



Elasmobranchs & Commercial Fisheries around the British Isles: Spatial and Temporal Dynamics

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Dissertação de Mestrado em Ciências do Mar

2009

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**Elasmobranchs & Commercial Fisheries around the British Isles:
Spatial and Temporal dynamics**

Dissertação de Candidatura ao grau de Mestre
em Ciências do Mar – Recursos Marinhos
submetida ao Instituto de Ciências Biomédicas
de Abel Salazar da Universidade do Porto.

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Sumário executivo

Os peixes elasmobrânquios desempenham um papel importante nos ecossistemas marinhos e as características dos seus ciclos de vida tornam-nos muito vulneráveis à exploração comercial. Embora, existam algumas pescarias dirigidas a espécies de elasmobrânquios com carácter sazonal e/ou local ao largo das ilhas Britânicas, os elasmobrânquios são comunemente capturados em pescarias mistas demersais.

A pescaria da palangre dirigida a espécies demersais é conhecida por ser altamente selectiva para certas espécies de elasmobrânquios, embora os padrões espaciais e temporais destas pescarias não tenham, ainda, sido descritos. Por conseguinte, uma descrição geral destas pescarias ao largo das ilhas britânicas foi conduzida. As principais zonas, em termos de desembarques na pescaria da palangre demersal (1990-2007) foram o sul do Mar do Norte (ICES IVc), Mar da Irlanda (VIIa) e Mar do Norte central (IVb). Enquanto que, as principais espécies capturadas nestas pescarias são o galhudo-malhado, bacalhau do Atlântico, raias e safio. Desde 2007, as capturas acessórias de raias no Mar do Norte têm uma quota de 25%, a qual foi revista recentemente, sendo apenas obrigatória para as embarcações com mais de 15 m de comprimento total (Regulamento CE n.º 40/2008). Existe ainda, uma quota de 5% para as capturas acessórias do galhudo-malhado em toda a área do ICES. Consequentemente, estas quotas poderão tornar-se problemáticas para os palangreiros, dependendo da zona de pesca e das outras espécies capturadas. No Mar Celta a diversidade de espécies capturadas é maior e, apesar da diversidade de peixes piscícolas capturados pelos palangreiros ser menor no Mar da Irlanda e no sul do Mar do Norte, estas quotas terão um impacto maior nestas áreas.

Os padrões das rejeições e retenções de elasmobrânquios na pesca comercial do Reino Unido (Inglaterra e País de Gales) foram, posteriormente, analisados. Duas eco-regiões foram consideradas, o Mar do Norte (ICES IV a-c, VIId) e o Mar Celta (ICES VIa, VIIa,b, e-j), com poucos dados disponíveis relativamente à pesca em águas profundas (ICES VIa, VIId,k). As análises incidiram sobre os tipos de artes para os quais existem registos significativos para as diferentes espécies estudadas (redes de arrasto com portas, rede de arrasto de vara, rede de arrasto de lagostins, redes de emalhar e palangre). Em geral, 42 espécies de Chondrichthyes foram registradas nos programas de observação de rejeições, incluindo espécies das famílias Rajidae (11 espécies), Scyliorhinidae (5 espécies) e Triakidae (3 espécies) e ainda, tubarões squaliformes (11 espécies). A eco-região do mar Celta contém a maior diversidade de espécies elasmobrânquios, embora esta eco-região contenha também alguns habitats de profundidade (por exemplo, VIa,

VIIb,h,j). Sendo de referir ainda que, amostragens em habitats equiparáveis no Mar do Norte (área IVa) não foram suficientemente obtidas. Em geral, os arrastões de vara capturaram proporcionalmente mais juvenis do que os arrastões com portas, com as redes de emalhar mostrando uma maior selectividade. Os dados para os arrastões de lagostim foram na sua maioria insuficientes para obter padrões conclusivos de rejeição/retenção, sendo que poucos elasmobrânquios são abundantes nestes habitats lamacentos. Em geral, os tubarões juvenis (triakidae e squaliformes) foram normalmente rejeitados, com grandes peixes retidos (dependendo da espécie). Os juvenis de raias (<50 cm TL) foram frequentemente rejeitados e, consoante as espécies e as artes de pesca, os comprimentos de 50% de retenção variaram entre os 45 e os 55 cm. Outros batóides (*Torpedo nobiliana*, *T. marmorata* e *Dasyatis pastinaca*) foram encontrados principalmente na eco-região do mar Celta, tendo todos os espécimes sido rejeitados.

Os desembarques de raias reportados pelo Reino Unido (2002-2007) indicam que, em geral, diversos tipos de arrastões com portas e rede de emalhar foram os principais em termos de desembarques de raias (58% e 24% da média anual dos desembarques, respectivamente), com as redes de arrasto de vara (7%) e linhas (5%) de importância secundária. Mais de metade da média anual dos desembarques provieram de quatro divisões do ICES (VIIa,e,f,j), com a maioria dos restantes remetidos para as divisões VIId,g,h, IVb,c e VIb. Os desembarques de raias são frequentemente agrupados em peixes batóides, continuando indisponíveis dados para cada espécie em separado, o que tem dificultado a avaliação e gestão dos stocks. Os dados dos programas de observação de rejeições (números por comprimento) das embarcações comerciais que operam nestas áreas do ICES, foram convertidos para biomassa a fim de estimar a composição das espécies de raias (Rajidae) retidas (desembarcadas). A região sul do Mar do Norte (IVc) é extremamente importante para a pesca de *Raja clavata*, embora *R. brachyura* seja igualmente importante a nível local.

As pescarias no Mar da Irlanda (VIIa) retiveram principalmente *R. clavata*, *R. brachyura*, *R. montagui* e *Leucoraja naevus*, com os arrastões com portas uma das principais pescarias dirigidas a raias (Rajidae). Estas espécies foram igualmente capturadas no canal de Bristol, embora a *R. microocellata* seja também uma importante componente nesta área. O número de espécies de raias capturadas e retidas foi maior nas divisões a sudoeste (VIIg-j), incluindo *Dipturus Batis* e *L. fullonica*. O Canal da Mancha (VIId/e) é localmente importante para a *R. undulata*, sendo esta espécie uma componente relativamente importante nas capturas dos arrastões com portas no Canal da Mancha ocidental (VIIe) e dos arrastões na região Leste do Canal da Mancha (VIId).

Executive Summary

Elasmobranch fish play an important role in marine ecosystems and their life history characteristics makes them vulnerable to overfishing. Although, commercial fisheries around the British Isles may seasonally and/or locally target elasmobranchs, many elasmobranchs species are susceptible to capture in mixed demersal fisheries. Demersal longline fisheries are known to be highly selective for certain species of elasmobranch, although the temporal and spatial patterns in these fisheries have not previously been described. Hence, an overview of these fisheries around the British Isles has been carried out. The main fishing grounds in terms of landings by demersal longline fisheries (1990–2007) were the southern North Sea (ICES Division IVc), Irish Sea (VIIa) and the central North Sea (IVb). The main species taken in these fisheries are spurdog, cod, skates and conger eel. Since 2007, a 25% bycatch quota for skates and rays in the North Sea was stipulated, being recently revised and only mandatory for vessels over 15 m length overall (EC regulation No. 40/2008). There is also a 5% bycatch quota for spurdog in the ICES area. These bycatch quotas can be problematic for longliners, depending on the area fished and the other species that may be taken. More species can be taken in the Celtic Sea, although the diversity of piscivorous fish taken on longlines is less in the Irish Sea and southern North Sea, thus bycatch quotas have a greater impact in these areas.

Elasmobranch discard and retentions patterns in UK (English and Welsh) commercial fisheries around the British Isles were examined. Two main ecoregions were analysed, the North Sea ecoregion (ICES Divisions IV a-c, VIId) and the Celtic Seas ecoregion (ICES Divisions VIa, VIIa,b,e-j), and only limited data were available for the deep-water ecoregion (ICES Divisions VIb, VIId,k). Analyses focused on the general gear types for which there were substantial records for the various species studied (otter trawls, beam trawl, *Nephrops* trawl, gillnets and longline). Overall, 42 chondrichthyan species were recorded from discards trips, including skates (Rajidae, 11 species), squaliform sharks (11 species), scyliorhinid catsharks (5 species) and triakid sharks (3 species). The Celtic Seas ecoregion contained the greatest diversity of elasmobranch species, although this ecoregion also contains some deep-water habitats (e.g. in VIa, VIIb,h,j), and comparable habitats in the North Sea ecoregion (in IVa) were not well sampled. Beam trawlers generally captured proportionally more small (juvenile) fish than otter trawlers, with gillnets showing a greater selectivity. Data for *Nephrops* trawlers were frequently too limited to draw an accurate discard/retention pattern, as few elasmobranchs are abundant on these muddy habitats. In general, juveniles sharks (triakids and squaliforms) were usually discarded with larger fish retained (depending on the species). Juvenile skates (ca. <50 cm TL) were often discarded and, depending on the species and gear, 50% retention of

skates occurred at lengths of approximately 45–55 cm. Other batoids (stingrays and electric rays) were encountered mainly in the Celtic Seas ecoregion and were all discarded.

Reported UK landings of skates (2002–2007) indicated that, overall, various types of otter trawl and gillnet were the main fisheries landing skates (58% and 24% of mean annual landings, respectively), with beam trawl (7%) and lines (5%) of secondary importance. Over half of the average annual landings originated from four ICES Divisions (VIIa,e,f,j), with the majority of the remaining landings reported from Divisions VIId,g,h, IVb,c and VIb. Such data are only available for “skates and rays” and species-specific data are lacking, which has hampered assessment and management. Data from discard observer trips (numbers at length) from commercial vessels operating in these ICES divisions were converted to biomass in order to estimate the species composition (biomass) of retained (landed) skates. The southern North Sea (IVc) is an important fishing ground for the highly commercial *Raja clavata*, although the large-bodied *R. brachyura* may be also locally important.

Fisheries in the Irish Sea (VIIa) retained mainly *R. clavata*, *R. brachyura*, *R. montagui* and *Leucoraja naevus*, with otter trawls one of the main UK skate fisheries. These species were also taken in the Bristol Channel, although *R. microocellata* was also an important component of catches in VIIf. More skate species were captured and retained in south-western areas (VIIg-j), including *Dipturus batis* and *L. fullonica*. The English Channel (VIId/e) is locally important for *R. undulata*, and this species was a relatively important part of the catch of otter trawlers in the western English Channel (VIIe) and beam trawlers in the eastern English Channel (VIId).

Résumé Exécutif

Les poissons selécien jouent un rôle important dans les écosystèmes marins et les caractéristiques de leurs cycles de vie les rendent vulnérables à la surpêche. Bien que, existent des pêches commerciales saisonnières et/ou localement dirigées aux selécien à la place des îles Britanniques, beaucoup d'espèces des selécien sont susceptibles de captures dans les pêches demersais mélangées.

La pêche de palangre dirigée à des espèces des demersais est connue être hautement sélective pour certaines des espèces des selécien, bien que les normes spatiales et séculières de ces pêches n'aient pas, encore, été décrite. Par conséquent, une description générale de ces pêches à la place des îles britanniques a été conduite. Les principales zones, dans des termes de débarquements dans la pêche de palangre demersal (1990-2007) ont été le sud de la Mer du Nord (CIEM IVc), la Mer de l'Irlande (VIIa) et la Mer du Nord central (IVb).

Tandis que, les principales espèces capturées dans celles-ci sont l' aiguillat commun, la morue de l'Atlantique, les raies et le congre d'europe. Depuis 2007, le capture accessoires de raies dans la Mer du Nord ont un quota de 25%, qui a été révisé récemment, en étant seulement obligatoire pour les bateaux avec plus de 15 m de longueur totale (Règlement CE n. ° 40/2008). Il existe encore, un quota de 5% pour les capture accessoires de l' aiguillat commun dans toute le secteur de Le CIEM.

En conséquence, ces quotas pourront se devenir des problématiques pour les palangriers, en dépendant de la zone de pêche et des autres espèces capturées. Dans la Mer Celte la diversité d'espèces capturées est plus grande et, malgré de la diversité de poissons des piscicolas capturés les palangriers être moindres dans la Mer de l'Irlande et dans le sud de la Mer du Nord, ces quotas auront un impact plus grand dans ces secteurs.

Les normes des rejets et les rétentions d'elasmobranquios dans la pêche commerciale du Royaume-Uni (Angleterre et Pays de Galles) ont été, ultérieurement, analysés. Deux eco-régions ont été considérés, la Mer du Nord (CIEM IV a-c, VIId) et la Mer Celte (CIEM VIIa,b,e-j), avec peu de données disponibles à l'égard de la pêche dans des eaux profondes (CIEM VIb, VIc,k). Les analyses sont arrivées sur les types d'arts pour lesquels existent des registres significatifs pour les différentes espèces étudiées (chalut à panneaux, chalut à perche chalut à panneaux des lagustins, filet maillant et palangre). En général, 42 espèces de Chondrichthyes ont été enregistrées dans les programmes de commentaire de rejets, y compris des espèces des familles Rajidae (11 espèces), Scyliorhinidae (5 espèces) et Triakidae (3 espèces) et encore, requins squaliformes (11

espèces). L'eco-région de la mer Celte comptera à la plus grande diversité d'espèces des selécien, bien que cette eco-région contienne aussi quelques-uns habitats de profondeur (par exemple, VIa, VIIb,h,j). En étant de se rapporter malgré, des échantillonnages dans habitats comparables dans la Mer du Nord (secteur IVa) suffisamment n'ont pas été obtenus. En général, les entraînements de poteau ont capturé proportionnellement plus juvéniles de ce que chalut à panneaux et filet maillant en montrant une plus grande sélectivité. Les données pour les entraînements de lagostim ont été dans leur plupart insuffisants pour obtenir des normes concluantes de rejet/rétention, en étant que peu des selécien sont abondantes dans ceux-ci habitats boueux.

En général, les requins juvéniles (triakidae et squaliformes) normalement ont été rejetés, avec de grands poissons retenus (en dépendant de l'espèce). Les juvéniles de raies (<50 cm) ont été fréquemment rejetés et, selon les espèces et les arts de pêche, les longueurs de 50% de rétention ont varié entre les 45 et 55 cm. D'autres batoides (*Torpile nobiliana*, *T. marmorata* et *Dasyatis pastinaca*) ont été trouvés principalement dans l'eco-région de la mer Celte, les spécimens ont été tous rejetés.

Les débarquements de raies reportés par le Royaume-Uni (2002-2007) indiquent que, en général, de divers types d'entraînements chalut à panneaux et filet maillant ont été les principaux dans des termes de débarquements de raies (58% et 24% de la moyenne annuelle des débarquements, respectivement), avec les filets d'entrave de poteau (7%) et de lignes (5%) d'importance secondaire.

Plus de moitié de la moyenne annuelle des ils débarquements sont venus de quatre divisions de le CIEM (VIIa,e,f,j), avec à la majorité des restes envoyés pour les divisions VIId,g,h, Ivb,c et VIb. Les débarquements de raies fréquemment sont regroupés dans des poissons batoides, en continuant d'indisponibles données pour chaque espèce séparément, ce qui a rendu difficile l'évaluation et la gestion de stocks. Les données des programmes de commentaire de rejets (nombres par longueur) des bateaux commerciaux qui opèrent dans ces secteurs de lui CIEM, ont été convertis pour biomasse afin d'estimer la composition des espèces de raies (Rajidae) retenues (débarquées). La région sud de la Mer du Nord (IVc) est extrêmement importante pour la pêche de *Raja clavata*, bien que *R. brachyura* soit également important à niveau local.

La pêche dans la Mer de l'Irlande (VIIa) a retenu principalement *R. clavata*, *R. brachyura*, *R. montagui* et *Leucoraja naevus*, avec la chalut à panneaux une des principales pêches dirigées à des raies (Rajidae). Ces espèces ont été également capturées dans le canal de Bristol, bien qu'à *R. microcellata* soit aussi un important composant dans ce secteur. Le nombre d'espèces des raies capturées et retenues a été plus grand dans les divisions le

sud-ouest (VIlg-j), y compris *Dipturus Batis* et *L. fullonica*. La Manche (VIId/e) est localement importante pour le *R. undulata*, en étant cette espèce une composante relativement importante dans les captures de chalut à panneaux dans La Manche occidentale (VIIe) et des entraînements dans la région Est de la Manche (VIId).

Acknowledgements

First, I would like to thank especially my supervisor Dr Jim Ellis who was always there for me with a word of encouragement, saying that everything can be done. In addition, I would like to thank Peter Robison for supplying the landings data, Grant Course for the discards data and Peter Randall for assisting with the data checking. Without their effort, this project could never have been carried out.

Concerning my master coordination, I would like to thank my supervisors in Portugal for agreeing that my thesis could be performed in the United Kingdom. Additionally, I would like to express my happiness that Dr Ivone Figueiredo agreed on taking over the supervision of this thesis.

Personally, I would like to thank my colleagues at Cefas and the friends I have found during these 7 months I spent in Lowestoft. With their support and friendship, they allowed this project to be an extraordinary experience.

At last but not least important, a special thanks to my family who never stopped believing that I could succeed, though sometimes it was especially hard for my sisters to cope with the distance.

Acronyms

BLR	Blonde Ray (<i>Raja brachyura</i>)
BT	Beam trawl
CITES	Convention on International Trade in Endangered Species
CUR	Cuckoo ray (<i>Leucoraja naevus</i>)
DGN	Greater-spotted dogfish (<i>Scyliorhinus stellaris</i>)
DGS	Spurdog (<i>Squalus acanthias</i>)
EC	European Commission
FAD	Fishing Activity Database
FAO	Food and Agriculture Organization of the United Nations
GAG	Tope (<i>Galeorhinus galeus</i>)
GN	Gillnet
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IUCN	International Union for Conservation of Nature
LSD	Lesser-spotted dogfish (<i>Scyliorhinus canicula</i>)
MLL	Maximum landing length
MLS	Minimum landing size
NAFO	Northwest Atlantic Fisheries Organization
NE	North East
NGO	Non-governmental organisations
NW	North West
OT	Otter trawl
PTR	Smalleyed ray (<i>Raja microocellata</i>)
RFMO	Regional Fisheries Management Organisation
RNS	Black skate (<i>Dipturus nidarosiensis</i>)
SAR	Sandy ray (<i>Leucoraja circularis</i>)
SDR	Spotted ray (<i>Raja montagui</i>)
SDS/SMH	Smoothhounds (<i>Mustelus</i> spp.)
SGS	Six-gill shark (<i>Hexanchus griseus</i>)
SHR	Shagreen ray (<i>Leucoraja fullonica</i>)
SKA	Skate (indeterminated)
SKT	Common skate (<i>Dipturus batis</i>)
SYR	Starry ray (<i>Amblyraja radiata</i>)
TACs	Total Allowable Catch
THR	Thornback ray (<i>Raja clavata</i>)

TL	Total length
UK	United Kingdom
UNR	Undulate ray (<i>Raja undulata</i>)

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I Introduction

Sharks, skates and rays (Elasmobranchii) together with chimaeras belong to the cartilaginous fishes Chondrichthyes, which have an evolutionary record extending back more than 400 million years (Pikitch *et al.*, 2008). Recent estimates refer to the existence of 1,164 species of cartilaginous fish (Compagno, 2008). Although including some of the oldest extant vertebrate taxa (Pikitch *et al.*, 2008), many aspects of the biology and ecology of elasmobranchs are still poorly understood.

Elasmobranchs have been historically captured in a variety of commercial fisheries both as target and non-target species (including bycatch and discards) and also in recreational fisheries. Elasmobranchs are taken mainly as a bycatch in mixed demersal trawl fisheries in shelf seas and deep-water (Cedrola *et al.*, 2005; Tamini *et al.*, 2006) and in pelagic longliners and nets targeting tunas and billfish in high seas fisheries (Camhi *et al.*, 2008a). The main species taken by pelagic fisheries are blue shark (*Prionace glauca*), silky shark (*Carcharhinus falciformis*) and shortfin mako shark (*Isurus oxyrinchus*) (Camhi *et al.*, 2008a). However, in UK waters there are also several seasonal and/or localised fisheries targeting skates using longline, gillnet or trawl (e.g. in the southern North Sea and Bristol Channel) or targeting spurdog (e.g. with longline) (ICES, 2007b).

The real extent of how shark and skate populations are affected by commercial fisheries and the amounts taken from the marine ecosystem are still relatively uncertain. Therefore, there has been an increase in conservation concern by management authorities (at national, regional and international levels), environmental and conservation bodies (including non-governmental organisations, NGO's), fishermen and the general public (Pawson & Vince, 1999).

Elasmobranchs are biologically vulnerable to overfishing, as a result of their biological features, which include slow growth, high longevity, late age at maturity, low fecundity and protracted gestation period (Holden, 1973; Ellis *et al.*, 2008). Furthermore, given the aggregating behaviour and large size of elasmobranchs, even at juvenile stages, they are susceptible to capture in trawl and gillnets from a young age, and their often-piscivorous nature makes them susceptible in targeted longline fisheries. Elasmobranchs are top-predators and may therefore play an important role in the trophic ecology and function of ecosystems and the consequences of their removal from marine ecosystems are still not well understood, but may include unpredictable effects, including changes to predator-prey relationships within trophic systems, and so affecting both fish and invertebrates at

lower trophic levels (Ellis *et al.*, 1996; Stevens *et al.*, 2000; Scacco *et al.*, 2002; Enever *et al.*, 2007; Myers *et al.*, 2007).

Over-exploitation of elasmobranch groups may also lead to shifts in the species composition, for example Walker & Hislop (1998) and Dulvy *et al.* (2000) suggested that the species composition of skates may have changed in the North Sea and Irish Sea. Smaller, more productive species, such as cuckoo ray (*Leucoraja naevus*), starry ray (*Amblyraja radiata*) and spotted ray (*Raja montagui*) may have increased in abundance, whilst larger species such as common skate (*Dipturus batis*), thornback ray (*Raja clavata*), blonde ray (*Raja brachyura*) and shagreen ray (*Leucoraja fullonica*), which may be more susceptible to over-exploitation (Dulby *et al.*, 2000), have declined.

Additionally, common skate, white skate (*Rostroraja alba*) and angel shark (*Squatina squatina*) are thought to be extirpated from some regions around the British Isles (Brander, 1981; Rogers & Ellis, 2000; ICES, 2008a,b). Elsewhere in the world, there has been concern for other large-bodied demersal elasmobranchs, including sawfish *Pristis* spp. (Simpfendorfer, 2000). Barndoor skate (*Dipturus laevis*) was considered to be close to extinction in the Northwest Atlantic (Casey & Myers, 1998), although the status of this species is now known to be better than originally feared (Gedamke *et al.*, 2005, 2008). Changes in the abundance of various shark species have also been recorded in the NW and NE Atlantic (e.g. basking shark *Cetorhinus maximus* and porbeagle *Lamna nasus*) and off California (e.g. tope, *Galeorhinus galeus*) (see Holden, 1977; Roger & Ellis, 2000; ICES, 2007). A recent study in the Mediterranean Sea has suggested large declines in the occurrence of hammerhead (*Sphyrna* spp.), blue shark (*Prionace glauca*), lamnid sharks (*Isurus oxyrinchus* and *Lamna nasus*), and thresher sharks (*Alopias vulpinus*) (Ferretti *et al.*, 2008), although this study has caused some controversy.

Fishing-induced changes in the life-history traits of elasmobranchs may also have occurred, although much of the evidence for this is anecdotal. Carbonnel *et al.* (2003) suggested that some elasmobranchs may have shorter generation periods (e.g. faster growth and early maturation) and/or a higher fecundity (number of pups) in comparison to historical data. Other studies have discussed possible density-dependent changes in fecundity (e.g. Ellis & Keable, 2008), although it is not always possible to clearly differentiate between temporal changes in life-history characters from methodological differences in the disparate studies (Ellis & Keable, 2008; Ellis *et al.*, 2008). However, fishing may have had positive consequences for some elasmobranchs, as some species may benefit from the increased food availability resulting from discards, as Olaso *et al.* (1998) suggested for lesser-spotted dogfish (*Scyliorhinus canicula*).

Elasmobranch catches are known to be higher than the ones reported (e.g. quantities from the FAO database). This is mainly due to poor recording (including the widespread use of non-specific reporting categories), lack of reporting (non-target species are of lesser importance) and underreporting (e.g. if quota is restrictive, or if bycatch limits have been brought in for certain species) (Camhi *et al.*, 2008a).

A major problem to stock assessment and fisheries management is the lack of species-specific landings data, e.g. the aggregation of spurdog and deep-water sharks as “dogfish sharks” and “dogfishes and hounds” in some fisheries; and that “skates and rays” are often reported as a group (Fahy, 1989; Ellis *et al.*, 2008). The lack of species-specific identification and recording can mislead the real status of some species, and some can decline in abundance or even disappear locally without notice (Brander, 1981). In addition, mis-identifications, due to morphological similarities can also occur (e.g. for long-nosed skate *Dipturus oxyrinchus* and black skate *Dipturus nidarosiensis*), hampering stock assessment. Hence, there is still a real need for education and user-friendly identification material to improve the collection of landing data.

Therefore, the knowledge of how fisheries affect the abundance and distribution of elasmobranch populations through collections of commercial fisheries and fisheries-independent survey data is of extreme importance in monitoring the status of the stocks. Fishery-independent surveys are relevant in terms of historical comparisons (e.g. Rogers & Ellis, 2000) as well as for informing on recent changes (Borges *et al.*, 2005; Ellis *et al.*, 2005b) and on the identification of sites of importance as nursery and pupping grounds (Ellis *et al.*, 2005a).

Observer programmes on commercial vessels have been increasingly used in recent years (Enever *et al.*, 2007) and such data are needed to estimate total removals of fish species (total removals equating with landings and dead discards). Data from observer programmes on commercial vessels may also provide relevant information regarding important areas for specific life-history stages (e.g. mating grounds, pupping areas, feeding areas), inform on the discard/retention pattern, and also provide additional sources of species-specific information for the species composition in those taxa often landed as species complexes (e.g. skates).

However, discards data can have some limitations due to the high variability in time and space (e.g. Rochet *et al.*, 2002). Discard patterns on particular trips will be influenced by a variety of factors (Catchpole *et al.*, 2005; Gonçalves *et al.*, 2007). For example, the amount of quota available, market price, market requirements (e.g. export markets for smoothhounds are better developed in recent years), local needs (e.g. landings of

scyliorhinids for pot bait), and bycatch ratios (e.g. more smoothhounds and lesser-spotted dogfish may have been retained during 2007 when there was a 25% bycatch quota for skates). The state of the fish might also affect discard selection, for example, some skippers may release tope if they are lively, but retain those that are dead or unlikely to survive. Similarly, those fish that are damaged (e.g. by rocks in the codend, or lacerated by the spines of spurdog) may be rejected for commercial reasons. Although hard to quantify, discards may also be affected by the presence of observers on board. Furthermore, comparatively low levels of sampling effort (in comparison to overall effort), and the use of raising factors may mis-lead the real status of populations distribution and abundance (especially for rare species).

Discard survival rates for elasmobranchs are also of importance for both stock assessment and for gauging the potential benefits of possible management measures. However, it is still very poorly documented for most species, although there have been studies for species like *S. canicula* and skates (mainly *Raja clavata*), as they are common species that are easy to handle and process after capture, and both these species can survive discarding (Revill *et al.*, 2005; Catchpole *et al.*, 2007). Studies on discard survival have used short-term survival in tanks (e.g. Kaiser & Spencer, 1995; Rodríguez-Cabello *et al.*, 2001; Laptikhovsky, 2004; Revill *et al.*, 2005; Catchpole *et al.*, 2007) and tagging programmes (Rodríguez-Cabello *et al.*, 2001; Catchpole *et al.*, 2007). Other studies have focused on the within-net survival (Stobutzky *et al.*, 2002) and short-term discard mortality (Mandelman & Farrington, 2007).

Generally, these studies have suggested that several factors affect elasmobranch survival rates. Species survival will depend on species biology, their physiological and morphological characteristics (Kaiser & Spencer, 1995). Other factors that may also affect survival rate include haul duration (e.g. trawl duration, soak time for longlines and gillnets), catch size, time spent on deck during catch processing, damage caused by the gear, animals or objects (e.g. rocks) in the catch and the effects of coming up from depth as the fish is brought on board (Rodríguez-Cabello *et al.* 2005). For example, Laptikhovsky (2004) observed that the survival of shallow-water shelf skate species was higher than the survival of deep-water species in the Falkland Islands. A recent study by Skomal (2007) on *Prionace glauca* suggested that stress provoked by the capture might also decrease post-release survival.

Studies for lesser-spotted dogfish (*Scyliorhinus canicula*) showed survival rates from 78% (ranging from 47.1-90.5% in commercial trawls) up to 90% (tagging studies) (Rodríguez-Cabello *et al.*, 2001). This is probably due to the fact this species is highly robust and can resist long periods of emersion and the fishing process (Revill *et al.*, 2005). A recent study

on skate survival (mostly thornback ray) caught by trawl in the Bristol Channel suggested 50 to 74% short-term survival and that survival is related to the amount of total catch within the nets (Catchpole *et al.*, 2007).

Concerning assessment and management, there are still plenty of research requirements. Nevertheless, important actions towards elasmobranch management are already taking place, and are briefly mentioned below (for a detailed review see for example Ellis *et al.*, 2008). The precautionary approach to fisheries management is particularly relevant to elasmobranchs, due to the highly vulnerability of the stocks, and that recovery may be extremely slow after depletion (FAO, 2000; Cedrola *et al.*, 2005).

In addition to fisheries management bodies (e.g. ICES, NAFO, ICCAT and FAO) increasingly addressing the management of elasmobranchs fisheries and assessment of the stocks, elasmobranchs have been an increasing focus for conservation bodies and legislation. For example, in 1994 CITES (Convention on International Trade in Endangered Species) adopted a Resolution on the trade in sharks and sharks products. Later in 2002, CITES listed the whale shark (*Rhincodon typus*) and basking shark (*Cetorhinus maximus*) in its Appendix II, with white shark (*Carcharodon carcharias*) listed on Appendix II since 2004. Sawfish were added to Appendix I (“*species threatened with extinction*”) in 2007 (except *Pristis microdon*, which was added to Appendix II) (Ellis *et al.*, 2008).

Considering that many elasmobranchs show high migratory patterns, in 1993, the first USA Federal Fishery Management Plan (FMP) for Atlantic highly migratory species (HMS) was implemented (subsequently amended in 1999 and 2003), where elasmobranchs (except for dogfish, skates and rays) were considered.

In 1999, the FAO published the International plan of Action for Sharks (IPOA-Sharks), although its voluntary implementation may have delayed the implementation and subsequent management in some nations, instead of pushing it forward. In 2004, NAFO set a quota for *Amblyraja radiata*, which turned to be the first elasmobranch stock's quota ever set by a Regional Fisheries Management Organization (RFMO). In the same year, ICCAT implemented the first significant measure in elasmobranchs management, requiring the full utilization of shark catches and prohibiting finning activities by vessels in ICCAT fisheries (Ellis *et al.*, 2008).

One of the major environmental organisations, the IUCN (International Union for the Conservation of Nature) is responsible for the “Red List of Threatened Species” where, cartilaginous fishes are also included. Nowadays, 126 species (including sharks, skates, rays and chimaeras) are considered threatened (critically endangered, endangered and

vulnerable) in the 2007 IUCN Red List of Threatened Species. The main species included belong to the Rajiformes (~55%) followed by Carcharhiniformes (~20%); with remaining species belonging to other Lamniformes, Orectolobiformes, Squaliformes, Squatiniformes and Torpediniformes (IUCN, 2008).

The European Commission does not have any legal protection concerning elasmobranchs, although white shark and basking shark have been listed as Prohibited Species on the TACs and quotas regulations since 2007, so that Community vessels are not allowed to fish for, to retain on board, to tranship and to land them (EC Regulation No. 40/2008). Some European nations have protected elasmobranchs under conservation legislations (e.g. the UK Wildlife and Countryside Act affords protection to basking shark and angel shark), and regional management can be applied in some areas (e.g. local Sea Fisheries Committee bylaws in UK coastal waters may allow for a Minimum Landing Size for skates).

In terms of finning, the policies (national, regional and international) are still inconsistent and create loopholes, which can be easily bypassed by fishermen. It needs to be noted that fishing activities in international waters are the most difficult to monitor, so finning may occur, which will underestimate landings and threatens the sustainability of shark fisheries.

