SR670; Ecological Risk Assessment of the effects of fishing for South West fisheries; ICES Divisions VII e,f,g & h

Author; Seafish

May 2014; Revised October 2014

ISBN No: 978-1-906634-76-6

This report should be referred to as;

Seafish (2014)
Ecological Risk Assessment of the effects of fishing for South West fisheries; ICES Divisions VII e,f,g & h
Seafish Report SR 670

There are two other linked documents;

Seafish (2014)
SR671 Ecological Risk Assessment of the effects of fishing for South West fisheries; ICES Divisions VII e,f,g & h ; Assessment spreadsheet
Seafish Report SR 671

www.seafish.org/media/publications/SR671ERAEF_Assessment_spreadsheet.xlsx

Seafish (2014)
SR672 Ecological Risk Assessment of the effects of fishing for South West fisheries; ICES Divisions VII e,f,g & h ;Supporting information
Seafish Report SR 672

www.seafish.org/media/publications/SR672ERAEFSupporting_information.pdf

Principle contact William Lart; W_Lart@seafish.co.uk + 44 1472 252323
see page iii

The method used has been published in the ICES Journal of Marine Science;

Cotter, J., Lart, W., de Rozarieux, N., Kingston, A., Caslake, R., Le Quesne, W., Jennings, S., Caveen, A., and Brown, M. A development of ecological risk screening with an application to fisheries off SW England. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu167

http://icesjms.oxfordjournals.org/cgi/content/full/fsu167?ijkey=kcWA59J92D7XGtB&keytype=ref

Seafish: Responsible Sourcing

Date: 21/10/2014

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

Author: Seafish

Executive summary

This report describes an exercise to assess the ecological effects of commercial fishing in waters off Southwest England (ICES Divisions VII e,f,g & h). We used the an Ecological Risk Screening (ERS) technique, which uses the available information about the effects of fishing on different ecological components; species or groups of species, habitats and ecological communities, to make an assessment of and provide advice on the relative risks to each component in relation to a pre-agreed set of principles and goals.

The ERS technique allows an informed judgement to be made about the potential risks from fishing to a wide range of ecosystem components and clearly, therefore, has some potential to help industry (and by association, society) move towards achieving the general goals of the ecosystem approach.

This analysis is intended to highlight the components most likely to have a higher risk from fisheries in the SW region. In this context, there is potential for ERS to be of value for regional fisheries management (i.e. at the Regional Advisory Council (RACs) or Inshore Fishery and Conservation Authority (IFCA) level), either to help the fishing industry reduce the ecological risks of fishing by identifying new and/or improving existing voluntary measures, or through more formal management channels by the development of appropriate regulations (i.e. by the IFCAs/ Marine Management Organisation (MMO)/European Union (EU)).

Currently, fisheries management is largely reactive to top-down implemented legislation (e.g. the management of European Marine Sites, Marine Conservation Zones etc), and the use of evidence to support decision-making in management is often patchy, can lack transparency, is of varying degrees of quality, and can be costly to generate. Conversely, ERS provides a systematic process which allows for the prioritization of risks for management (i.e. it is strategic), it is transparent in that the rationale for scoring is accounted for, and it can be used by managers to justify why they are taking certain actions over others. It is also a relatively cost-effective way of bringing experts, managers and other stakeholders together to actively discuss the ecosystem effects of fishing.

We envisage the ERS method being employed for focused risk assessments as required, and it could be repeated periodically (maybe every 5 years) as a process to facilitate adaptive management. For example, if the same risks are flagged up at the end of a 5-year period, management may be failing in some aspect. So, as well as

making the decision-making process transparent, the ERS approach could also be used to make management accountable.

Method

The method adopted for this risk assessment was Ecological Risk Screening**:** described in Cotter et al (2014). The method assesses ecological risks in relation to a set of pre agreed principles and goals; in this case as agreed with the industry development and training organisation Seafood Cornwall. This method enables expert knowledge to be translated into scores describing the relative impact of fishing activity. The resulting scores can then be used to rank the importance of further investigations, and hence further work as described below.

The essence of this approach is that it identifies the most sensitive attribute of an ecological sub-component, that is a habitat type, ecological community, fish or bird population, with which to estimate the risk from fishing or other activities in relation to that sub-component's survival, for example impacts on its abundance or food supply.

The resulting Relative Impact Score (RIS) provide an assessment of the effects of the fishing activity in the SW area judged to be most harmful to each ecological sub-component (where feasible) in relation to the operational objectives (where available) drawn from the principles and goals described in Section 3.

The scoring of the activities' effect on a unit of analysis is carried out in relation to four potential elements; the spatial and temporal overlaps and the relative intensity and duration of the interaction between units and the fishing activities in the SW area. The resulting scores are tabulated and discussed in Section 6.

Further work

During this exercise, which aimed to identify the most sensitive elements of each ecosystem sub component to fishing in the SW area, a number of actions and some further work were identified.

Communities and Habitats

The status of **demersal fish communities** is monitored data from Research Vessel Surveys using indices relating to the quantities of certain species (Large Species Indicator; LSI) and of large fish (Large Fish Indicator; LFI) in the catches. The idea is to understand changes in the structure of the fish communities over time.

These indices have been monitored in the past although there are breaks in the time series. They will be monitored in the future under the EU Data Collection Framework, so it will be possible to track changes in them over the coming years. However, we noted that there are no reference points for these indictors for the SW area and these will need to be developed if these indicators are to be useful management tools.

Potentially, increases in LSI and LFI can only be achieved through reducing fishing mortality and/or by improving the selectivity of fishing gears (so more fish survive to be large). Improvements' in the status of sole, cod, hake and plaice stocks (for example) have accompanied a reduction in fishing effort over the past decade, which suggests that the underlying fish community is sufficiently stable to respond to management efforts.

Improvements to data and assessments are a priority for a number of teleost species (monkfish, megrim, red mullet, brill, turbot, and lemon sole), so that scientific advice can be usefully applied to management aimed at MSY.

Indicators to score the effect of fishing on **pelagic fish communities** are lacking and it was difficult to obtain a robust basis for scoring effects on **plankton communities**, because they are strongly influenced by physical oceanographic effects and it may be difficult to detect the effects of fisheries even if such effects occur.

Information on the distribution, sensitivity and status of **benthic communities** is valuable in managing them in relation to the Marine Strategy Framework Directive and Marine Spatial Management. Whilst the location of some benthic communities is fairly well described (maerl beds, for example), improving our knowledge of the location of benthic habitats and the level of fishing intensity on them is clearly a basic requirement for ensuring their protection.

Fishing vessels are often equipped with advanced echo sounders and Olex™ systems, which could provide information that might improve mapping or ground-truthing of benthic communities. The Seafish guide to good practice for scallop fishing[1] encourages fishermen to avoid reefs and patches of hard ground in order to conserve biodiversity, and it also encourages fishermen to make information from their echo sounder records available for scientific research. High resolution spatial information from vessels of less than 15 m would also help to improve knowledge and hence management and conservation of the inshore (inside 12 nm) environment (see Caslake 2009[2]).

Teleost fish species
The most widely studied component in the SW area is teleost fish (particularly commercial species), and there are already numerous management initiatives in place to improve sustainability including: TACs and quotas; effort controls; Minimum Landing Sizes (MLS), species management plans; the Trevose box to protect spawning areas for cod; protection of nursery areas, mesh size controls and the upcoming EU landings obligation ("discard ban"). Some stocks, however, are considered to require further work:

- There is a need for improved assessments of the monkfish and megrim stocks, for which data have been of insufficient quality for a full assessment in recent years, due to difficulties in ageing monkfish and poor quality data for megrim.

[1] www.seafish.org/media/Publications/UK_Scallop_Industry_Good_Practice_Guide_for_consult.pdf

[2] www.seafish.org/media/Publications/SR617_VMSFinal.pdf

- Data-limited, or higher level, assessments should be considered for stocks of brill, turbot, red mullet and lemon sole.
- Pilchard (sardine) and sea bass stocks would benefit from management measures that enabled them to be exploited a rate corresponding to MSY.

Efforts should continue to reduce discards and improve selectivity, particularly for cod, haddock and plaice. One approach is to use 120 mm cod end mesh, rather than the 100 mm allowed under EU rules when targeting gadoids, which would help select against juvenile cod, haddock and plaice and would presumably also reduce mortality on other commercial and non-commercial species.

Elasmobranch species
Many elasmobranch species are well known to be at high risk from fishing because of their vulnerability to several gears and they mature at a relatively late age and have low fecundity (few young). Our risk screening method highlighted many species of this group as requiring further investigation and developments in management.

ICES has advised on management measures for individual elasmobranch species, other than TACs, which include: spatial management (taking advantage of the patchy distribution of these species); minimum and maximum landing sizes to conserve juvenile and/or breeding stock and gear modifications either to reduce abrasion (which can lead to post-release mortality) and/or excluded certain size groups from the catches.

ICES also noted that there is a need to use local knowledge to develop and implement viable measures in the context of the overall management of skate and ray stocks in the region. Shephard et al., (2012)[3] provide an example of how scientific and fishermen's data can be brought together to improve knowledge on the spatial distribution of these stocks.

Defra is currently progressing the shark, skate and ray plan, which includes a number of collaborative initiatives between fishers and scientists designed to improve knowledge of skate and ray stocks. Further information can be found at;

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224294/pb14006-shark-plan-review-20130719.pdf

http://webarchive.nationalarchives.gov.uk/20130505040140/http://archive.defra.gov.uk/environment/marine/documents/interim2/shark-conservation-plan.pdf

Shellfish
A number of requirements relevant to **shellfish** management were noted.

A research project (CRESH[4]), carried out by the Marine Biological Association of the UK and the University of Caen in France, has investigated aspects of **cuttlefish** spawning, the effects of environmental conditions on recruitment, and provides an

[3] http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0049307

[4] www.unicaen.fr/ufr/ibfa/cresh/?lang=en

opportunity to develop assessment and management methods. Because cuttlefish and **squid** grow rapidly and die after spawning (at age 2 and 1 respectively), it is important to ensure that sufficient adults survive to produce enough eggs for the next generation to develop properly. Consequently, setting appropriate TACs would need a shorter timescale than for teleosts.

Improving the assessment of **scallop** stocks is an important challenge, and a study[5] by the University of Bangor in collaboration with CEFAS and the industry seeks to develop an assessment methodology, together with an investigation of the environmental effects of scallop dredging in the English Channel.

Consideration should be given to a **whelk** MLS which is related to length at maturity.

Most of the current management of **edible crab** and **lobster** stocks is designed to conserve spawning stock through technical measures, but modelling studies suggest that small changes in effort levels can be as important with respect to stock sustainability. The ACRUNET[6] project is investigating possible international management strategies for edible crab fisheries.

International and local measures are required to improve management of **crawfish** stocks.

Seabirds
Further work would be to examine the possible effects of fisheries on food availability for foraging terns.

Sea turtles
Following the turtle code[7] and avoiding littering should be adequate mitigation measures for the very small number of turtles encountered.

Marine mammals
Although bycatch of **Bottlenose dolphins** is known to occur in the SW, there is not currently enough data to produce robust mortality estimates. Furthermore it is not known whether bycaught animals originate from the larger offshore population or from the smaller inshore group (or both) and ideally this should be determined so that observed bycatch rates can be placed in the correct context. The behaviour of bottlenose dolphins in relation to the presence of pingers is inconclusive, so it is questionable at this time if the use of pingers is a suitable approach for mitigating bycatch of this species.

The routine use of pingers by the offshore (>12m) fleet will reduce the bycatch rates of **harbour porpoises** (and probably **common dolphins**) in these fisheries. Howev-

[5] www.seafish.org/about-seafish/news-and-events/news/phd-student-tackles-scallop-habitat-survey-in-english-channel

[6] http://www.acrunet.eu/

[7] www.mcsuk.org/sightings/turtles.php

er, bycatch of both these species is known to occur in some inshore static net fisheries as well and efforts could be made in collaboration with industry to devise suitable targeted mitigation approaches for those particular fisheries. For **grey and common seals** monitoring of fisheries' interactions with this species should be continued.

Collaboration

One other important outcome from this exercise is that an improvement in communication of scientific and technical knowledge obtained by CEFAS and others in relation to the ecological effects of SW fisheries should be encouraged. Such an outcome would enable:

- A better understanding of the mitigation measures that are already implemented in SW fisheries and their efficacy.

- Priorities to be set for further investigations and actions concerning identified ecological risks. Such actions could include setting up task groups to tackle specific risks.

With this information, buyers will have greater knowledge of the ecological risks associated with the fisheries in the SW region from which they source fish, and could potentially participate in further investigations and initiatives to mitigate such risks.

Acknowledgments

This work was carried out as collaboration between a number of personnel at Seafish, Cefas and independent consultants. Several other individuals and organisations provided information and input.

Name	Organisation	Role
William (Bill) Lart	Seafish	Project Coordinator
John Cotter	FishWorld Science	Derived Ecological Risk Screening assessment method
Sam Lambourn	Seafood Cornwall	Provided Principles and goals
Andy Matchett		

The assessment working group was convened at Cefas, Lowestoft in October 2013

Name	Organisation	Role
Dr Mike Pawson	Independent Fisheries Consultant	Chair of Assessment Working Group
Dr John Cotter	FishWorld Science	Drafted the Assessment spreadsheet
William (Bill) Lart	Seafish	Project Co-ordinator
Nathan de Rozarieux	Tegen Mor Fisheries Consultants	Fisheries Expertise
Prof Simon Jennings	Cefas	Biodiversity, fisheries and environmental management
Dr Will Le Quesne	Cefas	Fisheries and environmental management
Dr Alex Caveen	Seafish	Fisheries and Marine Protected Areas
Richard Caslake	Seafish	Fisheries Expertise
Al Kingston	Sea Mammal Research Unit	Sea Mammal and Fisheries Expertise

The results of this working group are presented here as the collective view of the group, and are not necessarily the view of the organisations to which the individuals belonged.

Correspondence should be addressed to the Project Co-ordinator;
William (Bill) Lart
Sustainability and Data Advisor
Seafish | Origin Way, Europarc, Grimsby DN37 9TZ
T: +44 (0) 1472 252 323
W_Lart@seafish.co.uk

Advice on ecological components (see Table 1) was obtained from the following experts

Name	Organisation
Mary Brown managed the advice from Cefas.	Cefas
Ewen Bell, David Palmer, Beatriz Roel, Alan Walker, Jim Ellis, Steve Milligan, Alexander Koch, John Pinnegar, Robert Thorpe, Sara Pacitto, Tom Catchpole, Stefan Bolam, Will Le Quense	Cefas
Mike Pawson	Independent Fisheries Consultant
Lucas Mander	Institute of Coastal and Estuarine Studies, University of Hull
Isobel Bloor and Emma Jackson	Marine Biological Association, Plymouth
Al Kingston, Sophie Smout & Simon Northridge	Sea Mammal Research Unit
Rod Penrose	UK Cetaceans strandings Investigation Programme
Nick Tregenza	Chelonia Ltd

Table of Contents

1. Introduction 1
2. Project background 2
3. Principles and goals 3
4. Ecosystem and fisheries 4
4.1. Geographic region covered by the risk assessment 4
4.2. Ecosystem components 5
4.3. Conservation areas 6
4.4. Fisheries' activities assessed 8
4.5. Distribution of fishing effort in the SW area 8
4.6. Fishing effort over time 9
4.7. Catch information 12
4.8. Review of the effects of gear on benthic habitats and communities 15
5. Risk assessment : Ecological Risk Screening 17
6. Results and discussion of the ecological risk screening (ERS) outcome 21
6.1. Communities and habitats (Table 5) 21
6.2. Fish stocks 24
6.2.1 Teleosts (Table 6) 24
6.2.2 Elasmobranchs (Table 7) 26
6.3. Shellfish 26
6.3.1. Molluscs (Table 8) 26
6.3.2 Crustaceans (Table 9) 28
6.4. Seabirds (Table 10) 28
6.5. Sea Turtles (Table 11) 29
6.6. Marine Mammals (Table 13) 29
7. The ERS approach and the Marine Strategy Framework Directive (MSFD; EU 56/2008) 31
8. Further action and work 33
9. References 55
Appendix 1. Detailed descriptions of the main gear types used in the SW fisheries 59
Otter trawl 59
Operations and gear 59
Scallop Dredge 60
Fixed nets 61
Pots 63
Appendix 2 Ecological risk screening jargon 67

1. Introduction

The main source of information on responsible sourcing of fish products is currently based on scientific advice on the stock status of the more important commercial species, chiefly derived from ICES stock assessments. However, not all species that are exploited by fisheries in the South West region are subject to regular assessments, and an approach that focuses purely on the most important commercial species does not provide a full picture of the total effects of fishing in this area.

There are strong pressures from the supply chain for information that would enable buyers to identify fish from ‘sustainable’ sources, or at least be able to evaluate the “risks” involved with particular fishery operations. The options currently available range from information obtained from ICES stock advice and derivatives such as the Seafish Responsible Sourcing Guides, the Sustainable Fisheries Partnership[8], the Marine Conservation Society[9] and others, through to full assessments against the Marine Stewardship Council[10] (MSC) standard and consequent certification (which covers commercial stock status, wider impacts on the environment and the efficacy of existing management measures).

However, some fisheries may not perform well in these schemes because relevant information may be lacking or associated management does not fall within a particular scheme’s criteria. A “failure” or withdrawal of an assessment means that there is no publicly available risk assessment. For responsible sourcing, where knowledge of the risks within a pre-agreed framework is required, the imperative is to try to find information that will fill these gaps.

Where information is lacking, or a fishery does not satisfy MSC assessment criteria (for example), an Ecological Risk Assessment (ERA) framework can be used to assess the risks that a fishery poses to the ecosystem, including both exploited (i.e. commercially important) and non-exploited components. These frameworks are discussed at length in Cotter and Lart (2011). The ERA framework used for this analysis was developed by the CSIRO[11] (Hobday et al., 2011).

The ERA methodology includes an initial risk screening analysis termed **Ecological Risk Screening (ERS)**. This semi-quantitative approach considers the effects of fishing on all ecological components of a system and helps to prioritise issues worthy of more detailed analysis and/or possible management action.

The ERA process is designed to reveal which ecological components are most at risk from a fishery’s activities in relation to a pre-agreed set of principles and goals relating to fisheries management, ecosystem structure and biodiversity.

[8] www.sustainablefish.org

[9] www.fishonline.org/

[10] www.msc.org/

[11] Commonwealth Scientific and Industrial Research Organisation; Australian Government body charged with carrying out scientific research and development

This report describes the implementation and outcome of the use of the ERS methodology to risk–assess the ecosystem effects of fisheries' activities in the South West of England. It provides a description of the results of the assessment, with suitable caveats where knowledge is lacking, and descriptions of individual fisheries and mitigating factors that can be used for responsible sourcing.

