SR672 Ecological Risk Assessment of the effects of fishing for South West fisheries; ICES Divisions VII e,f,g & h ; Supporting information

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Ecological Risk Assessment of the effects of fishing for South West fisheries; ICES Divisions VII e,f,g & h

This document contains the supporting information prepared for the assessment. This consists of short reports describing fisheries interactions with the various ecological components; these were available to the members of the working group.

Information on marine teleost fish ecosystem component for Seafish Ecological risk assessment of South West fisheries; Oct 2013
Mike Pawson

The Marine Biological Association of the UK; Dec 2012
Seafish Ecological risk assessment of South West fisheries: Cephalopod ecosystem component
Isobel Bloor and Emma Jackson

CEFAS
Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem; July 2013

Component 1; Commercial Crustacea; crabs, lobsters, crawfish and spider crabs
Ewen Bell

Component 2; Commercial molluscs; scallops, oysters, mussels, whelks and squid
Dave Palmer and Beatriz Roel

Component 3; Component 3: Additional advice on lampreys, elasmobranchs and endangered fish species
Jim Ellis, Alan Walker and Mike Pawson

Component 4; Fish community structure
Will Le Quesne

Component 5; Discarding in the south west
Tom Catchpole

Component 6; Ichthyo, Zoo and phytoplankton
Steve Milligan

Component 7; Benthic habitats and communities including mobile epifauna
Stefan Bolam

Component 8, 9 & 10: Benthic habitat, nursery and spawning areas and human activities relating to the area
Alexander Koch, Sara Pacitto

UK Cetaceans Strandings Investigation Programme; Oct 2012
Fisheries turtle interactions
Rod Penrose

Sea Mammal Research Unit; August 2013
Marine Mammal Ecosystem Component
Al Kingston, Sophie Smout & Simon Northridge

Institute of Estuarine and Coastal Studies, University of Hull; June 2013
Ecological Risk Assessment of South West fisheries – summary of knowledge on the seabird ecosystem component
Lucas Mander, S.M Thomson & N.D Cutts

Chelonia Ltd; Oct 2012
Cetaceans and South West fisheries
Nick Tregenza

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Information on marine teleost fish ecosystem component for Seafish Ecological risk assessment of South West fisheries.

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The purpose of this synopsis is to identify any issues attending teleost fish populations caught by fisheries operating out of Cornish and South Devon ports, specifically those found in the western English Channel, western Approaches and eastern Celtic Sea (ICES Divisions VIIe,f,g,h), the "Area". Information on the distribution and biology of each species in the Area, and any known influences of climate change, is provided in Annex 1.

For ease of reference, these species are categorized to the following groups, which imply a decreasing order of concern over the impacts of exploitation and commercial importance.

The main commercial species, for which there is an analytical assessment of stock status and corresponding robust management of exploitation (TAC, effort control): cod, hake, plaice, Dover sole, mackerel, scad,

Commercial species, for which there are indications of stock status and corresponding management of exploitation (TAC or technical measures**):** whiting, haddock, megrim, monkfish, sea bass, pollack, saithe.

Other commercial species managed by TAC and/or specific technical measures: ling, black bream, herring, sprat.

Species with indications of stock trends, but no specific management measures: pilchard, anchovy, John dory, red mullet.

Species with no information on stock trends or specific management measures: wrasse, conger eel, flounder, grey gurnard, red gurnard, grey mullet, lemon sole, turbot, brill and pout.

Species with species conservation status: salmon, sea trout, shad and European eel

The main commercial species, for which there is an analytical assessment of stock status and corresponding robust management of exploitation (TACs and effort control).

Cod (*Gadus morhua*). The cod stock in the western Channel, Bristol Channel and Celtic Sea (ICES Divs VIIe-k) is highly dependent on incoming recruitment, and the ICES assessment estimated the 2009 year class to be the strongest since 2000. The spawning stock biomass (SSB) is at full reproductive capacity and is expected to increase further in view of decreasing fishing mortality (F), though this remains above F_{MSY} (the exploitation level that maximises sustainable yield).
2013: Fishing mortality at F_{MSY} proxy

Climate warming appears to have resulted in a northwards shift in the production of cod in the North Sea, but this effect has not been observed in SW waters. This may be reflected in the absence of a long-term management plan for this cod stock (plans are in place for the North Sea and Skagerrak, Kattegat, Eastern Channel, West of Scotland and Irish Sea cod stocks).

Cod is a TAC species. The main determinants of cod stock status are fishing mortality and environmental conditions. Since 2005, an area off north Cornwall (the Trevose Box) has been closed to fishing in March to protect spawning cod when they aggregate and are most vulnerable. The industry reports that cod is much more abundant and is consistently caught over a wide area (previously confined to Bristol Channel), where is it an unavoidable by catch and there can be significant discarding. In this respect, the impossibility to predict strength of incoming recruitment (at age 1+) means that scientific advice is not responsive or up-to-date.

Whiting (*Merlangius merlangus*). The ICES assessment of the whiting stock in ICES Div VIIe-k is indicative of trends only and there are no stock status reference points. SSB is estimated to have increased recently due to the recruitment of the above average 2008 and 2009 year classes, following poor recruitment since 2001. Fishing mortality estimates are not well estimated due to a lack of discard data in the assessment. . **2013;** Full assessment whiting now at F_{MSY} and above MSYBtrigger

Whiting is a TAC species. Whiting are taken mainly as a by catch in mixed-species demersal trawl fisheries, where mesh sizes may retain a high proportion of small whiting and discard rates are high. Consequently, TACs based on landings do not control overall catches in many areas, and information on the stocks is so poor that reliable assessments cannot be made. ICES' advice is that catches should not be allowed to increase and technical measures to improve the selectivity of fishing gears should be introduced to reduce discard rates.

Haddock (*Melanogrammus aeglefinnus*). Haddock is a northern species that occurs in SW waters only when very large year classes "overspill" from the main spawning and nursery areas west of Scotland. The ICES assessment of haddock in the English Channel, Celtic Sea and west of Ireland (ICES Divs VIIb-k) is indicative of trends only, noting that the abundance of haddock is increasing due to recruitment of the large 2009 year class, but exploitation status is unknown. ICES' advice is that catches should not increase and technical measures implemented to reduce discarding of small haddock, which is felt to be a problem in this area. **2013;** F above F_{MSY} and Biomass decreasing although not below MSYBtrigger

Haddock is a TAC species. Haddock is caught predominantly as a by catch in demersal trawl fisheries, in which there is a risk of a mismatch between the allocated quota and the catch which the fishermen are taking. This can be countered by improving species selectivity and/or controlling fishing effort. Though haddock have not been a consideration in SW waters in this respect, the industry report that the haddock stock has increased considerably since 2006, and for the past 3 years has been caught all year round in many areas, when previously it was a winter fishery confined to hard ground. Bigger fish are available on the south Cornish coast and west of the Lizard, where larger meshes are being used throughout otter trawl nets to reduce discards which can be up to 20% of the haddock catch per vessel per trip.

Hake (*Merluccius merluccius*). Hake in the Area are part of the 'northern stock' (occupying ICES Division IIIa, Subareas IV, VI, and VII, and Divisions VIIIa,b,d), for which ICES revised its assessment methodology in 2011 This is thought to have improved the quality of the assessment, but there are still uncertainties in estimates of SSB and F relative to reference points and ICES is not yet confident that reference points for the fishery are consistent with the MSY approach. Several high recruitments have enabled the SSB to increase since 1998 and it was estimated to be at a record high in 2011. Though F has been decreasing in recent years, it is estimated to be still above F_{MSY}. **2013** Assessment; F at F_{MSY}

Hake is a TAC species. The three main gear types used by vessels fishing for hake as a target species are lines, fixed-nets and otter-trawls. Hake are caught throughout the year, the peak landings being made in the summer months. By-catches of mainly juvenile hake in the *Nephrops* fisheries of northern Biscay are a key management issue, which was addressed by an EU emergency plan in 2001/2 through mesh size restrictions in specific areas off SW Ireland and in the Bay of Biscay (though not affecting SW English fisheries). A recovery plan for northern hake was agreed by the EU in 2004, which includes catch and fishing effort controls, and the stock has recovered substantially.

Plaice (*Pleuronectes platessa*). There are two plaice stocks in the Area. The ICES assessment for plaice in Division VIIe (western English Channel) indicates that the SSB has increased to above $B_{MSY\text{-}trigger}$ in the last two years due to recruitment of the strong 2008 year class. However, F is well above F_{MSY}. **2013;** Status is the same. Also similar trends in ICES VIId.

The ICES assessment for plaice in Divs VIIf-g (Bristol Channel and eastern Celtic Sea), is indicative of trends only (uncertainty due, in part, to the high rate of discarding) and reference points are not defined. SSB has increased to a stable level since reaching an historic low in 2004. F shows a declining trend since 2002, but is considered to be above F_{MSY}. **2013** Data limited advice SSB increasing fishing mortality remains uncertain. ICES advice for both stocks is that catches should be reduced and technical measures introduced to reduce discarding.

Plaice is a TAC species. Landings of plaice in the Area increased rapidly the 1970s until the late 1980s as beam-trawls began to replace otter-trawls and fishing effort in the UK and Belgian beam-trawl fleets increased. Landings declined throughout the 1990s. The management of plaice is closely linked with sole. When the primary target is sole, beam trawlers are permitted to use cod-end mesh sizes of 80 mm, whereas a much larger mesh size would be more suitable for plaice because of its wider body shape. This leads to discarding of undersized and less marketable small plaice, which constitute the most abundant group in inshore areas. Conservation of plaice stocks is aided by the restriction to a maximum aggregate beam length of 9 m and a maximum power of 221 kW for beam trawlers fishing within the 12-mile limits of UK waters, and an increase in beam trawling above 1998 levels is not allowed in these areas.

Dover sole (*Solea solea*). ICES' assesses two sole stocks in the Western English Channel (ICES Div. VIIe) and in the eastern Celtic Sea and Bristol Channel (ICES Divs VIIf & VIIg). In VIIe, recruitment has been fluctuating around average, and SSB is near the lowest observed values in the time series. F was above F_{MSY} until 2009, when there was a significant reduction to below F_{MSY}. . **2013;** SSB above MSY Btrigger, F close to F_{MSY}

In VIIf,g recent recruitment has been largely stable and the SSB has been above $B_{MSY\text{-}trigger}$ since 2001. F in VIIf,g has decreased to the lowest level in the time series and is now below F_{MSY}. **2013;** SSB still above MSYBtrigger, but F above Fpa; reduce catch to achieve F_{MSY}.

Sole is a TAC species. Sole are an important target species for beam-trawls (and to lesser extent otter-trawls) in the western English Channel and Celtic Sea, where fishing effort in the beam-trawl fleets increased in the late 1980s, reaching a peak in 1990 and decreased thereafter.

Whilst discarding of undersized sole (<24 cm) is generally low, as their body shape and flexibility allow the smaller fish to escape from the minimum mesh size used for most gears targeting sole (>80 mm), large numbers of undersize plaice are caught in some fisheries, which can result in very high discard rates. However, an increase in mesh size to reduce the by catch of undersized plaice would result in a significant reduction in the catch of marketable sole.

There is a management plan for the sole fisheries in the western English Channel, intended to reduce the fishing mortality on this stock through effort restrictions and gradual year-on-year reductions in TACs. Ultimately, the plans aim to achieve larger and more stable stocks and catches, and more profitable fisheries fished at MSY.

Mackerel (*Scomber scombrus*). In 2011, ICES estimated that the SSB of the NE Atlantic mackerel stock had more than doubled between 2002 and 2009 (the 2005 and 2006 year classes are the highest on record), and is currently at 2.9 mt, well above the precautionary level (B_{MSY} trigger = 2.2 million t). F was high during the 1990s, then declined and has been relatively stable since 2006, and in 2010 was just above F_{MSY} (0.22). **2013**; Stock now data limited, SSB improving fishing mortality uncertain

Mackerel is a TAC species. There have been substantial levels of discarding or "slipping" (release of catch prior to landing on deck) of mackerel caught in purse seines or trawls due to size or species composition not being suited to market needs, and it is known that few fish survive this experience. From January 2010, high-grading, discarding and slipping from pelagic fisheries targeting mackerel, horse mackerel, and herring have been banned by contracting parties to the Coastal States/NEAFC agreements on mackerel (arranged between the EU, Norway and the Faeroe Islands).

A more recent development has been the rapid expansion in the previously insignificant fisheries for mackerel in Icelandic and Faeroese waters since 2006, where quotas have been unilaterally declared that are outside the Coastal States/NEAFC agreements. No agreement on the management of the mackerel stock was reached in 2010 and 2011, with the result that all the parties declared their own quotas and there was no formal TAC for any area. The consequence is that fishing mortality in 2011 was well above that recommended by the management plan, which ICES would regard as unsustainable

Juvenile mackerel are protected within the 'mackerel box' off the Cornish coast and in the South Western Approaches, in which there is a ban on targeted fishing for mackerel by trawlers and purse seiners and where a handline fishery operates with a separate quota allocation.

Scad (*Trachurus trachurus* – horse mackerel). For stock assessment and management purposes, the Western spawning group is assumed to be separate from scad in the North Sea and Southern areas, though the Channel is an important area for juvenile scad, and provides a migratory route for both Western and North Sea spawning groups. SSB has been decreasing as recruitment has recently been low, and was estimated to be 1.85 million t in 2011, around the long-term mean. F has been increasing since 2006 and is now at F_{MSY}, so ICES considers that the stock is being fished sustainably. **2013;** F now above FMSY and SSB uncertain

Scad is a TAC species. Other than direct fishing mortality, there appear to be no detrimental impacts on the scad population in the Area. A management plan has been used since 2008 to set the EU TAC, though ICES found it to be precautionary only in the short term, and has not formally adopted it as a basis for advice. There are no specific technical measures for this species

Commercial species, for which there are indications of stock status and corresponding management of exploitation.

Megrim (*L. whiffiagonis*) and **four-spot megrim** (*L. boscii*). No analytical assessment has been carried out for megrim in the Area since 2006, when ICES decided that the available data are insufficient to provide a reliable age-structured analytic assessment of this stock. Consequently, it has not been possible to quantify SSB, F or recruitment, and data quality decreased further in 2009 and 2010. **2013;** Data limited stock approach gives a reduction of 20% for 2013 at 12,000 tonnes, and the same catch for 2014

Nevertheless, ICES used discard data and commercial and survey indices to conclude in 2011 that the stock appears stable at the present level of fishing. In each year, TACs are set that included a 5% contribution for four-spot megrim *L. boscii* in the landings, for which there never has been an assessment.

Megrim is a TAC species. Most UK landings of megrim are made by beam trawlers and, other than direct fishing mortality, there appear to be no detrimental impacts on the megrim population in the Area. The MLS of megrim was reduced from 25 to 20 cm length in 2000, to match the selection pattern of the gear. As a consequence, there is high-grading and substantial discarding of smaller megrim above 20 cm in some fisheries.

Sea bass (*Dicentrarchus labrax*). ICES considers that bass stocks around SW England have been exploited sustainably, at a moderate level of F and with an exploitation pattern that gives a near maximum yield per recruit, and above-average recruitment during the mid to late 1990s has led to an increase in exploitable biomass since the early 1990s. Though there is no assessment available beyond 2008, ICES reports that overall landings have been stable since 2005. The industry reports that there are encouraging signs of incoming year classes in the Area. **. 2013**; Data limited assessment; SSB now decreasing Fishing Mortality increasing probably above F_{MSY}.

Sea bass fisheries are regulated by a package of technical measures introduced in England and Wales in 1990 to protect the vulnerable juveniles. It is illegal to land bass <36 cm long, mesh sizes of 65–90 mm are banned in fixed nets, and fishing for bass from boats is prohibited in 34 inshore designated nursery areas in England and Wales, 11 of which are in south Devon and Cornwall. Although there are no direct effort or catch (TAC) restrictions on the international sea bass fishery, national regulations limit bass landings by French and UK pelagic trawlers fishing in the Channel to 5 t per boat per week or 15 t per month for the period 1 January to 30 April.

Monkfish (*Lophius piscatorious* **-** white anglerfish**)** and (*L. budegassa* **-** black anglerfish). There has been no accepted ICES assessment for either *L. piscatorius* or *L. budegassa* in Divisions VIIb–k and VIIIa,b,d, since 2007, and it has not been possible to quantify SSB, F or recruitment for either species. Consequently, the state of the stocks is not known, though ICES suggested that the biomass of *L. piscatorius* has been increasing as a consequence of good recruitment since 2001, and the industry that considers anglerfish stocks to be in good health. **2013; Data limited assessment** F unknown for both stocks but biomass trending upward

Anglerfish are TAC species. The UK currently takes around 10% of the total landings of both anglerfish species combined, chiefly by beam trawlers and tangle netters. Co-incident with the recent increased recruitment, an increasing proportion of small anglerfish is being caught and discarded, which has resulted in uncertainties in recent levels of catch. There is no minimum landing size for anglerfish, but an EU minimum marketing weight of 500 g. Since 1st February 2006, there has been a ban on gillnets set at depth greater than 200m along the shelf edge in Divisions VIa,b and VIIb,c,j,k. The industry reports that seal predation can be very severe in some areas

Pollack (*Pollachius pollachius*). There is no assessment of the status of the exploited population of pollack in the western Channel and Western Approaches. Pollack is a TAC species. Pollack are targeted by set nets, though the industry reports that more boats are hand lining on wrecks and catching smaller fish, and that seal damage is a problem. Other than direct fishing mortality, there appear to be no detrimental impacts on the pollack population and there are no specific technical measures for this species . **2013** assessment data limited approach advises a TAC of <4200 tonnes for 2013 and 2014. EU TAC was 13,495 t for Area VII, in 2012. Official landings 4432 t in 2012

Saithe (*Pollachius virens*). Saithe is a northern species that is less common in the area than the other gadoids dealt with here. The most relevant stock assessment is for saithe to the north of the Area, covering the North Sea, Skagerrak and west of Scotland. SSB has been above Bpa since 1997 but recruitment has been below average since 2006 and SSB has declined towards Bpa. Fishing mortality has fluctuated around F_{MSY} since 1997. Saithe is a TAC species. Other than direct fishing mortality, there appear to be no detrimental impacts on the saithe population in the Area and there are no specific technical measures for this species. **2013;** Fishing mortality has generally increased since 2004 and is currently around F_{MSY}. SSB just below MSYBtrigger

Other commercial species managed by TAC and/or specific technical measures.

Ling (*Molva molva*). There is no information on stock status of ling in the western Channel and eastern Celtic Sea, though it is A TAC species. Other than direct fishing mortality, there appear to be no detrimental impacts on the ling population in the Area and there are no specific technical measures for this species. 2013 & 2014 Data limited advice; 20% reduction in catches

Black bream (*Spondyliosoma cantharus*). There is no formal stock assessment for black bream in the English Channel and the status of exploited stock is not known**.** Although stocks in the English

Channel were heavily fished in the 1970s and 1980s, they have recovered in recent years and currently appear to be in a healthy state.

Because black bream are sequential hermaphrodites and the males create nests and guard eggs on the sea bed, the stock requires a balanced age structure and an appropriate sex ratio to reproduce successfully. There is no EU MLS for black bream, though Sussex SFC has mesh regulations and closed areas for the spawning season and Cornwall prohibits landing of sea bream below 23 cm, which effectively protects female bream and gives them a chance to spawn.

Atlantic herring (*Clupea harengus*). The present status of the small spawning groups of herring in the Area is unknown and they have remained largely unfished in recent years. Nevertheless, herring is a TAC species. Other than pollution and habitat destruction in inshore spawning sites (usually small estuary mouths), there appear to be no detrimental impacts due to fishing on the herring populations in the Area. There are no specific technical measures for this species.

Sprat (*Sprattus sprattus*). Though the status of exploited stock is not known, sprat is a
TAC species. Other than direct fishing mortality, there appear to be no detrimental impacts on the sprat population in the Area. There are no specific technical measures for this species.**2013** Data limited advice SSB improving

Species with indications of stock trends, but no specific management measures

Red mullet (*Mullus surmuletus*). The abundance has increased sharply over the course of the 20th Century, particularly in the eastern English Channel and the southern North Sea. Red mullet is taken as a by catch in trawl fisheries, and may also be a target species for small-meshed trawls and gill nets. Other than direct fishing mortality, there appear to be no detrimental impacts on the red mullet populations in the Area. 2013; ICES data limited assessment reduction of catch (by 20%) to no more than 2000 tonnes

Pilchard (*Sardina pilchardus*). The abundance of pilchards in the Bay of Biscay is monitored annually by an Ifremer acoustic survey which, together with catch data, is being used by ICES in exploratory assessments that will be benchmarked in 2013.. 2013; data limited assessment for Bay of Biscay and area VII indicates F below possible reference points and biomass decreasing to close to long term average. Recommends a TAC of 27, 544 t for 2014

The present local fishery in the shallow waters of the bays close to the Cornish coast was revived in 1994 and involves ring-netters and drift-netters. Other than direct fishing mortality, there appear to be no detrimental impacts on the pilchard population in the Area.

Anchovy (*Engraulis encrasicolus*). Although time series of data on anchovy in the Area are insufficient to identify abundance trends, the population in the northern areas appear to have increased in recent years. The main population nucleus is in the Bay of Biscay, and data for anchovy elsewhere are not routinely reported to ICES, which does not consider these populations to be locally substantial. Other than direct fishing mortality, there appear to be no detrimental impacts on the anchovy population in the Area.

John dory (*Zeus faber*). There is no stock assessment for John dory, but ICES reports that French commercial trawl survey abundance indices show that the population in the Celtic Sea and the Bay of Biscay has increased as a consequence of strong incoming year-classes in 1997, 2001, 2004 and 2007. Other than direct fishing mortality, there appear to be no detrimental impacts on the John dory population in the Area.

Grey gurnard (*Eutrigla gurnardus*) and **red gurnard** (*Aspitrigla cuculus*). Until recently, ICES has collected landings data for all gurnards combined, and assumed that they have mainly consisted of grey gurnard in the Area. However, the more valuable tub gurnard has become more common during the past decade, and their contribution to the reported landings has probably increased. There is insufficient information available to determine the stock structure of grey red gurnard in the Area, and no information on stock status. Grey and red gurnards 2013 Data limited reduction by 20% of mean of last three year's catch, but catch considered unreliable.

Gurnard are caught as a by-catch in demersal fisheries, and are of limited commercial importance. The industry reports a considerable decrease in gurnards around Wolf Rock. Other than direct fishing mortality, there appear to be no detrimental impacts on the gurnard populations in the Area. There are no specific management measures for these species.

Species with no information on stock trends or specific management measures. These species are taken as mainly by catch in commercial fisheries affected and are therefore affected by direct fishing mortality, but otherwise there appears to be no detrimental impacts on their populations in the Area.

Ballan wrasse (*Labrus bergylta*) and **cuckoo wrasse** (*L. bimaculatus*).
Conger eel (*Conger conger*).
Flounder (*Platichthys flesus*).
Grey Mullet (*Chelon labrosus* **-** thick lipped; *Liza ramad* **-** thin lipped; and *Liza aurata* – golden).
Lemon sole (*Microstomus kitt*). Important commercial species
Turbot (*Psetta maxima*) **and brill** (*Scopthalmus rhombus*). Important commercial species
Pout (*Trisopterus luscus* **-** pouting, bib).

Any other known conservation issues related to teleost fish (e.g. species that have Endangered, Threatened and Protected (ETP) status).

The most important ETP teleost species in the Area salmon (*Salmo salar*) and sea trout (*Salmo trutta*), both of which use many SW rivers for spawning and juvenile production, and for which strict measures on the use of enmeshing nets in particular are in place to protect the fish whilst at sea (Salmon Act 1986 and various EA and IFCA bye-laws). They are seldom encountered by other commercial gears.

European eels (*Anguilla anguilla*) also move between freshwater and the coastal waters and the European population is so depleted that a Recovery Plan has been implemented aimed at reducing anthropogenic mortality (including fishing) and maximising the escapement of adult silver eels to spawn. No marine fishery in the Area is affected.

The twaite shad (*Alosa fallax*) and allis shad (*Alosa alosa*), which migrate to spawn in freshwater but feed and grow mainly in coastal waters, are U.K. Biodiversity Action Plan (BAP) species and are listed and protected as Annex II species under the EC's Habitat and Species Directive (92/43/EEC). Whilst twaite shad are relatively common in the Area, allis shad are thought to be endangered, though it is unlikely that either species is threatened by marine commercial fisheries in the Area.

Other effects of man's activities such as pollution or mineral extraction on these species.

It is extremely difficult to attribute the effects of anthropogenic activity other than fishing on marine fish populations, or to distinguish such effects from influences on production and distribution such as climate change. We are well aware, however, that diadromous species (including herring) are vulnerable to habitat degradation (including chronic and episodal pollution) in freshwater and estuaries, but even then is has been difficult to estimate the magnitude of such effects in comparison with oceanic factors in the case of salmon, for example.

Seafish Ecological risk assessment of South West fisheries: Cephalopod ecosystem component

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1. A brief description of the cephalopod ecosystem component in this area

In European waters, cuttlefish are the most important commercial cephalopod resource (Pierce et al., 2010). Landings of the common cuttlefish *Sepia officinalis* (Linnaeus 1758) dominate (Denis and Robin, 2001) with the English Channel supporting the main fishery for this species (Dunn, 1999, Royer et al., 2006). The bulk of the population in this area has a 2-year life cycle which terminates with mass mortality of adults following spawning. The life cycle (Figure 1) begins in spring when mature adult females (Class 2) move inshore to spawn in coastal waters. Hatchlings (Class 0) emerge during the summer and undergo rapid growth before beginning their autumn migration offshore to overwintering grounds in the deep central waters of the Channel. The following spring juveniles (Class 1) begin their migration back inshore to coastal grounds in search of areas with high food abundance. After a second autumn migration back to their overwintering grounds, sexually mature adult cuttlefish (Class 2) complete their second and final inshore spring migration to spawning grounds where they reproduce and die.

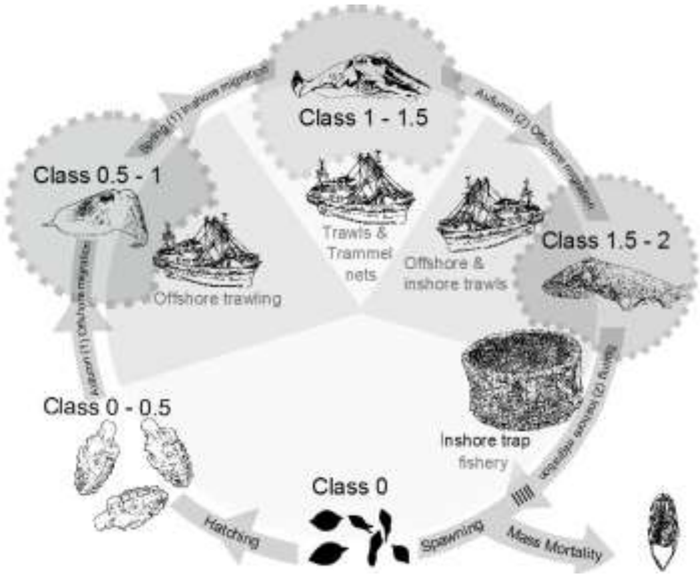

Figure 1: Biannual life cycle of *S. officinalis* within the English Channel

2. Current population status in relation to recognised reference points or conservation objectives, if available, and any information on trends over time

A two-stage biomass model has been developed as part of the EU Interreg IV CRESH (Cephalopod Recruitment from English Channel Spawning Habitats) project to assess the English Channel cuttlefish stock. The model highlights a stable or increasing trend of the resource from 1992 to 2004 followed by a decreasing trend in the period 2004-2008. These long-term trends are reflected in UK cuttlefish landings which have shown a slight downward trend since 2004 (ICES 2012). The majority of the UK catch is landed in the South West with Brixham port recording between 53 -79 % of annual landings (BTA pers comm. 2012). Biomass estimates from the model indicate that the resource can recover very quickly after a low recruitment. The model enables the estimation of exploitation rate, an indicator which does not reveal marked over-exploitation, but rather underlines inter-annual recruitment related variability (Gras, M., pers comm. 2012).

As part of the CRESH project, research analysing and comparing length weight measurements of sexually mature individuals has shown an increase in the percentage of the male population reaching sexual maturity in the first year from 4 % in 1999 (Dunn, 1999) to 14 % in 2010 (Grass, M., pers comm). In addition a decrease in the length (age) at maturity from 14.6 cm to 12.6 cm for males and from 16.4 to 12.9 cm for females was shown between 1999 and 2010 (Dunn, 1999; Grass, M. pers comm 2012). Whilst the comparison of only two periods does not indicate a trend, this could be an early warning of over-exploitation within this population and requires further investigation.

3. Effects of fisheries' actions on the component

S. officinalis are targeted by fisheries at all stages of their life cycle (Figure 1).

S. officinalis is a benthic spawner, attaching eggs to structures that are fixed to the seabed. These structures are known to include seaweeds, seagrass and sessile fauna (Bloor, 2012). Such biogenic structures are susceptible to physical disturbance by inshore scallop dredging, otter and beam trawling operating in the South Devon or North Cornwall area. Loss of areal extent of such habitat may have a negative impact on cuttlefish spawning through impacts on the quality or quantity of the benthic habitat and structures available for spawning (Bloor, 2012).

The inshore cuttlefish trap fishery operates in South West waters in spring. Egg mortality from cuttlefish traps is a potential area of concern within this fishery, as spawning cuttlefish lay eggs on the inside and outsides of these traps. In many cases, the traps are removed from the water and the eggs cleaned off using a pressure washer which causes mortality. An assessment of the quantity of eggs lost through this process has yet to be made in the English Channel, but a study by Bouchaud (1991) in Morbihan Bay estimated the total number of cuttlefish eggs laid on traps during a single spawning season to be between 18 to 40 million.

Discard sampling programs which have been undertaken by CEFAS in the English Channel since 2002 suggest that the rates of cuttlefish discarding can be significant, ranging from 6% to 23 % of the catch for the UK fishing fleet (ICES 2012). A study by Enerver et al., (2007) showed that *S. officinalis* was the second most discarded species by all English and Welsh gear groups, except otter trawlers. Whilst survival of discarded larger adult cuttlefish is quite high, the survival of smaller juveniles is very low (Revill, 2011).

4. Known mitigation measures and whether they have been tested for efficacy in South West fisheries and whether they are considered relevant

In 2009 a voluntary trial (Project 50 %) undertaken by Devon beam trawlers examined how net modification (e.g. bigger mesh sizes, lighter nets) may aid the protection of fish stocks. The results show that net modification could reduce the amount of juvenile fish (including cuttlefish) discarded by 57 % (CEFAS, 2009).

Previous work on eggs laid on traps indicate a 2% hatching rate for eggs removed by jet washing a 15 % hatching rate for those removed by hand (Bouchaud, 1991) and a 95% hatching rate for those left directly on the pots (Gouyen, 2001). During the CRESH project the issue of egg mortality from cuttlefish traps was discussed with South Devon fishermen and novel mitigation measures proposed.

The first involved the conversion of cuttlefish traps to fish for spider crab at the end of the fishing season, enabling pots to be worked whilst the eggs hatch (Malgrange, 2009). The second involved addition of a removable egg receptor to the pots to allow egg removal and redeployment (Zatylny, 2000). These mitigation measures have already trialled in France but not in the South West fisheries.

In South West waters, directed cuttlefish fishing is unregulated. A lack of minimum landing size for this non quota species means that any size cuttlefish can be landed. A study by (Revill et al., Submitted) examined survival rates of small (< 15 cm mantle length) cuttlefish on board a commercial beam trawler. Combined cuttlefish survival rates (pre-sorting and after 72 hours) provided an estimate of discarded cuttlefish survival of only 13 % for small cuttlefish. The potential conservation benefits of discarding small cuttlefish may be modest, however, a move towards releasing live small cuttlefish and efforts to reduce by-catch and increase survivability could benefit the stock by maximising the numbers of cuttlefish able to spawn (Revill et al., Submitted).

- **Other effects of man's activities such as pollution or mineral extraction**

The eggs of *S. officinalis* are generally laid in coastal waters and are attached to structures which are fixed to the seabed. Seagrass beds are susceptible to changes in water quality and clarity, and loss of these habitats may indirectly influence the spawning of cuttlefish and the stock. In addition the eggs themselves remain vulnerable to contaminant exposure over the entire duration of embryogenesis and continuing on into early life stages (ELS), until they migrate offshore for the winter (Lacoue-Labarthe et al., 2010). Adverse effects of contaminants on the digestive and immune systems of ELS cuttlefish can influence survival, digestion, growth, nervous system development and behaviour. The short life cycle of this species means that these effects can quickly affect recruitment and stock abundance (ICES 2012).

- **Ocean warming and cyclical climate phenomena such as the North Atlantic Oscillation**

The North Atlantic Oscillation (NAO) has been shown to affect the timing of migration of the Northern European squid *Loligo forbesi* within the English Channel (Sims et al., 2001) by up to 150 days, with eastward migrations occurring much earlier when water temperatures in the preceding months were higher (positive phase of the NAO). Although the effects of the NAO on *S. officinalis* are yet to be studied, it is probable that a similar pattern may be seen.

A marked change in the composition of cuttlefish species has been recorded during the MBA's standard monthly scientific trawls. *S. officinalis* has historically been the dominant species landed but in recent years there has been an increase in the less commercially important species *Sepia elegans*. Further analysis of this dataset is required to assess whether such changes in species composition are related to patterns of environmental conditions, ocean warming etc.

Research into the effects of ocean acidification and the associated changes in seawater carbonate chemistry on *S. officinalis* indicate it is capable of maintaining calcification, growth rates and metabolism when exposed to elevated partial pressures of carbon dioxide (pCO_2) (Gutowska and Melzner, 2009). A study by Lacoue-Labarthe et al., (2009) also showed that in the context of ocean acidification, decreasing pH to 7.85 could lead to beneficial effects for *S. officinalis*, such as a larger egg and hatchling size and a better incorporation of essential elements such as Zinc in the embryonic tissue (linked to improved survival of hatchlings). However, the longer term effects of ocean acidification and ocean warming have yet to be determined.

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Cefas C5615

Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem

Component 1: Commercial Crustacea; crabs, lobsters, crawfish and spider crabs

Ewen Bell

19 July 2013.

Forward

This report is one of a series of reports prepared to provide the background information for a Scale, Intensity and Consequence Analysis (SICA) of the ecological impacts of South West fisheries in ICES divisions VII e,f,g and h as part of an Ecological Risk Assessment (ERA) of South West fisheries lead by SeaFish.

A SICA analysis is qualitative assessment of the potential impacts of fishing on the marine environment and forms the first stage of a prioritised and focussed ERA. A SICA analysis is a deliberately broad ranging analysis conducted as an initial screening to identify the predominant impacts of a specific fishery which should be carried forward for consideration by more detailed assessment, and identify which impacts can be screened out as less significant at an early stage.

These reports have been prepared as high level summaries of existing knowledge regarding the status of ecosystem components within in ICES divisions VII e,f,g and h and the impact of fisheries on these components. These reports are not expected to provide exhaustive of definitive reviews of the topics they address.

Taking a progressive risk-based approach to the assessment of the ecological impacts of fishing enables an efficient and directed analysis of the ecological impacts of fishing in support objectives for sustainable fisheries conducted within the ecosystem based approach to fisheries management.

A brief description of the component in this area

All four of the macro-crustacean species covered in this section are subject to significant commercial and recreational fisheries around the South West. Although these four species are all part of the same biological order (Decapoda) they are diverse in their distribution, fishery and data availability. Being crustaceans, they share some common biological traits, growth by moulting, larval dispersal - life cycle, growth etc.

In the central English Channel the predominant currents are easterly but there is a westerly current close along the south Cornish coast. The inshore current then curls round the tip of Cornwall and moves north east taking larvae from the North Cornwall coast up towards the Bristol Channel and southern Irish Sea (Brown et al 2003).

Edible or Brown Crab (*Cancer pagurus*)

Cancer pagurus is a widely dispersed ominvorous decapod which is found at latitudes from Portugal to Norway and is present all round the UK. Of the four species within this review, edible crab dominates the landings in terms of both tonnage and value in principal areas (VIIe and VIIf).

Edible crab Tagging studies have shown that individuals are capable of undertaking long migrations and within this area mature females have been shown to move in a Westward migration through the English Channel, although individuals tagged on the north Cornwall coast did not appear to move far (CEFAS study M1103). Berried (egg bearing) female crabs are generally inactive and will dig into sediments whilst their eggs mature over a period of several months. There is a ban on the landing of berried female crabs, but this has relatively little impact upon the fishery as they rarely enter pots. After hatching from their eggs, the larvae are transported by hydrographic currents with a typical larval duration of around 5 weeks which is sufficient for significant dispersal.

The fisheries for brown crab are year round but with a strong seasonal pattern of relatively low landings January-March, building to a peak around October. The dominant method of capture is through potting and due to conflicts between static and mobile fishing gears, potting effort tends to be restricted to prescribed areas, particularly along the coast. An international agreement has been reached between the mobile and static fishers in the middle of the English Channel to allow both fishing sectors to access the grounds at different times of the year. The main area of landings are shown in figure 1

Table 1: Annual landings (tonnes) by ICES Division for *Cancer pagurus* as reported to the MMO

	VIIe	VIIf	VIIg	VIIh
2006	5,835	1,444	284	67
2007	7,389	1,587	287	46
2008	7,602	1,891	261	30
2009	4,625	1,477	518	27
2010	4,844	1,940	592	19
2011	5,055	2,156	400	27
2012	5,803	1,911	493	22

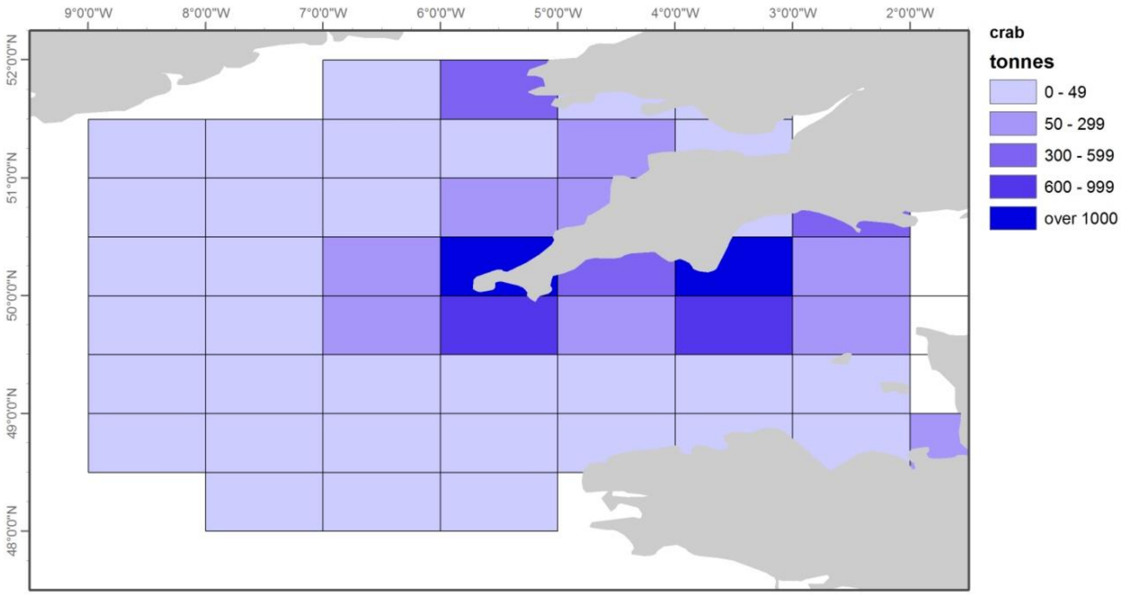


Figure 1: Average landings per ICES rectangle (2010-2012) for *Cancer pagurus*

European Lobster (*Homarus gamarus*)

Homarus gamarus shares a similar geographic distribution to *Cancer pagurus* ranging from North Africa to Norway and is present all round the UK. Although the landings of *H. gamarus* (table 2) are an order of magnitude lower than *C pagurus*, the price of lobster brings the value of the fisheries close to parity.

European lobster has slightly more specific habitat requirements than the edible crab and prefers rocky substrates in which they shelter. *H. gamarus* are opportunistic scavengers, as well as preying on small crustaceans, molluscs and polychaetes. They are highly territorial and known to be cannibalistic, this being a particular problem in pot fisheries where juveniles are observed to be eaten by larger con-specifics.

Both sexes are considered fairly sedentary, although some inshore/offshore and longshore migration may take place. Moulting occurs in summer approximately once a year for adults, becoming less frequent in older animals, and mating occurs soon after the female has moulted. There are 3 larval stages, lasting 3-4 weeks before the post larvae settle on the seabed.

Table 2: Annual landings (tonnes) by ICES Division for *Homarus gamarus* as reported to the MMO

	VIIe	VIIf	VIIg	VIIh
2006	171	196	72	2
2007	174	208	91	3
2008	168	203	74	3
2009	113	172	72	3
2010	109	161	84	2
2011	152	198	94	2
2012	152	207	101	2

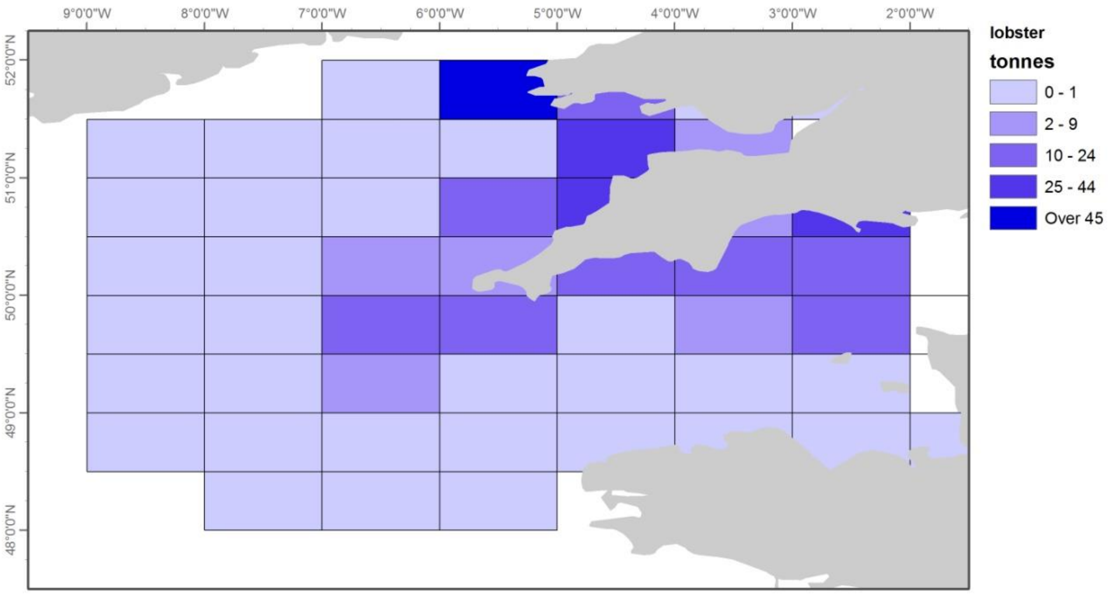


Figure 2: Average landings per ICES rectangle (2010-2012) for *Homarus gammarus*

Crawfish or Spiny Lobster (*Palinurus elephas*)

The Crawfish or Spiny Lobster is found in the western Mediterranean, Aegean and Adriatic seas as well as the western Atlantic and the British Isles represent the northern-most extent of its range. Around the UK the main area of landing is the south west, with reported landings of *P. elephas* rarely recorded in the eastern channel or North Sea.

Despite the commercial importance of this species in some areas (i.e. Mediterranean) there have been relatively few studies into the ecology of *P. elephas*. The habitat requirements of *P.* elephas are similar to *H. gamarus* in that they favour rocky substrates. Crawfish can grow to a large size but data indicate that the growth rate is fairly slow (2-14% per moult, Campillo & Amadei, 1978). The larval phase of *P. elephas* is considerably longer than the other species in this section at around 5 months which implies a very widespread dispersion of the young.

The high price achieved for this species makes it a particularly attractive target which, in combination to their vulnerability to fixed gears such as tangle nets is considered to have been a major factor in the apparent decline of this species. There is a strong seasonality to landings, with the peak in July and August. Only a few vessels specifically target Crawfish, between 2007 and 2012 the top 15 vessels (out of 359 reporting Crawfish) landed around two thirds of the total (UK vessels landing to England and Wales plus England and Wales landings abroad).

Table 3: Annual landings (tonnes) by ICES Division for *Palinurus elephas* as reported to the MMO

	VIIe	VIIf	VIIg	VIIh
2006	3.1	3.5	0.2	0.1
2007	2.5	4.8	1.8	0.4
2008	2.4	4.0	0.5	0.7
2009	2.7	4.9	0.3	0.4
2010	2.4	6.1	0.1	0.5
2011	2.4	5.3	0.6	0.1
2012	3.2	5.2	2.2	1.0

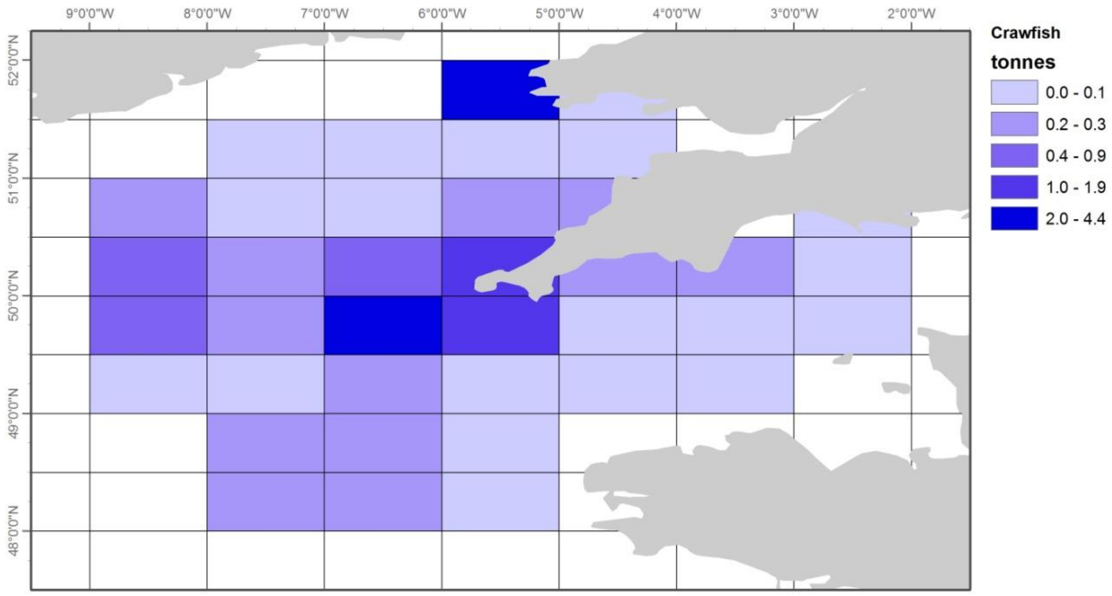


Figure 3 Average landings per ICES rectangle (2010-2012) for *Palinurus elephas*

Spider Crab (Maja brachydactyla formerly Maja squidano)

The common term "spider crab" is widely applied to any macro-crustacean with particularly long legs and has been applied to *Maja brachydactyla* (a.k.a "common spider crab"), Hyas araneus (a.k.a "great spider crab") and Lithodes maja (Northern stone crab). Of these three species only M. brachydactyla is subject to a commercial fishery in the South West, L maja being a northern species occuring off Scotland and the North Sea, whilst H. araneus is a relatively small crab for which there is no commercial fishery in UK waters.

The name change from *Maja squidano* to *Maja brachydactyla* follows studies which concluded that *M squidano* was in fact a separate species with a more southerly distribution.

Unlike the other crustacean species in this review, *M. brachydactyla* cease growing once maturity is reached (known as terminal moult). Spider crabs feed opportunistically, behaviour at least partly enforced by seasonal migrations that they perform. During the autumn and winter months, adults are usually found in offshore locations, usually between 40m and 80m depth (occasionally down to 120m). During the spring and summer, they are found further inshore usually in depths less than 10m and occasionally even in tidal water. Females may spawn up to twice in any one season and at 2-3 weeks the larval stage is shorter than the other species in this review.

Until relatively recently, spider crabs were considered a pest species by many fishermen. Opportunistic feeding means spider crabs are often caught as bycatch, frequently in pots (such as creels and inkwells) but also in enmeshing gears (such as tangle nets). In either case they were thought of as competing with the currently exploited species such as edible crabs and lobster. They also increased turnover time, particularly with nets, between hauling and shooting the gear. The UK fishery for spider crabs only began in 1977 with the development of an export market to Spain. The seasonality of the fishery is linked to the annual migration patterns with peak landings occurring around June.

Table 4: Annual landings (tonnes) by ICES Division for *Maja brachydactyla* as reported to the MMO

	VIIe	VIIf	VIIg	VIIh
2006	527	576	263	0
2007	550	457	244	1
2008	294	347	223	0
2009	230	469	236	0
2010	257	401	263	0
2011	313	368	154	0
2012	294	362	114	0

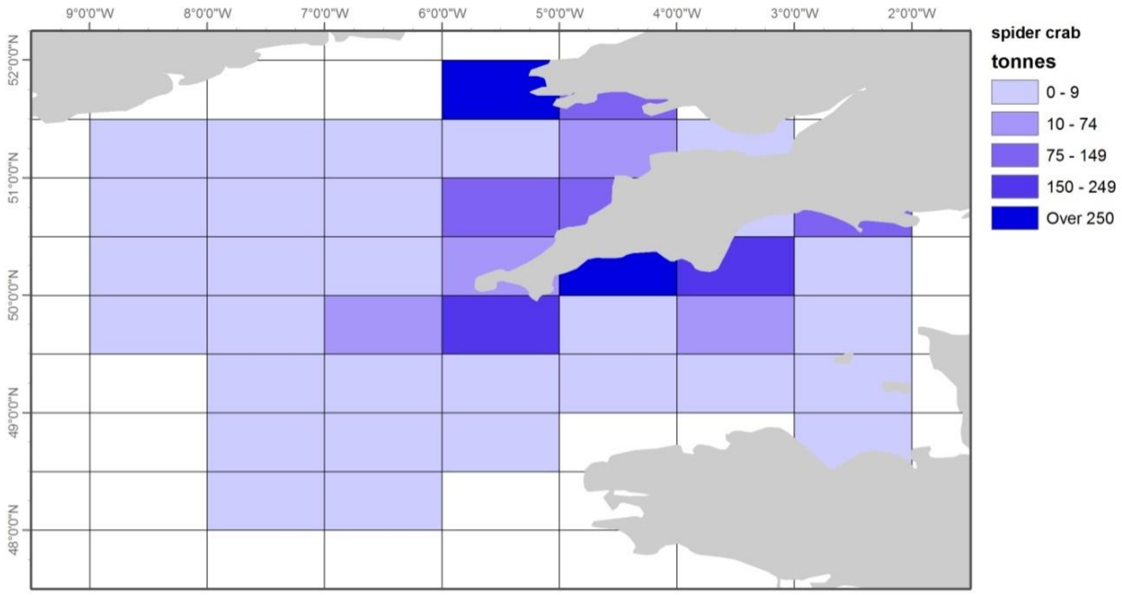


Figure 4: Average landings per ICES rectangle (2010-2012) for *Maja brachydactyla*

Management jurisdictions

With the exception of *Nephrops norwegicus*, the management of all crustacean fisheries within the European Union are the responsibility of the individual Member States. Fisheries management authority within English waters is divided between the Marine Management Organisation (MMO) and the 10 Inshore Fisheries Conservation Authorities (IFCAs), the boundary for jurisdiction lying at 6 nautical miles. Within the UK, there have been no specific management objectives for these stocks at a national (or devolved) level and the IFCAs are charged with ensuring that the fisheries within their waters are "sustainable". Consequently there are no agreed reference points or conservation objectives for the fisheries or the stocks they exploit.

There are four different bodies with fishery jurisdiction covering the area considered by this review. Three IFCAs (Scilly, Cornwall and Devon & Severn) have jurisdiction to 6 nautical miles. The MMO have jurisdiction between 6 and 12 nautical miles to control the fishing activities of all (permitted) nationalities. Beyond the 12 nautical mile limit the MMO have jurisdiction over UK registered vessels only.

There is a hierarchy of management measures in place. Measures imposed at the European Union level are considered the lowest common denominator, i.e. if the EU sets a minimum landing size of 140mm, then National/Regional management could further reduce this but not increase it. The various management measures are described in the "Mitigation measures" section.

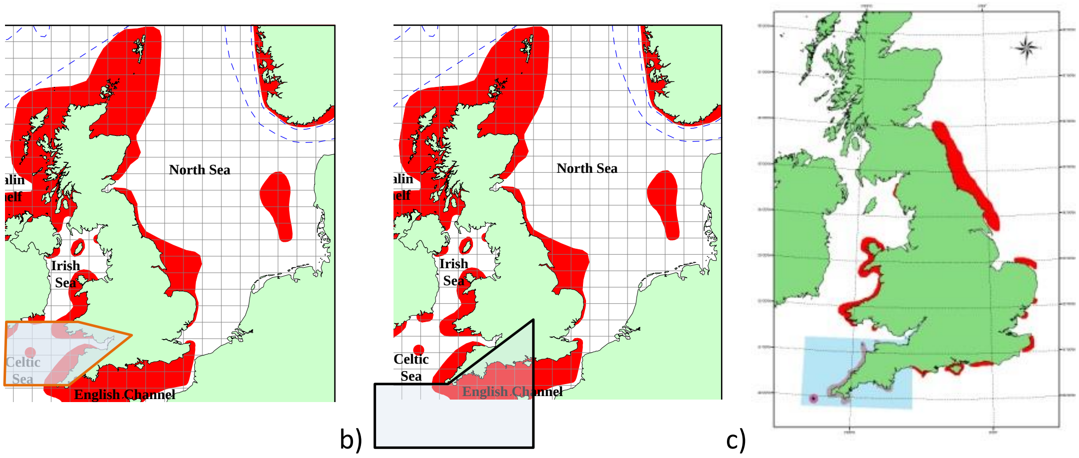
Data availability

There are a number of inconsistencies in the available fishery data for crustacean fisheries relating to both landings and effort. In 2006, two new data reporting schemes came into force. The Buyers and Sellers legislation covers the whole of the UK and requires that anyone purchasing more than 25kg of any one species from any one landing be officially registered and then all purchases to be reported. These sales notes are then compared to the landings reported by fishers and the effect of this legislation was to substantially increase the level of both landings and effort for many species. The second piece of legislation introduced in 2006 only affects the under 10m vessels with shellfish entitlements and only for England and Wales. The Monthly Shellfish Activity Report (MSAR) requires all fishers to file a monthly paper report of their landings and effort. The combination of these two pieces of reporting legislation have coincided with substantial increases in reported landings and effort in 2006 for many species, including those considered in this section. Subsequently, a further change in the way these data were handled in 2009 caused a further discontinuity in many data sets. The uncertainty surrounding the historical data therefore prevents any reliability in analysis of trends in stock/fishery development.

Although these stocks are prosecuted by a number of different nationalities there are no internationally agreed assessments of these stocks and therefore the assessments are only able to be performed on UK data (UK landings and sampling of landings to English ports). As estimates of absolute biomass are a direct function of total landings, any absolute biomass estimates reflect the portion of total stock which is prosecuted by UK vessels and may therefore be an under-representation of total stock size. The determination of fishing rate is less affected by the absolute magnitude of numbers landed as it is mainly drawn from the relative numbers at length, therefore provided foreign fisheries have the same selectivity at size, the estimates of fishing rate can be considered reasonably robust.

Stock assessment issues

Cefas undertakes 10 spatially distinct stock assessments for Brown Crab and Lobster (5 of each) of which the "Western Channel Crab", "Celtic Sea Crab" and "South West Lobster" apply to this review. The division into the different stock units was based upon knowledge of the hydrographical currents (governing larval dispersal), migration patterns and fishery activity. It is acknowledged that any boundary defined by these considerations is somewhat arbitrary and that movements between the areas will exist, however they are considered to be a reasonable representation of a complex system. The "Celtic Sea Crab" stock comprises areas VIIf and VIIg (figure 5) whilst the "Western Channel Crab" stock includes all of ICES areas VIIe, with parts of VIId and VIIh. The "South West Lobster" stock lies predominantly within VIIe and VIIf.



a) b) c)

Figure 5: Stock boundary definitions for a) Celtic Sea Crab, b) Western Channel Crab and c) South West Lobster stocks.

Population status

Of the four species listed here, only two (Brown Crab and European Lobster) are assessed in a formal stock assessment framework, spider crab and crawfish are monitored simply through the fishery statistics

Crab and lobster

The most recent stock assessments were performed in 2012 and show stock and fishery status up to the end of 2011. The summary sheets for these assessments are available on the Cefas web-site at http://www.cefas.defra.gov.uk/our-science/fisheries-information/commercial-species/shellfish.aspx. Stock and fishery status for these assessments is measured against proxies associated with the concept of Maximum Sustainable Yield (MSY). MSY, although not a formally agreed management objective for these stocks but is the current objective of the Common Fisheries Policy (CFP) and is being proposed as a metric for Good Environmental Status under the Marine Strategy Framework Directive for stocks falling under the CFP.

The methodology used for stock assessment of crabs and lobsters is Length Cohort Analysis (LCA, Jones ????). This approach primarily uses the length composition of the fishery to estimate the state of the stock and more importantly, the rate of fishery-induced mortality. This approach relies heavily upon biological data (e.g. regarding growth and maturity) as well as sampling of catches to determine the relative numbers at length. Whilst there is considerable uncertainty in many of these data sources they are considered to be more consistent than the historical series of catch and effort data which would be the primary source of data for many alternative assessment approaches. The

LCA methodology assumes that the population and fishery are in equilibrium (i.e. recruitment and fishery activity have been constant over a large number of years) and in order to reduce the influence of significant deviations from this assumption it is common practice to use a 3-year average of landings and length compositions.

Analytical derivation of MSY requires modelling of the relationship between stock and recruitment, as well as how the fishery impacts the stock. The LCA assessment approach does not generate the series of stock and recruitment values to define such a relationship and therefore it is not possible to calculate a direct estimate of MSY. In situations such as these, proxies for MSY are generally used and for the crab and lobster assessments the biomass of mature animal (Spawner per Recruit, SpR) resulting from each recruit is used as the metric. The observed SpR is then compared to the SpR expected in an unfished system and the ratio provides an indication of whether the observed fishing rate is appropriate. In stocks where an analytical determination of MSY is possible, around 35% of virgin SpR is often observed and is therefore considered a reliable proxy for MSY and this is the value chosen for the current crab and lobster assessments.

As stated previously, the landings are only considered sufficiently reliable since 2006 and in conjunction with the 3-year averaging process, the time series of assessment results has just 4 points (2006-2008, 2007-2009, 2008-2010, 2009-2011).

Stock status: Celtic Sea Crab

The 2011 assessment concludes that:

"The status of the stock of female Edible Crab in area Celtic Sea is good, approaching the level associated with Maximum Sustainable Yield1. Exploitation levels are moderate for females and likely to be sustainable but above the target MSY level. The various minimum landing sizes applicable within this area all allow individuals to generally spawn at least once, the larger limits offering greater probability of multiple spawning events before being retained by the fishery. The status of the stock has not changed since the last assessment in 2010."

Stock status: Western Channel Crab

The 2011 assessment concludes that:

"The status of the stock of Edible Crab in area Western English Channel is good with spawning stocks around the level required to produce Maximum Sustainable Yield. The exploitation levels are moderate to low and around the levels required to produce Maximum Sustainable Yield. The large minimum landing size ensures that multiple spawning events are possible before the individuals can be removed by the fishery. The status of the stock has not changed since the last assessment in 2010".

Stock status: South Western Lobster

The 2011 assessment concludes that:

"The status of the stock of lobster in the Southwest area is moderate; SSB levels are between the minimum recommended level and the level associated with MSY1 but are declining. The exploitation level is close to the MSY target level for females and slightly above the target for males. The status of the stock has not changed since the last assessment in 2010."

Crawfish and Spider Crab

There are no routine stock surveys or analytical assessments for spider crabs or crawfish undertaken in UK waters. In such circumstances, stock status is often inferred from fishery metrics such as landings and effort, however for both of these stocks there is a larger than normal degree of uncertainty surrounding the reported statistics. As mentioned above the introduction of buyers and sellers legislation had a significant effect upon reported landings for many species and it would appear that this may have been the case here, particularly for some spider crab fisheries.

The dispensation from reporting requirements within the "Buyers and Sellers" legislation for sales under 25 kg means that low-volume, high-value species such as European Lobster and in particular Crawfish may be under-represented on the MMO's official landings database. The same reporting issues also apply to the recording of fishing effort and the reported levels of fixed-gear effort is considered to be less robust than for the mobile gears. In addition to the uncertainty regarding the officially reported effort statistics, there is a secondary issue regarding *effective* effort in fixed gear deployment. For towed gears, fishing effort can be measured in the number of hours a gear is deployed, however for fixed gears the deployment time can vary from a few hours to several days or even weeks. It is therefore important to consider the "soak time" in terms of measuring effective effort and these data are not collected. A third issue regarding effective effort is that fixed nets rely upon passively capturing animals as they move around whilst baited pot fisheries rely upon attracting animals into the gear whereupon the presence of individuals within a pot will influence the decisions of subsequent individuals regarding pot entry. The combined effect of these issues implies that the use of Catch (or landing) per unit effort derived from the officially reported statistics as a measure of stock abundance are not considered reliable indicators of stock status.