Some nations have banned targeted fishing of all elasmobranchs in their territorial waters (in some or in all areas) like the Republic of Congo, Ecuador (where finning is prohibited since 2004), Egypt (where finning is prohibited since 2005 in Red Sea Egyptian territorial), Israel (since 1980 all sharks have a protected status) and Palau (only for foreign vessels). Although some nations have forbidden finning, the landings of fins are still allowed. For example, in terms of the EC (since 2003) the weight of fins landed should not exceed 5% of the live weight of the shark catch for those vessels which have a special permit to process sharks on board (other vessels should land them whole). Whilst finning has been banned in Canadian and US waters since 1994 and 2002/3 respectively (Camhi *et al.*, 2008b).

Management for elasmobranchs species may aim to protect both juveniles and larger females, due to the close stock-recruitment relationships (Ellis *et al.*, 2008). Examples of management measures include effort control and licensing schemes, restrictions by the use of TACs (Total Allowable Catch), quotas and bag limits, gear regulations and restrictions, closed areas and seasons and prohibiting the retention or landing of the rarest species (Ellis *et al.*, 2008).

For instance, since 2007, the bycatch of spurdog “shall not comprise more than 5% by live weight of the catch retained on board” according to EC Regulations for the North Sea. Furthermore, ICES (2008c) has recently advice that if target fisheries should continue, a precautionary maximum landing length should be set at 100 cm (to protect large females).

A non-specific species EC quota for “skates and rays” may hamper stock management because life-history stages and vulnerability to (over)-fishing may differ between species. Because of this, ICES (2008a,b) has recently advised on a species-specific basis for the first time. This advice, for both the Celtic Seas ecoregion (ICES Areas VIIa-c, e-k) and in the North Sea ecoregion (Subarea IV and Division VIId) was that there should be no targeted fisheries for common skate and undulate ray, and with no landings of white skate and angel shark. Other recent ICES advice was that Portuguese dogfish (*Centroscymnus coelolepis*) and leafscale gulper scale (*Centrophorus squasomus*) should have a zero catch and target fisheries for kitefin shark (*Dalatias licha*) should not exist in the Northeast Atlantic (ICES, 2008d,e).

Meanwhile, the US has, since 1993, been using several measures, including commercial catch quotas, trip limits and recreational bag limits to enforce elasmobranch stock management (Ellis *et al.*, 2008).

In terms of technical measures, these have mostly been used in the management of commercial teleosts, although there are instances where they have been applied to elasmobranchs (e.g. to minimise specific life-history stages being taken in directed fisheries and bycatch). Mesh size regulations exist in mixed demersal trawl and gillnet fisheries operating in North America and European waters, and some of these are relevant to fisheries capturing elasmobranchs. For example, there is a minimum mesh size in the codend of 320 mm in fisheries targeting starry ray in the NW Atlantic. Meanwhile, in UK waters, local minimum landings sizes (MLS) may exist for skates and rays, and in Norwegian waters there is a MLS of 70 cm for spurdog (Ellis *et al.*, 2008). It should also be noted that there are no minimum landing sizes operating at an EC level. Furthermore, gillnets are restricted in European deep-water fisheries and regulations in drift nets lengths have been also set. Within the UK waters, local bylaws were established to protect inshore waters through gear restrictions (Ellis *et al.*, 2008).

Marine protected areas and closing areas (all year or just seasonally) to fisheries activities has been used to protect specific-life stages (e.g. nursery areas, pupping areas, egg-laying grounds). For instance, bottom longline off North Carolina is prohibited, since 2005, from January to July to protect juveniles dusky (*Carcharhinus obscurus*) and sandbar (*C. plumbeus*) sharks, and the area of the Grand Banks is closed to shark fisheries all year

round as it is a mating ground for porbeagle (*Lamna nasus*). Additionally, concerning prohibited species within UK, it is illegal to possess, harm or trade basking shark while white shark is protected in California waters, South Africa, Australia, the Maldives and Malta (Ellis *et al.*, 2008).

The aims of the present project are to:

1. Undertake analyses of demersal longline fisheries around the British Isles and the main species caught, so as to better understand the temporal and spatial dynamics of these fisheries, with particular reference to spurdog and skates.
2. Undertake analyses of data from UK (England and Wales) discard observer schemes to examine (a) the spatial distribution of chondrichthyans, and (b) the length-based selection patterns of the main species in the various fisheries.
3. Undertake analyses of data from UK (England and Wales) landings data and observer data to (a) identify the main fisheries (by ICES Division and gear) landing skates and (b) estimate the species composition (by biomass) of the skates taken in these fisheries.

II Analysis of UK Demersal Longline Fisheries

II.1 Introduction

Longlining is, in many respects, one of the more environmentally friendly and selective fishing methods. It is generally fuel-efficient, has less impact on the sea floor, tends to be quite selective and the unwanted bycatch can generally be released in good condition, at least in shallower areas, although this can be affected by de-hooking/bait stripping machines (Milliken *et al.*, 1999). Longline fisheries, however, can be highly effective at capturing large piscivorous species, including some of those that are of management concern. Elsewhere in the world, there are also issues regarding the bycatch of albatross (and other seabirds), although this is less of a problem in UK inshore longline fisheries.

Longlining, in general, is used to capture demersal, deep-water or pelagic fishes and the exact specifications of the gear depend on the target species and area (Sainsbury, 1996). The longline system is one of the more basic types of fishing gear, and large numbers of hooks can be operated (Von Brandt, 1984). Within UK fisheries, there is (or has been) longlining for deep-water species and large pelagic fish, such as porbeagle *Lamna nasus*. Most UK longlining, however, is demersal longlining where the main species include cod, spurdog and skates. Regionally important bycatch species include other types of dogfish,

gadoids (e.g. whiting, haddock and ling), conger eel, bass and larger flatfish (e.g. turbot and halibut).

Bottom longlining involves deploying a main line, which may be >1 km long, with 100s-1000s of traces (also known as leaders or snoods) fixed to the main line (Von Brandt, 1984). For demersal longlining, the traces are usually attached at intervals of 1.5–5 m (Sainsbury, 1996). The main line is usually a tightly twisted nylon, polyester/Terylene, nylon/polypropylene or leaded polypropylene, with a diameter of 4–12 mm (Sainsbury, 1996). In some fisheries the snoods are made of monofilament line (with swivels), which has the advantage of lower visibility to fish and being more buoyant (Sainsbury, 1996), although other materials (e.g. wire) may be used in some fisheries, as monofilament may wear if fishing on coarser grounds. The use of wire leaders has been stopped in some pelagic longline fisheries to reduce shark bycatch (Ward *et al.*, 2008), as sharks may be able bite through monofilament lines, whereas tunas and billfish are less capable of doing this.

In general, the efficiency of longlines is influenced by many factors, including the size and type of hook (e.g. traditional J-hooks or circle hooks), bait, and the material, length and spacing of the snoods (e.g. Von Brandt, 1984; Bjordal, 1987; Franco *et al.*, 1987; Woll *et al.*, 2001; McFarlane *et al.*, 2005; Santana Hernandez *et al.*, 2008). In recent years, several studies have highlighted that circle hooks enable discarded fish to be released with a better health state (Diaz, 2008). Catch rates in bottom longlining will also be affected by bait loss, with crustaceans and small fish consuming bait (High, 1980; Tutui & Braga, 2007).

Bottom longlining can be undertaken from a variety of boats, and since it only needs a relatively small area for the setting operation, it is ideal for small inshore boats (Sainsbury, 1996). For bottom longlines, the grounds fished are often fairly soft, since the lines can be chafed, broken or even entangled, which hampers retrieval. Longlines may be deployed near particular topographic features (e.g. sandbanks and pits) where fish are known to aggregate and/or feed. In terms of bait, some fisheries bait with fresh squid or oily fish (e.g. mackerel or herring). Many inshore boats use frozen squid (or fish), with lines baited ashore and stored in freezers until required. Bait costs and staff costs for baiting (as well as replacing, sharpening or straightening hooks and making other repairs to the lines) are significant shore-based costs for longliners. Hence, many aspects of longlining are/were labour intensive, although various automated systems are now available. To further reduce costs, artificial baits are used in certain fisheries (Sainsbury, 1996).

The purpose of this report is to provide a summary of the seasonal and temporal patterns in reported UK longline landings, and to provide a brief overview of the main species taken.

II.2 Data

Landing data from UK-registered vessels were extracted from the Fishing Activity Database (which holds the official landings statistics for the UK) database for all catches recorded as being caught by longline (gear code 71). This code is used for pelagic, deep-water and demersal longlines. Records from outside the main study area, e.g. line-caught tuna and swordfish from Anglo-Spanish vessels operating outside UK waters were omitted, and species that are obviously pelagic (e.g. porbeagle and blue shark) or deep-sea (e.g. Portuguese dogfish and leafscale gulper shark) were also omitted from this study. Those species that may be taken in longline fisheries both on and off the continental shelf (e.g. hake, anglerfish and greater forkbeard) were included in data analyses.

The main fish species (and higher taxonomic groups) are summarised in Table I. In those areas where many species were landed in small quantities, these have been aggregated at higher taxonomic levels for illustrative purposes. For example, if landings of smoothhounds were small, they are combined with *Scyliorhinus* etc., as general 'dogfishes'. Reported catches of 'eel' have been assumed to refer to conger eel..

Dogfish	Spurdog	<i>Squalus acanthias</i>
	Lesser-spotted dogfish	<i>Scyliorhinus canicula</i>
	Greater-spotted dogfish	<i>Scyliorhinus stellaris</i>
	Dogfish (Scyliorhinidae)	<i>Scyliorhinus</i> spp.
	Tope	<i>Galeorhinus galeus</i>
	Smoothhounds	<i>Mustelus</i> spp.
	Unidentified dogfish	
	Angel Shark	<i>Squatina squatina</i>
Skates	Skates and rays	<i>Rajidae</i> spp.
Anguilliformes	Conger eel	<i>Conger conger</i>
Gadiformes	Torsk (Tusk)	<i>Brosme brosme</i>
	Cod	<i>Gadus morhua</i>
	Haddock	<i>Melanogrammus aeglefinus</i>
	Whiting	<i>Merlangius merlangus</i>
	Ling	<i>Molva molva</i>
	Greater forkedbeard	<i>Phycis blennoides</i>
	Pollack	<i>Pollachius pollachius</i>
	Saithe	<i>Pollachius virens</i>
	Norway Pout	<i>Trisopterus esmarki</i>
	Bib	<i>Trisopterus luscus</i>
	Hake	<i>Merluccius merluccius</i>
Lophiiformes	Anglerfish	<i>Lophius</i> spp.
Zeiformes	John Dory	<i>Zeus faber</i>
Scorpaeniformes	Gurnard (indet.)	<i>Triglidae</i> spp.
Perciformes	Bass	<i>Dicentrarchus labrax</i>

	Wreckfish	<i>Polyprion americanus</i>
	Dusky Perch	<i>Epinephelus marginatus</i>
	Red seabream	<i>Pagellus bogaraveo</i>
	Gilthead seabream	<i>Sparus aurata</i>
	Black seabream	<i>Spondylusoma cantharus</i>
	Seabream (indet.)	<i>Sparidae</i> spp.
	Ballan wrasse	<i>Labrus bergylta</i>
	Wrasses	<i>Labridae</i> spp.
	Red mullet	<i>Mullus surmuletus</i>
	Wolf-fish	<i>Anarhichas lupus</i>
Flatfish	Megrim	<i>Lepidorhombus whiffiagonis</i>
	Turbot	<i>Psetta maximus</i>
	Brill	<i>Scophthalmus rhombus</i>
	Witch	<i>Glyptocephalus cynoglossus</i>
	Halibut	<i>Hippoglossus hippoglossus</i>
	Dab	<i>Limanda limanda</i>
	Lemon sole	<i>Microstomus kitt</i>
	Flounder	<i>Platichthys flesus</i>
	Plaice	<i>Pleuronectes platessa</i>
	Sand sole	<i>Pegusa lascaris</i>
	Sole	<i>Solea solea</i>

Table I - Main fish species landed in UK (England and Wales) demersal longline fisheries

II.3 Species recorded

Brief descriptions of the main fish species taken by UK demersal longliners are given below, including information on their spatial distribution, and general life cycle and feeding habits.

II.3.1 Spurdog

Spurdog (*Squalus acanthias*) is widely distributed in the ICES area, ranging from northern Norway to the Iberian Peninsula, although it tends to be less abundant south of Brittany. For assessment purposes single stock in the ICES area has been considered.

Spurdog is taken in trawl, gillnet and longline fisheries all around the British Isles. It has been either a target or important bycatch species in longline fisheries, especially in the Irish Sea and southern North Sea (Figure I). It is a large-bodied species ($L_{max} = 120$ cm) that may aggregate by sex and size. It is generally regarded as forming seasonally important fisheries in most areas, although small numbers may be present throughout the year. Annual landings of spurdog by longline were 1 000–2 000 t.y⁻¹ during the 1990s, but have been less than 200 t.y⁻¹ in recent years.

Spurdog are aplacentally viviparous (lecitotrophic viviparity), with gestation lasting about 2 years. Litter size ranges from 2–21, with fecundity increasing with length (Ellis & Keable, 2008), and the young are born at a length of about 24 cm (range 19–30 cm). Spurdog feed on a variety of demersal and pelagic prey, including euphausiids, ctenophores, sprat and herring (Ellis *et al.*, 1996).

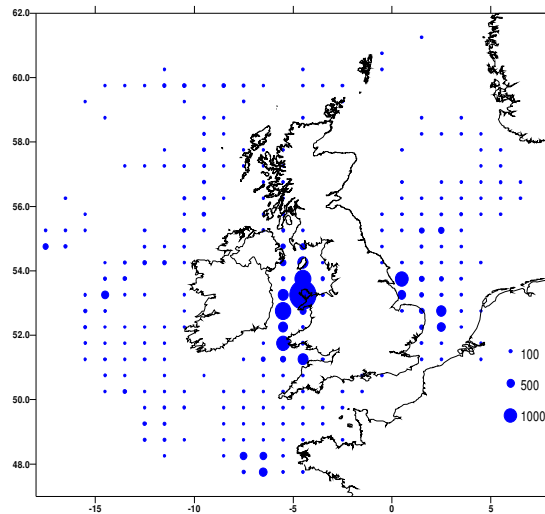


Figure I - Total reported landings (t) of spurdog taken in UK longline fisheries 1990-2007.
(Source of data: FAD).

II.3.2 Greater and lesser-spotted dogfish

Greater-spotted dogfish (*Scyliorhinus stellaris*) and lesser-spotted dogfish (*Scyliorhinus canicula*) have broadly similar biogeographical distributions, and both can be found in the NE Atlantic from Norway (*S. canicula*) or from southern Scandinavia (*S. stellaris*) to NW Africa (Mauritania and Senegal), including the Mediterranean Sea. *S. canicula* can also be found as far south as the Ivory Coast (Whitehead *et al.*, 1986; Compagno, 1984; Compagno *et al.*, 2005).

In addition to being taken by longlines, both species may be taken in demersal trawls and bottom gillnets (Compagno, 1984). Both are of low commercial value in the UK, although they may be landed for either human consumption or for pot bait (e.g. for whelk fisheries).

Lesser-spotted dogfish are smaller (Lmax= 80 cm) and are widespread around the British Isles, whilst the greater-spotted dogfish (*Scyliorhinus stellaris*) (Lmax = 162 cm) has a more patchy distribution and is locally abundant in parts of the Irish Sea (Ellis *et al.*, 2005a). Reported longline landings of both species are centred in the Irish Sea (Figure II). Both species predate on crustaceans, molluscs and demersal fishes, including small gadoids and flatfishes (Ellis *et al.*, 1996). Lesser-spotted dogfish also feed on small benthic invertebrates (e.g. polychaete worms) whilst *S. stellaris* tend to favour cephalopod prey.

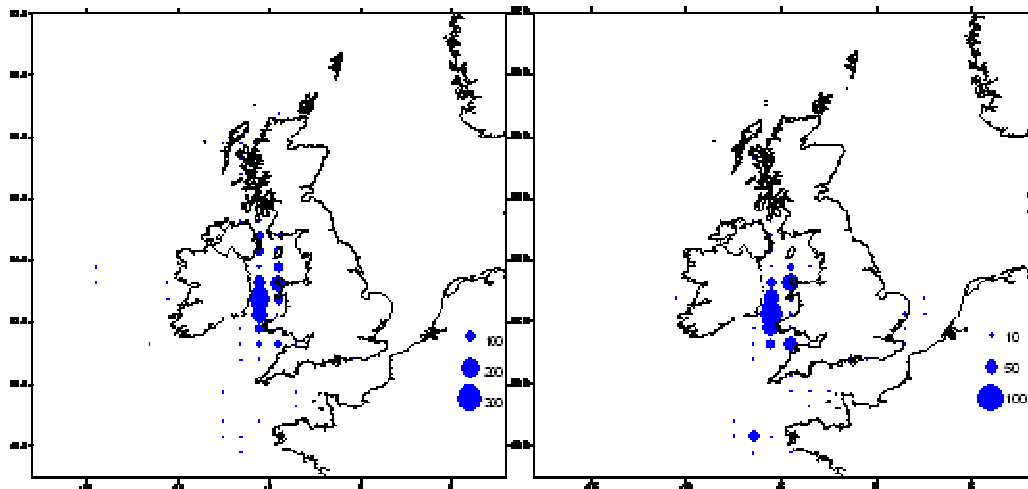


Figure II - Total reported landings (t) of greater-spotted dogfish (left) and lesser-spotted dogfish (right) taken in UK longline fisheries 1990-2007. (Source of data: FAD)

II.3.3 Tope

Tope (*Galeorhinus galeus*) is widely distributed in the NE Atlantic, occurring as far north as Norway. In British waters, it is most common in the southern North Sea, English Channel, Bristol Channel and Irish Sea (Figure III; Ellis *et al.*, 2005). It is considered to be a single stock of tope in the NE Atlantic.

Tope is a bycatch species in both demersal and pelagic longline fisheries. Tope has been an important commercial species in longline fisheries elsewhere in the world, but have traditionally been discarded in UK fisheries. In recent years, as markets for triakid sharks have developed on the continent, they have been subject to increased commercial interest. Tope are also of high interest to sport anglers and charter boats, and are targeted in many areas (although much of the catch is returned alive). Reported landings of longline-caught tope have ranged from 9–55 t.y⁻¹ in recent years, although an unknown quantity may have been included within the non-specific landings categories (e.g. dogfishes).

Tope is a large-bodied species (L_{max}= 200 cm) and can occur in small aggregations (Compagno, 1984). They primarily predate on pelagic and demersal fish and cephalopods, but smaller individuals also feed on benthic invertebrates (Compagno, 1984; Whitehead *et al.*, 1986; Ellis *et al.*, 1996; Morato *et al.*, 2003; Lucifora *et al.*, 2006). There have been few biological studies on the NE Atlantic stock of tope (e.g. Capape *et al.*, 2005; Domi *et al.*, 2005).

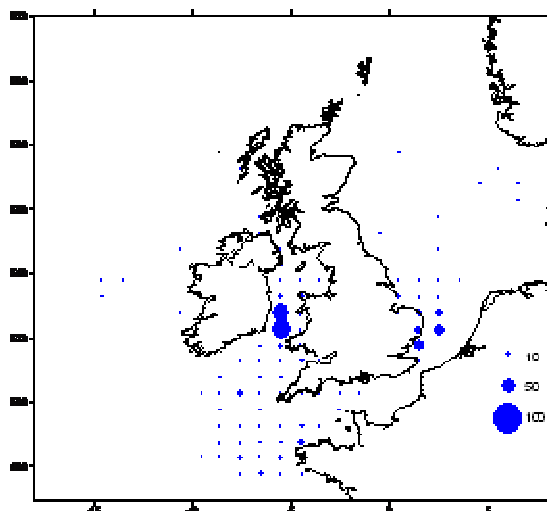


Figure III - Total reported landings (t) of tope taken in UK longline fisheries 1990–2007.

(Source of data: FAD)

II.3.4 Smoothhounds

Smoothhounds (*Mustelus* spp.) are widely distributed in the NE Atlantic, occurring as far north as Norway. In British waters, they are most common in the southern North Sea, English Channel, Bristol Channel and Irish Sea (Figure IV; Ellis *et al.*, 2005a).

Smoothhounds (*Mustelus* spp.) are low-value species that are often discarded, although there seems to have been an increased abundance in recent years (ICES, 2007b) and, as markets have developed for triakid sharks, they have been of an increased commercial interest, especially in the southern North Sea and English Channel. Reported captures in longlines appear low (Figure IV), and this may also be related to the fact that they are primarily crustacean feeders. Gillnet fisheries are known to take this species effectively.

Smoothhounds are large-bodied species (Lmax= 150 cm) and can occur in small aggregations (Compagno, 1984). They primarily predate on crustaceans (Ellis *et al.*, 1996). They are viviparous, but there have been few biological studies on this species in the NE Atlantic.

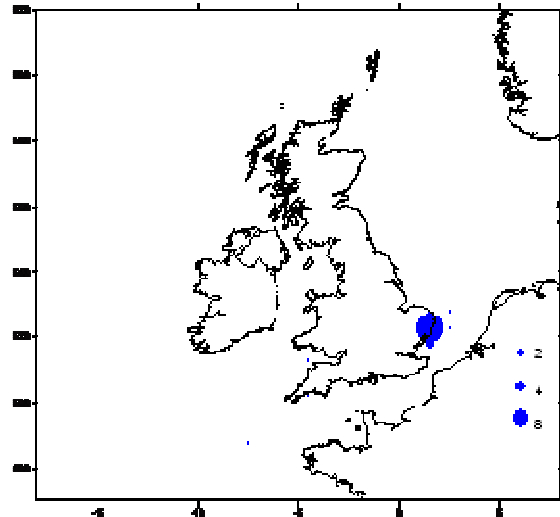


Figure IV - Total reported landings (t) of smoothhounds in UK longline fisheries 1990–2007.
(Source of data: FAD)

II.3.5 Skates and rays

The skate complex around the British Isles is relatively diverse, with about a dozen species occurring in shelf seas, and more occurring in deep water along the continental shelf. The stock structure for most species is unknown.

Several species of skate may be taken in demersal longline fisheries, especially in the southern North Sea and, to a lesser extent, the Bristol Channel and St George's Channel (Figure V). Fisheries in the Greater Thames Estuary and southern North Sea take primarily thornback ray (*Raja clavata*), with small quantities of blonde (*Raja Brachyura*) and spotted ray (*Raja montagui*) taken (Ellis *et al.*, 2008). All these species are also taken in St George's Channel and Bristol Channel, with smalleyed ray (*Raja microocellata*) also taken in the latter area. Blonde ray has a patchy distribution, and so can be one of the main species known in some localised and/or seasonal fisheries. Mean annual longline landings of skates were approximately 590 t.y⁻¹ during the 1990s, but this has declined to about 100 t.y⁻¹ in recent years, possibly due to quota restriction.

Skates are oviparous, each species having distinctive egg cases. Juvenile skates tend to feed on small crustaceans, with larger individuals either predating on larger crustaceans and/or fishes, including sand eels and small gadoids.

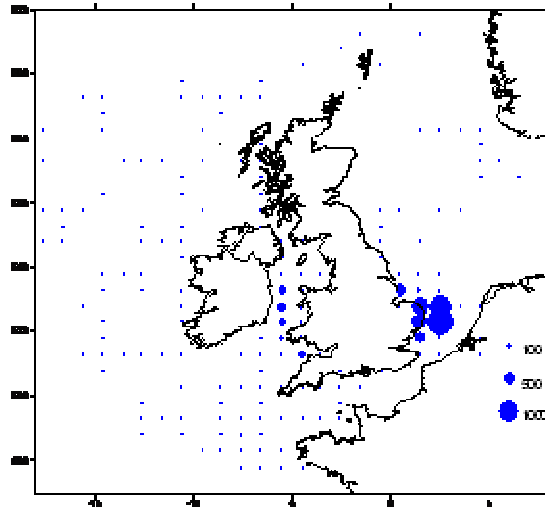


Figure V - Total reported landings (t) of skates and rays in UK longline fisheries 1990–2007.
(Source of data: FAD)

II.3.6 Conger eel

Conger eel (*Conger conger*) is a widely distributed demersal species, occurring in the NE Atlantic and Mediterranean Sea (Whitehead *et al.*, 1986). Around the British Isles they are reported mainly the continental shelf and shelf edge, on rocky bottoms and often associated with wrecks.

Conger is an important species for longline fisheries, especially in the Irish Sea, western English Channel and Bristol Channel (Figure VI). Mean annual landings (1990–2007) have been approximately 220 t.y⁻¹.

They can attain a maximum length of 3 m, and females are larger than males (Cau & Manconi, 1983; Whitehead *et al.*, 1986). They are primarily piscivorous (O'Sullivan *et al.*, 2004), but also predate on crustaceans (especially crabs) and cephalopods (especially octopuses). Although it is a relatively common and widely distributed fish, there are only a few studies on their biology (e.g. Fannon *et al.*, 1990; O'Sullivan *et al.*, 2003; Correia *et al.*, 2006).

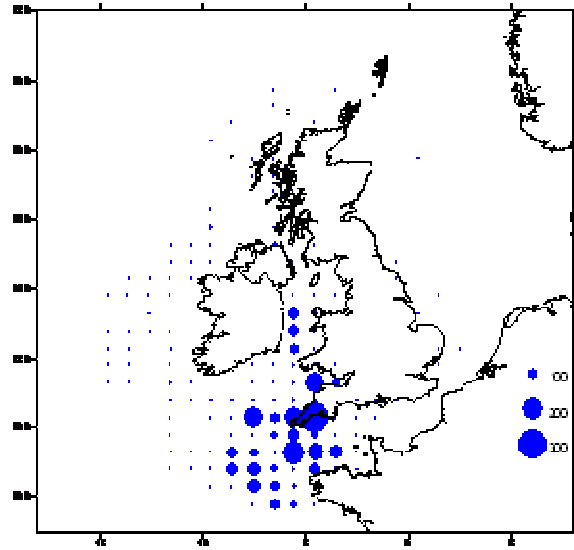


Figure VI - Total reported landings (t) of conger eel taken in UK longline fisheries 1990–2007.
Source of data: FAD.

II.3.7 Cod

Cod (*Gadus morhua*) is one of the most important commercial fish species in the NE Atlantic, occurring in both side of the North Atlantic (Whitehead *et al.*, 1986).

It is mainly caught in mixed whitefish fisheries using otter trawl, but is also targeted with gillnets and longline. There is an important UK longline fishery in the southern North Sea (Figure VII), with smaller amounts taken in other areas around the British Isles. Annual landings (2000–2007) by longlines have declined in recent years ($<400 \text{ t.y}^{-1}$), with 1 000–2 000 t.y^{-1} taken in the 1990s, and such declines should be viewed in the context of fishery regulations for this species.

Cod is a demersal species and is more commonly found on the continental shelf down to depths of 150–200m. Juveniles seem to prefer inshore grounds and bays, with adults found at all depths (Whitehead *et al.*, 1986; Cohen *et al.*, 1990; ICES-Fish Map, 2008). Cod may aggregate in schools during the day, while more dispersed at night (Cohen *et al.*, 1990). Atlantic cod is a voracious and omnivorous species predating primarily on demersal fishes, such as other gadoids (including cod), sandeels and flatfish, and larger decapod crustaceans. Juveniles feed mainly on polychaetes and small crustaceans (Whitehead *et al.*, 1986; Cohen *et al.*, 1990; Mattson, 1990; ICES-Fish Map, 2008).

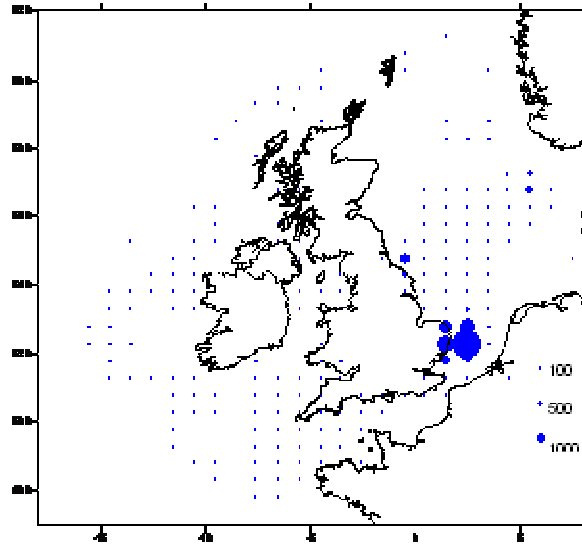


Figure VII - Total reported landings (t) of cod taken in UK longline fisheries 1990–2007.
(Source of data: FAD)

II.3.8 Haddock and whiting

Haddock (*Melanogrammus aeglefinus*) is as an important target species in North Atlantic fisheries, and is taken in mixed trawl and seine fisheries, along with cod and whiting, and as a bycatch in *Nephrops* fisheries (Cohen *et al.*, 1990; ICES-Fish Map, 2008). Around the British Isles, it is most abundant in the central and northern North Sea, off western Scotland, in the Celtic Sea and off Ireland (Cohen *et al.*, 1990; ICES-Fish Map, 2008). Mean annual landings (1990–2007) by longlines have been approximately 30 t.y⁻¹ (Figure VIII).

Haddock is a demersal species that prefers fine grounds at depths of 75–125 m, but they can occur over coarser grounds. Haddock can grow to 1 m in length, although they are more commonly seen to about 80 cm. Males are slightly smaller than females (Whitehead *et al.*, 1986; Cohen *et al.*, 1990; ICES-Fish Map, 2008). Haddock predate on small benthic organisms (small crustaceans, bivalves, brittlestars and polychaetes) and small fishes (Adlerstein *et al.*, 2002). As one of the most commercially valuable fish species in northern Europe, there are many studies regarding their biology, including age and growth (e.g. Bolle *et al.*, 2004), reproductive biology (Wright, 2005) and habitat (e.g. Hiddink *et al.*, 2005).

Whiting (*Merlangius merlangus*) is a commercially important species, especially in the North Sea, although smaller individuals are discarded in large quantities. It is caught mainly in mixed trawls fisheries along with cod and haddock. They occur all around the British Isles (Cohen *et al.*, 1990; ICES-FishMap, 2008). Mean annual landings (1990–2007) from longlines have been approximately 28 t.y⁻¹ (Figure VIII).

Whiting is primarily demersal, although they can move into mid-water for feeding (Whitehead *et al.*, 1986; ICES-FishMap, 2008). They can attain 70 cm in length, but are more commonly observed to about 50 cm (Whitehead *et al.*, 1986; Cohen *et al.*, 1990). Adults are one of the major fish predators in the North Sea, with juveniles feeding on benthic invertebrates and small fishes (Whitehead *et al.*, 1986; Cohen *et al.*, 1990; ICES-FishMap, 2008). This important commercial species has been subject to many biological studies, including its growth and reproductive biology (Gerritsen *et al.*, 2003), habitat (Atkinson *et al.*, 2004) and population structure (Charrier *et al.*, 2007).

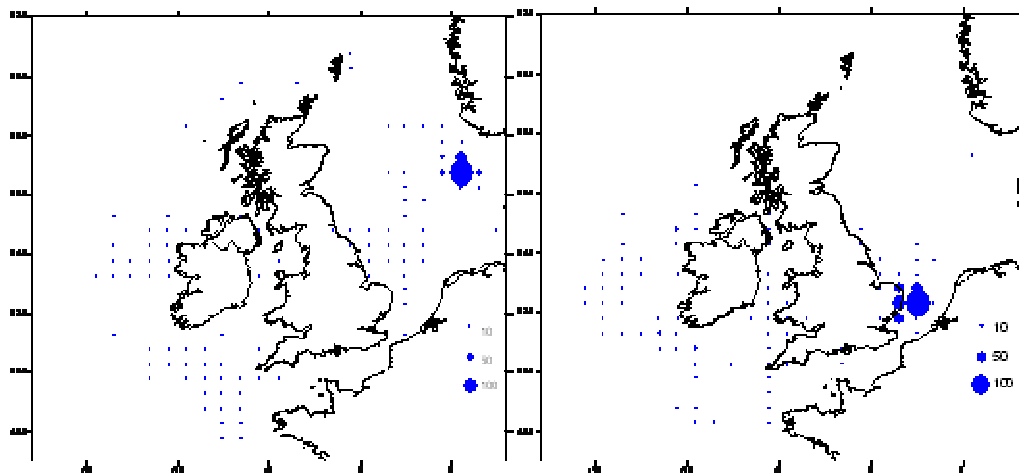


Figure VIII - Total reported landings (t) of haddock (left) and whiting (right) in UK longline fisheries 1990–2007. Source of data: FAD.