It also discusses the results of the ERS in relation to the European Union's Marine Strategy Framework Directive, which aims to bring Europe's entire marine environment within 'good environmental status' by the year 2020.

This information can be used by fishers, buyers, suppliers and customers in communications concerning responsible sourcing, and/or to help make improvements in their operating practices.

2. Project background

This project was initiated by Seafish in response to requests by major processors in the South West (SW) region for a more comprehensive assessment of the sustainability (in both commercial stock and wider ecosystem terms) of SW fisheries. Seafood Cornwall[12] (an industry training and development body) was initially consulted to steer the project and provide the principles and goals against which to assess the risks to various ecological components from fisheries' activities (see below), although it became clear from discussions at the Seafish South West conference held in Brixham in November 2012 that a broader representation should be sought.

A number of retailers had expressed an interest, and this project was discussed during a meeting held in March 2013 at the initiative of the Sustainable Fisheries Partnership Organisation, following which the information required to conduct an ERS for SW fisheries was compiled. The risk screening was carried out by technical experts on fisheries and fisheries science (see Acknowledgments) at a meeting in CEFAS Lowestoft during October 2013.

[12] http://www.seafoodcornwall.org.uk/

3. Principles and goals

In order to carry out a successful Ecological Risk Assessment, it is necessary to define the fisheries and ecosystem which are being assessed, and also to describe the overarching principles and goals against which the ERA is being made. After discussion with personnel from Seafood Cornwall, the following were agreed.

Principle: To leave for future generations the same or better opportunities to benefit from the marine environment around the South West peninsula as the present generation has enjoyed.

Goals:

1. To maintain an economically viable and regionally diverse fishing industry in South West England.

2. To maintain and protect essential ecological processes and food webs.

3. To avoid taking more fish from a stock than can naturally be replenished.

4. To protect biodiversity including vulnerable marine species and special types of habitat not specifically covered by legislation.

5. To minimise pollution as a consequence of fishing so far as practical and economical.

6. To comply with all legislation applicable to SW fisheries and fish products.

Operational Objectives

The principle and goals were used as guidance to derive operational objectives for the various components assessed (see Table 5 to Table 13). Some were based on external reference points. For example, operational objectives for commercial resource stocks were related to their status in relation to Maximum Sustainable Yield (MSY). Operational objectives for certain components, such as cetaceans, are subject to international agreement ASCOBANS[13] and these were used where available. For other components, the technical group agreed objectives consistent with the above. However, for many components the absence of agreed reference points means that these remain provisional, as discussed in the text. It was possible to score components (Section 5, page 17) where operational objectives were not defined, but the presence of operational objectives helped to define further work where appropriate.

[13] Agreement on the Conservation of small cetaceans of the Baltic, North East Atlantic, Irish and North Seas www.ascobans.org/

4. Ecosystem and fisheries

4.1. Geographic region covered by the risk assessment

Figure 1 shows the sea area included in this assessment, which covers ICES Divisions VIIe,f,g and h (light blue shading: the “SW area”). This is compatible with areas covered by many other studies and by the boundaries used by ICES for the purpose of stock assessment and provision of management advice. However, it was recognised that fisheries in the Bristol Channel tend to be distinct from the ”SW fisheries”, which are defined as those prosecuted by vessels fishing out of the ports along the area of coast coloured blue on the chart. Fisheries from these ports landed 84% of the 57,811 t live weight landed by UK vessels from ICES Division VII e,f,g&h in 2011.

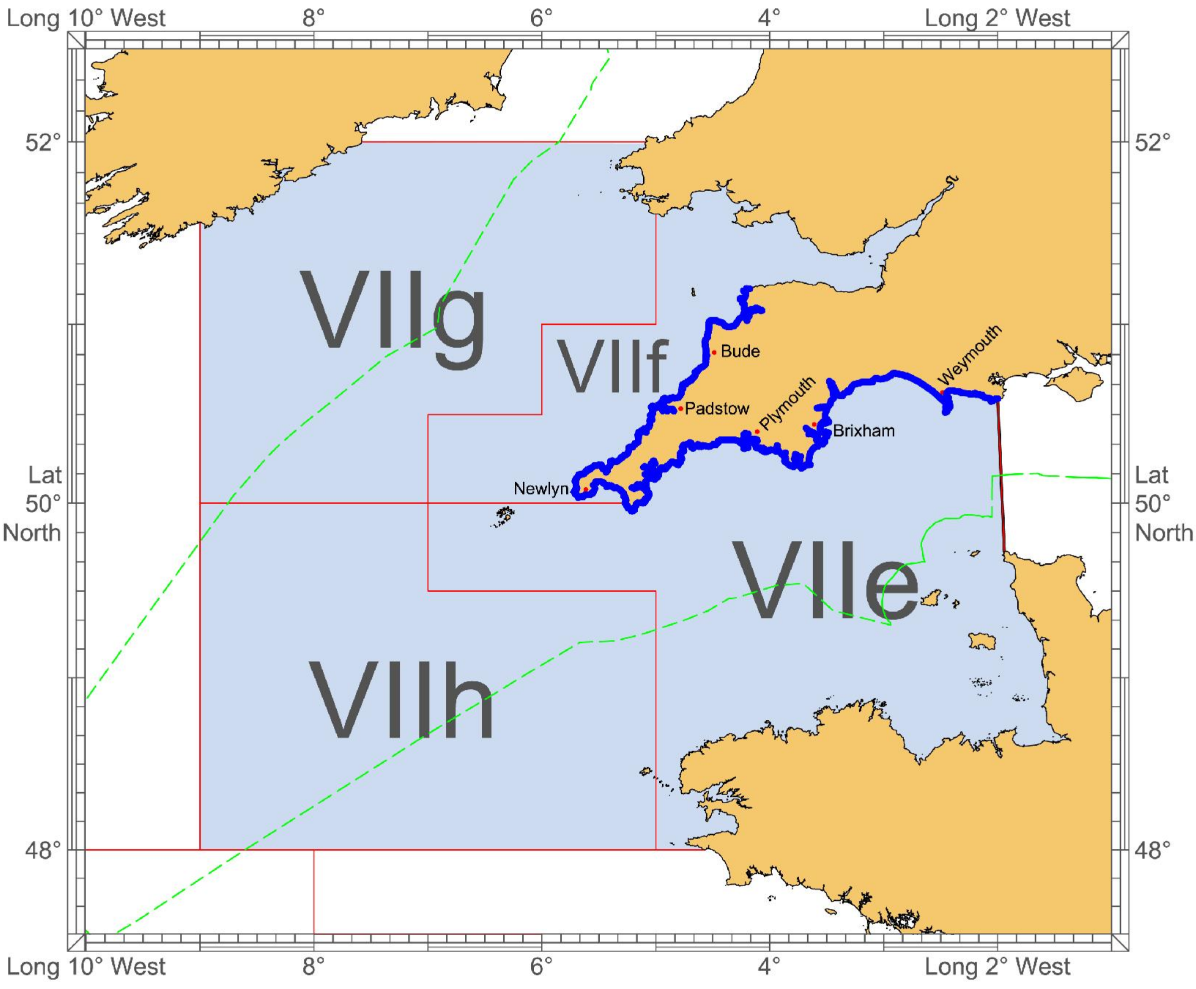


Figure 1 Area for the Ecological Risk Assessment of SW fisheries

4.2. Ecosystem components

To assess the effects of fisheries on marine ecosystems, it is necessary to identify the various ecosystem components, and these are outlined in Table 1.

Table 1: Ecosystem components on which information has been obtained

Ecosystem components	Sub component or Units of analysis	Source of descriptions; see below for link
Teleost fish	Cod, plaice, mackerel etc	Pawson (2013)
Elasmobranch fish	sharks, skate and rays	Ellis et al., (2013)
Commercial Invertebrates	Crustaceans; crabs, lobsters Cephalopods; cuttlefish, squid Bivalves; mussels, scallops Gastropods; whelks	Bell (2013) Bloor and Jackson (2013) Palmer and Roel (2013)
Sea birds	Terns, gulls, auks, etc	Mander and Thomson (2013)
Sea mammals	Cetaceans; porpoises, dolphins, whales Pinnipeds; seals	Kingston, A et al., (2013), Tregenza, (2012)
Reptiles	Turtles	Penrose (2012)
Habitats & Communities	Plankton	Milligan (2013)
	Fish Communities	Le Quesne (2013)
	Benthic habitats and communities	Bolam (2013).

See link
www.seafish.org/media/publications/SR672ERAEFSupporting_information.pdf

The information linked from Table 1 was provided by specialist scientists under the following headings:

- Description of the sub-component in the SW area.
- Current population status in relation to recognised reference points or conservation objectives, if available, and any information on trends over time.
- Effects of fisheries' actions on the sub-component, including post-encounter mortality and indirect effects (such as food depletion).
- Known mitigation measures and whether they have been tested for efficacy in SW fisheries and whether they are considered relevant.

Any other widely known and published conservation issues related to a sub-component that enables the effects of SW fisheries to be put in context. For example:

- Endangered, threatened and protected (ETP) status of the sub-component.
- Effects of activities such as pollution or mineral extraction.

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

4.3. Conservation areas

An important measure that is used to limit the risks to some components is the implementation of areas in which fishing is restricted or prohibited (often seasonally). The UK Inshore Fisheries and Conservation Authorities (IFCAs) are in the process of introducing a number of regulations under the EU Habitats Directive, aimed at reducing the effects of fishing on benthic communities. Full details of those inside the 6 mile limit can be found on the appropriate IFCA websites:

Cornwall
www.cornwall-ifca.gov.uk/
Isles of Scilly
www.scillyifca.gov.uk/
Devon and Severn
www.devonandsevernifca.gov.uk/
Southern
www.southern-ifca.gov.uk/

There are also measures to protect mearl beds and reefs in the Fal and Helford estuaries and also mudstone reefs in Lyme Bay and a number of other measures are being taken to conserve vulnerable habitats.

***Finding Sanctuary*[14]**

The 'Finding Sanctuary' project is the South West part of the regional Marine Conservation Zone project set up to recommend areas for Marine Conservation Zones in the context of the exiting Marine Protected Areas (SAC, SPA, SSIs, OSPAR MPA and Ramsar Sites), so that when all sites are put together they form a coherent network.

Figure 2 shows the main areas and proposed areas at the time of writing. All of these have been, or will be risked assessed for fisheries impacts under the auspices of the Marine Management Organisation; the Managing Marine Areas implementation group[15,16,17].

[14] http://publications.naturalengland.org.uk/publication/1561560

[15] www.marinemanagement.org.uk/protecting/conservation/ems_fisheries.htm

[16] www.marinemanagement.org.uk/protecting/conservation/documents/ems_fisheries/infonote1.pdf

[17] www.marinemanagement.org.uk/protecting/conservation/documents/byelaw_consultation_summary.pdf

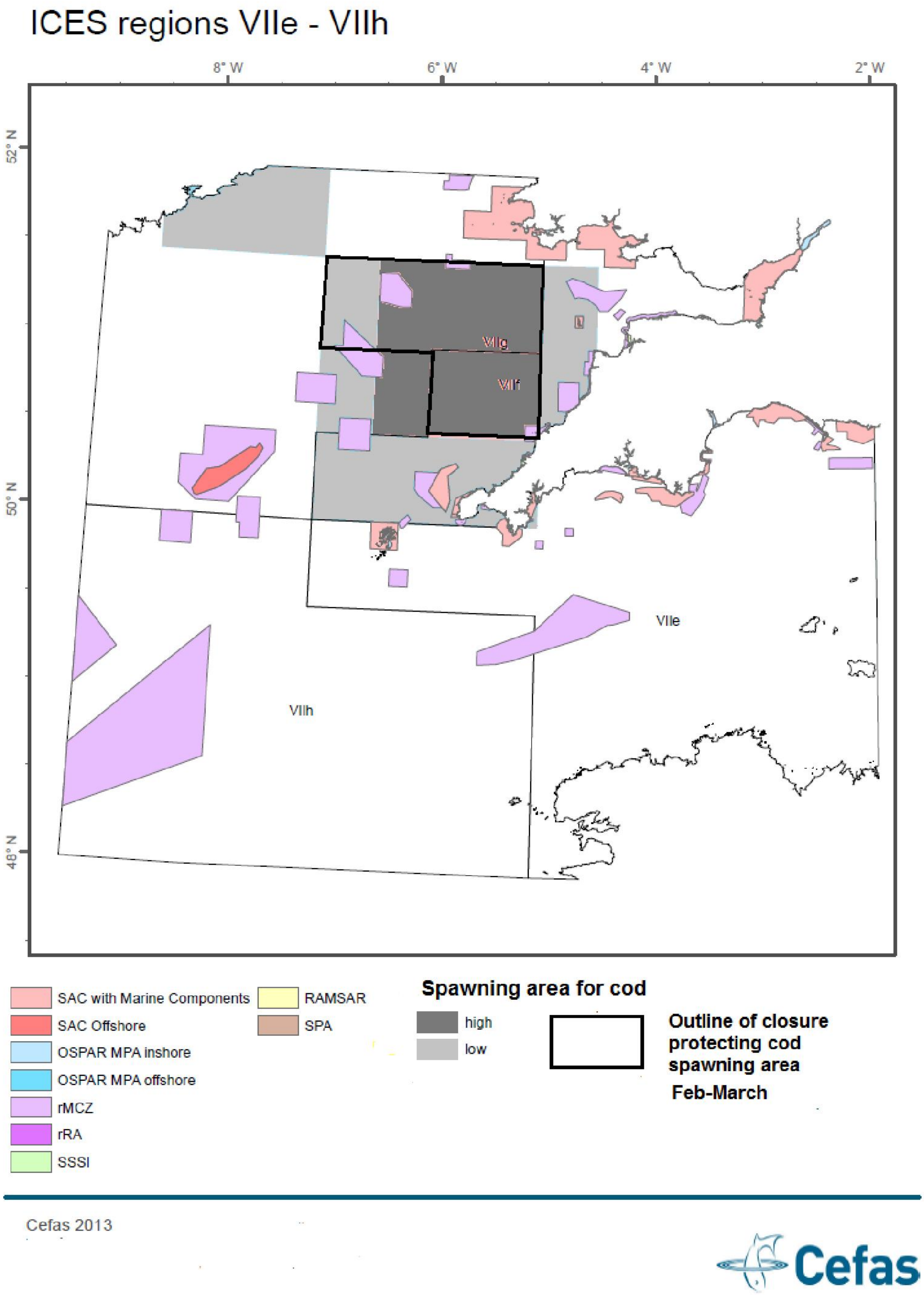


Figure 2 Main conservation areas within the SW region: SAC = Special Area of Conservation under the EU Habitats Directive; SPA = Special Protection Area under the EU Wild Birds Directive; Ramsar site = designated for wetland protection; OSPAR MPA = Marine Protected Area under the OSPAR convention; rMCZ = recommended Marine Conservation Zone;= rRA recommended Reference Area under the Marine and C Coastal Access Act. NB not all these are implemented at time of writing. Also shown are known cod spawning areas and seasonal closure the 'Trevose box' designed to protect spawning cod.

4.4. Fisheries' activities assessed

Prior to the risk assessment, a description of each of the relevant fisheries, the gear used and fishing activities, was obtained from NFFO's Annual Fisheries Report and Project Inshore[18], and data on effort, catches and discarding held by the Marine Management Organisation (MMO), the Centre for Environment Fisheries and Aquaculture Science (CEFAS) and the EU Scientific, Technical and Economic Committee for Fisheries (STECF).

Vessels from a number of nations operate in fisheries in the SW area and their effects on ecosystems should ideally be taken into account in the ERA. Though this assessment mainly concerns UK fisheries (for which good information is generally available), the effects of all fisheries (including those by non UK vessels) were analysed together, unless there was good reason not to do so. The following gear types were considered:

- Beam trawl (for sole in the Channel, megrim in the SW approaches)
- Otter trawl (from many ports)
- Scallop dredge (mostly highly mobile)
- Enmeshing (mostly static) gear (inshore and offshore)
- Pots (mostly inshore)
- Hand line (including anglers)
- Ring nets; pelagic seines
- Pelagic trawls

Descriptions of the operations of the main gear types, their target and main bycatch species, and the distribution of their fishing effort in 2007 from offshore VMS data, can be found in Appendix 1.

4.5. Distribution of fishing effort in the SW area

Information on the distribution of fishing effort shown in Figure 3 below and maps provided in Appendix 1 is based on VMS data that cover the over 15 m fleet. This does not reveal the true extent of inshore effort, most of which is conducted by boats under 15m. Nevertheless, it is apparent that beam trawling and fishing with static nets have the widest geographical distribution in the SW area, whilst potting and dredging are more concentrated in the near-shore regions in Divisions VIIe and VIIf. Demersal seine netting only occurs in a limited area in the eastern part of the SW waters. Fishing activity within the 12-nautical mile zone is mostly described as low intensity throughout the SW area (Koch and Pacitto 2013).