Reported landings of Crawfish are traditionally much lower than the other species in this review, however the substantial and rapid decline in landings from area VIIf between 1988 and 1993 (figure 6) are considered to be a genuine reflection of local abundance and mirrors similar reductions in the main fishing grounds off the Iberian Peninsula. The cause of this widespread decline is generally accepted as resulting from high levels of exploitation in the southern (Iberian) components which is a likely source of recruits for the stock components found around the British Isles.

The outlook for the abundance around the British Isles is therefore more likely to be influenced by the abundance and spawning success of individuals further south than local fishing activity.

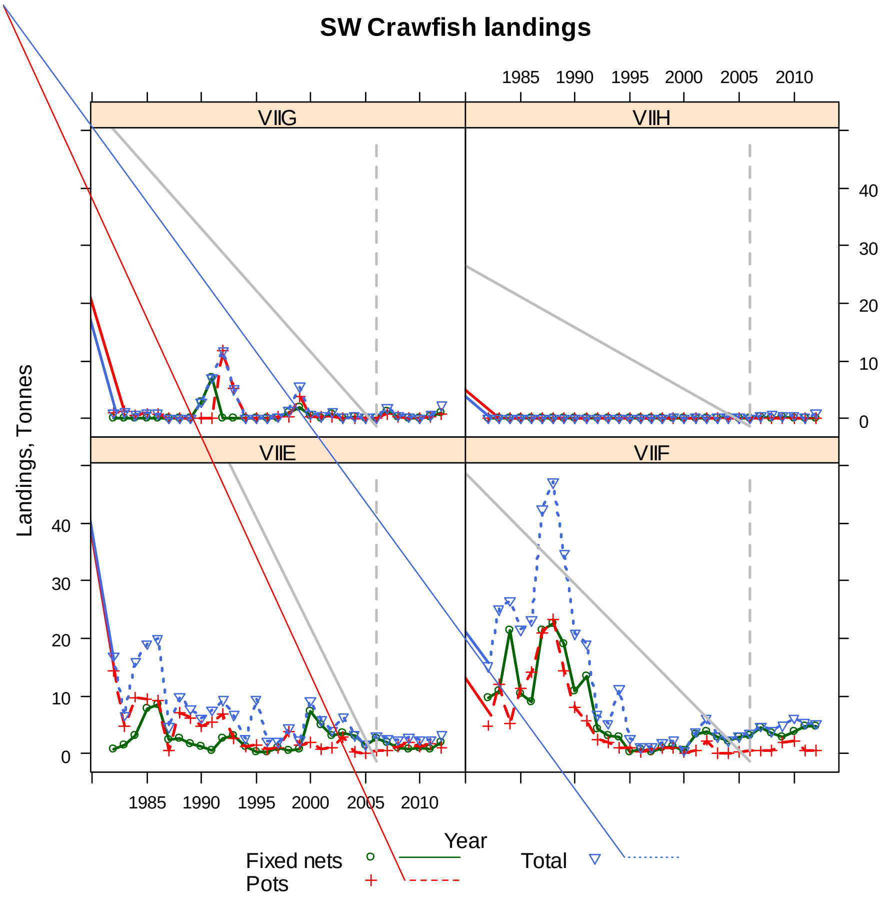


Figure 6 Annual landings per ICES division and gear for *Palinurus elephas*

The spider crab fishery has seen almost as wide a dynamic range as the crawfish fishery although recent landings are around the historic average. There is an obvious discontinuity in the landings in 2006 commensurate with the change in reporting legislation (sharp increase in landings, figure 7) and there is also some evidence of an impact with the change in recording process in 2008-2009 (seen as a drop in landings) making it difficult to draw any conclusions regarding the likely state of the stock in recent years.

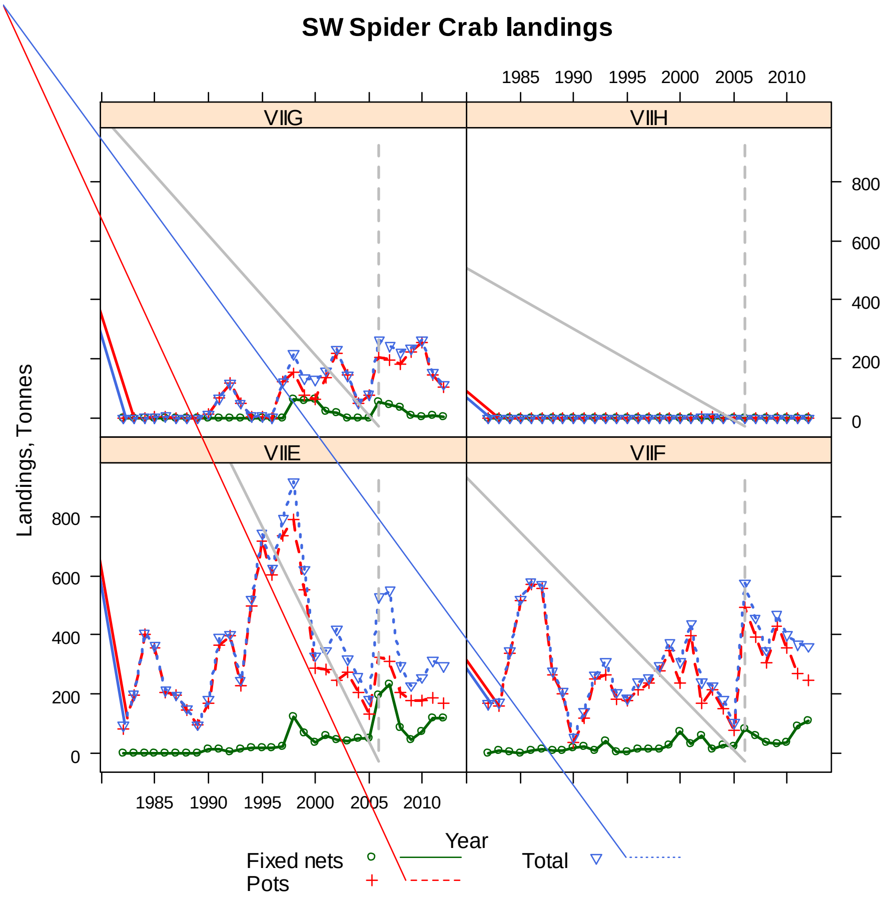


Figure 7: Annual landings per ICES division and gear for *Maja brachydactyla*

Effects of fisheries' actions on crustacea

Direct fishery effects:

Direct fishery effects upon any stock would be expected to include changes to spatial distribution, changes in age/size/sex composition and influences upon the recruitment levels. Any increase in total mortality rate above the natural level will induce change in age and size composition, decreasing the average age and size, indeed departures from the "expected" size composition form the basis of the LCA methodology used to assess the Edible Crab and Lobster stocks. As there is no routine measurement programme for the crawfish and spider crab fisheries there is no basis to determine if there has been a significant impact of the fishery upon the size structure of these stocks. With much of the static fishery effort being restricted to areas without mobile gear effort there is no basis to determine if the fishery activity has significantly changed the spatial distribution of the stocks. Having said that, the relatively low level of fishing mortality estimated for the South West Lobster and Western Channel Crab stocks, it is unlikely that there will have been any substantial changes to the spatial distribution of stocks.

A skewed sex ratio in the landings in which more males than females are landed would not be expected to affect the spawning potential of a stock provided that the remaining density of males was sufficient to successfully fertilise the females, however the skew in sex ratios observed in the Western Channel and Celtic Sea crab stocks is the other way round. Whilst there should be no shortage of males with which to mate, such a sex-bias in the landings will have an increased impact upon the spawning *potential* of the stock. That is not to say that the levels of fishing activity observed here are endangering future recruitment as there are many more stages between egg production and the arrival of new recruits to the mature stock. At present the stock assessment methodology and length of reliable data are insufficient to explore the relationship between the potential egg production and future recruitment in these crab populations. There is far less of a sex-ratio imbalance in the South West Lobster fishery.

In addition to the reported removals from the fishery there will be other fishery-induced sources of mortality. Inter and intra-specific competition occurs within the pots with lobsters in particular being known to attack and eat other organisms within the pots, including juvenile con-specifics. The act of retaining individuals in a pot inflicts little direct damage, although interaction with other animals whilst retained may induce some limb-loss. Although there is a reduced market value for such animals, damaged individuals over the minimum landing size are usually retained. Of those damaged individuals discarded there is little quantitative information regarding long term survivorship, however there are anecdotal reports of these so-called "crippled" individuals being repeatedly caught in traps implying a degree of survival. Decapod crustaceans are capable of limb-regeneration and therefore any crippling will be temporary. The only exception to this is where soft animals (i.e. recently moulted) are damaged in which case there is an increase in the potential for fatal injury, or risk of predation once discarded although individuals are sometimes observed to have survived and repaired significant shell damage.

Entanglement of macro-crustaceans in fixed nets can cause fishers significant issues in the time taken to clear the nets, and breaking the animals out (to reduce time and avoid damage to gear) is sometimes employed. Some survival of individual *C. pagurus* is reported where the two main claws have been removed but there is no data to establish the magnitude of such survival.

Indirect fishery effects:

Several studies have shown that the standard processes of setting and hauling pots has little or no detectable effect upon the immediate ecosystem assemblage (Eno et al 2001, Blythe et al 2004, Coleman et al 2013). Fixed nets, whilst having relatively little abrasion impacts upon the sea-bed do have a higher incidental mortalities when non-target organisms become enmeshed.

Occasionally strings or part strings of pots are lost during storms or due to conflict with mobile gears and there is evidence that these will continue to fish and exert mortality for a considerable time (Bullimore et al 2001). Similarly, lost fixed nets will continue to fish

It is sometimes claimed that the potting fisheries have a beneficial effect upon stocks in that the bait used within the pots artificially increases food supply and results in enhanced growth rates although such claims are unsubstantiated.

Known mitigation measures and whether they have been tested for efficacy in South West fisheries and whether they are considered relevant

As previously mentioned, several management jurisdictions are present within the study area. EU legislation forms the basis for any management action but is restricted to Minimum Landing Sizes (MLS) for the species listed here namely: *C pagurus* = 140mm, *H. gamarus* = 87mm, *P. elephans* = 95mm, *M. brachydactyla* = 120mm female, 130mm male. There is also some limitation on the effort which can be expended by vessels >15m (measured in Kilowatt days) although this cap covers all of ICES area VII and applies to the fleet as a whole rather than individual vessels. The effort cap has become an issue over the past couple of years and Defra and the MMO are currently working on ways of managing the effort quota between the >15m fleet. There are a few additional management measures in place by the UK government, namely the ban on landing v-notched lobsters, a ban on the landing of berried or soft *C. pagurus* and a MLS of 160mm for male *C. pagurus*. Within the 6 mile limit there are several other bylaws invoked by the local IFCAS

- **Cornwall**
  - Permit scheme is in operation for all vessels commercially exploiting the stocks within this section. Fishers operating outside scheme (i.e. those operating solely for personal consumption) have a limit of 2 individuals of species list combined. Individuals can be substituted for a pair of claws.
  - Crab
    - claws, max 30kg - must be from clearing nets.
    - MLS 150mm Hen, 160mm Cock
  - Lobster MLS 90mm, with additional bans on the landing of berried females, individuals with v-notches (or missing tail sections which might obscure a v-notch).
  - No tailing of Crawfish, MLS 110mm, berried ban
  - Spider crab, MLS 130mm
- **Scilly**
  - Lobster MLS 90mm
- **Devon and Severn**
  - Crab
    - Prohibition on detached parts (effectively a ban on the landing of claws).
  - Lobster
    - Ban on landing v-notched and berried females
    - 90mm MLS
  - Pots must have mandatory escape gaps (also applies to those parts of Cornwall IFCA that were previously within the Devon Sea Fisheries Committee)

Minimum landing sizes for all of these species are generally considered to be above the mean size at first maturity. By setting the MLS higher than the mean size at first maturity a degree of protection is offered to the spawning stock, allowing most individuals to spawn at least once. The size of eggs produced by a repeat spawner (a female spawning for the second or more time) are often larger and therefore setting higher MLS permits a greater proportion to spawn on multiple occasions. The practice of v-notching the tails of female lobsters (with legislation to ban the landing of such individuals) also prolongs the spawning opportunities for such individuals.

The introduction of mandatory escape hatches in the Devon and Severn IFCA, has lead to fewer instances of observed juvenile cannibalism (S. Clarke D&S IFCA pers comm).

There are no proven examples that the adoption of any individual additional technical conservation measures by the IFCAs has been beneficial to the stock and fishery. This is not to say that the measures have been ineffective, simply that definitive proof has yet to be established and, given that individuals will migrate beyond the artificial boundaries of the IFCAS, finding such definitive proof may be impossible. For the Edible Crab and Lobster stocks under consideration, the majority of landings come from outside the IFCA jurisdictions and differences in the management measures causes some difficulty in enforcement (e.g. where fishing activity has occurred either side of the 6 mile limit, animals may be legitimately on-board which are undersize for the IFCA jurisdiction). Modelling exercises designed to test the effect of changing technical measures such as MLS demonstrate that although such measures are likely to impact the long term sustainability of the stock, even small changes in effective fishing effort have the ability to mitigate the benefits of increasing MLS.

Whilst there is a lack of definitive proof of the efficacy of the individual management measures in force, it should be noted that the latest stock assessments for edible crab and lobster in this region indicate the stocks are in relatively good shape compared to some of their East-Coast counterparts, even though the more stringent IFCA rules only apply to a fraction of the total landings.

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Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem

Component 2: Commercial molluscs; scallops, oysters, mussels, whelks and squid

Dave Palmer and Beatriz Roel

19 July 2013.

Forward

This report is one of a series of reports prepared to provide the background information for a Scale, Intensity and Consequence Analysis (SICA) of the ecological impacts of South West fisheries in ICES divisions VII e,f,g and h as part of an Ecological Risk Assessment (ERA) of South West fisheries lead by SeaFish.

A SICA analysis is qualitative assessment of the potential impacts of fishing on the marine environment and forms the first stage of a prioritised and focussed ERA. A SICA analysis is a deliberately broad ranging analysis conducted as an initial screening to identify the predominant impacts of a specific fishery which should be carried forward for consideration by more detailed assessment, and identify which impacts can be screened out as less significant at an early stage.

These reports have been prepared as high level summaries of existing knowledge regarding the status of ecosystem components within in ICES divisions VII e,f,g and h and the impact of fisheries on these components. These reports are not expected to provide exhaustive of definitive reviews of the topics they address.

Taking a progressive risk-based approach to the assessment of the ecological impacts of fishing enables an efficient and directed analysis of the ecological impacts of fishing in support objectives for sustainable fisheries conducted within the ecosystem based approach to fisheries management.

A brief description of the component in this area

Scallop

The scallop (*Pecten maximus L.*) has a continuous distribution throughout the southwest region wherever the seabed is suitable, from the shallow sub-littoral out to 200 m or more. This includes rias such as the Fal estuary and Salcombe Harbour.

Scallop dredging has a long history in the western English Channel, but it is since the mid 1970s that it grown to its current status as one of the most valuable commercial species in the area.

The spring-loaded "Newhaven" dredge currently in use has changed little over the last forty years. It has a bag constructed from steel rings and a tooth-bar with up to nine teeth of up to 70 mm which penetrate the seabed to dig the scallops from their recess in the sea bed. The tooth-bar is sprung so that it will swing back when the dredge hits an obstruction.

Until 1999 a fixed tooth-bar "French" dredge was employed in some parts of the area. This was copied from the drague au volet used in the fishery in Baie St. Brieuc, Brittany. This was banned because of its tendency to retain fish by-catch, and because, particularly in Lyme Bay, the dredges were often used to target sole thus circumventing beam-trawl regulations.

Commercial diving for scallops occurs in sheltered inshore waters on the south coast. Dive caught scallops command a price premium but the production from this fishing method is tiny relative to that from dredging.

Oyster

The fishery for the native oyster is centred on the estuary of the River Fal and since the decline of The Solent, this is now the largest naturally recruiting population in England. The fishery is managed through a Regulating Order by Cornwall IFCA. There is a minimum size and engine powered vessels are not allowed to fish in the area covered by the order. There are around 12 sailing smacks and 11 punts operating in the fishery.

Small, relict populations of native oysters may be present in other SW estuaries where they were once abundant but these are no longer fished.

Mussel

Intertidal mussel beds are present in a number of SW estuaries, most notably the Exe and the Teign. These beds are managed by Devon and Severn IFCA. A long exploited sub-littoral mussel bed exists off Portland Bill which has been harvested at a small size and sold for seed to aquaculture sites around the UK and to Europe.

Mussels are also cultivated on ropes in the River Fal in Cornwall.

Whelk

Whelks are taken in specially constructed pots mostly from areas of sand and gravel throughout the SW region. Many of the vessels involved also prosecute crustacean pot fisheries.

Squid

The two commercially caught squid species in the area are *Loligo vulgaris* and *Loligo forbesi*. The abundance of both species is strongly seasonal, *L. forbesi* peaks in late summer-early autumn, *L. vulgaris* peaks in late autumn-early winter (CEPHSTOCK 2005). Squid are caught in commercially viable quantities in this area in the fourth quarter (Roel et al. 2007). Loligo forbesii can be found in waters as deep as 500 m in the Celtic Sea. Where its distribution overlaps with that of Loligo Vulgaris but L. Forbesii tends to be found in deeper waters.

Loligo vulgaris demonstrates high geographic variability of reproductive and growth parameters, and temperature is one of the main factors inducing such variability. The life cycle may be completed within approximately one year, with maximum lifespans of 15 months recorded in western Iberia (Moreno et al., 1996; Rocha and Guerra, 1999). Loligo vulgaris spawning occurs throughout the year with 2 main peaks between November and June. Spawning areas are poorly known but egg-mass recoveries indicate that spawning occurs at least between the depth of 2 – 120m. Egg clusters are laid in shallow water on the underside of rocky overgangs, on branched sessile organisms or on fishing lines and other static fishing devices, over sand and silt bottoms. L. forbesii is also known to be a benthic spawner.

Loligo forbesii is semelparous, displaying “intermittent, terminal spawning”, in which the females lay eggs in batches and die shortly after spawning (Rocha et al., 2001), it is commonly assumed to have an annual life cycle.

There is justification for considering both *L. forbesi* and *L. Vulgaris* of the English Channel as distinct stocks. Biologically, the life cycles take place entirely within the area. In addition, when analysing fisheries based abundance indices it was noted that abundance is high in the English Channel and that it decreases in the adjacent waters of the North Sea and Celtic Sea (Denis, 2000).

Loligo vulgaris is a carnivorous predator, eating relatively large active prey from a broad spectrum of species. Adults prey heavily on juveniles when other food is scarce, and therefore cannibalism may play an important role in the species trophic ecology when food is scarce. *Loligo forbesii* is an opportunistic predator that will take any prey it is able to capture and handle including its same species. Prey species recorded include various fish, crustaceans, molluscs and polychaetes. Loliginid squid are a prey item for many predators of the third and fourth trophic level. Predators include cetaceans, seals, pelagic and demersal fish.

Current population status in relation to recognised reference points or conservation objectives, if available, and any information on trends over time

Scallop

There are no formal assessments of scallop populations in England so the status of the stocks in the southwest can only be inferred from commercial fishery data. The trend in commercial catch from the region is given in figure 1 and shows that the fishery is now three times what it was in the late 1970s. Figure 2 shows the distribution of the catch in 2012. Scallop fishing is far more widespread across the area than was the case in the early years of the fishery and indeed has in recent times been more so than in 2012, with significant catches being made out in the western approaches. This suggests that the increase has been due to expansion of the area fished rather than increased intensity on traditional grounds.

At present there would seem to be no particular concern that the scallop stock is overfished in the Southwest, although local depletions occasionally reduce stock density to levels that make dredging commercially non-viable for inshore vessels. Most of the scallop fleet is very mobile and will readily move from area to area to maintain catching opportunities. Recruitment to the fishery occurs regularly and vessel catch-rates appear to be stable. However, because the fleet continues to move from one ground to another to maintain catch-rates, trends are often hard to discern and with effort levels at an historical high, it is vital that a more predictive assessment should be made. With this in mind a biological sampling programme is currently being trialled by Cefas in partnership with the scallop fishing industry.

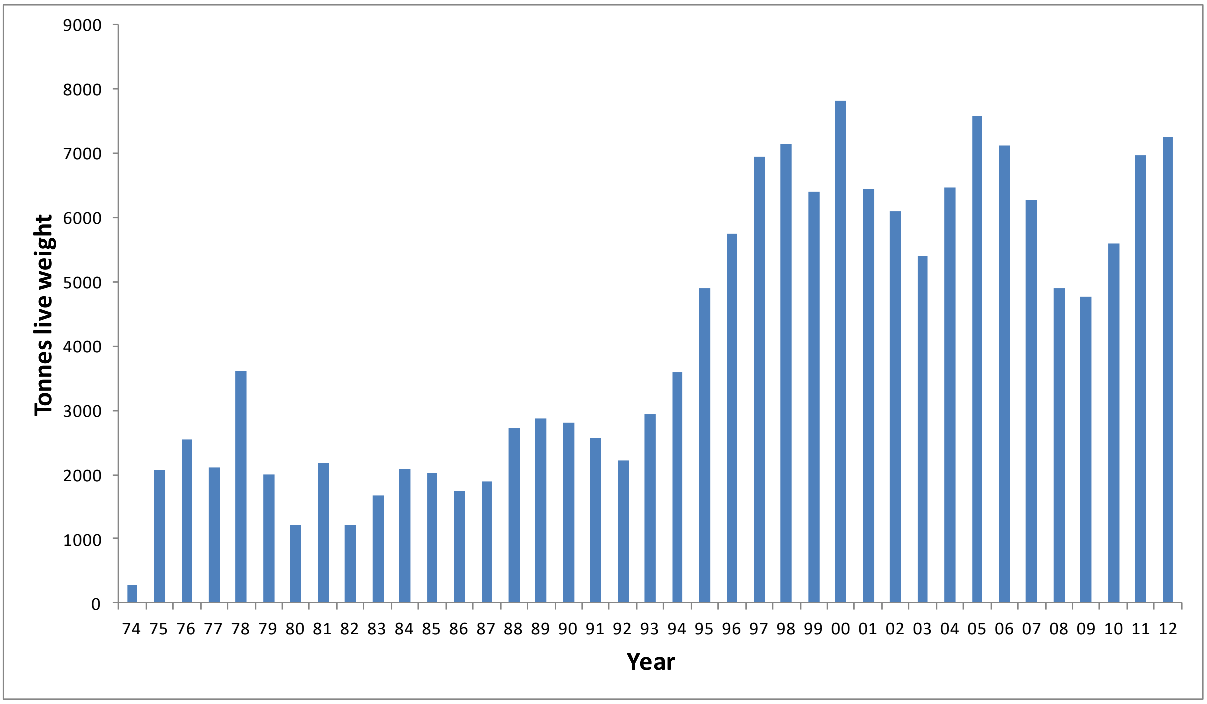

Figure 1: Annual landings of scallops from ICES divisions VIIe-h, by UK vessels landing in England and Wales

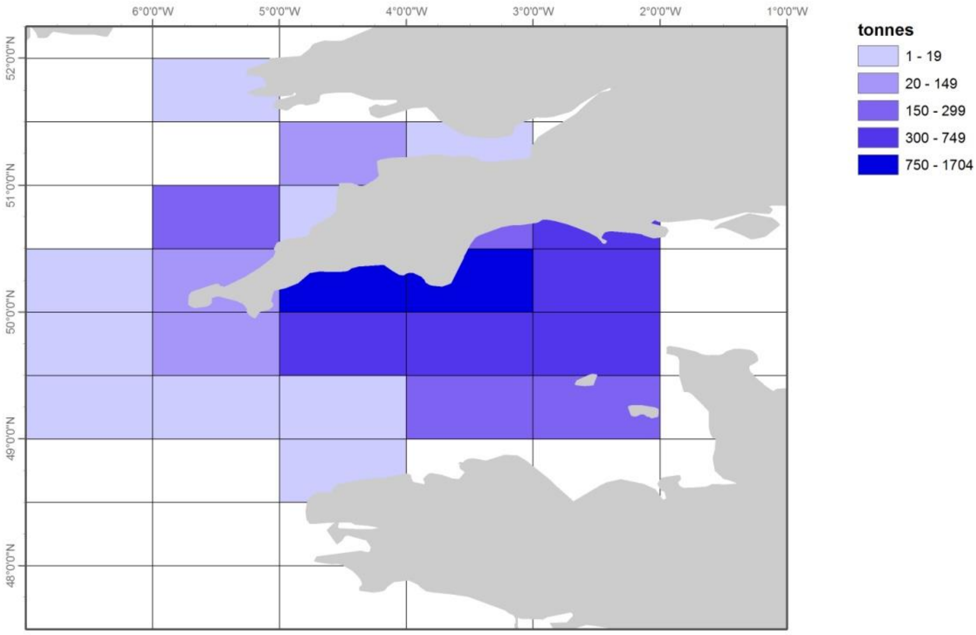

Figure 2: Distribution of landings of scallops by statistical rectangle, 2012

Oyster

The Fal oyster population has supported a fishery for many decades although it collapsed during the 1980s following an outbreak of the oyster disease Bonamia. Recovery began in the early 1990s and has been sustained, albeit relying upon occasional very strong recruitment and the most recent information is that strong recruitment from the 2010 year-class will sustain the fishery in the short term, following a dip in production (Vanstaen, 2013). The landings from the fishery are given in figure 3. Bonamia is still present in the population, but it would appear that Fal oysters have developed a tolerance to the disease and there have been no mortalities in recent years that can be attributed to it. A stock survey is carried out each year to provide information on trends in the stock and inform the fishery managers.

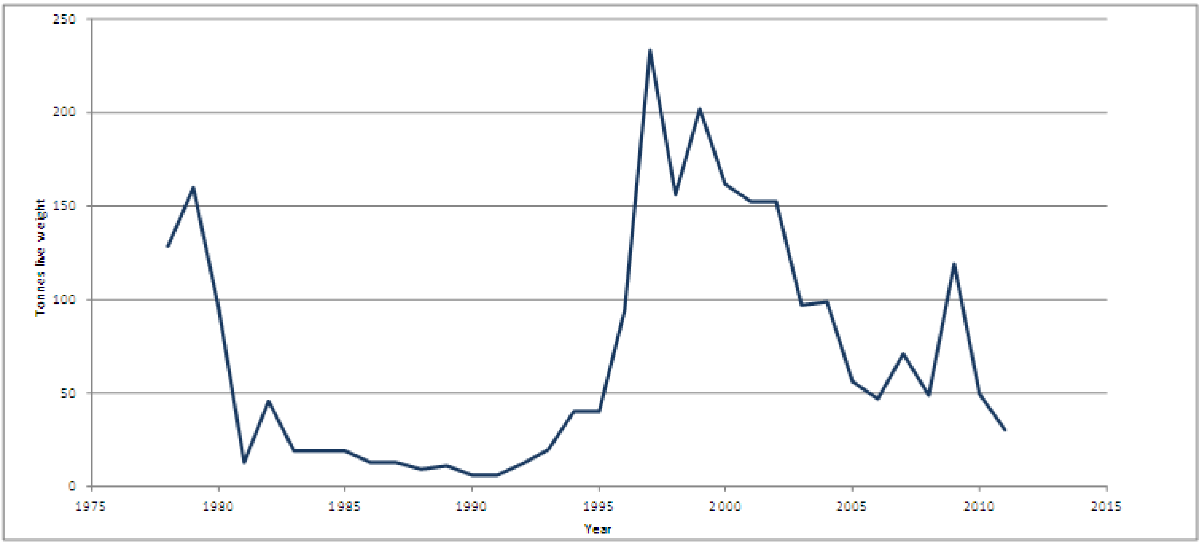

Figure 3: Annual landings of native oysters from the Truro Fishery Order

Whelk

Whelk fisheries have a long history in some parts of the UK but not so much in the southwest region. However the development of markets in the Far East during the 1990s led to a swift development of the fishery. Those markets were lost overnight following financial turmoil in the region, but economic recovery has restored those markets and landings have trebled in the last ten years (Figure 4). There is however, now concern about the state of the stock, for which there are no assessments. Whelks have low fecundity, compared to bivalves for example and have no dispersal phase. This makes them potentially very vulnerable to local overfishing and vessels must be prepared to move grounds in order to maintain viable catch-rates. There is evidence that the current EU MLS (45 mm) is too small, certainly in some regions. Work is currently underway at Cefas to study regional variations in size at maturity and to advise on appropriate minimum sizes for the fisheries.

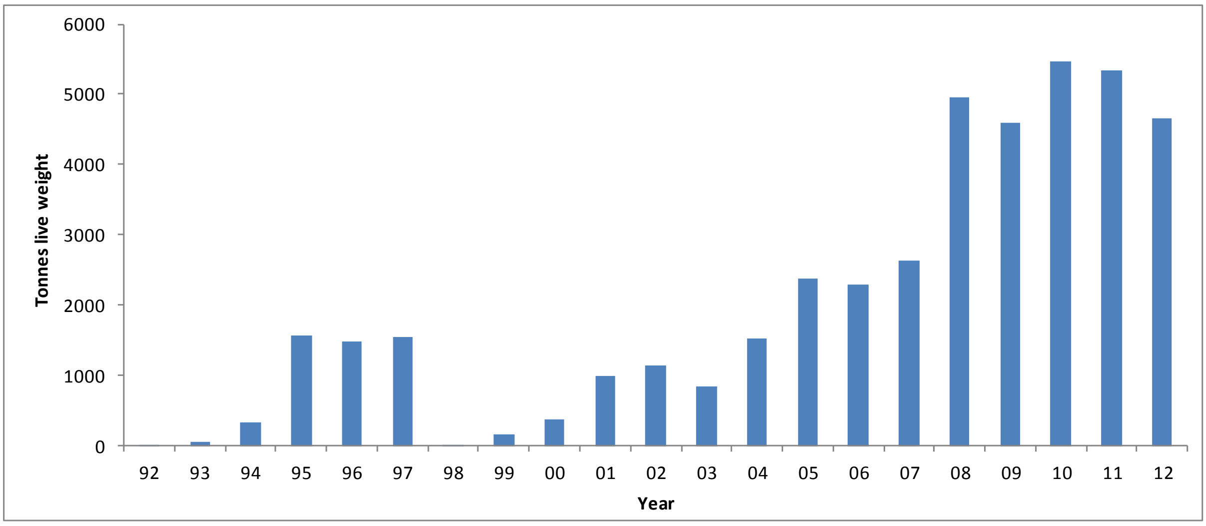

Figure 4: Annual landings of whelks in the UK from ICES divisions VIIe-h

Squid

Fisheries

In the English Channel and French waters, landings of *Loligo* are normally a mixture of *L. vulgaris* and *L. forbesii* (the species are normally not separated in the official statistics). Annual squid landings from the South West picked in the early 1990s with about 1000 tonnes declining thereafter when they fluctuated around 500 tonnes per annum (see Figure 5). Squid are predominantly caught in the western English Channel, ICES division VIIe, see Figure 6.

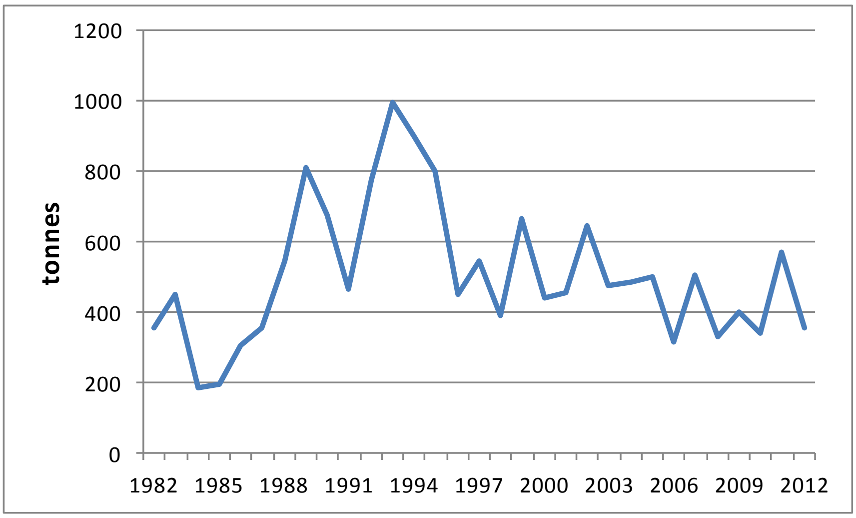

Figure 5: Squid annual landings from the South West of England

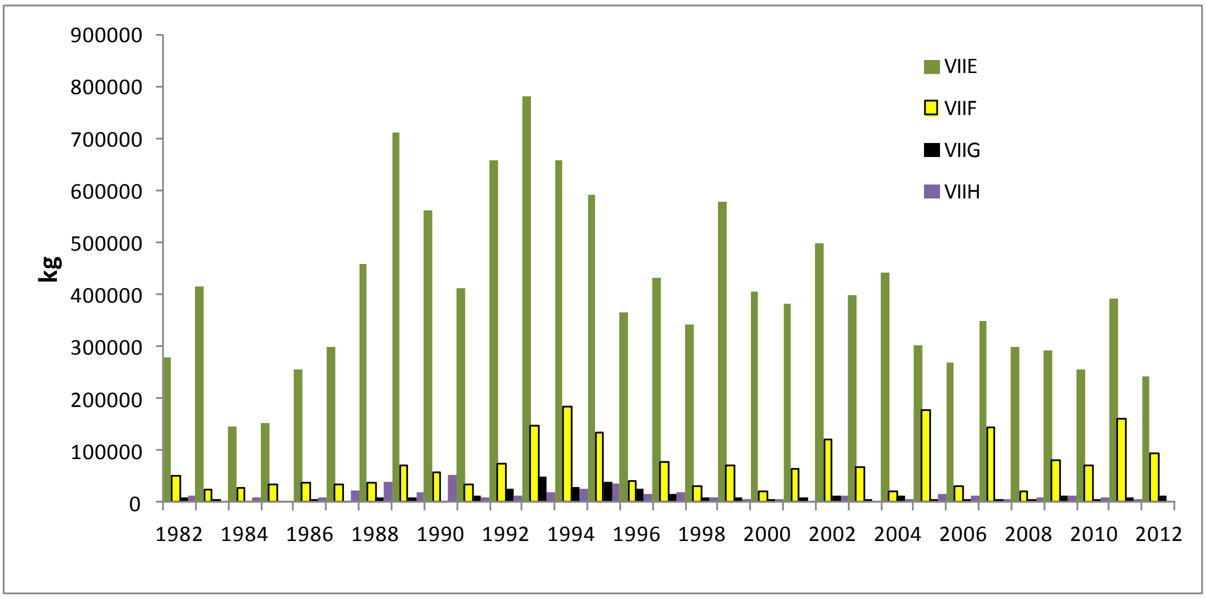

Figure 6: Squid annual landings by ICES division

Squid is caught in the southwest primarily as a bycatch of demersal trawlers and by handline. A breakdown of cumulative landings since 1982 is shown is Figure 7 illustrating that the majority of landings are taken by beam and otter trawlers with a small component taken by hand lines where jigging is included. While the West Country squid jigging season may tail off by mid January, it is possible that the use of high luminescence jigs may allow catches to continue. Whether UK squid are as attracted to light as those in warmer climates has been a mystery for years, but growing evidence suggests that a more luminescent jig brings a more aggressive response from squid (http://www.thisiscornwall.co.uk/). The effect of using lights when jigging for squid was investigated by Roel et al. (2007) in the context of the Fisheries Science Partnership. They concluded that fishing with lights appeared to be an effective method of catching *L. vulgaris*. However, the combination of bad weather in the fourth quarter and poor water clarity is likely to result in conditions where jigging with lights would not always be successful.

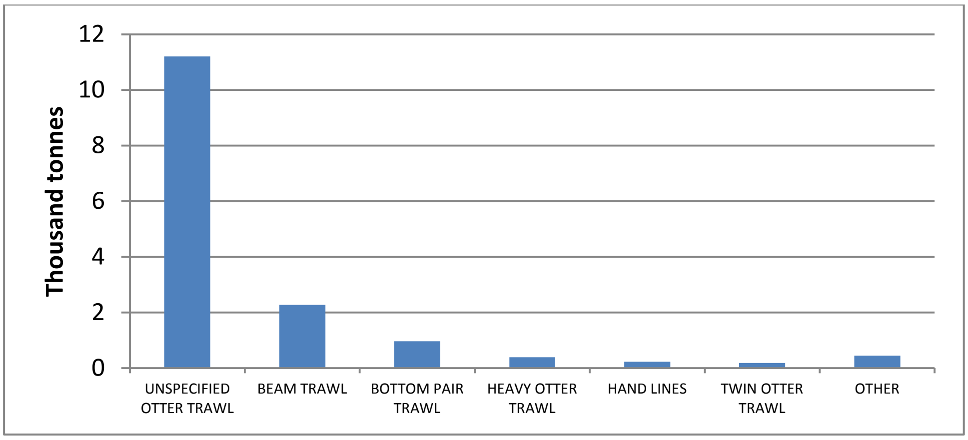

Figure 7: breakdown of total landings 1982-2012 by gear

There are still no regular assessment and management studies for *Loligo* fisheries due to the short life-span and the nature of its fisheries. In general, European cephalopod stocks are not currently valued sufficiently highly to warrant routine, full-scale assessments. Few of these stocks have been subjected to any type of rigorous stock assessments, with the notable exceptions of English Channel populations of *Loligo forbesii* and *L. vulgaris* (Royer et al., 2002) and cuttlefish (*Sepia officinalis*; Royer et al., 2006) and *L. forbesii* in Scottish waters (Young et al., 2004). All these assessments were retrospective, using historical data, but effective management of fishing on annual species such as squid, for example, to ensure escapement of a sufficient number of spawners, arguably requires real-time assessment as carried out in the Falkland Islands for management of their squid stocks.

Abundance indices used in stock assessment are based on commercial landings and effort data. Using an index of abundance based on commercial CPUE, Royer *et al.* (2002) observed that abundance of squid species in the English Channel were strongly seasonal and patterns were relatively constant between years. Further, recruitment showed high inter-annual variability.

Royer *et al.* conducted a stock assessment of *L. forbesi* in 2002 and concluded that the biomass in the English Channel was below 50% of pristine. Additional analyses, also by Royer *et al.,* suggested that increasing fishing effort might result in decreasing yield suggesting that the stock was exploited beyond sustainable levels. Analysis of the *L. vulgaris* CPUE data resulted in similar perception of the state of this stock.

Effects of fisheries' actions on molluscs

Scallop

Scallop dredging has been identified as the large scale fishing method that has the biggest physical impact on the seabed (Jennings & Kaiser 1998). There has therefore been a great deal of concern about their use in certain habitats, and indeed in some quarters, calls for a total ban.

The effects of dredging on the scallops themselves will obviously be an immediate removal of the landed part of the catch, but also there will be a degree of damage to those scallops and other organisms impacted by the dredge but left on the seabed, and to those scallops and other organisms caught, but then discarded as too small to be landed or not being marketable.

The efficiency of capture of species and damage rates encountered by the dredging has been studied during the Ecodredge (Lart, ed 2003) project and previous work in the Irish Sea. These results showed that whilst the damage rates of most organisms left on the seabed was similar to those found in the gear, the efficiency of capture by the gear varied from 2% for starfish and whelks to 25% for edible crabs. Efficiency on scallops was around 19% which is similar to results found in the Western Channel by Dare et al (1993).

Efficiency of dredges on small scallops (<90 mm) has been reported as low as 3% (Beukers-Stewart *et al* .,2001) suggesting good selectivity, and the Ecodredge study found selective effects at the teeth and belly rings for spring toothed dredges. The implications of selection of scallops were also studied. The amount of stress as indicated by behavioural (Jenkins and Brand, 2001) and adductor muscle energy levels[1] (Maguire, *et al.,* 2002) experienced by the scallops was related the duration and intensity of agitation of the scallops in the dredge bag. There was very little stress found in scallops which had made a single encounter with the dredge, but shell damage appeared to be related to first contact with the gear and stress related to time in the gear. Short term mortality of post-encounter scallops exposed to scavengers was more closely related to shell damage than stress levels.

Measurements of selectivity showed that 85 mm belly rings would be optimal for selection of 100 mm scallops (the MLS in ICES Division VIIe) when new, however as the rings aged with commercial use and lost marketable scallops. The UK legislation implemented 75 mm belly rings, whilst some French fisheries use 85 mm and larger rings. The stress and damage studies referred to above suggest that the main benefit from selecting scallops on the seabed would be reduced stress, but that scallops were capable of surviving post discarding. Sub-optimal selectivity through the use of 75 mm ring results in increased stress in scallops, however the effects of stress on post-encounter mortality remains un-quantified.

Whilst this information has been used to implement belly ring and tooth spacing measures no attempt has been made to quantify the effects of selectivity, damage and stress on the scallop stock as a whole for lack of a stock assessment to apply them to.

Scallop dredging is particularly damaging to areas of reef where erect, sessile organisms are common, but regular intensive dredging will change the benthic composition of mixed gravelly and soft substrate too. However very high spatial variations in substrate type and hence communities can make detection of these changes difficult.

[1] As assessed by adductor muscle Adenylyl Energy Charge levels

During the last five years, in response to these concerns, a number of modifications have been trialled in an attempt to reduce the impact of the dredge. These include the use of individually spring tines and skids to raise the steel ring belly off the seabed. These have shown promise in reducing seabed impacts and fuel consumption. It is likely however that dredging for scallops will remain a high impact fishing method for the foreseeable future.

The only other fishery likely to impact on the scallop population is beam-trawling. However while there are by-catches of scallops made by beam-trawlers, these are at a low level relative to scallop dredging. Incidental damage to scallops is also minimal, especially when compared to dredging.

Oyster

Hand hauled oyster dredges are light and skim the surface of the seabed. Oysters and other benthic organism suffer little damage during the catching process and the survival of undersize oyster returned to the seabed can be considered close to 100%. There are no other mobile gears operating in the estuary. Prawn pots are set in some areas and it possible that the dredge fishery could potentially come into conflict with this static gear. There are no reports that this has happened in the past.

Mussel

There are no issues of fisheries effects on mussel beds under the current management regime. The intertidal mussel beds are worked by hand and the IFCA has the power to close the bed to fishing if it becomes depleted to a dangerous degree. No other fisheries impinge on intertidal mussel beds. The sub-tidal mussel bed off Portland is on hard ground and unlikely to be trawled.

Whelk

Whelks are a robust species and although no studies have been carried out in this area, it is unlikely that any mobile fishing gear will have a significant impact on whelks, which will largely pass unharmed through the meshes of trawls and dredges.

Known mitigation measures and whether they have been tested for efficacy in South West fisheries and whether they are considered relevant

Currently dredging is banned (along with other mobile gear) in the Special Areas for Conservation (SAC) in Lyme Bay and Falmouth Bay. More SACs and other Marine Protected Areas (MPA) are proposed in this area. Those so far indicated will restrict scallop fishing to some degree, especially for small vessels, but should not do so to a great extent.

These MPAs must protect scallop spawning populations to an extent, although there is no evidence that the areas closed constitute an important component of the spawning stock.

Any other widely known and published conservation issues related to this component. For example;

Endangered, threatened and protected status of the species.
Other effects of man's activities such as pollution or mineral extraction.

Ocean warming and cyclical climate phenomena such as the North Atlantic Oscillation, Russell Cycle.

All inshore bivalve mollusc fisheries in the area are subject to water quality issues, particularly within estuaries. It is difficult to predict how this will change in the future. Extreme weather events, which may become more frequent with climate change, can lead to overflow in the sewage treatment systems and so contaminate shellfish beds. This can lead to a temporary closure of the fishery Under the Shellfish Growing Waters Directive and, if frequent, the possibility of permanent closure.

Rising sea temperature will potentially have consequences for mollusc fisheries which may be positive as well as negative. There is some evidence that increasing levels of recruitment in scallop populations in recent years can be related to increased temperature (L. Murray, unpublished data).

The effects of invasive alien species are impossible to predict either in terms of further spread of those already present or new species accidently or deliberately introduced. Those already present include the Manila clam, which may compete with native species while at the same time forming a valuable fishery resource and the carpet sea-squirt, Didendum vexillum, which has the potential to smother shellfish beds.

A study by Challier *et al.* (2005) concludes that, as for several other species of squid, *L. forbesi* recruitment is mostly dependent upon environmental conditions such as temperature. Sims *et al.* (2001) demonstrated that *Loligo forbesi* movement is temperature-dependent, and appears to be governed by climatic changes associated with the NAO. Recruitment timing may be expected to vary as a result of global warming, as suggested for *Illex illecebrosus* (Dawe et al. 2000) and *Loligo forbesi* stocks in Scottish waters (Zuur and Pierce 2004).

A report on Cephalopods biology (ICES 2010) states that Cephalopods are both sensitive (in terms of rapid response) and resilient (in terms of recovery to perturbations) including overfishing and, potentially, climate change. It may, therefore, be difficult to distinguish between the effects of directional climate change and local climate variation, and indeed, as is the case for all exploited species, between these effects and the effects of fishing. However, the combination of sensitivity and adaptability of Cephalopods to climate variation makes Cephalopods potentially useful indicators of climate change.

The native oyster was once very abundant, but since the 18th century populations in Europe have declined to a tiny fraction of that level. The main causes are assumed to be disease and overfishing. It is likely that continued use of mobile gears on former oyster beds has prevented their recovery. There is a biodiversity Action Plan in place for the native oyster and there is much interest in schemes to restore native oyster habitat. Disease will always be a threat to oyster populations and to other bivalves particularly as animals are often moved around and relayed. Bio-security is a vital issue for bivalve aquaculture because of the potential for disease to impact on wild populations.

No other native mollusc species are currently considered to be endangered .

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Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem

Component 3: Additional advice on lampreys, elasmobranchs and endangered fish species

Jim Ellis, Alan Walker and Mike Pawson

2 August 2013.

Forward

This report is one of a series of reports prepared to provide the background information for a Scale, Intensity and Consequence Analysis (SICA) of the ecological impacts of South West fisheries in ICES divisions VII e,f,g and h as part of an Ecological Risk Assessment (ERA) of South West fisheries lead by SeaFish.

A SICA analysis is qualitative assessment of the potential impacts of fishing on the marine environment and forms the first stage of a prioritised and focussed ERA. A SICA analysis is a deliberately broad ranging analysis conducted as an initial screening to identify the predominant impacts of a specific fishery which should be carried forward for consideration by more detailed assessment, and identify which impacts can be screened out as less significant at an early stage.

These reports have been prepared as high level summaries of existing knowledge regarding the status of ecosystem components within in ICES divisions VII e,f,g and h and the impact of fisheries on these components. These reports are not expected to provide exhaustive of definitive reviews of the topics they address.

Taking a progressive risk-based approach to the assessment of the ecological impacts of fishing enables an efficient and directed analysis of the ecological impacts of fishing in support objectives for sustainable fisheries conducted within the ecosystem based approach to fisheries management.

Lampreys, elasmobranchs and endangered fish species

This report addresses some of the fish species that occur in the southwest marine ecosystem and are of conservation interest, including the following groups of fish:

- Lampreys (Family Petromyzontidae)
- Sharks, dogfish, skates and rays (Sub-class Elasmobranchii)
- Sturgeon (Family Acipenseridae)
- Shads (Family Clupeidae)
- Sea-horses (Family Syngnathidae)
- Gobies (Family Gobiidae)

More information is provided for elasmobranchs, as this group of fish are widely acknowledged to be vulnerable to the impacts of exploitation, they are a diverse and abundant group in the southwest ecosystem and many species are taken in commercial fisheries.

Various anadromous fish are also included (e.g. sturgeon, shad and lamprey), and whereas these species are also of high conservation interest, populations of such species are generally considered to have been impacted primarily by changes to their freshwater habitats, although there was past historical exploitation in some areas. European eel *Anguilla anguilla*, which is catadromous, is not included in this report, and the reader is referred to Defra (2010) and ICES (2012b).

Two species of sea-horse and two species of goby, which are listed on the UK Wildlife and Countryside Act (1981), are also discussed briefly. These small-bodied species are, however, less likely to be impacted by existing fisheries in the southwest ecosystem.

Lampreys (Family Petromyzontidae)

Introduction: Two species of lamprey occur in UK coastal waters; river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus*. Please note that the following summary is provided for lamprey in UK waters only. Both species probably occupy the coastal waters of France and Ireland included in the Celtic Sea region (ICES VII e to h) but are not reported here because of the lack of local information available at the time of writing. Relatively little is known about the marine habits of either lamprey species. Much of the following information is extracted from Maitland (2004), with updates from more recent literature where appropriate.

River lamprey typically reaches 30–35 cm length (maximum 50 cm) at age of 5-7 years. They live in coastal waters, estuaries and accessible freshwater. They spawn in flowing freshwaters in April-May, having returned from the sea in autumn to spring. The ammocoete larvae live in silt for 3–5 years, before they metamorphose into adult form and migrate to the sea, returning 1–1.5 years later to spawn. Sea lamprey is larger, often reaching 50–70 cm (maximum 86 cm) at age of 7–9 years. They also inhabit the sea, estuaries and accessible rivers, spawning in flowing freshwaters in June- July. The young ammocoete larvae live buried in sandy silt in rivers for 2–5 years before they metamorphose and migrate to sea, returning in spring-early summer to spawn after 3–4 years.

In both species, the ammocoetes feed on filtered organic material, whereas the adults in the sea feed on fish. Both species are indigenous to the British Isles (Maitland, 2004), and therefore can be expected in estuaries and marine waters of the southwest area. Both species are opportunistic in their parasitisation of prey species in the marine. Fluctuations in abundance of prey are likely to influence abundance and distribution of lampreys, and exploitation of prey species may affect lamprey abundance.

Current population status: Lamprey populations will be affected by threats in estuaries and freshwaters (including habitat loss, barriers to migration and pollution). Although there were historical fisheries for lampreys in UK waters, they are no longer of commercial interest. Population data are limited for either species. Both are listed as UK BAP species because of long-term population declines and that the few remaining populations are under threat (2007, updated 2010). More recently, summary reports on the status of Habitats Directive Species for Natural England (unpublished) suggest that short-term trends in both species are at least stable.

Effects of fisheries: Neither species has been reported as targeted catch or bycatch by UK vessels fishing in the southwest marine ecosystem, although they are presumably an occasional bycatch. Adults are only very occasionally captured in scientific trawl surveys, whilst juveniles have been captured by scientific surveys in the Severn Estuary (Division VIIf) using fine mesh sub-surface trawls in 2012 and 2013. As the gears used in these scientific studies have a finer mesh than used in commercial fisheries in the southwest, it is likely that lamprey are only very occasionally caught in commercial otter trawl. As both species attach themselves to fish in the sea, their capture in the marine might be most likely as an accident during the capture of target fish species. Their absence from catch landing statistics suggests that they detach themselves and evade fishing gears when their host is captured, or they are discarded after capture. Although lampreys are marketed in French and Iberian markets, there is presumably little or no market for them in England.

Mitigation measures: Given that lampreys are not reported in catch records, and most gears presumably have a very low catchability for lampreys, there are no obvious mitigation measures that would be relevant.

Management applicable: The UK has obligations under The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and the Habitats and Species Directive (Council Directive 92/43/EEC) to promote national policies for the conservation of wild fauna, paying particular attention to endangered and vulnerable species. Both species are listed in Appendix III of the Bern convention. Sea lamprey is listed in Annex IIa of the Habitats and Species Directive, whereas river lamprey is listed in Annexes IIa and Va. Both lamprey species are listed as Priority Species in the UK Biodiversity Framework (JNCC/Defra 2012), and are designated species for Special Areas of Conservation (SAC) (McLeod et al., 2007). In addition, sea lamprey is listed as threatened and/or declining species in the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Commission, 2006).

Sharks, dogfish, skates and rays (Sub-class Elasmobranchii)

The vulnerability of elasmobranchs is well documented (see Ellis *et al.,* 2008 and references therein). Given the range of elasmobranchs in the southwest marine ecosystem, they have been divided into four ecological groups: pelagic elasmobranchs, deep-water sharks, coastal sharks and dogfish, and skates and rays. The fisheries and their history are briefly described for each group and an indication of stock status and other management considerations are given, focussing mainly on those species that are caught regularly in the study area or of high conservation interest.

Historically, the value of commercial fisheries directed to elasmobranchs has ranked low in comparison with commercially important teleost species, such as herring *Clupea harengus* or cod *Gadus morhua*, and elasmobranchs as a group were lightly exploited until the middle of the 20th century. In the Northeast Atlantic, there have been some directed fisheries for elasmobranchs, but the majority of shark, dogfish, skate and ray landings are made as a bycatch from fisheries directed at teleosts. Management measures, through the quota system, were introduced slowly, commencing with TACs for basking shark *Cetorhinus maximus* and porbeagle *Lamna nasus* landed by Norwegian vessels fishing in EU waters (2000) to the more recent TAC introduced for skates and rays in the Celtic Seas ecoregion (2009).

International landings statistics on elasmobranch species are compiled by ICES and FAO, but only a small proportion of the landings by most countries have been reported by species. Total landings of elasmobranchs increased from 1950 to 1970 (in 1969 the total landings of all non-teleost fishes from the Northeast Atlantic was around 127,000 t out of over nine million t of all finfish). Since then, there has been a more or less continuous decline.

Some directed fisheries for elasmobranch species have developed rapidly, and there are numerous examples where, following a number of years of good fishing on a locally abundant part of a species' population, the targeted species was reduced to the extent that the fishery was no longer worthwhile (so-called "boom and bust" fisheries). Relevant examples are spurdog in the Irish Sea and deep-water sharks, where unconstrained fishing and overexploitation resulted in the introduction of zero TACs, thus stopping all target fisheries and leadings to discarding in some mixed fisheries.

Pelagic elasmobranchs

Pelagic sharks are well represented in the fisheries of the North Atlantic although only a few members of this group are identified to species level in early landings statistics, although species-specific recording has improved in recent years.

The main pelagic sharks that may be encountered in the southwest marine ecosystem are basking shark *Cetorhinus maximus*, blue shark *Prionace glauca,* porbeagle *Lamna nasus* and tope *Galeorhinus galeus*, which may also be taken in coastal fisheries. More detailed information is provided for these four species below, and all species are addressed in the reports of the ICES Working Group of Elasmobranch Fishes (ICES, 2012a).

Other pelagic sharks that are caught occasionally include thresher shark *Alopias vulpinus,* although there are limited data on this species in northern European seas. Shortfin mako *Isurus oxyrinchus* is also reported occasionally, but this species is more oceanic and some records may refer to misidentified porbeagle.

Other pelagic elasmobranchs in the North-east Atlantic include big-eye thresher *Alopias superciliosus* and pelagic stingray *Pteroplatytrygon violacea* (Thorpe, 1997; Ellis, 2007), but both of these species favour oceanic waters south of the British Isles and only a small number of vagrants have been reported from the waters around the British Isles.

Porbeagle Lamna nasus

Introduction: Porbeagle shark is a highly migratory and aggregating species that, in the Northeast Atlantic, occurs in continental shelf and shelf edge waters from Iceland and the Barents Sea to Northwest Africa. It is among the most cold-tolerant of the pelagic sharks, and can therefore range further north than other large pelagic sharks. There have been several studies on the biology of this species around the British Isles (Gauld, 1989; Lallemand-Lemoine, 1991; Ellis & Shackley, 1995; Pade *et al.* 2009; Saunders *et al.*, 2011).

Current population status: ICES' perception is of a depleted stock, estimated to be well below its historical high levels of the 1930s–1950s. Following the precautionary approach, ICES advised, in 2012, that a zero fishing mortality appeared the only option to allow recovery of the stock; that there should be no fishery, landings of porbeagle should not be allowed, and a rebuilding plan should be developed, noting that the time for recovery will exceed a decadal time frame.

Effects of fisheries: Porbeagle has been exploited commercially since the early 1800s, principally by Scandinavian fishermen, and was subject to a "boom" period over the period 1930–1965 in a directed fishery prosecuted by specialised Norwegian longliners. Landings reached a peak of about 6,000 t in 1947, when the fishery reopened after World War II, with a progressive drop in landings from 1953–1960. Norwegian landings decreased from 160–300 t/annum in the early 1970s to around 10–40 t/annum in the late 1980s/early 1990s. France and England started landing significant quantities of porbeagles in the 1970s. The main fishing grounds were in the Celtic Sea and Bay of Biscay, from where over 77% of the total French catch of 640 t recorded by all gears in 1993 was landed. In the late 1990s, porbeagle was landed by many European countries, including small quantities by the Channel Islands and the UK.

Management applicable: The porbeagle fishery lasted until the TAC was reduced to zero in 2010. Current regulations prevent target fisheries for porbeagle and although they remain a bycatch in certain fisheries, including offshore gillnet fisheries, the zero TAC means they are discarded.

Mitigation measures: Although there are no longer any target fisheries, they are an occasional bycatch in pelagic trawl fisheries, and also a seasonal bycatch in gillnet fisheries operating in the Celtic Sea (Bendall *et al.,* 2012). As a ram-ventilating pelagic shark, the bycatch in gillnets will often be dead. No studies on gear mitigation, although seasonal/spatial management could be considered.

Blue shark Prionace glauca

Introduction: Blue shark has a circumglobal distribution, and within the Atlantic is most often found between latitudes 50°N and 50°S. The North Atlantic stock is distributed northwards from 5°N. It is taken mainly as a bycatch in surface longline and gillnet fisheries for tuna and billfish as far south as the west coast of Africa, including the Bay of Biscay, Celtic Sea and south-western Ireland between June and September. It is placentally viviparous and has litters of about 25–63 pups. A characteristic of this species is their tendency to segregate temporally and spatially by size and sex, according to their respective processes of feeding, mating-reproduction, gestation and birth, which contributes to increased uncertainty in quantitative and qualitative assessments. The biology of blue shark in the southwest ecosystem was studied by Stevens (1973, 1974, 1975), and there are many other studies from other parts of its range (see ICES, 2012a).

Current population status: The latest assessment of the North Atlantic blue shark stock was in 2008, when ICCAT considered that the stock's biomass was above the level that would support MSY and current harvest levels were below F_{MSY}. However, it is reiterated that catch data remain highly uncertain, which has major implications for model outputs. ICCAT also carried out an Ecological Risk Assessment to assess the risk based on biological productivity and susceptibility to a particular type of fishery, noting that blue sharks were consistently the species with the lowest level of risk, as this species is more productive than many of the other sharks taken in pelagic fisheries (e.g. the various lamniform sharks).

Effects of fisheries: Blue sharks have been the target of recreational anglers from ports in south-west England since the early 1950s, though the catches taken by this fishery have fallen considerably since 1960. Blue sharks are also taken in a sport fishery along the southern and western coasts of Ireland, where it is estimated that anglers catch a minimum of 1,500 blue sharks per year. A small-scale longline fishery for blue and porbeagle sharks was started off the south coast of Cornwall in 1990. In 1994, six vessels registered in England and Wales accounted for 893 t of shark in a fishery mainly off the shelf edge in the Celtic Sea and west of Ireland.

Like many of the large pelagic sharks taken in directed fisheries or as a bycatch, blue shark is also likely to have been the subject of fisheries elsewhere. It is taken mainly taken as a bycatch in surface longline fisheries for tuna and billfish (e.g. swordfish *Xiphius gladius*) by Spanish and Portuguese fishermen as far south as the west coast of Africa, and also in the Bay of Biscay (VIII), Celtic Sea and south-western Ireland (VIIg–k), mainly between June and September. In the late 1990s, between 30 and 35 thousand t of pelagic sharks were landed from the swordfish fishery each year, with 85% of the landings comprising blue shark and 10% shortfin mako. In addition, France, UK and Ireland have had seasonal gillnet fisheries for albacore tuna beyond the slope of the continental shelf, in which blue sharks are taken as a bycatch.

Management applicable: Currently no spefcies-specific management measures are in place for blue shark. As a species for which the meat has traditionally been viewed as of low value, blue shark taken in high seas fishes were often finned. EC Regulation No. 1185/2003 (and amended 2013) prohibits the removal of shark fins and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

Mitigation measures: This oceanic and pelagic shark may be an occasional bycatch in pelagic trawl and may be occasionally taken in gillnets. As a ram-ventilating pelagic shark, the bycatch in gillnets will often be dead. The main part of the stock, however, occurs in oceanic waters.

Basking shark Cetorhinus maximus

Introduction: The basking shark population in the Northeast Atlantic is presumed to be a single stock, which may have connectivity with the western Atlantic and/or Mediterranean Sea and southern Atlantic. Basking sharks are long-lived, slow-growing and have a high age-at-maturity, population productivity is low, with low fecundity and a protracted gestation period, and the risk of depletion in reproductive potential is high. As a zooplanktivorous species, basking shark is known to forage in areas of high productivity, including fronts and other oceanographic features. Hence, the spatial and bathymetric distribution may be strongly influenced by environmental conditions. The biology of the basking shark was reviewed recently (Sims, 2008).

Current population status: ICES advised in 2012 that no population estimates or fishery-independent survey data were available and there was no basis upon which to alter the perception of the depleted nature of the stock. ICES considered that no targeted fishing for basking shark should be permitted and additional measures should be taken to prevent by catch of basking shark in fisheries targeting other species. Basking shark is listed as a species that is prohibited from being targeted or retained on-board EC vessels. There has been no fishery for basking shark since 1998 (UK) and 2006 (Norway).

Effects of fisheries: Several nations have exploited this species during their inshore movements in the warmer months, and the history of some fisheries in the Northeast Atlantic extends back hundreds of years. Norwegian fishermen have always been the major catchers of basking sharks in the Northeast Atlantic, initially using hand harpoons launched from small boats, then using non-explosive harpoons fired from small whale guns. In the last twenty years, catches of basking shark have varied considerably, partly due to the fishes' fluctuating local availability and market prices for liver oil.