II.3.9 Saithe and pollack

Saithe (*Pollachius virens*) is an important commercial species in many northern European countries, and is caught primarily in trawl fisheries, along with other gadoids (Whitehead *et al.*, 1986; Cohen *et al.*, 1990; ICES-FishMap, 2008). It is distributed mainly along the western and northern coasts of the British Isles (Whitehead *et al.*, 1986; ICES-FishMap, 2008). Reported landings of saithe from UK registered longliners are mostly from western Ireland (Figure IX), with smaller quantities from the central North Sea. Mean annual landings by longlines (2000–2007) have usually been $<1 \text{ t.y}^{-1}$, compared to the 25 t.y^{-1} reported during the 1990s. The extent of misreporting is unknown.

Saithe is a demersal species, with juveniles inhabiting inshore areas and larger individuals occurring further offshore. They can attain 130 cm in length, and males are slightly smaller than females (Whitehead *et al.*, 1986; Cohen *et al.*, 1990). Juvenile saithe predate on suprabenthic and planktonic invertebrates, including euphausiids, amphipods and natantid shrimps, with larger individuals becoming increasingly piscivorous, predating on other gadoids, herring, pearlsides, sandeels and mackerel (Bergstad, 1991; Sarno *et al.*, 1994;

Floeter & Temming, 2005; Slotte *et al.*, 2005). There have been studies on various aspects of its biology, including growth (e.g. Bolle *et al.*, 2004) and reproduction (Storozhuk & Golovanov, 1976).

Pollack (*Pollachius pollachius*) is a relatively low value species, although it is targeted in some gillnet fisheries. It is also a bycatch in trawl and longline fisheries (Cohen *et al.*, 1990). This northerly species occurs all around the British waters, although it is most common along northern and western coasts (Whitehead *et al.*, 1986; Cohen *et al.*, 1990). Mean annual landings by longlines (2000–2007) have been about $<5 \text{ t.y}^{-1}$, and were about 31 t.y^{-1} during the 1990s (Figure IX). Once again, the extent of misreporting is unknown.

Juvenile pollack often appear close inshore over hard bottoms (Fromentin *et al.*, 1997; Kamenos *et al.*, 2004), with the adults moving offshore to deeper waters, where they often associate with wrecks and coarse grounds (Whitehead *et al.*, 1986; Cohen *et al.*, 1990). Pollack can attain 130 cm in length. Pollack are piscivorous, feeding on other gadoids, pearlsides etc., as well as cephalopods and benthic and suprabenthic crustaceans, including various shrimps (Cohen *et al.*, 1990; Bergstad, 1991; Sarno *et al.*, 1994). Suquet (2001) has recently summarised the biology of this species.

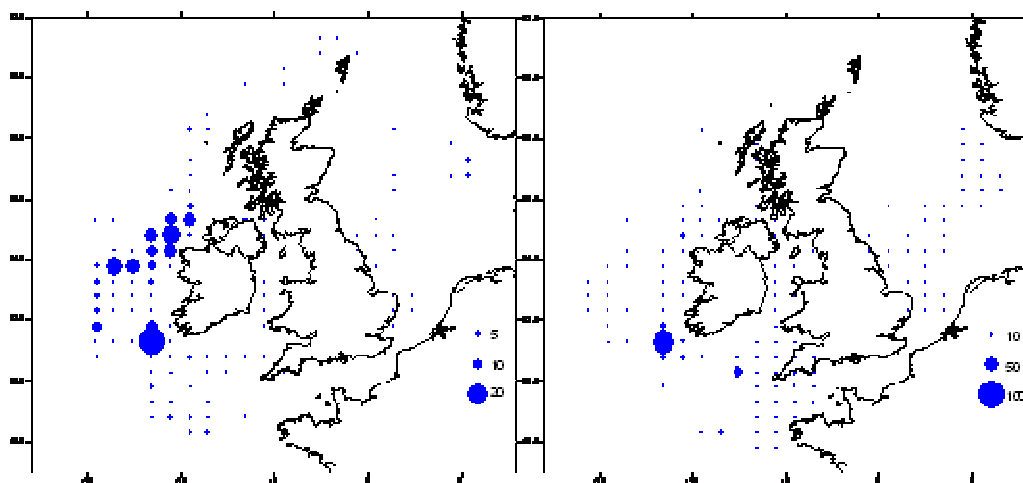


Figure IX - Total reported landings (t) of saithe (left) and pollack (right) in UK longline fisheries 1990–2007. Source of data: FAD.

II.3.10 Ling

Ling (*Molva molva*) is a relatively important commercial fish, which is commonly found on offshore grounds in the Northeast Atlantic. It is caught with bottom trawls, longlines and gillnets (Bjorndal, 1983; Whitehead *et al.*, 1986; Cohen *et al.*, 1990).

Longline catches of this species are generally from the western seaboard of the British Isles along the edge of the continental shelf and in the Celtic Sea, although they are taken

in small quantities in the Irish Sea, western English Channel and North Sea (Figure X). Mean annual landings (1990–2007) by longlines have been approximately 463 t.y⁻¹.

Ling can attain 220 cm in length, but are most commonly seen up to about 100 cm. They predate primarily on fish, including other gadoids, but also consume crustaceans, cephalopods and echinoderms (Whitehead *et al.*, 1986; Cohen *et al.*, 1990; Bergstad, 1991). There are comparatively few biological studies on this species (e.g. Moguedet, 1987; Bergstad *et al.*, 1998; Loekkeborg *et al.*, 2000).

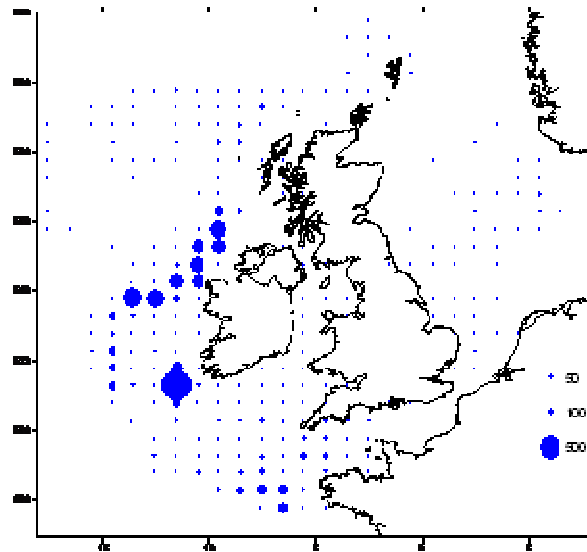


Figure X - Total reported landings (t) of ling taken in UK longline fisheries 1990–2007.

Source of data: FAD.

II.3.11 Greater forkbeard

Greater forkbeard (*Phycis blennoides*) is distributed from Iceland and Norway to the Mediterranean Sea (Whitehead *et al.*, 1986). Around the British Isles, they tend to be found on the outer parts of the continental shelf and off the continental slope in waters of 100–450 m depth. It can be found in slightly shallower waters and can extend to waters 800 m deep (Whitehead *et al.*, 1986; Cohen *et al.*, 1990).

Greater forkbeard is of minor commercial importance, and is taken as a bycatch in bottom trawl, longline and gillnet fisheries (Cohen *et al.*, 1990). Around the British Isles, it is taken by longliners operating around the edge of the continental shelf, with small quantities taken in the Celtic Sea (Figure XI). Mean annual landings for recent years (2000–2007) have been approximately 18 t.y⁻¹.

It can reach 110 cm in length, but are more commonly to about 45 cm, and females attain a larger size than males (Casas & Pineiro, 2000; Rotllant *et al.*, 2002; Rustighi *et al.*, 2004). Greater forkbeard is an epibenthic predator, with juveniles feeding on small

crustaceans and adults feeding on larger, decapod crustaceans and demersal fishes (Macpherson, 1978; Mauchline & Gordon, 1984; Whitehead *et al.*, 1986; Cohen *et al.*, 1990; Morte *et al.*, 2002). Most of the biological studies on this species are from the Mediterranean Sea (e.g. Massuti *et al.*, 1996; Matarrese *et al.*, 1998) and its biology in British waters is little known.

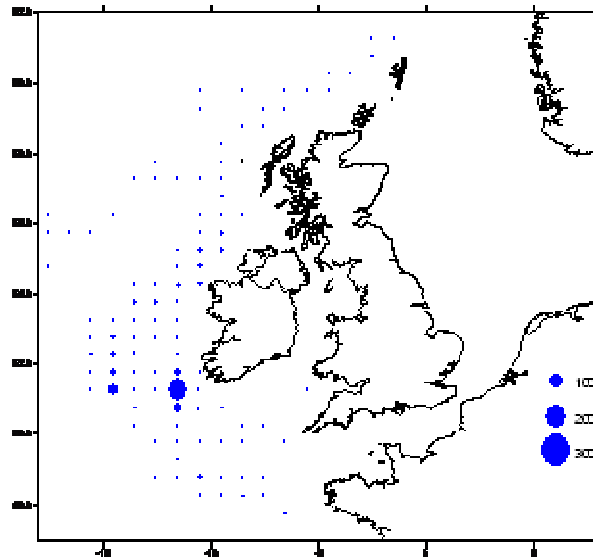


Figure XI - Total reported landings (t) of greater forkbeard taken in UK longline fisheries 1990–2007. Source of data: FAD.

II.3.12 Hake

Atlantic Hake (*Merluccius merluccius*) is distributed in the Northeast Atlantic, Mediterranean Sea and southern parts of the Black Sea. Around the British Isles, it occurs mainly off northern and western coasts (Cohen *et al.*, 1990; Lloris *et al.*, 2005).

Hake is one of the most important commercial fish species in Europe, and is taken in trawl, seine, longline and gillnet fisheries (Franco *et al.*, 1987; Cohen *et al.*, 1990; Lloris *et al.*, 2005). Longline-caught hake taken by UK registered vessels are mostly from the western seaboard of Ireland, with smaller quantities taken in the North and Irish Seas (Figure XII). Mean annual reported landings of longline-caught hake (1990–2007) are approximately 341 t.y⁻¹.

Hake is a demersal and a benthopelagic species that is most common at depths of 70–370 m. It occurs over a variety of substrates, including mud and muddy-sands on the outer continental shelf and slope. They can attain 140 cm in length, and females are larger than males (Cohen *et al.*, 1990; Lloris *et al.*, 2005). Juveniles predate on crustaceans (especially euphausiids, amphipods and natantid shrimps), with larger individuals becoming increasingly piscivorous, predating on other fish (e.g. juveniles hake,

anchovy, sardine and gadoids) and cephalopods (Cohen *et al.*, 1990; Guichet, 1995; Lloris *et al.*, 2005). There are numerous studies detailing the biology of this species (e.g. Agnew, 1989; Fahy & Gleeson, 1993; Lucio *et al.*, 1998; Castillo & Garcia-Vazquez, 2004).

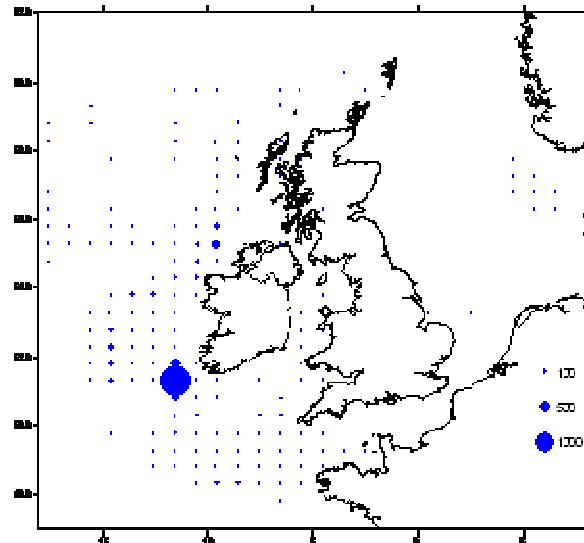


Figure XII - Total reported landings (t) of hake taken in UK longline fisheries 1990–2007.

Source of data: FAD.

II.3.13 Anglerfish

Two species of anglerfish occur in UK seas, anglerfish (*Lophius piscatorius*) and black-bellied anglerfish (*L. budegassa*). Both species occur along the outer continental shelf and slope along the western and northern parts of the British Isles (Figure XIII), with the former species also occurring on the inner continental shelf (Whitehead *et al.*, 1986).

Historically, anglerfish were discarded or landed as low-value bycatch, but in recent years they have become an increasingly important bycatch or target species, along with hake and megrim (e.g. Munch-Petersen & Sølgaard Andersen, 2007). Anglerfish is only occasionally taken in longline fisheries, with records showing mean annual landings of <1 t.y⁻¹ in recent years (2000–2007).

Anglerfishes are found on a variety of substrates in waters of about 18–550 m deep (Whitehead *et al.*, 1986). Early life-history stages have been observed close to the surface in open waters (Hislop *et al.*, 2001). Anglerfish can attain up to 200 cm (black-bellied anglerfish to 100 cm), with females attaining a larger size (Whitehead *et al.*, 1986; Ofstad & Laurenson, 2007). Anglerfishes are piscivorous, predating on flatfishes and gadoids etc. (Whitehead *et al.*, 1986; Fariña *et al.*, 2007). As a species of high economical value, there

have been an increased number of biological studies on this species in recent years (e.g. Woodroffe *et al.*, 2003; Laurenson & Priede, 2005; Landa *et al.*, 2007).

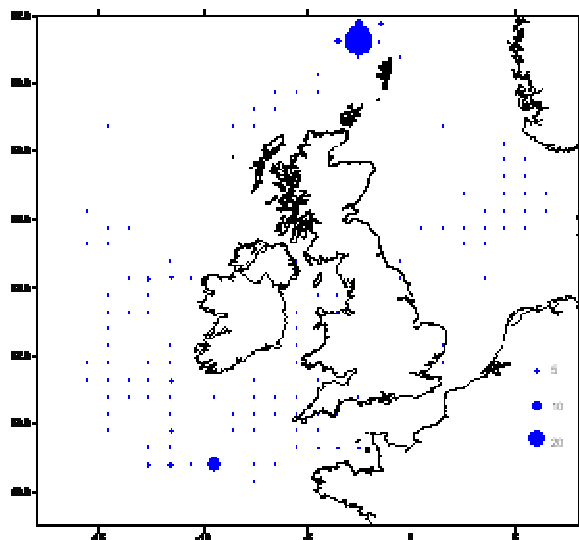


Figure XIII - Total reported landings (t) of anglerfish taken in UK longline fisheries 1990–2007. Source of data: FAD.

II.3.14 Bass

European bass (*Dicentrarchus labrax*) is widespread in the NE Atlantic and around the British Isles, and is common off Ireland, and in the Bristol Channel, English Channel and southern North Sea (Whitehead *et al.*, 1986; Pickett & Pawson, 1994; Moretti *et al.*, 1999).

Bass is a very important commercial and recreational fish in Europe, and is also farmed in aquaculture. It can be caught with beach and purse seine, trawls, trammel, gillnets and longlines, as well as rod and line (Arias, 1980; Pawson & Pickett, 1987; Pickett & Pawson, 1994; Moretti *et al.*, 1999; Fritsch *et al.*, 2005). Mean annual landings (1990–2007) by longliners have been approximately 7 t.y⁻¹, and are reported mostly from the southern North Sea (Figure XIV).

Bass is a demersal and benthopelagic species, and can occur from shallow inshore waters down to 100 m depth, and occurs over a variety of bottoms, including rocks, sandbanks, sand and gravel. Juveniles inhabit estuaries and inshore waters, where they can form large schools, with adults also occur further offshore (Whitehead *et al.*, 1986; Pickett & Pawson, 1994; Fritsch *et al.*, 2005). Bass can attain 100 cm in length, with females attaining a larger size (Whitehead *et al.*, 1986; Pickett & Pawson, 1994). Bass is a voracious predator, with juveniles feeding on small fishes and small crustaceans while adults predate mainly on fishes, but continue to take some benthic prey (Whitehead *et al.*, 1986; Pickett & Pawson, 1994). As an important commercial and recreational species,

there are several studies regarding its biology (e.g. Kennedy & Fitzmaurice, 1972; Pickett *et al.*, 2004).

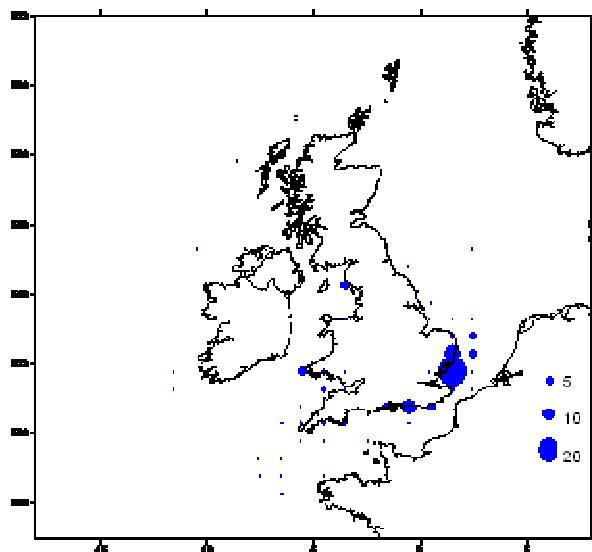


Figure XIV - Total reported landings (t) of bass taken in UK longline fisheries 1990–2007.

Source of data: FAD.

II.4 Regional variation in longline-caught species

This section presents an overview of the species taken and reported in longline fisheries by ICES Division around the British Isles from 1990–2007 along with the main ports (national and international) (see Appendix I). The data considers the total reported landings in tonnes for each year. The species, or aggregated species groups, highlighted account for approximately 95% of the total reported landings, with the remaining 5% including species of minor importance.

II.4.1 Northern and Central North Sea (IVa,b)

The two main ports reporting landings of longline-caught fish from ICES Division IVa were Grimsby and Milford Haven (accounting for ca. 80% of the total landings). However, UK-registered vessels also landed into Blyth (UK), Norwegian ports, Scheveningen (Netherlands), Hantsholm (Denmark) and Coruna (Spain). Annual landings were generally low, and reported landings indicated that UK-registered longliners did not fish in the division IVa each year.

The main species taken in the northern North Sea are anglerfish, gadoids (cod, ling, tusk, haddock), spurdog and skates, which accounted for >95% of reported longline landings (Table II). The remaining species included other gadoids (e.g. saithe, greater forkbeard and hake), halibut, wolf-fish, conger eel, lesser-spotted dogfish and tope.

The main ports reported landings of line-caught fish from the central North Sea (IVb) include Grimsby, with more than 50% of the total landings, followed by Whitby, Filey and Scarborough, with some vessels landing into other ports (e.g. Blyth, Bridlington, Lowestoft, Staithes as well as some Dutch and Danish ports. Three species (cod, spurdog and haddock) accounted for >95% of the reported landings (Table III).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Anglerfish	0.0				0.0			55.3	0.0	
Cod	2.1	4.7	0.3		12.4	2.9	2.2	2.4	5.2	
Spurdog	3.8	19.0	0.8		0.5		0.0	0.0	0.1	
Ling	1.0	0.7	0.0		2.3	0.2	0.6	0.1	0.1	
Tusk	0.5	0.2	0.0		3.7		0.8	0.3	0.4	
Haddock	0.1	0.6	0.0		2.3	0.4	0.3	2.0	0.8	
Skates	0.2	1.9	0.1		0.2					
Other (1)	0.5	0.7	0.0		2.4	0.4	0.3	0.2	0.1	
Total	8.2	27.7	1.2		23.8	3.8	4.1	60.3	6.6	

Year	2000	2001	2002	2003	2004	2005	2006	2007	Mean	%
Anglerfish			0.0				0.0		9.2	33.3
Cod			0.2				1.5	0.4	3.1	20.6
Spurdog							2.4	0.2	3.0	16.1
Ling							9.6	4.5	1.9	11.5
Tusk			0.3				1.8	3.7	1.2	7.0
Haddock			0.1				1.1	1.2	0.8	5.3
Skates							0.1	0.9	0.6	2.0
Other (1)			0.0				2.5		0.7	4.2
Total			0.6				19.0	10.8	-	100.0

(1) Including other gadoids (e.g. saithe, greater forkbeard and hake), halibut, wolf-fish, lesser-spotted dogfish, conger eel and tope.

Table II - Reported landings (t) from UK longliners operating in ICES Division IVa

Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cod	417.7	173.4	207.2	277.4	336.6	366.6	341.5	284.8	432.0	468.4
Spurdog	1013.9	115.6	85.0	84.2	130.5	17.8	65.3	145.0	20.8	295.8
Haddock	3.2	6.1	0.1	2.7	27.2	73.8	70.2	64.2	71.6	55.4
Other (1)	20.9	19.3	8.0	22.2	34.1	54.5	39.8	39.0	33.0	19.4
Total	1455.7	314.4	300.3	386.6	528.3	512.7	516.8	532.9	557.4	839.0

Years	2000	2001	2002	2003	2004	2005	2006	2007	Mean	%
Cod	267.6	68.8	118.0	53.2	30.0	44.6	26.0	40.1	219.7	55.8
Spurdog	264.1	49.6	49.6	0.0	0.2	22.3			147.5	33.3
Haddock	41.8	0.4	25.5	0.3	0.0	0.3	0.4	0.3	24.6	6.3
Other (1)	8.4	4.5	5.5	2.2	3.4	4.2	3.3	4.3	18.1	4.6
Total	581.9	123.3	198.6	55.8	33.7	71.3	29.8	44.6	-	100.0

(1) Including skates, ling and unspecified demersal fishes.

Table III - Reported landings (t) from UK longliners operating in ICES Division IVb

II.4.2 Southern North Sea (IVc) and eastern English Channel (VIId)

The main species taken in the southern North Sea are cod, spurdog and skates and rays (which will be mostly thornback ray and blonde ray), with these three groups accounting

for >96% of reported landings (Table IV). The remaining species were mostly whiting and tope, with smaller quantities of other species (e.g. bass). The main port reporting landings of line-caught fish was Lowestoft, with Boston, Orford, Harwich, Felixstowe, Aldeburgh, Grimsby, Southwold and Great Yarmouth also reporting landings. Annual landings ranged from about 1 400–2 100 t in the 1990s, but reported landings of longline-caught fish have declined to <500 t.y⁻¹ in recent years.

Although longline captures in the eastern English Channel (VIId) were generally small (often <1 t per year), a greater diversity of species was taken (Table V). The main species taken are bass, various gadoids (mostly cod with small amounts of pollack and whiting), spurdog, lesser-spotted dogfish, greater spotted dogfish, skates and conger eel. The main ports reported landings of line-caught fish from this Division include Grimsby, Dungeness, Langstone Harbour, Lymington, Eastbourne, Lowestoft, Selsey and Portsmouth.

Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cod	1444.6	984.1	710.9	1062.0	598.4	850.4	1196.5	891.0	1512.6	1438.2
Skates	364.5	466.6	595.3	535.3	615.7	485.0	227.0	354.5	284.8	162.1
Spurdog	262.2	395.2	552.5	205.9	160.5	261.7	69.4	131.1	85.6	96.5
Other (1)	77.1	76.9	86.8	86.3	61.7	66.4	52.6	43.3	22.4	18.2
Total	2148.4	1922.9	1945.5	1889.6	1436.2	1663.3	1545.5	1419.9	1905.5	1715.0

Years	2000	2001	2002	2003	2004	2005	2006	2007	Mean	%
Cod	615.1	323.4	105.6	235.9	144.7	33.2	37.6	111.4	683.1	59.4
Skates	158.2	177.8	166.3	147.2	156.8	97.9	52.4	82.8	285.0	24.8
Spurdog	78.2	107.7	49.3	16.8	25.7	21.8	11.1	14.5	141.4	12.3
Other (1)	21.6	17.7	26.8	20.7	21.6	7.9	7.7	19.3	40.8	3.6
Total	873.1	626.6	348.0	420.5	348.9	160.8	108.9	228.0	-	100.0

(1) Including other gadoids (e.g. whiting, bib), dogfishes (e.g. tope, smoothounds), bass, other flatfishes (sole, dab) and unspecified demersal fishes.

Table IV - Reported landings (t) from UK longliners operating in ICES Division IVc

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Bass	0.5	1.4	4.6	6.0	0.4	1.8	4.0	0.0		5.2
Cod	3.9	1.7	0.1		2.1	0.0	0.0			0.0
Dogfish (1)	3.9	0.1	0.2						0.0	
Spurdog			0.2		0.0		0.0		0.8	0.0
Skates	0.3	0.0	0.0		0.0	0.2	0.1		0.5	0.1
Conger eel (2)		0.0	0.2				1.0	0.0		0.0
Pollack		0.0	0.8			0.0			0.0	
Whiting	0.6		0.0				0.0			0.0
Other	0.7	0.1	0.4		0.0	0.0	0.3	0.0	0.1	0.0
Total	10.0	3.2	6.6	6.0	2.5	2.1	5.4	0.1	1.4	5.4

Year	2000	2001	2002	2003	2004	2005	2006	2007	Mean	%
Bass	0.0	0.1	0.1	0.6	0.1			0.2	1.7	54.7
Cod			0.0	0.1		0.0	0.0		0.7	17.2
Dogfish (1)				0.1			0.0		0.7	9.3
Spurdog				0.5		0.0			0.2	3.4
Skates	0.0		0.0	0.1		0.0	0.0	0.0	0.1	3.2
Conger eel (2)			0.0	0.8		0.0	0.0		0.2	4.7
Pollack				0.0					0.2	1.9
Whiting			0.0						0.1	1.4
Other	0.0	0.0	0.0	0.2		0.0			0.1	4.3
Total	0.1	0.1	0.1	2.3	0.1	0.0	0.1	0.2	-	100.0

(1) Including indeterminate dogfishes, lesser-spotted dogfish, greater spotted dogfish and tope.

(2) Including eel.

Table V - Reported landings (t) from UK longliners operating in ICES Division VIIId

II.4.3 Bristol Channel (VIIIf), western English Channel (VIIe) and Celtic Sea (VIIg-h)

The main species taken in longline fisheries in the Bristol Channel were spurdog, conger eel, skates, dogfishes (greater and lesser-spotted dogfish and unspecified dogfishes) and cod, and these accounted for >96% of landings (Table VI). The three main ports reported landings of line-caught fish include Milford Haven, Ilfracombe and Newlyn, with other fish occasionally landed into other ports (e.g. Holyhead, Padstow, Bideford, Plymouth, Clovelly and Newquay). Annual landings of longline caught fish were >100 t.y⁻¹ in the 1990s, and this has declined to <50 t.y⁻¹ in recent years.

With regards the western English Channel, the main species taken were conger eel, ling, spurdog, skates, tope and pollack, with these six taxa accounting for ca. 95% of the total landings. The main ports receiving landings of longline-caught fish from this area were along the coasts of Devon and Cornwall (e.g. Falmouth, Newlyn, Looe, Mevagissey, Plymouth, Brixham, Polperro and Helford River), with some vessels landing into French ports (Lorient, Roscoff, Douarnenez and Brest) and Spain. Annual landings of longline-caught demersal fish have ranged from 21–159 t.y⁻¹ (Table VII).

Reported longline landings from the Celtic Sea were generally greater than in the Bristol and English Channel, ranging from 127–557 t.y⁻¹ (Table VIII), with a higher diversity of fish taken in these fisheries. These species included spurdog, conger eel, various gadoids (e.g. ling, hake, and pollack), skates, greater- and lesser-spotted dogfish, tope,

unspecified demersal fishes and seabreams. The main ports reporting landings of longline-caught fish from the Celtic Sea include Milford Haven, Plymouth, Newlyn and Holyhead, with fish also landed into France (e.g. Lorient and Douarnenez), and Spain (e.g. Corunna).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Spurdog	80.1	36.8	155.4	79.1	129.7	85.5	75.3	54.5	36.8	51.5
Conger eel	9.6	108.2	40.7	28.4	77.0	79.0	77.5	50.3	36.9	20.4
Skates	9.5	13.7	28.3	13.7	52.2	48.1	35.4	19.2	26.2	13.2
Dogfish (indet.)	0.4	3.1	0.5	0.7				0.0	30.9	19.8
Greater-spotted dogfish	0.0		12.3	14.7	17.3	9.1	4.8	1.2	0.2	0.1
Lesser-spotted dogfish	0.3			0.8	6.3	16.8	6.3	5.5	2.3	0.2
Cod	1.0	2.3	3.7	2.3	5.7	4.9	6.0	6.1	2.6	1.8
Other (1)	1.7	9.9	4.5	13.0	12.1	6.7	5.9	9.3	4.5	2.7
Total	102.6	174.1	245.4	152.6	300.3	250.1	211.1	146.1	140.5	109.6

Year	2000	2001	2002	2003	2004	2005	2006	2007	Mean	%
Spurdog	39.4	44.6	31.0	8.2		5.4	0.0	20.2	54.9	44.4
Conger eel	16.7	2.4	2.2	2.1	0.4	0.3	0.2	0.1	30.7	26.2
Skates	21.1	9.4	6.6	0.5		0.1	0.0	0.7	17.5	14.2
Dogfish (indet.)	18.4		0.1	0.8			0.2		6.8	3.6
Greater-spotted dogfish	0.3	0.1	0.2	3.3				0.5	4.6	3.0
Lesser-spotted dogfish	1.7	7.8	9.6	0.0				4.8	4.8	3.0
Cod	1.6	0.8	0.8	0.4		0.0		0.1	2.5	1.9
Other (1)	0.6	3.8	0.8	1.0	1.7	0.2	0.1	0.3	4.4	3.7
Total	99.9	69.0	51.4	16.3	2.0	6.0	0.6	26.6	-	100.0

(1) Including other gadoids (e.g. ling, pollack, whiting and bib), tope, bass and undetermined demersal fishes.

Table VI - Reported landings (t) from UK longliners operating in ICES Division VII f

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Conger eel	52.3	81.5	17.3	48.5	40.4	96.3	59.6	18.3	10.1	25.5
Ling	15.3	43.7	20.6	10.6	15.5	36.9	22.6	14.2	5.7	18.7
Spurdog	0.1	0.3	0.1	0.0	0.7	13.9	0.8	0.4	0.0	0.3
Skates	1.0	2.3	1.6	0.5	1.7	6.0	10.9	1.8	0.4	6.5
Tope		0.2	0.1	0.5	0.0	0.2	0.0			0.0
Pollack	0.2	0.9	7.3	1.2	0.5	0.3	7.6	0.3	0.3	0.5
Other (1)	3.2	6.1	6.8	4.1	3.5	5.7	5.6	1.4	4.9	1.7
Total	72.0	135.0	53.8	65.5	62.3	159.3	107.0	36.3	21.4	53.3

Year	2000	2001	2002	2003	2004	2005	2006	2007	Mean	%
Conger eel	56.4	25.6	23.6	94.5	60.2	107.0	80.3	102.8	55.6	61.8
Ling	33.8	13.5	13.2	22.2	18.6	23.3	26.4	21.0	20.9	23.2
Spurdog	0.3	0.2	17.4	9.2	6.4	9.4	0.5	6.4	3.7	4.1
Skates	2.4	0.8	0.5	0.6	0.9	0.9	0.8	0.3	2.2	2.5
Tope	0.0	0.0	0.1	4.8	7.5	8.1	5.1	5.7	2.2	2.0
Pollack	1.0	0.8	0.2	0.6	0.4	4.0	3.0	0.9	1.7	1.9
Other (1)	1.1	1.2	8.3	4.6	3.1	4.8	3.7	3.7	4.1	4.6
Total	94.9	42.1	63.4	136.6	97.1	157.6	119.9	140.8	-	100.0

(1) Including other gadoids (e.g. cod, whiting, bib, hake and Norway pout), dogfishes (unspecified and lesser-spotted dogfish), anglerfish and bass.