[18] http://www.seafish.org/industry-support/fishing/project-inshore

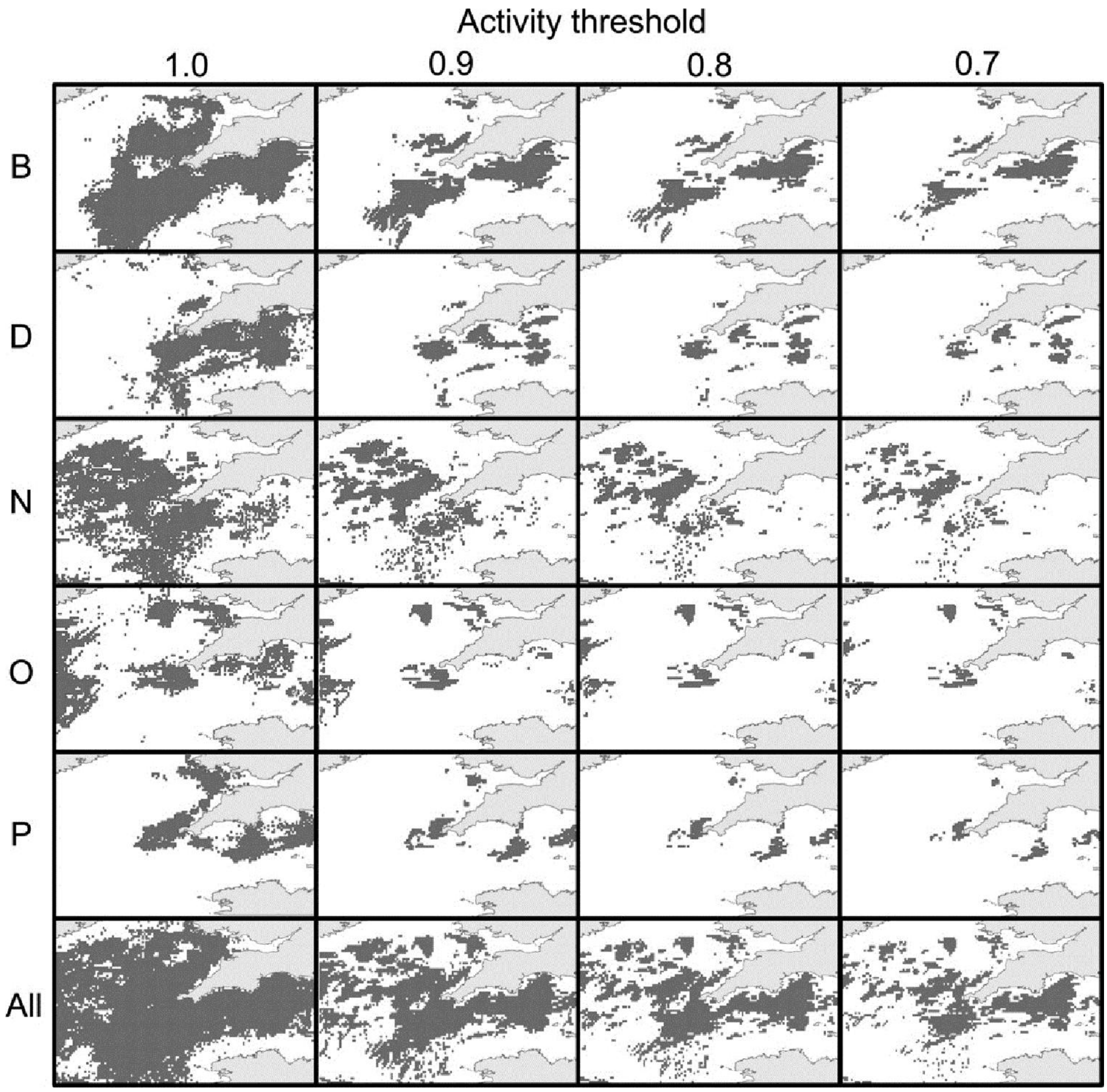


Figure 3: Spatial extent of proportions of fishing activity for vessels using the main gear types covered by VMS data (2006-2009 combined). Gear codes: B, beam trawls; D, dredges; N, nets; O, otter trawls; P, pots; All, all gears combined. From Jennings & Lee (2012).

The majority of effort by a particular fishery in the SW area is conducted within fishing grounds occupying a relatively small proportion of the total area available. This means that extensive parts of the SW area are relatively lightly fished (i.e. only 10% of the effort is spread across 50% of the total fishery area; Jennings & Lee, 2012).

4.6. Fishing effort over time

The effort trends (annual hours fished) by vessels of all nations fishing in ICES Divisions VIIe,f,g&h between 2003 and 2011 are shown in the following three figures (source STECF). Note that only hours fishing (i.e not fishing power) is presented in these graphs.

Figure 4 shows effort trends in demersal towed gears during this period, which indicates that otter trawl effort has fluctuated around 500,000 hr per annum (pa) over the past decade without an obvious trend, whilst beam trawl effort has decreased by approximately half. A combination of decommissioning, high fuel prices (fuel can constitute up to 40% of costs), restrictions on days at sea in the sole recovery zone (ICES Division VIIe) and diversification to other fisheries (e.g. scalloping) are the main reasons for these observed changes. Scallop dredging effort has increased from around 150,000 to 250,000 hr pa over the past decade due partly to vessels switching from other fisheries such as beam trawling. Demersal seine effort has increased but remains at a low overall level.

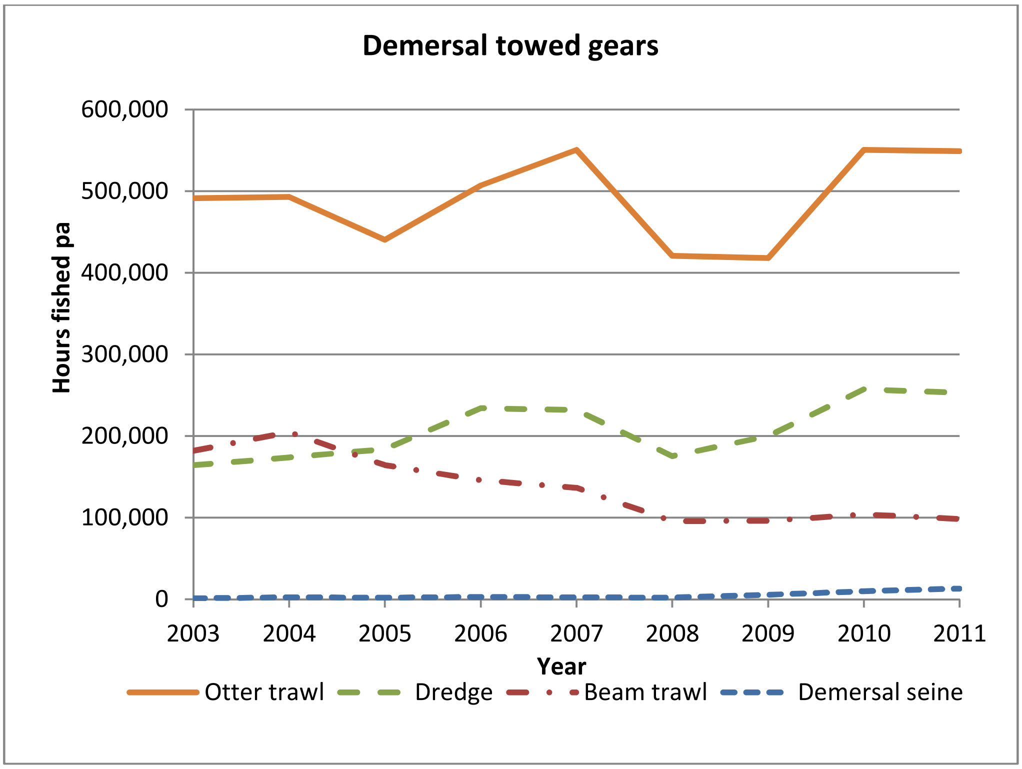


Figure 4;Annual effort (hours fished) by vessels of all nation operating in ICES Divisions VII,e,f,g,h using towed demersal gears, 2003 - 2011 (source STECF).

Static net (trammel and gill) fisheries show no clear trend over the same period (Figure 5), though there was a small rise to a peak in 2007 and then a decline to previous levels. Long-lining has shown a marked increase; whilst potting effort appears to have fallen by around 40% between 2007 and 2009, though it should be noted that potting effort is only considered accurate since 2006 when the Registration of Buyers and Sellers legislation was introduced.

Figure 6 suggests that there have been large fluctuations in the annual effort of vessels using pelagic seines (ring nets) in the area, but there is no clear upwards or downwards trend over the whole period.

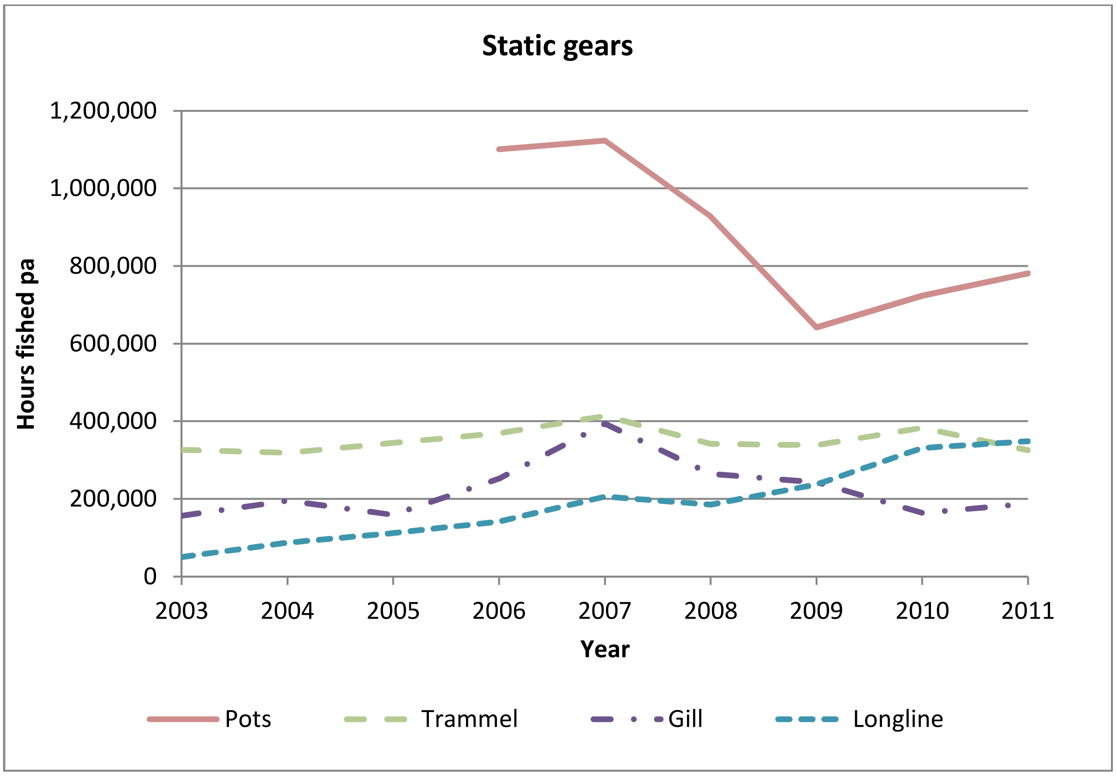


Figure 5 Annual effort (hours fished) by vessels of all nation operating in ICES Divisions VII,e,f,g,h using static gears, 2003 - 2011 (source STECF).

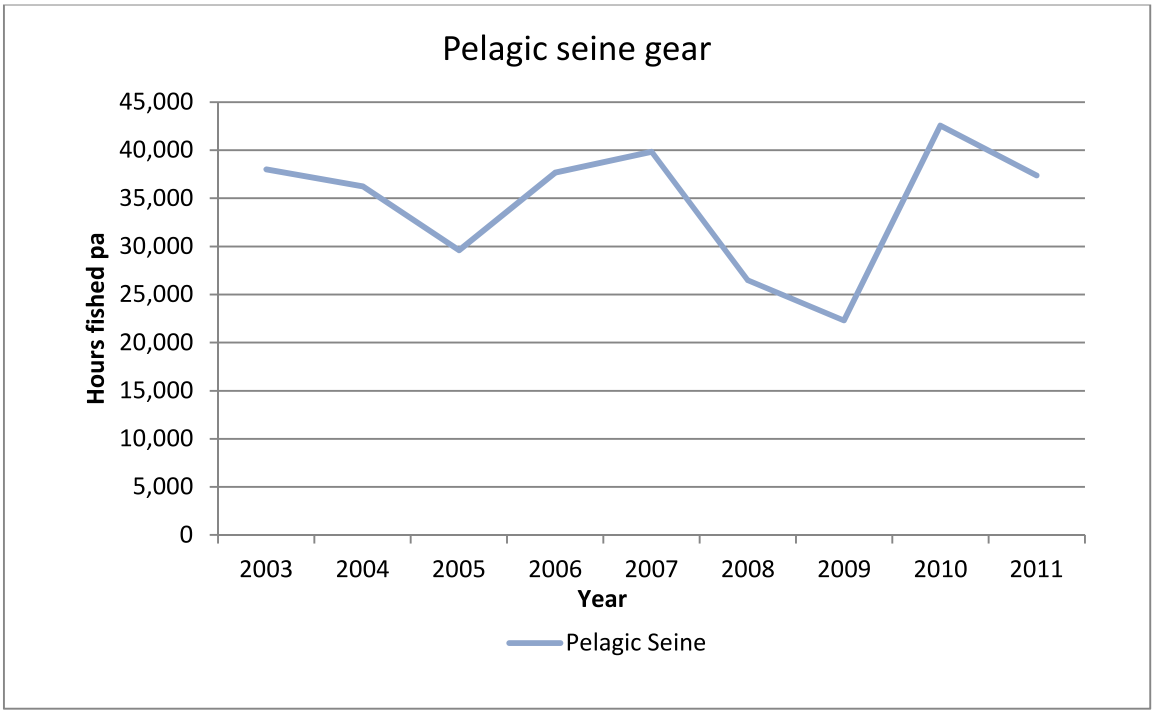


Figure 6 Annual effort (hours fished) by vessels of all nation operating in ICES Divisions VII,e,f,g,h using pelagic seine gears, 2003 - 2011 (source STECF).

4.7. Catch information

The quantities of each species landed in 2011 by gear type from UK vessels the SW area are shown in Table 2 and Table 3. Landed catch data from ICES catch data[19], and the percentage of that catch landed from the SW area as entered in the Ecological Risk Screening tables, from all gears are shown in Table 6 - Table 10 (source for UK vessels is MMO[20]).

[19] http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx

[20] www.marinemanagement.org.uk/fisheries/statistics/annual.htm

Table 2 Landed catches weight (tonnes) and first sale value 2011 for UK towed-gear fisheries in ICES Divisions VIIe,f,g,h

Demersal trawls and seines			Beam trawls			Dredges		
Species	Live Weight (t)	Value (£)	Species	Live Weight (ts)	Value (£)	Species	Live Weight (t)	Value (£)
Lemon Sole	468	2,288,966	Monkfish	2338	6,848,759	Scallops	7336	11,925,082
Monkfish	705	2,166,956	Cuttlefish	2358	6,483,066	Sole	25	305,500
Other demersal	3800	2,085,256	Sole	563	6,379,897	Turbot	28	283,196
Squid	440	2,066,583	Megrim	538	1,756,026	Monkfish	108	282,274
Skates and Rays	946	1,602,072	Lemon Sole	256	1,281,058	Brill	13	78,012
Haddock	1354	1,323,005	Plaice	630	1,055,258	Other shellfish	32	74,103
Horse Mackerel	4375	1,286,241	Turbot	89	954,859	Cuttlefish	20	52,626
Cuttlefish	356	1,083,070	Brill	137	922,918	Lemon Sole	5	20,301
Bass	152	990,198	Other demersal	858	784,261	Plaice	8	14,782
Megrim	329	964,095	Gurnard	696	550,106	Skates and Rays	6	7,560
Other pelagic fish	3478	797,244	Skates and Rays	230	341,917	Other pelagic	24	3,920
Whiting	594	585,200	Squid	68	341,304	Crabs	2	3,691
Sole	55	557,188	Cod	99	229,271	Other demersal fish	3	2,917
Plaice	351	503,365	Haddock	184	199,586	Gurnard	3	2,281
Nephrops	70	323,322	Scallops	119	168,262	Cod	1	1,831
Cod	137	322,047	Other shellfish	188	146,047	Squid	0	1,673
Turbot	32	305,367	Crabs	67	69,656	Megrim	1	1,565
Gurnard	229	265,268	Pollack	32	57,814	Lobsters	0	1,398
Brill	37	246,066	Lobsters	4	41,434	Bass	0	803
Witch	58	143,064	Ling	32	37,679	Pollack	0	454
Pollack	57	114,371	Bass	4	33,731	Haddock	0	451
Sardines	375	102,857	Whiting	42	33,487	Whelks	1	381
Hake	58	91,440	Hake	18	30,526	Mackerel	0	243
Ling	50	68,083	Witch	26	27,440	Ling	0	222
Mackerel	56	60,543	Dogfish	38	7,182	Dogfish	1	151
Other shellfish	38	51,952	Other pelagic	23	5,839	Whiting	0	78
Dogfish	153	47,653	Nephrops	2	2,770	Sardines	0	39
Scallops	21	33,843	Saithe	0	383	Hake	0	31

Table 3 Landed catches weight (tonnes) and value 2011 for UK fisheries in ICES Divisions VIIe,f,g,h using enmeshing gear, pots, traps and hooks

Enmeshing gear; drift and fixed nets			Pots and traps			Hook and line gears		
Species	Live Weight (t)	Value (£)	Species	Live Weight (t)	Sum of Value (£)	Species	Live Weight (t)	Value (£)
Pollack	1343	3,247,728	Crabs	7070	10,087,112	Mackerel	812	1,126,181
Monkfish	439	1,612,831	Lobsters	420	4,273,367	Bass	100	934,870
Turbot	150	1,552,126	Whelks	5304	3,502,017	Pollack	178	452,622
Bass	99	769,242	Cuttlefish	55	143,777	Squid	17	88,679
Sardines	3024	742,574	Other shellfish	7	111,146	Cod	23	53,528
Crabs	535	675,023	Shrimps and Prawns	2	33,606	Other demersal fish	15	31,424
Hake	285	611,201	Scallops	17	24,342	Whiting	21	20,006
Skates and Rays	292	515,392	Skates and Rays	10	18,428	Herring	16	14,588
Ling	306	445,048	Monkfish	4	13,381	Lobsters	1	11,897
Other demersal fish	267	436,750	Other demersal fish	11	12,159	Crabs	6	8,316
Cod	157	391,109	Turbot	1	9,231	Ling	5	7,378
Sole	25	306,325	Bass	1	8,712	Sole	1	7,310
Lobsters	20	195,713	Pollack)	4	8,185	Cuttlefish	2	4,518
Other shellfish	6	148,233	Squid	2	7,448	Monfish	1	4,284
Brill	18	142,566	Cod	2	5,593	Skates and rays	2	3,788
Haddock	79	117,285	Mackerel	3	3,539	Haddock	2	2,601
Mackerel	55	99,968	Sole	+	2,931	Sardines	2	2,063
Herring	179	97,033	Dogfish	3	2,545	Saithe	2	1,703
Whiting	65	75,383	Ling	2	2,262	Turbot	+	1,689
Saithe	41	58,974	Plaice	1	1,287	Scallops	+	1,279
Other pelagic fish	73	45,687	Brill	+	1,249	Plaice	1	1,174
Plaice	23	42,563	Lemon Sole	+	1,150	Brill	+	707
Scallops	17	28,211	Whiting	1	1,003	Lemon Sole	+	610
Squid	6	28,123	Haddock	1	697	Horse Mackerel	1	531
Lemon Sole	2	13,315	Megrim	+	577	Dogfish	+	197
Megrim	4	12,488	Other pelagic	+	205	Whelks	+	184
Gurnard	5	9,485	Gurnard	+	136	Gurnard	+	178
Whelks	13	8,468	Sardines	+	99	Other pelagic fish	+	167

4.8. Review of the effects of gear on benthic habitats and communities

The various gear types discussed are known to have differing physical effects on different habitats, which themselves have varying susceptibilities to physical disturbance. Below is a brief review of the effects of different gears (generally) and where available what is known about their effects specifically in the SW area.

Mobile demersal gear; otter trawling, beam trawling and scallop dredging

In ICES Division VIIe, where much of the trawling in the SW is carried out, two approaches have been used to evaluate the effects of mobile gear on benthic ecosystems in recent years;

1. Surveys of benthic communities have been carried out in areas which have been subject to differing levels of beam trawling activity as ascertained from VMS (Vessel Monitoring System) data (Defra, 2013). The resulting data were analysed to find out whether there was a detectable effect of beam trawling on the biomass and size composition of benthic communities.

