EFFECTS OF FISHING WITHIN UK EUROPEAN MARINE SITES: GUIDANCE FOR NATURE CONSERVATION AGENCIES

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CONTENTS

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EXECUTIVE SUMMARY

This report updates the ‘information’ component of decision-making in relation to fisheries activities within Natura 2000 protected sites. The habitats and species listed in the Habitats Directive (1992) are used to structure the report but any habitats likely to occur within the (sometimes broad) habitat definitions of the Habitats Directive are included. The Birds Directive (1979) does not specifically identify habitats in the same way as the Habitats Directive but a large number of species are listed. This report therefore addresses fishing impacts on two groupings of birds: sea birds and wildfowl and waders.

Since 1999, numerous scientific reports and reviews have been published that describe the impacts of fisheries on marine habitats and species. Notably, several fishery impact bibliographies have also been produced since 1999 and these have been referred to during this review.

The report is based on Gubbay & Knapman (1999). It repeats some of that information but includes additional descriptive and illustrative material. A further 95 articles have been reviewed and added to the 96 identified and tabulated in the 1999 report. The full set of references is now held in a database designed to provide the ‘back-end’ of an interactive Web site. The information has also been converted into a table.

Over fifty different types of fishing are catalogued in the database.

Mariculture is also included. Separate descriptions are given of fisheries impacts on Annex I habitats and on Annex II species from the Habitats Directive and more general accounts for species listed in Annex IV of the Habitats Directive and birds from the Birds Directive.

The reviewed papers indicate that, if located responsibly and appropriately managed, there are a number of fishing activities, which can have a minimal impact on species and habitats of marine natural heritage importance. In particular, static gears such as pots or creels and hand gathering are likely to have a minimal impact when compared to the use of mobile fishing gears. In many cases, static and mobile fishing methods are used to target the same species. For most types of fishing, recovery from damaging impacts is likely to be within less than a year or in a few years if fishing impact is infrequent. However, even where recovery occurs rapidly, the type of community present may change especially through loss of epibenthic and long-lived and slow growing species. An increase in scavenging and opportunistic species is also common in areas recently fished with some types of mobile gear.

Generally, more dynamic habitats that are subjected to regular, natural disturbance are able to recover more quickly from the effects of fishing. Although even these habitats may contain slow growing, long-lived species, which are unable to recover quickly from the physical damage caused by some fishing methods. It is on biogenic reefs and hard substratum where long-term damage to species and communities is most likely to occur. Aquaculture can have minimal impact if sensitively sited although substratum below aquaculture cages is likely to be changed and aquaculture is often responsible for the import and spread of non-native species.

Most of the studies reviewed have been undertaken in areas that have few sensitive species. Indeed, if sensitive species were once present, they may have been destroyed by bottom gear before the areas were subject to research. Some more recent studies have addressed actual or potential impacts on fragile habitats and species that are unlikely to

recover rapidly if at all. There are still significant gaps in our knowledge about impacts on a number of potentially sensitive habitats and species including those in sea lochs where habitats may not be protected by the Habitats Directive, hindering research into fishing practices that damage sensitive fauna and flora.

As more-and-more decisions about environmental protection use 'the ecosystem approach' it has been important to note some consequential effects of fishing on prey availability, nutrient cycling, substratum modification, collateral damage to wildlife interests etc.

Executive Summary reference: Gubbay. S. & Knapman, P.A. 1999. *A review of the effects of fishing within UK European marine sites*. Peterborough: English Nature (UK Marine SACs Project). 134 pages.

Reference to this report: Sewell, J. & Hiscock, K., 2005. Effects of fishing within UK European Marine Sites: guidance for nature conservation agencies. *Report to the Countryside Council for Wales, English Nature and Scottish Natural Heritage from* the *Marine Biological Association.* Plymouth: Marine Biological Association. CCW Contract FC 73-03-214A. 195 pp.

EFFEITHIAU PYSGOTA YN SAFLEOEDD MOROL EWROPEAIDD Y DEYRNAS UNEDIG: CANLLAWIAU AR GYFER ASIANTAETHAU GWARCHOD NATUR

CRYNODEB GWEITHREDOL

Mae'r adroddiad hwn yn diweddaru'r elfen o 'wybodaeth' sy'n rhan o'r broses gwneud penderfyniadau mewn perthynas â gweithgareddau pysgota yn safleoedd gwarchodedig Natura 2000. Defnyddir y cynefinoedd a'r rhywogaethau sy'n cael eu rhestru yn y Gorchymyn Cynefinoedd (1992) i lunio'r adroddiad, ond cynhwysir unrhyw gynefinoedd sy'n debygol o ddigwydd o fewn y diffiniadau o gynefinoedd a geir yn y Gorchymyn Cynefinoedd (sy'n gallu bod eang ar brydiau). Nid yw'r Gorchymyn Adar (1979) yn dynodi cynefinoedd penodol yn yr un modd â'r Gorchymyn Cynefinoedd, ond rhestrir nifer helaeth o rywogaethau. Felly, mae'r adroddiad hwn yn mynd i'r afael â'r effeithiau a gaiff pysgota ar ddau grŵp o adar: adar y môr, ac adar dŵr ac adar hirgoes.

Ers 1999, cafodd nifer o adroddiadau ac adolygiadau gwyddonol eu cyhoeddi sy'n disgrifio'r effaith a gaiff pysgodfeydd ar gynefinoedd a rhywogaethau morol. Yn benodol, cafodd nifer o lyfryddiaethau sy'n ymwneud ag effaith pysgodfeydd eu cynhyrchu ers 1999 a chyfeirir atynt yn yr arolwg hwn.

Mae'r adroddiad yn seiliedig ar Gubbay & Knapman (1999). Mae'n ailadrodd rhywfaint o'r wybodaeth honno ond mae'n cynnwys deunydd disgrifiadol ac eglurhaol ychwanegol. Cafodd 95 erthygl arall eu hadolygu a'u hychwanegu at y 96 a gafodd eu dynodi a'u cyflwyno ar ffurf tabl yn adroddiad 1999. Erbyn hyn, mae'r set gyflawn o gyfeiriadau'n cael ei chadw mewn cronfa ddata a gynlluniwyd i ffurfio 'rhan olaf' Gwefan ryngweithiol. Mae'r wybodaeth hefyd wedi'i chofnodi ar ffurf tabl.

Cofnodwyd dros 50 o wahanol fathau o bysgota yn y gronfa ddata.

Mae dyframaethu yn cael ei gynnwys yn ogystal. Rhoddir disgrifiadau ar wahân o effeithiau pysgota ar gynefinoedd Atodiad I a rhywogaethau Atodiad II y Gorchymyn Cynefinoedd, a cheir adroddiad mwy cyffredinol ar gyfer rhywogaethau a restrir yn Atodiad IV y Gorchymyn Cynefinoedd, ac adar o'r Gorchymyn Adar.

Mae'r papurau a gafodd eu hadolygu yn dangos y gallai nifer o weithgareddau pysgota, o'u lleoli'n gyfrifol a'u rheoli'n briodol, gael effaith fach iawn ar rywogaethau a chynefinoedd sy'n bwysig o ran treftadaeth naturiol y môr. Yn benodol, mae offer sefydlog megis potiau neu gewyll a chasglu â llaw yn debygol o gael effaith fach o gymharu â defnyddio offer pysgota symudol. Mewn nifer o achosion, defnyddir dulliau pysgota sefydlog a symudol i dargedu'r un rhywogaeth. Yn achos y rhan fwyaf o fathau o bysgota, mae'n debygol y gellid dadwneud yr effeithiau niweidiol o fewn llai na blwyddyn, neu mewn ychydig flynyddoedd os yw'r pysgota'n digwydd yn anaml. Eto i gyd, hyd yn oed pan geir adferiad cyflym, gall y math o gymuned sy'n bresennol newid, yn enwedig drwy golli rhywogaethau sy'n byw ar wely'r môr, rhywogaethau sy'n byw'n hir a rhywogaethau sy'n tyfu'n araf. At hynny, mae cynnydd yn y rhywogaethau sy'n bwyta sborion a rhywogaethau manteisgar yn gyffredin mewn ardaloedd lle defnyddiwyd rhai mathau o offer pysgota symudol yn ddiweddar.

Yn gyffredinol, mae cynefinoedd sy'n fwy dynamig, lle ceir aflonyddu naturiol, rheolaidd yn gallu adfer eu hunain yn gynt. Er hynny, gall hyd yn oed y cynefinoedd hyn gynnwys rhywogaethau sy'n tyfu'n araf ac yn byw'n hir, nad ydynt yn gallu adfer eu hunain yn gyflym o'r niwed a achosir gan rai dulliau o bysgota. Mae'r niwed hirdymor i rywogaethau a chymunedau'n fwyaf tebygol o ddigwydd ar riffiau biogenig ac is-haenau caled. Gall yr effaith a gaiff gweithgareddau dyframaethu fod yn fach o gael eu lleoli'n sensitif er bod is-haenau o dan y cewyll dyframaethu yn debygol o newid ac yn aml mae dyframaethu'n gyfrifol am weld rhywogaethau nad ydynt yn rhai cynhenid yn symud i mewn i ardal ac ymledu.

Cafodd y rhan fwyaf o'r astudiaethau a adolygwyd eu cynnal mewn ardaloedd lle ceir ychydig o rywogaethau sensitif. Yn wir, os oedd rhywogaethau sensitif yn bresennol ar un adeg, mae'n bosibl eu bod wedi cael eu dinistrio gan offer ar wely'r môr cyn i ymchwil gael ei gynnal yn yr ardal. Mae rhai astudiaethau mwy diweddar wedi mynd i'r afael â'r effeithiau posibl neu wirioneddol ar rywogaethau neu gynefinoedd bregus sy'n annhebygol o gael eu hadfer yn gyflym, os o gwbl. Erys bylchau sylweddol o hyd yn y wybodaeth sydd gennym am yr effeithiau ar nifer o gynefinoedd a rhywogaethau a allai fod yn sensitif, gan gynnwys y rheiny mewn culforoedd, lle nad yw'r cynefinoedd o bosibl yn cael eu gwarchod gan y Gorchymyn Cynefinoedd, ac mae hyn yn rhwystro ymchwil i arferion pysgota sy'n niweidio ffawna a fflora sensitif.

Wrth i fwy a mwy o benderfyniadau ynghylch gwarchod yr amgylchedd ddefnyddio'r dull 'ecosystem', mae'n bwysig nodi rhai o sgîl effeithiau pysgota ar yr ysglyfaeth sydd ar gael, cylchdroi maeth, addasu is-haenau a niwed cyfochrog i fuddiannau bywyd gwyllt ac ati.

Cyfeiriadau'r Crynodeb Gweithredol: Gubbay. S. & Knapman, P.A. 1999. *A review of the effects of fishing within UK European marine sites*. Peterborough: English Nature (UK Marine SACs Project). 134 pages.

Manylion yr adroddiad hwn: Hiscock, K., & Sewell, J. 2005. Effects of fishing within UK European Marine Sites: guidance for nature conservation agencies. *Report to the Countryside Council for Wales, English Nature and Scottish Natural Heritage from* the *Marine Biological Association.* Plymouth: Marine Biological Association. CCW Contract FC 73-03-214A. 195 pp.

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1. INTRODUCTION

The present report is an update and extension of the UK Marine SACs Project report by Gubbay & Knapman (1999) (referred to as “the 1999 report”). The objective of the 1999 report was to “bring together literature relating to the methods of commercial fishing (not including angling) which take place within European marine sites - marine Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) - and summarises their potential effects on the nature conservation interests within them”. In so doing, the report also aimed “to inform relevant authorities in the development and implementation of management schemes on European marine sites so the potential effects of fishing can be taken into account”.

This report has the same objectives as the 1999 report and additionally includes general information and illustrative material to help the user to understand what different sorts of fisheries involve. The effects of bait collection for angling, hand gathering intertidal organisms and some effects of sea angling, are also included in this report.

The structure of the report is based on the marine habitats and species listed in ‘Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora’, commonly referred to as the “Habitats Directive”. Council Directive 79/409/EEC on the conservation of wild birds, commonly referred to as the “Birds Directive” (1979), does not specifically identify habitats in the same way as the Habitats Directive and habitats are referred to mainly in terms of breeding (nesting) and feeding sites. This report therefore addresses fishing impacts on habitats and species that birds might use for feeding.

Appendix 1 contains a table, listing habitats and species identified for protection in the two Directives.

The Interpretation Manual of European Union Habitats (European Commission 2003) gives a description of Annex I habitats and the species and features likely to occur within them. Some of these features can be considered habitats in their own right and are included as separate sections in this report. The text has been reduced so that a summary of effects with some example references is given rather than a comprehensive review: that is available through interrogation of the database developed as a part of the present study. The database has also been used to produce tabulated summaries, which add to the table produced by Gubbay and Knapman (1999) and are included as Appendix 3.

The Glossary of Marine Nature Conservation and Fisheries (Lockwood, 2001) provides full definitions and descriptions of the terms used in this report.

Over the past five years, our approach to assessing ‘sensitivity’ of seabed habitats, communities and species and incorporating information into decision-making has progressed (see, for instance, Hiscock *et al*. 2003). The now widespread use of the Internet makes access to information and application of decision-support tools much easier. There is also now a great deal of effort to adopt an ‘ecosystem approach’ to fisheries management. And there has been an increase in associated literature describing how such approach can be applied to fisheries (see, for instance, Pope & Symes 2000).

Great attention has been drawn to the actual and potential impacts of fishing on sustainable exploitation of fish stocks and on the wider environment including biodiversity, over the past year. Reports that provide a view on fisheries impacts include ‘Turning the

Tide: addressing the impact of fisheries on the marine environment' (Royal Commission on Environmental Pollution, 2004) and the 'WWF Marine Health Check 2005' (Hiscock *et al*. 2005). The report 'Net Benefits: A sustainable and profitable future for UK fishing' (Cabinet Office, 2004) provides an economic appraisal of the UKs fishing industry, which acknowledges the responsibility that the fishing industry has for the protection of the marine environment. The report also highlights the importance of sustainable management of fisheries and recommends the introduction of 'comprehensive environmental management systems in all fisheries'. Current policy and legislation relating to fisheries is addressed comprehensively in a separate report (Symes & Boyes, 2005).

2. RESEARCHING AND ORGANISING INFORMATION RESOURCES

In order to provide a flexible information resource, a Microsoft Access database was developed to enter information from published material. The use of a database enables:

1. information to be organised as tables revised automatically as required;
2. information to be accessible through a Web front-end that is not static as it operates from a 'live' database and that can be interrogated to generate targeted information only;
3. new information to be added once and then presented in multiple formats;
4. references to be generated to a common style and format.

To facilitate population of the database, the report by Gubbay & Knapman (1999) was supplied as a Microsoft Word document so that information from the papers researched by Gubbay & Knapman (1999) could be easily transferred to the database. Further references were then added in the same format and numbered sequentially, following on from those already entered.

There has been a significant increase in literature available and progress in understanding the impact of fishing on marine ecosystems since the 1999 report. Many of those papers and reports have been accessed previously for *MarLIN* reviews and were readily available to the authors of this report. Searches of abstracting services have been undertaken to identify relevant literature. The National Marine Biological Library, Plymouth has been extensively used as a source of scientific material. The information resources used were predominantly published papers and reports as well as illustrative material obtained from a variety of sources.

Since the 1999 report, there have been several other reviews of literature published (Rester, 2003; Kenchington, 2002 and Dieter *et al*, 2003) which have provided a check for the authors. The COST-IMPACT study (http://www.cost-impact.org) has reviewed information on fisheries impacts and has identified the relative benefits and problems in relation to goods and services: an increasingly important approach because of conflicting policy objectives of sustainable development and conservation of biodiversity. The primary objectives of Cost-Impact are to provide advice to decision makers on:

1. How demersal fishing impacts the biodiversity of marine benthos and the associated goods and services, such as nutrient cycling that they provide
2. How these impacts influence other marine ecosystem processes
3. What the likely values of marine ecosystem goods and services are and how these values are affected by fishing.

In parallel with the work of Gubbay & Knapman (1999), Fowler (1999) reviewed effects of the collection of bait and other shoreline animals. There has not been the significant increase in information that occurred in relation to some other fisheries but, to make the current report as complete as possible, papers that document the effects of bait collection and that are additional to those in Fowler (1999) have been added to the database.

Information about UK SACs, including distribution maps, SAC status and sub-features was obtained from the JNCC website (www.jncc.gov.uk). This information is updated on a regular basis and was considered to be the most up-to-date and comprehensive source of information available.

Superscript numbers in the text refer to references in the database. General references are cited by author and date. All references are listed at the end of the text.

The researched information included in the database has been summarised in the text below and in Appendix 3. Whilst researchers are recommended to use the Microsoft Access database to search for information on fishing methods, Annex I habitats, Annex II species etc., a summary of key information extracted from the database has been presented in Appendix 2.

3. EFFECTS OF DIFFERENT FISHING TYPES

3.1 Introduction

In order to make the present report ‘stand-alone’, the summaries describing fishing types and effects have been transferred from the 1999 report and updated with any new information found during this review. Commercial fishing activities known or likely to be undertaken in SACs are those listed in Gubbay & Knapman (1999). A number of additional fishing types have also been included in this update such as bait digging, collecting soft crabs for bait from tiles and mussel seeding. All fishing types are divided into the following subcategories:

- Benthic dredges and trawls
- Suction (hydraulic) dredging
- Netting (bottom-set gill/tangle nets)
- Pots/creels
- Collecting
- Mariculture

For each fishing type, a simple table is included, which lists the Annex I habitats and Annex II, Annex IV and Birds Directive species (report sections are included in brackets), which may be affected by the fishing type.

3.2 Benthic dredges and trawls

3.2.1 Dredging for scallops, oysters, clams and mussels

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), Large shallow inlets and bays (5.5), Reefs (5.6).
Annex II, IV and birds directive species likely to be effected by this fishing type	Wildfowl and Waders (8.3)

There are several different types of dredge currently used in UK waters for the capture of bivalves. The more benign traditional, lightweight oyster dredges towed at slow speeds, usually in estuaries have a relatively low impact. Large, heavy, metal dredges, such as the Newhaven dredges often used to catch scallops living on the surface of sediments or buried in shallow depths of sediment, have spring loaded teeth that dig into the seabed or scrape hard substratum causing significant damage and change to the community. Some habitats, such as coarse sand, are likely to be naturally mobile and may recover quickly from any impacts of dredging. Some types of sediment will contain sensitive species such as, for instance, the fan mussel *Atrina fragilis*. Habitats such as maerl, horse mussel beds and hard substratum are likely to include sensitive species that will be damaged by the dredge causing long-term adverse effects. The account of likely effects given below, whilst based on the 1999 report, is expanded to take account of a significant number of studies undertaken since then.

Dredging for mussel seed to be used in mussel cultivation and dredging artificially laid bivalve beds is discussed in more detail in section 3.7.2.

Effects on seabed habitats and the water column: A number of effects on the seabed habitats result from dredging. Tracks are created on the seabed, fine sediments are lifted into suspension and large rocks can be overturned[30,40,42,45]. A mound of sediment may be carried in front of the dredge bar and deposited around the sides in distinct ridges, most obviously in the case of the spring-loaded scallop dredges[33].

Investigations into the effects of oyster dredging and the use of modified oyster dredges to harvest clams have shown that the top 10-15 cm may be removed by the action of the dredge, sediment plumes created, and tracks made on the seabed. The gravel fraction in the sediment can be reduced and sediments become more anoxic after dredging[21]. The suspended sediment may also have an indirect effect on species some distance from the dredging operation if they are smothered and there can be detrimental effects on eel grass beds.

A study looking at the effects of mussel dredging in a sheltered fjord in Denmark showed an increase in suspended particular matter but a return to initial conditions after 1 hour[32]. There was a significant decrease in oxygen levels as a result of the dredging but generally little change in nutrient levels except in the case of ammonia. This work suggests that water quality can be reduced by mussel dredging because of increasing nutrient loads, oxygen consumption and possibly phytoplankton production. The total annual release of suspended particles as a consequence of mussel dredging at this site was nevertheless considered to be relatively unimportant compared with the total annual wind-induced resuspension[32, 54]. Similarly the nutrient load entering the system from land was more significant than that caused by mussel dredging. Changes in the benthic flora and fauna as a consequence of repeated mussel dredging[32] were considered to have a more severe effect than suspension of sediments and increased nutrient loads caused by the action of the dredges[54]. Studies also suggest that following dredging, for a short while (4-6 months) after scallop dredging, the 'food quality' of sediments in silty sand habitats may be significantly reduced[130].

Effects on benthos Biogenic habitats may be displaced and the community changed to a different one. Dredging for queen scallops (*Aequipecten opercularis*) on beds of horse mussels *Modiolus modiolus* is likely to result in destruction of the horse mussel beds. Experience in the Strangford Lough cSAC provides a salutary lesson for statutory authorities. Horse mussel communities once covered much of the bottom of Strangford Lough, forming very extensive reefs, providing habitat for hundreds of other species. Most of the area where they once lived has now been destroyed by fishing, the recent surveys[159] having found only one remaining living pristine reef. Fishermen use mobile gear to trawl for queen scallops that live in the habitat provided by the horse mussel clumps. With this new evidence it is now unquestionable that the commercial trawling has caused the destruction of the reefs. The extent and the diversity of associated communities of horse mussel beds in the Irish Sea is believed to have been greatly reduced since surveys in the 1950's, almost certainly as a result of use of mobile fishing gear[132]. There is also evidence that bivalve dredges can cause severe damage to deep water *Lophelia* reefs[157].

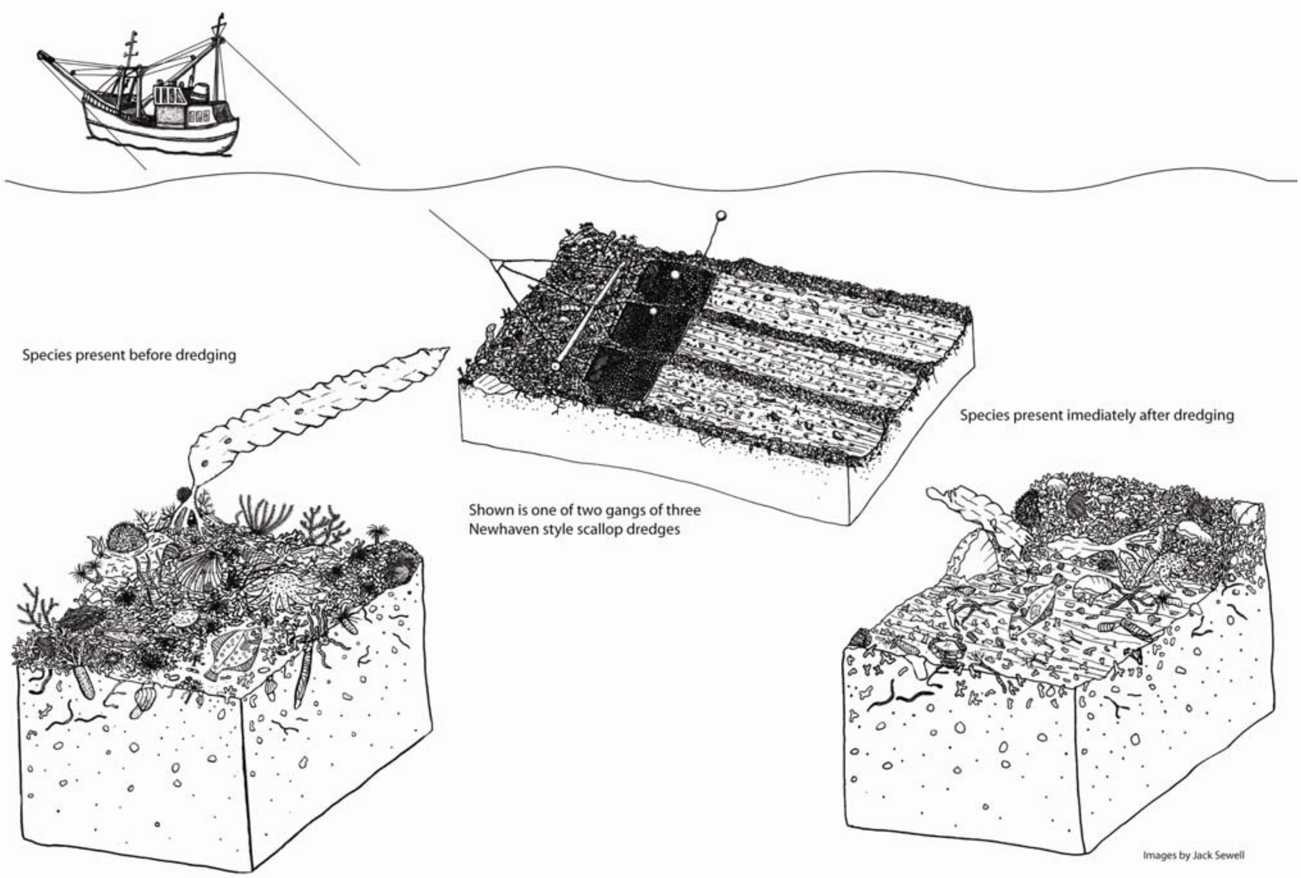


Figure 1. Potential effects of scallop dredging, on a healthy maerl bed (based on [16, 39, 114, 121]). These images are representations and species shown are more densely grouped than in real life. A large trench is formed, with sculpted ridges of debris. Large boulders are overturned and bottom features are removed. Maerl is broken into small fragments, removed or buried. Large algae, especially sugar kelp *Laminaria saccharina* are shredded and dislodged by the trawl. File shell (*Limaria hians*) nests are removed and individuals are left damaged and exposed to predators. Many large echinoderms, bivalves and flat fish are either caught in or damaged by the dredge.

Maerl beds may be severely impacted by scallop dredging[16, 39, 114, 121] (see Figure 1). Species most affected are large fragile organisms that are killed and included reefs of file shell *Limaria hians* that had not recovered after four years. For each kilogram of scallops collected, there was 8-15 kg of bycatch[114]. Furthermore, scallop dredging over maerl reduces structural heterogeneity and therefore reduces diversity of associated organisms [120].

On mixed substrata in particular, species composition in dredged areas may differ greatly compared to undredged areas. Scallop dredging may significantly reduce the number of species, number of individuals and lower biomass of macrofauna[127]. Species that appear adversely affected include hydroids, infaunal polychaetes and amphipods, crabs, erect bryozoans, large bivalves and sea urchins, brittle stars and sand eels[113, 101]. Most of the mortality to epifauna species appears to be left on the seabed dredge tracks rather than occurring as bycatch[118], indicating that through trawl samples alone, the destruction of seabed organisms may be underestimated.

In some situations, seasonal and inter-annual changes such as storm events, may be greater than those caused by dredging[3,16,44,69]. The maximum impact may not be immediate, suggesting that some indirect ecological changes such as exposed organisms becoming more vulnerable to predation, may be taking place[3]. In one study a 20-30 % decrease in abundance of most species was recorded 3.5 months after dredging, and some differences were still apparent after 8 months. In other instances, recovery may be quite rapid, for instance 6 months[130]. In another study more than 50 % of the common taxa of macrofauna were affected and significant differences from adjacent reference plots were still apparent after 3 months[88]. The collection and sorting of stones and shells by the dredge can also have an impact by removing encrusting sponges, hydroids, and small anemones and, by reducing habitat complexity may lead to increased predation on juveniles of some harvestable species[71]. Burrowing and tube dwelling infauna may be less affected than epifauna[42]. In a study carried out in the Skomer Marine Nature Reserve the numbers of sea anemones, *Cerianthus lloydii, Mesacmea mitchellii*, and the sand mason worm, *Lanice conchilega*, within and alongside dredge paths were similar to pre-dredge levels several weeks later. Fragile species such as the filigree worm, *Filograna implexa*, and ross, *Pentapora foliacea* (now *Pentapora fascialis*), appear to be particularly vulnerable[42,44]. Slow growing species will not be able to recover to pre-dredging numbers or sizes even if there is no dredging for several years if ever.

Dredged sites may also contain less attached epibenthic species, which may provide important habitats for commercially important species[98, 147]. In common with other forms of dredging, predatory fish, whelks, hermit crabs, scavenging starfish and brittlestars are attracted to the track to feed on damaged and exposed animals. For this reason, numbers of scavengers generally increases at recently dredged sites [30,33, 124,155]. Toothed dredges, including ‘rapido’ dredges, (currently used in the Mediterranean) and Newhaven style dredges may pierce and kill large, fragile organisms, particularly the fan mussel *Atrina fragilis*[123] a UK Biodiversity Action Plan species, found in soft, sheltered sediments.

Effects of scallop dredging across seagrass beds have also been investigated and show significant reduction in seagrass biomass and shoot numbers on both soft and relatively hard seabeds with the potential for both short and long-term effects on settlement of juvenile scallops and other invertebrates[85].

On gravelly seabeds around the Isle of Man, community composition has been shown to be related to the intensity of commercial dredging effort[86]. Effects may differ from those in areas of soft sediment due to the extreme patchiness of animal distribution, greater abundance of epifauna and the combined effect of the toothed gear and stones caught in the dredges. Impacts may also be apparent in lightly dredged areas, including the loss of a number of species including some potentially fragile tube-dwellers[85].

Recovery of habitats and species from these forms of dredging can take place but the timescale will vary depending on the conditions at the site and the outcome will not necessarily be identical to pre-dredging conditions[78]. Tracks are likely to become infilled, although at low energy sites this may be with fine sediment, creating some habitat variation[21].

In the bay of Fundy, Canada, scallop dredges have been used to catch sea urchins over hard substrate with large boulders. It is possible that this method may be used in UK waters. This activity results in severe damage to large kelp fronds, overturning and dislodging of boulders and decreased numbers of urchins[155].

Dredging of natural mussel beds may instantly remove large numbers of habitat forming individuals and significantly reduce the number of other species associated with the area for up to 40 days after dredging. The growth rate of remaining mussels may also be reduced by the dredging event[148].

Species do not recover immediately and, on mixed coarse sand, a period of 6 months is sometimes not sufficient[98]. However, with time, opportunistic polychaetes (bristle worms) and the surviving bivalves are thought to be likely early colonisers. Active polychaetes such as *Eteone longa* and more stable habitat species, such as *Cirriformia tentaculata*, may follow although continual disturbance will prevent recovery of communities typical of stable habitats[21].

3.2.2 Beam trawling

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), Large shallow inlets and bays (5.5), Reefs (5.6).

Beam trawling uses nets that are held open by a ‘beam’. The weight of gear and mode of deployment varies considerably: from lightweight trawls that may be used to catch shrimp to the heavy trawls that are used offshore for demersal fish.

The gear used by beam trawlers digs into the seabed leaving tracks and disturbs the surface sediments. The extent to which the seabed is affected depends on the type of fishing gear, the substratum and its physical characteristics[46, 67, 77, 78]. On sandy ground the gear may penetrate 10 mm and on muddy ground 30 mm[52], although there are also reports of tickler chains digging 60 mm into the sediment.

Analysis of by-catch data from the Netherlands beam trawl fisheries between 1965 and 1983 suggests that such fisheries had a considerable impact on the abundance of several by-catch species[72]. While the by-catch may include species of commercial value, e.g. crabs and scallops, much will be discarded. The mortality of affected species shows considerable variation – from around 10 % in starfish to 90 % in the Icelandic cyprinid, *Arctica islandica* after a single passage of a trawl. Later studies revealed similar mortalities in bivalves species with up to 68% of some species killed[111, 122]. Identifying mortality by inspecting by-catch may be misleading as the majority of mortality occurs on the seabed [111, 122]. Reefs formed by the polychaete *Sabellaria spinulosa*; beds of the eel grass, *Zostera marina*, and native oyster, *Ostrea edulis*, beds are also known to have been severely damaged by trawling and may be replaced by deposit feeding polychaetes which may influence the recovery of suspension feeding species[8,9,13,68]. However, light weight beam trawls used in brown shrimp (*Crangon crangon*) fisheries in the Wadden Sea were concluded to be incapable of damaging reefs of ross worm *Sabellaria spinulosa*: although the trawl shoes initially left impressions, they had disappeared 4-5 days after the experiment due to tube re-building by the worms[110].

The intense disturbance from repeated trawling may select for more tolerant species, with communities becoming dominated by juvenile stages, mobile species and rapid colonists[8, 68]. It can also lead to significant decreases in habitat heterogeneity[68] although in more current-swept areas, natural inter- annual changes in sediment grain size may be more pronounced than those caused by experimental trawling[69].