Table VII - Reported landings (t) from UK longliners operating in ICES Division VII e

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Spurdog	187.6	147.6	322.6	277.3	156.6	156.7	133.5	295.6	192.5	109.7
Conger eel	2.5	14.5	10.6	32.2	32.9	36.6	33.9	33.2	25.2	49.2
Ling	4.8	95.2	65.9	34.4	34.9	44.8	72.7	70.1	107.1	76.4
Skates	27.9	32.0	18.1	18.5	28.7	21.5	15.3	28.2	31.0	35.8
Hake	5.0	44.6	40.5	21.4	6.8	10.5	12.3	2.8	0.1	3.5
Greater-spotted dogfish	1.1	4.3	22.0	43.5	35.2	16.7	8.7	1.1	0.6	1.3
Lesser-spotted dogfish	1.0	0.0	0.1	7.7	7.6	26.1	5.0	7.8	5.9	9.6
Demersal fish (indet.)	2.9	25.0	39.5	11.6	9.6	16.6	8.8	8.4	2.7	0.9
Seabream (indet.)	0.0	4.1	20.5	3.3	4.4	37.4	7.7	5.6	1.3	0.3
Pollack	0.6	16.7	1.2	4.7	1.7	2.9	13.9	1.8	0.2	0.5
Tope	0.3	0.5	0.3	2.6	2.1	2.2	0.3	0.4	1.5	1.6
Other (1)	6.5	33.8	15.9	11.0	3.7	3.6	8.1	14.5	12.9	28.0
Total	240.3	418.2	557.3	468.1	324.0	375.5	320.2	469.5	381.0	316.5

Year	2000	2001	2002	2003	2004	2005	2006	2007	Mean	%
Spurdog	95.6	286.4	69.2	20.6	6.8	59.3	5.6	9.7	140.7	39.8
Conger eel	16.6	23.8	116.4	190.4	207.3	190.4	199.3	74.6	71.6	20.3
Ling	14.3	43.9	78.8	68.6	75.4	73.9	77.7	23.4	59.0	16.7
Skates	20.5	30.5	25.9	25.7	18.7	12.1	15.2	3.4	22.7	6.4
Hake	0.0	0.0	0.6	1.3	10.8	4.3	2.7	6.0	9.6	2.7
Greater-spotted dogfish	4.8	1.8	0.7	5.8	0.0	0.0	0.0	0.0	8.2	2.3
Lesser-spotted dogfish	39.9	9.6	8.8	1.5	0.0	0.0	1.9	0.0	7.4	2.1
Demersal fish (indet.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	2.0
Seabream (indet.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	1.3
Pollack	0.0	0.0	0.2	1.0	7.3	8.2	5.2	0.4	3.7	1.0
Tope	1.3	4.1	0.4	8.3	9.9	7.2	13.1	1.4	3.2	0.9
Other (1)	10.5	2.8	19.7	16.1	39.8	23.0	21.5	8.6	15.5	4.4
Total	203.5	403.1	320.6	339.2	376.0	378.4	342.3	127.5	-	100.0

(1) Including indeterminate dogfishes and other gadoids (e.g. haddock, cod, greater forkbeard and whiting).

Table VIII - Reported landings (t) from UK longliners operating in ICES Division VIIg-h

II.4.4 Irish Sea (VIIa)

Various elasmobranchs are the main species taken in Irish Sea longline fisheries, with spurdog the primary species taken (Table IX), and smaller quantities of skates, and greater and lesser-spotted dogfish also taken, with conger eel accounting for about 3% of landings. The main ports reported landings of longline-caught fish in the Irish Sea were Holyhead and Milford Haven, followed by Cemaes Bay, Whitehaven and Caernarvon. Although annual longline landings have been >1 000 t, landings have been <200 t in recent years.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Spurdog	1020.8	656.7	1008.1	918.5	413.5	285.4	391.7	461.4	701.6	930.3
Skates	79.2	86.5	121.4	101.8	99.3	30.7	77.1	78.8	116.7	204.4
Greater-spotted dogfish	12.3	4.2	69.3	214.0	144.5	69.0	100.0	68.2	150.1	173.4
Conger eel	9.4	24.1	31.8	23.6	19.6	12.6	27.3	23.0	43.6	83.9
Lesser-spotted dogfish	13.8	0.4	5.2	13.6	39.4	44.7	32.0	22.3	24.3	14.0
Other (1)	11.1	18.7	38.3	51.9	39.8	14.7	29.9	28.3	27.7	88.9
Total	1146.6	790.7	1274.1	1323.4	756.2	457.1	658.0	682.0	1063.9	1494.9

Year	2000	2001	2002	2003	2004	2005	2006	2007	Mean	%
Spurdog	556.1	557.3	292.5	95.9	114.0	122.4	138.6	107.6	487.3	69.7
Skates	122.0	126.0	45.2	10.1	4.0	14.9	7.5	0.2	73.7	10.5
Greater-spotted dogfish	67.0	70.0	33.6	44.7				4.2	81.6	9.7
Conger eel	52.4	25.5	13.7	4.8	1.0	0.0	0.0	0.1	22.0	3.2
Lesser-spotted dogfish	71.3	23.5	14.7	15.8	0.5		4.5	0.6	20.0	2.7
Other (1)	89.2	33.2	20.4	11.7	1.8	9.0	7.2	0.8	29.0	4.2
Total	958.1	835.3	420.1	182.9	121.3	146.4	157.8	113.5	-	100.0

(1) Including dogfishes (e.g. tope and unspecified dogfishes), gadoids (e.g. ling, cod) and other unspecified demersal fishes.

Table IX - Reported landings (t) from UK longliners operating in ICES Division VIIa

II.4.5 Other areas

UK-registered vessels have also reported landings from Faroese Grounds (Vb, Vc), Northwestern coast of Scotland and North of Ireland (VIa), Rockfall (VIb), West of Ireland (VIIb), Porcupine Bank (VIIc), Bay of Biscay (VIIIa-VIIId) and in Portuguese Waters (IXa). The main demersal species taken include gadoids (ling, hake, greater forkbeard), spurdog, conger eel, skates and unspecified demersal fishes, dogfishes and seabreams. Some of these fisheries will be deep-water fisheries also taking deep-water sharks etc.

II.5 Temporal changes in landings

This section provides information of the temporal changes for the main divisions around the British Isles concerning the different species and their reported landings. These temporal changes will consider the period between 1990 and 2007, where each year is divided by quarters. So, the first quarter (Q1) represents the period January to March, the second quarter (Q2) represents the April-June, the third quarter (Q3) represents July to September and the fourth quarter (Q4) represented October to December.

Data are shown to show the temporal trends in landings (tonnes) as well as the proportion of landings. This allows the potential impact of bycatch ratios (as introduced for skates and spurdog) to be gauged for these fisheries.

II.5.1 Northern and Central North Sea (IVa,b)

For the Northern North Sea there are several years without any reported landings (Figure XV), indicating the sporadic nature of longline fisheries in this Division, with occasional catches of spurdog (usually in Q2 and Q3), gadoids and anglerfish. Spurdog accounted

for approximately 50–80% of landings taken in longline fisheries in this region in the early 1990s (Figure XVI).

Considering the central North Sea, the main species taken are cod, spurdog and, to a lesser extent, haddock. Spurdog were generally taken in Q3, although longline captures of spurdog have declined since 2000 (Figure XVII). In terms of the proportion of catches, spurdog predominated in the captures during Q3, usually accounting for >60% of the reported landings (Figure XVIII).

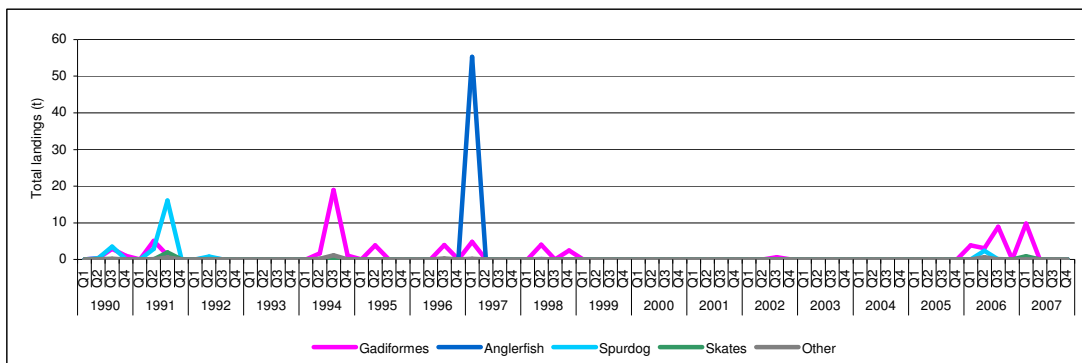


Figure XV - Reported landings (t) from UK longliners operating in ICES Division IVa

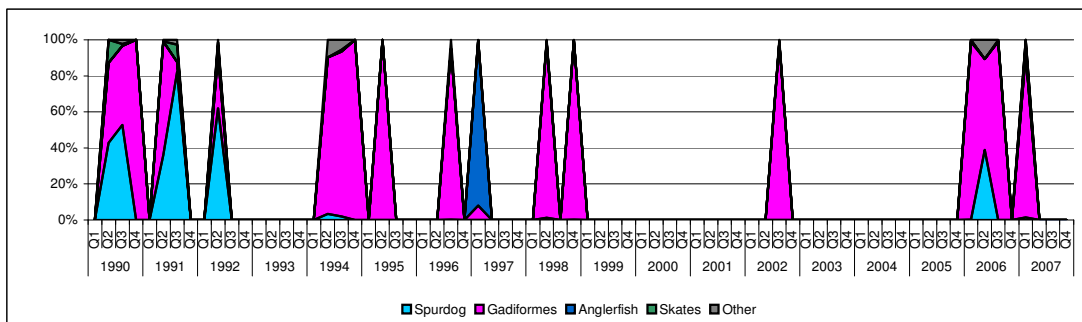


Figure XVI - Reported landings (%) from UK longliners operating in ICES Division IVa

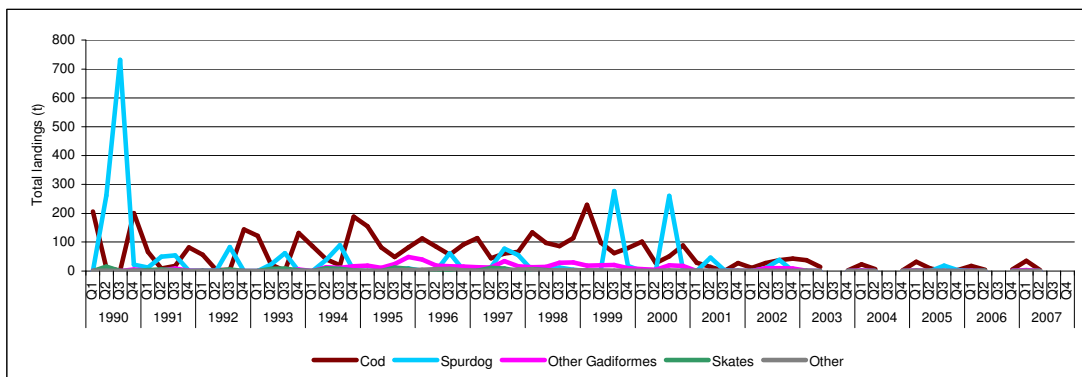


Figure XVII - Reported landings (t) from UK longliners operating in ICES Division IVb

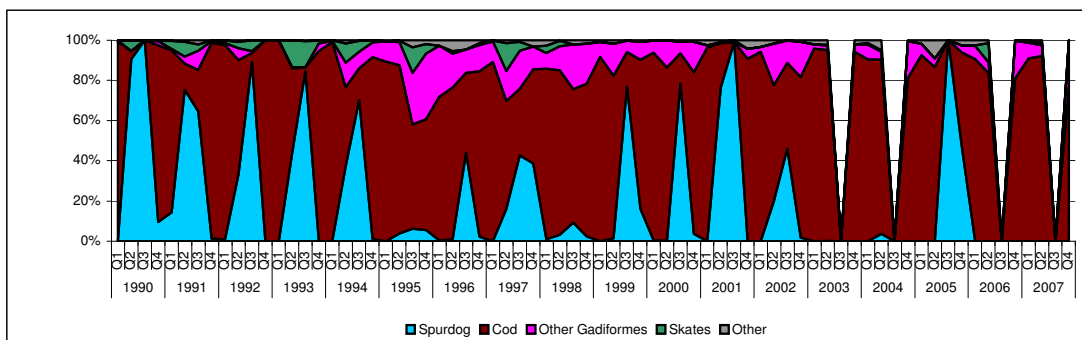


Figure XVIII - Reported landings (%) from UK longliners operating in ICES Division IVb

II.5.2 Southern North Sea (IVc) and eastern English Channel (VIId)

The three main species taken in the southern North Sea are cod, skates and spurdog. Catches of cod generally decline in Q3, with the major catches of skates and spurdog made in Q2 and Q3 (Figure XIX). Landings of spurdog were generally >5% of the total landings, and exceptionally 30–40% of landings (Figure XX).

Landings of longline caught fish in the eastern English Channel were sporadic, with bass peaking in Q2–Q3 (Figure XXI), and although spurdog were only taken in small quantities, these amounts could be greater than 5% (Figure XXII).

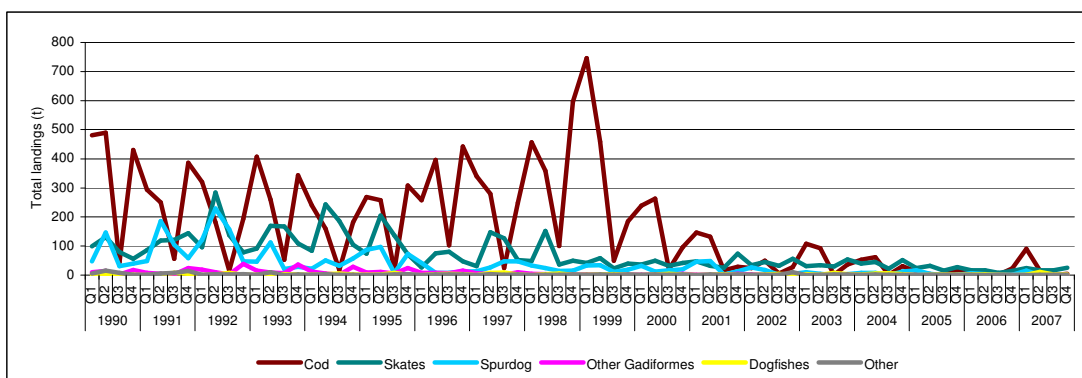


Figure XIX - Reported landings (t) from UK longliners operating in ICES Division IVc

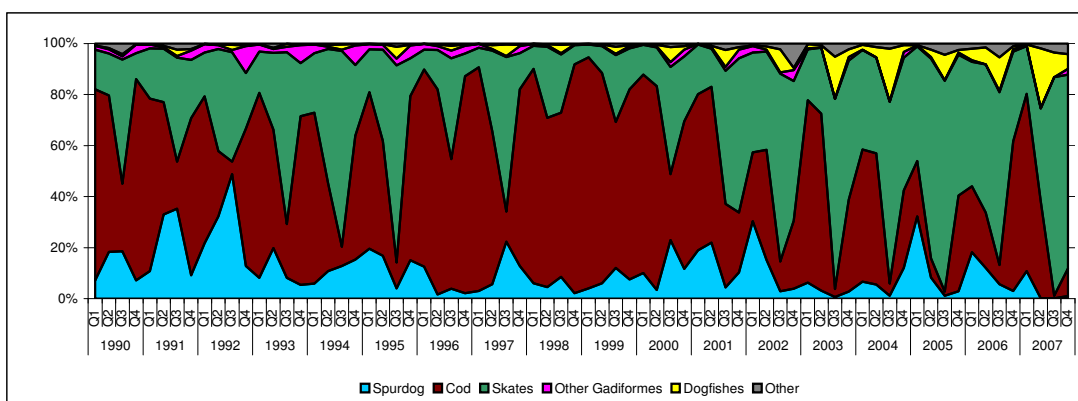


Figure XX - Reported landings (%) from UK longliners operating in ICES Division IVc

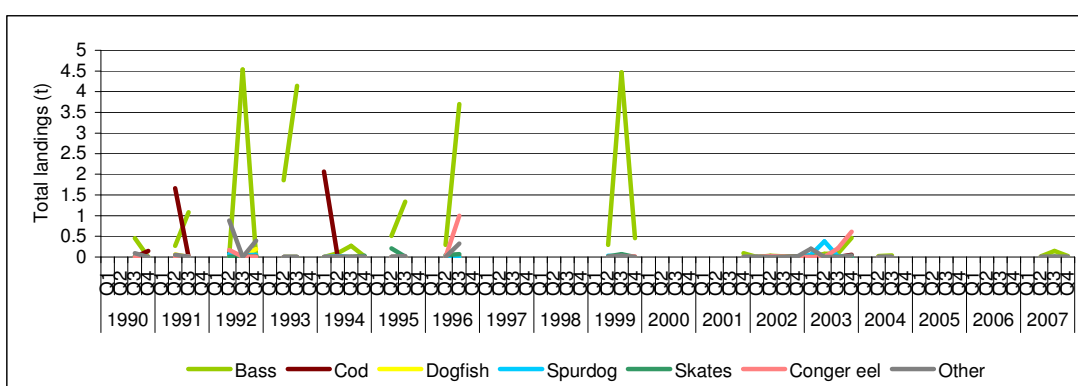


Figure XXI - Reported landings (t) from UK longliners operating in ICES Division VIId

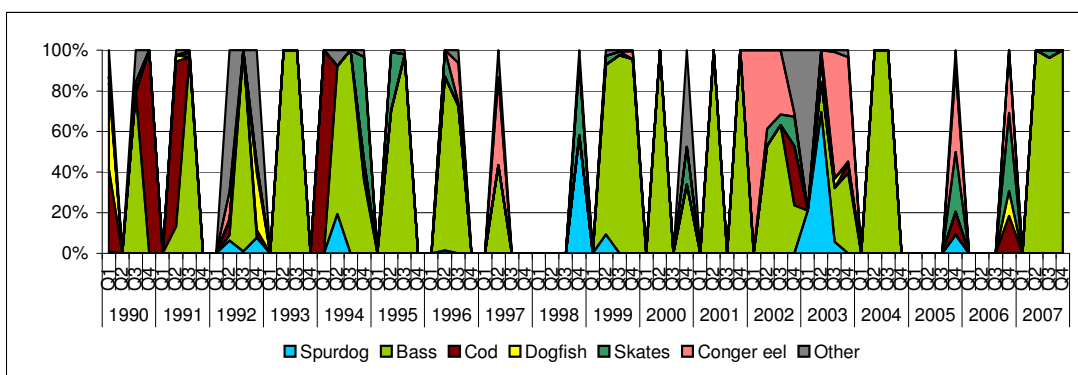


Figure XXII - Reported landings (%) from UK longliners operating in ICES Division VIId

II.5.3 Bristol Channel (VIIIf), western English Channel (VIIe) and Celtic Sea (VIIg-h)

In the Bristol Channel, the main species taken are spurdog, conger eel, skates, dogfishes and various gadiformes. The reported landings of all species have declined, with few longline landings since 2000. Peak captures of spurdog generally occurred in Q2 (Figure XXIII), accounting for >40% of landings at these times of the year (Figure XXIV), with conger eel often predominating at other times of the year.

In the western English Channel, conger eel is the main species taken by demersal longliners, followed by various gadiforms (Figure XXV). Spurdog were reported sporadically, and without a clear seasonal pattern, although on some occasions could account for >20% of quarterly landings (Figure XXVI).

There were important longline landings of spurdog from the Celtic Sea up to and including 2001, with a subsequent decline in landings, with landings of conger eel increasing during 2003–2006 (Figure XXVII). Peak captures of spurdog were generally in Q2 and Q3. Between 1990 and 2001, quarterly landings of spurdog accounted for approximately 20–80% of demersal fish captured in these fisheries (Figure XXVIII).

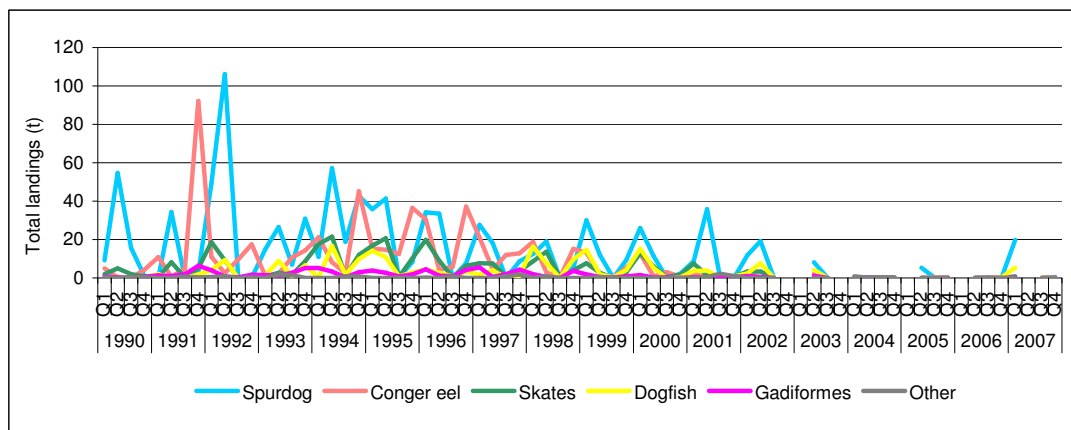


Figure XXIII - Reported landings (t) from UK longliners operating in ICES Division VIIIf

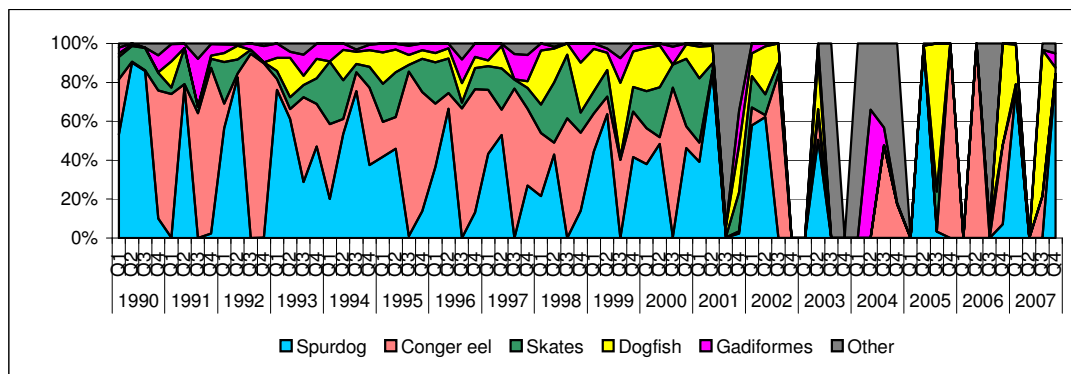


Figure XXIV - Reported landings (%) from UK longliners operating in ICES Division VIIIf

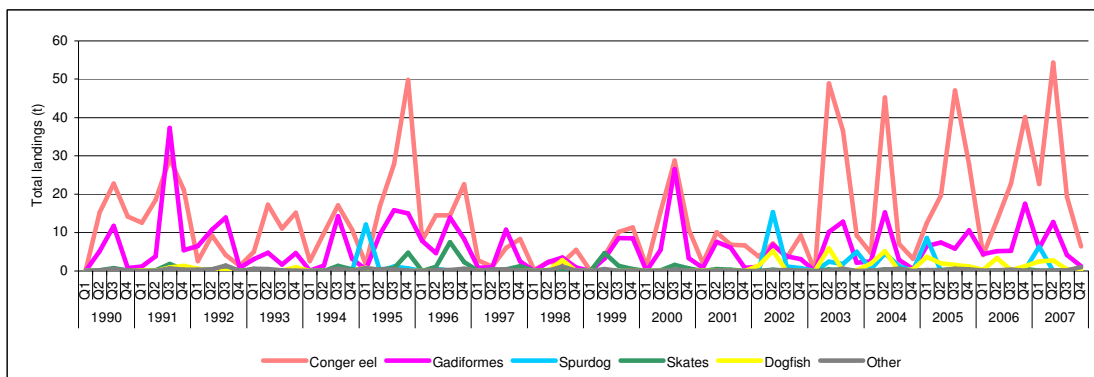


Figure XXV - Reported landings (t) from longliners operating in ICES Division VIIe

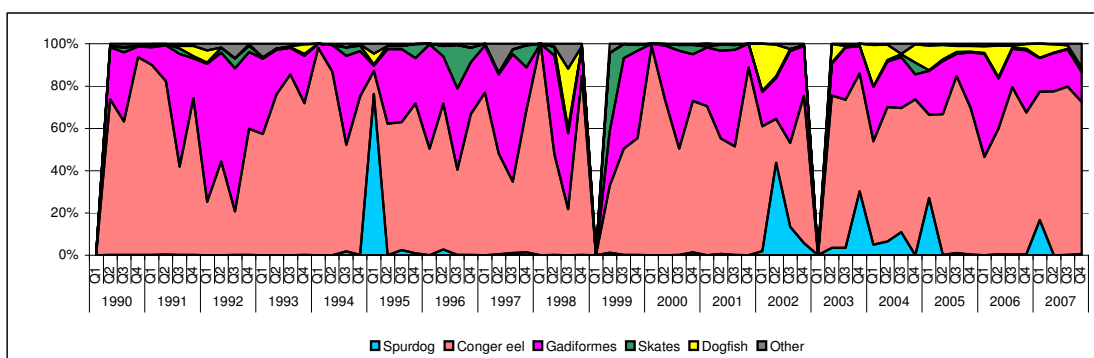


Figure XXVI - Reported landings (%) from UK longliners operating in ICES Division VIIe

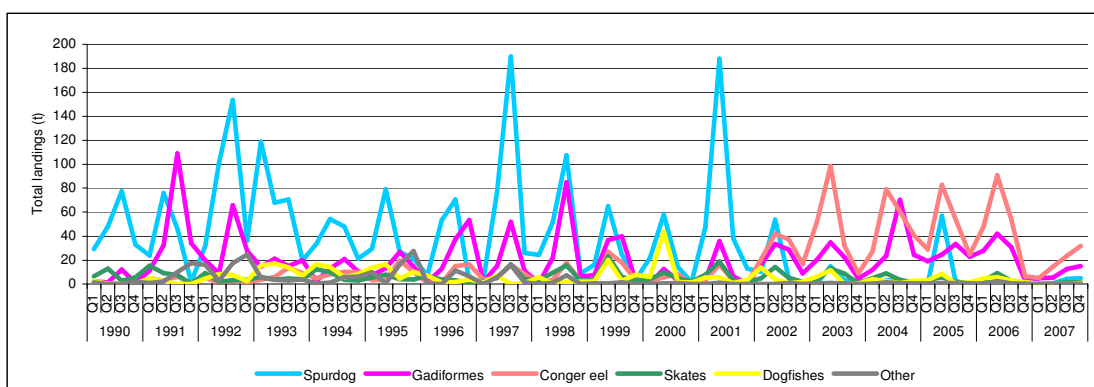


Figure XXVII - Reported landings (t) from UK longliners operating in ICES Division VIIg-h

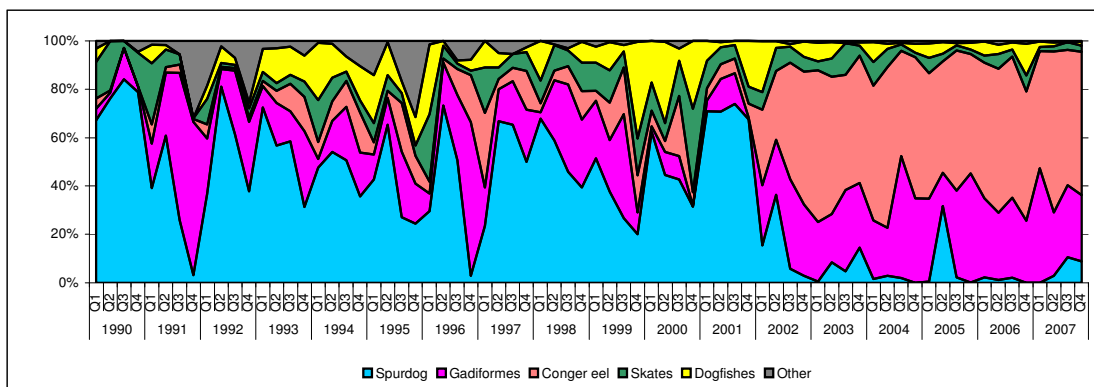


Figure XXVIII - Reported landings (%) from UK longliners operating in ICES Division VIIg-h

II.5.4 Irish Sea (VIIa)

As highlighted previously, longline fisheries in the Irish Sea land mostly elasmobranchs, and once again landings have declined since 2001/02 (Figure XXIX). Spurdog were taken mostly during Q3-Q4, although throughout the time series, they would account for 30% to >95% of the demersal fish landed (Figure XXX).

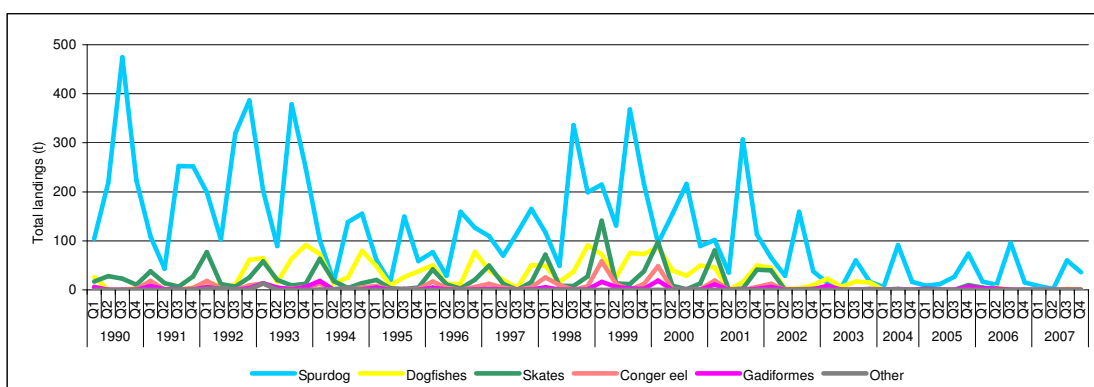


Figure XXIX - Reported landings (t) from UK longliners operating in ICES Division VIIa

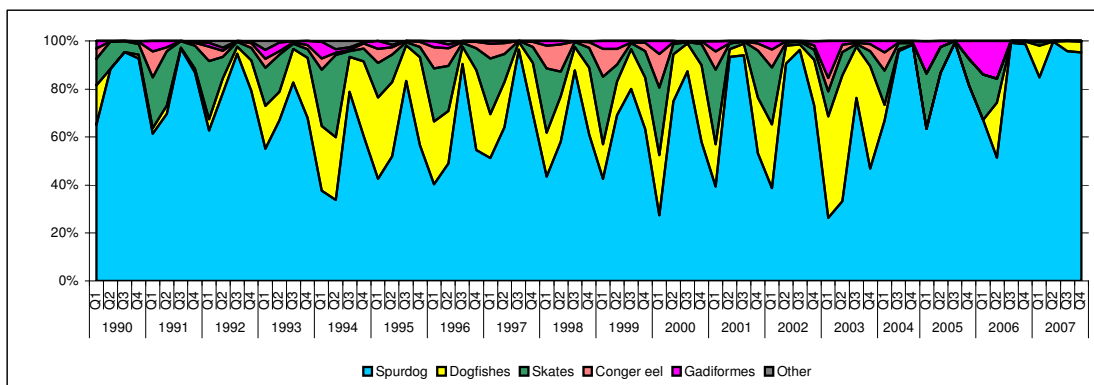


Figure XXX - Reported landings (%) from UK longliners operating in ICES Division VIIa

II.6 Summary

- In terms of the total landings of demersal longline-caught fish (1990–2007), the main fishing grounds are the southern North Sea (IVc), Irish Sea (VIIa) and the central North Sea (IVb).
- The two main species taken in UK demersal longline fisheries (1990–2007) were spurdog (> 21 000 t) and cod (>16 500 t). In the same period, species of secondary and/or local importance in UK demersal longline fisheries included skates (>7 500 t) and conger eel (>3 900 t).
- Total landings of longline-caught spurdog from the Irish Sea (>8 700 t) and central and southern North Sea (4 900 t) accounted for 40% and 22% of the total landings of spurdog caught by this method. The mean landings in the last five years (2003–2007) in the Irish Sea (VIIa), Celtic Sea (VIIg-h) and southern North Sea (IVc) were 115.7, 20.4 and 18 t.y⁻¹, respectively.
- Total landings of longline-caught cod were ca. 16 500 t, of which the vast majority (98%) were from the central and southern North Sea. The mean landings in the last five years (2003–2007) in the central (IVb) and southern North Sea (IVc) were 38.8 and 112.5 t.y⁻¹, respectively.
- Total landings of longline-caught skates were > 7 500 t, of which 5 130 t (68%) were from the southern North Sea and > 1320 t (17%) were from the Irish Sea. Mean annual landings in the southern North Sea (IVc), Celtic Sea (VIIg-h), and Irish Sea (VIIa) in the last 5 years (2003–2007) were 107.4, 15 and 7.3 t.y⁻¹, respectively.
- Total landings of longline-caught conger eel were > 3 900 t, of which > 2 800 t (72%) were taken in ICES Divisions VIIe-h. Mean annual landings in the southern Celtic Sea (VIIh) and Western English Channel (VIIe) over the last 5 years (2003–2007) were 154.6 and 89 t.y⁻¹, respectively.
- Ling and hake are taken in some of the UK longline fisheries operating on the continental shelf, although the majority of the landings of these species are taken in deep-water longline fisheries (which also take deep-water sharks etc.) that operate off the edge of the continental shelf along the western sea board of the British Isles. Total landings of longline-caught ling and hake (1990-2007) were 8 343 and 6 141 t, respectively.
- Examination of seasonal landings showed that spurdog is initially caught in the southern North Sea (IVc) in Q2, spreading further north to the central North Sea in

Q3. Meanwhile off western coasts, spurdog show a northward shift in landings from the south-western approaches (VIIg-h) to the Irish Sea (VIIa) during the period Q2–Q4.