   The results showed that the variation in biomass was more closely linked to environmental variables, (levels of chlorophyll, organic carbon, nitrogen and sediment type) than to the previous year's fishing effort. Although an effect of fishing was detected, it was considered insufficient to be a limiting factor for benthic biomass.

   When the same approach was used in the North Sea (Jennings et al., 2001, Jennings et al., 2002) more significant effects on benthic biomass have been attributable to beam trawling. Here there was a reduction in sea urchins and bivalves with no decrease in the quantity of polycheates in the heavily trawled areas.

   Interestingly, in the North Sea, the total reductions in benthic biomass due to beam trawling were estimated to be of a greater magnitude outside the core areas where most fishing occurred. The dominance of smaller infaunal species such as polycheates, relatively unaffected by beam trawling, in the core areas may account for this effect. Outside the core areas, beam trawling would be expected to have an effect on sea urchins and bivalve populations previously less affected by trawling.

2. The effects of fishing disturbance by beam trawling, otter trawling and scallop dredging combined, were compared with natural disturbance due to tidal and wave action (Diesing et al., 2013). Also assessed was the sensitivity of the communities; that is the likely physical interaction with gear and their likely recovery rate after disturbance (Bolam et al., 2014). Both of these studies covered the UK waters of the 'Greater North Sea', which includes the Western English Channel (VIIe) and extends through the northern North Sea to around 56^{o}N. The results suggest that communities in shallow sandy habitats where natural disturbance was high are less sensitive to trawl disturbance. Communities in deeper areas containing gravel or mud habitats were considered to be more sensitive.

Therefore it is possible to detect and assess the effects of mobile gears on benthic communities and this is the subject of ongoing work. However, no reference points have been developed to judge what intensity of fishing is appropriate to maintain “good environmental status” under the Marine Strategy Framework Directive (MSFD) see Section 7.

Static gears potting, gill and trammel nets

Several studies have found no detectable effect of the standard processes of setting and hauling pots upon the immediate ecosystem assemblage (Eno et al., 2001, Blythe et al., 2004, Coleman et al., 2013).

Fixed nets are considered to have relatively little impact upon the sea-bed itself and have mainly been studied in relation to protected species bycatch and in the context of lost nets that may carry on fishing (so-called “ghost fishing” Pawson (2003)). In areas of high wave and tidal action, lost nets are likely to entangle and bundle up, effectively ceasing to fish within a few weeks (Revill and Dunlin 2003). In deeper waters or areas less affected by hydrodynamic action, lost gear tends to fish for longer (Sancho et al., 2003). EU regulations (EC 227/2013) have recently been introduced stipulating measures which vessels should take to avoid losing these types of gears, especially in deep waters on the continental slope.

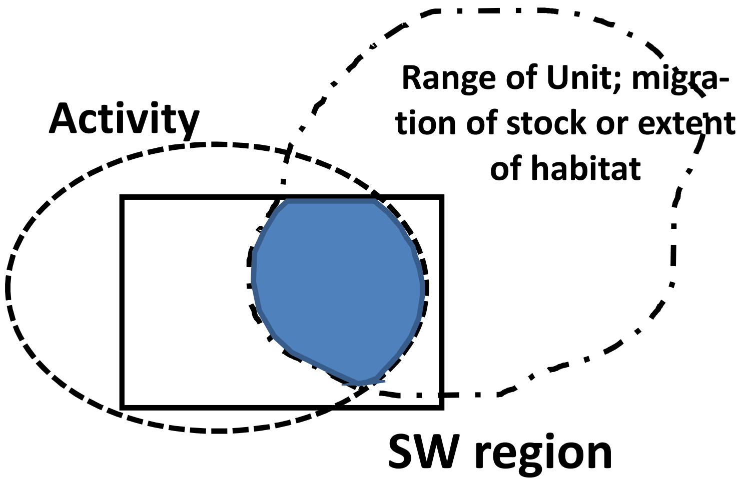
5. Risk assessment : Ecological Risk Screening

The method adopted for this risk assessment was Ecological Risk Screening**:** described in Cotter et al (2014). The essence of this approach is that it identifies the most sensitive attribute of an ecological sub-component ("unit of analysis") with which to estimate the risk from fishing or other activities in relation to that sub-component's survival, for example impacts on its abundance or food supply. The resulting Relative Impact Score (RIS) provide an assessment of the effects of the fishing activity in the SW area judged to be most harmful to each ecological sub-component (where feasible) in relation to the operational objectives (where available) drawn from the principles and goals described in Section 3 above.

The scoring of the activities' effect on a unit of analysis is carried out in relation to four potential elements; the spatial and temporal overlaps and the relative intensity and duration of the interaction between units and the fishing activities in the SW area. This is outlined diagrammatically below

Spatial and temporal effects; does the activity overlap with the range of unit of analysis in space and time?

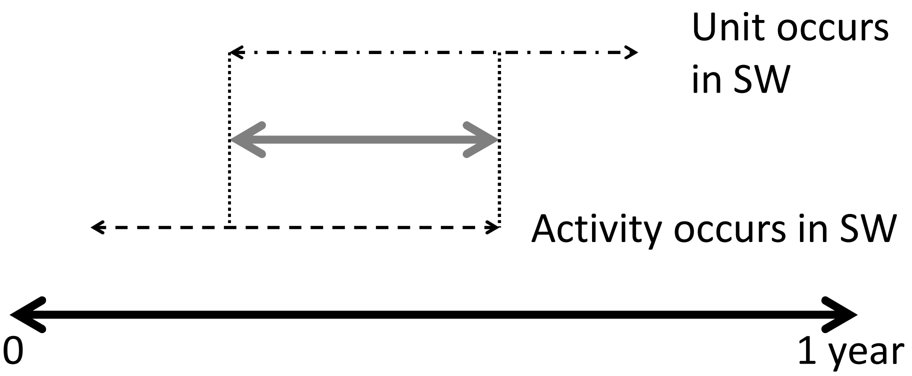
1. **Spatial scoring**



Spatial scale of the activity in the SW relative to the total area occupied by the unit of analysis while the activity occurs; is scored as follows:

0. Negligible
1. Less than 10% (of space where unit is vulnerable)
2. 10-20%
3. 20-50%
4. 50-90%
5. 90-100%

2. **Temporal scoring**



Temporal scale of the activity relative to the time spent in the SW by members of the unit; is scored as follows:

0. Negligible
1. Less than 10% (of time when unit is vulnerable)
2. 10-20%
3. 20-50%
4. 50-90%
5. 90-100%

Intensity and duration scoring

3. **Intensity of effect** on (or vulnerability of) members of the unit where and when the activity occurs

0. Negligible
1. Less than 10%
2. 10-20%
3. 20-50%
4. 50-90%
5. 90-100%

4. **Duration of effect** on the unit given that it was affected and that the activity has stopped

Does the effect last a long time? This may range, for example, from the more-or-less immediate recovery of a mobile sandy substrate after trawling, to removal of a reef structure which might never recover.

0. Immediate recovery, so no impact
1. Effect expected to last weeks or a few months
2. Effect expected to last about 1 year
3. Effect expected to last 1 to 3 years
4. Effect expected to last 3 to 10 years
5. Effect practically permanent

The scores used to assess these four effects, based on the expert opinion of the group, are then averaged (using a geometric mean; see Appendix 2) for each “unit” to produce a relative impact score. Note that:

- All scores range from 0 to 5
- Risk is zero if any one score is zero
- Risk is only 5 (the maximum) if all four scores are 5.

Following this approach, the ERS relative impact score provides a comparative measure of those effects which occur due to fishing activities in the SW area, and ranks them so that a decision can be made on whether further action is warranted within the area. Some units of analysis, for example mackerel, have a widespread distribution and a very low intensity of interaction with SW fishing gears, so have a very low relative impact score. Conversely, cuttlefish have a more localised distribution mainly within the SW area and a relatively intense interaction so end up with a high relative impact score.

It is important to understand that an ERS analysis provides a semi-quantitative (essentially qualitative) assessment of the potential impacts of an anthropogenic activity (fishing, in this case) on an ecosystem or environment and forms the first stage of an ERA. The ERS is deliberately broad ranging, and is conducted as an initial screening which helps to identify the predominant impacts of fisheries which can then be considered by more detailed assessments. In the context of the present exercise, ERS identifies those impacts that can be screened out at an early stage as being less significant (in an ecological sense) and can potentially be ignored. This is based on the assumption that nothing is likely to rapidly change that may influence the relative impact scores, and that there was sufficient understanding of all possible impacts within the assessment group.

Some units with a low spatial overlap with the SW area therefore have a relatively low relative impact score in relation to fishing activities within the SW area. For example, Leatherback turtles are endangered at the population scale (across the Atlantic Ocean, and globally), but the risks of fishing in the SW area for the survival of leatherback turtle populations is low when compared with fisheries effects elsewhere or the disruption of nesting beaches. For such units, which are widely distributed but vulnerable outside the SW region, we provide a discussion of relevant aspects of management and mitigating measures.

Mitigation scoring
If the assessment group considered that there is effective mitigation in place for specific impacts, 0.5 points was subtracted from the relative impact score. Conversely, if mitigation was not considered effective, 0.5 points was added to the relative impact score. These mitigation scores are shown in Table 5 to Table 13.

Table 4 Summary of implications of relative impact scores

Relative impact scores	Impact on Unit of analysis
0	No impact
1	Minimal impact on unit
2	Moderate impact on unit probably not contravening Operational Objectives or goals
3	Significant impact on unit and probably contravenes Operational Objectives reversibly and may contra-vene goals
4	Major impact on unit and contravenes Operational Objectives and likely to contravene goals and require several years to repair
5	Effectively permanent, widespread loss of the unit and clearly incompatible with Principle and goals

6. Results and discussion of the ecological risk screening (ERS) outcome

The spreadsheet containing the full scores is available at this link[21]. A summary of the scores is shown in Table 5 to Table 13 (pages 37- 54). In presenting the results of the ERS, we have focussed on three main outcome categories for individual units or components:

- those meeting their operational objectives; but with a relative impact score of at least 3
- those not meeting their operational objective and with a relative impact score of at least 3
- those where operational objectives are not defined and with a impact score of at least 3

In components where all units score below 3, e.g. seabirds, only the highest ranking unit of that component is discussed.

The results of the ERS have been discussed only for (a selection of) those units that have a relative impact score of at least 3, which occurs when the spatial, temporal and intensity scores are 20-50% and the duration is expected to last 1-3 years. The intention is to demonstrate how ERS can be used to indicate components or individual units that have a level of risk or sensitivity which would suggest further work. However, some units that scored low have been discussed in order to explain why they were not regarded as particularly sensitive using ERS.

We have not compared one score against another because a) it is essentially a ranking exercise and the scores are not quantitatively based and b) it is important to focus on the units with the highest risk and consider what further work or management measures are required to mitigate those risks, rather than fixate on the actual resulting scores.

During the exercise, a number of management or mitigation actions were identified that are already helping to ameliorate these effects and which were taken into account in the ERS.

6.1. Communities and habitats (Table 5)

Of 16 types of ecological community that were considered for risks arising from fishing, 6 indicator- or activity-community combinations were given ERS scores of ≥ 3.

Demersal fish communities

Three demersal fish community indicators were scored, based on time series of catch rates of fish in research vessel surveys;

[21] www.seafish.org/media/publications/SR671ERAEF_Assessment_spreadsheet.xls

- the Large Species Indicator (LSI); this tracks the proportion of fish by weight from species with a maximum potential length larger than a specified reference size, taking no account of the sizes of individual fish.
- the Large Fish Indicator (LFI); this tracks the proportion of individuals larger than that size, taking no account of species.
- the biodiversity indicator species richness: this tracks the number of species present in standard survey samples.

High levels of fishing would be expected to reduce the numbers of large fish in populations, potentially affecting the stability of the fish community, and these indicators have been proposed as robust indicators of the effects of fishing on community and foodweb structure as recognised in the European Community's Marine Strategy Framework Directive (Le Quesne, 2013).

Of these community indicators, the LSI and the LFI were considered likely to be most affected by fishing activity, whereas the biodiversity indicator is driven more by climate change effects. Time series results (from Le Quense 2013) indicate that both LSI and LFI decreased over the period 1988-2004, although there were signs of increase in the LFI from 2000 (the LSI has not been analysed after 2004). Species richness was reported to have increased since the 1980s, possibly in response to ocean warming.

Potentially, increases in LSI and LFI can only be achieved through reducing fishing effort and improving selectivity of fishing gears (so more fish survive to be large). Improvements in the status of sole, cod, hake and plaice stocks (for example) have accompanied a reduction in fishing activity over the past decade, which suggests that the fish community is stable enough to respond to management.

From observations on the improvement in these stocks, the ERS assessment group. decided that changes in the demersal fish communities had not reached the stage of disrupting ecological processes or the food-web. This is effectively the operational objective for fish communities, since other defined reference points for the LSI and LFI were not available for the SW area.

No management action additional to that already taking place under the CFP was indicated, though there is a need to develop indicators for pelagic fish communities (for which LSI and LFI, are less informative) see below.

Pelagic fish communities

There were no indicators available to score the effect of fishing on pelagic fish communities *per se*, so it was not possible to obtain a robust basis for scoring this effect. The status and effects of fishing on the various pelagic species was scored as individual species' stock units (see below).

Plankton communities

It is possible to envisage changes in the plankton community induced by the effects that changes in the fish and benthos community (due to fishing) have on larval production and grazing pressure (such effects have been observed in the Black Sea, Daskalov, 2007). However, it was difficult to obtain a robust basis for scoring these effects. It is known that plankton communities in the SW area are strongly influenced by physical oceanographic effects, such as the North Atlantic Oscillation (NAO) (Edwards et al., 2013), so it may be difficult to discern the effects of fisheries *per se*.

A high relative impact score for *zooplankton* communities was not thought justified, given the open aspect of SW waters to the Atlantic. Similarly, though *phytoplankton* communities can be vulnerable to coastal nutrient enrichment, possibly leading to increased frequencies of algal blooms, these are rare in the SW region. Communities consisting of planktonic fish larvae (*Ichthyoplankton*) were thought to be at risk from fishing because reductions in the numbers and sizes of spawning adults would reduce the quantity of larvae produced. Improvements in fish stock demography (increased numbers of larger spawning fish) would help to counter this risk.

Benthic habitats and communities (see also section 4.8)

Benthic habitats in the SW are at risk, not just from fishing, but from aggregate extraction and waste disposal, either by discharges from pipes or by dumping and other activities licensable under the Marine and Coastal Access Act 2009. However, part of the licencing procedure requires a risk assessment process (see Koch and Paccito 2013). A general problem with benthic habitats in the region is to know the extent and distributions of each type, given that available studies were restricted in geographic scope, objectives, or by sampling difficulties. Therefore scores obtained for effects of fishing on benthic habitats were considered to be indicative only.

Certain habitats, designated as 'Features of Conservation Importance' under the Oslo-Paris Convention and also present on the list of Priority Species and Habitats under the UK Biodiversity Action Plan, are potential issues with regard to fisheries management. Other *benthic* communities which occur sporadically: pink seafan colonies, ocean quahog, and fan mussel dominated systems; are fragile and readily damaged by fishing gear. These communities, and also biogenic habitats such as maerl beds, ross worm (*Sabillaria* species), and blue mussel beds, listed under the Habitats Directive and are to be risk assessed individually; see below. Therefore, these habitats were considered to be beyond the scope of this assessment. A suitable operational objective relevant to biodiversity of benthic communities could be that the key species in these communities and habitats are not depleted to the point that those habitats' survival is compromised.

Epibenthic assemblages in three categories: inner (30 to 130m) and outer (49 to 175m) shelf, and Celtic Sea deep mud, were thought to be vulnerable to alteration by trawling and dredging (noting that these communities may have historically been strongly modified by demersal fishing see Section 4.8). The integrity of epibenthic communities is relevant for maintaining biodiversity and ecological processes and, for some species, for sheltering juveniles and foraging.

All 4 units of analysis considered for *Infaunal* communities were assigned relative impact scores close to 3 in response to trawling and dredging activities, and disruption of ecological processes and foodwebs were considered not to have occurred significantly, though these results must remain tentative.

It is worth noting that the recent improvements in stocks of sole and plaice, which have occurred as beam trawl effort levels (

Figure 4) have reduced, suggests that the any cumulative effects of beam trawl fishing on the potential productivity of the SW area has not significantly inhibited the recovery of these stocks. At the same time there has been an increase in the hours fished per annum by scallopers, which would be expected to have a different pattern of fishing activity and hence a different impact from beam trawlers.

Although CEFAS (Koch and Paccito, 2013) estimated the distribution of fishing relative to the European Nature Information System[22] (EUNIS) habitats in the SW area, it was considered that the accuracy of the information on EUNIS habitats is insufficiently accurate to determine risk scores.

Clearly, different fishing gears have different physical and ecological effects and hence risk levels. The 'Finding Sanctuary' and subsequent risk assessment process being carried out by MMO (section 0) as part of the MCZ process is intended to make an assessment of the effects of the various gears on these habitats. There have been a number of risk assessments for benthic habitats and gears, for example Anon (2011) and Eno et al., (2013) which could be used for these focussed risk assessments.

6.2. Fish stocks

The main policy goals identified to be at risk from fishing were maintenance of viable fisheries and replenishment of stocks, and protection of ecological processes and biodiversity, though few ecological issues were raised. As for other ecosystem components, spatial scores were increased by considering local stocks rather than total species as the units of analysis.

6.2.1 Teleosts (Table 6)

Seven fish stocks in the SW area: cod (VII e-k); plaice (VIIe); Dover sole (VIIe and VIIfg); whiting (VII e-k); hake (Northern stock) and haddock (VIIb-k) have full analytical assessments, of which five, cod, whiting, both stocks of Dover sole and hake are considered by ICES to be close to maximum sustainable yield (MSY), whilst the remainder are inside safe biological limits (that is, their reproductive potential is not impaired). However, 14 of the 24 species-activity pairings for teleost fish received relative impact scores ≥ 3. Since they are all marketable species and therefore the focus of commercial fishing effort, this result is not surprising, and is reflected in recent advice from ICES.

Discards (caught fish that are returned to the sea either because they are undersized, unmarketable or outside quotas) are a source of risk (to cod, haddock and plaice in particular) because they not only reduce yields to the fishery but they also degrade the information on the total catch used for stock assessments. However, considerable effort is being made to reduce discarding (e.g. Catchpole 2013).

[22] http://eunis.eea.europa.eu/index.jsp

Factors identified as ameliorating the effects of fishing on teleost fish in the SW were management of the fishery as a whole under the EU's common fisheries policy (CFP; EU 1380/2013); local measures such the seasonal restriction on fishing in an area off North Cornwall (the Trevose box; Figure 2) to protect spawning cod and a number of restrictions on trawling under local bylaws; management plans for TACs on Dover sole in the Channel (ICES Div VIIe); allowing selective fishing by locality; voluntary use of large mesh nets by trawlers to reduce discarding of gadoids and plaice in particular, though this may be accomplished by the upcoming landing obligation (discards ban) under the CFP.