Changes in benthic community structure are known to occur following beam trawling but the effects can be variable[58, 77, 78]. One study which examined the effects of three

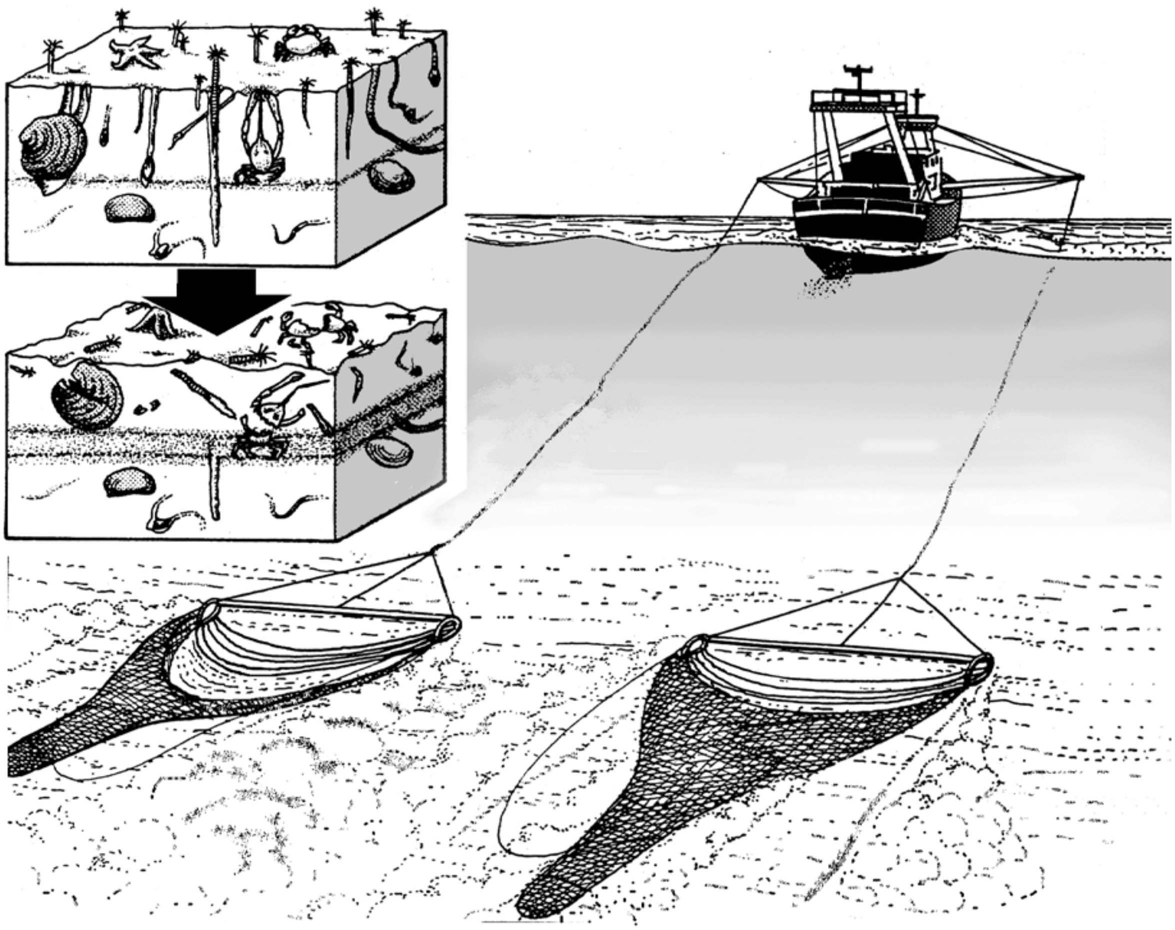


Figure 2. Illustration of the potential impacts of beam trawling on a sandy sediment community. Illustration by Alan Gilliland, published in the Daily Telegraph c. 1996. Reproduced with permission.

passages of a trawl over 2 days recorded a significant lowering of densities of echinoderms such as the common starfish, *Asterias rubens*, small sea potatoes,

Echinocardium cordatum, and of polychaete worms such as the sand mason, *Lanice conchilega*, (by 40-60 %)[1]. Decreases in the densities of small crustaceans and larger tellin shells, *Tellina fabula,* and sea potatoes were also recorded but were not as significant (10-20 %). The impact appears to be greatest on densities of small individuals, possibly because larger animals live deeper in the sediment or have better escape possibilities[1]. Some increases in numbers may also occur following beam trawling as illustrated by the considerable increase in the polychaete worms, *Magelona papillicornis*[1], *Chaetozone setosa*[74] and *Caulleriella zetlandia*[74] in various studies and, in the latter case only returning to similar numbers after 18 months with no fishing. For other species, e.g. small brittlestars, *Ophiura*, and molluscs (with the exception of *Tellina fabula*) there were no significant direct effects. The incidence of shell scars on the Icelandic cyprine, *Arctica islandica,* has been used to assess the long-term effects of beam trawling in the North Sea and shows a striking coincidence with the increased capacity of the Dutch beam trawling fleet since 1972[4].

Differences between effects in areas with different sediment characteristics are also apparent. In an area of uniform, stable, flat seabed, the abundance of 19 of the top 20 most common taxa at the site was lowered at fished sites[2]. Fragile infauna (e.g. bivalves, sea cucumbers etc) were particularly vulnerable to damage or disturbance but the abundance of sedentary and slow-moving animals was also significantly lowered. In contrast, there were no detectable differences in the diversity and abundance of taxa in areas characterised by mobile sediments and subject to frequent natural disturbance[2]. Changes in such areas may also be masked or insignificant compared to natural changes[66].

Animals damaged by beam trawling rapidly attract scavengers[2, 11, 22, 46, 78, 124]. Large numbers of whelks, *Buccinum undatum,*(98%) have been shown to survive beam trawling and they are capable of exploiting a wide variety of prey, feeding on damaged and moribund animals in the trawled areas[22]. It has been suggested that in areas of intense beam trawling, damaged animals could make up a considerable proportion of their diet. Fish such as gurnard, whiting and dogfish, and the sea urchin *Strongylocentrotus pallidus*, are also known to aggregate over beam trawl tracks to feed[11, 69]. Recent research on hermit crabs indicates that scavengers are far more selective than previously presumed and may provide a mechanism whereby fishing could change crustacean scavenger populations[65].

Areas which have been intensively trawled for several years still support profitable fisheries which would not be possible without ample benthic food. Therefore it has been suggested that it is not unlikely that the benthic community in these areas has shifted towards a dominance of highly productive, opportunistic species such as polychaetes[56, 68, 77]. At the same time the effects of bottom trawling have been described as the marine equivalent to forest clearcutting acting as a major threat to biological diversity and economic sustainability[76].

3.2.3 Otter trawling

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), Large shallow inlets and bays (5.5), Reefs (5.6). Submarine structures made by leaking gases (5.7)
Annex II, IV and birds directive species likely to be effected by this fishing type	Bottle-nosed dolphin, *Tursiops truncates* (6.4), Harbour porpoise, *Phocoena phocoena* (6.3), Grey seal, *Halichoerus grypus* and common seal (6.2) *Phoca vitulina,* Sturgeon, *Acipenser sturio* (6.5), Twaite shad, *Alosa fallax* and allis shad, *Alosa alosa* (6.7), All cetaceans (7.1), Marine turtles (7.2), Seabirds (8.2)

Otter trawls use hydrodynamics to keep the net open – water flow striking against ‘doors’ at the end of the trawl warps and angled into the direction of travel. In the case of demersal otter trawls, the passage of the trawl doors ‘mounds’ sediment as well as creating a scour furrow[94]. Tracks from otter trawls may still be visible in muddy sediments in sheltered areas after 18 months[78]. Demersal otter trawling has a negative effect on species richness and biomass. For example, on a sandy bottom, biomass of benthic species was 24% higher at untrawled sites[125].

Whilst fishermen will usually try to avoid reef areas, damage to such areas when encountered can be high. For instance, in north-western Australia, it was found that in an area of mixed substrata, on each tow of a trawl, 15.5% of benthic organisms (mainly gorgonians, sponges and soft corals) that stood higher than 20 cm off the seabed were removed[126]. There has been a clear and significant impact of deep-water trawling on reefs of the coral *Lophelia pertusa* and on other deep-water organisms in the north-east Atlantic since the 1980’s. Reefs have been observed to be severly damaged by

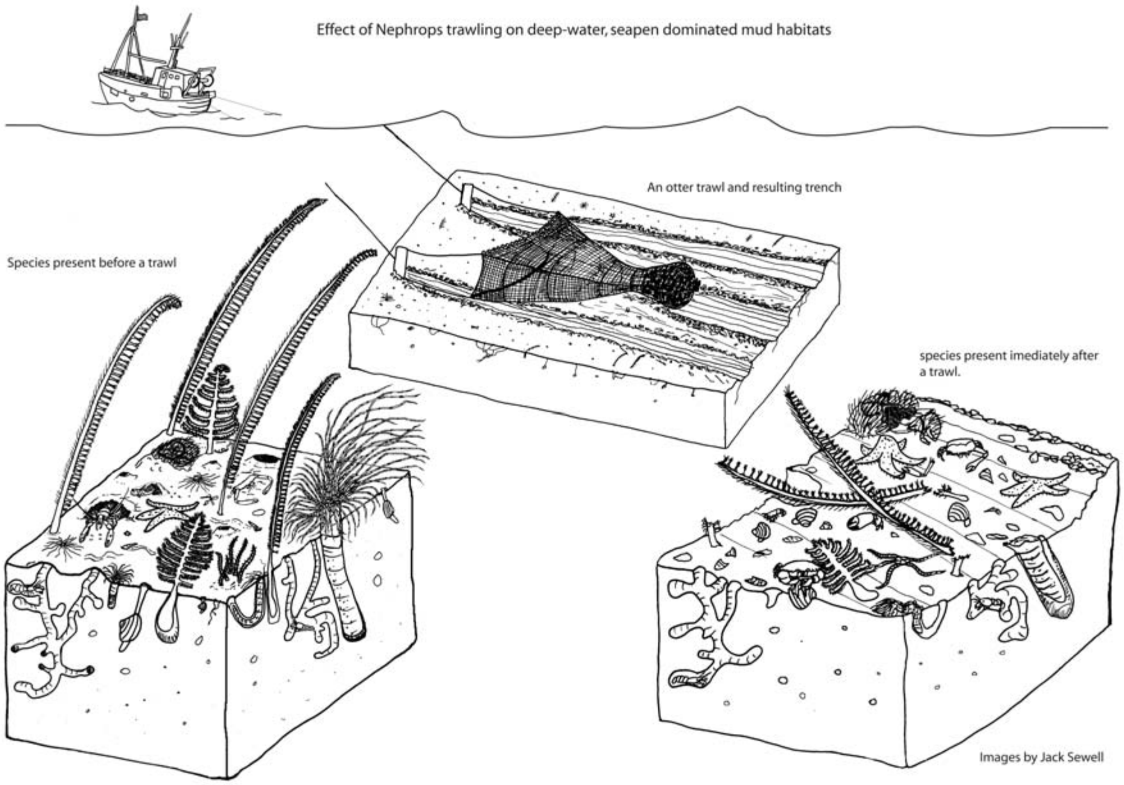


Figure 3. Diagrammatic cross-sections of sediment with infauna and the likely impact of otter trawling for *Nephrops* (scampi). These are representations and the sediment fauna is shown more crowded than in real life. Close up sections are of trenches created by trawl doors or the heavy cod-end. A detailed description of fauna represented is given at the end of the text. From Hiscock *et al.* (2005).

trawling[108, 109] and a recent review[157] has documented impacts. Tracks from otter trawls may still be visible in muddy sediments in sheltered areas after 18 months[78].

Otter trawls are used to catch Norway lobster (scampi) (*Nephrops norvegicus*) (Figure 3) and, on muddy sediments, may cause extensive damage to erect epifauna such as sea pens and burrowing anemones. Areas unfished for scampi were found to have a higher species diversity, numbers of individual organisms and biomass than fished areas: 49 species were recorded from unfished areas and 19 at fished sites[104, 112]. Large specimens of several molluscs and echinoderms were present at unfished but not fished sites.

Trawls may catch seals. For instance, 91% of trawlermen in the Clyde reported catching a seal in trawl gear rarely or occasionally – the seals almost always being dead on recovery[142].

Midwater or pelagic otter trawls and pair trawls, have no direct impact on the seabed, but may result in high levels of marine mammal bycatch[106, 115, 143, 158]. These methods may also result in bycatch of both shad species[145]. Semi-pelagic otter trawls fished just off the bottom, result in far less damage to benthic habitats than Demersal trawls and less bycatch, but may result in lower catches of target species[126].

3.2.5 Tractor harvesting for cockles

Annex I habitats that this fishing type is likely to effect	Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), Large shallow inlets and bays (5.5).
Annex II, IV and birds directive species likely to be effected by this fishing type	Seabirds(8.2), Wildfowl and waders (8.3)

Tractor-towed harvesters leave vehicle tracks as well as dredging furrows which remain visible for varying amounts of time depending on the conditions at the site[5]. In an area of stable sediment (poorly sorted fine sand) dredge tracks may be visible for long periods (more than 6 months have been recorded) whereas in more mobile sediments there may be no alteration in sediment characteristics[6]. On areas of cohesive sediment, the tracks appeared to act as lines from which erosion of the surface layer spread out. This appeared to accelerate the erosion phase of a natural cycle of cohesion of the surface sediment by worm tube mats[62]. Dredged areas often had a lot more dead shell scattered on the surface, an effect which can persist for several months. In undisturbed beds, most dead shell is normally under the surface which can create a shell layer limiting the depth to which small drainage channels can normally erode into a cockle flat[62].

The effect on infauna also depends on the exposure of the site [6,18,36]. Research suggests that in an area of stable sediments, as well as large reductions in the target species, mechanical dredging can result in a significant decline in numbers of the spire shell (*Hydrobia ulvae*) and decreased numbers of *Pygospio elegans*, a segmented worm whose tubes may be removed by the dredge[6,18, 134]. These effects may still be apparent 6 months later[6, 134]. The sand mason worm (*Lanice conchilega*), on the other hand, has more robust tubes and can retract below the depth disturbed by the dredge[18, 62] and although the distribution of white ragworm (*Nephtys hombergii*) was affected by dredging, populations have been shown to recover within six months[6]. There is evidence that tractor dredging causes a significant, short-term decline in numbers of small cockles and cockle spat [153].

3.3 Suction (hydraulic) dredging

3.3.1 Suction dredging – cockles

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), coastal lagoons (5.4) Large shallow inlets and bays (5.5).
Annex II, IV and birds directive species likely to be effected by this fishing type	Wildfowl and waders (8.3)

Suction dredgers (hydraulic continuous lift dredgers) are deployed from specially adapted or specially built shallow draft vessels and are used to harvest cockles in the Wash and Thames in particular. Depending on the stability of the sediment surface at the time and the prevailing tide or wind conditions, evidence of the tracks left by the dredge head, can persist for several months[62]. Where dredging was carried out in a sheltered area with eel grass (*Zostera*) beds, (Auchencairn Bay, Solway Firth), breaking the sward allowed erosion that produced clearly visible grooves down the shore[62]. The immediate effect of hydraulic dredging on the infauna can be significant. Studies have shown up to 30% reductions in the number of species and 50% reduction in number of individuals.

Comparison between dredged and undredged areas have shown recovery times varying from 14-56 days [93]. However, effects of hydraulic cockle dredging may last more than a year, even in dynamic systems [100].

In general the overall decrease in biomass of target species and non-target species is likely to be more pronounced in areas with stable environmental conditions and diverse communities. In sites with moderately mobile sediments it is possible for natural disturbances to have a greater effect than dredging[6, 77]. Sites with more tube dwelling and sedentary species appear to take longer to recover to pre-fishing levels than areas with more mobile fauna.

The time of year of exploitation will also influence recovery[36]. Avoiding dredging during periods of larval settlement or spawning, for example, can reduce time required for the restoration of infaunal communities. The sediment may change, at least in the short term, but how long this remains the case also depends on the exposure and stability of the site.

Effects on birds are varied. In some cases short-term increases of gulls and waders in the harvesting area, followed by a long term significant reduction in feeding opportunities for these birds has been noted[5]. In contrast, research linked to the Solway fishery concluded that because natural changes are very large the fishery may not have a significant effect on bird numbers unless a high proportion of the cockles are harvested[62].

A simulation model tested on the Exe estuary has been developed to explore the consequences of changes in fishing activities and bird numbers on commercial shellfish stocks and on the birds themselves[63]. Key predictions include that where a number of conditions apply it is possible to exploit shellfish stocks without increasing the winter mortality of shorebirds, that the effects of a given intensity of shellfishing depend crucially on local conditions of the climate and general abundance of food and that as fishing effort increases, shorebird mortality may be hardly affected initially but then may suddenly increase dramatically once a threshold level of fishing effort has been reached[63].

3.3.2 Hydraulic dredging - clams

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), coastal lagoons (5.4) Large shallow inlets and bays (5.5).
Annex II, IV and birds directive species likely to be effected by this fishing type	Wildfowl and waders (8.3)

Hydraulic dredges are predominantly used to harvest razor shells (*Ensis siliqua, Ensis ensis, Ensis arcuatus*) and some species of clam. Razor shells occur in intertidal and subtidal habitats. Owing to their relatively deep burrowing ability, adapted hydraulic cockle dredges, which allow for deeper penetration into the substrate, are required to harvest these species.

Studies have indicated that the fishing operation initially causes substantial physical disturbance to the substrate with trenches and holes throughout the fished area (0.5 - 3.5 m wide and 0.25 - 0.6 m deep)[27]. The length of time these features remain depends on the sites exposure. Tracks may be visible for a few days after dredging but not after 11 weeks[105]. In the same study, no statistically significant difference could be found in communities present in dredged and undredged areas after five days.

In another study[27], recovery to pre-fishing levels of non-target species was shown after 40 days. The effect on long lived bivalve species, which includes the target species, could be more serious – *Ensis siliqua* is estimated as living to 25 years[27].

A comparative study of the effects on *Ensis arcuatus* showed that suction dredging directly affected the size-class structure of the population and that shells from the dredged site showed signs of damage. Animals subsequently returned to the seabed were slow to re-bury and were considered to be highly vulnerable to attack from predatory crabs[79].

Experimental studies of the use of water jet dredgers concluded that there was little difference between the effects of this gear when compared to suction dredgers. In a sandy area swept by strong tidal flow where the gear was tested, trenches were created, there was fluidisation of sediments and although an immediate reduction in species abundance and biomass was apparent the biological effects were only considered to be short-term[75].

Effects of hydraulic dredging on maerl may be much more damaging and long-term. Live maerl becomes covered in silt as a result of suction dredging (up to 21 m away) and the dredge captures a high diversity and large numbers of benthic organisms including many large long-lived deep-burrowing animals and many large fragile organisms are killed[131].

3.4 Nets (bottom-set gill nets)

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), Large shallow inlets and bays (5.5), Reefs (5.6).
Annex II, IV and birds directive species likely to be effected by this fishing type	Harbour porpoise, *Phocoena phocoena* (6.3), Bottle-nosed dolphin, *Tursiops truncatus* (6.4), Twaite shad, *Alosa fallax* and allis shad, *Alosa alosa* (6.7), All cetaceans (7.1), Seabirds (8.2).

(Impacts of drift nets and of pair trawling are described in Sections 6 and 7.)

Bottom set gill nets are used to catch demersal fin fish and can result in the incidental catch of marine mammals and birds as well as non-target fish and sometimes invertebrate species such as sea fans. For instance, over the period 1990-1997, it was estimated that[116] 81-202 harbour porpoises were caught by 27 Grimsby gill netters. The mortality resulting from 30 Danish gill-netters suggested a by-catch of 3,500 to 4,500 in 1998. For the Celtic Sea (the western approaches to Britain and Ireland), it has been estimated[81] that, between August 1992 and March 1994, the total annual by-catch of 2200 porpoises was 6.2% of the estimated population of porpoises there. This high proportion raises serious cause for concern regarding the ability of the population to sustain such a level of by-catch.

Gill nets also have the potential to continue fishing after being lost or discarded, an effect which has been described as “ghost fishing”. A study into the effects of ghost nets reported catches of large number of elasmobranchs, crustaceans and fish[53]. Initially more fish were caught than crustaceans but the situation reversed by day 20. The greatest catches of crustaceans came more than a month after initial deployment of the nets. All the crustaceans caught are known to scavenge carrion. Other species such as the common starfish, *Asterias rubens*, and the brittle star, *Ophiothrix fragilis,* also aggregated to feed on animals in the nets.

The study showed that environmental conditions and the type of habitat on which the nets were lost were the main factors in affecting how long the net maintained a catching capability[53]. Nets lost in shallow water during spring and summer months when storms are infrequent could be active for up to 6 months, whereas, nets lost in winter storms are likely to have a limited life. Nets lost on fine sediment ground may only last a few weeks in reasonably good weather. Nets lost on reefs, very rocky ground or wrecks may have a longer period of activity as their meshes can snag on features and be held open. Limited observations on the fate of nets lost in deep water, where the effects of storm events will be less, indicate a continued fishing capability even after 1 year[80].

Plate 1. Scallop dredging. Maerl bed following passage of a scallop dredge, Stravanan Bay, Bute121. Image: Jason Hall-Spencer.

Plate 2. Scallop dredging. Fan mussels, *Atrina fragilis*, impaled during dredging (Mediterranean)[123]. Image: Jason Hall-Spencer.

Plate 3. Cockle suction dredger. The suction pipe is ready for deployment to the seabed. The Wash. Image: Eastern Sea Fisheries Joint Committee.

Plate 4. Setting a salmon net. Loch Buie, Harris. 1989. Image: Keith Hiscock.

Plate 5. Monofilament gill nets at Padstow Harbour. Image: Jack Sewell.

Plate 6. Sea fans, *Eunicella verrucosa*, entangled in a lost gill net. Image: Keith Hiscock.

Plate 7. Norway lobster (*Nephrops norvegicus*) creels. Balvicar, Firth of Lorn. Image: Keith Hiscock

Plate 8. Hand gathering winkles. River Yealm. Image: Keith Hiscock

Plate 9. Crab ‘tiles’ (plastic guttering), Tamar Estuary. Image: Keith Hiscock

Plate 10. Hand gathering. Hooking a lobster. Woolacombe. Image: Keith Hiscock

Plate 11. Hand gathering crawfish (*Palinurus elephas*) minimizes collateral damage compared to potting or tangle netting – but still removes crawfish. Lundy. Image: Keith Hiscock.

Plate 12. Mussel ropes at the entrance of Ob Gorm Mór, Loch Torridon. 1992. Image: Keith Hiscock.

Plate 13. Trays of Pacific oyster *Crassostrea gigas*. Image: Keith Hiscock.

Plate 14. 'Wild' Pacific oyster that have taken-over mussel beds in the Netherlands. 2004. Image: Norbert Dankers.

Plate 15. A hydraulic dredge used to capture razor clams (*Ensis* spp) from Camarthen Bay, South Wales. 2003 Image: Blaise Bullimore/CCW

Plate 16. Digging for bait. Brighton Pier, Sussex. Image: Keith Hiscock.

3.5 Pots and creels

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), coastal lagoons (5.4) Large shallow inlets and bays (5.5), Reefs (5.6). Submerged or partially submerged sea caves (5.8)
Annex II, IV and birds directive species likely to be effected by this fishing type	Otter, *Lutra lutra* (6.1), Marine turtles (7.2).

In the UK, a variety of pots and creels are used to trap crabs, lobsters, prawns and whelks. Potting (creeling) has been shown to have a limited adverse effect on epifauna[14, 119, 157]. For instance, sea pens are likely to 'bend' avoiding impact or, if uprooted, may reinsert themselves in the seabed. However, fragile species, ross *Pentapora fascialis*, are likely to be crushed. Bycatch and entanglement of marine mammals, fish and turtles is another potential problem. The use of pots or creels is thought to be far less damaging to benthic habitats than the use of mobile gears in general[98]. However, pots may cause some damage to fragile structures through impact and snagging when used over deep sea coral reefs[157]. The use of creels and pots is also known to cause mortality in coastal otter (*Lutra lutra*) populations[19, 47, 48, 49]. If pots are lost or discarded, they will continue to 'ghost fish' for many years, catching a range of commercial and non-commercial crustacean and fish species[84, 146]. Pots and their associated ropes may also entangle and drown marine turtles[171].

3.6 Collecting

3.6.1 Hand gathering on open sediment or mixed substrata – cockles, mussels, winkles, scallops

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), Large shallow inlets and bays (5.5), Reefs (5.6), Submerged or partially submerged sea caves (5.8).
Annex II, IV and birds directive species likely to be effected by this fishing type	Seabirds (8.2), Wildfowl and waders (8.3).

Hand gathering of shellfish (including use of rakes but not spades or forks) on open sediment shores or mixed substratum shores involves little substratum disturbance so that the main impact is on target species. However, disturbance to feeding and roosting birds, which is a concern in relation to bait digging on intertidal flats could also be an issue for gathering from intertidal areas.

Hand-raking for cockles results in some short-term community differences as well as damaging under-sized cockles when comparing raked and non-raked experimental plots[99, 107] Recovery appears to be rapid although, in one series of experiments, larger plots were in an altered state after 56 days. However, it was concluded[107] that effects were unlikely to be present beyond a year unless long-lived species were present. Where raking occurred in eelgrass beds no differences were found in plant biomass after two weeks between reference and experimental plots (although plant biomass was still reduced 10 months later where digging had been undertaken) [99].

In the case of collecting winkles, seaweed may be displaced and the shore fauna subject to dessication.

The use of salt to bring razor fish (*Ensis* spp) to the surface for gathering probably causes minimal disturbance although does affect the target stock and may be responsible for displacing birds whilst collectors are on the shore.

Divers may take scallops from the seabed but there will be no or very little damage to the habitat and only the stock will be reduced. Diver-gathering is an alternative to damaging scallop dredges in shallow (less than 30 m) depths.

In some areas, hand raking cockles may have associated impacts, for example, in the Solway Firth, the All terrain vehicles used by hand gatherers have been found to damage eelgrass beds and leave visible tracks in the sediment[192]. The loud noise they create is also likely to deter wildfowl, waders and seabirds from feeding in some areas. The activity may also have a greater impact when carried out on a large commercial scale, for example, in Morecombe Bay, large vessels have been used to transport cockles collected by up to 400 hand gatherers at a time from cockle beds[182]. Although no information on the effects of hand gathering at this scale could be found. Hand gathering at these levels is likely to have an impact on birds and have an impact on cockle numbers and recruitment in these areas.

3.6.2 Bait digging

Annex I habitats that this fishing type is likely to effect	Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), Large shallow inlets and bays (5.5).
Annex II, IV and birds directive species likely to be effected by this fishing type	Seabirds (8.2), Wildfowl and waders (8.3).

Bait digging is most frequently undertaken using a gardening fork to turn-over sediment in search of lug worm *Arenicola marina* or more rarely king rag *Nereis virens*. Sediments are often modified as a result of bait digging as stony substrata are brought to the surface[164]. Mechanical harvesting of bait species is likely to cause extensive and long term change including loss of target species and of associated species. For instance, mechanical lugworm dredgers operating in the Wadden Sea caused a decline in total intertidal zoobenthos biomass and the population of gaper clams, *Mya arenaria*, almost reached extinction and took five years to recover[133].

3.6.3 Crab tiling

Annex I habitats that this fishing type is likely to effect	Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), Large shallow inlets and bays (5.5)
Annex II, IV and birds directive species likely to be effected by this fishing type	Seabirds (8.2), Wildfowl and waders (8.3)

'Crab Tiling', also known as crab potting, is a method of collecting soft shore crabs (*Carcinus maenas*) for use as fishing bait for anglers. Crab tiling is a commercial activity and the shores of some estuaries are extensively laid with tiles. For instance, in Devon estuaries, 73,392 were counted in 1999-2001 which had increased by 3,685 in 2004[191]. The introduction of hard substratum will inevitably add to the habitats available to sessile and sedentary species including algae, barnacles and sea squirts especially. A study in the Menai Strait,North Wales revealed that the presence of tiles can significantly reduce species abundance, as can trampling by bait collectors, although neither impact reduce species richness or biodiversity[180]. It is also likely that the presence of large numbers of collectors on the shore will have a negative impact on numbers of feeding birds, particularly wildfowl and waders.

3.6.4 Hand gathering including boulder turning and use of hooks

Annex I habitats that this fishing type is likely to effect	Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), coastal lagoons (5.4) Large shallow inlets and bays (5.5), Reefs (5.6), Submerged or partially submerged sea caves (5.8).
Annex II, IV and birds directive species likely to be effected by this fishing type	Seabirds (8.2), Wildfowl and waders (8.3)

Boulders may be turned by anglers searching for bait, mainly crabs. In the Channel Isles, boulders are turned looking for ormers and, now that ormers have been introduced to parts of Cornwall and the Isles of Scilly, escapees or settled individuals from breeding may result, in the future, in boulder turning. Boulder turning may be highly destructive as a result of crushing on return of the boulder and of death if the boulder is not returned to its original location. Up to 90% of all boulders on a shore transect at Mumbles Head near Swansea could be turned within a two week period and some boulders may be turned 40 to 60 times during a summer[187]. Most boulders (60%) were not replaced to their original position. In the same area it was suggested that a minimum of 3,000 boulders were overturned daily during periods of reasonably low tides and that no 'serious' collector was seen to replace boulders in their original position[188].

Human presence on shores is likely to result in bird disturbance.

Underwater, divers may take lobsters, crabs and crawfish, sometimes using hooks. The damage is to the stock and there is likely to be minimal damage to the habitat or to other species. Hooks are also used to catch lobsters from deep in holes in rock. Some disturbance would be expected to attached fauna but no work has been undertaken to discover what impacts might occur.

3.6.5 Hand gathering – seaweed

Annex I habitats that this fishing type is likely to effect	Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), coastal lagoons (5.4) Large shallow inlets and bays (5.5), Reefs (5.6).
Annex II, IV and birds directive species likely to be effected by this fishing type	Seabirds (8.2), Wildfowl and waders (8.3)

The main species removed from shores are knotted wrack *Ascophyllym nodosum*, and carageen, *Chondrus crispus*. Harvesting of *Ascophyllum nodosum* will severely affect the population if the whole plant is removed. If stumps 10-20cm high are left the plants will re-sprout and harvesting is possible again in 3 to 6 years[174]. Where the whole plant is removed recovery is slow due to the slow growth rate and poor recruitment of *Ascophyllum nodosum*. Recovery from commercial harvesting of *Chondrus crispus* by drag-raking may take about 18 months but, at frequently harvested sites, the community structure may change[176, 175]. The red seaweed *Porphyra umbilicalis* is harvested and used for food. In Wales, the species is used to make 'lava bread'. However, the environmental impacts of collecting this species are not well known. The Biodiversity Action Plan species *Ascophyllum nodosum* ecad *Mackaii* (a detached form of knotted wrack), often found in sheltered bays is sometimes collected for its alginates. Collection of this species has been blamed for the 'decimation of populations' in the Uists[177].

3.7 Mariculture

3.7.1 Finfish

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), coastal lagoons (5.4), Large shallow inlets and bays (5.5), Reefs (5.6).
Annex II, IV and birds directive species likely to be effected by this fishing type	Grey seal, *Halichoerus grypus* and common seal *Phoca vitulina* (6.2), cetaceans (7.1), Seabirds (8.2)

The following text is largely from Gubbay & Knapman (1999).

Atlantic salmon (*Salmo salar*) is the most commonly farmed species although there are farms for halibut (*Hippoglossus hippoglossus*) and turbot (*Scophthalmus maxima*). Cod farming is a recent development that uses similar technology and equipment to salmon farming. The overwhelming majority of farms consist of floating cages at sea although there are some land-based farms utilising pump-ashore technology.

To date, studies have shown that the most obvious benthic impacts of finfish culture relate to the deposition of organic material (faeces and uneaten food) and dispersion of nitrogenous wastes in solution. Benthic impact has been well documented and tends to be restricted to the immediate vicinity of the cage group, with the extent and severity of impact being most pronounced at low energy locations where water exchange and/or wave action is limited. Figure 4 illustrates the sort of gradient of effect that can be expected from fin fish farm installations. Over the past few years a trend has developed in the salmon industry away from the most sheltered sites to those with greater tidal exchange which helps to ameliorate direct impact on the benthos. Studies on the recovery of the benthos following organic enrichment from salmon farming indicate varying periods of recovery depending on prevailing hydrographic conditions, with the majority of sites studied showing some recovery within two years. Clearly, pump-ashore farms offer the potential for treatment of effluent prior to discharge.

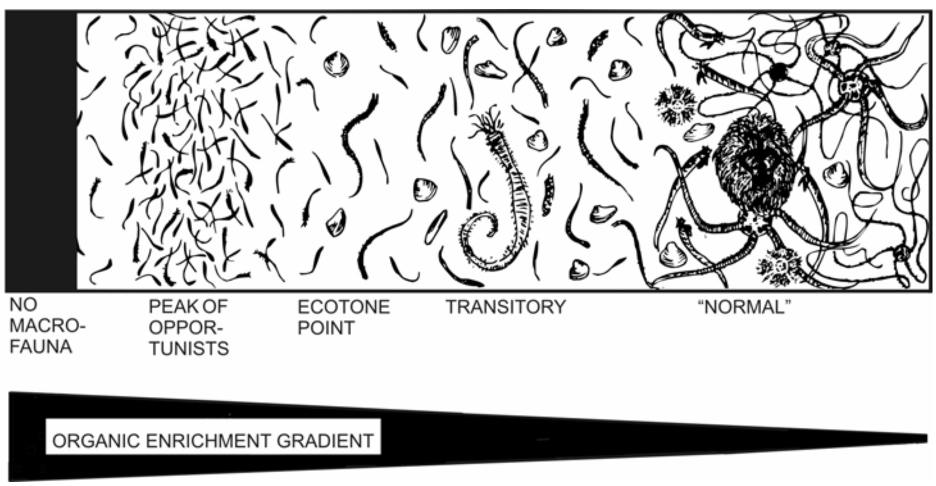


Figure 4. Diagrammatic representation of changes in abundance and species types along a generalised organic enrichment gradient (from Pearson & Rosenberg, 1978).

A further potential impact on the benthos within shallow inlets and bays arises from the use of chemicals and medicines. A variety of compounds are employed ranging from anti-fouling treatments to antibiotics and treatments for sea lice infestation of salmon. Anti-biotics are of concern due, for example, to their potential to impact on microbial processes and through the development of drug resistance in fish pathogens.

