remaining assumed to be targeting demersal fisheries.

4) Effort for pelagic trawls and seines were removed from effort estimations as these were assumed to target pelagic species and are not regulated under Council Regulation 1415/2004.

5) Effort calculations were restricted to vessels of greater than or equal to 10m in length for the BSA, and 15m for EU waters of ICES area VII as per Council Regulation 1415/2004.

3.6 Vessel monitoring system effort

Since 2003 the EU have required fishing vessels to have on board a satellite-based vessel monitoring system (VMS) transmit the geographical position and speed of vessels at intervals of two hours or less (EC, 2003a). Although VMS data does not specify the activity of a vessel, the speed at which it is travelling can be used to estimate fishing activity and its duration. As discussed by Gerritsen & Lordan (2014) and more recently Gerritsen & Kelly (2019), this method of estimating fishing activity works best for active gear where the majority of vessel time is engaged in fishing. Effort estimation for pelagic trawls is less accurate, where vessels spend the majority of time at sea seeking shoals and relatively short periods actively fishing. These short activities can be missed during the 2-hour time interval between VMS transmissions. For passive gear where soak time is a more appropriate measure of effort, such as gillnets and pots, data should only be used to provide an indication of fishing grounds. Therefore, as recommended most recently by Gerritsen & Kelly (2019) maps based on pelagic trawl data or passive gear data cannot be evaluated in a quantitative way.

The Marine Institute provided aggregated anonymised positional effort estimations based on VMS data from 2006 to 2018 within the BSA and Irish EEZ portion of the wider ICES Area VII. Data by non-Irish vessels outside the Irish EEZ is not consistently available. Absence of effort from maps outside the BSA and Irish EEZ within this report therefore does not equate to zero fishing activity. The methodology used to generate this data is as described in Gerritsen and Kelly (2019). The use of speed criteria to determine fishing activity is fallible, with vessels having legitimate non-fishing activities at similar, slower speeds, for example near ports. There is around an 85% alignment of VMS based effort estimation with logbook reported effort for active demersal gears (Gerritsen, pers coms). Gillnets, however, have a lower alignment with logbook reported effort, which can be linked back to the passive fishing method of this gear.

It should be noted when assessing VMS data presented within this report that VMS was available for vessels greater than or equal to 15m in length for the duration of the time period examined. From the 1st January 2012, this was extended to include vessels down to 12m in length under Council Regulation 1224/2009 (EC, 2009).

Effort hours fished by each nation for each gear type within the BSA was tabulated. Effort for nations with low or nominal effort were grouped as “other.” An additional row was included to represent the proportion of effort observed within the non-Irish EEZ portion of the BSA. Note, provision of data by non-Irish vessels in this area of the BSA was not consistently available.

3.7 Spawning and nursery areas

A combination of published information and data from ICES surveys were used to examine spawning and nursery areas within the BSA. For the purpose of this report, spawning areas are areas where either ripe fish were caught, or eggs collected. Nursery areas are those areas which had the youngest size class of species identified with preference given to fish < 1 year (Ellise *et al*., 2010; Ellise *et al*., 2012; Aires *et al*., 2014).

As a basis to build on, this report uses spawning and nursery grounds identified by ICES (2009a). For spawning, these areas were identified using a combination of egg and larval data (ICES MEGS surveys and Irish egg and larval surveys; Dransfeld *et al*., 2014) with observations of spawning fish observed during quarter 1 trawl surveys (a discontinued UK groundfish survey (Tidd and Warnes, 2006) and an Irish Q1 biological sampling survey (Gerritsen, unpublished). Nursery areas were identified primarily from the ICES quarter 4 IBTS ground fish surveys. The authors state these data sources should be interpreted with caution as a result of data bias including:

- Hydrodynamic conditions transporting eggs and larva away from the original spawning location diffusing and/ or distorting spatial and temporal coverage;
- Juveniles of some species may be inaccessible or have a low catchability on surveys, for example pelagic or flatfish species in demersal surveys; and
- The distribution of individuals may change seasonally or with size and or age, for example spawning aggregations.

Eggs identified during the tri-annual ICES MEGS surveys since 2009 for mackerel, horse mackerel, and when available, hake, were used to generate distributions maps of numbers at development stage. Survey data were available from the 2010, 2013, and 2016 surveys from the ICES data portal.

The ICES DATRAS database (http://datras.ices.dk, ICES, 2020c) of demersal surveys were used to generate annual CPUE (number of fish caught per hour) distribution maps of juvenile fish. Based on information from the literature the following species were mapped to highlight nursery grounds: monkfish (*Lophius piscatorius* and *Lophius budegassa*), whiting (*Merlangius merlangus*), cod (*Gadus morhua*), hake (*Merluccius merluccius*), haddock (*Melanogrammus aeglefinus*), megrim (*Lepidorhombus whiffiagonis*), and four spot megrim (*Lepidorhombus boscii*). Raw haul data were downloaded via the ices Datras package 1.3-0 (Millar *et al.*, 2019), screened for error and converted to CPUE before plotting distributions in R version 4.0.3 (R Core Team, 2020).

4. Literature review

In 2009 the EU requested ICES and STECF to review the impact of the BSA. Since which, STECF expert groups have continued to review effort within the area as part of its wide remit to review European fishing effort regimes. However, these initial reviews were over 10 years ago. During which time the marine environment has continued to change along with our understanding of species and the activity within the area. An updated review of the BSA was required to tie in with the wider upcoming review of the Common Fisheries Policy (CFP; EU, 2013). A variety of reports, peer-reviewed publications, council regulations, press articles and grey literature focusing on the BSA and surrounding ICES Area VII waters were reviewed. Articles were scored based on the scoring system developed by Pérez-Domínguez *et al.* (2016). The overall score of the papers included in the literature review was high (14.9). The score represents high applicability of evidence, high degree of confidence and high quality of information for all papers with the exception of press articles and websites which were marked down on the basis that such sources may include personal judgement in addition to the information reported.

4.1 History of the BSA

The waters around Ireland are host to commercially important fisheries. In 2003, an estimated 199,772 tonnes of fish and shellfish were landed from ICES divisions VIIb, g and j, the area overlapping with the BSA (Official Nominal Catches, 1950-2010). The main countries fishing in this area included Ireland, France, Spain, UK and Belgium (Official Nominal Catches, 1950-2010). In 2018, the landings of commercial species reduced to 118,670 tonnes (live weight) from the same area caught by similar nations: Ireland, France, Spain, UK and The Netherlands (Official Nominal Catches, 2006-2018).

To protect the rich Irish waters, areas have been given significant status and rules have been implemented to help preserve fisheries in the area. Around Ireland, there are a range of restrictions including (to name a few) closed areas in the north western waters protecting cod during spawning, coral grounds, deep water closures for orange roughy, transitional prohibitions on nets set at depths beyond 200m in ICES VIa, b, VIIb, c, j, k and subarea XII, seasonal closures on the Porcupine Bank for *Nephrops*, restricted fishing west of Scotland for cod, whiting and haddock and mesh size and effort restrictions within the BSA (Lutchman *et al*., 2007; Nolan *et al*., 2011; Dransfield *et al.,* 2014).

The BSA lies off the west and south coast of Ireland within the exclusive economic zones of Ireland and the United Kingdom. The area covers much of ICES divisions VIIg and VIIj, continental shelf portions of VIIb, upper portion of VIIh, and a small corner of VIIa in the Irish Sea (Figure 1). The BSA is considered an area of high biological activity and of importance to different life history stages for a variety of species (Dransfield *et al.,* 2014).

The BSA was designated for additional management measures in 2003 to protect the area from increased fishing pressure (EC, 2003b). The area comprised the southern part of the protective area known as the “Irish box” which had been formed in 1986 under the Iberian Act of Accession (EC, 1985). Article 6 of Council Regulation 1954/2003 (EC, 2003b) repealed the Irish Box protection. The BSA also overlaps with the “hake box” within which larger mesh size use for static and towed gears is required under Council Regulation 1162/2001 (EC, 2001) (Figure 1). Shortly after the BSA was formed, Council Regulation 1415/2004 (EC, 2004b), known as Western Waters Regulations created effort limitations for Member States across the north-east Atlantic area for shellfish, demersal, and crustacean fishing. These effort caps, hake box mesh size restrictions, and technical measures to protect juvenile fish (Council Regulation 850/1998; EC, 1998) and the northern hake stock (Council Regulation 494/2002; EC, 2002a) have been the primary means of limiting the fishing capacity within the BSA. Council regulation 850/1998 (EC, 1998) includes three tri-annual herring closed seasons which are within the inshore area of the BSA to protect juvenile herring. Table 1 shows a timeline of some of the main regulations and reports relevant to the history of the BSA.

Table 1: Timeline of the regulations and studies which have been instrumental in the formation and shaping of the BSA.

Regulation	Event
EC 1985	Iberian Act of Accession: the Irish Box was formed.
EEC 3760/1992	Introduction of the Common Fisheries Policy.
EC 850/1998	Conservation of fishery resources through technical measures for the protection of juveniles.
EC 685/95; EC 2027/95	Western waters regime.
EC 850/1998	Inshore closed seasons for herring within the BSA.
EC 1162/2001	Established a “hake box” within part of what became the BSA
EC 494/2002	Establishing additional technical measures for the recovery of the stock of hake in ICES sub-areas.
EC 2371/2002	Amendments made to the Common Fisheries Policy.
EC 1954/2003	Biologically sensitive area replacing the Irish Box.
EC 1415/2004	Western Waters Regulations: Fixing the maximum annual fishing effort per fishery for each member state in the BSA for vessels 10m and over.
EC 811/2004	Establish multi annual plan for the recovery of Northern hake.
EC 51/2006; EC 941/2006	Deep water gill net restrictions. Prohibited use to less than 200m, law later amended prohibit use between 200m and 600m.
STECF 2009	STECF began reviewing fishing effort within the BSA.
ICES 2009a	ICES deemed it not possible to draw conclusions on the usefulness of BSA due to a lack of objectives.
STECF 2011	Deemed information on fishing effort from certain member states unreliable and stated that they should not be used for management decisions (STECF, 2011).
EU 1380/2013	Revisions made to the Common Fisheries Policy including provision for the landing obligation, phasing in of a ban on discards from 2016 to 2019.
EC 123/2020	Remedial measures for cod and whiting in Celtic sea. Restricting mesh size.
European Union 2020	UK left the European Union. South-east corner of the BSA within UK EEZ and no longer governed by the CFP.
Dec-2022	Review of the Common Fisheries Policy (Regulations 1380/2013; EU, 2013)

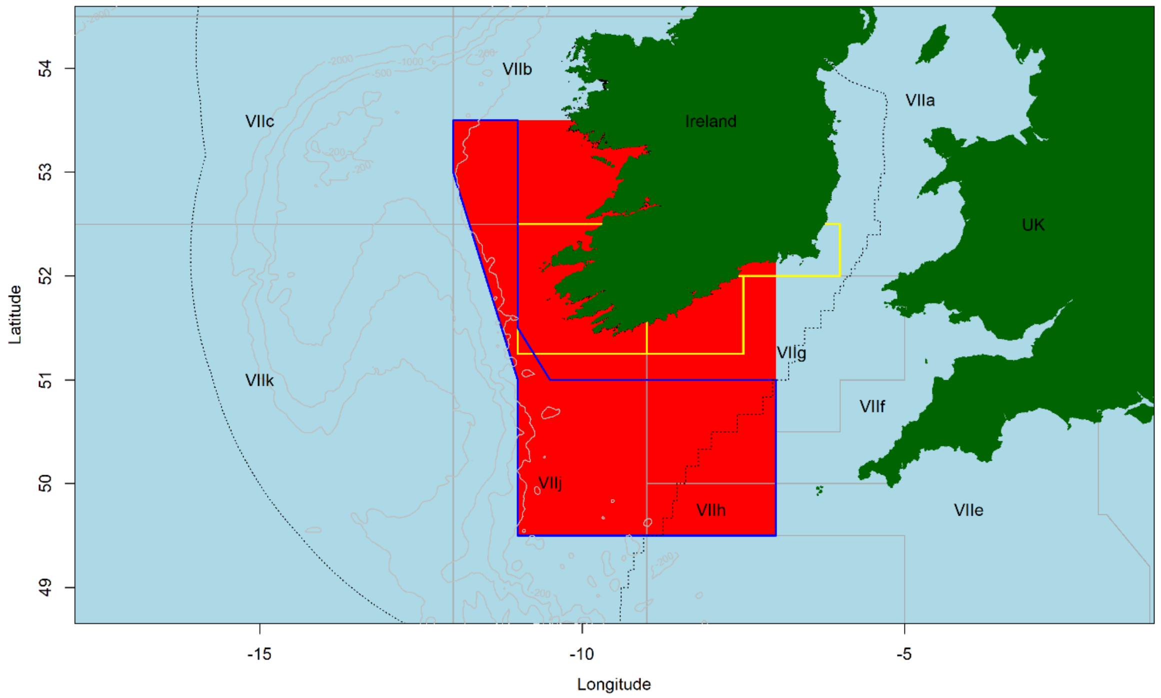

Figure 1: A map depicting the Biologically Sensitive Area (red box), hake box (blue outline) and herring box (yellow outline). Additional highlighted features of interest include the Irish EEZ (broken black line), ICES areas (dark grey lines) and bathymetry (200m, 500m, 1000m, and 2000m, light grey contours).

Research detailing evidence supporting the formation of the BSA in 2003 is lacking. However, in an annual report by the Marine Institute (Marine Institute, 2003), arguments for the preservation of part of the Irish box were made based on the evidence that the areas off the south and southwest of Ireland were some of the most important spawning grounds in the north-east Atlantic. Commercially important species considered to spawn within this area include mackerel, horse mackerel, blue whiting, hake, megrim, herring and nursery areas for herring, haddock, hake, whiting and megrim (Marine Institute, 2003).

The BSA encompasses a known hake nursery area, and part of a hake spawning area in ICES Area VII. The BSA overlaps with known important commercial demersal and pelagic stocks (ICES, 2009a). In part, the BSA was formed to assist with the recovery of hake, which at the time had been overfished for a prolonged period (ICES, 2020c). The lack of scientific evidence and clearly defined objectives may result from the BSA being formed due to political motivations. Political reasons guiding the formation of the BSA were noted in an earlier review carried out by ICES (2009a).

Newspaper articles reporting on the events at the time indicated concern in losing the Irish box, and as a result creating unlimited access to Irish waters by the Spanish fleet. It was considered this perceived lack of control would undermine previous efforts to protect fisheries resources (Creedon, 2003). Pressure for increasing access to the Spanish fleet was high. The BSA was negotiated by Irish ministers and the Irish Fishing Organisations to preserve a smaller part of the Irish Box maintaining restricted access to effort no greater than previous fishing levels (Creedon, 2003). According to the article, the Spanish were "hopping mad" over these continued restrictions and limited access within Irish waters (Creedon, 2003). Despite this “win” dissatisfaction still existed over the high levels of fishing permitted and large catches of hake being landed by foreign (particularly Spanish) fishing fleets (Creedon, 2003). The new Irish Conservation Box was planned to be subjected to new and non-biased effort regimes and various technical measures (Marine Institute, 2003).

Spatially managed fishing areas with poorly defined objectives, like the Irish box, were not uncommon in the common fisheries policy (Lutchman *et al*., 2007). The reasons for these areas was variable including fish stock management, nature conservation, and resource access (Lutchman *et al*., 2007). The Shetland box, Norway pout box, Mackerel box and Plaice box are just some examples (Lutchman *et al*., 2007). The formation of these areas was cited as stock protection, however, it may have also been to help protect local fishing fleets from competition or overcrowding from other Member States (Lutchman *et al*., 2007). At this time multipurpose spatial management was much more prevalent than fully protected areas prohibiting fishing for nature conservation and the few that exist were established later (Lutchman *et al*., 2007).

The European Union pledged to give additional protection (in the form of restricting or prohibiting fishing) to existing biologically sensitive areas and protect areas where evidence of heavy concentrations of fish below minimum conservation reference size are found and protect areas which are known fish spawning grounds (EU, 2013). The BSA is an existing sensitive area and includes spawning and nursery areas for a variety of fish (ICES, 2009a). The BSA, therefore, falls under the European Unions pledge.

4.2 Fisheries management measures within the BSA

When managing a fishery, a variety of tools can be applied. The three main methods used to restrict fishing include: (1) Effort restrictions which control the capacity and activity output of fishing vessels. Effort restrictions are generally a combination of time spent fishing and the capacity of the vessel, net and/ or boat engine (European Commission, 2010). The BSA was originally designed on this principle. (2) Technical measures which restrict how fish can be caught, such as specifying minimum codend mesh size or use of sorting grids. The hake box for example specifies a minimum codend mesh size that can be used. Finally, (3) output management controls, which restrict how much can be removed. In northern Europe this is typically through specification of total allowable catch (TAC) and quotas. Although not mandated to the BSA regulation, today, fishing in the BSA is restricted by a combination of all three methods. Species TACs are considered the main management tool within this area (ICES, 2018a). In the past the European Commission has used effort-based management as a primary means of control in some areas (European Commission, 2010).

4.2.1 Effort restrictions

Fisheries management within the BSA, was linked to The Western waters’ regime. This regime was originally established in 1995 (EC, 1995a) to safeguard the common fisheries policy (CFP) and ensure that there was no increase in fishing effort compared to previous levels. This regime was pertinent at the time due to the integration of Spain and Portugal into the CFP (European Commission, 2010a). The 1995 regulations were later replaced by Council Regulation 1415/2004 (EC, 2004b). In combination, these two regulations set effort restrictions across the western waters (ICES Area V down to CECAF Area 34.2.0) for many European fishing vessels. These effort restrictions, often referred to as the Western Waters Regulations, were based on the average annual fishing effort of each Member Sate between

1998 and 2002 (Table 2). The effort restrictions target demersal (excluding demersal species covered by Council Regulation 2347/2002; EC, 2002b), scallop, edible crab and spider crab fisheries (EC, 2004b). If a country exceeds annual fishing effort limits in ICES area VII, then the fisheries administration would close the area to those vessels targeting that species for the remainder of that year (UK Government, 2014).

Table 2: Western Waters Regulations effort restrictions for the BSA as defined by Council Regulation 1415/2004 (EC, 2004b).

Fishery	Demersal	Scallop	Crab	Total
Belgium	135,432	-	-	135,432
Denmark	-	-	-	-
Germany	8,326	-	-	8,326
Spain	5,642,215	-	-	5,642,215
France	9,559,653	31,039	84,690	9,675,382
Ireland	7,154,490	109,395	63,198	7,327,083
The Netherlands	-	-	-	-
Portugal	-	-	-	-
United Kingdom	3,061,485	1,223	393	3,063,101

The regulations only apply to vessels of 15m or more, except within the BSA where 10m minimum length is defined. This reduction in size restriction for the BSA is linked to accessibility. The 10m access restriction ensured smaller Irish vessels capable of making day trips to access the sensitive fishing grounds were included within the effort limitations (European Commission, 2010a). It should be noted that under 10m vessels are not included within the effort restrictions yet these vessels make up approximately 66% of the Irish fishing fleet (ICES, 2019c). Other Member State vessels less than 10m are unlikely to enter the BSA due to the prohibitive distance from other National shorelines. Fishing trips and catches for vessels of 10m or more are monitored by logbooks and those over 12m or more are also monitored by vessel monitoring systems (VMS) (EU, 2013).

The use of effort limitations as a primary means of limiting fishing has received criticism. In 2009, ICES reported inconsistencies in effort reported by nations compared to that calculated by VMS data (ICES, 2009a). In 2011, STECF to whom submission of national fishing information is an EU requirement under the Data Collection Regulation (EC, 2008a) deemed fishing effort information provided by certain Member States as unreliable and recommended that this information should not be used for management decisions (STECF, 2011). Over time the quality of information reported within logbooks has improved. However, variability in the quality and extent of information Member States submit to review groups, such as ICES and STECF remains an issue. The lack of consistency when comparing reported logbook effort and VMS data makes effort restrictions a difficult management tool to evaluate and brings into question the quality of the original effort limitations based on reported effort between 1998 and 2002. These original effort values cannot be cross-referenced due to the lack of VMS data for this period (ICES, 2009a). In general, efforts calculated by VMS are considerably lower than those reported to review groups (ICES, 2009a). This in part is the result of effort reporting within logbooks where time is completed manually and can be over or underestimated. The European Commission believed the enforcement of daily catch reporting via electronic logbooks and linking with VMS systems would improve accuracy (European Commission, 2010a).

4.2.2 Technical measures

Much of the BSA overlaps with a hake box which was established to assist with the recovery of the northern hake stock (ICES sub-areas III, IV, V, VI and VII and ICES division VIIa, b, d, and e). In 2000, this stock was at serious risk of collapse (ICES, 2020e). Council Regulation 1162/2001 (EC, 2001) and 494/2002 (EC, 2002a) established the hake box and created mesh size restrictions to reduce pressure on the stock. Within the box and more than 12nm from the coast, use of towed gear with less than 100 mm codend mesh size is prohibited, and less than 120 mm for static gears. At the time, towed gear mesh size ranges of 80 to 99mm, and less than 120mm for static gears, were commonly used to catch hake in ICES area VII (ICES, 2009a). Restrictions on the percentage of hake retained on board vessels over 12m and carrying fishing gear with mesh size between 55 to 99mm were implemented. For these vessels, the total catch of hake compared to the weight of the total catch of marine organism retained on board was not allowed to exceed 5% (vessel with a beam trawl) and 20% (vessel without a beam trawl; EC, 2002a).

Increasing mesh sizes is a common fisheries management tool used to promote the recovery of stocks (ICES, 2009b). Mesh sizes are frequently increased to allow juveniles to pass through the net and thus reduce the bycatch of smaller fish or shellfish (ICES, 2009b). Mesh size regulations have been used to help stabilise fishing mortality within the BSA and wider area (including the Bay of Biscay) since 2001 (ICES, 2009b). Although several species remain of concern within the BSA area, there are a variety of species which are fished at or below their maximum sustainable yield reference points (F_{MSY}). However, further research is needed as fishing mortality reference points for some stocks within the BSA are unknown (ICES, 2019c).

4.2.3 Output management controls

Many of the fisheries within ICES Area VII (and therefore the BSA) have been subject to total allowable catch (TAC) management measures since the 1980's (European Commission, 2010a). According to fishing opportunities Council Regulation 124/2019 (EU, 2019) TACs are set according to the following factors:

> *"The total allowable catch (TAC) should [therefore] be established, in line with Regulation (EU) No 1380/2013, on the basis of available scientific advice, taking into account biological and socio-economic aspects whilst ensuring fair treatment between fishing sectors, as well as in the light of the opinions expressed during the consultation of stakeholders, in particular at the meetings of the Advisory Councils (EU 2019/124)."*

Species under TAC within area VII includes: Hake, monkfish, megrim, cod, haddock, whiting, pollack, saithe, ling, sole, plaice, Norway lobster, along with several skate and ray species. The Current Celtic Sea cod (VIIe-k) ICES advice is for zero catches in 2021 (ICES, 2019e; 2020u), however a 805 tonne TAC was set. Such mismatches are common within EU waters, due to socio-economic pressures resulting from zero TACs. Precautionary TACs are set for commercial species with insufficient biological information for ICES to assess whether exploitation is sustainable (EU, 2019). TACs for the majority of species are adjusted annually, and since their introduction show a declining trend while managers attempt to bring stocks in line with maximum sustainable yields. It should be noted that there are other species which do not have TAC limitations (European Commission, 2010a) some of these are considered bycatch species, such as gurnards, while others are of commercial value such as squid.

Within Europe TACs are traditionally set for individual species or stocks. However, fishing methods generally catch more than one species, and demersal trawling will generally catch several different species (ICES, 2019c). There are more selective fisheries, for example, pelagic fisheries tend to be more selective and often target single species shoals. Issues can occur when utilising single-species fisheries management in fisheries targeting multiple species (mixed fisheries) with varying stock health. For example, in the Celtic Sea, cod are caught in combination with haddock and whiting which have greater TAC allocations. Cod therefore becomes a limiting factor in the sustainable exploitation of the three species. If haddock is fished at F_{MSY}, you invariably fish whiting and cod above F_{MSY} (ICES, 2019c). In these instances, managers are able to state there should be no directed fishery for the most vulnerable stock, setting a TAC to be used for bycatch only. Examples of this include cod, plaice, spurdog and small eyed ray (EU, 2019). Vessels which are subjected to landing obligations or bycatch avoidance programs can land up to the TAC however once reached, this species will act as a choke species forcing the fishermen to stop fishing in the area that these species are caught (STECF, 2017a).

The landing obligation regulation was introduced in an attempt to reduce the large volumes of unwanted catch and wasteful discarding of dead fish (EU, 2013a). This unwanted catch negatively affects the sustainability of a fishery and in turn the financial viability. The landing obligation was gradually introduced between 2016 and 2019, allowing the fishing industry time to adapt to new fishing practices. Non-TAC species are exempt from the landing obligation, unless a minimum landing size/ minimum conservation size has been specified. Species which were identified as having an increased chance of survival, generally elasmobranch species such as small eyed ray (*Raja microocellata*) , are exempt from the discard ban through special derogation. These species if caught, need to be released unharmed immediately (STECF, 2017a; EU, 2019).

The impact of single species TACs within a mixed fishery highlights the importance of a comprehensive view of fisheries management, and the importance of considering mixed fishery MSY based scenarios such as ‘min’ or ‘range’ (ICES, 2019c). Each method holds its limitations and predictions for each year are influenced by different catchability of fish. The catchability of fish can change as a response to environmental parameters, technical measures and policy change (ICES, 2019c).

4.2.4 Seasonal closures

Seasonal closures can be used to alleviate fishing pressure in instances when fish aggregate at predictable times and locations (Clark *et al.,* 2015), or are resident in relatively small areas. For example, spawning aggregations are often predictable in time and space and can be a valuable haul for fishers. However, these areas can be particularly vulnerable to overfishing due to the high concentration of mature individuals and their high catchability (Clark *et al.,* 2015). The disturbance of fishing can further influence, alter, and/ or disrupt the spawning process (Clark *et al.,* 2015). Unfortunately, closed areas are often seen as a last attempt to save a stock and examples of closed areas being implemented too late and having the perception of not being beneficial have been noted in the past (Clark *et al.,* 2015).

Within the BSA, seasonal closures have been implemented as a management tool. Three inshore closed seasons have been in place for herring for several decades (EC, 1998). These are tri-annual seasonal closures from January or November for 16 days, developed to protect spawning grounds and prevent catches of small and juvenile herring (ICES, 2013a). Herring spawning grounds have been identified along the south coast of Ireland in the Celtic Sea

(Fitzpatrick *et al.,* 2010). These closed seasons for herring coincide with Special Protection Areas (SPA, Connolly *et al.,* 2009).

There are no offshore closures within the BSA, however, a temporal closure for *Nephrops* on the Porcupine Bank, just beyond the BSA boundary, was introduced in 2010 due to a concern for stock sustainability (Lordan *et al.,* 2017). This *Nephrops* stock subsequently improved, as has the supporting scientific monitoring (Lordan *et al.,* 2017). In 2012 for example the closure ran from the 1st May 2012 to the 31st of July 2012 (Council Regulation 43/2012; EC, 2012). This closure, although targeted at protecting *Nephrops* provided additional protection to a number of other species including: cod, megrim, anglerfish, haddock, whiting, hake, plaice, pollack, saithe, skates and rays, common sole and spurdog.

4.3 Biological importance of the BSA

Numerous commercially valuable species are targeted in the BSA, this includes pelagic species (mainly horse mackerel, mackerel and herring; demersal fish (monkfish, hake, whiting, haddock and megrim), and shellfish (Nephorps, scallops, whelk, crab, and lobster; Dransfield *et al.,* 2014). For many of these species the BSA is of biological importance, notably for spawning or as nursery grounds (ICES, 2009a). Species which have known spawning areas within or overlapping with part of the BSA include megrim, blue whiting, anglerfish, hake, lemon sole, mackerel, plaice, sprat, horse mackerel, *Nephrops*, and spurdog. Whiting, haddock, cod and herring all spawn within inshore areas of the BSA. A number of species utilise part or all of the area as nursery grounds, this includes: hake, mackerel, horse mackerel, blue whiting, anglerfish, saith, lemon sole, ling, plaice, megrim, *Nephrops,* sprat, and common skate. Again, whiting, haddock, cod, and herring utilise more inshore areas (Connolley *et al*., 2009; ICES, 2009a; EC, 2010; Nolan *et al*., 2011; Dransfield *et al*., 2014). Several egg cases for sharks, skates and rays have been found within the BSA, indicating possible spawning and nursery sites. These species include undulate ray, common skate, blue skate, white skate, greater and lesser spotted dogfish, small eyed ray, common skate and thornback ray (Dransfield *et al*., 2014; Varian, 2017).

4.4 Vulnerable species

Many elasmobranch species are vulnerable to even low fishing pressures. This is partly due to slow growth and low reproduction rates which are common characteristics within this family (Clark *et al*., 2016). The combination of this with fishing pressure can result in low stock levels. Although there is no direct fishing for threatened cartilaginous fish in Irish waters, they form part of by-catch in fisheries (Clark *et al*., 2016). This subclass has received increasing research and concern in recent years.

A recent citizen science project reporting egg cases around Ireland has helped to identify a number of possible spawning, nursery, and essential habitats for endangered egg-laying skates, rays and flat sharks. Sites within Tralee Bay, Galway Bay and along the Donegal coastline have been identified as important nursery or critical habitat indicator sites, with several high priority sites noted in Tralee Bay (Varian, 2017). Both Tralee Bay and Galway Bay are within the BSA. Egg cases found indicate the presence of endangered skates and rays (*Raja undulata, Dipturus intermedia, Dipturus flossada, Rostroraja alba*) off the west coast of Ireland (Varian, 2017). For these species, ICES has advised zero catches, noting these stocks as depleted with limited information available, and requiring special management and conservation measures (ICES, 2019c). For several species the limited data available has prevented the estimation of fisheries references points (e.g. small eyed ray) and as such precautionary approaches have been recommended (ICES, 2019c). A lack of data is not an uncommon issue when assessing elasmobranchs. Worldwide, 44% of Chrondrichthyan species are categorised as data deficient (Dedman, 2017). In cases where species are vulnerable to the impacts of fishing, yet fisheries reference points cannot be defined, alternative tools can be applied to provide protection from fishing, including use of marine protected areas if abundance hotspots can be predicted (Dedman, 2017). Tools such as egg case searches and underwater video monitoring can be used to better understand important areas (Varian, 2017). The presence of these endangered and critically endangered skates and rays further highlights the importance and sensitivity of the BSA.

4.4.1 Natura 2000 sites

Within the offshore waters of the BSA and directly adjacent to the BSA boundary, there are several designated marine protected areas of international importance. These include seven designated Special Areas of Conservation (SAC) or Sites of Community Importance (SCI; Table 3). Many more inshore marine protected areas are located along the west and south coast of Ireland and fall within the BSA (Figure 2). These include several SCIs and SACs encompassing bays, inner estuaries and rivers (Natura, 2020).

Blasket Islands: A 227 km^2 Marine and Coastal SCI and SAC, located within the south-west region of the BSA and surrounding the uninhabited Blasket Islands. The site is designated for the following Annex I features under the EC Habitats Directive: Reefs' (code: 1170) and 'Submerged or partially submerged sea caves' (8330); in addition to the Annex II marine mammal species: common porpoise (*Phocoena phocoena*) and grey seal (*Halichoerus grypus*) which are both heavily protected under several international agreements.

Haig Fras: A designated SAC and SCI located within the southern region of the BSA. The area covers approximately 475.69 km^2 of marine area and is designated for the Annex I habitat 'Reefs' (code: 1170).

Roaringwater Bay and Islands: A designated SCI and SAC located on the south-western coast of Ireland within the BSA. Roaringwater Bay covers approximately 142.5 km^2 of marine and coastal area. The site is designated for the Annex I habitats 'Large shallow inlets and bays' (code: 1160), 'Reefs' (code: 1170) and 'Submerged or partially submerged sea caves' (8330). Additionally, the site is also designated for the Annex II marine mammal species common porpoise and grey seal which are both heavily protected under several international agreements.

Kenmare River: A designated SAC and SCI located on the south west of Ireland within the BSA. The Kenmare extends from the upper regions of the Kenmare river to offshore marine areas off the south-west of Ireland. The site covers an area of 432.68 km^2, of which approximately 94% is marine. The area is designated for several Annex I habitats including Large shallow inlets and bays (1160), Reefs (code: 1170) and 'Submerged or partially submerged sea caves' (code: 8330).

Kerry Head: A designated SCI and SAC that covers approximately 57.95 km^2 of marine area, located within the western region of the BSA and adjacent to the mouth of the Shannon estuary. The site is designated for the Annex I habitat 'Reefs' (code: 1170).

Lower River Shannon: A designated SCI and SAC which extends from the upper regions of the Shannon river down to the mouth of the Shannon estuary. The area covers an area of

683 km^2, of which approximately 87% is marine. The site is designated for several Annex I habitats including 'Sandbanks which are slightly covered by seawater all the time' (code: 1110), 'Mudflats and sandflats not covered by seawater at low tide' (code: 1140), 'Coastal lagoons' (code: 1150), 'Large shallow inlets and bays' (code: 1160) and 'Reefs' (code: 1170), The site is also designated for a number of Annex II species including common bottlenose dolphin (*Tursiops truncatus*), the freshwater pearl mussel (*Margaritifera margaritifera*), Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), brook lamprey (*Lampetra planeri*) and European river lamprey (*Lampetra fluviatilis*). Other important species found within the SAC are the sea urchin (*Paracentrotus lividus*) which is protected under Annex III of the Bern convention.

Inishmore Island: A designated SAC and SCI located within the western region of the BSA, west of Galway. The site covers approximately 144.94 km^2, of which 86% is marine and is designated for several Annex I habitats including 'Coastal lagoons' (code: 1150) and 'Reefs' (code: 1170). The site also contains *P. lividus* protected under the Bern convention

Tralee Bay and Magharees Peninsula, West to Cloghane: A designated SAC and SCI located within the western region of the BSA, extending from Tralee Bay west towards Cloghane. The site covers approximately 116.27 km^2, of which 89% is marine and is designated for several Annex I habitats including 'Mudflats and sandflats not covered by seawater at low tide' (code: 1140), 'Coastal lagoons' (code: 1150), 'Large shallow inlets and bays' (code: 1160) and 'Reefs' (code: 1170). Important species found within the site include the purple urchin (*Paracentrotus lividus*) which is protected under Annex III of the Bern Convention. Additionally, Tralee Bay is a known nursery for both angel shark (*Squatina squatina*) and white skate (*Rostroraja alba*) which are protected under Annex III of the Bern Convention, Annex II of the SPA/BD Protocol and Annex V of the OSPAR Convention.

Hook Head: A designated SAC and SCI located partially within the southern area of the BSA and covers approximately 170 km^2 of coastal cliff and marine area. The area is designated due to the presence of several Annex I habitats including 'Large shallow inlets and bays' (code: 1160) and 'Reefs' (code: 1170).

Porcupine Bank Canyon: A designated SCI and SAC, located west of the BSA and covers approximately 781.10 km^2 of marine area. The site was designated due to the presence of the Annex I habitat 'Reefs' (code: 1170). Other important species known to inhabit the area including the short-beaked common dolphin (*Delphinus delphis*) and the long-finned pilot whale *(Globicephala melas*). Both species are listed as of "Least Concern" on the IUCN Red List of Threatened Species and are protected under several international agreements (Hammond *et al.,* 2008; Minton *et al*., 2018). Porcupine Bank Canyon also contains newly discovered areas of the cold water coral *Solenosmilia variabilis* and sea pen reefs (Marine Institute, 2020b).

South-West Porcupine Bank: Located west of the BSA and adjacent to the Porcupine Canyon Bank SAC. The designated SCI and SAC covers approximately 329.30 km^2 of marine area and is designated due to the presence of the Annex I habitat 'Reefs' (code: 1170). The site also contains the cold-water coral *Lophelia pertusa*; which is protected under Annex II of CITES and listed as Endangered on the IUCN Red List of Threatened Species (Orejas *et al.,* 2015b). South-West Porcupine Bank also contains a newly discovered *S. variabilis* and sea pen reefs (Marine Institute, 2020b).

Belgica Mound Province: Located west of the BSA, the site is currently designated as a SCI and SAC consisting of 410.90 km^2 of marine habitat. The site contains the Annex I habitat ‘Reefs’ (code 1170). The site also contains several other important species including the cold water coral *L. pertusa* and the zigzag coral *Madrepora oculate*; which are both protected under Annex II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and listed as Endangered on the IUCN Red List of Threatened Species (Orejas *et al.,* 2015a,b).

Hovland Mound Province: Located west of the BSA and is the largest of the Natura 2000 sites in the vicinity of the BSA, covering approximately 1,086.55 km^2 of marine area. The site is currently designated as a SCI and SAC; and contains the Annex I habitat ‘Reefs’ (code 1170). The site also contains several important coral species including the cold water corals *L. pertusa* and *M. oculate*; which are both protected under Annex II of CITES and listed as Endangered on the IUCN Red List of Threatened Species (Orejas *et al.,* 2015a, b).

North-West Porcupine Bank: Located west of the BSA, covering approximately 716.30 km^2 of marine area. The site is currently designated as a SCI and SAC; and contains the Annex I habitat ‘Reefs’ (code 1170). The site also contains several important coral species including the cold water corals *L. pertusa* and *M. oculate*; which are both protected under Annex II of CITES and listed as Endangered on the IUCN Red List of Threatened Species (Orejas *et al.,* 2015a, b). A recent survey conducted by the Marine Institute along Ireland’s porcupine bank and continental shelf discovered *Solenosmilia variabilis* and sea pen reefs at depths of over 1600m. The growth rate of these reefs are estimated at approximately one mm per year and are thought to contain some yet to be described sea pen species (Marine Institute, 2020b).

Table 3: Selection of sites within the BSA sites which are designated as Special Areas of Conservation (SAC) and Sites of Community Importance (SCI).

Site name	Type of site	Site code	Area (km^2)	Designated site features
Blasket Islands	SAC, SCI	IE0002172	227	Reefs [1170] Submerged or partially submerged sea caves [8330] Common porpoise (*Phocoena phocoena*) Grey seal (*Halichoerus grypus*)
Haig Fras	SAC, SCI	UK0030353	475.69	Reefs [1170]
Roaringwater Bay & Islands	SAC, SCI	IE0000101	142.53	Large shallow inlets and bays [1160] Reefs [1170] Submerged or partially submerged sea caves [8330] Common porpoise (*Phocoena phocoena*) Grey seal (*Halichoerus grypus*)
Kenmore River	SAC, SCI	IE0002158	432.68	Large shallow inlets and bays [1160] Reefs [1170] Submerged or partially submerged sea caves [8330]
Kerry Head	SAC, SCI	IE0002263	57.95	Reefs [1170]
Lower River Shannon	SAC, SCI	IE0002165	683	Sandbanks which are slightly covered by seawater all the time [1110] Mudflats and sandflats not covered by seawater at low tide [1140] Coastal lagoons [1150] Large shallow inlets and bays [1160] Reefs [1170] Common bottlenose dolphin (*Tursiops truncatus*) Freshwater pearl mussel (*Margaritifera margaritifera*) Atlantic salmon (*Salmo salar*) Sea lamprey (*Petromyzon marinus*) Brook lamprey (*Lampetra planeri*) European river lamprey (*Lampetra fluviatilis*)
Inishmore Island	SAC, SCI	IE0000213	144.94	Coastal lagoons [1150] Reefs [1170]
Hook Head	SAC, SCI	IE0000764	170.06	Large shallow inlets and bays [1160] Reefs [1170]
Tralee Bay and Magharees Peninsula, West to Cloghane	SAC, SCI	IE0002070	116.27	Mudflats and sandflats not covered by seawater at low tide [1140] Coastal lagoons [1150] Large shallow inlets and bays [1160] Reefs [1170]

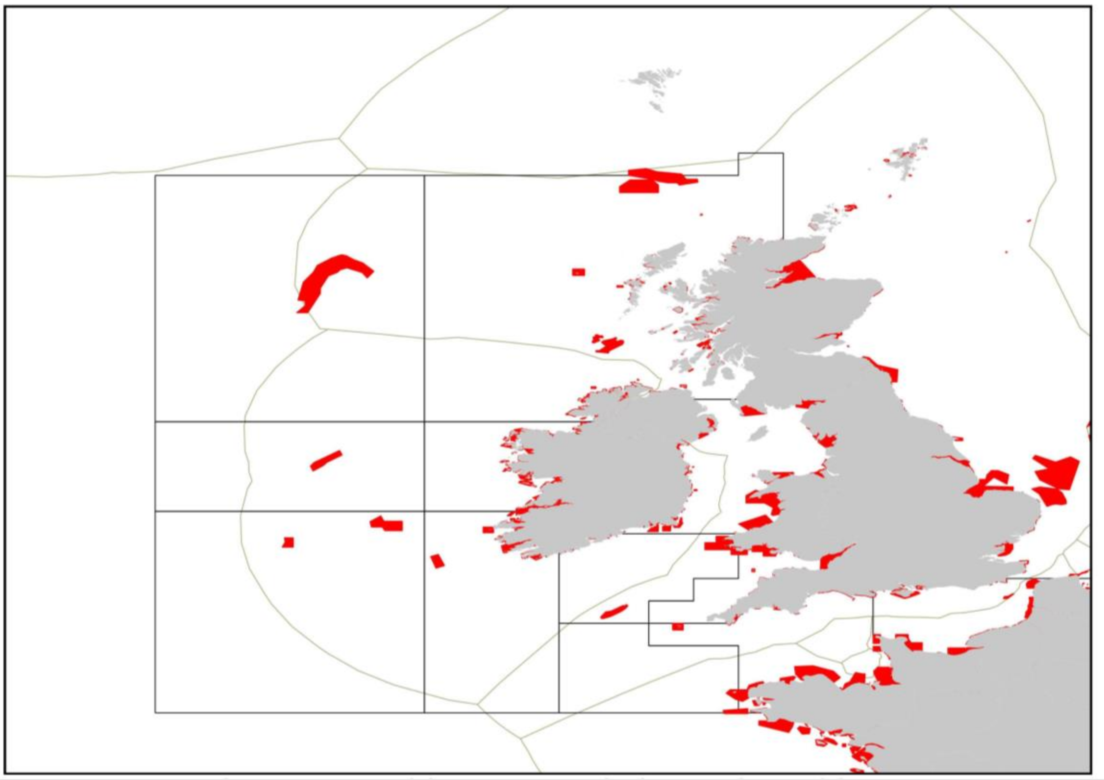

Figure 2: Natura Habitats directive map showing special areas of conservation and sites of community importance in north-western waters (European environmental agency www.eea.europa.eu; adapted from Nolan *et al*., (2011).

4.5 Anthropogenic impact on the environment

The activity of fishing extends beyond the mere act of catching fish and the commonly associated consequences, such as the threat of overfishing. Fishing can impact the wider ecosystem and environment. For instance, fishing has been found to impact the behaviour of certain seabirds, with gannet behaviour being affected by fishing vessels up to 11 km away (Bodey *et al.,* 2014). Discards of unwanted catch from fishing has the potential for both positive and negative impacts on scavenging seabirds (Bodey *et al.,* 2014).

The act of fishing, particularly demersal fishing has associated impacts. Bottom trawling can reduce the biodiversity of the seabed and the complexity of the seabed habitat. However, the degree to which trawling impacts a habitat depends on the type of habitat, the sensitivity of habitat, the type of gear deployed and the frequency of trawling (Hiddink *et al*., 2017; Eigaard *et al.,* 2017). The continental shelf around Europe has been trawled for centuries due to the high productivity of demersal fish. In the Celtic sea (VIIe, f, g, and h) and Southwestern shelf (VIIb, c, j, and k), it was estimated that 62% and 65% of the shallow zone area (0-200m) has been trawled and 42% and 2% of the deep zone (201-1000m) respectively (Eigaard *et al.,* 2017).

Fisheries are not the only concern to fragile habitats within the BSA. Other anthropogenic activity around Ireland has grown in recent years, and certain oil and gas sites are now approaching decommission. To reach energy demands and carbon budgets, further activities are being considered in a variety of locations and these all pose potential impacts to fisheries and vulnerable habitats.

4.5.1 Oil & Gas

Ireland's offshore area is largely unexplored in comparison to other waters such as the North Sea. Oil and gas exploration has taken place in Ireland since 1962. Although no commercial oil discoveries have been made, since the 1970s four commercial natural gas discoveries have been made (Irish Government, 2020). Of these, three are located within the BSA. The Kinsale Head gas field was first discovered in 1971 and is located approximately 50 km off the coast of Cork and is one of the largest hydrocarbon discoveries made in Ireland. Gas production at Kinsale occurs via two fixed steel production platforms constructed in 1977 (Alpha and Bravo) (Kinsale Energy, 2016). Several subsequent satellite gas fields within the BSA have been discovered. These include: Ballycotton in 1991; Southwest Kinsale in 1999 which now serves as an offshore gas storage facility; and most recently Seven Heads in 2003.

The gas fields reached the end of their productive life in July 2020 and are now in the process of decommissioning. Application to the Minister for Communications, Climate Action and Environment (DCCAE) for the decommissioning of several facilities including the platform and subsea well abandonments, platform topside and subsea infrastructure were made in July 2018 (Kinsale Energy, 2020). A further application was made to the DCCAE for the removal of the Kinsale Alpha and Bravo platforms in August 2019 (Kinsale Energy, 2020). Within Kinsale Ltd's Environmental Impact Assessment (EIA) report, several environmental effects were identified as being of potential significance and/ or with potentially moderate to severe impacts. These sources included:

- Physical presence of decommissioning operations;
- Physical disturbance;
- Underwater noise;
- Discharges to sea;
- Energy use and atmospheric emissions;
- Waste; and
- Accidental events.

However, the overall conclusion of the EIA report stated the decommission project would not result in significant adverse effects on the marine environment for the given scale, intensity and duration of required activities, in addition to proposed mitigation and risk reduction measures (Kinsale Energy, 2018).

4.5.2 Submarine cables & pipelines

Several sub-marine cables currently run through parts of the BSA, including the IRIS (Galway) and GTT Express (Cork) cables which both have landing points in Ireland that fall within the BSA (TeleGeography, 2020). Additionally, the Celtic Interconnector and the Ireland-France subsea cable are two proposed subsea cables expected to be constructed within the BSA in the coming years.

The Celtic Interconnector is a proposed subsea link between EirGrid and Réseau de Transport d'Electricité to allow the exchange of electricity between Ireland and France. The project is currently in stage four of a six stage process in which decisions are currently being made on the proposed landing sites and routes of the project. Four possible areas for development have been put forward, with a potential landing site in Claycastle on the south coast and converter station sites in Kilquane, Knockraha, and Ballydam. If built the project is due to be completed in 2026 (EirGrid Group, 2020). Ireland-France Subsea Cable Ltd (IFSC) is a proposed subsea fibre optic cable connecting Ireland and France. The preliminary cable route extends from Cork, Ireland to Lannion, France and the project is expected to have been completed by 2020 (Dawn-Hiscox, 2018).

Beyond the initial disturbance of installing subsea cables, long term impacts to the marine environment can, but not limited to, include small-scale thermal and electromagnetic pollution which could potentially affect attraction, orientation and migration of fish. This is a particular issue for electro-sensitive species such as sharks (Dransfield *et al.,* 2014).

4.5.3 Renewable energy

Latest Irish figures show that Irelands gross final energy consumption from renewable energy sources is currently at 11%, 9% below the EU's targets in which 20% of EU energy consumption must come from renewable energy sources (Gaughan & Fitzgerald, 2020). Ireland's location along the Atlantic Ocean means that the country has a huge potential to harness wind energy. Currently, Ireland's only operational offshore wind farm is located approximately 10 km from Arklow on the east coast of Ireland. However, several offshore wind projects, including sites within the BSA, have been fast-tracked by the Irish government for application (Electricity info, 2020; Richard, 2020). Currently the nearest one is Skerd Rocks offshore wind farm in Galway Bay off the west coast of Ireland (Electricity info, 2020).

Despite the sustainability benefits that renewable energy infrastructure offers, the construction and subsequent operation of offshore wind farms may have localised impacts on the environment through abrasion and scouring, substrate sealing, underwater noise, physical disturbance of sediments and could act as a barrier to migrating species (Dransfield *et al*., 2014).

4.5.4 Shipping & Ports

The ports and shipping sector play a vital role in the transportation of people and goods. As a result, large densities of shipping traffic can be found within the southern area of the Celtic sea. This includes several key merchant shipping routes associated with waters in southern Ireland, particularly the ports of Cork and the Shannon Foynes both of which are within the BSA. Additionally, two major ferry routes are located within the BSA, both landing at the port of Cork (McGowen *et al.,* 2018).

In 2001, the 'Motorways of the Sea' concept was introduced to reduce road transport and promote efficient inter-mode transport across the EU. Motorways of the sea are part of Trans European Network for Transport (TEN-T) which are a series of large core network ports and smaller comprehensive ports. Within the Celtic sea, several Irish ports within the BSA are part of the TEN-T. Cork and Shannon Foynes which are core ports and Rosslare and Waterford which are comprehensive ports (McGowen *et al.,* 2018).

In Ireland, ports are categorised as tier 1, 2, or 3 ports (Department of Transport, Tourism and Sport, 2013). Tier 1 and 2 ports are defined as those of national significance and included Cork, Shannon Foynes and Rosslare and Waterford. Tier 3 ports are regionally significant. Regionally significant ports within the BSA include Galway and New Ross. Tier 1 and 2 ports key policy priorities include continual commercial development to increase volumes of traffic, which will likely increase potential environmental impacts (McGowen *et al.,* 2018).

Between 2010 and 2015, freight transport increased by 12.4% in Ireland and 21.8% in gross weight of goods handled (McGowen *et al.,* 2018). The port and shipping sectors in Ireland are expected to increase in activity in the coming decades continuing this trend. However, the development of these sectors will pose a range of environmental impacts which include (Dransfield *et al*., 2014; McGowen *et al.,* 2018):

- Risk of introduction / spread of invasive-non-native-species (INNS) from ballast water;
- Accidental spills of oil, anti-fouling paints, and other pollutants;
- Pollution from marine litter;
- Underwater noise from increased shipping traffic;
- Port and channel dredging, which could lead to smothering and habitat loss, or exposing marine organisms to higher concentrations of contaminated sediment; and
- Development of coastal infrastructure which could alter hydrographical conditions and sensitive habitats.

5. Results

Below are presented the findings from a variety of data sources each forming a part of understanding fisheries activity within the BSA and wider ICES Area VII, how those species utilise the area and the health of those species. This includes landings, fishing effort derived from both logbooks and vessel monitoring system derived effort, trends in stock health, use of fishery independent CPUE estimates and egg distribution information.

5.1 Species landings

International landings from ICES divisions VIIb, VIIg and VIIj were selected to determine which species contributed to the top landings within ICES areas representing the majority of the BSA. Comparing total catch over the last 10 years of available data (2009 to 2018) to the 10 preceding years (1999 to 2008; Table 4), landings have increased by 20%. The top 15 species landings represent 89% of total landings between 2009 and 2018, and 86% between 1999 and 2008. Over the last 20 years, a shift in species composition was noted. Two new species to feature on the top species (percentage increase) include European sprat (24%) and witch (6%). Whilst ling species (52%) and cod (18%) have dropped out of the list (percentage decrease). On average, landings of pelagic species have increased by 112% (~~± 284~~; driven by boarfish), landings of demersal species (including *Nephrops*) have increased by 14% and edible crabs have decreased by 36%.

Table 4: International landings (tonnes live weight) for top 15 species over the last 10 years (2009-2018) from ICES divisions which overlap with the BSA (VIIb,g, and j). Species highlighted in grey are not included in the Western Water Effort Restrictions. Those denoted with a * were in only one top 15 period. Source: Official Nominal Catches 2006-2018.

Common name	Species	1999-2008 Landings (t)	2009-2018 Landings (t)	Percent change
Horse mackerel	*Trachurus spp*	422,297	486,571	15
Atlantic mackerel	*Scomber scombrus*	519,497	447,117	-14
Boarfishes	*Caproidae*	42,922	338,986	690
European hake	*Merluccius merluccius*	100,146	245,678	145
Monkfish	*Lophius spp*	82,691	117,668	42
Atlantic herring	*Clupea harengus*	115,348	113,206	-2
Megrim	*Lepidorhombus spp*	86,833	81,073	-7
Whiting	*Merlangius merlangus*	78,288	65,290	-17
Blue whiting	*Micromesistius poutassou*	106,241	63,756	-40
Nephrops	*Nephrops*	61,146	54,262	-11
Haddock	*Melanogrammus aeglefinus*	47,159	47,724	1
European sprat	*Sprattus*	*20,948	26,006	24
Rajiformes	*Rajiformes*	48,800	24,914	-49
Witch	*Glyptocephalus cynoglossus*	*22,789	24,118	6
Edible crab	*Cancer pagurus*	36,535	23,456	-36
Atlantic cod	*Gadus morhua*	28,017	*23,456	-18
Lings	*Molva spp*	27,379	*13,022	-52
Total		1,803,299	2,159,825	20

5.2 Stock assessments

ICES perform annual stock assessments against pressure and state indicators for many species within the Celtic Sea. Of particular interest are fishing mortality (F) relative to F_{MSY} (the fishing mortality which is expected to deliver maximum sustainable yield) and spawning stock biomass (SSB) in relation to a defined biomass level (below which the stock is considered to be at risk of impaired recruitment). For relevant stocks in and around the BSA spawning stock biomass (SSB) and/ or fishing mortality (F) values were collated and compared against available reference points to determine stock status. SSB is represented in tonnes, except when relative values apply. Trends for SSB and F relative to reference points are provided in and Figure 3 and Figure 4, indicating that not all stocks have had the same response to management measures within the area. Species lacking SSB or F values could not be represented graphically.

A greater number of stocks within ICES area VII are considered to be exploited at sustainable levels than compared to 2003 (Table 5 and Table 6). Stocks with good environmental status (GES), meaning that the SSB and F values are above or below MSY reference values respectively, include white anglerfish (mon.27.78abd), blue ling (bli.27.5b67), haddock (had.27.7a), hake (hke27.3a46-8abd), megrim (meg.27.7b-k8abd), sole (sol.27.7fg and sol27.7a), Irish Sea plaice (ple27.7a), tusk (usk.27.3a45b6a7-912b), albacore tuna (quantitative evaluation) and *Nephrops* in FU15 and FU17. Stocks with unknown SSB and sustainable fishing pressure include pollack (pol.27.67), bluefin tuna and *Nephrops* FU16.

Haddock (had.27.7b-k), blue whiting (whb.27.1-91214), mackerel (mac.27.1-89a14) and *Nephrops* FU 22 have sustainable SSB levels but are considered to be fished above sustainable levels. *Nephrops* in FU19 are fished at levels considered to be sustainable however, their respective SSB estimations remain below reference levels indicating reduced reproductive capacity. Herring (her27.6a7bc) and *Nephrops* in FU20-21 have an unknown stock abundance and are subjected to excessive fishing pressure.

The following species are considered to be overfished and have reduced reproductive capacity where estimated SSB is below specified reference points and fishing mortality is above reference points. For demersal species this includes Celtic Sea cod (cod.27.7e-k), Irish and Celtic Sea whiting (whg27.7a and 7b-c, e-k) and Celtic Sea plaice (ple27.7h-k). Two pelagic stocks are considered within this category, namely, herring (her27.7ajhjk) and horse mackerel (hom.27.2a4a5b6a7a-ce-k8). This horse mackerel stock is currently beyond precautionary reference points and at levels where there is a high probability of stock collapse or reduced reproductive capacity.

The sustainability of stocks without reference points cannot be assessed in this way. This includes cod (cod.27.7a) and boarfish (boc.27.6-8; Table 5 and Table 6) and many of the elasmobranch species (Table 7). In some cases, proxy MSY reference points or quantitative evaluations are used to provide an indication of stock health. This includes tusk, herring, pollack and tuna. In other instances, where available, trends can sometimes be used to qualitatively estimate stock health. ICES does this to provide advice for a number of species, in 2020 for example biomass trend for five rays stocks could be estimated: increasing for two stocks, thornback ray (rjc.27.7afg), undulate ray (rju.27.7de), decreasing for two small-eyed ray (rje.27.7fg), spotted ray (rjm.27.67bj), and stable for another spotted ray stock (rjm.27.7ae-h; ICES, 2020w).

Table 5: Summary of stock status for species of interest within the BSA. Fishing mortality (F) relative to F_{MSY} reference points, where red=above; green=below; grey=unknown. Spawning stock biomass (SSB) relative to $B_{trigger}$, where red=below; green=above; grey=unknown. Five stocks have been marked with an asterisk (*) to indicate that proxy assessments or qualitative evaluations were used as no reference values were available. Superscript letters denote references.

			Status (2003)		Status (recent)	
Common name	**Scientific name**	**Stock code**	**SSB**	**F**	**SSB**	**F**
White anglerfish	*Lophius piscatorius*	mon.27.78abd[39, 13]				
Blue ling	*Molva dypterygia*	bli.27.5b67[30, 15]				
Cod	*Gadus morhua*	cod.27.7e-k[18, 7]				
Cod	*Gadus morhua*	cod.27.7a[17,2]				
Haddock	*Melanogrammus aeglefinus*	had.27.7b-k[12, 19]				
Haddock	*Melanogrammus aeglefinus*	had27.7a[19, 28]				
Hake	*Merluccius merluccius*	hke.27.3a46-8abd[31, 42]				
Megrim	*Lepidorhombus whiffiagonis*	meg.27.7b-k8abd[6, 34]				
Sole	*Solea solea*	sol.27.7fg[11, 38]				
Sole	*Solea solea*	Sol.27.7a[5, 11, 37]				
Whiting	*Merlangius merlangus*	whg.27.7b-ce-k[9, 29]				
Whiting	*Merlangius merlangus*	whg.27.7a[10, 27]				
Plaice	*Pleuronectes platessa*	ple.27.7a[35]				
Plaice	*Pleuronectes platessa*	ple.27.7h-k[12, 23]				
Tusk *	*Brosme brosme*	usk.27.3a45b6a7-912b[26]				
Herring	*Clupea harengus*	her.27.7aghjk[14, 33]				
Herring *	*Clupea harengus*	her27.6a7bc[32]				
Horse mackerel	*Trachurus trachurus*	hom.27.2a4a5b6a7a-ce-k8[20, 24]				
Blue whiting	*Micromesistius poutassou*	whb.27.1-91214[3, 4, 8, 16]				
Mackerel	*Scomber scombrus*	mac.27.1-89a14[21, 22]				
Pollack *	*Pollachius pollachius*	pol.27.67[36]				
Boarfish	*Capros aper*	boc.27.6-8[41]				
Albacore tuna *	*Thunnus alalunga*	LB/AN05N[1]				
Bluefin tuna *	*Thunnus thynnus*	BFT/AE45WM[43]				

1	ICCAT, 2016	13	ICES, 2018i	24	ICES, 2019s	34	ICES, 2020h
2	ICES, 2012	14	ICES, 2018j	25	ICES, 2019t	35	ICES, 2020m
3	ICES, 2013a	15	ICES, 2018k	26	ICES, 2019v	36	ICES, 2020n
4	ICES, 2013b	16	ICES, 2019a	27	ICES, 2019x	37	ICES, 2020p
5	ICES, 2016a	17	ICES, 2019d	28	ICES, 2019y	38	ICES, 2020q
6	ICES, 2016b	18	ICES, 2019e	29	ICES, 2019z	39	ICES, 2020t
7	ICES, 2016c	19	ICES, 2019f	30	ICES, 2020b	40	ICES, 2020u
8	ICES, 2016d	20	ICES, 2019j	31	ICES, 2020e	41	Marine Institute, 2020a
9	ICES, 2017a	21	ICES, 2019k	32	ICES, 2020f	42	Martin, 1991
10	ICES, 2017b	22	ICES, 2019m	33	ICES, 2020g	43	SCRS, 2019
11	ICES, 2017c	23	ICES, 2019r				
12	ICES, 2018d						

Table 6: *Nephrops* functional units near or overlapping with parts of the BSA. Fishing mortality (F) relative to F_{MSY} reference points, where red=above; green=below; grey=unknown. Spawning stock biomass (SSB) relative to $B_{trigger}$, where red=below; green=above; grey=unknown (ICES, 2011; ICES, 2018e; ICES, 2019n, o, p; ICES, 2020i, j, k, l).

		Status (2003)		**Status (recent)**	
Common name	**Stock code**	Stock abundance	Harvest rate	Stock abundance	Harvest rate
Nephrops	nep.fu.15				
Nephrops	nep.fu.16				
Nephrops	nep.fu.17				
Nephrops	nep.fu.19				
Nephrops	nep.fu.2021				
Nephrops	nep.fu.22				

Table 7: Summary of elasmobranch stock status. IUCN assessments based on Europe wide information (Nieto *et al.*, 2015). Information from Clarke *et al.,* (2016) based on Irish assessment of cartilaginous fish.