The main spatial management measure applying to beam trawls is a restriction on combined beam length to less than 9 m inside the 12 mile limit, and there is a sole recovery zone in operation which restricts fishing effort on vessels using beam-trawl gear in ICES Division VIIe.

Megrim and monkfish are assessed using abundance indices from research vessel surveys, which cannot be used to provide advice for management at MSY. On the positive side, there has been a reduction in fishing effort in the fisheries which catch monkfish and megrim in offshore areas, and a recent law has tightened up control of tangle net fishing on the shelf edge which should reduce risks to monkfish stocks (EU 227/2013).

Of the data-limited stocks, turbot and brill were considered to be of higher consequence because of the lack of assessment and management measures. However, the risk to these stocks is reduced because growth is rapid and takes place outside the main area of the fishery. Sea bass are considered a higher risk than previously because of a reduction in stock biomass in the past 8 years, following a general increase from 1991 to 2005.

Pilchards (sardines) are an important stock in this area which supports a local (Cornwall) ring net fishery. Although ICES has assessed the stock as being at MSY, it is highly likely that environmental conditions affect production and availability to SW fisheries (Edwards et al., 2013). A lack of management for pilchard fishery was raised as an issue.

The stocks of hake and mackerel have a wide geographical distribution and have been the subject of considerable management attention in recent years. However, the fisheries which exploit them in the SW area are relatively small and therefore receive a relatively low score. A similar situation exists for John dory for which stock structure is unknown, there is no assessment, but the available data give no cause for immediate concern (ICES WGNEW).

Of the remaining stocks, lemon sole (VIIe,f,g,h), sprat (VIId,e) and black bream (VIId,e) are relatively localised and were considered lower risk due to the apparently low vulnerability of juveniles in the case of lemon sole, limits on vessel entry to the fishery in the case of sprat, and protection of the spawning habitat for black bream.

Other issues identified were the poorly known biology of megrim and lemon sole; the poorly known trophic role of pilchards in transferring primary production energy to higher trophic levels in the SW; and the influence of climate change on the distribution and abundance of red mullet.

Note that several teleost species including relative rarities, some of which are highly protected, such as the Atlantic sturgeon, Allis and Twaite shad, sea-horses or gobies were not scored.

6.2.2 Elasmobranchs (Table 7)

Of the 35 species-activity pairings for elasmobranchs that received relative impact scores, 20 were ≥ 3. Many elasmobranch species are well known to be at high risk from fishing because of their vulnerability to several gears and they mature at a relatively late age and have low fecundity (few young). This is reflected in their high duration and hence high relative impact scores. The ERS identified conservation concerns for the angel shark; common, white and long-nosed skates; the stingray, marbled and dark electric rays, plus 9 other ray species; the lesser-spotted dogfish, nursehound, spurdog and tope. Several of these species are widely distributed globally but received high spatial scores because of the importance of local stocks or groupings for local biodiversity and, possibly, food webs. Some species have reduced in numbers and/or range, or have (naturally) patchy distributions in the SW area. These include common skate, white skate, angel shark, stingray, electric ray, undulate ray and spurdog.

The more abundant and commercially important blonde, cuckoo and thornback rays appear to have higher recovery rates, and this is reflected in their lower relative impact scores. There are data limited assessments on these stocks which suggest that thornback rays are increasing in abundance, but numbers of blond and cuckoo rays and some other ray species are decreasing. However, the survey catch rates upon which these assessments are based are highly variable, and the surveys are not designed to sample these species, which appear to have centres of population outside the main trawling areas. Shepard et al., (2012) suggest that areas of low effort in the Celtic Sea, which are lightly fished because they are unsuited to fishing, may act as refugia for these species.

Operational objectives that can be monitored easily and will reliably indicate the viability of elasmobranch stocks were difficult to find because some species seldom occur in either Research Vessel (RV) surveys or under observer programmes, and there are no formal stock assessments. It is apparent that elasmobranchs may require special protection, and this is the focus of work by ICES, CEFAS, Defra and industry. Examples include agreeing Minimum Landing Sizes (MLS) and exploring possible spatial management measures.

However, several measures are already in place to protect elasmobranchs, including listing by the International Union for the Conservation of Nature (IUCN) and European conservation legislation, MLS and landing limits, e.g. for tope. An attribute of many elasmobranch species that helps to protect them is that they often survive being caught and discarded (Enever et al., 2009).

6.3. Shellfish

6.3.1. Molluscs (Table 8)

Of the 11 species-activity combinations considered for marketable molluscs, three were given an adjusted relative impact score ≥ 3, namely whelks, cuttlefish and scallops. The main concern was the declining viability of the fisheries, and notable issues were that operational objectives suitable for measuring stock status other than by using basic fisheries data were difficult to find, and the ecological importance of the scallop, as a filter feeder, was unknown.

Whelks are targeted using pots in eastern parts of Division VIIe. There is no planktonic phase in the lifecycle so recruitment is dependent on the level of local parent stock; hence the stock is allocated a high spatial score. The high intensity score is due to the perceived high catchability and low selectivity of pots/traps; the MLS is considered too small compared with the size at first maturity; and these factors result in a high relative impact score.

The **Cuttlefish** stock unit occurs within Divisions VIId & e and is subject to targeted fisheries, so it has high spatial and intensity scores. The beam trawl fishery targets the overwintering stock in the deeper waters of VIIe, catching smaller cuttlefish, whereas the trap fishery catches the adults inshore at or just before spawning in the spring and summer. Cephalopods have a short lifecycle and no stock assessments are carried out. Apart from measures controlling cod-end mesh size of trawls under EU Reg. 850/98 that affords a limited protection for small cuttlefish, there are no other specific management measures in place.

Scallops are present on mixed and gravelly substrate predominantly in Division VIIe. UK inshore fisheries and international offshore fisheries are relatively lightly regulated compared with the French coastal fisheries, which are tightly managed and have shown improved yields over recent decades. Assessment of scallop stocks is difficult because of their patchy distribution meaning some beds may be fully exploited whilst others are relatively lightly fished.

A combination of factors helps to mitigate the effects of fishing on scallops. The English scallop order regulates the design of scallop dredges (effectively 75 mm rings and 9 teeth to the bar), and allows the use of more than 8 dredges a side only outside the 12 mile limit. These management zones, are intended to protect inshore stocks from larger vessels. Although dredges have a relatively heavy physical effect, resulting in damage to some scallops (3-15%, the damage rate has been observed to vary between beds and is related to shell strength, Brand pers. com), those scallops not caught or discarded below the MLS survive well. There are also local vessel size and seasonal restrictions within 6 miles of the coast, and areas closed to scallop dredging in Falmouth and Lyme bays to protect maerl beds and mudstone reef communities respectively.

Fishermen tend to target scallop beds until they are fished down to an uneconomic catch rate, and then move on to other beds effectively leaving recently fished beds to replenish. This results in a rotational harvesting regime that is considered to help scallop stock sustainability. Though there has been an upward trend in effort in the scallop fishery, scallop dredging effort by UK vessels over 15 m in the SW area is subject to a ceiling on effort (in kw days) under the EU Western Waters effort regime, though this is not related to the status of scallop stocks.

Stocks of **blue mussels** and **native oysters** occur predominantly within estuarine areas and are tightly regulated by IFCA regulations.

6.3.2 *Crustaceans* (*Table 9*)

Of the 14 species-activity combinations considered for marketable crustaceans, 4 were given adjusted relative impact scores ≥ 3, namely the crawfish, lobster, edible crab, and spider crab. The main perceived risk of fishing activities was that the fisheries might lose economic viability and diversity. Issues arising were; incomplete knowledge of the biology of these species; poor or inconsistent reporting of landings; and the difficulty of finding an easily monitored and reliable indicator of stock status that could be used as an operational objective. As is the case for molluscs, better knowledge of these species' biology might alleviate concerns about the perceived consequences of fisheries.

With the exception of **crawfish,** which are thought to recruit to SW waters from the Iberian Peninsula, these stocks are considered to be local stocks although edible crab are known to migrate considerable distances. Intensively targeted fisheries, which are localised and of lengthy duration, contribute to the relatively high relative impact scores.

In the most recent assessment (2011), the two main stocks (**edible crab** and **lobster**) are considered at or close to MSY with which the relatively high relative impact scores are congruent. Most of the management measures are designed to conserve spawning stock through regulation of minimum landing size (MLS), use of escape gaps for undersized crabs or lobsters, and protecting parent stocks of lobsters through V-notching and return of egg-bearing ("berried") female lobsters (Bell 2013). Whilst these regulations are expected to be of benefit, the more stringent ones only apply within the IFCA waters (inside 6 miles). Although there are no controls on **pot numbers**, effort by the larger vessels (> 15 m) are regulated under the Western Waters effort regime, and there are licensing and other restrictions which are likely to constrain effort. Effort in the pot fishery (including for whelks) has decreased in terms of hours fished since 2006.

6.4. Seabirds (Table 10)

There have been both direct (negative) effects on seabirds due to interactions with fishing gear, and indirect effects: some positive, where food supplies have increased due to offal availability and discarded fish and some negative, where industrial fisheries have diminished food supplies for seabird populations (see Mander and Thomson 2013).

Of the 24 seabird-activity pairs subject to ERS scoring, three species, the sandwich, little and common terns were thought to be most at risk (relative impact score 2.6) indirectly from fisheries because of a possible reduction in small, surface-living fish (sprat) available for raising chicks within foraging range of nesting sites. Foraging ranges of these species are relatively small, making them vulnerable to localised depletions. This is not a proven causal effect and is an area for further investigation.

Whilst other assessed species were thought to be most at risk from interactions with the various types of fishing gear, none of the seabird-activity pairs generated a relative impact score above 2.6 in view of the relatively few observations of significant mortalities of seabirds during fishing operations in the SW region. Some species, such as fulmars, kittiwakes, gulls and gannet benefit from discarding. There is a considerable amount of quantitative data on seabirds, which might allow operational objectives to be set for monitoring the success of seabirds in the SW region.

The direct effect of gillnets on diving birds in St Ives' Bay is well documented and this fishery is subject to legislation designed to protect birds from bycatch. This legislation has only been used to control fishing activity once in its 10 year history (Cadman pers com.) suggesting that the relatively low relative impact scores for these species are appropriate

6.5. Sea Turtles (Table 11)

All five species of sea turtle that are sighted within the SW region, the leatherback, Kemp's Ridley, hawksbill, loggerhead and green turtles, are listed as endangered or critically endangered species by the IUCN and are therefore relevant primarily to the policy goal of biodiversity. The ERS indicated that all types of fishing put sea turtles at additional risk when present in the SW, either directly through entanglement in static gear buoy ropes or possible interactions with other gear types, and/or indirectly due to fisheries being a potential source of polythene litter which the leatherback is known to ingest.

All species had relative impact scores < 3 except for the leatherback which had an initial score of 2.8 which was adjusted upwards to 3.3 on account of its extreme rarity and the threats to its existence throughout its global range.

Because of the sporadic presence and observations of turtles in the SW, it is difficult to set a useful operational objective, though one possibility could be 'to avoid increasing the risk to global populations' which might be implemented with policies designed to minimise turtle bycatches and discharges of polythene.

6.6. Marine Mammals (Table 13)

Effects on marine mammal populations broadly divide into ecological effects, where there is competition for food supplies or habitats are affected by fishing, and direct or operational effects where there is incidental bycatch. Ecological effects discussed by Kingston et al., (2013) show that the size and species composition of fish targeted by fisheries may be an important factor in relation to their role as prey for marine mammals. However, such interactions are difficult to score in the ERS, and are probably not the most critical interaction.

Of the 10 cetacean or seal species assigned ERS scores, only bottlenose dolphin and harbour porpoise were ≥ 3. The main risk of fishing to both species was considered to be entanglement in static nets. It is worth mentioning that the common dolphin (which scored <3) is also taken by some static net and pelagic trawl fisheries in the region. These risks are relevant to policy goals biodiversity and protection of ecological processes, since marine mammals are top predators that may play a significant role in regulating population sizes at lower trophic levels.

As with turtles, it is difficult to set a useful operational objective for those marine mammal species that only occasionally appear in the SW. However, because there are population surveys and bycatch estimates for harbour porpoise and common dolphin, it is possible to estimate the magnitude of mortalities due to fisheries, and relate these to the operational objective of a maximum "*unacceptable interaction*" being the total anthropogenic removal above 1.7 % of the population set by ASCOBANS (the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas), to which the UK is a signatory. These operational effects are scored under the ERS where adequate information is available.

Bottlenose dolphins live in large offshore populations (estimated at some 30,000 for ICES Subareas VII and VIII) and also in small "family" groups numbering a few individuals which inhabit coastal waters of the south west (and elsewhere). If these inshore populations are relatively self-contained and live in SW waters year round, they attract high spatial and temporal scores which are reflected in their relative impact score.

Considerable research and development effort over the past 10 years to reduce **harbour porpoise** bycatch in static nets has led to the routine use of acoustic deterrent devices (pingers) by static net vessels larger than 12 m operating in most of Subarea VII under the requirements of EU Regulation 812/2004. The effectiveness of pingers on fixed nets to reduce common dolphin bycatch has not yet been fully quantified, though there is some evidence from SW fisheries of a mitigation effect for this species. The efficacy of pingers to reduce bottlenose dolphin bycatch is unknown at present and there are conflicting reports about this species' behaviour in relation to pingers from different parts of the EU.

Grey seals (and harbour seals to a lesser extent) are present in the southwest in relatively low numbers compared with other parts of Britain. They are considered to interact with fishing activity at a relatively low intensity hence their relatively low relative impact scores. That said, direct interactions with fishing gears by grey seals, both in terms of bycatch and depredation have been documented in the SW and are seal interactions are monitored under the UK bycatch programme.

7. The ERS approach and the Marine Strategy Framework Directive (MSFD; EU 56/2008)

The two main advantages of the ERS approach are that it enables all components to be judged on a similar scale, and that it utilises expert knowledge from a variety of backgrounds to produce the relative impact scores. The main weakness lies in its subjectivity; particularly when scoring the intensity of effect. ERS scores should not be judged on an absolute basis, they are simply a means to rank the effects and to help prioritise future action on the most sensitive issues.

This section considers the ERS approach and how it could be relevant to the implementation of the EU MSFD. It then looks at possible actions arising from the ERS and how those highlighted could be taken forward.

The MSFD '………. establishes a framework within which member states take all the necessary measures to achieve or maintain good environmental status in the marine environment by the year 2020.'

The MSFD has a number of operational objectives, of which the following descriptors are relevant to this assessment:

Descriptor 1 requires maintenance of biological diversity, in the sense that the objectives for most of the effects on the non-exploited species were to keep these populations at a level of at least a presence in the South West, or avoid any deleterious effects of fishing. Whilst it was possible to assess changes in biodiversity on fish communities, it was more difficult to assess the effects on habitats and benthic communities.

Descriptor 2 is not relevant here because non-indigenous species were not considered in the ERS.

Descriptor 3, which requires that all commercially exploited populations are within safe biological limits and exhibit population age and size structures that represent a healthy stock, was examined for most exploited stocks. Many assessed stocks met this descriptor and some also met the primary indicator of fishing mortality being at or below F_{MSY}. However, a number of stocks had no assessment (e.g. cuttlefish, brill and turbot) or there was a 'data limited' assessment for which the management aim is to keep the biomass stable until the assessment is improved such that MSY reference points can be defined (e.g. monkfish and megrim).

Descriptor 4 relates to good environmental status in terms of maintaining the function of food webs. In this case, we were able to use the large fish indicator (LFI) in the sense that, if this measure is considered satisfactory then the food web should be functioning well. There is also empirical evidence that the system as a whole is relatively intact and able to recover from the effects of fishing, based on the observation that many of the main stocks in the area have improved in recent years as effort has fallen or other management measures have been introduced.

Descriptor 6 concerns sea-floor integrity, and the MSFD highlights some of the difficulties that were encountered during this assessment. Though the locations of some features such as maerl beds have been identified, and protected, the ERS highlighted a number of potentially important sea floor habitats and species (that form biogenic reefs, for example) that still have to be mapped and assessed against fishing pressures.

The main conclusion of this exercise was that the ERS method has utility in highlighting progress towards ‘good environmental status’ and can help prioritise actions aimed at working towards this goal.

8. Further action and work

During this exercise, which aimed to identify the most sensitive elements of each ecosystem sub component to fishing in the SW area, a number of actions and some further work were identified.

With respect to **demersal fish communities**, it was apparent that the indicators LSI, LFI and species richness should be monitored into the future. The LFI was monitored up to 2008, but the LSI has not been analysed since 2004. There is a break in the time series in 2004 for some surveys (Le Quense 2013), though the surveys have been undertaken and it should be possible to calculate the indices. These indicators will be monitored under the EU Data Collection Framework, so it will be possible to track changes in them over the coming years. However, we noted that there are no reference points for these indictors for the SW area and these will need to be developed if these indicators are to be useful management tools.

Potentially, increases in LSI and LFI can only be achieved through reducing fishing mortality and/or by improving the selectivity of fishing gears (so more fish survive to be large). Improvements' in the status of sole, cod, hake and plaice stocks (for example) have accompanied a reduction in fishing effort over the past decade, which suggests that the underlying fish community is sufficiently stable to respond to management efforts.

Improvements to data and assessments are a priority for a number of teleost species (monkfish, megrim, red mullet, brill, turbot, and lemon sole), so that scientific advice can be usefully applied to management aimed at MSY.

Indicators to score the effect of fishing on **pelagic fish communities** are lacking.

It was difficult to obtain a robust basis for scoring effects on **plankton communities**, because they are strongly influenced by physical oceanographic effects and it may be difficult to detect the effects of fisheries even if such effects occur.

Information on the distribution, sensitivity and status of **benthic communities** is valuable in managing them in relation to the MSFD and Marine Spatial Management. Whilst the location of some benthic communities is fairly well described (maerl beds, for example), improving our knowledge of the location of benthic habitats and the level of fishing intensity on them is clearly a basic requirement for ensuring their protection. A suitable operational objective relevant to biodiversity of benthic communities could be that the key species in these communities and habitats are not depleted to the point that those habitats' survival is compromised.

Fishing vessels are often equipped with advanced echo sounders and Olex^{TM} systems, which could provide information that might improve mapping or groundtruthing of benthic communities. The Seafish guide to good practice for scallop fishing[23] encourages fishermen to avoid reefs and patches of hard ground in order to conserve biodiversity, and it also encourages fishermen to make information from their echo sounder records available for scientific research. High resolution spatial information from vessels of less than 15 m would also help to improve knowledge and hence management and conservation of the inshore (inside 12 nm) environment (see Caslake 2009).