In Scotland, Discharge Consents are being granted for only azamethiphos, cypermethrin, hydrogen peroxide, emamectin benzoate and teflubenzuron. Teflubenzuron is not currently in wide use in Scotland. Hydrogen peroxide, which degrades rapidly to water and oxygen, is not considered to be a hazard to marine life[169].

Sites with restricted exchange (lagoons) can be considered most vulnerable. In-feed treatments have a direct route to the benthos via any uneaten food. Recent studies of one such compound, Ivermectin, demonstrated mortality in sediment dwelling worms with potential consequences for the recovery of the seabed [82.]

In the preliminary report[169] of a study about to be completed it was stated: "if these medicines have ecosystem effects they are either difficult to separate from the natural variability present in such systems or are below the limits of detection of the methods currently available".

3.7.2 Shellfish

Annex I habitats that this fishing type is likely to effect	Shallow sandbanks which are slightly covered by seawater all the time (5.1), Estuaries (5.2) Mudflats and sandflats not covered by seawater at low tide (5.3), Large shallow inlets and bays (5.5), Reefs (5.6)
Annex II, IV and birds directive species likely to be effected by this fishing type	Seabirds (8.2), Wildfowl and waders (8.3)

A number of different methods of shellfish cultivation are used in UK waters with issues for consideration at the seed collection, on-growing, and harvesting stages of the process[64]. Depending on the species, molluscs may be suspended in lantern nets, laid in trays or poches (large meshed sacks) on the shore, attached to ropes suspended in midwater or re-laid in more suitable areas for re-growing. In the Wadden Sea however, massive mortalities of eider ducks have been associated with greatly reduced mussel stocks as a consequence of harvesting spat for aquaculture[82]. Intertidal collection may result in some effects such as from trampling and disturbance of foraging birds.

There has also been concern about the inadvertent introduction of alien species (such as the seaweed *Sargassum muticum*, the slipper limpet *Crepidula fornicate* and the American oyster drill *Urosalpinx cinerea*: all species that have adversely affected natural communities) on shellfish which are imported or moved around the UK as seed stock for cultivation[183]. Species imported for mariculture or to boost native stocks are also likely to 'go wild'. For instance, the Pacific oyster *Crassostrea gigas*, is now frequently found on rocky shores in south-west England and populations of the oyster have taken-over areas previously productive mussel beds in the Wadden Sea (see Plate 14).

The effects of on-growing depend on the habitat, type and scale of cultivation. Changes in sediment composition and benthic community structure have been observed under long-lived cultures of *Mytilus edulis* for example. A three year study showed that faecal matter and detached mussels increased sedimentation under the lines at a rate of 10 cm/yr. The effects on the sediment under the culture were reduced grain size, high organic content and a negative Redox potential. Benthic fauna were replaced by opportunistic polychaetes and only limited recovery was observed when the site was re-sampled 6 months after harvesting[89]. In these respects the effects are similar to those beneath finfish cages.

Examination of the sediment structure and the infauna beneath Manila clam lays revealed no significant differences in particle size, organic content or photosynthetic pigment between control areas and the lays while the clams were growing[20]. There were also no significant differences in the faunal diversity beneath the lays when compared to control sites, but there was a greater density of benthic species under the lays. The infauna were dominated by deposit feeding worms, *Lanice conchilega,* and the bivalve, *Mysella bidentata*, compared to the white ragworm, *Nephtys hombergii,* in the control area. In another study, species effects were seen in the first 6 months with the infauna dominated by opportunistic species[92]. The nets used to contain the clams and provide protection from predation, increased sedimentation and settlement of green macroalgae and are likely to have had a major influence on some of the infauna[92]. Effects on benthic communities of small scale culture may be limited and localised. If the area covered is large there is potential for conflict with bird feeding or roosting sites[64].

The harvesting stage of cultivation has also raised various concerns relating to physical disturbance. Harvesting of clams by hand raking has been reported as causing a 50 % reduction in diversity and abundance of infauna[97]. Suction dredging may be another method that is used. In one study this caused an 80-90 % reduction in non-target fauna and left a trench 10 cm deep[20]. A sediment plume was created but reduced to background levels within 40 days. Regeneration of species diversity and abundance, after harvesting in the winter, was completed by the summer - a period of 7 months. Natural sedimentation had nearly restored the sediment structure to pre-harvesting conditions after 4 months suggesting that there may be minimal long term effects if sites are left to recover. In Scotland Manila clam has only been trialed; no commercial production has taken place. Restricting harvesting to early winter could ameliorate site restoration if the main mechanisms for re-colonisation are by larval settlement.

Mussels are grown on ropes suspended from buoys or rafts. Inevitably, individuals and clumps of mussels become detached and fall to the seabed where they may attract scavengers such as the common starfish *Asterias rubens.* The shells provide hard substratum where none existed previously and the ecosystem is altered.

New aquaculture enterprises are developing including rearing ormers (abalone) *Haliotus tuberculata*. This form of aquaculture exists in the Channel Islands and trials are currently underway in the south-west of England to identify the feasibility of a cultivating the species in this region. Whilst this form of aquaculture may have a relatively low direct impact, the release of these non-natives into the wild may have an impact on native communities.

Mussel seeding involves a combination of fishing from wild populations and extensive mariculture. Seed mussels are collected using a small, light-weight dredge from areas with high spat-fall and transferred to areas with low spat-fall, but superior growing conditions. Spat is taken once sufficient ‘mussel mud’ has developed beneath the mussels to allow them to be removed, without damaging the substrate bellow[178]. The collection of spat is unlikely to have a severe impact when it takes place on very unstable beds, studies have shown that when this is the case, fisheries may remove a similar amount to natural winter storms[179]. It must however be noted that mussels ‘lost’ to winter storms may not be lost, but naturally re-dispersed to more suitable areas and removal for laying may prevent natural recruitment in other areas. Mussel seed is typically re-laid in sheltered areas with suitable food supply. Such areas include estuaries and sheltered mudflats. General effects of re-locating mussels for cultivation might Include the mussels acting as a vector for the introduction of some non-native species[179]. In high concentrations, laid mussels can smother existing benthic fauna and compete for space and resources[178], there is also some concern that they may remove the planktonic larvae of other species through filter feeding and inhibit dispersal[178]. Mussel beds can provide food and a complex habitat for a wide range of other organisms, including seabird species such as oystercatchers[178]. However, the harvesting of these beds, either using mechanical dredges or by hand can remove many of the species they support[179] and can have a number of other damaging impacts on the surrounding area. Nutrient and sediment re-suspension is a potential problem, as is disturbance to birds and physical damage to organisms through trampling or abrasion[178].

Competition may exist between different types of shellfisheries and shellfish mariculture. Recently, an application was made by cockle fishermen in the Bury Inlet to remove ‘mussel mud’ from a known cockle bed. In response, a study was undertaken to identify whether this would have a negative effect on oystercatcher populations[181]. The study found that removal of the 'mussel mud' would be unlikely to have a serious impact on the birds. Further more the results of the study suggest that fishing practices that reduce the number of shellfish within a bed are less likely to impact feeding birds than those which reduce the overall area of a bed. It is suggested that this is due to increased bird density and interferance competition, likely to occur as a result of reduced bed size.

3.8 Effects of fishing types - general conclusions

Mobile fishing gear, especially where heavy or penetrating gear is used, is likely to cause damage to seabed species and habitats compared to static gear such as set nets pots or creels. However, in the case of demersal fisheries and scallop dredging, level sandy sediments have often been found to be little affected and/or to recover within a few weeks after single passes or after cessation of studies involving multiple passes. There are few studies that indicate how fishing has affected seabed communities in the long-term. In the northern Bay of Biscay, in dredge surveys, 144 species were recorded in 1966 and 150 in 2002. In 28% of re-sampled stations, the benthic community was of the same type in 2002 as 1966[144]. It is on heterogeneous habitats with shells and stones present or where the substratum is of biogenic origin that the greatest reduction in species richness and the loss of fragile often slow-growing and long-lived species occurs. In both beam trawls and otter trawls, the greatest amount of mortality is left on the seabed rather than occurring as bycatch[111, 122, 126]. A similar situation also results from scallop trawling[118].

Many papers tell the same story for mobile fishing gear as the following: "Species diversity and richness, total number of species and number of individuals all decreased significantly with increased fishing effort" [132]. No papers were found that suggested species richness or biomass increased as a result of fishing.

4. ASSESSING ENVIRONMENTAL EFFECTS

At the time the 1999 report was published, relevant literature had been brought together into the following information reviews which were directly aimed at aiding management of European Marine Sites:

- Zostera biotopes (Davison *et al*., 1998)
- Intertidal sand and mudflats & Subtidal mobile sandbanks (Elliott *et al*, 1998)
- Sea pens and burrowing megafauna (Hughes, 1998a)
- Subtidal brittlestar beds (Hughes, 1998b)
- Maerl (Birkett *et al*., 1998a)
- Intertidal reef biotopes (Hill *et al*., 1998)
- Infralittoral reef biotopes with kelp species (Birkett *et al*., 1998b)
- Circalittoral faunal turfs (Hartnoll, 1998)
- Biogenic reefs (Holt *et al*., 1998)

Those reports continue to be a valuable source of information and have been used as a part of the research noted below.

In the period since the 1999 report, identification and mapping of biotopes and biotope complexes (habitats and their associated communities of species) has become a widely used tool for environmental protection and management. At the same time, information on the likely sensitivity of biotopes has become readily available mainly through research undertaken as a part of the Marine Life Information Network (*MarLIN*:

http://www.marlin.ac.uk) Biology and Sensitivity Key Information sub-programme. *MarLIN* is a Web-based resource enabling the user to identify sensitivity (i.e. intolerance and recoverability potential) of species and biotopes to different factors which can be linked to human activities.

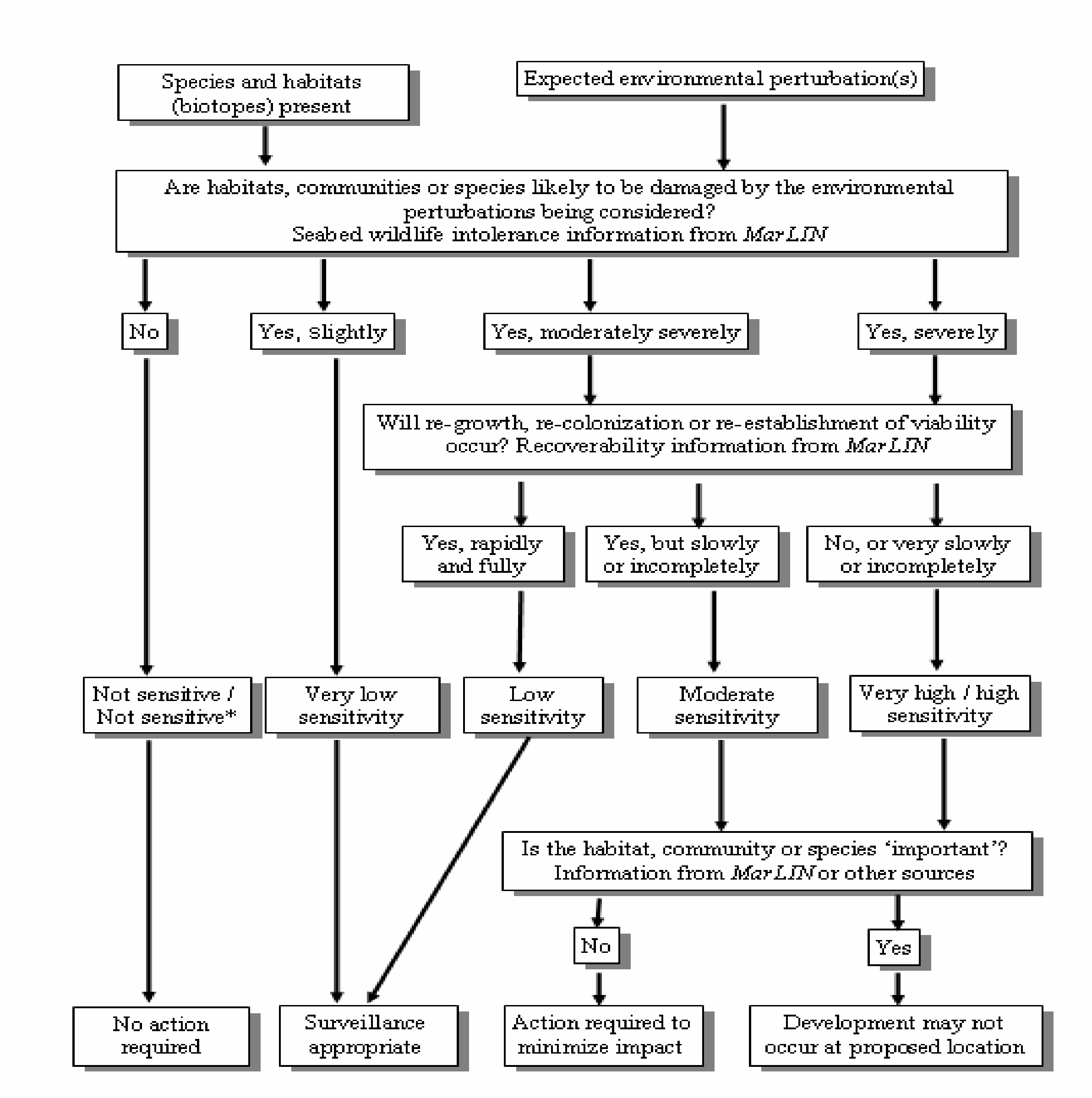


Figure 4. A decision tree that uses information available on biotopes or biotope complexes present and on sensitivity in relation to activities. From Hiscock & Tyler-Walters (in press).

With information on the biotope or biotope complexes present at a location and the sort of fishery being undertaken or planned, the *MarLIN* Web site can be interrogated to identify likely intolerance and recovery potential and therefore sensitivity of the location. It will then be possible to apply decision-making processes such as those illustrated in Figure 4.

Appendix 4 provides a 'match' between Annex I Habitats and the biotopes in the 1997 classification (Connor *et al,* 1997 a&b) and is a summary of biotope sensitivity in relation to factors likely to be brought about as a result of fishing (not including aquaculture).

5. THE POTENTIAL EFFECTS OF FISHING ON ANNEX I HABITATS IN EUROPEAN MARINE SITES

5.1 Introduction

The impacts of fishing have already been described according to gear types. This section therefore describes the fishing types likely to take place in different Annex I habitats, the likely severity of those impacts. It should be noted that information could not be found on the effects of all fishing types likely to take place in each habitat.

Current UK marine SACs are listed for each Annex I habitat and a distribution map is also shown. The grade of the feature in each SAC is shown on these maps and should be interpreted as follows:

- **A.** Outstanding examples of the feature in a European context.
- **B.** Excellent examples of the feature, significantly above the threshold for SSSI/ASSI notification but of somewhat lower value than grade A sites.
- **C.** Examples of the feature which are of at least national importance (i.e. usually above the threshold for SSSI/ASSI notification on terrestrial sites) but not significantly above this. These features are not the primary reason for SACs being selected.
- **D.** Features of below SSSI quality occurring on SACs These are non-qualifying features ("non-significant presence"), indicated by a letter D, but this is not a formal global grade.

Several Annex I habitats are habitat complexes, containing more than one sub-feature, for the purpose of this report, these sub-features are described and reference is made (where relevant) to other Annex 1 habitats containing these features. Some Annex 1 habitats are also likely to occur within other Annex 1 habitat complexes. For example; 'Mudflats and sandflats not covered at low tide' are likely to occur within 'Estuaries' or 'Large shallow inlets and bays'. Where this is the case, the reader is directed to other relevant sections of the report, to avoid the replication of text. Habitats are listed in the order they appear in the Habitats Directive.

A table at the end of each section lists the fishing types likely to take place in each habitat in UK waters, including a summary of possible effects. Several fishing types are likely to have similar effects on different habitats. The reader is therefore referred to a table summarising the effects of each fishing type in Appendix 2.

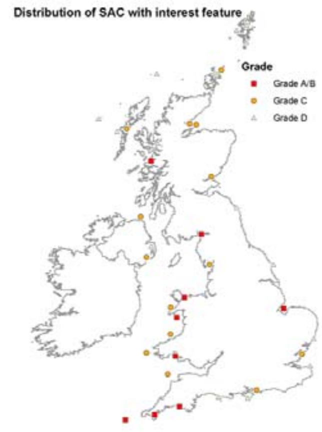
5.2 Shallow sandbanks which are slightly covered by seawater all the time

5.2.1 Introduction

"Sublittoral sandbanks, permanently submerged. Water depth is seldom more than 20 m below Chart Datum" (European Commission, 2003).

Shallow sandbanks may also occur within Estuaries (See 5.2) or Large, shallow inlets and bays (See 5.5). Shallow sandbanks may also directly connect with Mudflats and sandflats not covered by seawater at low tide (See 5.3). Shallow sandbanks can be divided into four main subtypes: gravelly and clean sands, muddy sands, seagrass (*Zostera* spp) beds and maerl beds.

SACs where Shallow sandbanks … is a primary feature	Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd, Fal and Helford, Isles of Scilly Complex, Pen Llyn a`r Sarnau / Lleyn Peninsula and the Sarnau, Plymouth Sound and Estuaries, Solway Firth, Sound of Arisaig (Loch Ailort to Loch Ceann Traigh), The Wash and North Norfolk Coast, Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay.
SACs where Shallow sandbanks … is a qualifying feature, but not a primary reason for site selection	Cardigan Bay/ Bae Ceredigion, Dornoch Firth and Morrich More, Essex Estuaries, Firth of Tay & Eden Estuary, Loch nam Madadh, Luce Bay and Sands, Lundy, Moray Firth, Morecambe Bay, Murlough, Pembrokeshire Marine/ Sir Benfro Forol, Rathlin Island, Sanday, Solent Maritime.



Distribution of UK SACs containing habitat 1110 Sandbanks which are slightly covered by sea water all the time. From: www.jncc.gov.uk.

5.2.2 Gravelly and clean sands and muddy sands

Mobile fishing (beam trawls, otter trawls and scallop dredges) mainly occurs over sediments and is likely produce the most damaging impact. Sandy sublittoral sediments have been extensively studied to identify impacts of mobile fishing gear. Many of those studies suggest little evidence of long-term trawling effects on existing benthos including in areas that had not been trawled for several years. The results of one study in a deepwater sandy bottom ecosystem, following a period of 12 years when no trawling took place suggest that trawling disturbance may mimic natural disturbance[184]. However, it has also been suggested that trawling reduces structural complexity in the habitat with consequential decrease in biodiversity[185]. Similarly, in relation to scallop trawling, "species diversity and richness, total number of species, and total number of individuals all decrease significantly with increasing fishing effort" [132]. The causes were "selective removal of sensitive species and, more importantly, habitat homogenization".

Sublittoral sediment communities that once included erect epifauna may no longer, because of trawling, be considered characterised by species such as anemones, soft corals, sponges, whelk eggs, bryozoans and ascidians that will be more abundant in unfished areas[129]. Anecdotal information (David Ainsley, pers. comm.) suggests that, where large epifaunal species such sea anemones and sea pens are present in sediments, they may be lost from an area as a result of dredging (for scallops) or trawling (for Norway lobsters). Some of those species are nationally rare (the anemone *Arachnanthus sarsii*) or scarce, the fireworks anemone *Pachycerianthus multiplicatus,* the tall sea pen *Funiculina quadrangularis*).

Where sublittoral sediment habitats are subject to natural disturbance from wave action and tidal currents, adverse effects on fauna are likely to be short-lived.

The use of pots or creels in over muddy sands is likely to have little direct environmental impact on species such as seapens as they are usually able to survive direct impact from such gears[119].

Table 1. Summary of the potential effects of fisheries on gravelly and clean sands and muddy sands.		
Fishery	**Method**	**Potential effects**
Scallops	Dredging	• Dredge tracks visible for varying amount of time, i.e. days or months. In stable conditions a relatively minor fishery may have a significant cumulative effect on bottom micro topography • Top 60 –100 mm of substrate disturbed. • Resuspension of sediment. • Many large fragile organisms killed whilst smaller more robust organisms may be largely unharmed (most of damage occurs on the seabed and little seen as by-catch). • Significant reduction in biomass of target and non target species immediately after fishing operation. Likely to be more pronounced with extended recovery times, i.e. many months, in areas with diverse communities and stable conditions. • Species diversity and richness, total number of species and numbers of individuals all decrease significantly with increased fishing effort. Where biogenic reefs – especially horse mussels – have been destroyed, recovery not observed. • Species dominance increases with increased fishing effort. • Soft or fragile species damaged or killed. • Reduce structural complexity of habitats (Lead to habitat homogenisation) and reduce biodiversity. • Large amounts of bycatch.
Razor clams	Hydraulic dredge	• Subtidal dredge tracks, deeper than a conventional hydraulic cockle dredge (e.g. 0.5 – 3.5 m wide, 0.25 – 0.6 m deep). Visible for weeks/months in mobile sediments. • Substantial physical disturbance of substratum. • Significant reduction in abundance of non-target species immediately after fishing operation. Weeks/months to recover to pre fishing levels in mobile sediment. (Other references suggest shorter-period effects.) • By-catch, Smothering and reburial of live maerl, including smothering over a large area. • Large, fragile and long-lived species may be directly killed or caught as by-catch, whilst smaller robust organisms are generally unharmed.
Demersal fish and bivalves	Mobile bottom gears (general), particularly beam-trawls, otter trawls	• Reduce structural complexity of habitat (Lead to habitat homogenisation) and reduce biodiversity. • As fishing effort increases, species diversity and richness and total number of species decrease. • Sensitive species, particularly large, fragile ones will be selectively removed. • Remove erect epifaunal species and large sessile species. • Where the habitat is naturally highly disturbed, the effects of mobile gears may be relatively short lived, but in undisturbed areas, effects will be detectable for longer. • Some muddy sand species, which are rare or nationally scarce may be completely lost from some areas as a result of fishing.
crustaceans	Pots and creels	• Will have minimal impact on large benthic fauna such as seapens.

5.2.3 Subtidal eel grass (*Zostera* spp) beds

'Shallow sandbanks' are characterized in the Directive as including areas colonized by seagrasses which might also be damaged by mobile fishing gear. Evidence for such damage has not been identified in the UK but, in parts of the Mediterranean, obstructions have been placed on the seabed to protect seagrass, *Posidonia oceanica*, from damage by trawling. The use of hydraulic dredges targeting bivalves has in the past led to the complete disappearance of areas of eel grass[192]. Subtidal eelgrass beds or sections of them may sometimes become exposed at extreme low tides. For more details of the impacts of fishing on these areas see section 5.3.1.

Table 2. Summary of the potential effects of fisheries on Subtidal eel grass (*Zostera spp*) beds.

Fishery	Method	Potential effects
Demersal fish and bivalves	Mobile bottom gears (general)	• Likely to cause physical damage to beds through abrasion, and physical removal of beds.
Bivalves	Hydraulic dredging	• Can be very damaging, has led to disappearance of beds in some areas.

5.2.4 Maerl beds

'Shallow sandbank' habitats include maerl. Maerl beds are highly susceptible to mobile fishing gear especially heavy scallop dredges[114,121] and are unlikely to recover for many years if at all. File shell reefs are also damaged by scallop dredging and may not recover[114,121]. Studies have shown that if hydraulic suction dredges are used to harvest razor clams from maerl beds, impacts can be extremely damaging. Live maerl may be buried and suspended sediment may smother beds over a wide area[131].

Table 3. Summary of the potential effects of fisheries on Maerl beds

Fishery	Method	Potential effects
Scallops	dredging	• Maerl crushed, smothered and killed and Reburial of live maerl. • Many large fragile organisms killed whilst smaller more robust organisms may be largely unharmed (most of damage occurs on the seabed and little seen as by-catch). • Loss of file shell nests. • Extensive habitat destruction and reduced habitat complexity in complex fragile habitats. • Large amounts of bycatch. • In long lived, complex biogenic habitats effects are likely to be long-lasting.
Razor clams	Hydraulic dredging	• By-catch, Smothering and reburial of live maerl, including smothering over a large area. • Large, fragile and long-lived species may be directly killed or caught as by-catch. • Smaller robust organisms generally unharmed.

5.2.5 Ross worm *Sabellaria spinulosa*

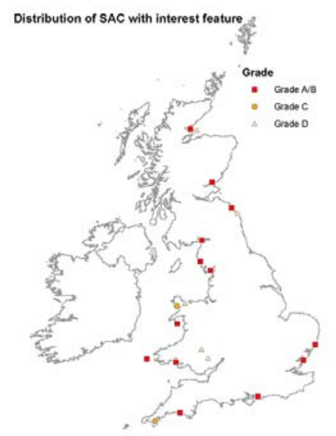
The ross worm *Sabellaria spinulosa* is likely to be present attached to cobbles or pebbles and there is a perception that ross worm is in some way 'important'. *Sabellaria spinulosa* is most frequently found in disturbed and polluted conditions and is a 'r-strategist' ("a life strategy which allows a species to deal with the vicissitudes of climate and food supply by responding to suitable conditions with a high rate of reproduction. R-strategists are continually colonising habitats of a temporary nature" (from Baretta-Bekker *et al.*, 1992)).

Re-colonization of *Sabellaria spinulosa* after disturbance by mobile fishing gear would be rapid.

Table 4. Summary of the potential effects of fisheries on Ross worm *Sabellaria spinulosa*		
Fishery	**Method**	**Potential effects**
Mixed	Mobile gears	• Due to the life history of the species, re-colonisation following disturbance would be rapid.

5.3 Estuaries

SACs where Estuaries is a primary feature	Alde, Ore and Butley Estuaries, Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd, Dornoch Firth and Morrich More, Drigg Coast, Essex Estuaries, Firth of Tay & Eden Estuary, Morecambe Bay, Pembrokeshire Marine/ Sir Benfro Forol, Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau, Plymouth Sound and Estuaries, Solent Maritime, Solway Firth, Tweed Estuary.
SACs where Estuaries is a qualifying feature, but not a primary reason for site selection	Fal and Helford, Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh.



Distribution of SACs containing habitat 1130 Estuaries. From: www.jncc.gov.uk

"Downstream part of a river valley, subject to the tide and extending from the limit of brackish waters. River estuaries are coastal inlets where, unlike 'large shallow inlets and bays' there is generally a substantial freshwater influence. The mixing of freshwater and sea water and the reduced current flows in the shelter of the estuary lead to deposition of fine sediments, often forming extensive intertidal sand and mud flats. Where the tidal currents are faster than flood tides, most sediments deposit to form a delta at the mouth of the estuary" (European Commission 2003).

As well as being physiographic features in their own right, estuaries are habitat complexes that may contain several other Annex I habitats, including Shallow sandbanks (see 5.1), eelgrass beds (see 5.1.2) and maerl beds (see 5.1.3) mudflats and sandflats (see 5.3), including *Zostera noltii* beds (see 5.3.2), reefs (see 5.6), including rock reefs (see 5.6.1) and biogenic reefs (see 5.6.2, 5.6.3, 5.6.4 & 5.6.5) and submerged or partially submerged sea caves (see 5.8). The outer parts of some estuaries may also be considered for protection as large, shallow inlets and bays (see 5.5). Estuaries may also contain the various types of salt marsh habitat, included in Annex I of the Habitats Directive, but these are not reviewed in this report.

Tidal flats, saltmarshes, areas of shingle, rocky shores, lagoons, sand dunes and coastal grassland may be elements of coastal and intertidal areas, and muddy and sandy seabed, gravels and rocky areas may be found in the subtidal zone. There is a rich source of invertebrates within the sediments of many estuaries, making them extremely productive areas as well as important feeding and overwintering grounds for waders and wildfowl (see 8.3). The UK has the largest single national area of estuaries in Europe, making up around one quarter of the total estuarine habitat of North Sea shores and the Atlantic seaboard of western Europe (Davidson *et al.,* 1991).

Estuaries are highly accessible and may be subject to a wide range of fisheries. Some of those fisheries have been pursued for hundreds of years and include salmon netting, collecting (seaweed, winkles, cockles) and dredging (especially oysters). They are also attractive for some forms of aquaculture especially oyster and clam cultivation and, in the past few years, have more-and-more been used for crab tiling. Some fishing activities in estuaries may have consequences that are unexpected or not easily predicted. For instance, oyster harvesting may significantly affect suspended sediment levels and, in Chesapeake Bay, decline in oyster stocks is considered to have had major ecosystem effects (for instance, Newell, 1988). Movement of shellfish may also result in import of non-native species[183], as happened in Strangford Lough when oysters were imported and *Sargassum muticum* 'appeared' adjacent to the oyster farm. Non-native species also introduced intentionally for aquaculture (for instance *Mercenaria mercenaria* in the Solent, *Crassostrea gigas* in a large number of estuaries) and may 'escape' into the wild and, although usually 'fitting-in' may displace native species as has happened in parts of the Wadden Sea where Pacific oysters *Crassostrea gigas* have taken over large areas (see Plate 14).

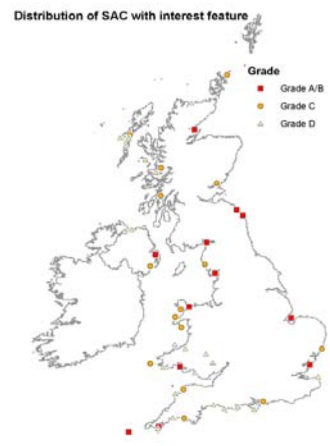
Table 5. Summary of the potential effects of fisheries on Estuaries

Fishery	Method	Potential effects
Oysters & mussels	Light dredge	• Subtidal and intertidal dredge tracks visible for varying amounts of time, i.e. Months in stable sediments, hours in mobile sediments. • Top 10-15 cm of substrate disturbed and sediment plumes created. • Change in benthic flora and fauna as a consequence of repeated dredging.
Cockle & clam	Tractor towed dredge	• Intertidal dredge tracks visible for varying amounts of time, i.e. months in stable sediments, a tide in mobile sediments. • Sediment layers may be altered causing erosion to cockle bed. • Significant reduction in abundance and biomass of target and non-target species immediately after fishing operation. Effects last more than half a year in areas with diverse communities and stable conditions. • Top 10-15 cm of substrate disturbed and sediment plumes created. • Change in benthic flora and fauna as a consequence of repeated dredging. • Bird numbers initially increased but then decreased for 50 days or more.
Cockle & clam	Hydraulic dredge	• Level seabed changed to one with furrows. • Fauna smothered and displaced. • Can be very damaging to eel grass habitat, has led to disappearance of beds in some areas.
Cockle & clam	Hand gathering (including raking)	• Holes and tailings left on the intertidal visible for varying amounts of time, i.e. Months in stable sediments, a tide in mobile sediments. • Sediment layers may be altered causing erosion to cockle bed. • Under size target species damaged or exposed to predation, desiccation or freezing. • Significant reduction in biomass of target and non-target species immediately after fishing operation. Likely to be more pronounced with extended recovery times, i.e. many months, in areas with diverse communities and stable conditions. • Disturbance of wading bird species.

		• Eelgrass beds damaged although recovery may be rapid.
Bait collecting (worms)	Digging	• Sediment re-distributed so that coarse material brought to the surface with associated changes in community structure. • Declines in abundance of some non-target species.
	Mechanical lugworm harvesting	• Total zoobenthic biomass declined and takes several years to recover. • *Mya arenaria* almost extinguished and not recovered for 5 years.
	Crab tiles	• Decrease in abundance and number of species under tiles. • Decrease in abundance of species in trampled areas.
Finfish Mariculture	Cages	• Smothering of benthic communities with faecal and waste food. • Anoxic conditions underneath cage. • Raised levels of dissolved gases, hydrogen sulphide, and ammonia. • Sublethal effects of chemical disease and sea lice treatments on lug worm. • Potential for hypernutrifiaction in low energy locations. • Mammals caught in anti-predator nets.
Oyster mariculture	Trays	• Increased sedimentation and effects on infauna beneath mussel cultures. • Deliberate (oysters) and accidental introduction of alien species.
Clam mariculture	Lays	• Manila clam cultivation in lays increases density of benthic species, changes in infauna and increased sedimentation. • Harvesting with hand raking reduces species diversity and abundance by 50%; suction dredging reduces species abundance by 80-90%. Recovery to pre-harvesting levels may take long periods e.g. 7 months. • Deliberate (clams) and accidental introduction of alien species.
Mussel cultivation	Ropes	• No specific references found. Pseudofaeces and detached mussels may change bottom type and attract scavengers such as starfish.
	Seed	• Introduction of non-native species. • Seed collection removes food of some birds. • Created mussel beds form a new habitat supporting a wide diversity of organisms. • Mussels in the seeded area are a source of food for birds. • The balance of different bird species may change.

5.4 Mudflats and sandflats not covered by seawater at low tide

SACs where Mudflats & sandflats … is a primary feature	Berwickshire and North Northumberland Coast, Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd, Dornoch Firth and Morrich More, Essex Estuaries, Fal and Helford, Morecambe Bay, Solway Firth, Strangford Lough, The Wash and North Norfolk Coast, Tweed Estuary, Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay.
SACs where Mudflats & sandflats … is a qualifying feature, but not a primary reason for site selection	Alde, Ore and Butley Estuaries, Braunton Burrows, Drigg Coast, Firth of Tay & Eden Estuary, Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh, Loch Moidart and Loch Shiel Woods, Loch nam Madadh, Luce Bay and Sands, Mòine Mhór, Murlough, Pembrokeshire Marine / Sir Benfro Forol, Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau, Plymouth Sound and Estuaries, Sanday, Solent Maritime.