Common name	**Scientific name**	**IUCN**	**Ireland**
Undulate ray	*Raja undulata*	Near Threatened	Endangered
Small eyed ray	*Raja microocellata*	Near Threatened	Least Concern
Thornback ray	*Raja clavata*	Near Threatened	Least Concern
Blond ray	*Raja brachyura*	Near Threatened	Near Threatened
Common skate complex	*Dipturus batis-complex*	Critically Endangered	Critically Endangered
Spotted ray	*Raja montagui*	Least Concern	Least Concern
Cockoo ray	*Leucoraja naevus*	Least Concern	Vulnerable
Sandy ray	*Leucoraja circularis*	Endangered	Near Threatened
Shagreen ray	*Leucoraja fullonica*	Vulnerable	Vulnerable
White skate	*Rostroraja alba*	Critically Endangered	Critically Endangered
Lesser spotted dogfish	*Scyliorhinus canicula*	Least Concern	Least Concern
Greater spotted dogfish	*Scyliorhinus stellaris*	Near Threatened	Least Concern
Smooth hounds	*Mustelus spp.*	Vulnerable/ Near Threatened	Least Concern
Angel shark	*Squatina squatina*	Critically Endangered	Critically Endangered
Basking shark	*Cetorhinus maximus*	Endangered	Endangered
Portuguese dogfish	*Centroscymnus coelolepis*	Endangered	Critically Endangered
Tope shark	*Galeorhinus galeus*	Vulnerable	Vulnerable
Spurdog	*Squalus acanthias*	Endangered	Endangered

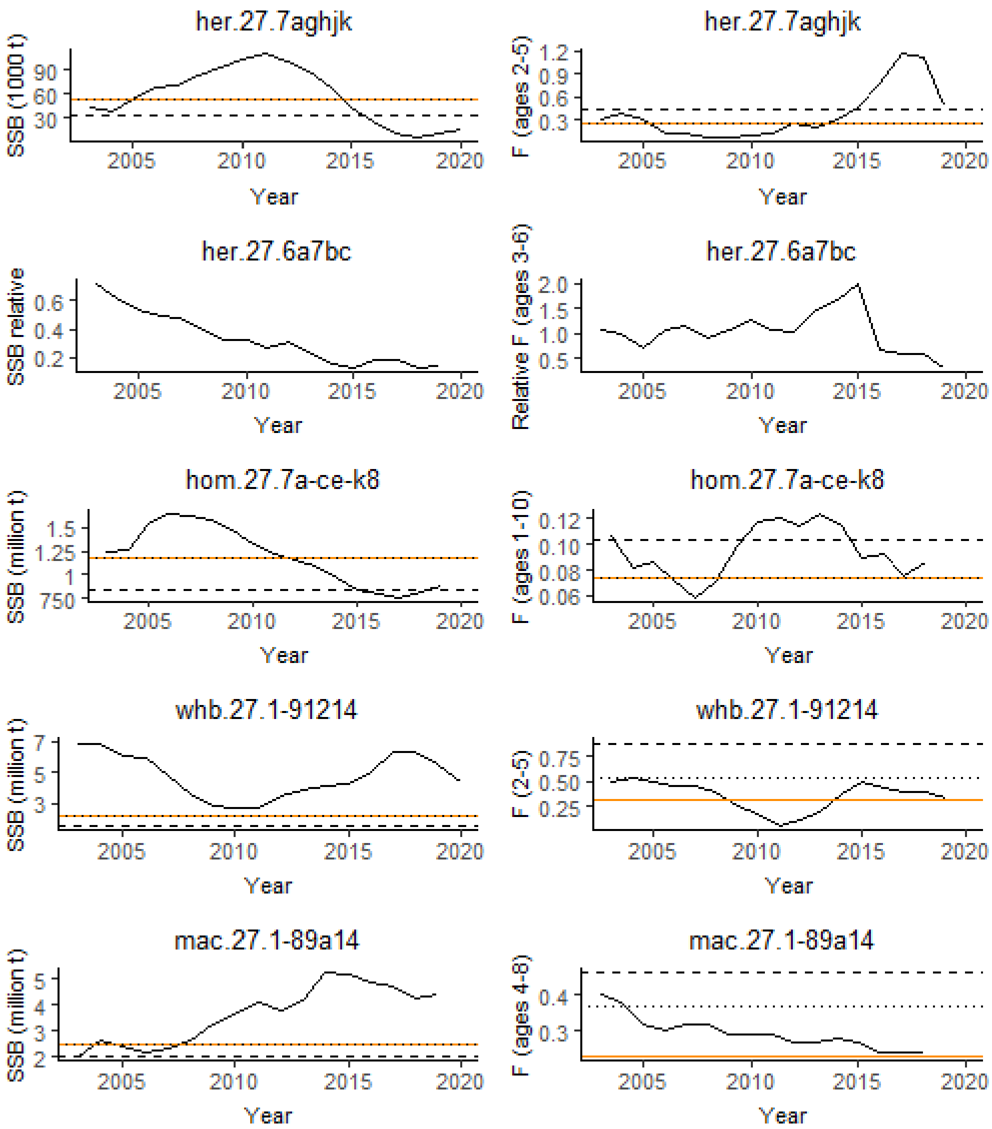

Figure 3: Representation of pelagic species stock assessment. Spawning stock biomass (SSB; tonnes) and fishing mortality (F) represented since 2003 to most recent ICES assessment available. Black lines represent limit (B_{lim} or F_{lim}; dashed) and precautionary (B_{pa} or F_{pa}; dotted line) reference points. Orange line represented MSY $B_{trigger}$ or F_{MSY} reference points as defined by ICES Advisory committee (2016 – 2020). Note: hom.27.7a-ce-k8 heading shortened, full heading: hom27.2a4a5b6a7a-ce-k8.

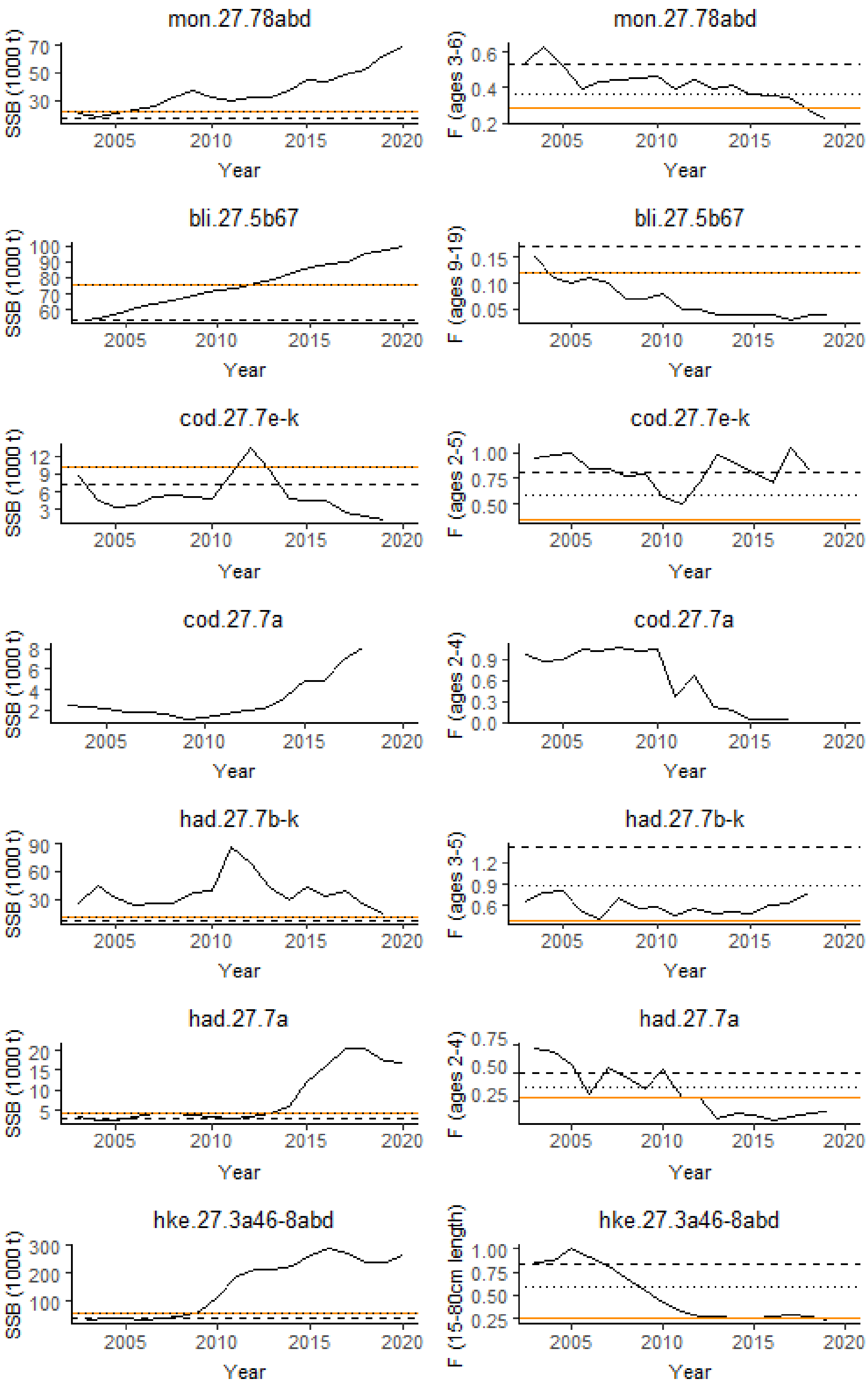

Figure 4: Representation of demersal species stock assessment. Spawning stock biomass (SSB; tonnes) and fishing mortality (F) represented since 2003 to most recent ICES assessment available. Black lines represent limit (B_{lim} or F_{lim}; dashed line) and precautionary (B_{pa} or F_{pa}; dotted line). Orange line represented MSY $B_{trigger}$ or F_{MSY} reference points as defined by ICES Advisory committee (2016 – 2020).

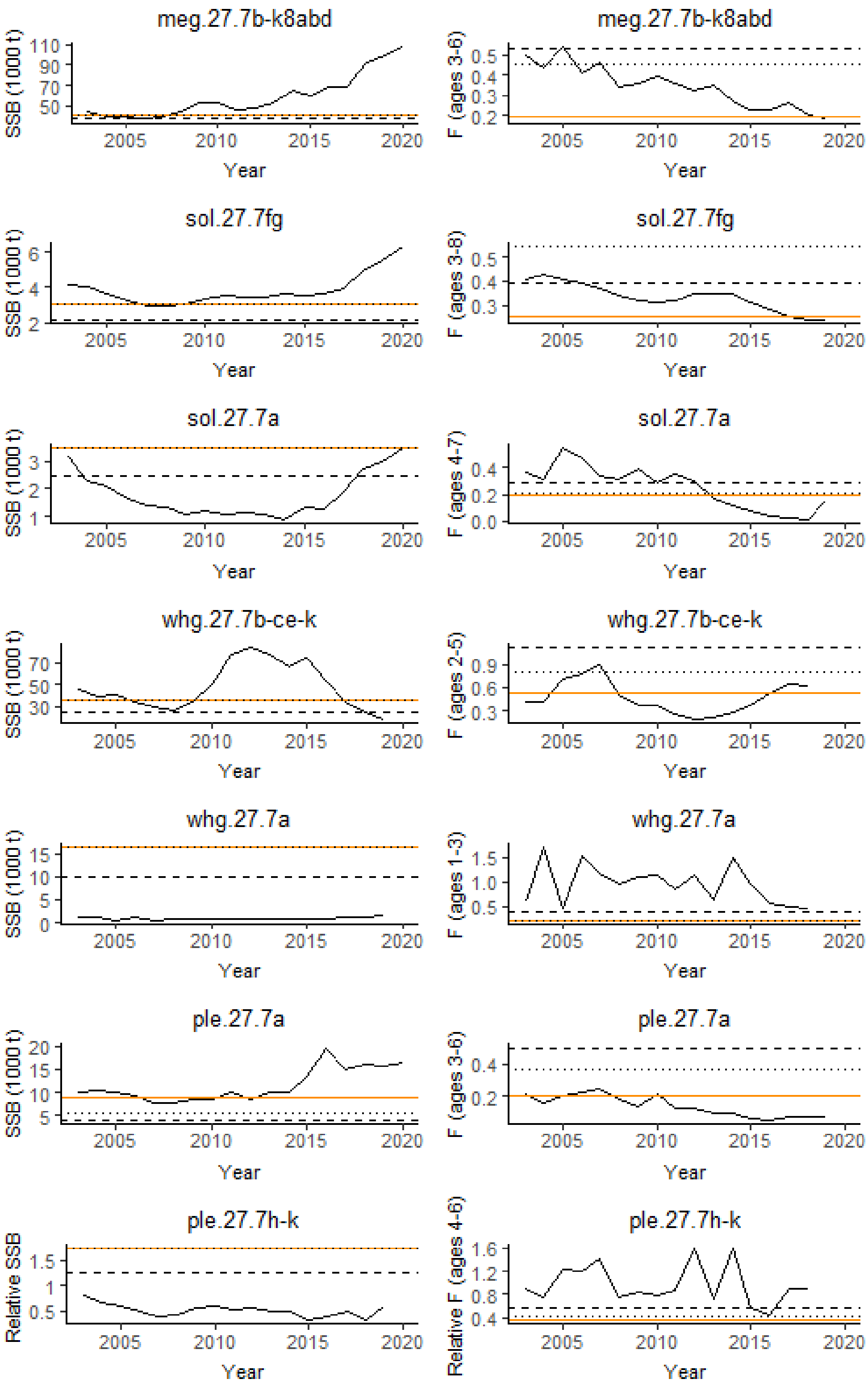

Figure 4 Cont. Representation of demersal species stock assessment. Spawning stock biomass (SSB; tonnes) and fishing mortality (F) represented since 2003 to most recent ICES assessment available. Black lines represent limit (B_{lim} or F_{lim}; dashed line) and precautionary (B_{pa} or F_{pa}; dotted line). Orange line represented MSY $B_{trigger}$ or F_{MSY} reference points as defined by ICES Advisory committee (2016 – 2020).

5.3 Length frequency distributions

Length frequency distributions of commercially sampled landings and discards can provide information regarding the sizes classes of fish caught and the proportions or numbers of landed and discarded fish. Insight can be gained into the catchability of juvenile fish, undersize fish (according to minimum conservation/landing size or weight) or any selective high-grading where unwanted oversize fish are discarded. Changes to the proportion of larger fish landed can be used as an indicator of stock health. A healthy stock would be expected to have greater proportions of larger fish within the landings, whilst an overfished stock could be expected to have very few larger individuals.

Figure 5 and Figure 6 include landing and discard information for elasmobranchs. Species represented include the critically endangered *Rostroraja alba* (White skate*)* and the *Dipturus batis* species complex, previously referred to as *Raja batis* (common skate complex). This complex consists of two species *Dipturus flossada* (blue skate) and *Dipturus intermedia* (flapper skate). Other species represented include the endangered *Squalus acanthias* (spurdog); the vulnerable *Galeorhinus galeus* (tope shark*) and Leucoraja fullonica* (shagreen ray); the endangered to near threatened *Raja undulata* (undulate ray); the vulnerable to least concern *Mustelus spp.* (*Mustelus asterias;* starry smooth hound and *Mustelus mustelus;* common smooth-hound); the near threatened *Raja brachyura* (blond ray*);* the near threatened to least concern *Raja clavate* (thornback ray), *Raja microocellata* (small eyed ray) and *Scyliorhinus stellaris* (greater spotted dogfish); and the least concern *Raja montagui* (spotted ray) and *Scyliorhinus canicular* (small spotted dogfish).

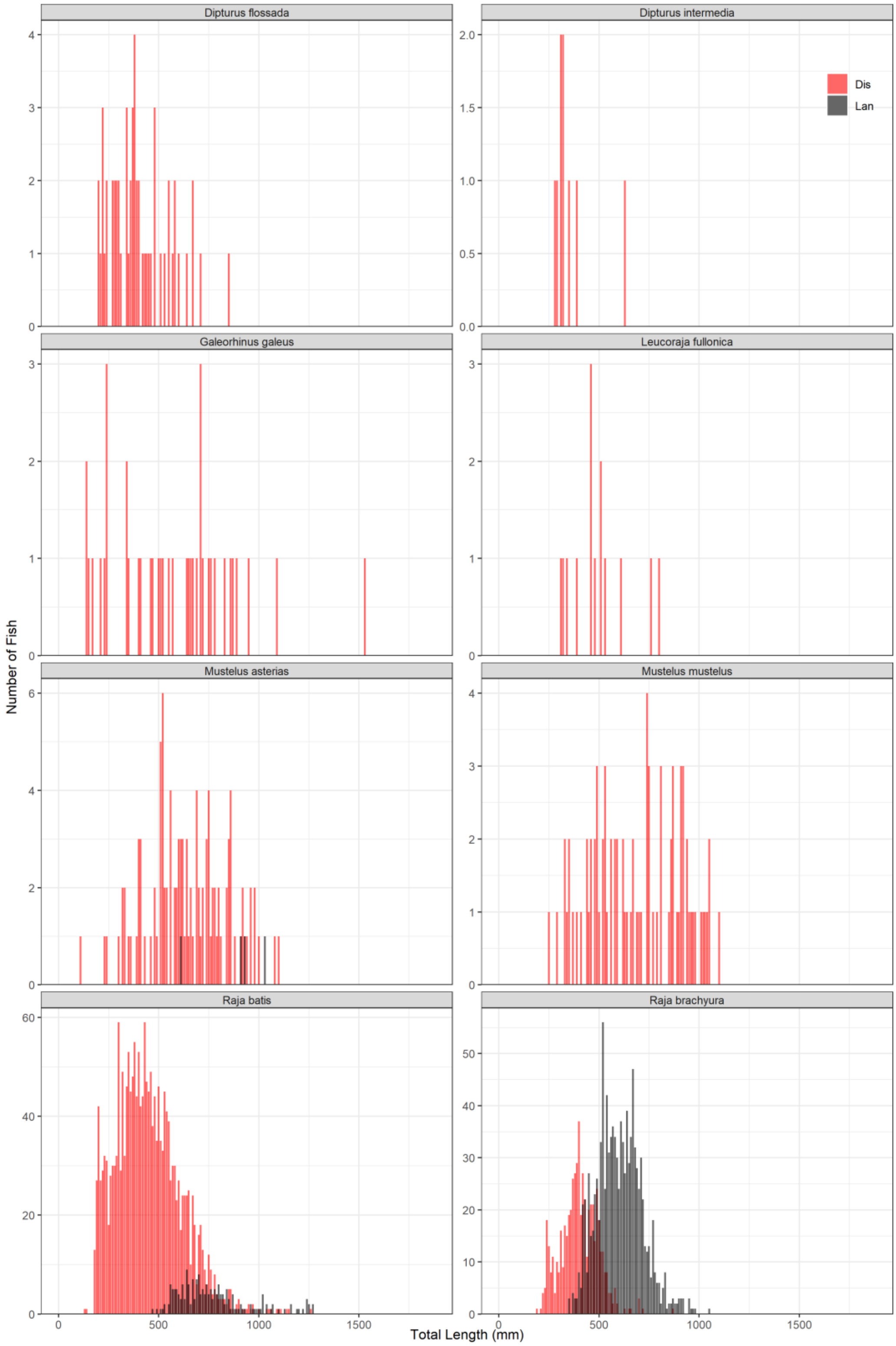

Figure 5: Length frequency numbers for a selection of elasmobranchs caught in the BSA between 2000 and 2020 from ICES divisions VIIg and VIIj. Red bars represent discarded (dis) catch and black bars represent landed (lan) catch.

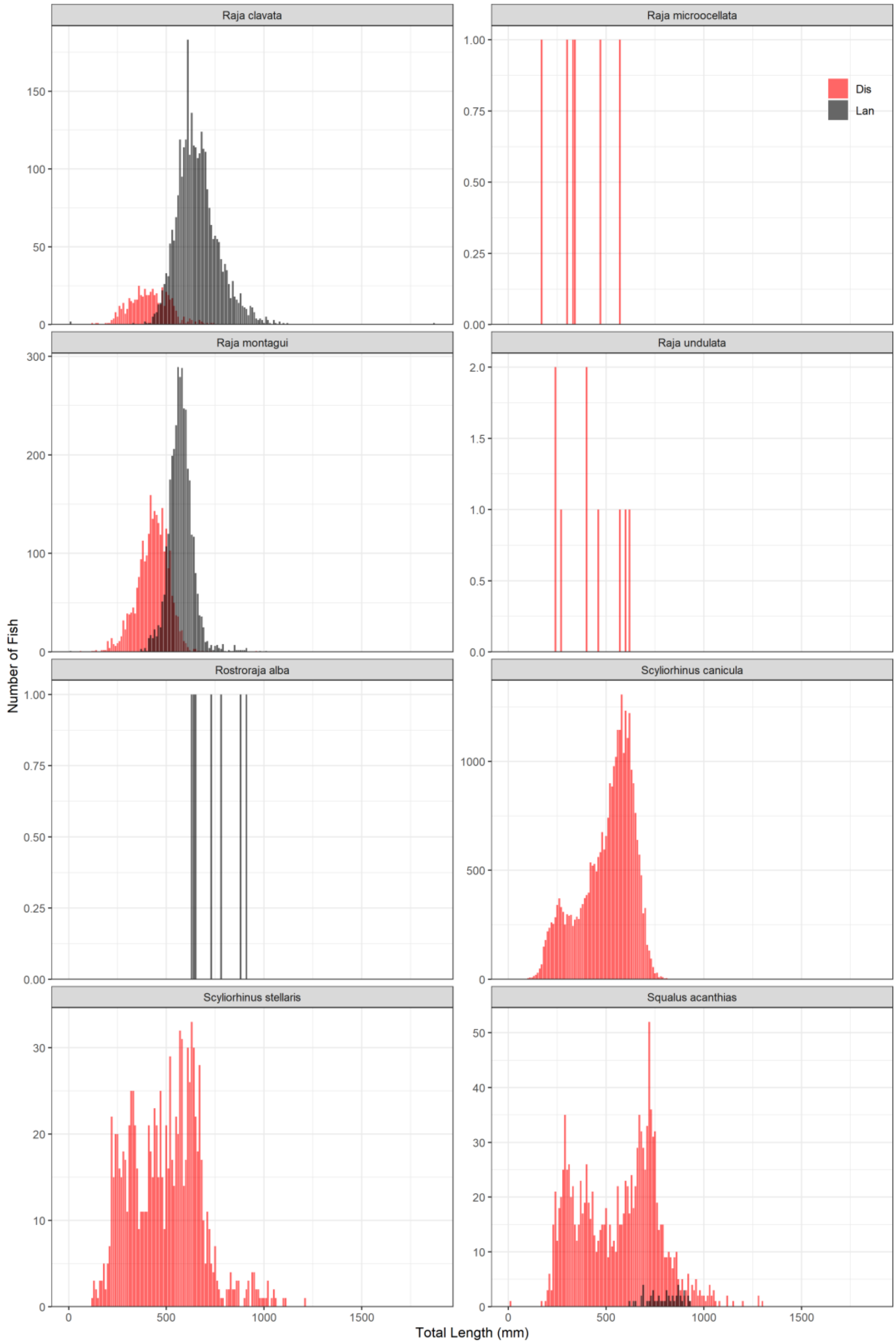

Figure 6: Length frequency numbers for a selection of elasmobranch species caught in the BSA between 2000 and 2020 from ICES divisions VIIg and VIIj. Red bars represent discarded (dis) catch and black bars represent landed (lan) catch.

Additional length frequency distributions are presented in Appendix 2 for a variety of commercially important species caught in ICES divisions VIIg and VIIj. Number of fish sampled per year, species and division are given in Appendix 3 Where sampling within a division was low, due to a lack of landings, these distributions were not presented.

Landings sampling for pelagic species is not always collected. In relation to herring, mackerel and horse mackerel, discard distributions all show proportions above the minimum landing size (Figure A-2 1 to Figure A-2 6).

Trends in hake distributions indicate possible high-grading in 2011-2012 and again in 2016-2017 within VIIj where fish sizes previously landed have been discarded (Figure A-2 8). Overall, in both VIIj and VIIg (Figure A-2 7) landings size distribution appears to have increased, with preference for larger fish now, discarding sizes above MLS which had previously been landed. Cod shows similar patterns in increased proportions of fish over MLS being discarded 2011-2013 and aging 2016-2017 (VIIg Figure A-2 9 and VIIj Figure A-2 10).

Discarding of undersize, and juvenile fish occurs for both haddock (Figure A-2 11 and Figure A-2 12) and whiting (Figure A-2 15), distributions indicate that the peak lengths discarded occur at or in some cases, particularly for whiting, above the MLS. There does appear to be some extension of the landing distribution to larger sizes in more recent years. Less whiting were sampled from VIIj (Figure A-2 16), although a similar trend was present.

For flatfish species, plaice (Figure A-2 23 and Figure A-2 24) and megrim (Figure A-2 21 and Figure A-2 22) discarding in many years peaks at or above the MLS, although few juveniles (<11cm) are caught. That said, more of these small plaice are caught VIIj. Monkfish (Figure A-2 27 and Figure A-2 28) have discard length peaks below the estimated MLS in earlier years. There was, however, a shift to slightly larger fish later in the time series.

5.4 Logbook fishing effort

Fishing effort recorded in the BSA and ICES area VII is presented below to provide an indication of effort exerted over time (since 2003) for demersal, scallop and crab fisheries by each nation assigned an effort ceiling in ICES area VII under Council Regulation 1415/2004 (EC, 2004b). Effective estimated effort based on logbook effort reported to STECF is presented in kilowatt fishing days (kW days) in comparison to effort limitations. Estimated effort within the BSA is given in Table 8 between 2003 and 2016 (the last year of the STECF time series).This effort limitation is displayed as a red line (Figure 7 to Figure 14). For each fishery, estimated effort is represented as a total effective effort and separated by Member State. In general, estimated effort is below the effort caps, however, the estimated effort for the crab fishery within the BSA was noted as an exception. This increased effort in the BSA crab fishery is linked to Irish vessels apparently exceeding assigned effort limitations (Figure 10). Further examples of countries perceived to be exceeding effort allocations (excluding those with negligible effort) are apparent in Figure 8 for Irish and UK BSA demersal fisheries and Figure 9 for Irish BSA scallop fisheries. In the wider EU waters of ICES Area VII, Member States apparently exceeding effort ceilings include Irish and Belgium demersal fisheries (Figure 12), Belgium, Irish, Netherlands and UK scallop fisheries (Figure 13) for and Irish and UK crab fisheries (Figure 14). It should be noted that effort expended by vessels greater than or equal to 15m within the BSA was included within estimations for the wider ICES Area VII.

Table 8: Estimated effort by demersal, scallop and crab fisheries within the BSA, 2003-2016. Effort in kw fishing days based on STECF (2017) compiled data. Ceilings relate to the effort limits as stipulated by Council Regulation 1415/2004 (EC, 2004b).

	Country	Ceilings	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Demersal	Belgium	135,432														
	Denmark	-														
	Germany	8,326	32,698	38,186	18,512		4,862									
	Spain	5,642,215								2,341,286	2,766,486	1,885,711	1,956,951	1,324,053		1,229,585
	France	9,559,653	8,352,280	7,530,865	7,165,864	6,910,504	6,808,121	5,472,169	4,875,413	3,803,914	3,713,559	4,056,365	4,539,370	3,766,339	4,059,035	4,414,566
	Ireland	7,154,490	10,555,981	9,300,833	8,508,536	6,573,909	6,922,820	6,241,082	6,403,906	6,572,594	5,537,559	6,547,362	6,826,517	6,771,350	6,720,934	6,930,119
	The Netherlands	-	19,680				762		1,530	708		4,221	500	367	1,000	
	Portugal	-														
	United Kingdom	3,061,485	1,839,739	1,951,880	1,488,290	1,894,500	1,746,624	1,848,490	1,715,125	2,106,293	1,987,220	2,328,773	2,090,172	1,743,395	3,037,552	3,423,418
	Total	25,561,601	20,800,379	18,821,764	17,181,202	15,378,913	15,483,189	13,561,741	12,995,973	14,824,795	14,004,825	14,822,432	15,413,508	13,605,505	13,818,520	15,997,688

	Country	Ceilings	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Scallop	Belgium	-														
	Denmark	-														
	Germany	-														
	Spain	-														
	France	31,039	4,744	7,496	11,654	933	16,897	12,776	16,441	11,530	6,076	875				507
	Ireland	109,395	151,478	88,826	129,942	69,943	74,968	89,568	116,733	89,882	44,640	128,922	108,188	49,862	51,073	32,621
	The Netherlands	-														
	Portugal	-														
	United Kingdom	1,223	4,685	358	189	423	103	5,188	3	983	11	158	899	22	2,276	33
	Total	141,657	160,907	96,679	141,785	71,299	91,968	107,531	133,178	102,394	50,727	129,955	109,087	49,884	53,349	33,161

	Country	Ceilings	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Crab	Belgium	-														
	Denmark	-														
	Germany	-														
	Spain	-														
	France	84,690	5,700	20,501	3,853	5,650	2,094	439	914	666	1,085		168	226		
	Ireland	63,198	38,161	81,782	112,567	73,824	181,692	167,703	145,667	195,472	157,452	169,820	149,055	156,288	128,546	174,614
	The Netherlands	-														
	Portugal	-														
	United Kingdom	393		45											143	
	Total	148,281	43,861	102,327	116,420	79,473	183,786	168,142	146,581	196,138	158,537	169,820	149,223	156,514	128,689	174,614

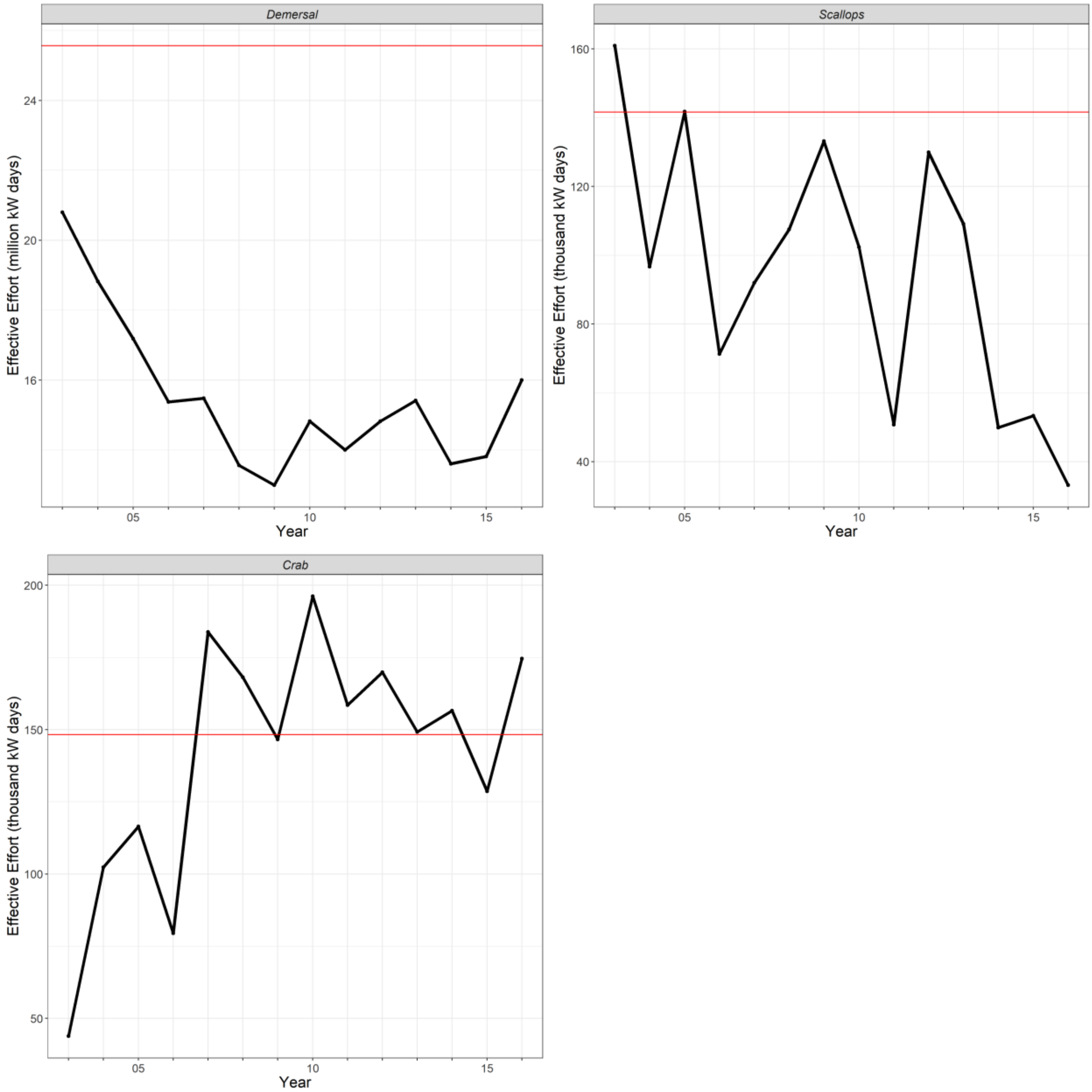

Figure 7: BSA effective effort for demersal, scallop and crab fisheries recorded over time. Effective effort presented as kW fishing days. Red line indicates effort limitation as per Council Regulation 1415/2004 (EC, 2004b). No Spanish data pre-2010.

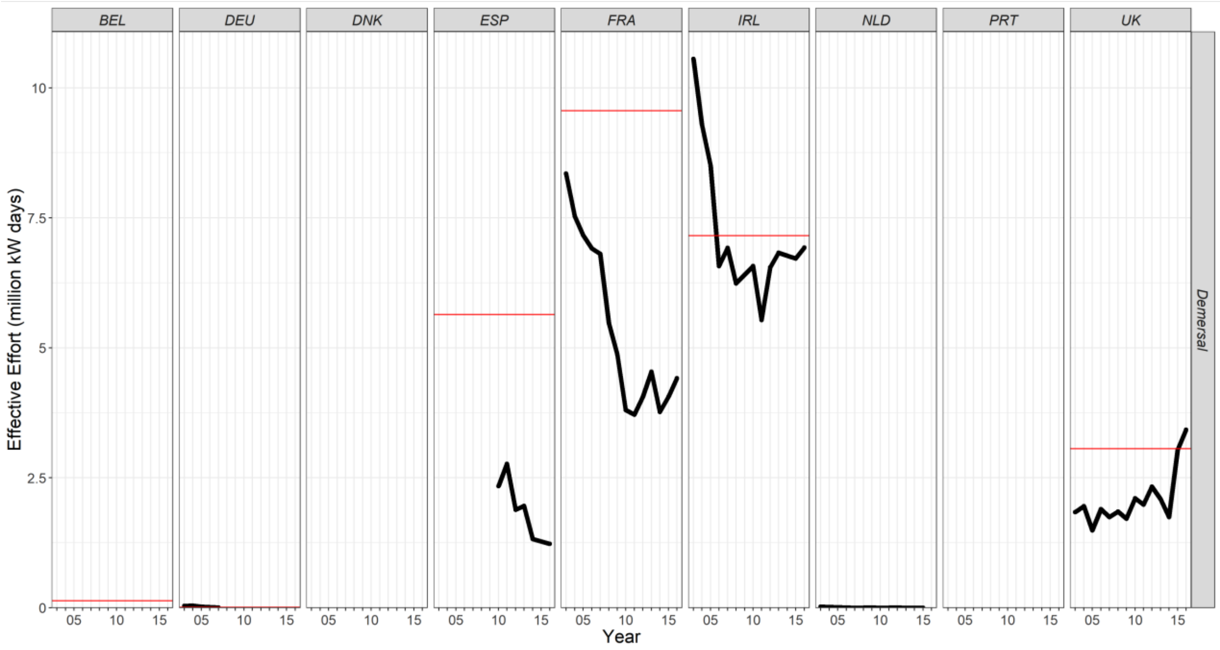

Figure 8: BSA effective effort over time for demersal fisheries. Effective effort presented as kW fishing days. Red line indicates effort limitation as per Council Regulation 1415/2004 (EC, 2004b). BEL = Belgium, DEU = Germany, DNK = Denmark, ESP = Spain, FRA = France, IRL = Ireland, NLD = Netherlands, PRT = Portugal and UK = United Kingdom.

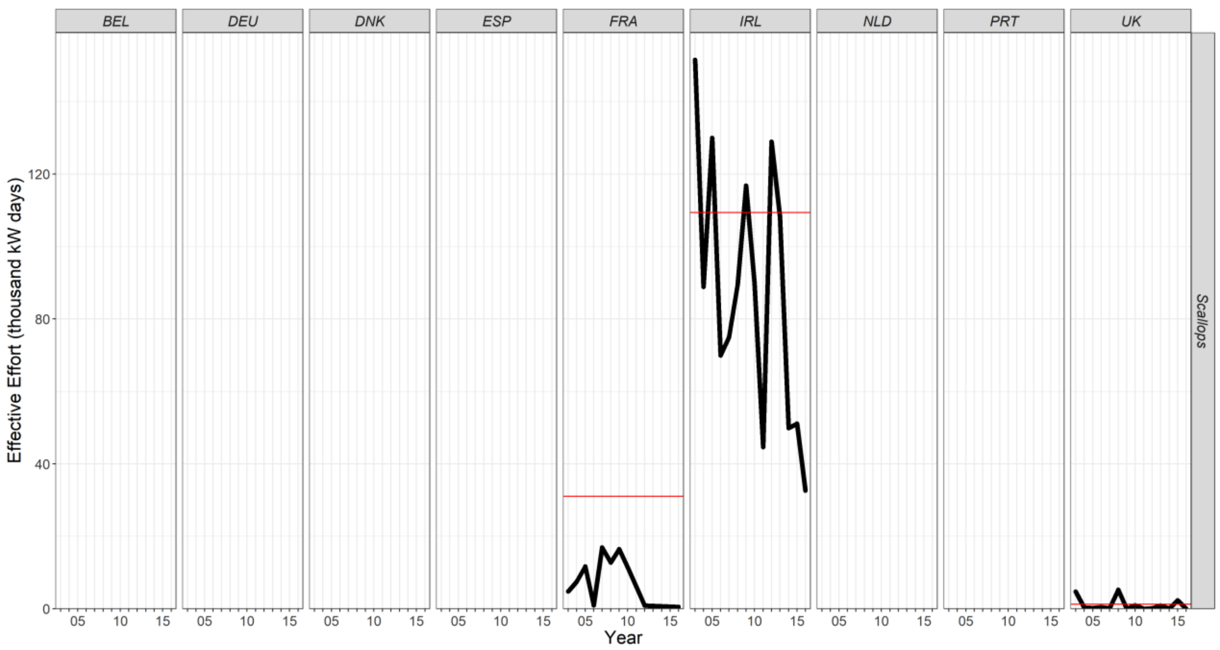

Figure 9: BSA effective effort over time for scallop fisheries. Effective effort presented as kW fishing days. Red line indicates effort limitation as per Council Regulation 1415/2004 (EC, 2004b). BEL = Belgium, DEU = Germany, DNK = Denmark, ESP = Spain, FRA = France, IRL = Ireland, NLD = Netherlands, PRT = Portugal and UK = United Kingdom.

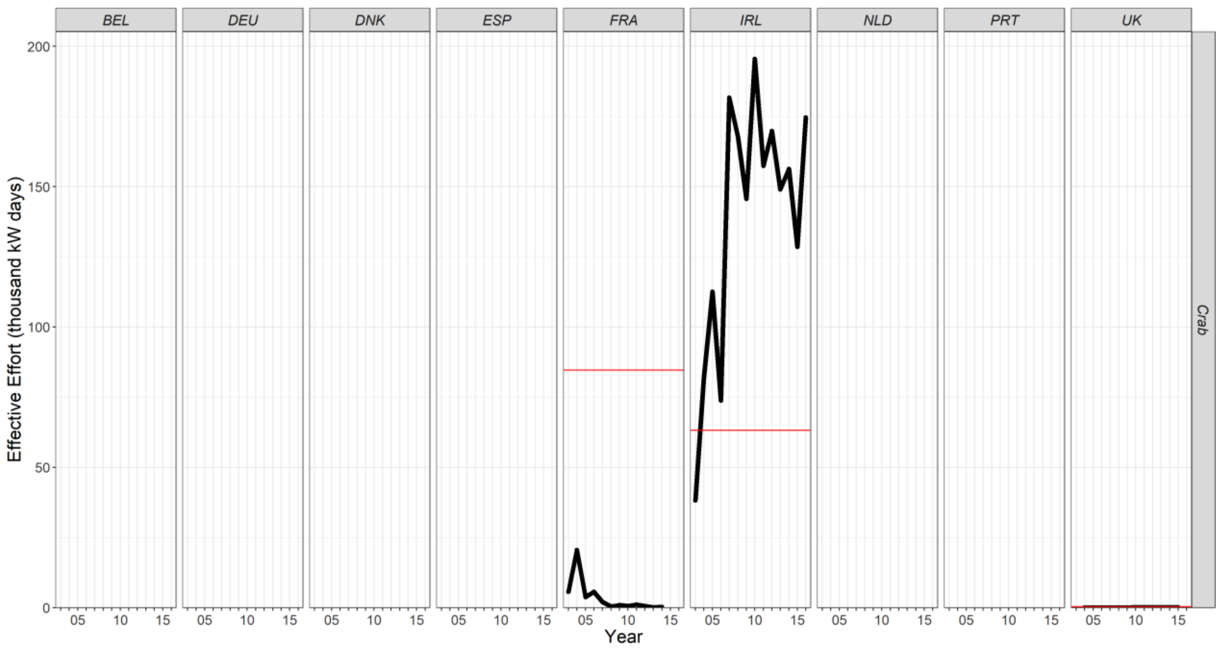

Figure 10: BSA effective effort over time for crab fisheries. Effective effort presented as kW fishing days. Red line indicates effort limitation as per Council Regulation 1415/2004 (EC, 2004b). BEL = Belgium, DEU = Germany, DNK = Denmark, ESP = Spain, FRA = France, IRL = Ireland, NLD = Netherlands, PRT = Portugal and UK = United Kingdom.

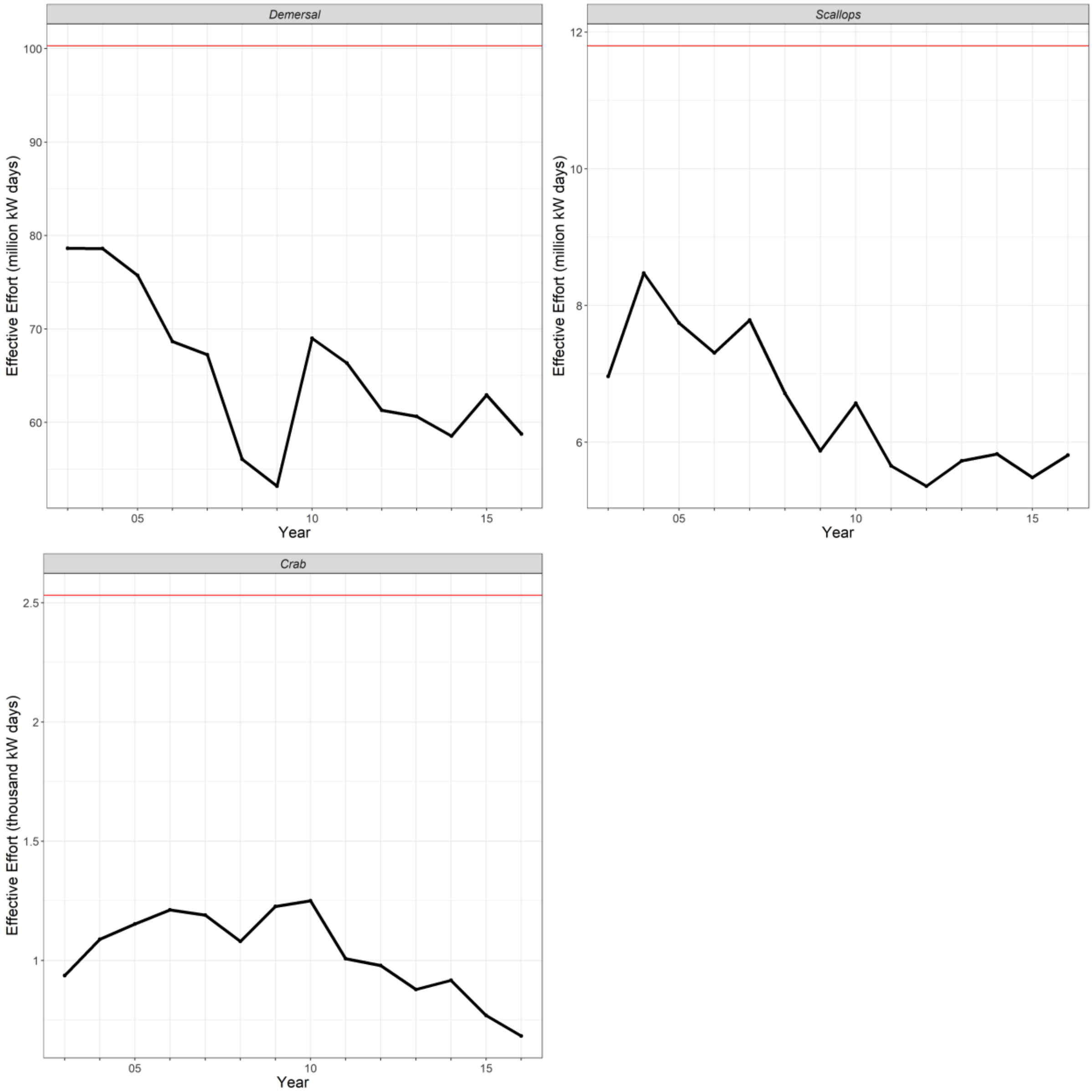

Figure 11: EU waters of ICES Area VII effective effort for demersal, scallop and crab fisheries recorded over time. Effective effort presented as kW fishing days. Red line indicates effort limitation as per Council Regulation 1415/2004 (EC, 2004b). No Spanish data pre-2010.

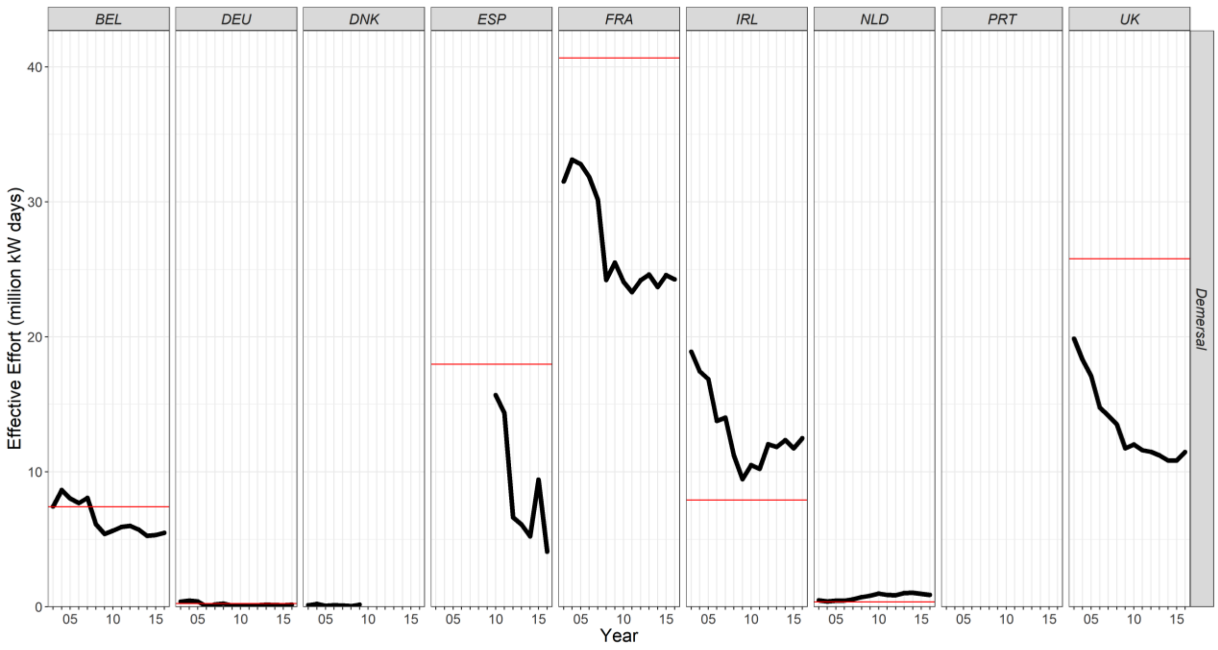

Figure 12: EU waters of ICES area VII effective effort over time for demersal fisheries. Effective effort presented as kW fishing days. Red line indicates effort limitation as per Council Regulation 1415/2004 (EC, 2004b). BEL = Belgium, DEU = Germany, DNK = Denmark, ESP = Spain, FRA = France, IRL = Ireland, NLD = Netherlands, PRT = Portugal and UK = United Kingdom.

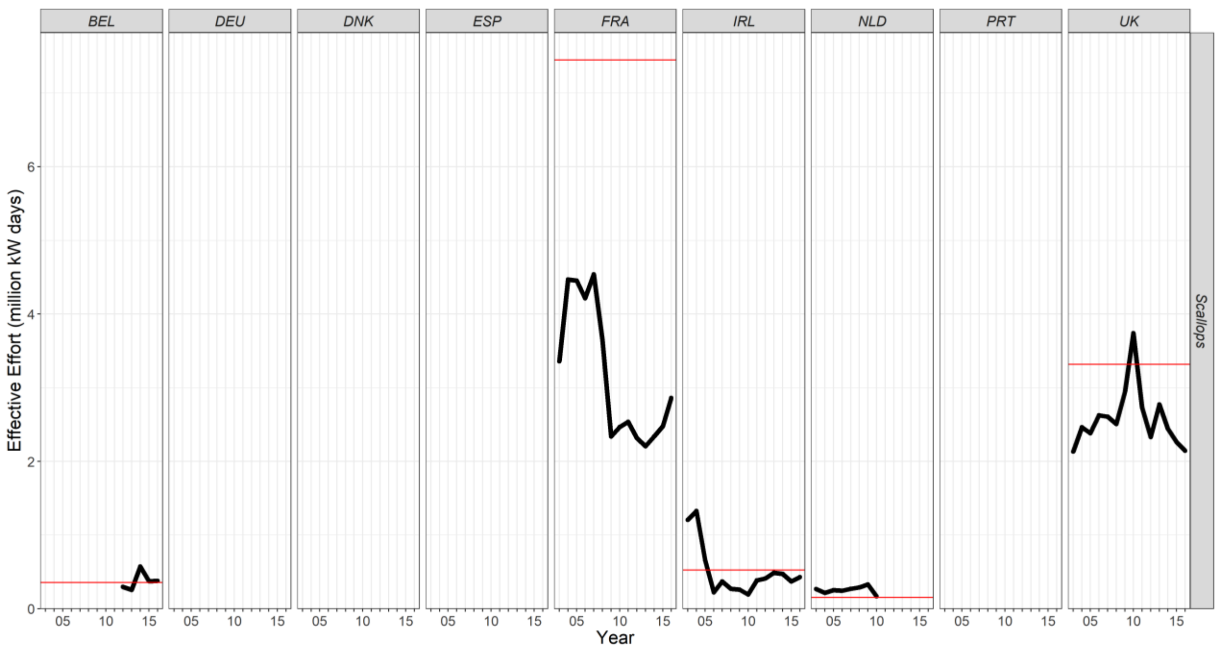

Figure 13: EU waters of ICES area VII effective effort over time for scallop fisheries. Effective effort presented as kW fishing days. Red line indicates effort limitation as per Council Regulation 1415/2004 (EC, 2004b). BEL = Belgium, DEU = Germany, DNK = Denmark, ESP = Spain, FRA = France, IRL = Ireland, NLD = Netherlands, PRT = Portugal and UK = United Kingdom.

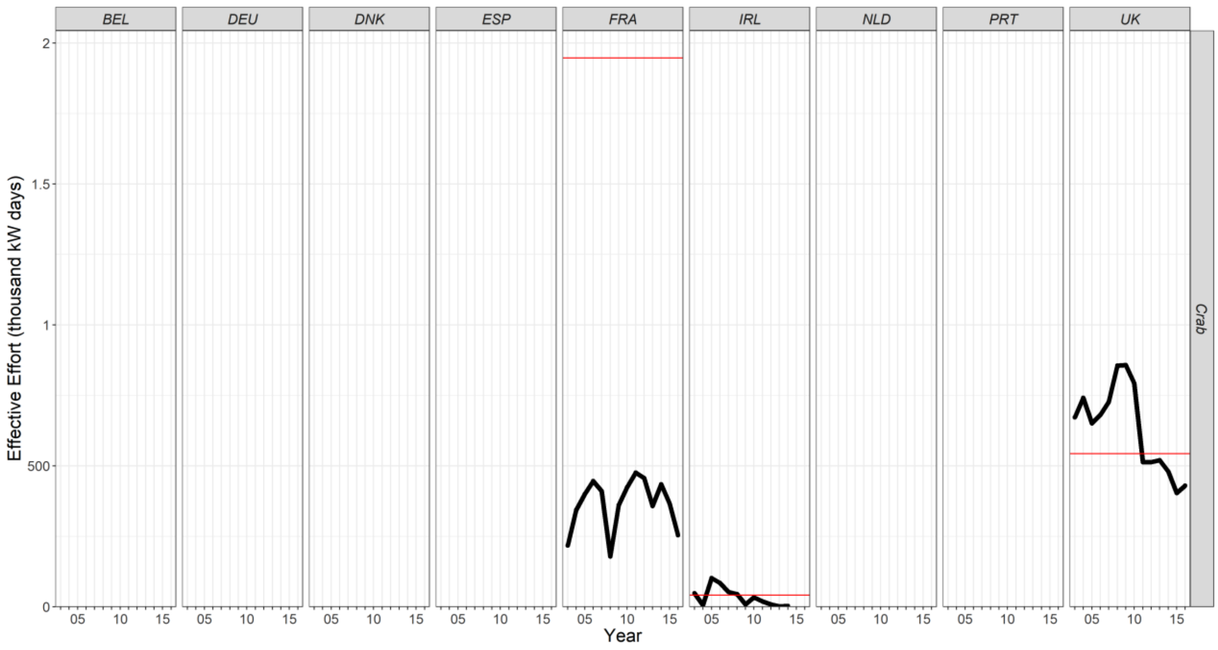

Figure 14: EU waters of ICES area VII effective effort over time for crab fisheries. Effective effort presented as kW fishing days. Red line indicates effort limitation as per Council Regulation 1415/2004 (EC, 2004b). BEL = Belgium, DEU = Germany, DNK = Denmark, ESP = Spain, FRA = France, IRL = Ireland, NLD = Netherlands, PRT = Portugal and UK = United Kingdom.

5.5 Vessel monitoring system fishing effort

Tracking the movement of vessels using VMS can give an insight into the areas used by fishing vessels, by nation and registered gear, over time. VMS derived fishing effort in hours per nautical mile (nm) recorded in and around the BSA are summarised below to give a reflection of effort in space and time (per year). Annual VMS based fishing effort estimates (in hours) within the BSA area by dominant gears and nations was tabulated (Table 9). Those gears and nations less active within the BSA were grouped into "other" gear and nation categories. This category includes effort where gear type could not be established. Effort within the south-eastern area of the BSA beyond the Irish EEZ is provided for each gear. Noting, effort within this area is not consistently available for non-Irish vessels.

Effort estimated from VMS was used to visually represent fishing intensity across the BSA for the most active gears and nations to highlight fishing grounds(Figure 15 to Figure 45 For each of the main gears a summary of spatial changes in fishing intensity between 2013 and 2018 are provided followed by yearly effort representations for 2006, 2013, and 2018. Noting, prior to 2012 VMS was limited to vessels 15m or more, after which this was extended down to vessels of 12m or more.

Table 9: VMS derived fishing effort within the BSA. Showing annual (2006-2018) hours effort per gear and nation fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available – 'Outside' refers to the effort (by all nations) in area of the BSA that is outside the Irish EEZ.

Gear	Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Beam	Belgium	0	72	80	74	0	8	0	0	4	14	2	1,680	834
	Ireland	11,522	11,763	7,067	9,580	7,842	4,760	7,898	9,709	9,887	13,119	10,814	11,803	10,665
	Other	903	778	389	0	0	0	0	0	68	5	0	0	2
	Outside	2,677	1,509	1,051	551	1,114	1,685	1,374	1,914	295	887	1,813	1,723	1,217
Bottom otter trawl	Spain	28,601	27,224	20,231	18,918	17,703	23,193	17,242	17,475	9,932	9,112	8,489	10,177	8,289
	France	48,006	50,871	38,633	40,492	28,482	26,178	28,775	31,476	16,253	21,051	21,208	26,027	20,212
	UK	13,772	14,065	15,515	16,486	17,500	16,851	18,895	17,606	13,404	12,932	10,399	4,778	3,957
	Ireland	47,489	51,717	50,384	59,890	55,252	46,228	46,035	48,135	51,961	52,587	58,898	52,465	47,174
	Other	4,272	3,097	2,612	1,269	1,758	1,813	1,563	529	81	24	106	105	22
	Outside	13,242	11,709	12,420	12,495	12,331	15,323	15,692	15,456	22,331	22,810	26,824	33,429	27,902
Dredge	UK	0	0	0	0	0	0	0	8	4	44	0	0	0
	Ireland	587	1,160	1,642	1,547	1,747	1,552	3,352	2,672	865	1,498	501	1,813	1,764
	Outside	177	186	176	124	435	147	503	48	18	54	310	50	73
Gill net	France	5,573	8,503	4,584	4,522	2,954	4,057	3,753	3,414	2,193	5,497	3,717	4,227	4,852
	UK	2,065	1,585	1,782	3,578	2,842	3,082	2,597	2,165	1,940	2,436	2,826	2,298	2,255
	Ireland	4,600	5,357	5,728	6,001	6,673	5,023	5,615	4,856	8,584	8,951	9,990	8,154	8,365
	Other	0	409	197	138	0	0	0	13	0	185	4	6	10
	Outside	870	1,453	861	1,339	1,407	1,269	1,173	1,170	906	1,038	1,257	3,075	3,106
Longline	Spain	2,145	1,530	1,129	1,624	427	194	2,212	4,450	3,617	4,362	1,931	7,532	11,077
	France	14	77	672	293	228	378	467	2,137	1,284	2,930	2,328	4,145	4,337
	UK	107	72	219	70	50	52	180	417	500	622	540	802	213
	Other	171	160	238	16	13	13	12	79	370	82	6	4	65
	Outside	81	116	507	202	376	274	470	175	415	276	643	866	736
Pelagic trawls	France	1,116	1,220	1,045	1,525	1,126	588	95	95	260	228	265	30	69
	UK	368	166	204	507	882	609	495	203	368	378	139	137	121
	Ireland	2,135	3,211	2,850	2,846	3,307	2,632	3,144	4,520	3,679	1,991	1,610	1,119	1,178
	Netherlands	621	807	976	1,461	685	981	894	541	346	218	278	164	226
	Other	245	473	718	920	579	574	629	447	325	202	166	41	19
	Outside	1,146	1,203	877	644	434	953	377	696	671	1,032	133	297	299
Seines	France	0	0	0	0	4	99	397	1,164	601	485	321	333	3
	UK	0	0	0	0	106	234	278	54	123	171	150	104	0
	Ireland	5,762	5,627	4,089	4,237	5,277	8,457	7,595	8,657	7,138	6,477	6,954	6,401	7,144
	Other	1,353	1,137	605	23	165	0	24	179	23	54	2	0	0
	Outside	16	12	116	31	145	33	198	147	254	92	67	1,046	34
Other	Spain	925	880	1,807	1,699	2,270	1,751	635	188	60	23	0	15	30
	France	1,435	513	1,008	951	1,315	1,034	1,177	483	347	1,159	1,125	974	405
	UK	954	686	115	104	214	307	152	32	168	61	1,516	5,472	6,545
	Ireland	4217	2314	883	348	307	34	4035	3404	1625	2598	1804	1661	7915
	Other	47	106	380	95	10	18	46	272	16	63	67	95	149
	Outside	587	490	383	160	224	579	3050	645	1685	1160	1427	7142	1082

Within the BSA beam trawl fishing was predominantly conducted by Ireland. UK and Belgium generally use this gear outside the Irish EEZ, with little or inconsistent annual effort within the BSA. Ireland and Belgium have increased fishing effort within the BSA since 2013, with Belgium logging their greatest hours increase in 2017 and 2018. The UK has decreased their effort hours since 2013 (Figure 15). Area of fishing appears to have shifted slightly for all three countries. Irish beam trawl fishing appears to have shifted inshore (Figure 16), UK beam trawl fishing appears to have moved out of the Irish EEZ (Figure 17) and Belgium beam trawl fishing, after zero effort hours in 2013, has spread into the inshore BSA region (Figure 18).