The most widely studied component in the SW area is **teleost fish (particularly commercial species),** and there are already numerous management initiatives in place to improve sustainability including: TACs and quotas; effort controls; Minimum Landing Sizes (MLS), species management plans; the Trevose box; protection of nursery areas, mesh size controls and the upcoming EU landings obligation ("discard ban"). Some stocks, however, are considered to require further work:

- There is a need for improved assessments of the monkfish and megrim stocks, for which data have been of insufficient quality for a full assessment in recent years, due to difficulties in ageing monkfish and poor quality data for megrim.
- Data-limited, or higher level, assessments should be considered for stocks of brill, turbot, red mullet and lemon sole.
- Pilchard (sardine) and sea bass stocks would benefit from management measures that enabled them to be exploited a rate corresponding to MSY.

Efforts should continue to reduce discards and improve selectivity, particularly for cod, haddock and plaice. One approach is to use 120 mm cod end mesh, rather than the 100 mm allowed under EU rules when targeting gadoids, which would help select against juvenile cod, haddock and plaice and would presumably also reduce mortality on other commercial and non-commercial species.

ICES has advised on management measures for individual **elasmobranch species**, other than TACs, which include: spatial management (taking advantage of the refugia effects noted previously); minimum and maximum landing sizes to conserve juvenile and/or breeding stock and gear modifications either to reduce abrasion (which can lead to post-release mortality) and/or excluded certain size groups from the catches.

ICES also noted that there is a need to use local knowledge to develop and implement viable measures in the context of the overall management of skate and ray stocks in the region. Shephard et al., (2012) provide an example of how scientific and fishermen's data can be brought together to improve knowledge on the spatial distribution of these stocks.

[23] www.seafish.org/media/Publications/UK_Scallop_Industry_Good_Practice_Guide_for_consult.pdf

Defra is currently progressing the shark, skate and ray plan, which includes a number of collaborative initiatives between fishers and scientists designed to improve knowledge of skate and ray stocks. Further information can be found at;

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224294/pb14006-shark-plan-review-20130719.pdf

http://webarchive.nationalarchives.gov.uk/20130505040140/http://archive.defra.gov.uk/environment/marine/documents/interim2/shark-conservation-plan.pdf

A number of requirements relevant to **shellfish** management were noted. Consideration should be given to a **whelk** MLS which is related to length at maturity.

A research project (CRESH[24]), carried out by the Marine Biological Association of the UK and the University of Caen in France, has investigated aspects of **cuttlefish** spawning, the effects of environmental conditions on recruitment, and provides an opportunity to develop assessment and management methods. Because cuttlefish and **squid** grow rapidly and die after spawning (at age 2 and 1 respectively), it is important to ensure that sufficient adults survive to produce enough eggs for the next generation to develop properly. Consequently, setting appropriate TACs would need a shorter timescale than for teleosts.

Improving the assessment of **scallop** stocks is an important challenge, and a study[25] by the University of Bangor in collaboration with CEFAS and the industry seeks to develop an assessment methodology, together with an investigation of the environmental effects of scallop dredging in the English Channel.

Most of the current management of **edible crab** and **lobster** stocks is designed to conserve spawning stock through technical measures, but modelling studies suggest that small changes in effort levels can be as important with respect to stock sustainability (Bell, 2013). The ACRUNET[26] project is investigating possible international management strategies for edible crab fisheries.

International and local measures are required to improve management of **crawfish** stocks.

Seabirds: Further work would be to examine the possible effects of fisheries on food availability for foraging terns.

Sea turtles: Following the turtle code[27] and avoiding littering should be adequate mitigation measures for the very small number of turtles encountered

---

[24] www.unicaen.fr/ufr/ibfa/cresh/?lang=en

[25] www.seafish.org/about-seafish/news-and-events/news/phd-student-tackles-scallop-habitat-survey-in-english-channel

[26] http://www.acrunet.eu/

[27] www.mcsuk.org/sightings/turtles.php

Marine mammals: Although bycatch of **Bottlenose dolphins** is known to occur in the SW, there is not currently enough data to produce robust mortality estimates. Furthermore it is not known whether bycaught animals originate from the larger offshore population or from the smaller inshore group (or both) and ideally this should be determined so that observed bycatch rates can be placed in the correct context. The behaviour of bottlenose dolphins in relation to the presence of pingers is inconclusive, so it is questionable at this time if the use of pingers is a suitable approach for mitigating bycatch of this species.

The routine use of pingers by the offshore (>12m) fleet will reduce the bycatch rates of **harbour porpoises** (and probably **common dolphins**) in these fisheries. However, bycatch of both these species is known to occur in some inshore static net fisheries as well and efforts could be made in collaboration with industry to devise suitable targeted mitigation approaches for those particular fisheries. For **grey and common seals** monitoring of fisheries' interactions with this species should be continued.

Collaboration

One other important outcome from this exercise is that an improvement in communication of scientific and technical knowledge obtained by CEFAS and others in relation to the ecological effects of SW fisheries should be encouraged. Such an outcome would enable:

- A better understanding of the mitigation measures that are already implemented in SW fisheries and their efficacy.

- Priorities to be set for further investigations and actions concerning identified ecological risks. Such actions could include setting up task groups to tackle specific risks.

With this information, buyers will have greater knowledge of the ecological risks associated with the fisheries in the SW region from which they source fish, and could potentially participate in further investigations and initiatives to mitigate such risks.

Table 5 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on ecological communities and habitats					
Component and unit of analysis	**Operational objective**	**Achieved in 2013?**	**Relative impact score**	**Discussion and mitigation**	**Mitigated relative impact score**
Demersal fish community					
Demersal fish community indices: large fish indicator (LFI), and large species indicator (LSI) monitored from research vessel survey data. The trends in these indicators are used to indicate changes in the balance/status of the fish community; a decline is indicative of a potentially less biologically stable situation	No change in the indices that indicate changes disruptive to ecological process and food webs	No reference points have been set for these indices. However, trends have been detected over time; see Section 6.1	LSI=4.5 LFI= 4.5	Time series dating from the 1980s show a decline until around 2004. Subsequent time series are short, but there appear to be no adverse trends in the LFI. Improvements can only occur through better selectivity and reduced fishing mortality. These trends are evident in many assessed stocks. Hence, reduced score for LFI. There is a requirement for government to monitor trends in these indices under the EU data collection framework.	LSI =4.5 LFI= 4.0
Biodiversity of species in the demersal fish community as monitored by research vessel surveys	No change in the indices that indicate changes disruptive to ecological process and food webs	No reference points have been set for these indices. However, trends have been detected over time; see Section 6.1	2.9	Few species found in trawl surveys are unique to the SW; climate change influences species productivity and introduces new species	2.4

Table 5 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on ecological communities and habitats

Component and unit of analysis	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Epibenthos; seabed surface communities					
Epibenthos, inner shelf assemblage (30-130m); Dominated by brittle stars, swimming and hermit crabs	No change indicative of disruption to ecological process and food webs	The communities have only recently been described and no reference points have been set for these communities. see Sections 4.8 and 6.1 for discussion of modification due to fishing	3.1	These were scored at lower spatial extent and intensity than the fish communities; there are large areas of seabed not affected by high intensity by fishing. Gear modifications such as benthic release panels and large mesh in trawls mitigate risks to epi-benthos	3.1
Epibenthos, outer shelf assemblage (49-175m); Dominated by Nantandid shrimps, swimming crabs and starfish			3.1		3.1
Epibenthos, Celtic Deep mud assemblage; Dominated by bivalves, Nephrops			3.0		3.0
Infaunal communities; communities living within the sediment					
Infauna Div VIIe offshore community; starfish, and ribbon worms (nemerteans)	No change indicative of disruption to ecological process and food webs	The communities have only recently been described. No reference points have been set. See Sections 4.8 and 6.1 for discussion of modification due to fishing	2.9	Considered to have slightly reduced risk from fishing due to reduced intensity of interaction because of these species live below the surface of the sediment.	2.9
Infauna Div VIIf-h comm. 1 Dominated by starfish and polychaete worms			2.9		2.9
Infauna VIIf-h community 2; Dominated by starfish, sea urchins and bristle worms			2.9		2.9
Infauna VIIe inshore community Dominated by white furrow shell clam (*Abra alba*) and poly-			2.9	Protection from large scale beaming and scalloping afforded by	2.4

Table 5 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on ecological communities and habitats

Component and unit of analysis	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
cheates				management and SACs	
Communities and habitats not risk assessed					
Plankton communities	Whilst it is possible to envisage links between fisheries effects and plankton (e.g. Daskalov 2007), it is difficult to devise specific and measurable objectives	Not applicable	Not assessed	Oceanographic phenomena such as the North Atlantic Oscillation (NAO) (Edwards et al., 2013) tend to obscure plankton changes which could be ascribed to fisheries	Not assessed
Communities, habitats and species listed under OSPAR and the EU Habitats Directive					
Maerl calcareous red algae Pink seafan colonies Ross worm (*Sabellaria* species) reefs Ocean quahog communities (Also Heart cockles) Fan mussel communities Sea grass communities	Favourable conservation status	Maerl beds in Falmouth Bay are well described and protected. There is a closed area in Lyme Bay designed to protect pink seafan colonies, although they also exist in other locations in the SW. Ross worm, ocean quahog and fan mussel communities tend to be isolated and are difficult to locate.	Not assessed	These are priority habitats under the Habitat Directive and OSPAR Conventions and will receive protection during the SAC designation and management process. This should result in fishing being managed to avoid damage to the favourable conservation status of these species & habitats. The MMO are currently undertaking a risk assessment programme to assess risk posed to these habitats. See	Not assessed

Table 5 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on ecological communities and habitats

Component and unit of analysis	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Blue mussel communities	Favourable conservation status	Not assessed	Not assessed	Figure 2 for locations. Blue mussel communities are usually located within estuaries, where they are managed by the IFCAs although some are offshore.	Not assessed
EUNIS level 3 sea bed habitat classifications.	None set		Not assessed	Though seabed maps of these habitats were compared with fishing intensity, (Koch and Pacitto 2013) these were not considered accurate enough for a satisfactory assessment to be made	Not assessed
Pelagic habitats and communities	None set		Not assessed	Individual pelagic fish species were assessed as were pelagic cetaceans (see Table 6 and Table 12.)	Not assessed

See Bolam (2013) for details of benthic communities

Table 6 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on teleost fish; landed catches from all nations http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx

Component and unit of analysis	Landed Catch (t) 2011; ICES	%in Divs VIIefgh	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Atlantic cod Div VIIe-k	4720	99.3	$F \leq F_{MSY}$;SSB> MSYBtrigger	Yes; Yes	4	Managed under CFP; F decreasing; Trevose box closed during first quarter to protect spawning cod. However, discarding reduces yield, and degrades information on stock	4
Turbot, Div VIIefgh	772	100	None known	No stock assessment	3.9	No management measures; BUT nursery and fishing areas are separated which reduces risks	3.9
Brill Div VIIefgh	553	100	None known	No stock assessment	3.7	No management measures; BUT nursery and fishing areas are separated which reduces risks	3.7
Megrim, Div VIIb,c,e-k, VIIIa,b,d	12100	34.0	Data limited assessment; aim to stabilise stock	Yes	3.7	Management under CFP; spatial differences at age and by sex therefore lower spatial score than cod	3.7
Plaice,: Div VIIe	1330	100	$F \leq F_{MSY}$;SSB> MSYBtrigger	No; Yes	3.7	Management under CFP; ICES advises reduced catches for better long term yield. Beam length & kW restricted within 12-mile limit. Trevose box benefits f & g only; BUT high discarding reduces yield and degrades information. Div f and g data limited assessment carried out, but agreed TAC higher than recommended	3.7
Plaice, Div VIIfg	422	100	$F \leq F_{MSY}$;SSB> MSYBtrigger	Data limited assessment	3.7		3.7
Dover sole, Div VIIf,g	1029	100	$F \leq F_{MSY}$;SSB> MSYBtrigger	Yes;Yes	3.7	Management under CFP; ICES advises reduced catches for better long term yield. Beam length & kW restricted within 12-mile limit.	3.7

Table 6 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on teleost fish; landed catches from all nations http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx

Component and unit of analysis	Landed Catch (t) 2011; ICES	%in Divs VIIefgh	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Pilchard or sardine, Sub area VII	12447	90	F_{MSY} or proxy	Yes; $F=F_{MSY}$ using data limited methods	3.1	There is no management on this stock	3.6
Red mullet, Biscay & Channel DivVI, VIIa-c,e-k VIII and IXa	3116	23.4	Data limited assessment: aim to stabilise stock	Data limited assessment carried out but no TAC agreed	3.5	Targeted towards East Channel by large seine netters; use of 70mm mesh risks increases catches of juveniles	3.5
Whiting, Div VIIe-k	9077	98	$F \leq F_{MSY}$;SSB> MSYBtrigger	Yes; Yes	3.5	Management under CFP; no size based discarding predominates over quota based discarding; ICES advises technical measures to reduce size based discarding	3.2
Dover sole, Div VIIe	847	100	$F \leq F_{MSY}$;SSB> MSYBtrigger	Yes; Yes	3.7	Managed under CFP; Div VIIe management plan reducing TACs to bring stock to MSY over past 5 years	3.2
Sea bass, Div VIIefgh	1798	100	F_{MSY} or proxy	No; F> FMSY from data limited assessment	3.1	Although not limited by TAC, there are closed nursery areas and gillnet mesh size and MLS measures to avoid mortality on juvenile fish. Stock now declining after a long period of increase to 2005	3.1
Haddock, Div VIIb-k	26800	44	$F \leq F_{MSY}$;SSB> MSYBtrigger	No; Yes	3.3	Management under CFP; Trawlers need to use larger mesh to reduce discards particularly important when there is high recruitment	3
Monkfish or Anglerfish, Sub area VII	28400	46	Data limited assessment aims to sta-	Stock abundance is fluctuating, but	3.2	Management under CFP, TACs set; recent legislation has improved management of this offshore gill nets set on shelf edge (Div VIa,b, VIIb,c,j,k), considered important for conser-	3

Table 6 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on teleost fish; landed catches from all nations http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx

Component and unit of analysis	Landed Catch (t) 2011; ICES	%in Divs VIIefgh	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
and Div VIIIa,b,d,e			bilise stock	considered to be increasing		vation of adults (EU 227/2013).	
Pollack, Sub area VII	4177	85	F_{MSY} or proxy	Yes; $F=F_{MSY}$ using data limited methods	3	Netting selective for adults; Trevose box protects spawners	2.9
Lemon sole, Div VIIefgh	2214	100	F_{MSY} or proxy	No stock assessment	2.9	Fishery mainly within Div VIIe. Juveniles are not caught and the survey time series indicate a stable stock that maybe increasing	2.9
Ling, Sub area VII	7804	20	F < Fmsy; SSB > MSYBtrigger	No stock assessment	3.4	Low catchability over favoured hard ground;	2.9
Northern hake IIIa, IV, VI, VIII VIIIa,b,d	75200	4	F < Fmsy; SSB > MSYBtrigger	Yes	3.4	Managed under CFP; EU recovery plan since 2004; F decreasing and SSB at record high; Netting is size selective	2.6
Saithe Sub			F < Fmsy; SSB > MSYBtrigger	Yes	2.6	Seldom targeted in this area	2.6
Anchovy			F_{MSY} or proxy	No stock assessment	2.9	Stock probably extends into the whole of Sub Areas VII and VIII	2.6

Table 6 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on teleost fish; landed catches from all nations http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx

Component and unit of analysis	Landed Catch (t) 2011; ICES	%in Divs VIIefgh	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Sprat, Div VIIde	3176	100	F_{MSY} or proxy	No stock assessment	2.4	Management under CFP; quota and local bylaws; pelagic licensing; no new entrants to fishery; limited market	2.4
John dory Sub Areas VII, VIII	3348	39	F_{MSY} or proxy	No stock assessment	2.4	Stock extends into the whole of Sub Areas VII and VIII	2.4
Black bream; SW & Channel population (2 rows)	2229	100	F_{MSY} or proxy	No stock assessment	2.4	Potential closed spawning grounds in Eastern Channel	2.4
Scad = Horse mackerel, NE Atlantic	199593	3	In line with management plan	No	2.4	Management plan under CFP to set TAC since 2008;	2.4
Mackerel, NE Atlantic	938819	0.2	F_{MSY} or proxy	No stock assessment	1.7	Stock mostly out of SW region currently; only handline fishery currently operating in SW, where mackerel box protects juveniles. High-grading, discarding & slipping banned from 2010. Large extra-TAC catches by Iceland & Faroes	1.7

Post the WG the following teleost fish species Atlantic herring, Ballan wrasse, conger eel, flounder, grey gurnard SW stock, red gurnard, grey mullet; thick-lipped, grey mullet; thin-lipped, golden mullet and pout whiting (bib) were scored by a sub group. Of these only grey and red gurnard were scored at higher than 3 for their relative impact score. Allis and twaite shads, Atlantic sturgeon, sea horses and gobies were not scored due to insufficient information; these are protected species and best protected by protection of their habitat.