Distribution of SACs containing habitat 1140 Mudflats and sandflats not covered by seawater at low tide. From www.jncc.gov.uk

5.4.1 Introduction

"Sands and muds of the coasts of the oceans, their connected seas and associated lagoons, not covered by sea water at low tide, devoid of vascular plants, usually coated by blue algae and diatoms." (European Commission 2003.)

Mudflats and sandflats occur extensively at the mouths of large rivers (the downstream parts of estuaries) and in bays. The habitat is therefore often a part of 'Estuaries' (see 5.2) and 'Large shallow inlets and bays' (See 5.5). Mudflats and sand flats can be divided into the following types; Clean sands, muddy sands and mudflats. Eel grass (Zostera) beds, exposed at low tide are also included in this habitat type. Mudflats and sand flats are also of particular importance as feeding grounds for wildfowl and waders for further information on this see section 8.3. Mudflats and sandflats may also be directly connected to sandbanks which are slightly covered by sea water all the time (see 5.1) and salt marsh habitat.

5.4.2 Clean sands, muddy sands and mudflats

On sand flats or areas of mixed substrata including gravel, pebbles and cobbles, cockle collecting may be pursued and, in recent years has become mechanized. Whilst the effects of hand gathering may be negligible or last only a few days, undersized cockles may be damaged[107], mechanical harvesting may have a significant impact on abundance and diversity of intertidal organisms and last for more than a year [100].

Bait digging is likely to occur on scales from personal use (for angling) to commercial collection. Even for personal use, bait diggers are likely to dig-over extensive areas of foreshore. Mud and sandflats are often sediment overlying coarser material that has historically sunk into the sediment or been covered by sediment. Bait digging brings deeper sediments including pebbles and cobbles to the surface and may change the substratum type and therefore the community present significantly and for ever[164]. Mechanical harvesting is likely to cause extensive change to intertidal communities that may last for several years. For example, one study indicated that it took three years for the density of lugworms and five years for the density of gaper clams *Mya arenaria* to return to pre-exploitation levels following mechanical lugworm harvesting on a tidal mudflat in the Wadden Sea[133].

Table 6. Summary of the potential effects of fisheries on Clean sands, muddy sands and mudflats

Fishery	Method	Potential effects
Cockles	Hand gathering	• Holes and tailings left on the intertidal visible for varying amounts of time, i.e. Months in stable sediments, a tide in mobile sediments. • Sediment layers may be altered causing erosion to cockle bed. • Under size target species damaged or exposed to predation, desiccation or freezing. • Significant reduction in biomass of target and non-target species immediately after fishing operation. Likely to be more pronounced with extended recovery times, i.e. many months, in areas with diverse communities and stable conditions. • Disturbance of wading bird species. • On a larger scale, hand gathering may damage undersized cockles and lead to resource depletion. • All terrain vehicles used for hand gathering may have adverse effects on habitats.
Cockles	Suction dredging	• Level seabed changed to one with furrows. • Fauna smothered and displaced.
Cockles	Tractor harvesting	• Intertidal dredge tracks visible for varying amounts of time, i.e. months in stable sediments, a tide in mobile sediments. • Sediment layers may be altered causing erosion to cockle bed. • Significant reduction in abundance and biomass of target and non-target species immediately after fishing operation. Effects last more than half a year in areas with diverse communities and stable conditions. • Top 10-15 cm of substrate disturbed and sediment plumes created. • Change in benthic flora and fauna as a consequence of repeated dredging. • Bird numbers initially increased but then decreased for 50 days or more.
Bait collecting (worms)	Bait digging by hand	• Sediment re-distributed so that coarse material brought to the surface with associated changes in community structure. • Declines in abundance of some non-target species.
	Suction dredging	• Total zoobenthic biomass declined and takes several years to recover. • Removal and loss of some slow-growing, long-lived species including *Mya arenaria* almost extinguished and not recovered for 5 years.
Crustaceans	Tiles	• Decrease in abundance and number of species under tiles. • Decrease in abundance of species in trampled areas.
Oyster mariculture	Trays	• Increased sedimentation and effects on infauna beneath mussel cultures. • Deliberate (oysters) and accidental introduction of alien species.
Clam mariculture	Lays	• Manila clam cultivation in lays increases density of benthic species, changes in infauna and increased sedimentation. • Harvesting with hand raking reduces species diversity and abundance by 50 %; suction dredging reduces species abundance by 80-90%. Recovery to pre-harvesting levels may take long periods e.g. 7 months. • Deliberate (clams) and accidental introduction of alien species.

Mussel cultivation	Seed	• Introduction of non-native species. • Seed collection removes food of some birds. • Created mussel beds form a new habitat supporting a wide diversity of organisms. • Mussels in the seeded area are a source of food for birds. • The balance of different bird species may change.

5.3.3 Intertidal eel grass (*Zostera noltii*) beds

Intertidal eel grass beds often occur on mudflats and areas of intertidal sand. Usually in estuaries or other sheltered locations. They are potentially vulnerable to trampling by bait collectors and clam and cockle digging or raking. Studies have shown that while raking is less damaging to eel grass beds than digging, both can potentially lead to loss of plant biomass in eel grass beds [99].

In the Solway Firth, Scotland, fishers gathering cockles by hand use all terrain vehicles, which leave deep tracks through eelgrass beds although the long-term impact of this is not certain[191].

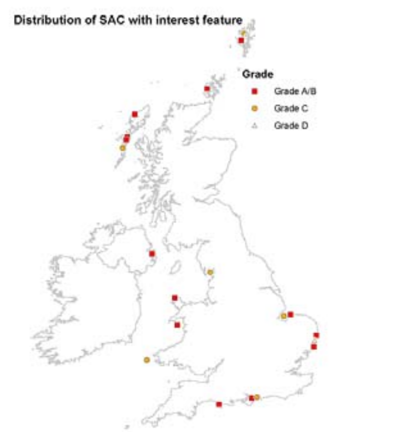
Table 7. Summary of the potential effects of fisheries on Intertidal eel grass (*Zostera noltii*) beds

Fishery	Method	Potential effects
Clams and cockles	Hand gathering, raking and digging	• Raking is potentially less damaging to eel grass beds than digging, but both may result in the loss of plant biomass. • Eelgrass beds damaged although recovery may be rapid. • ATVs used to access hand gathering sites may cause damage to eel grass beds.
Cockle & clam	Hydraulic dredge	• Can be very damaging to eel grass habitat, has led to disappearance of beds in some areas.

5.5 Coastal lagoons

"Lagoons are expanses of shallow coastal salt water, of varying salinity and water volume, wholly or partially separated from the sea by sand banks or shingle, or, less frequently, by rocks. Salinity may vary from brackish water to hypersalinity depending on rainfall, evaporation and through the addition of fresh seawater from storms, temporary flooding of the sea in winter or tidal exchange"(European Commission 2003).

SACs where Coastal lagoons is a primary feature	Bae Ceylon/ Cemlyn Bay, Benacre to Easton Bavents Lagoons, Chesil and the Fleet, Loch nam Modish, Loch of Stenness, Loch Roag Lagoons, North Norfolk Coast, Obain Loch Euphoirt, Orfordness – Shingle Street, Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau, Solent and Isle of Wight Lagoons, Strangford Lough, The Vadills.
SACs where Coastal lagoons is a qualifying feature, but not a primary reason for site selection	Morecambe Bay, Pembrokeshire Marine/ Sir Benfro Forol, Solent Maritime, South Uist Machair, Sullom Voe, The Wash and North Norfolk Coast.



Distribution of SACs containing habitat 1150 Coastal lagoons. From www.jncc.gov.uk

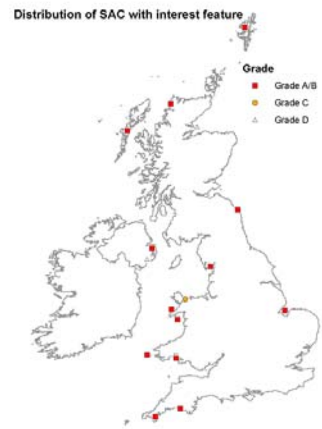
Commercial fisheries are rare in lagoons although some aquaculture does take place. Lagoons are more vulnerable to aquaculture related impacts than shallow inlets and bays or estuaries due to their restricted water exchange. Some types of lagoon may contain commercial species of bivalve mollusc and algae as well as some invertebrate species commonly collected as fishing bait. There is little evidence about how the exploitation of these resources may affect this type of habitat specifically, although impacts similar to those observed in other habitat types are possible. These habitats may also contain eelgrass beds (see 5.1.2 & 5.3.2).

Table 8. Summary of the potential effects of fisheries on Coastal lagoons

Fishery	Method	Potential effects
Cockle & clam	Hand gathering (including raking)	• Holes and tailings left on the intertidal visible for varying amounts of time, i.e. Months in stable sediments, a tide in mobile sediments. • Sediment layers may be altered causing erosion to cockle bed. • Under size target species damaged or exposed to predation, desiccation or freezing. • Significant reduction in biomass of target and non-target species immediately after fishing operation. Likely to be more pronounced with extended recovery times, i.e. many months, in areas with diverse communities and stable conditions.
Winkles	Hand collecting	• Harvesting may reduce numbers, average size of winkles. No specific habitat effects were found during this report.
Bait collecting (worms)	Digging	• Sediment re-distributed so that coarse material brought to the surface with associated changes in community structure. • Declines in abundance of some non-target species.
Seaweed collection	Hand collecting	• Reduced protection from desiccation of underflora and fauna. • Decimation of populations of some species of seaweed (particularly *Ascophyllum nodosum* ecad *Mackaii*).
Finfish Mariculture	Cages	• Smothering of benthic communities with faecal and waste food. • Anoxic conditions underneath cage. • Raised levels of dissolved gases, hydrogen sulphide, and ammonia. • Sublethal effects of chemical disease and sea lice treatments on lug worm. • Potential for hypernutrifiaction in low energy locations. • Mammals caught in anti-predator nets. • In very sheltered areas with poor water exchange, effects are likely to be amplified.
Oyster mariculture	Trays	• Increased sedimentation and effects on infauna beneath mussel cultures. • Deliberate (oysters) and accidental introduction of alien species. • In very sheltered areas with poor water exchange, effects are likely to be amplified.
Mussel cultivation	Ropes	• No specific references found. Pseudofaeces and detached mussels may change bottom type and attract scavengers such as starfish. • In very sheltered areas with poor water exchange, effects are likely to be amplified.
	Seed	• Introduction of non-native species. • Seed collection removes food of some birds. • Created mussel beds form a new habitat supporting a wide diversity of organisms. • Mussels in the seeded area are a source of food for birds. • The balance of different bird species may change.
Crustaceans	Hand gathering (incl. hooks)	• Rocks may be overturned and not replaced. • Some disturbance to birds. • Danger of some abrasion from hooks.

5.6 Large shallow inlets and bays

SACs where Large shallow inlets and bays is a primary feature	Berwickshire and North Northumberland Coast, Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd, Fal and Helford, Loch Laxford, Loch nam Madadh, Luce Bay and Sands, Morecambe Bay, Pembrokeshire Marine/ Sir Benfro Forol, Pen Llyn a`r Sarnau / Lleyn Peninsula and the Sarnau, Plymouth Sound and Estuaries, Strangford Lough, Sullom Voe, The Wash and North Norfolk Coast.
SACs where Large shallow inlets and bays is a qualifying feature, but not a primary reason for site selection	Y Fenai a Bae Conwy / Menai Strait and Conwy Bay.



Distribution of SACs containing habitat 1160 Large shallow inlets and bays.

"Large indentations of the coast where, in contrast to estuaries, the influence of freshwater is generally limited. These shallow* indentations are generally sheltered from wave action and contain a great diversity of sediments and substrates with a well developed zonation of benthic communities. These communities have generally a high biodiversity. The limit of shallow water is sometimes defined by the distribution of the *Zosteretea* and *Potametea* associations." (European Commission 2003).

*In the UK "shallow" is interpreted as a depth of less than 30 m below Chart Datum and depths would be shallower than 30 m across at least 75% of the site.

There are three sub-types of this habitat complex relevant to the UK, these are: embayments, fjardic sea-lochs and rias (voes in Shetland).

This habitat complex may contain several other Annex I habitats, including; Sandbanks which are slightly covered by sea water all the time (see 5.1), including eelgrass beds (see 5.1.2), maerl beds (see 5.1.3), Mudflats and sandflats not covered by sea water at low tide (see 5.3), Reefs (see 5.6), including rock reefs (see 5.6.1) and biogenic reefs (see 5.6.1, 5.6.2, 5.6.3, 5.6.4 & 5.6.5) and submerged or partially submerged seacaves (see 5.8) The outer parts of some very large estuaries (see 5.2) may also be included in this habitat complex. Impacts specific to these other habitats have been omited from this section and the reader is directed to these sections for fishing types likely to occur in these habitats for further information. Other habitat types, not included elsewhere in the Habitats Directive may also occur within this habitat complex. Deep sediment habitats (5.10) may also occur to some extent in this habitat complex, particularly in some Scottish sea lochs.

Virtually all of the fishing types identified in this study could take place in large shallow inlets and bays and inlets are also suitable for finfish cages, oyster cultivation and mussel cultivation.

Habitats such as horse mussel beds, maerl beds(5.2.4), file shell (*Limaria hians*) reefs, *Sabellaria spinulosa* reefs and eel grass beds occur in the sublittoral parts of Large shallow inlets and bays and they may be especially vulnerable to mobile fishing gear. For instance, the horse mussel beds in Strangford Lough cSAC have been virtually destroyed in the past few years as a result of scallop dredging[159,162]. Damage by mobile fishing gear to *Sabellaria spinulosa* reefs appears largely speculative and research suggests that the sort of gear used to catch prawns is too light to cause other than superficial damage to reefs[110]. There is information pointing to the former presence of *Sabellaria spinulosa* reefs along the margins of the Lune Channel where there are records of *Sabellaria* reef being pulled up by the fishermen. The reefs appear to have disappeared some time ago, allegedly as a result of the pink shrimp fishery which is practised in the same area, using bottom towed gear (Chris Lumb, pers.comm.). Fishing gear used on level sediment seabeds is likely to result in some damage to wildlife but recovery will most likely to within a few days, weeks or months. Static gear fisheries are also pursued in Shallow inlets and bays including the use of set nets, pots (creels) and angling. Nets may entangle seabed species and 'ghost fishing' by lost nets results in continued mortality of fish, crustaceans and sessile species such as sea fans.

Table 9. Summary of the potential effects of fisheries on Large shallow inlets and bays

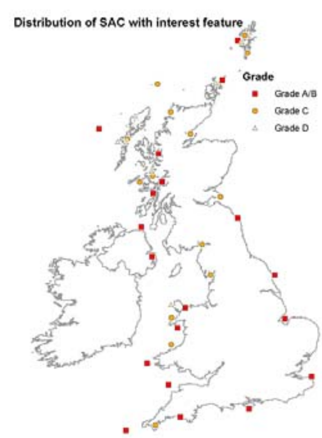
Fishery	Method	Potential effects on habitats
Scallops	Dredging	• Resuspension of sediment. • Many large fragile organisms killed whilst smaller more robust organisms may be largely unharmed (most of damage occurs on the seabed and little seen as by-catch). • Significant reduction in biomass of target and non target species immediately after fishing operation. Likely to be more pronounced with extended recovery times, i.e. many months, in areas with diverse communities and stable conditions. • Species diversity and richness, total number of species and numbers of individuals all decrease significantly with increased fishing effort. Where biogenic reefs – especially horse mussels – have been destroyed, recovery not observed. • Species dominance increases with increased fishing effort. • Fan mussels Atrina fragilis damaged, displaced or impaled. • Reduce structural complexity of habitats (Lead to habitat homogenisation) and reduce biodiversity. • Large amounts of bycatch.
Oysters & mussels	Light dredge	• Subtidal and intertidal dredge tracks visible for varying amounts of time, i.e. Months in stable sediments, hours in mobile sediments. • Top 10-15 cm of substrate disturbed and sediment plumes created. • Change in benthic flora and fauna as a consequence of repeated dredging.
Demersal fin fish	Beam trawling	• Trawl tracks visible for varying amount of time, i.e. Days or months. • Top 10 – 60 mm of substrate disturbed. • Non-target organisms caught and die as discards. • Influx of scavenging species post fishing operation. • Over fishing reduces food availability for seabirds. • Resuspension of sediment. • Sediment structure may change from coarse grained sand/gravel to fine sand/coarse silt. • Reduced diversity, abundance and biomass of sediment infauna. • Significant reduction in biomass of target and non-target species immediately after fishing operation. Likely to be more pronounced with extended recovery times, i.e. many months, in areas with diverse communities and stable conditions. • Considerable variation in damage or mortality to affected species. Fragile, long-lived, slow moving or sedentary species most vulnerable.

		• Repeated trawling may cause benthic community structure to change, favouring more mobile species, rapid colonisers and juvenile stages.
Demersal fin fish	Otter trawling	• Similar effects to beam trawling although severe adverse effects generally less. • Significantly lower amount of epifauna at fished locations.
Norway lobster (Nephrops)	Otter trawling	• Reduction in species diversity, number of individuals and biomass. • Loss of large epifauna species such as tall sea pens *Funiculina quadrangularis* and fireworks anemones *Pachycerianthus multiplicatus*.
Cockle & clam	Hydraulic dredge	• Level seabed changed to one with furrows. • Fauna smothered and displaced.
Razor clams	Hydraulic dredge	• Subtidal dredge tracks, deeper than a conventional hydraulic cockle dredge (e.g. 0.5 – 3.5 m wide, 0.25 – 0.6 m deep). Visible for weeks/months in mobile sediments. • Substantial physical disturbance of substratum. • Significant reduction in abundance of non-target species immediately after fishing operation. Weeks/months to recover to pre fishing levels in mobile sediment. (Other references suggest shorter-period effects.)
Demersal fish and bivalves	Mobile gears (general)	• Reduce structural complexity of habitat (Lead to habitat homogenisation) and reduce biodiversity. • As fishing effort increases, species diversity and richness and total number of species decrease. • Remove erect epifaunal species and large sessile species. • In undisturbed areas, effects will be detectable for longer. • Some muddy sand species, which are rare or nationally scarce, may be completely lost from some areas as a result of fishing. • Large, fragile and long-lived species may be directly killed or selectively removed, whilst smaller robust organisms are generally unharmed.
Demersal and Pelagic fish	Fixed or drift (gill) nets	• 'Ghost fishing', dependent on condition of gear. In rocky, less exposed areas may be active for months, on clean exposed ground, days to weeks.
Crustaceans	Tangle nets	• No specific references found. Danger of snagging and removing attached benthic organisms and of ghost fishing if lost.
Crustaceans	Pots / creels	• Fragile, brittle species such as ross, Pentapora fascialis, crushed when pots make contact. • 'Ghost fishing' – parlour pots can continue to fish in excess of 270 days. A cycle of capture, decay and attraction of species of commercial and non-commercial interest takes place. • Will have minimal impact on large benthic fauna such as seapens and seafans.
Cockle & clam	Hand gathering (including raking)	• See 'estuaries' and 'mudflats and sandflats not covered by seawater at low tide'
Winkles	Hand collecting	• Harvesting may reduce numbers, average size of winkles. No specific habitat effects were found during this report.
Bait collecting (worms)	Digging	• See 'estuaries' and 'mudflats and sandflats not covered by seawater at low tide'
	Mechanical lugworm harvesting	• See 'estuaries' and 'mudflats and sandflats not covered by seawater at low tide'
Crustaceans	Tiles	• See 'estuaries' and 'mudflats and sandflats not covered by seawater at low tide'
	Hand gathering	• Rocks may be overturned and not replaced.

	(incl. hooks)	• Some disturbance to birds.
Seaweed collection	Hand collecting	• Reduced protection from desiccation of underflora and fauna. • Decimation of populations of some species of seaweed (particularly *Ascophyllum nodosum* ecad *Mackaii*)
Finfish Mariculture	Cages	• Smothering of benthic communities with faecal and waste food. • Anoxic conditions underneath cage. • Raised levels of dissolved gases, hydrogen sulphide, and ammonia. • Sublethal effects of chemical disease and sea lice treatments on lug worm. • Potential for hypernutrifiaction in low energy locations. • In very sheltered areas with poor water exchange, effects are likely to be amplified.
Oyster mariculture	Trays	• Increased sedimentation and effects on infauna beneath mussel cultures. • Deliberate (oysters) and accidental introduction of alien species. • In very sheltered areas with poor water exchange, effects are likely to be amplified.
Clam mariculture	Lays	• Manila clam cultivation in lays increases density of benthic species, changes in infauna and increased sedimentation. • Harvesting with hand raking reduces species diversity and abundance by 50 %; suction dredging reduces species abundance by 80-90%. Recovery to pre-harvesting levels may take long periods e.g. 7 months. • Deliberate (clams) and accidental introduction of alien species.
Mussel cultivation	Ropes	• No specific references found. Pseudofaeces and detached mussels may change bottom type and attract scavengers such as starfish.
	Seed	• See 'estuaries' and 'mudflats and sandflats not covered by seawater at low tide'

5.7 Reefs

SACs where Reefs is a primary feature	Berwickshire and North Northumberland Coast, Firth of Lorn, Flamborough Head, Isles of Scilly Complex, Loch Creran, Lochs Duich, Long and Alsh Reefs, Lundy, Papa Stour, Pembro keshire Marine/ Sir Benfro Forol, Pen Llyn a`r Sarnau / Lleyn Peninsula and the Sarnau, Plymouth Sound and Estuaries, Plymouth Sound and Estuaries, Rathlin Island, Sanday, Y Fenai a Bae Conwy / Menai Strait and Conwy Bay, The Wash and North Norfolk Coast, South Wight Maritime, Thanet Coast, Strangford Lough, St Kilda.
SACs where Reefs is a qualifying feature, but not a primary reason for site selection	Cardigan Bay/ Bae Ceredigion, Dornoch Firth and Morrich More, Fal and Helford, Isle of May, Loch Laxford, Loch nam Madadh, Luce Bay and Sands, Morecambe Bay, Mousa, North Rona, Solway Firth, Sullom Voe, Sunart, Treshnish Isles.



Distribution of SACs containing habitat 1170 Reefs. From www.jncc.gov.uk

5.7.1 Introduction

"Submarine, or exposed at low tide, rocky substrates and biogenic concretions, which arise from the sea floor in the sublittoral zone but may extend into the littoral zone where there is an uninterrupted zonation of plant and animal communities. These reefs generally support a zonation of benthic communities of algae and animals species including concretions, encrustations and corallogenic concretions" (European Commission 2003).

This habitat definition may also include stable boulders and cobbles. Reefs are often highly complex, habitats, including overhangs, gullies, walls, outcrops and rockpools. They may also be associated with sea caves (see 5.8) and included in estuaries (see 5.2), coastal lagoons (see 5.4) and large shallow inlets and bays (see 5.5). For the purpose of this report, five types of biogenic reef are considered separately to 'rock reefs'.

5.7.2 Rock reefs

Sublittoral rock reefs are mainly fished using static gear (especially pots/creels) for crustaceans. Traps may 'catch' on sessile organisms and displace them and are known to crush fragile colonies of ross, *Pentapora fascialis*[14,119]. There is some diver collection of crustaceans which is likely to cause minimal co-lateral damage but may significantly reduce stocks of large crustaceans. Tangle nets are used to catch crawfish and sessile invertebrate species may also be tangled and removed. Reefs may be affected by mobile fishing gear where they are low-lying and do not pose a threat to the gear. In Lyme Bay, such fishing had a substantial impact on reef communities including populations of sea fans. This is particularly the case if the rock is relatively soft, making them vulnerable to structural damage as well as removal of epifauna, as shown by a study in Lyme Bay, South Devon[12] which showed that hydroids, anemones, corals, bryozoans, tunicates and echinoderms are vulnerable to mobile fishing gear.

Scallop dredging may 'work' sand gullies amongst reef areas and significant damage to reef communities may be caused, for instance in the Firth of Lorn cSAC (video evidence collected by David Ainsley, pers. comm.).

Intertidal reefs are subject to bait collection and collection of large crustaceans. Where collection involves boulder-turning, substantial damage may be done as boulders are often not returned to their original position[187, 188]. In the early 1990's, there were reports that chalk reefs were being broken-up to collect piddocks for the restaurant trade. No evidence has been found to suggest that this practice continues. Destruction of reefs to collect *Lithophaga lithophaga* in the Mediterranean led to disappearance of epibiota and patchy distribution of communities[186].

Table 10. Summary of the potential effects of fisheries on rock reefs

Fishery	Method	Potential effects
Scallops (sometimes sea urchins)	Dredging	• Relatively soft rocky outcrops can be subject to physical damage. • Soft or fragile species damaged or killed. • Reduce structural complexity of habitats (Lead to habitat homogenisation) and reduce biodiversity. • May cause damage to large algae such as kelp.
Demersal fish and bivalves	Mobile gears (general)	• Reduce structural complexity of habitat (Lead to habitat homogenisation) and reduce biodiversity. • Remove erect epifaunal species and large sessile species. • Physical damage may be caused to fragile structures. • Large, fragile and long-lived species may be directly killed or selectively removed, whilst smaller robust organisms are generally unharmed. •

Crustaceans	Tangle nets	• No specific references found. Danger of snagging and removing attached benthic organisms and of ghost fishing if lost.
Crustaceans	Pots / creels	• Fragile, brittle species such as ross, *Pentapora fascialis*, crushed when pots make contact. • 'Ghost fishing' – parlour pots can continue to fish in excess of 270 days. A cycle of capture, decay and attraction of species of commercial and non-commercial interest takes place. • Will have minimal impact on large benthic fauna such as seapens and seafans.
Winkles	Hand collecting	• Harvesting may reduce numbers, average size of winkles. No specific habitat effects were found during this report.
Rock boring bivalves	Hand collection	• Destroying rocks to extract rock boring bivalves such as paddocks may lead to disappearance of epibiota and patchy communities.
Crustaceans	Hand gathering	• Rocks may be overturned and not replaced. • No specific references found for the use of hooks, although this may cause some abrasion. • Collection of large crustaceans by divers may significantly reduce populations of target species.
Seaweed collection	Hand collecting	• Reduced protection from desiccation of underflora and fauna.

5.7.3 Biogenic reefs (honeycomb worms, *Sabellaria alveolata*)

Honeycomb worm reefs are easily damaged by physical impact associated with trampling and bait collection[177]. The worms are also occasionally gathered by anglers for use as bait[177]. The extent to which these factors are likely to pose a threat to reefs is not yet known. There is evidence that following physical damage, the worms are often unaffected and are able to re-build tubes rapidly[189]. It has been suggested that reefs may also be able to withstand the impact of a lightweight beam trawl as used to catch shrimp[110]. Although studies have only been carried out on a small scale, allowing the worms time to rebuild damaged tubes and the effect of repeated trawling may be far more damaging.

Table 11. Summary of the potential effects of fisheries on Biogenic reefs (honeycomb worms, *Sabellaria alveolata*)

Fishery	Method	Potential effects
Shrimp	Lightweight beam trawl	• Reefs may be able to withstand occasional trawls. • The effects of repeated trawls may be more damaging.
Bait collecting (worms)	Removal of worms from Sabbelaria alveolata reefs.	• Removal of worms does occur on a small scale, but effects of removal are unknown. • Trampling by bait collectors may damage structures, but worms are able to rebuild and recover quickly.

5.7.4 Biogenic Reefs (mussels, *Mytilus edulis*)

Mussel (*Mytilus edulis*) beds are subject to dredge fisheries and to hand collecting. They are important commercially in several estuaries and in the Wash in the UK. In the Netherlands, some commercial mussel beds have been overwhelmed by the non-native oyster *Crassostrea gigas* which, although a food species and likely to provide the same ecological niche and 'goods and services' as mussels, makes solid masses of sharp shells that are not collectable (Norbert Dankers, pers. comm).

Table 12. Summary of the potential effects of fisheries on Biogenic Reefs (mussels, *Mytilus edulis*)		
Fishery	**Method**	**Potential effects**
mussels	Light dredge	• Subtidal and intertidal dredge tracks visible for varying amounts of time, i.e. Months in stable sediments, hours in mobile sediments. • Top 10-15 cm of substrate disturbed and sediment plumes created • Change in benthic flora and fauna as a consequence of repeated dredging.
Oyster mariculture	Trays	• Deliberate (oysters) and accidental introduction of alien species. • Where non-native oysters become established, they may smother existing species (particularly mussel reefs).

5.7.5 Biogenic Reefs (ross worms, *Sabellaria spinulosa*)

Reefs of the tube worm *Sabellaria spinulosa* are unusual – more often, the worms occur as separated individuals or crusts colonising mobile or sand-scoured substrata. Where reefs occur, they form robust structures. There is information pointing to the former presence of *Sabellaria spinulosa* reefs along the margins of the Lune Channel where there are records of *Sabellaria* reef being pulled up by the fishermen (although the species is not recorded). The reefs appear to have disappeared some time ago, allegedly as a result of the pink shrimp fishery which is practised in the same area, using bottom towed gear (Chris Lumb, pers.comm). As for *Sabellaria* alveolata reefs, It has been suggested that reefs may also be able to withstand the impact of a lightweight beam trawl as used to catch shrimp[110]. Although studies have only been carried out on a small scale, allowing the worms time to rebuild damaged tubes and the effect of repeated trawling may be far more damaging.

Table 13. Summary of the potential effects of fisheries on Biogenic Reefs (ross worms, *Sabellaria spinulosa*)		
Fishery	**Method**	**Potential effects**
Shrimp	Lightweight beam trawl	• Sabellaria reefs may be able to withstand occasional trawls. • The effects of repeated trawls may be more damaging. • Shrimp trawls have, in the past been blamed for the disappearance of Sabellaria spinulosa reefs.

5.7.6 Biogenic Reefs (horse mussels, *Modiolus modiolus*)

Horse mussel beds occur in the UK predominantly on level sedimentary seabed. The queen scallop *Aequipecten opercularis* is a targeted fishery that uses heavy dredges. Although dredges may glide over some horse mussel reefs, large areas of horse mussels have been lost in the Irish Sea[132] at least and the horse mussel reefs in the Strangford Lough cSAC have been virtually destroyed[159, 162].

Table 14. Summary of the potential effects of fisheries on Biogenic Reefs (horse mussels, *Modiolus modiolus*)		
Fishery	**Method**	**Potential effects**
Scallops	Dredging	• *Modiolus modiolus* reefs and associated fauna and flora damaged or destroyed. • Resuspension of sediment. • Where horse mussels reefs have been destroyed, recovery not

		observed. • Species dominance increases with increased fishing effort. • Reduce structural complexity of habitats (Lead to habitat homogenisation) and reduce biodiversity. • In long lived, complex biogenic habitats such as this effects are likely to be long-lasting.

5.7.7 Biogenic Reefs (deep water coral reefs)

Deep-water reefs are damaged or destroyed by otter trawling[157, 108, 109, 190] and, since 1999, much research has been completed to identify the likely long-term impacts of such trawling. Deep-water reefs have also received significant press coverage and therefore public appreciation of the importance of protecting them. The ‘Darwin Mounds’ in the extreme north-west of UK waters have received particular attention and are now protected by European fisheries regulations.

Trawled areas of deep-water coral are often characterised by coral rubble and sparse, living broken up fragments of coral, with much lower habitat complexity and species diversity than unimpacted reef areas[108, 190] and may even be completely flattened by heavy gears [109]. The resuspension of sediments caused by trawling may also impair coral reefs[157, 190].

Deep-water coral reefs can also be damaged by lost fixed-gears, such as gill nets and pots, which can become tangled in reef structures[109]. Anchors and weights associated with this type of fishery may also cause physical damage to reef structures[157].

It is believed that, once coral grounds are disrupted, it would be many decades or even centuries before the former habitat complexity of mature reefs is restored[190]. Further to impacts on the coral itself, many of the species targeted by fisheries in deep water areas are especially vulnerable to the effects of over fishing due to their long life histories[190].

Table 15. Summary of the potential effects of fisheries on Biogenic Reefs (deep water coral reefs)

Fishery	Method	Potential effects
Demersal fish and bivalves	Mobile gears (general)	• Deep-water coral reefs crushed reducing structural complexity and species diversity. • As fishing effort increases, species diversity and richness and total number of species decrease. • Remove erect epifaunal species and large sessile species. • Physical damage may be caused to fragile structures. • Large, fragile and long-lived species including corals may be directly killed or selectively removed, whilst smaller robust organisms are generally unharmed. • Physical damage to long-lived, biogenic structures will be extremely long lasting.
Demersal fish	Fixed (gill) nets	• Nets can become tangled in complex structures and lost, continuing to entangle marine life. • Nets may snag and break off sections of fragile reef. • Anchors and weights may damage fragile structures.
Crustaceans	Tangle nets	• No specific references found. Danger of snagging and removing attached benthic organisms and of ghost fishing if lost.
Crustaceans	Pots / creels	• pots and ropes can become tangled in complex structures and lost, continuing to trap and kill marine life.

5.8 Submarine structures made by leaking gases

SACs where Submarine structures made by leaking gases is a primary feature	No UK marine SACs currently exist for this Annex I habitat.