- Regarding the current 5% bycatch quota for spurdog, seasonal analyses showed that this would impact on most longline fisheries, at least seasonally, throughout British waters. However, the main area impacted is the Irish Sea (VIIa), where spurdog account from 26% to nearly 100% of seasonal captures.

III Bycatch and discarding patterns of elasmobranchs taken in commercial fisheries around the British Isles

Draft manuscript for submission to a peer-review journal.

III.1 Introduction

Sharks, dogfishes, skates, rays and chimaeras (Chondrichthyes) are an important component of marine ecosystems, and have biological characteristics (e.g. slow growth, protracted development, low fecundity) that make them highly vulnerable to over-exploitation (Ellis *et al.*, 2008). Although there are several seasonal and/or localised UK fisheries targeting elasmobranchs (e.g. longline fisheries for skates or spurdog; gillnet and trawl fisheries targeting skates), many elasmobranch species are susceptible to capture in mixed demersal trawl fisheries, where they may be retained or discarded (Cedrola *et al.*, 2003; Tamini *et al.*, 2006).

There has been an increased focus on using observers to monitor discard patterns in the European fisheries (Borges *et al.*, 2005; Enever *et al.*, 2007; Gonçalves *et al.*, 2007), so that catches of commercial species can be better estimated. There have been relatively few studies, however, examining the bycatch and discard patterns of elasmobranchs in these fisheries (Carbonell *et al.*, 2003; Coelho *et al.*, 2003, 2005). Data from observer trips can also provide valuable information on the spatial distribution, length-frequency and species composition of elasmobranchs, which can supplement those data collected during fishery-independent surveys (e.g. Ellis *et al.*, 2005a, b).

The lack of swimbladders in elasmobranchs, and the robustness of some of these species, may result in a relatively high discard survival, depending on the fishery (e.g. Broadhurst *et al.*, 2006). To date there have been comparatively few studies examining discard survival of elasmobranchs (e.g. Kaiser & Spencer, 1995; Stobutzki *et al.*, 2002; Laptikhovsky, 2004; Mandelman & Farrington, 2007). Studies on the more robust species, such as lesser-spotted dogfish (*Scyliorhinus canicula*), have indicated high discard survival, ranging from 78–98% (Revill *et al.*, 2005; Rodríguez-Cabello *et al.*, 2005). The

survivorship of less robust elasmobranchs, such as skates, will depend on the gear used and tow duration/soak time (Catchpole *et al.*, 2007).

The present study analyses the chondrichthyan bycatch, as recorded during observer trips on commercial fishing vessels, in order to illustrate the spatial distributions of those elasmobranchs recorded; and determine the length-based discard/retention patterns of some of the elasmobranchs taken in UK fisheries operating around the British Isles.

III.2 Materials and methods

III.2.1 Observer data

The CEFAS observer programme to monitor catch and discard data on UK (English and Welsh) registered commercial fishing vessels has been undertaken since 2002, as required by EC Data Collection Regulation 1639/2001 (Figure XXXI). Vessel selection and trip sampling has been described by Enever *et al.* (2007), and multiple hauls would typically be sampled, depending on the duration of the trip. Once the gear was retrieved, the species and sizes of fish were recorded for retained and discarded fish. If the catches were too large to sample in their entirety, then a sub-sample of known proportion was sampled and subsequently raised to haul level. All length measurements of the elasmobranchs refer to total length (TL), as measured to the cm below.

III.2.2 Data filtering

Species identification issues continue to be a major problem in fisheries studies (Daan, 2001; ICES, 2007a), with skates (Rajidae) and smoothhounds (*Mustelus* spp.) problematic taxa in the Northeast Atlantic. To minimise potential misidentification issues, the spatial distribution of all taxa (see III.3.2) and size distributions (see III.3.3) were examined, so that records of fish outside their known biogeographical and/or bathymetric range, $<L_{\text{birth}}$ or $>L_{\text{max}}$ could be checked. The original data were then checked and electronic data corrected if wrong. If no appropriate corrections could be made, then these data were excluded from subsequent data analyses, or treated at a higher taxonomic level (in the case of uncertain species identification). Due to the taxonomic confusion between starry smoothhound (*Mustelus asterias*) and common smoothhound (*M. Mustelus*), data for these two species were pooled. Other sympatric species for which there can be identification problems (e.g. due to similar colour patterns) include starry ray (*Amblyraja radiata*) and thornback ray (*Raja clavata*), blonde ray (*R. brachyura*) and spotted ray (*R. montagui*), and lesser-spotted dogfish (*Scyliorhinus canicula*) and greater-spotted dogfish (*S. stellaris*).

Data have been examined by broad eco-regions to cover the North Sea and eastern English Channel (ICES Divisions IVa-c, VIId), Celtic Seas (VIa, VIIa,b,e-j) and deep-water (ICES Divisions Vb, VIb, VIId,k). Data from other regions were excluded from analyses.

III.3 Results

III.3.1 Species recorded during observer trips

Overall, 42 chondrichthyan species were recorded from discard trips around the British Isles, including 11 skates (Rajidae), 11 squaliform sharks, five scyliorhinid catsharks, three triakid sharks and three rabbitfish (Holocephali). Other families were represented by 1–2 species (Table X).

Nineteen species were observed in the North Sea eco-region, where the most frequently encountered species were starry ray (*Amblyraja radiata*), lesser-spotted dogfish (*S. canicula*), thornback ray (*Raja clavata*), spotted ray (*Raja montagui*) and smoothhounds (*Mustelus* spp.). These five taxa accounted for >90% (by numbers) of the chondrichthyans recorded.

The elasmobranch fauna of the Celtic Seas eco-region was more diverse, with 39 species recorded, although 15 of these were deep-water species that occur along the continental shelf. The most frequently recorded species were *S. canicula*, *R. montagui*, *Mustelus* spp., *R. clavata*, cuckoo ray (*Leucoraja naevus*), blonde ray (*Raja brachyura*) and smalleyed ray (*Raja microocellata*), and these seven taxa accounted for >90% (by numbers) of the chondrichthyans reported.

Data from observer trips in deeper areas (ICES Divisions VIb, VIId,k) were limited, with 17 species of shark, three identified species of skate and three species of rabbitfish recorded.

III.3.2 Species distribution

The distributions (presence by ICES Rectangle) of all the chondrichthyans species recorded during the observer trips were examined as part of the data checking process. These are illustrated in Appendix II.

Observer data can also provide important information on the locations of important life-history stages. The occurrence of juvenile and mature female spurdog (Figure XXXII) highlights the importance of the south-west and Irish Sea to this stock. However, data for juveniles were too limited to draw an accurate identification of pupping/nursery grounds for this species. Data for juvenile and large female smoothhounds (Figure XXXII) highlight the importance of shallow, inshore waters of southern and western coasts (Greater Thames Estuary, English Channel and Bristol Channel) as nursery grounds, and potential

pupping grounds. Although data for juvenile and large female tope were more limited, the overall distributions were similar to that of smoothhounds.

III.3.3 Discard and retention patterns

III.3.3.1 Spurdog

Spurdog (*Squalus acanthias*) was taken by beam trawl, otter trawl, *Nephrops* trawl, gillnet (in the Celtic Sea) and midwater pair trawl (Table X). Although few specimens were taken by trawl in the deep-water ecoregion (all retained), there were too few data for meaningful analysis in this area. Spurdog was more commonly recorded from the Celtic Seas ecoregion than the North Sea ecoregion, although captures in the North Sea were generally of larger fish (Figure XXXIII).

In the North Sea, spurdog were reported most from otter trawlers, and the majority of the catch (ca. 96%) was retained (TL 49–128 cm). Smaller individuals were generally discarded, as were occasional larger specimens.

Similar results were observed in otter trawl catches in the Celtic Seas ecoregion, with retained fish ranging from 41–118 cm, and most specimens <49 cm discarded. Spurdog caught by gillnet in this ecoregion were mostly retained at 57–120 cm, with spurdog <57 cm discarded. Once again, larger spurdog were discarded occasionally, usually in small numbers. Spurdog were mostly discarded from beam trawl catches, although some larger specimens (>60 cm) were retained.

III.3.3.2 Scyliorhinid catsharks

Lesser-spotted dogfish (*Scyliorhinus canicula*) was taken throughout the Celtic Seas and North Sea ecoregions, and was taken by all gear types (Figure XXXIV). There were also occasional records of this species in the deep-water ecoregion. Although not usually taken for human consumption, this species is often landed for pot bait.

Beam trawlers operating in the North Sea and eastern English Channel discarded ca. 98% of the catch, across an overall length range of 9–67 cm. Only occasionally were *S. canicula* (≥ 25 cm) retained (Figure XXXIV). *S. canicula* taken by otter trawls in the North Sea ecoregion were also mainly discarded (78%) throughout the length range observed (13–79 cm). Other than for the smallest individuals, there was no apparent size-based retention of *S. canicula*, with retained specimens ranging from 21–74 cm. Gillnet fisheries in the North Sea ecoregion also discarded *S. canicula* (60% discarded in total), across a length range of 30–80 cm. Retained specimens were mostly >47 cm.

Within the Celtic Seas, *S. canicula* (8–82 cm) taken by beam trawls were mainly discarded, with comparatively few records of fish being retained. The discard/retention

patterns of *S. canicula* taken by otter trawlers in the Celtic Seas showed similar patterns to that observed in the North Sea, although retained fish were usually >30 cm.

Approximately 90% of the *S. canicula* caught by *Nephrops* trawl in the Celtic Seas were discarded, with most of the retained fish ranging from 41–69 cm. Gillnet fisheries tended not to catch smaller individuals (the overall length range observed was 31–81cm) and about 90% of the total catch was discarded, with retained specimens generally > 50 cm.

Greater spotted-dogfish (*Scyliorhinus stellaris*) was more commonly found in the Celtic Seas than in the North Sea, where it was taken by otter trawl, beam trawl, gillnet and *Nephrops* trawl (Figure XXXV). Juvenile *S. stellaris* (from 26–49 cm) were mainly discarded from otter trawlers, although there was some retention of fish >50 cm. Beam trawlers in the Celtic Seas mostly discarded this species (over the observed length range of 10–159 cm) and, similarly, gillnet fisheries usually discarded this species (61–113 cm).

III.3.3.3 Triakid sharks

Smoothhounds (*Mustelus* spp.) were most commonly observed in the Celtic Seas rather than in the North Sea ecoregion. The main gear types for the capture of this species were beam trawl, otter trawl, gillnet and midwater pair trawls. The overall length ranges found in the two ecoregions were similar, 26–121 cm and 20–122 cm in the North Sea and Celtic Seas, respectively (Figure XXXVI).

Beam trawlers in the North Sea generally discarded *Mustelus* spp., which were generally smaller fish (ca. 26–65 cm). Otter trawlers in this ecoregion took a greater proportion of larger sized fish (> 65 cm), and a greater proportion of these larger fish were retained. *Mustelus* spp. taken by gillnet also comprised larger fish, with juveniles usually discarded and larger fish (>66 cm) generally retained. There were comparatively few records of *Mustelus* spp. being taken by *Nephrops* trawlers, reflecting at least in part the more southerly distribution of smoothhounds in the North Sea (with the *Nephrops* grounds further north), and most of these were discarded.

Mustelus spp. were commonly taken in all Celtic Seas fisheries. Beam trawlers captured proportionally more juveniles (most records were for fish of about 35–70 cm), with comparatively fewer adults were observed, and the juveniles were discarded. High rates of discarding were also apparent in otter trawls, where about 78% of the total catch was discarded, although this was also mostly for smaller fish (<50 cm). A greater proportion of fish >70 cm were taken with this gear than by beam trawl, and such fish were often retained. Gillnets were more selective for larger fish, with few fish <70 cm observed, and most of these larger fish were retained, and smaller fish (<60 cm) usually discarded.

Tope (*Galeorhinus galeus*) was frequent in both the North Sea and Celtic Seas ecoregions, although only two individuals were caught and retained by otter trawls in deep-water areas. This species was taken by beam trawl, otter trawl, *Nephrops* trawl, gillnet and longline. The overall length range observed was 47–189 cm (Figure XXXVII), with larger fish mostly retained and individuals <70 cm typically discarded.

Catches by length (including both discards and retentions) by gear were analysed for the main commercial ‘dogfish’-like sharks (*Mustelus* spp., *G. galeus* and *S. acanthias*), as the morphology of these species are broadly similar. Beam trawls caught proportionally more juveniles of this species complex, followed by otter trawls (Figure XLIII) with gillnets and longlines more selective for large fish. It should be noted that data were more limited for longline fisheries. The discard-retention patterns was analysed in more detail for *Mustelus* spp. (Figure XXXIX). There was much variability in the discard patterns for these species, which were very occasionally retained at lengths of 31 cm and 50% retention was at ca. 85 cm.

III.3.3.4 Deep-water sharks

Although several species of deep-water squaliform and scyliorhinid sharks were taken, these data were from a very limited number of trips, and so only qualitative information is presented below. Some species, such as velvet belly *Etmopterus spinax*, were observed occasionally in trips on the edge of the continental shelf, whilst only 2–3 trips were made on the gillnetters, longliners and trawlers operating in the deeper waters along the western seaboard of the British Isles.

The three most commonly observed deep-water squaliform sharks were leafscale gulper shark *Centrophorus squamosus*, Portuguese dogfish *Centroscymnus coelolepis* and birdbeak dogfish *Deania calcea*. Discarding rates were particularly low for *C. squamosus* and *C. coelolepis* although smaller individuals (< ca. 75 cm) were usually discarded. *D. calcea* were discarded at lengths of <66 cm. Longnose velvet dogfish *C. crepidater* do not attain as large a size than the congeneric *C. coelolepis* and so a greater proportion were discarded, although larger individuals were retained. False catshark *Pseudotriakis microdon* were mostly retained, although there were very few observations of fish <150 cm long. Data were also too limited to estimate the sizes of retention/discarding for kitefin shark *Dalatias licha*.

In general, the smaller-bodied deep-water sharks were discarded, with 100% discarding of great lantern shark *Etmopterus princeps*, *E. spinax* and black dogfish *Centroscyllium fabricii*. Occasional individuals of four species (Iceland catshark *Apristurus laurussoni*, Mouse catshark *Galeus murinus*, Greenland shark *Somniosus microcephalus* and sailfin

rough shark *Oxynotus paradoxus*) were observed, and these individuals were all discarded. Three chimaeroid species were also observed (see Table X), and all were discarded.

III.3.3.5 Miscellaneous sharks

Most records of six-gill shark (*Hexanchus griseus*) were from deep-water gillnetting, *Nephrops* trawl and otter trawl. However, some specimens were recorded by otter trawls, longline and *Nephrops* trawl in the offshore areas of the Celtic Seas, and one specimen was recorded from otter trawl in the northern North Sea. The specimens recorded were 63–169 cm long (Figure XXXVII), with the larger specimens recorded in deep-water and the smallest individual from the North Sea. Data were too limited to draw definitive answers on retention patterns, although it was noted that smaller fish (63–105 cm) were most often discarded and larger fish (112–169 cm) often retained.

Porbeagle (*Lamna nasus*) was reported from both the Celtic Seas and deep-water ecoregions, and were taken in gillnet, midwater pair trawl and otter trawl (Celtic Seas). The overall length range of observed specimens was 90–270 cm, and all the specimens were retained except for the case of those caught by midwater pair trawlers.

Only one example of angel shark (*Squatina squatina*) was recorded, with this 37 cm specimen taken in the English Channel.

III.3.3.6 Skates

Common skate (*Dipturus batis*) was most frequently observed in the Celtic Seas, with few records from the North Sea ecoregion, where it was observed in otter trawl and *Nephrops* trawl. In the Celtic Seas it was taken mainly by beam trawl, with some individuals recorded from otter trawl, *Nephrops* trawl and gillnet. A few specimens were also noted in the deep-water eco-region. The majority of common skate observed in the Celtic Seas beam trawl fishery were juveniles (<50 cm), and these were generally discarded (79%). Retention rates increased for fish >50 cm (Figure XLa).

Starry ray (*Amblyraja radiata*) was most commonly observed in the North Sea, with only four specimens taken by otter trawls in Celtic Seas, and these may reflect misidentifications. In the North Sea, this species was taken by otter trawl, *Nephrops* trawl, beam trawl and gillnet, with an overall observed length range of 12–60 cm, and the majority (>98%) were discarded (Figure XLc/d). Small numbers of fish (27–59 cm) were retained occasionally.

Shagreen ray (*Leucoraja fullonica*) was mostly taken in the Celtic Seas by beam trawl, with some records for otter trawl and gillnet. *L. fullonica* was discarded at lengths of 12–61

cm, and retained at lengths of 49–114 cm (Figure XLb), with 50% retention at approximately 54–55 cm. Only three individuals were recorded in the North Sea ecoregion, and these were all retained.

Cuckoo ray (*Leucoraja naevus*) was also more commonly reported from the Celtic Seas than the North Sea ecoregion (although it should be noted that this species is more common in the Scottish waters of the NW North Sea, which was not well sampled). Most records of *L. naevus* were from beam trawl, otter trawl, and gillnet, and data were too limited for *Nephrops* trawl to identify clear discard/retention patterns (Figure XLI). In the North Sea, *L. naevus* was recorded mostly from otter trawlers, with the majority of the catch (ca. 78%) discarded (17–62 cm). Adults were mostly retained at 44–67 cm.

Within the Celtic Seas, the majority of the catch (ca. 82% by numbers) was discarded by beam trawlers, with most of these juveniles (<50 cm). Retained fish range from 24–86 cm length, with 50% retention at lengths of about 51–52 cm. Similar results were recorded for otter trawlers in this ecoregion, although the proportion of juveniles captured was less than caught by beam trawl, and 50% retention occurred at a length of approximately 48 cm. As expected, gillnets were more selective, capturing mostly larger individuals, the majority of which were retained (47–72 cm).

Blonde ray (*Raja brachyura*) was more commonly found in the Celtic Seas than North Sea ecoregion and was taken by all gear types (Figure XLII). In the North Sea otter trawl fishery, juvenile blonde rays were mostly discarded (<43 cm), larger fish (50–106 cm) generally retained, and 50% retention was at ca. 45 cm. Although, the majority of the catch captured by *Nephrops* trawlers in this ecoregion was discarded (49–68 cm), data were too limited to infer accurate discard/retention patterns.

Within the Celtic Seas, *R. brachyura* was captured by otter trawl and beam trawl, with an overall observed length range of 13–119 cm. The majority of the catch was retained by beam trawlers (35–109 cm), with 50% retention at a length of ca. 44 cm, and juveniles were mostly discarded. Otter trawlers in the same ecoregion recorded a higher proportion of larger individuals, and such fish (38–119 cm) were retained, and 50% retention occurred at a length of about 52 cm.

Thornback ray (*Raja clavata*) was taken by all gear types in the North Sea and Celtic Seas ecoregions, and there were a few captures by otter trawls in deep-water (Figure XLIII). Data for *Nephrops* trawls, for both ecoregions, was too limited to draw definitive answers on discard/retentions patterns, though it was noted that juveniles were mostly discarded (<50 cm) with larger *R. clavata* mostly retained (50–95 cm).

Discard/retention patterns were broadly similar in both ecoregions, with beam trawlers capturing proportionally more juveniles (<50 cm), which were mostly discarded. Retained fish were larger (51–106 cm). Proportionally more of the larger fish were captured by otter trawl, with juveniles generally discarded. The overall length range of discarded *R. clavata* in the North Sea and Celtic Seas ecoregion were 12–78 cm and 8–58 cm, respectively. The length at 50% retention was approximately 50 cm and 47–48 cm in the North Sea and Celtic Seas, respectively.

In the North Seas gillnet fishery, juvenile *R. clavata* were mostly discarded (<45 cm) and larger fish generally retained ($\geq$ 54 cm), with 50% retention at about 49 cm.

Smalleyed ray (*Raja microocellata*) occurs mostly in the Celtic Seas ecoregion, although it does occur in the eastern English Channel, and was taken by beam trawl, otter trawl and gillnet. Beam trawlers would mostly discard juveniles (13–48 cm) and retain larger specimens (45–97 cm). Similar patterns were also observed for otter trawl catches, where 50% retention occurred at a length of about 51 cm. (Figure XLIVa/b)

Spotted ray (*Raja montagui*) was more commonly found in the Celtic Seas than in the North Sea ecoregion, and was taken by beam trawls, otter trawls, *Nephrops* trawls, gillnets, and longline (in the North Sea ecoregion). Larger *R. montagui* were found in the Celtic Sea (Figure XLV). Data from the North Sea *Nephrops* trawl fishery were limited. *R. montagui* captured by beam trawl in the North Sea ecoregion were discarded at 10–58 cm and, retained at 36–69 cm, with 50% retention at about 50 cm. Once again, otter trawlers captured proportionally more larger fish than beam trawlers, and most of these were retained (38–69 cm), with juveniles (< 48 cm) often discarded (50% retention at about 47–48 cm).

Within the Celtic Seas, beam trawlers captured mostly juveniles (11–48 cm), which were discarded. Retained specimens ranged from 34–83 cm, with 50% retention at approximately 48–49 cm. The discard patterns from otter trawlers in this ecoregion were similar to that observed in the North Sea, with juveniles discarded (10–49 cm), fish retained at lengths of 27–79 cm, and 50% retentions at approximately 50 cm.

Undulate ray (*Raja undulata*) was also more frequently observed in the Celtic Seas (although they are distributed as far east as the eastern English Channel), and most observations of this species were from beam trawl and otter trawl catches. In the beam trawl fishery, juveniles were mostly discarded (overall length range of discards was 16–52 cm) and larger fish (53–102 cm) were generally retained. *R. undulata* captured by otter trawlers were mostly retained across the 29–100 cm length range and there were few records of discards (Figure XLIVc/d).

The length of skates (all rajids combined) caught, including discarded and retained fish, were analysed by gear (Figure XLVI). Beam trawls caught proportionally more juveniles than any other gear, followed by smaller gillnets (90-150 mm mesh size) and otter trawls. Larger gillnets (>200 mm mesh size) and longlines were more selective, with proportionally more adults and fewer small fish. However, it should be noted that data for longlines catches were limited.

The length at 50% retention for the major commercial skate species was analysed, combining across gears and ecoregions (Figure XLVII). The lengths at 50% retention were lowest for *R. undulata* and *R. clavata* (45.2 cm and 48.0 cm, respectively), and highest for the large, offshore species (54.3 and 54.8 cm for *L. fullonica* and *D. batis*, respectively). The lengths at 50% retention for *R. montagui*, *R. brachyura*, *L. naevus*, *R. microocellata* were 49.0–50.2 cm. Data were limited for *R. undulata* and, to a lesser extent, *D. batis* and *L. fullonica*, and so the regression coefficients, although still significant, were lower than observed in other species.

III.3.3.7 Rays

Three other species of batoid were observed, and these taxa are typically discarded (although some fishermen retain live specimens to supply public aquaria). Electric ray (*Torpedo nobiliana*) was only taken in the Celtic Sea ecoregion, with most records from beam trawlers operating in the south-west. All electric rays (16–115 cm) were discarded. Marbled electric ray (*Torpedo marmorata*) was only recorded by beam trawlers in the Celtic Seas, and all specimens (13–68 cm) were discarded.

Stingray (*Dasyatis pastinaca*) was also only reported from the Celtic Seas, although it is known to be a bycatch species in the southern North Sea and eastern English Channel. Most observations were from otter trawl and beam trawl, and one specimen was recorded in a gillnet catch. All stingrays (43–84 cm) were discarded.

III.4 Discussion

This study summarises the chondrichthyans taken in a variety of the UK commercial fisheries operating around the British Isles. Such data complement data from fishery-independent survey, which have already been summarised (Ellis *et al.*, 2005a,b). Given that commercial landings are often reported to non-specific level, this account provides a more accurate species-specific regional account of which species are taken. Given the problems with raising catches of 'rare' species, especially where catches have often been sub-sampled, we have not used discard data to extrapolate to estimate total catches of these species.

Prior to data analysis, several methods of quality assurance were undertaken. Examining the spatial distributions, length distributions and species compositions of similar species (e.g. *Scyliorhinus* spp.) helped identify and correct obvious outliers, which may have been due to misidentification or database errors. Such data checks are recommended for future studies of discards data for other taxa.

The species distributions (see Appendix II) indicate the broad biogeographical distributions of the various species, but even after correcting for obvious outliers, there is still the potential for errors. Those sympatric taxa for which errors were most commonly observed included lesser and greater-spotted dogfish, blonde and spotted rays, and thornback and starry rays. Other species that can be confused include smalleyed and sandy ray, but this may be as much related to the use of common names as identification itself, as smalleyed ray are known as 'sandy rays' in some areas (e.g. Bristol Channel). Some of the instances where data are still suspicious, but cannot be excluded as incorrect include the record of starry ray off the west coast of Ireland (Appendix II, g). Although there were records of black skate (*Dipturus nidarosiensis*) of NW Scotland, the absence of records of long-nosed skate (*Dipturus oxyrinchus*) would indicate there is potential confusion between these species. Hence, improved training for discard observers could improve the quality of such data.

Marine Protected Areas (MPAs) or space-time technical restrictions have been suggested as potentially useful management measures for elasmobranchs, however data from scientific trawl surveys provide a relatively restricted amount of data. Data from observer programmes on commercial vessels provided comparable data, with the Greater Thames Estuary, English Channel and Bristol Channel confirmed as regionally important for juvenile triakid sharks. Incorporating fisher knowledge would likely be required to get a more accurate delineation of important elasmobranch habitats.

Data from observer programs can provide valuable information on the general length-based discard-retention patterns of elasmobranchs in mixed fisheries. It should be recognised, however, that discard patterns on individual trips might be influenced by a variety of factors. For example, the amount of quota available, quantities of other (more profitable) fish captured and market price will affect retention patterns. Market requirements will also have an affect, for example, the continental market for smoothhounds has increased in recent years, but may only be worthwhile when there are sufficient quantities caught, and landings of scyliorhinids for pot bait will be influenced by local needs. Management measure, such as bycatch ratios, will also have been potential factors in recent years, for example it has been suggested that more smoothhounds and lesser-spotted dogfish would have been retained in the North Sea during 2007, when

there was a 25% bycatch quota for skates. The state of the fish might also affect discard selection; for example, some skippers may release species such as tope if they are lively, but retain those that are dead or unlikely to survive. Similarly, those fish that are damaged (e.g. by rocks in the codend, or lacerated by the spines of spurdog) may be rejected for commercial reasons. Additionally, discards may be affected by the presence of observers on board, although this is hard to qualify.

Beam trawlers caught proportionally more juveniles (Figure XXXVIII and Figure XLVI) than otter trawlers. Gillnetting and longlining tended to be more selective, with proportionally fewer small fish caught. Although data for longline catches were limited, this gear appears to be the most selective for larger fish, which is to be expected.

The discard-retention patterns of sharks indicated that scyliorhinids were usually discarded. A proportion of larger fish were retained, presumably for bait in pot fisheries, as these are not often taken for human consumption in the UK. Nevertheless, scyliorhinids are taken for human consumption in other parts of Europe (e.g. Carbonnel *et al.*, 2003).

In general, results for skates retentions were comparable and in agreement with Catchpole *et al.* (2007), in which skates >50 cm long were usually retained, with some instances of smaller individuals retained (usually > 30 cm). The discard retention patterns were somewhat more variable for *D. batis* and *R. undulata* and discarding practices may be influenced by the conservation and/or recreational importance of these species.

Discards are often considered a waste of resources, and some nations have attempted to minimise discarding (e.g. through discard bans). However, the rationale for such bans is often influenced by fisheries in which there is a high mortality rate (e.g. offshore fisheries for gadoids). The lack of a swim bladder in elasmobranchs, and the robust nature of some of the species, means that there is some potential survivorship. Survival rates vary between species and fisheries, and even on a haul basis (e.g. mortality may be related to cod end weight in trawl fisheries), and so it is difficult to determine values of survivorship. On one extreme, lesser-spotted dogfish is extremely hardy. Rodríguez-Cabello *et al.* (2001) reported survival rates from 78% (ranging from 47.1-90.5% in commercial trawlers) up to 90% (tagging surveys) for *S. canicula*, and this is a particularly resilient species. A recent study on skates (mostly thornback ray) caught by trawl in the Bristol Channel Catchpole *et al.* (2007) suggested that short-term survival ranged from 50 to 74%. Further studies on discard survival are clearly required to gauge the effectiveness of potential management measures. Given the potential survivorship of discarded elasmobranchs, including such species in 'discard bans' could increase fishing mortality.

Tables and Figures

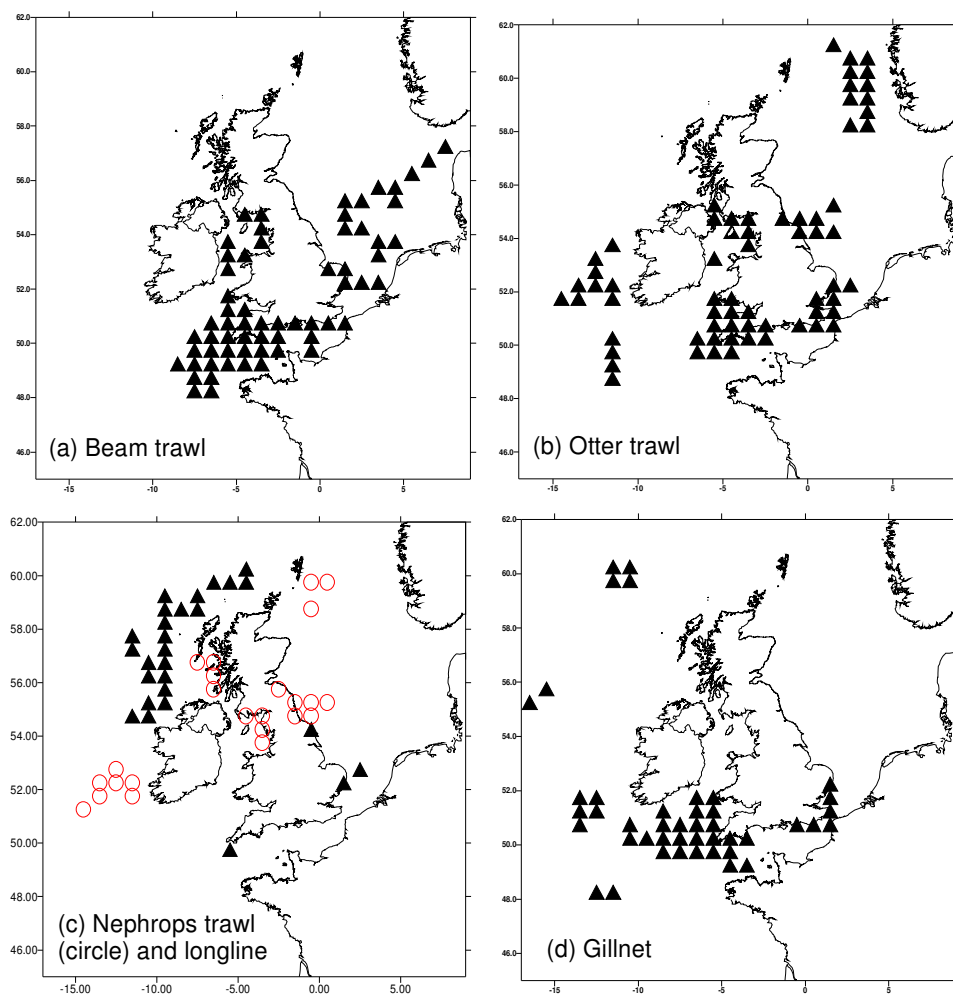


Figure XXXI - Spatial distribution of observer trips on (a) beam trawlers, (b) otter trawlers; (c) *Nephrops* trawlers and longliners, and (d) gillnetters.