Table 7 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on elasmobranch fish

Component and unit of analysis	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Angel shark, SW group	Secure presence in SW	All these species of uncertain status or rare in this area	4.5	High survival if discarded; protected species	4.5
Common skate, Celtic Sea group	Secure presence in SW		4.5	Depleted throughout its range; no landings allowed; high survival if discarded	4.5
White skate	Secure presence in SW		4.5	Depleted throughout its range; no landings allowed; high survival if discarded	4.5
Stingray, SW group	Secure presence in SW		4.5	High survival if discarded	4.5
Longnose skate	Secure presence in SW		4.5	Protected species	4.5
Marbled electric ray	Secure presence in SW		4.5	High survival if discarded	4.5
Dark electric ray or Atlantic torpedo	Secure presence in SW		4.5	High survival if discarded	4.5
Undulate ray, local populations in south-west	Stabilise stock through data limited assessment then aim for MSY or proxy.	Not known	4.4	Patchy distribution around Channel Islands. ICES advised no targeted fishery and bycatch to be minimised; localised populations	4.4
Thornback ray, Celtic Sea & West Channel	Aim for MSY or proxy. Where MSY is not determined, advice using data limited assessment aims to stabilise	Survey index is stable or increasing	3.7	ICES advises an increase in catch would be feasible; since all rays are landed under the same TAC single species catches' are not limited	3.7
Blonde ray		No; decreasing	3.7	ICES advises 20% lower catches; since all rays are	3.7

Table 7 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on elasmobranch fish

Component and unit of analysis	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
	the stocks	survey index		landed under the same TAC single species' catches are not limited	
Sandy ray		No; decreasing survey index	3.7	Deep water shelf edge spp; mostly absent from SW ICES advises 20% lower catches.	3.7
Spotted ray, Celtic Sea & Channel		No; decreasing survey index	3.7	ICES advises 20% lower catches since all rays are landed under the same TAC single species' catches are not limited	3.7
Lesser spotted dogfish, SW group	Adult CPUE > X?	Not defined	4	Usually discarded with good survival; relatively high productivity	3.5
Nurse-hound or greater-spotted dogfish	Adult CPUE > X?	Not defined	4	Often survives discarding;	3.5
Small-eyed ray (also Painted & Sandy ray), Celtic Sea, Bristol & W Engl. Channel stocks		No; decreasing survey index	3.4	ICES advises 20% lower catches; since all rays are landed under the same TAC single species' catches are not limited	3.4
Shagreen ray, Celtic Sea, Biscay		No; decreasing survey index	3.4		3.4
Spurdog	Aim for MSY or proxy	No; decreasing survey index	3.4	Restrictive TAC since 2007, currently zero; EC max landing length since 2009 = 100 cm; ICES recommend re-building plan	3.3
Cuckoo ray, Celtic Sea, E. Channel	Aim for MSY or proxy. Where MSY is not determined, advice using data limited assessment aims to stabilise the stocks	No; decreasing survey index	3.1	ICES advises 20% lower catches; high survival if discarded	3.1
Starry ray		No; decreasing survey index	3.1	ICES advises 20% lower catches; same as cuckoo	3.1

Table 7 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on elasmobranch fish

Component and unit of analysis	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Tope, NE Atlantic stock	Secure presence in SW	y	Gill net=3	Not targeted; max UK catch < 45 kg/day; may be discarded alive	3
		y	Trawl = 2.1		2.1
Smooth-hounds (starry and common)	Aim for MSY or proxy. Where MSY is not determined, advice using data limited assessment aims to stabilise the stocks	Survey index is increasing	3.4	ICES found an increasing survey index and advises a small reduction in TAC on precautionary grounds. There is no TAC on these species.	2.9
Basking shark	Secure presence in SW	y	2.2	Zero TAC since 2007. UK fishery stopped in 1998; protected in UK waters; finning prohibited by EC reg 1185/2003, 2013; listed in CITES App II	2.2
Porbeagle	Secure presence in SW	y	2	ICES advised no fishing or landings. Rebuilding plan needed; zero TAC from 2010; migratory species	2
Shortfin mako shark	Secure presence in SW	y	2		2
Thresher shark	Secure presence in SW	y	2	Migratory species	2
Blue shark	Secure presence in SW	y	1.9	Finning prohibited by EC reg 1185/2003, 2013. Migratory species	1.9
The deepwater sharks leafscale gulper, Portuguese dogfish, longnose velvet dogfish, velvet belly, gulper shark, black dogfish were not scored. However, conservation of these species is improved by zero TACs where appropriate, and restrictions on deep sea fishing since 2007					
River and sea lamprey species were not scored but perceived to have a low interaction with fishing gear in the SW					

Table 8 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on molluscan shellfish

Component and unit of analysis	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Whelks, SW population	MSY or proxy	No stock assessment	3.7	MLS may not be big enough; discard survival is high	3.7
Cuttlefish, VIId, e (English Channel)	Aim for MSY or proxy	No stock assessment	Beam trawl 3.6	Project 50% to reduce discarding including cuttlefish see Catchpole (2013)	3.6
			Traps 2.6	Traps only catch large individuals CRESH research project to investigated mortality of cuttlefish eggs laid on traps see Section 8	2.6
			Otter trawl 2.2		2.2
Scallops, SW stock	Aim for MSY or proxy	y	3.5	MLS, minimum belly ring size, effort control (Kw days), restricted tooth spacing, rotation of fished beds for economic reasons, closed areas & MCZs	3.5
Squid (2 species), Channel stock	MSY or proxy	No stock assessment	Otter trawl 2.2	Mesh size regulations (80-100mm); square mesh panels north of 50°N	2.2
			Jig fishery 1.6		1.6
Native oyster, R. Fal and other SW estuaries (2 rows)	Abundance > X	Y	2.6	Managed estuarine fishery with annual survey	2.6
Blue mussels in SW	Adult abundance > X	Y	2.6	Blue mussel (M edulis) is also farmed extensively; should be covered under Communities	2.6
Native oyster, R. Fal and other SW estuaries	Condition > X g	Y	2.2	Resistance to Bonamia seems to have developed in Fal; controls on movements of oysters	2.2

Table 9 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on crustacean shellfish

Component and unit of analysis	Operational objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Crawfish or spiny lobster, SW stock	Maintain catch aim for MSY or proxy	No	3.5	The fishery occurs for a limited period; 4- 5 months of the year. There is a minimum landing size. However recruitment via larval drift from Iberian Peninsula may be unreliable	3.5
Lobster, SW stock	Maintain spawning stock for MSY	No, but close to MSY (2011)	Potting =3.7	There is a minimum landing size, restrictions on landing soft, berried and V-Notched lobsters and discards survive well. Escape panels are implemented in some fisheries and effort is restricted through shellfish licences.	3.2
			Netting = 2.6	Daily catch limit BUT caught lobsters may be damaged on removal from net;	2.6
			Trawling=2.0	Daily catch limit BUT lobsters may be damaged	2.0
Edible crab, W Channel & Celtic Sea stocks	Maintain spawning stock for MSY	Yes (2011)	Potting=3.6	There is a minimum landing size, restrictions on soft and berried crabs, discards survive well. Escape panels are implemented in some fisheries and effort is restricted through shellfish licences.	3.1
			Netting=3.5	Daily catch limit and limits on Kg landed BUT caught crabs are damaged on removal from net;	3
			Trawling=2.7	Daily catch limit BUT caught crabs are damaged on removal from net;	2.2
Spider crab, SW fishery (3 rows)	Aim for MSY or proxy	No stock assessment	Netting = 3	No market for small individuals BUT frequently damaged on removal from nets	3
			Potting = 2.6	MLS effective in saving small crabs; no market for small individuals	2.6
			Trawling= 2.1	No market for small individuals BUT frequently damaged on removal from trawls	2.1
Green crab	Aim for MSY or proxy	No assessment	2.4	No management measures	2.4
Velvet crab			2.1	MLS exists	2.1

Table 10 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on bird species					
Component and unit of analysis	**Operational Objective**	**Achieved in 2013?**	**Relative impact score**	**Discussion and mitigation**	**Mitigated relative impact score**
Sandwich, common and little terns, SW breeding groups	Avoid food limitation due competition for fish between birds and fisheries	No population assessment	2.6	At present we have no evidence that there is competition between breeding terns and fisheries for small fish.	2.6
Balearic shearwater	Maintain presence in SW	Believed to migrate through Channel waters	1.9	It is not clear whether there is any interaction with fisheries, though interaction with seiners has been reported elsewhere. IUCN critically endangered; low score does not reflect IUCN rating.	2.4
Northern fulmar	Breeding numbers in SW > X		2.1		2.1
Razor-bill	Breeding numbers in SW > X		2.1	St Ives Bay gill net fishery bylaw	1.9
Common guillemot	Breeding numbers in SW > X		2.1	St Ives Bay gill net fishery bylaw	1.9
Atlantic puffin	Breeding numbers in SW > X		1.9	St Ives Bay gill net fishery bylaw	1.9
Black-legged kittiwake	Avoid food limitation due competition for fish		1.9	Foraging range much larger than terns, and no industrial sand eel fisheries	1.9
Manx shearwater	Breeding numbers in SW > X		1.9		1.9
European shag	Breeding numbers in SW > X		1.9	St Ives Bay gill net fishery bylaw; unknown why sharper decline for shags than cormorants	1.7
Great cormorant	Breeding numbers in SW > X		1.9	St Ives Bay gill net fishery bylaw	1.7

Table 10 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on bird species

Component and unit of analysis	Operational Objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Northern gannet	Breeding numbers in SW > X		1.9	St Ives Bay gill net fishery bylaw; Torry lines could be used on trawlers if effects of injury on trawl wires were considered a risk	1.9
Arctic tern, Black-headed gull, Herring gull, Common gull, Greater black-backed gull, Mediterranean gull, Lesser black-backed gull, European storm-petrel, Red-throated diver, Black-throated diver, Great northern diver were all scored at a relative impact score of 1.0					

Table 11 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on turtle species

Component and unit of analysis	Operational Objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Mitigated relative impact score
Leatherback turtle Atlantic population	Avoid ingestion of plastic bags from litter discharged from ship and shore	Not determined	2.8	This is covered under the MARPOL convention and Seafish Responsible fishing scheme. However, the consequential risks are high because of the IUCN critically endangered status of this species.	3.4
	Avoid injury due to encounters with static gear buoy lines	Rare occurrence	2.1	Following the MCS turtle code (see section 8) will mitigate this risk. However, the consequential risks are high because of the IUCN critically endangered status of this species.	2.6
Kemp's Ridley turtle Hawksbill turtle Loggerhead turtle Green turtle Atlantic populations	Avoid ingestion of plastic bags	Not determined	1.8	These species are vagrants when encountered in SW waters and are not likely to survive the cold conditions. However, littering may cause persistent plastic pollution, affecting other parts of the ocean	1.8

Table 12 ERS; effect of fishing in ICES Divisions VIIe,f,g,h on whales, dolphins and porpoises

Component and unit of analysis	Operational Objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Relative impact score
Bottlenose dolphin; inshore stock as family groups in SW	Presence in SW	Know to be present	3.2	There is uncertainty over the structure and status of the inshore populations and their interaction with offshore populations. Interaction with fishing gear known but levels uncertain. Effect of pingers inconclusive.	3.2
Harbour porpoise; Celtic & Irish Sea population	Bycatch of less than 1.7% of population (ASCOBANS and OSPAR)	Presence yes; discard rate uncertain	3.3	The use of pingers under EC Reg 812/2004 for netters > 12m is intended to work towards fulfilling the requirement of bycatch mortality of less than 1.7% of population abundance.	3
Short-beaked common dolphin; British & Irish waters	Presence in SW	Yes	2.5	The UK pair trawl fleet targeting bass has seen a reduction in the number of common dolphins caught, though it is uncertain whether the use of pingers has been instrumental in this. The ban on tuna drift netting (from 2000) has reduced mortality. Some bycatch occurs in bottom set static nets and although it is not clear if the use of pingers will significantly reduce bycatch rates for this species there is some evidence of a mitigating effect	2.2
Northern minke whale	Presence in SW	Not known	1.8	Very occasional entanglement in static gear buoy ropes and 1 recorded bycatch from a midwater pair trawl in the SW area.	1.8

ERS not completed for Atlantic white sided dolphin, white beaked dolphin, killer whale, humpback whale, sperm whale and Culver's beaked whale due to lack of information on interaction with fisheries in the SW

Table 13 ERS; effect of fishing in ICES Division VIIefgh on seals

Component and unit of analysis	Operational Objective	Achieved in 2013?	Relative impact score	Discussion and mitigation	Relative impact score
Harbour (or common) seal; west England & Wales	OSPAR objective: no appreciable population decline	Declining across England and Wales	2.7	Conservation of seals Act 1970; EC Habitats Directive 1992 requires seal SACs (but no action taken yet)	2.7
Grey seal; Irish Sea to SW	OSPAR objective: no appreciable population decline	Yes	2.5	Conservation of seals Act 1970; EC Habitats Directive 1992 requires seal SACs (but no action taken yet)	2.5

9. References

Those marked * are available at
www.seafish.org/media/publications/SR672ERAEFSupporting_information.pdf

Anon (2011). Advice from the Joint Nature Conservation Committee and Natural England with regard to fisheries impacts on Marine Conservation Zone habitat features. JNCC and Natural England: 113.

*Bell, E. (2013). Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem; commercial crustacea; crabs, lobsters, crawfish and spider crabs.

Blythe, R. E., Kaiser, M. J., Edwards-Jones, G. and Hart, P. J. B. (2004), Implications of a zoned fishery management system for marine benthic communities. Journal of Applied Ecology, 41: 951–961

*Bloor, I, and Jackson, E 2013 Seafish Ecological risk assessment of South West fisheries: Cephalopod ecosystem component Marine Biological Association of the UK

*Bolam, S. (2013). Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem; benthic habitats and communities including mobile epifauna.

Bolam SG, Coggan R.C., Eggleton J., Diesing M., Stephens D. (2014) Sensitivity of macrobenthic secondary production to trawling in the English sector of the Greater North Sea: A biological trait approach

Journal of Sea Research Volume 85, Pages 162–177

Caslake, R (2009) SR617_Seafish Inshore VMS Pilot Project_SFA003
www.seafish.org/media/Publications/SR617_VMSFinal.pdf

*Catchpole, T. (2013). Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem; discarding in the south west.

Coleman R.A., Hoskin M.G., von Carlshausen E. and , Davis C.M. (2013) Using a no-take zone to assess the impacts of fishing: Sessile epifauna appear insensitive to environmental disturbances from commercial potting. Journal of Experimental Marine Biology and Ecology 440 (2013) 100–107

Cotter, J., and Lart, W. (2011). A guide for ecological risk assessment of the effects of commercial fishing (ERAEF). (Grimsby, UK: Sea Fish Industry Authority).
www.seafish.org/media/Publications/SR644_A_Guide_to_ERAEF_March_2011.pdf

Cotter, J., Lart, W., de Rozarieux, N., Kingston, A., Caslake, R., Le Quesne, W., Jennings, S., Caveen, A., and Brown, M. A development of ecological risk screening with an application to fisheries off SW England. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu167

http://icesjms.oxfordjournals.org/cgi/content/full/fsu167?ijkey=kcWA59J92D7XGtB&keytype=ref

Daskalov, G.M (2007) Overfishing Affects More than Fish Populations: Trophic Cascades and Regime Shifts in the Black Sea. In; Advances in Fisheries Science: 50 years on from Beverton and Holt. Editors Andy Payne, John Cotter, Ted Potter Chapt 17; p 418-433

Defra, (2012) Ecosystem approach to fisheries Project MF 1001 Evidence Project Final Report

Diesing M, D Stephens, J Aldridge (2013). A proposed method for assessing the extent of the seabed significantly affected by demersal fishing in the Greater North Sea
ICES Jounal of Marine Science **Vol 70 (6): 1085-1096.**

*Edwards M, Beaugrand G, Helaoue¨ t P, Alheit J, Coombs S (2013). Marine Ecosystem Response to the Atlantic Multidecadal Oscillation. PLoS ONE 8(2): e57212. doi:10.1371/journal.pone.0057212

*Ellis J, Walker, A and Pawson, M (2013) Advice to Seafish on input to ecological risk assesement of the effects of fishing in the southwest marine ecosystem; Component 3: Additional advice on lampreys, elasmobranchs and endangered fish species

Enever, R Catchpole, T.L., Ellis, J.R., Grant., A (2009)
The survival of skates (Rajidae) caught by demersal trawlers fishing in
UK waters Fisheries Research 97 (2009) 72–76

Eno, N.C., Frid, C.L.J., Hall, K., Ramsay,, K., Sharp, R.A.M., Brazier, D.P., Hearn, S., Dernie, K.M., Robinson, K.A., Paramor, O.A.L., et al. (2013). Assessing the sensitivity of habitats to fishing: from seabed maps to sensitivity maps. J. Fish Biol. *83*, 826–846.

Eno, N. C., MacDonald, D. S., Kinnear, J. A. M., Amos, C. S., Chapman, C. J., Clark, R. A., Bunker, F. St P. D., and Munro, C. 2001. Effects of crustacean traps on benthic fauna. – ICES Journal of Marine Science, 58: 11–20.

Hobday, AJ, A. D. M. Smith, I.C. Stobutzki, C. Bulman, R. Daley, J.M. Dambacher, R.A. Deng J. Dowdney, M. Fuller, D. Furlani, S.P. Griffiths, D. Johnson, R. Kenyon, I.A. Knuckey, S.D. Ling, R. Pitcher, K.J. Sainsbury, M. Sporcic, T. Smith, C. Turnbull, T.I. Walker, S.E. Wayte, H. Webb, A. Williams, B.S. Wise, S. Zhou (2011). Ecological risk assessment for the effects of fishing Fisheries Research 108; 372-384

Jennings, S. and Lee, J. 2012. Defining fishing grounds with vessel monitoring system data. ICES Journal of Marine Science (2012), 69(1), 51–63.

Jennings, S., M.D. Nicholson, T.A. Dinmore & J. Lancaster, (2002). Effects of chronic trawling disturbance on the production of infaunal communities. Marine Ecology Progress Series 243: 251–260.

Jennings, S., J.K. Pinnegar, N.V C. Polunin & K.J. Warr, (2001). Impacts of trawling disturbance on the trophic structure of benthic invertebrate communities. Marine Ecology Progress Series 213: 127–142.

*Kingston, A., Smout, S., & Northridge, S (2013)
Ecological Risk Assessment of Southwest Fisheries: Marine Mammal Ecosystem Component Sea Mammal Research Unit (SMRU), University of St Andrews.

*Koch, A., and Pacitto, S. (2013). Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem; benthic habitat, nursery and spawning areas and human activities relating to the area.

*Mander, L., and Thomson, N.D. (2013). Ecological risk assessment of south west fisheries - summary of knowledge on the seabird ecosystem component. Institute of Estuarine and Coastal studies

*Milligan, S (2013). 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

*Palmer, D and Roel, B (2013) 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

Pawson, M. G (2003)
The catching capacity of lost static fishing gears: introduction
Fisheries Research Volume 64, Issues 2–3, November 2003, Pages 101–105

*Pawson, M. (2013) Information on marine teleost fish ecosystem component for Seafish Ecological risk assessment of South West fisheries.

*Penrose, R 2012 Fisheries Turtle Interaction; Advice to the Sea Fish Industry Authority

*Le Quesne, W. (2013). Advice to Seafish on input to ecological risk assessment of the effects of fishing in the southwest marine ecosystem; fish community structure.

Revill, A,S and Dunlin, G (2003) The fishing capacity of gillnets lost on wrecks and on open ground in UK coastal waters Fisheries Research Volume 64, Issues 2–3, November 2003 107-113

Shephard S, Gerritsen H, Kaiser MJ, Reid DG (2012) Spatial Heterogeneity in Fishing Creates de facto Refugia for Endangered Celtic Sea Elasmobranchs. PLoS ONE 7(11): e49307. doi:10.1371/journal.pone.0049307

Sancho, G, Puente E, Bilbao A, Gomez, E, Arreg, L (2003)
Catch rates of monkfish (Lophius spp.) by lost tangle nets in the Cantabrian Sea (northern Spain) Fisheries Research Volume 64, Issues 2–3, November 2003, Pages 129–139

*Tregenza N (2012) Cetaceans and South West Fisheries; Advice to the Sea Fish Industry Authority

Appendix 1. Detailed descriptions of the main gear types used in the SW fisheries

Beam trawl

Operations and gear

This fishery operates throughout the SW area. The main target species are Dover sole, plaice, megrim, anglerfish (monkfish) and cuttlefish. Most beam trawlers in the SW fleet are between 25-30 m in length. Echo sounders and Olex^{TM}, together with historical information, are used to identify suitable fishing locations and tow paths. The trip lengths are mostly up to 7 days and the vessels store the fish on ice (Caslake, pers comm).