"Spectacular submarine complex structures, consisting of rocks, pavements and pillars up to 4 m high. These formations are due to the aggregation of sandstone by a carbonate cement resulting from microbial oxidation of gas emissions, mainly methane. The methane most likely originated from the microbial decomposition of fossil plant materials. The formations are interspersed with gas vents that intermittently release gas. These formations shelter a highly diversified ecosystem with brightly coloured species" (European Commission, 2003).

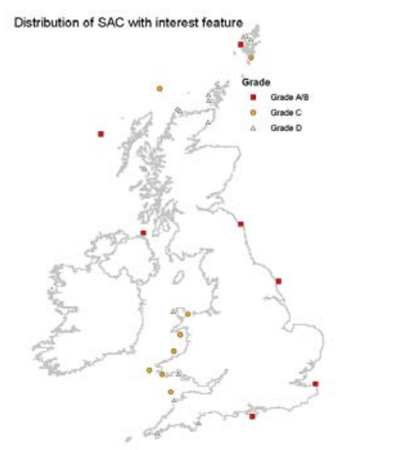
The habitat described is one that occurs in the Kattegat especially and is being sought in the North Sea where pavement concretions are known to occur associated with methane seep 'pockmarks'. It seems likely that such structures would be damaged by mobile fishing gear.

Table 16. Summary of the potential effects of fisheries on Submarine structures made by leaking gases

Fishery	Method	Potential effects
Deep sea fish	Mobile bottom gear (general)	• Physical damage may be caused to fragile structures. • Sensitive species, particularly large, fragile ones will be selectively removed. • Remove erect epifaunal species and large sessile species.

5.9 Submerged or partially submerged sea caves

SACs where Submerged or partially submerged sea caves is a primary feature	Berwickshire and North Northumberland Coast, Flamborough Head, Papa Stour, Rathlin Island, St Kilda, Thanet Coast.
SACs where Submerged or partially submerged sea caves is a qualifying feature, but not a primary reason for site selection	Cardigan Bay/ Bae Ceredigion, Limestone Coast of South West Wales / Arfordir Calchfaen de Orllewin Cymru, Lundy, Mousa North Rona, Pembrokeshire Marine / Sir Benfro Forol, Pen Llyn a`r Sarnau / Lleyn Peninsula and the Sarnau, Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay.



Distribution of SACs containing habitat 8330 Submerged or partially submerged sea caves. From www.jncc.gov.uk

"Caves situated under the sea or opened to it, at least at high tide, including partially submerged sea caves. Their bottom and sides harbour communities of marine invertebrates and algae" (European Commission 2003).

Sea caves are typically associated with rock reefs (see 5.6.1) and are often home to the grey seal, *Halichoerus grypus* (see 6.2). They may also occur within Large shallow inlets and bays (see 5.5) and estuaries (see 5.2).

Caves are generally unsuitable areas for fishing and are therefore unlikely to be damaged or deteriorate as a direct result of fishing activity. It is however possible that fishing related marine litter, such as pots, creels and discarded nets will be washed into marine caves causing abrasion to epifauna and creating a possible tangle hazard for the larger species that may take refuge in these sheltered habitats. No references found on the effects of fishing activity on caves.

Table 17. Summary of the potential effects of fisheries on Submerged or partially submerged sea caves.

Fishery	Method	Potential effects
crustaceans	potting	• Lost or discarded pots may be washed into sensitive areas and damage fragile species through abrasion. • Lost or discarded pots and ropes may entangle larger organisms.
		• Most types of fishing are unlikely to take place in this habitat.

5.10 Other habitats: deep sediments

The Habitats Directive does not include deep sediment habitats. The fragile and important features of some of those habitats may be threatened by human activities and, whilst this report is concerned with advice for implementation of the Habitats Directive, it would be negligent not to mention damage caused by fisheries to deep sediment and especially deep mud. Deep mud in sea lochs supports a community that includes long-lived, slow growing species such as the fireworks anemone *Pachycerianthus multiplicatus* and the tall sea pen *Funiculina quadrangularis* that are likely to be endangered by otter trawls catching Norway lobster, *Nephrops norvegicus*. The issue is addressed and likely impacts illustrated in the WWF-UK Marine Health Check 2005 (Hiscock *et al,* 2005) and the illustration from that report is included here as Figure 2.

Table 18. Summary of the potential effects of fisheries on deep sediments

Fishery	Method	Potential effects
Norway lobster (*Nephrops*)	Otter trawling	• Reduction in species diversity, number of individuals and biomass. • Loss of large epifauna species such as tall sea pens *Funiculina quadrangularis* and fireworks anemones *Pachycerianthus multiplicatus.*
Crustaceans	Pots / creels	• Will have minimal impact on large benthic fauna such as seapens.

6. THE POTENTIAL EFFECTS OF FISHING ON ANNEX II SPECIES

6.1 Introduction

Under the Habitats Directive, Annex II species require the establishment of a network of SACs to protect their habitats. The following species are listed in the order that they appear in the Habitats Directive. Current UK marine SACs are listed for each species and all SACs are shown on maps where applicable. The grade of the feature in question for each SAC is shown on these maps and should be interpreted as follows:

A. Outstanding examples of the feature in a European context.
B. Excellent examples of the feature, significantly above the threshold for SSSI/ASSI notification but of somewhat lower value than grade A sites.
C. Examples of the feature which are of at least national importance (i.e. usually above the threshold for SSSI/ASSI notification on terrestrial sites) but not significantly above this. These features are not the primary reason for SACs being selected.
D. Features of below SSSI quality occurring on SACs These are non-qualifying features ("non-significant presence"), indicated by a letter D, but this is not a formal global grade.

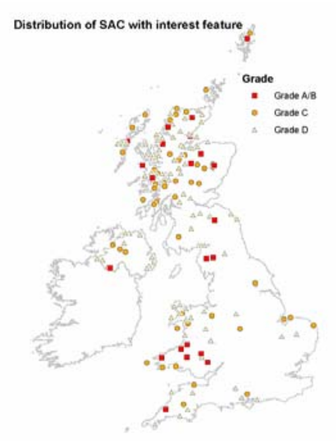
The turtles *Carretta carretta* and *Chelonia mydas* are listed in section 7.2.

The effects of fishing are summarised in tables at the end of each section. #

6.2 Otter, *Lutra lutra*

The following section is taken directly from Gubbay and Knapman (1999) with minor changes, as no new, relevant scientific literature was found during this study.

SACs , which have been designated to protect *Lutra lutra* (marine sites only)	Yell Sound Coast, Rum, Sunart, Loch nam Madadh, Dornoch Firth and Morrich More,
SACs where *Lutra lutra* is a qualifying feature, but not a primary reason for site selection (marine sites only)	Pembrokeshire Marine / Sir Benfro Forol, The Wash and North Norfolk Coast, North Norfolk Coast.



Distribution of UK SACs containing *Lutra lutra*. From: www.jncc.gov.uk

Otters live on the coast as well as along inland water courses. In coastal environments they forage in intertidal and shallow rocky areas, feeding on fish and crustaceans, and therefore come into contact with certain types of fishing gear.

Otters are known to be attracted to eels, fish and crustaceans, which are used as bait or caught in fyke nets and creels. There is documented evidence of otter mortality in fyke nets, creels (for lobsters, crabs and prawns), fish farm nets and wade nets[19,48,49] as well as through entanglement in lost fishing net[50]. A survey of drowned otters in lobster creels off the Uists revealed that the majority drowned while foraging in depths of 2-5 m and that mortality increased with the incorporation of a parlour in the creels used in the area[46]. Crab creels did not appear to pose such a threat as the gear was usually set on sandy seabed in deeper water, further offshore, and therefore outside the favoured foraging area of otters[47].

The majority of documented deaths of otters in eel fyke nets and creels are of adult females[46,48.] The areas of capture correspond to sites where the fisheries operate near otter populations but data suggest that eel fyke nets can also attract and kill otters living at very low densities[51]. A marked concentration of drownings in autumn and winter has been recorded and may be partly explained by the seasonality of fish and the fact that this is when their main food may not be as easily available, leading them to investigate prey in nets and pots[51]. Various types of otter guards have been tested and some form of guard is now mandatory for eel fyke nets. No suggestions have been put forward on how to reduce the threat from crustacean traps nor is there a clear indication of whether mortality from this cause is a conservation problem.

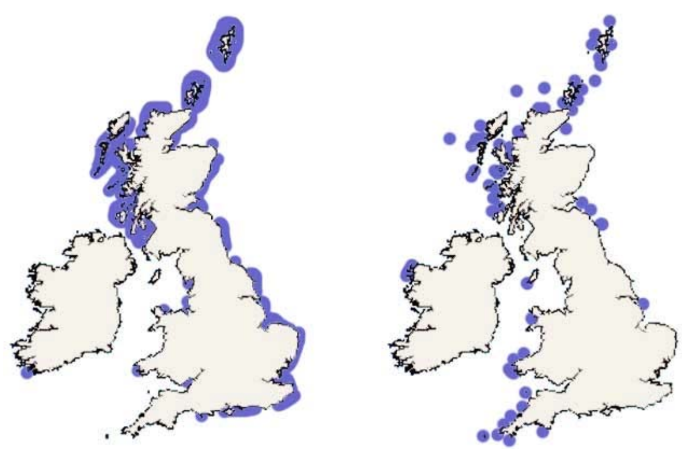
Table 19. Summary of the potential effects of fisheries on Otter, *Lutra lutra*

Target species	Method	Potential effects
Eels and salmon	Fyke nets	• Inquisitive and foraging otters becoming accidentally caught in these nets have led to mandatory use of otter guards.
crustaceans	Pots and creels	• Inquisitive and foraging otters accidentally caught in these traps. Occurrence of accidental capture may be linked to season and availability of food.

6.3 Grey seal, *Halichoerus grypus* and common seal *Phoca vitulina*

6.3.1 Introduction

These are the two species of seal most commonly found in UK waters. Grey seals tend to live in rocky wave exposed sites and form pupping aggregations on land during autumn. The pups remain on the shore for 3-5 weeks. Although they are usually distributed around coastal areas, grey seals are known to travel considerable distances. Common seals favour more sheltered inshore areas, using islands and sand banks as haul out sites. They tend to be more localised than grey seals, staying in the same general area to breed, feed and rest. They form smaller colonies than the grey seal and pups usually leave the shore on the first high tide after birth. Despite the differences between the two species, they face many similar threats. Also, accounts of bycatch, particularly by fishermen are often non-species-specific and in some cases could refer to either species. Therefore, for the purpose of this report, threats to both species are discussed together.

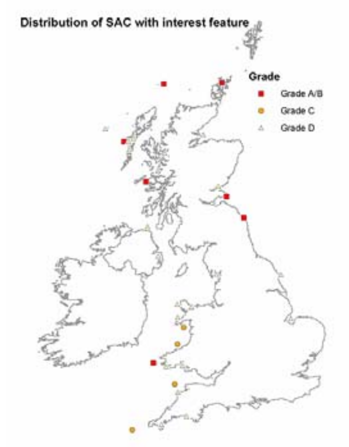


UK recorded and expected distribution of *Phoca vitulina* (Left) and *Halichoerus grypus* (right). From: www.marlin.ac.uk

SACs , which have been designated to protect *Phoca vitulina*	Yell Sound Coast, The Wash and North Norfolk Coast, South-East Islay Skerries, Sanday, Mousa, Firth of Tay & Eden Estuary, Eileanan agus Sgeiran Lios mór, Dornoch Firth and Morrich More, Ascrib, Isay and Dunvegan.
SACs where *Phoca vitulina* is a qualifying feature, but not a primary reason for site selection	Strangford Lough, Murlough.

Distribution maps of UK SACs containing *Phoca vitulina* (above) and *Halichoerus grypus* (below). From www.jncc.gov.uk

SACs , which have been designated to protect *Halichoerus grypus*	Treshnish Isles, Pembrokeshire Marine / Sir Benfro Forol, North Rona, Monach Islands, Isle of May, Faray and Holm of Faray, Berwickshire and North Northumberland Coast.
SACs where *Halichoerus grypus* is a qualifying feature, but not a primary reason for site selection	Pen Llyn a`r Sarnau / Lleyn Peninsula and the Sarnau, Lundy, Isles of Scilly Complex, Cardigan Bay / Bae Ceredigion.



6.3.2 Effects of Fixed gears

Seal bycatch is often associated with static gears. Incidental catch of grey seals and common seals in gill nets has been widely reported[19, 43]. Mortality of grey seals consistent with being entangled in gill nets has been recorded and it has been suggested that young seals are more likely to become caught in this way[10, 19].

6.3.3 Effects of finfish mariculture

Mortality of seals may result from capture in anti-predator nets set around salmon farms[19, 41, 59]. Fish farm operators and fishermen are permitted to shoot seals, under the Conservation of Seals Act 1970, to prevent damage to their nets or any fish within them. The impact of this is difficult to assess but is probably localised and limited in extent. Although it could have a significant effect on local populations[89], seal mortality around fish farms and other fishery related mortality has not had a deleterious effect on the seal population in UK waters[19, 41].

6.3.4 Effects of mobile gears

Several studies have revealed that pair trawls, targeting herring, have been responsible for taking grey seal bycatch in the Celtic Sea[143, 106]. In one study, observers recorded a by-catch of grey seals equivalent to around 60 individuals per year[106]. It is likely that seals are captured whilst feeding on the shoals of pelagic fish targeted by the fishery. During a consultation exercise with trawlermen and creel fishers operating in the Clyde Sea, Scotland[142], 91% of trawlermen consulted, reported catching a seal in their towed gear rarely or occasionally. The majority of these were reported as being dead when recovered. It has also been suggested that Cornish trawl fisheries are responsible for taking relatively large numbers of grey seals annually[170].

Some studies looking at the effects of fisheries on seals have information from areas in and around European marine sites (Cardigan Bay[10], Farne Islands[19], Orkney[43]) but the more general studies, for example covering the North Sea[9, 43] and the Celtic Sea[143, 106] are also relevant as fishery related mortality can occur far from, but still effect the breeding and haul out sites which have been selected as European marine sites. This is particularly the case for grey seals where non-breeding adults have been tracked many hundreds of kilometres from capture sites. Common seals are more likely to stay near breeding sites although they can switch to other sites.

Table 20. Summary of the potential effects of fisheries on grey seal, *Halichoerus grypus* and common seal *Phoca vitulina*

Target species	Method	Potential effects
Demersal and pelagic fish	Fixed nets	• Entanglement in nets has been recorded for both species. • Young seals most vulnerable.
Finfish mariculture	cages	• Entanglement in 'anti-predator nets'. • Fish farmers permitted to shoot seals.
Demersal fish	Towed gear	• Both species, but particularly grey seals may occur as bycatch. • Grey seals may travel long distances out to sea, making them particularly vulnerable to capture in offshore fisheries.
Pelagic fish (herring)	Pair trawls	• Grey seals likely to occur as bycatch.

6.4 Harbour porpoise, *Phocoena phocoena*

6.4.1 Introduction

Harbour porpoise are seen regularly in certain coastal areas around the UK with peak numbers from March to April and July to November. The harbour porpoise feeds on a range of fish species and as a result is vulnerable to bycatch by a number of different fishing gears[177]. They are not confined to coastal areas, moving offshore at other times of year. There is evidence to suggest that seasonal movements and aggregations of harbour porpoise for feeding or calving may lead to 'by-catch hotspots' in certain areas at certain times of the year[116]. Where fisheries co-exist with harbour porpoise populations, they may create competition for natural food supplies.

UK recorded and expected distribution for *Phocoena phocoena.* From: www.marlin.ac.uk

SACs , which have been designated to protect *Phocoena phocoena*	**There are currently no SACs in the UK designated to protect this species**

6.4.2 Effects of fixed gears

Set net fisheries, which include gill nets, drift nets and trammel nets, account for the majority of marine mammal by-catch in British waters[23,34]. The harbour porpoise is considered to be one of the more vulnerable cetaceans to entanglement in nets[8,9,31,43,34,35].

It is likely that in all locations where harbour porpoises and bottom-set gill net fisheries co-exist, bycatch will occur[115]. It is also possible that actual levels of bycatch may be underestimated as individuals drop from nets during hauling and may go unreported.

The analysis of stranding data collected between 1990-95 recorded fixed nets as one of the most frequent causes of death in harbour porpoises (38% of those examined) [23]. In 1998, the annual by-catch from the Danish set net fishery in the eastern North Sea was estimated to be between 3500 and 4500 animals[116]. Between 1997 and 1998 it is estimated that bottom-set gill net fishers targeting cod in the North Sea, fishing out of Grimsby alone caught between 95 and 202 individuals[116]. It is estimated that North Sea gill and tangle net fisheries operating out of the UK in 2000 took around 600 individuals[158]. Gill net fisheries in the Celtic Sea are also know to take a high harbour porpoise bycatch. In 1992-1994, independent observers estimated that vessels in the 15 m and over sector took around 740 harbour porpoises per year during this period[158].

There is evidence to suggest that harbour porpoises are unable to effectively detect most types of gill net in time to avoid collision by using echo location[139].This may result in the porpoise becoming accidentally entangled in gill nets and may explain high levels of bycatch in this type of fishery. The presence of ‘pingers’, designed to prevent cetacean bycatch can effectively deter the harbour porpoise at least temporarily[138] although there is some doubt as to how effective these measures will be in the long term. There is evidence that the harbour porpoise may eventually become habituated to pingers, reducing their effect as a deterrent[140].

There are reports of harbour porpoise being caught by long-line fisheries, entangled in creel or pot lines and salmon stake nets but the numbers are not thought to be significant[19]. It is reported that harbour porpoises are more likely to be entangled during storms or at night.

The impact of incidental capture on porpoise populations around the UK is not known. However it has been suggested that incidental by-catch could be a significant contributory factor in the overall decline in abundance of harbour porpoise in European waters[9] and a serious cause of concern in relation to Celtic Sea populations in particular[81]. In other parts of the world there are examples where decline in populations are considered to be at least partly a result of entanglement in gill nets. A study of incidental catch of harbour porpoise in SW Bay of Fundy (Canada), for example, suggested that significant changes in length frequencies of the porpoises could be attributed to the fishery, and that sustained adult mortality in the gill-net fishery may have compressed the size, and possibly the age structure of the population[31]. Given the slow reproductive rate of the harbour porpoise, these catches were considered to be a serious threat to the relatively discrete harbour porpoise population in the area.

Table 21. Summary of the potential effects of fisheries on Harbour porpoise, *Phocoena phocoena*

Target species	Method	Potential effects
Demersal and pelagic fish	Gill netting - drift nets, trammel nets set nets	• Accidental entanglement and capture. It is considered that this is the most frequent cause of death of the harbour porpoise and, with their slow reproductive rate, means that there could be a serious threat to sustainability of discrete populations. • Unable to detect gill nets by echolocation in time to avoid collision. • Pingers may deter temporarily, but habituation may follow making the ineffective.

6.5 Bottle-nosed dolphin, *Tursiops truncatus*

6.5.1 Introduction

The bottlenose dolphin is commonly seen in coastal waters and resident or semi-resident groups are known from several locations around the UK. Large schools, which do not appear to be linked to any particular area, may also be seen in coastal waters. It is also worth noting that fisheries that co-exist with the bottle-nosed dolphin may compete for the animal's natural food supply.

UK recorded and expected distribution for *Tursiops truncatus.* From: www.marlin.ac.uk

6.5.2 Effects of fixed gears

There is evidence that, in USA fisheries, bottlenose dolphins do suffer some mortality because of entanglement in gill nets[136]. However, studies have shown that individuals will often interact with bottom-set gill nets, including acts of depredation (steeling fish from nets) but only rarely become entangled[103, 137]. Unlike the harbour porpoise, It is likely that bottle-nosed dolphins are more able to detect gill nets using echolocation, giving them sufficient time to avoid collision[139]. There is evidence that bottle-nosed dolphins may be deterred in the short term by pingers[139]. However, it is possible that dolphins will become habituated to pingers over time. Given the behaviour of dolphins around nets, pingers may even begin to act as 'dinner bells' alerting dolphins to an easy meal[139].

SACs , which have been designated to protect *Tursiops truncatus*	Moray Firth, Cardigan Bay / Bae Ceredigion.
SACs where *Tursiops truncatus* is a qualifying feature, but not a primary reason for site selection	Pen Llyn a`r Sarnau / Lleyn Peninsula and the Sarnau.

Distribution of UK SACs containing *Tursiops truncatus.* From: www.jncc.gov.uk

6.5.3 Effects of mobile gears

Studies of stranded bottlenose dolphins in the USA have indicated that shrimp trawls and other commercial fisheries are a cause of some mortality in the species[135]. There is also evidence that some by-catch may occur in large-scale pelagic trawls[143] but the precise scale of this by-catch is currently unknown.

6.5.4 Effects of angling

Post mortem examinations of some bottle-nosed dolphins have revealed that angling is a potential cause of mortality in the species. In the USA, dolphins have died as a result of asphyxiation and secondary complications resulting from the consumption of fish that have been hooked and lost by anglers with large amounts of line attached[102]. The problem of line breaking, resulting in the loss of fish, with large amounts of line attached can be avoided by using appropriate gear.

Table 22. Summary of the potential effects of fisheries on Bottle-nosed dolphin, *Tursiops truncatus*

Target species	Method	Potential effects
Demersal and pelagic fish	Bottom-set-gillnets	• Despite high levels of interaction with gear, only occasional entanglements occur due to effective echolocation. • Likely to habituate to pingers.
Pelagic fish and shrimp	trawls	• May occur as bycatch.
Demersal and pelagic fish	angling	• Consumption of fish lost by anglers with line attached may result in the death of individuals.

6.6. Sturgeon, *Acipenser sturio*

The following section is mainly taken from Gubbay and Knapman (1999), as no new, relevant, scientific literature was found during this study.

SACs , which have been designated to protect *Acipenser sturio*	**There are currently no SACs in the UK designated to protect this species**

The west European (Atlantic) population of the common sturgeon (*Acipenser sturio*) is known to have had a range extending from the Atlantic coast of France to the Severn Estuary and Pembrokeshire in western Britain, and north to the Firth of Forth on the Scottish east coast and the Limfjord on the west coast of Denmark in the North Sea. There are now few catches in these waters and the only location where a spawning stock is known to remain in this range is the Gironde basin in France. The adults migrate into estuarine and brackish waters to spawn and juveniles move between estuaries and the sea. The causes of its decline in Europe have been a directed fishery, pollution of the lower reaches of rivers, damage to spawning grounds and man-made obstacles restricting migration. There have also been reports of accidental catches in trawls and nets at sea and in estuaries when fishing other species, which add another pressure on stocks[60].

In June 2004, a sturgeon thought to be *Acipenser sturio* measuring 261 cm and weighing 120kg was caught in the Bristol Channel, south of Swansea. The fish was caught in an otter trawl, indicating that despite the rarity of the species, individuals may still be caught as by-catch by mobile gears.

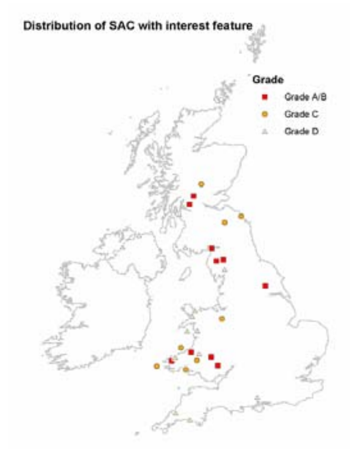
The sturgeon is only occasionally reported in UK waters and is unlikely to be found moving into estuaries to spawn. Reintroduction programmes are being considered in France and if sturgeon do become more common in UK waters as a result, the reduction of physical obstacles for migrating fish, safeguarding spawning grounds in rivers and estuaries, and care over any incidental catch will be important factors in assisting any recovery[60, 61].

According to the Habitats Directive, *Acipenser sturio* is a priority species.

Table 23. Summary of the potential effects of fisheries on Sturgeon, *Acipenser sturio*		
Target species	**Method**	**Potential effects**
Demersal fish	Trawling, netting	• Accidental by catch, but main reason for decline due to poor water quality and blocked migration routes.

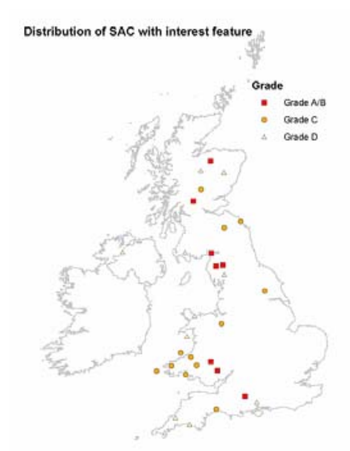
6.7 Lampern, *Lampetra fluviatilis* and sea lamprey, *Petromyzon marinus* .

SACs , which have been designated to protect *Lampetra fluviatilis* (marine sites only)	Solway Firth
SACs where *Lampetra fluviatilis* is a qualifying feature, but not a primary reason for site selection (marine sites only)	Tweed Estuary, Pembrokeshire Marine / Sir Benfro Forol, Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd, Cardigan Bay / Bae Ceredigion.



Distribution maps of UK SACs containing *Lampetra fluviatilis* (above) and *Petromyzon marinus* (below). From www.jncc.gov.uk

SACs , which have been designated to protect *Petromyzon marinus* (marine sites only)	Solway Firth
SACs where *Petromyzon marinus* is a qualifying feature, but not a primary reason for site selection (marine sites only)	Tweed Estuary, Pembrokeshire Marine / Sir Benfro Forol, Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd, Cardigan Bay / Bae Ceredigion.



6.7.1 Introduction

The lampern (*Lampetra fluviatilis*) is widespread in the UK with substantial populations in some rivers and streams although not present in others where they used to be common. The main populations are probably those which migrate into the Severn estuary from the Bristol Channel and adjacent offshore waters. The sea lamprey (*Petromyzon marinus*) is uncommon in the UK and, although found around the coast, the main population centres are concentrated on the Bristol Channel. Both species migrate up rivers to spawn and spend the larval stage buried in the muddy substrates in freshwater. Once metamorphosis takes place the adults migrate to the sea where they live as a parasite on various species of fish.

In addition to the direct impacts of fishing, it is possible that declining numbers of sea lamprey are related to reduced stocks of salmon, seatrout and shad (their preferred prey species) [173], which may be in part due to overfishing.

6.7.2 Effects of static gears

There is evidence that the majority of fishing related by-catch of lampreys occurs in eel traps and salmon traps in estuaries where they occur[173]. The sea lamprey in particular is sometimes caught in large numbers when high concentrations migrate upstream for breeding[173].

6.7.3 Effects of mobile gears

Neither species of lamprey is regularly recorded from trawls. It is likely that this is due to their size and shape, which may facilitate their escape from nets[173].

6.7.4 Effects of direct extraction

Anglers use both species of anadromous lampreys for bait. Young, larval individuals are dug from the muddy river sediment in which they live, damaging their habitat and reducing population numbers. Adults are also caught for bait using traps from rivers and estuaries[161]. The impact that direct extraction has on UK populations is not known, but is a potential problem and requires further investigation.

The sea lamprey has been commercially fished throughout its European range but fishing is now generally limited to some small local fisheries. The main reasons for its decline and that of the lampern are considered poor water quality, and obstructions in rivers that prevent migration for spawning rather than any impact associated with fisheries[61].

Table 24. Summary of the potential effects of fisheries on Lampern, *Lampetra fluviatilis* and sea lamprey, *Petromyzon marinus*.

Target species	Method	Potential effects
Salmon and eels	Traps and static nets	• Bycatch occurs in estuaries and coastal areas where they occur. • Caught in high concentrations when individuals gather for upstream migrations.
Direct extraction	Traps in estuaries and digging	• Impact on populations is unknown but probably significant.
Demersal fish	Trawling	• Neither species is regularly recorded in trawls. • Decline may be related to overfishing of prey species.

6.8 Twaite shad, *Alosa fallax*, and allis shad, *Alosa alosa*

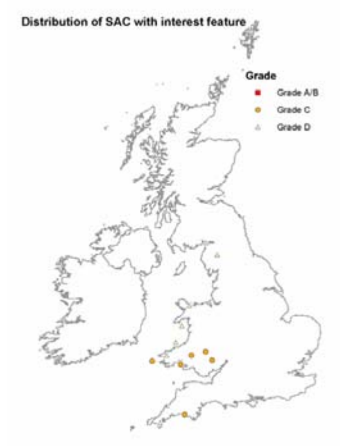
6.8.1 Introduction

Twaite shad (*Alosa fallax*) and Allis shad (*Alosa alosa*) migrate up rivers to spawn, the adults return to salt water immediately and juveniles at a later stage. The population of Allis shad in the UK has declined since the mid-nineteenth century to the point where it has a sporadic distribution around the coast with only a few possible spawning rivers. These are thought to include the Tamar, Fowey and Torridge rivers in the south west of England[145]. The Twaite shad has also declined and some of the few spawning populations are the Severn, Usk, Wye and Twyi and possibly rivers feeding the Solway Firth.

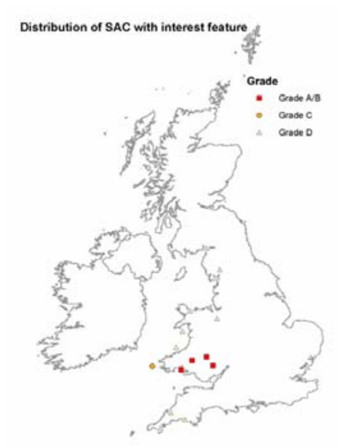
6.8.2 Effects of Fixed gears

Static gear fisheries operate in the locations frequented by both species and there are reports of catches in drift nets and salmon nets[61]. Both species of shad are caught occasionally in fixed, salmon nets in south west estuaries. Coastal gill nets set for bass and for pilchards have taken shad, sometimes in large numbers[145]. Salmon traps and fixed nets represent the highest levels of fishery related mortality for both shad species in south Wales[173]. Fixed shrimp nets operating in the Severn Estuary also take occasional bycatch of shad[173].

SACs , which have been designated to protect *Alosa alosa* (marine sites only)	There are currently no UK SACs designated to protect this species.
SACs where *Alosa alosa* is a qualifying feature, but not a primary reason for site selection (marine sites only)	Plymouth Sound and Estuaries, Pembrokeshire Marine / Sir Benfro Forol, Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd.



Distribution maps of UK SACs containing *Alosa alosa* (above) and *Alosa fallax* (below). From www.jncc.gov.uk



SACs , which have been designated to protect *Alosa fallax* (marine sites only)	Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd.
SACs where *Alosa fallax* is a qualifying feature, but not a primary reason for site selection (marine sites only)	Pembrokeshire Marine / Sir Benfro Forol.

6.8.3 Effects of mobile gears

There are reports of shad (Twaite, Allis and unidentified) being caught frequently by trawls including beam, pair and otter trawls from fisheries operating in the south west. Trawls represent the greatest source of shad capture overall in the South west of England. The catch of shad by trawlers also appears to be greatest during the winter. For example, in February, 2000, 30 Allis shad were reportedly taken in an individual haul and landed in Looe, Cornwall. Also between February and January 2000, pair trawlers operating seven to eight miles from the same fishing port, reported catches of up to 7kg a day of young Allis shad[145]. Both species of shad are frequently recorded in trawls around Wales and England. It is likely that the high intensity of trawling activity in some regions, this may cause significant losses to shad populations[173]. It is suggested that Welsh herring stocks, which spawn in Milford Haven may be recovering from their depleted state. If a fishery for the species becomes re-established, it may pose a threat to shad stocks and should be carefully managed with this in mind[173].

6.8.4 Effects of angling

Both species have been recorded as being caught by anglers in the south west of England, from the shore, estuaries and by boat in coastal waters, particularly during the summer months[145].

Table 25. Summary of the potential effects of fisheries on Twaite shad, *Alosa fallax*, and allis shad, *Alosa alosa*

Target species	Method	Potential effects
Mixed fish species, including shad	angling	• Both species occasionally caught, particularly during the summer months.
Demersal and pelagic fish	Beam, pair and otter trawls	• Caught as bycatch, sometimes in large numbers.
Salmon, bass and pilchards shrimp	Fixed nets and traps	• Occasionally caught as bycatch. • Salmon traps represent greatest source of fishing related mortality in south Wales.

7. POTENTIAL EFFECTS OF FISHING ON ANNEX IV SPECIES

7.1 Introduction

Annex IV of the Habitats Directive, lists species, which must be given strict protection, but do not require the designation of SACs. For this reason, the relevant species are discussed in broad groups and only a general overview of the effects of fishing is given. Several species included in Annex IV of the directive are also listed in Annex II and most are discussed in the previous section. *Lutra lutra*, *Acipenser sturio, Phocoena phocoena* and *Tursiops truncatus* are therefore excluded from the following section. However, two species of marine turtle (the loggerhead turtle *Caretta caretta* and the green turtle *Chelonia mydas*) are also listed in Annex II of the Habitats Directive, but are considered to be vagrant species and occur only very occasionally in UK waters[171]. For this reason the two species are considered only in this section of the report. The effects of fishing are summarised in tables at the end of each section.

7.2 All cetaceans

7.2.1 Introduction

Thirty five species of whales and dolphin have been recorded in European seas. There is extensive literature about the effects of fishing on the numerous species of whale and dolphin, many of which are seen only occasionally in UK waters. Due to the limited scope of this study, threats to non-Annex II, cetacean species are mentioned here only briefly.

It should also be noted that fisheries are likely to compete with toothed whales, dolphins and piscivorous baleen whales for food resources where they co-exist[177]. However, the level at which this is likely to be a significant problem is not known as it is inherently difficult to quantify.