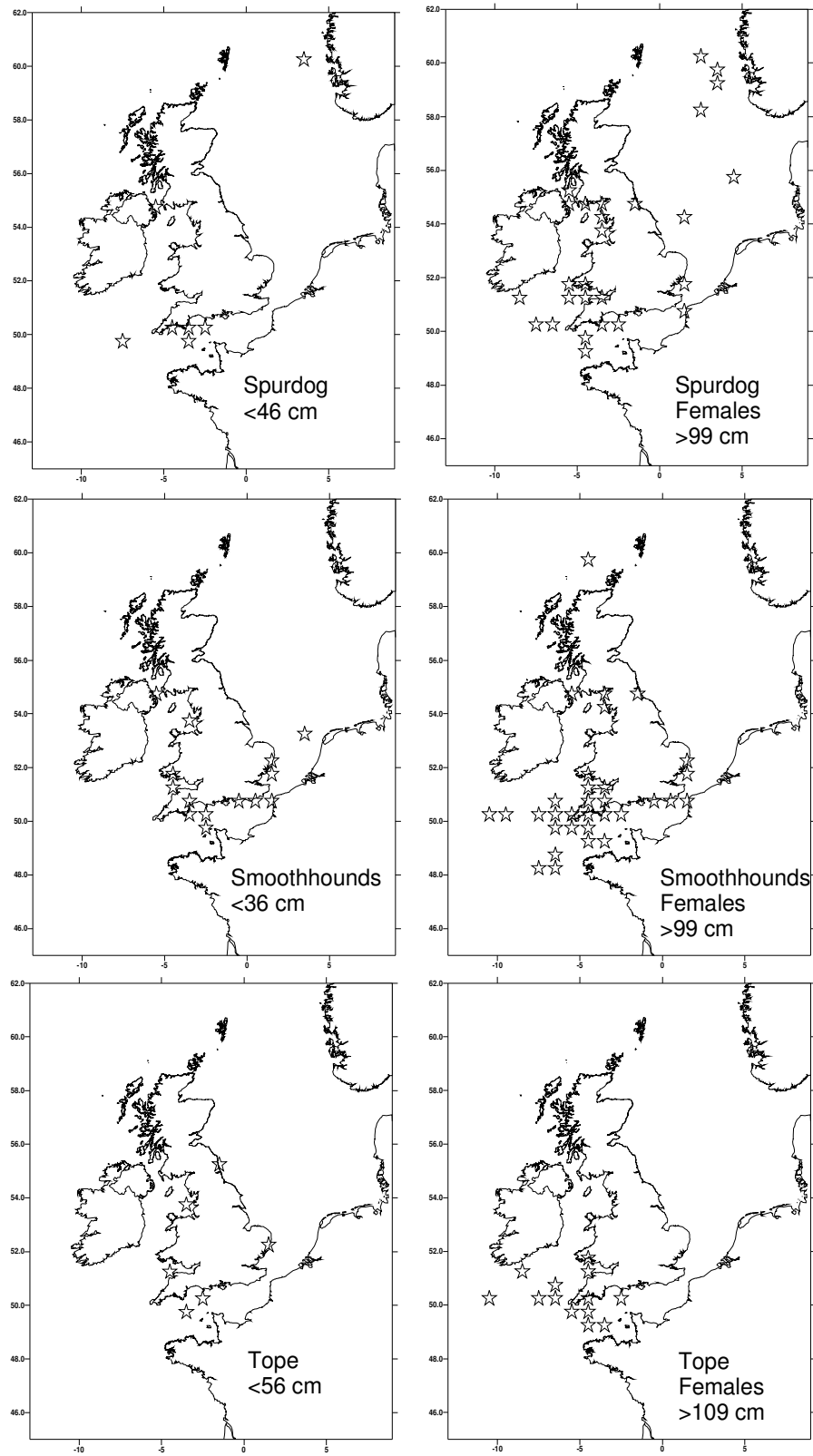


Figure XXXII - Location of juvenile and mature female tope, smoothhounds and spurdog

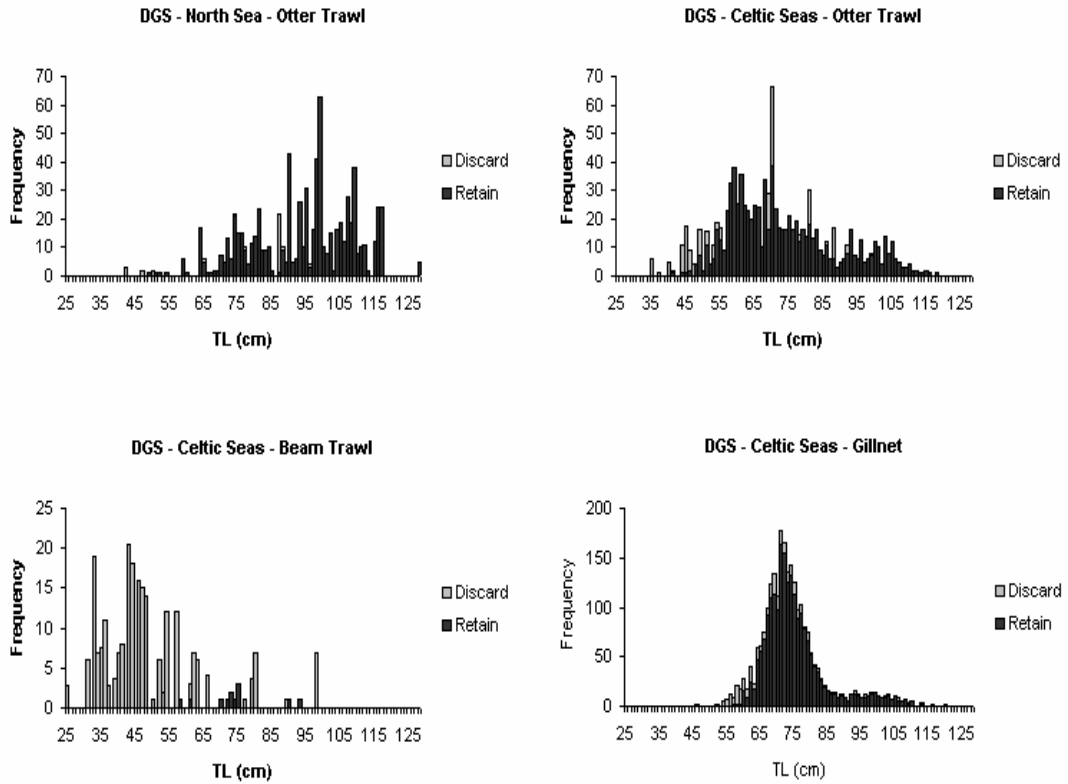


Figure XXXIII - Length-frequency of spurdog discarded and retained by otter trawl in the North Sea and Celtic Seas ecoregion, and by beam trawl and gillnet in the Celtic Seas.

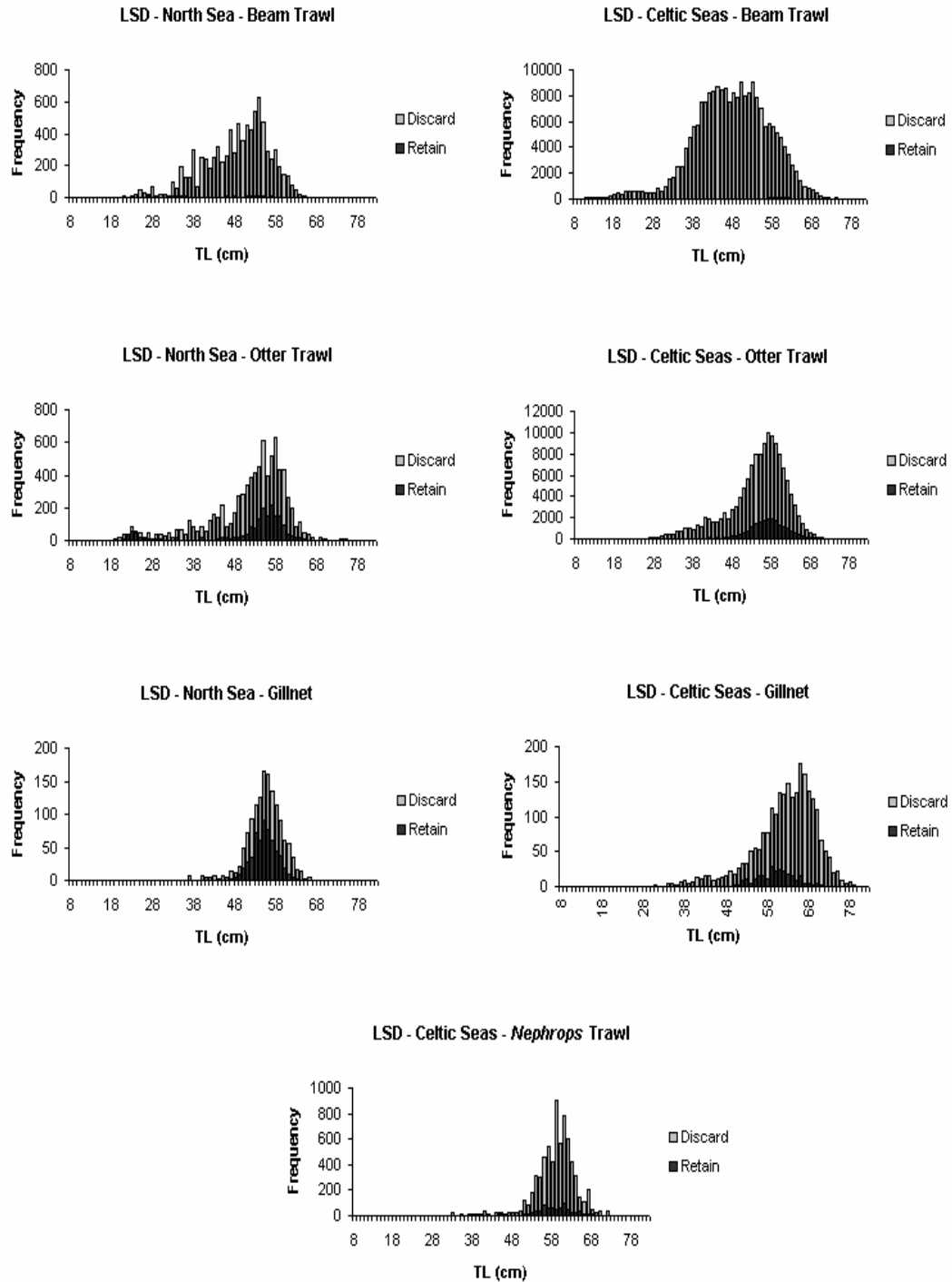


Figure XXXIV - Length-frequency of lesser-spotted dogfish discarded and retained by beam trawl, otter trawl and gillnets in the North Sea and Celtic Seas ecoregion, and by *Nephrops* trawl in the Celtic Seas.

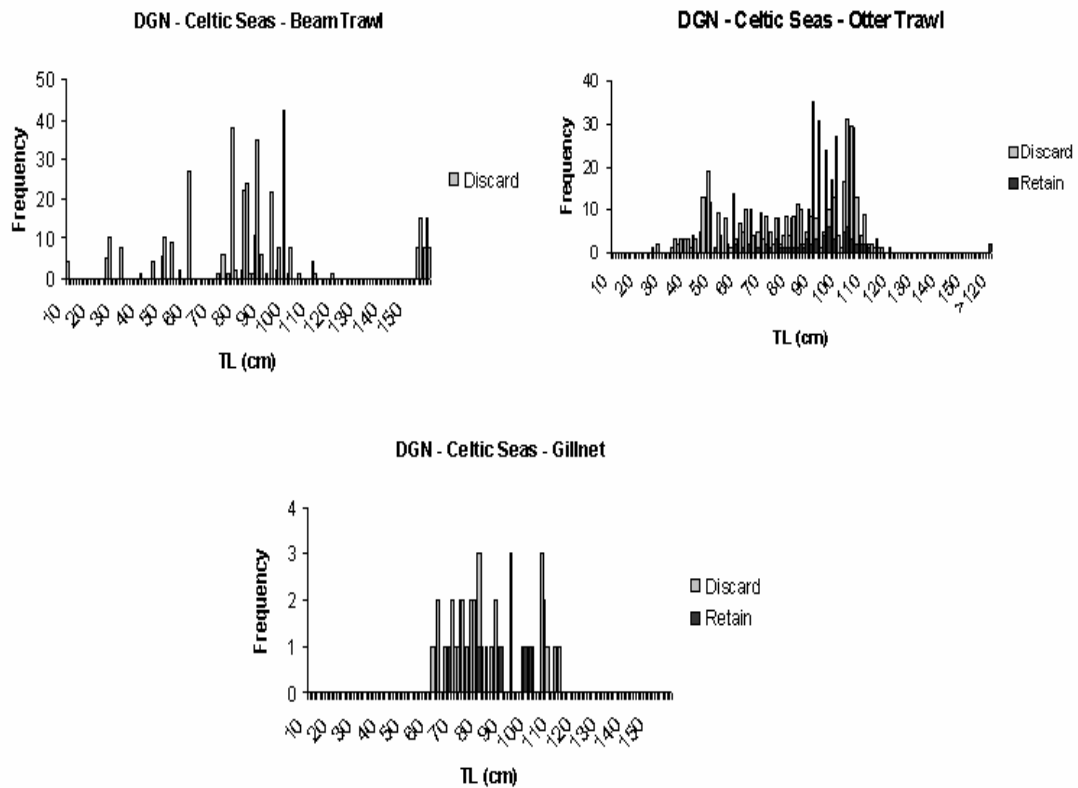


Figure XXXV - Length-frequency of greater spotted dogfish discarded and retained by beam trawl, otter trawl and gillnets in the Celtic Seas ecoregion.

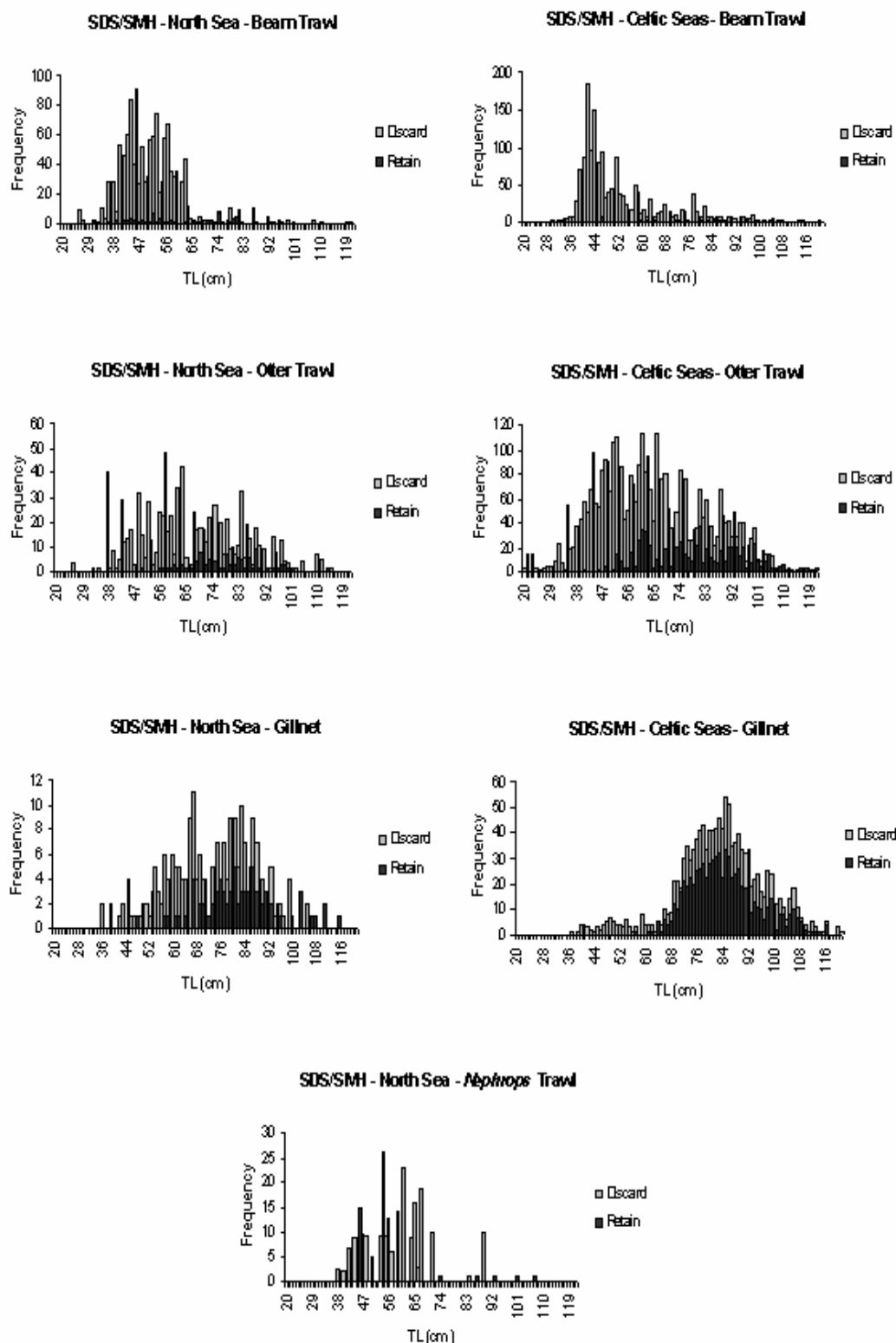


Figure XXXVI - Length-frequency of smoothhounds discarded and retained by beam trawl, otter trawl and gillnets in the North Sea and Celtic Seas ecoregion, and by *Nephrops* trawl in the North Sea.

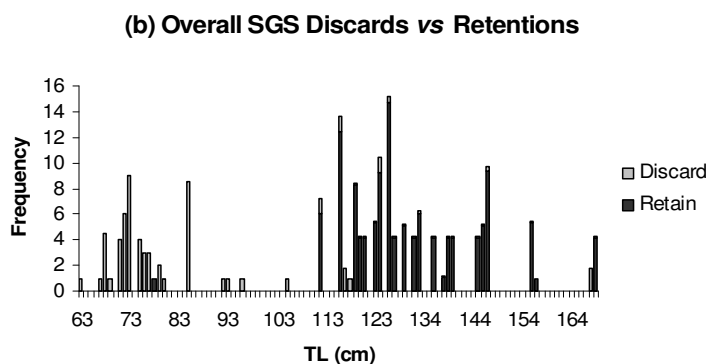
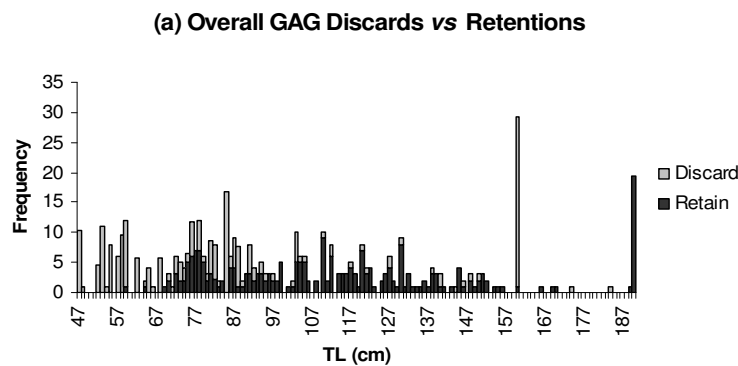


Figure XXXVII - Length-frequency of (a) tope and (b) six-gill shark discarded and retained in the North Sea and Celtic Seas ecoregion.

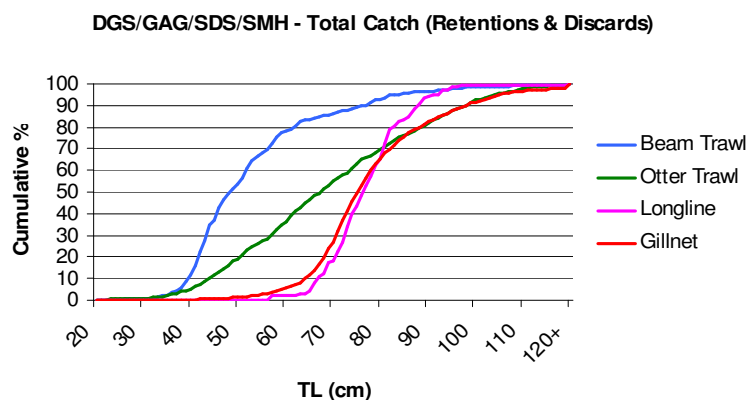


Figure XXXVIII – Preliminary examination of the comparative gear selectivity of broad gear types, illustrating the cumulative size frequency of dogfish-like sharks (spurdog, tope and smoothhounds combined). Beam trawlers take proportionally more small fish with longline and gillnet fisheries more selective for larger-sized fish.

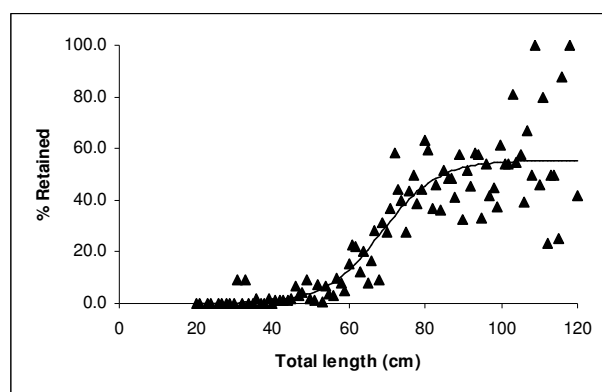


Figure XXXIX - Percentage of smoothhounds (*Mustelus* spp.) retained by length in UK fisheries ($r^2 = 0.79$).

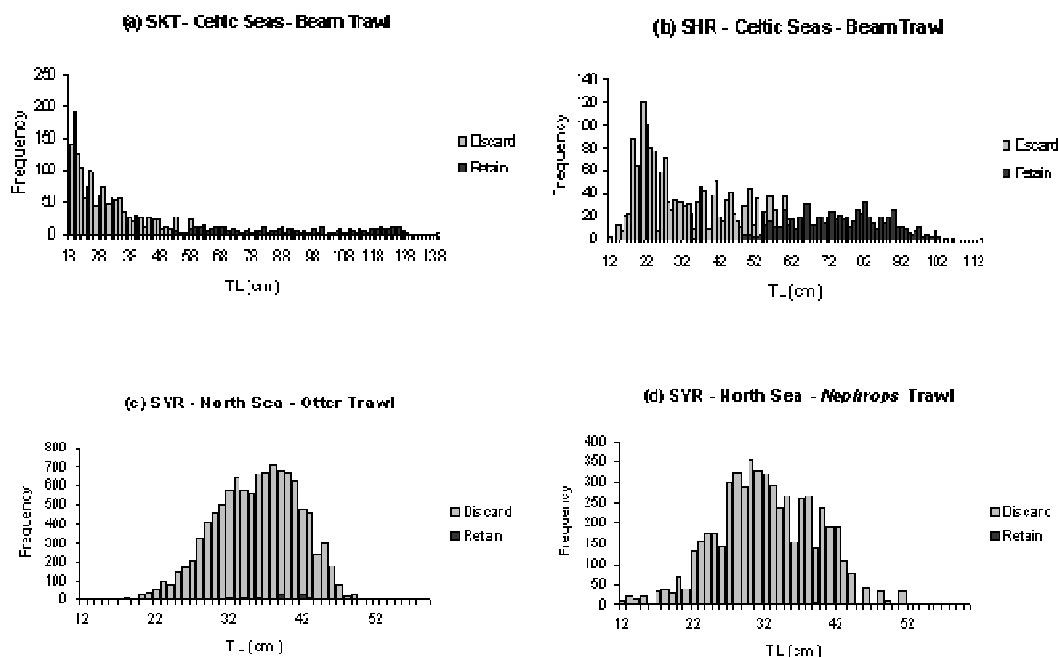


Figure XL - Length-frequency of (a) Common skate and (b) Shagreen ray discarded and retained by beam trawl in the Celtic Seas ecoregion; and length-frequency of starry ray discarded and retained by (c) otter trawl and (d) *Nephrops* trawl in the North Sea ecoregion.

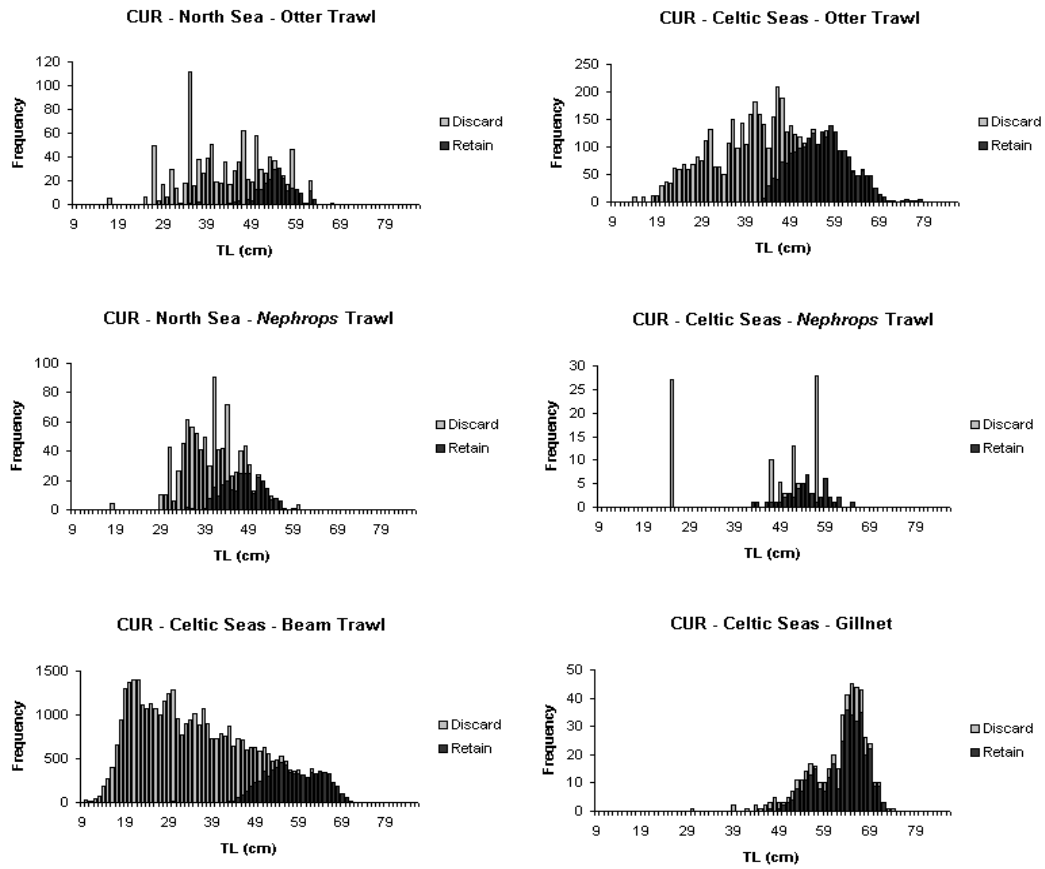


Figure XLI - Length-frequency of cuckoo rays discarded and retained by otter trawl, gillnets and *Nephrops* trawl in the North Sea and Celtic Seas ecoregion.

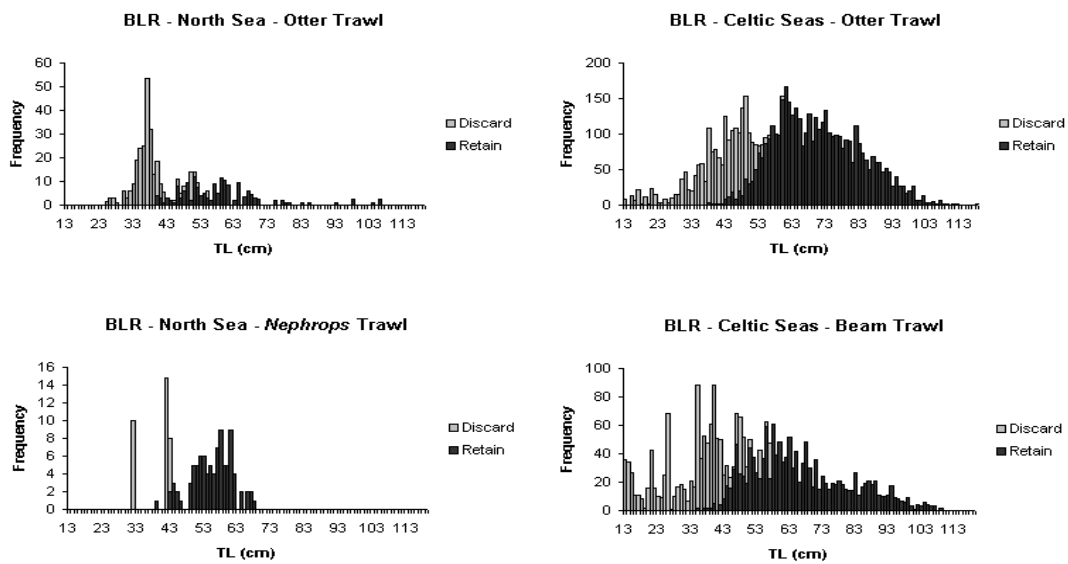


Figure XLII - Length-frequency of blonde rays discarded and retained by trawl in the North Sea and Celtic Seas ecoregion.

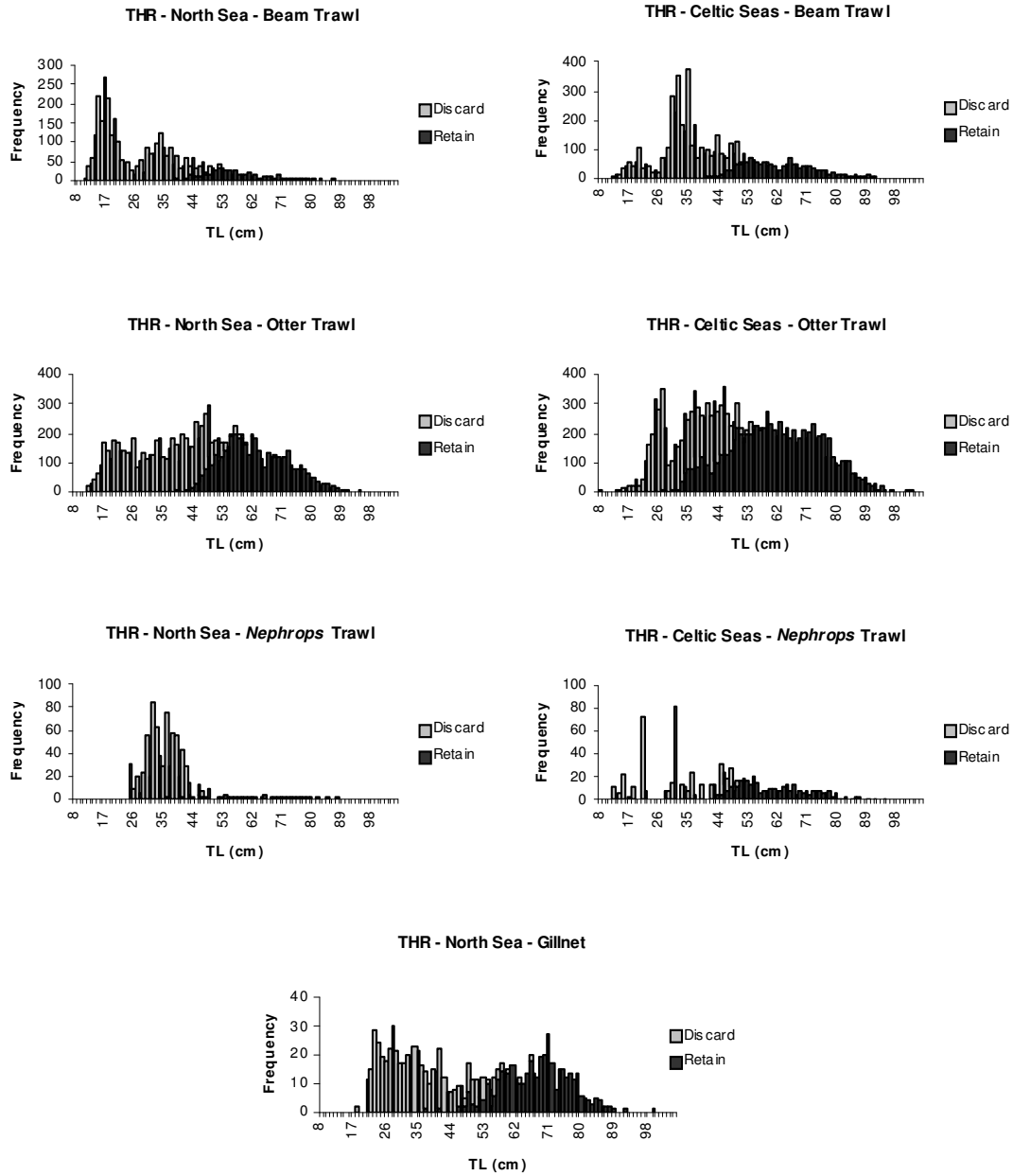


Figure XLIII - Length-frequency of thornback ray discarded and retained by beam trawl, otter trawl and *Nephrops* trawl in the North Sea and Celtic Seas ecoregion, and by gillnets in the North Sea.