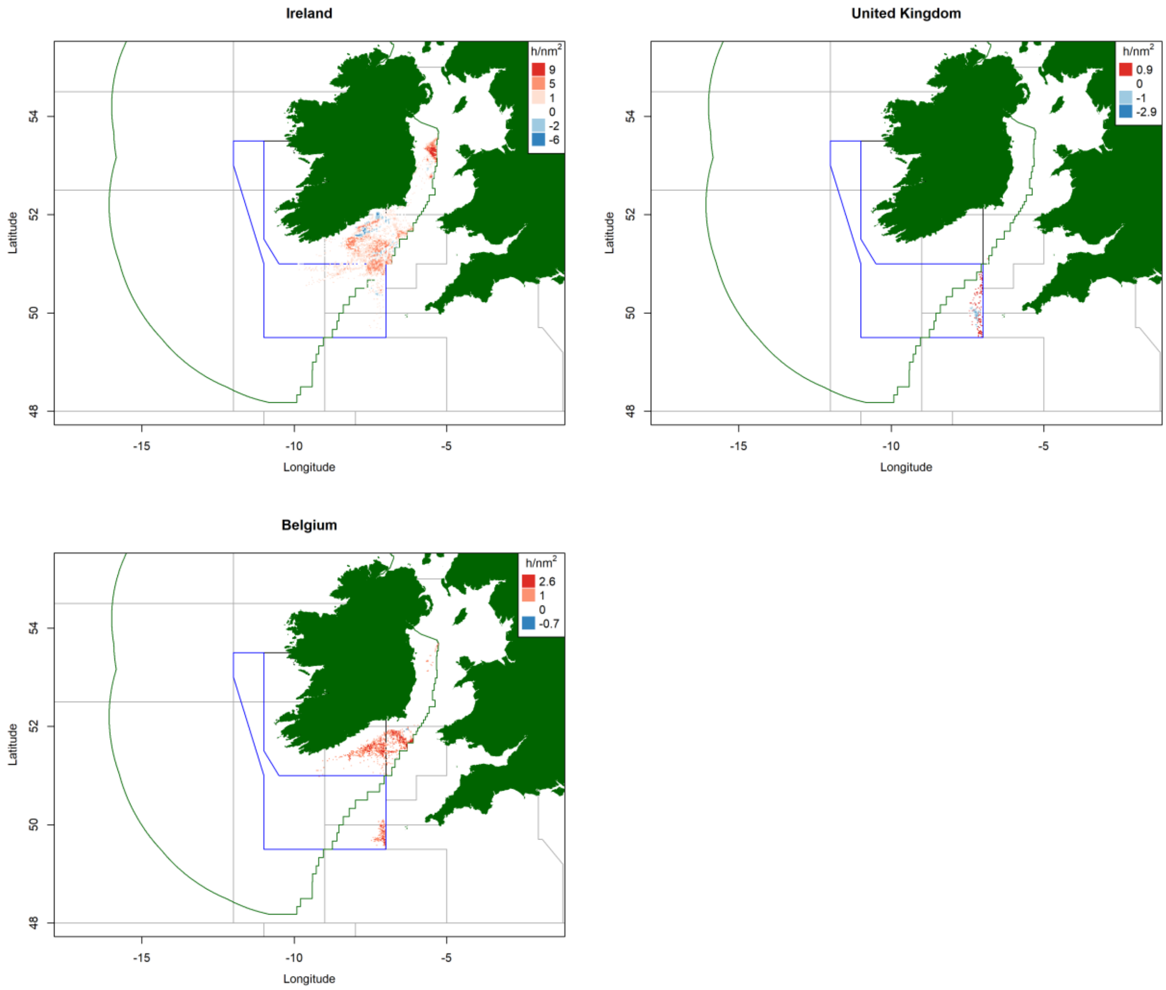

Figure 15: Map of changes in beam trawl VMS fishing effort distribution between 2013 and 2018 for Ireland, UK, and Belgium. Data of non-Irish vessels outside the Irish EEZ was not consistently available.

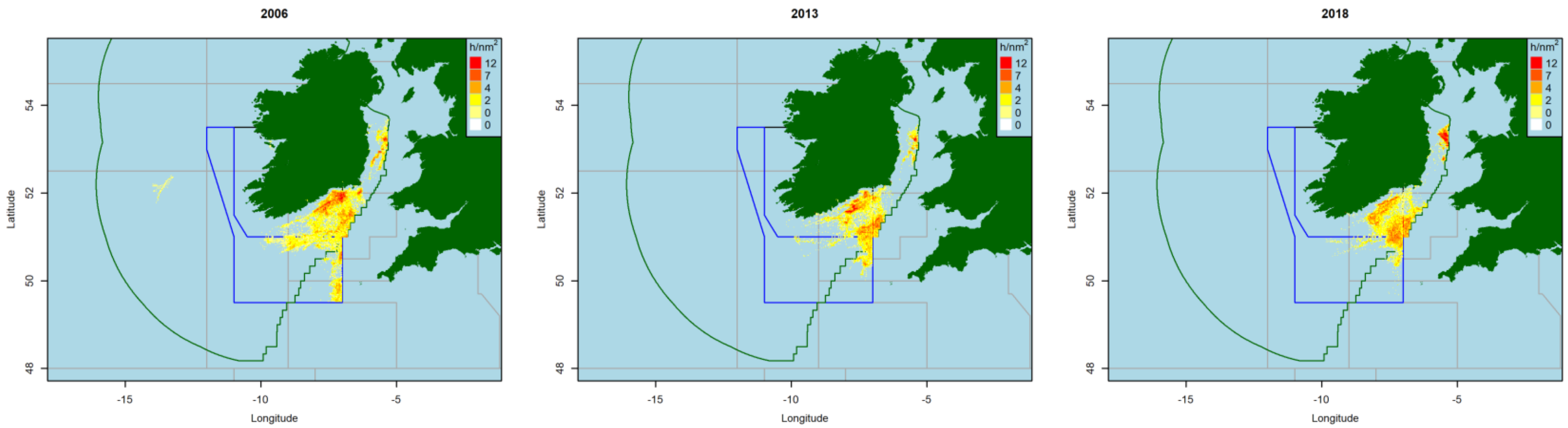

Figure 16: VMS estimated effort for Irish beam trawl fishing. Data of non-Irish vessels outside the Irish EEZ was not consistently available.

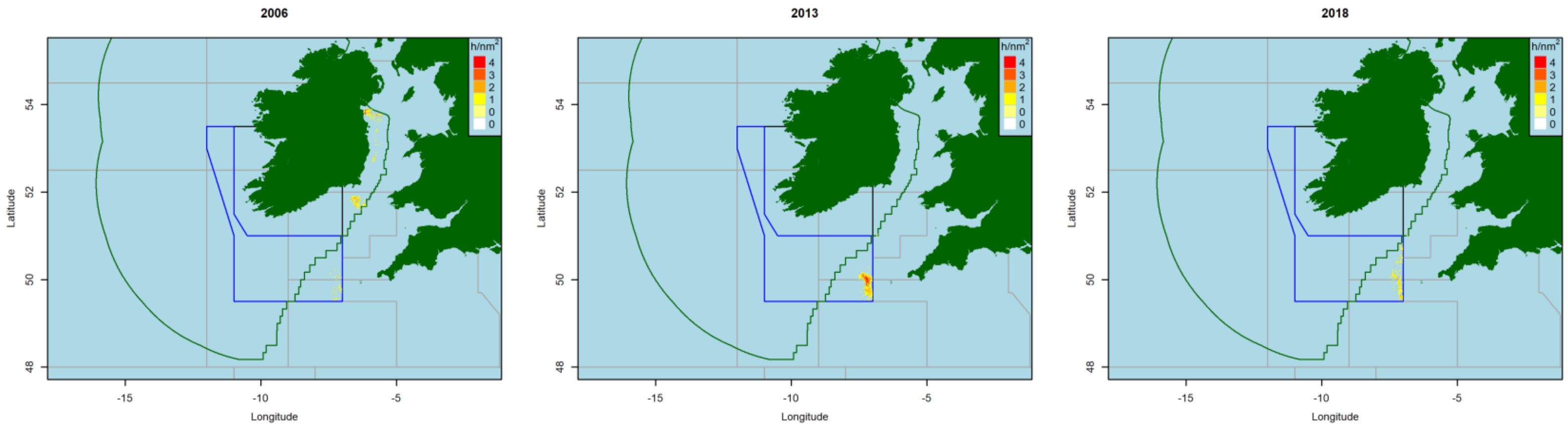

Figure 17: VMS estimated effort for UK beam trawl fishing. Data of non-Irishvessels outside the Irish EEZ was not consistently available.

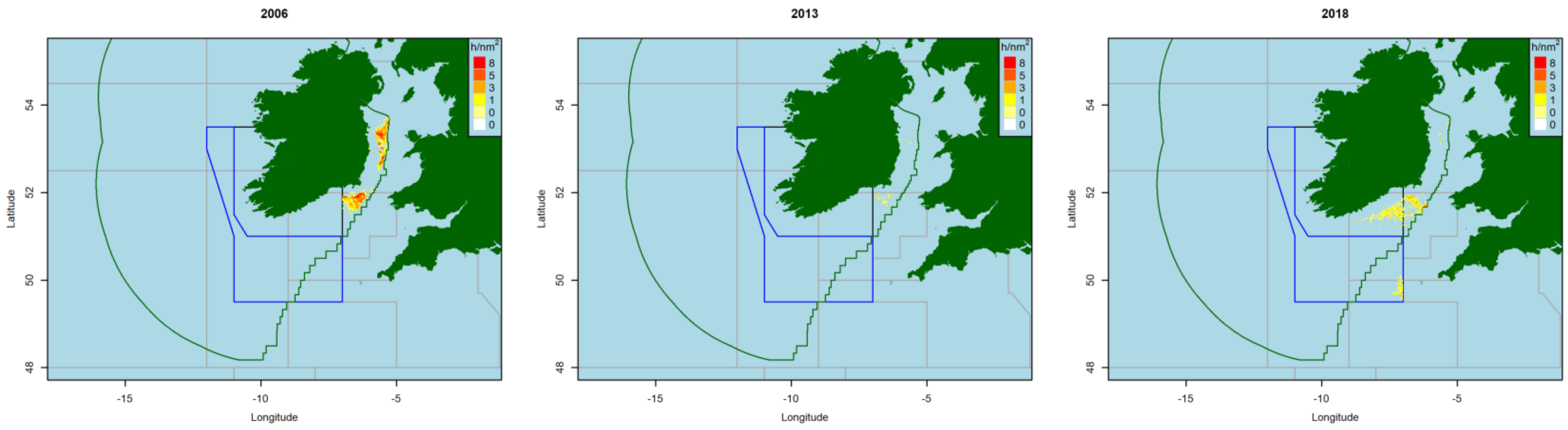

Figure 18: VMS estimated effort for Belgium beam trawl fishing. Data of non-Irishby vessels outside the Irish EEZ was not consistently available.

Bottom otter trawl fishing is the most dominant form of fishing within the BSA. Although fishing occurs across much of the BSA, one of the most active grounds is along the western boundary of the BSA, tracing the continental shelf edge. Seven countries have recorded effort within the BSA over the last 10 years. The most active of which are Ireland, France, Spain, and the UK (Figure 19). Although Portugal used to fish within the area no effort has been recorded since 2014 (Figure 22). Bottom otter trawl fishing has almost halved for both Spain and the UK since 2013. While Ireland and France have remained fairly consistent since 2013 with a small increase for Ireland and a small decrease for France. Spain and the UK fish more to the west and south of the BSA (Figure 23 and Figure 24) while fishing over a larger area was evident for Ireland and France (Figure 20 and Figure 21).

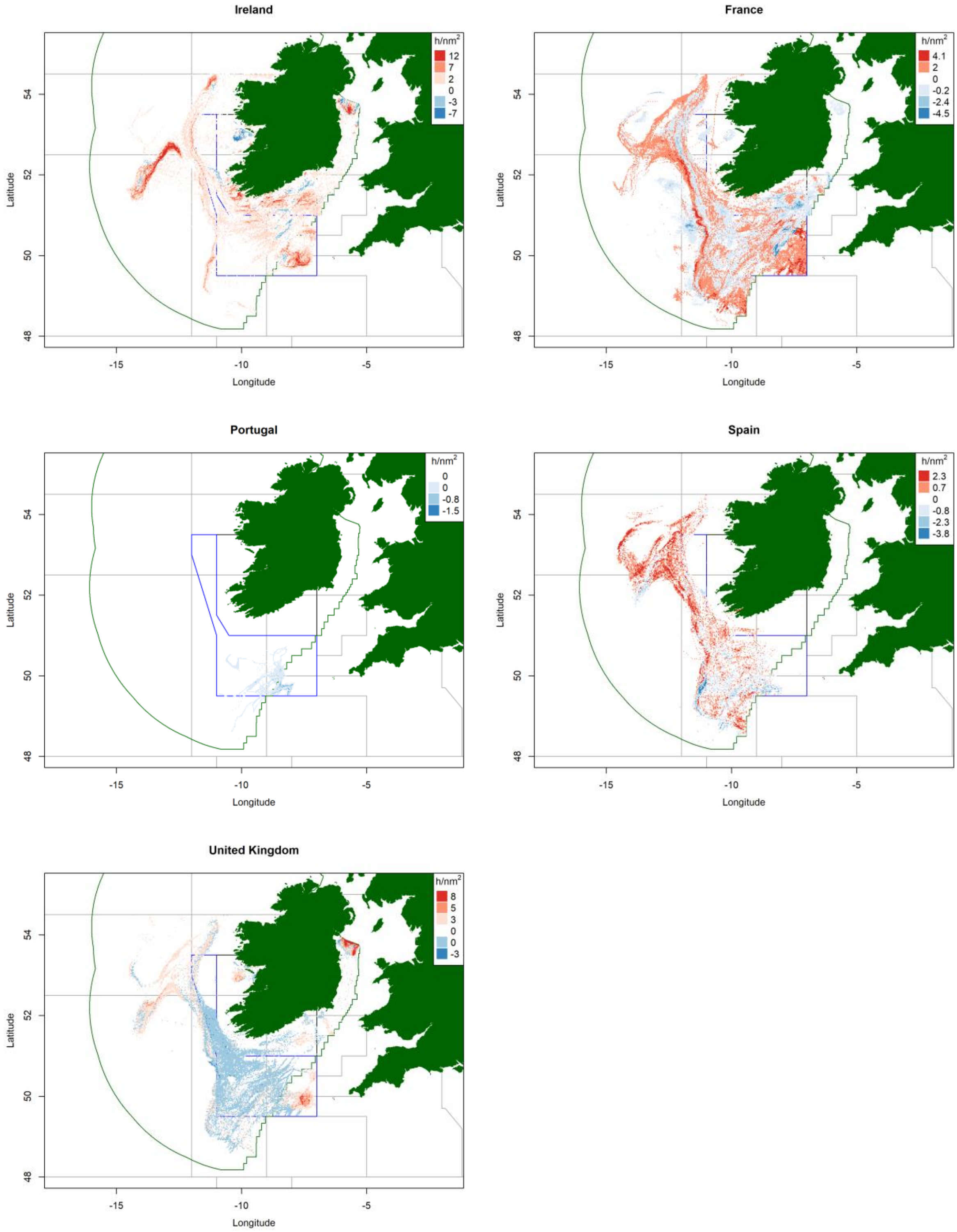

Figure 19: Map of changes in bottom otter trawl VMS fishing effort distribution between 2013 and 2018 for Ireland, France, Portugal, Spain, and the UK. Data by non-Irish vessels outside the Irish EEZ was not consistently available**.**

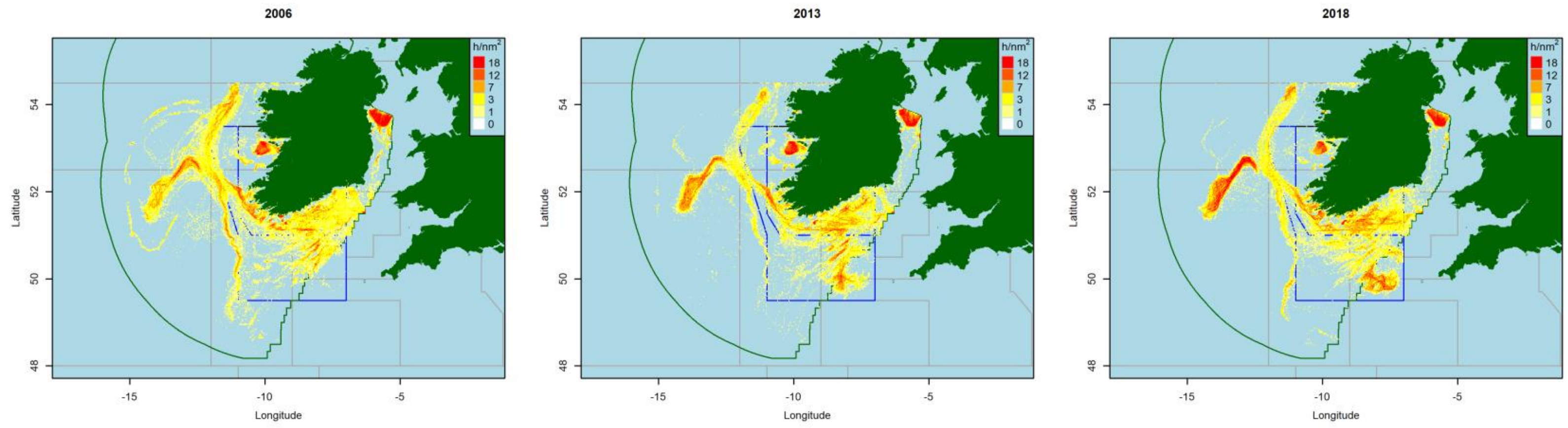

Figure 20: VMS estimated effort for Irish bottom otter trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

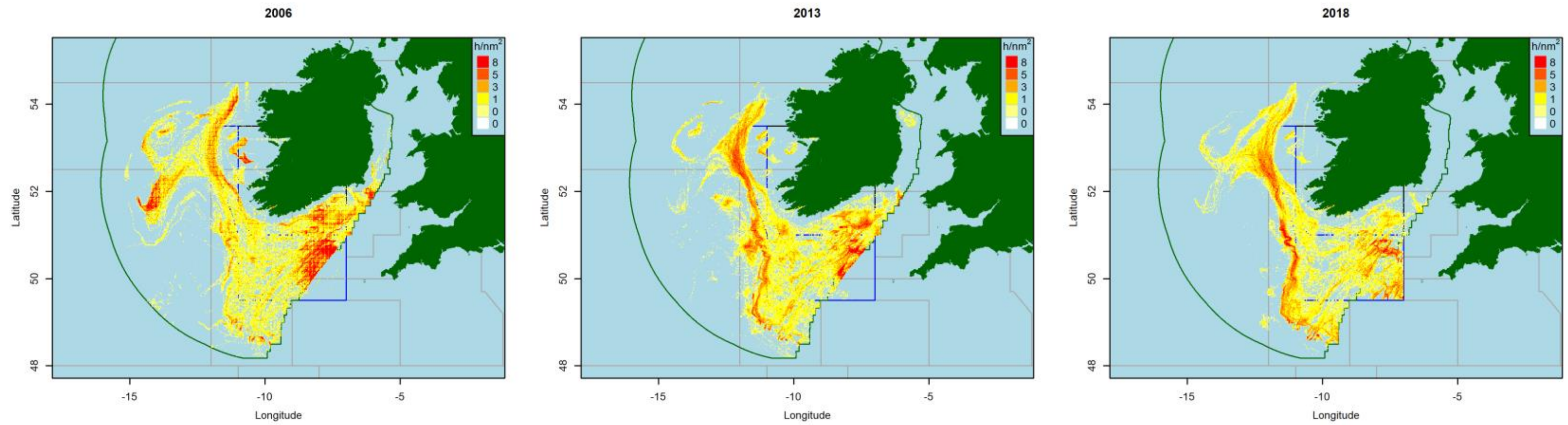

Figure 21: VMS estimated effort for French bottom otter trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

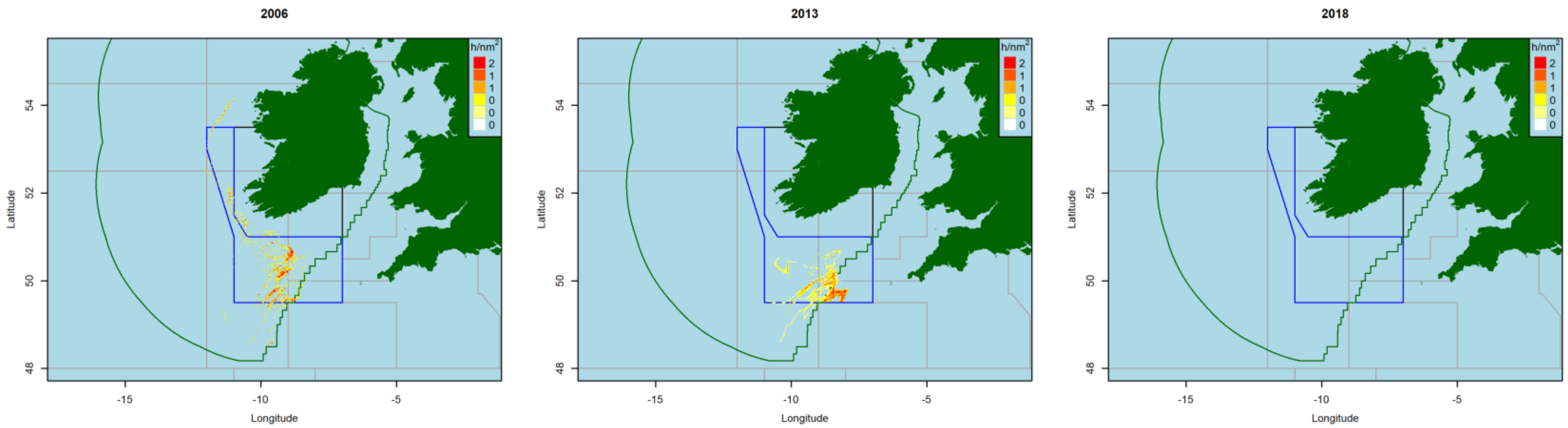

Figure 22: VMS estimated effort for Portugal bottom otter trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

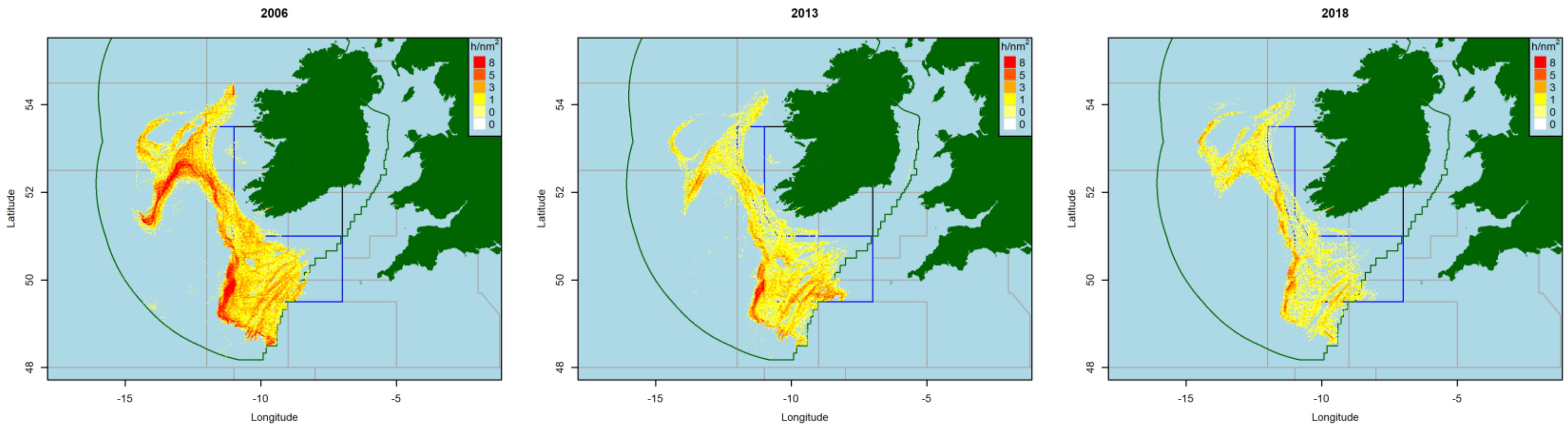

Figure 23: VMS estimated effort for Spanish bottom otter trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

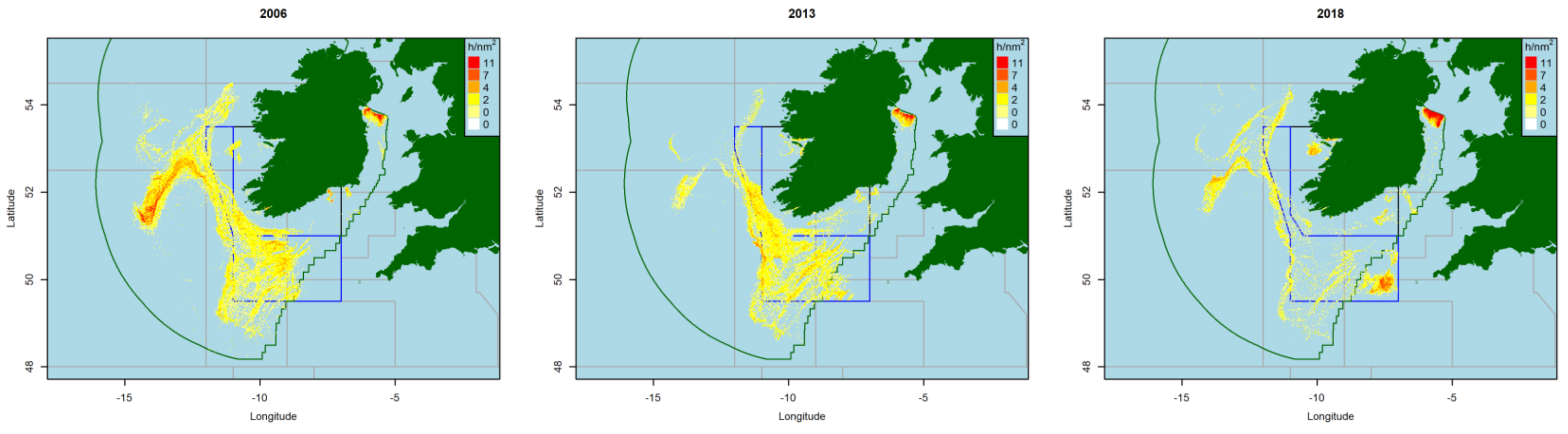

Figure 24: VMS estimated effort for UK bottom otter trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

Dredging is one of the smallest fisheries within the BSA. The spatial distribution of this fishery straddles the eastern boundary off the south coast of Ireland. Although effort within the BSA as a whole has decreased (Table 9) at a fine spatial scale the footprint of the fishery has increased (Figure 25), particularly since 2006 (Figure 26).

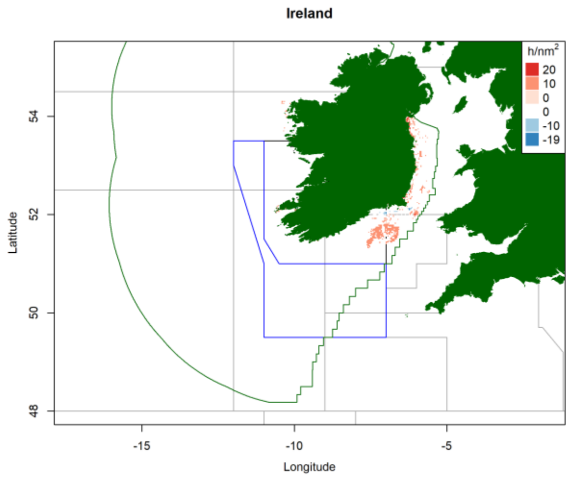

Figure 25: Map of changes in dredge VMS fishing effort distribution between 2013 and 2018 for Ireland.

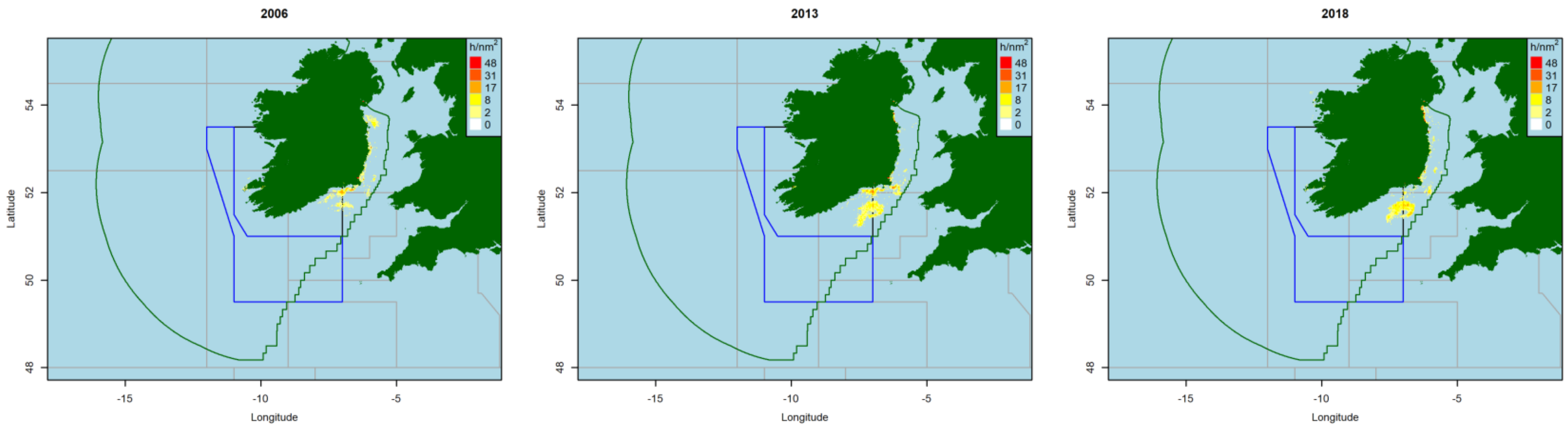

Figure 26: VMS tracks for Irish dredge fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

Gill net fishing was conducted by three countries, namely France, UK, and Ireland, within the BSA. Spain recorded a small portion of gill net fishing south-west and south of the BSA (Figure 31). Gill net fishing has increased since 2013, with greater increases noted for Ireland and France (Figure 27). Irish gill net fisheries appear widely distributed within the BSA (Figure 28), France gill net fisheries were predominantly targeted along the western edge of the BSA (Figure 29) and UK was distributed along the southern portion of the BSA (Figure 30).

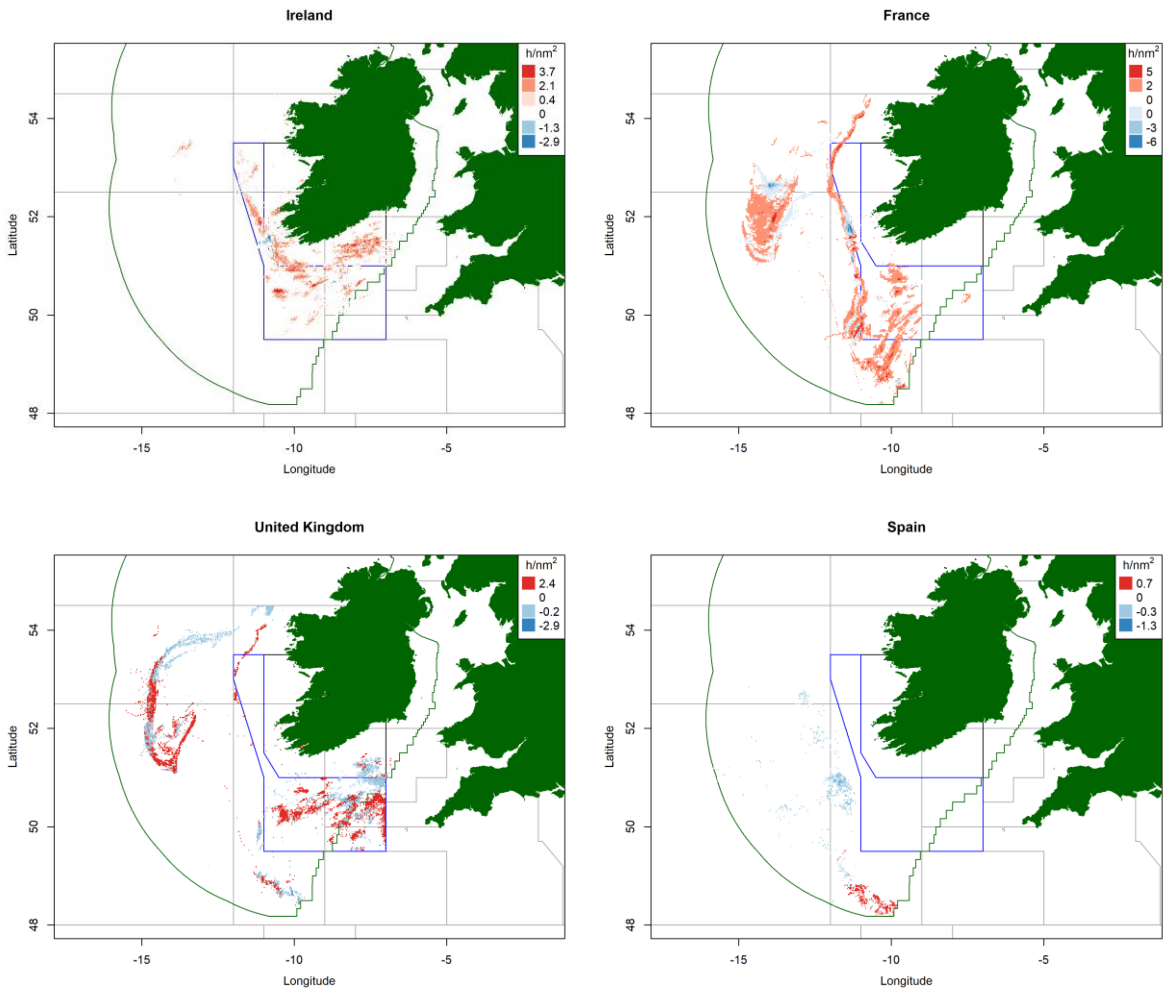

Figure 27: Map of changes in gillnet VMS fishing effort distribution between 2013 and 2018 for Ireland, France, UK, and Spain. Data by non-Irish vessels outside the Irish EEZ was not consistently available**.**

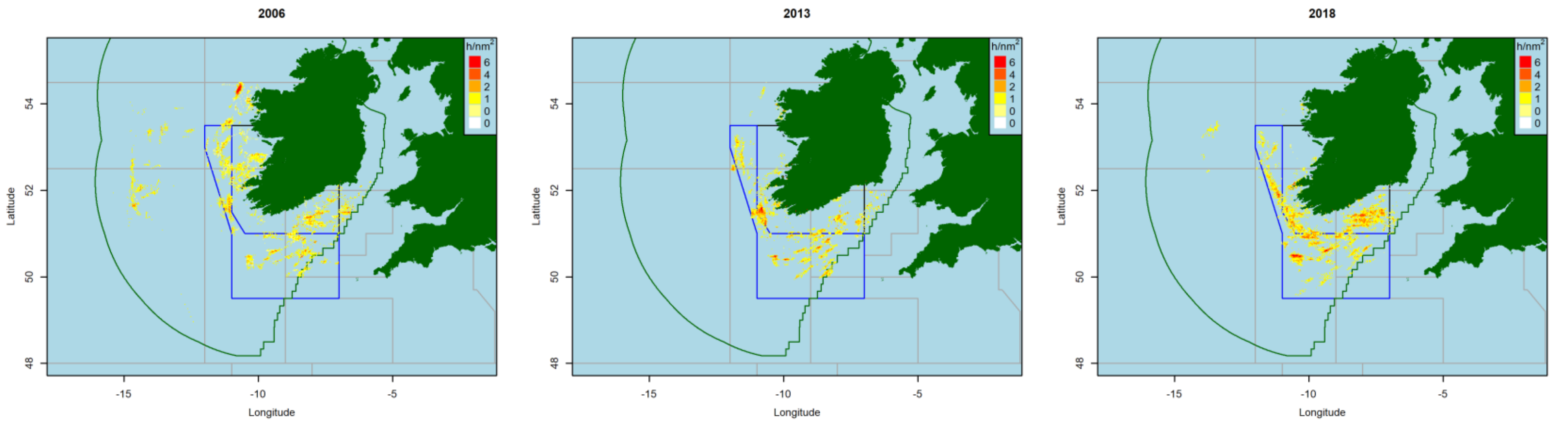

Figure 28: VMS estimated effort for Irish gill net fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

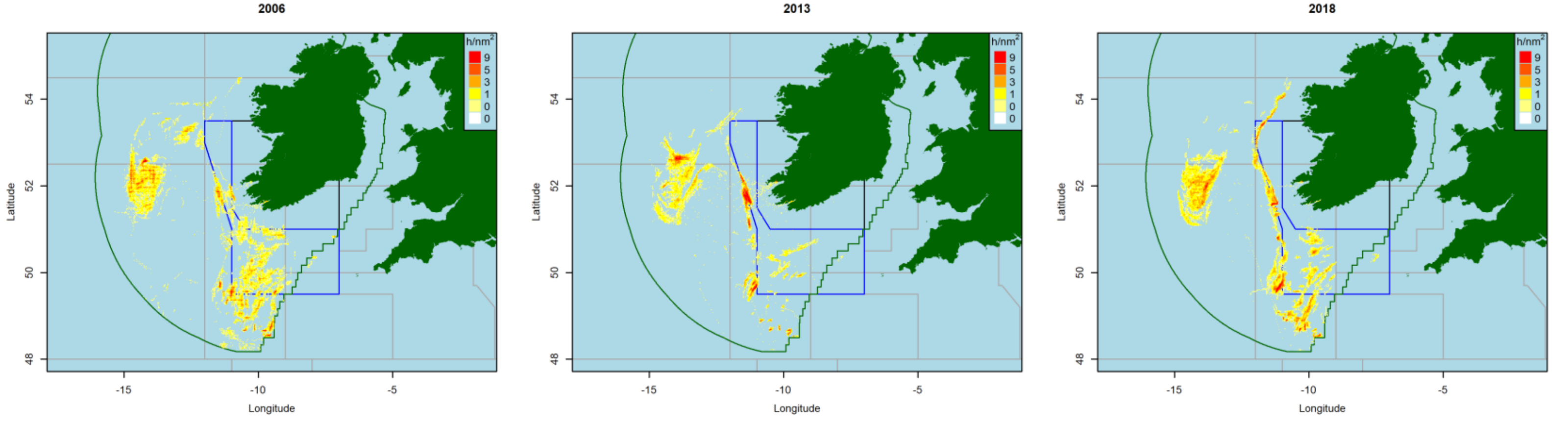

Figure 29: VMS estimated effort for French gill net fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

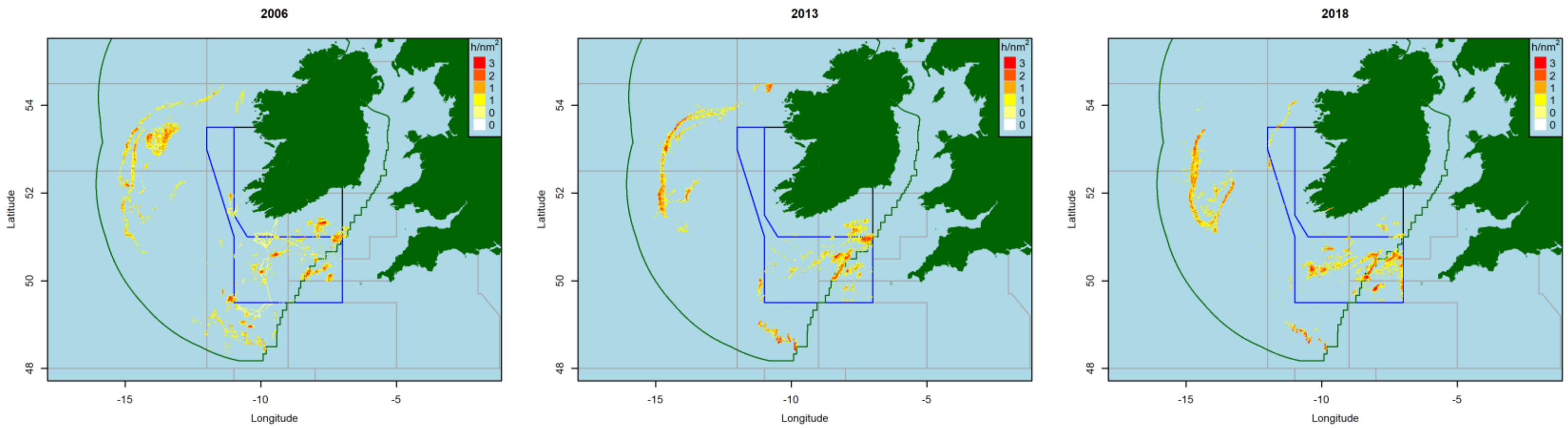

Figure 30: VMS estimated effort for UK gill net fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

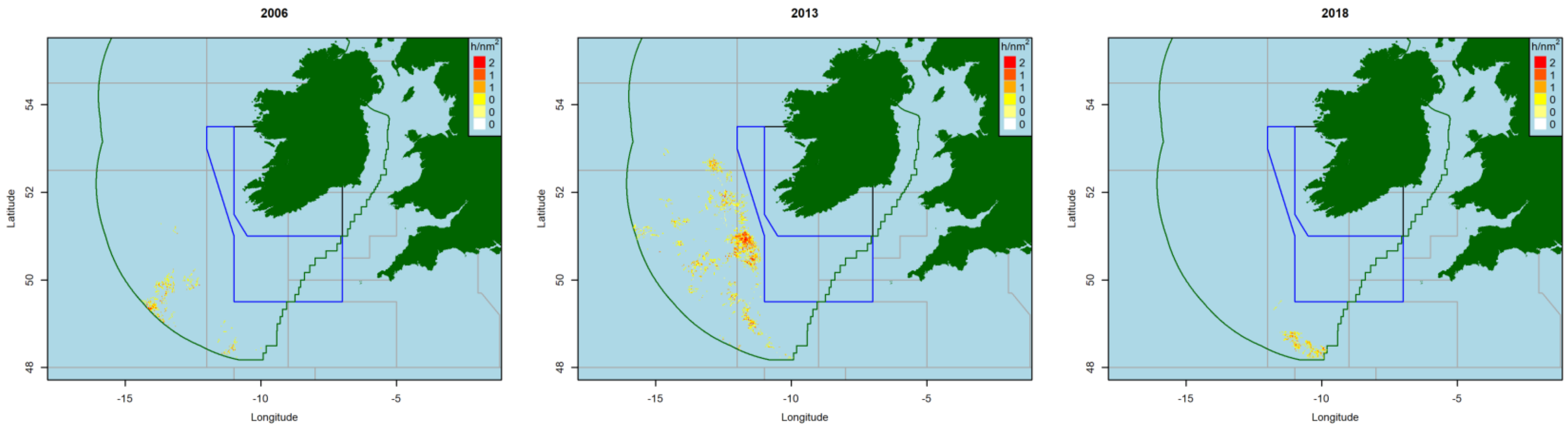

Figure 31: VMS estimated effort for Spanish gill net fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

Longline fishing was conducted by three countries, namely France, Spain, and the UK within the vicinity of the BSA. Within the BSA effort has increased for Spain and France but decreased for the UK (Figure 32 and Table 9). This fishery is typically targeted along the western edge of the BSA (Figure 33 to Figure 35). Low effort sporadic longline fisheries have been carried out by Ireland, Germany, and Portugal within the BSA area.

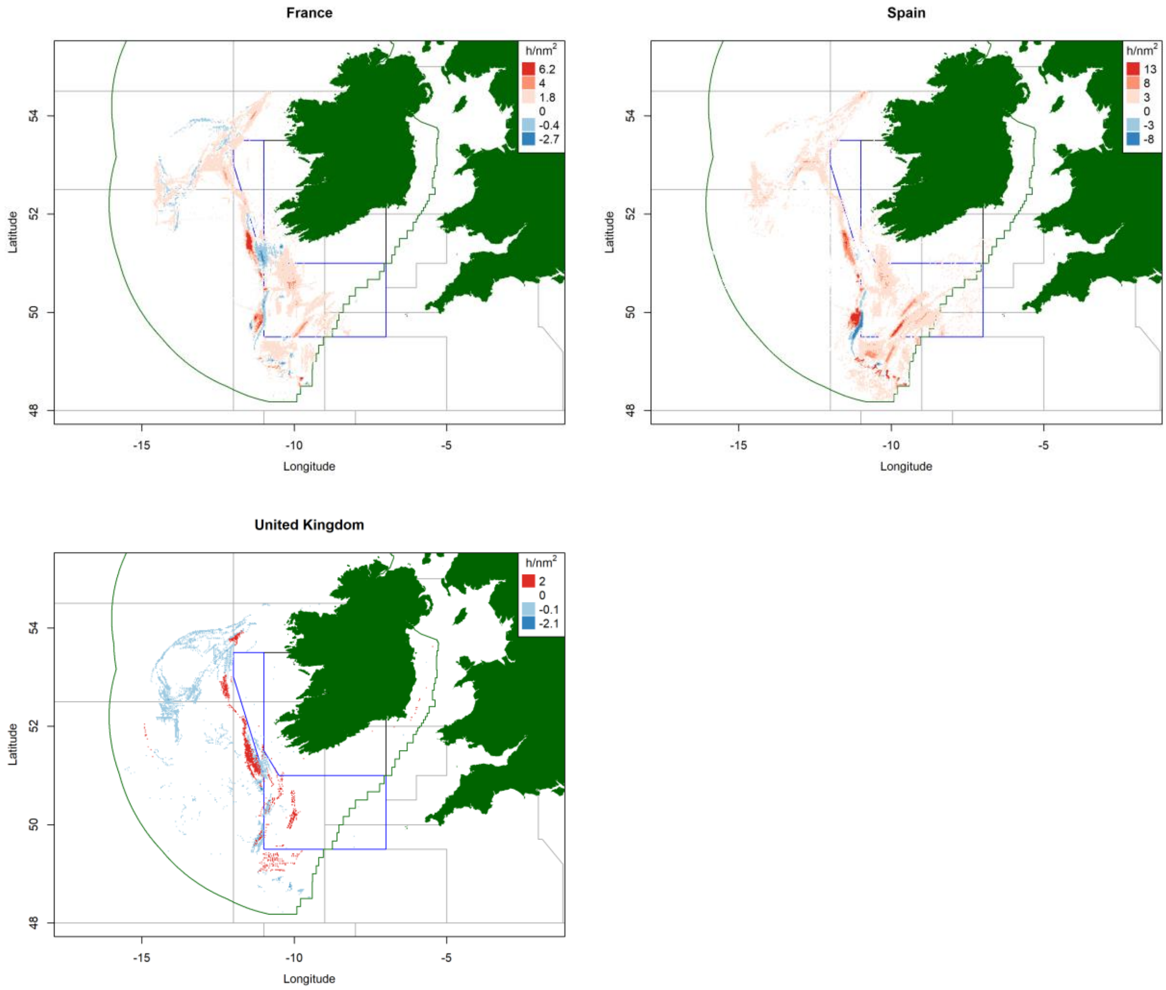

Figure 32: Map of changes in longline VMS fishing effort distribution between 2013 and 2018 for France, Spain, and UK. Data by non-Irish vessels outside the Irish EEZ was not consistently available**.**

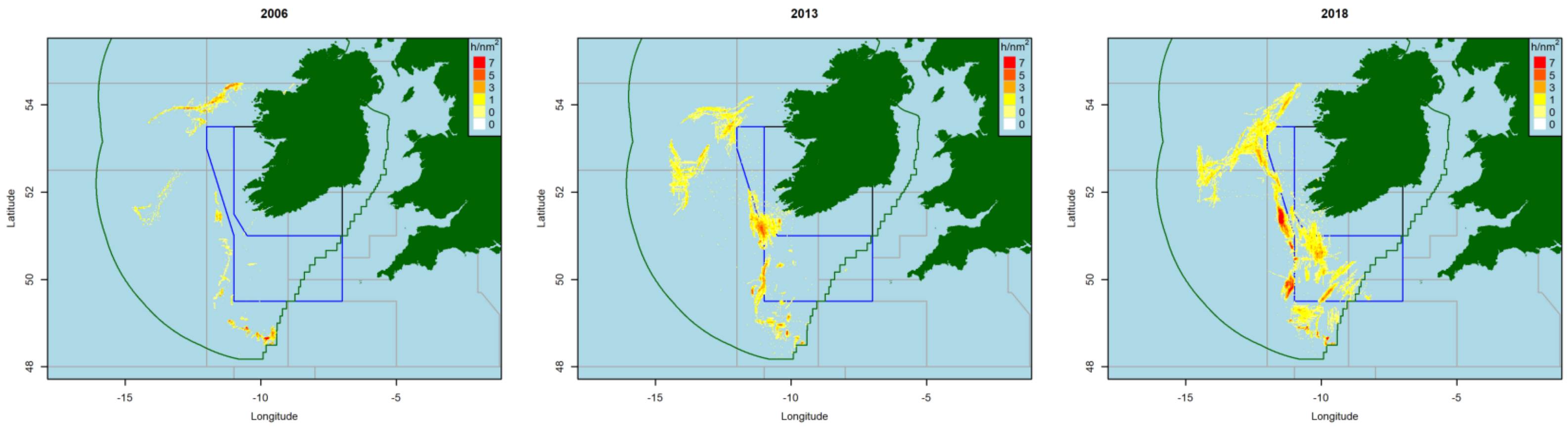

Figure 33: VMS estimated effort for French longline fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

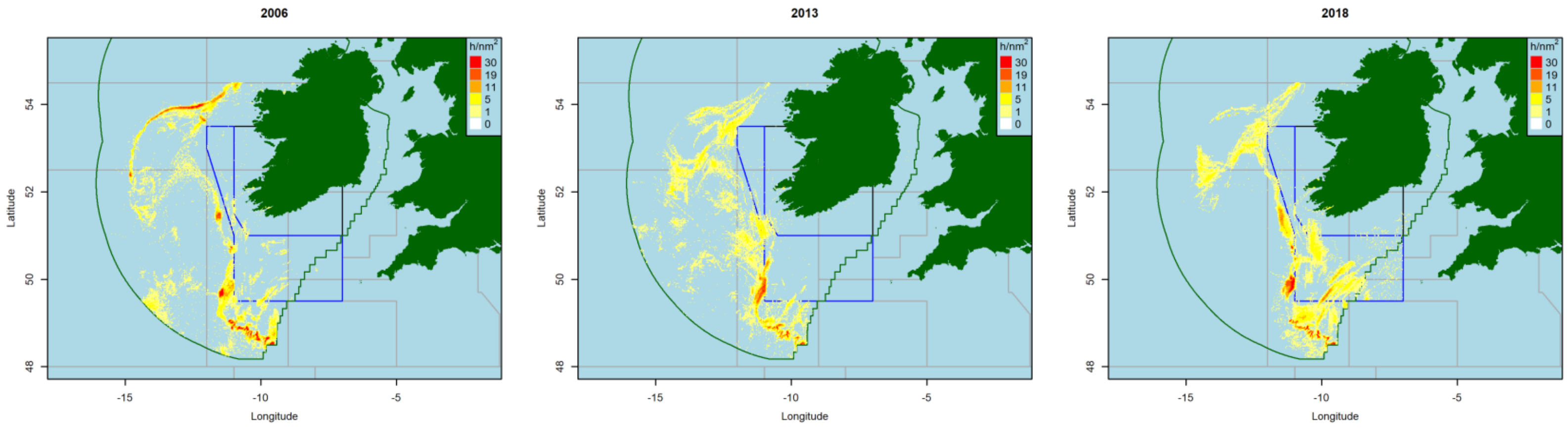

Figure 34: VMS estimated effort for Spanish longline fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

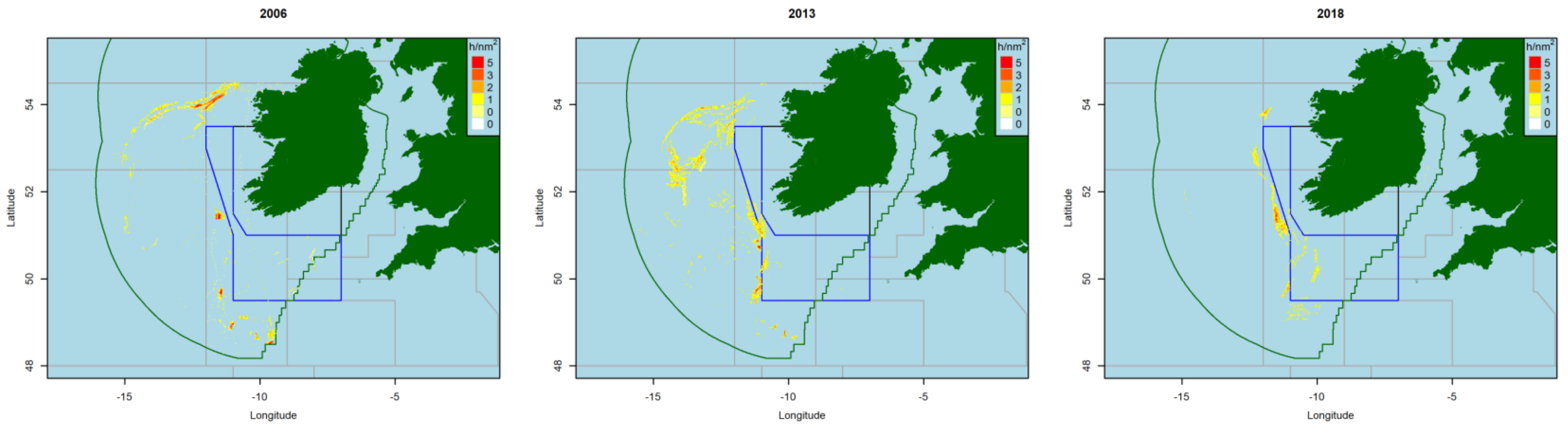

Figure 35: VMS estimated effort for UK longline fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

Pelagic trawl fisheries predominantly occur beyond the BSA boundaries. Ireland directs the majority of effort within the BSA. Pelagic fishing occurs in short bursts following time spent in search of large shoals, this results in small patches of high VMS effort estimations. As such changes in effort within specific locations are inevitable and underrepresent fishing effort. As such, VMS effort should be considered qualitative (Figure 36). This fishery was concentrated on the western side of the BSA (Figure 37). Other nations, namely, France, The Netherlands, UK, Germany and Denmark use pelagic trawls, targeting areas predominantly outside of the BSA (Figure 38 to Figure 42).