7.2.3 Effects of fixed gears

Most small cetacean species, which target shoals of fish also targeted by commercial fisheries, are vulnerable to capture in a variety of static gear. The Celtic sea gill-net fishery is known to produce high levels of common dolphin bycatch and it is estimated that an average of 200 individuals are taken by this fishery alone every year[158]. Other small cetacean species found around UK waters may also be taken in drift nets and bottom set gill nets[115].

7.2.4 Effects of mobile gears

Large pair trawls targeting bass are known to take very high numbers of common dolphin bycatch, particularly between February and March. Between 2001 and 2003, the average number of dolphins taken by this fishery per trawl was four, with a maximum of ten in one trawl[158]. Studies have shown that a number of European pelagic trawl fisheries produce bycatch of white sided dolphins, common dolphins, bottle-nosed dolphins[143] and other species of small cetaceans[115].

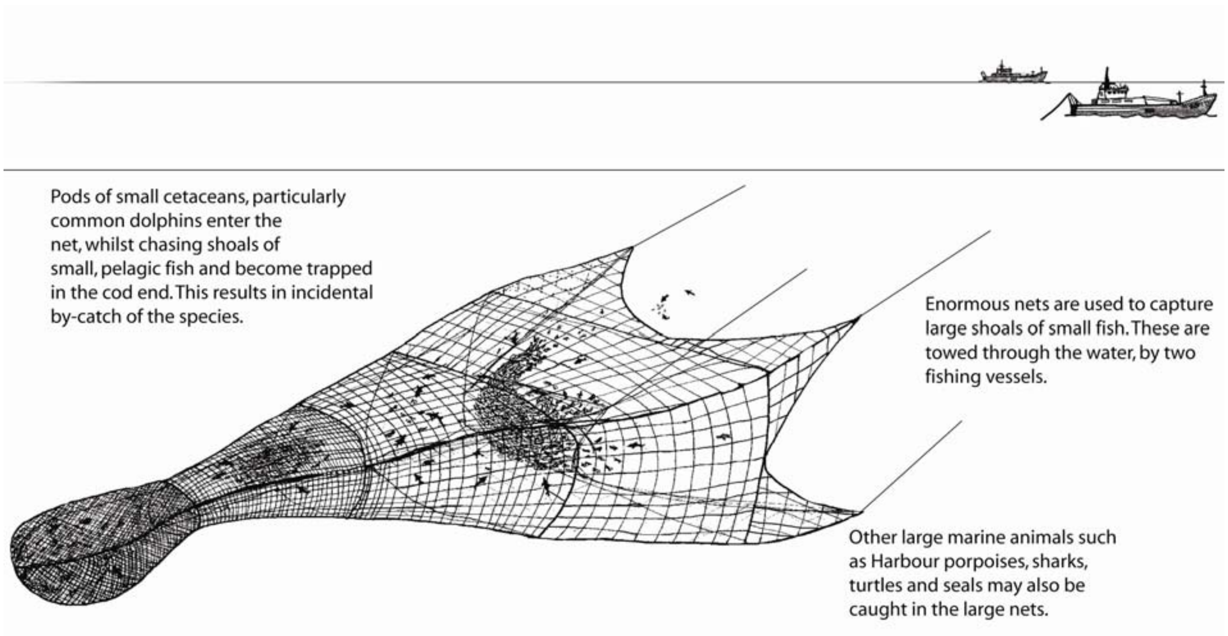


Figure 5. Cetacean by-catch whilst mid-water pair trawling for shoaling pelagic fish. Drawings by Jack Sewell

7.2.5 Effects of aquaculture

There are reports of (unspecified species of) dolphins being caught in anti-predator nets around fish farms[19, 59]. These and other reports suggest that certain nets and locations may precipitate catches of cetaceans.

Table 26. Summary of the potential effects of fisheries on 'all cetaceans'

Target species	Method	Potential effects
Demersal and pelagic fish	Fixed gill-nets	• Most species that feeding on shoaling fish targeted by fisheries are likely to become caught as bycatch. • Fisheries may compete with piscivorous whales for food resources.
Pelagic fish	Pair trawls	• Potentially high levels of dolphin and small cetacean bycatch. • Bycatch levels are highest between February and March. • Fisheries may compete with piscivorous whales for food resources.

7.3. Marine turtles

Pierpoint (2000)[171] has carried out a thorough review of marine turtle bycatch based on historic records held on the 'TURTLE' database and the following is largely based on his findings. For further details, please refer to the Pierpoint review[171].

There are records of all five turtle species listed in Annex IV of the Habitats Directive from UK and Irish waters. Only one of these, the leatherback turtle *Dermochelys coriacea*, is reported annually and is considered a 'regular and normal' member of UK marine fauna. It has a wide range and travels to cold waters to forage. Most turtles are recorded in the UK between August and October. Other species found less often in the UK are thought to be vagrant species, carried from their natural habitats by strong currents. The loggerhead turtle, *Caretta caretta* and Kemp's ridley turtle, *Lepidochelys kempii*, occur occasionally. The hawksbill turtle, *Eretmochelys imbrecata* and the green turtle *Chelonia mydas* are very rare.

Around the British coast, loggerhead and leatherback turtles have been killed as a result of drowning after entanglement with fishing gear. Following an expansion of the pot fishery for whelks in Carmarthen Bay, SW Wales between 1995 and 1997, a 'conspicuous clustering' of strandings and bycatch was observed in the area. Several turtle mortalities around the UK and Eire have been associated with entanglements with fishing line, nets and creel ropes. Turtle bycatch is also known to take place in French, English and Irish tuna drift net fisheries operating in the northeast Atlantic.

In the last 20 years, the most significant known catch of leatherback turtles in our waters has been by inshore pot fisheries (more than 60%) and pelagic drift nets. Some have also been caught in prawn-, midwater- and beam-trawls, as well as in gill nets. One was also taken by an angler, but released alive. In 2003, only one leatherback turtle was reported as bycatch in the UK[172]. The turtle was found tangled in salmon nets in Eire and was released alive.

The leatherback turtle is the only species of turtle significantly affected by fisheries in the UK and Ireland and although the global significance of bycatch in this area is not fully known, it is likely that any impact on the declining global population may prove important.

Table 27. Summary of the potential effects of fisheries on marine turtles

Target species	Method	Potential effects
Whelks	potting	• Pot fisheries for whelks may lead to an increase in strandings.
crustaceans	potting	• Entanglement with pot ropes.
Demersal and pelagic fish	Angling, and fixed and drift nets	• Entanglement with lines and nets has been recorded. • Some bycatch possible by fixed and drift nets.
Prawns and pelagic and Demersal fish	Prawn-, midwater- and beam trawls	• Some bycatch recorded.

8. POTENTIAL EFFECTS OF FISHING ON BIRDS

8.1 Introduction

The Birds Directive is concerned with the conservation of all species of naturally occurring birds in the wild, in the territory of Member States. Measures are required to preserve, maintain or re-establish a sufficient diversity and area of habitats for these species. This should be achieved through the creation of protected areas, the upkeep and management of habitats inside and outside these areas, and the re-establishment of destroyed biotopes. The site protection measures require the classification of Special Protection Areas (SPAs) for species listed in Annex I of the Directive. Eleven of these are seabirds which occur around the UK although some, like the Mediterranean gull, and Cory's shearwater are only observed on an occasional basis. The Directive also specifies that special conservation measures should be taken with regard to the habitats of regularly migrating species not listed in Annex I (see Table in Appendix 1). All species of marine bird that breed in the UK are currently protected via a network of breeding site SPAs. Such protection is largely limited to land above mean low water (or mean low water springs in Scotland). The extension seaward of some of these SPAs is currently being considered, to protect the foraging areas for several seabird species. A recent report by McSorely *et al* (2003) contains further details on this subject. The impact of fisheries on seabirds is an extensive and often specialist topic. For this reason, the following section is broad ranging and by no means exhaustive and reference is made to at least one broad review paper. The effects of fishing are summarised in tables at the end of each section.

Classified SPAs with significant inter-tidal element*	Alde-Ore Estuary, Alt Estuary, Benacre to Easton Bavents, Benfleet and Southend Marshes, Blackwater Estuary, Breydon Water, Burry Inlet, Castlemartin Coast, Chesil Beach and The Fleet, Chichester and Langstone Harbours, Colne Estuary, Coquet Island, Deben Estuary, River Crouch Marshes, Dengie, Duddon Estuary, Exe Estuary, Farne Islands, Flamborough Head and Bempton Cliffs, Foulness, Gibraltar Point, Glannau Aberdaron and Ynys Enili, Glannau Ynys Gybi, Grassholm, Great Yarmouth North Denes, Hamford Water, Humber Flats Marshes and Coast, Lindisfarne, Medway Estuary and Marshes, Mersey Estuary, Minsmere-Walberswick, Morecambe Bay, North Norfolk Coast, Old Hall Marshes, Pagham Harbour, Portsmouth Harbour, Ramsey and St Davids Peninsula Coast, Ribble and Alt Estuaries, Rockcliffe Marches, Severn Estuary, Skokholm and Skomer, Stour and Orwell Estuaries, Tamar Estuaries Complex, Teesmouth and Cleveland Coast, Thanet Coast and Sandwich Bay, The Dee Estuary, The Swale, The Wash, Traeth Lafan, Upper Solway Flats and Marshes, Ynys Feurig, Cemlyn Bay and the Skerries, Monach Isles, North Uist Machair & Islands, Dornoch Firth and Loch Fleet, Moray & Nairn Coast (Moray Basin Firths & Bays), Loch of Strathbeg, Ythan Estuary Sands of Forvie & Meikle Lochs, East Sanday Coast, Gruinart Flats, Bridgend Flats (Islay), Montrose Basin, Cromarty Firth, Inner Moray Firth, Loch of Inch and Torrs Warren, South Uist Machair & Lochs.
Potential SPAs with significant inter-tidal element*	Dungeness to Pett Levels, Northumberland Coast, Poole Harbour, Southampton Water and Solent Marshes, Thames Estuary and Marshes, Inner Clyde Estuary, Firth of Tay and Eden Estuary, Firth of Forth.

* As at September 1999 (Taken from Gubbay and Knapman 1999)

8.2. Seabirds

8.2.1 Effects of fixed gears

Set nets of various types are a particular hazard to diving seabirds and have been implicated in the decline of seabird populations in some parts of the world [7,8,9,17,29]. In northern Norway, for example, the breeding populations of guillemots at two sites are estimated to have declined by 95% from the early 1960's to 1989. This figure could be explained entirely by gill-net mortalities based on observed catch rates. The numbers of birds killed in nets depends on their abundance, diving habits and distribution within the fishery area[7]. Species which have been caught in these nets include shearwaters, red-throated divers, Leach's petrel, gannet, shag, guillemot, razorbill, and great northern diver. In fact, any species of diving bird, which actively hunts large shoals of small fish species commonly targeted by set nets are likely to become by-catch[167].

Inshore gill nets can have a relatively high incidental by-catch around diving seabird colonies or where there are high densities gathered on the water surface, making it inadvisable to set nets in such areas[167]. Large numbers of razorbills are known to have drowned in gill nets at the mouth of the Tagus estuary in Portugal, for example, where this species congregates on occasions[43]. Gillnets set for bass in St Ives Bay, Cornwall have taken an annual by-catch of hundreds, possibly thousands of razor bill and guillemot[167]. in one incident in the UK an estimated 900 auks were caught by bass gill-nets over 8 days in nets set below seabird colonies[17]. Herring nets and bottom-set cod nets have also killed large numbers of diving seabirds (an estimated 25,000 in the southeast Kattegat between 1982 and 1988), most of which were found in the bottom-set cod nets[45]. Catches of shags in trammel nets may be a threat to populations of this species in Spain[43]. The threat will depend on which species are present at the time nets are put out, weather, tidal fluctuations and fishing effort. Gill and tangle net fisheries in Cardigan Bay, for example, often occur at or near the cormorant colony but to date there has been no major entanglement problem[10].

High incidental catches of guillemots, razorbills and divers have been reported in drift nets from Danish fisheries, and significant catches of auks in the salmon driftnet fisheries in Ireland and Denmark[43] as well as Greenland[167] Anti-predator nets around aquaculture facilities are also known to entangle seabirds[59,82]. Ghost fishing by lost nets and fragments of nets is also known to entangle birds. Studies of dead bird strandings have shown that large numbers of gannets and cormorants are killed by lost fishing gear in the North Sea every year[167]. It has also been recorded that gannets often build nests from monofilament line from nets or angling, resulting in entanglement and starvation of young and adult birds[167].

The effect of non-net fisheries, such as long lining and pots is not well known in UK waters although catches are reported from elsewhere. Long-line fisheries targeting cod in the north Atlantic are known to take bird bycatch at rates of up to 1.75 birds (particularly the northern fulmar) per 1000 hooks[167]. Birds take hook baits as they enter the water and drown as the line sinks and pulls them under. Mortalities are reportedly much lower when lines are set at night.

8.2.2 Effects of mobile gears

Guillemots have been recorded in industrial sand eel trawls operating in the North Sea in the vicinity of feeding colonies and a minimum of 22 birds were taken in five hauls[167].

8.2.3 Indirect effects of commercial fishing

An indirect effect of some finfish fisheries has been an increased food source for some seabirds resulting from the discarding of by-catch and offal[168]. The discards are taken by species such as fulmar, gannet, great skua, common gull, great black-backed gull and herring gull and may have contributed to the rapid growth of some seabird populations. It is now considered to be such an important component of the diet of scavenging seabirds in the North Sea that changes in the amount of discards may affect the relative and absolute abundance of various species. Using fisheries data from the late 1980’s and early 1990’s, the number of seabirds potentially supported by the fishery waste from North Sea fisheries has been estimated to be around 5.9 million and an area based analysis suggests that discards may easily support all scavenging seabirds in southern and south-eastern sub-regions of the North Sea[55]. There is however evidence that nesting birds and some species including the black-legged kittiwake will avoid eating offal and discards, preferring to hunt for fresh prey[168]. It is thought that this decision may be due to the decreased reproductive success that results from a diet composed mainly of offal and discards[168]. It is also likely that overfishing of some fish stocks can reduce the reproductive success of some species of seabird[168].

Table 28. Summary of the potential effects of fisheries on seabirds		
Target species	**Method**	**Potential effects**
Demersal and pelagic fish	Mobile bottom gears (general)	• Increase in scavenging seabird species due to discarding of unwanted catch and offal. • Consuming discards may reduce reproductive success in some species. • Overfishing of some stocks may reduce food availability and reproductive success.
	Gill netting	• Accidental capture of diving birds foraging for food in and around nets. • By-catch increases with proximity to breeding colonies. • Any species of diving, foraging bird is likely to be caught as by-catch.
	Long lining	• Accidental by-catch may occur at high levels. • By-catch reduced when lines are dropped at night.
	angling	• Birds may become entangled in lost or discarded line and die. • Lost or discarded line may be used as nest material and kill juveniles.
Sand eels	Large scale Suction trawling	• Guillemots have been recorded as bycatch in the North Sea.
Finfish mariculture	Fish cage	• Entanglement in anti-predator nets.
Cockles and clams	Hydraulic & tractor dredge, hand gathering	• Short term increase in scavenging seabirds due to increased food.

8.3. Wildfowl and waders

8.3.1 Effects of Shellfish harvesting and mariculture

It is unlikely that intertidal mariculture of shellfish such as oysters or blue mussels will have a significant negative effect on the feeding behaviour and presence of waders and seabirds[166, 151] although disturbance caused by human presence may disrupt feeding activity temporarily. Mussel harvesting can drive oyster catchers away from their preferred food source. In a recent study, such disturbance forced birds to move to nearby fields to feed on earthworms. Authors found that if this shift was unsuccessful, birds died[167]. Studies have also shown that extensive, industrial cockle dredging in the Wadden Sea was the main cause of a large common eider duck mortality between 1999 and 2000 when approximately 21,000 birds died[160]. Dredging for *Spisula* clams over sandbanks in the southern North Sea has had a negative impact on common scoter populations. The disturbance caused by the large vessels is thought to drive the birds away and excessive fishing is thought to have depleted their food supply[167]. This is also a secondary food supply for the common eider and the fishery may have contributed to the high mortalities in the Wadden Sea between 1999 – 2000, mentioned previously[160]. A study investigating the effects of tractor dredging for cockles showed that, following a short period of increased feeding activity immediately after dredging (probably due to temporarily increased food availability), the feeding activity of curlews and gulls was reduced for up to 80 days and oyster catchers 50 days[134].

8.3.2 Effects of fixed gears

Ducks such as the common scoter and long-tailed duck are known to have become entangled and died in set nets[7].

8.3.3 Effects of bait digging

Studies have shown that prolonged use of mudflats by bait diggers can force feeding birds to move to other feeding areas. If there is insufficient food in these areas, birds may die[167].

Table 29. Summary of the potential effects of fisheries on wildfowl and waders

Target species	Method	Potential effects
Mussels	Mariculture	• Harvesting can drive birds away from preferred food source if an alternative is not found, this can result in starvation.
Bait for angling	Digging/ collection	• Prolonged use of mudflats may force feeding and roosting to move to less suitable areas.
Cockles and clams	Hydraulic & tractor dredge, hand gathering	• General disturbance of feeding and roosting birds. • Competition for food and disturbance may drive birds away from normal feeding grounds and may result in starvation. • Mass mortalities may result from depletion of food supplies.

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Further text for Figure 2

The diagram (bottom left) shows burrows of the crustaceans *Callionassa subterranea*, *Upogebia* spp and *Nephrops norvegicus* and the fish *Lesueurigobius friesii*, a burrowing sea urchin *Brissopsis lyrifera, the common starfish Asterias rubens* the arms of *Amphiura* spp, terebellid worms, the sea-pens *Pennatula phosphorea* and *Funiculina quadrangularis*, burrowing bivalves, *Corbula gibba, Nucula sulcata and Thyasia flexuosa* the crab *Gonoplax rhomboides* auger shells *Turritella communis* and the anemones *Cerianthus lloydii* and *Pachycerianthus multiplicatus*. Width of illustrated area is about 2 m. The centre diagram shows an otter trawl similar to that used for the capture of the Norwegian lobster *Nephrops norvegicus* over deep mud habitats with resulting trenches caused by the otter boards and full cod-end.

The final diagram (bottom right) shows a cross section of sediment following a trawl, many of the species previously present have been damaged, removed or destroyed. Some deep burrowing species including *Upogebia* spp have avoided damage due to their deep burrows. Some scavenging species the edible crab *Cancer pagurus* and common starfish *Asterias rubens* have moved into the area to feed on the remains of damaged organisms.

10. GENERAL REFERENCES

The following references provide general or background information and are not included in the database.

Baretta-Bekker, J.G., Duursma, E.K. & Kuipers, B.R. (ed.), 1992. *Encyclopaedia of Marine Sciences.* Berlin, Springer-Verlag.

Birkett, D.A., Maggs, C.A. & Dring, M.J., 1998a. Maerl. an overview of dynamic and sensitivity characteristics for conservation management of marine SACs. *Natura 2000 report prepared by Scottish Association of Marine Science (SAMS) for the UK Marine SACs Project.*

Birkett, D.A., Maggs, C.A., Dring, M.J. & Boaden, P.J.S., 1998b. Infralittoral reef biotopes with kelp species: an overview of dynamic and sensitivity characteristics for conservation management of marine SACs. *Natura 2000 report prepared by Scottish Association of Marine Science (SAMS) for the UK Marine SACs Project.*

Cabinet Office Strategy Unit, 2004. *Net Benefits: A sustainable and profitable future for UK fishing*. London, Cabinet Office, Prime Minister's Strategy Unit.

Connor, D.W., Dalkin, M.J., Hill, T.O., Holt, R.H.F. & Sanderson, W.G., 1997a. Marine biotope classification for Britain and Ireland. Vol. 2. Sublittoral biotopes. *Joint Nature Conservation Committee, Peterborough, JNCC Report* no. 230, Version 97.06.

Connor, D.W., Brazier, D.P., Hill, T.O., & Northen, K.O., 1997b. Marine biotope classification for Britain and Ireland. Vol. 1. Littoral biotopes. *Joint Nature Conservation Committee, Peterborough, JNCC Report* no. 229, Version 97.06.

Davison, D.M. & Hughes, D.J., 1998. *Zostera* biotopes: An overview of dynamics and sensitivity characteristics for conservation management of marine SACs, Vol. 1. *Scottish Association for Marine Science, (UK Marine SACs Project)*.

Davidson, N.C., Laffoley, D.A. Doody, J.P. ,Way, Gordon, L.S., Key, R., Pienkowski, M.W., Mitchell, R. & Duff, K.L., 1991. *Nature conservation and estuaries in Great Britain*. Nature Conservancy Council, Peterborough.

Dieter, B.E., Wion, D.A. & McConnaughy, R.A., 2003. *Mobile fishing gear effects on benthic habitats: A bibliography (Second edition)*. NOAA Technical memorandum NMFS-AFSC-135.

Elliot, M., Nedwell, S., Jones, V., Read, S.J., Cutts, N.D. & Hemingwat, K.L., 1998. *Intertidal sand and mudflats & subtidal mobile sandbanks (volume II) An overview of dynamics and sensitivity characteristics for conservation management of marine SACs.* Scottish Association for Marine Science (UK Marine SACs Project).

European Commission, 2003. *Interpretation Manual of European Union Habitats*. Version EUR25. Commission of the European Community, Brussels.

Fowler, S.L., 1999. *Guidelines for managing the collection of bait and other shoreline animals within UK European marine sites*. English Nature, Peterborough (UK Marine SACs Project).

Gray, M.J., 1995. The coastal fisheries of England and Wales, Part III: A review of their status 1992-1994. *MAFF Fisheries Research Technical Report*, No.100. Lowestoft: Directorate of Fisheries Research.

Gubbay. S. & Knapman, P.A. 1999. *A review of the effects of fishing within UK European marine sites*. Peterborough, English Nature (UK Marine SACs Project). 134 pages.

Hartnoll, R.G., 1998. Circalittoral faunal turf biotopes (Volume VIII). An overview of dynamics and sensitivity characteristics for conservation management of marine SACs. *Scottish Association of Marine Sciences, Oban, Scotland.* [UK Marine SAC Project. Natura 2000 reports.]

Hill, S., Burrows, S.J. & Hawkins, S.J., 1998. *Intertidal Reef Biotopes (Volume VI). An overview of dynamics and sensitivity characteristics for conservation management of marine Special Areas of Conservation.* Oban, Scottish Association for Marine Science (UK Marine SACs Project).

Hiscock, K., Elliott, M., Laffoley, D., Rogers, S., 2003. Data use and information creation: challenges for marine scientists and for managers. *Marine Pollution Bulletin*. **46**. 534-541.

Hiscock, K. & Tyler-Walters, H. in press. Identifying sensitivity in marine ecosystems: the *MarLIN* programme. *Hydrobiologia* (Proceedings of the 38th European Marine Biology Symposium).

Hiscock, K., Sewell, J. & Oakley, J. 2005. Marine Health Check 2005. A report to gauge the health of the UK's sea-life. Godalming, WWF-UK.

Holt, T.J., Rees, E.I., Hawkins, S.J. & Seed, R., 1998. Biogenic reefs (Volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. *Scottish Association for Marine Science (UK Marine SACs Project)*, 174 pp.

Hughes, D.J., 1998a. Sea pens and burrowing megafauna. An overview of dynamics and sensitivity characteristics for conservation management of marine SACs. *Natura 2000 report prepared for Scottish Association of Marine Science (SAMS) for the UK Marine SACs Project.*

Hughes, D.J., 1998b. Subtidal brittlestar beds. An overview of dynamics and sensitivity characteristics for conservation management of marine SACs. *Natura 2000 report prepared for Scottish Association of Marine Science (SAMS) for the UK Marine SACs Project.*

Jennings, S. & Kaiser, M.J., 1998. The effects of fishing on marine ecosystems. *Advances in Marine Biology*, **34**, 201-352.

Kenchington, T., 2002. *Gadus Associates' Bibliography of the Effects of Fishing Gear on the Seabed and Benthic Communities 2002 Edition*. Gadus Associates, Nova Scotia, Canada.

Lockwood, S. J. (ed.), 2001. A glossary of marine nature conservation and fisheries. Bangor, Countryside Council for Wales.

McSorely, C.A., Dean, B.J., Webb, A. & Reid, J.B., 2003. *Seabird use of waters adjacent to colonies: Implications for seaward extensions to existing breeding seabird colony Special Protection Areas*. JNCC Report, No. 329.

Newell, R.I.E. 1988. Ecological Changes in Chesapeake Bay: Are they the result of overharvesting the Eastern oyster (*Crassostrea virginica*)? In: M.P. Lynch and E.C. Krome, (eds.) Understanding the Estuary: *Advances in Chesapeake Bay Research*. Pp 536-546. (Chesapeake Research Consortium Publication 129 (CBP/TRS 24/88)), See: http://www.vims.edu/GreyLit/crc129.pdf

Pearson, T.H. & Rosenberg, R., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology: an Annual Review*, **16**, 229-311.

Pope, J.G. & Symes, D. 2000. *An ecosystem-based approach to the Common Fisheries Policy: defining the goals*. English Nature, Peterborough.

Posford Duvivier, 1999. *Guidelines for managing and monitoring aggregate extraction within UK European marine sites.* Bangor, Countryside Council for Wales (UK Marine SACs Project).

Rester, J.K., 2003. *Annotated Bibliography of Fishing Impacts on Habitat - September 2003 Update*. Gulf States Marine Fisheries Commision, Report no.115

Royal Commission on Environmental Pollution, 2004. Turning the tide: addressing the impact of fisheries on the marine environment. London, The Stationary Office.

Saunders, C.R. 1999. *Guidelines for managing recreational interactions within UK European marine sites.* Bangor, de Council for Wales (UK Marine SACS Project).

Stroud, D.A., Mudge, G.P., & Pienkowski, M.W. 1990. *Protecting internationally important bird sites (A review of the EEC Special Protection Area network in Great Britain).* Peterborough,Nature Conservancy Council.

Symes, D., & Boyes, S. 2005. *Review of fisheries management regimes and relevant legislation in UK waters*. Report to the Countryside Council for Wales, English Nature and Scottish Natural Heritage from the Institute of Estuarine & Coastal Studies, University of Hull.

11. NUMBERED REFERENCES

The following references are included in the database, details are shown in a table in Appendix 3 .

1. Bergman, M.J.N. & Hup, M., 1992. Direct effects of beam trawling on macro-fauna in a sandy sediment in the southern North Sea. *ICES Journal of Marine Science,* **49,** 5-11.
2. Kaiser, M.J. & Spencer, B.E., 1996. The effects of beam trawl disturbance on infaunal communities in different habitats. *Journal of Animal Ecology,* **65**, 348-358.
3. Currie, D.R. & Parry, G.D., 1996. Effects of scallop dredging on a soft sediment community: a large scale experimental study. *Marine Ecology Progress Series,* **134**, 131-150.
4. Witbaard, R. & Klein, R., 1994. Long-term trends on the effects of the southern North Sea beamtrawl fishery on the bivalve mollusc *Arctica islandica* L. (Mollusca, Bivalva). *ICES Journal of Marine Science,* **51**, 99-105.
5. Ferns, P.N., 1995. The effects of mechanised cockle harvesting on bird feeding in the Burry Inlet. *Burry Inlet & Loughor Estuary Symposium, March 1995, Part ,*11-18. Burry Inlet and Loughor Estuary Liaison Group.
6. Rostron, D.M., 1995. The effects of mechanised cockle harvesting on the invertebrate fauna of Llanrhidian sands. *Burry Inlet & Loughor Estuary Symposium, March 1995. Part 2,* 111-117. Burry Inlet and Loughor Estuary Liaison Group
7. Harrison, N. & Robins, M., 1992. *The threat from nets to seabirds, RSPB Conservation Review,* **6**, 51-56.
8. Dayton, P.K., Thrust, D.F., Agardi, M.T. & Hofman, R.J., 1995. Environmental effects of marine fishing. *Aquatic conservation: marine and freshwater ecosystems,* **5**, 205-232.

9. Gislason, H., 1994. Ecosystem effects of fishing activities in the North Sea. *Marine Pollution Bulletin,* **29**, 520-527.

10. Thomas, D., 1993. *Marine wildlife and net fisheries in Cardigan Bay.* RSPB/CCW

11. Kaiser, M.J. & Spencer, B.E., 1994. Fish scavenging behaviour in recently trawled areas. *Marine Ecology Progress Series,* **112**, 41-49.

12. Devon Wildlife Trust, 1993. *Lyme Bay: A report on the nature conservation importance of the inshore reefs and the effects of mobile fishing gear.* Survey report carried out by the Devon Wildlife Trust.

13. Rees, H.L. & Eleftheriou, A., 1989. North Sea benthos: A review of field investigations into the biological effects of man's activities. *J. Cons. Int. Explor. Mer,* **54**, 284-305.

14. Eno, N.C., MacDonald, D.S. & Amos S.C., 1996. *A study on the effects of fish (crustacea/mollusc) traps on benthic habitats and species*. Report to the European Commission.

15. Walker, P., Cotter, A.J.R. & Bannister, R.C.A., 1995. *A preliminary account of the effects of tractor dredging on cockles in Burry Inlet, South Wales.*

16. Hall-Spencer, J., 1995. The effects of scallop dredging on maerl beds in the Firth of Clyde. *Porcupine Newsletter,* **6**, 16-27.

17. Robins, M., 1991. *Synthetic gill nets and seabirds*. Report to WWF and RSPB

18. Moore, J., 1991. *Studies on the Impact of Hydraulic Cockle Dredging on Intertidal Sediment Flat Communities: Final Report.*

19. Northridge, S., 1988. *Marine Mammals and Fisheries: a study of conflicts with fishing gear in British waters.* Report to Wildlife Link Seals Group

20. Kaiser, M.J., Edwards, D.B. & Spencer, B.E., 1994. Infaunal community changes as a result of commercial clam cultivation and harvesting. *Aquatic Living Resources,* **9**, 57-63.

21. Southern Science., 1992. *An experimental study on the impact of clam dredging on soft sediment macro invertebrates*. Report to English Nature

22. Evans, P.L., Kaiser, M.J. & Hughes, R.N., 1996. Behaviour and energetics of whelks, *Buccinium undatum* (L.), feeding on animals killed by beam trawling. *Journal of Experimental Marine Biology and Ecology,* **197**, 51-62.

23. Kirkwood, J.K., Bennett, P.M., Jepson, P.D., Kuiken, T., Simpson, V.R. & Baker J.R., 1996. *Entanglement and other causes of death in cetaceans stranded on the coasts of England and Wales.*

24. Leth, J.O. & Kuijpers A., 1996. Effects on the seabed sediment from beam trawling in the North Sea. *ICES 1996. Annual Science Conference. Mini-symposium: Ecosystem Effects of Fisheries*. ICES C.M. 1996/Mini 3.

25. Kaiser, M.J., Ramsay, K. & Spencer, B.E., 1996. *Short-term ecological effects of beam trawl disturbance in the Irish Sea. A review,* ICES C.M. 1996/Mini 5.

26. Emerson, C.W., Grant, J. & Rowell, T.W., 1990. Indirect effects of clam digging on the viability of soft-shelled clams Mya arenaria. *Netherlands Journal of Sea Research,* **27**, 109-118.

27. Hall, S.J., Basford, D.J. & Roberts, M.R., 1990. The impact of hydraulic dredging for razor clams *Ensis* sp. on an infaunal community. *Netherlands Journal of Sea Research,* **27**, 119-125.

28. Philippart, C.J.M., 1996. *Long-term impact of bottom fisheries on several bycatch species of demersal fish and benthic invertebrates in the southeastern North Sea*. ICES C.M. 1996/Mini 6

29. Bourne, W.R.P., 1989. New evidence for bird losses in fishing nets. *Marine Pollution Bulletin,***10**, 482.

30. Caddy, J.F., 1973. Underwater observations on tracks of dredges and trawls and some effects of dredging on a scallop ground. *Journal of the Fisheries Research Board of Canada,* **30**, 173-180.

31. Read, A.J. & Gaskin, D.E., 1988. Incidental catch of Harbour Porpoises by gill nets. *Journal of Wildlife Management,* **52**, 517-523.

32. Riemann, B. & Hoffman, E., 1991. Ecological consequences of dredging and bottom trawling in the Limfjord, Denmark. *Marine Ecology Progress Series,* **69**, 171-178.

33. Chapman, C.J., Mason, J. & Drinkwater, J.A.M., 1977. Diving observations on the efficiency of dredges used in the Scottish fishery for the scallop, *Pecten maximus* (L). *Scottish Fisheries Research,* **10**, 16.

34. Jefferson, F.A. & Currey, B.E., 1994. Global review of porpoise. (Cetacea: Phocoenidae) mortality in gill nets. *Biological Conservation,* **76**, 167-183.

35. Polacheck, T., 1989. Harbour porpoises and the gill net fishery. *Oceanus,* **32**, 63-70.

36. Rostron, D., 1993. *The effects of tractor towed cockle dredging on the invertebrate fauna of Llandhidrian Sands, Burry Inlet. Subsea Survey*. Report to Countryside Council for Wales.

37. Dawson, S.M., 1991. Modifying gill nets to reduce entanglements of cetaceans. *Marine Mammal Science,* **7**, 274-282.