As sole, megrim, and anglerfish are quite sparsely distributed, the economics of beam trawling depend on covering large amounts of ground at speed. Most fishing is carried out at 6 knots or higher and tow duration varies between 30 min on grounds with high benthos and debris to 2 – 3 hr on clean ground. The port and starboard nets are hauled alternately, rapidly emptied into pounds on the deck and lowered back over the side to start fishing while the crew sort the catch. In this way beam trawlers can fish almost continuously whilst on the fishing grounds.

There are seasonal differences in grounds fished and mesh-size used in beam trawls, depending on the target species: cod-end mesh sizes vary from 80-90 mm (for sole) to 100-119 mm (anglerfish, plaice). The majority of vessels use chain matrix gear, but some use ‘open’ or tickler chain gear on softer seabed.

In order to reduce fuel costs while maintaining high sole catches, there has been a progressive reduction in the size and weight of materials used in the beam trawl, especially in the chains that have ground contact.

Otter trawl

Operations and gear

This gear is used inshore and offshore throughout the Channel to catch a mix of flatfish (plaice, sole, lemon sole, dab) and gadoids (cod, whiting, pout, pollack, hake, ling), with anglerfish, gurnads, rays, squid and cuttlefish at the appropriate season.

Vessels vary between <10 m and 25 m in length. Small vessels undertake 1-3 day trips and larger vessels 4 – 7 day trips. They will steam to the grounds and locate suitable tows using echo sounder and/or Olex^{TM} ground discrimination systems and historical knowledge. Tows are likely to last 4-5 hours. Monitoring systems utilising sonic communication from gear mounted transducers are used to ensure correct gear geometry. The spatial distribution of effort in 2007 is shown in Figure A1 with relative intensity for all beam and otter trawls.

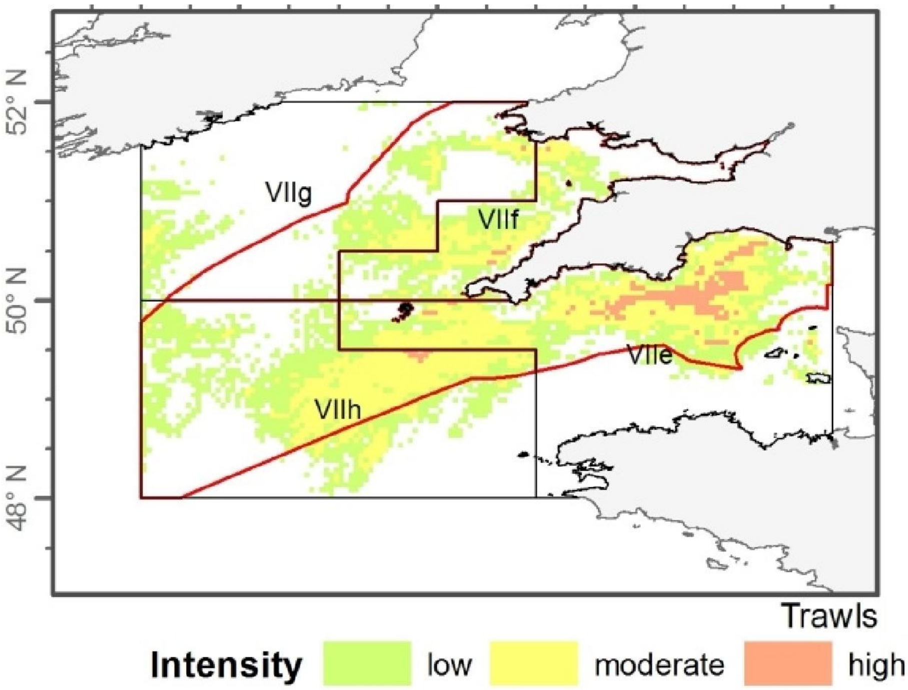


Figure A1 Relative fishing intensity by beam and otter trawls combined from offshore VMS data (2007) (source: see Koch and Paccito, 2013).

Scallop Dredge

Operations and gear

Echo sounder, Olex^{TM} and other ground discrimination systems are used together with historical knowledge are used to find grounds and guide fishing. Spring-toothed Newhaven gear is used exclusively in the UK fisheries; “French” gear having been banned because of its high bycatch of fish.

The length of tow is generally shorter than with beam trawling, at ½ to 1 ½ hours in duration and at a lower speed c 2.5 knots (determined to a large extent by the quantity of rocks in the gear). The boats vary in size from <10 m to 25-30 m. Larger vessels tend to tow at higher speed in straight lines from scallop patch to scallop patch, whereas smaller, more manoeuvrable vessels tend to concentrate on one patch at a time. Grounds tend to be fished serially, with each one being reduced to an uneconomical catch per effort before the boats move to a new ground (Palmer pers com). Trip length varies from one day to a maximum of 7 days to ensure fish quality.

The spatial distribution of dredge effort in 2007 is shown in Figure A2.

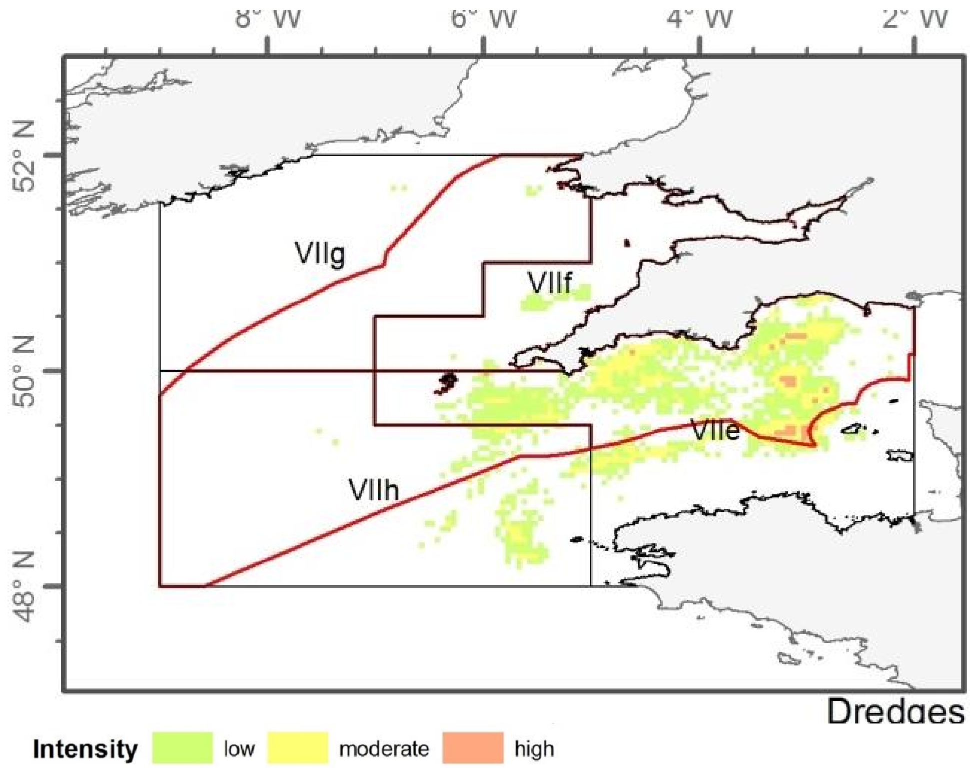


Figure A2 Fishing intensity of scallop dredges from offshore VMS data (2007).

Fixed nets

Operations and gear

The enmeshing net fisheries in SW England employ a variety of fixed gill and tangle nets and drift nets to target species such as bass, cod, flatfish and rays in different fisheries, depending on the local availability of a given species throughout the year. Mesh sizes vary depending on the target species, from less than 70 mm for catching red mullet to mesh sizes up to 300 mm to catch turbot and brill, rays and monkfish. Many of the boats involved in these fisheries may use other gears, such as trawls, lines or pots, seasonally and to target other species. The majority of the fleet is composed of <10 m vessels operating as day boats (sailing and landing within 24 hr), and fishing effort is often dependant on weather and the presence of a suitable launch site. The larger boats at 15-25 m tend to work offshore on 6-8 day trips, coming in to land the fresh catch whilst the gear stays in water during the season (though gear is often retrieved before bad weather or strong spring tides).

The main fisheries are summarised in Table 14.

Gill and tangle nets are set for sole, plaice, rays, turbot, brill, pollack and cod, and gill nets with a mesh size of 120-160 mm are set over rough ground and wrecks for cod, pollack, ling and rays. Small-meshed (<120 mm) tangle nets are set for sole and plaice on smooth grounds, whereas larger ones (>200 mm) are set for rays, turbot, monkfish and brill. Tangle nets are also used for (the now rare) crawfish and also take spider crabs.

Some of the larger netting boats work out as far as 70 miles offshore in a directed gill-net fishery for hake in the deep-water grounds to the south-west and south of Ireland. Hake gill netters use a 120 mm mesh that retains only larger fish and a low by catch of pollack, cod, haddock and saithe, in declining order, and very few discards.

A traditional directed gill-net fishery for spurdog is now banned (since 2010, all spurdog must be returned to the sea).

Netting vessels rely on echo sounders and Olex^{TM} to find suitable grounds. A key element is avoiding setting gear where it may be towed away by trawlers, using Automatic Identification Systems for radar identification and tracking of trawlers. Gear is shot away, soaked for an appropriate length of time; tangle nets soak for 48-72 hours, gill nets for 24 hrs, and then hauled.

There are no management measures relating specifically to effort in static enmeshing net fisheries (apart from indirectly through catch quotas), but technical measures include mesh size controls (by target species), requirements for marking gear, maximum by catch of crab claws etc. EU regulations (227/2013) have been introduced stipulating measures which vessels should take to avoid losing these gears, especially in deep waters on the continental slope, and there are regulations concerning how gear should be marked.

The spatial distribution of netting effort (relative intensity) in 2007 is shown in Figure A3

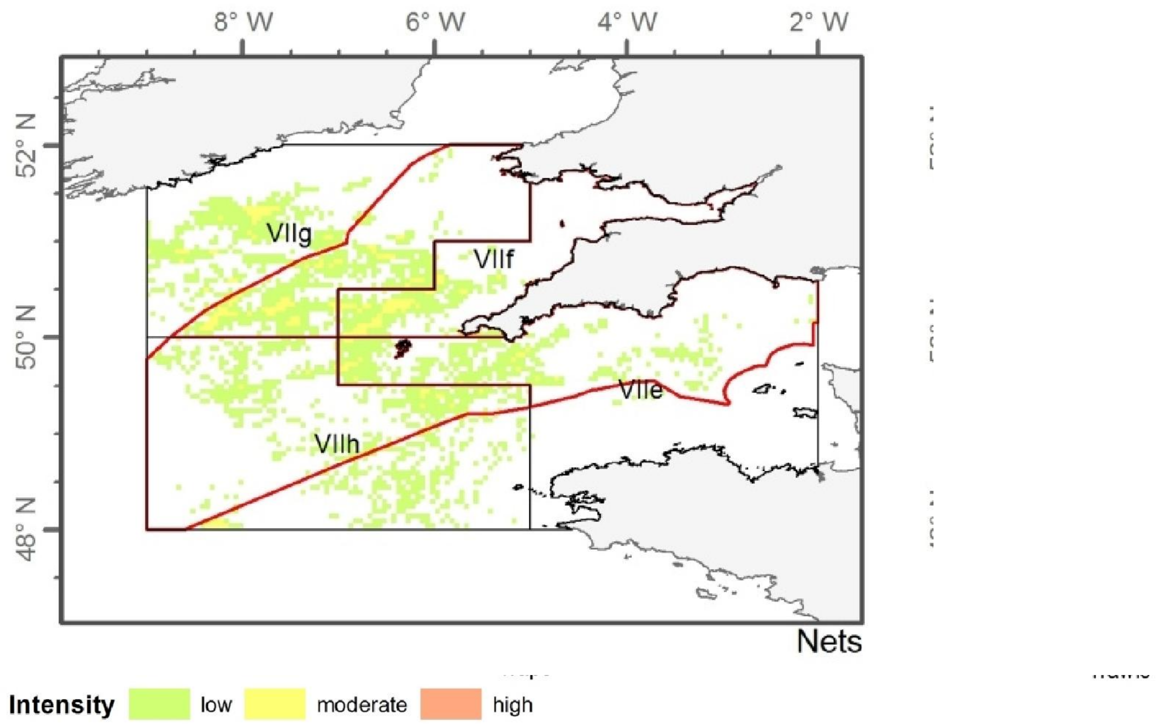


Figure A3 Fishing intensity from offshore VMS data (2007) for netting.

Pots

The activities of this fishery can be split into those by large nomadic vivier vessels (≥15 m) targeting crabs and lobsters, and smaller day boats (<10 m) fishing for crabs and lobsters whilst some target whelks particularly in the east of Div. VIIe. Crab and lobster fisheries use inkwell and parlour pots, whilst specialised gear is used for whelk. Pots are normally soaked for 24 to 48 hours. Fishing effort is not as influenced by tidal conditions as set net fishing.

All these fisheries use various sources of bait. The grounds are located using echo sounders, local knowledge Olex™ and other forms of ground discrimination equipment. As with netting, there is an imperative to avoid the risk of gear being damaged or towed away by mobile gear, and vessels use Automatic Identification Systems to track and avoid trawlers. There are local agreements off Start point for alternating use of grounds by potters and trawlers, and there are areas closed or seasonally closed to trawling (with French agreement); the South Devon crabbing and potting agreement is now in UK legislation and will become a part of the MCZ network.

The spatial distribution of pot fishing effort in 2007 is shown in Figure A4

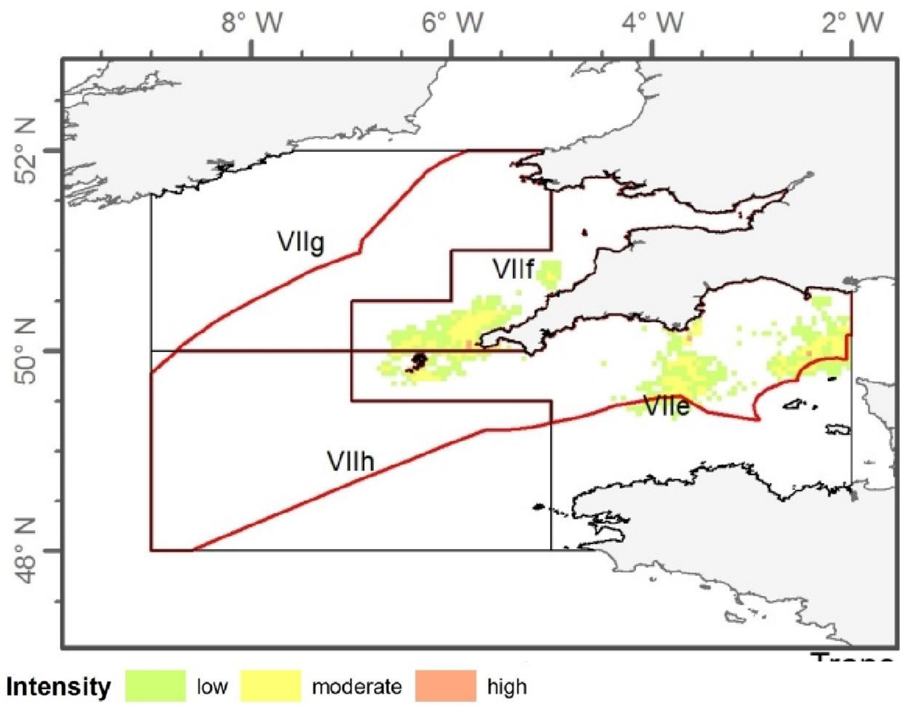


Figure A4 Potting fishing intensity from offshore VMS data (2007).

Table 14; Main enmeshing gear metiers operating in SW Engalnd

Type	Species	Season	Gear and catch data table	Area	Comments
Demersal	Red mullet; by-catch of other species	Inshore fishery in summer, May-Sept	<70mm monofilament gill nets	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	Area restrictions prevent near-surface set nets (<3m) and drift nets to avoid capture of salmon and migratory trout. Also measures to prevent bird mortalities.
Semi Pelagic	Bass and grey mullet; and other species	All year round – localised inshore bass fisheries during winter months	90-150 mm monofilament gill nets Surface drift and bottom set nets	Close inshore; known bycatch of seabirds in some areas	
Demersal fisheries	Dover sole, plaice	All year round – increased intensity during July-October	110-150 mm monofilament gill and trammel nets, Inshore	Smooth ground generally inside the 6 mile limit, to avoid large beam trawlers	Highly weather dependant
Demersal fisheries	Pollack, ling, cod	All year round	125-150 mm multi monofilament gill nets	On or near rough ground	Longer lengths of net 500 m

Type	Species	Season	Gear and catch data table	Area	Comments
	Cod, pollack, ling	All year round -	110-149 mm mono 150-210 mm Mono filament wreck nets + longer whitefish	Shot on very short lengths - 250 m - on wrecks and rough ground Pinger CC related to mesh size	Inshore fishery more intensive during summer months
	Hake	All year round	120 mm monofilament gill nets	Tier lengths 1000 – 5000 m Offshore mostly outside 12 miles	Uses pingers
	Monkfish, turbot, ray, (crawfish by catch)	Summer fishery	260-300 mm monofilament tangle nets	Ground dependent on target species, 500m+ lengths of nets used dependant on vessel size	Pingers required
Demersal fisheries	Spider crabs	Late Mar – early July	260-320mm –tangle nets No catch data 30- 40 boats small scale Cornwall + Devon	Close inshore fishery, relatively short length of gear 300 - 1000m	

.

Appendix 2 Ecological risk screening jargon

Activity = one of the activities of the agent, e.g. towing a trawl

Agent of change (abbreviated to 'agent') = anything likely to be causing changes in the ecosystem, e.g. a fishery.

Analysis; analysis of data or scores to obtain an estimate of relative risk or as part of a modelling process. E.g. Virtual Population Analysis for populations; Risk screening analysis for ecological components.

Assessment; using the results of an analysis to judge outcome against some sort of operational objective.

Attribute = Feature of a unit beneficial to survival, e.g. abundance

Component = colloquial grouping of units, e.g. 'sharks

Effect = change to an attribute of a unit resulting from an activity

Unit of analysis (abbreviated to 'unit') = a stock, a species, a habitat, a functional group, or a community

Operational Objective set pursuant to Goals; intended to control the effect of an activity.

Member of a unit = a single stock, an individual organism, a single instance or part of a habitat or community (as appropriate)

Calculation of geometric mean score
The calculation of the relative impact score is carried out as follows

Relative impact score = 4√Spatial score*Temporal score*Intensity score * Duration

Effectively this means that if a score is 0 the relative impact is zero, whilst an arithmetic mean would have resulted in a positive score.

.