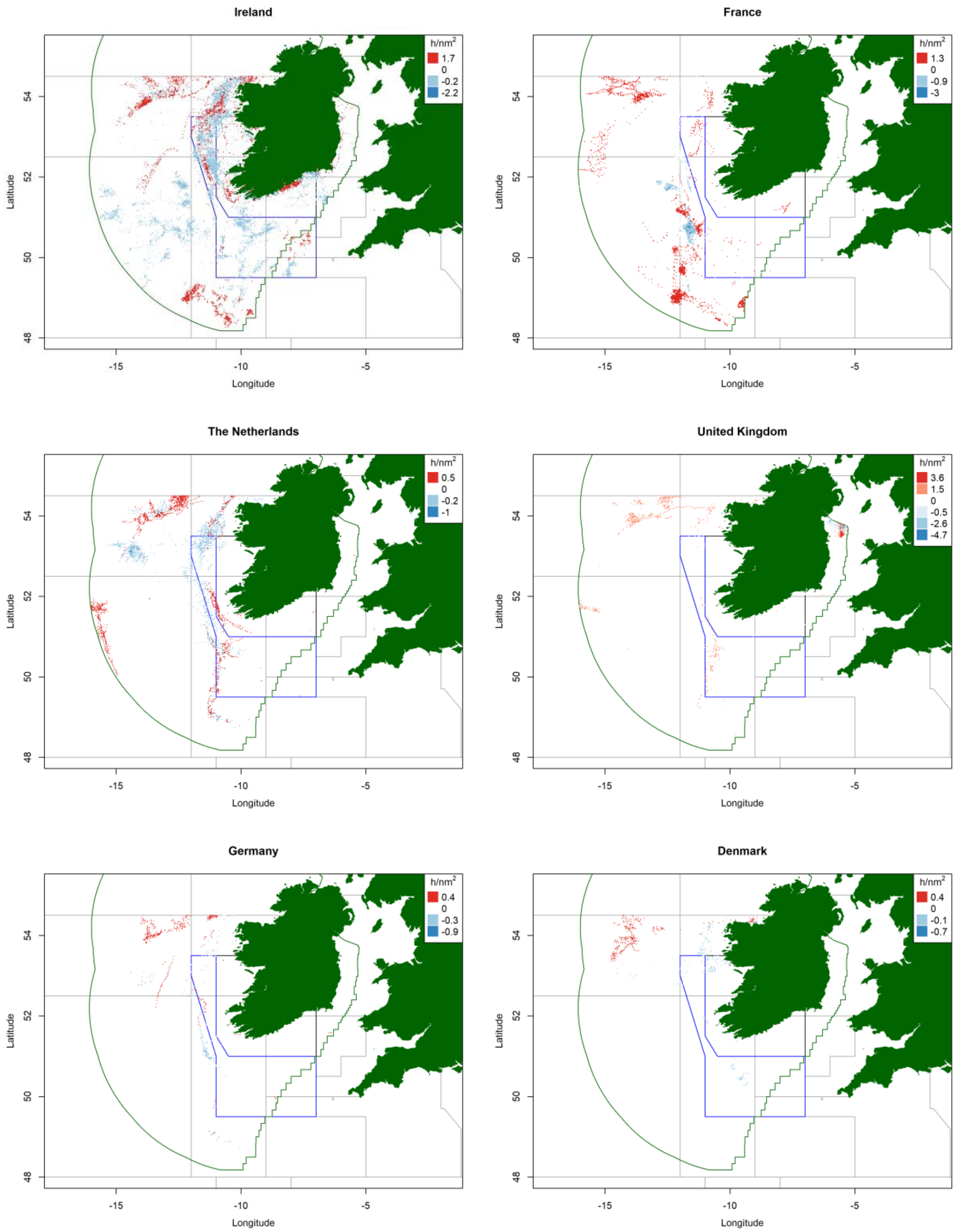

Figure 36: Map of changes in pelagic trawl VMS fishing effort distribution between 2013 and 2018 for Ireland, France, The Netherlands, UK, Germany, and Denmark. Provision of data by non-Irish vessels outside the Irish EEZ was not consistently available**.**

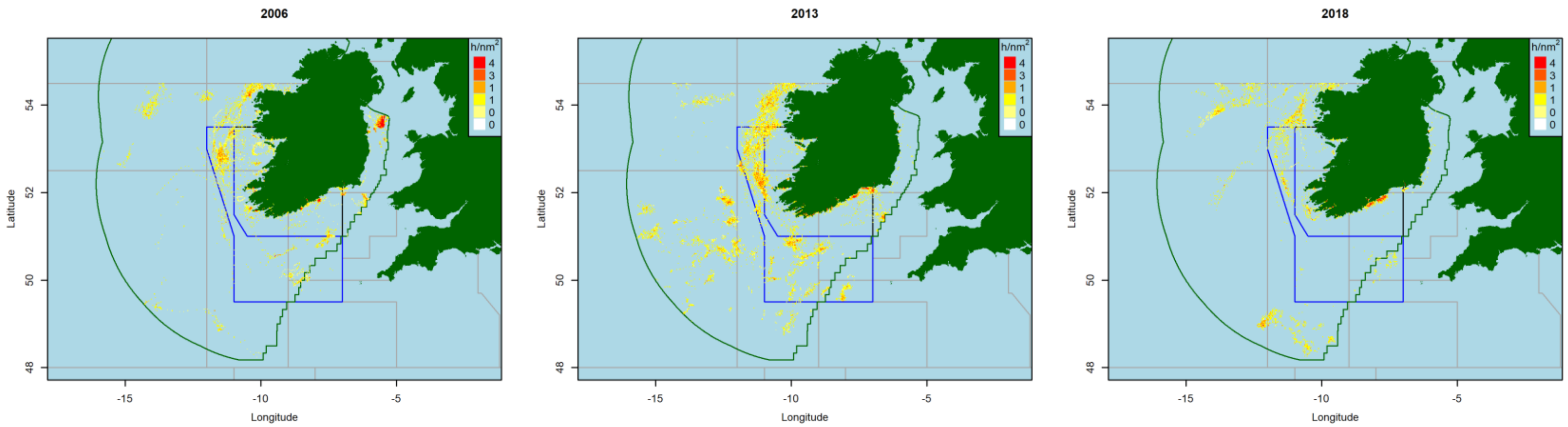

Figure 37: VMS estimated effort for Irish pelagic trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

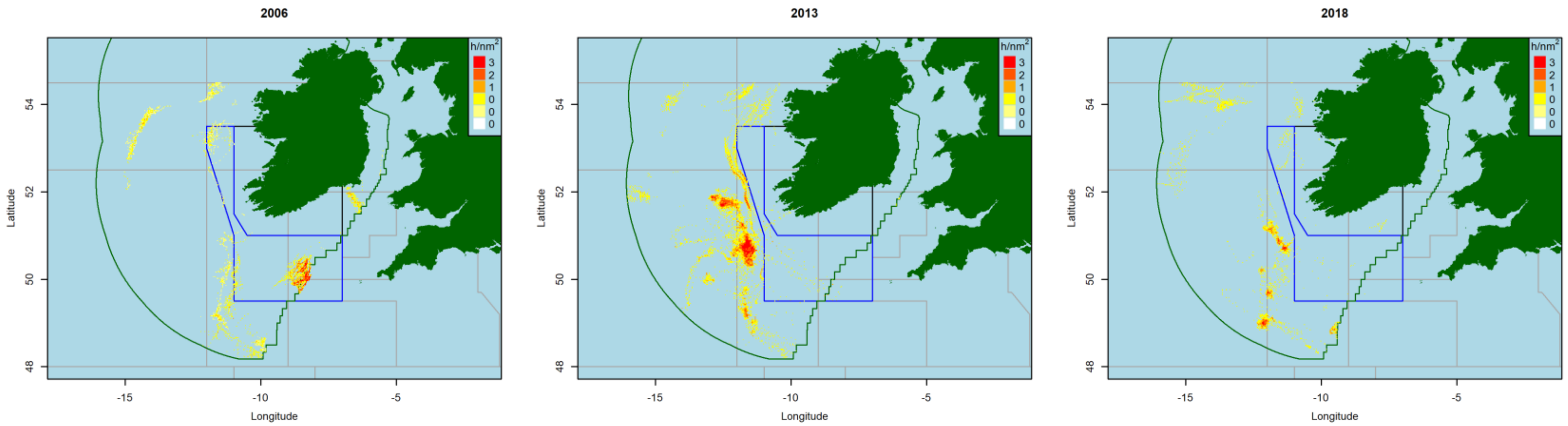

Figure 38: VMS estimated effort for French pelagic trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

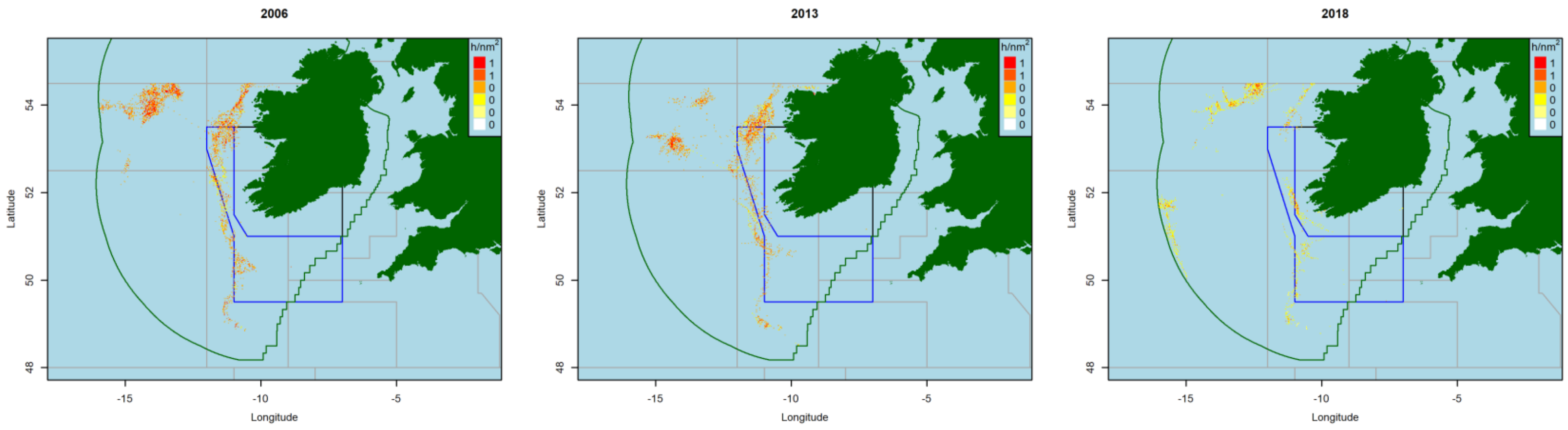

Figure 39: VMS estimated effort for Netherlands pelagic trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available**.**

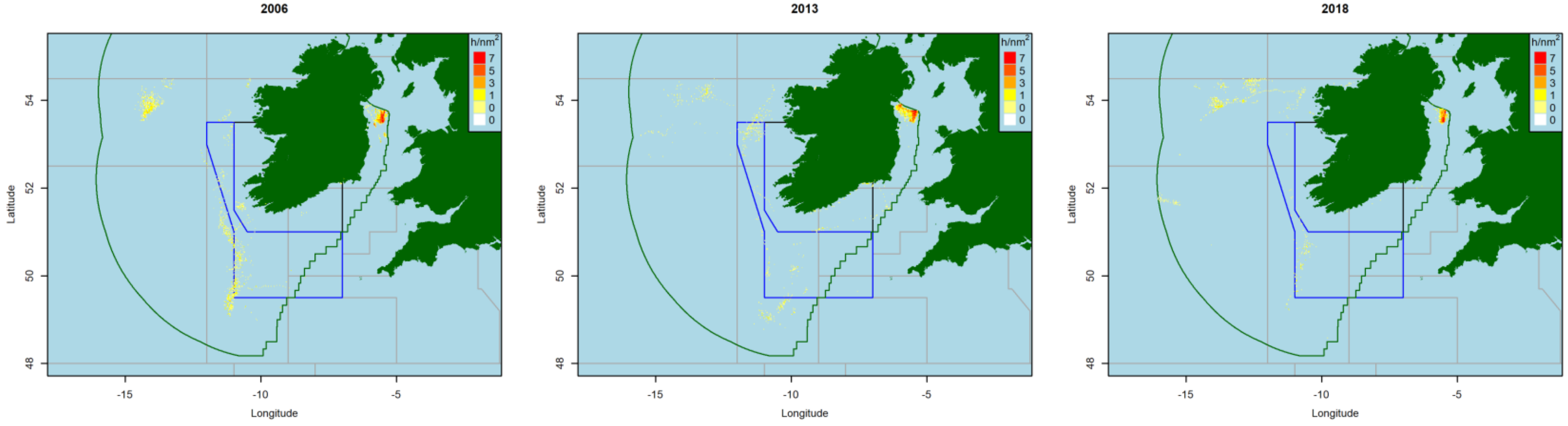

Figure 40: VMS estimated effort for UK pelagic trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available**.**

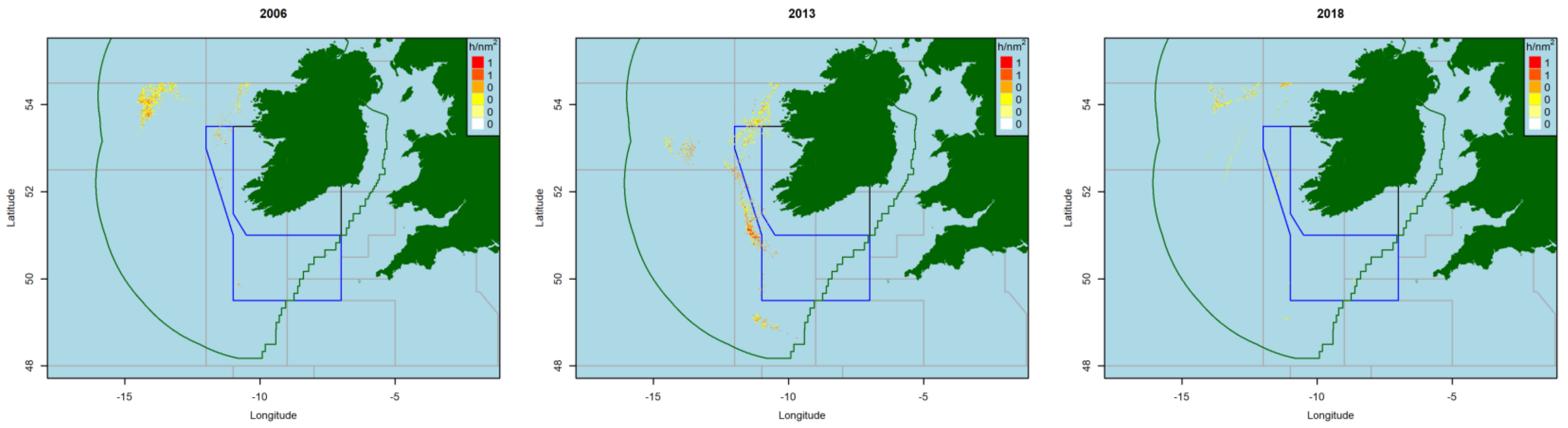

Figure 41: VMS estimated effort for German pelagic trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available**.**

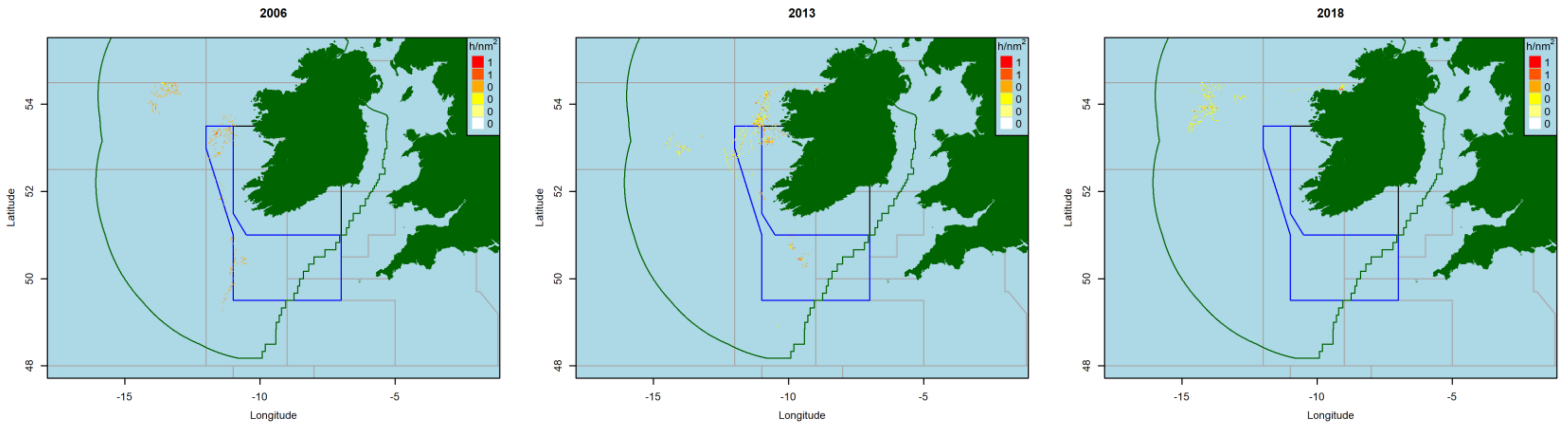

Figure 42: VMS estimated effort for Denmark pelagic trawl fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

Comparatively little demersal seine fishing occurs within ICES Area VII. Of which, Ireland is the main nation using this gear within the BSA. Much of this effort is within 12nm of the Irish coast (Figure 44). France targeted the 12nm area in 2013 (Figure 45), however, since then has moved outside the BSA and resulted in a substantial decrease in effort hours (Figure 43).

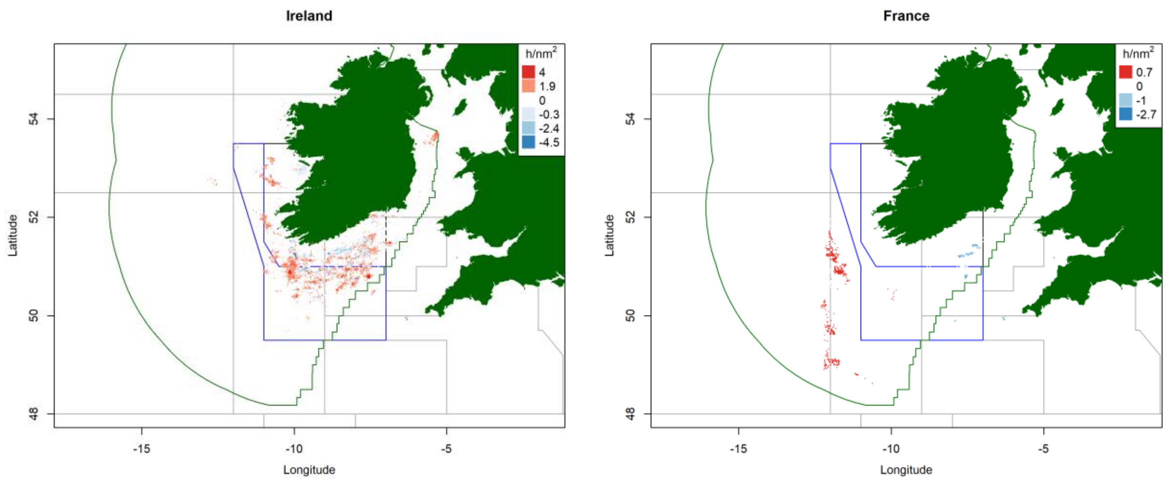

Figure 43: Map of changes in seine net VMS fishing effort distribution between 2013 and 2018 for Ireland, France, Denmark, UK, Spain. Data by non-Irish vessels outside the Irish EEZ was not consistently available**.**

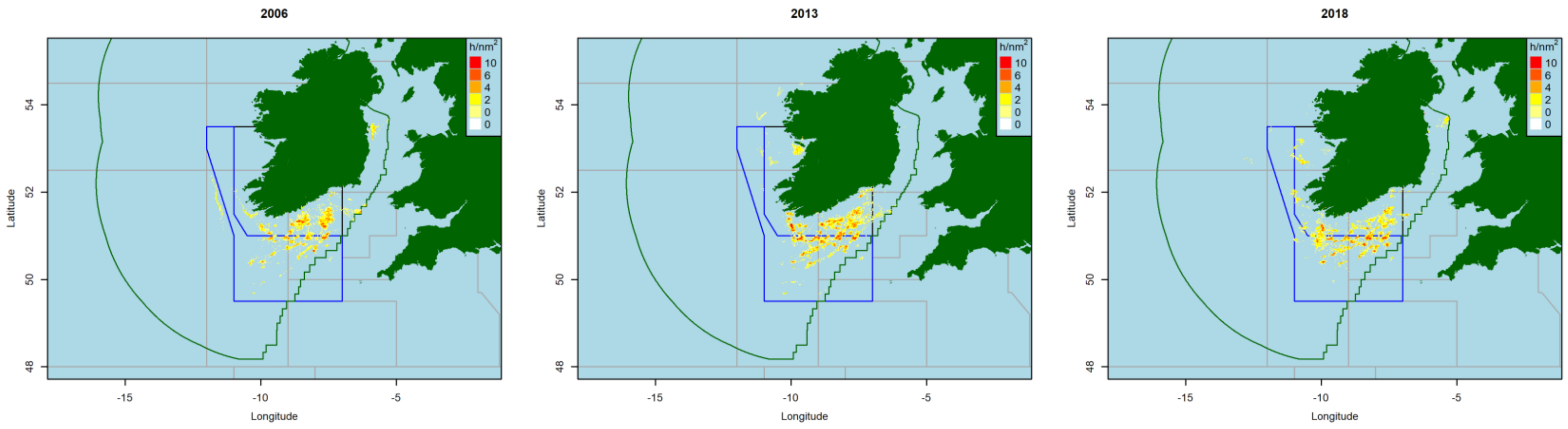

Figure 44: VMS estimated effort for Irish seine net fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

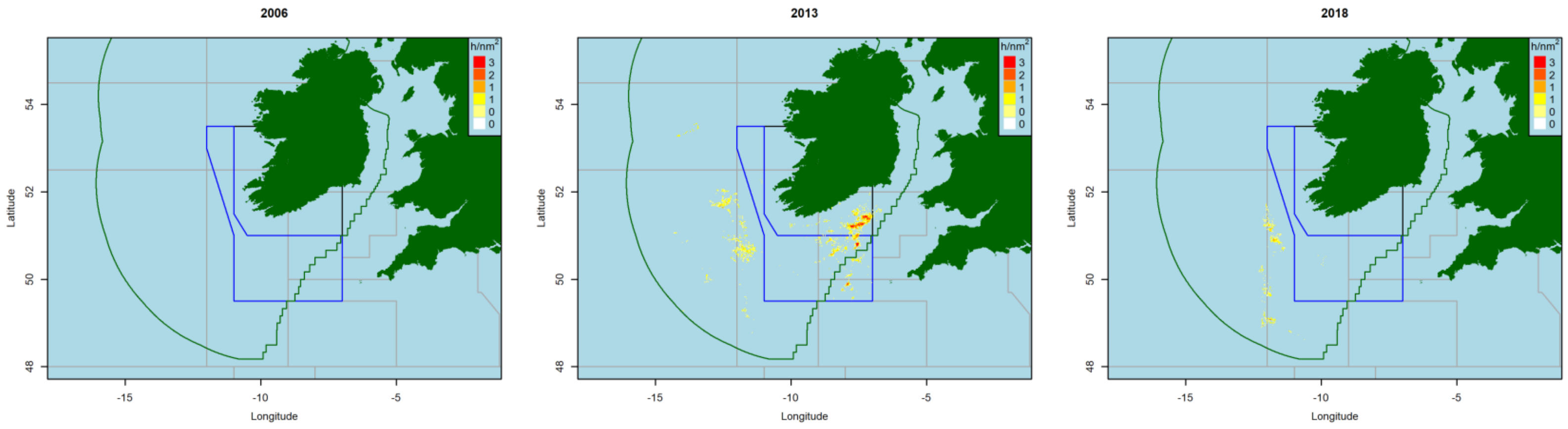

Figure 45: VMS estimated effort for French seine net fishing. Data by non-Irish vessels outside the Irish EEZ was not consistently available.

5.6 Spawning and nursery areas

A wide variety of commercially important and vulnerable fish are noted to utilise the BSA area as a spawning and/ or nursery ground. A summary of published information on these sites is given below (Table 10). Nursery and spawning areas for sole were included in some of the papers reviewed, however, these did not coincide with the BSA and therefore are not included (Coull *et al.*, 1998, Ellis *et al.*, 2012, Aries *et al.,* 2014; Dransfield *et al.,* 2014). Interestingly, agreement did not occur across the literature for species within the BSA. For example, Coull *et al.* (1998) did not identify nursery areas for Norway pout, sandeel or sprat. Nolan *et al.* (2011) also failed to identify sprat nursery areas while Ellis *et al.* (2012) reported no plaice spawning grounds.

Table 10: Summary of species with spawning and/ or nursery areas near or immediately adjacent to the BSA. Grey shaded cells highlight commercially important species which were noted by the Marine Institute (2003) as supporting evidence for the designation of the area, to have spawning or nursery areas within the BSA. Letters refer to compass direction of species in relation to the BSA. * denotes spawning or nursery areas which were marked as having a high density within the BSA, not all studies include areas of high and low density.

Species	Inside BSA			Near BSA border	
	Spawning	Nursery	Egg cases	Spawning	Nursery
Anglerfish (unknown)		✓*[5, 7, 8]			
Anglerfish (white bellied)		✓*[4, 6]		E[6]	
Anglerfish (black bellied)	✓[8]	✓[4, 8]			
Blue skate			✓[9, 10]		
Blue whiting	✓[4]	✓[4, 6]		W[1, 5, 6]	
Cod	✓*[1, 4, 5, 6, 8]	✓*[4, 6, 8]			
Common/ flapper skate		✓[5, 6]	✓[8, 9, 10]		
Greater spotted dogfish			✓[8]		
Haddock	✓[1, 4, 5, 8]	✓*[4, 5, 7, 8]			NE[1]
Hake	✓ *[4, 5, 6, 8]	✓*[4, 5, 6, 7, 8]			
Herring	✓*[1, 2, 4, 5, 8]	✓*[1, 4, 5, 6, 7, 8]			
Horse mackerel	✓*[4, 5, 6, 8]	✓*[4, 5, 6, 7, 8]			
Lemon sole	✓[1, 5, 8]	✓[1, 5]			
Lesser spotted dogfish			✓[8]		
Ling		✓[5, 6]		SE[5, 6, 8]	
Mackerel	✓*[1, 3, 4, 5, 6, 8]	✓*[1, 4, 5, 6, 7, 8]			
Megrim	✓*[4, 8]	✓[4, 5, 8]			
Nephrops	✓[1, 4, 8]	✓[1, 4]			
Norway pout		✓[7]			
Painted/ small eyed ray			✓[8]		
Plaice	✓[1, 5, 8]				
Saithe		✓[1, 5]			
Sandeel		✓[6]		E[6]	
Spotted ray			✓[8]		NE[5, 6]
Sprat	✓[1, 5, 8]	✓[7, 8]			
Spurdog		✓[5, 6]			
Thornback ray			✓[8]		NE[5, 6]
Tope shark					NE[5, 6]
Undulate ray			✓[8, 9, 10]		
White skate			✓[8, 9, 10]		
Whiting	✓[1, 4, 5, 8]	✓*[1, 4, 5, 6, 7, 8]			E[6]

1= Coull *et al*., 1998
2= Fitzpatrick *et al.,* 2005
3= Connolley *et al*., 2009
4= Lordan & Gerritsen 2009
5= Nolan *et al*., 2011
6= Ellis *et al*., 2012
7= Aires *et al*., 2014
8= Dransfield *et al*., 2014
9= Varian 2017
10= Varian *et al*., 2020

The following information uses ICES (2009a) as a basis, combined with additional information from the literature. In addition to juvenile distribution trends from 2003-2019 for a number of the demersal species of interest and egg stage distribution for mackerel, horse mackerel since 2009, and hake in 2016.

Hake occurs from the Bay of Biscay up to the west of Scotland. Hake spawning and nursery grounds were identified as one of the primary reasons for developing the BSA. The spawning ground is believed to primarily follow the 200m depth contour up from the Bay of Biscay area, spreading over some of the Celtic Sea shelf area into the BSA (Figure 46). The majority of the spawning area would fall outside of the BSA. Eggs collected during the MEGs survey are not analysed and reported on a regular basis, although in 2016 these were reported to ICES (Figure 47). The first stage eggs can be seen following the shelf edge with some occurring on the shelf within the BSA area as expected. Nursery grounds occur to the south and west of Ireland, with an additional area of lesser importance to the west of Scotland. ICES IBTS surveys, since ICES (2009a), examining distributions indicate this remains the case. One thing more recent survey data appears to suggest is that the importance of the western coastal zone varies, while the zone to the south is more consistent (Figure 48). In years with high numbers of juveniles, such as 2012, numbers are greater in more coastal areas, including the area between the two zones.

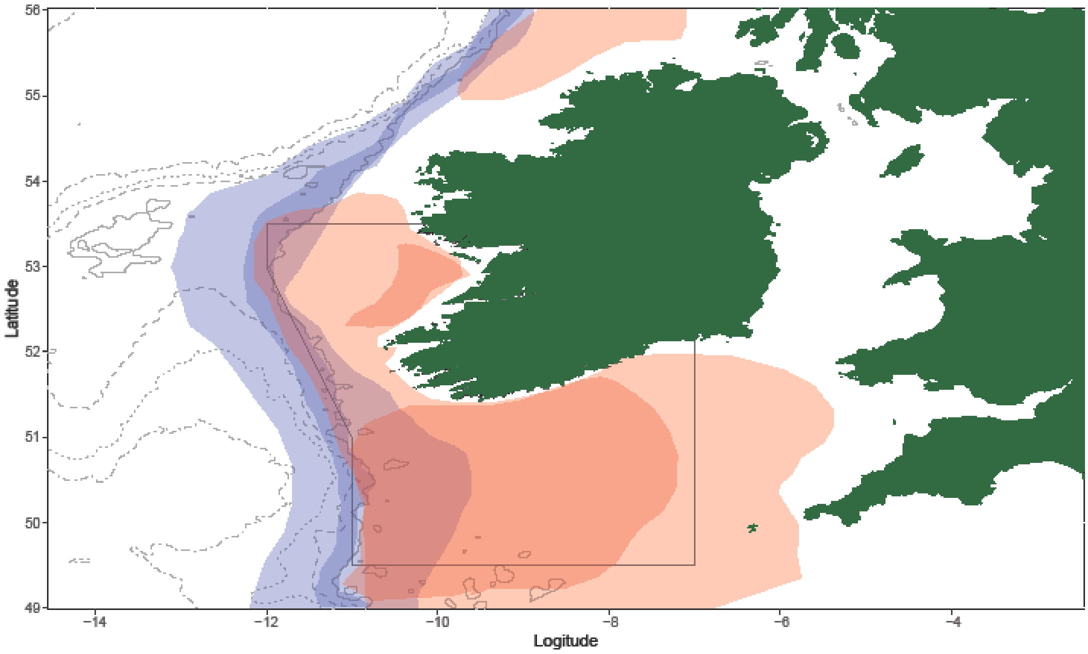

Figure 46: The location of hake spawning (blue) and nursery (red) grounds around the Irish coast (the darker shading indicates main areas). Areas from ICES (2009a).

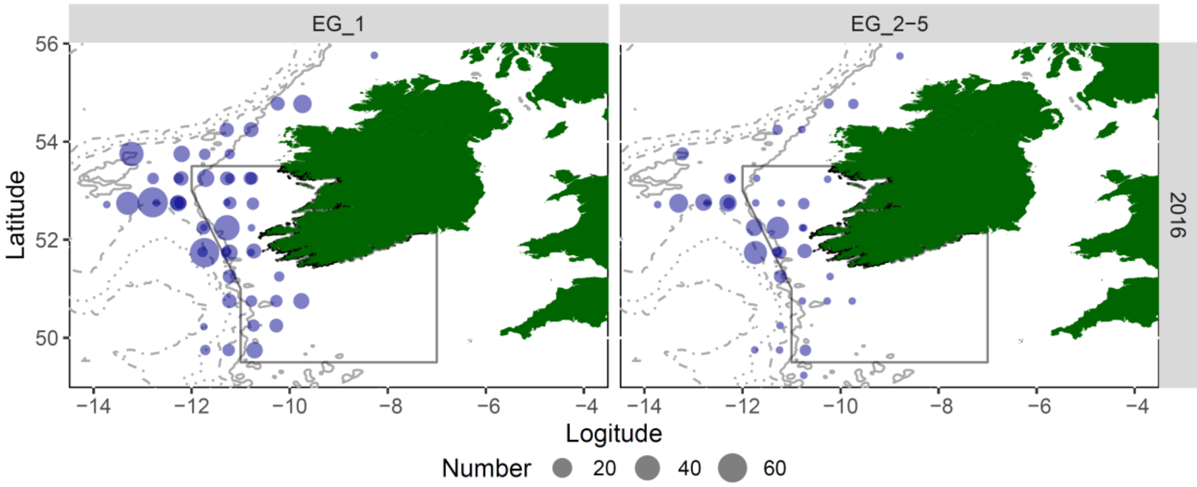

Figure 47: Hake egg distribution from open source ICES MEGS survey data in 2016 by egg development stage, where stage 1 are new fertilised eggs as detailed in the MEGS survey manual for sampling at sea (ICES, 2014).

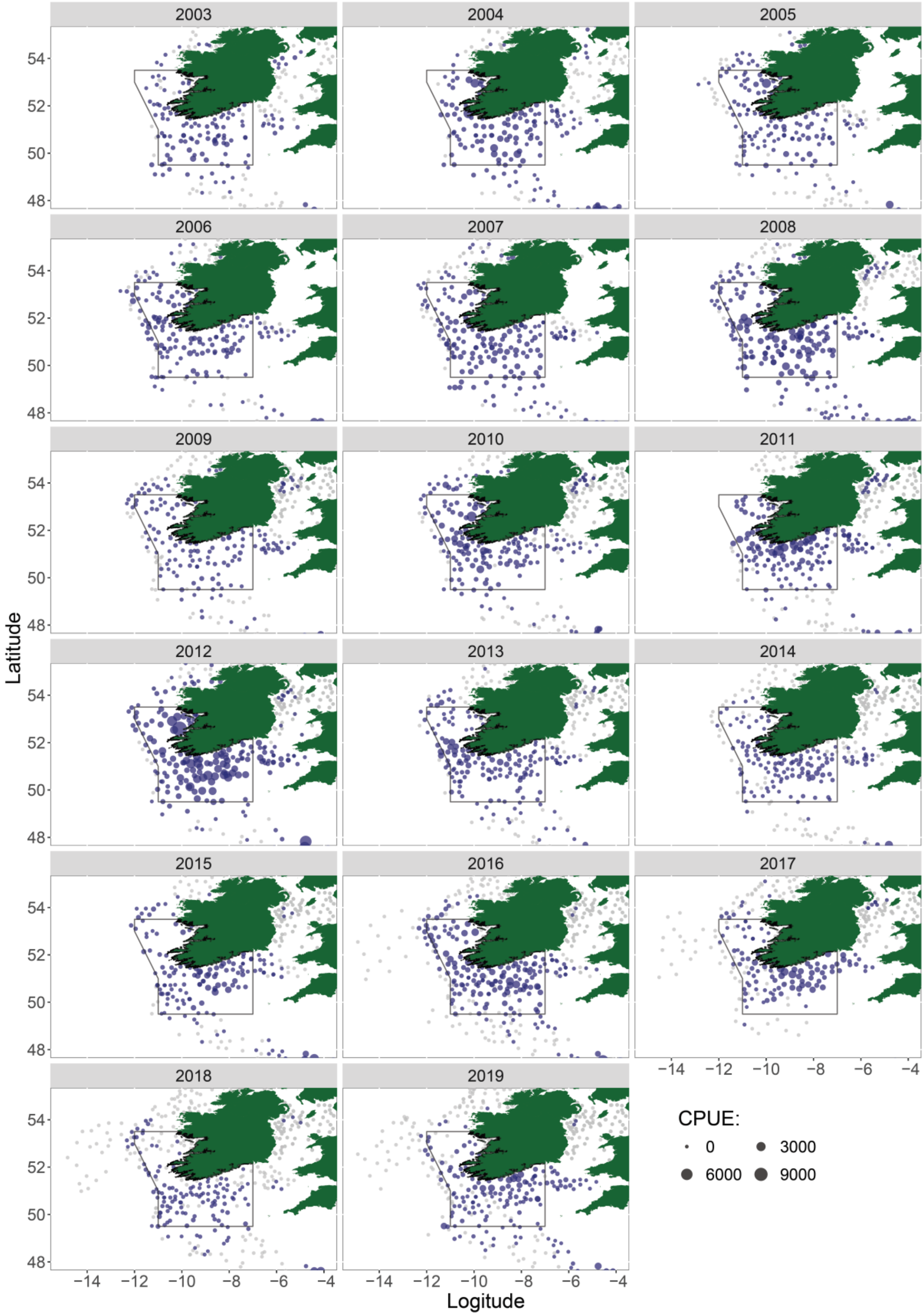

Figure 48: Annual juvenile hake (<20cm length; Ellis *et al.*, 2012) distribution from open source ICES IBTS survey data, 2003-2019.

Megrim spawning is believed to be focused on the continental shelf (<200m) to the west and south of Ireland, although grounds appear to extend near the shelf edge to the north and out as far as the 500m contour to the west of Ireland (Figure 49). As ICES (2009a) highlight, the ICES bottom trawl survey has low catchability of small megrim (those below 11cm). This size is in line with juvenile lengths of other flatfish species (Ellis *et al.,* 2012). There are two species of megrim which occur in the area, *Lepidorhombus whiffiagonis* (megrim) and *Lepidorhombus boscii* (four spot megrim), the former is more prevalent. The distribution of megrim less than 11cm caught by the IBTS are given in Figure 50. Distribution is in line with that of the areas previously described by ICES (2009a), although in most recent years there has been a greater presence along the 200m contour, and just beyond the BSA western border. Very few small four spot megrim were caught, of those caught they were along the 200m contour (not presented).

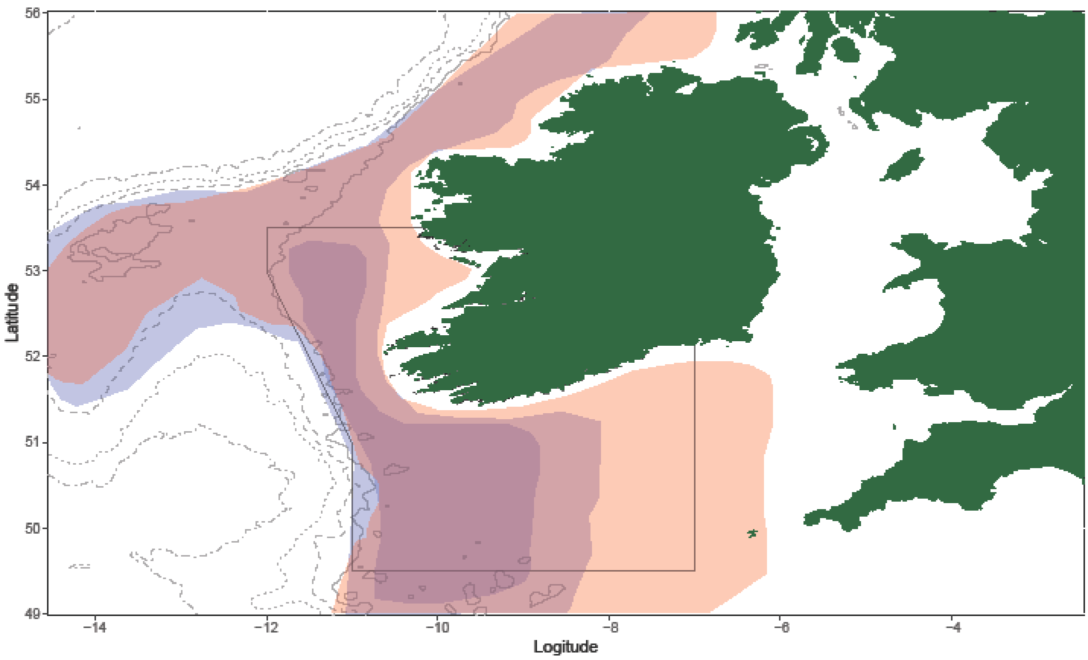

Figure 49: The location of megrim spawning (blue) and nursery (red) grounds around the Irish coast (the darker shades indicate main areas). Areas from ICES (2009a).

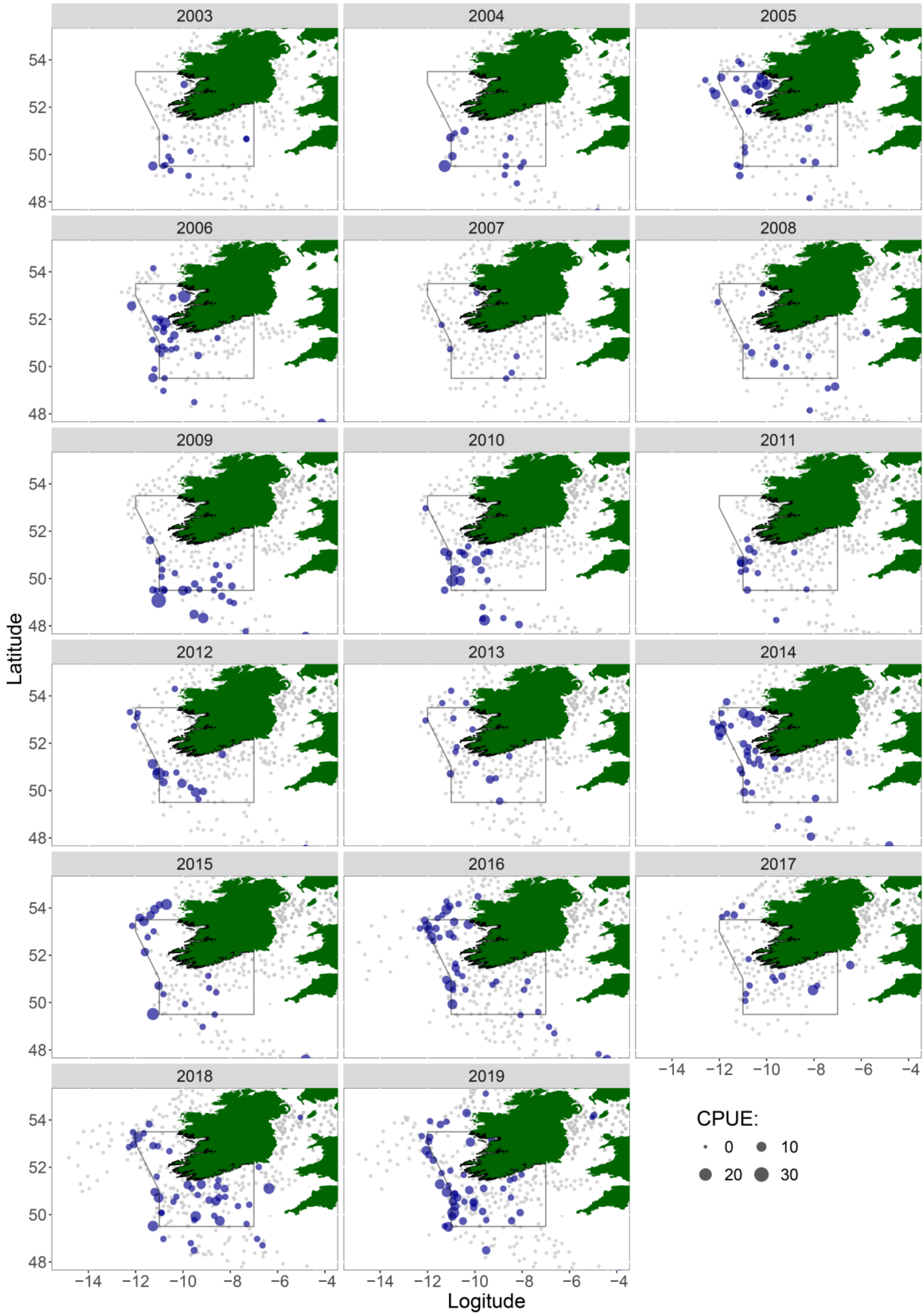

Figure 50: Annual juvenile megrim (*Lepidorhombus whiffiagonis*; <11cm length) distribution from open source ICES IBTS survey data, 2003-2019.

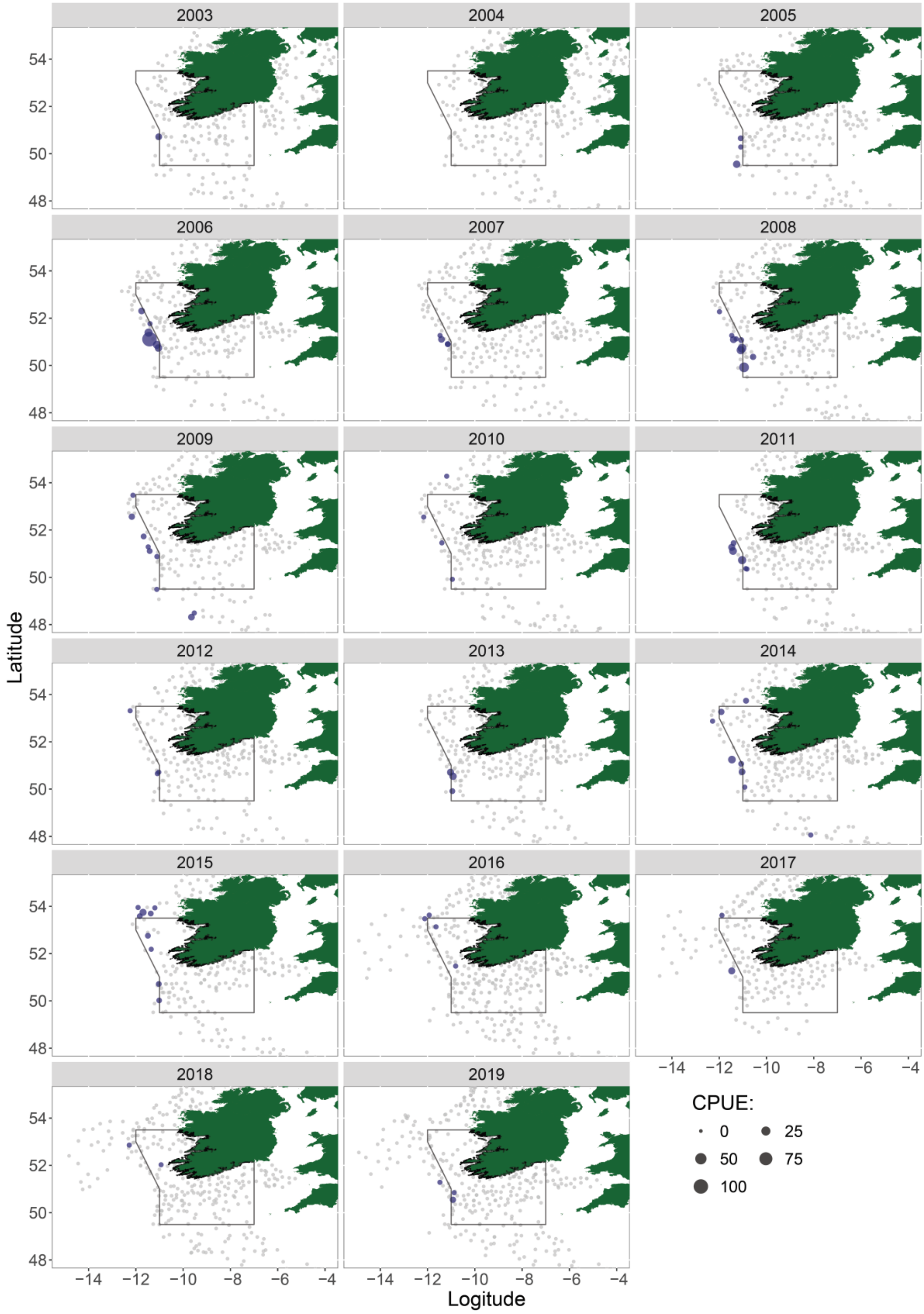

Figure 51: Annual juvenile four spot megrim (*Lepidorhombus boscii*; <10cm length) distribution from open source ICES IBTS survey data, 2003-2019.

There are two anglerfish/monkfish species present in VII, the white-bellied (*Lophius piscatorius*) and black-bellied (*Lophius budegassa*) anglerfish. The white-bellied variety is more common in the waters around Ireland, although the black-bellied anglerfish can account for up to 30% of anglerfish landings (Lordan, unpublished data). The spawning locations are not known for either species. It is therefore not known whether spawning takes place within the BSA. However, as ICES (2009a) highlight, studies in other areas indicate spawning could occur in deeper water (Landa, *et al.*, 2008).

In contrast to spawning areas, more is known about nursery areas for this species, and the BSA covers much of their distributions around Ireland (Figure 52). White-bellied anglerfish within IBTS survey data were observed up to the waters off of County Mayo (Figure 53) but with greater numbers along the southern coast to out to the continental shelf edge. Black-bellied anglerfish appear to have a hot spot off the south west coast of Ireland and the continental shelf edge (

Figure 54: Annual juvenile black-bellied anglerfish (Lophius budegassa; <17cm length; Aires et al., 2012) distribution from open source ICES IBTS survey data, 2003-2019.

). This species is believed to have a more southerly juvenile distribution, which is not hugely evident in IBTS data.

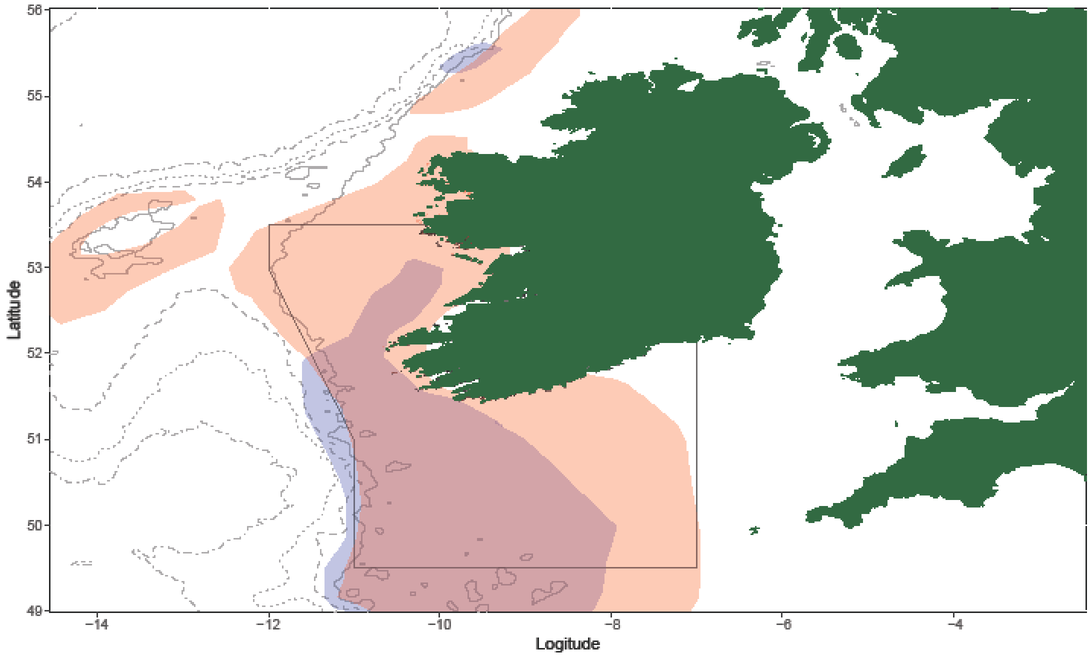

Figure 52: The location of black bellied nursery (*Lophius budegassa;* blue) and white bellied nursery (*Lophius piscatorius;* red) grounds around the Irish coast. Areas from ICES (2009a).

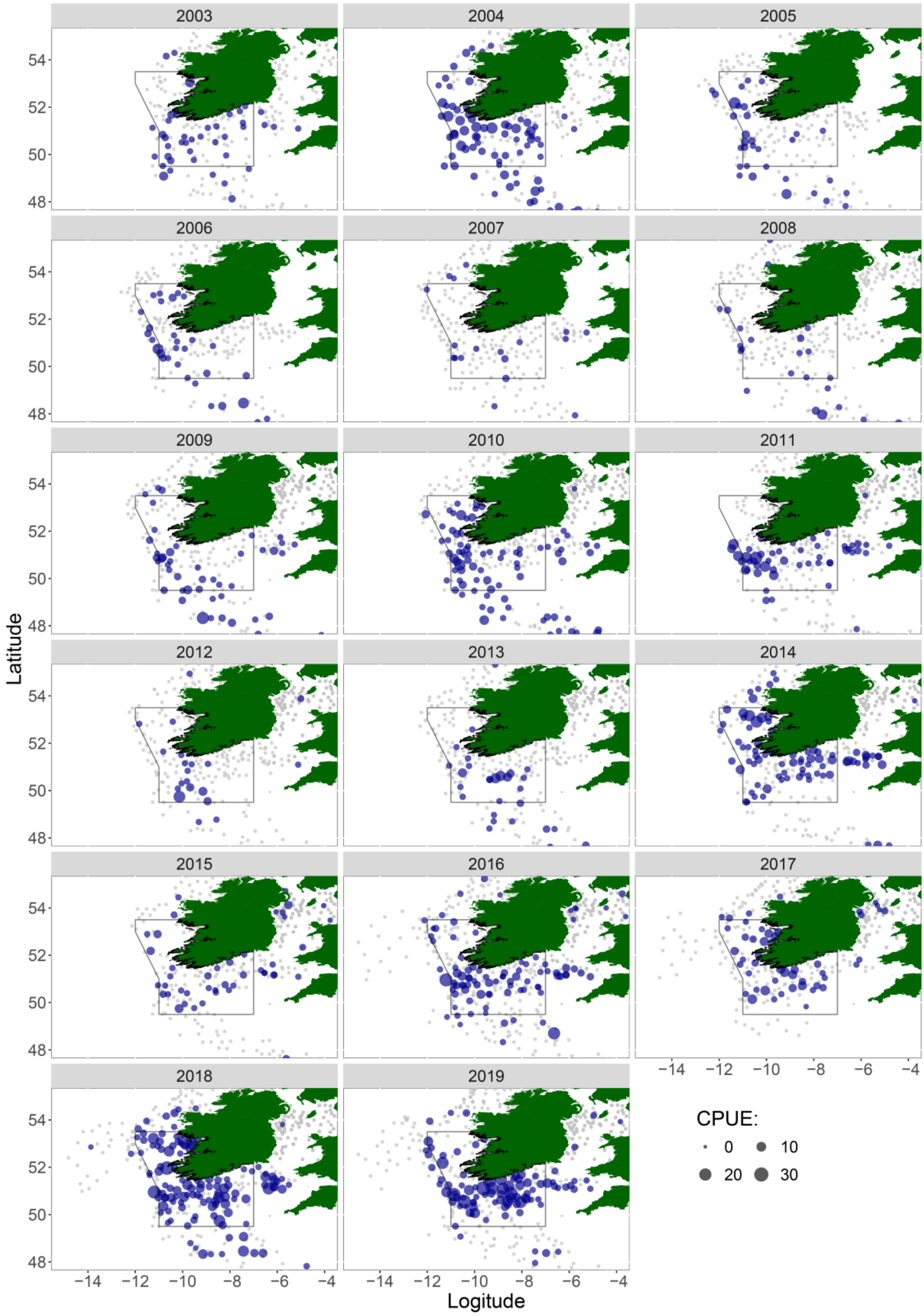

Figure 53: Annual juvenile white-bellied anglerfish (*Lophius piscatorius*; <17cm length; Aires *et al*., 2012) distribution from open source ICES IBTS survey data, 2003-2019.

Figure 54: Annual juvenile black-bellied anglerfish (Lophius budegassa; <17cm length; Aires et al., 2012) distribution from open source ICES IBTS survey data, 2003-2019.

There are a number of whiting spawning and nursery areas around Ireland (Figure 55). Many of the areas are beyond the boundary of the BSA, particularly within the Irish Sea and further east of the BSA. Within the BSA, these are limited to more coastal areas. Ellis *et al.* (2012) found no whiting spawning within the BSA. As highlighted by ICES (2009a), the Irish Sea continues to have the greatest numbers of juvenile fish (Figure 56). The importance of Galway Bay, inside the BSA, as a nursery area may have decreased, although the number of samples taken from this area can vary.

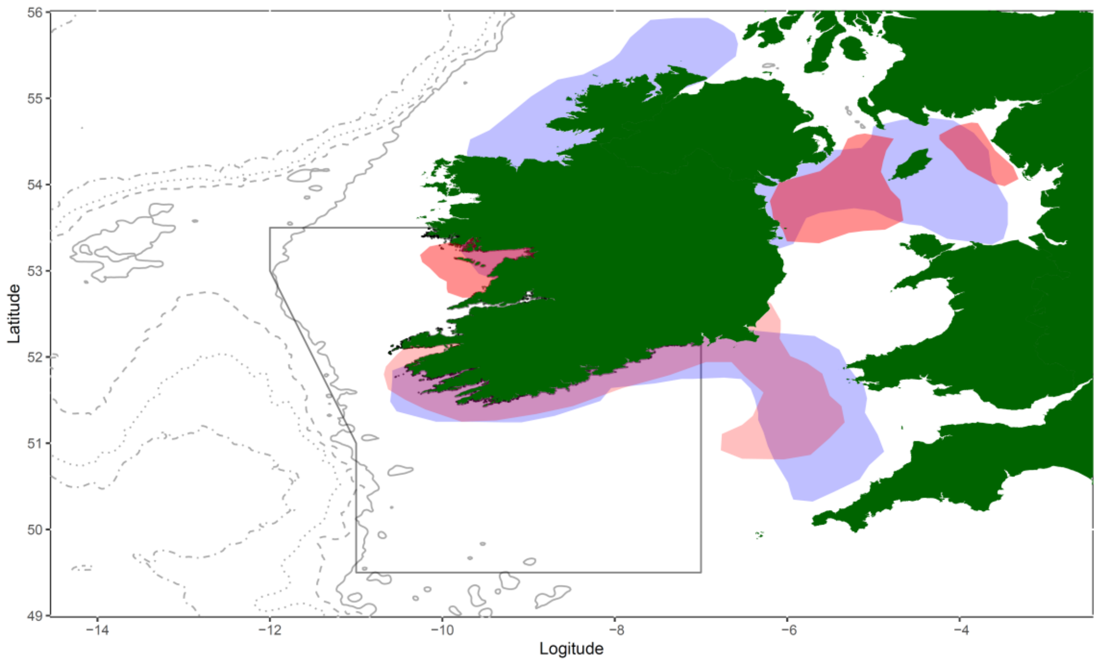

Figure 55: The location of whiting spawning (blue) and nursery (red) grounds around the Irish coast (the darker shade indicates main areas). Areas from ICES (2009a).

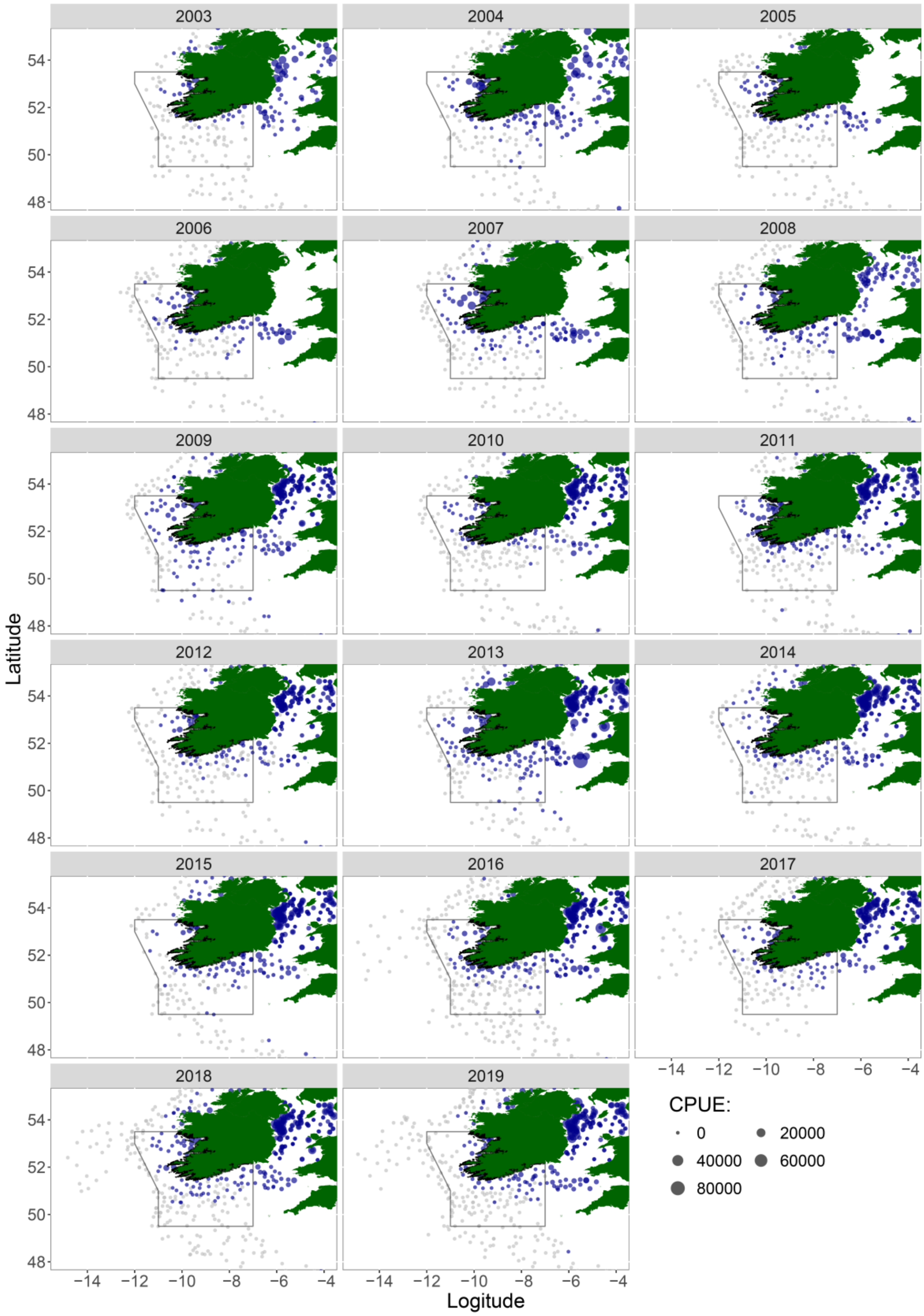

Figure 56: Annual juvenile whiting (<21cm length; Aires *et al*., 2012; Ellis *et al*., 2012) distribution from open source ICES IBTS survey data, 2003-2019.

Nephrops occur in distinct patches based on substrate with little movement between patches. As such adults and juveniles are mixed together on the same grounds. There are three main grounds within the BSA (Figure 57; taken from ICES (2009a) managed as three functional units (FU17, FU19 and FU20-21).

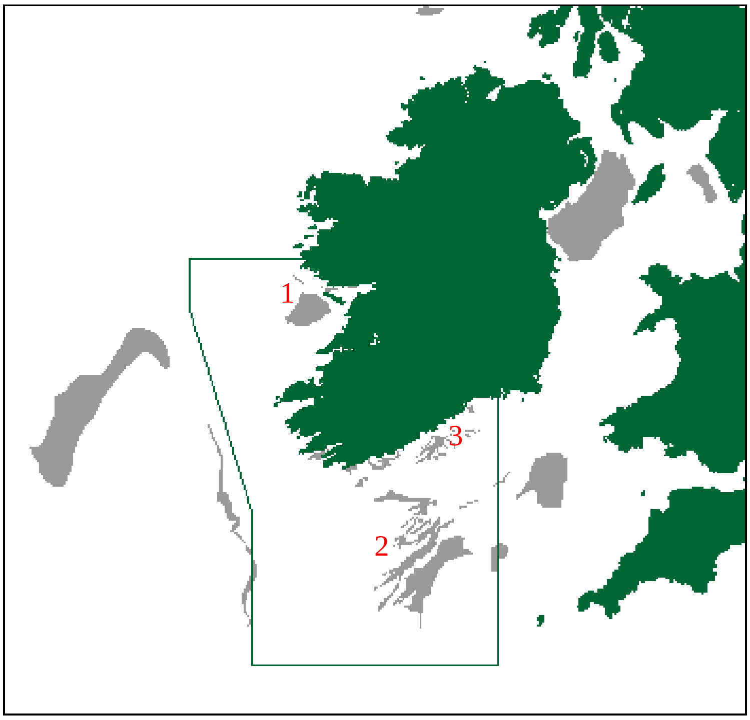

Figure 57: *Nephrops* spawning and nursery areas around Ireland. The BSA is shown with dark green lines. 1) Aran Grounds; 2) East and West Labadie, Jones and Cockburn Banks; 3) Cork coast. Figure taken from ICES (2009a).

Haddock show several spawning and nursery grounds around Ireland (Figure 58). Within the BSA these are more coastal. Interestingly, Coull *et al.*, (1998) and one of the representations by Nolan *et al.*, (2011) do not include haddock nursery areas within the BSA. It appears locations can vary with the strength of a year class. In years of greater juvenile numbers, the BSA area can become more important. Whilst in low strength years there appears to be more stability in depicting the Irish Sea as a primary nursery area (Figure 59).

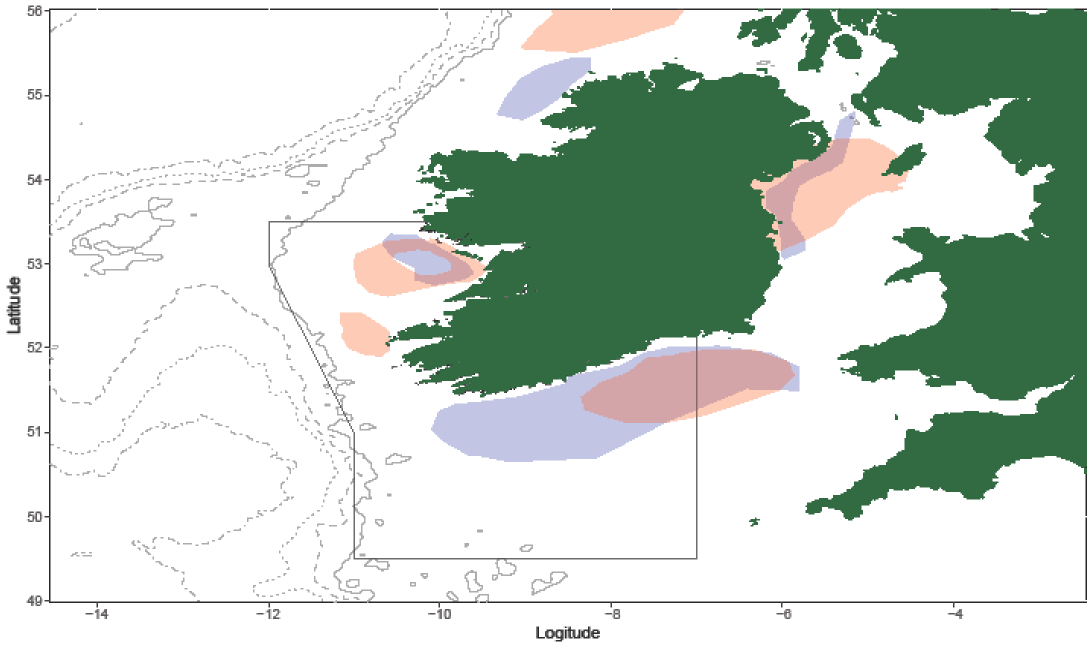

Figure 58: The location of haddock spawning (blue) and nursery (red) grounds around the Irish coast. Areas from ICES (2009a).