Management applicable: Basking shark has been listed as a Prohibited Species on EC TAC and quota regulations since 2007. The basking shark has been protected from killing, taking, disturbance, possession and sale in UK territorial (12 mile) waters since 1998. They are also protected in two UK Crown Dependencies: Isle of Man and Guernsey.

EC Regulation No. 1185/2003 (and amended 2013) prohibits the removal of shark fins and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

The CITES, Appendix II listing of this species means that the exporting nation must document that the catch of basking shark is not detrimental to the stock. This species was recently listed on the Convention on the Conservation of Migratory Species of Wild Animals (CMS). This Convention aims to promote the collaborative management of migratory stocks and strict protection of threatened species. It has not yet been implemented in the ICES area.

Mitigation measures: This oceanic and pelagic shark may be a very occasional bycatch in pelagic trawl and may be occasionally taken in gillnets. They may also be snagged in the ropes associated with static gear. Implementing mitigation measures may be difficult for species which may only be encountered sporadically, although some fishers may avoid areas of seasonal aggregation.

Tope Galeorhinus galeus

Introduction: Tope is a bentho-pelagic species that is considered highly vulnerable to overexploitation, as it has low population productivity, relatively low fecundity (which increases with maternal length), and a protracted (possibly three year) reproductive cycle. It is also a long-lived species, with tag returns showing longevity of at least 36 years. There is thought to be a single stock in the Northeast Atlantic (ICES, 2012a).

Current population status: Tope is not encountered in fishery-independent surveys in sufficient numbers to determine trends in relative abundance, although landings have been relatively stable during the last two decades, albeit lower than in the late 1970s and early 1980s, and declined since 2002. The state of the stock is unknown and, in 2012, ICES advised that catches should be reduced by 20% in relation to the average of the last three years. ICES also advised that measures to identify pupping areas should be taken, which are thought to occur in certain inshore areas (e.g. the Bristol Channel). Protecting pupping and nursery habitats has been considered an important tool for the Australian tope stock, where seasonal closures and gear restrictions have been used to protect pregnant females when they migrate to pupping grounds.

Effects of fisheries: Currently there is no directed commercial fishery for tope in European waters, but they are taken as a bycatch in bottom trawl, gillnet and longline fisheries of all countries bordering the Northeast Atlantic, and especially by French vessels fishing in the English Channel, Western Approaches and northern Bay of Biscay. Preliminary studies have indicated that juvenile tope of 50–94 cm total length tend to be discarded in demersal trawl fisheries and larger individuals are usually retained. Tope caught in drift- and fixed-net fisheries are usually retained. Tope is an important target species in charter boat and recreational sea angling in several areas, with most anglers and angling clubs following catch and release protocols.

Management applicable: Under Council Regulation (EU) No. 43/2012 catches of tope taken with longlines cannot be landed and must be promptly released. The UK's Tope (Prohibition of Fishing) Order 2008 limits catches to 45 kg per day.

Mitigation measures: This shark is an occasional bycatch in otter trawl and gillnet fisheries, and juveniles may be occasionally taken in beam trawls. Spatial management has been used elsewhere in the world.

Demersal dogfish, catsharks and smooth-hounds

The main species in this group are spurdog *Squalus acanthias*, lesser-spotted dogfish (or small-spotted catshark) *Scyliorhinus canicula,* greater-spotted dogfish (or nursehound) *Scyliorhinus stellaris,* smooth-hounds *Mustelus* spp. and angel shark *Squatina squatina.* Collectively, landings of this group comprise around half the total weight of elasmobranchs taken from the Northeast Atlantic.

Spurdog, smooth-hounds and angel sharks are all viviparous, whilst scyliorhinid catsharks are oviparous, with eggs deposited on macroalgae and sessile invertebrates. Scyliorhinids and *Mustelus* spp. are often regarded as some of the more productive elasmobranchs. In contrast, spurdog and angel sharks are considered more susceptible to the impacts of overfishing.

Whilst there is an extensive time-series of species-specific landings data for spurdog, landings data for other dogfishes were often aggregated, with species-specific data only available for more recent years.

Spurdog Squalus acanthias

Introduction: By far the most important of the directed fisheries for elasmobranchs in the Northeast Atlantic have been those targeting spurdog (see Pawson *et al.* 2009), which is a widespread coastal and shelf species, moving in large packs, often segregated by size and sex, a behaviour that results in high variability in catch rates in the commercial fisheries and in surveys. The extensive migrations of this species can result in a group of fish being the target of a fishery in the English Channel or Western Approaches, and later the same group of fish can be taken in another fishery in the North Sea or off the west coast of Scotland. Spurdog is a long-lived, slow-growing, and late-maturing species, with low fecundity and a protracted (2-year) gestation period, and hence population productivity is low. In addition, aggregations of large mature females are easily targeted by longline and gillnet fisheries and it is, therefore, particularly vulnerable to exploitation. There is assumed to be one biological stock in the North-east Atlantic.

Current population status: Relatively good assessment data are available and ICES carried out a benchmark assessment in 2011 (see also de Oliveira *et al.*, 2013) showing that the stock suffered a high fishing mortality for more than four decades and the spawning biomass and recruitment have declined substantially since the 1960s and are now stable at a low level.

Effects of fisheries: Spurdog has been fished in England since the beginning of the 20th century. English and Scottish landings of spurdog remained between 6 and 10 thousand t annually from the mid 1950s to the late 1970s, with most catches being taken in two main fisheries: whitefish trawlers off the north and west coasts of Scotland; and a small fleet of inshore longliners in a seasonally directed fishery off the east coast of the UK. The Scottish landings of spurdog reached a peak in 1975/76, when over 10,000 t were reported; landings by English vessels working in the North Sea declined from over 4,000 t in 1981 to around 500 t in 1995; whilst there was peak of catches in the Irish Sea between 1985 and 1988, at 3-4,000 t each year, with landings falling below 1,000 t in 1995.

Norway had an inshore fishery for spurdog in the Norwegian Sea from at least 1930 and, after the Second World War, developed an extensive directed offshore long line fishery off the west coast of Norway in winter-spring (which shifted to the northern North Sea in the 1960s) and on the banks north of Scotland in summer-autumn. Norwegian landings of spurdog peaked at roughly 34 thousand t in 1963, when they accounted for 87% of the total European landings of the species. Though many Norwegian vessels were modernised with automatic baiting and handling systems for longline gear towards the end of the 1970s, spurdog landings continued to decline and catches in the North Sea fell below 1,000 t in 1996.

Although most other spurdog landings were taken as by-catch in otter trawls and seines aimed principally at whitefish, directed fisheries for this species continued to operate locally and seasonally. In the Celtic Sea, spurdog has been caught primarily by French trawlers, and by English and Welsh longliners and in fixed gill nets in the Bristol Channel and Irish Sea. Catches taken by French trawlers working from the Faeroes south to northern Biscay, and by longlining in the Celtic Sea and the western English Channel, peaked at 7–11 thousand t in 1981–84 and again in 1987–88, but had fallen to under 1,500 t by 1995. Landings from the North Sea, west coast of Scotland, the Irish Sea and west of Ireland also peaked in the mid 1980s, at around 6,000 t, but together amounted to just over 200 t in 1994. Overall French landings decreased from just under 15,000 t in 1983 to 1,760 t in 1993.

By the late 1990s, the main fishing grounds for spurdog were in the Norwegian Sea, North Sea, North-west Scotland and the Celtic Sea and landings were around 15,000 t per year.

Management applicable: Although a TAC was introduced in the North Sea in 2000, management was not thought to have been restrictive until 2007, when measures to deter targeting were introduced. ICES advice is that there should be no targeted fishery in 2013, catches in mixed fisheries should be reduced to the lowest possible level, and a rebuilding plan should be developed, noting that any stock recovery will be slow. In 2009, a maximum landing length (100 cm) was introduced in EC waters, to deter fisheries targeting mature females, though it will not impede females being discarded if they are harvested together with smaller individuals (< 100 cm). There is currently a zero TAC for spurdog.

Mitigation measures: Although there have been studies in the North-west Atlantic to examine the utility of grids to prevent capture of spurdog (Chosid *et al.*, 2012), there has been little consideration of mitigation measures in European seas. Given the aggregating nature of spurdog, bycatch in trawl and gillnet fisheries can sometimes be very high and unpredictable.

Lesser-spotted dogfish Scyliorhinus canicula

Introduction: Lesser-spotted dogfish *Scyliorhinus canicula* is common on all coasts (Ellis *et al*.,2005a), and contributes substantially to the mixed-species landings of 'dogfish' from the English Channel and Celtic Sea. As a small-bodied demersal species that is oviparous and with a relatively high fecundity, this is one of the more productive elasmobranchs in UK seas. Most of the landings in the UK are from the bycatch in towed demersal gears, usually in otter trawl and beam trawl mainly targeted at gadoids and flatfish, and they are also landed as a bycatch from some gillnet fisheries.

Current population status: The stock size indicator form the UK beam trawl survey is 31% higher in the last two years (2010–2011) than the average of the five previous years (2005–2009), which may indicate that the exploitation rate has declined. In 2012, ICES advised that current catches could be increased by a maximum of 20%. ICES did not advise that an individual TAC be set for this stock, at present.

Effects of fisheries: Although not often used for human consumption, some vessels land this species for use as bait for pot fisheries. Landings of lesser-spotted dogfish are not considered reliable, as an unknown proportion is reported under generic landing categories, and high levels of discarding may occur.

Management applicable: No species-specific management applicable.

Mitigation measures: Discard survival is generally very high for this species (Revill *et al.*, 2005; Rodriguez-Cabello *et al.*¸2005), and so the development of mitigation measures may be considered to be of low priority.

Greater-spotted dogfish Scyliorhinus stellaris

Introduction: This species is found on rough, even rocky grounds on inshore waters to the south and west of the UK (Ellis *et al*.,2005a), extending to the Mediterranean. Because it is comparatively scarce, in comparison to the lesser-spotted dogfish, it has only a minor contribution to commercial fisheries and there is very limited information on its status.

Current population status: The status of this species in unclear, as its patchy distribution on rocky inshore grounds means that it is not sampled effectively in existing fishery-independent trawl surveys (Ellis *et al.*, 2005b). It may be locally abundant in some areas.

Effects of fisheries: Although not often used for human consumption, some vessels land this species for use as bait for pot fisheries. Landings of greater-spotted dogfish are not considered reliable, as an unknown proportion is reported under generic landing categories, and high levels of discarding may occur. It may be a locally important species for recreational fisheries.

Management applicable: No species-specific management applicable.

Mitigation measures: It may be presumed that discard survival is generally very high for this species, based on studies of the related *S. canicula.*

Starry smooth-hound Mustelus asterias

Introduction: Two species of smooth-hound occur in northern European seas, common smooth-hound *Mustelus mustelus* and starry smooth-hound *Mustelus asterias,* with the latter species by far the more common in UK seas. Smooth-hounds are relatively productive elasmobranchs that may be important predators on brown crab *Cancer pagurus* and velvet swimming crab *Necora puber* in some areas.

Current population status: The relative abundance of smooth-hounds in trawl surveys has increased in the Celtic Seas since the mid-1990s, and the average catch rate in the last two years (2010–2011) is 42% higher than the average of the five previous years (2005–2009) in the Celtic Sea.

Effects of fisheries: They are taken as a bycatch in mixed demersal and gillnet fisheries, and are important species for recreational fisheries in some areas. Catches appear to have increased in recent years, a reflection, possibly, of increased abundance and/or improved marketing opportunities for the species (given the zero TAC for spurdog). Although ICES advised that catches could be increased by 20% in relation to the last three years' average catch. ICES also advised that, as exploitation is unknown, that catches should decrease by 20% as a precautionary buffer (corresponding to a total reduction of 4%).

Management applicable: No species-specific management measures.

Mitigation measures: Traditionally viewed as a bycatch species that has increased in importance in some areas in recent times. No published information available on discard survival. No mitigation measures are known, although similarly to tope, the protection of pupping and nursery grounds could be considered as a management measure.

Angel shark Squatina squatina

Introduction: Angel shark *Squatina squatina* is a large-bodied inshore shark species that has been rarely reported in recent landings data. There are also few recent records of captures of angel shark, although small local populations may exist in the Celtic Seas ecoregion, where the population is thought to be depleted.

Current population status: No information on current status available, although it is now rarely encountered on grounds where it was formerly abundant (Rogers & Ellis, 2000). In 2012, ICES advised on the basis of the precautionary approach that there should be no catches of angel shark, and that it should remain a species prohibited from being fished. Measures should be taken to minimize bycatch.

Effects of fisheries: The decline in angel shark is thought to be due to past over-fishing on local concentrations. French landings have declined from >20 t per year in the 1970s to less than 1 t per year prior to the prohibition on landings in 2009.

Management applicable: Angel shark is currently on the EU prohibited species list, and it is also listed on the UK Wildlife and Countryside Act (1981).

Mitigation measures: No mitigation measures in place. Given its sedentary nature and thick skin, it may have a high discard survival, but studies to confirm this are lacking. Inshore fisheries often have short tow duration or soak time, which in theory should maximise the chances of very occasional bycatch being released in good condition.

Skates and rays

Around 10 species of ray and skate (Rajidae) are regularly landed from north European waters, of which cuckoo ray *Leucoraja naevus* and thornback ray *Raja clavata* are the most important species landed by France, whose catches of Rajidae far exceed the declared landings of any other country. The main countries involved in these fisheries are Ireland, UK, France, and Spain, with smaller catches by Belgium and Germany.

Skates and rays are caught mainly as a bycatch in mixed demersal beam- and otter- trawl fisheries for roundfish and flatfish and in mixed gillnet fisheries, although there are some localized, seasonal fisheries targeting skates (e.g. *R. clavata*) using longline or tangle-nets, and some trawl fisheries target various skate species in the Bristol Channel. Size selection by trawl gears is minimal owing to the shape of rays. The traditional practice in most countries is for 4–5 species of rays to be landed together in particular size categories, rather than by species, which makes the collation of accurate quantitative landings data by species difficult. Historically, some segregation occurred on French markets, and French fisheries statistics are among the most detailed in Europe (in terms of reporting landings of skates and rays to species level), although there are some concerns over the accuracy of some of these data. In recent years, species-specific recording of skates has been introduced for nations fishing in the Celtic Seas and, although there are come concerns over the accuracy of some of these data (Iglesias *et al.,* 2010; ICES, 2012a; Silva *et al.,* 2012), it is providing improved species-specific information for most nations.

Advice on stock status and fishing prospects for skates and rays for 2013 and 2014 was given by ICES in October 2012. Due to the lack of species-specific historic landings data mentioned above, there were no analytical assessments, F_{MSY} was not defined for these species and biomass reference points have not been set. Instead, ICES used its approach to data-limited stocks to evaluate the general status of the major species based on trawl survey catch rates (for example, see Parker-Humphreys, 2004; Burt *et al*., 2013) although these surveys do not sample all the size classes and habitats for the various species. Specifically, the abundance trend is estimated from the change between mean survey catch rates in 2005 –2009 and the mean in 2010–2011.

In general, skates and rays are slow growing, have a late age-at-maturity, a low reproductive capacity, and are have a large size and shape that makes them vulnerable to most demersal netting gears. Because of this the larger-bodied species in particular are considered to be highly vulnerable to over-exploitation. Some species may be locally common and found only in specific areas. Historically, common skate was known to predate on individuals of smaller skate species, and the longer-term decline in the larger skates may have benefited populations of smaller skate species.

At present, fisheries on rays and skates are managed by means of a generic, multi-species TAC, along with prohibitions for some species, including the most severely depleted. In no case does ICES advise that an individual stock TAC could be set (at the current time), observing that restrictive TACs may lead to high discarding. Instead, the development of a suite of species- and fishery-specific measures such as closure to fishing of spawning and/or nursery grounds, and measures to protect the spawning component of the population (e.g. maximum landing length), are thought to be important in managing the fisheries on the commercial species and achieve recovery of the depleted species.

The following account provides information on the main species in the southwestern ecosystem. Other species of skate that are also found in this ecoregion include long-nose skate *Dipturus* *oxyrinchus* and there are some landings declared for starry ray *Amblyraja radiata*, although the latter species is not thought to occur in the study area.

Several others species of ray occur in the southwestern ecosystem, including stingray *Dasyatis pastinaca*, marbled electric ray *Torpedo marmorata* and electric ray *Torpedo nobiliana.* These species are all more common further south, and are generally discarded, and so are not included below.

Given the large shape and size of skates, they are susceptible to capture in many gear types. Although not established in northern European seas, some shrimp fisheries elsewhere in the world have used Turtle Excluding Devices (TEDs) to reduced capture of sea-turtles, and such grids are also thought to prevent the capture of batoids. There have been some studies on the discard survival of skates. In general, longline caught fish should have a good chance of survival. Inshore gillnet fisheries tend to have a short soak time, with a high discard survival for soak times of <30 h. The soak time in offshore gillnet fisheries is longer, and mortality will increase. About half of the skates taken in trawl fisheries may survive, although this will vary with species, size, sex, tow duration and the weight and contents of the trawl (Enever *et al.*, 2009).

Blonde ray Raja brachyura

Introduction: This large-bodied skate has a patchy distribution in the study area (Ellis *et al*.,2005a, 2011), with areas of high abundance in parts of the western English Channel (e.g. Channel Islands) and Bristol Channel. It is an important species for commercial fisheries. There are known identification issues between blonde ray and spotted ray (*R. montagui*) in landings and potentially in surveys.

Current population status: The state of the stock is unknown and there is insufficient information to present trends in species-specific landings for this stock. Although some survey catch rates are increasing, larger individuals are only encountered infrequently, which may be related to low gear selectivity for larger fish in the survey gear and that adults may occur around sandbanks. The surveys are, therefore, not appropriate for informing on stock status. In 2012, ICES advised that catches should be decreased by at least 20% compared to the last three years' average.

Effects of fisheries: See the introductory text.

Management applicable: This species is included within the generic 'skates and rays' TAC, although no species-specific measures are in place. Some inshore areas have a minimum landing size for skates (Rajidae).

Mitigation measures: See the introductory text.

Thornback ray Raja clavata

Introduction: Thornback ray *Raja clavata* is one of the more commercially-important ray species in the Area. It is mainly caught close to the eastern side of the Irish Sea by beam and otter trawlers, and in the Bristol Channel. Thornback ray is also the main commercial skate species in the North Sea and eastern English Channel.

Current population status: The VIIa,f stock has increased, with the abundance estimate (catch rates in the UK beam-trawl survey) in the last two years 35% above the previous five year average. There is no change in the length distribution over time. In 2012, ICES advised that catches could be increased by a maximum of 20%. The status of this species in the western English Channel is less well studied.

Effects of fisheries: See the introductory text.

Management applicable: This species is included within the generic 'skates and rays' TAC, although no species-specific measures are in place. Some inshore areas have a minimum landing size for skates (Rajidae).

Mitigation measures: See the introductory text.

Small-eyed ray Raja microocellata

Introduction: Small-eyed ray *Raja microocellata* is a medium-bodied skate species that is concentrated in the Bristol Channel (Ellis *et al*.,2005a), though larger individuals also occur in the Celtic Sea. There are also smaller areas of high local abundance in parts of the western English Channel (Ellis *et al*.,2011). It is unclear if these are discreet stocks or if there is a single stock in the area. It favours sandy substrates, including sand banks.

Current population status: The stock abundance estimate for the Bristol Channel (survey catch rates) in the last two years is 21% below the preceding five year average, although the longer-term trend has been increasing. Considering that exploitation is unknown, ICES recently advised that catches should decrease by a further 20% as a precautionary buffer. This results in a decrease of 36% in catches in relation to the last three years' average.

Effects of fisheries: See the introductory text.

Management applicable: This species is included within the generic 'skates and rays' TAC, although no species-specific measures are in place. Some inshore areas have a minimum landing size for skates (Rajidae).

Mitigation measures: See the introductory text.

Spotted ray Raja montagui

Introduction: Spotted ray *Raja montagui* is a small-bodied skate species that tends to occur on coarser grounds than some related species, although the juveniles also occur inshore (Ellis *et al*.,2005a). Catches of this species are widespread throughout the study area. There are known identification issues between *R. brachyura* and *R. montagui*.

Current population status: The stock has increased both in the short and the long term, and the UK survey catch rates in the last two years is 33% higher than the preceding five year average. In 2012, ICES advised that catches could be increased by 20%.

Effects of fisheries: See the introductory text.

Management applicable: This species is included within the generic 'skates and rays' TAC, although no species-specific measures are in place. Some inshore areas have a minimum landing size for skates (Rajidae).

Mitigation measures: See the introductory text.

Undulate ray Raja undulate

Introduction: Undulate ray *Raja undulata* is one of the larger-bodied species and is patchily distributed in inshore waters of the English Channel, where it may form a discrete stock (Ellis *et al*.,2012). It is most abundant on the grounds from the Isle of Wight to the Normano-Breton Gulf. There are also some smaller areas of high local abundance of south-west Ireland.

Current population status: Survey catch rates are low and highly variable, and ICES' perception of the stock is uncertain. ICES' advice is that there be no targeted fishery for undulate ray, and measures should be taken to minimize bycatch. Undulate ray has been on the EU prohibited species list since 2009, although ICES did not advise that this species should be listed as such.

Effects of fisheries: See the introductory text.

Management applicable: Undulate ray has been on the EU prohibited species list since 2009.

Mitigation measures: See the introductory text.

Sandy ray Leucoraja circularis

Introduction: Sandy ray *Leucoraja circularis* is one of the larger-bodied species that is caught in low numbers in mixed fisheries on the outer continental shelf. Survey coverage is insufficient to describe the stock status, and the biology of this species remains poorly known.

Current population status: Population status unknown. Since sandy ray is only frequently encountered in one contemporary survey (around the Porcupine Bank) where catch rates appear stable at low levels. In 2012, ICES advised that catches should be decreased by 20%.

Effects of fisheries: See the introductory text.

Management applicable: This species is included within the generic 'skates and rays' TAC, although no species-specific measures are in place.

Mitigation measures: See the introductory text.

Shagreen ray Leucoraja fullonica

Introduction: Shagreen ray *Leucoraja fullonica* is a large-bodied species that is caught in low numbers in mixed fisheries on the continental slope. Shagreen ray is now only regularly encountered in one survey, in which catch rates fluctuate but with an overall decline.

Current population status: Population status unknown. Since shagreen ray is only frequently encountered in one contemporary survey (Bay of Biscay and Celtic Sea), where catch rates appear to have declined, ICES (in 2012) advised that catches should be decreased by 20%.

Effects of fisheries: See the introductory text.

Management applicable: This species is included within the generic 'skates and rays' TAC, although no species-specific measures are in place.

Mitigation measures: See the introductory text.

Cuckoo ray Leucoraja naevus

Introduction: Cuckoo ray *Leucoraja naevus* is an offshore species normally caught by trawl rather than by inshore gill or tangle nets. It is widespread in the Celtic Sea and western English Channel, but less frequent in the inner Bristol Channel and in coastal waters.

Current population status: Abundance trends are variable, and though an increase of 12% in biomass (from a low level) is found in the Celtic Sea, the overall stock abundance is estimated to have decreased. ICES recommended a 20% decrease in catches in relation to the last three years' average landings, with a further 20% decrease as a precautionary buffer, considering that exploitation was unknown. This would result in a decrease of 36% in catches in relation to the last three years' average.

Effects of fisheries: See the introductory text.

Management applicable: This species is included within the generic 'skates and rays' TAC, although no species-specific measures are in place. Some inshore areas have a minimum landing size for skates (Rajidae).

Mitigation measures: See the introductory text.

Common skate complex Dipturus batis

Introduction: The common skate complex (*Dipturus batis*) is now considered to consist of two species (Iglesias *et al.,* 2010). The larger of the two is flapper skate *Dipturus* cf*. intermedia* and the smaller and, at least in the study area, more frequent, is the common skate *Dipturus batis* cf. *flossada* (Griffiths *et al.*, 2010; Bendall *et al.*, 2012). These species are slow growing, have a late age-at-maturity and low reproductive capacity, and are considered to be particularly vulnerable due to their large size.

Current population status: There has been a longer-term decline in the distribution of 'common skate' in northern European seas (Brander, 1981), and so ICES continues to advise that the common skate complex is depleted in the Celtic Seas, that there should be no target fishery for either species, and that measures should be taken to minimize bycatch. However, ICES did not advise that these species should be included on the prohibited species list.

Effects of fisheries: Commercial fisheries existed for the common skate in the past, but declining numbers now means that recent catches have generally been a bycatch, although there is some suggestion that catches have improved in recent years.

Management applicable: The common skate complex has been on the EU prohibited species list since 2009.

Mitigation measures: See the introductory text.

White skate Rostroraja alba

Introduction: The British Isles forms the northern limits of the distribution of this eastern Atlantic skate species. Reportedly one of the main skate species targeted in the English Channel during the 19^{th} century, but with very few recent records. It is thought to be near-extirpated from the area.

Current population status: Given the near absence of this species from recent data sources, the most recent ICES advice is that white skate remains on the Prohibited Species List.

Effects of fisheries: Thought to have declined due to over-fishing on areas of high local abundance (Rogers & Ellis, 2000; Ellis *et al*., 2010).

Management applicable: Listed as a Prohibited Species on the EC TAC and quota regulations. Protected in UK waters through the Wildlife and Countryside Act (1981).

Mitigation measures: See the introductory text.

Deep-water sharks

Introduction: Several species of deep-water shark occur along the shelf edge of the Celtic Sea, although the study area only includes a small section of suitable habitat, in the south-western corner of Division VIIh, and most of the main deep-water fisheries operate outside the study area.

The main deep-water sharks targeted were leafscale gulper shark *Centrophorus squamosus* and Portuguese dogfish *Centroscymnus coelolepis.* These species are long-lived with a low productivity, and so can only sustain very low rates of exploitation. As with other squaliform sharks, these species are live bearers and the pregnant female component of the stock can be particularly vulnerable to exploitation. Other squaliform sharks that have been reported include long-nose velvet dogfish *Centoscymnus crepidater*, gulper shark *Centrophorus granulosus*, kitefin shark *Dalatias licha,* birdbeak dogfish *Deania calcea*, great lanternshark *Etmopterus princeps* and velvet belly *Etmopterus spinax.*

Other deep-water sharks in the area include six-gill shark *Hexanchus griseus* and seven-gill shark *Heptranchias perlo* (Hexanchidae), and black-mouth catshark *Galeus melastomus* and other scyliorhinids. The latter family is more productive than the squaliform and hexanchiform sharks, and so may be considered less susceptible to the effects of exploitation.

Although deep-water sharks are infrequent on the main fishing grounds on the shelf of the study area, although there can be occasional captures of velvet belly and six gill shark on the outer continental shelf.

Current population status: In 2012, ICES provided information on stock status and catch history for individual deep-water shark species in the NEAFC Convention Area, with a view to defining specific management measures. Most species were considered to be data limited, being caught only as bycatch rather than in target fisheries, and a number of species have been reported in generic landings categories. It has not been possible to perform analytical stock assessments for the majority of these species, and a perception of stock status was given only in those cases where trends in survey indices and/or landings were available.

ICES gave separate advice for Portuguese dogfish and leafscale gulper shark for the first time in 2012. The perception is that the stocks of both species are depleted, and landings have declined in response to reduced abundance and restrictive management measures. ICES advice is that there should be no catches of Portuguese dogfish or leafscale gulper shark (as for 2011 and 2012).

Effects of fisheries: A deep-water fishery developed since 1990 along and beyond the continental slope in the Northeast Atlantic, generally in depths greater than 500 m and extending from Arctic waters south to the coast of Africa, although the focus here is on fisheries in or adjacent to the Area. This fishery targets species such as grenadiers (Macrouridae), argentines (*Argentina* spp.), and some 12 species of shark are caught regularly caught. The most significant landings of deep-water sharks have been by large French trawlers of leafscale gulper shark and Portuguese dogfish and, lately, black dogfish *Centroscyllium fabricii*. A Spanish longline fishery for deep-water sharks in waters deeper than 1,000 m started in 1991 whilst, more recently, longliners from Norway and trawlers and longliners from Scotland and Ireland have caught deep-water sharks. Both Portuguese dogfish and leafscale gulper shark (and other deep-water sharks) are an unavoidable bycatch in deep-water trawl, longline and gillnet fisheries. Fishing effort has declined since restrictions on deep-water fishing were put in place in 2007.

Six European countries have reported landings of longnose velvet dogfish *Centoscymnus crepidater*, including the UK from Subarea VII. Reported landings have declined to zero, probably as a result of the ban on deep-water gillnet fishing and reduced EU TACs for deep-water sharks. Four European countries have reported landings of velvet belly *Etmopterus spinax*, including the UK from Subarea VII. The UK landed 8 t in 2007 but has reported no landings since then. It is noted that very small landings of gulper shark *Centrophorus granulosus* were reported by UK vessels from Subarea VII since 2002, but these are considered to be misidentified. Reported landings of black dogfish *Centroscyllium fabricii* have been mainly from Division Vb and Subarea VI. There have been no reported landings by any country since 2008.

Management applicable: A zero TAC for deep-water sharks has been in place from 2010 onwards.

Mitigation measures: The zero TAC for deep-water sharks should deter fishing in areas of high abundance and will likely restrict the economic viability of deep-water longline fisheries. Deep-water sharks will also be taken in deep-water trawl fisheries and also in gillnet fisheries operating along the edge of the continental shelf. The discard survival in trawl fisheries is unknown, whilst the high soak times in some offshore gillnet fisheries likely results in high mortality of bycatch.

Atlantic sturgeon Acipenser sturio

Introduction: Atlantic sturgeon has declined throughout its European range, and spawning is now restricted to a few European rivers, such as the Gironde in France (e.g. Williot et al., 1997; Rochard et al., 2001). For the last 100 years it has been regarded as a vagrant in British Seas, although Wheeler (1978) noted that "*throughout the 19th century there were numerous records of its occurrence far up British rivers, the majority in May and June, while the remainder fell between April and October. This suggests that spawning may have taken place in larger British rivers at one time*". The decline in Atlantic sturgeon may be due to a variety of factors, ranging from over-fishing to degradation of estuarine and river habitats, including pollution, presence of locks and barriers and damage to spawning grounds (OSPAR Commission, 2006).

Current population status: The population has declined throughout its range, and would now be regarded as a very rare vagrant in British waters.

Effects of fisheries: Sturgeon has been very occasionally reported from the Bristol Channel and other parts of the south-west, where they may be taken as a very infrequent bycatch in coastal trawl and net fisheries. Although there are very few recent records, there are existing programmes in France to try and rebuild stocks, which some of these fish may range into northern European seas.

Management applicable: Given the conservation concern over Atlantic sturgeon, in 1992 it was legally protected on Schedule 5 of the Wildlife and Countryside Act (1981). It is also listed on Appendix I of the Convention on International Trade on Endangered Species (CITES).

Mitigation measures: Protected species, so should always be discarded if caught, but no specific mitigation measures in the southwest marine ecosystem

Shads (Family Clupeidae)

Introduction: Two species of shad occur in UK waters, the allis shad *Alosa alosa* and twaite shad *Alosa fallax.* Both species occur in coastal and shelf seas of the south-west (and elsewhere in European seas), and they migrate up rivers to spawn. *Alosa alosa* are thought to breed in the River Tamar and *Alosa fallax* known to breed in various tributaries to the Severn and in south-east Ireland, with adults of both species occurring in the study area (e.g. Aprahamian, 1988; King and Roche, 2008; Jolly *et al.,* 2012).

Current population status: The current population status is unknown. Although they have long been taken in commercial fisheries, they are not highly regarded food fish (Wheeler, 1978). The decline in shad has been linked to problems in river and estuarine ecosystems (e.g. pollution, obstructions and siltation of gravel spawning beds).

Effects of fisheries: Shad may be a bycatch in some coastal gillnet fisheries and they may also be an occasional bycatch of shad in otter and pelagic trawl fisheries.

Management applicable: In 1998, Allis shad was legally protected on Schedule 5 of the Wildlife and Countryside Act (1981), in terms of both Section 9(1) and 9(4a) whilst twaite shad was originally only protected under Section 9(4). In 2011, protection for twaite shad was extended to Section 9(1) as well.

Mitigation measures: Protected species, so should always be discarded if caught, but no specific mitigation measures in the southwest marine ecosystem

Sea-horses (Family Syngnathidae)

Introduction: Two species of sea-horse occur in the UK seas, short-snouted sea-horse *Hippocampus hippocampus* and spiny sea-horse *H. guttulatus.* Sea-horses occur primarily in coastal waters and are encountered at various locations off the southern coast of England (e.g. Garrick-Maidment, 1998; Stebbing *et al*., 2002; ICES, 2003; Garrick-Maidment *et al.,* 2010), which is towards the northern limits of their distributions. Data for the two species may also be confounded. The biology and distribution of sea-horses in the southwestern marine ecosystem are poorly known, although they likely associate with seagrass meadows and areas of high hydroid cover.

Current population status: Many sea-horses around the world have been exploited for the aquarium trade and as marine curios. The current population status is unknown, and it is not known to what extent they may have declined.

Effects of fisheries: Sea-horses may be a very infrequent bycatch in trawl fisheries, although their small size and cryptic body form and colouration means they may often be overlooked when examining catches. They may conceivably be taken in pot fisheries (OSPAR Commission, 2006). Data to estimate dead bycatch are lacking.

Management applicable: All sea-horses are listed on Appendix I of CITES and, in 2008, both short-snouted sea-horse and spiny sea-horse were legally protected on Schedule 5 of the Wildlife and Countryside Act (1981).

Mitigation measures: Protected species, so should always be discarded if caught, but no specific mitigation measures in the southwest marine ecosystem

Gobies (Family Gobiidae)

Introduction: Two species of goby are listed on the Wildlife and Countryside Act. Giant goby *Gobius cobitis* is a little-known species that is reported mostly from the intertidal zone and shallow sub-littoral waters from a few sites around southwest England, from the Isles of Scilly to Wembury in South Devon (Wheeler, 1993).

Couch's goby *Gobius couchi* is another very little-known goby that is reported mostly from the intertidal zone and shallow sub-littoral waters from a few sites along the coasts of southern England (e.g. Helford River and River Fal (Cornwall), and Poole Bay, The Fleet, Weymouth Bay and Portland Harbour) and Ireland, including Lough Hyne (Miller and El-Tawil, 1974; Minchin, 1988; Baldock and Kay, 2012).

Current population status: The current population status is unknown for both species.

Effects of fisheries: Given the apparent preferences of *G. cobitis* for intertidal and very shallow waters, and that Couch's goby is generally found in waters <15 m (Baldock & Kay, 2012), these species are unlikely to be impacted by existing fisheries. They may possibly be taken in pots deployed close to shore, but would presumably have a high chance of surviving when discarded.

Management applicable: In 1998, both giant goby and Couch's goby were legally protected on Schedule 5 of the Wildlife and Countryside Act (1981).

Mitigation measures: Protected species, so should always be discarded if caught. Although no specific mitigation measures in the southwest marine ecosystem, there would be a low spatial overlap with the main southwestern fisheries, although improved monitoring of fisheries in shallow coastal waters could be considered.

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Appendix: Future work

Sharks, dogfish, skates and rays (collectively termed 'elasmobranchs') are vulnerable to over-fishing and slow to recover from population depletion. In general, these species have a slow growth rate, late age at maturity and produce low numbers of young. Their aggregating nature also makes them vulnerable to capture in many fisheries. A number of species are targeted in commercial fisheries and others are a bycatch in mixed fisheries, where they may be retained or discarded. Populations of some elasmobranch species around the UK have changed over the course of the last century, some large-bodied species (e.g. white and common skate) having disappeared from areas where they were once common, and some stocks that were previously subject to target fisheries are now thought to be depleted (e.g. porbeagle and spurdog). In contrast, the populations of some of the more productive species have increased. Fisheries for some of these species have expanded in recent years, but it is unclear whether these fisheries are sustainable.

Cefas has recented begun a three year Defra funded project to better understand the current status of selected elasmobranch species, through:

- Working with commercial fishermen in the south-west to collect more robust data for spurdog, porbeagle, common skate and other elasmobranch species;
- Summarising which sharks, skates, rays and chimaeras occur in UK waters, prioritising species of conservation and commercial importance, and identifying important data gaps;
- Conducting field studies and biological investigations to better understand the ecology, life history and population status of selected elasmobranch stocks of commercial and conservation interest.

This work will provide evidence to assess the status of elasmobranch fishes around the British Isles, including their conservation and commercial importance, and address important data gaps in our current understanding of stocks of interest. These assessments will be used by Defra in support of national and international commitments in relation to stock assessments (through ICES), fisheries negotiations, the Defra shark plan, conservation of biodiversity (IUCN and Convention of Biodiversity), marine planning, and the Marine Strategy Framework Directive (MSFD).

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Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem

Component 4: Fish community structure

Will Le Quesne

19 July 2013.

Forward

This report is one of a series of reports prepared to provide the background information for a Scale, Intensity and Consequence Analysis (SICA) of the ecological impacts of South West fisheries in ICES divisions VII e,f,g and h as part of an Ecological Risk Assessment (ERA) of South West fisheries lead by SeaFish.

A SICA analysis is qualitative assessment of the potential impacts of fishing on the marine environment and forms the first stage of a prioritised and focussed ERA. A SICA analysis is a deliberately broad ranging analysis conducted as an initial screening to identify the predominant impacts of a specific fishery which should be carried forward for consideration by more detailed assessment, and identify which impacts can be screened out as less significant at an early stage.

These reports have been prepared as high level summaries of existing knowledge regarding the status of ecosystem components within in ICES divisions VII e,f,g and h and the impact of fisheries on these components. These reports are not expected to provide exhaustive of definitive reviews of the topics they address.

Taking a progressive risk-based approach to the assessment of the ecological impacts of fishing enables an efficient and directed analysis of the ecological impacts of fishing in support objectives for sustainable fisheries conducted within the ecosystem based approach to fisheries management.

A brief description of the component in this area

Fish community structure can be considered in relation to a number of different aspects, or measures, of community structure. This includes traditional measures of species biodiversity, such as species richness (the number of species making up the fish community) and species evenness, as well as structural measures of the community such as average trophic level or size based measures.

Species richness is of interest for describing community structure as the different species making up a community are the fundamental building blocks that community is comprised of. The species richness indicator also has relevance to biodiversity commitments under the Convention on Biological Diversity. Therefore species richness is one of the fish community indicators covered in this report.

However when considering the 'structural' aspects of fish communities the responses of traditional biodiversity metrics to fishing impacts can be inconsistent and are often not well understood (Bianchi et al. 2000; Piet & Jennings 2005; Trenkel & Rochet 2003). Therefore standard biodiversity metrics are not well suited to assess the impacts of fishing on fish community structure and alternative structural measures of fish communities and food webs have been proposed. Structural measures of fish communities and food webs are of note given specific commitments under the Marine Strategy Framework Directive (MSFD) to achieve Good Environmental Status in relation to ecosystem and food web structure.

Since the work of Pauly et al. (1998) on fishing down food webs the structural impacts of fishing on fish communities and food webs have been examined in terms of trophic indicators such as the Marine Trophic Index (MTI, Pauly 2005). But more recent studies have found that neither average trophic level of landings, nor the average trophic level of the ecosystem, track fishing pressure (Branch et al. 2010). Similarly the average trophic level of landings, such as the MTI itself, is highly sensitive to fisher's behaviour as well as ecosystem status and can provide a misleading impression of the development of the fish community over time (Essington et al. 2006).

In response, indicators based on size, in terms of the size of individuals making up the community or the potential size of species making up the community (i.e. their species' Lmax), have been proposed as an alternative framework to provide robust indicators of the effects of fishing on community and food web structure. Species' Lmax is a good proxy for life-history characteristics (Gislason et al. 2010) and therefore a species' sensitivity to mortality (Jennings et al. 1998; Reynolds et al. 2005), and fishing is a size selective process. Furthermore predator-prey relationships in aquatic environments are strongly size dependent (Jennings et al. 2001; Kerr & Dickie 2001).

Therefore the concept of size as a proxy for both exposure and sensitivity to fishing impacts is well grounded in theory, and comparative studies of the ability of indicators to show fishing signals have demonstrated that size-based indicators are responsive to the effects of fishing (Bianchi et al. 2000; Greenstreet & Rogers 2006; Jennings et al. 2002; Piet & Jennings 2005).

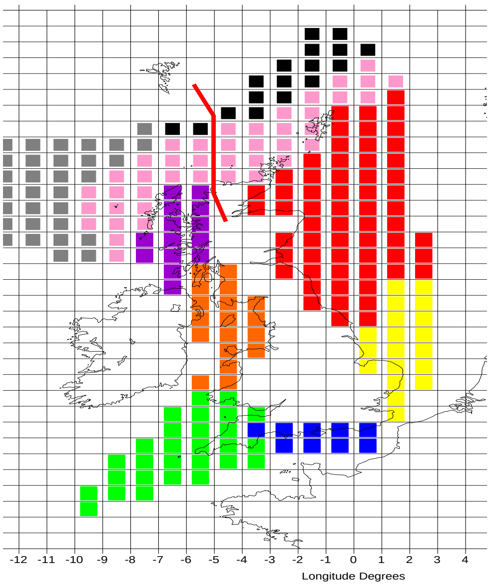
Two different size-based fish community measures are considered in this study, the Large Fish Indicator (LFI) and the Large Species Indicator (LSI). The LFI is the proportion of individuals (by weight) in a survey larger than a specified reference size. The species identity of fish is ignored and only the size of the fish is taken into account. In contrast the LSI is based on the maximum potential length of fish taken by a survey and takes no account of the size of individual fish at the time of sampling; the calculation of the LSI is just based on each species' maximum possible length. The LSI is the proportion of fish (by weight) from species with a maximum length larger than a specified reference size.

These two indicators, the LFI and LSI, give related but complementary information on the status of the fish community. The LSI indicates the proportion of the fish community that is made up from individuals of large species and is a size based measure of the species composition of the fish community. In the case of trophic structure of the community it is the actual size of the individuals in the community, and not their species identity, that is of more importance. The LFI is therefore a measure of the food web structure of the fish community (ICES 2012).

Fish community indicators are typically calculated from fishery-independent research surveys. The indicator values for community indicators such as species richness, the LFI and LSI are survey specific as they depend on the geographic area covered by a survey and the catchability at size of species by the survey gear. Therefore individual reference, or target levels have to be defined for each survey for each indicator.

To date there is no hard theoretical basis underpinning the selection of reference values for the indicators, where reference levels have been defined this was based on comparison with past baseline or reference periods. No reference levels have been agreed, or proposed, in relation to the fish community structure indicators considered in this study. Although a reference level has been specified for the North Sea LFI and has been adopted as the OSPAR EcoQO for the North Sea fish community. Similarly a reference level has been proposed for the Celtic Sea for the English West Coast Ground Fish Survey (WCGFS, Shepherd et al. 2011), however the WCGFS was discontinued in 2004.

Current population status in relation to recognised reference points or conservation objectives, if available, and any information on trends over time



The species richness indicators presented are based on three GOV otter trawl survey time series (Greenstreet et al 2012) covering the UK component of ICES VII efgh (Figure 1). The WCGFS operated in quarter 1 and provided consistent coverage from 1984 until the survey was stopped in 2004. Two more recent surveys have started in the Celtic Sea, both operating in quarter 4. The English South West Bottom Trawl Survey (ESWBTS) started in 2003 and the French Celtic Sea Ground Fish Survey (FCSGFS) which started in 1997.

Figure 1: Chart showing the Charting Progress II assessment regions used for calculation of the species richness indicator. Results are presented for the Western Channel and Celtic Sea region (green). Adapted from Greenstreet et al 2012

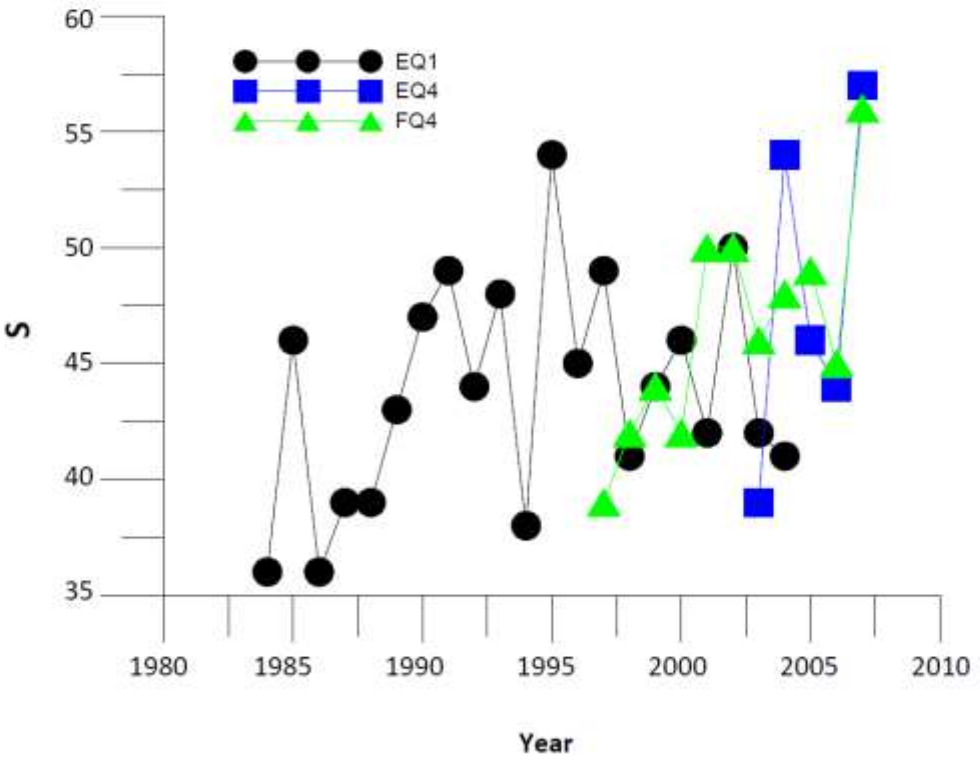


Figure 2: Species richness (S) in the Western Channel and Celtic Sea Charting Progress II region for the WCGFS (black), ESWBT (blue) and FCSGFS (green). From Greenstreet et al 2012

Although the three separate surveys show different year to year variation they all show similar long term trends in increasing species richness over time from the early 1980s through to the most recently analysed data (Figure 2).

Shephard et al (2011) calculated the LFI and the LSI for WCGFS survey covering the period from 1986 until the survey was discontinued in 2004. The survey predominantly covered ICES areas VII efgh but also partially covered VII j. Both indicators showed a general declining trend over this period indicating deterioration in the fish community structure both in terms of the trophic structure of the community and the species composition of the community (Figure 3).

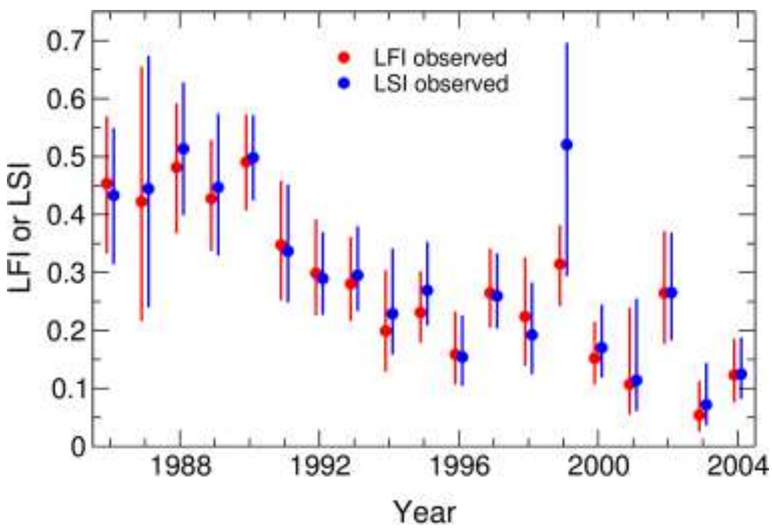


Figure 3: Time series of the LFI and LSI for the Celtic Sea WCGFS (dots). Lines indicate corresponding simulation results from a size-based ecosystem model. From Shephard et al 2012

Greenstreet et al (2012) calculated the LFI for the duration of the WCGFS and also the more recent period covered by the ESWBTS and FCSGFS. The ESWBTS and FCSGFS both show an increasing trend in the LFI from 2004 until 2008 (Figure 4). Greenstreet et al (2012) did not calculate the LSI so

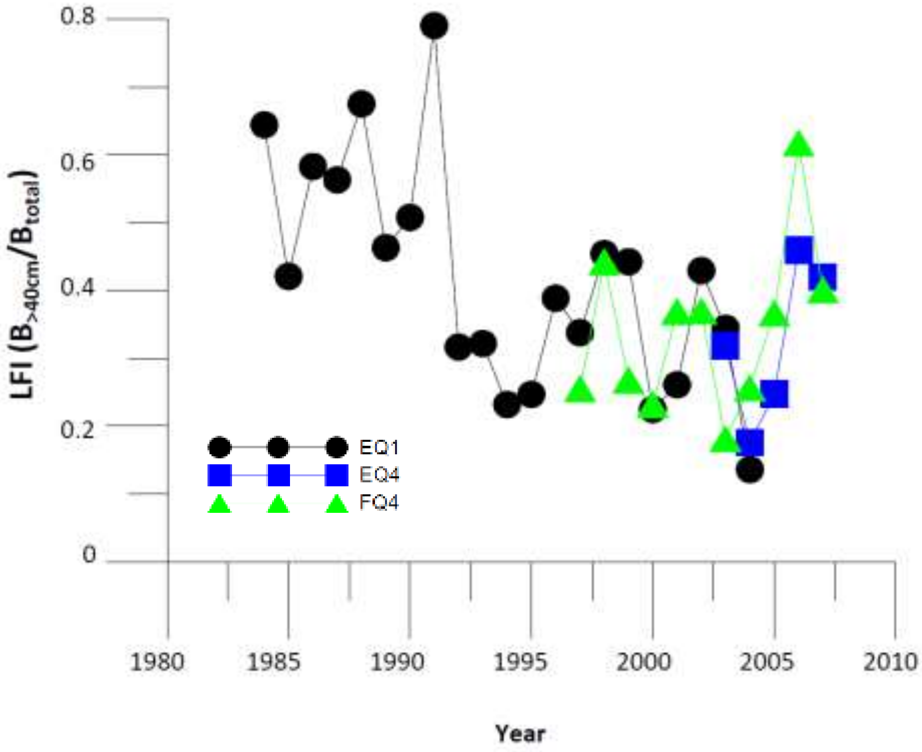


Figure 4: The LFI in the Western Channel and Celtic Sea Charting Progress II region for the WCGFS (black), ESWBT (blue) and FCSGFS (green). From Greenstreet et al 2012

it is not possible to determine whether the LSI would have shown a similar increase over this period.

As no reference points have been defined for these indicators it is not possible to evaluate whether the current condition of community status is favourable or otherwise. Species richness has shown an increasing tendency over the duration of the time series (but see below). The more recent data for the LFI indicates that it is improving, but that it is still below the condition observed in the mid 1980s.

Effects of fisheries' actions on the component, see below for list of fisheries and gears, this would include post-encounter mortality and indirect effects

The effect of individual fisheries on community composition and structure has not been evaluated. Indicators of community structure are normally interpreted in relation to the combined affects of all fisheries as a whole. It is not clear the extent to which it is possible to evaluate the impact of individual fisheries on fish community structure. Despite this caveat size based metrics of fish community structure are known to be particularly responsive to fishing, (Bianchi et al. 2000; Greenstreet & Rogers 2006; Jennings et al. 2002; Piet & Jennings 2005) and the trends on the LFI and LSI are likely to reflect the varying nature of the aggregate impact of fishing in the south west region.

The response of species diversity indicators, such as species richness, to changes in fishing pressure are less predictable (Bianchi et al 2000), and species diversity can be sensitive to changes in environmental conditions (see below). Therefore the increasing trend in species richness in the south west region may be driven by changing environmental conditions rather than fishing pressure. However given the sensitivity of some fish species to fishing mortality fishing could cause declines in target or non-target species (Le Quesne & Jennings, 2012). Initial analyses indicated that up to 40% of the species in the Celtic Sea are potentially at risk of being exposed to unsustainable levels of fishing mortality (Le Quesne & Jennings 2012), however more focussed analyses would be required to establish whether actual fishing impacts do occur in accordance with the identified risk.

Research into the relationship between fishing pressure and fish communities, and the impact of individual fisheries on fish community metrics is on-going in relation to understanding the requirements of the MSFD. Therefore it may be expected that over the next few years greater more specific information will become available in relation to effects of individual fisheries on community structure and advice on mitigating measures proposed.

Known mitigation measures and whether they have been tested for efficacy in South West fisheries and whether they are considered relevant.

Fish community structure and composition are generally considered in relation to the aggregate impact of fishing activities, therefore specific mitigation measures have not been proposed to reduce the impact of fishing on community structure beyond a general reduction in fishing pressure. Whilst a general reduction in fishing pressure lead to an improvement in metrics of fish community structure it has been proposed that there could be a lag of 10 years or more between the change in fishing activity and the corresponding change in the community status (Shephard et al 2011, Greenstreet et al 2011).

In the case of species richness, if declines in individual species are identified and attributed to specific fisheries, mitigation measures can be proposed. This may include proposed gear modifications, spatial or temporal closures or measures related to handling practices to improve the survival of individuals caught and returned to the sea. Analyses considering all species within the fish community have not yet been conducted.

Any other widely known and published conservation issues related to this component. For example;

Ocean warming and cyclical climate phenomena such as the North Atlantic Oscillation, Russell Cycle

The comparative sensitivity of species richness to changes in community average fishing pressure and water temperature was evaluated by Hofstede et al (2010, Figure 5). They concluded that the observed increase in species richness in the Celtic Sea was predominantly driven by increasing abundance of southern warm water associated Lusitanian species in the region. In contrast analyses of the relative response of size-based metrics of community structure to changes in temperature and fishing pressure have concluded that size-based metrics are more response to fishing pressure (Blanchard et al 2005), therefore the observed changes in the LFI and LSI are likely to be driven by fishing activity in the Celtic Sea.

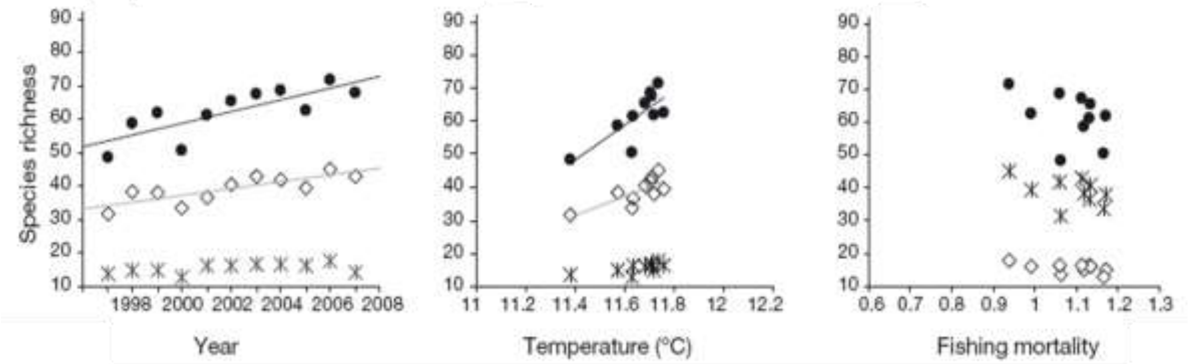


Figure 5: Changes in species richness in the Celtic Sea (VII ghj) i) over time, ii) in relation to temperature, and iii) in relation to fishing pressure for all species (dots), northern boreal species (crosses) and southern Lusitanian species (open diamonds). From Hofstede et al 2010

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Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem

Component 5: Discarding in the south west

Tom Catchpole

30 July 2013.

Forward

This report is one of a series of reports prepared to provide the background information for a Scale, Intensity and Consequence Analysis (SICA) of the ecological impacts of South West fisheries in ICES divisions VII e,f,g and h as part of an Ecological Risk Assessment (ERA) of South West fisheries lead by SeaFish.

A SICA analysis is qualitative assessment of the potential impacts of fishing on the marine environment and forms the first stage of a prioritised and focussed ERA. A SICA analysis is a deliberately broad ranging analysis conducted as an initial screening to identify the predominant impacts of a specific fishery which should be carried forward for consideration by more detailed assessment, and identify which impacts can be screened out as less significant at an early stage.

These reports have been prepared as high level summaries of existing knowledge regarding the status of ecosystem components within in ICES divisions VII e,f,g and h and the impact of fisheries on these components. These reports are not expected to provide exhaustive of definitive reviews of the topics they address.

Taking a progressive risk-based approach to the assessment of the ecological impacts of fishing enables an efficient and directed analysis of the ecological impacts of fishing in support objectives for sustainable fisheries conducted within the ecosystem based approach to fisheries management.

A brief review on R&D on discard mitigation in south western waters

Discards are the portion of a catch which is not retained on board during commercial fishing operations and is returned, often dead, to the sea. Cefas has recently completed an in depth research project into the practice of discarding. The project 'Practical steps to reducing discards' had a central objective to develop technologies and strategies which minimise discarding to the practicable minimum across English fishing fleets. During the period of the project (2008-2013), and in part, due to the success of the project, the issue of discarding has grown in profile in the media and with the public, becoming a priority issue for the UK government and the EU administrations. Outputs from this project, alongside the Cefas Fisheries Partnership Programme and work conducted by Seafish and the Marine Management Organisation, have influenced and shaped regulation, policy, attitudes and behaviour towards discards. In the 2013 reforming of the Common Fisheries Policy (CFP) an approach to end discards has been agreed, which benefited from much of what is presented below.

The Cefas research project was substantial; it consisted of forty self-contained but related modules. Here, a summary of the relevant components of the project are provided. This section is structured into three main topics; within each there is a description of the objectives, approaches, results and outcomes from the modules relating to that topic. It includes outputs from the Cefas research project and studies from other organisations where specified:

1. Understanding discards: using empirical data; using social data
2. Applying practical solutions: through gear technology research; through pilot projects
3. Influencing and evaluating policy

The Cefas project was inclusive with contributions from many other organisations including Seafish, Defra, MMO, IFCAs, ICES and science institutes (DTU-Aqua, IFREMER, IMARES, IEO, MATIS and ILVO). At its heart, was the collaboration with the fishing industry; practical fieldwork was conducted with 102 fishing vessels and partnerships were forged with many fishing industry organisations and companies including NFFO, SWPO, NUTFA, Hastings Fishermens Protection Society, Brixham Trawler Agents, UFI Fish Industries, Plymouth Trawler Agents, North Shields Fish Quay and Interfish.

The work has been disseminated widely through online reports, scientific publication and in the media (Channel 4 'Fishfight', BBC2 'Fishermen's apprentice') and through numerous presentations (e.g. ICES, Coastal Futures, Discard Action Group, Defra). The project also successfully attracted matched funding and added value projects funded through the European Fisheries Fund, Fisheries Challenge Fund, Seafish, Keo films and Marish ERA-Net.

Understanding discards

Empirical data

The Cefas research project aimed to understand more of the patterns, extent and drivers of discarding with a view to identifying appropriate mitigation measures and was made up of three main bodies of work:

1) *Identifying trends in fleet discarding patterns*
2) *Describing the composition, rates and length frequency of discards by fishery and species*
3) *Identifying the drivers of discarding*

Overview of methods

Research into the extent, composition, trends and drivers of discarding was based on information derived from the Cefas Observer Programme. The Cefas Observer Programme has monitored catches of fishing vessels registered in England and Wales since 2002. Scientific at-sea observers currently sample 200-250 trips and around 1,200 hauls each year on English and Welsh vessels, in which ~350,000 fish are measured, representing 0.5–1% of the total fishing effort. It is from these data that estimates of discards are generated for inclusion into the fish stock assessment process. The discard data were used in combination with measures of fishing effort and landings data from official EU logbooks completed by fishers. In these analyses, gear descriptions were merged into four general populations of gear groupings to reflect the main fisheries: beam trawl, otter trawl, Nephrops trawl and gill/trammel nets. Sampled trips were available from four fishing grounds based on the DCF definitions (ICES subdivisions IV&VIId, VIIfgh, VIIe and VIIa).

The participation by skippers in the observer programme is voluntary. Vessels are randomly selected each quarter. Length measurements are taken from all fish species, commercial crustaceans, and cephalopods (mostly squid and cuttlefish). Numbers-at-length are raised to haul, then to trip, and length–weight relationships allow estimated weights to be calculated. A novel bootstrap method was developed and applied to ascertain 90% CIs around the estimates.

Identifying trends in fleet discarding patterns

To assess performance against the Defra objective to minimise discarding, the project team were tasked with developing a robust statistical measure to chart progress in minimising discards. There was an equivalent EC objective to monitor progress toward the objective of eliminating discards. Research was conducted within the ICES Workshop on ecosystem indicators of discarding (WKEID).

Indices of discards were successfully developed for the purpose of illustrating temporal changes in discard patterns in the English and Welsh fishing fleet. This work delivered:

- A discard quantity index to monitor the annual changes in total quantity of discards with associated confidence intervals (Figure 2a).
- A discard rate index and discard proportion indices to monitor how discarding behaviour during fishing operations changes with time (Figure 2b).
- It demonstrated that there had been a reduction of 61% between 2002 and 2008 in the weight of discards observed (Catchpole and Gray, 2011).
- The reduction in discards was due to the reduced fishing effort (number of fishing vessels operating and allocated fishing time) rather than improvements in the selectivity of fishing practices (Catchpole and Gray, 2011).

Describing the composition, rates and length frequency of discards by fishery and species

These data are presented within this report in the agreed format.