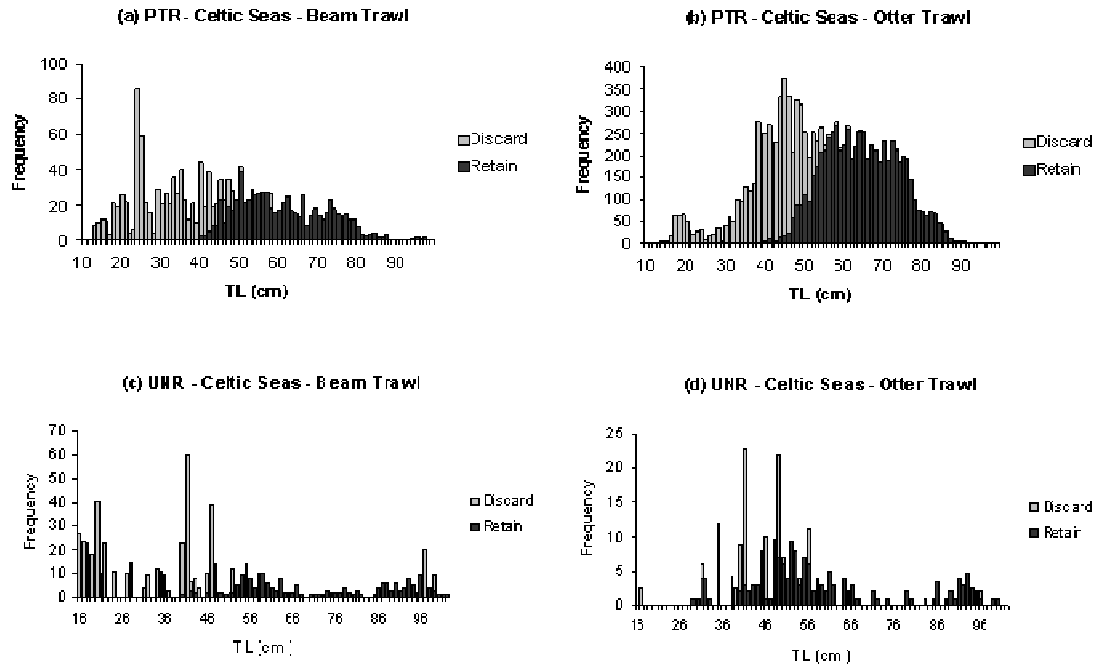


Figure XLIV - Length-frequency of smalleyed ray discarded and retained by (a) beam trawl and (b) otter trawl, and of undulate ray discarded and retained by (c) beam trawl and (d) otter trawl in the Celtic Seas ecoregion.

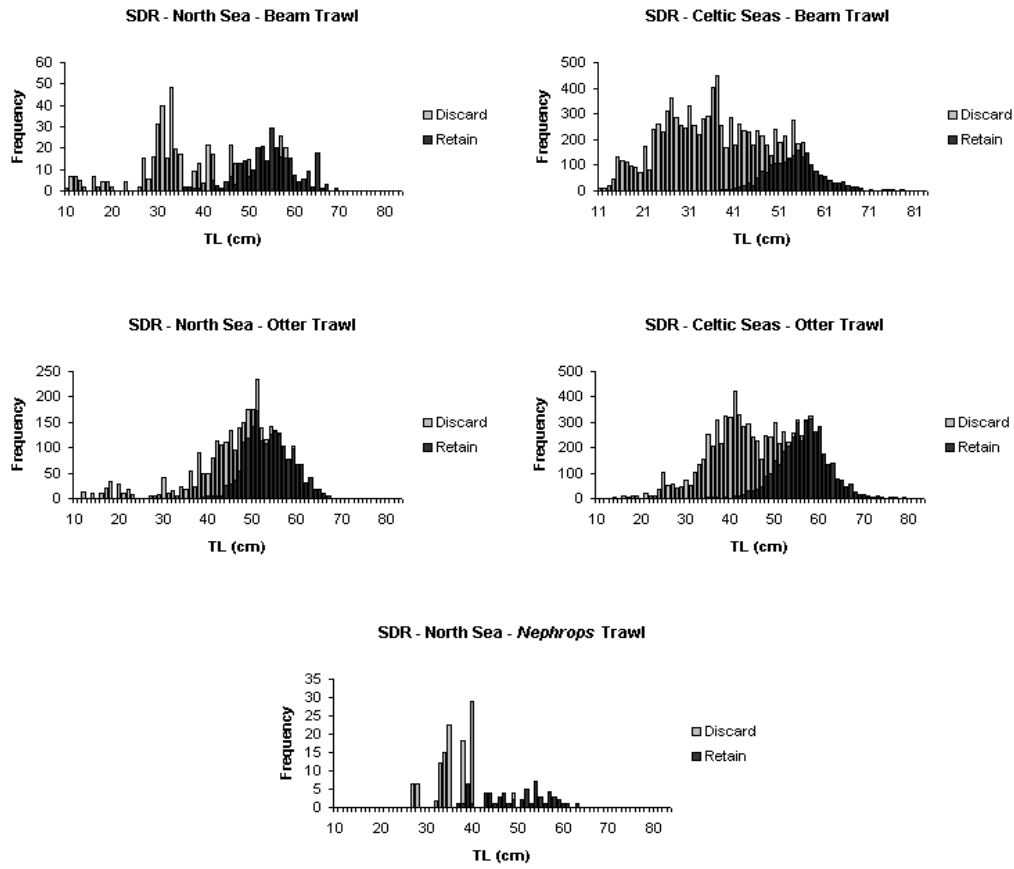


Figure XLV - Length-frequency of spotted ray discarded and retained by beam trawl and otter trawl in the North Sea and Celtic Seas ecoregion, and by *Nephrops* trawl in the North Sea.

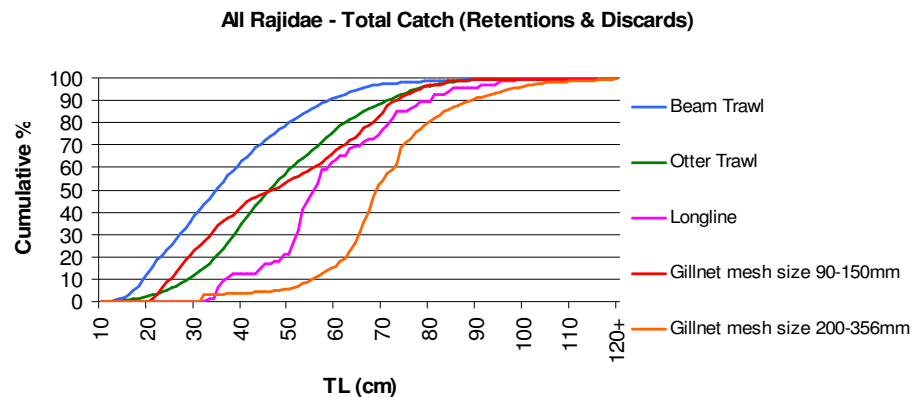


Figure XLVI - Preliminary examination of the comparative gear selectivity of broad gear types, illustrating the cumulative size frequency of skates (Rajidae). Beam trawlers take proportionally more small fish, and longline and large-mesh gillnet fisheries are more selective for larger-sized fish. [Length classes <10 cm were excluded]

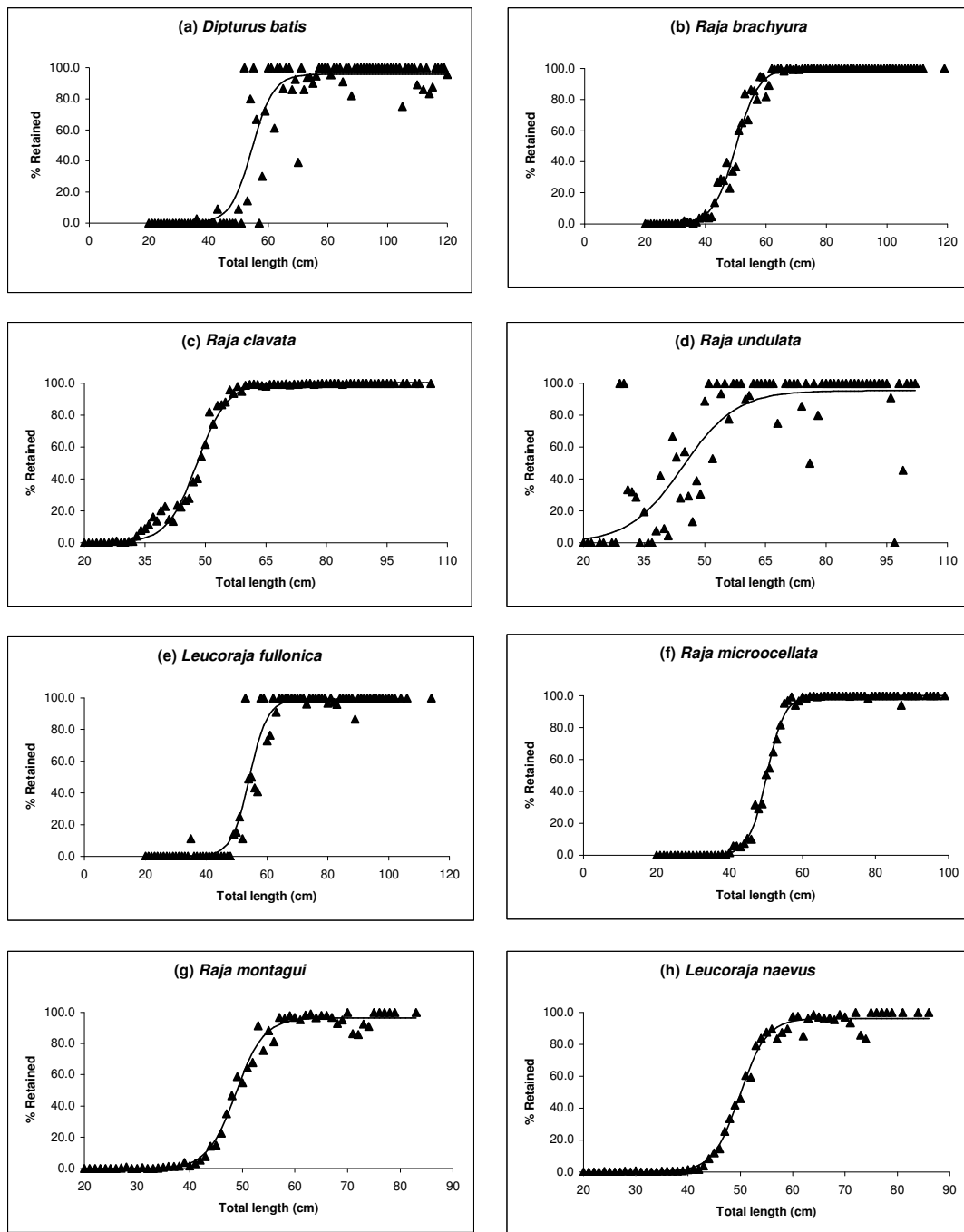


Figure XLVII - Percentage of skates retained by length in UK fisheries, including (a) *D. batis* ($r^2 = 0.88$), (b) *R. brachyura*, (c) *R. clavata*, (d) *R. undulata* ($r^2 = 0.63$), (e) *L. fullonica* ($r^2 = 0.96$), (f) *R. microocellata*, (g) *R. montagui* and (h) *L. naevus* ($r^2 = 0.99$ unless otherwise specified).

(a) Common name	Scientific name	Length range observed (cm)	Beam trawl		Otter trawl		Nephrops trawl		Gillnet		Longline		Other	
			N	n	N	n	N	n	N	N	N	n	N	n
Six-gill shark	<i>Hexanchus griseus</i>	63			1	1								
Velvet belly	<i>Etmopterus spinax</i>	25–58			2	117					1	112		
Spurdog	<i>Squalus acanthias</i>	42–128	3	132	11	769	3	16					1	4
Blackmouth dogfish	<i>Galeus melastomus</i>	35–73			1	10	1	1			1	1514		
Lesser-spotted dogfish	<i>Scyliorhinus canicula</i>	9–80	15	8469	57	8058	9	61	35	1402	4	199	2	16
Greater spotted-dogfish	<i>Scyliorhinus stellaris</i>	35–112	4	58	2	5			2	26				
Tope	<i>Galeorhinus galeus</i>	47–166	1	1	10	87	3	33	1	2	1	164		
Smoothhounds	<i>Mustelus spp.</i>	26–121	13	1315	34	924	27	237	31	253			1	2
Starry ray	<i>Amblyraja radiata</i>	12–69	8	3830	65	10703	70	5473	4	22				
Common skate	<i>Dipturus batis</i>	33–65			1	1	2	6						
Shagreen ray	<i>Leucoraja fullonica</i>	72–99									1	3		
Cuckoo ray	<i>Leucoraja naevus</i>	17–67	1	6	49	1042	68	944	1	2				
Blonde ray	<i>Raja brachyura</i>	11–108	9	233	25	419	10	124	4	194	1	1	2	3
Thornback ray	<i>Raja clavata</i>	10–100	22	3349	73	10083	39	791	41	917	3	50	5	73
Smalleyed ray	<i>Raja microocellata</i>	26–87	3	5	4	21							1	6
Spotted ray	<i>Raja montagui</i>	10–77	16	636	58	3270	33	171	6	10	3	10	1	32
Undulate ray	<i>Raja undulata</i>	15–99	7	82	6	106							1	10
Skate (indet.)	<i>Rajidae</i>	33			1	1								
Rabbit fish	<i>Chimaera monstrosa</i>	26–55			5	53					1	26		

(b) Common name	Scientific name	Length range Observed (cm)	Beam trawl		Otter trawl		Nephrops trawl		Gillnet		Longlines		Other	
			N	n	N	n	N	n	N	n	N	n	N	n
Six-gill shark	<i>Hexanchus griseus</i>	68–168			3	34	1	2	4	4	2	5		
Leafscale gulper shark	<i>Centrophorus squamosus</i>	31–143			1	133			2	1759	3	25420		
Portuguese dogfish	<i>Centroscymnus coelolepis</i>	42–125			1	60			2	1397	3	1400		
Longnose velvet dogfish	<i>Centroscymnus crepidater</i>	35–88			1	80					3	312		
Black dogfish	<i>Centroscyllium fabricii</i>	47–86							1	875	2	145		
Kitefin shark	<i>Dalatias licha</i>	46–126			1	6			1	4				

Birdbeak dogfish	<i>Deania calceus</i>	29–113			2	187	1	1	2	40	3	369		
Great latern shark	<i>Etmopterus princeps</i>	15–83			1	6					3	1169		
Velvet belly	<i>Etmopterus spinax</i>	48–59			1	4					1	10		
Spurdog	<i>Squalus acanthias</i>	25–120	24	242	65	1025	8	9	22	2400			1	75
Angel shark	<i>Squatina squatina</i>	37			1	4								
Basking shark	<i>Cetorhinus maximus</i>	382							1	1				
Porbeagle	<i>Lamna nasus</i>	106–270			1	1			7	11			1	2
Iceland catshark	<i>Apristurus laurussoni</i>	64									1	1		
Blackmouth dogfish	<i>Galeus melastomus</i>	16–73	3	6	7	176	1	51	7	13				
Mouse catshark	<i>Galeus murinus</i>	37			1	5					1	1		
Lesser-spotted dogfish	<i>Scyliorhinus canicula</i>	8–82	133	211729	336	136227	37	6938	48	2412			19	327
Greater spotted-dogfish	<i>Scyliorhinus stellaris</i>	10–159	25	379	69	634	5	7	17	44			3	15
False catshark	<i>Pseudotriakis microdon</i>	46–257							1	44	2	9		
Tope	<i>Galeorhinus galeus</i>	47–189	3	31	20	71	2	2	25	227				
Smoothhounds	<i>Mustelus spp.</i>	20–122	43	1695	165	3838	6	120	28	1264			5	20
Blue shark	<i>Prionace glauca</i>	62–224							3	11	2	4	1	1
Electric ray	<i>Torpedo nobiliana</i>	16–115	27	199	2	3			1	1			2	3
Marbled electric ray	<i>Torpedo marmorata</i>	13–68	13	200										
Starry ray	<i>Amblyraja radiata</i>	36			1	4								
Common skate	<i>Dipturus batis</i>	15–146	38	2139	10	71	1	48	10	210				
Black skate	<i>Dipturus nidarosiensis</i>	39–180			2	4	1	11			1	1		
Sandy ray	<i>Leucoraja circularis</i>	14–94	3	31										
Shagreen ray	<i>Leucoraja fullonica</i>	12–114	49	2292	8	20			11	40				
Cuckoo ray	<i>Leucoraja naevus</i>	9–86	89	40235	81	5012	11	127	28	456			6	201
Blonde ray	<i>Raja brachyura</i>	13–119	79	2506	110	6045	2	223	16	95			1	2
Thornback ray	<i>Raja clavata</i>	8–106	49	5221	162	14097	27	786	2	4			4	20
Smalleyed ray	<i>Raja microocellata</i>	13–99	46	1506	90	11309			2	3			2	5
Spotted ray	<i>Raja montagui</i>	10–83	113	10043	167	8806	6	223	16	111			9	48
Undulate ray	<i>Raja undulata</i>	16–102	38	642	50	242							2	2
Skate (indet.)	Rajidae	32–107	1	2	1	3			1	108	1	2		
Sting ray	<i>Dasyatis pastinaca</i>	43–84	6	23	14	37			1	1				
Rabbit fish	<i>Chimaera monstrosa</i>	8–110			2	612	1	47	2	1116	1	2		
Spearnose chimaera	<i>Rhinochimaera atlantica</i>	71–94							1	103				

(c) Common name	Scientific name	Length range observed (cm)	Otter trawl		Nephrops trawl		Gillnet		Other	
			N	n	N	n	N	n	N	n
Six-gill shark	<i>Hexanchus griseus</i>	67–169	2	6	1	12	1	127		
Leafscale gulper shark	<i>Centrophorus squamosus</i>	80–146					2	5088		
Black dogfish	<i>Centroscyllium fabricii</i>	62–85					1	889		
Portuguese dogfish	<i>Centroscymnus coelolepis</i>	79–137					2	2730		
Longnose velvet dogfish	<i>Centroscymnus crepidater</i>	72–108					1	25		
Kitefin shark	<i>Dalatias licha</i>	34–150	1	46			2	41		
Birdbeak dogfish	<i>Deania calceus</i>	66–114					2	1994		
Sailfin roughshark	<i>Oxynotus paradoxus</i>	39–79					1	3		
Greenland shark	<i>Somniosus microcephalus</i>	170–280					1	2		
Spurdog	<i>Squalus acanthias</i>	68–90	2	5						
Velvet belly	<i>Etmopterus spinax</i>	20–55	2	36	1	36				
Porbeagle	<i>Lamna nasus</i>	90–219					1	1	1	6
Blackmouth dogfish	<i>Galeus melastomus</i>	13–70	2	390	1	101	1	1		
Lesser-spotted dogfish	<i>Scyliorhinus canicula</i>	59–70	1	34						
False catshark	<i>Pseudotriakis microdon</i>	120–230					2	26		
Tope	<i>Galeorhinus galeus</i>	74–98	1	2						
Blue shark	<i>Prionace glauca</i>	160					1	1		
Common skate	<i>Dipturus batis</i>	76–108	2	17						
Black skate	<i>Dipturus nidarosiensis</i>	67–192					2	33		
Thornback ray	<i>Raja clavata</i>	83–88	1	2						
Skate (indet.)	Rajidae	68–77					1	83		
Rabbit fish	<i>Chimaera monstrosa</i>	15–110	1	89	1	7	2	1101		
Large-eyed rabbitfish	<i>Hydrolagus mirabilis</i>	30–42					1	382		
Spearnose chimaera	<i>Rhinochimaera atlantica</i>	61–106					2	112		

Table X - Taxonomic list of chondrichthyans sampled, and their occurrence in discard observer trips in (a) the North Sea ecoregion (ICES Divisions IV a-c, VIId); (b) Celtic Seas ecoregion (ICES Divisions VIa, VIIa,b,e-j); and (c) deep-water areas (V, VIb, VIId,k), by gear type, giving the number of trips on which they were observed (N) and raised number of individuals recorded (n). Data for *Mustelus asterias* and *M. Mustelus* combined.

IV Species composition of skates (Rajidae) in commercial fisheries around the British Isles

Draft manuscript for submission to a peer-review journal.

IV.1 Introduction

Skates (Rajidae) and other batoid fish are an important component of the demersal fish assemblage in many parts of the world. The biological characteristics of skates (e.g. their slow growth, protracted development, low fecundity) make them highly vulnerable to over-exploitation, and their large size and flattened shape make them susceptible to capture in various fisheries (Ellis *et al.*, 2008). Although there are several, localised UK fisheries targeting skates (e.g. in the southern North Sea and Bristol Channel), skates are often an important bycatch in mixed demersal fisheries.

Traditionally, most nations (including the UK) have reported skate landings under the generic category of “skates and rays”. The lack of species-specific data has meant that formerly frequent skate species disappeared from parts of their former range unnoticed at the time, including common skate *Dipturus batis* and white skate *Rostroraja alba*, (Brander, 1981; Rogers & Ellis, 2000). This lack of species-specific landings data has hampered stock assessments for these species, and recent advice for skate stocks has been based on the interpretation of distribution and abundance trends in fishery-independent groundfish surveys (ICES, 2008a,b).

In recent years, there have been attempts to better examine species composition from market sampling, although some of the national programmes for this have been hampered by poor species-identification (ICES, 2007a). Although there are defined national requirements for the number of skate samples to be measured under the Data Collection Regulations, these have been area-based targets, thus restricting the utility of extrapolating such data to estimate landings (although there will be metier-based targets in the future).

There has been an increased utilization of discard observers on commercial vessels to examine discard/retention patterns in European fisheries (Borges *et al.*, 2005; Enever *et al.*, 2007; Gonçalves *et al.*, 2007), so that catches of commercial species can be better estimated. Such studies may also provide useful data on the species composition of those taxa that are not routinely reported to species in landing statistics.

The present study analysed the skate bycatch as recorded during observer trips on commercial fishing vessels in order to provide preliminary estimates of the species

composition of skates taken in UK fisheries (by ICES Divisions and broad category of gear type).

IV.2 Materials and methods

IV.2.1 Landings data

Landings data for UK-registered vessels were extracted from the UK Fishing Activity Database (FAD) for the period 2002–2007 inclusive, with data allocated to gear and ICES Division. The various gears were allocated to the following broad categories of gear type (i) beam trawl, (ii) otter trawl (including pair trawl, twin rig trawl and mid-water trawl), (iii) *Nephrops* trawl, (iv) gillnets (including drift and trammelnets), (v) lines (including hand lines and longlines) and (vi) other gears. These data were examined in order to identify which combinations of gear and ICES Division accounted for most of the reported skate landings. It is recognised that these data may not be fully accurate for inshore fleets, where several gears can be used by a single vessel, and the degree of misreporting is unknown. Additionally, each of these broad gear types could be split into various distinct métiers.

IV.2.2 Observer data

See section III.2.1, though in this chapter only the retained species were examined not the discarded ones.

IV.2.3 Data filtering of observer data

Species identification of skates, both in fisheries-independent and fishery-dependent data, remains problematic (Daan, 2001; ICES, 2007a). These problems can result from either poor species-identification or, more simply, from the use of non-specific common names. In the former case, several sympatric species for which there can be identification problems include starry ray (*Amblyraja radiata*) and thornback ray (*Raja clavata*), and blonde ray (*R. brachyura*) with spotted ray (*R. montagui*). In terms of the use of common names, ‘sandy ray’ is widely used for the offshore *Leucoraja circularis*, but is also used regionally (e.g. in the Bristol Channel) to refer to smalleyed ray (*Raja microocellata*). Similarly, both smalleyed ray and undulate ray (*Raja undulata*) are sometimes called ‘painted ray’.

To minimise potential misidentification issues, the spatial distribution of all species and their size distributions were examined, so that records of fish outside their known biogeographical and/or bathymetric range, $<L_{\text{birth}}$ or $>L_{\text{max}}$ could be checked. Where possible, these data were corrected (see Chapter III). If no appropriate corrections could be made, then the records were treated at a family level. At the start of the discard

observer scheme, 120 cm was used as a default maximum length in the database, and a few early records of *D. batis* (n = 7) and *D. nidarosiensis* (n=1) reported lengths of '120 cm+' on original data sheets. These data were converted to the mean length of specimens >120 cm recorded in subsequent years (126 cm for *D. batis* and 159 cm for *D. nidarosiensis*).

IV.2.4 Conversion of length to weight

Data from commercial observer programmes are based on numbers at length. In order to estimate biomass, data collected during scientific groundfish surveys were used to determine the length-weight relationships for the various species (Table XI). Data for black skate (*Dipturus nidarosiensis*) and *L. circularis* were too limited to determine a species-specific length-weight relationship, and so we applied length-weight relationships for congeneric species (*D. batis* and *L. fullonica*, respectively). Skates of uncertain identification were treated as Rajidae, and lengths were converted to weight using the length-weight relationship for *R. clavata*.

IV.2.5 Data analysis

For those Division/gear combinations where there were a low number of observer trips, the species composition (by estimated biomass) was derived from catch data that was aggregated across all trips. For those Division/gear combinations with the most observer coverage, the data were calculated as the mean across trips and were also calculated by quarter (Q1: January-March; Q2: April-June; Q3: July-September; Q4: October-December).

IV.3 Results

IV.3.1 Reported landings from UK-registered vessels

From 2002–2007, UK-registered vessels have reported, on average, about 3,086 t of “skates and rays” each year, ranging from 2,484–3,885 t. These landings were made primarily by otter trawl (58.2%) and gillnet (23.9%), with smaller quantities taken by beam trawl (7.2%), lines (5.3%), *Nephrops* trawl (3.1%) and ‘other gears’ (2.4%). In terms of the spatial distribution, the majority of landings (>80%) from UK-registered vessels were reported from eight ICES Divisions, covering the south-western approaches (VIIf: 20.1%; VIIe: 12.5%; VIIj: 9.7% and VIIg: 7.4%), Irish Sea (10.6%), and the eastern English Channel and central and southern North Sea (7.6%, 7.1% and 6.8%, respectively). More than 80% of reported skate landings originated from 21 combinations of gear and Division (Table XII).

IV.3.2 Estimates of species composition in the major fisheries

Overall, eleven skate species were recorded from discard observer trips around the British Isles. White skate was the only inshore skate species listed as occurring in British waters (Wheeler, 1992) that was not reported during the observer scheme.

Official landing statistics indicated that, in recent years, >80% of skate landings were reported from 21 combinations of fishing gear/ICES Division, although there were no observer data available for two of these fisheries (line fisheries in VIId and beam trawl catches in VIIj). A further six fisheries were subject to too few observer trips to conduct analyses, and only anecdotal information is given (see IV.3.9)

Most reported skate landings were from otter trawlers in the Bristol Channel (VIIf), western English Channel (VIle) and Irish Sea (VIIa) where there were also sufficient data to examine seasonal patterns in the skates retained (see Table XIII and Table XIV).

Many skates have patchy distributions. Indeed, within a single ICES Division, one species can predominate at a particular locale and even account for up to 100% of the skates caught/retained, with another species predominant elsewhere in the Division. Nevertheless, the following should provide preliminary estimates of the skate compositions on a regional basis.

IV.3.3 Southern North Sea (IVc) and eastern English Channel (VIId)

The southern North Sea is an important fishing ground for skates and they are caught primarily in trawl and gillnet fisheries (although there are also inshore longline fisheries, which may be under-represented in official landing statistics). *R. clavata* was clearly the main species retained by the gillnet fishery (with skates retained in 22 of the 30 observed trips), accounting for >99% of the retained skate biomass (Table 3). Other species, such as *A. radiata* and *R. brachyura* were caught and retained occasionally. *R. clavata* was also the main species taken by otter trawlers (97% of the total retained biomass observed across 27 trips), with *R. brachyura* and *R. montagui* of secondary importance. Despite the apparent low relative importance of *R. brachyura*, this species has a patchy distribution (Ellis *et al.*, 2005a) and can be seasonally/locally important, and could account for 16.7% of skate biomass in an individual trip.

Skates taken in UK fisheries in the eastern English Channel (VIId) were caught primarily by longline, otter trawl or gillnet. Skates retained by otter trawlers operating in the eastern English Channel (12 observer trips) landed two main species, *R. undulata* (44%) and *R. clavata* (36%) (Table XIII). A further three species, *R. montagui*, *R. brachyura* and *R. microocellata* were of secondary importance (ca. 9%, 8% and 2%, respectively). These

preliminary estimates were based on only 12 trips and so further studies on this fleet are required.

Data were more limited for the gillnet fishery in this Division (10 trips, 7 of which landed skates), with *R. clavata* (11%) and *R. brachyura* (88%) the main species taken (Table XIII), and further studies to examine these fisheries are required. UK beam trawl catches in IVc and VIId were of lesser importance in terms of the proportion (in weight) of UK skate landings, although data from seven trips in IVc where skates were caught continued to indicate the preponderance of *R. clavata* (68.5%) and the secondary importance of *R. montagui* and *R. brachyura* (18% and 13%, respectively, Table XIII). These three species were also the three main species taken in beam trawl fisheries in VIId (13 trips containing skates), with smaller amounts of *R. microocellata* (<1%) and *R. undulata* (3%) also taken.

IV.3.4 Western English Channel (VIle)

The fisheries landing the greatest proportion of UK skate landings in the western English Channel were otter trawlers and gillnetters, although there is also an important beam trawl fleet operating in this Division.

The otter trawl fleet operating in the western English Channel was the best-studied Division/gear combination (213 observer trips caught skates, of which 177 landed skates). Overall, the main species retained were *R. clavata* (31%), *L. naevus* (28%), *R. montagui* (16%) and *R. brachyura* (12%), with another four species (*R. microocellata*, *R. undulata*, *L. fullonica* and *D. batis*) also taken (Table XIII).

R. clavata were frequently retained across trips, occurring in 36-45% of trips during the year (Table XV). This species could account for up to 65.8% (Q3) of retained skates (Table XIV), but was less important at other times of the year (e.g. accounting for about 7% of retained skates in Q1). *R. montagui* also occurred frequently (30–56% of trips), and seasonally this species accounted for 7–25% of the retained skate biomass, with the highest proportional biomass taken in Q1 and Q2. Although *R. brachyura* was observed less frequently, occurring in 20–33% of trips, this large-bodied species accounted for 6–21% of the retained skate biomass. *L. naevus* occurred in 11-12% of trips in Q1 and Q4, but more frequently in Q2 and Q3 (25–33%). The proportion of the retained biomass ranged from 10–36%.

With regard to the other four species taken, *D. batis* and *L. fullonica* were only caught occasionally (recorded in <4% of trips). *R. microocellata* was infrequently reported in Q2 (13% of trips), although it was observed in 20–28% of trips at other times of the year. *R. undulata* was infrequently seen in Q1 and Q2, but occurred in 28–40% of trips during Q3 and Q4. These two species accounted for about 4.5–6.6% of the retained skate biomass.

Six species were observed in gillnet catches from VIIe (Table XIII), and *D. batis* comprised the highest proportion of the retained skate biomass (>50%), although this was due to two trips where it accounted for 95.5 and 100% of the total biomass, and this species was only observed in 9% of trips. The most commonly observed skates in this fishery were *L. naevus* (73% of trips), *R. brachyura* (36%), *R. montagui* (27%) and *L. fullonica* (23%) (Table XV), with *L. naevus* and *R. brachyura* comprising major proportions of the retained skate biomass (Table XIII).

Extensive data were also available for beam trawl fisheries in VIIe, with 81 trips containing skates. Eight skate species were observed (Table XIII), with only one species (*L. fullonica*, 2%) of minor importance. The remaining species accounted for 6.6–37.6% of skates retained.

IV.3.5 Bristol Channel (VIIIf)

The Bristol Channel otter trawl fishery is the single largest UK skate fishery (where skates are targeted at some times of the year) and accounted for approximately 18% of reported UK skate landings (Table XII), with relatively important gillnet fisheries also operating in this Division.