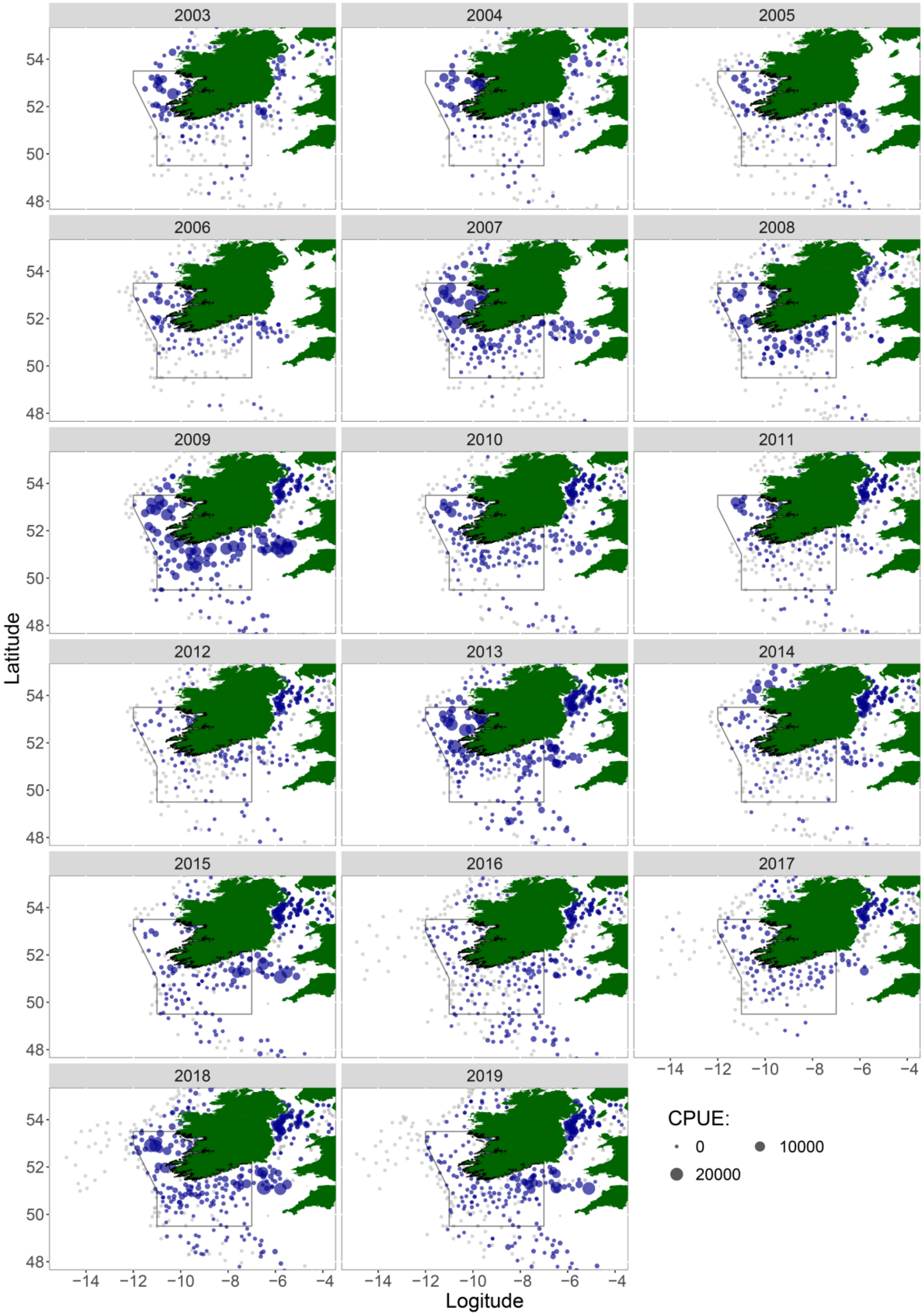

Figure 59: Annual juvenile haddock (<22cm length; Aires *et al*., 2012) distribution from open source ICES IBTS survey data, 2003-2019.

Cod spawning occurs primarily beyond the boundaries of the BSA (Figure 60). It is believed in the past cod also spawned on the west coast not evident in the information used by ICES (2009a) to map spawning and nursery areas. Findings by Coull *et al.,* (1998), Nolan *et al.*, (2011) and Aires *et al.*, (2014) did not highlight the BSA as continuing cod nursery grounds. Whilst ICES (2009a) report young fish surveys carried out by the Marine Institute have yielded relatively high catches of juveniles in several areas along the Irish southern coast. The limitation of juveniles to inshore locations is supported by the lack of individuals within the IBTS (Figure 61). Since 2009 the IBTS has been identifying more juveniles within the Irish Sea, although noting in several of the earlier years presented the Irish Sea was not surveyed.

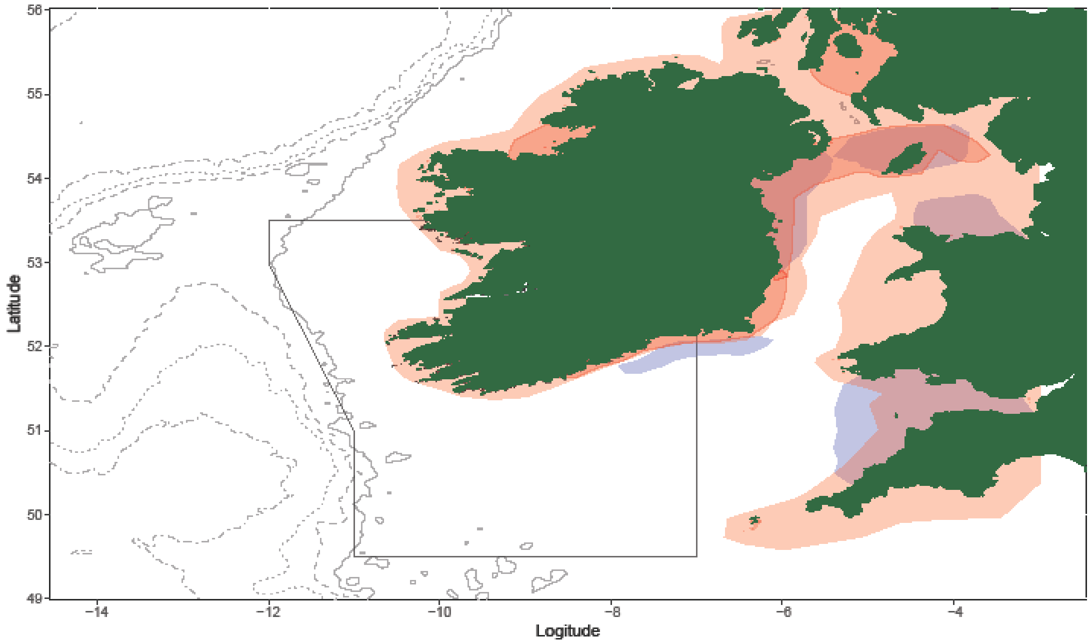

Figure 60. The location of cod spawning (blue) and nursery (red) grounds around the Irish coast (the darker shades indicate main areas). Areas from ICES (2009a).

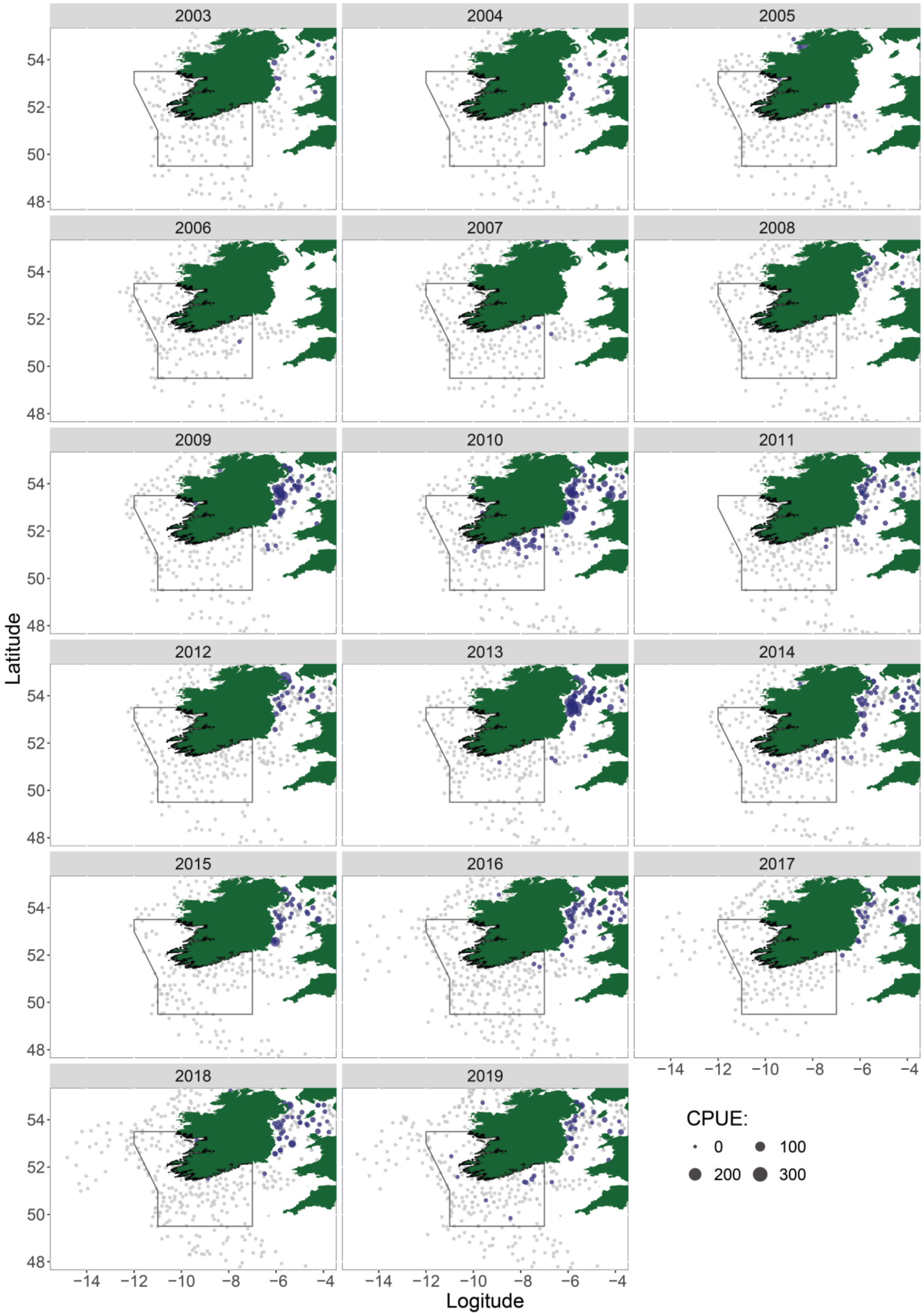

Figure 61: Annual juvenile cod (<31cm length; Aires *et al*., 2012) distribution from open source ICES IBTS survey data, 2003-2019.

Mackerel as a widely distributed stock unsurprisingly have wide spawning and nursery areas in the waters sounding Ireland (Figure 62). The main spawning area is along the continental shelf edge around the 200-1000m depths to the west of Ireland. There is an additional area identified by ICES to the south of Ireland within the BSA. For the most part egg distributions from 2010 to 2016 tri-annual MEGS survey follow the same pattern (Figure 63). Mackerel egg distribution in 2010 follows a similar pattern to Figure 62, however in 2013 and 2016, the egg distribution appears more restricted with the second shallower spawning area less obvious. Juvenile mackerel show a preference for the shallower coastal continental shelf waters, some of which occur within the BSA. However, it is unlikely that this species is impacted by the BSA effort restrictions as mackerel are generally targeted with pelagic gears which are not included in the effort limitations.

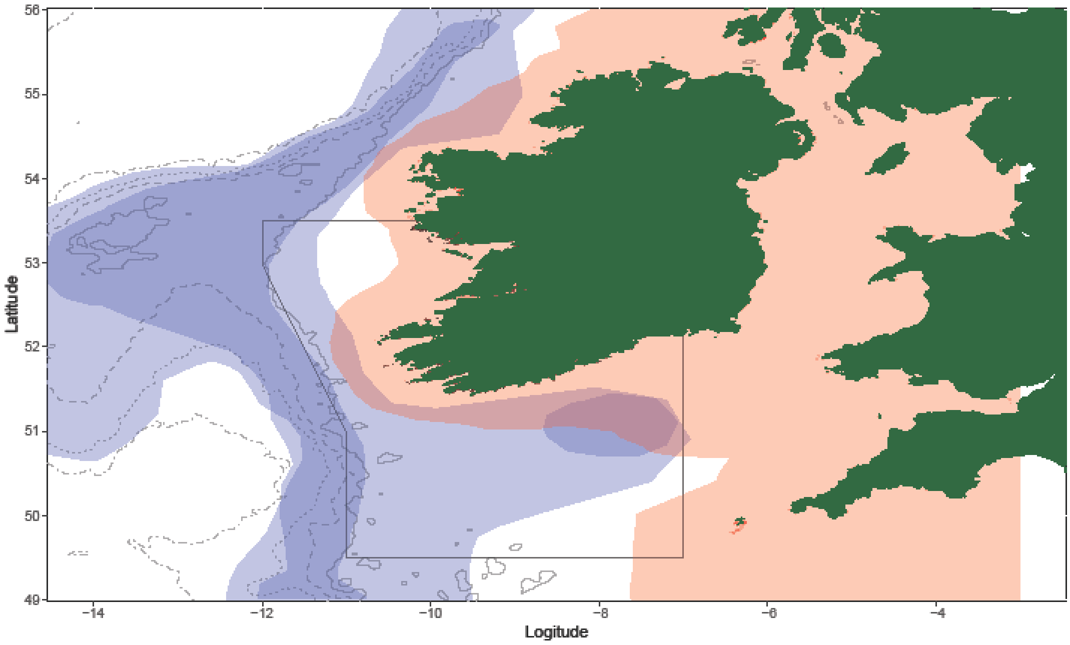

Figure 62: The location of mackerel spawning (blue) and nursery (red) grounds around the Irish coast (the darker shade indicates the most important area). Areas from ICES (2009a). BSA boundary depicted by black outline and depth contours are depicted as grey lines: 200m solid, 500m dashed, 1000m dotted, 2000m dot-dashed.

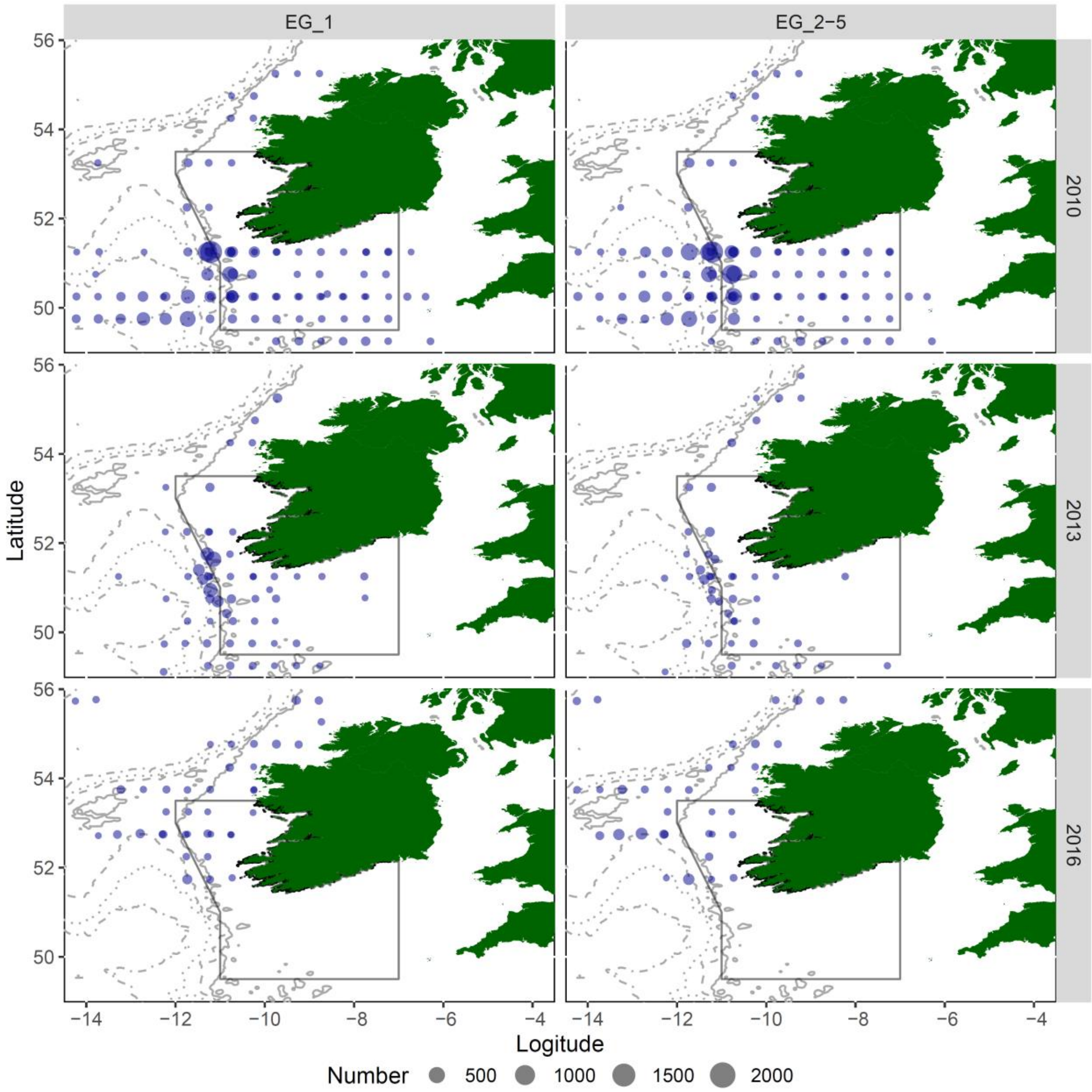

Figure 63: Mackerel egg distribution from open source ICES MEGS survey data in 2010, 2013 and 2016 by egg development stage, where stage 1 are new fertilised eggs as detailed in the MEGS survey manual for sampling at sea (ICES, 2014).

Horse mackerel is again a widely distributed stock, and like mackerel show a similar preference for spawning along the shelf edge, although this does not extend as far north as for mackerel (Figure 64). Interestingly, egg distribution from the subsequent MEGs surveys show a reduction in egg distribution in the 2013 and 2016 surveys is focused toward the more gradual 200-500m slope zone around 53 degrees latitude (roughly in line with Galway Bay; Figure 65). The nursery grounds are more widely spread across the whole continental shelf area, and possibly into deeper waters. There are two main nursery areas highlighted by ICES (2009a), a portion of the southern area may occur inside the BSA. As with mackerel, these species are unlikely to be impacted by the BSA effort limitations which do not include pelagic gears.

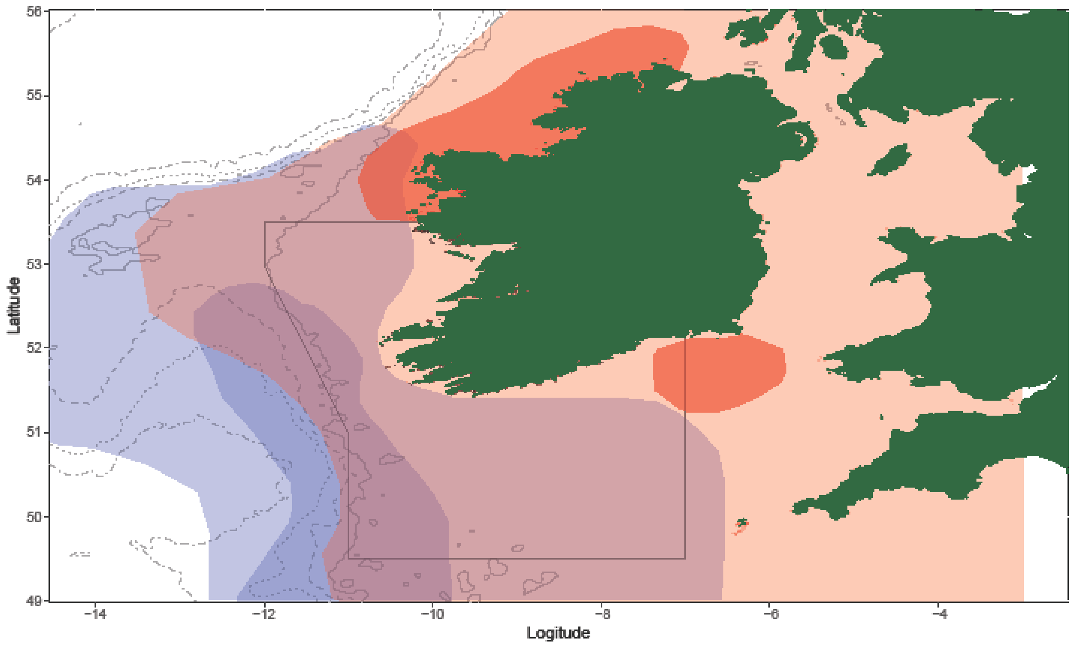

Figure 64: The location of horse mackerel spawning (blue) and nursery (red) grounds around the Irish coast (the darker shade indicates the most important area). Areas from ICES (2009a).

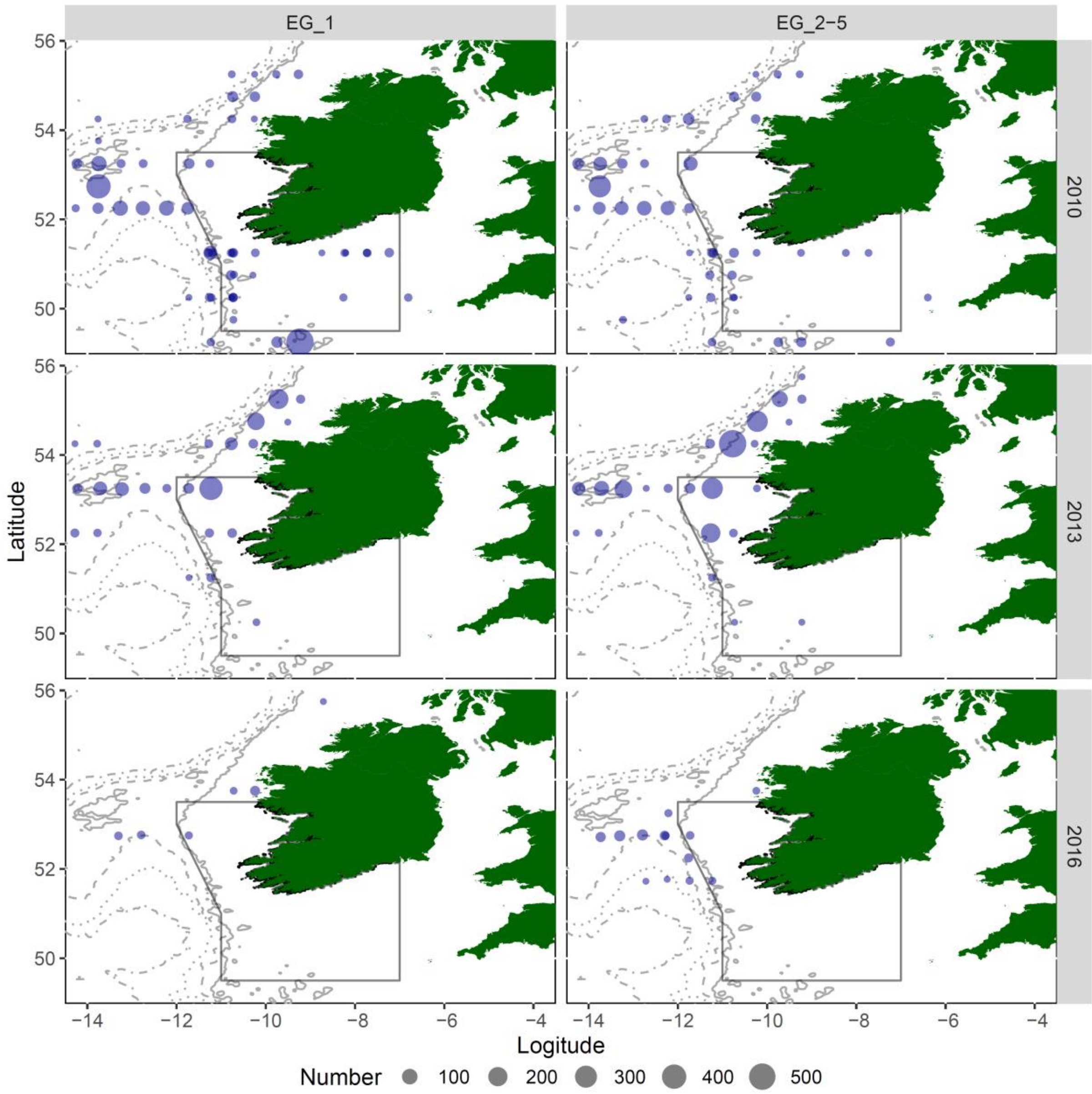

Figure 65: Horse mackerel egg distribution from open source ICES MEGS survey data in 2010, 2013 and 2016 by egg development stage, where stage 1 are new fertilised eggs as detailed in the MEGS survey manual for sampling at sea (ICES, 2014).

Blue whiting spawning and nursery grounds are offshore in deeper waters beyond the edge of the continental shelf. This is depicted in the distribution occurring predominantly beyond the 200m contour (Figure 66) as estimated by ICES (2009a), . Coull *et al.*, (1998), Nolan *et al.*, (2011) and Aires *et al.*, (2014) estimations of nursery areas are in general agreement. Spawning areas are depicted in approximately the same area, with some publications showing a slightly more western distribution.

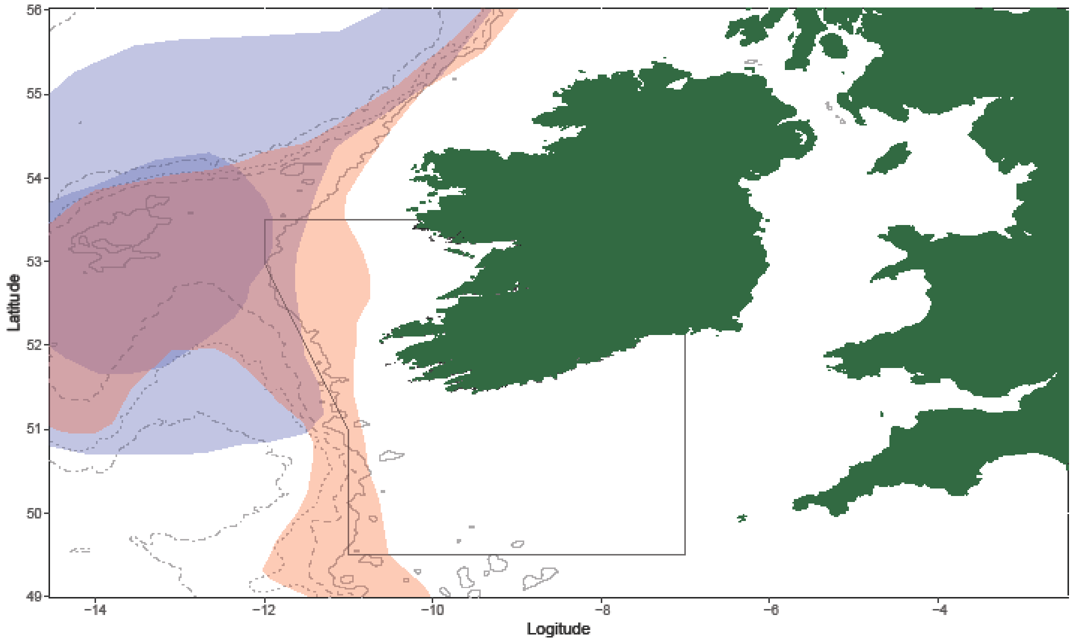

Figure 66: The location of blue whiting spawning (blue) and nursery (red) grounds around the Irish coast (the darker shade indicates the most important area). Areas from ICES (2009a).

Herring spawning and nursery grounds occur across many shallow inshore waters (Figure 67). ICES (2009a) highlight that much of the work carried out to identify these areas was based on unpublished data complied across industry and science surveys. This may explain why Ellis *et al.* (2012) found no herring spawning within the BSA.

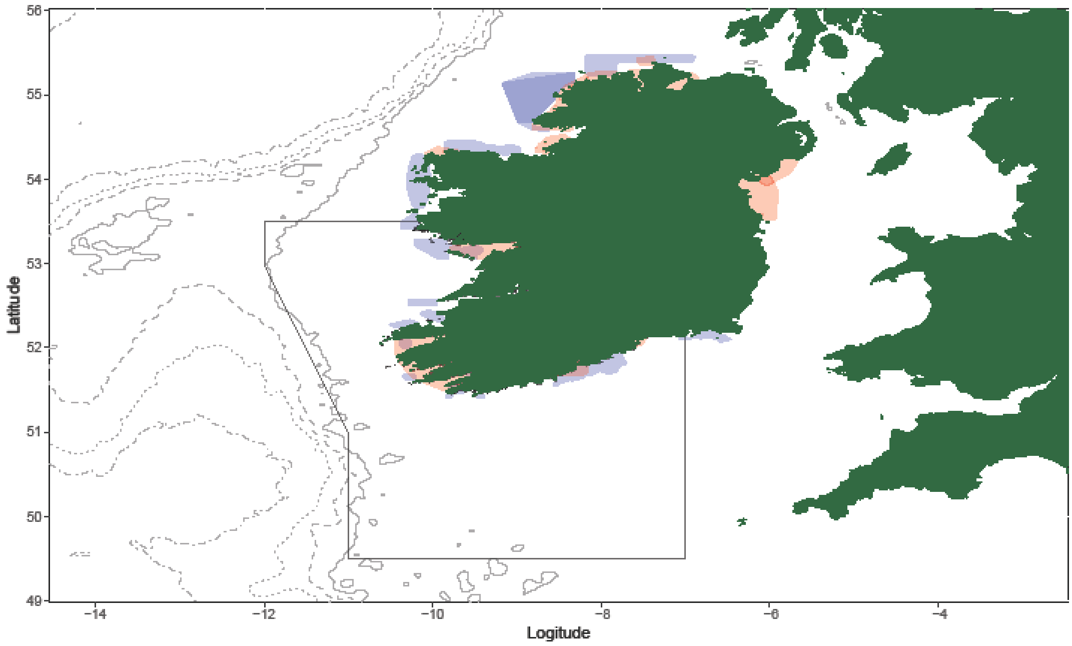

Figure 67: The location of herring spawning (blue) and nursery (red) grounds around the Irish coast (the darker shades indicate autumn spawners and the lighter shade shows winter spawners). Areas from ICES (2009a).

6. Discussion

The marine ecosystem off southern and western Ireland holds significant value to a host of species including fisheries, marine mammals, birds, and corals (Nolan *et al*., 2011; Dransfield *et al*., 2014; Orejas *et al.,* 2015ab; Varian, 2020). This area is an important spawning and nursery area to a variety of commercially important fisheries which are targeted by various commercial fishers (ICES, 2009a; Nolan *et al*., 2011; Dransfield *et al*., 2014). Fisheries in the BSA range from overfished to stable and are managed by a range of fisheries management measures (Marine Institute, 2020b). The BSA is currently managed by effort limitations specific to the area. These effort ceilings have been criticised as ineffective when considered alone (ICES, 2009a). However, other methods including gear restrictions, closed seasons, and single species TACs have been implemented to help ensure the fishery is managed in a sustainable way. Below specific topics are addressed in more detail, including fish landings, stock health, effort use, VMS, spawning and nursery areas. After which data gaps and areas of further research are discussed.

6.1 Landings and stock assessments

Landings over time are not static and have shifted slightly within the BSA over the last decades. However, a similar set of species still make up a large proportion of the landings. Changes in stock size, market demand, vessel capacity, technology, management measures and available TACs can influence what portion of catch was retained. In some instances, landed values may be influenced by miss-specification or miss-reporting leading to incorrect values being recorded.

According to ICES (2019a), pelagic landings within the Celtic Sea ecoregion, in which the BSA is situated, increased from the 1960s to the mid-1990s and thereafter a declining trend was noted. An upwards trend for demersal species has been noted with some declines in the 1990s and 2000s. Landings from the crustacean fisheries (dominated by *Nephrops*) are reported to have remained stable over time (ICES, 2019c). A shift in the species composition of top landing species from 2009 to 2018 has been noted when compared to 1999 to 2008, within this shift an average increase (112%) in pelagic landings has occurred over the last 10 years. This increase was largely due to the substantial increase in landings of boarfish (690%). Prior to 2006, boarfish was a non-target species with low landings. However, since 2006, boarfish landings have increased substantially and is now an important fishery (ICES, 2019c). Discounting boarfish, pelagic landings have decreased slightly (3%) over the period, in line with ICES findings (2019c). For the demersal fishery, in line with ICES findings, landings have increased by 14% over the last 10 years (ICES, 2019c). Fifteen years after the formation of the BSA, hake still accounts for the majority of demersal landings in the Celtic sea and west of Ireland.

The health of fish stocks since 2003 have on average increased (for the assessed stocks), however, not all stocks have improved, and a number are still of concern. Within the BSA and wider ICES Area VII 12 stocks are now considered to be sustainably exploited and have good environmental status (GES) under the marine strategy framework directive (MSFD; EC, 2008a). This includes: white anglerfish (VII), blue ling (VII), haddock (VIIa), hake (VII), megrim (VIIb-k), sole (VIIa and VIIf, g), plaice (VIIa), tusk (VII), *Nephrops* (functional units 15 and 17), and albacore tuna, stocks. Note no small pelagic fish stocks are currently considered to have GES. While cod (VIIe-k), haddock (VIIb-k), whiting (VIIa and VIIb-k, e-c), plaice (VIIh-k), herring (VIIb,c and VIIa, g, h, j, k), horse mackerel (VIIa-c, e-k), blue whiting (VII), mackerel (VII) and *Nephrops* FU19 to 22 were noted to have concerning biomass levels and or fishing mortality rates. The decrease in landings of cod, whiting, herring, blue whiting, and mackerel are likely linked to this poor stock status as TACs attempt to bring the stocks and fishing pressures into alignment to reach GES. Fishing mortality for benthic and demersal stocks (with known status) has shown a declining trend since the 1990s (ICES, 2019c). Further information and management measures to improve stock health are required to assist in the recovery of stocks with concerning biomass levels and increase the understanding of unassessed stocks.

Stock assessments for a range of stocks within the BSA have yet to be conducted by the relevant advisory bodies (i.e. ICES) resulting in a deficient of knowledge regarding the sustainability of these stocks. Further knowledge of the fisheries and stock status of species in the BSA is urgently required. Reference points in relation to biomass or fishing mortality for fisheries are not available for over 44% of the 103 stocks assessed in the Celtic Sea ecoregion (ICES, 2019c).

Skates and rays are important demersal species, with many commercially caught as bycatch, yet limited information is available for these stocks. In 2009, TAC for certain skates and rays was introduced. These TACs have been adjusted several times since their introduction. TAC was initially adjusted downwards by a total of 63% until 2016, since which the total TAC has been increased by 5% and 10% in 2017 and 2018 respectively (ICES, 2020v). Species level reporting of elasmobranchs has improved in recent years, however, miss specification within logbooks is still a common problem, with data pre-2008 remaining largely unreliable (ICES, 2020v). This is particularly noted for the *Dipturus batis* species complex, consisting of two critically endangered species namely *Dipturus flossada* (blue skate) and *Dipturus intermedia* (flapper skate), pre-2010 these species were recognised as one species (*Raja batis*; Clark *et al*., 2016). Reference points for skates and rays have generally not been defined, however, reports have noted stocks levels are of concern and many of the species are considered threatened (ICES. 2018f; ICES. 2018l; ICES. 2018m; ICES. 2020a; ICES. 2020s; Nieto *et al*., 2015; Varian *et al.,* 2020). Of the European Chondrichthyes species assessed, 32.1% are listed as threatened on the European Red List of Marine Fishes and 20.6% were assessed as data deficient (Nieto *et al*., 2015).

A decrease in landings of *Rajiformes,* as seen in the last 10 years, are likely as a result of low abundance and limitation of fisheries to bycatch only. A general lack of knowledge regarding *Rajiformes* is of concern and requires attention. Limited knowledge exists regarding their spawning grounds, nursery sites, and wider use of the area. The spawning and nursery grounds are likely inshore based on information obtained from egg case surveys (Varian, 2017). Evidence of a wider distribution of adults was apparent from the length frequency graphs, and supported by maps compiled by Clark *et al.* (2016). Of the distributions overlapping with the BSA, Clark *et al.,* (2016) noted an inshore distribution for white skate, blond ray and undulate ray; and an offshore distribution for shargreen ray. While a more mixed distribution was noted for the common skate complex, small eyed ray, spur dog, cuckoo ray, tope shark, spotted ray, greater spotted dogfish, thornback ray, starry smooth hound, and lesser spotted dogfish. Species distributed within the 6 and 12nm range can be locally managed, however, species with a wider distribution may be landed by international vessels and require wider management.

The length at maturity is absent for a number of the elasmobranch species. Of the critically endangered to vulnerable species with known maturity size as summerised by Clark *et al*., (2016), *Rostroraja alba* landings were under the estimated maturity size, *Squalus acanthias* landings were above the estimated maturity size, however, discards ranged above and below the estimated maturity size, *Galeorhinus galeus* almost all landings and discards were below the estimated maturity size, *Raja undulata* all discards were below the estimated maturity size and for *Mustelus asterias* landings and discards were both above and below the estimated maturity size. These findings indicated that catches of undersized elasmobranchs are still a concern.

Bycatch studies are linked to the relatively high perceived survival rate of elasmobranch species. This results in certain elasmobranch species being exempt from the landing obligation enabling catches to be returned to the water as it is believed that these species generally have a higher survival rate STECF (2017a). This information currently requires further research as the survival rate of elasmobranchs is dependent on a number of factors. including the species was caught, what gear was used, handling of the species and aspects such as haul duration (STECF, 2017a). STECF (2017a) notes that by including skates and rays into the landing obligation, the incentive to reduce catches of skates and rays through gear modification and improved fishing techniques may increase. However, further studies are needed to assess these assumptions and quantify survival rate (ICES, 2020v).

ICES is attempting to provide advice for this species group although this is currently, hampered by the limited information available, and are generally only able to provide precautionary advice. Further research is planned in the Celtic Sea, and includes an observer program, Raywatch and bycatch studies (ICES, 2020v). It is hoped that information pertaining to mitigation measures such as operation measures, spatial and seasonal closures will develop from these projects (ICES, 2020d). Although no targeted fisheries currently occur for elasmobranch species, bycatches from trawl and tangle net fisheries are a concern, particularly in the vicinity of Tralee Bay (ICES, 2018f).

Within the BSA, crustaceans, compared to other demersal and pelagic species account for less landings by weight. Measuring species importance by weight landed could over emphasise focus on small pelagic species as these species are typically caught in large quantities, particularly when compared to crustaceans. However, crustaceans have higher per kilo values than small pelagic species (herring, mackerel, horse mackerel) and many demersal species (Davie *et al.,* 2015) and thus are still an important contributor and require management and protection. The most valuable landing in Ireland in 2018 was *Nephrops* (CSO, 2020). In comparison, for example, edible crab were valued at €15,999,000, horse mackerel at €19,759,000, European hake were valued at €45,826,000 and *Nephrops* at €61,879,000 (CSO, 2020).

Due to the limited range that *Nephrops* have, they are assessed as functional units (ICES, 2020i), although for the most part there are multiple FUs within a TAC management area. There is a single TAC for the whole of ICES area VII, however, in this instance there is a qualification on the catches to be taken from FU 16 (Porcupine Bank). The distinction of FU16 was the result of increased effort in the Porcupine bank between 2002 and 2007 which resulted in a decline of the stock (ICES, 2011). *Nephrops* (functional units 15 to 17) stocks are considered to have good environmental status, however, concerns regarding *Nephrops* in functional units 19 to 22 were noted (ICES, 2019n, 2019o, 2020i, 2020j). *Nephrops* are assessed through remote underwater videos where burrow counts are conducted (Leocádio *et al.,* 2018). This data is then used to help advise on TAC.

Nephrops occur on discrete patches of soft substate into which they are able to burrow. The fishery target exposed individuals with bottom trawl gear. These fisheries are often linked to demersal fishing given similarity of gears used and often mixture of *Nephrops* and demersal fish species are captured including cod, megrim, haddock, whiting, hake. and anglerfish (ICES, 2011).

Landings of edible crab in the BSA are managed by a combination of minimum conservation reference size of 130mm (south of 56 degrees North; EC,1998) and effort restrictions for vessels of 10m or more (EC, 2004b). TACs are not set for this species, nor are stocks assessed by ICES. Little information was available regarding the stock status of crab. The Marine Institute *Stock Book* publication (2020a) show four stocks, of which, two may occur within the BSA (the “south east” and “south west” stocks). Of the crab stocks which may occur in the BSA, although the fishing pressure has been reported as sustainable (Marine Institute, 2020a), the lack of knowledge on the stock size and its sustainability link to other reports of crab stocks being of concern (Marine Institute 2019; Annual Report from France, 2020). Landings reported between 1999 and 2008 and in the last 10 years have decreased by 36%.

The demersal fishery in the Celtic Sea generally targets mixed species. This can result in a variety of challenges when managing a fishery and choke species become an important consideration. Those most vulnerable species, with the lowest TACs are what can be termed a choke species, whereby in a zero-discard situation reaching the most limiting TAC prevents further fishing. Gaining a further understanding of how species interact in the ecosystem can help predict changes which could result from stock declines. Multi-species modelling is one tool which can be used to gain a further understanding of these interactions. Although multi-species ecosystem modelling in the Celtic Sea is lacking, such modelling from the North Sea can be used to infer certain species interactions. For example, an increase in the abundance of cod, saithe, and mackerel (predator species) could cause a decrease in the SSB for whiting and haddock (prey species) and an increase in the SSB of herring and sand eel (ICES, 2019c).

Using tools such as stock assessments and length frequency distributions, we can gain a further understanding of how fisheries are under pressure and which management measures and tools may best benefit them. The species based length frequency distributions showed evidence of discarding marketable sized fish, for both demersal and pelagic species, with large overlaps between the landings and discard distributions. Pelagic fisheries have been known to return whole hauls when the average size of individuals is thought to be below the target size. In the demersal species length frequencies, there was evidence of high-grading, a practice occurring when quotas are limiting, with marketable individuals over the size preferred by individual fishers being returned in preference of retaining only those which would achieve the greatest market price. The peak frequency discard size class be compared to the minimum landing size (MLS) to see if an excess of individuals are discarded below this, which would be an indication changes to the gear configuration are required to enable these individuals to escape. Further efforts are needed to reduce undersized catches and/ or discards for mackerel (VIIg), hake (VIIg, j), cod (VIIg, j), haddock (VIIg, j), ling (VIIg), whiting (VIIg, j), plaice (VIIg, j) and monkfish (VIIg, j). In some instances the peak discard size was noted to occur above the MLS, indicating fisher preference for a minimum fish size larger than the legal minimum permitted over the MLS, again possibly as a result of restrictive quotas or market preference for “plate sized” fish.

MLS or minimum conservation reference size, as defined by council regulations means “*the size of a living marine aquatic species taking into account maturity, as established by Union law, below which restrictions or incentives apply that aim to avoid capture through fishing activity* (EU, 2013a).” High catches of fish below MLS are not desired by a fishery. This bycatch in the past was returned to the sea (discarded). However, with the introduction of the landing obligation, this practice is no longer allowed for TAC species. Landing obligations were introduced with the aim of reducing the wasteful discard of dead fish (EU, 2013a). This ban was introduced to different fisheries and vessels at different times. For western waters, the landing obligation was phased in from the 1st of January 2016. The 2016 landing obligations applied to all target species. A discard ban for cod, haddock, whiting, saithe, *Nephrops*, common sole, plaice and hake was applied between 2016 and 2018. The landing obligation applied to all other TAC and minimum landing size (MLS) species (except those exempt) from the 1st of January 2019 (EU, 2013a).

The introduction of the landing obligations posed challenges to fisheries and measures to reduce the amount of unwanted catch through adapting fishing techniques became an increasingly important consideration. Unwanted catches can be reduced through using more selective gear and special avoidance. Achieving this can be challenging (Calderwood & Reid, 2019). Towed gears are predominantly used in the mixed demersal fisheries and traditionally have one of the highest proportions of unwanted catch and discarding rates. *Nephrops* are noted as one of the fisheries with the greatest discards (Calderwood & Reid, 2019). The use of sorting and separator grids such as “Swedish grids” can reduce fish catches when targeting *Nephrops*. These technical measures were initially used within the Irish Sea where its use enabled fishers to continue fishing under the cod long term management plan measures (Davie *et al.*, 2011a). There are mixed feelings on the use of these technical alterations within the industry where some believe they lack efficiency and are difficult to use (Calderwood & Reid, 2019). Further technical measures have been used in the fishing industry to improve catch selectivity, for example, square mesh panels can help reduce catches of whiting, hake, megrim, monkfish and undersized fish; increasing the mesh size of the codend to larger mesh sizes (e.g. ≥100mm) and switching from twin rig to quad rig in prawn trawlers (Calderwood & Reid, 2019). Implementing tactical measures such as avoiding spawning grounds at certain times, moving between fishing grounds to avoid cod and haddock, sharing of information between skippers and moving-on if undesirable catches are noted (Calderwood & Reid, 2019). Future measures which could help reduce undersize and unwanted catch include suggestions of rewarding trawlers which use mesh sizes greater than 120mm, introducing tamper proof gear which is inspected and policed, improving the speed at which new measures are introduced, improve local management and utilising effort-based management and area closures to protect spawning and nursery areas for skates and rays (Calderwood & Reid, 2019).

6.2 Estimated Fishing effort

The BSA area is managed by effort restrictions (calculated in kilowatt days at sea) laid down by Council Regulation 1415/2004 (EC, 2004b). Below effort limitations implementation within the BSA and wider ICES area VII are considered using effort estimations generated from the Member State logbooks reported to STECF.

It should be noted, that there are a number of different ways to determine or estimate fishing effort. In the case of the BSA effort limitations “*the calculation of fishing effort by vessel in a particular area, the activity is defined, for a vessel absent from port, as the number of days at sea by trip in the area, rounded up to the nearest whole number*” multiplied by the kilowatt engine power of the vessel (EC, 2004b). As highlighted within the Methods above (section 3.5), STECF calculate 3 different measures of fishing effort: days-at-sea; fishing days (or nominal effort); and hours fished. As previously described, days-at-sea effort includes all time a vessel is absent from port, including time spent steaming, fishing-days, discount days on which no fishing activity occurs, and hours fished is only the time reported in the logbooks vessels were activity fishing. Inclusion of steaming time can therefore overestimate effort within an area if a significant amount of time is spent reaching, or moving between, fishing grounds. While fishing hours relies on accurate completion of logbooks and in the past has been less reliable. STECF estimated fishing days were therefore the closest definition of effort available in relation to the regulation definition, and considered appropriate for comparison. These two methods do not account for any form of technological creep or the skill of the skipper, both of which can influence the effectiveness of fishing activity. Fishing capacity can be improved by improving a range of activities including gear, technology, and fishing methods. However, the fishing effort specified within the regulation accounts only for engine size, and assumes a stronger engine equates to more effort (European Commission, 2010a).

Using fishing effort as a management tool can account for a wide range of species together (such as mixed fisheries), and where uncertainty in understanding of biomass exist, providing a general limit while other methods, such as scientifically based catch limits are developed (FAO, 2012). However, factors such as catchability of a species can create uncertainty and effort-based management may create unintended incentives to increase catching efficiency to maximise catches and revenue or result in Olympic fisheries (FAO, 2012). To account for technological creep or improvements in efficiency, effort limitations require regular review and input controls implemented to prevent excessive increases in inputs such as vessel size and increased productivity (FAO, 2012). Multiple management measures are often used in conjunction, and this hybrid of tools can assist in improving the sustainability of a fishery (FAO, 2012). This is the reality of the BSA, within which vessels operate under effort, technical and catch limitations.

Member States which have displayed apparent effort in excess of nominal ceilings were considered to be artefacts of the effort estimation method. For example, Belgium and the Netherlands both have estimated effort above their scallop fishery limits within the wider ICES area VII. The Netherlands have a low but increasing trend in estimated demersal effort beyond the specified ceiling. The UK government notes that effort is actively monitored by the MMO for vessels 15m and over and as for other Member States vessels are expected to report the purpose for entering the BSA (fishing, travelling, or maintenance; UK Government, 2014). However, the bodies commissioned to review and assess functionality and effectiveness of effort regimes are not necessarily provided with the same data submitted to the European Union for control and enforcement purposes. As such, assessment of incomplete or more generalised data sets make acting on findings difficult. For instance, STECF were requested to review the effectiveness of the effort regime in 2010 (STECF, 2011). France, Portugal, and Spain had supplied incomplete data sets pre 2010 (STECF, 2011). Council Regulation 1954/2003 (EC, 2003b) noted the effort regime and other management measures in the area would be reassessed in 2008. However, this poor effort data availability likely prevented accurate conclusions from being made. STECF (2011) noted that "*the fishery-dependent information is unreliable and not representative of the fisheries in the area and should not be used as a basis for management decisions*."

With improved vessel monitoring and the enforcement of electronic logbooks (EC, 2009) it is believed effort information has improved, providing better representations of activity (Holmes *et al.,* 2018; EPRS, 2019). However, variation between reporting bodies and Member States can still result in variations in information submitted. This means that differences between databases may occur. Furthermore, countries may resubmit data which may result in updates and changes to previous years, meaning that data may show inconsistencies when compared to earlier reports. This can make interpreting and comparing effort difficult and for this purpose, estimated effort has been displayed for the complete available time series thus reducing the need to make direct comparison to earlier reports. Despite this, conclusions are similar in this report and many of the conclusions noting the lack of limiting reference values reiterate previous findings.

In general, overall effort limits within the BSA are not restrictive. This finding is in line with other reports examining effort within this area (ICES, 2009a; European Commission, 2010a; STECF, 2011). ICES (2009a) stated Belgium, France, Ireland, and UK reported that less than 52% of their effort was used in 2008 while Spain reported that 92% of their effort ceiling was used. As of 13th October 2020, the UK fishing fleet had only used 55% (crab fishery) and 49% (scallop fishery) of their allocated effort for 2020 within ICES area VII (UK Government, 2020). It is believed the effort ceilings were restrictive for many Member States when limits were first introduced in 2004. This was visualised by the sharp drop in effort between 2003 levels and 2004 levels for scallop and the demersal fleets (note when looking at grouped demersal effort, Spanish effort is only present from 2010 onwards). For demersal and scallop fleets, estimated effort within the BSA on average has declined. Total apparent effort expended was noted as below the limitations by 2006. However, the UK exceeded apparent demersal effort in 2015 and 2016, as this was the final year of this available dataset it is not known if this trend continued. Both Ireland and France held decommissioning schemes to reduce capacity within their demersal fishing fleets early in the regulation period which aided their declines in effort having permanently removed capacity from the fleet. These are discussed further below. Crab directed fisheries effort has increased, and is estimated to exceed the effort limitation since 2007. Estimated Irish crab fishing effort continues in excess of ceilings and Ireland regularly gets swaps from other countries to keep the fishery open.

A letter from the Killybegs Fishermen's Organisation (KFO; 2009), Ireland noting the restrictive effort for crab fishing in the BSA was published in 2009. In this letter they detail missed economic fishing opportunities in 2007 and 2008 where fishing for crabs had to come to a hold due to effort limitations being exceeded and the crab fishery regularly needing to close early as a result. These limits are exceeded due to several reasons ranging from the primary cited reason of inadequate effort allocations, to fishers not fully understanding how to calculate effort (KFO, 2009). From the calculated effort, crab effort estimated for Irish vessels in 2008 was at its second greatest recorded levels (2010 was the highest of the time series). The KFO notes that effort calculations between 1998 and 2002, coincided with a time of rapid expansion of the Irish crab fishery and effort calculations did not represent the actual fishing taking place. Given the lack of recording and records from this time period, and subsequent years it is likely that effort from 1998 to 2002 may have contained inaccurate estimations, possibly due to a lack of reporting by vessel owners. KFO (2009) notes that this lack of accuracy was due to effort estimations not being correctly advertised nor fully understood. The letter continues to note that static gear should not be governed by effort restrictions and the enforcement of this regulation in other areas has provoked more intensive fishing, greater landings and lead to subsequent negative economic responses.

The Marine Institute (2019) note a decrease in landings of edible crab since 2015 in many areas except Clare, Cork and Wexford. This was despite an increase in pots and a decrease in discards having been noted for many Irish areas.. The increased effort may have resulted in landings above biological limits. The decreased catch coupled with the reported increased effort indicates that the increased estimated effort observed in the crab fishery requires further management measures (FAO, 2012). A further report notes that the brown crab fishery in ICES areas VII and VIIIa, VIIIb and VIIId are overfished and over harvested (Annual Report from France, 2020). The Marine Institute (2019) further note that effort limitations are ineffective for the Irish crab fishery in the BSA and ICES area VI. This relates back to the type of effort stated within the limit. For passive gears, the soak duration or number of pots are more appropriate representations of fishing effort than days at sea or fishing days where vessels do not stay with the gear while it is in the water (FAO, 2012).

Comparing the estimated fishing effort within and beyond the BSA should highlight any fishing displacement as a result of restrictive effort limitations. The wider ICES area VII has a range of habitats, including complex shallow water areas and extensive deep-water areas (STECF, 2009). However, in EU waters of ICES area VII, effort ceilings overall have not been limiting, and apparent fishing effort was typically less than the limits. Below, we will discuss Western Waters effort limitations in ICES area VII, comparing them to the BSA.

France was allotted one of the largest effort ceilings, however, was consistently below limits. This has likely assisted in maintaining overall effort below total fishery ceilings. Nationally, a general decrease in estimated effort over time has been noted. This trend was apparent for Belgium, France, Spain, Ireland, and the UK for the demersal fishery; France and Ireland for the scallop fishery and Ireland and the UK for the crab fishery. It is estimated that several effort ceilings have been exceeded. Initial rises in effort between 2004 and 2009 were noted for the French scallop and UK crab fishery before declines were noted. The Irish demersal fishery, however, was estimated to be continually above the effort limit.

The UK scallop fishery peaked in 2010, where estimated effort was reported to be above the effort limit. The 2010 peak was followed by a sharp decline to below effort limits thereafter. Between 2002 and 2019, estimated effort associated to scallops increased in ICES area VII by 26% (UK Fleet Capacity Report, 2019). This increase is partly linked to the diversion of vessels from other areas and the increase in activity by vessels active in ICES area VII (UK Fleet Capacity Report, 2019), particularly from ICES areas V and VI which declined by 64% over the same period. In a response to UK fleets approaching their limits in ICES area VII, a scheme to limit the allocated days at sea was implemented in 2012 and UK effort directed to scallop fisheries has since declined by 10% (UK Fleet Capacity Report 2019).

For the Irish demersal fishery, estimated effort in 2003 was roughly twice that of the limit, dropping to its lowest level in 2009 at 9.5 million kW days (limit 7.9 million). Since which estimated effort increased. Some effort included in the decrease may have been associated with other fisheries, such as deep-water fishing, although little deep-water fishing occurred within Ireland towards the end of the period. In 2006 gillnetting limits below 200m (with later amendments allowing some gill net fishing for hake and monkfish between 200m and 600m, with the aim of limiting deep-water shark catches) were introduced (EU 2006a; EC 2006b; EU, 2013b). As a result, French, German and Spanish gillnetters targeting hake, monkfish and deep-water sharks had to alter their fishing practices or cease fishing (STECF, 2006; ICES, 2018b).

The estimated effort over the effort limit for the Irish demersal fishery in ICES area VII and the crab fishery in the BSA is of concern. Effort regulations state that if effort allocation has been exhausted, then fisheries should be closed (EC, 2009). However, Council Regulation 1954/2003 also state that "t*he Commission may, upon request of a Member State, shift the fishing effort between areas or divisions in order to allow the Member State to fully take up its fishing possibilities*" (EC, 2003b). A formal request by the UK was recorded in 2014 to move an amount of demersal fishing effort from ICES area VII to ICES area VIII. As of August 2014, the new effort limitation for the UK in ICES area VII for demersal fisheries was 25,756,266 kW days (a decrease of 30,000 kW days; EC, 2014).. This was the only observed formal adjustment of the Western Waters effort ceilings associated with Council Regulation 1415/2004 (EC, 2004). Ireland agrees effort swaps with other countries to cover excees effort above the effort limitations. No further information to account for this apparent effort increase has been noted in this review.

A decrease in fleet capacity has been clearly observed for many Member States. Vessel decommissioning schemes and similar incentives such as entry and exit schemes were implemented in an attempt to reduce the overfishing commonly reported, largely due to over capacity within the fishing fleet (European Commission, 2010b; UK Fleet Capacity Report, 2019). Overcapacity within the community fishing fleet was cited as one of the fundamental problems with the CFP in 2010 (European Commission, 2010b). Where over capacity can be linked to overfishing stock decline, poor fishing yields and a poor economic profitability of the fishery (European Commission, 2010b). EU capacity reportedly reduced by 331 000 GT and 1,123,000 kW between 2003 and 2008 alone, leading to a net reduction in tonnage and power of approximately 16% and 15% respectively and a decrease of 12,400 vessels or 13.3% (European Commission, 2010b). Despite these early changes, reports of overcapacity and overfishing continued. Such schemes have been ongoing since the mid-1990s, with reports of further decommissioning schemes ongoing.

Since the introduction of the effort restrictions, there have been a number of national decommissioning schemes which may account for some of the effort reductions noted. The Irish fleet capacity has decreased since 2003 through a series of decommissioning schemes. The 2005/2006 and later 2008 schemes removed 3,323 GT and 6,914 GT from the fleet respectively (DAFM, 2019). The 2008 scheme was said to have improved quota availability and the viability of the remaining whitefish fleet (DAFM, 2019). In total between 2003 and 2018, an approximate decrease of 60,400 kW and 35,000 GT was reported (DAFM, 2019). In the UK, several decommissioning schemes were implemented between the mid-1990s and 2011. With a decrease of approximately 50,000 GT (21%) and approximately 200,000 kW (22%) recorded (UK Fleet Capacity Report, 2019). The French fleet has also noted a decrease in vessels over time. In 2011, there were a recorded 7,380 vessels in France, by 2018 this number had dropped by 10% to 6 629, of these only 5,570 were reported as active (Annual Report from France, 2020).

In 2009, Spain reported a total of 9,014 vessels, of which, only 8,007 (88.8%) were active (Annual Report on the Activity of the Spanish Fishing Fleet, 2020). With engine power and gross tonnage in international waters decreasing between 2009 and 2019 from over 580,000 kW to approximately 560,000 kW (approximately 20,000 kW decrease) and from less than 157,000 to approximately 150,000 GT (approximately a 7,000 GT decrease; Annual Report on the Activity of the Spanish Fishing Fleet, 2020). The amount of this decrease which relates to EU waters is unclear.

The relationship between fishing effort and landings is not linear, whereby change in fishing effort does not necessarily reflect a similar change in landings, particularly if a species occurs in aggregations or a decline in fish stock has been noted (FAO, 2012). However, since 1998-2002, on which the effort ceilings are based, fishing effort has considerably reduced in both the BSA and wider ICES area VII, a decrease which coincides with decreased landings reported from ICES Area VII. One of the original goals of these effort limitations to assist with the integration of Spain and Portugal into the CFP has been achieved (European Commission, 2010a). Should effort levels increase to those specified within the regulation it is likely the substantial increase would lead to overfishing within the area. As such, revising effort limitations downwards is a necessary future step to ensure recent gains towards reaching sustainable fisheries within the area continue.

6.3 VMS effort

Using vessel monitoring systems (VMS), we can further understand the activities of fishing vessels. Information such as the area most targeted, the gear used and the amount of time that a nation spends fishing can help gain a greater insight into fisheries and increases the spatial understanding of important fishing grounds. VMS transmits vessel information to satellite-tracking devices to monitoring centres of the flag Member State (EC, 2009). Within the Irish EEZ, an average of 500 fishing vessels are active per day. This activity is estimated to result in 1.8 million fishing hours per year (Gerritsen & Kelly, 2019). The fishing activity of these vessels is varied, however trawling activity results in much of the Irish sea floor being trawled at least once per year and possibly as much as 10 times per year (Gerritsen & Kelly, 2019). VMS data does not differentiate if a vessel is fishing or steaming. This information is assumed based on the speed that the vessel was travelling. Speed information was used to infer vessels behaviour such as fishing or steaming time (Gerritsen & Lordan, 2011). Due to the speed assumption, some apparent fishing effort may be incorrectly noted when the vessel is steaming at a slower speed and some methods may have increased levels of biases, for instance, some pelagic trawl effort is likely under represented (Gerritsen & Lordan, 2011).

With the ecosystem approach to fisheries management (EAFM), VMS has the ability to show fine scale area usage and hotspots allowing an understanding of area usage and areas which may need specific localised protection. Spatial information improves the level of management available and enables increasingly complex spatial and temporal management of areas and diverse recourses (Gerritsen & Lordan, 2011). The traditional scale of effort and landings is no longer appropriate in many situations (Gerritsen & Lordan, 2011). Fisheries may shift over time due to a variety of factors including market, regulations, vessels and skipper preference (Gerritsen & Kelly, 2019). With VMS and electronic logbooks, changes in fishing location, target species, intensity and gear use can be monitored at a more granular level, enabling depth understanding of the fishery over time. This allows spatial and seasonal closures to be more efficiently targeted and the results to be better monitored. This information has been increasingly used within the scientific community; however, access can still prove problematic due to legal and confidentiality constraints (Gerritsen & Lordan, 2011; Gerritsen & Lordan, 2014).