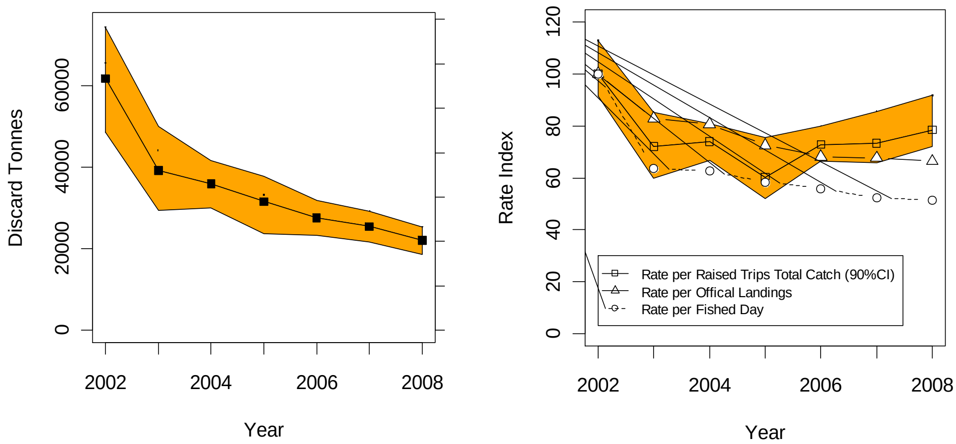
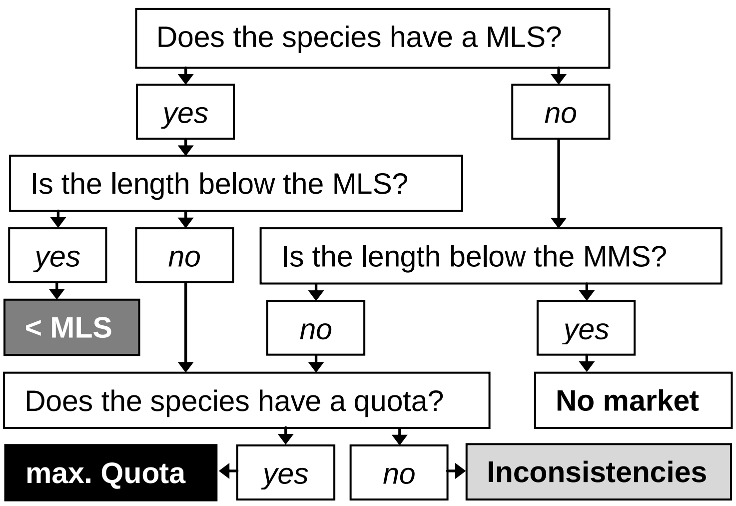


Figure 1: Discard quantity index (a); discard rate indices (b)

Identifying the drivers of discarding

A novel method was developed that made inferences on the causes of discarding by partitioning discards into four categories based on the length of the fish and the associated legislative restrictions (Figure 2). The drivers were defined as; fish discarded below the legal minimum landing size; fish for which there is no market; fish for which there are inconsistencies in market and sorting practices; and the maximum of discards that attributed to fishermen's responses to quota restrictions. The method was applied to all data from the English Observer programme and some data generated from observer programmes from five other Member States (Catchpole et al., submitted).

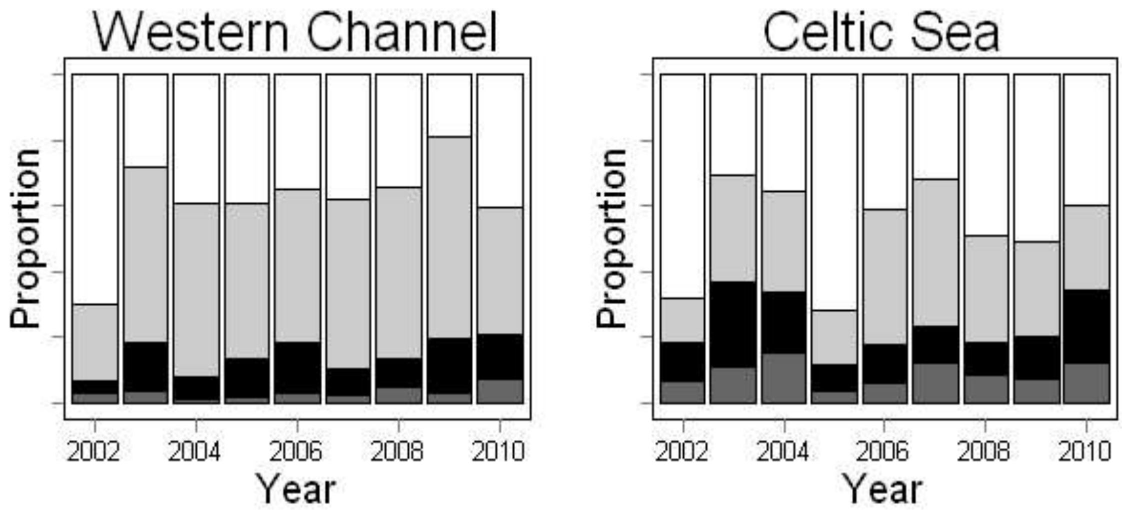
Figure 2: The decision tree used in the analysis to categorize the at-length discards estimates to infer the four drivers of discarding



For all the English fisheries, the mean contributions to the total discard weight from each of the drivers remained relatively constant between 2002 and 2010; 17% were of fish under MLS, 37% were of fish for which there was no market, 24% attributable to inconsistencies in markets and sorting and 22% of discards were attributed to the maximum amount of quota derived discards.

Each of the four drivers, therefore, made a substantial contribution to the total discard quantity when examined at a national fleet level.

Figure 4: Annual proportionate contributions to the total of fish and commercial cephalopods and crustaceans discarded in ICES VIIe (Western Channel) and ICES VIIfgh (Celtic Sea) attributed to each of four inferred drivers (2002-2010).: maximum quota (black), <MLS (dark grey), no market (white) and inconsistency of market (light grey)



The contributions of the discard drivers are the fishing grounds of ICES VIIe (Western Channel) and VIIfgh (Celtic Sea) were dominated by market forces, with discards driven either by an absence of a market or inconsistencies in the market, and this was relatively constant (Catchpole et al., submitted).

Table 1: Mean proportion contributions of the four inferred drivers to the total discard quantity for selected combinations of area, country, gear and species

Period	Sampled trips	Species	Gear	Fishing area	<MLS	No market	Inconsistencies	max. Quota
2002-10	515	all	TBB, OTB, GNS	VIIe	0.03	0.38	0.48	0.11
2002-10	138	all	TBB, OTB, GNS	VIIfgh	0.09	0.46	0.3	0.15

The outputs from the project included detailed numerical descriptions of the discard patterns of the English fishing fleet. The extent of discarding, the change in discard patterns over time, the composition and rates of discarding and the reasons for fishermen discarding catches have been delivered. The work showed which species are discarded in the highest quantities and by which fisheries, and the relative importance of legislative and market drivers behind discarding behaviour. The work has demonstrated that area-fishery-species patterns need to be considered when identifying and evaluating discard mitigation measures.

Social data

Three pieces of work were commissioned to provide actionable insights into fishers discarding behaviours in specific English fisheries where discarding was considered to be high, while a fourth study provided an analyses of these and other European case studies within a European project (Badminton - Bycatch And Discards: Management INdicators, Trends and location. Another project was conducted within the Cefas Fisheries Partnership Programme (FSP) on fully documented fisheries.

1. Project 50 Per Cent: A Cefas project to reduce discards amongst Devon beam trawlers by 50% (CorporateCulture, 2009).
2. Scoping Study: actionable insight into discarding behaviours of trawlermen in the North East. Final Report to Cefas and Defra (McArthur and Howick, 2010).
3. Actionable insight into the discarding behaviours of fishermen in the North West (CorporateCulture, 2010).
4. Socio-economic and institutional incentives influencing fishers behaviour in relation to fishing practices and discard (Eliasen et al., in press).
5. Scoping industry approaches to fully documented fisheries[1]

The aim of the research in 1-4 was to gain insight into the attitudes and behaviours of fishermen in specific fisheries towards the issue of discarding and to develop actionable insights and recommendations on potential mechanisms for changing discarding behaviour in the future.

In the Project 50 per cent, social study responses were consistent between crew, skippers and owners.. In summary, Devon beam trawl fishermen had a strong sense of community and were frustrated at the poor public perception of their occupation. All say they are working more days, shorter-handed and for relatively less money than twenty years ago. Fishing is still a dangerous occupation, with all interviewees having lost a close friend or relative at sea.

There was considered a need for improved communication in every area and by every audience. This is a key weakness and unless addressed, was thought would hinder the success of any new innovations or programmes to reduce discards. It was stated that it was entirely appropriate that Cefas technical information and other scientific trials are written up as 'academic' reports for scientists and experts. However, they must also be produced in a format that is relevant and digestible. There was strong support for a programme of fishing gear trials which should include experiments with mesh size to optimise the escape of juvenile fish. The success of trials should be publicised widely, and with positive coverage in the media; it is possible to achieve over 50% discard reduction in this fleet.

These insights were acted upon through the initiation of Project 50% (Armstrong and Revill, 2010); (described below). The reports from all three studies are available online and the work will also be published in the scientific literature (Eliasen et al., in press).

In a collaborative Fisheries Science Partnership (FSP) project, the National Federation of Fishermen's Organisations (NFFO) and Cefas sought to scope industry-led approaches to Fully Documented Fisheries. The proposed reform to the Common Fisheries Policy (CFP) sets out a move to a land-all catch policy for EU fishing vessels, with a requirement for full reporting of fishing and onboard processing activity. Recent trials in several Member States for 'Fully Documented Fisheries' (FDFs)

[1]Dolder, P. J., Mangi, S.C., Catchpole, T.L., Rodmell, D., Deas, B. and de Rozarieux, N. Scoping Industry Approaches to Fully Documented Fisheries. Fisheries Science Partnership 2012-2013. Final report. 76 pp. http://www.cefas.defra.gov.uk/industry-information/fisheries-science-partnership/current-programme.aspx

operating with catch quotas have demonstrated how Remote Electronic Monitoring (REM) technology can be utilised to deliver the monitoring requirements for FDFs.
Both the fishing industry and fisheries managers recognise that REM may not be suitable for all fisheries, so there is a need to evaluate REM alongside other approaches to documenting activity, such as observers, self-sampling and self-reporting reference fleets, so that each approach can be assessed in terms of its suitability and applicability to different fisheries. The project had four main objectives; (i) evaluate the data required to deliver FDFs; (ii) establish the mechanisms available to collect the data required for FDFs; (iii) assess the relative strengths and weaknesses of different approaches and supporting technologies; and, (iv) consider whether different fishery characteristics might benefit from different FDF approaches.

To achieve these aims, the project team (i) completed a literature review of available approaches and technologies, establishing a matrix of strengths and opportunities, weaknesses and threats (a SWOT analysis); (ii) identified and examined three case study fisheries with different characteristics (trawl/net, inshore/offshore) through semi-structured interviews with fishermen and other stakeholders; and (iii) organised a workshop of invited expert stakeholders including fishermen, scientists, regulators and practitioners to gather views on approaches, the barriers that exist and the incentives that are necessary for effective implementation of FDFs. Two of the three case study fisheries were in the south western waters region; the inshore (<15 m) trawl fishery and the offshore (>15 m) gillnet fishery.

Practical solutions

Several recent stand alone gear technology trials have been conducted, two of which were conducted within Cefas research projects; the others within the Cefas Fisheries Science Partnership (FSP) and by Seafish:

1. Survival of discarded ray in trawl fishery (Enever et al., 2009)
2. Roller ball beam trawl (Seafish)
3. Hake gillnet selectivity (FSP)[2]
4. Red Mullet gillnet selectivity (FSP)[3]
5. Beam trawl benthic release panels[4]

Survival of discarded ray in trawl fishery

Gear modifications were investigated as a means to increase the survival, and reduce the discarding of rays, recognising the vulnerability to over fishing for this group of species. 100mm diamond mesh and 100mm square mesh were compared against the standard, 80mm diamond mesh codend aboard a twin-rigged trawler, in the Bristol Channel. Small-eyed rays (*Raja microcelata*) were kept on board in aquarium tanks for condition/survival studies, to determine which gear was the more favourable for maintaining 'good' specimen condition. Both experimental codends successfully reduced discards with no major loss of commercial species. The 100mm diamond mesh codend

[2] A. Revill, J. Cotter, J. Ashworth, R. Forster, G. Caslake, M. Armstrong, Final Report, Fisheries Partnership Programme 8, 2005/06: Hake selectivity http://www.cefas.defra.gov.uk/media/38031/fsp-2005_06-prog-8-hake-selectivity-final-report.pdf
[3] R. Forster, S. Smith, Final Report, Fisheries Partnership Programme, Selectivity of Gillnets used in the Cornish Red Mullet Fishery http://www.cefas.defra.gov.uk/media/464417/fsp%202010_11redmulletselectivityreport_final.pdf
[4] Revill, A. S. and S. Jennings (2005). "The capacity of benthos release panels to reduce the impacts of beam trawls on benthic communities." Fisheries Research (Amsterdam) 75(1-3): 73-85.

reduced discarding by 72% with a -3% difference in the catch value. The 100mm square mesh reduced discarding by 68% with a +1% difference in the catch value. The experimental trawls increased the chances of ray survival (59-67% compared with 56%). As codend weight increased, the health of rays decreased. Females were healthier than males and larger fish were healthier than smaller ones.

Roller ball beam trawl

Seafish, working with part of the team responsible for the Cefas 50% discard project trialled the innovative roller ball footrope. Unlike traditional beam trawl gear the roller ball system involves replacing the standard hopper footrope with rubber rollers. This allows the trawl to roll across the seabed as opposed to being dragged so reducing ground impact. During the seven day trial a standard trawl was towed on one side of the vessel and compared with the concept roller ball towed on the opposite side. Initial results show that the roller ball system reduces the impact and overall drag on the seabed and unwanted benthos. Initial findings suggest that the roller ball process has provided somewhere between 14% and 20% reduction in the towed weight of the gear.

Hake gillnet selectivity

Selectivity characteristics of 120mm mesh gill nets used by UK hake fishermen off the south west coast of England were investigated. The experiment was carried out by comparing the catches in nets of mesh size 80, 100, 120 and 140mm deployed simultaneously at two fishing grounds. Additional 120mm nets were shot to obtain further data on size composition of hake. The work was carried out in October and November 2005, using the vessel Carol H.

Hake taken by the 120mm nets were mainly in the length range 60 – 90cm. This contrasts markedly with the international fishery landings in 2004 which is predominantly fish of a much smaller size. It was concluded that the 120mm mesh gill nets used by UK hake fishermen in the south west are optimum in terms of their catch rates of hake in the 60 – 100 cm range and their low selectivity for hake < 60cm long.

Red Mullet Gillnet Selectivity

This project provided an analysis of the catch compositions made by 63, 68, 75, and 80 mm mesh gillnets deployed in Falmouth Bay, off southern Cornwall in late 2010. The fishing trials took place over 20 days in November and December, using the vessel *Lady Hamilton*. They were intended to show the effect of varying mesh size and hanging ratio, to determine if there was a technical solution to the discards problem encountered by the inshore fleet. A series of length frequency curves was produced for the principal species caught. Some species, such as red mullet, showed a definite upward shift in modal length with increasing mesh size, whereas other species, particularly those prone to entanglement rather than being gilled by this type of gillnet, e.g. cod, showed no such trend. Overall, it was concluded that the location of fishing ground and the time of year are likely to have a far greater influence on catch composition than the specification and construction of the type of gillnets used for red mullet.

Beam trawl benthic release panel

Beam trawls impact benthic communities because the ground gear crushes and dislodges animals on the seabed, and because animals are caught in the trawl and subsequently die. Based on a study of the relative performance of seven designs of benthic release panels in commercial beam trawl

fisheries, it was demonstrated that panel designs consisting of 150mm×5mm double polyethylene square mesh or 150mm×6mm single polyethylene square mesh, respectively, reduced invertebrate bycatches by 75 and 80%, and that >90% of the animals released survived. Is was concluded that the use of benthic release panels may reduce the overall environmental impact (expressed as invertebrate mortality) of beam trawl fisheries by 5–10% without affecting their profitability.
Pilot projects

A series of pilot projects has been undertaken in the south western waters region. These include five projects from the Cefas project and a continuation of the Catch Quota Scheme managed by the Marine Management Organisation:

1) Project 50% (Revill, 2010)
2) Southwest otter trawl discards project (SWOT discards) (Catchpole and Gray, 2011)
3) Discard ban trials (Catchpole and Gray, 2011)
4) Self-sampling of the inshore fishing fleet (SESAMI)
5) Catch Quota trials (Course et al., 2011) [5]

Project 50%: A partnership project to reduce discarding in the Devon beam trawl fleet by 50% - The Devon beam trawl fleet had one of the highest discard rates of English and Welsh fisheries. The Cefas led 50% Project brought together fishermen and stakeholders from the Devon beam trawl fleet and Cefas scientists in a meaningful and working collaboration. As a consequence, the group were able to take positive action to address this discarding issue.

Using a social marketing approach to guide the 50% Project (see Understanding discards social section), many of the barriers and impediments to reducing discards were successfully overcome. Twelve vessels, crews and skippers, were involved in the project. The focus of the mechanism to minimise discarding was to develop more selective trawl nets. Working alongside local net-makers, skippers of the vessels involved developed 12 modified nets with different configurations and mesh sizes. Larger meshes, square mesh escape panels and novel headlines were used in their construction, with each skipper designing their own new trawl, tailored to their individual fishing patterns. Discarding in participating beam trawl vessels was reduced by an average of 57%. A launch event in 2010 generated considerable interest in the media, and gave an opportunity for Cefas to feedback the overall results and to thank fishermen for taking part. The project created much goodwill and facilitated communications with other fishing communities. A follow up study in 2011 identified that most participating vessels were using trawls developed within 50% Project, and some vessels that did not originally participate had also adopted designs from the project. The project provided an effective framework which was used in the delivery of subsequent pilot projects.
Southwest otter trawl discards project (SWOT discards project):

The otter trawl fisheries have a relatively high discard rate (see Understanding discards – data section) and preliminary contacts with the SW industry showed a willingness of the sector to work with Cefas to take actions to address the issues.

The SWOT Discards Project was a wholly collaborative project which developed otter trawl designs that substantially reduce discards to levels and to identify the means to get uptake of those trawl designs. Nineteen skippers and seven net makers worked in collaboration with Cefas scientists to reduce the capture of unwanted fish. The design of the modified trawls was decided by the skippers,

[5] Marine Management Organisation (2013). Catch Quota Trials 2012: Final report. Available from www.marinemanagement.org.uk/fisheries/management/quotas_cqt.htm

who in turn have provided data on the performance of the modifications, with Cefas scientists collecting additional data to validate the results. Over 400 hauls were conducted and fifteen designs produced a reduction in discard weight, with skippers demonstrating reductions of up to 55%. Seven skippers reported a reduction of 19-55% in discards without a loss in landed fish. Work was also done to understand how different species of fish react inside trawls. This provided new insights into how fish behave inside the trawl and led to the development of innovative trawl designs. Seventeen skippers continued to use the modified trawls after the trials. Improving the selectivity of trawls was considered by the skippers to be the most effective approach to reducing discards. The opportunity to test new trawl designs coupled with the legal requirement to use proven selective trawl designs was considered by skippers to be the best way to cut discards.

Discard ban trials:
A completed scoping study and ongoing full trial. Initiated in recognition of the urgent need to find out what this major change in management would mean for English fisheries, this is a practical test of the proposed policy by simulating how commercial fishing vessels could be affected by a discard ban. A short discard ban scoping study was conducted in 2011 followed by a full trial which is due to report at end 2013. In particular the research concerns the economic impacts of a discard ban, the impact on fishing mortality compared to current practice, markets for fish otherwise discarded, enforcement of a ban, practical constraints once fish is landed (e.g. transport, ports, unsold fish, other) and an assessment of the fish caught – proportion of species, size, length.
Self-Sampling of the Inshore under-10m fleet (SESAMI)

This project was set up following meetings held between New Under Ten Fishermen's Association (NUTFA) and Cefas scientists where it was recognized that there is a lack of useful data sets on the fishing practices and catch patterns of the inshore fleet.

SESAMI was therefore initiated as a self-sampling trial where under 10m skippers collect their own data during fishing operations. The project was focused on under ten fishermen using gill, trammel and tangle nets, and hand lines fishing in South of England, ICES area VIIdefgh. The first phase of the project involves data collection by skippers and crew, and the validation of the data collected by Cefas Fisheries Observers. In the second phase, participating vessels will be involved in trials to develop the most selective configurations and strategies for the nets they are using.

Each of 32 selected vessels (17 vessels from the South West and 15 from South East) has agreed to provide 100 days of data from consecutive fishing trips between August 2012 and June 2013. These vessels are using a mixture of gear types but can largely be split as 23 using nets as their main gear and nine using hand lines. Each skipper has been provided with a log book on which they fill in details of effort (details of gear, duration and area) and retained and discarded catch. Twenty one fisheries observer trips have been conducted on the vessels to validate the data collected by the skippers. With a fundamental shift in how fisheries are monitored with the reform of the CFP, from a situation whereby fishing vessels are restricted in what can be retained onboard to one where they will be restricted in what can be discarded. This change will require new methods that will monitor total catches taken by fishing vessels. The SESAMI project will be used determine the potential for self-sampling as a method to monitor catches.

Catch Quota trials:
The principle of a catch-quota system is that all fish caught are deducted from the catch-quota, including undersized fish. During this trial fishermen were not permitted to discard any cod caught, except those under the minimum landing size. Once the quota is reached, the vessel has to stop

operating. Because all catch quota species count against quota, fishermen are expected to alter their fishing practices to fish in a way that optimises the value of their catch by adopting avoidance techniques either by enhanced gear selectivity or in a spatial context. The English catch quota trial for North Sea Cod commenced in May 2010, participating vessels received up to 30% additional quota pro-rata for the year with all cod caught being deducted from this quota.

The estimates of total catch derived from the REM equipment correlated strongly with data provided by the fishers and with that generated by scientific observers. The work demonstrated the potential to use the technology as a monitoring and enforcement tool, but where observers can be used, the quality and quantity of collected data would be superior. The successful technical trial of the REM technology has led to an expanding catch quota scheme now managed by the MMO including several vessels in the SW.

Table 2: Participating vessels in MMO catch quota scheme 2012 by gear type and fishery in south western waters

Gear type	Number of vessels	Species subject to catch quota terms
Beam trawl	1	Area VIIe Western Channel sole, VIIde Channel plaice, VII Western hake, VII anglerfish, VII megrim and VIIhjk sole
Beam trawl	2	Area VIIe Western Channel sole, VIIde Channel plaice, VII Western hake, VII anglerfish, VII megrim
Beam trawl	1	Area VIIe Western Channel sole, VIIde Channel plaice, VII anglerfish, VII megrim
Beam trawl	3	Area VIIe sole

These latest trials included seven vessels from the south western waters region, and demonstrated discard rates of 0-1.7% discards (Table 3). The work has shown there may be gaps in the discard data which need to be assessed. For example, the discard data for VIIde plaice is taken predominantly from the offshore area where the rate of discarding may be considerably lower than for more inshore areas frequented by smaller vessels. It is therefore intended to focus on potentially high discard stocks in 2013 trials. It recognised that the implementation of this approach should not be regarded as a 'plug and play' system; the operational requirements and data needs need to be fully understood both by managers and operators which will vary from one fishery to another. As such applying EM should be carried out on a fishery by fishery basis rather than a big bang approach. It is considered that there is scope for greater collaboration between fisheries managers and scientists to ensure that EM data can be fully and efficiently used.

Table 3: Percentages of undersized and unmarketable catches with observed discard values and official discard rates in MMO 2012 catch quota scheme

Gear group	ICES area	Species	Undersize and damaged weight (kg)	Total catch (kg)	Percentage undersize and damaged catch	Percentage	UK discard rate (2011 data)
Beam trawl	VIIe	Sole	97.8	75,483	0.1	0.1	5.9
Beam trawl	VII	Anglerfish	204.6	147,741	0.1	0.7	11.4
Beam trawl	VII	Hake	18.5	301	6.1	1.7	18.2
Beam trawl	VII	Megrim	1,033.2	14,048	7.4	0.6	10.6
Beam trawl	VIIde	Plaice	1,121.3	49,319	2.3	0.6	4.9
Beam trawl	VIIhjk	Sole	0.1	233	0.0	0.0	N/A

The work described in this section will be applied and developed further during the implementation of the reformed Common Fisheries Policy to assist the fishing industry in the transition to the catch quota system. Understanding the patterns and drivers for discarding and applying gear technology developments will be essential to enable maximising the revenues from their catch quotas.

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Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem

Component 6: Ichthyo, Zoo and phytoplankton

Steve Milligan

19 July 2013.

Forward

This report is one of a series of reports prepared to provide the background information for a Scale, Intensity and Consequence Analysis (SICA) of the ecological impacts of South West fisheries in ICES divisions VII e,f,g and h as part of an Ecological Risk Assessment (ERA) of South West fisheries lead by SeaFish.

A SICA analysis is qualitative assessment of the potential impacts of fishing on the marine environment and forms the first stage of a prioritised and focussed ERA. A SICA analysis is a deliberately broad ranging analysis conducted as an initial screening to identify the predominant impacts of a specific fishery which should be carried forward for consideration by more detailed assessment, and identify which impacts can be screened out as less significant at an early stage.

These reports have been prepared as high level summaries of existing knowledge regarding the status of ecosystem components within in ICES divisions VII e,f,g and h and the impact of fisheries on these components. These reports are not expected to provide exhaustive of definitive reviews of the topics they address.

Taking a progressive risk-based approach to the assessment of the ecological impacts of fishing enables an efficient and directed analysis of the ecological impacts of fishing in support objectives for sustainable fisheries conducted within the ecosystem based approach to fisheries management.

A brief description of the component in this area.

The Celtic Sea region (ICES divisions VIIe, f, g & h) is a large area of sea which is part of the Exclusive Economic Zone (EEZ) of three nations (Ireland, France and the UK). It is an exposed region, open to the prevailing south-westerly winds. Despite this, there are a few long term datasets mainly from inshore areas of the UK, which can provide useful detail in helping to provide an ecological assessment of plankton in this region. There is also a long-term and relatively consistent plankton dataset, gathered by Continuous Plankton Recorders (CPR), which covers the whole region of interest (Figure 1) and Warner and Hays (1994). Both of these datasets have been thoroughly reviewed by Southward et al, (2005).

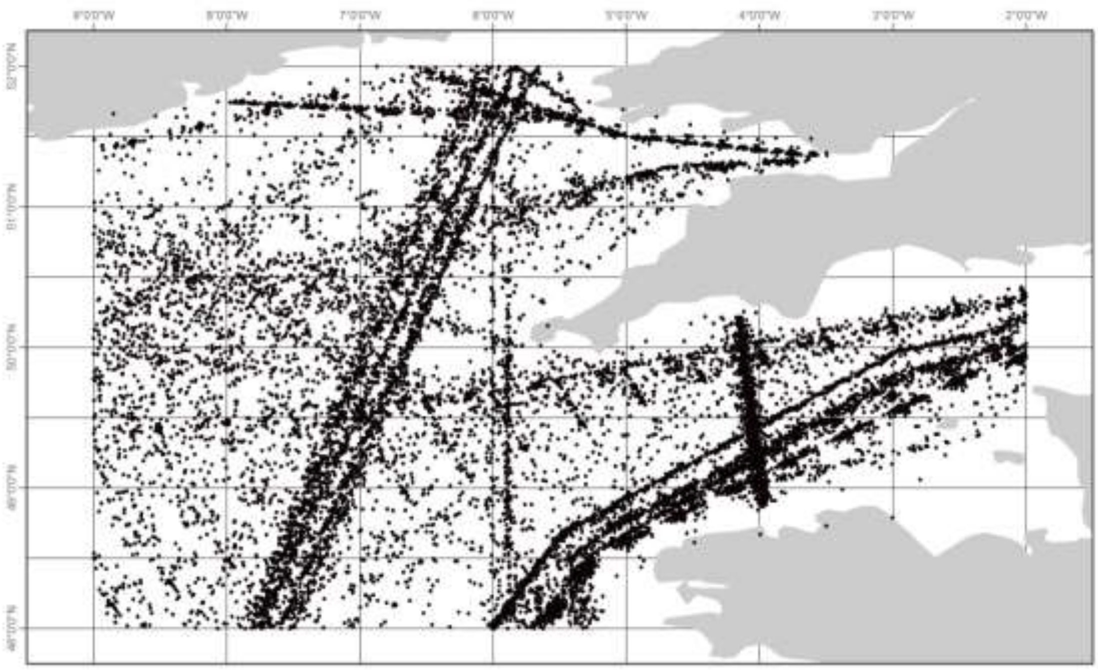

Figure 1: Chart showing the locations of plankton samples collected from the CPR 2000 – 2011

The Continuous Plankton Recorder (CPR) survey has been operating in the English Channel since 1957. The survey is currently managed by the Sir Alistair Hardy Foundation for Ocean Science (SAHFOS, Plymouth. http://www.sahfos.ac.uk/). The CPR devices are deployed from ships of opportunity (ferries, merchant vessels etc) and some routes have been covered routinely for many years. Samples are integrated for each 10nml of towing distance and are analysed for all plankton components. Although there are limitations in these data, it remains a very comprehensive and consistent dataset which is freely available.

The CPR samples are analysed to strict protocols. Phytoplankton abundance is estimated using a greenness index and a qualitative analysis is also conducted to provide species composition. The most comprehensive dataset is that for the zooplankton components, which are analysed to species whenever possible, and for which there are hundreds of thousands of records. The ichthyoplankton have been identified to varying degrees but most fish eggs are not identified further. However, fish larvae have been identified to taxonomic groups and occasionally species. A recent programme has resulted in the compilation of results of fish larvae analysis from 1948 – 2005 covering a large area of the NE Atlantic, including the Celtic Sea (Edwards et al, 2011). This is available to download from the SAHFOS website.

Phytoplankton

The seas around the south-west are some of the most oceanic and temperate around the UK (Figs 2 & 3). These milder conditions coupled with relatively clear, more oceanic water, which allows good light penetration, are ideal for phytoplankton growth.

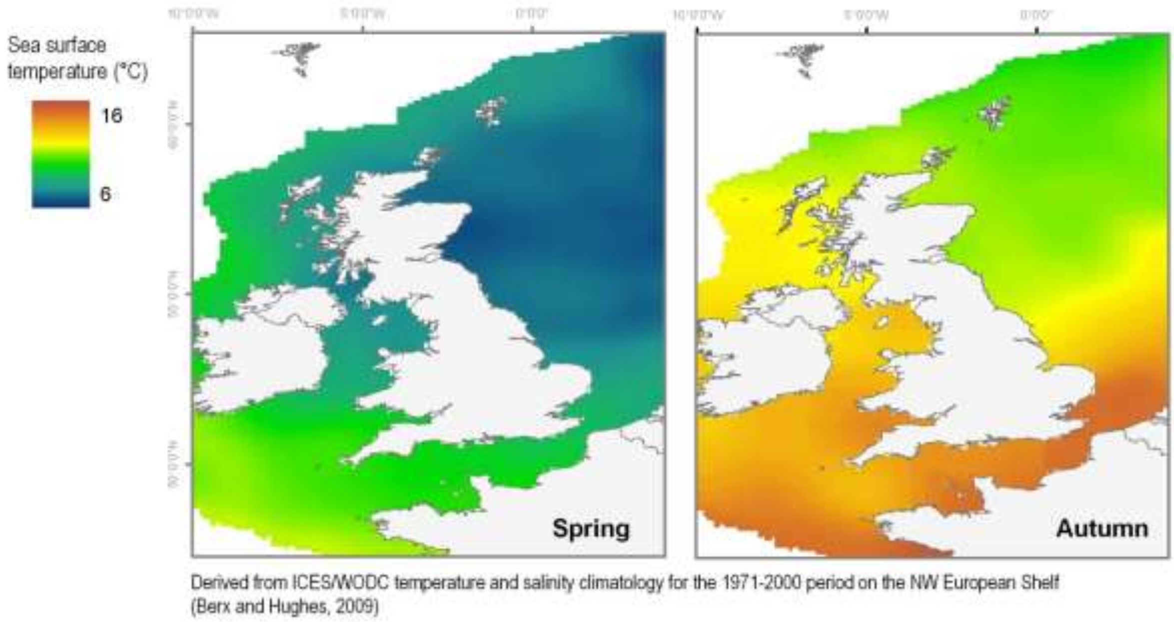

Figure 2: Mean sea surface temperatures around the UK (1971-2000) in spring and autumn

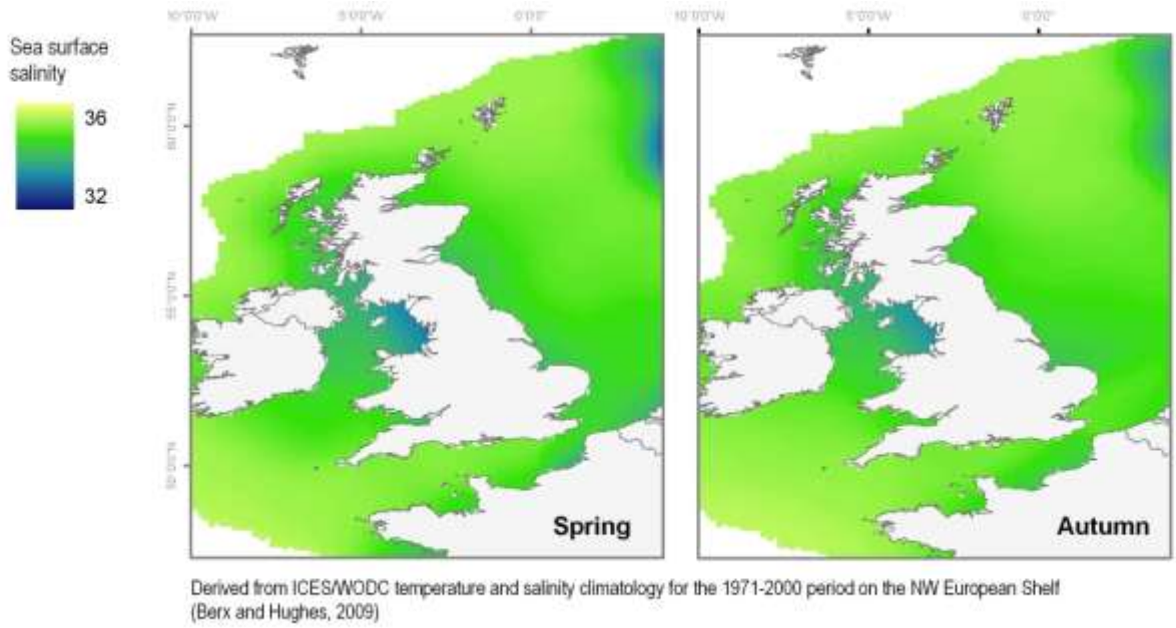

Figure 3. Mean sea surface salinity around the UK (1971-2000) in spring and autumn

These favourable environmental conditions generally allow phytoplankton production to begin earlier and to be sustained for longer than elsewhere in UK waters. As in most temperate seas, phytoplankton production peaks in the spring but slowly decreases during the summer months as nutrients are utilised. This is usually followed by a secondary peak of production later in the year, as autumnal gales re-energise the system by bringing nutrients closer to the surface once again.

As day length shortens and temperatures decreases, phytoplankton production also wanes reaching a minimum during the winter.

The Celtic Sea region encompasses a range of habitats from offshore oceanic, to inshore neritic zones, including some very sheltered bays and estuaries with their own specific environmental conditions. These habitats allow a very large range of temperate phytoplankton species to thrive. Some of these species occasionally form dense blooms which can lead to discolouration of the water, foams or scum at the surface as the blooms break down, and deoxidisation of the water or suffocation of sessile marine life as they degrade and settle out. Satellite observations of ocean colour, which can detect these blooms, or be an indicator of chlorophyll levels, are routinely made by the Plymouth Marine Laboratory (http://www.pml.ac.uk/). A few phytoplankton species produce toxins which can directly affect fish or can be accumulated by filter feeders (i.e. bivalve shellfish) which are then ingested by humans, causing health problems.

There are routine monitoring programmes for phytoplankton around the UK which are driven by EU Regulations or Directives. The Food Standards Agency (FSA) is the responsible authority in the UK for compliance with the EU Shellfish hygiene regulations. A monitoring programme for potentially toxic algae in shellfish production areas has been established in England and Wales since 1992. Weekly, monthly and annual summary of these results can be found on the FSA website at http://www.food.gov.uk/enforcement/monitoring/shellfish/ewbiotoxin/. The delivery of this programme is managed by Cefas and further details can be found on the Cefas website at http://www.cefas.defra.gov.uk/our-science/animal-health-and-food-safety/food-safety/algal-toxins-surveillance/biotoxin-monitoring-programmes.aspx

Compliance with the Water Framework Directive (WFD) is the responsibility of the Environment Agency (EA) in England and Wales http://www.environment-agency.gov.uk/research/planning/33362.aspx. Monthly water samples are taken from coastal and transitional waters and full phytoplankton community analysis (identification and numeration) is undertaken for each sample collected.

Zooplankton

Zooplankton, both holo and meroplankton, closely follow the seasonal succession of the phytoplankton with a slight time lag. Again, the region contains a diverse range of species because of the temperate conditions and wide variety of habitats. A few of the colder water species, see frequently elsewhere around UK coasts, may be less common in this region but conversely the Celtic Sea region is more likely to contain species which are more common in warmer waters further south. The zooplankton does contain the larval stages of some important commercial species such as those of the Brown Crab (*Cancer pagurus*, L.) and the European lobster (*Homarus gammarus*, L.). Cefas have conducted plankton surveys specifically to estimate the spatial distribution of spawning crabs in the English Channel (Thompson et al, 1995 and Eaton et al (in press)).

Ichthyoplankton

Unsurprisingly, the ichthyoplankton closely reflects the distribution of fish species present in the area. Many studies have focussed on the abundant pelagic species which are present and attempting to explain the large inter-annual fluctuations which sometimes occur in their distribution and abundance. The failure of the significant herring fishery after 1936 around the SW coast of the UK, the detection of large changes in the plankton (Russell, 1935a, b), and the replacement of the herring stock by pilchard (Cushing, 1961) are evidence of the importance placed upon such work.

In addition, Cefas conducted a series of plankton surveys in 1990, which covered the spawning period of many fish species between the north Cornish coast and south Wales (most of ICES division VIIf). The ichthyoplankton (both eggs and larvae) were identified to species where possible and the distribution and abundance of those of the sole (*Solea solea* L.) have been reported by Horwood (1993).

Current population status in relation to recognised reference points or conservation objectives, if available, and any information on trends over time

Plankton species distribution and abundance are notoriously variable and there have been significant changes in all three plankton components at various spatial and temporal scales. Southward et al (2005) report that '*many of these changes are related to climate, manifested as temperature changes, acting directly or indirectly*'. The observations conducted from the various Plymouth based laboratories, '*span significant periods of warming (1921-1961; 1985-present) and cooling (1962-1980). During these periods of change, the abundance of key species underwent dramatic shifts*' with '*the first period of warming seeing changes in zooplankton, pelagic fish and larval fish, including the collapse of an important herring fishery*'.

With continual concerns about anthropogenic affects leading to climate change, ocean warming and acidification, the fluctuations already seen in plankton distributions are likely to be exacerbated in the future. Recent work on the CPR data has provided evidence of large-scale changes in the biogeography of some calanoid copepods, with a northward shift in distribution of more than 10˚ latitude of warm-water species, associated with a decrease in the number of colder-water species (Beaugrand et al., 2002).

Many policy decisions for the marine environment are based on the premise that we must maintain clean, healthy, and diverse seas, and that any 'harvesting' should be conducted in a sustainable way. As most life in the seas has a plankton phase, then the importance of the long-term time series collected by the CPR and the fixed plankton sampling stations off Plymouth (L4, L5, L6, and E1) are becoming increasingly important as indicators of change and the health of the sea in this region (Southward et al, 2005, and CPR survey team, 2004)

Effects of fisheries' actions on the component, see below for list of fisheries and gears, this would include post-encounter mortality and indirect effects

One of the effects of fishing activity on plankton components is as the result of over-fishing on the spawning stocks and therefore the reduction in the production of eggs and larvae in subsequent spawning seasons. This will have a knock-on effect, as less ichthyoplankton larvae may result in less grazing activity on lower trophic levels. In addition, the removal of large numbers of pelagic fish will also have an impact on overall predation pressure of various plankton components and could enhance the potential for more frequent phytoplankton blooms.

Trawling activity, particularly with large beam trawls, has been shown to destroy benthic communities and habitats. This will consequently have an influence on the future production of eggs and larvae and the subsequent re-colonisation of these areas. The use of demersal trawl gear on the spawning grounds of herring and sandeel can have a direct and significant detrimental effect on the survivability of the benthic eggs of these species. In addition, disturbance of the ground can cause sediment plumes which settle elsewhere and can smother the eggs of these species as they lay on the seabed (see below).

There are also indirect effects of trawling activity which can affect the balance of fish species in a region, as one or two species are targeted allowing other species to increase in number. For instance the removal of large numbers of cod, whiting and other predatory fish species could have a dramatic affect on the abundance of pelagic species such as sprat and herring. By lowering the predation pressure these plankton feeders could significant increase which would have a corresponding impact on the survivability of many plankton components, including ichthyoplankton. A recent study by Pliru et al, (2012) has demonstrated that sprat will selectively target the eggs of plaice in areas of high spawning activity such as Liverpool Bay (eastern Irish Sea). This in turn could affect the subsequent year class strength of the plaice stock in that area as mortality during the early life stages is thought to be the main determinant of year-class strength for many fish species (Nash and Geffen, 2000; Payne et al 2009).

Endangered, threatened and protected status of the species

There are no known endangered species of phytoplankton or holoplankton currently recorded.

Other effects of man's activities such as pollution or mineral extraction

One of the most acute marine pollution incidents to affect the UK happened when the 'Torrey Canyon' oil tanker ran aground on the Seven Stones reef between Cornwall and the Isles of Scilly, in 1967. The oil spill and subsequent excessive application of toxic dispersants have been shown to have had long term effects on a number of benthic organisms, including macro-algae, limpets and barnacles (Southward and Southward, 1978 and Hawkins and Southward, 1992). The effects on the plankton community are not well described but given the wide spread dispersal of both oil and dispersants it is difficult to believe that there were no toxic effects, at least in the short term.

Chronic effects of antifoulants, particularly tributyltin (TBT) have also been shown to have had toxic effects on a range of non-target organisms (Bryan and Gibbs, 1991), including gastropod molluscs and the diatom *Skeletonema costatum* (Walsh et al., 1985). Despite the fact that the use of TBT has now been banned in the UK, there is still some evidence that contamination from TBT in sediments continues (Evans et al., 1991). It is likely that TBT and similar chemicals have a toxic effect on a range of phytoplankton species and that accumulation effects would occur, which would affect many other plankton components through grazing and predation.

One of the most significant anthropogenic influences is thought to be caused by an excessive input of nutrients from fresh-water run-off, which can lead to eutrophication. Elevated levels of nitrogen and phosphorus are thought to have a detrimental effect on the marine environment, particularly in inshore areas, as they are known to increase phytoplankton growth. This can not only manifest itself through in an increase in algal blooms but also by causing a disturbance to the balance of species present. The Water Framework Directive (WFD) aims to monitor and ultimately mitigate against such disturbances.

Other disturbances are related to mechanical damage or disturbance to the sea floor, either through offshore developments (e.g. windfarms, cable laying etc.) or by extraction of marine aggregates. These disturbances can have a number of effects including direct damage to marine organisms and habitats (similar to that caused by the heavy chain mats of beam trawls) or by causing sediment plumes which settle out and smother less mobile organisms. The disturbance to spawning grounds is also a major concern, particularly when it affects commercial species such as brown crab and herring (*Clupea harengus* (L.)). Herring are the only commercial species of fish in UK waters which lay benthic eggs and at one time were the basis of a large and important fishery in the Celtic Sea region. The eggs are laid on coarse sand or gravels, and if these are removed then this may restrict the area available for herring spawning. In addition, the eggs develop for between 1 and 3 weeks on the seabed and are therefore susceptible to both direct mechanical damage and being covered by fine plumes of silt as a result of activities elsewhere. All of these anthropogenic influences will ultimately affect the abundance and species composition of the plankton.

Plankton can also be transferred in the ballast water of ships from one part of the world to another. This has been internationally recognised as a problem which could lead to significant changes in species contribution through the introduction of non-native species. These species could out-compete similar native species, cause more direct predatory pressures or themselves be harmful in some way, i.e. the introduction of a toxic phytoplankton species. As most commercial marine traffic enters UK waters through the Celtic Sea region then this area is particularly susceptible to any ballast water transfers which take place.

Ocean warming and cyclical climate phenomena such as the North Atlantic Oscillation, Russell Cycle

Anthropogenically driven global climate change together with regional effects such as fishing and pollution, are identified as major influences on marine ecosystems (Hawkins et al, 2003 and Richardson and Schoeman, 2004). Climate and weather patterns affect the timing, abundance, species composition and distribution of phytoplankton, which as the base of the marine food web, directly influences other trophic levels. Variations in zooplankton abundance may be controlled in a more complex way by the interaction of prey abundance, hydrography and predators.

According to Southward (2005), changes in the ecology of the western English Channel are characterised by large shifts in the abundance of key species, with a period of warming (1930-1961), cooling (1962-1979) and a subsequent warming from 1985. The changes seen in the western English Channel, sometimes separated by relatively stable periods, have been collectively termed the Russell Cycle (Cushing and Dickson, 1976). Short lived species including phytoplankton and holoplankton can often respond to these changes relatively rapidly but the higher trophic levels may take years to respond with corresponding influences on the meroplankton.

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Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem

Component 7: Benthic habitats and communities including mobile epifauna

Stefan Bolam
19 July 2013.

Forward

This report is one of a series of reports prepared to provide the background information for a Scale, Intensity and Consequence Analysis (SICA) of the ecological impacts of South West fisheries in ICES divisions VII e,f,g and h as part of an Ecological Risk Assessment (ERA) of South West fisheries lead by SeaFish.

A SICA analysis is qualitative assessment of the potential impacts of fishing on the marine environment and forms the first stage of a prioritised and focussed ERA. A SICA analysis is a deliberately broad ranging analysis conducted as an initial screening to identify the predominant impacts of a specific fishery which should be carried forward for consideration by more detailed assessment, and identify which impacts can be screened out as less significant at an early stage.

These reports have been prepared as high level summaries of existing knowledge regarding the status of ecosystem components within in ICES divisions VII e,f,g and h and the impact of fisheries on these components. These reports are not expected to provide exhaustive of definitive reviews of the topics they address.

Taking a progressive risk-based approach to the assessment of the ecological impacts of fishing enables an efficient and directed analysis of the ecological impacts of fishing in support objectives for sustainable fisheries conducted within the ecosystem based approach to fisheries management.

Background

The epibenthic assemblages in offshore waters have been well described for the North Sea (Jennings et al., 1999; Zühlke et al., 2001; Callaway et al., 2002), parts of the English Channel (Kaiser et al., 1999) and Irish Sea and Bristol Channel (Ellis et al., 2000), however there has traditionally been a paucity of published information regarding the Celtic Sea. The inshore areas, particularly those sites near to the marine biological stations at Plymouth (UK), and Concarneau and Roscoff (France) have been subject to several investigations (e.g. Hinschberger et al., 1967; Glémarec, 1965, 1969), and there have also been field investigations along the continental slope, including the Porcupine Sea Bight and Goban Spur (Lampitt et al., 1986; Flach and Heip, 1996; Flach and de Bruin, 1999). However, there have been few studies across the continental shelf and shallower parts of the upper continental slope in this area. Le Danois (1948) provided extensive descriptive information, including species lists, on the marine fauna of the Celtic Sea, Bay of Biscay and Cantabrian Sea although quantitative information was generally lacking. Hartley and Dicks (1977) used a variety of sampling gears in the Celtic Sea, and subsequently reported on the molluscs caught (Hartley, 1979). More recently, Mackie et al. (1995) sampled the Celtic Deep in a wider study of benthic communities of the southern Irish Sea and St George's Channel.

Regarding the infaunal invertebrates which inhabit the sediment matrix, despite the wealth of studies that have contributed towards our awareness of the range of such benthic organisms around the UK (including those recently compiled by Somerfield et al. (2009) at a pan-European scale), there remains a distinct lack of an overarching study conducted specifically to create a contemporary reference point of information on the diversity and spatial distribution of benthic organisms inhabiting the whole of the UK's territorial waters. Given their important role in maintaining ecosystem functions and their established status as effective indicators for the evaluation of the environmental consequences of human activities, the absence of such broad-scale information limits our capability to assess, understand and therefore effectively and holistically manage our seas.

This report aims to briefly describe the spatial distribution of epibenthic assemblages (Section 2) and macrofaunal communities (Section 3) within the Seafish Southwest Ecological Risk Assessment region. However, describing the invertebrate assemblages and communities of this large spatial extent affords a somewhat limited basis upon which to undertake a risk assessment for fishing impacts, as the presence of any designated species may not be highlighted by the basis upon which such assemblages and communities are defined. Thus, the synoptic descriptions of Sections 2 and 3 is followed by a list of species and habitats with designatory status for which specific management practices might apply to ensure fishing impacts on these features are minimised (Section 4). Further information regarding ecology, distribution and potential threats from fishing are given for those designated features which of particular concern (i.e. they are of comparative widespread distribution) within the Seafish Southwest Ecological Risk Assessment region.

In this report, the term 'community' will be adopted for the infauna, where discrete sampling practices generally provide habitat-specific information on species occurrences and on the consequences of any interactions, and the term 'assemblage' for the epifauna, because the towed gears which are typically employed in macroscale sampling may pass over multiple habitats (Rees et al., 2008).

Epibenthic assemblages

Although a number of studies have been undertaken to provide synoptic assessments of the epifaunal assemblages within the Seafish Southwest Ecological Risk Assessment region, most of these have focussed on specific regions, or small-scale assessments (Glémarec, 1965, 1969; Lampitt et al., 1986; Flach and Heip, 1996; Flach and de Bruin, 1999). Of particular relevance, however, to the present review is the study by Ellis et al. (2013), its spatial extent covering nearly the whole of the present Seafish southwest Ecological Risk Assessment region. This allows spatial variability of the different assemblages to be made with unbiased sampling effort for certain regions which would otherwise result from collating and reviewing independent studies. Ellis et al. (2013) observed that a number of taxa were relatively ubiquitous, being found in > 50% of the samples. These taxa included the natantid shrimps *Processa* spp. and *Crangon allmanni*, the hermit crabs *Pagurus prideaux* and *Anapagurus laevis* sand star *Astropecten irregularis* and common brittlestar *Ophiura ophiura*. All these species were recorded in >50% of trawl samples. Although these widely distributed species were also important numerically, some of the other species that were also numerically abundant included the auger shell *Turitella communis*, Devonshire cup coral *Caryophyllia smithii*, the serpulid worm *Ditrupa arietina*, the brittlestar *Ophiura affinis* and the nut shell *Nucula sulcata*, and these species were very abundant at certain sites. There were some large-scale patterns discernable for the epibenthic assemblages and Ellis et al. (2013) proposed that, using multivariate approaches, six assemblages were present (Figure 1), two of which (shelf edge and deep water) lie outside the limits of the Seafish southwest Ecological Risk Assessment region. The four assemblages within the current region were as follows;

- Inner shelf assemblage (30–130 m deep), mainly Bristol Channel and western English Channel. Dominated by species typical of the inner continental shelf, including *O. ophiura*, *C. allmanni*, the swimming crab *Liocarcinus holsatus*, *A. laevis* and the common hermit crab *Pagurus bernhardus*.

- Outer shelf assemblage (49–175 m deep), north of 49 °N. Species rich, dominated by natantid shrimps (*C. allmanni*, *Processa* spp., *Pontophilus spinosus*), anomurans (*P. prideaux*, *A. laevis*) and brachyurans (e.g. harbour crab *Liocarcinus depurator*). Other abundant species included the starfish *A. irregularis* and *Asterias rubens*.

- Southern Celtic Sea assemblage (132–232 m deep), mainly south of 49 °N. In addition to the relatively ubiquitous hermit crab *P. prideaux*, other dominant species on these grounds included *C. smithii*, the starfish *Stichastrella rosea*, red cushion star *Porania pulvillus* and goose-foot starfish *Anseropoda placenta* (Table 4). Other important taxa included *M. tuberculatus*, *Colus gracilis* and the tube-forming polychaete *Hyalinoecia tubicola*.

- Mud assemblage (110–116 m deep), in the Celtic Deep, other parts of the Celtic Sea and on the Grande Vasière. This assemblage, the least speciose of the six, is dominated by the bivalve *Nucula sulcata*, snapping shrimp *Alpheus glaber* and Norway lobster *Nephrops norvegicus*, which are characteristic of muddy biotopes (Glémarec, 1973).

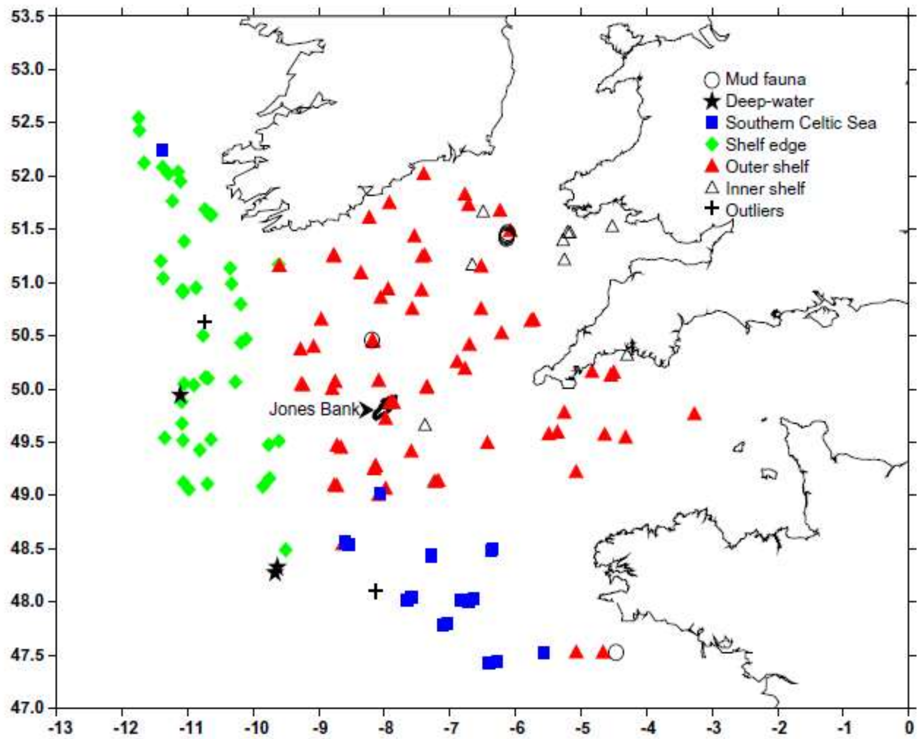

Figure 1: Distribution of epibenthic assemblages in the Celtic Sea inferred from multivariate data analysis of 2m beam trawl catches (taken from Ellis et al., 2013)

Benthic infaunal communities

A feature of the southern and western seaboards of the UK is the patchy occurrence of appreciably coarser substrata than generally encountered in the North Sea, presenting a significant challenge for quantitative macroscale synoptic surveys and partly explaining the paucity of historical information (Rees et al., 2008). An early solution was the use of dredges to generate semi-quantitative data, for example the use by Holme (1961) of an anchor dredge and by Cabioch (1968) of the robust Rallier-du-Baty dredge, which may be deployed successfully on very rough terrain, although inevitably combining infaunal and epifaunal components. The surveys of Holme (1961, 1966) provided valuable insights into biogeographical trends, especially the partitioning of eastern and western English Channel fauna, corresponding respectively to a transition from shallower mixed to deeper stratified waters. However, this work was targeted principally at the bivalve and echinoderm components of the infauna and therefore did not provide full species inventories. The intensity and spatial extent of sampling by Cabioch (1968) and co-workers from the 1960s on was greater, embracing the English Channel and parts of the Celtic Sea, although not all samples were fully worked up or published.

Following a study across the English part of the English Channel, Bolam et al. (2008) indicated that the western limit of their study (region VIIe) was dominated by an "*Echinocyamus*/Nemertean" community: a relatively species-rich community for the English Channel which was also characterised by high abundances of polychaetes such as *Glycera lapidum*, *Polycirrus* spp., *Aonides paucibranchiata* and *Lumbrineris gracilis*. Within more inshore waters in this region this community gave way to an "*Abra*/*Scalibregma*" community, which also comprised high numbers of *L. gracilis* and the bivalve *Nucula nitidosa*. This community exhibited lower species diversity than the *Echinocyamus*/Nemertean community of more offshore waters but displayed higher total abundance.

The English sector of the remaining ICES regions within the current study area (VIIf-h) was described by Anon (2007). Anon (2007) indicated that a number of invertebrate communities were present within this region (sampled using a regular design of 33 stations), the most widespread being an "*Echinocyamus/Lumbrineris gracilis*" community, with a "*Magelona minuta/Corbula gibba*" community also prevalent across this region. Communities defined for other stations within this region were generally dominated by taxa in these first two groups indicating that the numerically-dominant taxa sampled across the region did not vary significantly.

Species of conservational interest in the Seafish Southwest Ecological Risk Assessment region

Features of Conservation Importance (FOCI)

Habitats

Table 1 lists features of conservation importance from the OSPAR List of Threatened and/or Declining Species and Habitats and the UK List of Priority Species and Habitats. Species and habitats on the OSPAR list were identified based on evidence of threat, decline, rarity and sensitivity (OSPAR, 2003) while those for UK BAP include international importance, high risk or rapid decline and habitats that are important for rare species (Biodiversity Reporting and Information Group, 2007). While this list comprises those found across the shelf regions of England and Wales, many are likely to not be found within the Seafish southwest Ecological Risk Assessment region. However, without a full spatial assessment of the present study region, it is not currently possible to unequivocally conclude the absence of a particular habitat or species of conservation importance.

Table 1: Habitats of conservation importance (Habitat FOCI) of potential relevance for the Seafish southwest Ecological Risk Assessment region

Habitat FOCI	UK List of Priority Species and Habitats (UK BAP)	OSPAR List of Threatened and/or Declining Species and Habitats
Blue mussel beds	Yes	Yes
Cold-water coral reefs	Yes	Yes
Coral gardens		Yes
Deep-sea sponge aggregations	Yes	Yes
Estuarine rocky habitats	Yes	
File shell beds	Yes	
Fragile sponge and anthozoan communities on subtidal rocky habitats	Yes	
Intertidal boulder communities	Yes	
Coastal saltmarsh	Yes	
Intertidal mudflats	Yes	Yes
Maerl beds	Yes	Yes
Horse mussel (*M. modiolus*) beds	Yes	Yes
Mud habitats in deep water	Yes	
Sea-pen and burrowing megafauna communities		Yes
Native oyster (*Ostrea edulis*) beds		Yes
Honeycomb worm (*Sabellaria alveolata*) reefs	Yes	
Ross worm (*Sabellaria spinulosa*) reefs	Yes	Yes
Saline lagoons	Yes	
Seagrass beds	Yes	Yes
Sheltered muddy gravels	Yes	
Subtidal sands and gravels	Yes	
Tide-swept channels	Yes	

The habitat FOCIs identified are those regarded as deserving protected within MPAs to conserve and aid recovery of rare, threatened or declining habitats. Habitat FOCI with no relevance to the present study region can only be ascertained via a full assessment of the region. Those in green are those which potentially present a greater issue with respect to fisheries management in the Seafish Southwest Ecological Risk Assessment Region. The likelihood of a habitat FOCI being of concern to a particular fishing practice or certain region can only be assessed following a review of the occurrence of that habitat together with an assessment of the spatial variations of the various fishing tecniques: this is beyond the scope of the present report.

Species

Akin to the situation for habitat FOCI, a number of species of conservation importance (species FOCI) have been regarded by JNCC and Natural England as deserving protection within MPAs to conserve and aid recovery of rare, threatened or declining species. Species FOCI were identified from the OSPAR List of Threatened and/or Declining Species and Habitats, the UK List of Priority Species and Habitats (UK BSP) and Schedule 5 of the Wildlife & Countryside Act (1981). Those species that may potentially be of relevance to the Seafish Southwest Ecological Risk Assessment region are presented in Table 2. As for habitat FOCI, although some species from the full list have been removed due to presence being confined to other areas, one cannot unequivocally rule out the presence of the remaining species unless a full assessment of the whole of the present study region is undertaken.

Table 2: Species of conservation importance (species FOCI) which may be founds within the Seafish Southwest Ecological Risk Assessment region

Scientific name	Common name	UK List of Priority Species and Habitats (UK BAP)	OSPAR List of Threatened and/or Declining Species and Habitats
Anotrichium barbatum	Beared red seaweed	Yes	
Cruoria cruoriaeformis	Burgundy maerl paint weed	Yes	
Grateloupia montagnei	Grateloup's little-lobed weed	Yes	
Lithothamnion coralloides	**Coral maerl**	**Yes**	
Padina pavonica	Peacock's tail	Yes	
Phymatlithon calcareum	Common maerl	Yes	
Victorella pavida	Trembling seamat	Yes	
Amphiamthus dohrnii	Sea-fan anemone	Yes	
Eunicella verrucosa	**Pink sea fan**	**Yes**	
Haliclystis auricula	Stalked jellyfish	Yes	
Leptopsammia pruvoti	Sunset cup coral	Yes	
Lucernariopsis cruxmelitensis	Stalked jellyfish	Yes	
Swiftia pallida	Northern sea fan	Yes	
Pollicipes pollicipes	Gooseneck barnacle	Yes	
Palinurus elephas	Spiny lobster	Yes	
Arctica islandica	**Ocean quahog**	**Yes**	
Atrina fragilis	**Fan mussel**	**Yes**	
Nucella lapillus	Dog whelk		Yes
Ostrea edulis	Native oyster	Yes	Yes
Paludinella littorina	Sea snail		Yes
Tenellia adspersa	Lagoon sea slug	Yes	

Those in green are those which potentially present a greater issue with respect to fisheries management in the Seafish Southwest Ecological Risk Assessment Region. The likelihood of a species being of concern to a particular fishing practice or certain region can only be assessed following a review of the occurrence of that species together with an assessment of the spatial variations of the various fishing techniques: this is beyond the scope of the present report.