38. Charreire, F., 1993. *A report for Greenpeace on recent dolphin strandings along the French Atlantic coast*.

39. Hall-Spencer, J., 1995. The effects of scallop dredging on maerl beds in the Firth of Clyde.

40. Sea Fish Industry Authority, 1993. *Benthic and ecosystem impacts of dredging for pectinids*. (reference 92/3506) Consultancy Report No.71

41. Thompson, P.M., 1992. The conservation of marine mammals in Scottish waters.

100B: 123-140 *Proceedings of the Royal Society of Edinburgh,* **100B**, 123-140.

42. Bullimore, B., 1985. *An investigation into the effects of scallop dredging within the Skomer Marine Reserve*. Skomer Marine Reserve Subtidal Monitoring Project. Report to the Nature Conservation Council.

43. Northridge, S., di Natale, A., Kinze, C., Lankester, K., Ortiz de Zarate, V. & Sequeira, M., 1991. *Gill net fisheries in the European Community and their impacts on the marine environment*. MRAG Ltd. A report to the European Commission's Directorate General Environment.

44. Collie, J.S., Escanero, G.A. & Hunke, L., 1996. *Scallop dredging on Georges Bank: Photographic evaluation of effects on benthic epifauna,* ICES CM, 1996/Mini: 9

45. ICES, 1992. *Report of the study group on ecosystem effects of fishing activities,* ICES C.M. 1992/G:11

46. De Groot, S.J. & Lindeboom, H.J., 1994. *Environmental impact of bottom gears on benthic fauna in relation to natural resources management and protection of the North Sea.* Netherlands Institute for Sea Research. NIOZ-Rapport 1994-11, RIVO-DLO report CO26/94.

47. Twelves, J., 1983. Otter *Lutra lutra* mortality in lobster creels. *Journal of Zoology, London,* **201**, 585- 588.

48. Jefferies, D.J., Green, J. & Green, R., 1984. *Commercial fish and crustacean traps: a serious cause of otter Lutra lutra (L.) mortality in Britain and Europe.* 31.Vincent Wildlife Trust, London.

49. Vincent Wildlife Trust, 1988. *The effects of otter guards on the fishing efficiency of eel fyke nets.* **47**. Vincent Wildlife Trust, London

50. Jefferies, D.J., Johnson, A., Green, R. & Hanson, H.M., 1988. Entanglement with monofilament nylon fishing net: a hazard to otters. *Journal of the Otter Trust.***11-15**.

51. Jefferies, D.J., 1989. Further records of fyke net and creel deaths in British otters *Lutra lutra* with a discussion on the use of guards. *Journal of the Otter Trust.***13-19**.

52. de Groot, S.J., 1995. *On the penetration of the beam trawl into the sea bed.* ICES C.M. 1995/B:36

53. Kaiser, M.J., Bullimore, B., Newman, P., Lock, K. & Gilbert, S., 1996. Catches in 'ghost fishing' set nets. *Marine Ecology Progress Series,* **145,** 11-16.

54. Dyekjaer, S.M., Jensen, J.K. & Hoffman, E., 1995. *Mussel dredging and effects on the marine environment*. ICES C.M. 1995/E:13 ref.K.

55. Garthe, S., Camphuysen, K.C.J. & Furness, R.W., 1996. Amounts of discards by commercial fisheries and their significance as food for seabirds in the North sea. *Marine Ecology Progress Series,* **136**, 1-11.

56. Rijnsdorp, A.D., Buijs, A.M., Storbeck, F. & Visser, 1996. *Micro-scale distribution of beam trawl effort in the southern North Sea between 1993 and 1996 in relation to the trawling frequency of the sea bed and the impact on benthic organisms.* ICES C.M. 1996/Mini 11.

57. ICES, 1996. *Report of the Working Group on Ecosystem effects of fishing activities*. ICES C.M. 1996/Assess/ Env:1. Ref: G.

58. de Groot, S.J., 1984. The Impact of bottom trawling on benthic fauna of the North Sea. *Ocean Management,* **9**, 177-190.

59. Ross, A., 1988. *Controlling nature's predators on fish farms.* 96. Marine Conservation Society, Ross-on-Wye

60. Rochard, E., Castlenaud. & Lepage, M., 1990. Sturgeons (Pisces: Acipenseridae); threats and prospects. *Journal of Fish Biology,* **37**, 123-132. (Supplement A)

61. Potts, G.W. & Swaby, S.E., 1993. *Marine Fishes on the EC Habitats and Species Directive.*

62. Rees, E.S., (in press). *Environmental effects of mechanised cockle fisheries: a review of research data*. A report commissioned by the Ministry of Agriculture Fisheries and Food.

63. Stillman, R.A., Goss-Custard, J.D., McGrorty, S., West, A.D., Durell, S.E.A., le V. dit, Clarke, R.T., Caldow, R.W.G., Norris, K.J., Johnstone, I.G., Ens, B.J., Bunskoeke, E.J., v.d Merwe, A., van der Meer, J., Triplet, P., Odoni, N., Swinfen, R. & Cayford, J.T., 1996. *Models of Shellfish Populations and Shorebirds: Final Report*. Institute of Terrestrial Ecology Report to the Commission of the European Communities, Directorate-General for Fisheries.

64. Kaiser, M.J., Laing, I., Utting, S.D. & Burnell, G.M., 1998. Environmental impacts of bivalve mariculture. *Journal of Shellfish research,* **17**, 59-66.

65. Kaiser, M.J., Ramsay, K & Hughes, R.N., 1998. Can fisheries influence interspecific competition in sympatric populations of hermit crabs? *Journal of Natural History,* **32**, 521-531.

66. Kaiser, M.J., Edwards, D.B., Armstrong, P.J., Radford, K., Lough, N.E.L., Flatt, R.P. & Jones, H.D., 1998. Changes in megafaunal benthic communities in different habitats after trawling disturbance. *ICES Journal of Marine Science,* **55**, 353-361.

67. Auster, P.J., 1998. A conceptual model of the impacts of fishing gear on the integrity of fish habitats. *Conservation Biology,* **12**, 1198-1203.

68. Engel, J. & Kvitek, R., 1998. Effects of otter trawling on benthic community in Monterey Bay National Marine Sanctuary. *Conservation Biology,* **12**, 1204-1214.

69. Schwinghamer, P., Gordon, D.C. Rowell, T.W., Prena, J., McKeown, D., Sonnichson, G. & Guignes, J.Y., 1998. Effects of experimental otter trawling on surficial sediment properties of a sandy-bottom ecosystem on the Grand Banks of Newfoundland. *Conservation Biology,* **12**, 1215-1222.

71. Auster, P.J., Malatesta, R.J., Langton, R.W., Watling, L., Valentine, P.C., Donaldson, C.L.S., Longton, E.W., Shephard, A.N. & Babb, I.G., 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (northwest Atlantic): implications for conservation of fish populations. *Reviews in fisheries Science,* **4**, 185-202.

72. Philippart, C., 1996. Long-term impact of bottom fisheries on several bycatch species of demersal fish and benthic invertebrates in the southeastern North Sea. *ICES Annual Science Conference,* ICES.

73. Nickell, T.D., Black, K.D., Pearson, T.H., Davies, J.M. & Provost, P.G., 1998. *The recovery of the seabed after the cessation of fish farming: benthos and biogeochemistry*. CM 1998/V:1

74. Tuck, I.D., Hall, S.J., Robertson, M.R., Armstrong, E. & Basford, D.J., 1998. Effects of physical trawling disturbance in a previously unfished sheltered Scottish sea loch. *Marine Ecology Progress Series,* **162**, 227-242.

75. Fisheries Research Services, 1998. *A Study of the effects of water jet dredging for razor clams and a stock survey of the target species in some Western Isles populations*. Marine Laboratory, Aberdeen. Report No. 8/98

76. Watling, L. & Norse, E.A., 1998. Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. *Conservation Biology,* **12,** 1180-1197.

77. Jennings, S. & Kaiser, M.J., 1998. The effects of fishing on marine ecosystems. *Advances in Marine Biology,* **34**, 201-352.

78. Lindeboom, H.J & de Groot, S.J., 1998. *The effects of different types of fisheries on the North Sea and Irish Sea benthic ecosystems*. RIVO-DLO Report C003/98

79. Robinson, R.F. & Richardson, C.A., 1998. The direct and indirect effects of suction dredging on a razor clam (*Ensis arcuatus*) population. *ICES Journal of Marine Science,* **55**, 970-977.

80. Cooper, R.A., 1988. *Manned submersible and ROV assessment of ghost gillnets on Jeffries and Stellwagen banks, Gulf of Maine*. NOAA Undersea Research Programme Research Report 88-4.

81. Tregenza, N.J.C., Berrow, S.D., Hammond, P.S., & Leaper, R., 1997. Harbour porpoise (*Phocoena phocoena* L.) by-catch in set gillnets in the Celtic Sea. 54:896-904. *ICES Journal of Marine Science,* **54**, 896-904.

82. Black, K.D., 1996. *Aquaculture and sea lochs*. Scottish Association for Marine Science

83. Midlen, A. & Redding, T., 1998. *Environmental Management for Aquaculture,* 223. Chapman & Hall. London

84. Breen, P.A., 1987. Mortality of Dungeness crabs caught by lost traps in the Fraser River Estuary, British Columbia. *North-American Journal of Fisheries Management,* **7**, 429-435.

85. Fonseca, M.S., Thayer, G.W., Chester, A.J. & Foltz, C., 1984. Impact of scallop harvesting on eelgrass (*Zostera marina*) meadows:implications for management. *North American Journal of Fisheries Management***, 4,** 286-293.

86. Bradshaw, C., Veale, L.O., Hill, A.S., & Brand, A.R., (in press). Effects of scallop dredging on gravelly seabed communities. *The Effects of Fishing on Non-target Species and Habitats: Biological, onsevation and socio-economic issues*. (ed. M.J. Kaiser & S.J. de Groot)

87. Hill, A.S., Veale, L.O., Pennington, D., Whyte, S.G., Brand, A.R. & Hartnoll, R.G., (in press). Changes in Irish Sea benthos: possible effects of forty years of dredging. *Estuarine, Coastal and Shelf Science*.

88. Thrush, S.F., Hewitt, J. E., Cummings, V. J. & Dayton, P.K., 1995. The impact of habitat disturbance by scallop dredging on marine benthic communities; what can be predicted from the results of experiments? *Marine Ecology Progress Series,* **129**, 141-150.

89. Mattson, J. & Linden, O., 1983. Benthic macrofauna succession under mussels, *Mytilus edulis*, cultured on hanging long-lines. *Sarsia,* **68**, 97-102.

90. Andrew, N.L. & Pepperell, J.G., 1992. The by-catch of shrimp trawl fisheries. *Oceanography and Marine Biology. An Annual Review,* **30**, 527-565.

91. Berghahn, R., 1990. On the potential impact of shrimping on trophic relationships in the Waden Sea. In: Trophic Relationships in the Marine Environment. *Procedings of the 24th European Marine Biology Symposium*. (ed. M. Barnes & R.N. Gibson).

92. Spencer, B. E., Kaiser, M. J. & Edwards, D. B., 1997. Ecological effects of intertidal Manila clam cultivation: observations at the end of the cultivation phase. *Journal of Applied Ecology,* **34**, 444-452.

93. Hall, S.J. & Harding, M.J.C., 1997. Physical disturbance and marine benthic communities: the effects of mechanical harvesting of cockles on non-target benthic infauna. *Journal of Applied Ecology,* **34**, 497-517.

94. Gilkinson, K., Paulin, M., Hurley, S., Schwinghamer, P., 1998. Impacts of trawl door scouring on infaunal bivalves: results of a physical trawl door model/dense sand interaction. *Journal of Experimental Marine Biology and Ecology,* **224**, 291-312.

95. Auster, P. J. & Langton, R.W. (in press). The effects of fishing on fish habitat. *American Fisheries Society Symposium.*

96. ICES, 1998. *Report of the working group on environmental interactions of mariculture*. ICES CM 1998/F:2. Ref:ACFM+ACME+E

97. MAFF, 1997. Clam cultivation:localised environmental effects. Results of an experiment in the River Exe, Devon *Clam cultivation:localised environmental effects. Results of an experiment in the River Exe, Devon*. Directorate of Fisheries Research, Conwy

98. Blyth, R.E., Kaiser, M.J., Edwards-Jones, G., & Hart, P.J.B., 2004. Implications of a zoned fishery management system for marine benthic communities. *Journal of Applied Ecology,* **41**, 951-961.

99. Boese, B.L., 2002. Effects of recreational clam harvesting on eelgrass (*Zostera marina*) and associated infaunal invertebrates: *in situ* manipulative experiments. *Aquatic Botany,* **73**, 63-74.

100. Hiddink, J.G., 2003. Effects of suction-dredging for cockles on non-target fauna in the Wadden sea. *Journal of Sea Research,* **50**, 315-323.

101. Eleftheriou, A., Robertson, M.R., 1992. The effects of experimental scallop dredging on the fauna and physical environment of a shallow sandy community. *Netherlands Journal of Sea Research,* **30**, 289-299.

102. Gorzelany, J.F., 1998. Unusual deaths of two free-ranging Atlantic bottlenose dolphins (*Tursiops truncatus*) related to ingestion of recreational fishing gear *Marine Mammal Science,* **14**, 614-617.

103. Read, A.J., Waples, D.M., Urian, K.W. & Swanner, D., 2003. Fine-scale behaviour of bottlenose dolphins around gillnets. *Proceedings of the Royal Society of London,* 270, S90-S92.

104. Ball, B.J., Fox, G. & Munday, B.W., 2000. Long- and short-term consequences of a *Nephrops* trawl fishery on the benthos and environment of the Irish Sea. *ICES Journal of Marine Science,* **57**, 1315-1320.

105. Tuck, I.D., Bailey, N., Harding, M., Sangster, G., Howell, T., Graham, N. & Breen, M., 2000. The impact of water jet dredging for razor clams, *Ensis* spp., in a shallow sandy subtidal environment *Journal of Sea Research,* **43**, 65-81.

106. Berrow, S.D., O'Neill, M. & Brogan, D., 1998. Discarding Practices and marine mammal by-catch in the Celtic Sea herring fishery. *Biology and Environment: Proceedings of the Royal Irish Academy,* **98B**, 1-8.

107. Kaiser, M.J., Broad, G. & Hall, S.J., 2001. Disturbance of intertidal soft-sediment benthic communities by cockle hand raking. *Journal of Sea Research,* **45**, 119-130.

108. Hall-Spencer, J., Allain, V. & Fossa, J.H., 2002. Trawling damage to Northeast Atlantic ancient coral reefs. *Proceedings of the Royal Society of London,* **269**, 507-511.

109. Fossa, J.H., Mortensen, P.B. & Furevik, D.M., 2002. The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. *Hydrobiologia,* **471**, 1-12.

110. Vorberg, R., 2000. Effects of shrimp fisheries on reefs of *Sabellaria spinulosa* (Polychaeta) *ICES Journal of Marine Science,* **57**, 1416-1420.

111. Bergman, M.J.N. & Van Santbrink, J.W., 2000. Fishing mortality of populations of megafauna in sandy sediments. In *The Effects of Fishing on Non-target Species and Habitats: Biological, conservation and socio-economic issues* (ed. M.J. Kaiser & S.J. de Groot), pp. 49-78. Oxford: Blackwell Science.

112. Ball, B.,Munday, B. & Tuck, I., 2000. Effects of otter trawling on the benthos and environment in muddy sediments. In *The Effects of Fishing on Non-target Species and Habitats: Biological, conservation and socio-economic issues* (ed. M.J. Kaiser & S.J. de Groot), pp. 69-82. Oxford: Blackwell Science.

113. Bradshaw, C., Veale, L.O., Hill, A.S. & Brand, A.R., 2000. The effects of scallop dredging on gravelly seabed communities. In *The Effects of Fishing on Non-target Species and Habitats: Biological, onsevation and socio-economic issues* (ed. M.J. Kaiser & S.J. de Groot), pp. 83-104. Oxford: Blackwell Science.

114. Hall-Spencer, J.M. & Moore,P.G., 2000. Impact of scallop dredging on maerl grounds. In *The Effects of Fishing on Non-target Species and Habitats: Biological, conservation and socio-economic issues* (ed. M.J. Kaiser & S.J. de Groot), pp. 105-117. Oxford: Blackwell Science.

115. Tregenza, N.J.C., 2000. Fishing and cetacean by-catches. In *The Effects of Fishing on Non-target Species and Habitats: Biological, onsevation and socio-economic issues* (ed. M.J. Kaiser & S.J. de Groot), pp. 105-117. Oxford: Blackwell Science.

116. McGlade, J.M. & Metuzals, K.I., 2000. Options for the reduction of by-catches of harbour porpoises (*Phocoena phocoena*) in the North Sea. In *The Effects of Fishing on Non-target Species and Habitats: Biological, onsevation and socio-economic issues* (ed. M.J. Kaiser & S.J. de Groot), pp. 105-117. Oxford: Blackwell Science.

117. Kaiser, M.J., Cheney, K., Spence, F.E. Edwards, D.B. & Radford, K., 1999. Fishing effects in northeast Atlantic shelf seas: Patterns in fishing effort, diversity and community structure VII. The effects of trawling disturbance on the fauna associated with the tubeheads of serpulid worms. *Fisheries Research,* **40**, 195-205.

118. Jenkins, S.R., Beukers-Stewart, B.D. & Brand, A.R., 2001. Impact of scallop dredging on benthic megafauna: a comparison of damage levels in captured and non-captured organisms. *Marine Ecology Progress Series,* **215**, 287-301.

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

120. Kamenos, N.A., Moore, P.G. & Hall-Spencer, J.M., 2003. Substratum heterogeneity of dredged vs un-dredged maerl grounds. *Journal of the Marine Biological Association of the United Kingdom,* **83**, 411-413.

121. Hall-Spencer, J.M. & Moore, P.G., 2000. Scallop dredging has profound long-term impacts on maerl habitats. *ICES Journal of Marine Science,* **57**, 1407-1415.

122. Bergman, M.J.N. & van Santbrink, J.W. 2000. Mortality in megafaunal benthic population caused by trawl fisheries on the Dutch continental shelf in the North Sea. *ICES Journal of Marine Science,* **57**, 1321-1331.

123. Hall-Spencer, J.M., Froglia, C., Atkinson, R.J.A. & Moore, P.G., 1999. The impact of rapido trawling for scallops *Pecten jacobaeus* (L.) on the benthos of the Gulf of Venice. *ICES Journal of Marine Science,* **56**, 111-124.

124. Ramsay. K., Kaiser. M.J. & Hughes, R.N., 1998. Responses of benthic scavangers to fishing disturbance by towed gears in different habitats. *Journal of Experimental Marine Biology and Ecology,* **224**, 73-89.

125. Prena, J., Schwinghamer, P., Rowell, T.W., Gordon Jr, D.C., Gilkinson, K.D., Vass, W.P. & McKeown, D.L., 1999. Experimental otter trawling on a sandy bottom ecosystem of the Grand Banks of Newfoundland:analysis of trawl bycatch and effects on epifauna. *Marine Ecology Progress Series,* **181**, 107-124.

126. Moran, M.J. & Stephenson, P.C., 2000. Efects of otter trawling on macrobenthos of demersal scalefish fisheries on the continental shelf of north-western Australia. *ICES Journal of Marine Science,* **57**, 510-516.

127. Pranovi, F., Raicevich, S., Franceschini, G., Farrace, M.G. & Giovanardi. O., 2000. Rapido trawling in the northern Adriatic Sea: Effects on benthic communities in an experimental area. *ICES Journal of Marine Science,* **57**, 517-524.

128. Smith, C.J., Papadopoulou, K.N. & Diliberto, S., 2000. Impact of otter trawling on an eastern Mediterranean commercial trawl fishing ground. *ICES Journal of Marine Science,* 57, 1340-1351.

129. McConnaughey, R.A., Mier, K.L. & Dew, C.`B., 2000. An examination of chronic trawling effects on soft-bottom benthos in the eastern Bering Sea *ICES Journal of Marine Sceince,* **57**, 1377-1388.

130. Watling, L., Findlay, R.H., Mayer, L.M. & Schink, D.F., 2001. Impact of a scallop drag on the sediment chemistry, microbiota and faunal assemblages of a shallow subtidal marine benthic community. *Journal of Sea Reasearch,* **46**, 309-324.

131. Hauton, C., Hall-Spencer, J.M. & Moore, P.G., 2003. An experimental study of the ecological impacts of hydraulic bivalve dredging on maerl. *ICES Journal of Marine Science,* **60**, 381-392.

132. Veale, L.O., Hill, A.S., Hawkins, S.J. & Brand, A.R., 2000. Effects of long-term physical disturbance by commercial scallop fishing on subtidal epifaunal assemblages and habitats. *Marine Biology,* **137**, 325-337.

133. Beukema, J.J., 1995. Long-term effects of mechanical harvesting of lugworms *Arenicola marina* on the zoobenthic community of a tidal flat in the Wadden Sea. *Netherlands Journal of Sea Research,* **33**, 219-227.

134. Ferns, P.N., Rostron, D.M. & Siman, H.Y., 2000. Effects of mechanical cockle harvesting on intertidal communities. *Journal of Applied Ecology,* **37**, 464-474.

135. McFee, W.E. & Hopkins-Murphey, S.R., 2002. Bottlenose dolphin (*Tursiops truncatus*) strandings in South Carolina, 1992-1996. *Fishery Bulletin,* **100**, 258-265.

136. Friedlaender, A.S., McLellan, W.A. & Pabst, D.A., 2001. Characterising an interaction between coastal bottlenose dolphins (*Tursiops truncatus*) and the spot gillnet fishery in southeastern North Carolina, USA. *Journal of Cetacean Reseacrh and Management,* **3**, 293-303.

137. Cox,T.M., Read, A.R., Swanner, D., Urian, K. & Waples, D., 2003. Behavioural responses of bottlenose dolphins, *Tursiops truncatus* to gillnets and acoustic alarms. *Biological Conservation,* **115**, 203-212.

138. Culick, B.M., Koschenski, S., Tregenza, N. & Ellis, G.M., 2001. Reactions of harbor porpoises *Phocoena phocoena* and herring *Clupea harengus* to accoustic alarms. *Marine Ecology Progress Series,* **211**, 255-260.

139. Kastelein, R.A., Au, W.W.L. & de Haan, D., 1999. Detection distances of bottom-set gillnets by harbour porpoises (*Phocoena phocoena*) and bottlenose dolphins (*Tursiops truncatus*). *Marine Environmental Research,* **49**, 359-375.

140. Cox, T.M., Read, A.J., Solow, A. & Trengenza, N., 2001. Will harbour porpoises (*Phocoena phocoena*) habituate to pingers? *Journal of Cetacean Research and Management,* **3**, 81-86.

141. Norris, K., Bannister, R.C.A. & Walker, P., 1998. Seasonal changes in the number of oystercatchers *Haematopus ostralgus* wintering on the Burry Inlet in relation to the biomass of cockles *Cerastoderma edule* and its commercial exploitation. *Journal of Applied Ecology,* **35**, 75-85.

142. Moore, P.G., 2003. Seals and fisheries in the Clyde Sea area (Scotland): traditional knowledge informs science *Fisheries Research,* **63**, 51-61.

143. Morizur, Y., Berrow,S.D., Tregenza, N.J.C., Couperus, A.S. & Pouvreau, S., 1999. Incidental catches of marine-mammals in pelagic trawl fisheries of the northeast Atlantic *Fisheries Research,* **41**, 297-307.

144. Le Loc'h, F. & Hily, C., (in press). How does benthic and demersal fishery affects biodiversity, structure and functioning of the 'Grande Vasiere' benthic communities (Bay of Biscay, NE Atlantic)? *Hydrobiologia (38th European Marine Biology Symposium)*. (Ed H, Queiroga)

145. Hillman, R., 2003. *The Distribution, Biology and Ecology of Shad in South-West England*. R&D Technical Report W1-047/TR, Environment Agency, Bristol.

146. Bullimore, B.A., Newman, P.B., Kaiser, M.J., Gilbert, S.E. & Lock ,K.M., 2001. A study of catches in a fleet of 'ghost fishing' pots. *Fishery Bulletin,* 99, 247-253.

147. Collie, J.S., Escanero, G.A. & Valentine, P.C., 2000. Photographic evidence of the impacts of bottom fishing on benthic epifauna. *ICES Journal of Marine Science,* **57**, 987-1001.

148. Dolmer, P., Kristensen, T., Christiansen, M.L., Kristenesen, P.S. & Hoffmann, E., 1999. Short-term impact of blue mussel dredging (*mytilus edulis* L.) on a benthic community. *Journal of shellfish Research,* **18,** 714.

149. Hauton, C., Atkinson, R.J.A. & Moore, P.G., 2003. The impact of hydraulic blade dredging on a benthic megafaunal community in the Clyde Sea area, Scotland. *Journal of Sea Research,* **50**, 45-56.

150. Cryer, M., Whittle, G.N., Williams, R., 1987. The impact of bait collection by anglers on marine intertidal invertebrates. *Biological Conservation,* **42**, 83-93.

151. Caldow, R.W.G., Beadman, H.A, S. McGrorty, S., Kaiser, M.J, Goss-Custard, J.D, Mould, K. & Wilson, A., 2003. Effects of intertidal mussel cultivation on bird assemblages. *Marine Ecology Progress Series,* **259**, 173-183.

152. Brown, B. & Wilson, W.H., 1997. The role of commercial digging of mudflats as an agent for change of infaunal intertidal populations. *Journal of Experimental Marine Biology and Ecology,* **218**, 49-61.

153. Cotter, A.J.R., Walker, P., Coates, P., Cook, W. & Dare, P.J., 1997. Trial of a tractor dredger for cockles in Burry Inlet, south Wales. *ICES Journal of Marine Science,* **54**, 72-83.

154. Gilkinson, K.D., Fader, G.B.J., Gordon Jr,D.C., Charron, R., McKeown, D., Roddick, D., Kenchington, E.L.R., MacIsaac, K., Bourbonnais, C., Vass, P., Liu, Q., 2003. Immediate and longer-term impacts of hydraulic clam dredging on an offshore sandy seabed: effects on physical habitat and processes of recovery. *Continental Shelf Research,* **23**, 1315-1336.

155. Robinson, S.M.C., Bernier, S.& MacIntyre, A., 2001. The impact of scallop drags on sea urchin populations and benthos in the Bay of Fundy, Canada *Hydrobiologia,* **465**, 103-114.

156. Spencer, B.E., Kaiser, M.J. & Edwards, D.B., 1998. Intertidal clam harvesting: benthic community change and recovery. *Aquaculture Research,* **23**, 429-437.

157. Freiwald, A., Fossa, J.H., Grehan, A., Koslow, T. & Roberts, J.M., 2004. *Cold-water coral reefs*. pp. 37 - 39. UNEP - WCMC, Cambridge, UK.

158. House of Commons Environment, Food and Rural Affairs Committee, 2004. *Caught in the net: by-catch of dolphins and porpoises off the UK coast*. 3rd Report of session 2003 - 2004. The House of Commons, London.

159. Roberts, D. 2003. *Work Package 2 - The current status of Strangford* Modiolus*. KA 2.1: Diving Survey 2003*. Strangford Lough Ecological Change Investigation, Queen's University, Belfast

160. Camhuysen, C.J., Berrevoets, C.M., Cremers, H.J.W.M., Dekinga, A., Dekker, R., Ens, B.J., van der Have, T.M., Kats, R.K.H., Kuiken, T., Leopold, M.F., van der Meer, J. & Piersema, T., 2002. Mass mortality of common eiders (*Somateria mollissima*) in the Dutch Wadden Sea, winter 1999/2000: starvation in a commercially expoited wetland of international importance. *Biological Conservation,* **106**, 303-317.

161. Maitland, P.S., 2003. *Ecology of the river, brook and sea lamprey,* , . Conserving Natura 2000 Rivers Ecology Series No.5. English Nature, Peterborough.

162. Service, M. & Magorrian, B.H., 1997. The extent and temporal variation of disturbance to epibenthic communities in Strangford Lough, Northern Ireland. *Journal of the Marine Biological Association of the United Kingdom,* **77**, 1151-1164.

163. Sparks-McConkey, P.J. & Watling, L., 2001. Effects on the ecological integrity of a soft-bottomed habitat from a trawling disturbance. *Hydrobiologia,* **456**, 73-85.

164. Edwards, A. & Garwood, P., 1992. The Gann Flat, Dale: thirty years on. *Field Studies,* **8**, 59-75.

165. Bradshaw, C., Veale, L.O., Hill, A.S. & Brand, A.R., 2001., The effect of scallop dredging on Irish Sea benthos: experiments using a closed area. *Hydrobiologia,* **465**, 129-138.

166. Hilgerloh, G., O' Halloran, J.O., Kelly, T.C. & Burnell, G.M., 2001. A preliminary study on the effects of oyster culturing structures on birds in a sheltered Irish estuary. *Hydrobiologia,* **465**, 175-180.

167. Tasker, M.J., Camphuysen, C.J., Cooper, J., Garthe, S., Montececchi, W.A. & Blaber, S.J.M., 2000. The impact s of fishing on marine birds. *ICES Journal of Marine Science,* **57**, 531-547.

168. Camphuysen, C.J. & Garthe, S., 2000. Seabirds and commercial fisheries: population trends of piscivorous seabirds explained? *The Effects of Fishing on Non-target Species and Habitats: Biological, onsevation and socio-economic issues*. (ed. M.J. Kaiser & S.J. de Groot), pp. 163-184. Oxford: Blackwell Science.

169. Black, K.D., Blackstock, J., Gillibrand, P., Moffat, C., Needham, H., Nickell, T.D., Pearson, T.H., Powell, H., Sammes, P., Somerfield, P. and Willis, K., 2003. *The Ecological Effects of Sealice Medicines, Interim Public Report*. Scottish Association for Marine Science, Aberdeen.

170. Bosetti, V. & Pearce, D., 2003. A study of environmental conflict: the economic value of grey seals in southwest England. *Biodiversity and Conservation,* **12**, 2361-2392.

171. Pierpoint, C., 2000. *Bycatch of marine turtles in UK and Irish waters*. JNCC Report No 310

172. Penrose, R.S., 2004. *UK & Eire marine turtle strandings & sightings annual report 2003*. Marine Environmental Monitoring, Cardigan, West Wales.

173. Henderson, P.A., 2003. *Background information on species of shad and lamprey.* Bangor, Countryside Council for Wales Marine Monitoring report no: 7.

174. Baardseth, E., 1970. Synopsis of the biological data on knotted wrack *Ascophyllum nodosum* (L.) Le Jolis. *FAO Fisheries Synopsis,* 38. Rev. 1.

175. Mathieson, A.C. & Burns, R.L., 1971. Ecological studies of economic red algae. 1. Photosynthesis and respiration of *Chondrus crispus* (Stackhouse) and *Gigartina stellata* (Stackhouse) Batters. *Journal of Experimental Marine Biology and Ecology,* **7**, 197-206.

176. Sharp, G.J., Tetu, C., Semple, R. & Jones, D., 1993. Recent changes in the seaweed community of western Prince Edward Island: implications for the seaweed industry. *Hydrobiologia,* **260-261**, 291-296.

177. UK Biodiversity Group., 1999. *Tranche 2 Action Plans - Volume V: Maritime species and habitats*. UK Biodiversity Group

178. Beadman, H.A., 2003. *Impact of mussel cultivation with special reference to the Menai Strait and Conwy Bay candidate Special Area of Conservation*. CCW Contract Science Report No: 580. Countryside Council for Wales

179. Rees, E.I.S., Dare, P., Domer, P. & Smaal, A.C., 2004. *Peer review of a CCW commisioned report: Beadman, H. (2003) Impacts of mussel seabed-lay bottom cultivation, with special reference to the Menai Strait and Conwy bay candidate special area of conservation*. CCW Contract Science Report No: 657. Countryside Council for wales.

180. Cook, W., Jones, E., Wyn, G. & Sanderson, W.G., 2002. *Experimental studies on the effects of shore crab collection using artificial shelters on an intertidal sandflat habitat*. CCW Contract Science Report No 511. Countryside Council For Wales

181. Rimington, N., 2002. *The relationship between mussel and oystercatcher populations in the Burry Inlet, Part 2*. CCW Contract Science Report No 491

182. Andrews, J., 2003. Sands of change. Portrait of the cockle fishery in Morecombe Bay: November 2002 - October 2003. *Shellfish News,* 16, 21-24.

183. Eno, N.C., Clark, R.A. & Sanderson, W.G., 1997. *Non-native marine species in British waters: a review and directory*. Joint Nature Conservation Committee, Peterborough.

184. Kenchington, E.L.R., Prena, J., Gilkinson, K.D., Gordon, Jr, D.C., MacIsaac, K., Bourbonnais, C., Schwinghamer, P.J., Rowell, T.W., McKeown, D.L. & Vass, W.P., 2001. Effects of experimental otter trawling on the macrofauna of a sandy bottom ecosystem on the Grand Banks of Newfounland. *Canadian Journal of Fisheries and Aquatic Sciences,* **58**, 1043-1057.

185. Thrush, S.F., Hewitt, J.E., Funnell, G.A., Cummings, V.J., Ellis, J., Schultz, D., Talley, D. & Norkko, A., 2001. Fishing disturbance and marine biodiversity: role of habitat structure in simple soft-sediment systems. *Marine Ecology Progress Series,* **221**, 255-264.

186. Fraschetti, S., Bianchi, C.N., Terlizzi, A., Fanelli, G., Morri, C. & Boero, F., 2001. Spatial variability and human disturbance in shallow subtidal hard substrate assemblages: a regional approach *Marine Ecology Progress Series,* **212**, 1-12.