The introduction of VMS to vessels meant that they were required to report position, and later position, speed, and course information (EC, 1997; EC, 2003a). The requirement for vessels to contain a VMS onboard has been staggered over time based on the length of the vessel. Introduction began in 2000 for vessels greater than or equal to 24m (EC, 1997), then 18m in 2004, 15m in 2005, (EC, 2003a) and most recently vessels of 12m or more in 2012 (EC, 2009).

When interpreting VMS data presented within this report the following should be noted. Gears data was in the first instance obtained from the Irish logbooks; for foreign vessels or cases where there was no logbook match, the fleet register was used.. Furthermore, it is assumed that VMS data from 2006 to contain all vessels 15 m and over, and from 2013 all vessels 12m and over are represented. Note, positional data from France was reported pre-rounded and this may have resulted in distortions when viewing the grid. When viewing VMS maps, the requirement to report entry and exit from an effort monitored area, may result in pings on the boarder of the BSA. This is an artefact of this reporting method and not displacement fishing.

The Irish fleet accounted for the highest proportion of activity within the BSA, fishing much of the area with a variety of gears targeting both inshore and offshore fishing grounds. The most dominant fishing gear used within the BSA was bottom otter trawls. This finding was in line with previous studies which have noted demersal otter trawls are one of the most widespread fishing methods and account for the most fishing effort within the BSA (ICES, 2009a; Gerritsen & Lordan, 2014).

Ireland was the most active nation using bottom otter trawls within the BSA, followed by France, Spain and the UK. Ireland and France utilise this fishing method across the whole of the BSA, , the latter of which extends shows greater effort in the southern and western areas , and likely extends into UK waters to the east. Much of the bottom otter trawl effort occurs along the full extent of the western BSA boundary (north to south) and expands out to waters west of the BSA. The topography in this area includes a descent from 200m to approximately 2000m. Part of the BSA falls over ICES areas which overlap with part of the 200m and 1000m depth contour. ICES (2009a) noted a particular overlap within this area of the UK fishery with the Spanish fleet reflecting UK flagged vessels owned or managed by Spanish companies. There is a great deal of effort within this general area, much of which is not covered by the BSA.

Previous reports have noted that *Nephrops* fishing accounts for one of the greatest proportions of effort within the BSA and have noted an inshore distribution of the fishing grounds (ICES, 2009a). As noted within this report, Ireland has an important otter trawl fishery targeting gadoid species, particularly found along the south coast of Ireland and a mixed demersal fishery targeting flatfish and gadoid species along the Irish coast (within 20nm); in agreement with previous reviews (ICES, 2009a). In eastern areas the French target several different species groups: anglerfish and megrim, gadoid species, and *Nephrops* (ICES, 2009a). Within the offshore area of the BSA, bottom otter trawl fisheries tend to target predominantly megrim, hake and anglerfish (and some bycatch of tusk, forkbeard, ling and squid), with high fishing effort occurring along the slope edge between 150m to 500m depth contour on the western edge of the BSA (ICES, 2009a).

The spatial distribution of the otter trawl fleet has shown some shifts over time. Such changes can be linked to a variety of factors including fuel prices, target species, quota availably, weather, and vessel range some of which were highlighted by Gerritsen and Lordan (2011). Shifts are apparent when looking at the change in effort distributions for countries such as Portugal which ceased using bottom otter trawls in the BSA, France which has shown decreased fishing effort in inshore BSA waters and Spain increasing bottom otter trawl effort in the north-western area of the BSA. The UK fishery appears to have noted nominal change with a slight increase in bottom otter trawling noted along the north western border of the BSA and a slight increase in use of gillnets within the southern area of the BSA.

Ireland also carries out the majority of beam trawling within the BSA, predominantly on the eastern edge of the area within 12nm of Ireland. These trawls target more benthic species including flatfish, anglerfish, and ray species with lesser catches of gadoids (haddock and cod). This behaviour was also noted by ICES (2009a).

A comparably small amount of gillnet is used in the BSA. However, effort calculations from VMS data for this type of passive gear are unlikely to be representative of actual effort spent fishing. As with the use of pots, soak time would be a more appropriate method of effort estimation. This is in line with views of other work carried out assessing VMS effort (such as Gerritsen & Lordan, 2014). VMS can, however, be used to identify nations utilising this gear and their fishing grounds. Ireland was the dominant user of gillnets in 2018, followed by France and the UK. Ireland use this gear widely across the BSA, although an increased focus was noted within 12nm, consistent to previous findings by ICES (2009a). French gillnet fisheries predominantly focus along the western boundary and along the slope. UK vessels operate more within the southern area. Gillnet fisheries primarily targeted hake, much of which was landed from ICES rectangles along the western boundary of the BSA, particularly 32D8. Among other species of interest are pollack and saithe were caught south of Ireland along the 12nm line. Cod was caught inshore on the south-eastern side of Ireland (STECF, 2017b). In 2006, regulations were implemented to prohibit gillnet use beyond certain depths (EC, 2006b) to provide additional protection to deeper water shark species. As there is little deeper water within the BSA, apart from a small amount along the western boundary this has had little impact on BSA effort. Furthermore, no significant change in gillnet effort was noted between 2006 and 2007.

As with gillnets, there is a small proportion of vessels fishing with longlines, predominantly Spanish, and again effort is not well recorded by VMS data, although fishing grounds can be identified. These vessels are typically targeting the slope edge along the western boundary. Within the BSA landings are primarily hake caught in ICES rectangle 31D8 (STECF, 2017b). This high proportion of hake was previously noted by ICES (2009a). Longline effort has generally increased since 2013, particularly for France and Spain where a two-fold increase was evident and focused along this western boundary. Albacore tuna and other pelagic species are also targeted by longlines within ICES area VII although the specific locations vary, this can occur within the BSA.

VMS data is a poor representation of the pot fishing occurring within the BSA, not only due to the static fishing effort being generally poorly represented, but the majority of these vessels are not required to carry VMS being less than 12m (Gerritsen & Lordan, 2014). Many of which are actually below 10m and therefore not subject to the effort limitations within the BSA. These vessels tend to stay closer to the coast, limited from travelling further by their size. These fisheries target crabs and lobster.

Seine, pelagic trawl, and dredge gears make up the smallest proportion of effort within the BSA, mostly carried out by Irish vessels. Nominal levels of effort were recorded by France and Spain, often to the south-west of the BSA. Seine net landings were dominated by whiting, in line with the broader gadoid description given by ICES (2009a). Dredging occurs in a small area which straddles the eastern BSA boundary to the south of Ireland targeting scallops.

Pelagic trawls catch a variety of species, often in large shoals in a short space of time, this can distort the effort estimated by VMS data where fishing events can occur between transmissions. The target area for widely distributed species such as mackerel and horse mackerel may vary over time (Gerritsen & Lordan, 2014; Gerritsen & Kelly, 2019). Identified pelagic trawl fishing grounds are generally easy to associate with the target species. Mackerel, horse mackerel and some boarfish were targeted along the western edge of the BSA, boarfish were also caught along the southern portion of the BSA (STECF, 2017b). Herring and sprat were both targeted inshore, herring to the east of the BSA and sprat along the south coast of Ireland.

VMS effort classified here as “other” gear or “other” nation accounted for 5% of the effort hours in 2018. This was a relatively large portion of the total effort hours. This is made up of effort from vessels where the country or gear activity within the area was low, for example Poland or Latvia, or this information was not available.. This effort primary occurred along the western boundary of the BSA.

No notable effort increases to the south or west of the BSA boundary were noted by this, or previous reports (ICES, 2009a). VMS data for Spain, in particular, showed a greater effort outside the western BSA boundary, along the 200 m depth contour. This area is the most notable fishing ground within the vicinity of the BSA. As this fishery straddles the BSA boundary and has a relatively high concentration of effort it may impact the effectiveness of the BSA. Bottom otter trawl, longlines, gillnets, and some pelagic trawls all target this area and it is known to be an important hake fishing (and spawning) ground. High landings have been obtained from ICES rectangles that straddle the BSA boundary line (31D8, 32D8, 33D8, 34D8; STECF, 2017b). Fine scale effort comparisons along the eastern BSA boundary, were not possible as this area falls outside the Irish EEZ, as does the south easterly tip of the BSA and VMS data is incomplete within this area making a full comparison difficult.

Many of the countries fishing within the BSA are noted to have mixed fisheries and the inclusion of VMS movement and species caught in these areas is able to provide a greater insight into the spatially explicit use of the BSA. It has also highlighted the need for a mixed species approach to fisheries management in this area to account for the diversity of practices and targeting behaviours (Moore *et al.*, 2019). Using metiers to group fishing trips with similar vessel and fishing practices and collating this into patterns and tactics can be an important tool when managing mixed fisheries and could be used to further assess and manage fisheries in a more integrative way (Davie *et al.*, 2011b; Gerritsen & Lordan, 2011; Moore *et al.*, 2019).

6.3.1 Brexit

As of the 1st January 2021, the UK left the European Union, and with it the CFP. While societal borders may be enforced, fisheries resources for a variety of species will remain shared. The UK and the EU intend to jointly manage approximately 100 shared fish stocks (European Commission, 2020a). Given the proximity of Ireland to the UK, many of these shared stocks are of interest to both Ireland and the UK and reside within the waters between the two closely linked nations. To ensure that these stocks are managed sustainably, cooperation between the UK and the wider EU is essential. To achieve this, reciprocal access to waters and quota arrangements have been set (European Commission, 2020a).

This affects the BSA as the south-eastern corner falls within UK waters. When looking at fishing effort in the UK waters portion of the BSA, fishing activity is noted to occur. Although VMS data may be incomplete for this area, whereby non-Irish vessels are not required to report their effort within this area to Ireland from which the data within this report was supplied, some inferences as to use can be derived. This includes bottom otter trawling by French, Irish and UK vessels, UK gillnetting, and Irish beam trawling. The main species landed from within ICES rectangles covering this area include from bottom otter trawls: hake, anglerfish, cod, haddock, megrim, and *Nephrops*; hake by gillnets; and megrim and anglerfish from beam trawls (data is available from: https://stecf.jrc.ec.europa.eu/dd/effort; STECF, 2017b).

At the time of writing this report, the full implications of Brexit are unclear. However, on the 1st of January 2021, the UK and EU entered into a Trade and Cooperation Agreement. Between 1st of January 2021 and 30th June 2026, a transitional period will be in force (European Commission, 2020b). During this period, full access has been granted by both parties to their waters to fish certain TAC and non-quota stocks within their EEZ (12nm to 200nm). Some special allowances have been made to allow EU Member States into UK coastal waters (between 6nm and 12 nm) and within the waters of the Crown dependencies of the UK (<6nm; European Commission, 2020b).

Provision for a gradual phasing of stock allocations have been made for the next six years. A list of these stocks and the percentage allocation to the EU and UK are available in EU (2020). For the UK, a number of the allocated stocks are set to gradually increase (generally only by a few percent) over the next six years, however, some are set to decrease while others remain unchanged. The catch allowance for the following three stocks, for example, are set to gradually increase: anglerfish (ANF/07) 21.22% to 23.38%, blue ling (BLI/5B67) 22.69% to 25.00% and cod (COD/7A) 43.95% to 44.80%. While the annual catch allowance is set to remain the same for other stocks, for example: plaice (PLE/07A) 51.11%, pollack (POL/56-14) 36.62% and boarfish (BOR/678) 6.36% (EU, 2020). An annual catch allowance or TAC shall be set for each of the listed stocks. The TAC will be based on scientific advice, socio-economic aspects, multi-year conservation and management strategies. Agreements shall be reached on the transfer of TAC, effort allocations, TAC for stocks not listed in the regulation, prohibited stocks and other management measures (EU, 2020). The TAC of relevant species are to be agreed annually. If a decision cannot be made then TAC will be set based on the level advised by ICES.

Some adjustments to the management areas of stocks may be made, this will be further discussed before the end of 2021 and will be made under the guidance of ICES (EU, 2020). Parties are further allowed to decide on measures applicable to its waters provided a set of principles and objectives are followed. Some of these objectives are included below and many of the CFP priorities have been preserved. For example, EU (2020) Article: Fish 2 states:

1. "*The Parties shall cooperate with a view to ensuring that fishing activities for shared stocks in their waters are environmentally sustainable in the long term and contribute to achieving economic and social benefits, while fully respecting the rights and obligations of independent coastal States as exercised by the Parties.*"

2. "*The Parties share the objective of exploiting shared stocks at rates intended to maintain and progressively restore populations of harvested species above biomass levels that can produce the maximum sustainable yield.*"

Examples of additional aspects which have been retained include obtaining good environmental status (GES) for marine stocks, promoting long-term sustainability for marine stocks, fishing is in accordance to the precautionary approach, basing management decisions on best available scientific advice (such as ICES), improving selectivity to protect spawning and nursery fish, reducing bycatch and preserving biodiversity. Further aspects relating to data sharing for the conservation of shared stocks and to combat IUU fishing were addressed (EU, 2020).

Agreements may be terminated. If this occurs, a nine-month termination period shall be enforced. Termination of access to certain waters, importation and landing of fish products shall require a longer termination period, generally at least three years (EU, 2020).

Although Brexit has undoubtedly resulted in considerable changes across a wide array of topics, the effects of Brexit on the BSA, at present, are unknown. Although each nation is required to promote sustainable fisheries, annual consultations for management measures such as effort restrictions are set to take place. "*Annual consultations are to occur regarding management measures, including, where appropriate, fishing effort"* (EU, 2020). One of the greatest perceived changes (in regards to the fisheries and stock stability) set to occur as a result of Brexit is the intention for the percentage of TAC shares for several shared stocks within the BSA to change over time. Further changes may occur in future years, especially beyond 2027 when the transition phase ends. The importance of safeguarding the area, particularly due to its importance as a biologically diverse spawning and nursery area, is a concern regarding the future of the BSA beyond this transition phase.

6.4 Spawning and nursery areas

Ecologically important marine habitats include sites of importance to species specific life history stages, including breeding (mating, spawning and parturition areas), recruitment, early development and growth (nursery areas), feeding areas and migration routes (Ellis *et al*., 2010). An understanding of these areas can help improve planning, risk assessment, and use within an area. Understanding spatial and temporal use of areas by species, such as for spawning or nursery aggregations, can provide important information on the vulnerability of an area to disturbance. This then allows possible damaging impacts to be assessed and the effects mitigated. For example, seismic surveys or piling in the offshore energy industry could result in negative effects to ecologically important marine habitats (Aires *et al*., 2014). Effects of these activities on fish may include rupture of internal structures (particularly swim bladders), damage to auditory system and can cause malformations in development growth (Aires *et al*., 2014).

Fishing activity can impact ecologically important areas causing disturbance or damage. The BSA was formed on a political basis and few articles link to the motivations behind this area, however, some information noted that the BSA was formed on the basis of this area being of ecological importance, requiring protection from increased fishing activity, with two main biological reasons noted (Marine Institute, 2003; ICES, 2009a). The first was linked to the importance of a hake spawning ground to the south and southwest of Ireland. This spawning ground was said to be some of the most important grounds for hake in the North-east Atlantic (Marine Institute, 2003). The second reason cited related to the high abundance of commercially important species said to utilise the area for spawning (mackerel, horse mackerel, blue whiting, hake, megrim, herring) or as a nursery ground (herring, haddock, hake, whiting and megrim; Marine Institute, 2003).

The extent of spawning grounds is linked to the specific reproductive behaviour of species. For instance, those which aggregate to spawn within set periods and narrow environmental constraints or locations are likely to have concentrated spawning grounds. Alternatively, if spawning behaviour is more sporadic and less affected by specific variables wider potential spawning areas can occur or result in spatial shifts (Ellis *et al*., 2010). The method of reproduction will further dictate the spatial extent of spawning grounds, for example, broadcast spawning vs mating. This is further influenced by the settlement phase of the fertilised eggs and the spatial extent can vary greatly if the eggs are pelagic or deposited on the sea floor (Ellis *et al.*, 2010). For instance, herring are a pelagic species with demersal eggs, pelagic larval stages and will often use estuaries as nursery areas (Ellis *et al*., 2012). For herring, spawning generally occurs over coarse sand and gravel beds, however, the areas of spawning can change over time (Ellis *et al*., 2012). This may result in widely distributed spawning and nursery areas for herring. This distribution may change and increase when comparing different surveys conducted over a range of years and may lead to inconsistencies when comparing studies. Spawning areas are generally identified by three features (1) the physical presence of ripe fish caught in the area (generally stage VI), (2) a high concentration of eggs and (3) recently hatched eggs (Fitzpatrick *et al*., 2005; Aires *et al*., 2012). However, when determining a spawning area, species specific information is an important consideration, and generalised spawning assumptions may not be applicable for individual species, or areas. This is particularly relevant for recently hatched eggs as different species and areas may affect this process. The most notable example are species such as eel which undergo a leptocephalus larval phase during which the larvae may drift considerable distances and hatch in areas which are not near the original spawning area (Wang & Tzeng, 2000). A further example is the dependence of mackerel eggs on water temperature for development and egg hatching rates, where these were recorded to range from 49.5 hours at 21ºC to 177 hours at 11ºC (Russel, 1976).

For many species, juveniles (those generally less than age one) have different requirements to their adult counterparts. For example, different depth, temperature, salinity, or food needs. In these instances, adults and juveniles occupy different spatial or temporal areas. Nursery areas can be determined by the presence of juvenile fish in numbers within an area (Ellis *et al*., 2010).

When looking at the spawning and nursery areas which overlap with the BSA, a number of species have been identified, consisting of a mix of both commercial and vulnerable species. The following species were identified as having spawning areas: mackerel, horse mackerel, megrim, herring, anglerfish, cod, haddock, lemon sole, *Nephrops* and sprat (ICES, 2009a; Nolan *et al*., 2011; Ellis *et al*., 2012; Dransfield *et al*., 2014). While nursery areas for haddock, hake, whiting, white and black bellied anglerfish, herring, horse mackerel, mackerel, lemon sole, ling, megrim, *Nephrops* and saithe have been identified, with varying levels of concentrations noted for some (ICES, 2009a; Nolan *et al*., 2011; Ellis *et al.*, 2012; Dransfield *et al*., 2014). This constitutes a greater diversity of commercial species than was originally put forward for the creation of the BSA.

Of the known spawning areas in and around the BSA, some species were noted to occur on the edge of the BSA with distribution difficult to determine. Ling spawning populations were noted to occur on the eastern edge of the BSA boundary, while hake and blue whiting spawning grounds occur on the western boundary. Interestingly, although the importance of hake spawning grounds within the area was one of the reasons put forward for the formulation of the BSA, and some spawning is reported to occur (ICES, 2009a; Nolan *et al*., 2011), the primary spawning area is outside its boundary following the slope edge of the continental shelf.

A number of inconsistencies between studies were noted. Spawning areas for blue whiting, whiting, herring and plaice; nursery areas for cod, blue whiting, haddock, sprat, Norway pout, whiting and sandeel; and egg case or nursery areas for spotted ray and thornback ray seem to have undergone a shift in spatial extent with some studies no longer documenting these areas to coincide with the BSA. The reason for these changes could be due to a variety of factors. The variation in spawning and nursery areas may be linked to changes in the survey such as area surveyed, water depth, timing, gear, method and analysis (Ellis *et al*., 2010; Aires *et al*., 2012). The methods of identifying spawning and nursery areas can be biased. Pelagic eggs could have drifted or dispersed from the original spawning site on the tide, currents, or wind (Ellis *et al*., 2010). Many skates and rays lay small numbers of eggs and attach them to objects such as seaweed. These egg cases wash up onto (generally local) beaches and are sometimes caught in trawls. The presence of egg cases can be used to infer spawning and/ or nursery areas for these species. However, it is worth noting that occasionally, egg cases may drift further afield and therefore could bias results. Data on spawning areas for elasmobranchs are limited (Ellis *et al*., 2010). Catchability can vary for juveniles and factors such as egg settlement (e.g. settling in inaccessible areas), survey locations, and what survey sampling equipment was used (ICES, 2009a). Furthermore, surveys are only able to take a snapshot in time and if sampling does not coincide with spawning for a species, or if the area distribution of juveniles changes with size/ age, grounds may not be identified. The ability to map spawning and nursery grounds is dependent upon the quality of information, sampling scale and intensity within an area (ICES, 2009a; Ellis *et al*., 2010).

Varying fish behaviour may be linked with a change in distribution, timing and spawning behaviour. Aspects such as spawning stock biomass could affect the amount and size of spawning events particularly spawning aggregations (Sadovy & de Mitcheson, 2012). Environmental cues such as temperature, wind, rainfall, sea state and even climate change could have resulted in spatial and temporal changes (Coull *et al*., 1998; Nemeth, 2009). There are a multitude of reasons why areas of fish sensitivity (spawning and nursery areas) may shrink, expand and move (Aires *et al*., 2012). Coull *et al*. (1998) noted that the distribution of the spawning areas needs to be under constant revision and maps produced should not be seen as rigid. For instance the change in nursery areas by cod noted by Coull *et al*. (1998) and later Nolan *et al*., (2011) falling outside the BSA, while ICES (2009a), Ellis *et al*. (2012) and Dransfield *et al.* (2014) noted that cod nursery areas were present within the BSA. The variation in conclusions could be linked to the distribution of cod and the surveyed area. Catches of juvenile cod in coordinated bottom trawl surveys are known to be rare along the south coast of Ireland as the 0-age group are distributed inshore (ICES, 2009a). Such groundfish surveys do not always sample nearshore sites, despite their importance as nursery grounds (Aires *et al*., 2012; Ellis *et al.,* 2012). Cod tend to use estuarine environments and other inshore habitats as nursery areas (Ellis *et al.,* 2012). Catches of juvenile cod appear less common and it is believed that spawning areas were previously more abundant (Tidd & Warnes, 2006; ICES, 2009a). This discrepancy is, therefore, likely due to a combination of a decrease in abundance coupled with inshore distribution which can reduce catch efficiency.

Not all species that spawn in or have nursery areas within the BSA receive protection from fishing. Effort limitations originally set are no longer limiting on fisheries and therefore hold little value in protecting spawning and nursery areas. Several species have their main spawning or nursery grounds outside of the BSA (spawning and juvenile blue whiting and spawning hake; ICES, 2009a). Gear restrictions, particularly the hake box, has some benefit to certain species. Species which likely benefit from increase mesh size regulations include juvenile hake, spawning megrim, possibly juvenile megrim, juvenile anglerfish and spawning and juvenile whiting (ICES, 2009a). However, as this larger minimum mesh size does not cover the coastal areas of the BSA, inshore spawning and nursery grounds do not receive the protection offered by this regulation including cod, haddock, and possibly *Nephrops* (ICES, 2009a).

In addition to the commercial fish species already mentioned, indications of spawning and nursery areas for elasmobranchs have been noted within the BSA thanks to the egg case project conducted by marine dimensions (Varian, 2017). Spawning and nursery areas in the BSA for elasmobranchs species (some based on the presence of egg cases found in the area) include blue skate, common skate, greater spotted dogfish, lesser spotted dogfish, painted/ small eyed ray, spurdog, undulate ray, white skate and angel sharks (Varian, 2017; Varian *et al*., 2020). The presence of many of these threatened and commercially important species indicate the importance of the BSA, and further research and protection is needed. Although no targeted fisheries are apparent on many of the elasmobranch species, bycatches from the trawl fishery and the tangle net fishery are a concern particularly in the vicinity of Tralee Bay (ICES, 2018a). Prohibitions on the tangle net fishery in the vicinity of Tralee Bay do exist, however, enforcement is difficult. Further measures to enforce this and mitigate bycatch are required (ICES, 2018a). Several projects have been highlighted for 2020 including studies in a potential hotspot, Tralee Bay (located within the BSA; ICES, 2020v). Studies will focus on abundance, distribution and composition of elasmobranch species in Dingle Bay, Tralee Bay, Brandon Bay and Shannon Estuary. Methods being used include catch and release studies, egg case collections, photo identification, movement and bycatch studies (ICES, 2020v; Varian *et al*., 2020). Data from the findings will hopefully be used to better protect these vulnerable species during spawning and nursery life stages and hopefully safeguard them to re-establish a healthy population and move off the threatened species list.

6.5 Climate change

While spawning and nursery areas have the potential to shift over time due to a variety of factors, climate change can further influence these changes. One of the biggest perceived threats within the BSA area being changes to water temperature. At the Rockall Trough to the north of the BSA, a peak increase in water temperature of 0.8°C and an increase in salinity were noted in the upper 800m of water in 2006 from averages between 1975 and 2003 (ICES, 2018h).

Temperature changes can influence marine animals and can change aspects such as distribution, phenology, and physiology (McQueen & Marshall, 2017). Those species with narrow temperature ranges (relative to the changing sea surface temperature) are predicted to be those most affected by temperature changes (Evens & Bjørge, 2013). This includes those at the edge of their geographical ranges, as is the case for several Celtic Sea species (ICES, 2018a), where even slight changes to the water temperature could impact their continued presence, this includes cod (Drinkwater, 2005). Temperature changes are known to influence the migration, distribution, and onset of spawning for various species including blue whiting, Northeast Atlantic mackerel, western horse mackerel and boarfish (McQueen & Marshall, 2017; ICES 2018a). Such changes can also be expected to affect recruitment in some Celtic Sea gadoid species (ICES, 2018a). As stated above mackerel eggs are dependent on water temperature for development and egg hatching rates (Russel, 1976).

Temperature changes can further influence the food chain by causing a shift in the presence, emergence, and abundance of phytoplankton and zooplankton. For example, a change in abundance of copepods towards more warm-water species and less cold-water species (McQueen & Marshall, 2017; ICES 2018a). This change is predicted to be a response to climate change and can have far-reaching consequences to a variety of species. Ensuring a healthy and intact ecosystem will assist in increasing resilience to the effects of climate change (Kopke & O'Mahony, 2011). Research on different species found in the area may help identify changes which may be occurring.

6.6 Summary of findings

The BSA was further noted as an area which hosted several important spawning and nursery habitats for commercially important species, particularly hake (EC, 2003b; Marine Institute, 2003). Ultimately the BSA was designed in a political context, but also to address a basic need regarding the integration of Spain and Portugal into the common fisheries policy and the requirement of reducing overfishing to sustain the intrinsic, economic and social value of the fishing industry (ICES, 2009a). Effort restrictions were therefore put in place to ensure that fishing in the BSA area was not subjected to increased fishing pressure (EC, 2003b).

Effort restrictions were based on the average fishing effort of each Member State for demersal, scallop and edible crab/ spider crabs in the period 1998 to 2002 (EC, 2004b). This added to measures already in place creating an overlap with the BSA area. These included the "hake box" technical measures and herring seasonal closures (EC, 1998; EC, 2001) and TACs for many individual species. Further measures were later implemented and these measures, although not directly linked to the management of the BSA, did encompass some or all of the same area. These measures included further TAC reductions and introduction of TAC for additional species, additional technical measures, deep water gillnet restrictions, and other capacity reducing measures such as vessel decommissioning schemes and introduction of a landing obligation (EC, 2006a; EU, 2013a; MMO, 2019; EC, 2020). This combination of measures is believed to have helped reduce pressure on fish stocks associated with the BSA. Certain stocks have shown signs of recovery or maintained healthy stock assessments (ICES area/division), including: monkfish (VII), blue ling (VII), haddock (VIIa), hake (VII), megrim (VIIb-k), sole (VIIa, f, g), plaice (VIIa), tusk (VII), pollack (VII), albacore tuna, bluefin tuna and *Nephrops* (functional units 15 to 17). However, positive improvements have not been observed in all stocks, and some show signs of instability or decline (ICES area/division), namely: cod (VIIe-k), haddock (VIIb-l), whiting (VIIa, b-c, e-k), plaice (VIIh-k), herring (VIIa, g, h, j, k), horse mackerel (VIIa-c, e-k) and *Nephrops* (functional units 20 to 22).

Although the original effort limitations held value in their ability to restrict fishing activity, helping to reduce fishing effort within the BSA, they are generally no longer limiting. A decrease in effort of 35% in the Celtic Seas ecoregion was noted between 2003 and 2014 (Dransfield *et al.,* 2014). Effort reduction could be linked to a multitude of factors including reduced opportunity, catch quotas and vessel decommissioning (MMO, 2019). Between 2005 and 2009, through decommissioning Ireland reduced its whitefish fishing fleet by 37% (DAFF, 2009). Similar measures have been implemented in other countries. According to MMO (2019) the number of vessels active in ICES area VII since 2003 has fallen by almost a third.

One area of concern remains the Irish crab fishery. The estimated high levels of effort have remained unchanged and using logbook data compiled by STECF, remain above the effort ceiling. Unlike the UK, no formal evidence of Ireland requesting to alter their effort allocation within Council Regulation 1415/2004 (EC, 2004b) was discovered. Although pots are generally noted to be target-specific and environmentally friendly, the high apparent effort exerted is of concern. Some evidence that the edible crab stocks are being overfished was noted, however, this species generally lacks formal assessments (Marine Institute, 2019; Annual Report from France, 2020) making it difficult to determine sustainability. Further investigation is required to understand why Ireland has been estimated to exceed the effort allocation and formal assessments on the state of the crab stocks are needed to assess the degree of impact from this apparent increased exertion.

Effort restrictions in Council Regulation 1415/2003 (EC, 2003b) were based on average effort from a period of reported fleet overcapacity and stocks at serious risk of a collapse (EC, 2002a; Berkow, 2018). It is likely that the effort exerted between 1998 and 2002 exceeded the capacity of the fishery, and that the reduced effort seen in recent years is more closely linked with improved fisheries management. Furthermore, given the difficulty noted in assessing effort by both ICES (2009a) and STECF (2011), due to inaccuracies in effort data, particularly prior to 2003, the average effort used to set the BSA effort restrictions were likely the best estimates of fishing effort within the area. A review by December 2008 of effort uptake was specified within Council Regulation 1954/2003 (EC, 2003b) and implied measures within the BSA were to be considered. However, possibly due to data limitations, regular revisions have not been applied in the BSA and as a result, fishing effort in this review was noted to be generally ineffective as a management tool. This conclusion supports previous reports and findings (ICES, 2009a; European Commission, 2010a; STECF, 2011).

A revision to effort ceilings is now essential and needs to be a priority of future management if the BSA is to continue. An increase to current limits by all Member States would likely have negative impacts on stocks within the area. Effort restrictions can form a valuable tool in the management of fisheries and have been applied in a number of fisheries globally. Effort restrictions can help reduce fishing pressure on stocks which have not been assessed or due to lack of data cannot be assessed (FAO, 2012). They can also act as a safeguard in the event of the development of a new fishery. However, poorly managed effort restrictions can result in overfishing. Effort restrictions applied in other areas, such as days at sea restrictions applied within the cod long term management plan (EC, 2008b) were set annually in the same way the majority of TACs are set annually to better reflect the needs of a fishery. STECF (2010) proposed other methods of managing fishing effort within the BSA. Firstly, effort could be adapted to reflect recently deployed effort, applying a three most recent year average from regular reviews. Alternatively, retaining the same allocation proportions for a reduced total effort based on most recent years STECF (2010) advised that certain areas could be reviewed so that the effort regime has an increased relevance to the fishing grounds and key species fished in the area. Allocating effort at a finer scale than currently specified, creating lower ceilings for more vulnerable areas. The key to this would be regular revisions to account for improvements in technology and efficiency (FAO, 2012). Other fisheries management models for effort restrictions exist, in particular status quo effort. Status quo effort is when the effort for each fleet is set to the effort in the most recently recorded year (ICES, 2019c). This approach may be preferable to the current effort restrictions governing fishing within the BSA. However, concerns regarding changes to methods governing fishing could result in undesirable changes. Previous recommendations have advised a precautionary approach which retains the current methods limiting fishing and recommend the implementation of improved monitoring systems (ICES, 2009a).

Currently, the use of TACs within the area is the more effective method of controlling pressure on stocks. Managing a fishery using TAC has several benefits and limitations. Unlike effort limitations, TAC management incentivises reduction in catch and time spent fishing, as well as an increase in market price (FAO, 2012). However, the cost of research and assessments, linked with the risks involved when determining a quota for a species and the need to monitor and control the implementation of such quotas can be prohibitive (FAO, 2012). Using more than one form of management can prove beneficial and several forms of management are noted in the BSA (FAO, 2012).

Fishing in the BSA is diverse and managing such fisheries can pose additional complications. The BSA contains a diverse range of demersal, pelagic, and crustacean fishing grounds targeted by a variety of gears and nations. Many of the fisheries target a variety of species and therefore, management of these fisheries needs to account for this mixed fishery nature. VMS data enables an understanding of the diversity of activities, the spatial scales at which individual fisheries operate and where overlaps occur, essentially identifying discrete activities (or metiers). The bottom otter trawl fishery comprises of various nations, targeting the largest area, yet often focussing on specific grounds for particular species, such as hake, anglerfish and megrim along the western boundary, or whitefish (haddock, whiting, and cod) in waters off the south coast of Ireland. The current regulation however only specifies effort for bottom otter trawls targeting demersal species. In agreement with ICES (2009a) this report finds the diversity too great to hold such a simplistic view, and issues of sustainability vary between the targeted (and bycatch) demersal species. For instance, gadoid species are commonly targeted and bycatch species in bottom otter trawls, however, both Celtic Sea whiting and cod have concerning stock status, and require additional protection not provided by a blanket effort limitation.

The variety of target species needs to be taken into account within management and the traditional scale is no longer appropriate given technological improvements and our improved understanding of spatial distributions and fishing grounds. TAC and effort restrictions within management measures can be more refined to help reduce excessive pressure in certain areas and on particular species. Although the landing obligation has attempted to account for the most venerable within a mixed fishery, the creation of "choke" species is both a help to safeguard vulnerable species and a hindrance preventing exploitation of sustainable stocks.

The location of the BSA was derived from a greater area known as the Irish box and the south-west of Ireland was chosen due to the presence of several nursery and spawning areas, and the importance of hake to the area (Marine Institute, 2003). ICES (2009a) along with this report agree that this area is used by a variety of species as a spawning and/ or nursery ground. Hake, although one of the main reasons for the implementation of the BSA, do not have their main spawning grounds within the BSA. Only a limited proportion of hake spawn within the BSA, with the main spawning grounds found west of the BSA boundary. One of the main nursery area for hake occurs within the BSA and forms an important habitat for juvenile hake. Further, the BSA is noted to hold value as a spawning and nursery area for several vulnerable and threatened elasmobranch species including spurdog, ray, white skate and undulated ray (Ellis *et al.,* 2012; Varian *et al.,* 2020). Much of this research was based on the presence of egg cases and further research is needed to determine the exact spawning and nursery areas. For a number of species there is some overlap between spawning and/ or nursery grounds and the BSA, although for several species like hake, the main grounds are further offshore, beyond the BSA's western boundary on the continental shelf slope. This includes anglerfish, mackerel, horse mackerel, blue whiting, and megrim. These areas are not isolated and fish migrating to such spawning areas often exhibit other behaviours such as catchment, staging and courtship (Sadovy & de Mitcheson, 2012). Furthermore, the migration to these spawning areas plays an important role in the transfer of energy such as nutrients from inshore to offshore areas (Sadovy & de Mitcheson, 2012).

In agreement with ICES (2009a), it is believed that, of these species, only certain ones are likely to be impacted by the BSA protection. As it stands, the effort limitations at present are unlikely to provide any protection to demersal species given the excess of effort available. Nor does it provide protection to pelagic species, given pelagic fishing gears are not included within the regulation. The increased minimum mesh size implemented by the hake box is however likely to reduce the mortality of juvenile hake and a number of other gadoids (ICES, 2009a). This could also include small flatfish such as megrim which were noted to have spawning and nursery populations which overlapped with the BSA. Although nursery areas for anglerfishes were noted to occur within the BSA, given the morphology of these species (their large head) all bar the smallest individuals are unlikely to receive many benefits from the increased mesh size. Vessels targeting *Nephrops* grounds within the BSA typically employ larger mesh size trawls than in other areas as individuals are larger (ICES, 2009a), therefore the hake box measures will provide minimal protection. This technical measure does not extend within 12nm of the coast. Therefore herring, whiting, haddock, and cod which have inshore spawning and nursery areas within the BSA would not receive additional protection from this regulation. The herring temporal closures only occur every three years, and although likely to provide protection within those years, they remain vulnerable in alternate years. Further protection for other inshore species and sites could be sought under Irish designations.

Use of VMS to visualise fishing effort identified the edge of the continental shelf, where the seabed drops away into deep-water to be an important high intensity fishing ground, tracing the 200m depth contour to the west of Ireland. The area is fished by Ireland, France, Spain, and the UK utilising mostly bottom otter trawls, and to a lesser extent longlines and gillnets, targeting hake, megrim, and anglerfish. This area straddles the BSA boundary with effort from the same fishery falling both inside and outside. When the BSA was initiated, management areas were typically defined by straight lines for ease of navigation. The use of straight lines for the boundary of the BSA has meant that some sensitive areas were excluded, or partially excluded from additional recognition and protection. Given current technologies, use of straight-line definitions are no longer needed and boundaries of protected areas can follow whatever shape is required. The area is a spawning area for hake, anglerfish, mackerel, horse mackerel, megrim, anglerfish, and blue whiting. It is likely some of the high effort within the area invariably targets aggregations of spawning adults, perceived as improved fishing opportunities (Sadovy & de Mitcheson, 2012). However, these spawning aggregations form a vulnerable life history stage for many species and targeted fishing on spawning aggregations has been linked to stock declines and stock collapse (Sadovy & de Mitcheson, 2012). Providing spawning aggregations protection is vital when managing a fishery which display this life-history trait (Sadovy & de Mitcheson, 2012).

The reduction in fishing effort noted in the BSA has a knock-on effect linked to a reduction in the spatial fishing footprint, and the number of times the seabed is trawled per annum (ICES, 2018a). A reduction of seabed trawling can, depending on the habitat type of the trawled area, have a positive effect and reduce the impacts on vulnerable benthic fauna and flora. For instance, trawls over cold water coral can have a negative effect as cold water coral have been found to be an important contributor to increasing local-scale biodiversity (Roberts *et al*., 2003). The full extent of the BSA habitat being fished can be noted by VMS fishing tracks, however, this level of detail was not provided for this report.

In addition to the commercial fishery found in this area, an increase in coastal anthropogenic activity has further affects. Herring is vulnerable as the spawning population has specific substrate requirements. This species is being impacted by the dumping of dredge spoil, aggregate extraction and construction of marine structures in the vicinity of spawning grounds (ICES, 2019i). The BSA affords no protection from such activity.

Several Natura 2000 sites have been designated within or near the BSA area. These have highlighted several unique and important marine features and species which require recognition and protection beyond the consideration of fishing and fisheries management. There are likely many more such sites, which remain vulnerable to the impacts and consequences of fishing or other anthropogenic activity.

The identification and naming of the BSA as biologically sensitive and establishment of area specific regulations (effective or not) likely holds value even without being a formal marine protected area. The current designation can form a strong starting point for further, more formalised, protection and research regarding the continued biological importance of the area. Regulations such as the need to report fishing in this area could act as a deterrent to fishers. Further measures are recommended to transition the BSA to an area that provides more focused protection to biological diversity within the area.

Impacts such as climate change could result in substantial effects, particularly to spawning and nursery populations which are susceptible to climate-related changes, including temperature change and ocean acidification. Ensuring that legislation is appropriate, fit for purpose, and able to dynamically respond to changes in vulnerability is vital. An inability to maintain fishing pressures at, or below, sustainable levels leaves the biodiversity within the BSA and wider ecosystem more susceptible to climate related changes.

6.7 Gaps in knowledge

Since the BSA was first designated in 2003, considerable knowledge has been gained about the marine environment through increased research and technological advances. As has our understanding of fisheries and awareness of vulnerable species. However, gaps have been identified in several instances and these make a full assessment of the BSA difficult. knowledge gaps are identified below and future recommendations are further discussed in the following section. We acknowledge that within this list there are a number of easier, more achievable gaps which can be filled, while others would require either large funds or systematic shifts in process (those relating to ICES or EU ways of working).

1. Many species caught within the BSA are regulated by TAC. Not all these are supported by assessments or information on stock status including reference points. These are required for all commercially exploited species targeted in the area. This would improve monitoring and protection of vulnerable species and sensitive fish stocks.ICES is continuously working on improving the basis of the catch advice and has developed methods to estimate proxy-reference points for stocks that cannot be analytically assessed. Indicators of stock status of commercially exploited species are also being developed under MSFD descriptor D3. This work will address some of these gaps but there is room for Ireland to develop assessments independently, particularly for stocks that occur exclusively within Irish waters.
2. Irish effort in relation to the crab fishery was estimated to regularly exceed the established effort limitations. The limited information pertaining to the state of the crab fishery makes assessing the validity of this estimation and its impact difficult.
3. The presence of sensitive life history stages were part of the substantiating evidence for the formation of the BSA. This information is an important part of assessing the managements function and effectiveness. A lack of information was highlighted for several commercially important species, particularly anglerfish, many of the bycatch species such as elasmobranchs, and life history stages, notably egg and larval stages. For this, up-to-date information is required to map spawning and nursery areas. In this report, these were produced based on open source ICES surveys.
    a. Egg and larval surveys are conducted in the BSA, including the tri-annual ICES mackerel egg survey. This survey gathers a large amount of information that is not currently utilised. This includes identification of species other than mackerel and horse mackerel. In some years hake eggs and larvae have been identified but this is not a requirement or done routinely. Increasing the capacity of this work to include the identification of the full range of eggs and larvae species collected would provide additional and much-needed insight into the use of the area as a spawning ground. Samples from previous surveys (where available) could easily be post-processed for additional species for comparatively little additional investment adding value to the overall survey. Priority should be given to hake given current knowledge of their use of the area for spawning, followed by other species of commercial importance such as gadoids. Furthermore, the addition of days to the existing survey would enable stations within the southern, south-eastern area of the BSA to be sampled. This would present a much more cost effective alternative than developing a dedicated egg survey within the BSA. Having an additional expert on board dedicated to identifying hake eggs/ larvae could also be a consideration for future surveys.

b. Routine ICES surveys use a specific set of sampling gear and sampling locations, these gears or locations are not always appropriate to target all species and their life stages present within an area. Expansions to the sampling gear used to include a greater representation of flatfish within the BSA would provide much-needed information regarding these commercially important species. This could be done by adding days to existing ground fish surveys during which time alternative gear could be applied or inshore stations sampled encompassing targeted areas of the BSA, with the possibility of targeting different areas on a longer-term cycle.

c. Two discontinued quarter one surveys used to collect samples from within the BSA. An Irish survey which took place between February and March from 2004 to 2009, and a UK groundfish survey (Tidd and Warnes, 2006). The timing of this survey was ideal to collect information on the distribution of ripe and spawning adults. A new quarter one survey began in 2016, however, this survey specifically targets areas further offshore for anglerfish and megrim beyond the BSA boundaries. It is recommended that these surveys be expanded. By adding days to the existing survey, stations could be added to encompass targeted areas of the BSA, with the possibility of targeting different areas on a longer-term cycle. This would present a much more cost effective alternative than a dedicated monitoring survey within the BSA. Such data could then be added to existing information to further understand and validate current working knowledge of how species utilise the BSA for spawning. Data can be used with either simple presence/absence methods of reporting distribution or more complex modelling.

d. Many national institutes carry out additional, localised surveys, examining for example inshore areas or tagging surveys to track movement. Although occurrence of public sharing portals is increasing, data is not always available from such investigations. Increased accessibility of this information would be beneficial.

e. It is noted that ICES provide a wide variety of data within their open source portal. For bottom trawl surveys this has been coordinated into a user-friendly database (DATRAS). The same is not the case for pelagic surveys, where each survey for each year are presented, creating a barrier to its ease of use.

f. A restricted list of information collected from these surveys is required to be submitted to ICES, although additional information is routinely collected. For instance, the maturity status of sampled species is often collected but not submitted. This data would be of particular use in understanding the distribution of mature ripe individuals.

4. Several studies identified the presence of spawning and nursery areas for elasmobranchs within the BSA. This information was based on egg case beach searches and therefore only a rough estimate into the area and populations was possible. Further supporting evidence for these species, including information on the abundance, composition and distribution of elasmobranch species found in the BSA would prove beneficial. This could include the use of species distribution modelling methods such as effort-based modelling, taxon-based modelling (pseudo-absence modelling), presence-only modelling or expert-based modelling. Making use of the variety of ICES demersal species surveys, any more national surveys or commercial sampling, and available published or grey literature available in combination with environmental and habitat associated variables within the BSA to identify areas these

species are likely to occur. Priority should be placed first on the on the most critically endangered local species, then expanding out to those of lesser concern.

5. Anglerfish are an important commercial fishery in the BSA, however, spawning information about this species has yet to be identified, further studies are required to provide a greater understanding of how this important species utilises the area in and around the BSA. The Marine Institute has been carrying out a survey focused on sampling for mature and ripe anglerfish in quarter 1 since 2016. This timeseries should now be used to examine, model and estimate spawning areas.

6. The effectiveness of the hake box for hake and a variety of other species is thought to have been beneficial, particularly at reducing the catch of undersized species and therefore helping to build resilience into future recruitment (ICES, 2009a). However, conclusive evidence supporting the hake box is lacking. To further assess the benefits of the hake box, assessments comparing discard information from international trawls conducted inside and outside the hake box would be required.

7. Effort estimations and landings data is traditionally available to advisory groups reviewing fisheries management, including ICES and STECF. However, this data has been shown to be inconsistent with information submitted by Member States for the purposes of control and enforcement such as quota and effort uptake. The information submitted for control and enforcement should be made available to these advisory groups to improve the capacity to accurately review management impacts.

8. Further information on important habitats, such as feeding areas and migration routes is required. This information would enable a comprehensive understanding of the interconnectedness of the different environments supporting commercially important species within the BSA. Such work could be carried out via tagging studies, tracking movements of a small number of individuals to then infer habitat use and preference through modelling.

9. The diversity of habitats and the mixed fishery noted in the BSA means that the single-species approach to fisheries management in this area is not suitable. Studies within the BSA focusing on the ecosystem approach are needed to gain a comprehensive view of the links between species and the wider impacts of exploitation on the ecosystem.

10. Research on climate change is needed to understand how this may affect the range of species in the area and will enable improved awareness of the shifts which could be noted in fisheries and would require changes to management measures to ensure additional protection for these stocks.

7. Future steps

The BSA lacks clearly defined, measurable goals and objectives upon which the function and effectiveness of management measures can be assessed. This was also highlighted by ICES (2009a). Nor is there a specific monitoring plan or program for the area, this would be needed to ensure progress towards goals and objectives could be assessed. These two aspects are vital for any protected area. It is recommended that the concept of a BSA should be retained within the area given research to date has shown it to be an area of high biodiversity and hosts a range of sensitive habitats including SAC, SCIs, nursery and spawning areas. However, these clear goals, objectives, and monitoring need to be developed and put in place.

The BSA is an important area for commercial fisheries and a variety of species are targeted in these waters. The effort restrictions originally designed to manage the fishery and limit overfishing are no longer limiting. The lack of revisions to the effort limitations do not reflect the changing fishing practice and species composition within the area. Without regular review of management measures, certain species may be vulnerable to increased effort. An urgent revision of the effort management must be made, reducing effort to more recent levels. It is believed that for passive gears the effort measure currently in place is not appropriate and alternative measures such as soak time should be used. One of the main advantages of the effort regime is its ability to safeguard against the exploitation of new fisheries and effort dislocation (European Commission, 2010a). However, hybrid management systems are typically more effective, combining effort and TAC restrictions.

With the use of single species TAC restrictions, gaining an increased understanding of individual stocks is vital to determine whether activities are sustainable. However, a lack of assessments for a variety of species was identified and further assessments and reference points are needed for species in the area. This would improve monitoring and protection of vulnerable species (particularly elasmobranchs) and sensitive fish stocks. It is therefore advised that improving stock assessments to cover a wider range of species be made a priority.

Additional, spatially explicit, tools should be implemented to complement effort and TAC regimes, such as expansion of the BSA area, gear restrictions, technical measures, seasonal or temporary closures and move-on rules. A number of these types of measures currently exist within the BSA, and many are thought to hold value, particularly the hake box, closed seasons, gear restrictions, SAC's and SCI's. However, they are each governed independently and not linked to the status of the BSA. The cumulative impact of these measures is believed to be more effective than the BSA. Using this perspective of the cumulative impact, possible corridors and/ or the expansion of current measures can be further identified in line with the most effective measures to protect vulnerable habitats and areas. Increasing the use and area covered by technical measures designed to reduce the number of juveniles caught should be considered, similar to those applied within the hake box in which minimum mesh sizes were specified above those commonly applied within the area. Although no definitive studies into the value of the hake box have been made, the likely benefit in reducing juvenile bycatch in the area has been noted. A greater number of species utilising the BSA as a nursery ground could benefit from targeted technical restrictions. Investigations into such benefits and impacts on the economic viability of more inshore fisheries should be made.

From the information within this report, there are strong indications the BSA should be expanded to the west. This would be in order to protect spawning and nursery grounds for several species, including hake, which occur along and around the 200m depth contour. Such drop offs are recognised to play an important part in fish spawning aggregations and are often a vulnerable life stage and susceptible to overfishing. VMS data highlighted the same area as one with high fishing intensities, targeting the same species. The review by ICES (2009a) suggests a seasonal closure: "*Thus if the objectives are to protect hake at spawning time then an area along the 500-120m depth contour from 45° N to 55° N from February to July would cover the majority of the Northern spawning area."* An expansion of the BSA and application of a seasonal closure should be considered for this area. The extent of the value this area has is not yet fully understood, further research into this area is therefore advised. A western extension of the BSA could pose additional challenges, extending into deeper waters and additional species with their own vulnerabilities.

The presence of several critically endangered elasmobranch species has been highlighted in this area, which urgently requires proactive protection and research into local distribution and habitat use in order to better protect spawning and nursery life stages. Although no targeted fisheries are apparent on many of the elasmobranch species, bycatches from the trawl fishery and the tangle net fishery are a concern particularly in the vicinity of Tralee Bay (ICES, 2018n). It is noted, that the tangle net fishery is prohibited in the vicinity of Tralee Bay although enforcement is difficult. Further measures to enforce this and mitigate bycatch are required (ICES, 2018n). New special protection areas within the BSA could be formed for the protection of species on the OSPA list of threatened and declining species including endangered skates, for example in Tralee Bay.

Ecosystems are intrinsically linked and measures implemented in one area or on one species can create a secondary impact on others. For instance, the effort reduction has resulted in reduced bottom trawling and therefore a decrease in spatial intensity and footprint of trawling, reducing the pressure on the seabed (ICES, 2018b). This is just one example of why a full and connected (ecosystem) view of the area and subsequent management measures are necessary. Further investigation into the Ecosystem Approach to Fisheries Management (EAFM) is advised. The EAFM is one of the most effective forms of management and forms part of a variety of international agreements and the reform of the Common Fisheries Policy (DAFF, 2009). The EAFM views management measures within the context of the whole ecosystem and links stakeholders, fisheries management, governance and both human and ecosystem wellbeing (DAFF, 2009). For effective management, a mixture of different management measures are recommended (ICES, 2009a). This style of management is in line with recommendations from the European Commission: *"An ecosystem-based approach to fisheries management needs to be implemented, environmental impacts of fishing activities should be limited and unwanted catches should be avoided and reduced as far as possible* (EU, 2013a)*."*

Clear standardised effort reporting methods needed to be defined, the recent improvements in monitoring and reporting systems on board fishing vessels should aid this process. Uptake as reported to monitoring and enforcement agencies needs to be shared with those bodies and agencies tasked with reviewing management effectiveness. At present, various reporting bodies have different requirements for reporting information. A concerted effort to standardise reporting requirements across all Member States submitting information and organisations compiling it may help reduce variations in estimations and errors and improve analyses.

Any changes to current measures should be further researched and consultation with the fishing community should be held to improve support, knowledge, and compliance of measures with an aim of creating a beneficial integrative community approach (Jones, 2012).

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Appendix 1 Review of literature papers and scoring

Number	Author	Year	Title	Quality of Information Source	Applicability of Evidence	Strength of Conclusion	Total rating
1	Aires et al	2014	Updating fisheries sensitivity maps in British waters	5	5	5	15
2	BIM	2006	Fisheries Management	5	5	5	15
3	BIM	2007	Fisheries Management	5	5	5	15
4	BIM	2008	Fisheries Management	5	5	5	15
5	BIM	2009	Fisheries Management	5	5	5	15
6	BIM	2010	Fisheries Management	5	5	5	15
7	BIM	2011	Fisheries Management	5	5	5	15
8	BIM	2012	Fisheries Management	5	5	5	15
9	BIM	2013	Fisheries Management	5	5	5	15
10	BIM	2014	Fisheries Management	5	5	5	15
11	BIM	2015	Fisheries Management	5	5	5	15
12	BIM	2016	Fisheries Management	5	5	5	15
13	BIM	2017	Fisheries Management	5	5	5	15
14	BIM	2018	Fisheries Management	5	5	5	15
15	BIM	2019	Fisheries Management	5	5	5	15
16	BIM	2020	Fisheries Management	5	5	5	15
17	Bodey *et al*	2014	Seabird movement reveals the ecological footprint of fishing vessels	5	4	5	14
18	Caddey & Agnew	2003	Recovery plans for depleted fish stocks: an overview of global experience.	5	5	5	15
19	Clark et al	2016	Ireland Red List No. 11: Cartilaginous fish (sharks, skates, rays and chimaeras).	5	5	5	15
20	Clark & Egan	2017	Good luck or good governance? The recovery of Celtic Sea herring	5	5	5	15
21	Coffey & Dwyer	2000	Manaing EC inshore fisheries: Time for change	5	5	5	15
22	Connolly et al	2009	MEFEPO North Western Waters Atlas	5	5	5	15
23	Creedon T	2003	Spanish said to be "hopping mad" after fishing negotiations"	3	5	5	13
24	Coull et al	1998	Fisheries Sensitivity Maps in British Waters.	5	5	5	15
25	Dawn-Hiscox	2018	Ireland-France Subsea Cable Limited plans cross-channel submarine system	4	5	5	14
26	Dedman	2017	Spatial approaches towards achieving management targets: the case of the elasmobranch fisheries in the Irish Sea	5	5	5	15
27	Dransfeld et al.,	2014	North Western Waters Atlas 3rd Edition	5	5	5	15
28	Department of Agriculture, Fisheries and Food	2009	Ireland's Response To the Commission's Green Paper on the Reform of the Common Fisheries Policy	5	5	5	15
29	EC	1985	European Communities. L302: 1-497. Documents concerning the ascension of the United Kingdom of Spain and the Portuguese Republic of the European Communities. Official Journal of the	5	5	5	15
30	EC	1993	Proposal for a Council Regulation on the management of the fishing effort relating to certain Community fishing areas and resources and modifying Regulations (EEC) 2847/93	5	5	5	15
31	EC	1995	Council Regulations (EC) No 685/95 of 27 March 1995 on the management of the fishing effort relating to certain Community fishing areas and resources	5	5	5	15
32	EC	1995	Council Regulations (EC) No 2027/95 of 15 June 1995 establishing a system for the management of fishing effort relating to certain Community fishing areas and resources	5	5	5	15
33	EC	1998	Council Regulations (EC) No 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms	5	5	5	15
34	EC	2001	Commission Regulations (EC) No 1162/2001 of 14 June 2001 establishing measures for the recovery of the stock of hake in ICES sub-areas III, IV, V, VI and VII and ICES divisions VIII a, b, d, e and associated conditions for the controlof activities of fishing vessels	5	5	5	15
35	EC	2002	exploitation of fisheries resources under the Common Fisheries Policy	5	5	5	15
36	EC	2002	Council Regulations (EC) No 2347/2002 of 16 December 2002 establishing specific access requirements and associated conditions applicable to fishing for deep-sea stocks	5	5	5	15

37	EC	2002	Fixing for 2003 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
38	EC	2002	No 494/2002 establishing additional technicalmeasures for the recovery of the stock of hake in ICES sub-areas III, IV, V, VI and VII and ICES divisions VIII a, b, d, e III, IV, V, VI and VII and ICES divisions VIII a, b, d, e	5	5	5	15
39	EC	2003	Article 6 of Council Regulation 1954/2003. On the management of the fishing effort relating to certain Community fishing areas and resources and modifying Regulation (EC) No 2847/93 and repealing Regulations (EC) No 685/95 and (EC) No 2027/95	5	5	5	15
40	EC	2003	Fixing for 2004 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
41	EC	2004	Council Regulation 1415/2004. Fixing the maximum annual fishing effort for certain fishing areas and fisheries	5	5	5	15
42	EC	2004	Fixing for 2005 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
43	EC	2005	Fixing for 2006 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
44	EC	2006	Fixing for 2007 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
45	EC	2006	Fixing for 2006 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
46	EC	2007	Fixing for 2008 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
47	EC	2008	Fixing for 2008 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
48	EC	2009	Fixing for 2009 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
49	EC	2010	Fixing for 2010 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
50	European Comission	2010	Communication from the Commission to the European Parliament and the Council. Review of fishing effort management in western waters. SEC(2010) 1367	5	5	5	15
51	EC	2011	Fixing for 2011 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
52	EC	2012	Fixing for 2012 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
53	EC	2013	Fixing for 2013 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
54	EC	2013	No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC	5	5	5	15

55	EC	2014	Fixing for 2014 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
56	EC	2015	Fixing for 2015 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
57	EC	2016	Fixing for 2016 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
58	EC	2017	Fixing for 2017 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
59	EC	2018	Fixing for 2018 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
60	EC	2019	Fixing for 2019 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
61	EC	2019	Fixing for 2019: the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters	5	5	5	15
62	EC	2020	Fixing for 2020 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required	5	5	5	15
63	EC	2020	Council Regulations (EU) 2020/123 of 27 January 2020 fixing for 2020 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters	5	5	5	15
64	Eigaard et al	2016	The footprint of bottom trawling in European waters: distribution, intensity, and seabed integrity	5	5	5	15
65	Eirgrid Group	2020	Celtic Interconnector	5	5	5	15
66	Electricity info	2020	Ireland – offshore wind	4	5	5	14
67	Ellis et al	2010	Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones)	5	5	5	15
68	Ellis et al	2012	Spawning and nursery grounds of selected fish species in UK waters	5	5	5	15
69	EU	2013	Regulations (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC	5	5	5	15
70	Farrell et al	2010	Sustainable fishing in Irish waters: assessment of current practices, policies and alternative approaches (Economics Working Paper no. 165)	5	5	5	15
71	Fitzpatrick et al	2005	Employing nested survey techniques to identify the relationships between benthic and pelagic environments within a 3-Dimensional framework	5	5	5	15
72	Flannery et al	2010	Preparing the ground for marine spatial planning in Ireland	5	5	5	15
73	Frid et al	2003	Environmental status of the european seas	5	5	5	15
74	Gaughan & Fitzgerald	2020	An Assessment of the Potential for Co-located Offshore Wind and Wave Farms in Ireland	5	5	5	15
75	Gerritsen & Lordan	2011	Integrating Vessel Monitoring Systems (VMS) data with daily catch data from logbooks to explore the spatial distribution of catch and effort at high resolution	5	5	5	15
76	Gerritsen & Lordan	2014	Atlas of Commercial Fisheries around Ireland, second edition	5	5	5	15

77	Gerritsen & Kelly	2019	Atlas of Commercial Fisheries around Ireland, third edition	5	5	5	15
78	Gov.ie	2020	Oil and Gas Exploration and Production	5	5	5	15
79	GOV.uk	2014	Manage your fishing effort: Western Waters crabs and scallops: https://www.gov.uk/guidance/manage-your-fishing-effort-western-waters-crabs	5	5	5	15
80	Hammond et al	2008	*Delphinus delphis*	5	4	5	14
81	Hiddink *et al.,*	2017	Global analysis of depletion and recovery of seabed biota following bottom trawling disturbance	5	5	5	15
82	ICES	2005	Report of the Working Group on Habitat Mapping (WGMHM)	5	5	5	15
83	ICES	2009	ICES Advice. Book 5: Celtic Sea and West of Scotland. Special Requests: Review of the Biologically Sensitive Area/Irish Box. 8 pp.	5	5	5	15
84	ICES	2009	Book 9 Widely Distributed and Migratory Stocks	5	5	5	15
85	ICES	2010	Working group for the Celtic Seas Ecoregion (WGCSE)	5	5	5	15
86	ICES	2012	Report of the ICES Advisory Committee 2012	5	5	5	15
87	ICES	2013	HAWG Report: Annex 5 – Stock Annex Herring in the Celtic Sea and VIIj	5	5	5	15
88	ICES	2013	Report of the ICES Advisory Committee 2013	5	5	5	15
89	ICES	2016	Stock Annex: Hake (Merluccius merluccius) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock (Greater North Sea, Celtic Seas, and the northern Bay of Biscay)	5	5	5	15
90	ICES	2017	Report of the Working Group on Celtic Seas Ecoregion (WGCSE)	5	5	5	15
91	ICES	2018	Stock Annex: Herring (Clupea harengus) in Divisions 7.a South of 52°30'N, 7.g, 7.h, 7.j and 7.k (Irish Sea, Celtic Sea, and southwest of Ireland)	5	5	5	15
92	ICES	2018	Celtic Seas ecoregion – Ecosystem overview	5	5	5	15
93	ICES	2019	Celtic Seas ecoregion – Fisheries overview, including mixed-fisheries considerations	5	5	5	15
94	ICES	2020	Cod (Gadus morhua) in divisions 7.e–k (western English Channel and southern Celtic Seas)	5	5	5	15
95	ICES	2020	Working Group on Elasmobranch Fishes (WGEF).	5	5	5	15
96	ICES	2020	Whiting (Merlangius merlangus) in divisions 7.b–c and 7.e–k (southern Celtic Seas and western English Channel)	5	5	5	15
97	ICES	2020	Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE; outputs from 2019 meet-ing).	5	5	5	15
98	ICES	2018	Report of the Working Group on Mixed Fisheries Advice (WGMIXFISH-ADVICE), 22–26 May 2017, Copenhagen, Denmark.	5	5	5	15
99	Kennedy	1994	SFF leads assault on permit plan	3	5	5	13
100	Kinsale energy	2016	History	5	5	5	15
101	Kinsale energy	2018	Kinsale Area Decommissioning Project: EIA Main text	5	5	5	15
102	Kinsale energy	2018	Kinsale Area Decommissioning Project: Non Technical summary	5	5	5	15
103	Kinsale energy	2020	Kinsale Alpha and Bravo Platforms Shallow Geological Survey	5	5	5	15
104	Kinsale energy	2020	Decimissioning	5	5	5	15
105	Lannin et al	2005	A bet-hedging strategy for hake enables maximum viable egg production	5	5	5	15
106	Lepic	2020	PSE Kinsale Energy ceases gas production from Kinsale field	5	5	5	15
107	Lordan & Gerritsen	2009	Working Document on the Assessment of the "Irish Box" in the context of the Western Waters Regime.	5	5	5	15
109	Lordan et al	2017	Porcupine Bank Nephrops Grounds (FU16) 2017 UWTV Survey Report and catch options for 2018	5	5	5	15