Main species of conservational relevance to the Seafish Southwest Ecological Risk Assessment region

While many of the habitat and species FOCI listed in Tables 1 and 2 are likely to be comparatively rare, or restricted to certain regions not likely to be targeted by any fishing activity in the Seafish Southwest Ecological Risk Assessment region, a small number of designated features are relatively widespread and, consequently, are likely to have greater implications for fisheries management in this region. The ecological importance, habitat preferences and sensitivity to fishing activities of a number of these are outlined below. Due to insufficient data at present, it is not possible to map the distribution of these features and thus, it is difficult to unequivocally predict which fishing gears may spatially coincide with these habitats and/or species.

Ross worm (*Sabellaria spinulosa*) reefs

Ross worms build tubes from sand and shell fragments. The worms are usually found individually, but in some shallow water areas they are found in colonies. The tubes of large numbers of the worms can form reefs, which at their largest can be about half a metre in height and cover an area of several hectares. Ross worms require a good supply of sand grains for tube-building, and so like murky water. These worm-built reefs are important because they provide a habitat for a wide range of other seabed-dwelling animals. A greater variety of marine life is found association with ross worm reefs than on other similar areas of the seabed. Where they occur on the soft seabed, they are of particular significance for nature conservation. By providing a complex seascape with hard surfaces and nooks and crannies in an otherwise flat, featureless seabed, they provide a home for animals which would not normally be found there.

S. spinulosa reefs are known from all European coasts, except the Baltic and the waters of the Kattegat and Skagerrak, but are typically limited to areas with very high levels of suspended sediment. In the UK aggregations of *S.spinulosa* are reported to occur at a number of locations around the British Isles (OSPAR Regions II and III) including the Bristol Channel, although there are few records for Scottish waters. Not all of these aggregations could be described as “reefs”, for instance where the species may only form superficial crusts on mixed substrata.

The greatest impact on this habitat is thought to be physical disturbance from fishing activities. Dredging for oysters and mussels, trawling for shrimp or finfish, net fishing and potting can all cause physical damage to these reef communities. While the reefs appear to recover well from minor damage, serious impacts from mobile fishing gear break the reefs down into small pieces.

Horse mussel (*Modiolus modiolus*) beds

The horse mussel *M. modiolus* forms dense beds at depths of 5–70 m in fully saline, often moderately tide-swept areas off northern and western parts of the British Isles. Although it is a widespread and common species, true beds forming a distinctive biotope are much more limited and are not known south of the Humber and Severn estuaries.

M. modiolus is a long-lived species and individuals within beds frequently exceed 25 years in age. Juvenile *M. modiolus* are heavily preyed upon, especially by crabs and starfish, until they are about 3–6 years old, but predation is low thereafter. Recruitment is slow and may be very sporadic; there may be poor recruitment over a number of years in some populations.

The byssus threads secreted by *M. modiolus* have an important stabilising effect on the seabed, binding together living *M. modiolus*, dead shell, and sediments. As *M. modiolus* is a
filter feeder, the accumulation of faeces and pseudofaeces probably represents an important flux of organic material from the plankton to the benthos. This rich food source, together with the varied habitat, means that extremely rich associated faunas, sometimes with hundreds of species, may occur on dense beds.

Trawls and scallop dredges have been shown to cause widespread and long-lasting damage to beds in Strangford Lough and off the south-east of the Isle of Man. Effects include flattening clumps of *M. modiolus* causing fatalities, and loss of much of the associated epifauna, especially emergent types such as *Alcyonium digitatum*. Fishing impacts are likely to be occurring on *M. modiolus* beds elsewhere.

Blue mussel (*Mytilus edulis*) beds

These small, blue mussels are a common sight on UK coasts. They can form extensive beds, with living and dead mussels, sand and mud all bound together by the mussels' sticky 'beards' of byssus threads. Blue mussel beds occur mostly on the lower shore between the tides or permanently submerged in shallow water.

Mussel beds provide an important food source for wintering waders. When beds were lost from parts of Holland in 1990, the eider duck numbers decline significantly. Otters may also get some of their food supply from blue mussel beds, and the 'mussel mud' formed by the blue mussels' waste is an important source of nutrients for animals living within the seabed.

Blue mussel beds have a particularly important role where they occur on soft seabeds, as they provide a hard surface in otherwise muddy or sandy areas. This attracts and supports a greater range of marine life than would otherwise be found there. 133 different animals and plants have been recorded in blue mussel beds, including seaweeds, anemones, barnacles, sea snails, crabs, starfish and worms.

The threats to blue mussel beds include their removal for food or bait, and the damage caused by mobile fishing gear, anchoring or mooring chains, or, for beds found between the tides, by trampling. Blue mussel beds take at least five years to recover from damage, and those in southern England are some of the most threatened in Europe.

Maerl (*Lithothamnion coralloides*)

Maerl is a collective term for several species of red seaweed, with hard, chalky skeletons. It is rock hard and, unlike other seaweeds, it grows as unattached rounded nodules or short, branched shapes on the seabed. Like all seaweeds, maerl needs sunlight to grow, and it only occurs to a depth of about 20m. Maerl can form large beds, when the conditions are right – a fast tidal flow or sufficient wave action to remove fine sediments, but not strong enough to break the brittle maerl branches. Within these beds, layers of dead maerl build up with a thin layer of pink, living maerl on the top.

Maerl beds are an important habitat for many different types of marine life, which live amongst or are attached to the surface of maerl, or burrow in the coarse gravel of dead maerl beneath the top living layer. Maerl beds can be of importance to sustainable fisheries, providing nursery grounds for commercial species of fish and shellfish.

Due to the fragility of maerl, the beds are easily damaged and have probably declined substantially in some areas. Pressures on maerl beds include scallop dredging, bottom trawling, aquaculture and pollution, and Bordehore et al. (2003) demonstrated that otter trawling can significantly reduce maerl bed habitat complexity and associated faunal diversity. Maerl beds are very slow to develop and are unlikely to return if removed or lost. As such, they should be treated as a non-renewable resource. In England, the Fal and Helford Special Area of Conservation includes the largest maerl beds in southwest Britain.

Pink sea fan (*Eunicella verrucosa*)

The pink sea fan *E. verrucosa* is one of the UK's most spectacular soft coral. Recorded northwards to north Pembrokeshire and eastwards to Portland Bill in Britain, *E. verrucosa* is common in parts of south Devon and Cornwall and at Lundy, mainly on upward facing bedrock in areas where water movement (wave action or tidal streams) is moderately strong.

The "pink" sea fan may be white to deep pink in colour. Colonies branch profusely and the branches are covered in warty protuberences from which the small anemone-like polyps emerge. Colonies may be up to 50 cm high but more often up to 25 cm and are usually oriented in one plane (at right angles to the prevailing water currents).

Despite protection under the Wildlife and Countryside Act, pink sea fans continue to be threatened by bottom trawling for fish and scallops, divers and by water pollution (Lumbis et al., 2009).

Ocean quahog (*Arctica islandica*)

A. islandica is found at extreme low water level but predominately on sublittoral firm sediments including offshore areas, buried (or part buried) in sand and muddy sand that range from fine to coarse grains. *A. islandica* is found around all British and Irish coasts.

The main threat to *A.islandica* in OSPAR Region II stems from disturbances to the seabed. This is particularly linked to beam trawling which is known to cause shell damage and direct mortality (e.g. Witbaard & Klein, 1994; Piet et al., 1998). *A. islandica* becomes immediately exposed at the sediment surface when a beam trawl is towed over the sea bottom. This happens also to spat of *A. islandica* (Witbaard & Bergman, 2003). Specimens that have been injured by beam trawls would have only a limited ability to rebury.

The related heart cockle *Glossus humanus*, another large bivalve that is susceptible to trawl damage, is also known to occur in the Celtic Sea. The biology of this species, however, remains very little studied.

Fan mussel (*Atrina fragilis*)

The fan mussel, *A. fragilis*, is a species of large saltwater clam, reaching 30 to 48 cm long, and is one of the rarest species of marine mollusc in the UK. It is protected under Schedule 5 of the Wildlife and Countryside Act 1981. This species lives with the narrow half of its shell anchored in the sediment, but the large part of the fragile shell protrudes from the sea floor, making the species very vulnerable to bottom fishing gears. This species is only reported infrequently (e.g. Burt et al., 2013) and populations have declined from inshore waters of the southwest UK and any abundance over the last 20 years has come from deep water trawls. This suggests that depletion of *A. fragilis* may have resulted from trawling damage over the course of the 20th century. Significant impacts of trawling on *A. fragilis* have recently been demonstrated by Fryganiotis et al. (2013).

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Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem

Component 8, 9 & 10: Benthic habitat, nursery and spawning areas and human activities relating to the area

Alexander Koch, Sara Pacitto

19 July 2013.

Forward

This report is one of a series of reports prepared to provide the background information for a Scale, Intensity and Consequence Analysis (SICA) of the ecological impacts of South West fisheries in ICES divisions VII e,f,g and h as part of an Ecological Risk Assessment (ERA) of South West fisheries lead by SeaFish.

A SICA analysis is qualitative assessment of the potential impacts of fishing on the marine environment and forms the first stage of a prioritised and focussed ERA. A SICA analysis is a deliberately broad ranging analysis conducted as an initial screening to identify the predominant impacts of a specific fishery which should be carried forward for consideration by more detailed assessment, and identify which impacts can be screened out as less significant at an early stage.

These reports have been prepared as high level summaries of existing knowledge regarding the status of ecosystem components within in ICES divisions VII e,f,g and h and the impact of fisheries on these components. These reports are not expected to provide exhaustive of definitive reviews of the topics they address.

Taking a progressive risk-based approach to the assessment of the ecological impacts of fishing enables an efficient and directed analysis of the ecological impacts of fishing in support objectives for sustainable fisheries conducted within the ecosystem based approach to fisheries management.

Contents

A brief description of the component in this area

This report examines habitat distribution in ICES regions VIIe to VIIh and the overlap and distribution of anthropogenic that affect these habitats. Furthermore the habitats are related to the presence of spawning and nursery grounds. The extent of spawning and nursery grounds and the pressure on these grounds from inshore and offshore fishing activity are considered.

The potential impact of fishing and different human activities on the habitats is examined by calculating the overlap between habitat distribution and the areas where the activities area conducted. Table 1 lists the combinations of habitats and features considered in the overlap analysis.

Table 1: Combinations between feature and human activity examined

Feature	Activity
Seabed habitat	Aggregate dredging areas
Seabed habitat	Disposal sites
Seabed habitat	Fishing vessel activity
Nursery grounds	Aggregate dredging areas
Nursery grounds	Disposal sites
Nursery grounds	Fishing vessel activity
Spawning grounds	Aggregate dredging areas
Spawning grounds	Disposal sites
Spawning grounds	Fishing vessel activity

A list of the sources of the features and activities is provided below.

Table 2: Sources and data layer names for each feature/activity

Feature/activity	Layer	Source
Aggregate dredging areas	Licensed aggregate activities	Crown Estate, 2012
Disposal sites	Open disposal sites	Crown Estate/MMO, 2012
Benthic habitat	EUSeaMap, EUNIS level 3	JNCC, 2012
Nursery grounds	Nursery grounds based on half ICES statistical rectangles	Cefas, 2012
Spawning grounds	Spawning grounds based on half ICES statistical rectangles	Cefas, 2012
Inshore vessel activity	Inshore sightings data from various sources (see Vanstaen and Silva, 2010)	Cefas, 2010
Offshore vessel activity	VMS data	Cefas , 2007

Fishing activity

Demersal fishing activity (i.e. otter & beam trawl) affects the seabed by disturbing the upper layers of the seabed, removal, damage or displacement of flora and fauna on and in the seabed, alteration of habitat structures by i.e. flattening of wave forms as well as attracting carrion consumers into the path of the fishing gear for a short term (Kaiser et al., 2001). As the area of interest exists mainly of smaller grain size sediment, re-suspension is an effect that occurs widely. Re-suspension causes the release of nutrients stored in the seabed, the exposure of anoxic layers, increases the biological oxygen demand and causes smothering of feeding and respiratory organs of ground living fauna (Kaiser et al., 2001).

Inshore fishing activity

Vessel Monitoring System (VMS) data were only available for vessels >15m for the period of data availability. Inshore fishing activity (vessels <15m) for the period of analysis relies data from sightings and boardings collected by the Sea Fisheries Committees of England and Wales and the Marine Management Organisation (MMO). In this report fishing activities are grouped according to gear type (dredging, trawling, netting, potting, lining). The data is normalised by surveillance density. Full details on the development and limitations of this data layer can be found in Vanstaen and Silva (2010). Figure 1 shows the confidence of the data based on surveillance (Vanstaen and Silva, 2010).

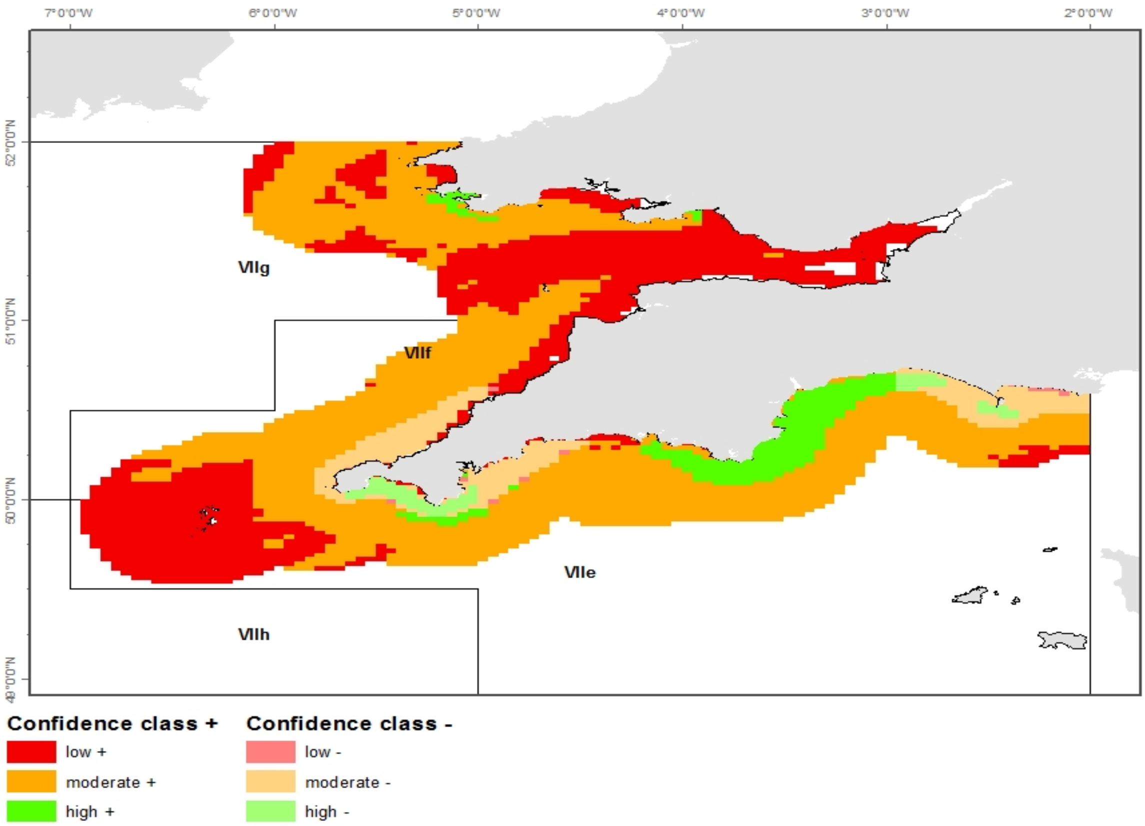

Figure 1: Confidence levels of inshore data based on surveillance density. Darker colours include sightings and GPS data, bright colours showing data relying on boardings only (Vanstaen and Silva, 2010)

Offshore vessel activity (Vessel Monitoring System – VMS)

VMS data were used for the analysis of fishing effort distribution. All vessels greater than 15m were subject to VMS. The VMS data were processed using the methodology described by Lee et al. (2010). Using the vessel identifier, the VMS records were linked to databases containing information on fishing gear used by the vessel at the time (for UK registered vessels) or the fishing gear used for the majority of the year (for non-UK registered vessels). This is a potential source of error as not every country is reporting which gear type has actually been used while fishing (Figure 2). Vessel speed was used to differentiate between fishing and non-fishing events, based on a simple speed rule whereby fishing events were assumed to take place between 1 and 6 knots. This simplification may lead to over- or underestimation of actual fishing activity (see Lee et al., 2010 for details on confidence).

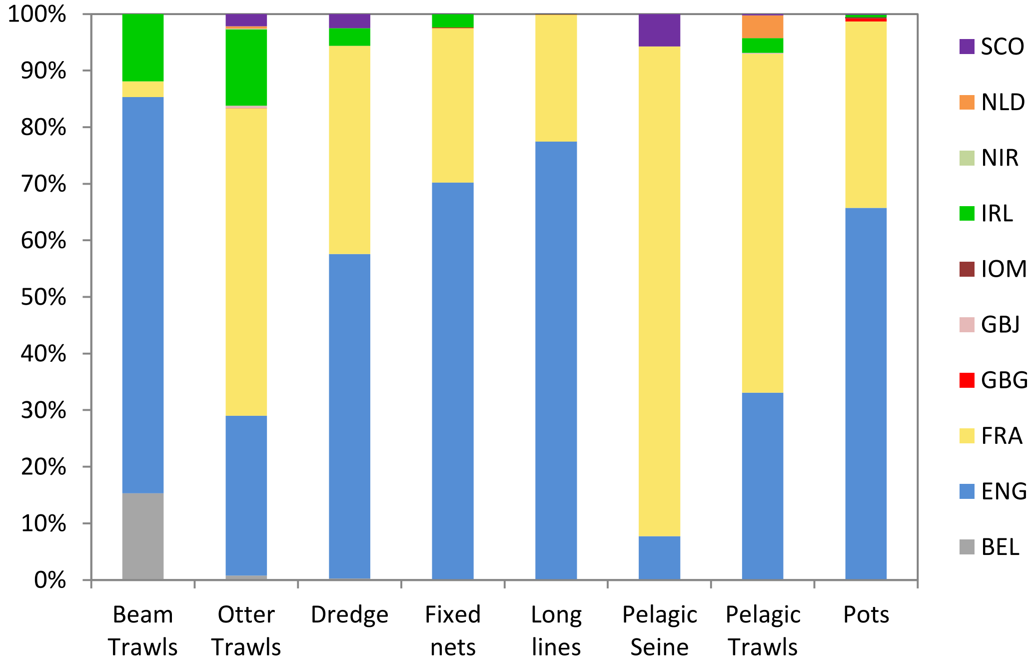

Figure 21: Proportion of effort (hours fished 2012) in ICES Divisions VIIe-h from STECF

Spawning & Nursery grounds

Many fish species spawn in defined areas, or spawning grounds. Thes map layers show spawning habitats including oviposition sites (for egg-laying elasmobranchs) and parturition sites (for live-bearing species) collated from numerous surveys conducted by Cefas and associated UK fisheries laboratories, and from internationally-coordinated ichthyoplankton surveys. It should be noted that multi-species data are not available for the Celtic Sea and thus the locations are only indicative field for both, oviparous and viviparous species (Ellis et al., 2012).

Nursery grounds areas with a high proportion of juveniles, which might result in a higher contribution to adult recruitment than non-nursery grounds (see Beck *et al.*, 2003; Heupel *et al.*, 2007). Data from national groundfish surverys were used to identify nursery grounds (for details see Ellis et al., 2012).

Spawning and nursery ground GIS layers are generated based on half ICES statistical rectangles, with sites of higher importance noted for selected species (Ellis et al., 2012) (Figure 3–7). In this report the importance of the spawning and nursery ground for a species is indicated as *SpeciesIntensity* (e.g. CodH – Cod spawning or nursery ground with high importance).

For a detailed description of the spawning and nursery grounds for each species investigated see Ellis et al. (2012).

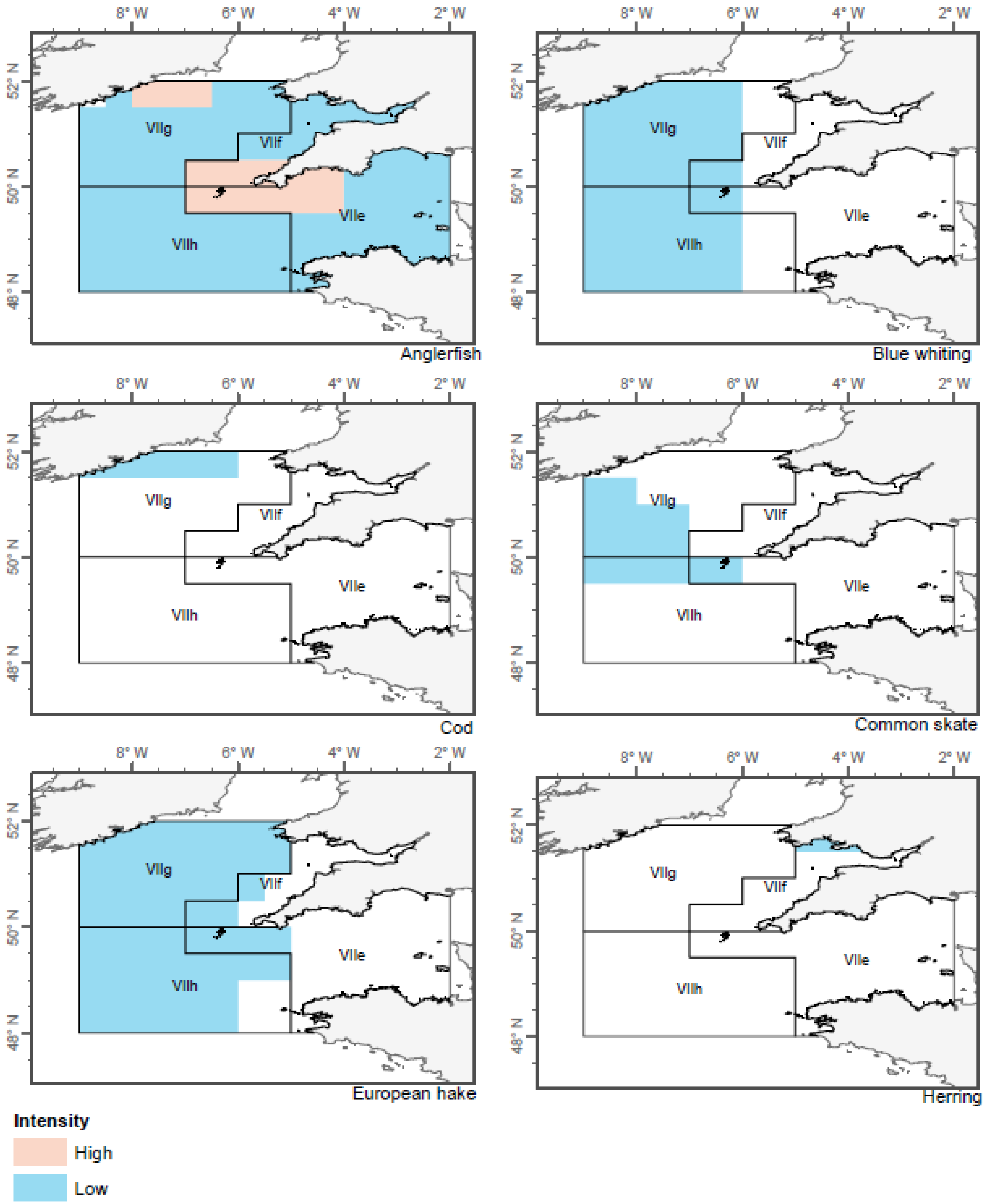

Figure 3: Nursery grounds and their importance for anglerfish, blue whiting, cod, common skate, European hake and herring

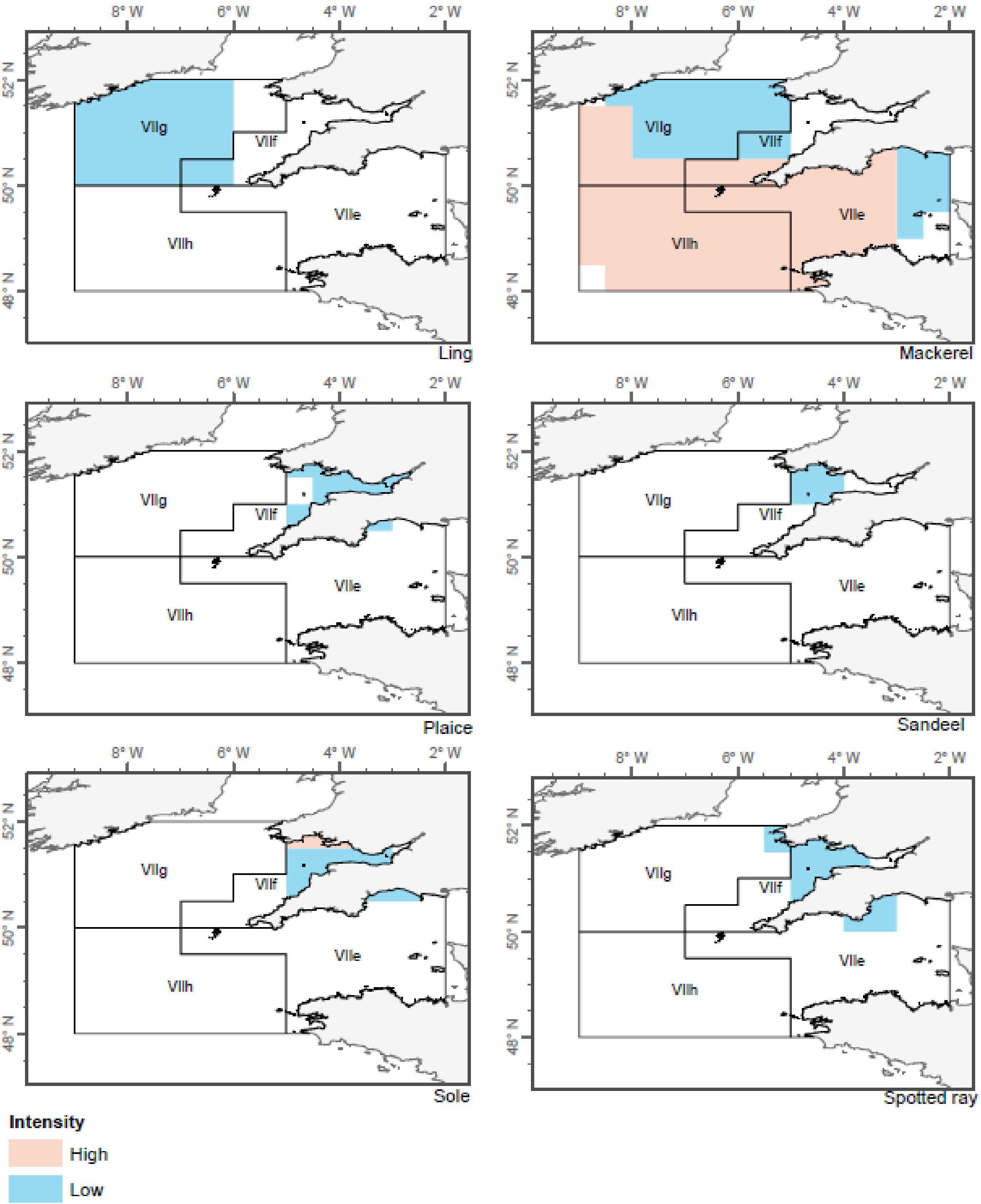

Figure 4: Nursery grounds and their importance for ling, mackerel, plaice, sandeel, sole and spotted ray

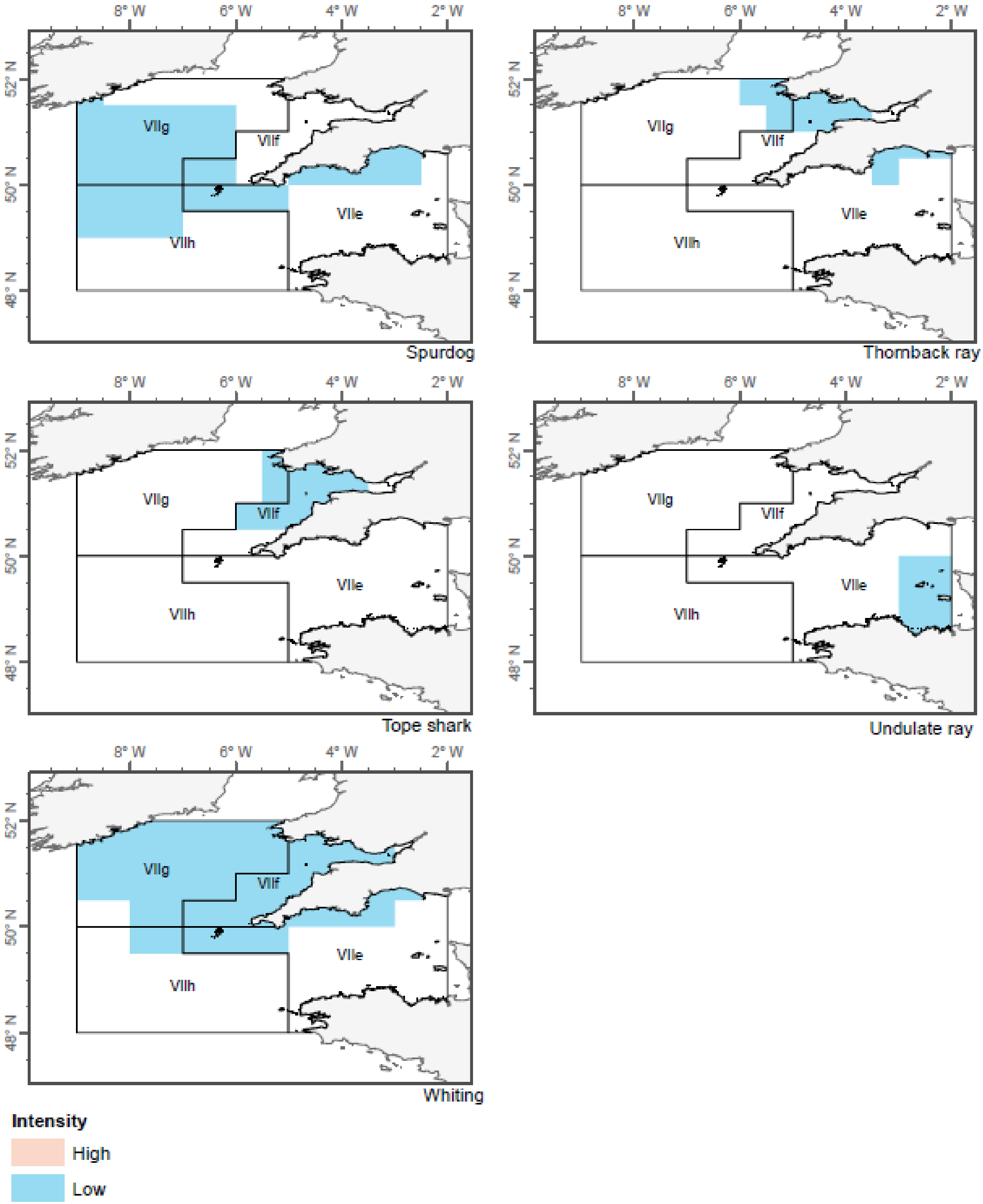

Figure 5: Nursery grounds and their importance for spurdog, thornback ray, tope shark, undulate ray and whiting

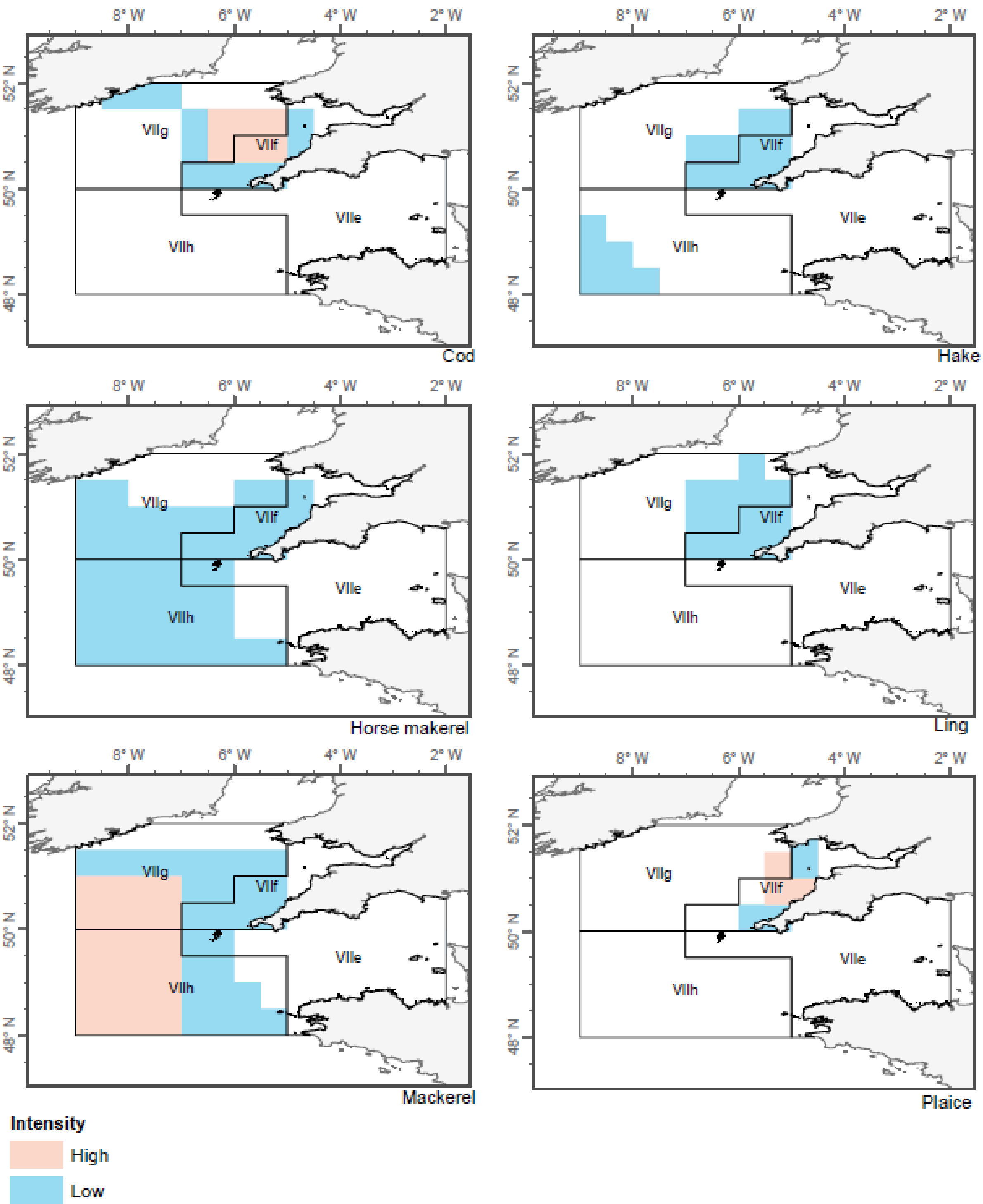

Figure 6: Spawning grounds and their importance for cod, hake, horse mackerel, ling, mackerel and plaice

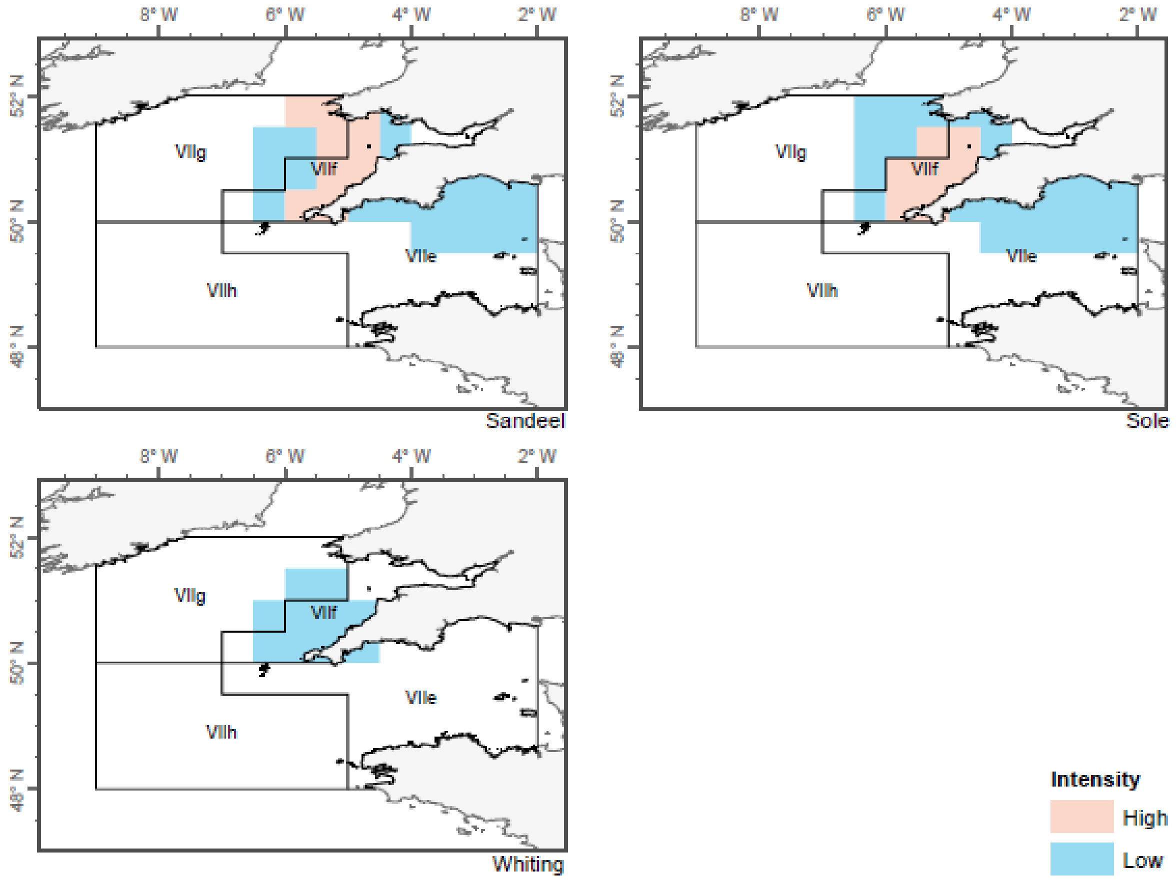

Figure 7: Spawning grounds and their importance for sandeel, sole and whiting

Sediment and seabed habitat

The ICES regions VIIe–VIIh mainly consist of mud, sand gravel and mixtures of these sediment types. The sediment in the Bristol Channel is characterised by the sediment load from the estuary and creates the basement for tidal-swept faunal communities. The rest of VIIf is characterised by a high proportion of coarser sediment in shallow water. Region VIIe is mainly covered by coarse material with larger patches of mixed sediment towards the middle of the region and sand to fine sand patches on the coasts of the UK and France. A distinguishing feature of VIIe is a rocky patch in the middle of the area. VIIh is characterised by fine sand to sand and coarse sediment with a large patch of mixed sediments in the east. The habitat in the western region of VIIh marks the transition between shallow waters and deeper regions towards the Atlantic. In the north western region of VIIh rocky outcrops are indicative of higher energy exposure. This patch also extends into VIIg, which is dominated by sandy sediment types (Figure 8).

The EUSeaMap was used as the source of the benthic habitat information; the EUSeaMap is the most up to date map providing regional information regarding benthic habitats. The EUSeaMap, as with all currently existing regional habitat maps is based on modeled habitat distributions informed with limited observational data. Therefore the habitat information should be viewed as having on limited confidence, this is particularly the case with limited and patchy habitat types. The EUSeaMap presents habitats categorised according to the EUNIS habitat designations. The EUNIS habitat classification scheme has several different levels of habitat description. For this report we are using the EUNIS level 3 classification. The EUNIS habitat classification attempts to unify habitat classifications to achieve a uniform habitat classification system across Europe waters (Cameron & Askew, 2011). In this report however some of the habitat types used are non-EUNIS classifications. These types are used to increase the coverage and are stated when used.

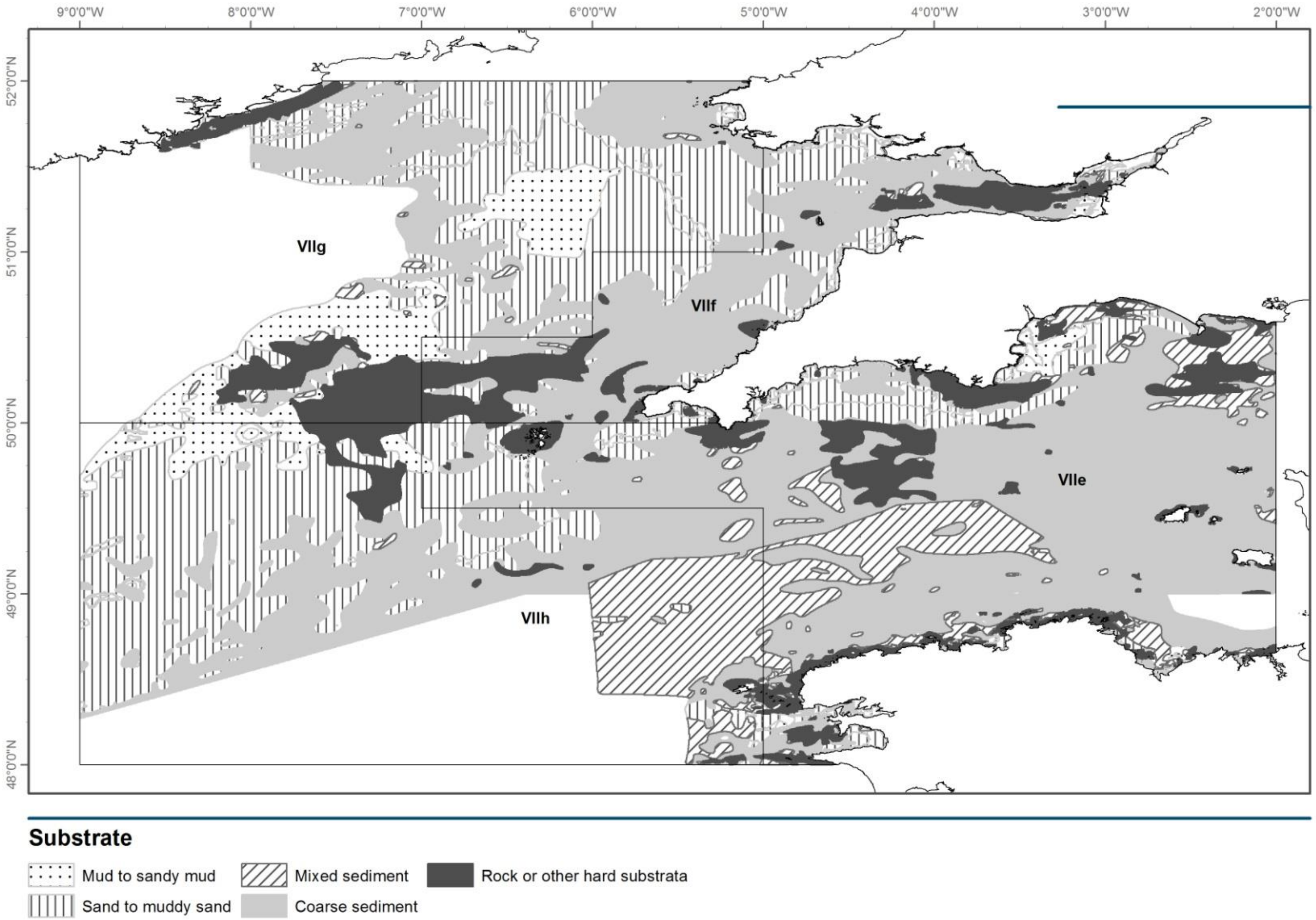

Figure 8: Seabed habitat classified according to EUNIS levels (JNCC, 2012), see map page 8

Aggregate dredging areas

This report will focus on English and Irish waters of the study area only.

The removal of aggregates from the marine environment for our construction needs has been taking place for several years, with approximately a quarter of the nation's aggregates coming from the marine environment. Aggregate extraction is a licensable activity covered under the marine bill. It is closely regulated by licensing bodies (MMO & WG) for England and Wales.

Aggregate extraction can cause various impacts to the marine environment, the most significant being direct habitat loss, disturbance and changes to coastal processes and hydromorphology (Seiderer and Newell, 1999; Boyd et al., 2005). Besides removal, re-deposition can have significant impact on the benthic community as harbour sediments can be heavily polluted and thus may lead to contaminant dispersal (Watling and Norse, 1998).

Due to the disturbance, noise and physical presence of the vessels, mobile species of fish will move out of the area during extraction. Therefore aggregate extraction only has a significant effect on those sedentary fish species and those where at certain stages in the life cycle they can not move, e.g. during spawning. Species such as Herring, Black bream, brown crabs and sand eel are particularly susceptible to aggregate activities. Herring lay their eggs in gravel and black bream build their nests in the gravel, if these are removed then the ongoing survival and growth of the population will be diminished. Buried female brown crabs don't move during this period so aggregate extraction would remove these individual species and effect the long term survival of the population. Sand eels are an important food source for larger fish and seabirds, so aggregate extraction in an area designated as seabird feeding grounds needs to be considered as it could lead to further impact down the food chain.

Other filter feeding species such as shellfish may be impacted temporarily following extraction due to the re-suspension of material.

These issues are carefully considered in the aggregate licensing process, before any licence is issued. In some cases timing restrictions may be applied to the licence and/or careful monitoring or the area may not be licensed.

In the area of study there are currently (as of 2nd May 2013):

- 7 aggregate option areas (areas where aggregate companies have exclusive right to the submit applications in this area),
- 19 licence applications submitted.
- 14 active licences.

All of which fall within area Vllf and are all located within the Bristol Channel, see figure 1.

The aggregate application and licence areas in the western half of the channel overlap some spawning grounds for: Sandeel, plaice, sole, lemon sole, cod, horse mackerel and sprat. The impacts of the aggregate activity on these species would have or will be assessed in the application process, prior to the issue of any licence.

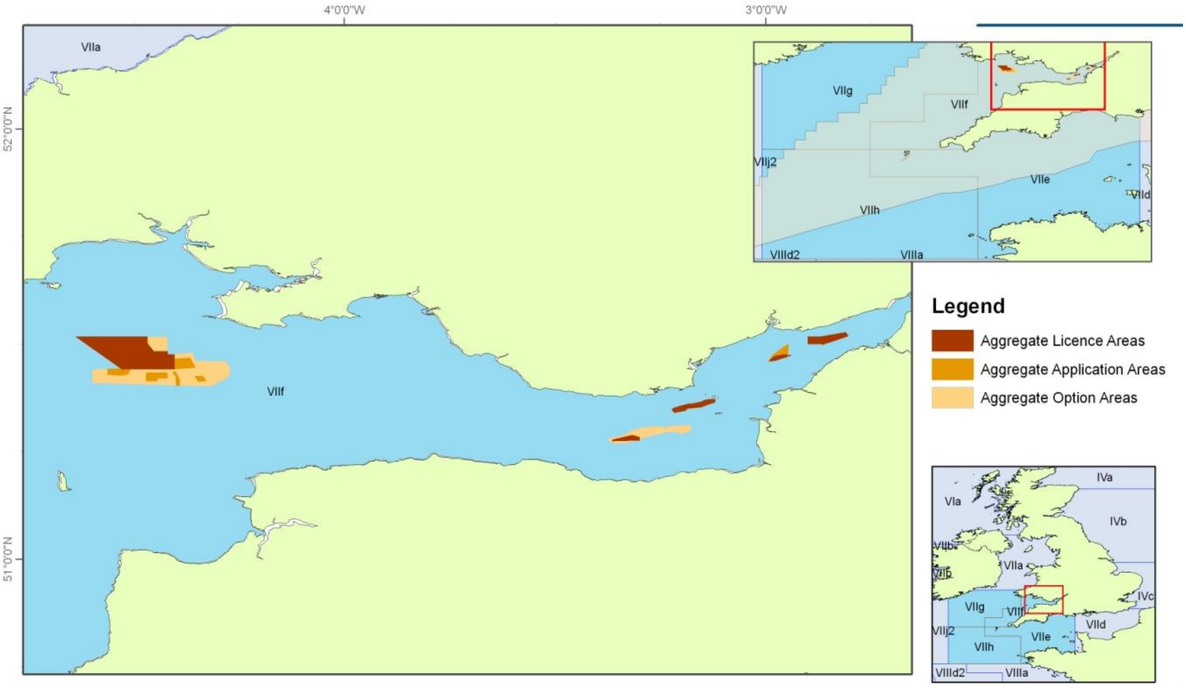

Figure 9: Aggregate sites in the study area

Contamination & disposal sites

One potential impact on the marine environment is that from chemical & radioactive contamination.

Chemical contamination includes determinants such as heavy metals, organotins, organohalogens & hydrocarbons to name a few. They are the result of past or present human activities; including mining, manufacturing, shipping, agriculture etc. This contamination can enter the marine environment through a number of sources, as runoff, piped discharge, dumping, atmospheric emission etc.

The effects that contamination can have on the environment are as diverse as the number and types of contaminates present. This can include for example, chronic effects such as death or acute effects such as the ability of a species to eat, hunt, breath, reproduce or on its DNA. TBT for example lead to impose particularly in dog whelks, this has since been banned but as more chemicals/ compounds are produced new products take their place. It is important to remember that the environment hosts a cocktail of contaminants, some contaminants can work antagonistically (to counter act the effects) or synergistically to magnify the effects. Whilst most substance will break down over time this can be many hundreds of years, even if they do breakdown readily, the break down products of a substance are occasionally more toxic than the source contaminant; for example DDT and DDE are more toxic than the parent DDT.

The ability of an organism to tolerate or withstand the contaminants around it varies from species to species, the stage of the life cycle, the degree of contact, type/form the contaminant is present in as well as the concentrations. Even if the smaller species can survive the contamination present the effects can be biomagnified up the food chain, and have more serious effects on the top predators.

One example of this is DDT which affected the thickness of the egg shells of birds. This caused breading failure and has consequently been banned.

Most of the area in question is in open sea. Human activity is restricted in these areas to ship or fishing traffic. There is not likely to be any significant contamination in this area (unless there is a ship wreck). Contamination is only likely to be found close to the coastline, where human activities are dominant.

In the Celtic Sea there is only one nuclear power station, located at the coast; Hinkley located on the River Severn. In the England & Wales the discharge and any licensable dredging activity are closely assessed for contamination from radioactive substances, before license are issued. The dumping of radioactive waste to sea is no longer permissible in the UK.

Discharges through pipes are licensed and regulated by the Environment Agency (EA) however there are many ways contamination can enter the sea unmanaged. Particularly through surface runoff off e.g. from agricultural land, or through activities that occur adjacent to the water (docks, harbours or works sited adjacent to water), or directly from ships (e.g. oil, litter, loss of cargo, munitions testing).

If contamination isn't dispersed through the water column, it will sink to the seabed. This report will focus on sediment chemical contamination. The degree of contamination in the sediment is influenced by the sediment type. Courser sediments such as gravel and course sands have larger interstitial poor spaces, whilst silts, clays have smaller poor spaces and a larger surface area, thus binding the water and contamination to the sediment more readily. Sands and gravels along with glacial material (untouched by modern human activities) are therefore considered clean, and rarely tested for contamination.

Contamination in situ will have a localised effect on species living in, on or closely reliant upon the sediment, e.g. shellfish, sand eels or benthic species (or benthic live stages), unless the material is disturbed and the contamination/sediment re-suspended; where it can be transported further a field.

Contaminated material may be re-distributed through activities such as excavation, dredging and trenching as well as storms or strong oceanographic processes.

All such works (if below the mean high water line, will be subject to a MCAA (Marine and Coastal Access Act) licence. Issue of a licence will be subject to assessment, as part of this assessment the material can and is often chemically tested. Each country has its own Action Levels, (in the UK the chemical analyses are compared against Cefas Action Levels), these were developed to help decision makers ensure that heavily contaminated material is not dumped at sea. If contamination is found to exceed the levels, the material is excluded from disposal at sea. If the material is removed to land, the licence will also ensure that this is done is such a way as to mitigate the re-suspension of the contaminated material, for example the material may be removed behind silt curtains or if in shallower waters at low tide.

Any material permitted for disposal to sea must be placed in a licensed disposal area (Figure 10). These are assessed for suitability including a risk assessment to the environment before they are designated. This includes the risk of the material migrating to sensitive habitats/species. Material to be deposited is also taken into consideration against the type of material at the disposal site. So for example silt material would not be placed on top of gravel.

In this case study area there are 36 open disposal sites (in UK) located within 12nm from the coastline, one in Ireland and one along the French coast. These occupy a small proportion of the sea bed and are not likely to cause an impact to fisheries in terms of contamination.

The UK, France and Ireland have signed up to both the OSPAR and LC/LP conventions, (both with the aim of protecting the marine environment in the NE Atlantic (OSPAR) and globally (LC/LP), as part of this they both monitor dumping at sea. Anything dumped with levels exceeding Action levels has to be reported and justified. This has not happened in UK waters (except as a capping trial in the North Sea).

Whilst some parts of the study area around the English and Welsh coastline do have high levels of some determinants, sometimes exceeding upper Action Levels, these areas are regulated and dumping at sea is non-permissible, however, these areas are small and any effects to the fish population will be localised.

Designated sites for waste disposal are allocated by the MMO. In this report only open disposal sites are used as the scope is an assessment of the current status of the SW waters; however no data on the amount or spatial extent of actual disposal activity are available for this report.

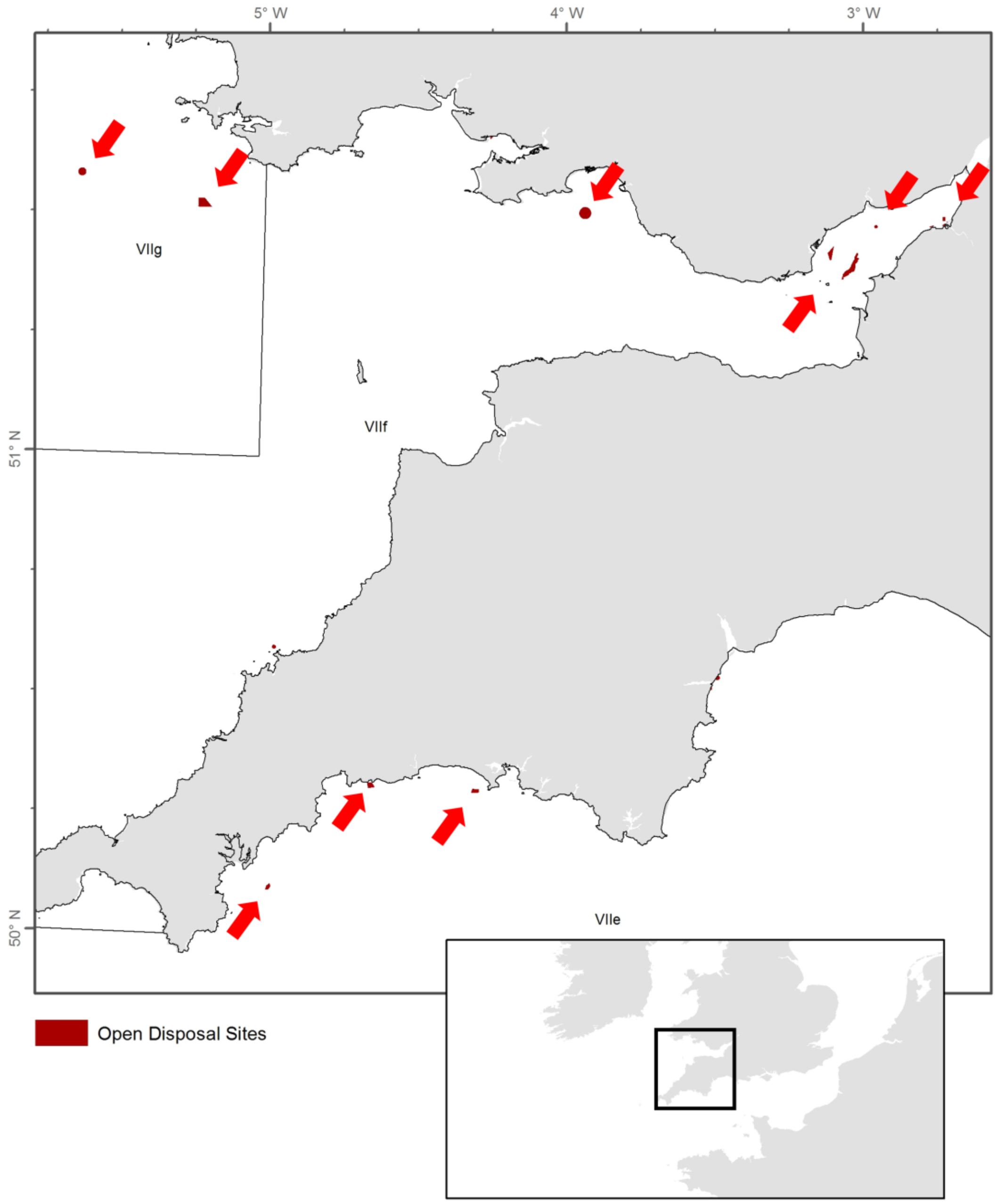

Figure 10: Locations of open disposal sites

Methodology

The data used in this assessment consists mainly of extrapolated point data. Instead of using the raw point data the extrapolated product was used for the overlapping analysis. For details on the creation of the EU SeaMap see Cameron and Askew (2011). Details on the creation of nursing and spawning grounds can be found in Ellis et al. (2012). See Lee et al (2010) for the creation of fishing intensity layers from VMS data and Vanstaen and Silva (2010) for the national inshore fishing layer. The raw data for disposal sites and areas of aggregate dredging are license areas and therefore available as polygon data.

In general data were clipped to the extent of each ICES region and the area of each feature was then calculated in the metric coordinate system WGS1984 UTM 30N, which is suitable to calculate areas. Following the composition in Table 1 intersection between the features were calculated in area and percentage using either the 'Intersect' tool[1] or the 'Tabulate Intersection' tool[2] in ArcGIS 10.1. The outputs were then compiled in one master table (Figure 11).

The calculated percent overlap between activities and features is based on the distribution of the feature within ICES areas VIIe-h, and not the total extent of the feature.

VMS raster data as well as inshore vessel data were reclassified (raster data with the 'Reclassify' tool[3], shapefiles by indexing based on value ranges) to low, moderate and high intensity following the approach by Vanstaen and Silva (2010) (Table 3). This approach was chosen as the data distribution of both VMS data and inshore sightings is skewed towards low activity and an equal interval colour scheme would provide poor differentiation between areas of relatively low and relatively high fishing activity intensity (Vanstaen and Silva, 2010). In this approach a geometric sequence is used to define the intervals for the colour scheme, *i.e*. each class upper limit is an increment three of the upper limit of the previous class (Figure 3).

---

[1] Computes a geometric intersection of the input features. Features or portions of features which overlap in all layers and/or feature classes will be written to the output feature class. (Esri, 2011)

[2] Computes the intersection between two feature classes and cross-tabulates the area, length, or count of the intersecting features. (Esri, 2011)

[3] Reclassifies (or changes) the values in a raster. (Esri, 2011)

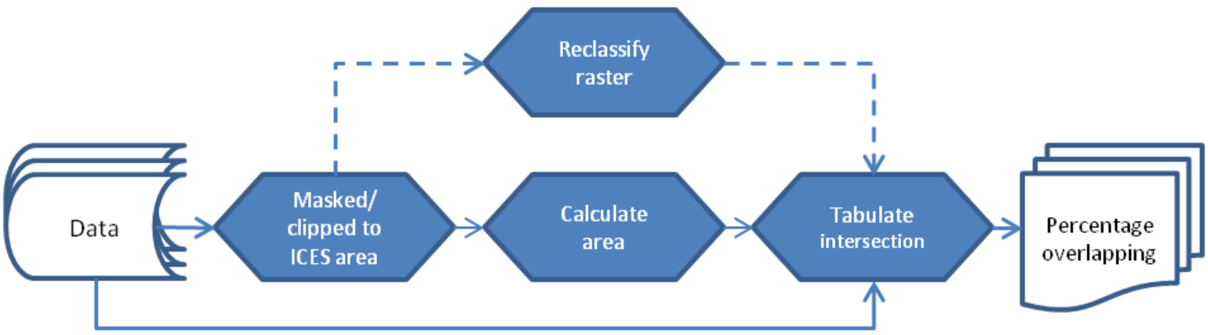

Figure 2: Work flow chart for the creation of percentages of overlapping between features

Table 3: Qualitative intensity in relation to actual values

Intensity	VMS (Hours fished per year)	Inshore fishing activity (Sightings per unit effort)
Low	0 – 25.1	0 – 0.075
Moderate	>25.1 – 225.9	>0.075 – 0.675
High	> 225.9	>0.675

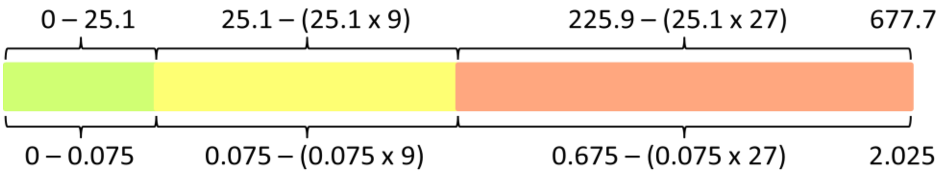

Figure 3: Relative fishing activity classification colour scheme used in the maps presented in this report

Results

VMS data in the ICES regions

VMS data from 2007 have been plotted for the ICES regions VIIe-h and the percentage of the fishing intensities (low, moderate & high) per gear type in each ICES region have been calculated. Low intensity fishing is covering the highest percentage of each ICES region with maxima VIIf (35.67%) and VIIh (27.21%) when using trawls and maxima in VIIg (27.21%) and VIIe (13.41%) when using nets. The lowest coverage has gear type seines (2.20% only in VIIe) (Figure 13 and 14).