The three species most frequently caught and retained by otter trawlers were *R. microocellata*, *R. brachyura* and *R. clavata*, accounting for approximately 39.5%, 27% and 27%, respectively of the retained skate biomass (47 trips, 30 of which contained skates). *R. montagui* was of lesser importance, and *L. naevus* and, and *L. fullonica* were caught and/or retained only occasionally (<1% retained skate biomass).

Otter trawl catches in the Bristol Channel showed some seasonality in the species composition, although it should be noted that there were fewer trips in Q4 (Table XIV). *R. microocellata* was the major species in Q1-3 (35–47% of the retained skate catch), and was of lesser importance in Q4 (Table XIV). In contrast, *R. brachyura* was proportionally more important in Q3 and Q4 (36–37% of the retained skate biomass) than in preceding times of the year.

Five species were observed in Bristol Channel gillnet fisheries, although data were limited (nine trips contained skates). *R. brachyura* comprised 68% of the overall retained skate biomass, with *L. naevus* and *R. montagui* of lesser importance (15% and 14%, respectively), with *R. microocellata* and *L. fullonica* of low importance. These trips were all off the Cornish peninsula, so explaining the absence of *R. clavata*.

Twelve observer trips on beam trawlers were also conducted, and of the six skate species observed, the main species were *R. brachyura* (48%), *R. montagui* (16%), *L. naevus* (16%), *R. microocellata* (14%) and *R. clavata* (5%), with *L. fullonica* of minor importance.

IV.3.6 South-western Approaches (VIIg-j)

Important skates landings from this area include otter trawl catches from VIIg,j, gillnet catches from VIIg,h and beam trawl catches from VIIh,j. Although no data were available for beam trawl catches in VIIj, data were available for beam trawl catches in VIIg-h.

Beam trawlers operating in VIIh retained eight species, which were mainly *L. naevus*, *D. batis* and *L. fullonica* (ca. 65%, 19.5%, 14% of the total retained skates, respectively). *R. montagui*, *R. clavata*, *R. brachyura*, *L. circularis* and *R. microocellata* were generally of minor importance (Table XIII). Although these eight species were also observed in VIIg beam trawl catches, there were contrasting patterns, with *R. clavata*, *R. microocellata* and *R. brachyura* the main species (34%, 22% and 17% of the retained skate biomass) taken in VIIg. Data on otter trawl catches in VIIg,j were limited, but broadly corresponded with observations from beam trawl catches.

Six species were observed in gillnet fisheries in VIIg, although only 10 trips reported skates. The species that accounted for most of the retained biomass were *L. naevus*, *D. batis*, *R. montagui* and *R. brachyura* (37%, 28%, 18% and 10%, respectively). *D. batis* was retained in 70% of trips. There were too few data regarding the skates taken in gillnet fisheries in VIIj.

IV.3.7 Irish Sea (VIIa)

The Irish Sea otter trawl fishery is one of the main UK skate fisheries, accounting for approximately 8.4% of UK skate landings. Otter trawlers in the Irish Sea retained mainly four species: *R. clavata*, *R. brachyura*, *R. montagui* and *L. naevus* (ca. 40%, 31%, 19.5% and 8%, respectively of the total retained skate biomass). *Dipturus batis*, *L. fullonica*, *R. microocellata* and *R. undulata* were of minor importance.

Data for beam trawl and *Nephrops* trawl fisheries were also available for VIIa. Although data were limited for the former (five trips reported skates) (Table XIII) this confirmed the regional importance of the four main species. Beam trawl fisheries took a slightly greater proportion of *R. montagui* and *L. naevus* (25% and 16%, respectively) than otter trawlers, with a slightly decreased proportion of *R. clavata* and *R. brachyura*, which could be related to a more offshore distribution of the beam trawl fleet and/or gear selectivity. The main *Nephrops* grounds in VIIa are south-west of the Isle of Man and off Cumbria, and the same four species were all recorded, with *R. clavata* accounting for nearly 90% of the retained skate biomass.

IV.3.8 Central North Sea (IVb)

Skates are also taken in the central North Sea (IVb) including otter trawl, *Nephrops* trawl and gillnet fisheries. Available data for the central North Sea were mostly for otter and *Nephrops* trawl, and data were limited for beam trawlers and gillnetters (Table XIII).

Across all observer trips on otter trawlers (57 trips containing skates), *R. montagui* accounted for the greatest proportion of retained skate biomass (66%), with *R. clavata* of lesser importance (20.5%). *A. radiata*, *R. brachyura*, *L. naevus* and *D. batis* were also taken.

In IVb *Nephrops* fisheries, the most commonly retained species were *L. naevus*, *R. brachyura* and *R. clavata*, comprising 37%, 25% and 25% of the retained skate biomass, respectively. Although, *R. montagui* were frequently present throughout trips (41.3%), the biomass retained was less than 11%.

IV.3.9 Other fisheries

Observer data were too limited for detailed analysis for six of the fisheries, although brief descriptions are given below. Otter trawl fisheries in VIIj recorded three species (*D. batis*, *D. nidarosiensis* and *L. fullonica*), although it should be noted that there might be some confusion between *D. nidarosiensis* and *D. oxyrinchus*, as these species are morphologically similar. Otter trawl fisheries in VIIg were comprised mostly of inshore species, dominated by *R. microocellata* (34.5%), *R. clavata* (33%) and *R. brachyura* (28%), and with smaller quantities of *R. montagui* and *L. naevus* (6.0 and 0.9%, respectively). However, due to the aggregating nature of skates, four species (*R. microocellata*, *R. clavata*, *R. brachyura* and *R. montagui*) could comprise >50% of the skates retained in any one haul. These four species also occurred in otter trawl fisheries in VIa.

Data for the skate catches in some of the regional gillnet fisheries were limited (Table XIII), although it can be noted that small numbers of *L. naevus* and *R. montagui* were landed from gillnet fisheries in IVb, and *L. naevus* and *D. batis* were landed in VIIh. Data from gillnet catches in VIb were extremely limited, with *D. nidarosiensis* the only species caught, but all were discarded.

IV.4 Discussion

To date, one of the major problems for the assessment and management of skates is that landings data have usually been collected for all species combined (Fahy, 1988, 1989; Dulvy *et al.*, 2000; Machado *et al.*, 2004; Figueiredo *et al.*, 2007; Ellis *et al.*, 2008). Although some species may be landed separately in some fisheries, they have often been

landed according to ease of processing and size, and so species with similar morphological characteristics have often been combined (Fahy, 1988, 1989). This is slowly changing, with 2008 TAC and quota regulations for Rajidae in EC waters of IIa and IV requiring that “*Catches of cuckoo ray, thornback ray, blonde ray, spotted ray, starry ray and common skate shall be reported separately*” (EC Regulation No. 40/2008).

There have been several studies of the commercially landed species composition of skates caught in northern Europe (e.g. Gallagher *et al.*, 2005). Under the Data Collection Regulations, more structured market sampling of skates has been undertaken by national laboratories since 2001, although targets were not fleet-based until January 2008.

Species composition information data by area are available from scientific surveys (e.g. see section 18.4 of ICES (2007) and references cited there in), but such data only inform on that section of the skate community sampled by that gear, and are not necessarily indicative of the species composition that would be taken or landed by commercial fleets. In contrast, data from observers on commercial vessels allow for the species composition of retained skates to be estimated for a variety of commercial gears. Such data should not be viewed as totally accurate (e.g. fishing patterns can have high spatial and temporal variability due to economic, environmental and biological factors, and fisher behaviour may be different when observers are onboard (Catchpole *et al.*, 2005)). and so there is still an urgent requirement for skate landings to be recorded by species. Furthermore, observers will often sub-sample large catches, and the use of raising factors for ‘rare’ species encountered in sub-samples could over-estimate the numbers being taken.

Hence, the data presented should here be viewed as approximate estimates of the species composition in the main fisheries. These estimates are based on aggregated data, and it is important to note that skates have an aggregating nature, and so individual hauls/trips can have very different catch compositions.

Previous studies on skate distributions have been based only on fishery-independent groundfish surveys (e.g. Ellis *et al.*, 2005a), although such data are useful when accurate commercial data are unavailable, discards data allow for a broad spatial and temporal coverage to be considered (Borges *et al.*, 2005). The results obtained in this study are in agreement with earlier studies (e.g. Ellis *et al.*, 2005a) with regards a higher diversity of skates in the south-western waters of the British Isles than in the southern and central North Sea. Data for the northern North Sea were too limited to draw firm conclusions regarding the current skate diversity in this region.

R. clavata was one of the main skate species taken in ICES Divisions IVc, VIIa,d,f, and this species is widely distributed in UK shelf seas (e.g. Ellis *et al.*, 2005a). A similar

geographical distribution occurred for *R. montagui*, although this species tends to be taken slightly further offshore (e.g. it was more one of the main species in the central North Sea (IVb), but proportionally less common in the southern North Sea. *L. naevus* was the one of the main species taken in the western English Channel and Celtic Sea (VIIe,g-h), and also in parts of the Irish Sea. Although *R. brachyura* also had a wide geographical distribution, this species tends to have a patchy distribution, and so the species composition in various ICES Divisions could be quite variable. For example, it accounted for ca. 8% of the skates retained by otter trawlers in VIId, but was one of the main species taken in gillnet catches (88%, but based on few trips).

Many other skates had more restricted distributions, with *R. microocellata* taken primarily in VIIf-g, with low numbers in VIId-e, and *R. undulata* was only taken in appreciable quantities in VIId-e. Further offshore, both *L. fullonica* and *D. batis* were taken in the south-western areas, and further studies to better ascertain their status in the northern North Sea are required. There were few records of *L. circularis*, and some of those records may have been due to confusion with *R. microocellata* (both being known locally as sandy ray).

The present study also highlights the need for better education and identification material if species-specific data on skates are to be collected. Although discard observers are trained in species identification, there are potential identification problems between *A. radiata* and *R. clavata*, *R. montagui* and *R. brachyura*, and members of the genus *Dipturus* spp. The absence of long-nose skate *D. oxyrinchus* may have been due to mis-identification with *D. nidarosiensis*. Different skate species having the same common names in various regions may also exacerbate identification problems.

Most of the data collected to date have been based on trawl catches, and data from gillnets and longlines were much more restricted. Given that these latter gears may often be used to target skates seasonally and locally, this could lead to a bias perception of the species composition in these analyses as these gears are more selective (and have fewer discards), and have traditionally been a lower priority for discard sampling (c.f. trawl fisheries), although further data collection for these vessels should be encouraged if managers are to have a better understanding of the spatial and temporal dynamics of skate fisheries.

Tables and Figures

Species	Acronyms	n	Length range	Length-weight relationship	r-sq
<i>Amblyraja radiata</i>	SYR	453	8–49 cm	$W = 0.0105.L^{2.9374}$	0.963
<i>Dipturus batis</i>	SKT	61	20–156 cm	$W = 0.0024.L^{3.2318}$	0.994
<i>Leucoraja fullonica</i>	SHR	118	14–101 cm	$W = 0.0044.L^{3.0286}$	0.948
<i>Leucoraja naevus</i>	CUR	1098	10–69 cm	$W = 0.0038.L^{3.1284}$	0.993
<i>Raja brachyura</i>	BLR	420	12–102 cm	$W = 0.0025.L^{3.2764}$	0.995
<i>Raja clavata</i>	THR	4096	10–98 cm	$W = 0.0042.L^{3.1093}$	0.992
<i>Raja microocellata</i>	PTR	1015	12–83 cm	$W = 0.0031.L^{3.2039}$	0.995
<i>Raja montagui</i>	SDR	2209	10–74 cm	$W = 0.0037.L^{3.1456}$	0.991
<i>Raja undulata</i>	UNR	69	15–81 cm	$W = 0.0053.L^{3.0611}$	0.961

Table XI - Relationships between total weight (W) and total length (L) for nine skate species

ICES Division	Gear group	% Mean annual landings	Cumulative percentage	Amount of observer data for trips where skates were caught (either discarded or retained)	
				Trips	Hauls
VII f	Otter trawl	17.9	17.9	47	245
VII e	Otter trawl	8.6	26.5	213	491
VII a	Otter trawl	8.4	34.9	30	231
VII j	Otter trawl	6.6	41.6	3	7
IV c	Otter trawl	4.1	45.7	31	189
VII g	Otter trawl	3.6	49.3	6	19
VI b	Gillnet	3.5	52.8	1	3
VII d	Lines	3.4	56.2	-	-
IV b	Gillnet	3.1	59.2	3	7
VII h	Gillnet	2.3	61.6	2	6
IV c	Gillnet	2.3	63.9	30	110
VII e	Gillnet	2.2	66.1	22	65
VII d	Otter trawl	2.0	68.2	12	48
VII h	Beam trawl	1.8	70.0	44	704
IV b	Otter trawl	1.8	71.8	74	291
VII j	Beam trawl	1.7	73.5	-	-
VII g	Gillnet	1.6	75.1	11	39
VII f	Gillnet	1.5	76.6	10	28
IV b	Nephrops trawl	1.3	77.9	117	231
VI a	Otter trawl	1.3	79.2	2	12
VII d	Gillnet	1.3	80.5	10	33

Table XII - Major landings of skates by UK-registered vessels (2002–2007 inclusive) by gear and area (note: some regional, inshore line and net fisheries may be under-represented in official landing statistics).

ICES Div.	Gear	N	% total biomass retained											
			BLR	THR	PTR	SDR	UNR	CUR	SHR	SAR	SKT	RNS	SYR	SKA
IVa	Longline	1	Only <i>Leucoraja fullonica</i> observed											
	<i>Nephrops</i> trawl	1	Only <i>Dipturus batis</i> observed											
	Otter trawl	1	Only <i>Leucoraja naevus</i> observed											
IVb	Beam trawl	4	1.4	7.0	-	91.6	-	-	-	-	-	-	-	-
	Gillnet	2	Specimens of <i>Leucoraja naevus</i> and <i>Raja montagui</i> observed											
	Longline	1	Only <i>Raja montagui</i> observed											
	<i>Nephrops</i> trawl	63	25.4	25.1	-	10.2	-	36.8	-	-	-	-	2.5	-
IVc	Otter trawl	57	3.5	20.5	-	65.6	-	7.7	-	-	0.1	-	2.8	-
	Beam trawl	7	13.1	68.5	-	18.4	-	-	-	-	-	-	-	-
	Gillnet	22	0.03	99.6	-	-	-	-	-	-	-	-	0.3	-
	Longline	2	Specimens of <i>Raja brachyura</i> , <i>Raja clavata</i> and <i>Raja montagui</i>											
VIa	Otter trawl	27	2.3	97.0	-	0.6	-	-	-	-	-	-	0.1	-
	Longline	1	Only <i>Dipturus nidarosiensis</i> observed											
	<i>Nephrops</i> trawl	1	Specimens of <i>Raja brachyura</i> , <i>Raja montagui</i> and <i>Dipturus batis</i>											
VIIa	Otter trawl	2	Specimens of <i>Raja brachyura</i> , <i>Leucoraja naevus</i> , <i>Raja montagui</i> and <i>Raja clavata</i>											
	Beam trawl	5	24.1	34.9	-	25.2	-	15.8	-	-	-	-	-	-
	<i>Nephrops</i> trawl	24	0.8	89.8	-	2.1	-	7.4	-	-	-	-	-	-
	Otter trawl	30	30.6	39.9	0.1	19.5	0.01	8.3	0.04	-	1.6	-	-	-
VIIc	Otter trawl	2	Specimens of <i>Dipturus batis</i> and <i>Raja clavata</i> observed											
VIId	Beam trawl	13	31.0	61.7	0.6	3.8	2.9	-	-	-	-	-	-	-
	Gillnet	7	88.1	10.9	-	1.0	-	-	-	-	-	-	-	-
	Otter trawl	12	8.3	36.4	2.2	9.1	44.0	-	-	-	-	-	-	-
VIIe	Beam trawl	81	37.6	6.6	8.6	9.0	14.5	14.5	2.1	-	6.6	-	-	0.4
	Gillnet	22	10.0	-	0.2	1.5	-	27.6	6.1	-	54.5	-	-	-
	Otter trawl	177	12.3	31.2	4.5	15.6	6.6	28.3	0.4	-	1.2	-	-	-
VIIf	Beam trawl	12	48.3	5.3	14.0	16.2	-	16.0	0.1	-	-	-	-	-
	Gillnet	9	67.8	-	1.8	14.4	-	15.1	0.9	-	-	-	-	-
	Otter trawl	45	27.4	27.1	39.5	5.3	-	0.7	0.01	-	-	-	-	-
VIIg	Beam trawl	15	17.0	34.4	21.7	16.1	-	7.9	0.4	0.4	2.0	-	-	-
	Gillnet	10	9.6	2.9	-	18.2	-	37.3	3.8	-	28.2	-	-	-
	Otter trawl	6	28.4	32.8	34.5	3.0	-	1.0	-	-	-	-	-	0.3
VIIh	Beam trawl	43	0.04	0.2	0.1	1.1	-	65.3	13.7	0.1	19.5	-	-	-
VIIh-k	Gillnet	4	-	-	-	-	-	0.4	0.2	-	1.1	98.3	-	-
	Otter trawl	4	-	-	-	-	-	-	4.3	-	25.6	70.1	-	-

Table XIII - Species composition of retained skates (percentage of aggregated data) by ICES Division and gear.

Fishery	Period	N	% Biomass of retained skates									
			BLR	THR	PTR	SDR	UNR	CUR	SHR	SKT	SYR	SAR
IVb OT	Q1	20	3.7	64.0	-	17.8	-	3.3	-	0.2	11.1	-
	Q2	12	4.6	19.6	-	18.4	-	57.4	-	-	-	-
	Q3	17	3.3	5.1	-	87.1	-	4.4	-	-	0.1	-
	Q4	7	3.9	19.0	-	34.3	-	42.8	-	-	-	-
IVc OT	Q1	7	-	99.2	-	0.6	-	-	-	-	0.3	-
	Q2	9	-	100.0	-	-	-	-	-	-	-	-
	Q3	6	-	100.0	-	-	-	-	-	-	-	-
	Q4	5	3.4	95.9	-	0.7	-	-	-	-	-	-
VIIa OT	Q1	9	28.3	46.0	-	18.6	-	4.4	0.1	2.7	-	-
	Q2	12	39.6	35.7	-	11.7	-	11.4	0.1	1.5	-	-
	Q3	5	11.4	49.6	-	24.9	-	14.1	-	-	-	-
	Q4	4	40.0	21.3	0.4	28.9	0.04	9.3	-	-	-	-
VIIe OT	Q1	50	20.8	7.0	8.3	24.7	5.9	33.2	0.1	-	-	-
	Q2	32	15.3	25.2	2.8	24.7	1.1	23.9	-	7.0	-	-
	Q3	40	6.3	65.8	2.6	6.9	8.7	9.7	-	-	-	-
	Q4	55	8.4	32.6	3.6	10.4	8.1	35.8	0.9	0.3	-	-
VIIIf OT	Q1	11	19.5	31.2	41.2	7.4	-	0.6	-	-	-	-
	Q2	16	20.0	34.3	35.1	9.1	-	1.5	-	-	-	-
	Q3	12	35.9	15.6	46.7	1.5	-	0.3	0.02	-	-	-
	Q4	6	37.3	34.4	24.3	3.2	-	0.8	-	-	-	-
VIIh BT	Q1	13	0.04	0.2	-	0.2	-	80.2	12.0	7.5	-	0.1
	Q2	14	-	0.3	-	2.3	-	64.4	13.0	20.1	-	-
	Q3	9	0.1	0.2	-	0.4	-	47.1	15.1	36.7	-	0.3
	Q4	7	-	-	0.7	2.5	-	62.0	17.1	17.7	-	-

Table XIV - Quarterly species composition of retained skates (percentage of aggregated data) by ICES Division and gear (N = the number of trips in which skates were retained).

Fishery	Period	N	Presence/Retained across trips (%)									
			BLR	THR	PTR	SDR	UNR	CUR	SHR	SKT	SYR	SAR
IVb OT	Q1	20	30.0	65.0	-	80.0	-	30.0	-	5.0	10.0	-
	Q2	12	8.3	25.0	-	50.0	-	91.7	-	-	-	12
	Q3	17	23.5	41.2	-	47.1	-	70.6	-	-	5.9	-
	Q4	7	14.3	71.4	-	57.1	-	57.1	-	-	-	-
IVc OT	Q1	7	-	100.0	-	14.3	-	-	-	-	14.3	-
	Q2	9	-	100.0	-	-	-	-	-	-	-	-
	Q3	6	-	100.0	-	-	-	-	-	-	-	-
	Q4	5	60.0	100.0	-	60.0	-	-	-	-	-	-
VIIa OT	Q1	9	44.4	100.0	-	55.6	-	66.7	11.1	11.1	-	-
	Q2	12	41.7	100.0	-	33.3	-	33.3	8.3	8.3	-	-
	Q3	5	40.0	100.0	-	60.0	-	60.0	-	-	-	-
	Q4	4	50.0	100.0	25.0	50.0	25.0	50.0	-	-	-	-
VIIe OT	Q1	50	30.0	36.0	28.0	56.0	10.0	12.0	2.0	-	-	-
	Q2	32	25.0	43.8	12.5	50.0	6.3	25.0	-	3.1	-	-
	Q3	40	20.0	45.0	20.0	30.0	27.5	32.5	-	-	-	-
	Q4	55	32.7	41.8	25.5	41.8	40.0	10.9	3.6	1.8	-	-
VIIf OT	Q1	11	100.0	63.6	90.9	72.7	-	45.5	-	-	-	-
	Q2	16	81.3	75.0	93.8	87.5	-	62.5	-	-	-	-
	Q3	12	83.3	66.7	83.3	66.7	-	41.7	8.3	-	-	-
	Q4	6	66.7	66.7	83.3	66.7	-	66.7	-	-	-	-
VIIh BT	Q1	13	7.7	7.7	-	30.8	-	92.3	92.3	38.5	-	7.7
	Q2	14	-	21.4	-	42.9	-	85.7	85.7	85.7	-	-
	Q3	9	11.1	22.2	-	44.4	-	100.0	100.0	77.8	-	11.1
	Q4	7	-	-	14.3	71.4	-	100.0	85.7	28.6	-	-
Fishery	Period	N	Presence/Retained across trips (%)									
			BLR	THR	PTR	SDR	UNR	CUR	SHR	SKT	SYR	SAR
IVb NT	Annual	63	12.7	38.1	-	41.3	-	68.3	-	-	7.9	-
IVc GN	Annual	22	4.5	100.0	-	-	-	-	-	-	4.5	-
VIIId OT	Annual	12	33.3	83.3	16.7	66.7	50.0	-	-	-	-	-
VIIId GN	Annual	7	42.9	100.0	-	42.9	-	-	-	-	-	-
VIIe GN	Annual	22	36.4	-	4.5	27.3	-	72.7	22.7	9.1	-	-
VIIf GN	Annual	9	66.7	-	11.1	44.4	-	55.6	11.1	-	-	-
VIIg GN	Annual	10	30.0	20.0	-	40.0	-	40.0	40.0	70.0	-	-

Table XV – Annual (top) and Quarterly (bottom) percentage occurrence of retained skates by ICES Division and gear (N = the number of trips in which skates were retained).

V Conclusions

The present study focused on elasmobranchs fishes, which are known to be biologically vulnerable to overfishing. Many demersal elasmobranch species are taken as a bycatch in mixed demersal fisheries around UK, although there are seasonal and/or locally important target fisheries that may use trawl (e.g. skates in the Bristol Channel), gillnets (e.g. for various skates) and demersal longline (e.g. for spurdog *Squalus acanthias* and skates).

The spatial and temporal dynamics of elasmobranch stocks and fisheries in the Northeast Atlantic are not fully understood, which may restrict both stock assessment and management. Analysis of demersal longline fisheries around the British Isles was carried out due to its high selectivity for certain elasmobranch species. Results confirmed, as expected, the importance of elasmobranchs taken by longliners off the coasts of England and Wales. In terms of the main species taken spurdog and skates, as well as two large-bodied teleosts (cod and conger eel) where off high importance. Landings of these four taxa (1990-2007) were 21 000, 7 500, 16 500, and 3 900 t, respectively. The main fishing grounds for demersal-longliners (1990-2007) were the southern North Sea (IVc), Irish Sea (VIIa) and the central North Sea (IVb). Additionally, special focus was given to spurdog, due to the present bycatch quota of 5% in the ICES area. Results highlight that this bycatch quota will be restrictive for longliners throughout inshore English and Welsh waters. Although a problem in most areas seasonally, this measure will have the greatest affect in the Irish Sea, where landings of spurdog accounted from 26% to nearly 100% of longline catches. Overall, bycatch quotas in longline fisheries can be difficult for fishermen, as catches can depend on several factors, such as the area fished, and the other species that may be captured. Given the aggregating nature of spurdog, cod and skates, it could be hard for fishermen to determine when to discard/retain species subject to a bycatch quota when the lines are brought on board, and other measures (trip limits, size restrictions) may be more practicable for such fisheries. In recent years, the ICES Working Group on Elasmobranch Fishes (WGEF) had made progress in appraising the status of various demersal elasmobranchs (ICES, 2007b), and this had enabled ICES to provide advice to the EC on the status of the stocks. Nevertheless, the most utilised data in these studies have been those data collected during fishery-independent groundfish surveys, and there have been fewer studies on data from commercial fisheries. Given that discard observer trips collect potentially useful data on elasmobranchs, these data have been subject to more detailed analyses. Therefore, spatial distribution and length-sized selection patterns of the main species taken by commercial fisheries operating around the British Isles were examined, in order to, complement data from fishery-independent groundfish surveys (already summarised in Ellis *et al.*, 2005a,b).

Potential errors can appear in large databases, whether this is due to misidentification or inputting errors. Hence, checking of the data quality is a critical stage that should be undertaken prior to analyses of such data. The most common errors observed were related to morphologically similar species, such as between lesser-spotted dogfish (*Scyliorhinus canicula*) and greater-spotted dogfish (*S. stellaris*), blonde and spotted ray (*Raja brachyura* and *R. montagui*), and thornback ray and starry rays (*R. clavata* and *Amblyraja radiata*). Other errors may be related to the use of regional common names for different species in some areas, as in the case of small-eyed ray (*R. microocellata*) which is sometimes referred to as 'sandy ray' in the Bristol Channel area, whereas scientists use sandy ray to refer to *Leucoraja circularis*. In order to check the quality of the data, the spatial distributions and length distributions of retained/discarded fish were examined to identify obvious outliers and to check and correct where appropriate. Similar to discards data, the quality of landings data has also restricted their utility in the assessment process, although the major problem comes from the reporting of aggregated species groups and the lack of species-specific data. This is most common for skates (Rajidae), which have traditionally been reported as 'skates and rays', and for deep-water sharks and spurdog, which can be reported as "dogfish sharks" or "dogfishes and hounds".

Stock assessments may be hampered and related to an inaccurate reality if these data are used without previous checking and filtering. Overall, these problems simply highlight the urgent need for improvements on education and availability of more user-friendly identification material to ensure the collection of accurate landings and discards data. Additionally, more robust data checks on fisheries data are undoubtedly required.

Results from the analyses of elasmobranch bycatch and discard/retention patterns showed that the Celtic Seas eco-region (ICES Division VIa, VIIa,b,e-j) is biologically more diverse than the North Sea eco-region (ICES Division IVa-c, VIId), with 39 species of elasmobranch recorded, although this does include some deep-water species along the edge of the continental shelf, and such habitats were less studied in the North Sea. The more frequently observed species in the Celtic Seas eco-region were *S. canicula*, *R. montagui*, *Mustelus* spp., *R. clavata*, *L. naevus*, *R. brachyura*, *R. microocellata* while in the North Sea eco-region *A. radiata*, *S. canicula*, *R. clavata*, *R. montagui* and *Mustelus* spp. were the more important species.

Regarding the length-based discard/retention patterns analyses, these showed that spurdog was usually retained, whilst other dogfishes (e.g. lesser-spotted dogfish and smoothhounds) were often discarded. The smallest individuals of these taxa were discarded, but there was no full retention of the larger fish. Hence, the retention patterns for those species were not only size-based but also dependent on other factors. This fact

is in agreement with the general view that discards can be a highly variable phenomenon, which may be influenced by the commercial value of the species, market demand, quota restrictions, state/quality of the fish, bycatch quotas and also by the presence of discard observers on board. Length-based retention patterns were better defined for skates, with discarding of smaller fish, near 100% retention of larger fish and the length at 50% retention ranging from 45.2 cm (in the case of *R. undulata*) to 54.8 cm (*D. batis*). Concerning the analysis of the species composition of skates around the British Isles, the results obtained in terms of spatial distribution were in agreement with earlier studies (e.g. Ellis *et al.*, 2005a). However, discards data were often too limited for gillnets and longlines (especially for the latter) as most of the observer trips are conducted on otter, beam and *Nephrops* trawlers. The paucity of these data might mislead the real spatial and temporal distribution of skates, thereby hampering fisheries management, and observer trips on more selective gears should still be encouraged. Therefore, this study provides a preliminary overview of the species captured by the main gears and main ICES Divisions, although further analyses should also be undertaken. Given that there is a move towards collecting species-specific data in some areas (e.g. the North Sea), the data presented in the current study will provide a valuable baseline with which to note any major dissimilarities in species composition.

Results showed a greater diversity of skate species taken in south-western areas (VIIg-j), with up to nine species, with several species locally and/or seasonally important (including *D. batis* and *L. fullonica*). Furthermore, some species may aggregate and be locally common in specific areas, this is the case for *R. microocellata* in the Bristol Channel (VIIIf) and *R. undulata* in the English Channel (VIIId-e). Important skate's fisheries are known to occur in the Irish Sea (VIIa) and in the Bristol Channel (VIIIf), retaining mainly *R. clavata*, *R. brachyura*, *R. montagui* and *Leucoraja naevus*, with *R. microocellata* also an important component of catches in VIIIf.

In conclusion, this study achieved its main aims in terms of providing an overview of the spatial and temporal dynamics of some of the commercial fisheries around the British Isles, with special focus on elasmobranchs fishes. Additionally, it is believed that this study will be useful and helpful in terms of facilitating more accurate stock assessments and robust species-specific management advice. This is the case for example for the Bristol Channel (VIIIf) as, according to ICES (2007b) the discards data for skates have not previously been examined. Nevertheless, future improvements should still be carried out in order to make improve the assessment, advisory and management process, especially through species-specific landings data, further data collection through discard observer programmes, and better training and identification material for those collecting such data.

Furthermore, in order for the utility of various management options to be evaluated, studies of discard survivorship for various species are required. As there have been studies mainly on the robust lesser-spotted dogfish, which has a high survivorship, and some preliminary studies on skates (which can have a high survival in some inshore fisheries, but lower survival in larger offshore trawlers).

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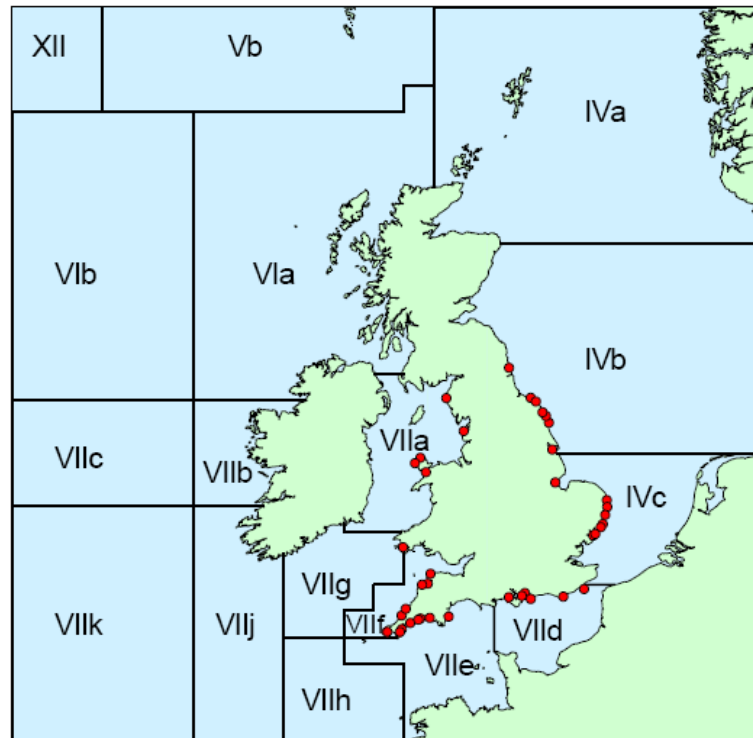
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Appendix I: ICES Divisions around the British Isles (top) and the main UK Ports for longliners (bottom)



Appendix II: Occurrence of chondrichthyan fishes around British Isles as observed in discard observer programmes.