110	Lutchman et al	2007	Review of EU legislation and implementation of marine protected areas (MPAs)	5	5	5	15
111	McGown et al	2018	Overview Report on the Current State and Potential Future Spatial Requirements of Key Maritime Activities	5	5	5	15
112	Marine Dimensions	2015	To Improve Information Available for Management of Ireland's Threatened Species of Skate and Ray	5	5	5	15
113	Marine Institute	2003	Annual report	5	5	5	15
114	Marine Institute	2006	Assessing, researching and advising on the sustainable exploitation of living marine resources in a healthy ecosystem	5	5	5	15
115	Marine Institute	2006	Catch data	5	5	5	15
116	Marine Institute	2006	The Stock Book	5	5	5	15
117	Marine Institute	2007	The Stock Book	5	5	5	15
118	Marine Institute	2008	The Stock Book	5	5	5	15
119	Marine Institute	2020	The Stock Book	5	5	5	15
120	Marine Institute	2006	Oceans of Opportunity Exploring Ireland's Marine Resources	5	5	5	15
121	Marine Institute	2009	Review of the Fisheries of Relevance to Ireland	5	5	5	15
122	Marine Institute	2009	Atlas of the Commercial Fisheries Around Ireland	5	5	5	15
123	Marine Institute	2018	Cruise report Irish Anglerfish & Megrim Survey 2019	5	5	5	15
124	Marine Institute	2019	Cruise report Irish Anglerfish & Megrim Survey 2018	5	5	5	15
125	Marine Institute	2019	Shellfish stocks and fiseries review	5	5	5	15
126	Marine Institute	2020	New expedition finds deepest ever Irish corals	5	5	5	15
127	Minton et al	2018	*Globicephala melas*	5	4	5	14
128	MMO	2019	UK Sea Fisheries Statistics 2019	5	5	5	15
129	Natura	2020	Natura 2000 Network Viewer	5	5	5	15
130	Neachtain	2002	We must protect the fishing industry	2	5	5	12
131	Nolan et al	2010	A technical review document on the ecological, social and economic features of the North Western Waters region	5	5	5	15
132	Nolan et al	2011	North Western Waters Atlas 2nd Edition	5	5	5	15
133	Nortan et al	2018	Valuing Ireland's Coastal, Marine and Estuarine Ecosystem Services	5	5	5	15
134	Nortan et al	2018	Estimating the value of the benefit…	5	5	5	15
135	Orejas et al	2015	*Madrepora oculata*	5	5	5	15
136	Orejas et al	2015	*Lophelia pertusa*	5	5	5	15
137	Poseidon	2010	European Commission. LOT 2: Administrative experience with effort management concerning the NE Atlantic	5	5	5	15
138	Prez-dominguez et al	2016	Designing and applying a method to assess the sensitivities of highly mobile marine species to anthropogenic pressures	5	5	5	15
139	Richard	2020	Ireland fast-tracks seven offshore wind farms	3	5	5	13
140	Stange	2016	Building a knowledge base for management of a new fishery: Boarfish (Capros aper) in the Northeast Atlantic	5	5	5	15
141	STECF	2010	Report of the SGMOS-09-05 Working Group Fishing Effort Regime Part 3 Deep Sea and Western Waters	5	5	5	15
142	STECF	2010	Development of Protocols for Multi-annual Plan Impact Assessments	5	5	5	15
143	STECF	2011	Evaluation of Fishing Effort Regimes Deep Sea and Western Waters (STECF-11-12)	5	5	5	15
144	STECF	2017	Long-term management of skates and rays (STECF-17-21)	5	5	5	15
145	TeleGeography	2020	Submarinecablemap	5	5	5	15
146	Tidd & Warnes	2006	Species distributions from English Celtic Sea groundfish surveys, 1992–2003	5	5	5	15
147	Varian	2017	To identify spawning, nurseries and essential habitat of endangered skates off the west coast of Ireland.	5	5	5	15
148	Varian et al	2020	To identify spawning, nurseries and essential habitat of endangered skates off the west coast of Ireland	5	5	5	15

Appendix 2 Length frequency distribution

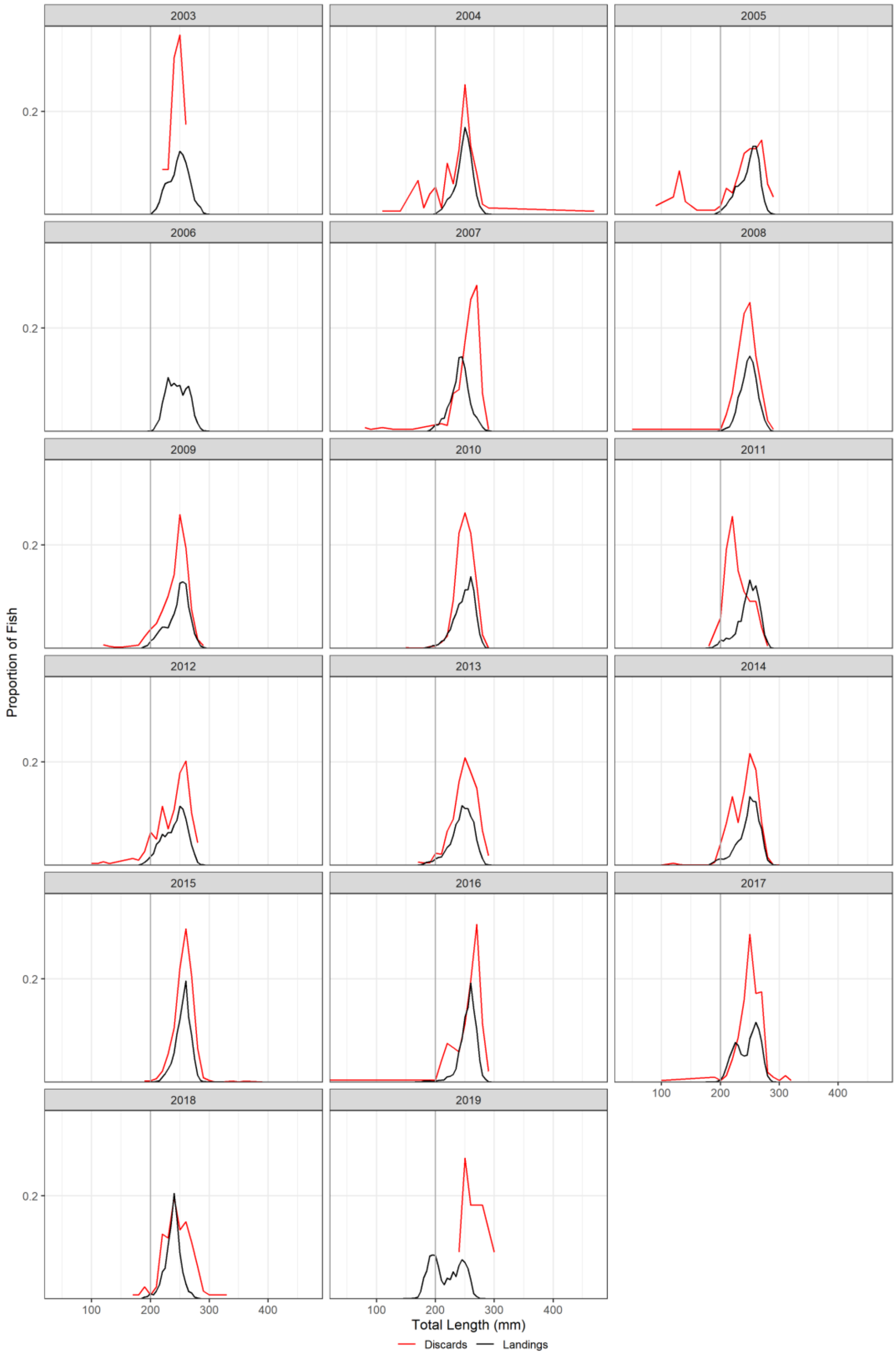

Figure A-2 1: Length frequency proportions from 2003 to 2019 for herring in ICES division VIIg. Vertical line indicated minimum landing size.

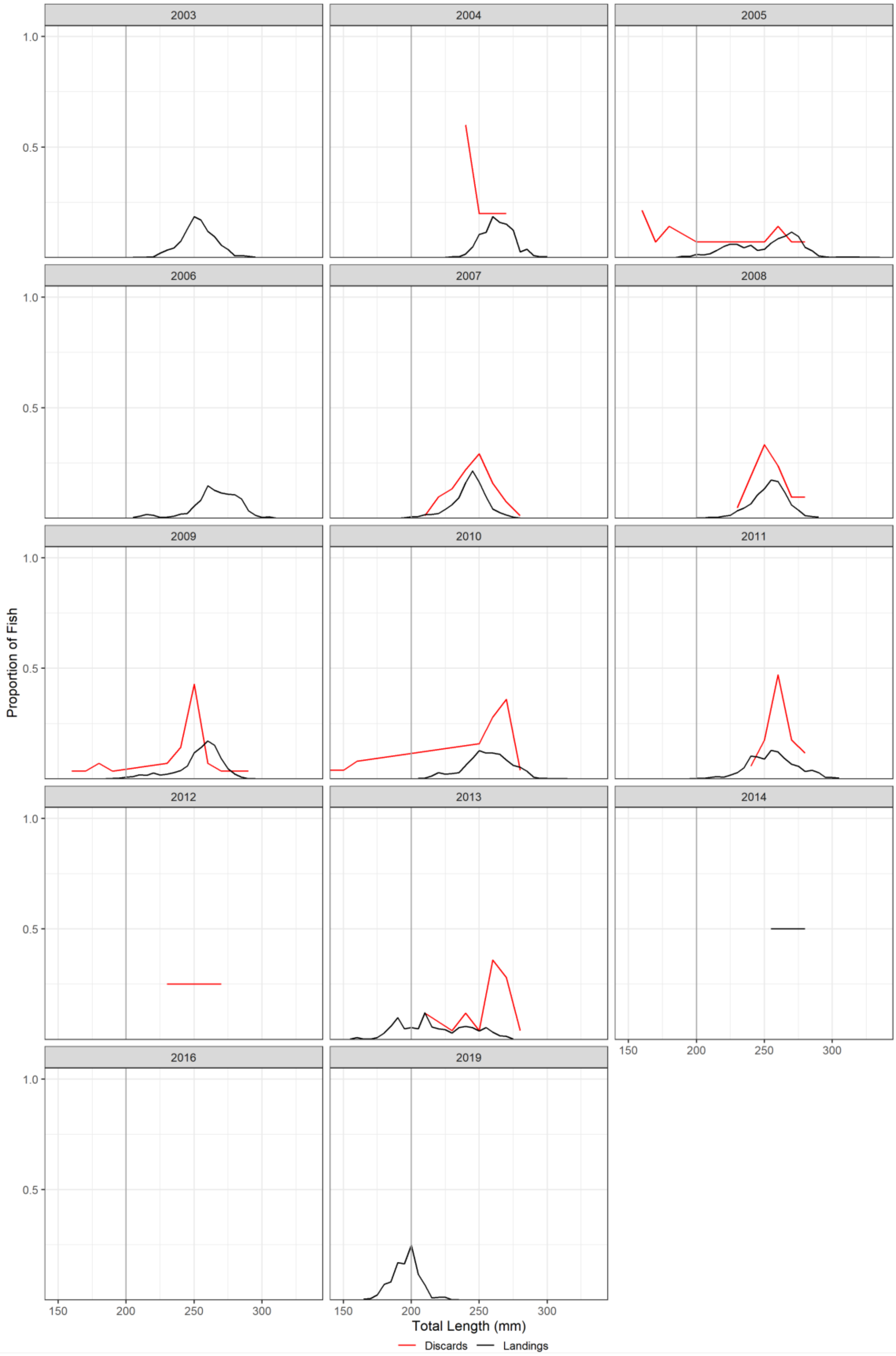

Figure A-2 2: Length frequency proportions from 2003 to 2019 for herring in ICES division VIIj. Vertical line indicated minimum landing size.

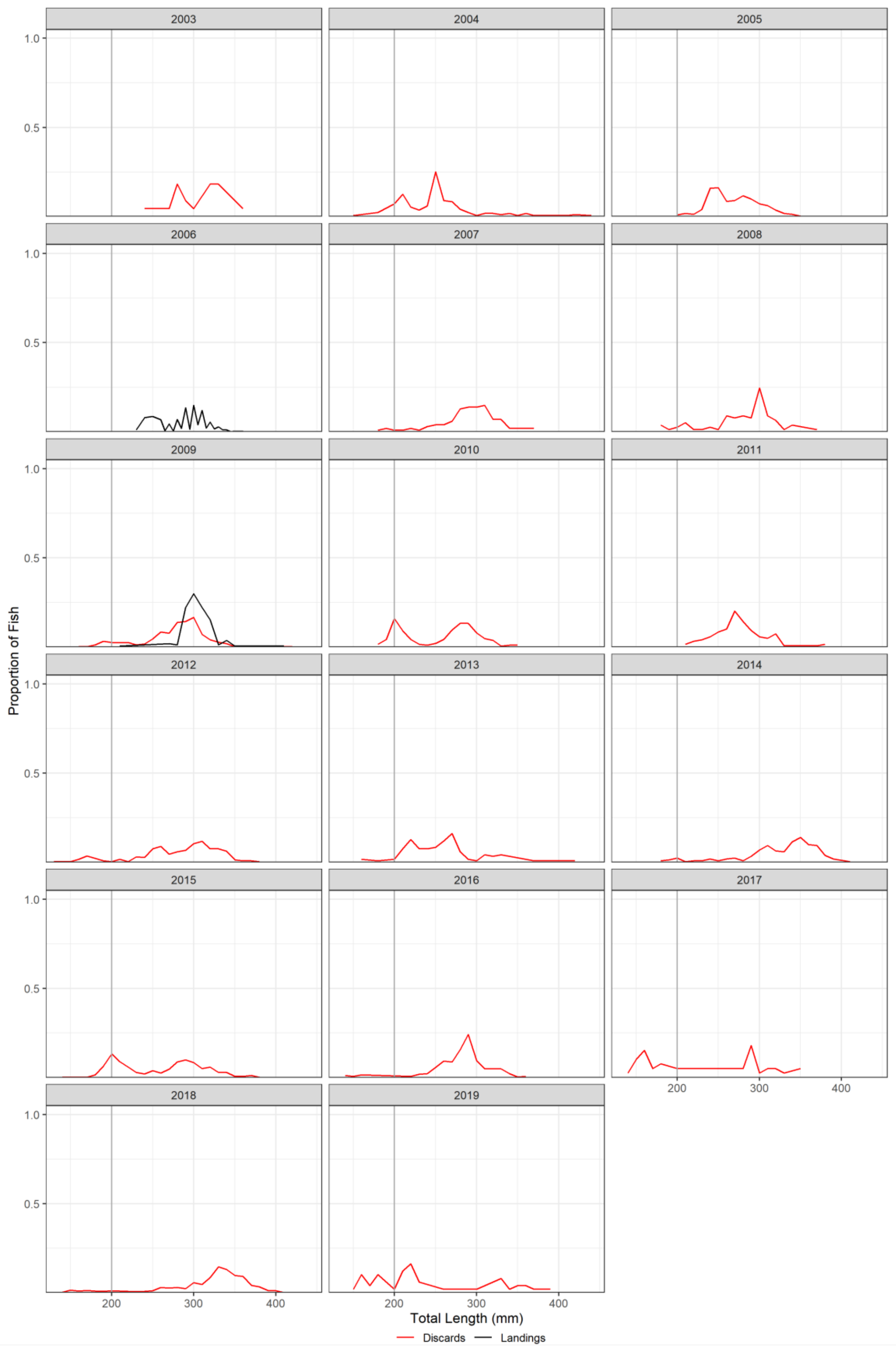

Figure A-2 3: Length frequency proportions from 2003 to 2019 for mackerel in ICES division VIIg. Vertical line indicated minimum landing size.

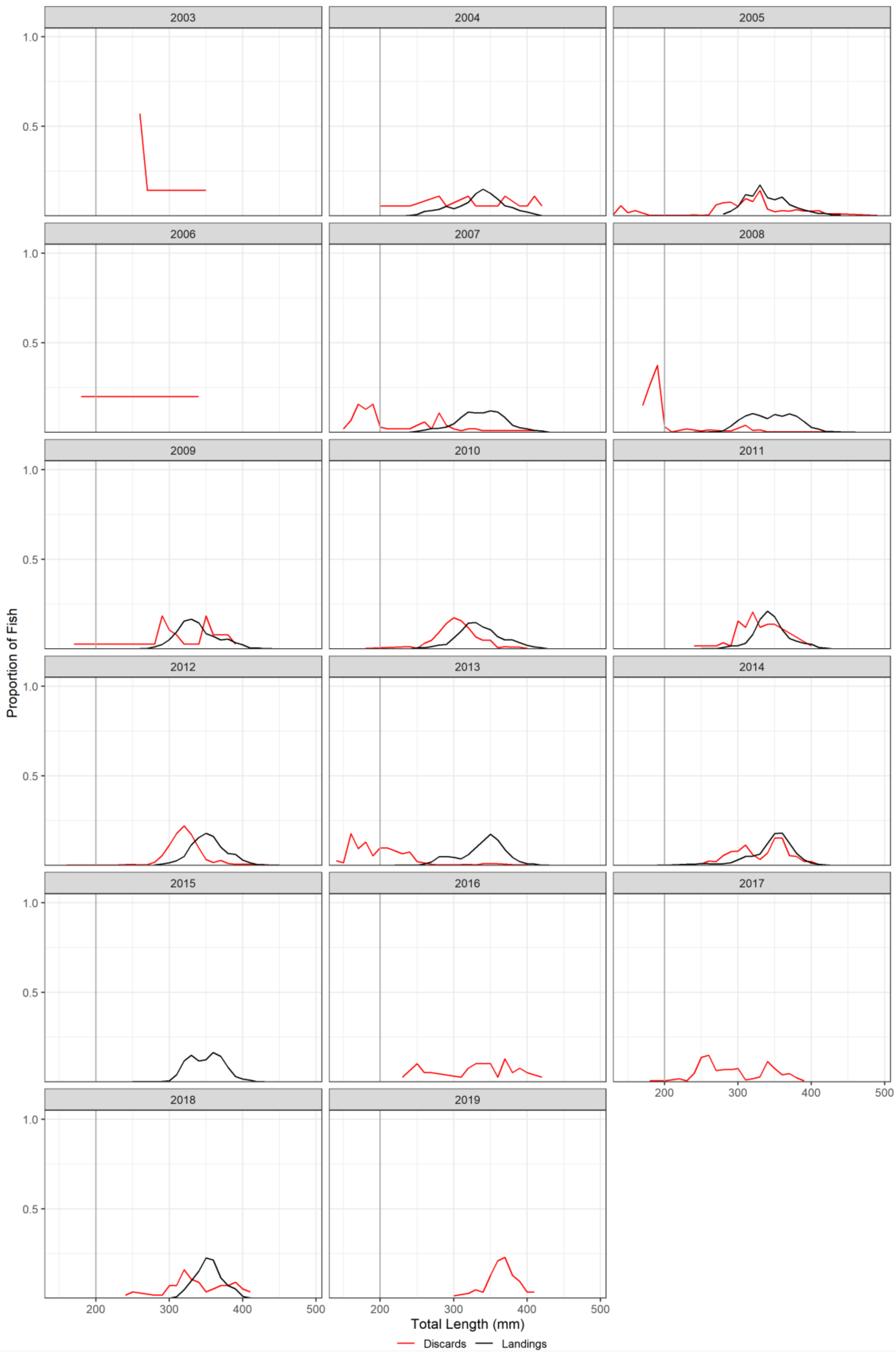

Figure A-2 4: Length frequency proportions from 2003 to 2019 for mackerel in ICES division VIIj. Vertical line indicated minimum landing size.

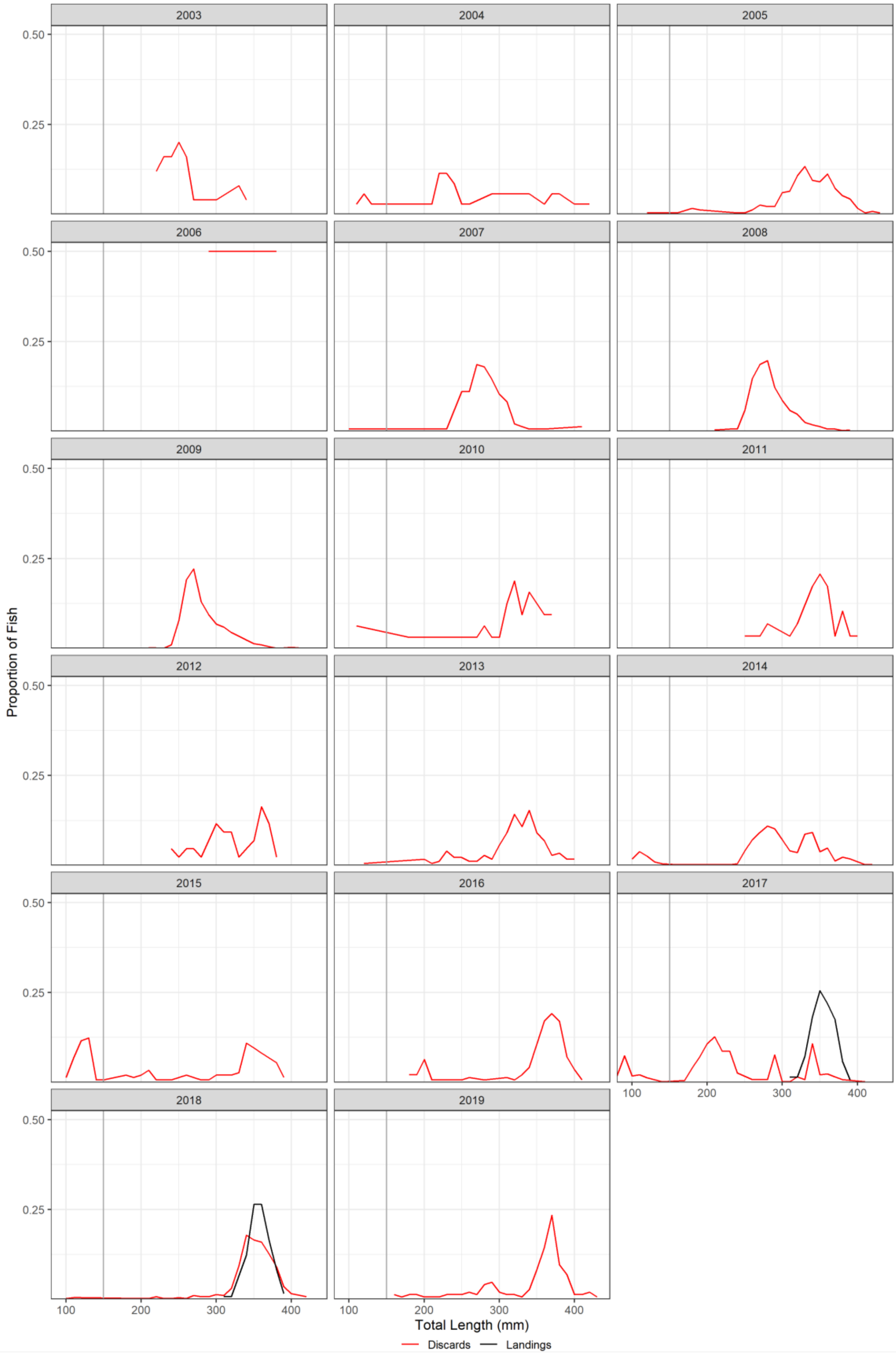

Figure A-2 5: Length frequency proportions from 2003 to 2019 for horse mackerel in ICES division VIIg. Vertical line indicated minimum landing size.

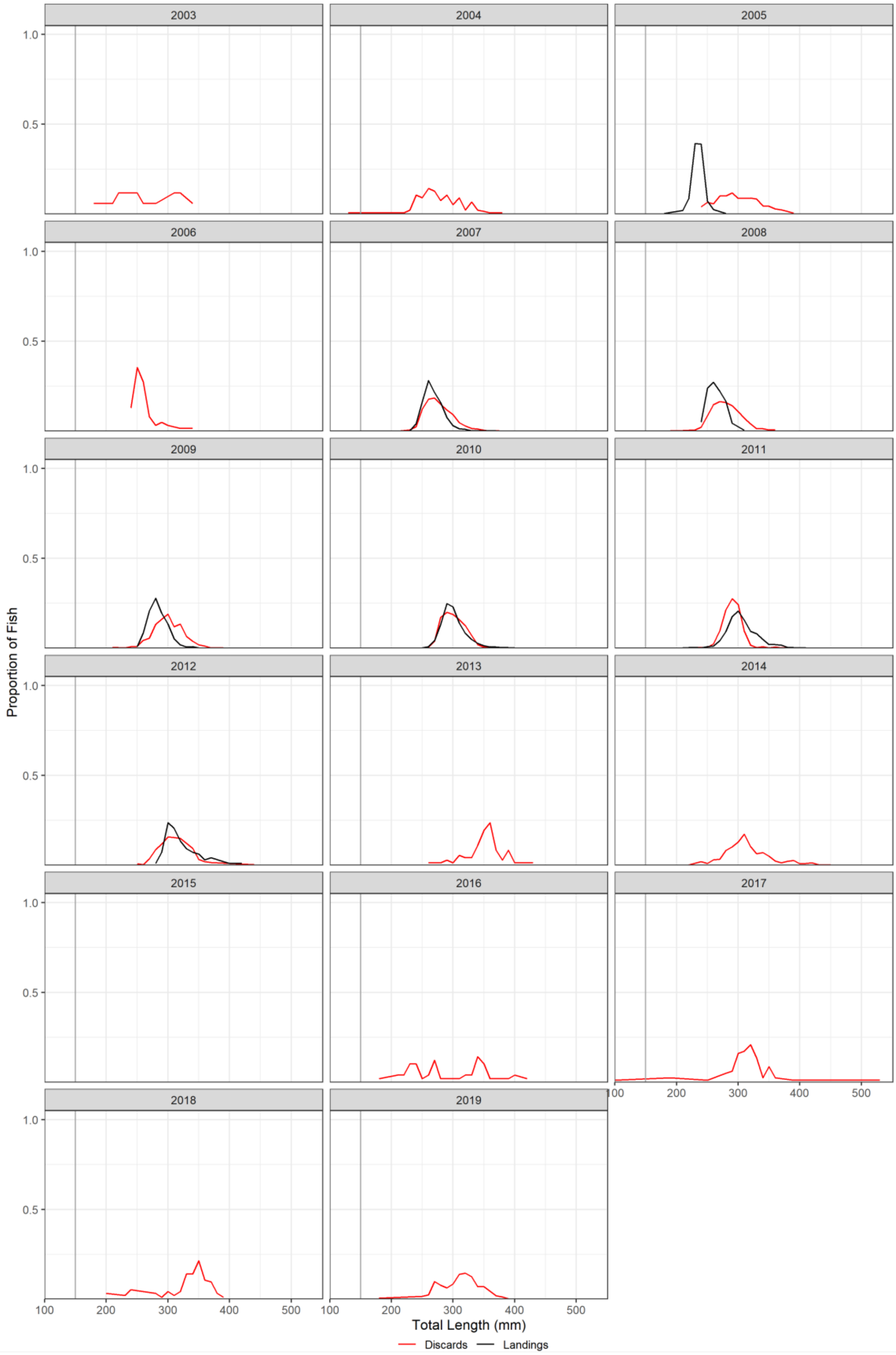

Figure A-2 6: Length frequency proportions from 2003 to 2019 for horse mackerel in ICES division VIIj. Vertical line indicated minimum landing size.

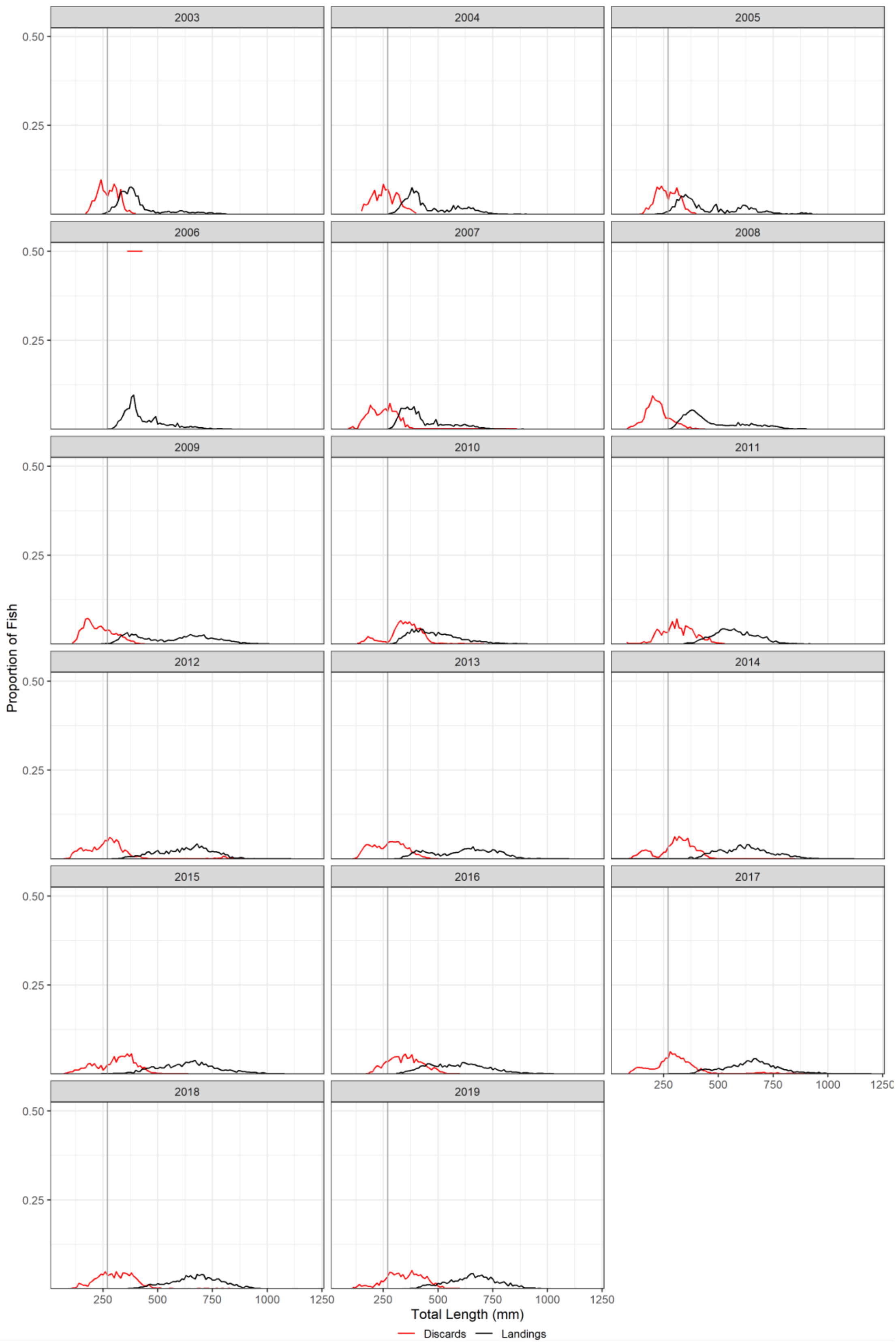

Figure A-2 7: Length frequency proportions from 2003 to 2019 for hake in ICES division VIIg. Vertical line indicated minimum landing size.

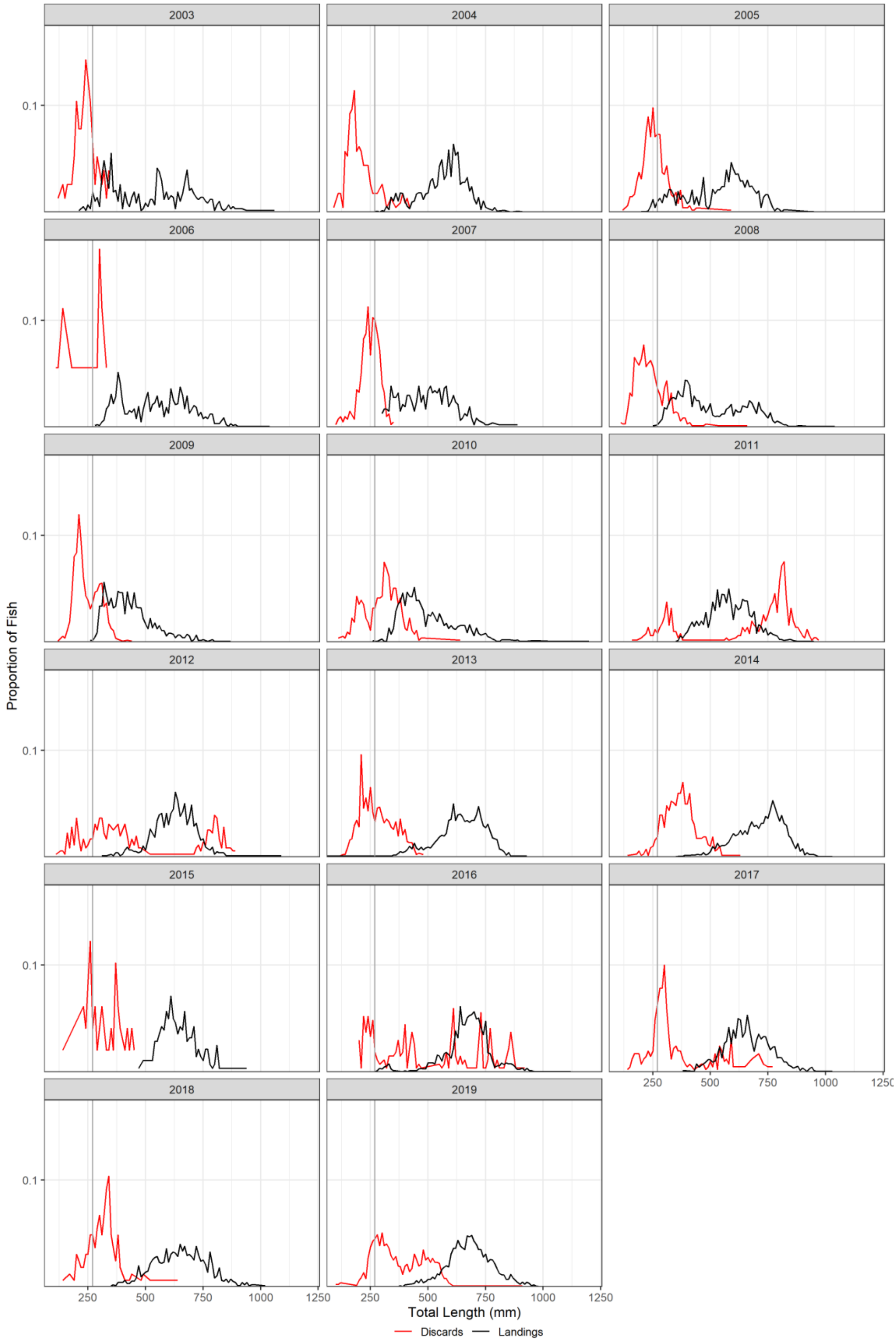

Figure A-2 8: Length frequency proportions from 2003 to 2019 for hake in ICES division VIIj. Vertical line indicated minimum landing size.

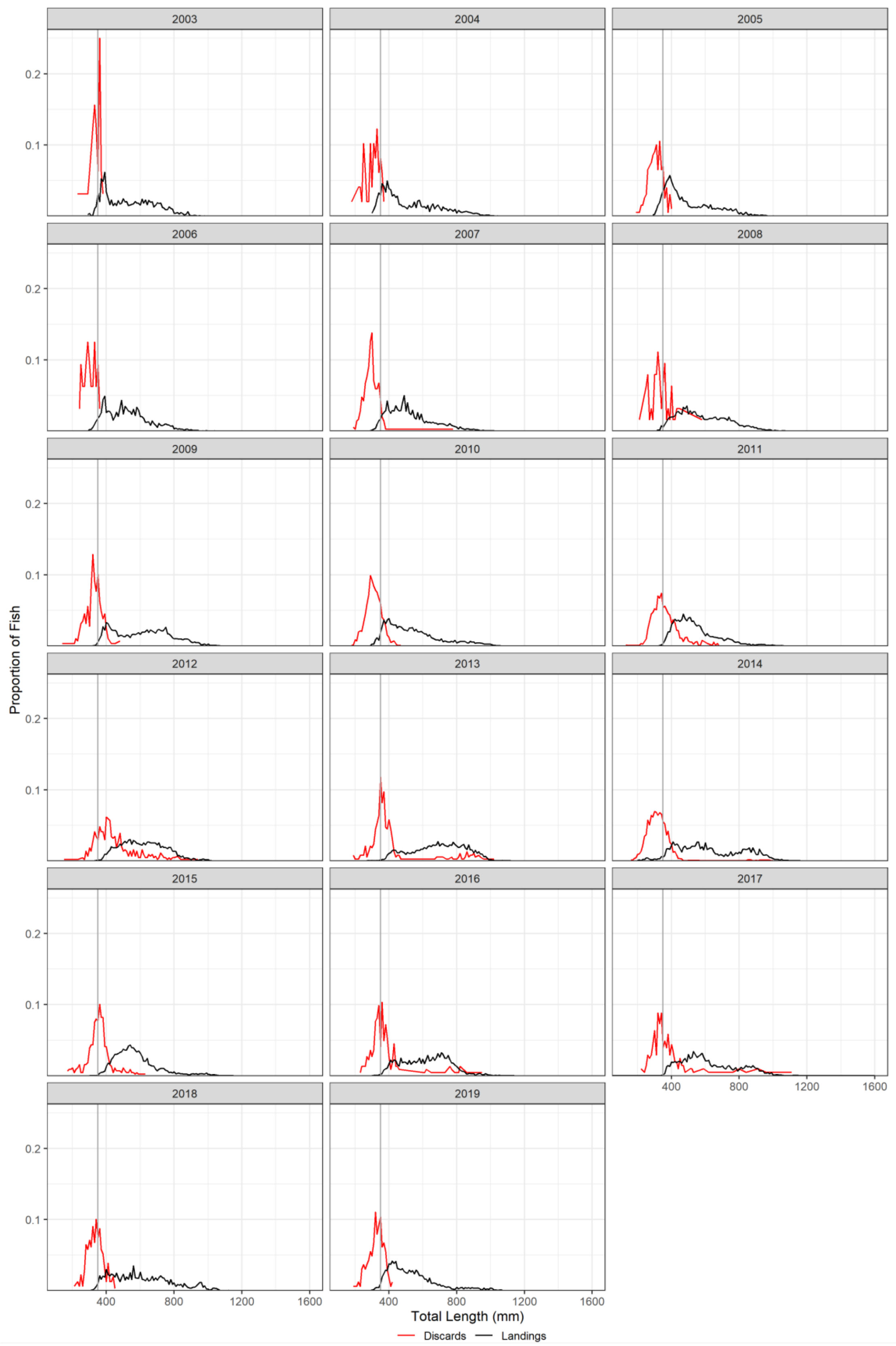

Figure A-2 9: Length frequency proportions from 2003 to 2019 for cod in ICES division VIIg. Vertical line indicated minimum landing size.

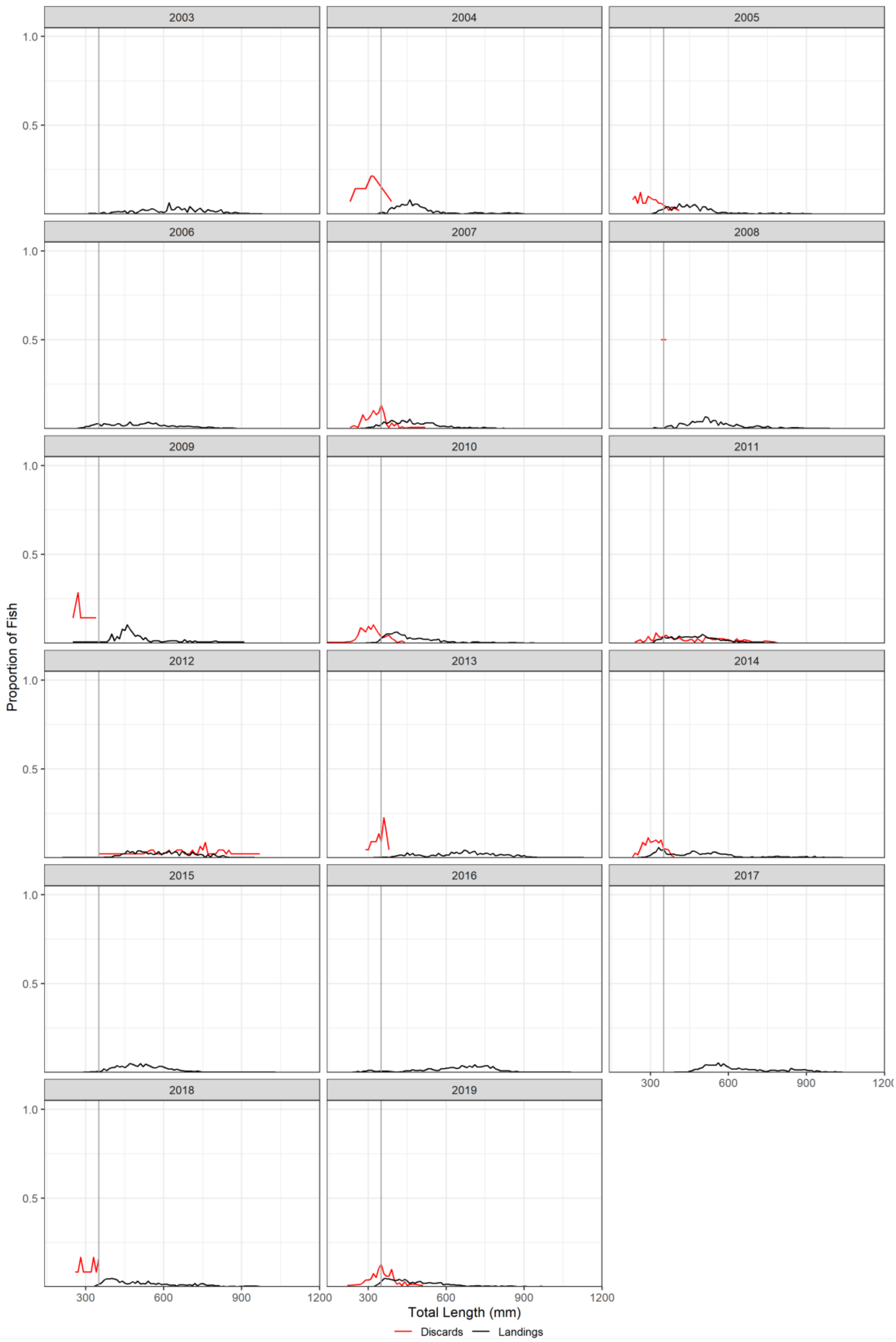

Figure A-2 10: Length frequency proportions from 2003 to 2019 for cod in ICES division VIIj. Vertical line indicated minimum landing size.

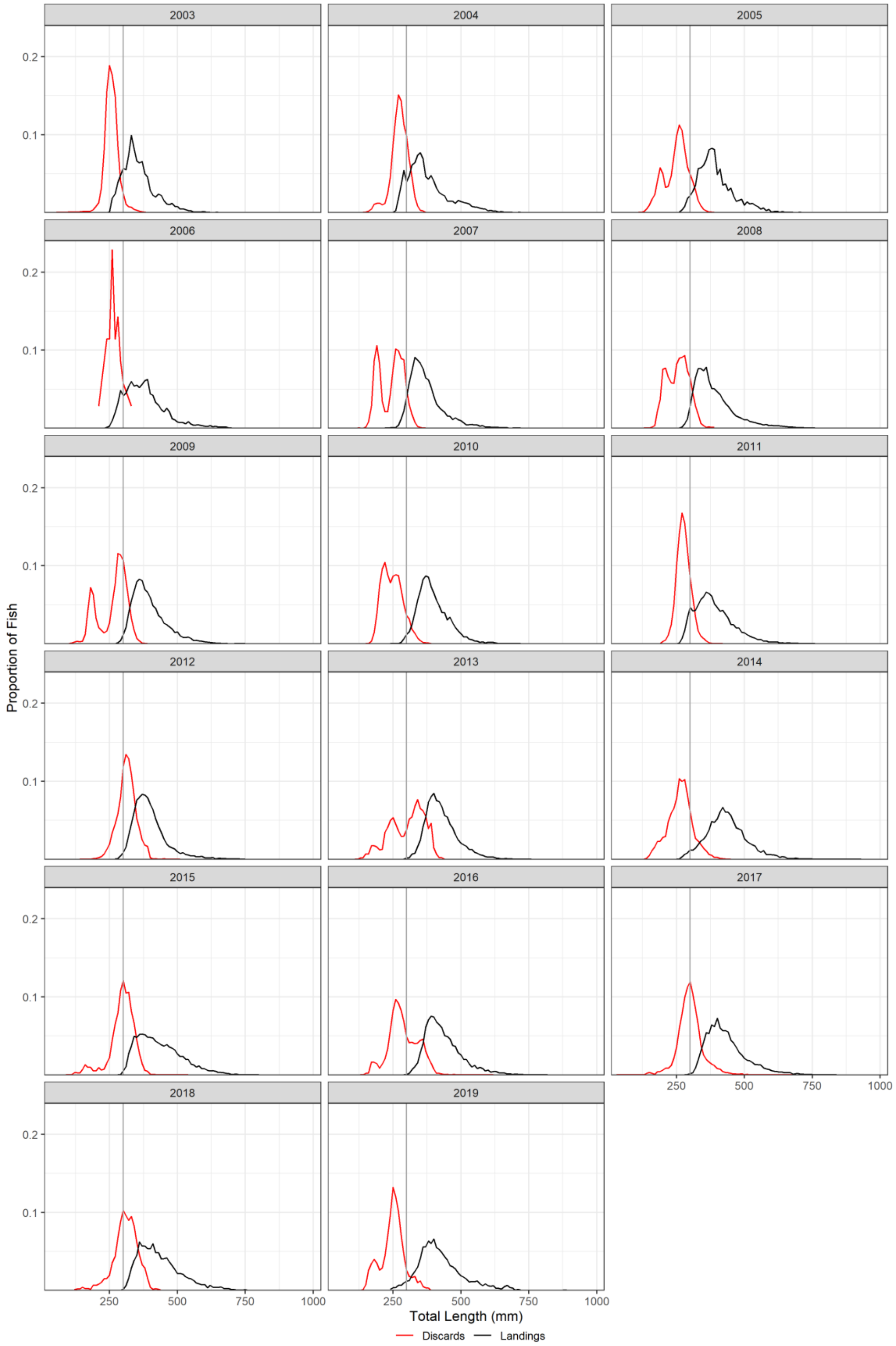

Figure A-2 11: Length frequency proportions from 2003 to 2019 for haddock in ICES division VIIg. Vertical line indicated minimum landing size.

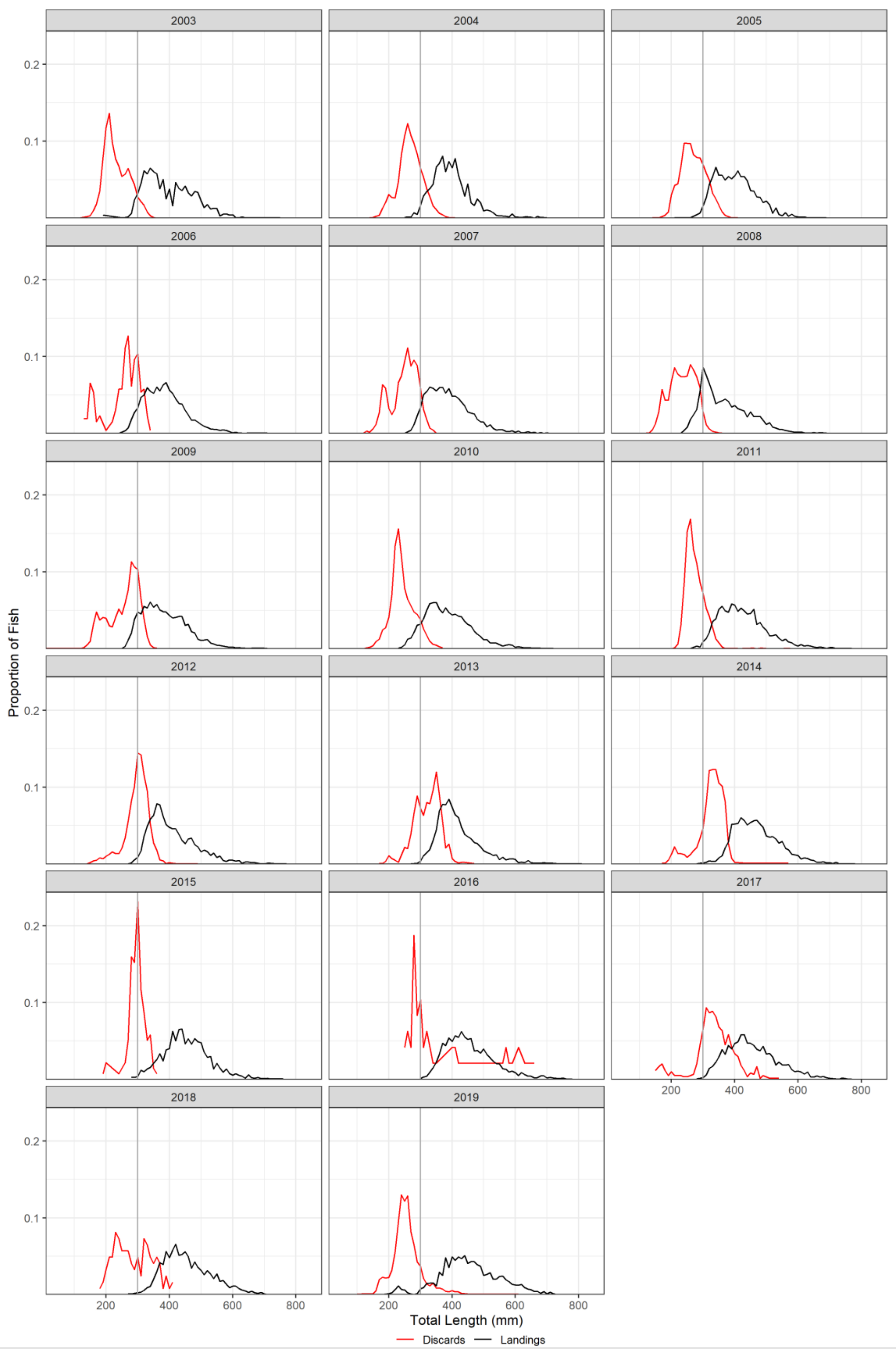

Figure A-2 12: Length frequency proportions from 2003 to 2019 for haddock in ICES division VIIj. Vertical line indicated minimum landing size.

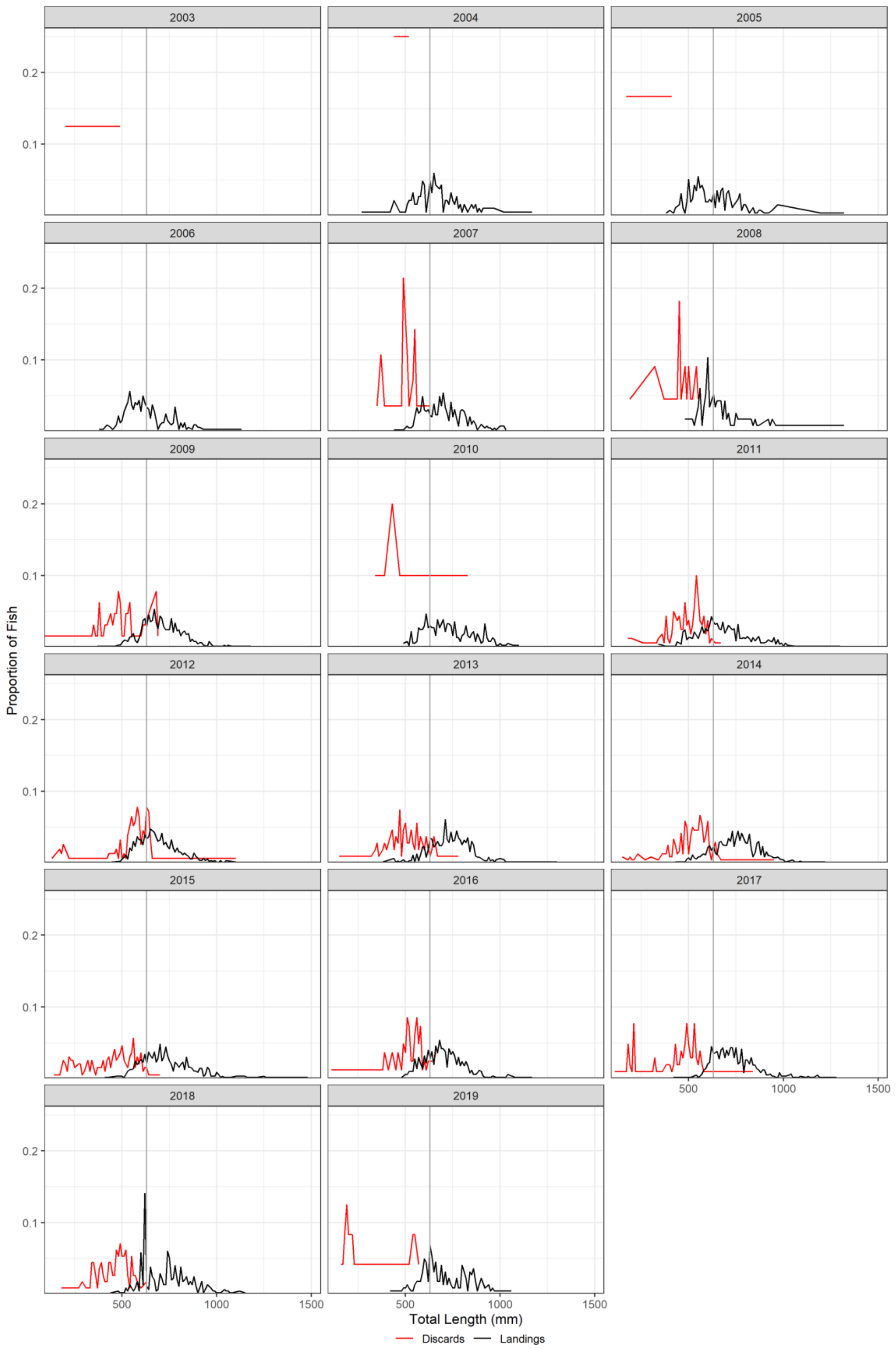

Figure A-2 13: Length frequency proportions from 2003 to 2019 for ling in ICES division VIIg. Vertical line indicated minimum landing size.

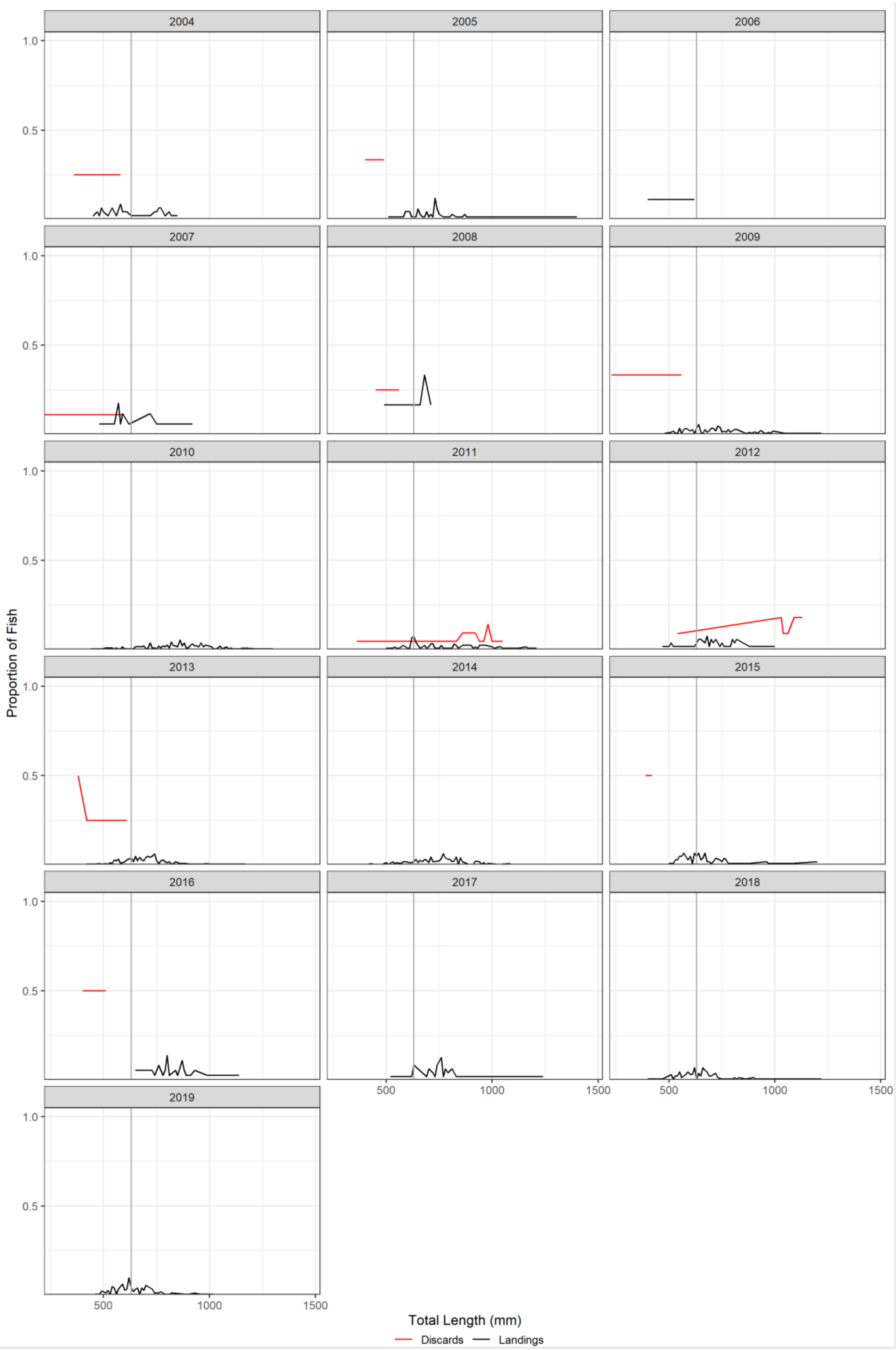

Figure A-2 14: Length frequency proportions from 2003 to 2019 for ling in ICES division VIIj. Vertical line indicated minimum landing size.