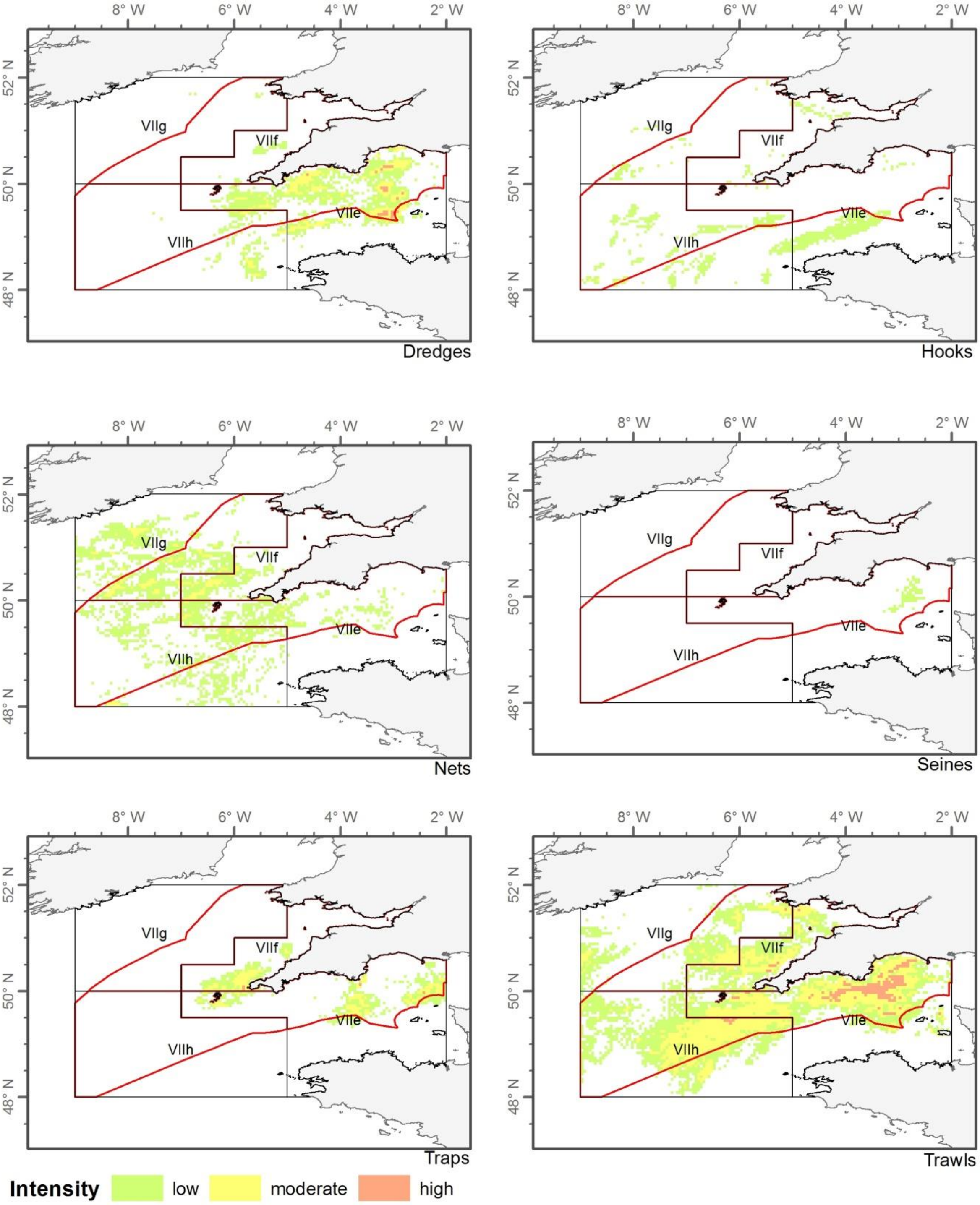

Figure 13: Fishing intensity from VMS data (2007) for different gear types

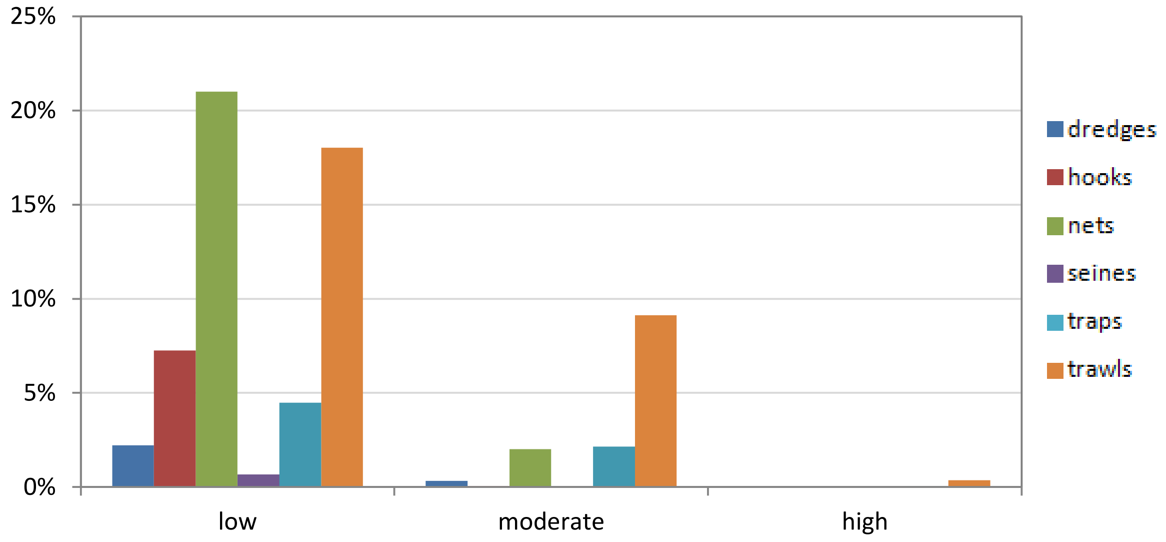

Figure 14: Percentages of low, moderate and high intensity fishing activity from VMS data in all ICES regions

The coverage of moderate intensity is less than for low fishing intensity, however is reflecting the same general pattern, with highest percentages for trawls and to lesser extent for nets (Figure 13 and 14).

Only few areas a fished with high intensity and only two gear types are present in high intensity fishing in SW waters (traps and trawls). VIIe and VIIf having the highest proportion of high intensity fishing activities (Figure 13 and 14).

Inshore fishing activities

Inshore fishing (<12nm off shore, but exceptions up to 16nm (Vanstaen, pers. comm.)) is showing the same general pattern as the VMS data, with high percentages of areas affected by different types of gear under low intensity fishing (up to 78% in VIIf for dredges and lining; Figure 15 and 16) and an decrease in coverage under increasing intensity with only a few gear types with lower percentages until only one gear type is left with negligible coverage (dredges, 0.02% in VIIg). VIIh has no inshore activity as it is outside the range of vessels smaller than 15m (from UK).

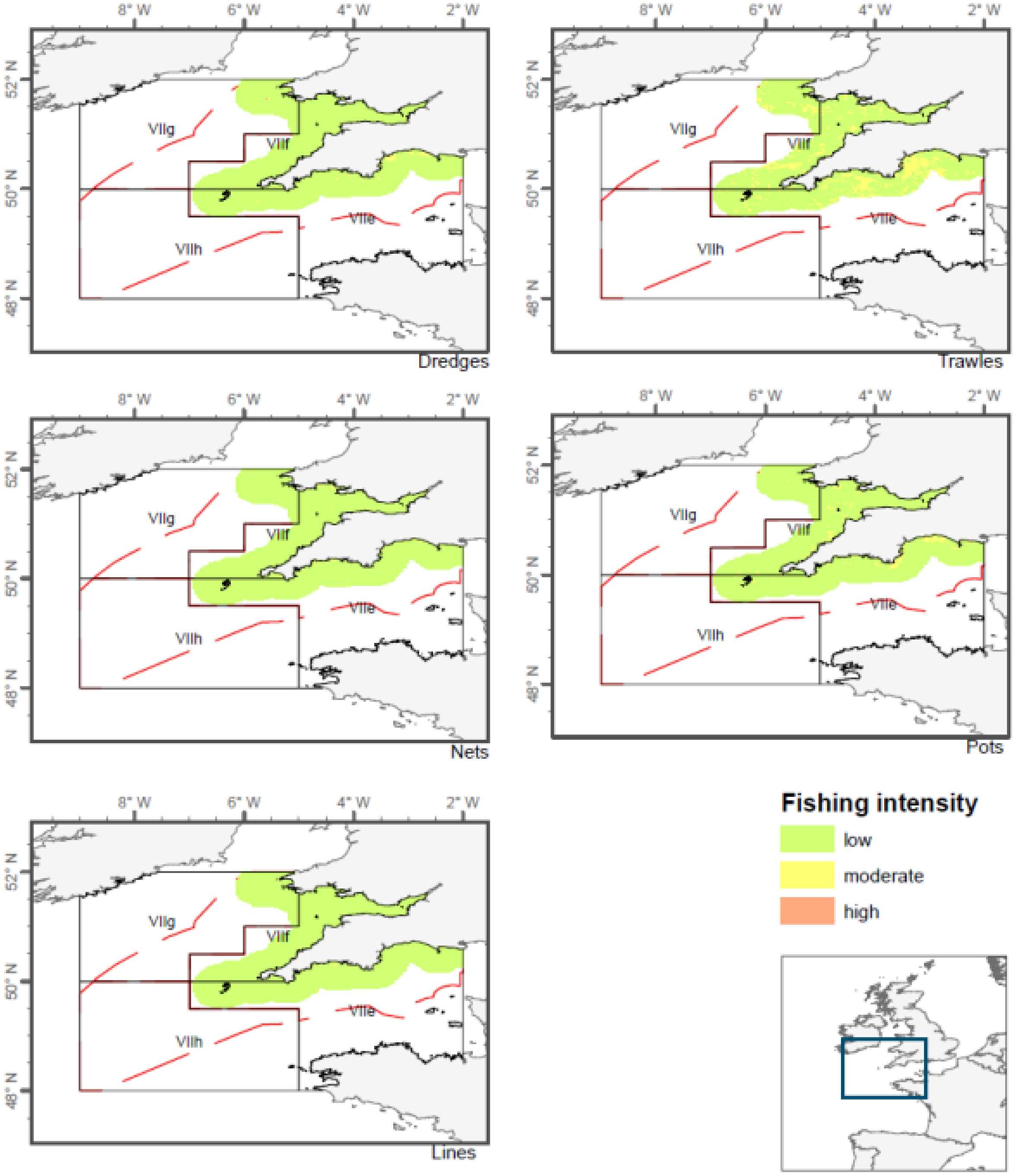

Figure 15: Fishing activity from inshore sightings (2009) grouped into different gear types

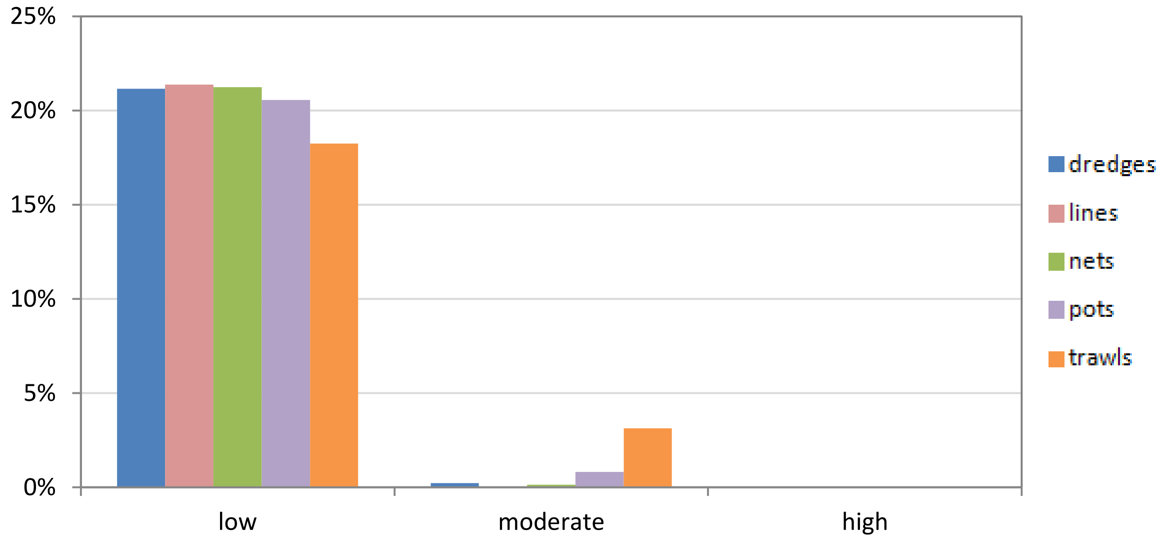

Figure 16: Percentages of low, moderate and high intensity fishing activity from inshore data by ICES region VIIe-g

Region VIIf experiences the highest percentage of low level fishing activity as it is also the region that lies almost completely within the range of inshore fishing vessels (Figure 15 and 16). There is very little difference between the gear types associated with low intensity fishing. Under moderate intensity mostly trawling is used, this is in contrast to low intensity areas where trawling is the least used gear. Very little high intensity fishing occurs in the ICES regions VIIe to VIIg. Fishing with dredges is the only gear type that is used with high intensity.

Fishing overlap with habitats

Fishing activities from vessels greater than 15m extents over all seabed habitat types as well as all spawning and nursery grounds. The affected area decreases with increasing fishing intensity as already visualised in figure 15 and figure 16.

Low intensity fishing activity affects most of the seabed habitat types, with trawls, nets and dredges are the main overlapping gears. The highest overlap exists between trawls and fine deep sea sediment (59% sand; 41% mud) (Figure 18). Whereas trawls and nets cover all four ICES regions, the majority of fishing with dredges occurs in VIIe only. Seines are the gear type overlapping with the least seabed habitats, all of them classified as rock or coarse/mixed sediment in VIIe. In three habitats, moderate circalittoral rock, circalittoral coarse sediments and circalittoral mixed sediments, all six gear types are present.

Overlapping between moderate fishing activity and seabed habitat is dominated by trawling and netting as both activities again cover all four ICES regions (Figure 13 and Figures 19-20). Trawling has the highest overlaps with up to 38% (sandy mud/mud) (Figure 20). Fishing with hooks decreases rapidly under moderate intensity and affects only upper slope seabed in VIIh.

Trawls are again the major gear type under high intensity fishing (Figure 21), as it overlaps with both, coarse and fine circalittoral sediment by approximately 6%. The overlap maily occurs in VIIe but VIIf and VIIh are also affected. The gear type with the second largest impact is dredges in VIIe (approx. 1.5% overlap with coarse sediment).

Conclusions on the interaction of fishing with benthic habitats needs to be treated with caution due to the limited confidence in the benthic habitats maps.

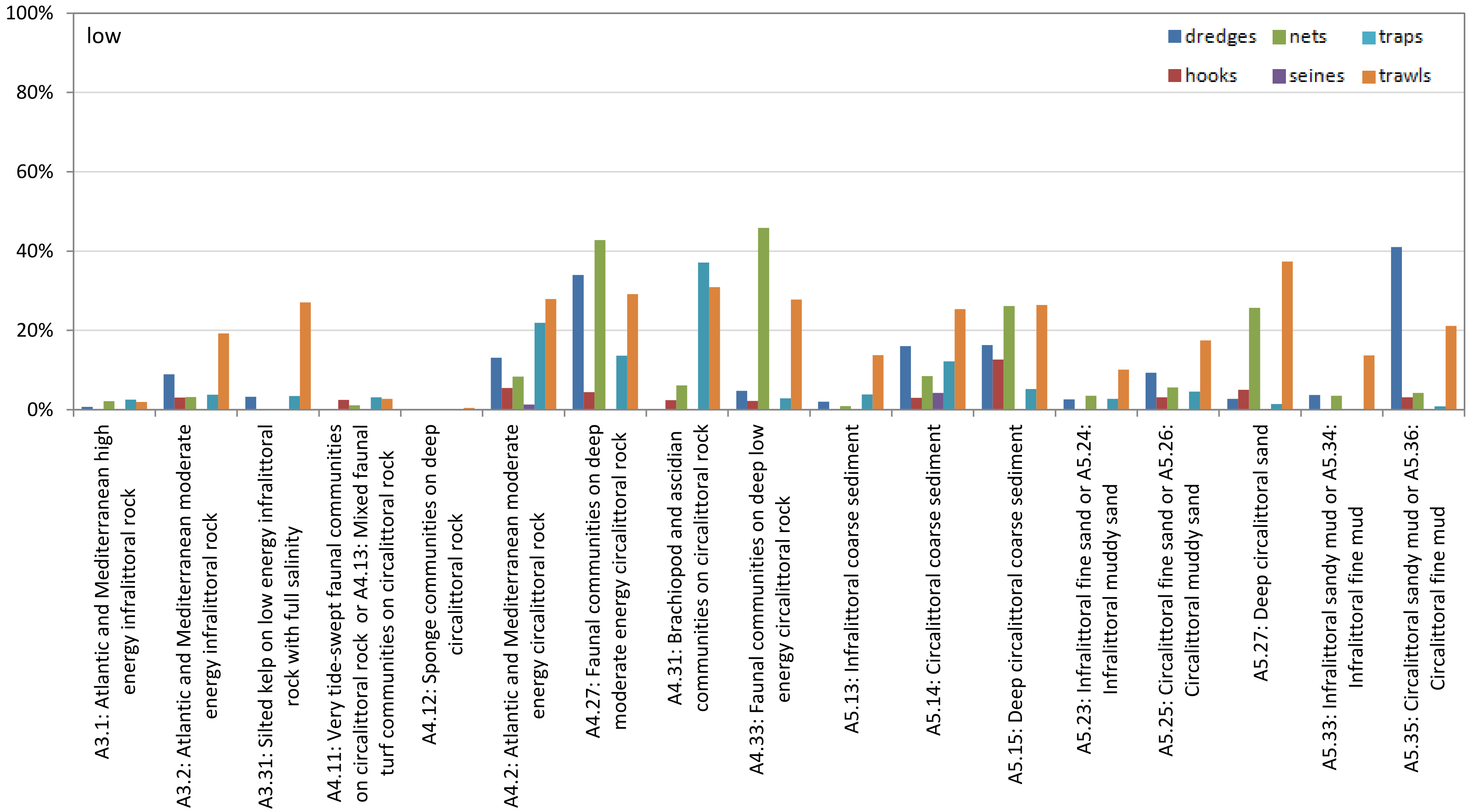

Figure 17: Overlapping from VMS gear (low intensity) with EUNIS habitat (Part 1)

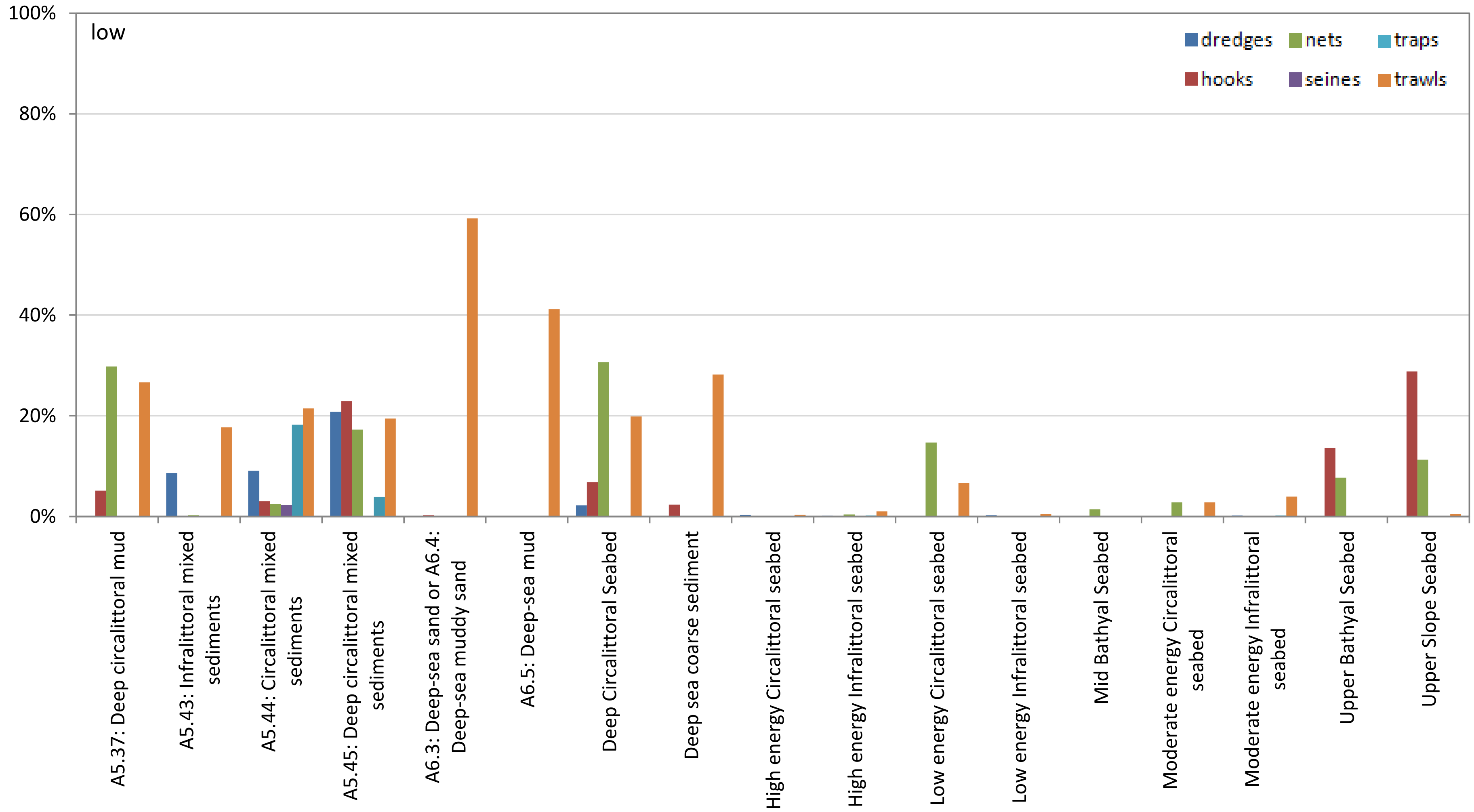

Figure 18: Overlapping from VMS gear (low intensity) with EUNIS habitat (Part 2)

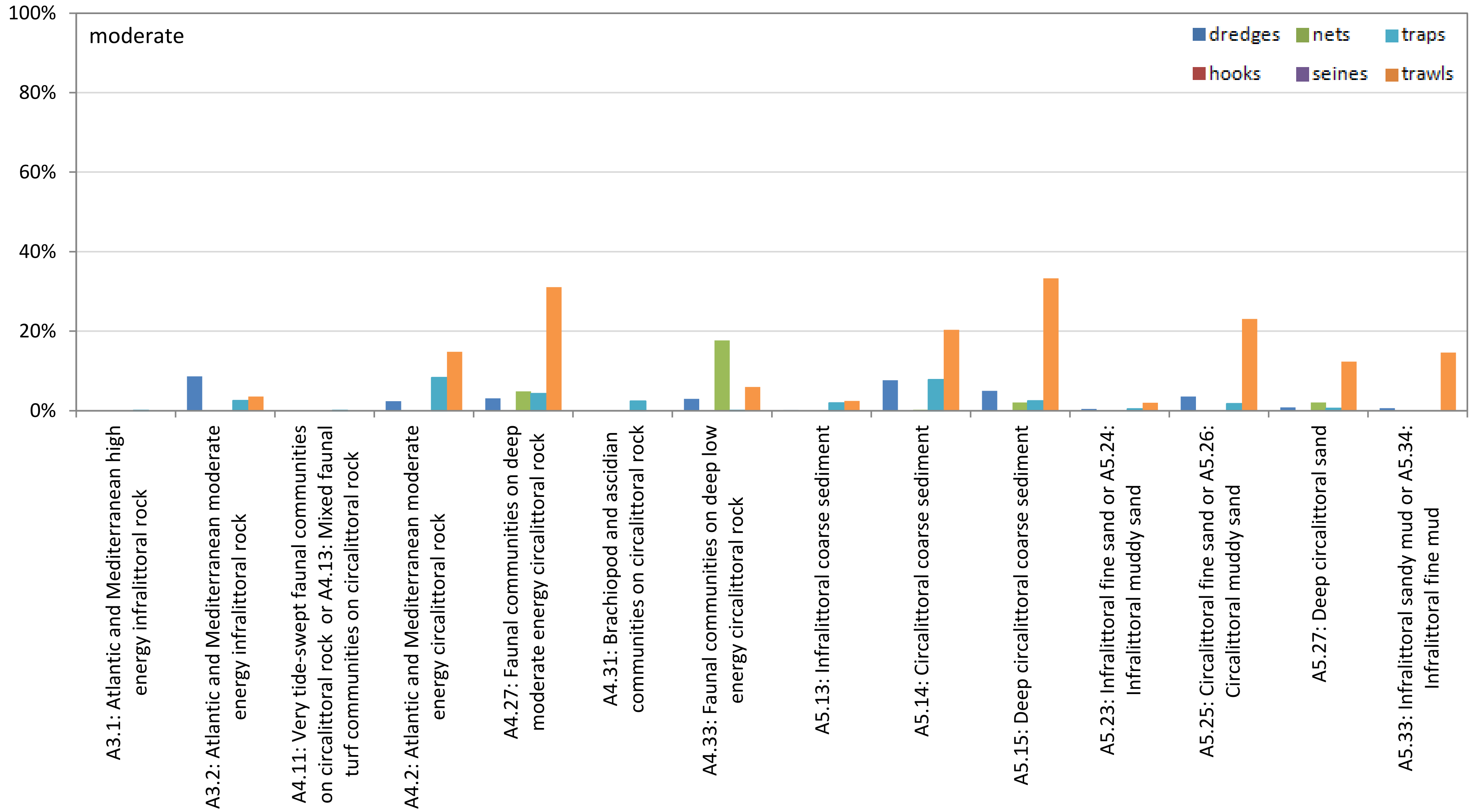

Figure 19: Overlapping from VMS gear (moderate intensity) with EUNIS habitat (Part 1)

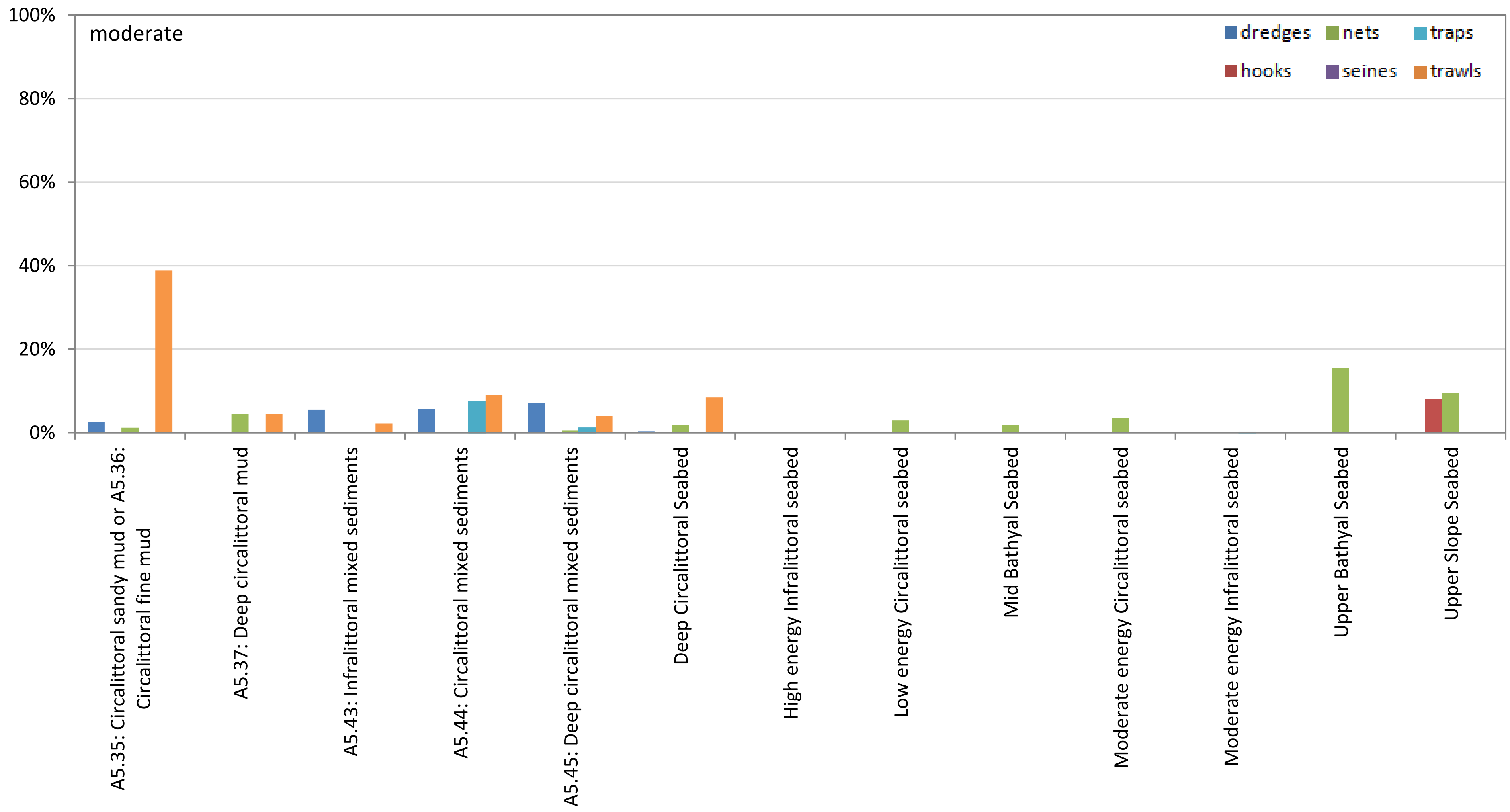

Figure 20: Overlapping from VMS gear (moderate intensity) with EUNIS habitat (Part 2)

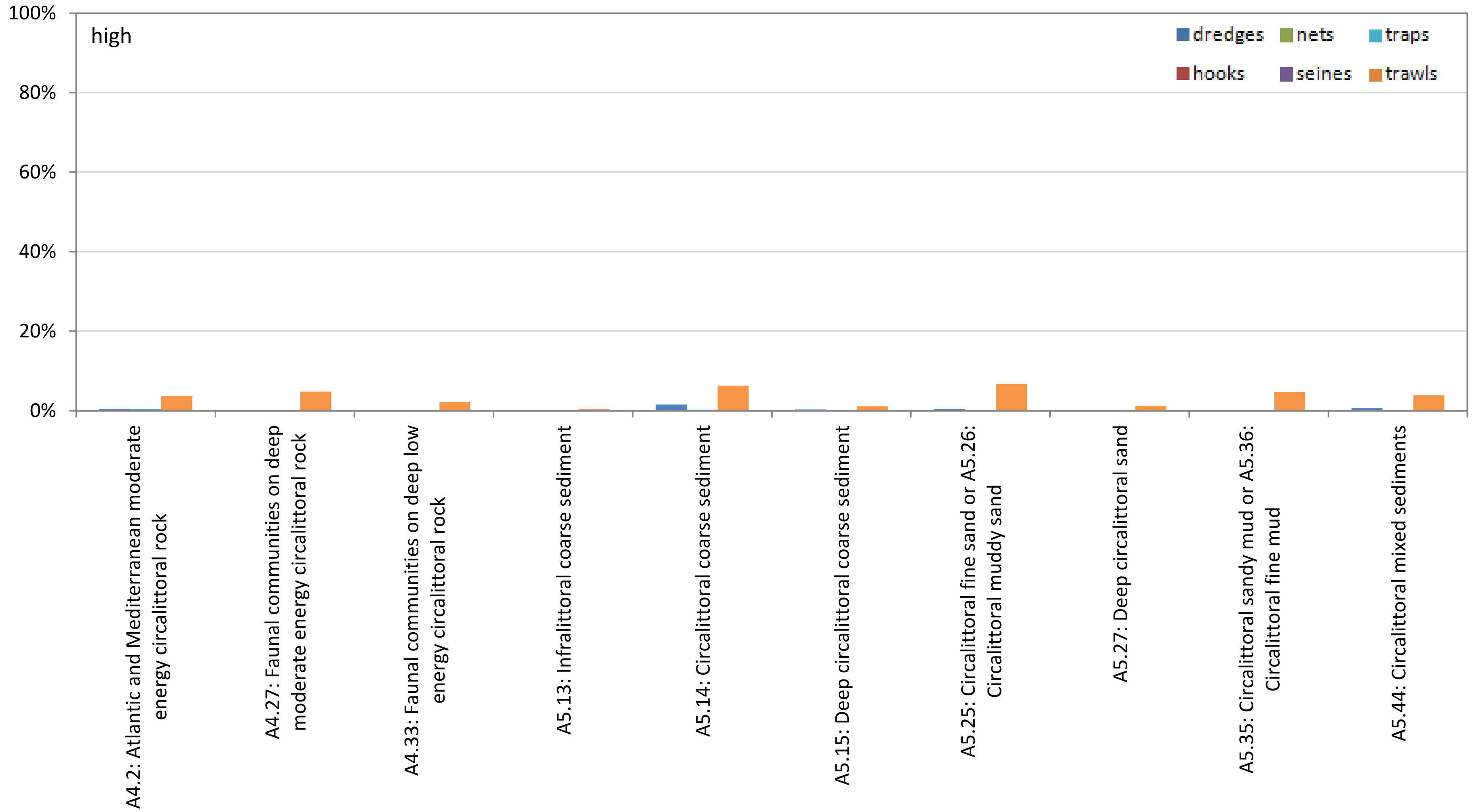

Figure 21: Overlapping from VMS gear (high intensity) with EUNIS habitat

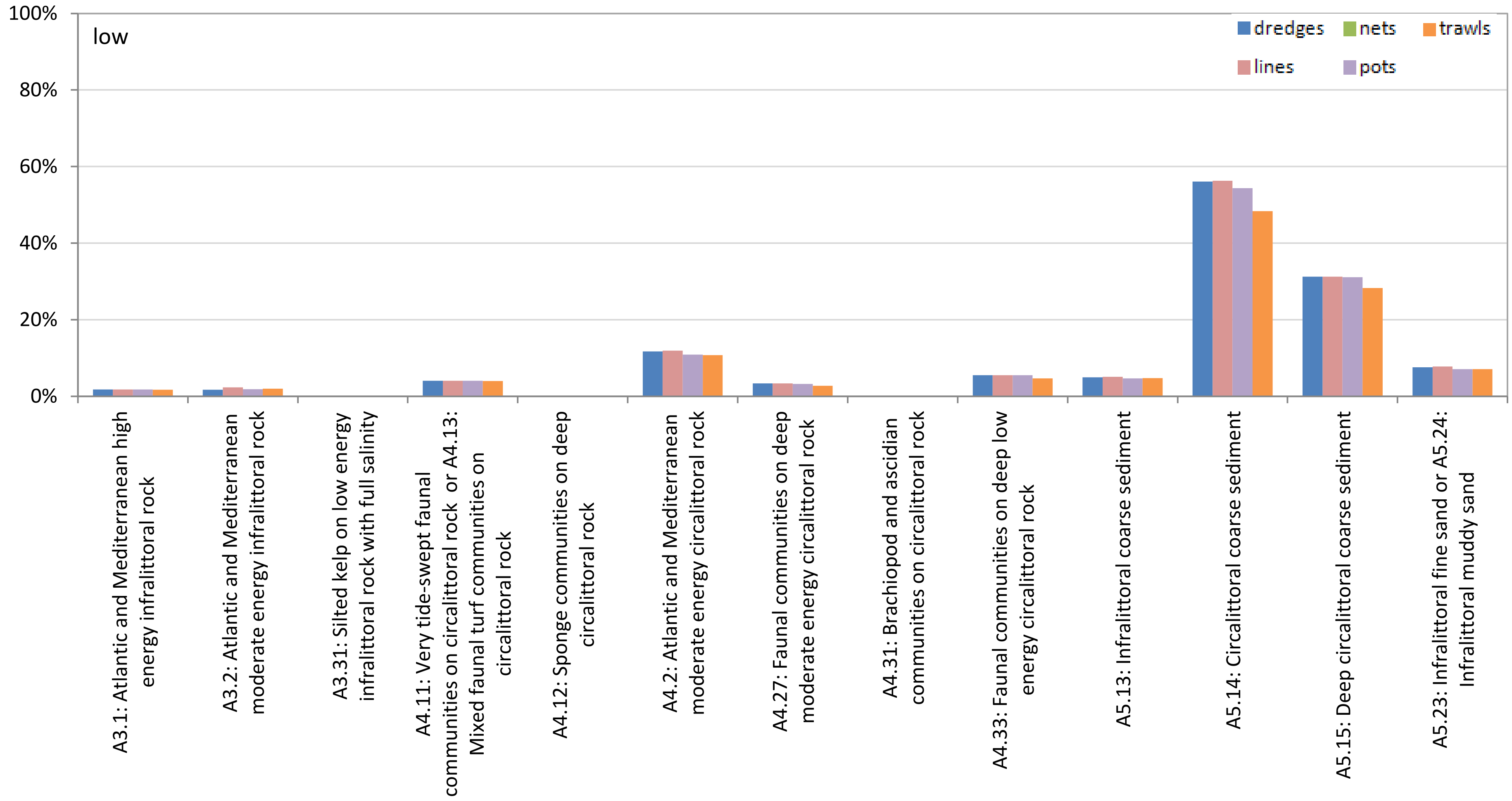

Figure 22: Overlapping from inshore sightings (low intensity) with EUNIS habitat (Part 1)

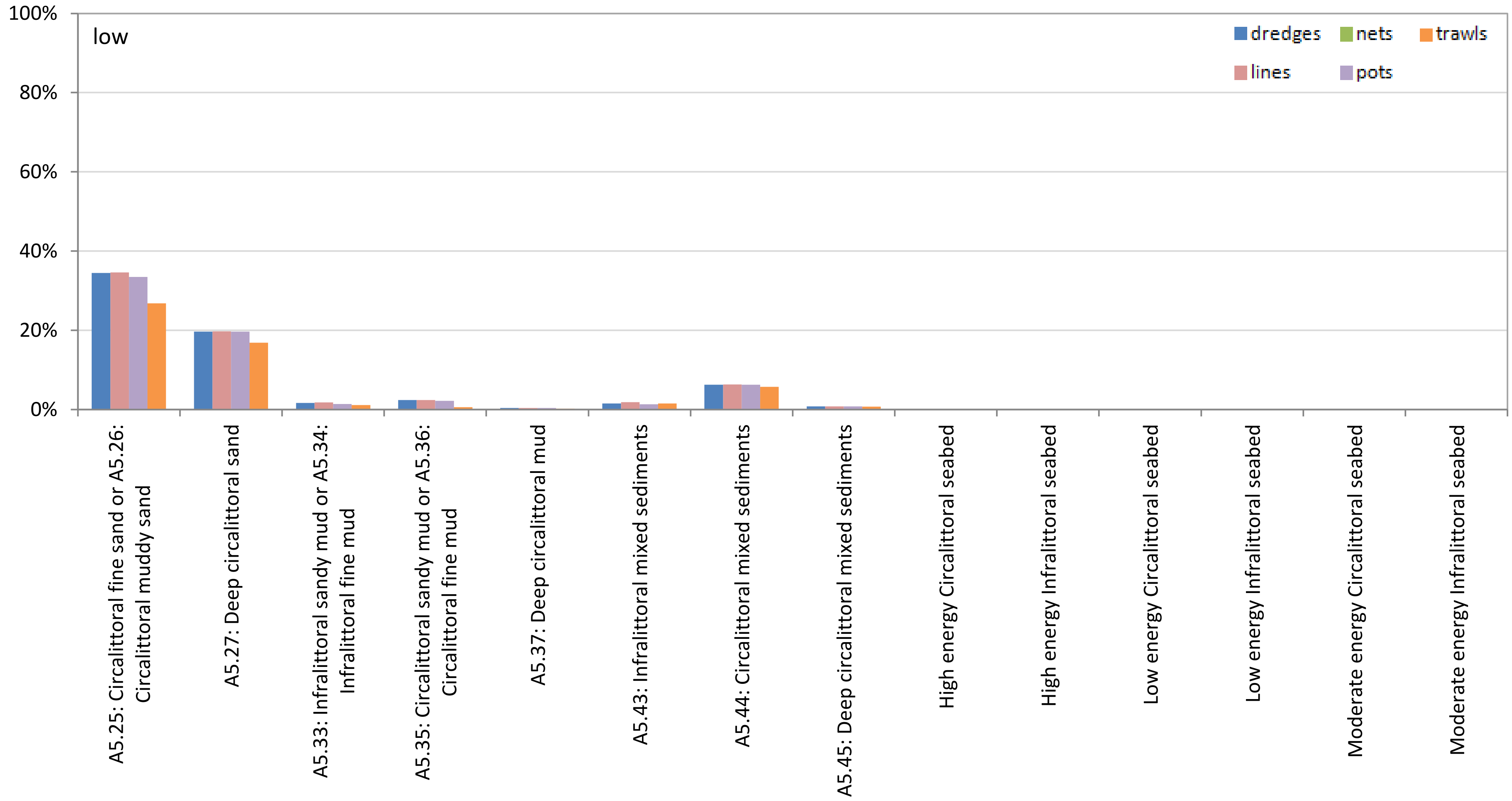

Figure 23: Overlapping from inshore sightings (low intensity) with EUNIS habitat (Part 2)

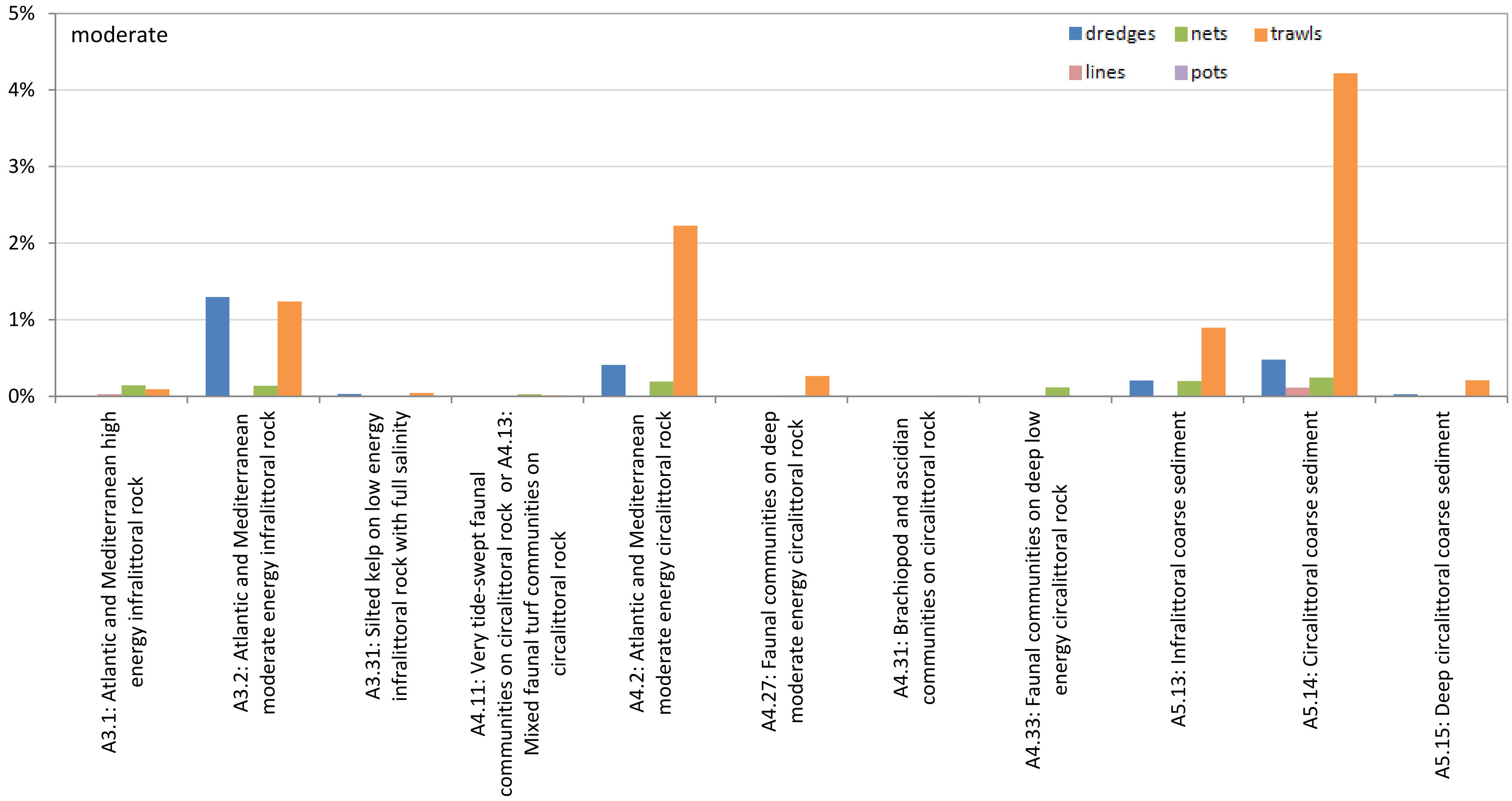

Figure 24: Overlapping from inshore sightings (moderate intensity) with EUNIS habitat (Part 1)

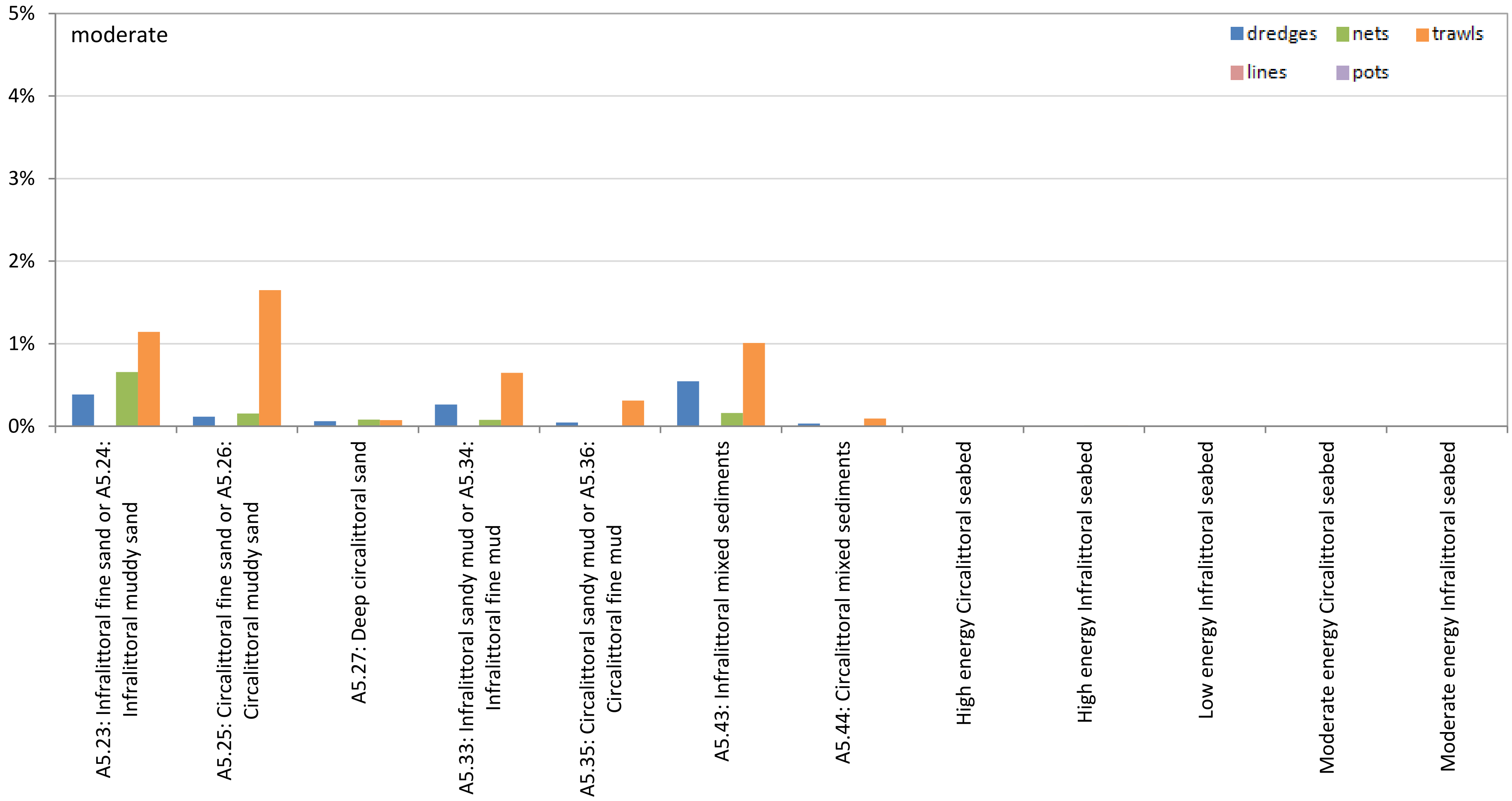

Figure 25: Overlapping from inshore sightings (moderate intensity) with EUNIS habitat (Part 2)

Fishing overlap with nursery grounds

Nursery grounds are primarily affected by fishing with nets and trawls (Figure 26). Low intensity fishing with nets has the highest overlap with a single species (common skate) with approximately 40% as both fishing activity and nursery grounds are predominately located in VIIg. Fishing with trawls has high overlaps (approx. 25%) with the majority of nursery grounds due to the high dispersion of the fishing activity (Figure 13).

A similar pattern can be observed in the moderate fishing intensity, with approximately 15% overlapping of trawls with the majority of nursery grounds and a peak of 27% overlapping with anglerfish nursery grounds (Figure 27).

Trawling is also the predominant gear type under high intensity fishing (especially in VIIe) as it has the highest overlaps of all six gear types with almost all species nursery grounds. The highest overlap of a species with trawling has the spotted ray (11%) as its nursery ground is located in the same areas (VIIe and VIIf) as the high intensity trawling (Figures 5, 13 & 28). High intensity fishing with hooks, nets, traps and seines overlaps less than 1% of nursery grounds of any species listed.

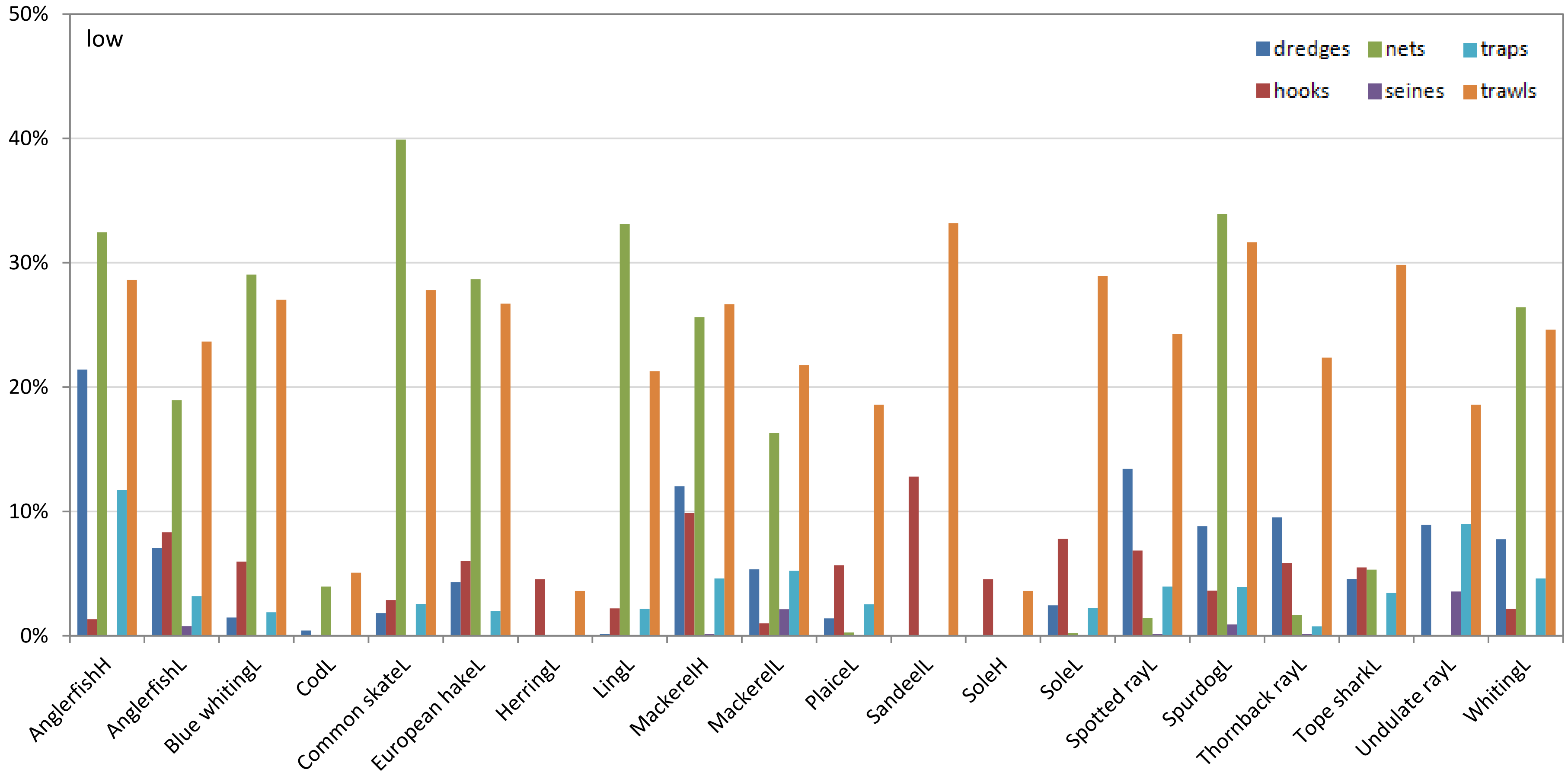

Figure 26: Overlapping between low intensity fishing (VMS data) and nursery grounds

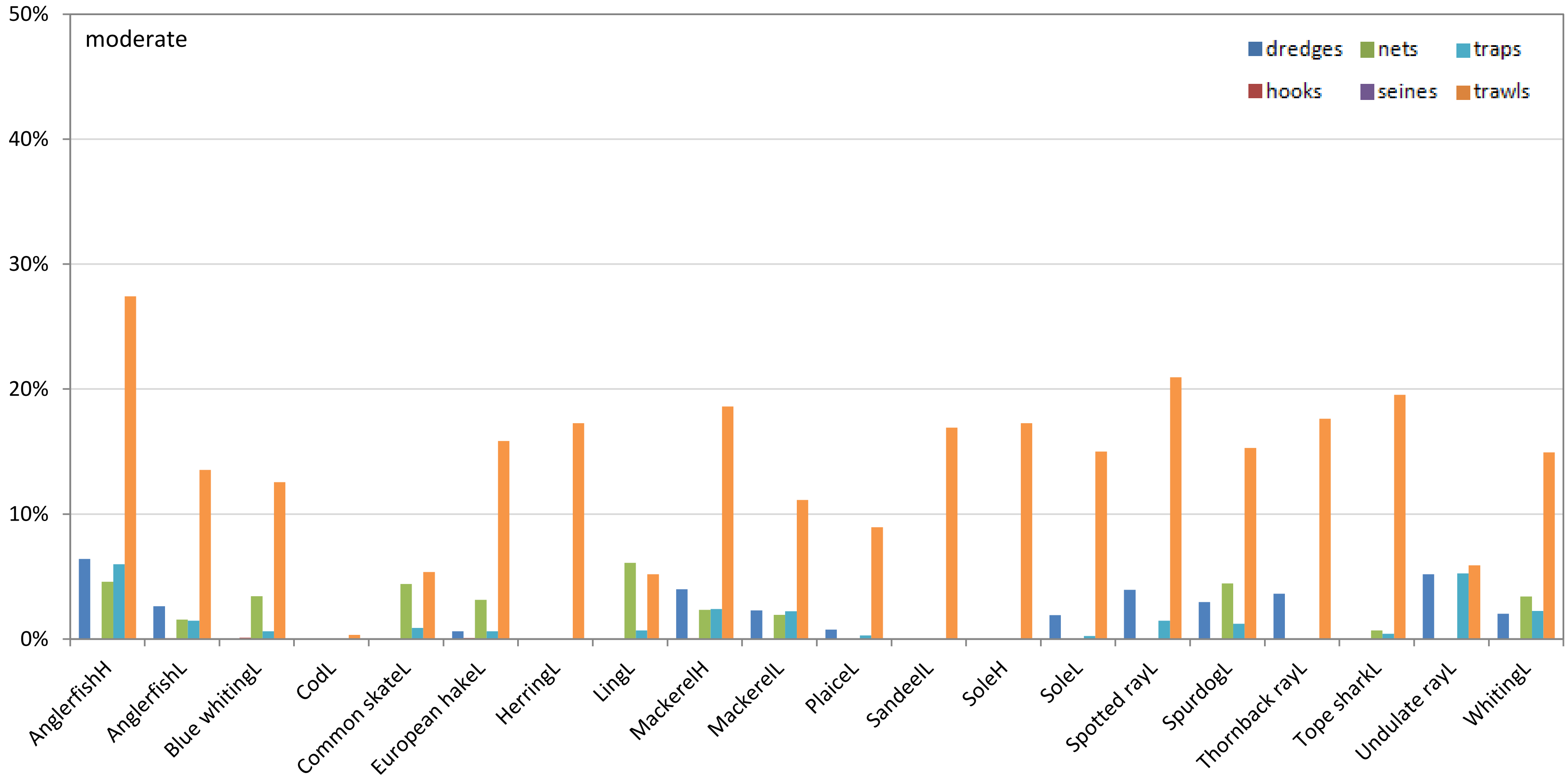

Figure 27: Overlapping between moderate intensity fishing (VMS data) and nursery grounds

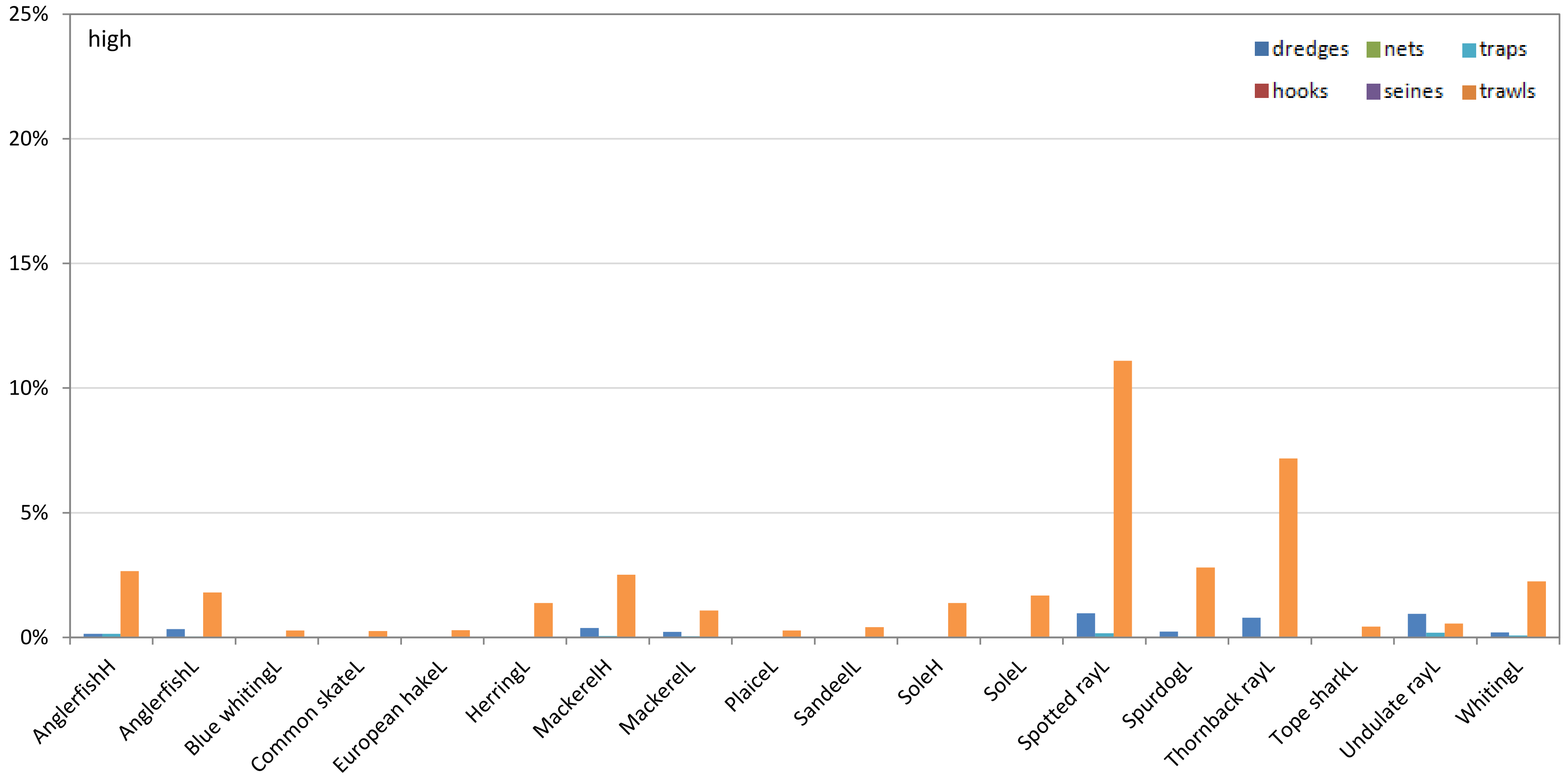

Figure 28: Overlapping between high intensity fishing (VMS data) and nursery grounds (Note the different scale)

Fishing overlap with spawning grounds

Most of the spawning grounds have major overlaps with low intensity fishing using nets and trawls. Trawls overlap of approximately 30% with all spawning grounds due to the widespread distribution of this fishing gear (Figures 13 & 29).

A similar pattern can be observed under moderate fishing intensity (Figure 30), with over half of all spawning grounds have overlaps of over 25% with trawling. Compared to low intensity fishing and other fishing activities, the gear type traps increases its overlap, especially in the spawning area of plaice. Here traps overlap up to 17% with the low importance spawning area.

Spawing areas and high intensity fishing overlap only marginally (Figure 31) except sandeel and sole, as their spawning areas are located in the regions VIIe and VIIf in which also high intensity fishing with trawls occurs (Figures 8, 13 & 31).

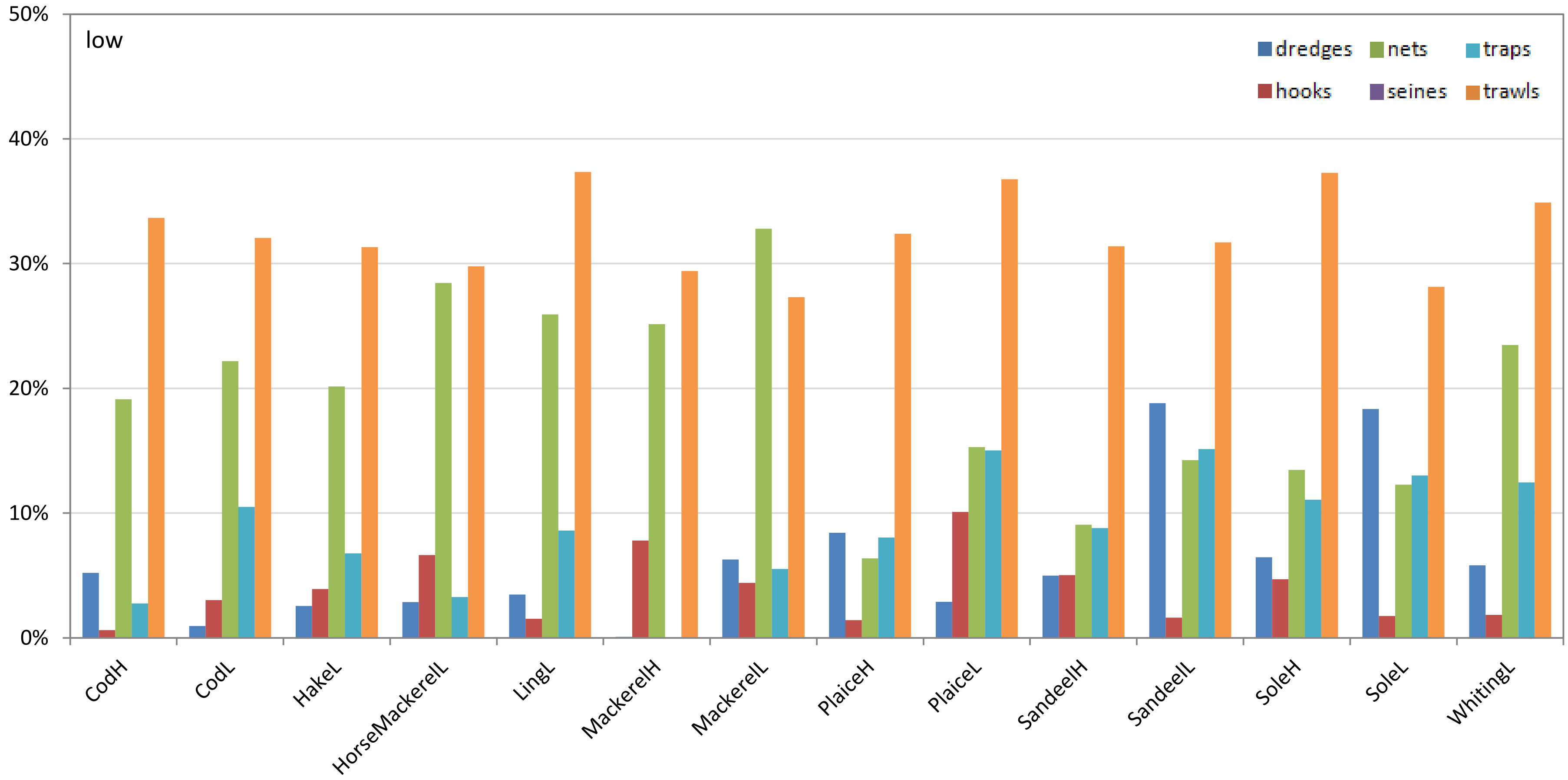

Figure 29: Overlapping between low intensity fishing (VMS data) and spawning grounds

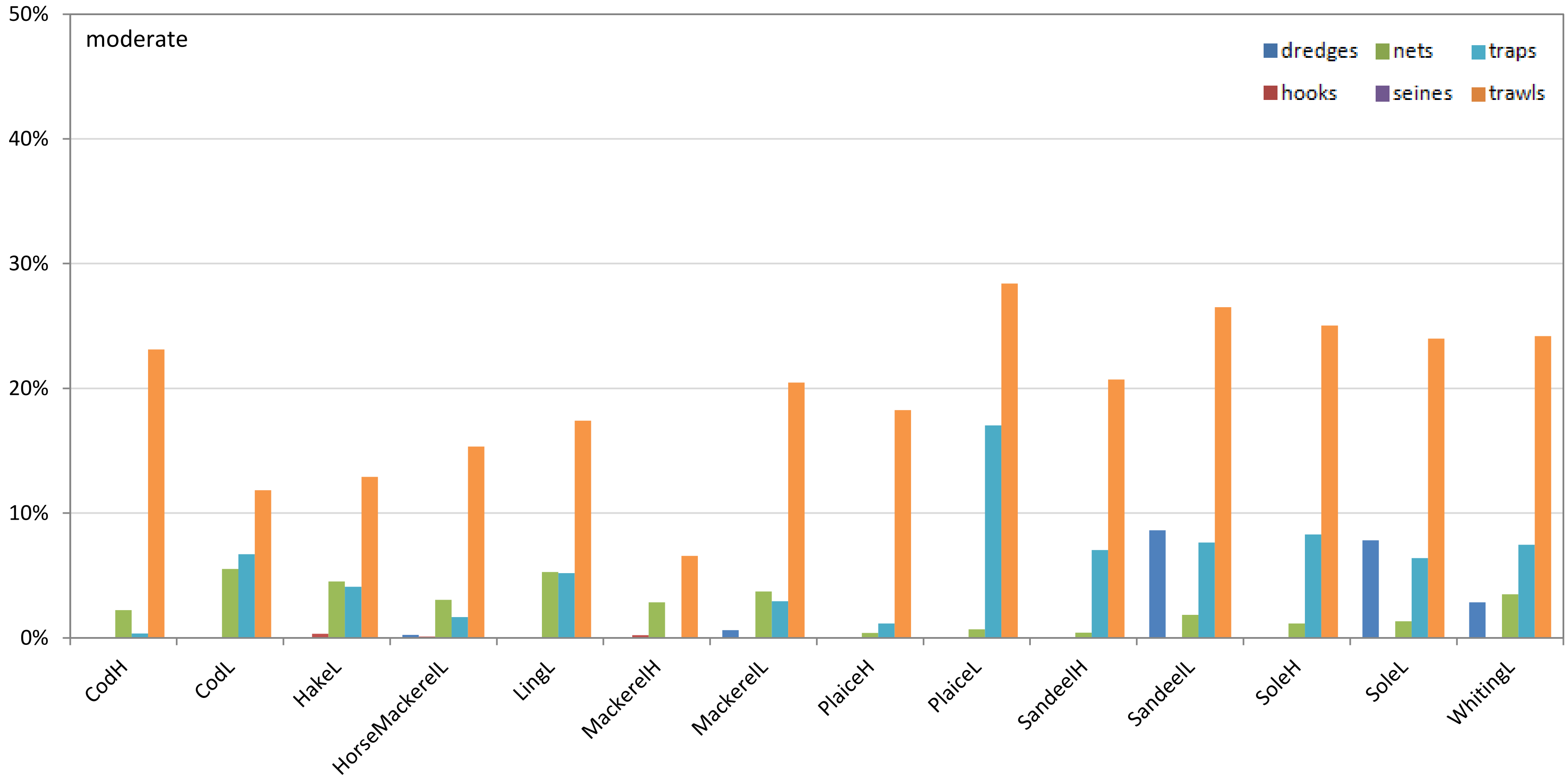

Figure 30: Overlapping between moderate intensity fishing (VMS data) and spawning grounds

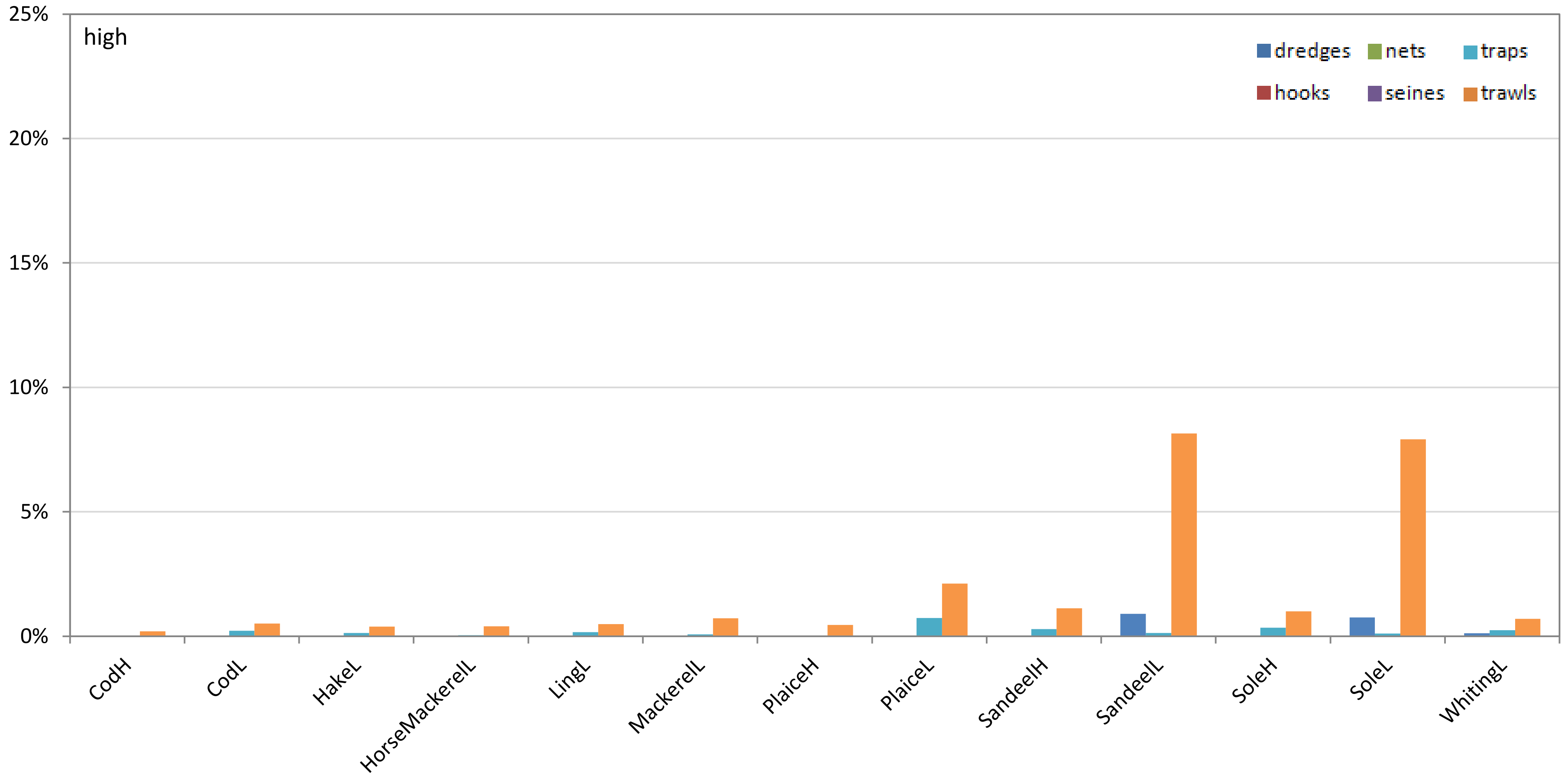

Figure 31: Overlapping between high intensity fishing (VMS data) and spawning grounds (Note the different scale)

Habitat classification

As the EUNIS classification would have included 21 different habitat types over all four ICES regions, only habitat types that have a higher than average percentage are separately included in Figure 32.

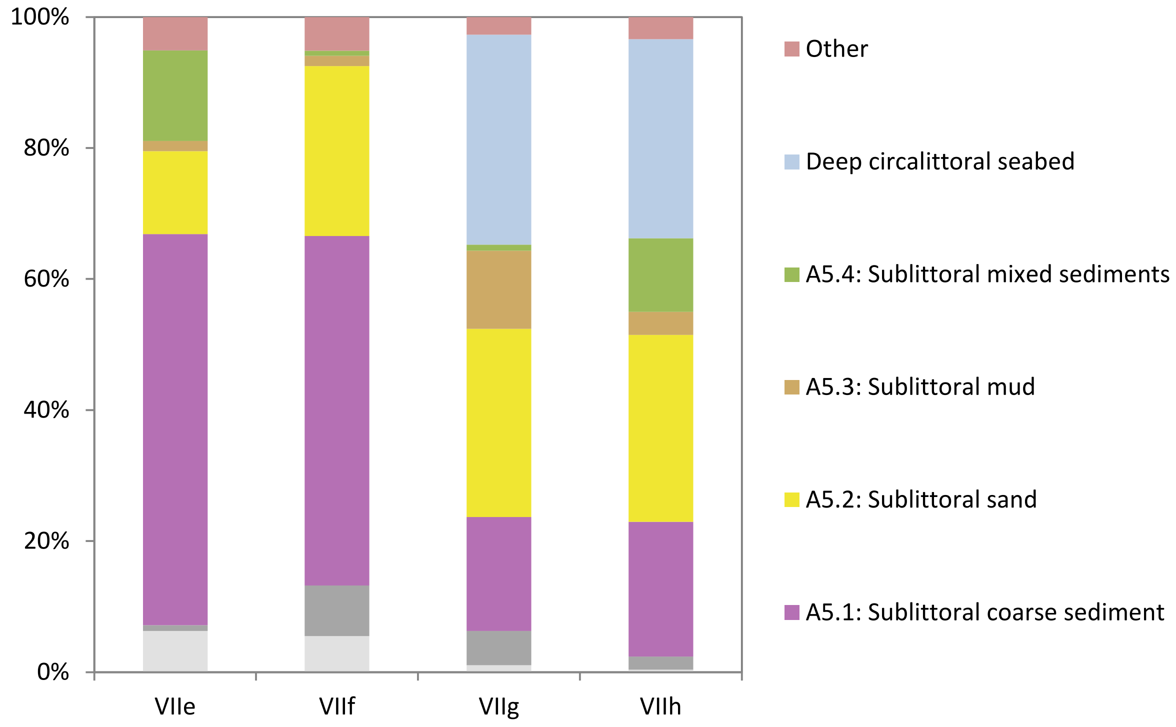

Figure 32: Stacked bar charts of percentages of EUNIS and non-EUNIS habitat types on ICES region VIIe-h

The predominant habitat in ICES regions VIIe and VIIf is sublittoral coarse sediment, whereas in the further westerly areas VIIg and VIIh deep circalittoral sediment, a non-EUNIS habitat type is the majority. Sublittoral sand is widespread thorough all four ICES regions.

Aggregate dredging

Aggregate dredging occurs only in VIIf and affects only four habitat types and affects to its largest extent high energy infralittoral rock, where it is assumed to be subject to high dispersion (Table 4).

Table 4: Percentage of area affected from EUNIS and non-EUNIS habitat types by aggregate dredging per ICES region

Aggregates	VIIe	VIIf	VIIg	VIIh
A3.1: Atlantic and Mediterranean high energy infralittoral rock	0	4	0	0
A4.1: Atlantic and Mediterranean high energy circalittoral rock	0	1	0	0
A5.1: Sublittoral coarse sediment	0	1	0	0
A5.2: Sublittoral sand	0	1	0	0

Overlapping between aggregate dredging and nursery and spawning ground is limited to region VIIf. Plaice is the most impacted species with aggregate dredging overlaps with 1.92% of the low intensity nursery area (Figure 33a). Similar to nursery grounds, there is only a limited overlap between spawning areas and aggregate dredging. The highest percentage of overlap exists with sole (low importance) (1.18% of the whole spawning area) (Figure 33b).

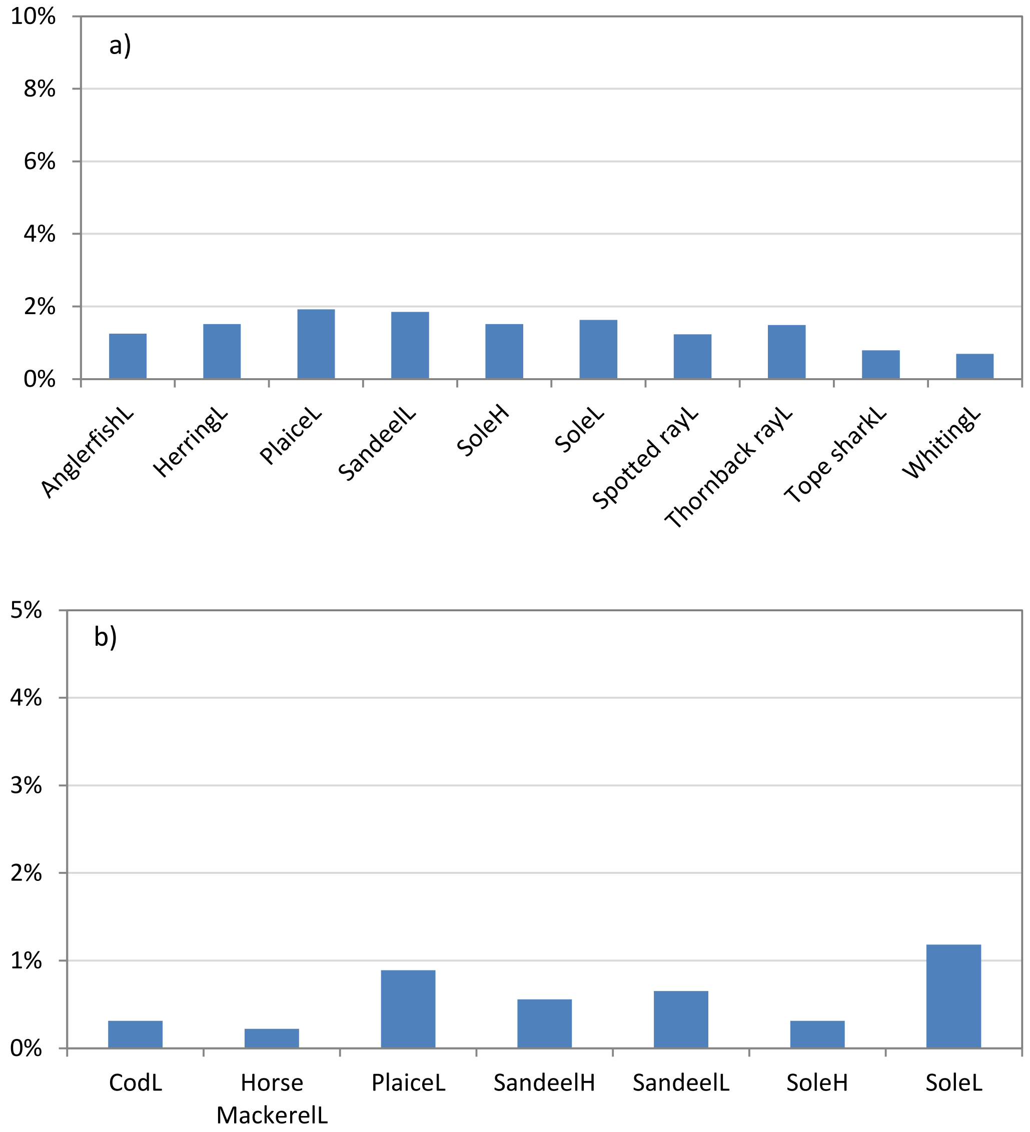

Figure 33: Percentage of overlap between nursery grounds (a) and spawning grounds (b) with aggregate dredging (Note the different scales)

Disposal activity

Disposal activity is more widespread than aggregate dredging and occurs in all ICES regions except VIIh. Up to 16% of all sublittoral sand in VIIe is affected by disposal activities; however none or almost none is affected in any of the other regions. In VIIf mixed sediments are most affected by disposal activities (approx. 3.2%).

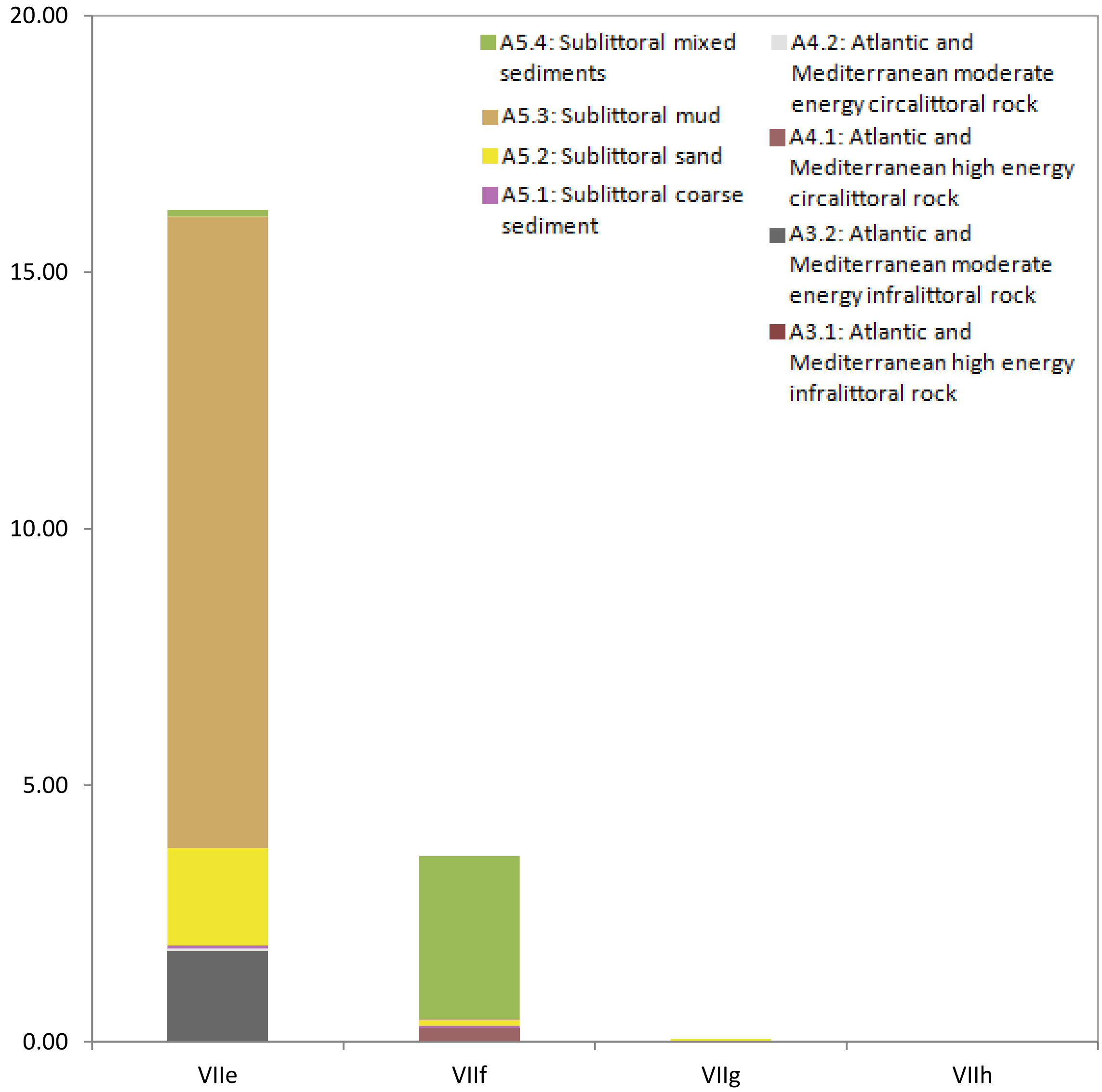

Figure 34: Percentages of sea bed habitat types affected by disposal activities

In comparison to aggregate dredging, disposal activities not only affect a larger overall area of nursery grounds, but also a higher percentage of single nursery grounds with a maximum of up to 6% of the whole nursery ground of spotted rays and thornback rays (both low importance) (Figure 35a).

Unlike nursery grounds, the extent of spawning grounds is not significantly more affected by disposal activity compared to aggregate dredging (Figure 35b). The species with the highest percentage of overlap is whiting (low) (1.78% of total species spawning area) which occurred in VIIe, where also the highest overlap occurred.

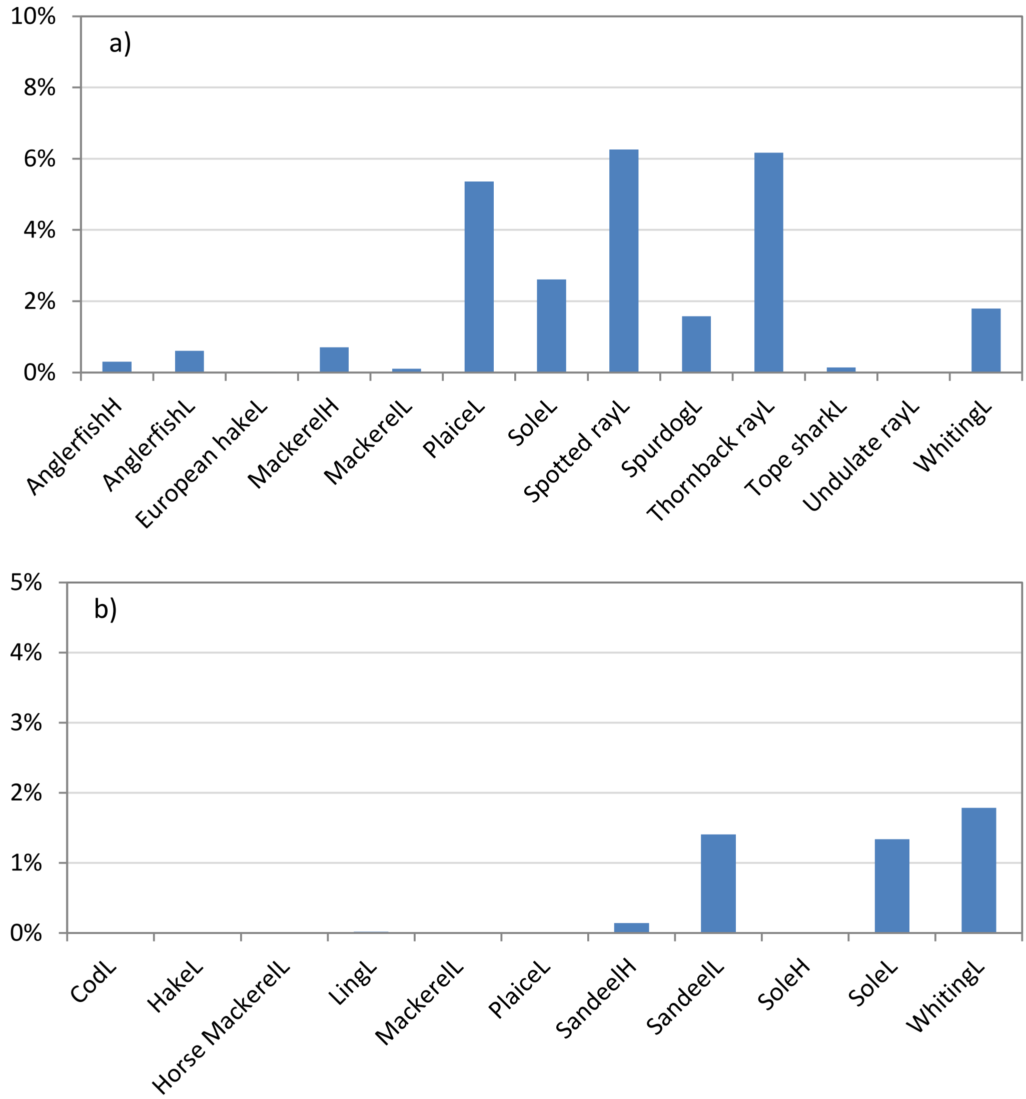

Figure 35: Percentage of affected area by disposal activities from total area of nursery grounds (a) and spawning grounds (b) of different species (Note the different scales)

Summary

The sediment in the SW waters changes from east to west from coarse sediments in the ICES regions VIIe and VIIf to finer sediments towards the Atlantic.

Fishing activity has a more widespread influence than aggregate dredging or disposal activities. Trawling and fishing with nets are the most dispersed gear types. Traps and dredges are more limited to the near shore regions in VIIe and VIIf, fishing with hooks is scattered over all ICES regions and seines only occur in a limited area in the eastern part of the SW waters. Inshore activity is mostly limited to low intensity fishing and covers the whole 12-miles zone around the UK coastline in this region. When overlapping fishing activities with seabed habitats trawls, nets and to a certain extent dredges, show the most diverse and highest overlap with seabed habitats. This pattern is also observed when overlapping fishing gears with nursery and spawning grounds and is due to the widespread usage of these gear type.

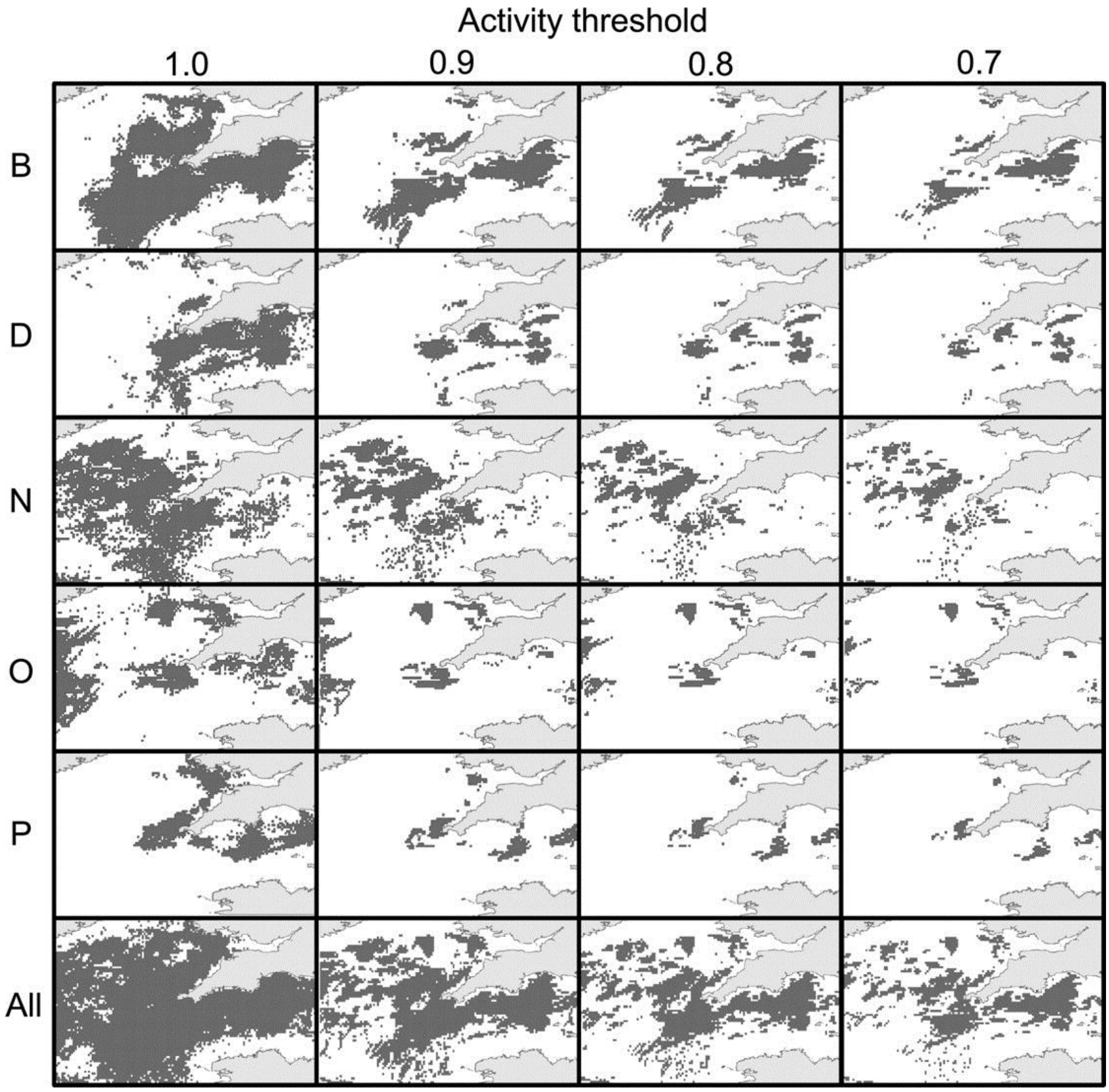

Figure 36: Spatial extent of fishing effort that includes 100, 90, 80 and 70% of fishing activity (activity threshold show as proportions) for combined 2006-2009 VMS data. Fleet codes: b, beam trawlers, D, dredges, N, netters, O, otter trawlers, P, potters, All, all fleets combined. From Jennings & Lee 2012.

The relative impact of fishing activity on different benthic habitat is not solely dependent on the relative overlap of fishing activities with different habitats as the sensitivity of habitats to fishing impacts is variable, and different fishing gears have different impacts on a given habitat (Kaiser, 1998; Bolam et al 2013). This report has not addressed the issue of the relative susceptibility of different habitats to different fishing activities. Methods have been developed to predict the relative sensitivity of different habitats to fishing activity on the basis of the widely available physical and hydrodynamic data (Diesing et al 2013), but these have yet to be applied across the whole area considered by this report.

Fishing effort in the SW is not evenly spread across the total area covered by a fishery and the majority of fishing effort is conducted within ‘core’ fishing grounds that only cover a limited proportion of the total area fished (Figure 36, Jennings and Lee 2012). The core fishing areas accounting for 90% of the effort are typically 50% smaller than the total fished area. Conversely this means there are extensive lightly fished margins to the overall fishing grounds, with only 10% of the effort spread across 50% of the total area of a fishery. The implications of this is that if the overlap between fishing activity and an ecosystem feature is considered undesirable or unacceptable, exclusion of fishing activity from the margins will have far less impact on a fishery’s activity than excluding activity from a similar area within the core fishing ground.

Aggregate dredging and disposal activities are restricted to near shore areas and affect a larger proportion of fine sediments in Ve than coarse sediment. Due to their limited distribution in VIIe and VIIf, aggregate dredging and disposal activities overlap with only a limited number of species’ nursery and spawning grounds. Mainly plaice, spotted ray and thornback ray nursery grounds and sandeel, sole and whiting spawning grounds are affected by these human activities.

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Fisheries turtle interactions

Rod Penrose

Of the seven marine turtle species, five of these species have been recorded in UK and Irish waters. Of these only one, the leatherback turtle *(Dermochelys coriacea)* is reported annually and is considered a regular and normal member of our marine fauna. The largest recorded leatherback in the World was found drowned entangled in pot-rope at Harlech, North Wales in September 1988 and measured 2.91 metres long and weighed 914 kilos.

The remaining four species are all "hard-shell" and comprise of the loggerhead *(Caretta caretta),* Kemp's Ridley *(Lepidochelys kempii),* green *(Chelonia mydas)* and the hawksbill turtle *(Eretmochelys imbricate).*

Of these, the IUCN has listed the hawksbill, Kemp's Ridley and the leatherback as "Critically Endangered" with the green turtle and loggerhead turtle classified as "Endangered".

The spatial distribution of "hard-shell" records indicate that arrival in waters of the European continental shelf is most likely driven by North Atlantic current systems. Records of all these species have been recorded in the British Isles & Republic of Ireland TURTLE database. Records include "sightings" and "strandings" and comprise of 2582 records extending back to 1748.

Records in TURTLE are not linked to the ICES areas but are recorded to the nearest land-based country/county. The corresponding counties have been used as a search criteria within TURTLE for the ICES sea areas VIIe, VIIf, VIIg and VIIh.

Within these areas since 1748, 974 leatherback turtles have been recorded with 127 "hard-shells" comprising one green turtle, one hawksbill, 18 Kemp's Ridleys, 65 loggerheads, and 42 unidentified hard-shells. A further 105 unidentified turtles were recorded in this area where data was insufficient to determine further identification. Of the 974 leatherbacks recorded within this area 94 were reported as entangled in fishing gear. Of the 127 "hard-shells" ten animals were recorded entangled comprising one green turtle, one hawksbill, two Kemp's Ridleys, three loggerheads and three unidentified hard-shells. A further nine unidentified turtles were reported entangled.

The most common capture for leatherback turtles is entanglement in rope, particularly those used in pot fisheries targeting crustaceans and whelk. However, the database also includes records of leatherback capture in driftnets, trawls, set gill nets, purse seines and longline fisheries.

Live leatherback turtles found entangled in gear should be disentangled and released where found since towing animals back to shore, to disentangle them, is inadvisable as this usually results in the animal drowning.

Leatherback turtles are able to raise their body temperatures to cope with the cold waters around the UK. However, all hard-shell species do not have this ability and become lethargic in UK waters and will most probably die. Wherever possible live entangled "hard-shell" species should be recovered and the relevant country co-ordinator contacted so that rehabilitation and eventual repatriation to warmer waters can be arranged. Further details can be found in the UK Turtle Code at
http://www.mcsuk.org/downloads/wildlife/turtlecode.pdf

Wherever possible dead marine turtles should be recovered (if in a fresh to moderate condition) and the local co-ordinator informed so these carcasses can be examined within the relevant government research programme (see the UK Turtle Code). Within the UK, the Cetacean Strandings Investigation Programme (CSIP) freephone telephone reporting line can be used **0800 6520333**.
Although leatherbacks have been recorded in all months of the year Fig.1. shows the months of peak concentrations. Of the "hard-shell" species, the loggerhead is the most frequent species recorded and although numbers are low these have been recorded in all months as shown in Fig.2.

Other known conservation issues related to marine turtles, discarded fishing gear/marine debris, collision, ingestion of plastics.

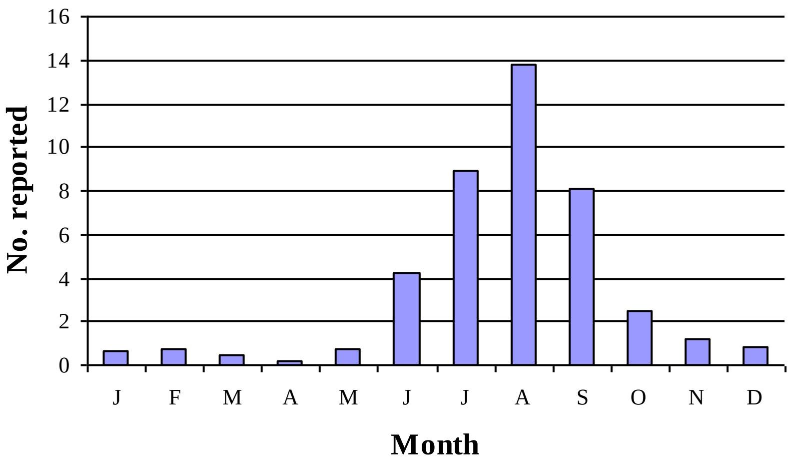

Fig. 1. Average leatherback reports by month over the ten year period 2001-2011.

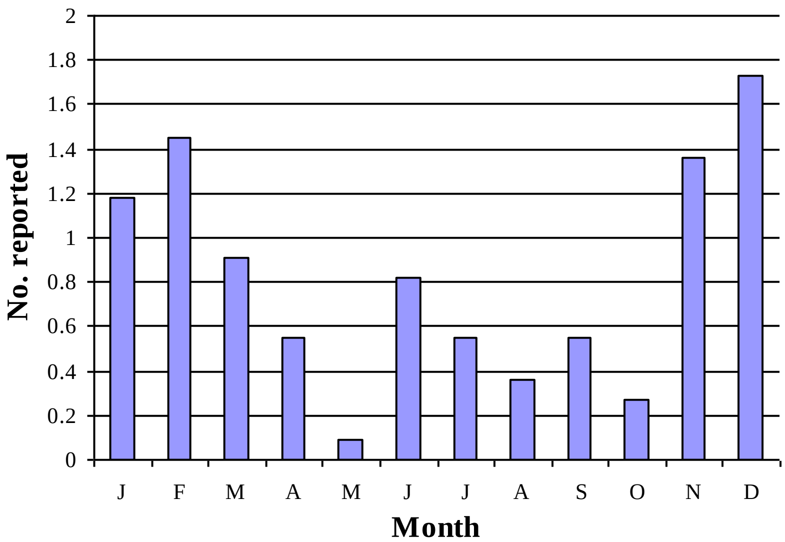

Fig. 2. Average loggerhead reports by month over the ten year period 2001-2011.

Sea Mammal Research Unit

Ecological Risk Assessment of Southwest Fisheries:

Marine Mammal Ecosystem Component.

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August 2013.

Introduction.

This short report provides background information about marine mammal populations and their interactions with human activities, particularly fisheries, in the Southwest UK (ICES Divisions VIIefgh). This information has been requested by Seafish to form part of a preliminary Ecological Risk Assessment for Southwest fisheries (SWERA). This document provides a summary of current knowledge in relation to 5 specific themes that are listed in the ERA guidance, as follows.

Theme 1: A brief description of the component in this area.

Two of the four broad marine mammal taxonomic groups found globally occur in Southwest waters, Order Cetacea (whales, dolphins and porpoises) and Suborder Pinnipedia (seals). Order Sirenia (sea cows) and Family Mustelidae (sea otters) are not found in this region.

Harbour Porpoises, Short-beaked Common Dolphins, Bottlenose Dolphins (nearshore component), Risso's Dolphins, Minke Whales, Long-finned Pilot Whales and Grey Seals are likely to be present in the South West Approaches (Celtic Sea & Western Channel) in varying numbers throughout the year.

Other species such as Striped Dolphins, Atlantic White-sided Dolphins, White-beaked Dolphins, Bottlenose Dolphins (offshore component), Killer Whales, Sei Whales, Fin Whales, Humpback Whales, Sperm Whales and Cuvier's Beaked Whales are either seasonal or occasional visitors. Common seals may be present at times in small numbers.

Cetacean distributions for UK waters have been published by the JNCC (Reid et al 2003).

Theme 2: Current population status in relation to recognised reference points or conservation objectives, if available, and any information on trends over time.

Abundance estimates have been produced for some cetacean species from data collected during the Scans I (1994), Scans II (2005) and CODA (2007) surveys. These surveys had different geographical ranges consisting of different survey blocks and focussed to some extent on different species so direct comparisons cannot be made between surveys. Additionally the survey blocks do not correspond exactly to the area covered by the SWERA. Nevertheless the Scans I and II survey estimates allow a cautious assessment to be made of the population status for Harbour Porpoise within the wider Southwest area. The data do not suggest any significant change in Harbour Porpoise abundance over the period 1994-2005 (see Table 1). Data limitations mean it is not possible to provide similar comparisons for other species.

Abundance estimates for Short-beaked Common Dolphin from Scans II, for the English Channel and Celtic Sea, are provided in Table 1 and combined abundance estimates are also provided for the entire survey area (ICES Subareas IV-VII) from Scans II & CODA for other recorded cetacean species.

Data for seal species are provided in Table 2. Grey seal pup production is estimated from ground counts of white coat pups during the breeding season, and a minimum estimate for the corresponding adult population can be crudely approximated by simply doubling this number, though this conversion does not account for adults that have not successfully mated in a particular year. Furthermore, this rough population estimate does not account for seals that may forage in SW waters but breed elsewhere e.g. in Scotland. Common seals, population estimates of which are based on counts of adults during the moulting season, do not appear to be abundant in this area: colonies in Ireland are mainly found on the West coast and recorded counts in Southwest England and Wales are small. (For further details see SCOS reports http://www.smru.st-andrews.ac.uk).

Currently the most widely accepted and used biological reference point in Europe, specifically in relation to bycatch of small cetaceans, is 1.7% of best abundance estimate annual removal rate. For this to be a useful management tool reliable estimates of both the population size and bycatch rates are required. This information is only currently available for 2 species, Harbour Porpoise and Common Dolphin. Bycatch estimates for the Southwest region have been produced annually for a number of years and can be found in the UK reports to the EU on Regulation 812/2004 (2006-2012). Notional bycatch limits are provided where appropriate in Table 1.

Table 1: Cetacean abundance estimates and notional bycatch limits.

Species	Area	Scans I (CV)	Scans II (CV)	Scans II / CODA combined	Notional Bycatch limits (1.7%)
Harbour Porpoise	Celtic Sea	36,280 (.57)	80,613 (.5)	-	1370
	English Channel	-	40,927 (.38)	-	696
Common Dolphin	Celtic Sea	-	11.141 (.61)	-	189
	English Channel	-	14,349 (1.66)	-	244
Harbour Porpoise	ICES Subareas IV - VIII.	-	-	385,617	6555
Common Dolphin		-	-	167,216	2843
White-beaked Dolphin		-	-	16,787	285
Minke Whale		-	-	25,364	-
Bottlenose Dolphin		-	-	31,940	543
Striped Dolphin		-	-	67,414	1146
Long-finned Pilot Whale		-	-	25,101	-
Fin Whale		-	-	9,019	-
Sperm Whale		-	-	2,077	-
Beaked Whales		-	-	6,992	-

Table 2: Pinniped abundance estimates.

Species	Area	
Grey Seal pup production	SW England	250
	Wales	1650
	Ireland	100
Common Seal moulting survey	SW England	20
	Ireland	3853

Theme 3: Effects of fisheries' actions on the component, this would include post-encounter mortality and indirect effects.

Fisheries interactions with marine mammals are typically described as either "operational" or "ecological". These terms are conceptually similar to the "direct" and "indirect" impacts that are more commonly used to describe fishing gear effects. Operational interactions include bycatch and depredation. Ecological interactions include competition for prey, trophic effects and possible habitat impacts.

Bycatch is probably the most widely studied of these interactions and a dedicated bycatch monitoring programme has been run in the UK since 1995. The results of almost 20 years of monitoring indicate that in the majority of UK fisheries marine mammal bycatch is a fairly sporadic occurrence though there are some exceptions. In the Southwest, bycatch of Harbour Porpoises occurs most frequently in static net fisheries. Common dolphins are bycaught in some midwater trawl fisheries and occasionally in static net fisheries. Grey seals are taken mainly in static net fisheries but seal bycatch has been recorded under the bycatch programme from UK midwater trawl fisheries targeting herring in the North Sea and from Irish midwater trawl fisheries targeting herring in the Celtic Sea so the potential certainly exists for seal bycatch from this gear type in the Southwest. Other species that have been recorded as bycaught in the Southwest under the UK bycatch programme are Bottlenose Dolphin, Risso's Dolphin and Minke Whale but recorded numbers for these species are currently too low to allow reliable overall estimates of bycatch mortality to be produced.

Monitoring of various demersal trawl fisheries (under the bycatch programme and the DCF) suggests that marine mammal bycatch is a rare occurrence in this broad gear type in the Southwest. Monitoring levels from other gear types used in the Southwest such as ring nets, longlines, pots, drift nets and lines etc are currently insufficient to produce estimates of bycatch rates but anecdotal evidence suggests that bycatch rates in these gears are unlikely to be significant.

Seal depredation on the catch has been reported by skippers of static net vessels (inshore and offshore) in the Southwest for a number of years and in response, incidences of possible seal damage have been routinely recorded under the bycatch programme since 2008. Assuming the interpretation is correct, the results show that seal damage is a relatively regular occurrence in some fisheries (up to 20% of net fleets in certain fisheries show signs of some seal damage) and this may have significant financial implications for affected vessels. The underlying mechanisms of depredation, such as: is it opportunistic or considered behaviour, how do seals locate the gear, are few or many individuals involved etc, are not well understood at present.

Although little is known about the ecological interactions between fishing activity and marine mammal populations in the Southwest, some commercial fisheries in Subarea VII target fish species that are also eaten by marine mammals. Grey Seals and Harbour Porpoises, both relatively abundant in the SWERA area, are highly adaptable foragers with a broad range of prey species in their diets, typically consuming substantial quantities of sandeels where these are available, together with various non-commercial benthic species such as dragonet, poor cod and gobies. Their diet can also include commercial fish species such as plaice (and other flatfish), cod, whiting, herring and mackerel. Prey items of Grey Seals and Porpoises are often of smaller size than those targeted by fishing boats and consequently foraging may be concentrated in areas that are not regularly used by commercial fisheries targeting those particular species.

There is little doubt that fishing activity could impact indirectly on cetacean and seal populations if certain fish stocks are over exploited, and maybe particularly if recruitment is significantly reduced. However, in theory some marine mammal populations might also benefit from a certain level of fishing mortality if larger fish are removed from the system (a fairly typical pattern of fisheries exploitation) thus removing predation pressure on smaller size groups or fodder species which are preyed on by some mammal species. This may not apply to mammals that also target larger prey items such as Killer Whales.

The relative energy content of the diet may also be an important factor for marine mammals, especially in relation to the health of younger individuals meaning reductions in the abundance of energy-rich prey (particularly oily fish such as small pelagics) may be of particular concern. Prey quality (i.e. energetic content) also appears to be important for Common Dolphins that preferentially select energy rich prey species such as mackerel and other small pelagics, and their diet resembles those of sea bass which may provide a possible explanation for their association with sea bass winter/spring spawning aggregations in the Western Channel and subsequent interactions with the sea bass fishery.

Theme 4: Known mitigation measures and whether they have been tested for efficacy in South West fisheries and whether they are considered relevant.

A number of mitigation measures aimed at reducing bycatch are currently in place in the South West. These range in scale from local initiatives (Cornwall IFCA code of conduct) to regional measures (the prohibition of pair-trawling inside the 12nm limit in the Western Channel) to international level regulations (EC Council Regulation 812/2004) which requires the use of acoustic deterrent devices (pingers) by all >12m vessels using static nets in most of Subarea VII (and elsewhere).

It is not possible to say if spatial measures such as the UK 12nm ban on bass pair trawling in VIIe have had a positive effect in reducing bycatch rates because the effects of effort displacement in these circumstances are typically difficult to predict. However historical data from the bass fishery suggests that this particular measure is likely to have been ineffective or possibly worse, as bycatch rates in the past in this fishery have tended to be higher offshore. This particular measure also only applies to UK vessels which contribute a small proportion of effort to the total international fishery.

A number of pinger models have been tested in static net fisheries in the Southwest over the past 15 years. These trials have focussed on both practical handling characteristics and bycatch reduction efficiency. A number of practical and safety issues with certain devices were highlighted in early trials (Seafish 2003) by the offshore netting industry which has delayed full implementation of the 812/2004 Regulation. However these issues prompted further trials of a louder device (meaning fewer are needed), between 2008 and 2011, in close collaboration between scientists and the South West industry (full reports available on request). This particular device appears to be both effective at reducing bycatch (up to 90% depending on the deployment configuration), is more practical for industry to use and has therefore removed many of the barriers to effective compliance and enforcement. Regulation 812/2004 was subsequently implemented on the 1st July 2013 for all UK vessels over 12m using certain static nets in the North Sea (IV) and any static nets in most of Subarea VII (including all of the SWERA area).

Other relevant ongoing research in the Southwest is looking at an alternative approach to bycatch mitigation by investigating whether modifications to certain gear characteristics can lead to significant reductions in bycatch rates.

Since about 2000, a voluntary collaboration between industry and scientists has allowed various mitigation measures (pingers, sorting grids, escape hatches) to be tested in the bass pair trawl fishery in the Western Channel, a fishery with a well-documented Common Dolphin bycatch issue. Due to operational practicalities the use of loud pingers appears to be the favoured approach among skippers and has shown some promise as a mitigation measure with bycatch rates lower (approximately 1/10th) in recent years while these devices have been used. However, despite some evidence of efficacy, the lack of a proper experimental approach means it is still not completely clear if recent reductions in bycatch rates are directly and wholly a result of pinger use or if some other as yet unknown factor or factors are also contributing to the observed results.

Theme 5: Any other known conservation issues related to this component. For example;

- Endangered, threatened and protected status of the species

Important Legislation affecting the protection of seals is set out in the Conservation of Seals Act 1970 and the EC Habitats Directive (1992) which requires the designation of SACs specifically for seals but so far none has been proposed for this purpose in the SWERA area.

Under Annex IV of the EC Habitats Directive and the Wildlife and Countryside Act (1981) all cetaceans in UK waters are protected (e.g. from deliberate killing or disturbance). Protection throughout the European Atlantic, North Sea and Baltic areas is co-ordinated under ASCOBANS (1994).

Under the OSPAR convention, the UK is also committed to a number of ecological objectives relating to marine mammals which are currently under review, and which (to date) include (i) ensuring there is no appreciable population decline in Harbour and Grey Seal populations (ii) limits on total Harbour Porpoise bycatch rates.

- Other effects of man's activities such as pollution or mineral extraction.

Various studies have indicated the general deleterious effects of toxins such as DDTs, PCBs and heavy metals in cetaceans and seals, though few such studies have been focussed on populations in Subarea VII. Work on fish species indicates the presences of contaminants such as TBTs in the food web in this area, and points to the damage caused by oil spills.

If substantial offshore construction is undertaken for the purpose of developing renewable sources of energy, then this may raise concerns over (i) the disruption of sandeel habitat with potential impacts on the availability of these important prey and (ii) disturbance of marine mammals due to noise during operation and especially during construction at these sites, with potential consequences for populations.

- Ocean warming and cyclical climate phenomena such as the North Atlantic Oscillation, Russell Cycle

We currently do not have strong evidence linking the status of marine mammal populations in UK waters to long-term trends in climate, though there are indications of local effects of oceanographic features and primary production over smaller scales in time and space e.g. concentrations of mammals may be related to the presence of tidal fronts. Algal blooms are occurring with increasing frequency in UK waters, perhaps at least partly due to increasing temperatures, and toxic effects may have negative impacts on the health of marine mammals.

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UNIVERSITY OF Hull
Institute of Estuarine and Coastal Studies

Ecological Risk Assessment of South West fisheries – summary of knowledge on the seabird ecosystem component

Final Report

Report to Seafish

Institute of Estuarine and Coastal Studies
University of Hull

10th June 2013

Author(s): L. Mander, S.M Thomson & N.D Cutts

Report: ZBB823-F-2013

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Seafish

Ecological risk assessment of south west fisheries: summary of knowledge on the seabird ecosystem component

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For and on behalf of the Institute of Estuarine and Coastal Studies

Approved by:	Nick Cutts
Signed:	
Position:	Deputy Director, IECS
Date:	10th June 2013

TABLE OF CONTENTS

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1. INTRODUCTION

This document identifies the ecological risk posed by fisheries activities on seabirds, seaduck and divers species occurring in waters off the south west of England. Seabirds, divers and seaduck comprise those species of bird that depend wholly or mainly on the marine environment for their survival. They spend the majority of their lives at sea, exploiting its surface and the water column to varying depths for food. Most of these species come ashore only to breed. Waterbird species associated with estuaries are not considered in this ecological risk assessment.

The document presents the species assemblage occurring in the area, the species status and trends, and the sites of importance around the south west coast. It examines the evidence of fisheries' impacts from published literature around the world, with the focus on the species occurring off the south west of England. Based on the evidence reviewed, it presents the potential ecological risks associated with the south west fisheries.

2. BRIEF DESCRIPTION OF DESIGNATIONS AND SEABIRD ASSEMBLAGE IN THE RVEIW AREA

The region is close to the southern limit of the breeding ranges of several species and 18 species of seabirds are recorded as breeding in the area (Table 1).

Table 1: Seabirds regularly breeding in the area considered (including offshore Islands).

Family	Species
Procellariidae	Three species of Petrel: Northern Fulmar (*Fulmarus glacialis*), Manx Shearwater (*Puffinus puffinus*) and European Storm Petrel (*Hydrobates pelagicus*).
Phalacrocoracidae	Two species of Cormorant: Great Cormorant (*Phalacrocorax carbo*) and European Shag (*Phalacrocorax aristotelis*).
Sulidae	One species: Northern Gannet (*Morrus bassanus*).
Laridae	Six species of Gull: Herring Gull (*Larus argentatus*), Black-headed Gull (*Larus ridibundus*), Lesser Black-backed Gull (*Larus fuscus*), Great Black-backed Gull (*Larus marinus*), Mediterranean Gull (*Larus melanocephalus*) and Black-legged Kittiwake (*Rissa tridactyla*).
Sternidae	Three species of Tern: Sandwich tern (*Sterna sandvicensis*), Common Tern (*Sterna hirundo*), and Little Tern (*Sterna albifrons*).
Alcidae	Three species of Auk: Common Guillemot (*Uria aalge*), Razorbill (*Alca torda*), and Atlantic Puffin (*Fratercula arctica*).

The relative unimportance of the area for breeding seabirds is illustrated by the limited number of breeding sites designated for either the individual species or seabird assemblage they support. Seabirds are key components of marine ecosystems and although they are well-protected at a number of major breeding colonies, they have received considerably less protection at sea. There are two Special Protection Areas (SPAs) in the review area supporting important breeding seabird colonies: the Isles of Scilly SPA) and the Chesil Beach & Fleet SPA (Dorset) (Stroud et al., 2001) (Figure 1). Both SPAs are also Important Bird Areas (IBAs), and were selected by Bird Life International for their numbers of seabirds. Other seabird colonies located outside the area considered in this ecological risk assessment are designated as SPA for their seabird species and assemblage, including Grassholm, Skokholm and Skomer (Figure 1).

Table 2: Breeding seabird in Devon, Cornwall and Dorset. Source: Mitchell et al. (2004).

Species	Devon	Cornwall	Dorset	Isles of Scilly
Northern Fulmar (*Fulmarus glacialis*)	471 (AOS)	1,692 (AOS)	94 (AOS)	180 (AOS)
Manx Shearwater (*Puffinus puffinus)*	166 (AOS)	0	0	201 (AOS)
European Storm-petrel (*Hydrobates pelagicus)*	0	0	0	1,475 (AOS)
Great Cormorant (*Phalacrocorax carbo)*	181 (AON)	199 (AON)	150 (AON)	56 (AON)
European Shag (*Phalacrocorax aristotelis)*	260 (AON)	1,109	67 (AON)	1,092 (AON)

Species	Devon	Cornwall	Dorset	Isles of Scilly
		(AON)		
Mediterranean Gull (*Larus melanocephalus*)	0	0	5 (AON)	0
Lesser Black-backed Gull (*Larus fuscus*)	426 (AON)	39 (AON)	10 (AON)	3,603 (AON)
Herring Gull (*Larus argentatus)*	4,035 (AON)	4,940 (AON)	606 (AON)	900 (AON)
Great Black-backed Gull (*Larus marinus*)	166 (AON)	4,940 (AON)	74 (AON)	0
Black-legged Kittiwake (*Rissa tridactyla)*	1,204 (AON)	1,853 (AON)	115 (AON)	281 (AON
Sandwich Tern (*Sterna sandvicensis)*	0	0	31 (AON)	0
Common Tern (*Sterna hirundo)*	0	0	262 (AON)	96 (AON)
Little Tern (*Sterna albifrons)*	0	0	81 (AON)	0
Common Guillemot (*Uria aalge)*	3,926 (I)	1,426 (I)	954 (I)	196 (I)
Razorbill *(Alca torda)*	1,137 (I)	465 (I)	41 (I)	261 (I)
Atlantic Puffin *(Fratercula arctica)*	13 (AOB)	33 (AOB)	26 (AOB)	121 (AOB)

Notes: AON: Apparently Occupied Nests, AOB: Apparently Occupied Burrows, P: Pairs, AOS: Apparently Occupied Sites, I: Individuals

The Isles of Scilly form an archipelago of over 200 islands and rocks. They lie some 45km south west of Land's End and experience low levels of disturbance and predation, making them suitable for nesting seabirds. The Isles of Scilly include over 1% of the UK population of European Storm Petrel (*Hydrobates pelagicus)*, with a total of 1,475 Apparently Occupied Sites (AOS) and 3,603 Apparently Occupied Nests (AON) of Lesser Black-backed Gull (*Larus fuscus*) (Mitchell et al., 2004).