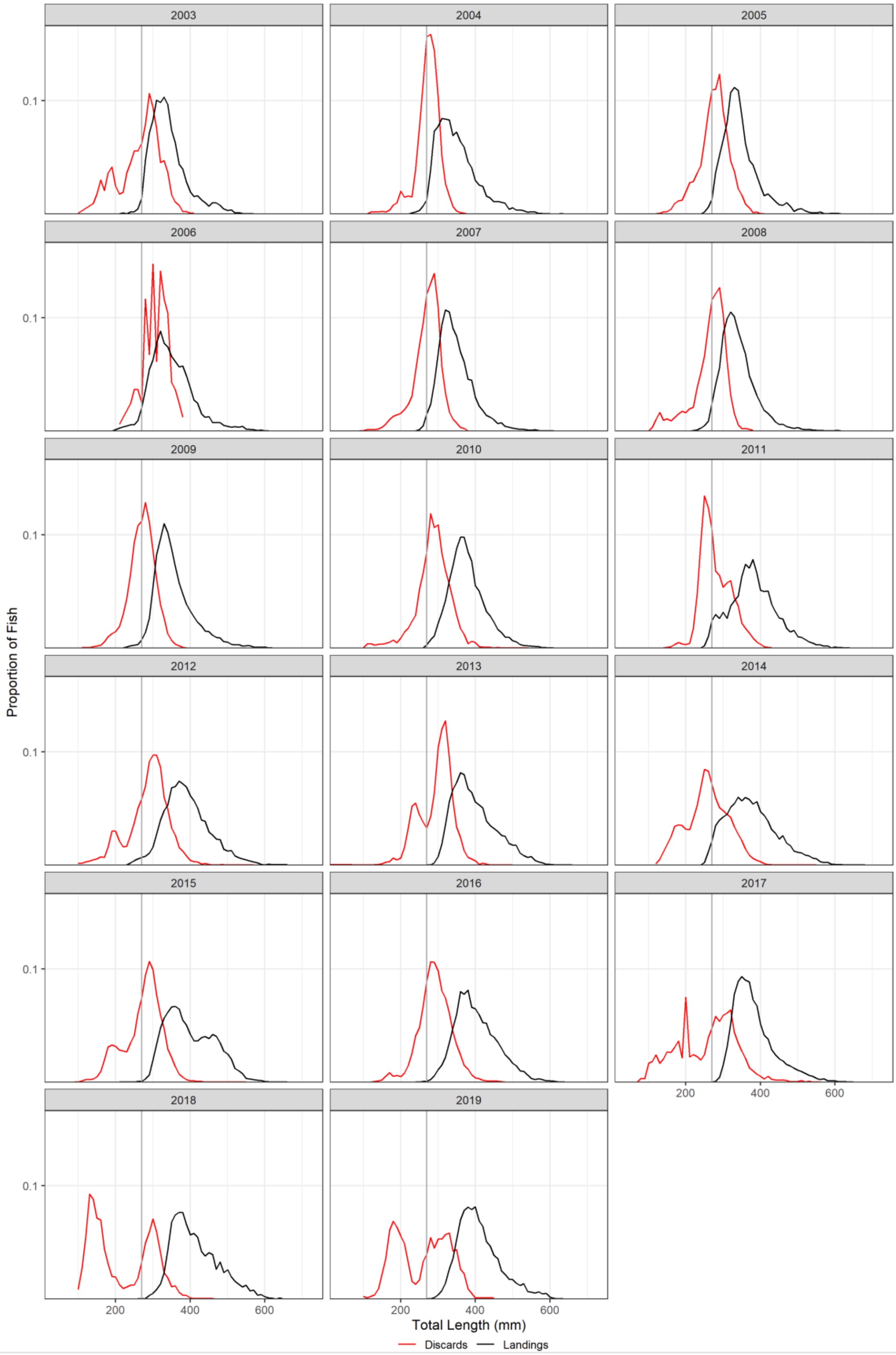

Figure A-2 15: Length frequency proportions from 2003 to 2019 for whiting in ICES division VIIg. Vertical line indicated minimum landing size.

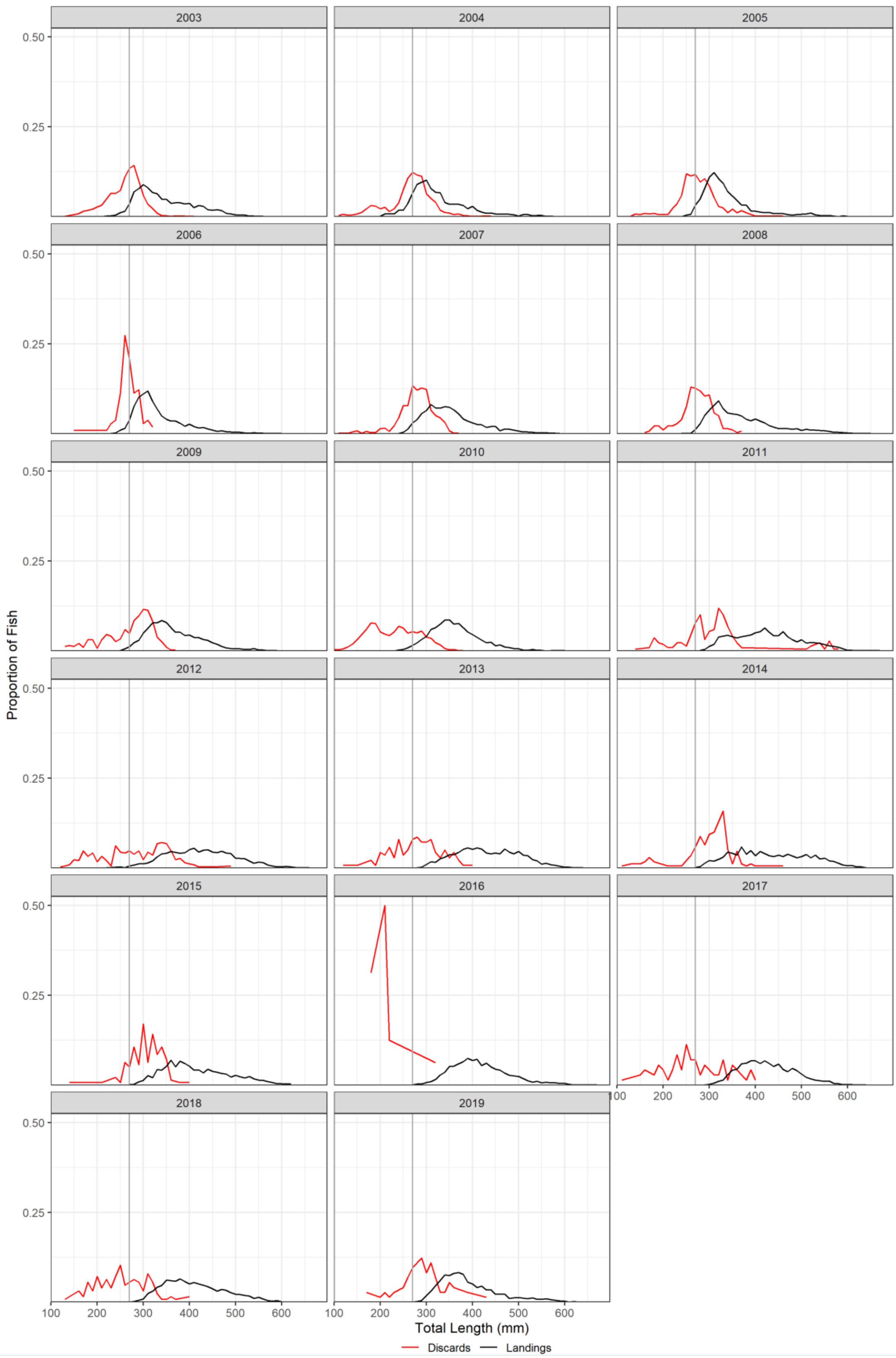
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
0.50
0.25
Proportion of Fish
100
200
300
400
500
600
Total Length (mm)
Discards
Landings

Figure A-2 16: Length frequency proportions from 2003 to 2019 for whiting in ICES division VIIj. Vertical line indicated minimum landing size.

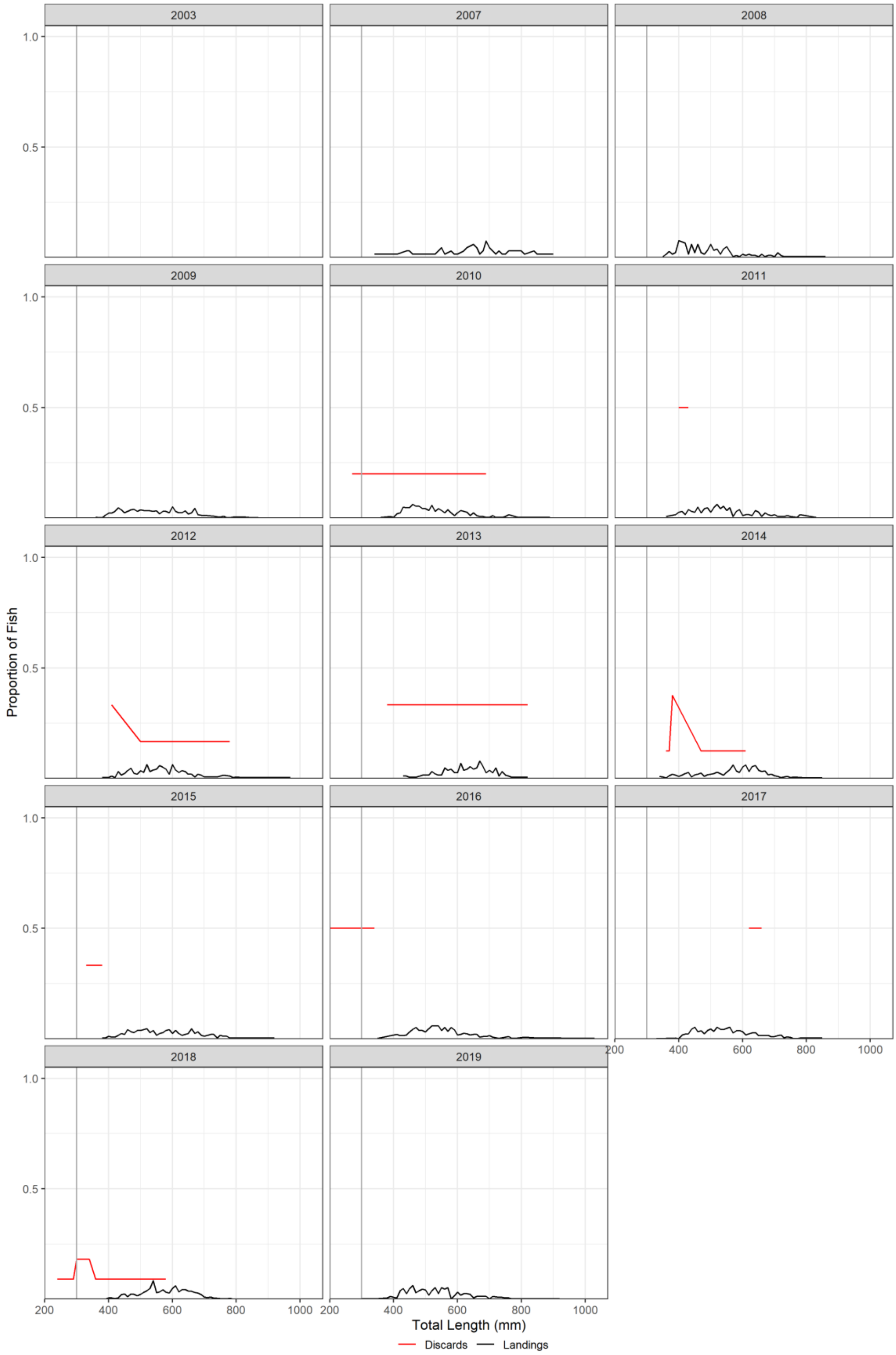

Figure A-2 17: Length frequency proportions from 2003 to 2019 for pollack in ICES division VIIg. Vertical line indicated minimum landing size.

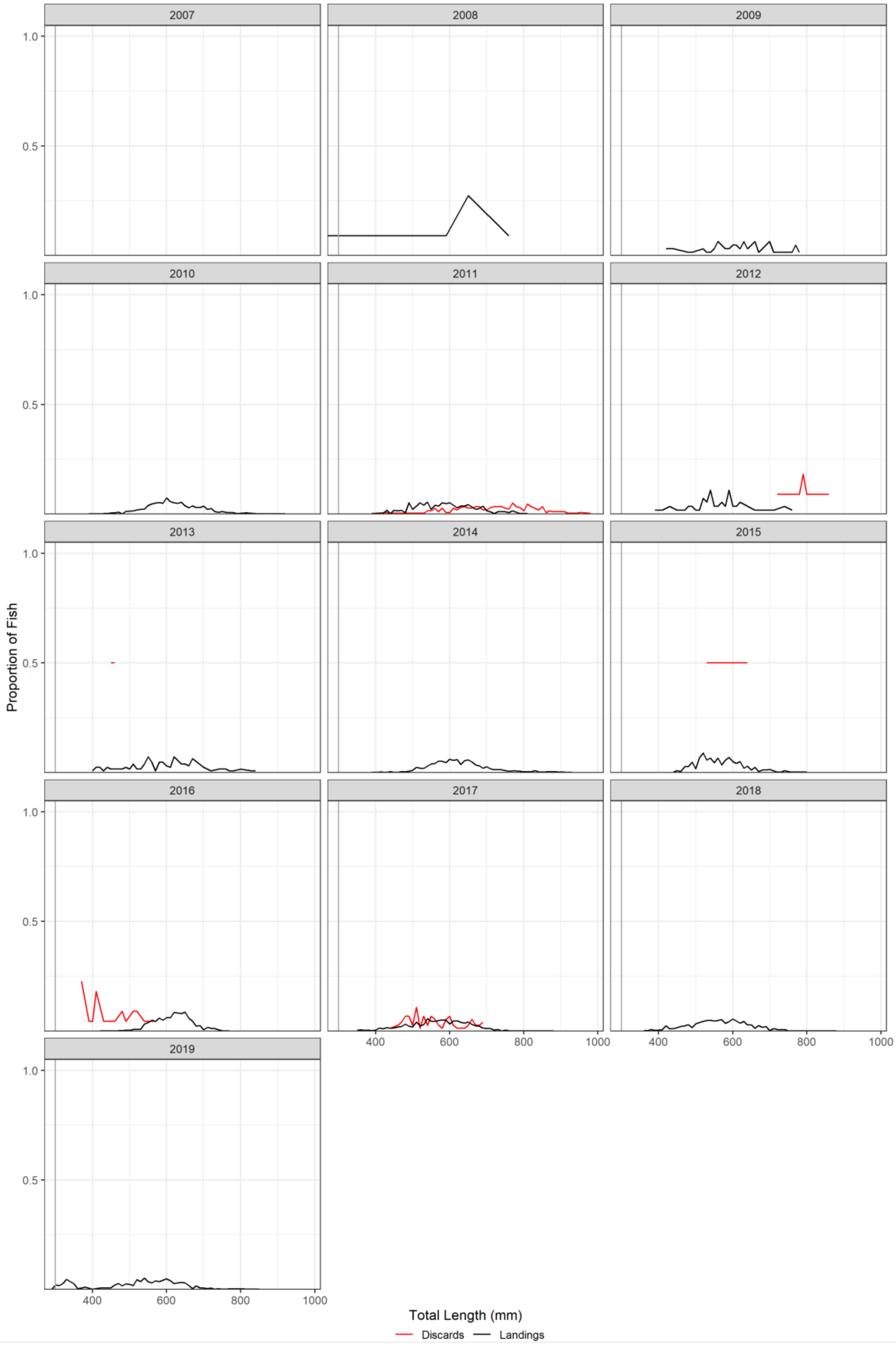

Figure A-2 18: Length frequency proportions from 2003 to 2019 for pollack in ICES division VIIj. Vertical line indicated minimum landing size.

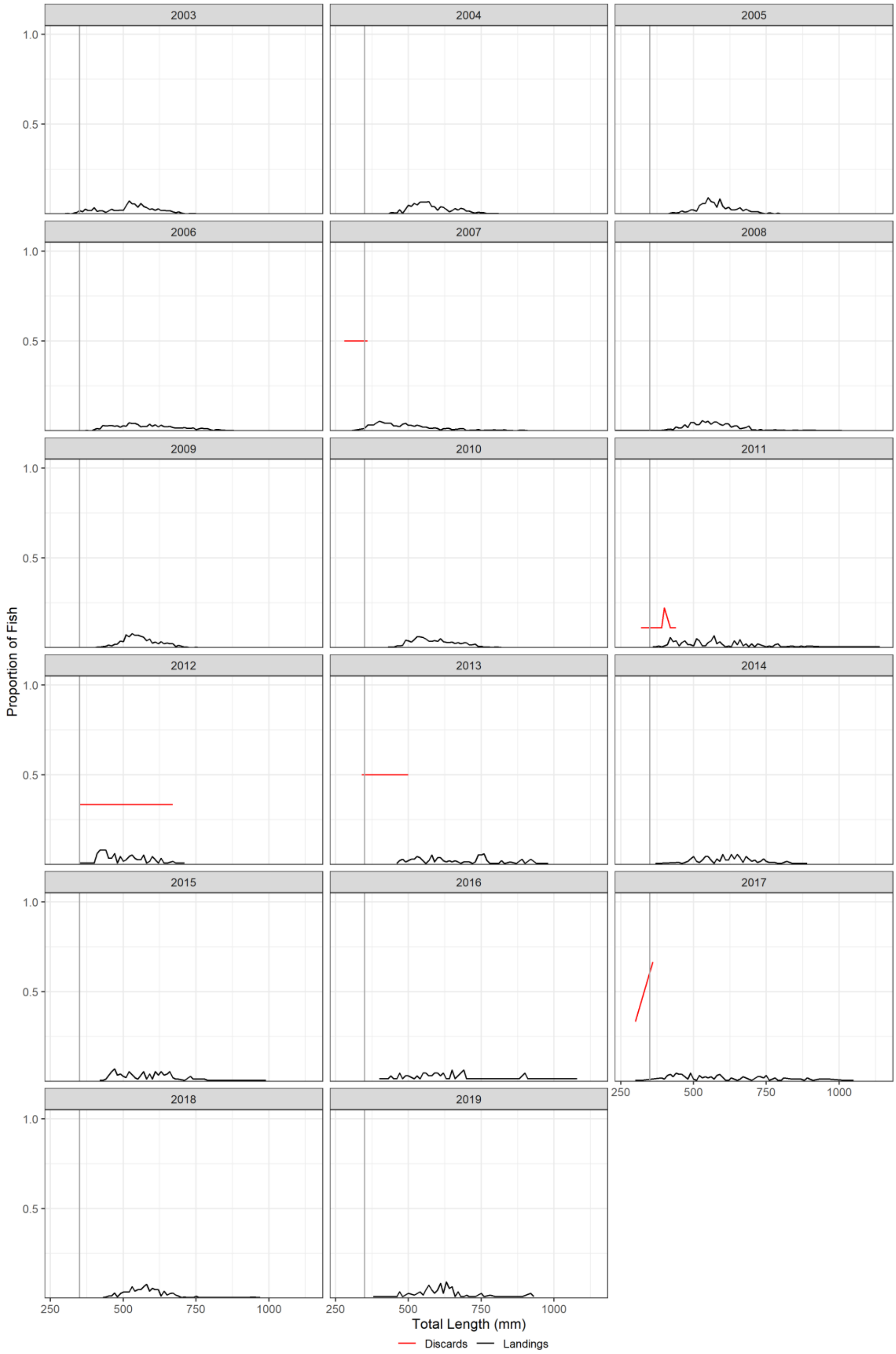

Figure A-2 19: Length frequency proportions from 2003 to 2019 for saithe in ICES division VIIg. Vertical line indicated minimum landing size.

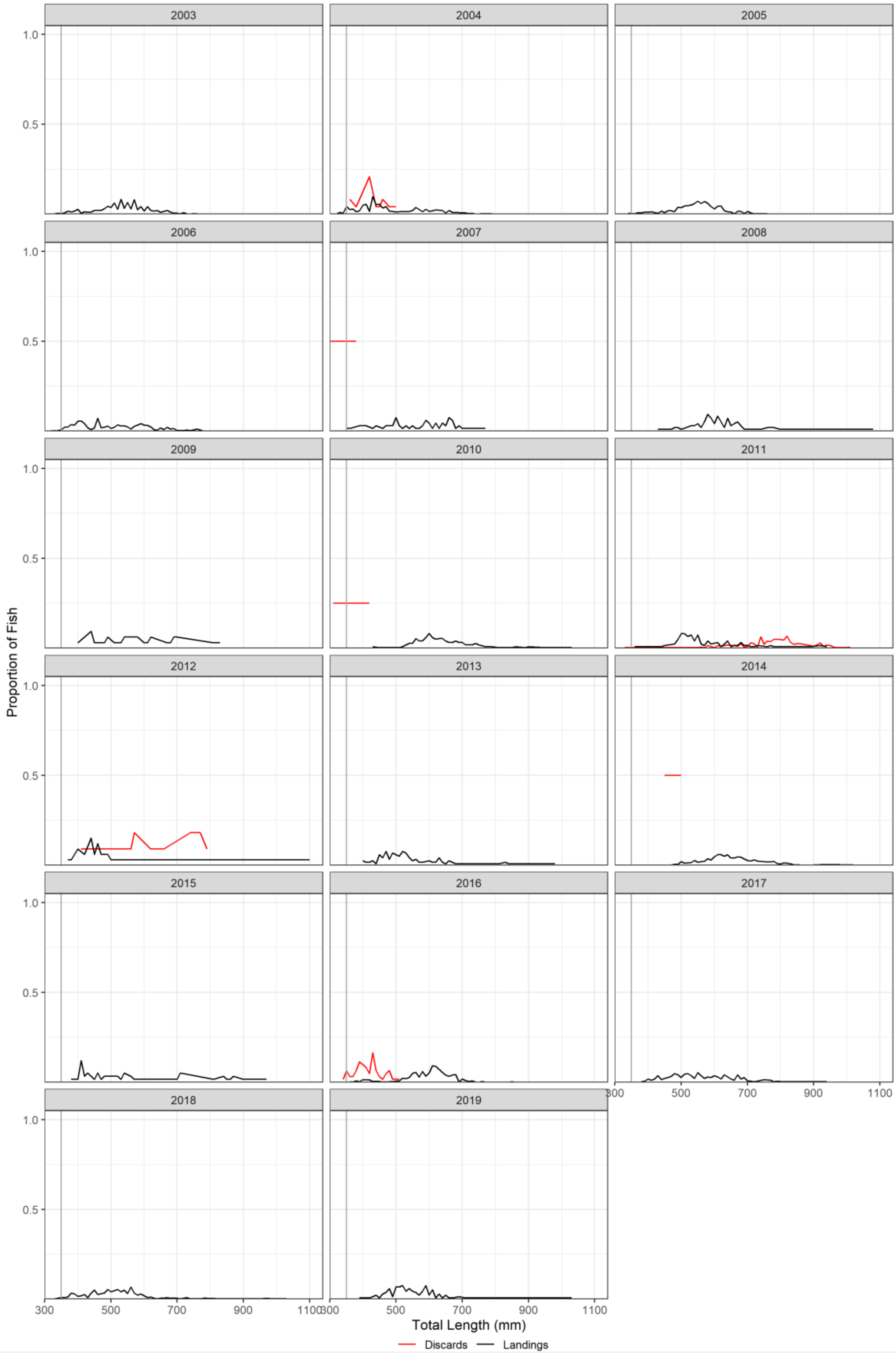
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
1.0
0.5
Proportion of Fish
300
500
700
900
1100
Total Length (mm)
Discards
Landings

Figure A-2 20: Length frequency proportions from 2003 to 2019 for saithe in ICES division VIIj. Vertical line indicated minimum landing size.

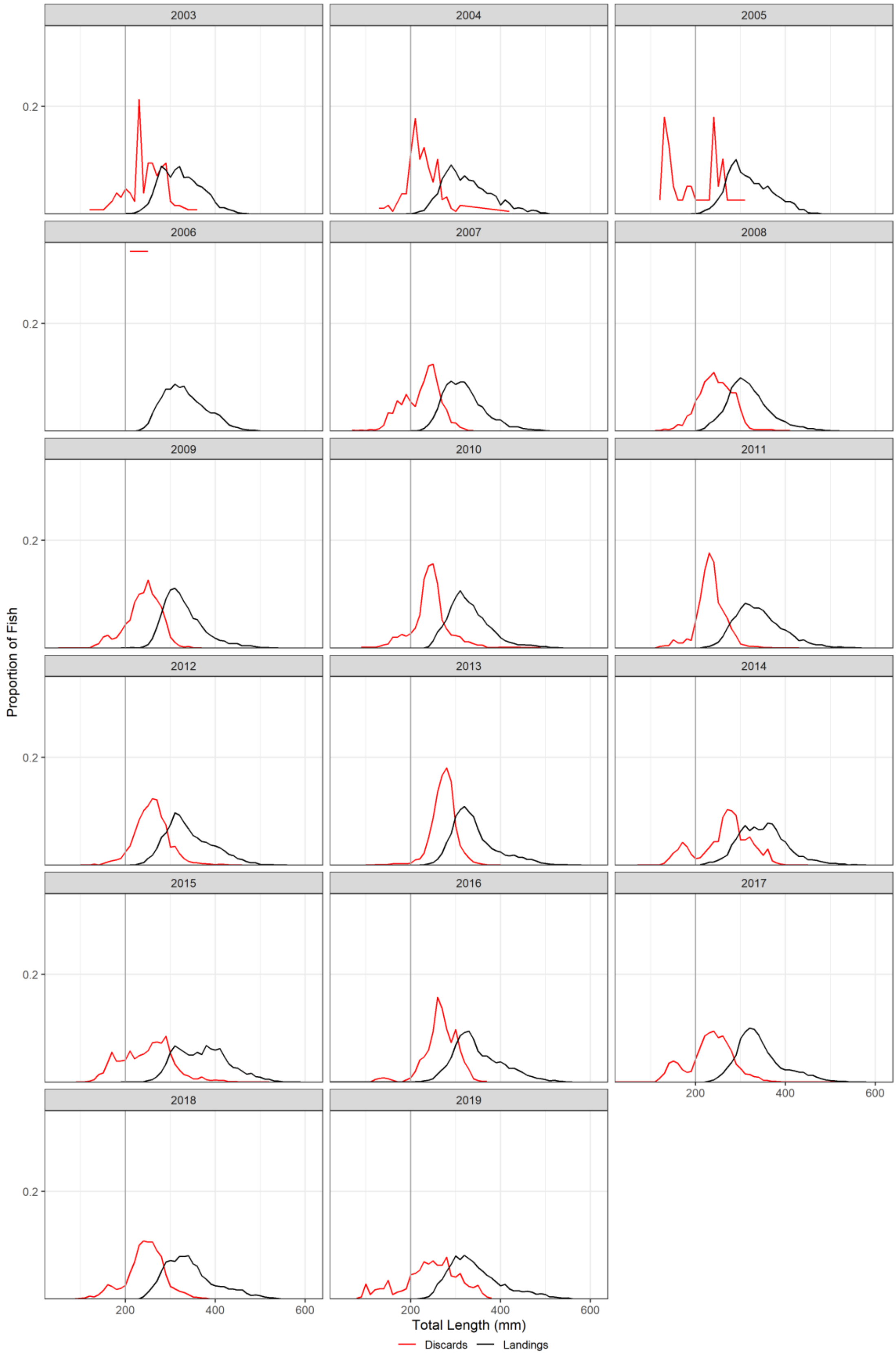
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
0.2
Proportion of Fish
200
400
600
Total Length (mm)
Discards
Landings

Figure A-2 21: Length frequency proportions from 2003 to 2019 for megrim in ICES division VIIg. Vertical line indicated minimum landing size.

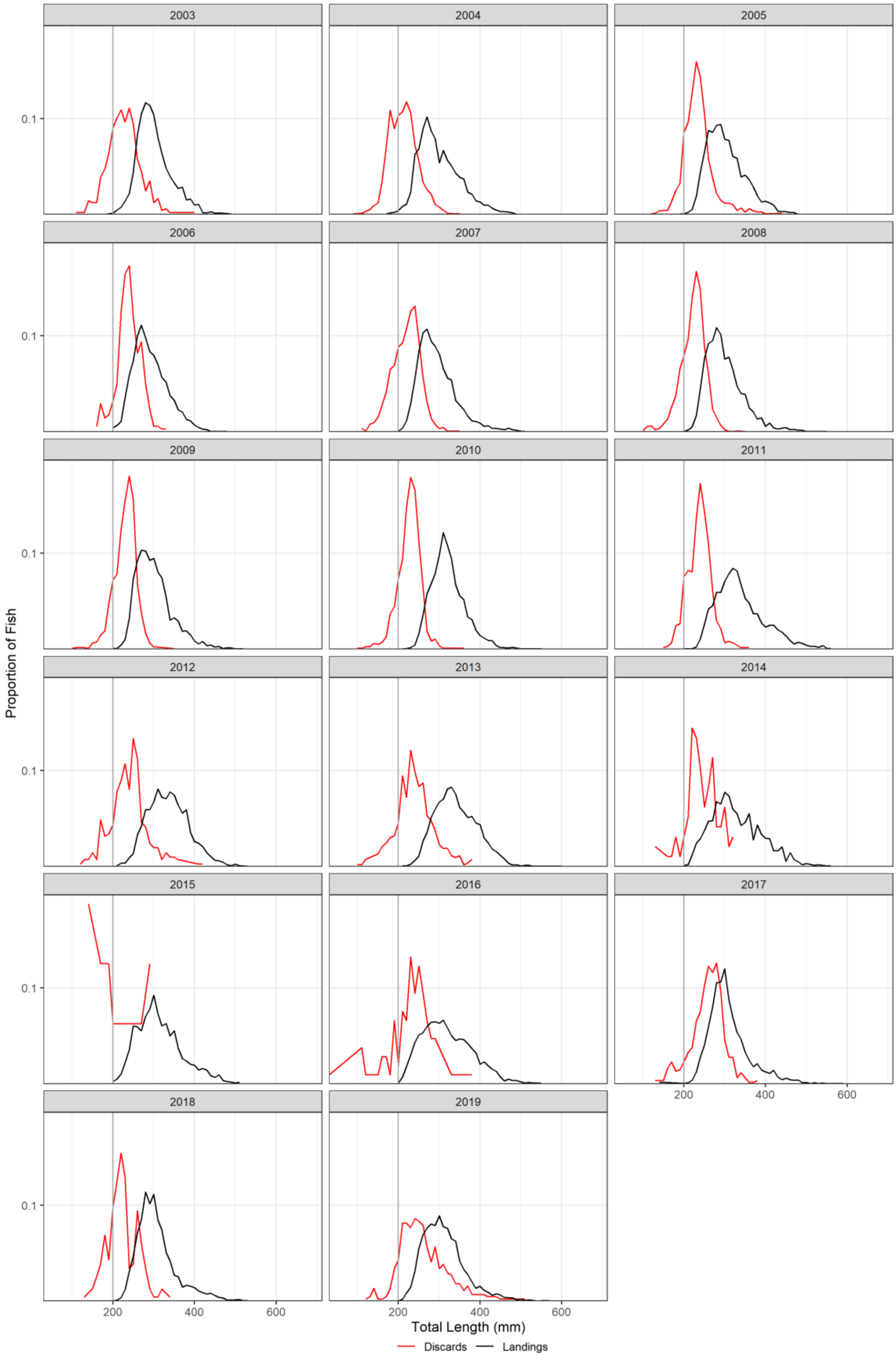
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
0.1
Proportion of Fish
200
400
600
Total Length (mm)
Discards
Landings

Figure A-2 22: Length frequency proportions from 2003 to 2019 for megrim in ICES division VIIj. Vertical line indicated minimum landing size.

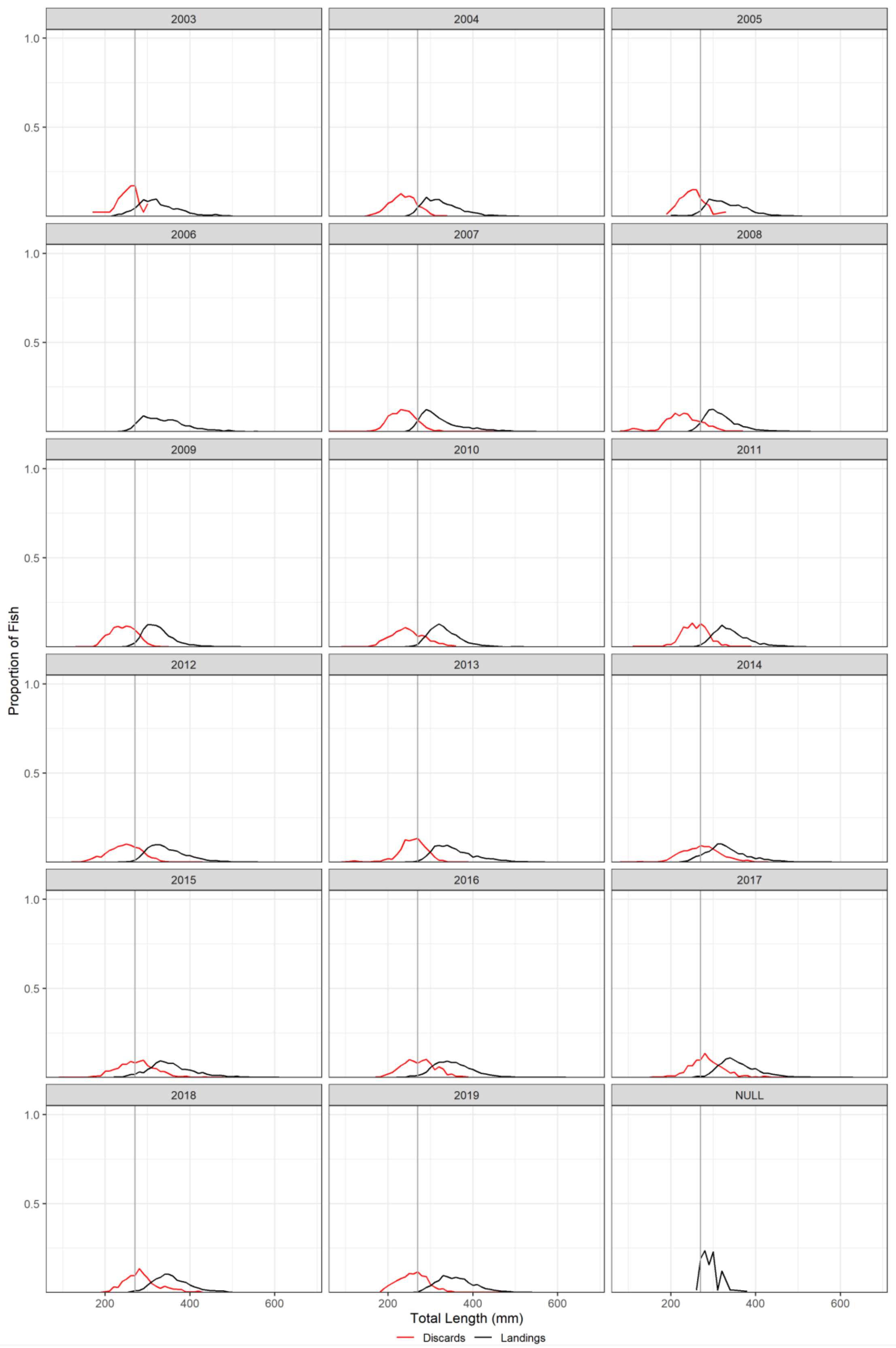

Figure A-2 23: Length frequency proportions from 2003 to 2019 for plaice in ICES division VIIg. Vertical line indicated minimum landing size.

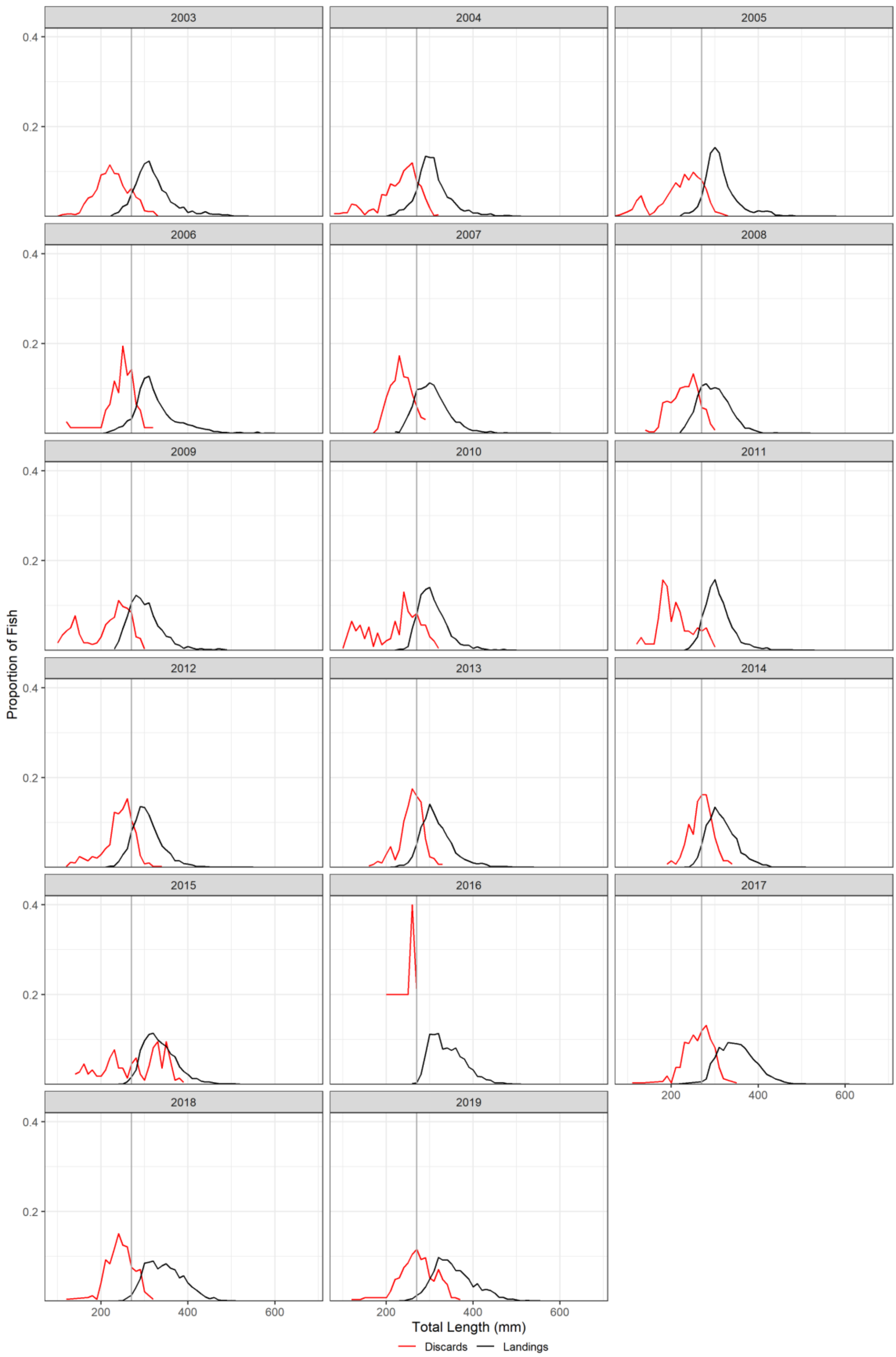
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
0.4
0.2
Proportion of Fish
200
400
600
Total Length (mm)
Discards
Landings

Figure A-2 24: Length frequency proportions from 2003 to 2019 for plaice in ICES division VIIj. Vertical line indicated minimum landing size.

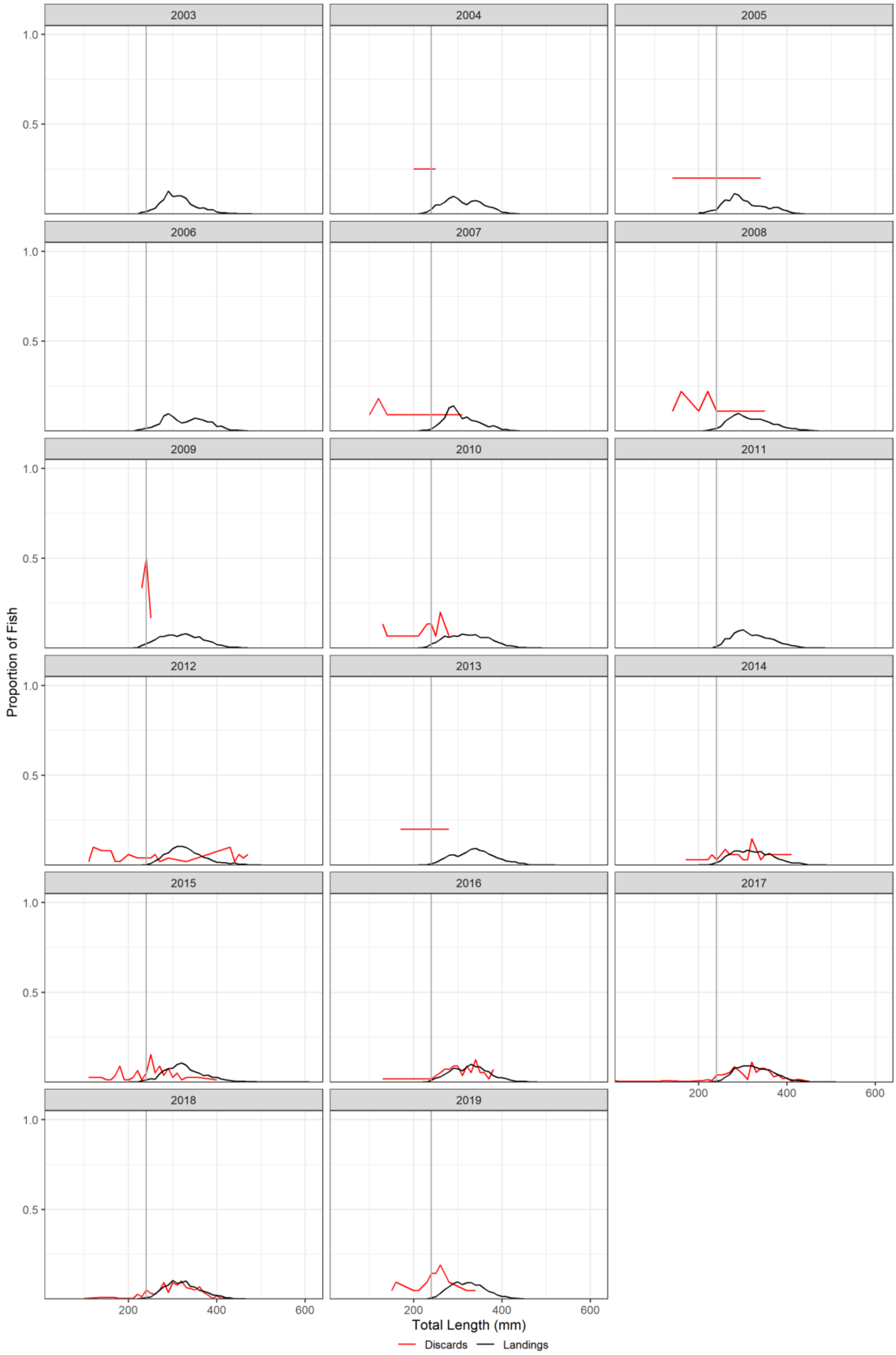

Figure A-2 25: Length frequency proportions from 2003 to 2019 for sole in ICES division VIIg. Vertical line indicated minimum landing size.

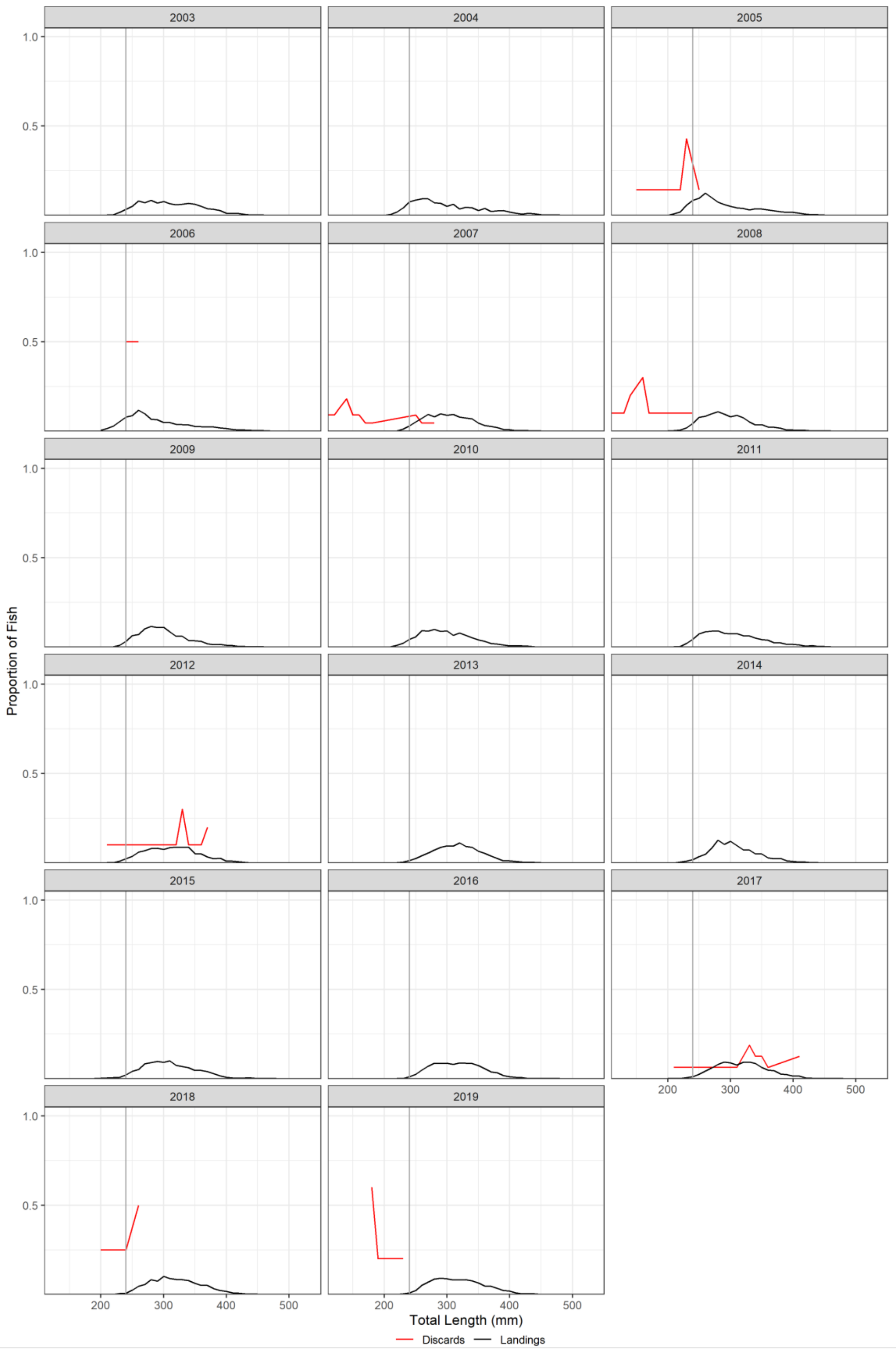

Figure A-2 26: Length frequency proportions from 2003 to 2019 for sole in ICES division VIIj. Vertical line indicated minimum landing size.

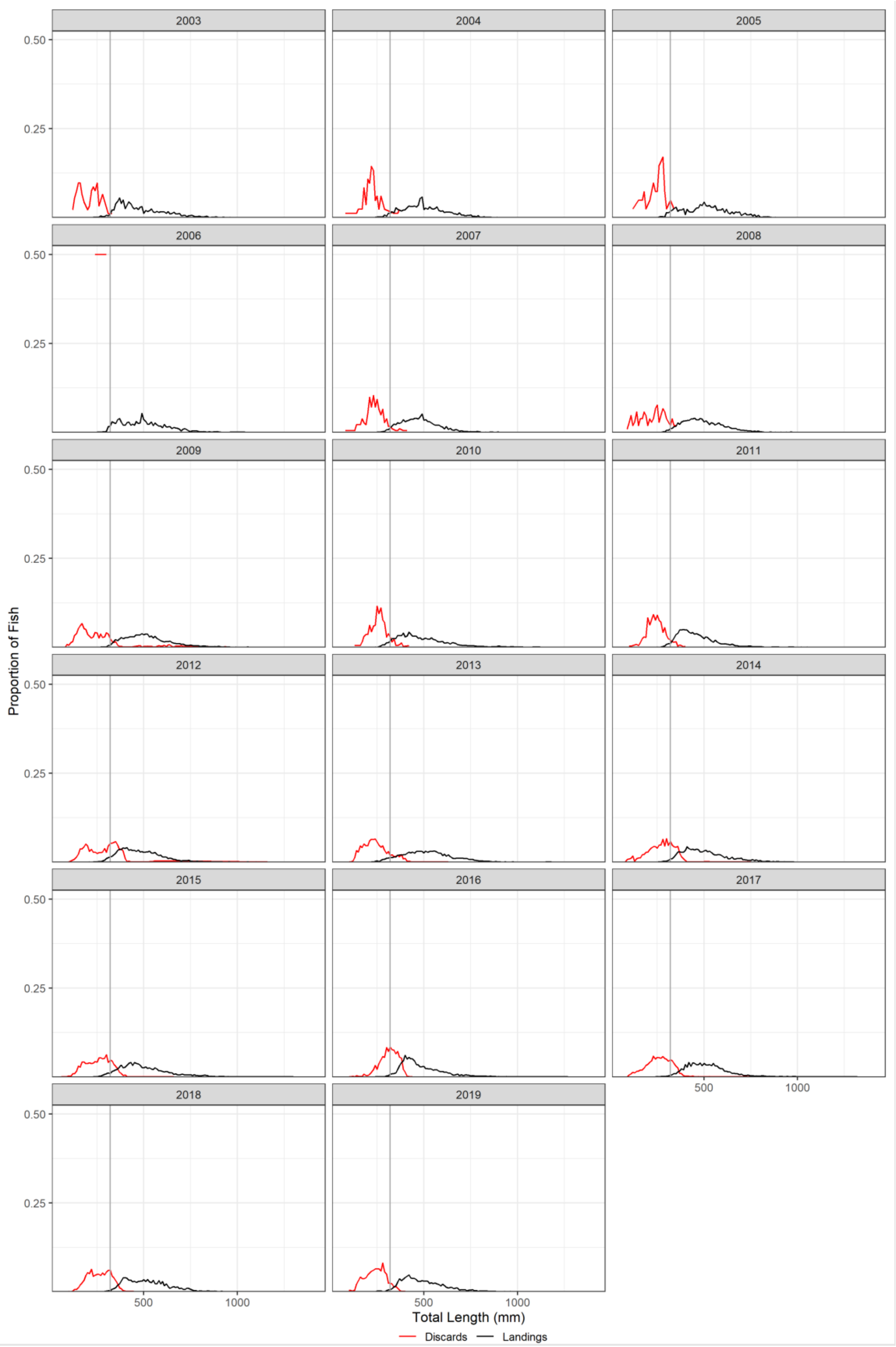

Figure A-2 27: Length frequency proportions from 2003 to 2019 for monkfish in ICES division VIIg. Vertical line indicated minimum landing size.

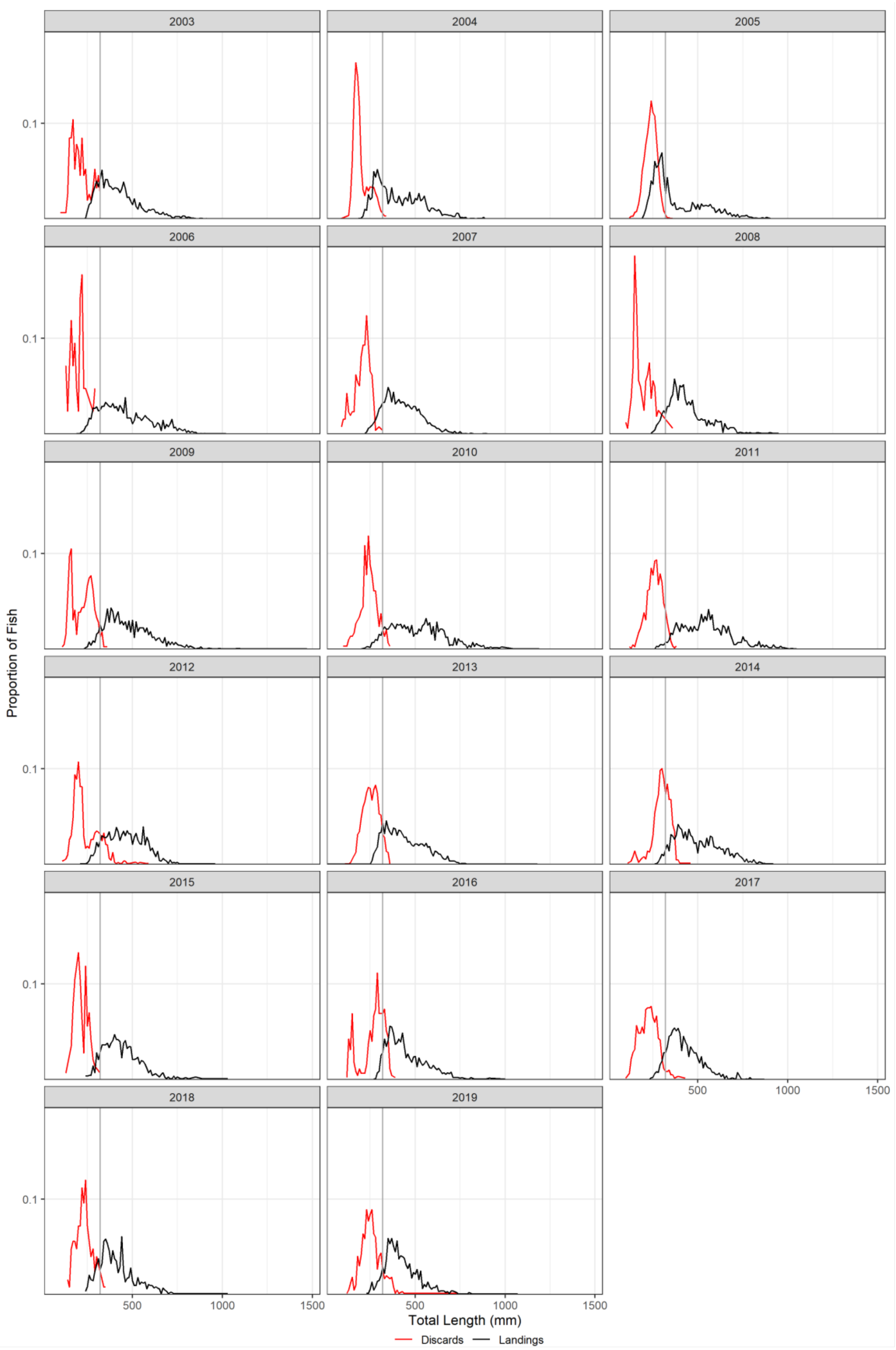

Figure A-2 28: Length frequency proportions from 2003 to 2019 for monkfish in ICES division VIIj. Vertical line indicated minimum landing size.

Appendix 3 Commercial catch length sampling in VIIg and VIIj

	Division	7g																
	Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
MON	Discard	92	83	41	2	182	104	875	389	576	1,712	1,479	1,460	3,431	1,913	3,380	2,092	1,188
	Landed	3,441	4,029	2,253	3,471	6,574	6,201	4,497	4,001	3,985	7,385	5,758	4,034	5,487	5,465	6,883	5,657	3,480
COD	Discard	32	49	199	32	355	63	287	1,221	1,105	437	380	1,813	438	222	204	309	163
	Landed	3,210	4,689	5,781	5,290	7,640	5,935	4,533	5,525	6,472	6,638	4,956	3,128	4,878	2,927	3,868	2,808	3,369
HAD	Discard	4,847	9,938	5,605	35	5,316	5,893	6,775	9,632	13,270	7,990	4,201	9,482	10,860	5,502	9,174	4,894	2,678
	Landed	6,848	6,223	6,492	9,384	12,436	11,481	13,144	9,581	8,989	14,759	10,519	7,760	10,576	9,614	13,413	11,183	7,526
HER	Discard	23	151	118		258	240	964	1,211	219	297	649	1,737	1,503	239	314	127	11
	Landed	5,050	4,385	6,704	5,228	6,570	6,119	6,295	4,637	4,657	8,176	8,233	6,280	3,334	5,636	5,420	2,731	2,144
HKE	Discard	339	307	747	2	709	1,216	3,531	1,344	518	1,924	4,480	2,728	1,848	1,093	2,820	2,247	800
	Landed	3,586	3,320	2,113	2,511	5,361	5,720	4,873	3,916	2,727	2,291	3,220	1,695	1,968	2,721	4,239	3,857	2,084
HOM	Discard	25	35	232	2	145	441	1,028	32	29	43	176	391	146	141	379	363	145
	Landed															137	121	
LEZ	Discard	127	186	39	3	853	743	3,074	1,289	1,973	3,579	6,358	2,509	2,130	1,861	5,231	2,141	461
	Landed	6,264	6,272	3,836	5,197	8,511	9,246	13,344	10,547	7,907	11,801	10,760	6,880	9,405	8,175	17,364	15,600	9,587
LIN	Discard	8	4	6		28	22	64	10	160	154	108	240	195	82	104	113	24
	Landed		184	255	319	388	116	617	364	653	863	626	697	561	502	578	447	222
MAC	Discard	22	167	376		101	77	461	187	119	221	117	200	435	261	39	707	49
	Landed				635			157				1						
PLE	Discard	41	1,071	80	1	878	744	808	989	320	1,945	842	1,706	2,212	669	1,310	820	456
	Landed	6,952	8,442	6,590	7,459	11,880	11,671	5,369	6,193	3,249	4,322	3,682	2,760	2,537	3,589	3,943	3,569	3,125
POK	Discard	1				2	1			9	3	2		1		3		
	Landed	691	716	568	1,013	798	565	752	882	176	111	131	155	142	63	150	228	108
POL	Discard	1				2		1	5	2	6	3	8	3	2	2	11	
	Landed					66	182	453	259	259	255	188	406	239	344	550	1,273	305
SOL	Discard		4	5		11	9	6	15	1	50	5	34	78	56	198	216	21
	Landed	2,758	4,213	3,129	4,732	4,717	5,690	2,700	2,938	2,827	2,654	2,367	1,973	2,075	2,684	3,367	2,669	3,559
WHG	Discard	1,297	8,925	7,047	163	7,447	5,258	6,860	2,972	4,386	6,977	5,142	9,029	11,284	4,418	4,109	3,530	755
	Landed	8,922	8,179	10,184	10,395	17,371	14,044	9,798	9,154	8,804	10,674	8,480	8,926	13,844	9,365	14,028	8,105	5,857

	Division	7j																
	Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
MON	Discard	154	1,701	2,337	42	258	161	390	295	813	885	1,662	856	143	448	600	125	596
	Landed	4,181	5,615	3,585	2,898	3,478	1,180	1,939	2,424	1,830	1,726	2,907	1,407	1,102	1,269	2,270	822	1,201
COD	Discard	1	14	49		251	2	7	219	153	46	22	228	1		1	12	132
	Landed	467	1,511	1,044	1,215	872	418	153	948	1,081	543	697	891	946	673	658	949	996
HAD	Discard	2,849	5,303	2,656	260	2,368	5,102	3,411	6,666	5,425	2,393	1,186	797	138	48	599	123	2,012
	Landed	1,750	3,278	2,096	4,961	5,225	3,897	4,188	4,584	3,244	3,416	4,713	3,229	1,816	2,705	2,617	2,761	2,175
HER	Discard		5	14	1	82	21	28	25	17	4	25			1			3
	Landed	608	420	935	1,067	3,349	988	1,468	744	644		332	2					378
HKE	Discard	77	228	481	18	399	688	1,087	535	505	357	812	686	49	269	409	164	1,265
	Landed	579	3,095	1,585	1,225	468	1,405	1,213	1,347	1,222	758	1,164	4,023	281	2,630	1,295	949	3,022
HOM	Discard	17	132	366	62	875	418	615	339	652	254	72	496	1	49	81	93	317
	Landed			231		748	180	545	1,660	532	97							
LEZ	Discard	487	1,318	1,601	341	1,154	2,194	1,859	1,168	608	412	528	97	16	106	612	233	442
	Landed	5,637	8,862	4,255	9,167	5,893	3,224	3,818	3,639	2,722	2,305	5,943	1,524	1,178	1,964	4,437	4,601	4,965
LIN	Discard		4	3		9	4	3		21	11	4	1	2	2			
	Landed		46	67	9	17	6	139	178	118	51	207	218	103	36	47	126	141
MAC	Discard	7	18	258	5	101	251	38	286	58	912	415	236	1	39	175	56	148
	Landed		1,238	377		2,791	1,553	1,762	2,449	2,298	811	1,616	3,433	2,121			1,119	
PLE	Discard	946	469	626	77	878	278	297	230	140	621	303	136	221	5	319	239	268
	Landed	6,816	8,687	6,014	6,398	2,479	2,328	1,626	2,072	1,905	2,917	2,955	2,671	2,034	2,489	2,848	2,711	2,018
POK	Discard		24	1		2	1		4	265	11	1	2		61		1	
	Landed	913	1,000	693	802	66	95	32	219	122	33	117	856	58	994	264	307	131
POL	Discard					1			1	259	11	2		2	22	73		
	Landed						11	62	776	271	55	125	1,044	332	2,055	845	714	418
SOL	Discard	2	1	7	2	22	10	1	1	1	10	1	1			16	4	5
	Landed	2,604	3,943	4,691	6,620	2,392	1,788	1,445	1,906	2,307	2,401	2,216	2,302	2,146	3,674	3,670	3,699	3,615
WHG	Discard	1,250	1,184	527	106	566	277	389	1,635	219	338	139	170	141	16	71	126	73
	Landed	3,888	5,024	5,079	7,701	2,812	3,224	2,741	4,206	1,561	2,470	1,991	2,648	1,402	2,147	2,526	2,807	2,692

Further details available on www.emff.marine.ie

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An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
This measure is part-financed by the European Maritime and Fisheries Fund

Marine Institute
Foras na Mara