The Chesil Beach & the Fleet SPA in Dorset is an important breeding site for Little Terns (*Sterna albifrons)* which feed in the shallow waters of the lagoon, as well as adjacent waters outside the SPA. The site supports 55 pairs of Little Terns (Mitchell et al., 2004).

Lundy Island in the Bristol Channel although not designated as an SPA (it is an Special Area of Conservation (SAC)) is important for its breeding seabird populations, particularly Manx Shearwater (1,081 Occupied Sites on the island in 2008) along with nine other species of seabirds, amongst them Razorbill (*Alca torda)* (1,045 individuals) and Common Guillemot (*Uria aalge)* (3,302 individuals) (Brown et al., 2011).

The area considered in the Ecological Risk Assessment also encompasses the South Cornwall Coast Important Bird Area (IBA). The IBA which extends 6km out to sea was also selected by Bird-Life International for its numbers of wintering seabirds (Bird-Life, 2011). O'Brien et al. (2012) found the sea adjacent to the coast of south Cornwall to support important numbers of wintering Divers and Grebes. It must be emphasised that, in the UK, IBAs do not offer any legal protection to birds.

In summer, seabirds forage in waters adjacent to the colonies, although foraging ranges vary both within and between species, and within the breeding season. For example, Manx Shearwater, Northern Gannet, and Northern Fulmar (*Fulmarus glacialis*), have the largest foraging ranges (maximum ranges >330, 590 and 580km, respectively), whereas Red-throated Diver (*Gavia stellata*) and Little Tern have the smallest (maximum ranges 9 and 11km, respectively) (Thaxter, 2012). Foraging ranges for seabird species breeding at the SPA sites in the area reviewed and further afield (Grassholm, Skokholm and Skomer SPAs) are mapped in Appendix III.

Whist all seabird colonies around the UK are systematically surveyed (Mitchell et al., 2004), the coverage of inshore and in particular offshore waters is more patchy. Data collected on seabird distribution at sea is gathered into the European Seabirds At Sea (ESAS) database and available at a fairly coarse spatial resolution. Nonetheless, they represent the most comprehensive dataset available on the distribution and relative abundance of birds in UK waters (Stone et al., 1995; Camphuysen, 2005; Kober, et al., 2010).

The numbers of birds at sea are generally low in the area reviewed compared to waters further to the north of the UK.

In summer, low densities of seabirds are found off the south west coast with the exception of the waters further to the west which support relatively high densities of Northern Gannet and Manx Shearwater (Skov et al., 1995; Pollock & Barton, 2006).

Outside the breeding season, Skov et al. (1995) reports relatively high numbers of Gannet just off the Plymouth coast between November and February. There is also a number of regularly occurring non-breeding seabirds which visit the waters off Devon, Cornwall and Dorset. One of these species is the Balearic Shearwater (*Puffinus mauretanicus*) which only breeds in the Balearic Islands. Despite breeding in the Mediterranean Sea, the species gathers to moult between July and October, in the western English Channel, with Portland Bill in Dorset being a prime site. Birds are also seen off the Cornwall, Devon and west Wales coasts.

A recent analysis of ESAS boat transect surveys carried out between 1980 and 2004 off the south west of England provided the relative distribution of a number of seabirds and a general indication of how seabird densities vary on a large spatial scale (IECS, in prep). The results indicated auks (Common Guillemot and Razorbill) to be widespread in low densities throughout the year, with the exception of waters off Falmouth (Cornwall) where relative high densities were found in winter. In summer, European Storm Petrels were evenly distributed in low numbers, in the offshore waters of the Celtic Sea and the western English Channel. Shearwaters were also found in low numbers but their distribution was patchier in the western English Channel. Outside the breeding season, there were noticeable moderate densities of Shearwaters off the south western tip of Cornwall (IECS, in prep).

3. CONSERVATION OBJECTIVES, POPULATION STATUS AND TRENDS

European Site Conservation Objectives are set for each bird feature which qualify under the Special Protection Area (SPA) and are referred to in the Conservation of Habitats and Species Regulations 2010 (the "Habitats Regulations") and Article 6(3) of the Habitats Directive 1992. With regard to the individual species and/or assemblage of species for which the site has been classified, the site Conservation Objectives for a SPA are set to avoid the deterioration of the habitats of the qualifying features, and the significant disturbance of the qualifying features, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive.

The area reviewed in this document encompasses two Special Protection Areas (SPAs) designated for their seabird species and assemblage: Isles of Scilly (Table 3) and the Chesil Beach & the Fleet SPA (Table 4). Figure 1 shows the location of all coastal SPAs including those designated for waterbirds.

A full review of the UK SPA network both in terms of the number of sites selected and the species that qualify within these sites has been produced by Stroud et al., (2001) in The UK SPA network: its scope and content. The information presented in the following section is extracted from Stroud et al. (2001).

Table 3: Isles of Scilly - qualifying species assemblage qualification and populations listed in Annex 1 of the directive. Source: Stroud et al. (2001).

Status	Species	Population
Breeding	European Storm Petrel (*Hydrobates pelagicus*)	5,406 pairs representing at least 6.4% of the breeding population in Great Britain (Count as at 1999)
	Lesser Black-backed Gull (*Larus fuscus*)	3,608 pairs representing at least 2.9% of the breeding Western Europe/Mediterranean/Western Africa population (Count as at 1999)

This site also qualifies during the breeding season, the area regularly supporting 26,616 individual seabirds (Count as at 1999) including: Great Black-backed Gull (*Larus marinus)*, European Shag (*Phalacrocorax aristotelis)*, Lesser Black-backed Gull and European Storm Petrel.

Table 4: Chesil Beach & the Fleet SPA - qualifying species assemblage qualification and populations listed in Annex 1 of the directive. Source: Stroud et al. (2001).

Status	**Species**	**Population**
Breeding	Little Tern (*Sterna albifrons)*	55 pairs representing up to 2.3% of the breeding population in Great Britain (Count as at 1997)

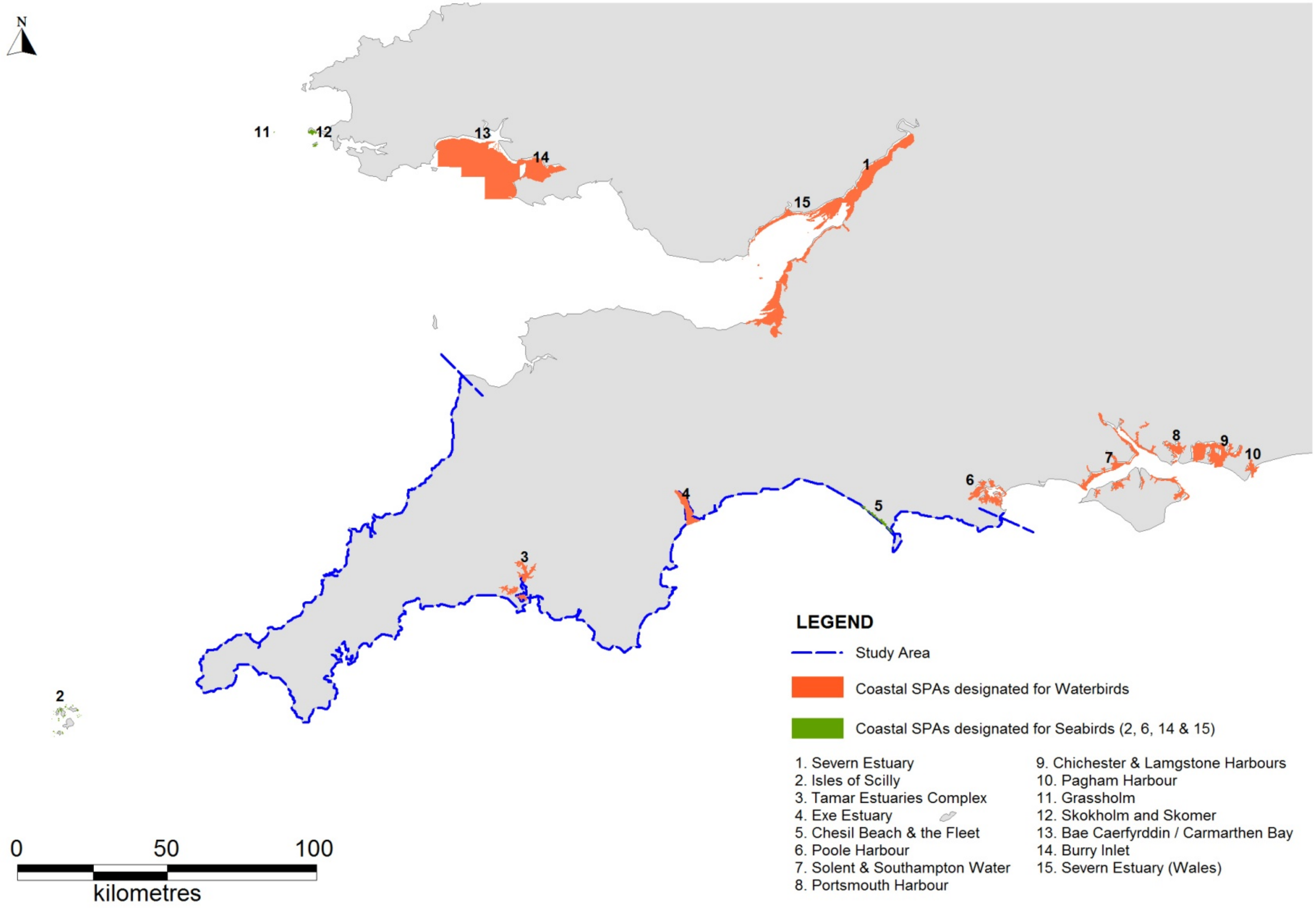

Figure 1: SPAs designated for seabirds and waterbirds.

Since 2000, there has been a decline of 9% in the numbers of seabirds breeding around the UK, with offshore surface divers suffering the sharpest decline in UK (Table 5). The decline is attributed due to a greater frequency of poor breeding productivity, notably in species that feed on shoals of small fish, such as sandeels (Ammodytes sp) (JNCC, 2009). It is thought that food shortage leads to lower adult survival and reduced breeding productivity, as observed in Black-legged Kittiwake (*Rissa tridactyla*) and European Shag. Historically, over-fishing of sandeels was considered to be the main cause, but there is more recent evidence of a progressive increase in sea temperature affecting the availability of sandeels (Frederiksen et al., 2004; Wanless et al., 2007).

Global climate change is driving rapid distribution shifts in marine ecosystems. For example, increase in sea temperature may be increasing the occurrence of the Balearic Shearwater, a globally critically endangered species, in northeast Atlantic waters. Since the mid-1990s, there has been a dramatic increase in the numbers of Balearic Shearwater in the south west of England (Wynn et al., 2007). This species has a tiny breeding range around the Balearic Islands (Spain) and a small population which is undergoing an extremely rapid population decline owing to a number of threats, in particular predation at breeding colonies by introduced mammals and at-sea mortality as a result of fisheries by-catch. In addition to change in prey availability, predation by non-native mammals (such as American mink) or introduced native mammals to the islands (such as rat), have contributed to reduced breeding productivity at seabird colonies around the UK.

The attributes of species (including biological) found breeding or wintering in the area are presented in Appendix I.

Table 5: Changes in numbers of seabirds breeding in the UK during 1969-2008; 1986-2008 and 2000-2008. Only species breeding in Devon, Cornwall, Dorset and Isles of Scilly are presented. The latest population estimates are in breeding pairs, apart from those of Common Guillemot, and Razorbill, where individual adults present at the colony were counted. Source: JNCC, 2009.

Group and species	Latest population estimate (1998-2002)	Change in population 1969-2008	Change in population 1986-2008	Change in population 2000-2008
Inshore surface-feeders				
Mediterranean Gull (*Larus melanocephalus*)	115	NA	NA	NA
Black-headed Gull (*Larus ridibundus*)	77,000	17%	11%	11%
Common Gull (*Larus canus*)	21,000	NA	NA	NA
Herring Gull (*Larus argentatus*)	130,000	-69%	-42%	-33%
Sandwich Tern (*Sterna sandvicensis*)	12,000	-2%	29%	-13%
Common Tern (*Sterna hirundo*)	10,000	-15%	-16%	-2%
Little Tern (*Sterna albifrons*)	1,900			
Inshore diver-feeders				
Great Cormorant (*Phalacrocorax carbo*)	7,500	19%	9%	-3%
European Shag (*Phalacrocorax aristotelis*)	27,000	-33%	-45%	-25%
Offshore surface-feeders				
Northern Fulmar (*Fulmar glacialis*)	500,000	53%	-14%	-11%
Manx Shearwater (*Puffinus puffinus*)	300,000	NA	NA	NA
European Storm-Petrel (*Hydrobates pelagicus*)	26,000	NA	NA	NA
Northern Gannet (*Morrus bassanus*)	220,000	66%	30%	18%
Lesser Black-backed Gull (*Larus fuscus*)	87,000	7%	-17%	-41%
Great Black-backed Gull (*Larus marinus*)	17,000	-16%	-10%	-6%
Black-legged Kittiwake (*Rissa tridactyla*)	380,000	-40%	-52%	-36%
Offshore diver-feeders				
Common Guillemot (*Uria aalge*)	1,400,000	131%	28%	-2%
Razorbill (*Alca torda*)	190,000	50%	27%	5%
Atlantic Puffin (*Fratercula arctica*)	580,000	36%	40%	-1%

4. EFFECTS OF FISHERIES' ACTION

4.1 Overview of fisheries impact

Fisheries can compete with seabirds for the fish they eat. Off southeast Scotland a sandeel fishery that operated in the 1990s significantly depressed adult survival and breeding success of Black-Legged Kittiwakes at adjacent colonies compared with years prior to the fishery opening and after it was closed. Since 2000 there has been a ban on sandeel fishing off eastern Scotland and north-east England.

For years, seabirds have also benefited from fisheries through food provided at sea by discharging offal and discarding undersize fish. As a result, the abundance of scavenging species (e.g. Northern Fulmar) may have been elevated above levels that naturally occurring food sources could sustain. The necessary introduction of measures to conserve fish stocks has consequently reduced the amount of discards, as has the decline of some commercial fisheries, which has also resulted in less offal being discharged. It is conceivable that the reduction in food provided by the fishing industry may have contributed to a population downturn of Northern Fulmars and other offshore surface-feeders since the mid-1990s.

Seabirds are also susceptible to entanglement in offshore fishing nets and regularly take the baited hooks of long-line fisheries (e.g. Northern Fulmar). Auks can become trapped in inshore salmon nets. However, data are currently lacking on the numbers of seabirds caught by long-line and other fisheries in UK waters.

4.2 Assessment of impact

Impacts of fishing were reviewed by Tasker et al. (2000) and Furness (2003), based on case studies from all around the world, and with particular focus on fisheries causing direct mortalities and change of food supply.

The following table provides an assessment of impact of fisheries on the species identified in previous section as occurring off the coast off Cornwall and Devon. The table focuses on direct and indirect impacts from fisheries as well as natural changes such as the impact of climate change. The evidence presented in this table is derived from a series of published scientific papers purposely collated for the assessment (Table 6).

Table 6: Overall assessment of the impact (Negative; Positive; blank = no interactions) based on case studies around the British Isles and further afield (within European waters) by species encountered off Devon, Cornwall and Isles of Scilly. This is a general review for the seabird species occurring in the south west of England. Nevertheless, it must be noted that not all fisheries are present in the south west of England.

		Fisheries				Others	
		Direct impact	Indirect impact			Climate change	
Foraging group	Species	By-catch	Disturbance	Target fisheries on forage fish	Discard / Offal	Increase in sea temperature	Increase occurrence of summer storms
Inshore surface-feeders	Mediterranean Gull (*Larus ridibundus*)						
	Black-headed Gull (*Larus ridibundus*)	Possible negative impact with long lining but lack of evidence			**Positive** - Profiting from discards and offal around trawlers in inshore waters (Garth et al., 1996).		
	Common Gull (*Larus canus*)	Possible negative impact with long lining but lack of evidence			**Positive** - Profiting from discards and offal around trawlers in inshore waters (Garth et al., 1996). **Negative** - if fishing effort reduced.		
	Herring Gull (*Larus argentatus*)	Possible negative impact with long lining but lack of evidence			**Positive** - Profiting from discards and offal around trawlers in inshore waters (Garth et al., 1996). **Negative** - if fishing effort and thus discard is reduced in winter (Huppop and Wurm, 2000).		

Table 6: continued

		Fisheries				Others	
		Direct impact	Indirect impact			Climate change	
Foraging group	**Species**	**By-catch**	**Disturbance**	**Target fisheries on forage fish**	**Discard / Offal**	**Increase in sea temperature**	**Increase occurrence of summer storms**
Inshore surface-feeders	Sandwich Tern (*Sterna sandvicensis*)	Possible negative impact with long lining but lack of evidence.	Possible negative impact with fisheries activity (e.g. boat transit) but lack of evidence.	Possible negative impact with sandeels fisheries but lack evidence			
	Common Tern (*Sterna hirundo*)						
	Little Tern (*Sterna albifrons*)						
Inshore diver - feeders	Great Cormorant (*Phalacrocorax carbo*)	**Negative** - birds may become entangled in fishing gear (lines as well as nets) (Camphuysen, 1990, 1994).					
	European Shag (*Phalacrocorax aristotelis*)	**Negative** - locally suffers from accidental entanglement and subsequent drowning in gill-nets (fishing nets) (Wanless and Harris 1997).	Possible negative impact with fisheries activity (e.g. boat transit) but lack of evidence.				

Table 6: continued

		Fisheries				Others	
		Direct impact	Indirect impact			Climate change	
Foraging group	Species	By-catch	Disturbance	Target fisheries on forage fish	Discard / Offal	Increase in sea temperature	Increase occurrence of summer storms
Inshore diver - feeders	Black-throated Diver (*Gavia arctica*)	**Negative** – the species is susceptible to be caught and drowned in in gill nets (del Hoyo et al., 1992).	**Negative** - Divers are easily disturbed by boat activity and this could to lead to possible avoidance of feeding areas.				
	Great-northern Diver (*Gavia immer*)	**Negative** - entanglement in monofilament fishing lines (used for sport fishing) and commercial fishing nets can cause significant mortality at sea (del Hoyo et al., 1992).					
Offshore surface-feeders	Northern Fulmar (*Fulmarus glacialis*)	**Negative** - long lining to catch Atlantic cod (*Gadus morhua*) and bottom fish in NE Atlantic (Tasker, 2000).			**Positive** - Profiting from discards and offal around trawlers (Garth et al., 1996). Possible negative impact - if fishing effort and thus discard is reduced but lack of evidence.		

Table 6: continued

		Fisheries				Others	
		Direct impact	Indirect impact			Climate change	
Foraging group	**Species**	**By-catch**	**Disturbance**	**Target fisheries on forage fish**	**Discard / Offal**	**Increase in sea temperature**	**Increase occurrence of summer storms**
Offshore surface-feeders	Manx Shearwater *(Puffinus puffinus)*						
	Balearic Shearwater (*Puffinus mauretanicus*)	**Negative** - The species' gregarious behaviour and its close association with fishing boats means that occasional "mass mortality" is likely to occur when long-line boats fish close to flocks (Arcos et al., 2008). Increasing evidence on this has been compiled in the last few years, with events of up to a hundred or more birds caught in a single event, in occasions involving other fishing gear such as purse-seiners (ICES 2008, Louzao et al., 2011).			Possibly positive impact but lack of evidence. Possible negative impact – if fishing effort is reduced but lack of evidence.	**Negative -** The gradual northward movement of the non-breeding population may be affecting adult survival, and this shift may be due to climate change (Wynn and Yésou 2007)	

Table 6: continued

		Fisheries				Others	
		Direct impact	**Indirect impact**			**Climate change**	
Foraging group	**Species**	**By-catch**	**Disturbance**	**Target fisheries on forage fish**	**Discard / Offal**	**Increase in sea temperature**	**Increase occurrence of summer storms**
Offshore surface-feeders	European Storm-petrel (*Hydrobates pelagicus)*						
	Northern Gannet *(Morrus bassanus)*	**Negative** - birds may become entangled in fishing gear (lines as well as nets) (Camphuysen, 1990, 1994)			**Positive -** Profiting from discards and offal around trawlers (Garth et al., 1996). Possibly negative impact - if fishing effort is reduced but lack of evidence.		
	Lesser Black-backed Gull (*Larus fuscus*)	Possible negative impact with long lining but lack of evidence			**Positive -** Profiting from discards and offal around trawlers (Garth et al., 1996). **Negative** - reduction in fishing discard had an effect on breeding success in Skomer Island (Pembrokeshire) (Perrins & Smith, 2000).		

Table 6: continued

		Fisheries				Others	
		Direct impact	Indirect impact			Climate change	
Foraging group	Species	By-catch	Disturbance	Target fisheries on forage fish	Discard / Offal	Increase in sea temperature	Increase occurrence of summer storms
Offshore surface-feeders	Great Black-backed Gull (*Larus marinus*)	Possible negative impact with long lining but lack of evidence			**Positive** - Profiting from discards and offal around trawlers (Garth et al., 1996)		
	Black-legged Kittiwake (*Rissa tridactyla*)			**Negative** - In 1990, a summer industrial fishery for sandeels started around the Wee Bankie off the Firth of Forth, south-east Scotland. Subsequent research indicated that the Wee Bankie fishery almost certainly caused local depletion of sandeel numbers, which coincided with reduced breeding success of kittiwakes (Rindorf, Wanless & Harris, 2000). More recently, the sandeel fishery had a strong effect on demographic performance, although the exact mechanism is unclear as kittiwakes and fishermen target different sandeel age groups (Frederiksen et al., 2004)	**Positive** - Profiting from discards and offal around trawlers (Garth et al., 1996).	**Negative** – In Increase in sea temperature reduces breeding productive output (Wanless et al., 2007)	

Table 6: continued

		Fisheries				Others	
		Direct impact	Indirect impact			Climate change	
Foraging group	**Species**	**By-catch**	**Disturbance**	**Target fisheries on forage fish**	**Discard / Offal**	**Increase in sea temperature**	**Increase occurrence of summer storms**
Offshore diver-feeders	Common Guillemot (*Uria aalge*)	**Negative -** impact where gill nets are set immediately beside colonies e.g. Gillnets set in late winter for bass (*Dicentrarchus labrax*) in St Ives Bay, Cornwall (Robins, 1991).		**Negative** - Sandeel industrial fisheries in the North Sea had a negative impact on Guillemot breeding success (Monagahan et al., 1994; Rindorf et al., 2000)		Possible negative impact but lack of evidence	**Negative** – Stormy weather can reduce breeding success (Heubeck, 1999; Finney et al., 1999).
	Razorbill (*Alca torda*)	**Negative -** As per Common Guillemot + entrapment of Razorbills in salmon-fishing nets may have been contributed to declines in Ireland during the 1970s and 1980s but this no longer pose a significant threat; since 1990 annual catches of salmon in Ireland have fallen by 57% compared with 1962-1989 (North Atlantic Salmon Conservation Organisation, 2003).		Possible negative impact from Industrial sandeels fisheries but lack of evidence		Possible negative impact but lack of evidence	

Table 6: continued

		Fisheries				Others	
		Direct impact	Indirect impact			Climate change	
Foraging group	**Species**	**By-catch**	**Disturbance**	**Target fisheries on forage fish**	**Discard / Offal**	**Increase in sea temperature**	**Increase occurrence of summer storms**
Offshore diver-feeders	Atlantic Puffin (*Fratercula arctica*)	**Negative -** impact where fishing nets are set by the colony e.g. fishing nets set for salmon and sea trout in Filey Bay, North Yorkshire.		Possible negative impact from Industrial sandeels fisheries but lack of evidence		Possible negative impact but lack of evidence	

4.3 Potential ecological risk associated with the South West Fisheries

4.3.1 DEMERSAL FISHERIES

Towed gears

The inshore otter and beam trawlers land a variety of demersal fish throughout the year off Devon and Cornwall, with seasonal variations according to market and seasonal abundance. This fishery is not likely to have an effect on the seabirds' prey availably given that it is targeting large fish. Paradoxically, the discharge of offal and discards from the fisheries is likely to benefit large gull species wintering off Devon and Cornwall. Additionally, the SPA population of Lesser-Black-backed Gull which breeds on the Isles of Scilly could also benefit in summer from this fishery. Indeed, this fishery is likely to make available to scavenging gulls benthic fish that are too deep for most birds to reach, and too large for those able to dive to the seabed to swallow. Based on cased studies reviewed in Table 7, it is believed that the risk of direct mortalities from trawling is on the whole considered to be low, although it has been know that small numbers of seabirds, especially inexperienced young birds, can be drowned in trawls.

Enmeshing gears

These fisheries have the potential to pose the greatest risk of direct mortalities to seabirds. The impact of by-catch from techniques used in south west England (i.e. fixed gill, tangle and drift nets) is globally well documented. The species most likely to be at risk of mortalities are the offshore diver-feeders (Common Guillemot, Razorbill) as well as the inshore diver-feeders (European Shag, Great Cormorant, Great-northern Diver and Black-throated Diver). Offshore surface-feeders such as Northern Gannet, Manx Shearwater and Balearic Shearwater are, to a lesser extent, also vulnerable to entrapment in gill nets and other gears, since they often shallow dive to catch their prey near the surface. However, as reviewed in Table 7, the greatest impact from drifting nets and gill nets is on auk species, particularly when enmeshing gears are set immediately besides a colony during the breeding season. There is plenty of evidence of high mortality rates of auks drowned in gill nets around the UK coastline, although the overall demographic impact is often considered low on the local population.

However, it is understood that the enmeshing net demersal fisheries in south west England are extremely diverse (Appendix II). Within the demersal fisheries, the risk to seabirds may vary according to the type of gear used, the depth at which the nets are set, the season, the proximity of the fishing ground to the seabird colonies etc. Therefore, each demersal fishery may have different impacts but overall it is conceivable that the risk to inshore diver species may be medium, whilst the risk to offshore diver species (Common Guillemot and Razorbills) may be considered to be medium to high when the nets are set within or near the seabirds` feeding ground (e.g. near shore concentration in winter) or near a breeding colony in summer. The risk is assessed as medium to high given than demersal tangle nets are positioned on the seabed and pose therefore a lesser risk to diving birds than surface nets for example. Even though there is small risk to offshore feeders such as Northern Gannet, Manx Shearwater, and Balearic Shearwater of drowning in the nets, the consequence for a highly threatened species such as Balearic Shearwater can be dramatic. Indeed, the species is critically endangered and the added mortally caused by fishing activity (by-catch) would have serious demographic repercussions. There is potential for this species to suffer from incidental mortalities off Devon and Cornwall given the increasing occurrence of Balearic Shearwaters in offshore waters in the south west of England, and thus the potential risk from enmeshing gears is considered to be medium for this species.

4.3.2 PELAGIC FISHERIES

Hand lining

There is a traditional small-boats hand line fishery for mackerel in the area, when shoals appear inshore along the south coast between autumn and spring, and during the spring and summer. The risk of direct mortality (by-catch) from this activity is considered to be very low to almost non-existent on seabirds encountered off Devon and Cornwall. Northern Gannet can feed on Mackerel but given that this activity is not undertaken on an industrial scale, the effect on prey availability is considered to be low (Table 8). Additionally, Northern Gannet is unlikely to compete with the hand line fishery preferring smaller sizes fish. Therefore, it is considered that Northern Gannets are at low risk of impact from this mackerel fishery.

Towed and encircling gears

Pilchards and scad (horse mackerel) are taken within the Mackerel Box by industrial trawlers, most of which are from Scotland or Denmark. Small purpose-built ring-net vessels are increasingly targeting pilchards (marketed as Cornish sardines, MSC certified). As with the mackerel fisheries, the risk of direct mortality is considered to be very low to almost non-existent. Nonetheless, these fish can be taken by seabirds, in particular Northern Gannet. Although, there are no breeding colonies of Gannets in Devon or in Cornwall, Gannet can fly long distances to forage (up to 500km for a day trip) and birds from the Welsh and Irish colonies will feed in waters off Cornwall and Devon (Appendix III). Thus, there may be a risk of direct competition for pilchards between the industrial trawlers and the seabirds, in particular Northern Gannets. The risk of direct competition may exist also for other species which feed on pilchard (Manx Shearwater and Balearic Shearwater). Nevertheless, it is also conceivable that gulls and Northern Gannet will benefit from discards from the industrial trawlers.

Herring and sprats are also taken in pair and otter trawls. Whilst there is a low risk of direct mortalities caused by entanglement and subsequent drowning in nets, the greatest ecological risk may be however from the reduction of fish stock during the breeding season, which could affect the reproductive output and possibly the adult survival of offshore diver-feeders and surface-feeders. Indeed, sprat and herring are the main forage fish species for seabirds, and along with sandeels the preferred prey species of a wide range of seabirds. Although, it is unclear when the fishing activity is taking place, offshore diver-feeders (e.g. common Guillemot and Razorbill) and surface feeders (e.g. Northern Gannet, gulls and shearwaters) could be exploiting the same species in the same place. Paradoxically, scavenging birds such as Northern Gannet and gull species may benefit from discards and offal from the herring and sprat fisheries.

Enmeshing gear

Bass and mullet are caught in fixed and drifted gill nets and seine nets close inshore and in estuaries (Appendix II), although netting restrictions issued to protect salmonids and bass in designated bass nursery areas effectively preclude this fishery in many estuaries, where bass fishing from a boat or with sandeels as bait is prohibited between 1 May to 31 October in Devon and 1 May and 31 December in Cornwall. The bass and mullet fishery could potentially pose a medium risk to inshore diver-feeders (Terns in particular), causing direct mortalities by drowning in drifted or gill nets set up close inshore. There is also a risk of direct mortalities on offshore diver-feeders breeding along the coast of Devon and Cornwall such as Common Guillemot, Razorbill, in particular during the pre-breeding season (March and April) when both species gather near their breeding colonies (Table 8).

4.3.3 OTHER FISHERIES

Scallop dredging

Scallop dredging can be expected to impact benthic animals. It is understood that this activity takes place in inshore grounds off Cornwall and Devon. Whilst this activity is expected to have a low risk of impact on surface feeders, inshore diver-feeders (e.g. Black-throated Diver and Great-northern Diver) which are known to occur in the Important International Bird Area (IBA) off the south Cornwall coast could be affected indirectly from this activity, since they feed in shallow waters (< 40m) and on prey items that in turn feed on the benthos. Other species belonging to the inshore diver-feeder group could be also at a low risk, including European Shag and Great Cormorant (Table 9).

Lobster and crabs using pots

The south Devon coastline supports one of the largest brown crab potting fleets in the UK, comprising vivier-equipped offshore boats each setting up to 2,000 pots out to the middle of the English Channel and often landing their catches into France. It has long been known that small numbers of seabirds, especially those that are inexperienced can be drowned in lobster pots. Given the scale of this fishery, there could be a low risk of impact on seabirds.

Prawn and whelk using pots

There is also a low risk of offshore and inshore divers drowning in prawn and whelk pots while searching for prey.

Cuttlefish

Cuttlefish are also taken in traps and nets by small boats working within one mile of the shore during the spring and summer months.

Spider crabs using enmeshing gear

Although demersal tangle poses a far lower risk than surface nets, it is conceivable that net sets in inshore areas between late March and early July could have a medium risk impact on offshore diver-feeders (during the breeding season) and inshore diver-feeders species whilst the risk to offshore surface-feeders such as Northern Gannet, Manx Shearwater and Balearic Shearwater might be lower (Table 9).

Table 7: Level of ecological risk associated with the demersal fisheries.

Gear	Species targeted	Direct mortality (by-catch)	Reduction in stocks	Discharge of offal and discards	Disturbance
Beam and otter trawling	**Dermersal fish**	Low	Low	**Medium** (offshore surface- feeders)	Low
		Low	Low	Low	Low
Enmeshing gears	**Dover sole, plaice**	**Medium** (offshore diver-feeders such as Common Guillemot and Razorbill near breeding colony or near feeding concentration. **Medium** (inshore diver-feeders) **Medium** (offshore surface- feeders such as Northern Gannet, Manx Shearwater and Balearic Shearwater)	Low	Low	Low
	Cod, Pollack and ling	**Medium** (offshore diver-feeders such as Common Guillemot and Razorbill near breeding colony or near feeding concentration. **Medium** (inshore diver-feeders) **Medium** (offshore surface- feeders such as Northern Gannet, Manx Shearwater and Balearic Shearwater)	Low	Low	Low
	Pollack, ling and cod	**Medium** (offshore diver-feeders such as Common Guillemot and Razorbill near breeding colony or near feeding concentration. **Medium** (inshore diver-feeders) **Medium** (offshore surface- feeders such as Northern Gannet, Manx Shearwater and Balearic Shearwater)	Low	Low	Low

Gear	Species targeted	Direct mortality (by-catch)	Reduction in stocks	Discharge of offal and discards	Disturbance
	Hake	**Medium** (offshore diver-feeders such as Common Guillemot and Razorbill near breeding colony or near feeding concentration. **Low** (inshore diver-feeders) **Medium** (offshore surface- feeders such as Northern Gannet, Manx Shearwater and Balearic Shearwater)	Low	Low	Low
	Monk, turbot, ray and crawfish	**Medium** (offshore diver-feeders such as Common Guillemot and Razorbill near breeding colony or near feeding concentration. **Medium** (inshore diver-feeders) **Medium** (offshore surface- feeders such as Northern Gannet, Manx Shearwater and Balearic Shearwater)	Low	Low	Low
	Spider crabs	**Medium** (offshore diver-feeders such as Common Guillemot and Razorbill near breeding colony or near feeding concentration. **Medium** (inshore diver-feeders) **Medium** (offshore surface- feeders such as Northern Gannet, Manx Shearwater and Balearic Shearwater)	Low	Low	Low

Table 8: Level of ecological risk associated with the pelagic fisheries.

Gear	Species targeted	Direct mortality (by-catch)	Reduction in stocks	Discharge of offal and discards	Disturbance
Hand lining	**Mackerel**	Low	Low	Low	Low
Towed and encircling gears	**Pilchard and scad**	Low	**Medium** (offshore surface- feeders)	**Medium** (offshore surface -feeders)	Low
	Herring and sprat	Low	**Medium** (offshore- surface feeders and offshore diver-feeders)	**Medium** (offshore surface- feeders)	Low
Enmeshing gear	**Bass and grey mullet; and other species**	**High** (offshore diver-feeders such as common Guillemot and Razorbill near breeding colony) **Medium** (inshore diver-feeders as such European Shag, Great Cormorant and Diver species)	Low	Low	Low
	Red mullet	**High** (offshore diver-feeders such as common Guillemot and Razorbill near breeding colony) **Medium** (inshore diver-feeders as such European Shag, Great Cormorant and Diver species)	Low	Low	Low

Table 9: Level of ecological risk associated with other fisheries.

Gear	Species targeted	Direct mortality (by-catch)	Reduction in stocks	Discharge of offal and discards	Disturbance
Towed gear	Scallop	Low	Low	Low	Low
Pots	Lobster; Brown, velvet, green shore and spider crabs	Low	Low	Low	Low
	Prawn and whelk	Low	Low	Low	Low
	Cuttlefish	Low	Low	Low	Low
Enmeshing gear	Spider crab	**Medium** (offshore diver-feeders such as Common Guillemot and Razorbill near breeding colony or near feeding concentration. **Medium** (inshore diver-feeders) **Low** (offshore surface- feeders such as Northern Gannet, Manx Shearwater and Balearic Shearwater)	Low	Low	Low

5. KNOWN MITIGATION MEASURES IN SOUTH WEST ENGLAND

There exists a byelaw in St Ives Bay gill net fishery made by the Sea Fisheries Regulation Act 1966. This byelaw prevents the netting of fish around St Ives Bay when high mortalities of birds through entanglement with gill nets are observed.

The byelaw stipulates that no person shall use in fishing for sea fish, any gill net, within that part of the District which lies to the landward side of a line drawn 119° True from St Ives Head (50° 13'.16N, 005° 28'.69W) to the northern extremity of the Black Cliffs (50° 12'.06N, 005° 25'.43W) which is to the east of the Hayle Estuary, during any temporary closure of the fishery. A temporary closure will be implemented by the Chief Fishery Officer, or a Senior Fishery Officer, when the deaths of birds through entanglement with gill nets, as witnessed by fishery officers and other relevant officials, exceeds a predetermined level over any consecutive five day period.

The St Ives Bay Gill Net Fishery is known to have taken an annual by-catch of hundreds of Razorbills and Guillemots, possibly reaching 1,000 (Robins, 1991). However, it must be emphasised that the birds probably derive from a wide catchment area, diluting any possible population effect (Thomas, 1992). Studies of by-catch mortality in Britain showed that large numbers of auks may be caught and drowned in these nets but the rates were insufficient to cause local population declines (Mitchell et al., 2004).

It appeared that the byelaw was effectively used in January 2012 when the deaths of more than 100 sea birds had triggered the first use of a byelaw temporarily preventing fisherman from netting fish in a Cornish bay from 5th to 26th January. The Cornwall Inshore Fisheries and Conservation Authority (CIFCA) attributed the high mortality rates of auks to the concentrations of birds present in larger numbers than usual. This was due to the onshore wind and the rise in fish numbers in the area, according to the CIFCA.

Although the use of gill nets is widespread around the country and known to cause direct mortalities of auk species, the byelaw in St Ives Bay is thought the only one of its kind in the country.

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7. APPENDICES

Appendix I: Species attributes of seabirds breeding and non-breeding recorded off the coast of Cornwall and devon; Foraging group is the group of birds considered to have similar foraging behaviour; Age maturity (source BTO); Adult survival rate (source BTO); threat status (IUCN Red List Category).

International name	Scientific name	Foraging group	Age Maturity	Adult survival rate	Threat Status	World population individuals
Mediterranean Gull	*Larus melanocephalus*	Inshore surface-feeders	No Data	No Data	Least Concern	75,000
Black-headed Gull	*Chroicocephalus ridibundus*	Inshore surface-feeders	2 years	0.900	Least concern	c.4,800,000-8,900,000 individuals
Common Gull	*Larus canus*	Inshore surface-feeders	3 years	0.860	Least concern	c.2,500,000-3,700,000 individuals
Herring gull	*Larus argentatus*	Inshore surface-feeders	4 years	0.880	Least Concern	2.7-5.7 million individuals
Sandwich Tern	*Sterna sandvicensis*	Inshore surface-feeders	3 years	0.898	Least concern	No Data
Common Tern	*Sterna hirundo*	Inshore surface-feeders	3 years	0.900	Least concern	c.1,600,000-4,600,000
Little Tern	*Sternula albifrons*	Inshore surface-feeders	3 years	0.899	Least concern	c.190,000-410,000 individuals
Great Cormorant	*Phalacrocorax carbo*	Inshore diver-feeders	3 years	0.880	Least concern	c.1,400,000-2,900,000
European Shag	*Phalacrocorax aristotelis*	Inshore diver	4 years	0.878	Least concern	No Data
Black throated Diver	*Gavia arctica*	Inshore diver	3 years	0.890	Least concern	c.280,000-1,500,000 individuals
Great-northern Diver	*Gavia immer*	Inshore diver	6 years	No data	Least concern	No Data
Northern Fulmar	*Fulmarus glacialis*	Offshore surface-feeders	9 years	0.972	Least concern	c.8,400,000-13,200,000 individuals
Manx Shearwater	*Puffinus puffinus*	Offshore surface-feeders	5 years	0.905	Least concern	1,050,000-1,170,000

International name	Scientific name	Foraging group	Age Maturity	Adult survival rate	Threat Status	World population individuals
Balearic Shearwater	*Puffinus mauretanicus*	Offshore surface-feeders	No Data	No data	Critically endangered	2,000-2,400 breeding pairs
European Storm-petrel	*Hydrobates pelagicus*	Offshore surface-feeders	4 years	0.870	Least concern	1,290,000-1,530,000
Northern Gannet	*Morus bassanus*	Offshore surface-feeders	5 years	0.919	Least concern	950,000-1,200,000 individuals
Lesser Black-backed Gull	*Larus fuscus*	Offshore surface-feeders	4 years	0.913	Least concern	No data
Great Black-backed Gull	*Larus marinus*	Offshore surface-feeders	4 years	No data	Least concern	No data
Black-legged Kittiwake	*Rissa tridactyla*	Offshore surface-feeders	4 years	0.941	Least concern	c.17,000,000-18,000,000 individuals
Common Guillemot	*Uria aalge*	Offshore diver-feeders	5 years	0.946	Least concern	> c.18,000,000 individuals
Razorbill	*Alca torda*	Offshore diver-feeders	4 years	0.900	Least concern	No data
Atlantic Puffin	*Fratercula arctica*	Offshore diver-feeders	5 years	0.924	Least concern	No data

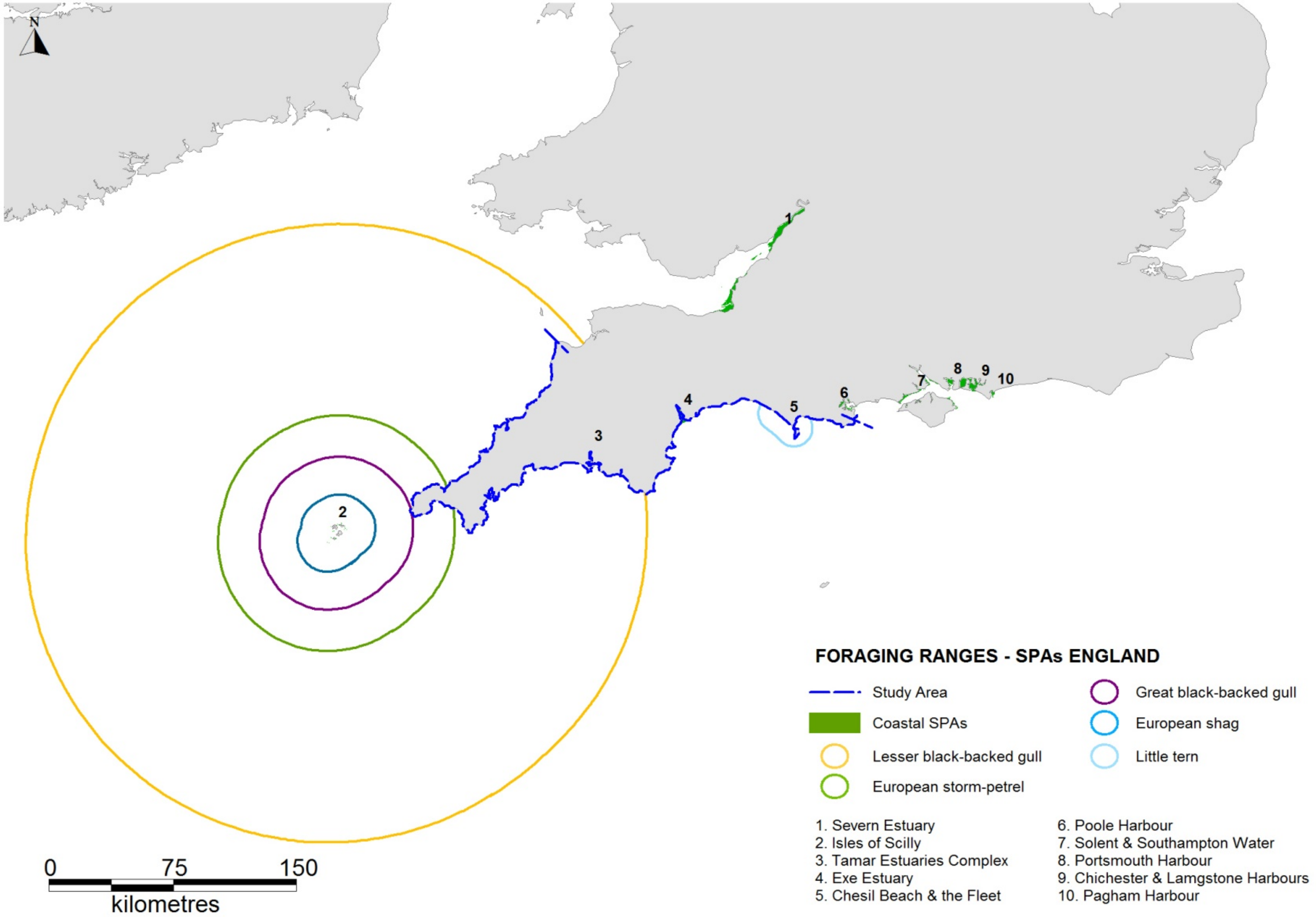
Appendix I: Types of enmeshing gear and their use in south west waters

Type	Species	Season	Gear	Area	Comments
Demersal	Red mullet; bycatch of other species	Inshore Summer fishery May-Sept	<70mm monofilament Metier 1	Close inshore, codes of conduct to protect young fish and bass http://www.cornwall-ifca.gov.uk/sitedata/Misc/Red_Mullet_Netting_Code_of.pdf	Areas where restrictions from surface set nets to avoid capture of migratory salmon and trout. Also measures to prevent bird mortalities; see above
Semi Pelagic	Bass and grey mullet; and other species	All year round – localised inshore bass fisheries during winter months	90-150 mm monofilament Surface and bottom rigged No catch data	Close inshore; known bycatch of seabirds	
Demersal fisheries	Dover sole, plaice	All year round – increased intensity during July-October	110-150 mm monofilament Inshore No catch data	Smooth ground generally just inside the 6 mile limit, to avoid large beam trawlers	Inshore Fishery – Highly weather dependant
Demersal fisheries		All year round	125-150 mm multi monofilament	On or near rough ground	Longer lengths of net

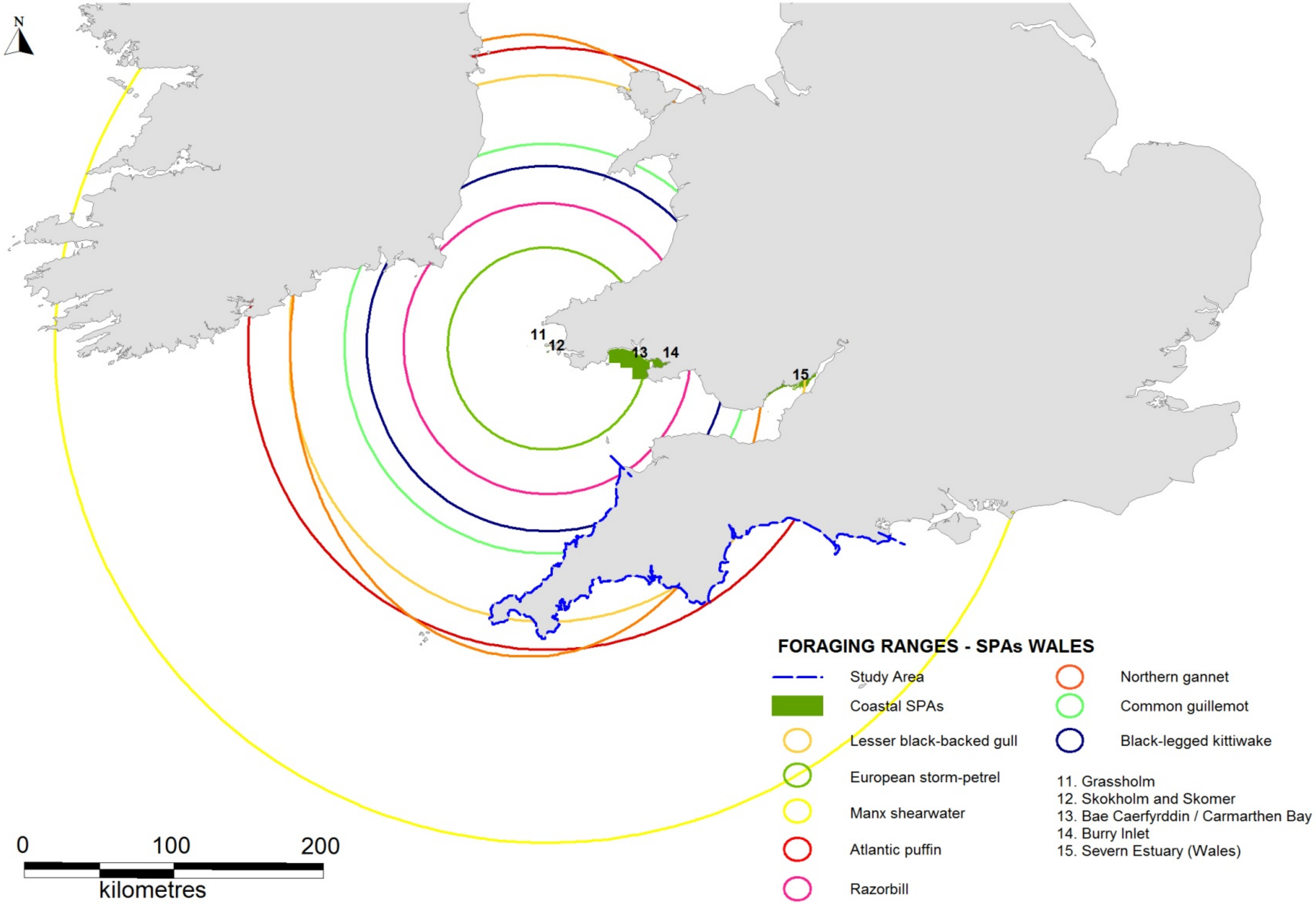
Type	Species	Season	Gear	Area	Comments
					500 m
	Pollack, ling, cod Cod, pollack, ling	All year round -	110-149 mm monofilament wreck nets + longer whitefish Metier 2 plus metier 3 150-210	Shot on very short lengths on wrecks and rough ground Pinger CC related to mesh size	Short lengths 250 m Inshore fishery more intensive during the summer months
	hake	All year round	120 mm monofilament Metier 2 part 2	Tier lengths 1000 – 5000 m Offshore mostly outside 12 miles Pingers	
	Monk, turbot, ray, (Crawfish; bycatch now)	Summer fishery	260-300 mm monofilament Metier 4 tangle net single sheet Metier 4 trammel 3 sheets; turbort	Ground dependent on target species Pinger reg	500m+ lengths of nets used dependant on vessel size
Demersal fisheries	Spider crabs	Late Mar – early July	260-320mm –tangle nets No data 30- 40 boats small scale cornwall + Devon	Close inshore fishery	Relatively short length of gear 300-

Type	Species	Season	Gear	Area	Comments
					1000m

Appendix III a: Foraging range of seabirds breeding at SPA sites in the area reviewed.



Appendix IIIb: Foraging range of seabirds breeding at SPA sites in the vicinity of the area reviewed.


N
11
12
13
14
15
FORAGING RANGES - SPAs WALES
Study Area
Coastal SPAs
Lesser black-backed gull
European storm-petrel
Manx shearwater
Atlantic puffin
Razorbill
Northern gannet
Common guillemot
Black-legged kittiwake
11. Grassholm
12. Skokholm and Skomer
13. Bae Caerfyrddin / Carmarthen Bay
14. Burry Inlet
15. Severn Estuary (Wales)
0
100
200
kilometres

Cetaceans and South West fisheries

Nick Tregenza Chelonia Ltd

The species most strongly affected by with fisheries are the Harbour Porpoise, Bottlenose Dolphin, Common Dolphin, Striped Dolphin, Risso's Dolphin, and Pilot Whale.

All cetacean species are protected from deliberate harassment and takes under international, EU and UK law, and monitoring of incidental captures is required under the EU Habitats Directive.

The first three species are of commercial value to marine tours.

Pollution: a general issue

Pollution with persistent organochlorine compounds caused massive declines of otters and some bird species and is the most likely cause of major declines in some cetaceans with particularly severe impacts on those that live longest, feed at the highest level of the food chain, and feed closest to shore.

These compounds had impacts starting in the mid-1900s when the DDT group of pesticides, including Aldrin, Dieldrin, and Lindane, were the main pollutants. Those pesticides have shown declining levels following bans in the 1970s, but industrial PCBs used in electrical equipment, sealing compounds etc. remain at significant levels although they are also bans.

This pollution effect is probably the main cause of the disappearance of Killer Whales and Bottlenose Dolphins from much of their European and global habitat. It reduces the disease resistance and reproductive success of cetaceans, making their populations much more vulnerable to low rates of by-catch.

Harbour Porpoise, *Phocoena phocoena*

Population and trends

Formerly found widely around Britain, including in estuaries and larger rivers where it was formerly subject to commercial hunts (Fal and Severn) and to shooting by River Boards as a possible predator on trout and salmon. Porpoises declined early in the second half of the last century, probably due to pollution, across a wide swathe of sea from the Baltic / Southern North Sea / English Channel / Celtic Sea and Bristol Channel / Atlantic coast of France / Mediterranean.

Two international surveys SCANS1, in 1994, and SCANS2, in 2005, showed a stable total population and evidence they have moved southwards in the North Sea and into the Celtic Sea.

Evidence from sightings in Cornwall and strandings on the French coast also indicates a local rise in their numbers that is probably also due to the southward movement. Pollutant levels in this species have fallen and some recovery may now be possible.

Fishery impacts and mitigation

Porpoises are particularly subject to bycatch in gill and tangle nets, and an observer program in the early 1990s estimated an annual bycatch in the Celtic Sea of around 2,200 animals, or 6.9% of the population. This is above the level of 1.7% set by ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas) as the upper level of bycatch for this species that could be considered 'safe'. Bycatch in towed or other gears is very rare and not significant.

A UK bycatch estimate of ca 840 porpoises in 2009 was mainly due to bycatch in the SW area.

Pingers are a well tested method of reducing porpoise bycatch, typically achieving 80% reduction, and E**C** Regulation 812/2004 required all netters over 12m long to use pingers. They did not do so in most EU waters, on grounds of safety, cost and durability in use.

Recently a pinger (the Banana Pinger) that aims to solve all the known problems and reduce the cost to fishers has been developed by Fishtek Limited and is currently in trials run by the Cornwall Wildlife Trust. An earlier version was suspected of increasing seal bycatch, a known problem in some fisheries, so this version has been made much less audible to seals.

A large and very loud pinger, the DDD, has been tried in some of the vessels subject to the EU regulation with evidence of useful effect. However it is very difficult to monitor substantively, and is more costly than the Banana Pinger which has become available after the end of those trials, which were conducted by the Sea Mammal Research Unit.

Bottlenose dolphins, *Tursiops truncatus*

Population and trends

Bottlenose dolphins have two effective sub-species. One is relatively numerous, lives along the edge of the continental shelf and is probably in 'good conservation status'.

The other is the inshore form that exists in generally distinct coastal groups. This species has been more studied than other cetaceans and there is strong evidence that they are intelligent animals with both self-awareness and awareness of the minds of other individuals including humans. They sometimes have remarkable culturally transmitted hunting strategies, and the SW group showed this before their extinction but it has not been seen since recolonisation (see below). This species also uses individual 'names' that are represented by specific whistles, and they have very large brains – much larger than ours and showing a similar ratio of brain weight to lean body mass as humans.

Eleven nearshore populations were proposed by the ASCOBANS/HELCOM Working Group, 2009, as separate management units. These range from Portugal to Scotland and three are within the South West area: Southern England; Channel Islands and Normandy coast; Brittany coast and islands.

Inshore bottlenose dolphins have been doing very badly in the South West and all around Europe, with another long-standing group (in the Gulf of Arcachon, France) going extinct since 2000 and others in decline. The South West effectively lost the species from the SW of England in the 1970s, but the area was recolonized in 1990 by a small group of animals that are seen regularly from the coast but have failed to increase in numbers, and the number of these residents appears to be below 20 individuals.

Larger groups are resident outside the SW, in Cardigan Bay, the Moray Firth, and on the west coast of Ireland. When inshore groups disappear recolonisation is very rare – the group in the SW of England may be the only example known at present.

The main cause is probably pollution as above. This magnifies the impact of bycatch on the survival of the group. However the inshore bottlenose dolphins of the SW of England are known to be producing calves so they are not in a hopelessly polluted condition.

Fishery impacts and mitigation

Bycatch of this species in gill or tangle nets is known from almost every country that has the species, including the UK, but no direct estimate of bycatch rates of inshore bottlenose dolphins is possible for such a small population. Bycatch is also known from mid-water trawls in the Celtic Sea. The population origin of those animals is unknown. This species is known in some locations to feed around bottom trawls, but bycatch in these nets appears rare.

The evidence of useful effect of pingers on dolphins in general is much less clear than for porpoises, and habituation may occur. A recent acoustic assessment of the Banana Pinger suggested quite a large effect on dolphins and will be investigated further.

Common dolphins, Striped Dolphins. *Delphinus delphis, Stenella coeruleoalba*

Population and trends

Common dolphins are the commonest dolphin here and are the cetacean most often seen by fishers. They spend relatively little time very close to the coast and move over long distances, coming into the Western Approaches and Channel in winter, and living mainly off the shelf edge in summer. The Celtic Sea population was assessed by SCANS1, 1994, as 75,450 (95% CI = 23,000-149,000) and by SCANS2, 2005, as less than half of this. The difference may be largely due to changes in assessment methods and in distribution but it should be noted that in the Mediterranean a very steep decline in this species has been clearly documented.

Fishery impacts and mitigation

Common dolphins are subject to bycatch in mid-water trawls, and in gill and tangle nets including drift nets. A UK bycatch estimate of ca600 common dolphins in 2009 was mainly due to bycatch in the SW area.

The UK unilaterally banned mid-water trawling inside its 12nm limit in response to public concern over stranded bycaught dolphins in Devon and Cornwall. This is unlikely to have reduced bycatch as it will have moved it further offshore where there are as many dolphins but stranding of bycaught animals is less likely.

In the SW bycatch in pelagic trawls for bass, hake, tuna, mackerel and smaller pelagic species is substantial, and the Sea Mammal Research Unit has been obtaining useful mitigation in trials using DDD pingers on trawls.

It is not known whether the bycatch of this species is within safe limits.

Striped Dolphins are a more southerly species and have been most impacted by bycatch in tuna drift nets. There is likely to be some benefit from pingers on static nets, and a long-running study of pingers on swordfish drift nets in California has shown enduring benefit from their use.

Risso's Dolphin, Pilot Whale. *Grampus griseus, Globicephala melas*

Population and trends

Less is known of these two species than those above, there is no information on population trends, and both are present only in small numbers. Both species range widely and dive to great depths off the shelf edge. Pilot whales eat fish and cephalopods, while Risso's dolphin only eats the latter.

Fishery impacts and mitigation

Risso's dolphins are subject to bycatch in gill and tangle nets, while Pilot whales are also subject to infrequent bycatch in mid-water trawls. The mitigation measures appropriate to the other species above can only be presumed to be similarly useful for these species.

Other factors

Climate change

No clear relationship has been identified between observed trends in cetaceans and climate change although a number of possible mechanisms of future impact have been described. Ocean acidification and temperature changes affecting overall productivity are perhaps the biggest.

Ship strike

The rate of lethal ship strikes on larger whales has been rising as vessel speeds rise, but it has not been identified as a significant problem for the species discussed here.

Fish stock depletion

This is a possible source of impact on small cetaceans, which includes all the species discussed here, but it is notoriously difficult to assess. There has been an increase in cases of starvation of porpoises examined by DEFRA's Cetacean Stranding Investigation Program, but the demography and cause have not yet been investigated or established.

Noise pollution

Man made noise is steadily increasing the level of background noise at low frequencies in the sea. Such noise particularly affects large whales that communicate at very low frequencies. The frequencies made, and used, by the species discussed here are much higher and are consequently much more rapidly absorbed during transmission through seawater, so they are less affected by long range transmission of man-made noise.

However the rising power of boat sonars is a potential problem as these are often at the frequencies (e.g. 50kHz) of maximum sensitivity of the cetaceans hearing, and an animal may swim into the down-facing sonar beam with little warning apart from a diffuse echo from the sea bed. Intensities in the beam are high enough to cause deafness.

Acoustic monitoring has shown that some inshore areas are now only used by small cetaceans at night when less boats are at sea inshore.

Documents: a few relevant sources:

Report to the EC on the implementation of regulation 812/2004 by the UK for 2009

ICES CM 2009/ACOM:21

Report of the Working Group on Marine Mammal Ecology (WGMME)

February 2–6 2009, Vigo, Spain

ICES CM 2010/ACOM:25

Report of the Study Group on Bycatch of Protected Species (SGBYC)

1–4 February 2010, Copenhagen, Denmark

ICES CM 2011/ACOM:25

Report of the Working Group on Marine Mammal Ecology (WGMME 2011)

21–24 February 2011, Berlin, Germany

Bycatch of Vulnerable Species: Understanding the Process and Mitigating the Impacts

Contract Reference: MF1003, Final Report by SMRU to DEFRA March 2011

ASCOBANS

MOP 3: Resolution on Incidental Take of Small Cetaceans (Bristol 2000)

3rd Session of the Meeting of Parties, Bristol, United Kingdom

26 – 28 July 2000

Organochlorine pollution

Many references. See esp. Jepson et al for UK findings

SW cetacean trends

Tregenza, 1992, Biological Conservation

Bycatch in SW
Harbour porpoise (Phocoena phocoena L.) by-catch in set gillnets in the Celtic Sea 1996 N. J. C. Tregenza, S. D. Berrow, P. S. Hammond and R. Leaper.
ICES Journal of Marine Science, Volume 54, Issue 5 Pp. 896-904
And subsequent SMRU reports on pinger trials and observer programs.

http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=15987&FromSearch=Y&Publisher=1&SearchText=Mitigating%20cetacean%20bycatch&SortString=ProjectCode&SortOrder=Asc&Paging=10