187. Bell, D.V., Odin, N., Austin, A., Hayhow, S., Jones, A., Strong, A. & Torres, E., 1984. *The impact of anglers on wildlife and site amenity*. Department of Applied Biology, UWIST, Cardiff.

188. Liddiard, M., Gladwin, D.J., Wege, D.C. & Nelson-Smith, A., 1989. *Impact of boulder-turning on sheltered sea shores*. Report to the Nature Conservancy Council. School of Biological Sciences, University College of Swansea. NCC CSD Report 919.

189. Cunningham, P.N., Hawkins, S.J., Jones, H.D. & Burrows, M.T., 1984. *The geographical distribution of* Sabellaria alveolata*(L.) in England, Wales and Scotland, with investigations into the community structure of and the effects of trampling on* Sabellaria alveolata *colonies*. Nature Conservancy Council, Peterborough, Contract Report no. HF3/11/22.

190. Rogers, A.D., 1999. The biology of *Lophelia pertusa* (Linnaeus, 1758) and other deep-water reef-forming corals and impacts from human activities. *International Review of Hydrobiology,* **84**, 315-406.

191. Black, G., 2004. *Report on Surveys in 2003/04 of Crab Tiling Activity on Devon's Estuaries and Comparison with 2000/01 Crab Tile Survey Data*. Devon Biodiversity Records centre, Exeter.

192. Lancaster, J & Smith, J., 2004. *Solway Firth Regulating Order Draft Management Plan*. Solway Shellfish Management Association, Dumfries

APPENDIX 1. List of habitats and species in the UK that require protection under the Habitats and Birds Directives**.** (From Gubbay and Knapman, 1999.)

UK marine habitats listed in Annex I of the Habitats Directive whose conservation requires the designation of Special Areas of Conservation

Estuaries
Lagoons
Large shallow inlets and bays
Submerged or partly submerged sea caves
Sandbanks which are slightly covered by seawater all the time
Mudlfats and sandflats not covered by seawater at low tide
Reefs

UK marine species on Annex II of the Habitats Directive whose conservation requires designation of Special Areas of Conservation

Grey seal	*Halichoerus grupus*
Common seal	*Phoca vitulina*
Bottlenose dolphin	*Tursiops truncatus*
Harbour porpoise	*Phocoena phocoena*
Otter	*Lutra lutra*
Allis shad	*Alosa alosa*
Twaite shad	*Alosa fallax*
Lampern	*Lampetra fluviatilis*
Sea lamprey	*Petromyzon marinus*
Sturgeon	*Acipenser sturio*
Houting	*Coregonus oxyrinchus*

Seabirds and estuarine/coastal birds occuring around the UK which are on Annex 1 of the Birds Directive

Red throated diver	*Gavia stellata*
Black throated diver	*Gavia arctica*
Great northern diver	*Gavia immer*
Slavonian grebe	*Podiceps auritus*
Storm petrel	*Hydrobates pelagicus*
Leach's petrel	*Oceanodroma luecorhoa*
Avocet	*Recurvirostra avosetta*
Golden plover	*Pluvialis apricaria*
Red-necked phalarope	*Phalaropus lobatus*
Mediterranean gull	*Larus melanocephalus*
Sandwich tern	*Sterna sandvicensis*
Roseate tern	*Sterna dougallii*
Common tern	*Sterna hirundo*
Arctic tern	*Sterna paradisaea*
Little tern	*Sterna albifrons*
Black tern	*Childonias niger*
Smew	*Mergus albellus*
Bar-tailed Godwit	*Limosa lapponica*
Great Bittern	*Botaurus slellaris*
Little Egret	*Egretta garzetta*
Whooper Swan	*Cygnus cygnus*
Barnacle Goose	*Branta leucopsis*
Eurasian Marsh Harrier	*Circus aeruginosus*
Hen Harrier	*Circus cyaneus*
Ruff	*Philomachus pugnax*

Regularly occurring migratory seabirds and estuarine/coastal birds around the UK not on Annex 1 of the Birds Directive

Fulmar	*Fulmaris glacialis*
Manx shearwater	*Puffinus puffinus*
Gannet	*Sula bassana*
Cormorant	*Phalacrocorax carbo*
Shag	*Phalacrocorax aristotelis*
Pink-footed Goose	*Anser brachyrhynchus*
Light-bellied brent	*Branta bernicla bernicla*
Dark-bellied brent	*Branta bernicla hrota*
Little Grebe	*Tachybaptus ruficollis*
Wigeon	*Anas penelope*
Gadwall	*Anas strepera*
Scaup	*Aythya marila*
Shelduck	*Tadorna tadorna*
Eider	*Somateria mollissima*
Long-tailed duck	*Clangula hyemalis*
Common Teal	*Anas crecca*
Northern Pintail	*Anas acuta*
Common scoter	*Melanitta nigra*
Velvet scoter	*Melanitta fusca*
Goldeneye	*Bucephala clangula*
Red-breasted merganser	*Mergus serrator*
Goosander	*Mergus merganser*
Oystercatcher	*Haematopus ostralegus*
Ringed plover	*Charadrius hiaticula*
Grey plover	*Pluvialis squaratola*
Lapwing	*Vanellus vanellus*
Knot	*Calidris canutus*
Sanderling	*Calidris alba*
Little Stint	*Calidris minuta*
Purple sandpipe	*Calidris maritima*
Dunlin	*Calidris alpina*
Common snipe	*Gallinago gallinago*
Black-tailed godwit	*Limosa limosa*
Whimbrel	*Numenius phaeopus*
Curlew	*Numenius arquata*
Redshank	*Tringa totanus*
Spotted redshank	*Tringa erythropus*
Greenshank	*Tringa nebularia*
Green sandpiper	*Tringa ochropus*
Common sandpiper	*Actitis hypoleucos*
Turnstone	*Arenaria interpres*
Arctic skua	*Stercorarius parasiticus*
Great skua	*Stercorarius skua*
Little gull	*Larus minutus*
Black-headed gull	*Larus minutus*
Common gull	*Larus canus*
Lesser black-backed gull	*Larus fuscus*
Herring gull	*Larus argentatus*
Iceland gull	*Larus glaucoides*
Glaucous gull	*Larus hyperboreus*
Great black-backed gull	*Larus marinus*
Kittiwake	*Rissa tridactyla*
Guillemot	*Uria aalge*
Razorbill	*Alca torda*
Puffin	*Fratercula arctica*

APPENDIX 2. Summary of the potential impacts of different fishing methods and gear on habitats and marine life.

The adverse effects listed are not necessarily an inevitable consequence of particular sorts of fishing and depend on habitat and species involved. Based on Gubbay & Knapman (1999) with additional information from the current review.

1. **Habitats.** The summary has not been separated into different Annex I habitats - potential impacts in each Annex 1 habitat are likely to be similar. Impacts on target species are not generally listed.

Fishery	Method	Potential effects on habitats
Scallops	Dredging	• Biogenic reefs (including *Modiolus modiolus* and *Limaria hians*) and associated fauna and flora damaged or destroyed. • Dredge tracks visible for varying amount of time, i.e. days or months. In stable conditions a relatively minor fishery may have a significant cumulative effect on bottom micro topography. • Top 60 –100 mm of substrate disturbed. • Resuspension of sediment. • Many large fragile organisms killed whilst smaller more robust organisms may be largely unharmed (most of damage occurs on the seabed and little seen as by-catch). • Significant reduction in biomass of target and non target species immediately after fishing operation. Likely to be more pronounced with extended recovery times, i.e. many months, in areas with diverse communities and stable conditions. • Species diversity and richness, total number of species and numbers of individuals all decrease significantly with increased fishing effort. Where biogenic reefs – especially horse mussels – have been destroyed, recovery not observed. • Species dominance increases with increased fishing effort. • Maerl crushed, smothered and killed and Reburial of live maerl. • Associated biota of maerl caught, damaged or smothered by resuspended sediment. • Relatively soft rocky outcrops can be subject to physical damage. • Soft or fragile species damaged or killed. • Fan mussels *Atrina fragilis* damaged, displaced or impaled. • Reduce structural complexity of habitats (Lead to habitat homogenisation) and reduce biodiversity. • Large amounts of bycatch. • In long lived, complex biogenic habitats effects are likely to be long-lasting. • May cause damage to large algae such as kelp.
Oysters & mussels	Light dredge	• Subtidal and intertidal dredge tracks visible for varying amounts of time, i.e. Months in stable sediments, hours in mobile sediments. • Top 10-15 cm of substrate disturbed and sediment plumes created. • Change in benthic flora and fauna as a consequence of repeated dredging.

Demersal fin fish	Beam trawling	• Trawl tracks visible for varying amount of time, i.e. Days or months. • Top 10 – 60 mm of substrate disturbed. • Non-target organisms caught and die as discards. • Influx of scavenging species post fishing operation. • Over fishing reduces food availability for seabirds. • Resuspension of sediment. • Sediment structure may change from coarse grained sand/gravel to fine sand/coarse silt. • Reduced diversity, abundance and biomass of sediment infauna. • Significant reduction in biomass of target and non-target species immediately after fishing operation. Likely to be more pronounced with extended recovery times, i.e. many months, in areas with diverse communities and stable conditions. • Considerable variation in damage or mortality to affected species. Fragile, long-lived, slow moving or sedentary species most vulnerable. • Repeated trawling may cause benthic community structure to change, favouring more mobile species, rapid colonisers and juvenile stages. • Biogenic reefs, e.g. *Sabellaria,* and species that stabilise sediments, e.g. eel grass, may be severely damaged resulting in resuspension of sediment. Repeated trawling may cause benthic community structure to change, favouring more mobile species, rapid colonisers and juvenile stages.
Shrimp	Lightweight beam trawl	• *Sabellaria* reefs may be able to withstand occasional trawls. • The effects of repeated trawls may be more damaging. • Shrimp trawls have, in the past been blamed for the disappearance of *Sabellaria spinulosa* reefs.
Demersal fin fish	Otter trawling	• Similar effects to beam trawling although severe adverse effects generally less. • Significantly lower amount of epifauna at fished locations. • Incidental catch may include seals.
Norway lobster (*Nephrops*)	Otter trawling	• Reduction in species diversity, number of individuals and biomass. • Loss of large epifauna species such as tall sea pens *Funiculina quadrangularis* and fireworks anemones *Pachycerianthus multiplicatus.*
Cockle & clam	Tractor towed dredge	• Intertidal dredge tracks visible for varying amounts of time, i.e. months in stable sediments, a tide in mobile sediments. • Sediment layers may be altered causing erosion to cockle bed. • Significant reduction in abundance and biomass of target and non-target species immediately after fishing operation. Effects last more than half a year in areas with diverse communities and stable conditions. • Top 10-15 cm of substrate disturbed and sediment plumes created. • Change in benthic flora and fauna as a consequence of repeated dredging. • Bird numbers initially increased but then decreased for 50 days or more.
Cockle & clam	Hydraulic dredge	• Level seabed changed to one with furrows. • Fauna smothered and displaced. • Can be very damaging to eel grass habitat, has led to disappearance of beds in some areas.
Razor clams	Hydraulic dredge	• Subtidal dredge tracks, deeper than a conventional hydraulic cockle dredge (e.g. 0.5 – 3.5 m wide, 0.25 – 0.6 m deep). Visible for weeks/months in mobile sediments. • Substantial physical disturbance of substratum.

		• Significant reduction in abundance of non-target species immediately after fishing operation. Weeks/months to recover to pre fishing levels in mobile sediment. (Some references suggest shorter-period effects.) • By-catch, Smothering and reburial of live maerl, including smothering over a large area. • Large, fragile and long-lived species may be directly killed or caught as by-catch, whilst smaller robust organisms are generally unharmed.
Demersal fish and bivalves	Mobile gears (general)	• Reduce structural complexity of habitat (Lead to habitat homogenisation) and reduce biodiversity. • As fishing effort increases, species diversity and richness and total number of species decrease. • Remove erect epifaunal species and large sessile species. • Where the habitat is naturally highly disturbed, the effects of mobile gears may be relatively short lived, but in undisturbed areas, effects will be detectable for longer. • Some muddy sand species, which are rare or nationally scarce, may be completely lost from some areas as a result of fishing. • Likely to cause physical damage to eelgrass beds through abrasion, and physical removal. • Physical damage may be caused to fragile structures. • Large, fragile and long-lived species may be directly killed or selectively removed, whilst smaller robust organisms are generally unharmed. • Deep-water coral reefs crushed reducing structural complexity and species diversity. • Physical damage to long-lived, biogenic structures will be extremely long lasting.
Demersal and Pelagic fish	Fixed or drift (gill) nets	• Incidental catch of marine life including marine mammals and birds. • 'Ghost fishing', dependent on condition of gear. In rocky, less exposed areas may be active for months, on clean exposed ground, days to weeks. • Nets can become tangled in complex structures and lost, continuing to entangle marine life. • In deep water coral reefs, nets may snag and break off sections of fragile coral. • Anchors and weights may damage fragile structures.
Crustaceans	Tangle nets	• No specific references found. Danger of snagging and removing attached benthic organisms and of ghost fishing if lost.
Crustaceans	Pots / creels	• Fragile, brittle species such as ross, *Pentapora fascialis*, crushed when pots make contact. • 'Ghost fishing' – parlour pots can continue to fish in excess of 270 days. A cycle of capture, decay and attraction of species of commercial and non-commercial interest takes place. • Will have minimal impact on large benthic fauna such as seapens and seafans. • Lost or discarded pots may be washed into sensitive areas and damage fragile species through abrasion. • Lost or discarded pots and ropes may entangle larger organisms. • Pots and ropes can become tangled in complex structures and lost, continuing to trap and kill marine life.

Cockle & clam	Hand gathering (including raking)	• Holes and tailings left on the intertidal visible for varying amounts of time, i.e. Months in stable sediments, a tide in mobile sediments. • Sediment layers may be altered causing erosion to cockle bed. • Under size target species damaged or exposed to predation, desiccation or freezing. • Significant reduction in biomass of target and non-target species immediately after fishing operation. Likely to be more pronounced with extended recovery times, i.e. many months, in areas with diverse communities and stable conditions. • Disturbance of wading bird species. • Eelgrass beds damaged although recovery may be rapid. • All terrain vehicles used for hand gathering may have adverse effects on habitats. • Raking is potentially less damaging to eel grass beds than digging, but both may result in the loss of plant biomass.
Winkles	Hand collecting	• Harvesting may reduce numbers, average size of winkles. No specific habitat effects were found during this report.
Rock boring bivalves	Hand collection	• Destroying rocks to extract rock boring bivalves such as paddocks may lead to disappearance of epibiota and patchy communities.
Bait collecting (worms)	Digging	• Sediment re-distributed so that coarse material brought to the surface with associated changes in community structure. • Declines in abundance of some non-target species.
	Mechanical lugworm harvesting	• Total zoobenthic biomass declined and takes several years to recover. • Removal and loss of some slow-growing, long-lived species including *Mya arenaria* almost extinguished and not recovered for 5 years.
	Collecting worms from *Sabbelaria alveolata* reefs.	• Removal of worms does occur, but direct impacts are unknown. • Trampling by bait collectors may damage worm tubes, but worms are able to rebuild and recover quickly.
Crustaceans	Tiles	• Decrease in abundance and number of species under tiles. • Decrease in abundance of species in trampled areas.
	Hand gathering	• Rocks may be overturned and not replaced. • Some disturbance to birds. • No specific references found for the use of hooks, although this may cause some abrasion. • Collection of large crustaceans by divers may significantly reduce populations of target species.
Seaweed collection	Hand collecting	• Reduced protection from desiccation of underflora and fauna. • Decimation of populations of some species of seaweed (particularly *Ascophyllum nodosum* ecad *Mackaii*)
Finfish Mariculture	Cages	• Smothering of benthic communities with faecal and waste food. • Anoxic conditions underneath cage. • Raised levels of dissolved gases, hydrogen sulphide, and ammonia. • Sublethal effects of chemical disease and sea lice treatments on lug worm. • Potential for hypernutrifiaction in low energy locations. • Mammals caught in anti-predator nets. • In very sheltered areas with poor water exchange, effects are likely to be amplified.
Oyster mariculture	Trays	• Deliberate (oysters) and accidental introduction of alien species. • Where non-native oysters become established, they may smother existing species.

		• In very sheltered areas with poor water exchange, effects are likely to be amplified.
Clam mariculture	Lays	• Manila clam cultivation in lays increases density of benthic species, changes in infauna and increased sedimentation. • Harvesting with hand raking reduces species diversity and abundance by 50 %; suction dredging reduces species abundance by 80-90%. Recovery to pre-harvesting levels may take long periods e.g. 7 months. • Deliberate (clams) and accidental introduction of alien species.
Mussel cultivation	Ropes	• No specific references found. Pseudofaeces and detached mussels may change bottom type and attract scavengers such as starfish.
	Seed	• Created mussel beds form a new habitat supporting a wide diversity of organisms. • Mussels in the seeded area are a source of food for birds. • The balance of different bird species may change. • Introduction of non-native species. • Seed collection removes food of some birds.
	Trays	• Increased sedimentation and effects on infauna beneath mussel cultures.

2. Species. Habitats Directive Annex II species and general groupings for Annex IV and Birds Directive species. Grouping of tables 19 to 29 listed in the order they appear in the report.

Fishery	Fishing method	Potential effects
		Otter, *Lutra lutra*
	Fyke nets	• Inquisitive and foraging otters becoming accidentally caught in these nets have led to mandatory use of otter guards.
	Pots and creels	• Inquisitive and foraging otters accidentally caught in these traps. Occurrence of accidental capture may be linked to season and availability of food.
		Grey seal *Halichoerus grypus* and common seal, *Phoca vitulina*
Demersal and pelagic fish	Fixed nets	• Entanglement in nets has been recorded for both species. • Young seals most vulnerable.
Finfish mariculture	cages	• Entanglement in ‘anti-predator nets’. • Fish farmers permitted to shoot seals.
Demersal fish	Towed gear	• Both species, but particularly grey seals may occur as bycatch. • Grey seals may travel long distances out to sea, making them particularly vulnerable to capture in offshore fisheries.
Pelagic fish (herring)	Pair trawls	• Grey seals likely to occur as bycatch.
		Harbour porpoise, *Phocoena phocoena*
Demersal and pelagic fish	Gill netting - drift nets, trammel nets set nets	• Accidental entanglement and capture. It is considered that this is the most frequent cause of death of the harbour porpoise and, with their slow reproductive rate, means that there could be a serious threat to sustainability of discrete populations. • Unable to detect gill nets by echolocation in time to avoid collision. • Pingers may deter temporarily, but habituation may follow making them ineffective.
		Bottle-nosed dolphin, *Tursiops truncatus*
Demersal and pelagic fish	Bottom-set-gillnets	• Despite high levels of interaction with gear, only occasional entanglements occur due to effective echolocation. • Likely to habituate to pingers.

Pelagic fish and shrimp	trawls	• May occur as bycatch.
Demersal and pelagic fish	angling	• Consumption of fish lost by anglers with line attached may result in the death of individuals.
Sturgeon, *Acipenser sturio*		
Demersal fish	Trawling, netting	• Accidental by catch, but main reason for decline due to poor water quality and blocked migration routes.
Lampern, *Lampetra fluviatilis* and sea lamprey, *Petromyon marinus*		
Salmon and eels	Traps and static nets	• Bycatch occurs in estuaries and coastal areas where they occur. • Caught in high concentrations when individuals gather for upstream migrations.
Direct extraction	Traps in estuaries and digging	• Impact on populations is unknown but probably significant.
Demersal fish	Trawling	• Neither species is regularly recorded in trawls. • Decline may be related to overfishing of prey species.
Twaite shad, *Alosa fallax* and allis shad, *Alosa alosa*		
Mixed fish species, including shad	angling	• Both species occasionally caught, particularly during the summer months.
Demersal and pelagic fish	Beam, pair and otter trawls	• Caught as bycatch, sometimes in large numbers.
Salmon, bass and pilchards shrimp	Fixed nets and traps	• Occasionally caught as bycatch. • Salmon traps represent greatest source of fishing related mortality in south Wales.
All cetaceans		
Demersal and pelagic fish	Fixed gill-nets	• Most species that feeding on shoaling fish targeted by fisheries are likely to become caught as bycatch. • Fisheries may compete with piscivorous whales for food resources.
Pelagic fish	Pair trawls	• Potentially high levels of dolphin and small cetacean bycatch. • Bycatch levels are highest between February and March. • Fisheries may compete with piscivorous whales for food resources.
Marine turtles		
Whelks	pottting	• Pot fisheries for whelks may lead to an increase in strandings.
crustaceans	potting	• Entanglement with pot ropes.
Demersal and pelagic fish	Angling, and fixed and drift nets	• Entanglement with lines and nets has been recorded. • Some bycatch possible by fixed and drift nets.
Prawns and pelagic and Demersal fish	Prawn-, midwater- and beam trawls	• Some bycatch recorded.
Sea birds		
Demersal and pelagic fish	Mobile bottom gears (general)	• Increase in scavenging seabird species due to discarding of unwanted catch and offal. • Consuming discards may reduce reproductive success in some species. • Overfishing of some stocks may reduce food availability and reproductive success.

	Gill netting	• Accidental capture of diving birds foraging for food in and around nets. • Bycatch increases with proximity to breeding colonies. • Any species of diving, foraging bird is likely to be caught as by-catch.
	Long lining	• Accidental by-catch may occur at high levels. • Bycatch reduced when lines are dropped at night.
	angling	• Birds may become entangled in lost or discarded line and die. • Lost or discarded line may be used as nest material and kill juveniles.
Sand eels	Large scale Suction trawling	• Guillemots have been recorded as bycatch in the North Sea.
Finfish mariculture	Fish cage	• Entanglement in anti-predator nets.
Cockles and clams	Hydraulic & tractor dredge, hand gathering	• Short term increase in scavenging seabirds due to increased food.
Wildfowl and waders		
Mussels	mariculture	• Harvesting can drive birds away from preferred food source if an alternative is not found, this can result in starvation.
Bait for angling	Digging/ collection	• Prolonged use of mudflats may force feeding and roosting to move to less suitable areas.
Cockles and clams	Hydraulic & tractor dredge, hand gathering	• General disturbance of feeding and roosting birds. • Competition for food and disturbance may drive birds away from normal feeding grounds and may result in starvation. • Mass mortalities may result from depletion of food supplies.

APPENDIX 3. Compilation of information from the database.

Details are limited to information relevant to the UK marine habitats and species listed in the Habitats Directive and the Birds Directive. References 1 – 97 are taken from Gubbay and Knapman (1999).

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 1 **Year published:** 1992 **Peer reviewed?:** Yes **Study Location:** Southern North Sea **Reviewed by**: Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays Relevant Species: None	Pre and post experimental investigation, within 30m depth contour, with 7 tonne, 12m beam trawl including 5x22mm and 3x18mm tickler chains, 3x20mm and 8x14mm net tickler chains, mesh size of 9cm in the cod-end. Area trawled three times over 2 days and samples taken up to 2 weeks after trawling. **Habitat effects:** Tickler chains penetrate at least 6cm into the sediment surface indicated by catches of *Echinocardium cordatum* and *Arctica islandica*. Tracks made by the beam trawl shoes were still apparent on sidescan sonar after 16hrs. **Species and community effects:** Some benthic species showed a 10-65% reduction in density after trawling the area three times. There was a significant lowering of densities (40-60%) of echinoderms *Asterias rubens* and small *Echinocardium cordatum*, and of polychaete worms *Lanice conchilega* and *Spiophanes bombyx*. Vertical distribution in sediment appears to be an important factor in catchability. Decrease in density (10-20%), although not significant for small crustaceans and larger *Tellina fabula* and *E. cordatum*. Except for the starfish *A. rubens* most of these animals live in the sediment at a depth up to 15cm. The effect of beam trawling on densities of small individuals tends to be much greater than on densities of large individuals (larger animals tend to live deeper or have better escape possibilities). The polychaete worm *Magelona papillicornis* showed a considerable increase in numbers, this may be attributable to a change in the vertical distribution of the species in the sediment. The numbers of small Ophiura living in the top centimetre of sediment did not change after trawling the area three times, suggesting the species escape unharmed through the net mesh. Also no direct effect on densities of molluscs (except *T. fabula*) and worms (except *Magelona papillicornis, L. conchilega* and *S. bombyx*). Less abundant worm species (including *Spio filicornis Scolelepsis bonnieri, Scoloplos armiger* and *Owenia fusiformis*) and less abundant molluscs (including *Thracia* sp. *Venus striatula*, *Montecuta ferruginosa* and *Mysella bidentata)* showed no change in total density after trawling. About 90% of *A. islandica* caught by the 22m trawl were severely damaged. **Further notes:** Conclusions were that direct effects on some benthic species in the area appears to be considerable and that beam trawling may contribute to changes in benthic systems in the North Sea. However, direct effects cannot be extrapolated to interpret long-term effects as there was no comparison with untrawled areas. (Fine to hard muddy sediment)	Bergman, M.J.N. & Hup, M., 1992. Direct effects of beam trawling on macro-fauna in a sandy sediment in the southern North Sea. *ICES Journal of Marine Science,* **49**, 5-11.
Ref Number: 2 **Year published:** 1996 **Peer reviewed?:** Yes **Study Location:** Liverpool Bay, England	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Experimental beam trawl over a 4x2km area, at a depth between 26 and 34m. A commercial beam trawl, weighing 3.5 tonne fitted with a chain matrix and 8cm diamond mesh cod-end was used. Waylines were fished either 10 or 20 times to adequately disturb trawl area. **Habitat effects:** Physical characteristics of the surface sediment were altered by the passage of the beam trawl but effects varied in different parts of the experimental area. Surface roughness of the relatively uniform, stable, flat areas were not altered by trawling but lowered in fished sites in the SE sector which was characterised by sand waves and some ripples. In the latter case the surface ripples were flattened but the megaripples were unaffected. Passage of the chain matrix may have caused sediment to become unconsolidated as shell and gravel currents. Conclusions were that particle size distribution was not affected and observed changes may only be in the superficial layers of the sediments. Newly exposed shell and gravel material would provide surfaces for recolonisation and settlement, epizoites on surfaces which were overturned would be smothered.	Kaiser, M.J. & Spencer, B.E., 1996. The effects of beam trawl disturbance on infaunal communities in different habitats. *Journal of Animal Ecology*. **65**. 348-358.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Reviewed by: Gubbay and Knapman 1999			**Species and community effects:** Beam trawling altered the benthic community structure in the uniform, stable, flat areas having a measurable deleterious effect on the number, abundance and diversity of taxa. Of the top 20 most common taxa, abundance of 19 were lowered at fished sites, nine of which were statistically significant. Fragile infaunal species which live on or within the surface sediments (bivalves, holothurians, gastropods) were particularly vulnerable to damage or disturbance. The abundance of sedentary and slow-moving animals organisms was significantly lowered. Some animals were fatally injured or crushed, others only damaged (eg cropping of *Mya* siphons). Tissues of animals damaged by beam trawling rapidly attract scavengers. Analysis of diet indicated they were feeding on the damaged animals, most notably *Ampelisca* spp. There were no detectable differences in the diversity and abundance of taxa in the areas characterised by mobile sediments and subject to frequent natural disturbance. **Further notes:** (Coarse sand, gravel and broken shell)	
Ref Number: 3 **Year published:** 1996 **Peer reviewed?:** Yes **Study Location:** Port Phillip Bay, Australia **Reviewed by:** Gubbay and Knapman 1999	Oyster dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Large scale investigations on soft sediment communities depth between 12-15m, 2km offshore. Six vessels towing 3m wide commercial 'Peninsula' dredge with scraper/cutter bars not extending below the dredge skids. Site dredged for 3hrs day-1 over 3 days covering the dredge area at least twice. Dredging intensity was typical of local commercial fishing intensity. **Habitat effects:** Typically top 2cm of surface sediment disturbed but up to 6cm. Observations 8 days after dredging revealed seabed formations such as pits and depressions filled in and mounds formed by burrowing shrimps removed. Parallel tracks from dredge skids apparent after dredging. Physical changes in the seabed still apparent one month post-dredging. Six months post dredging most physical features reformed (abundance and size of callianassid mounds similar to those present before dredging) however some flattened areas still apparent. No physical differences between dredged and control sites after 11 months. **Species and community effects:** Ther number of species in dredged areas decreased significantly. Maximum impact did not occur immediately after dredging suggesting some indirect ecological changes such as uncovered organisms becoming more vulnerable to predation by invertebrates and demersal fish. Most species decreased in abundance by approximately 20-30% in the 3.5 months after dredging. The duration of the decrease in abundance species varied, with effects still apparent in some species after 8 months and in two species up to 14 months although this was possibly due to undersampling in the pre-impact period. 11 animals were not found in the sample area after dredging, mostly sedentary and therefore unable to re-establish except by larval recruitment. Susceptibility to dredging not correlated to feeding type or rarity. Fragile groups such as nemerteans were greatly damaged by dredging, polychaetes probably cut and killed by passing dredge. Other species may have been affected by high rates of dredging induced sedimentation, which may be 2-3 orders of magnitude greater than storm produced sedimentation, or buried when depressions filled in. Two species showed significant increase in abundance following dredging (*Diamorphostylis cottoni* and *Oedicerotid* sp.) whereas the isopod *Natalolona carppulenta* decreased sharply and then increased to be consistently higher on the dredged plot for 8 months possibly due to greater availability of prey. Seasonal and interannual changes in community structure much greater than those caused by dredging. Long-lived and slow recruiting epifaunal species (eg sponges and ascidians) likely to be particularly vulnerable to dredging. Long-term effects may be different to the short and medium-term effects. Needs to be studied over longevity of longest lived component species.	Currie, D.R. & Parry, G.D., 1996. Effects of scallop dredging on a soft sediment community: a large scale experimental study.. *Marine Ecology Progress Series*. **134**. 131-150.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 4 **Year published:** 1994 **Peer reviewed?:** Yes **Study Location:** North Sea **Reviewed by:** Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	*Artica islandica* was used as an indicator species for investigation of long-term effects of beam trawling intensity in the North Sea with sampling clusters in the NW, mid-west and SE. **Species and community effects:** A high incidence of damage found on shells of *Artica islandica* from highly fished areas particularly in the south eastern North Sea. In specimens with two values only 10% of the SE North Sea specimens were undamaged and in other areas around 40% were undamaged. 80-90% of the damage found on posterior ventral side of the shell was explained by the orientation of the living shell in the upper sediment layer and the horizontal motion of tickler chains. Observed trends in the occurrence of shell scars per year show a striking coincidence with the increased capacity of the Dutch beam trawling fleet since 1972. Another effect may be on age frequency distribution as juveniles (1-4cms) were rarely found in the SE North Sea. Less resistance to damage may be a factor although the authors indicate that other researchers have contradictory information on this. **Further notes:** (Soft sediment)	Witbaard, R. & Klein, R., 1994. Long-term trends on the effects of the southern North Sea beamtrawl fishery on the bivalve mollusc *Artica islandica* L. (Mollusca, Bivalva). *ICES Journal of Marine Science*. **51**. 99-105.
Ref Number: 5 **Year published:** 1995 **Peer reviewed?:** No **Study Location:** Burry inlet **Reviewed by:** Gubbay and Knapman 1999	cockle tractor dredge	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide **Relevant Species:** Wildfowl and waders	Experimental dredging using tractor towed cockle harvester at Burry Inlet (east of Whiteford Point and northern edge of Llanrhidian Marsh). **Habitat effects:** Vehicle tracks and dredging furrows created. **Species and community effects:** Dredging attracted black-headed and common gulls which fed on very small prey items lying on the surface of harvested furrows including *Crangon*, *Corophium,* broken cockles, intact small cockles which pass through the drum, and polychaetes. The number of birds attracted and the places they fed depended on the abundance of prey items revealed by harvesting and presence of people. Peak count at Llanrhidian was 200 black-headed gulls and 55 common gulls, mostly adults which fed preferentially in the most recently harvested furrows. Other species present were curlew, dunlin and oyster catchers. The increased feeding activity of birds was short lived, 14 days for oystercatchers and 7 days for gulls and small waders. Significant reduction in bird feeding activity apparent thereafter and still detectable after four months. Oystercatchers responded more quickly to changes suggesting harvesting may have been less disruptive or recovery quicker. Overall the short term increase in the number of gulls and waders in the harvesting area was followed by a long term significant reduction in feeding opportunities for bird species. Birds may then leave to find food elsewhere, leading to the considerable alteration in normal seasonal distribution pattern of shorebird populations. Average density of birds were reduced in this trial by between 15 and 75% in harvested area.	Ferns, P.N., 1995. The effects of mechanised cockle harvesting on bird feeding in the Burry Inlet. *Burry Inlet & Loughor Estuary Symposium, March 1995. Part 1.* 11-18. Burry Inlet and Loughor Estuary Liaison Group.
Ref Number: 6 **Year published:** 1995 **Peer reviewed?:** No	mechanical cockle dredge	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide **Relevant**	Experimental dredging of sandflats with mechanical cockle dredge. Two distinct sites sampled. Site A: Poorly sorted fine sand with small pools and *Arenicola marina* casts with some algal growth. Site B: Well sorted fairly coarse sand, surface sediment well drained and rippled as a result of wave activity. **Habitat effects:** Dredge track visible after 6 months at Site A (stable sediments). No alteration in sediment parameters by dredging at Site B (mobile sediments). **Species and community effects:** Effects of dredging on biota apparent at Site A after 3 months may be attributed to	Rostron, D.M., 1995. The effects of mechanised cockle harvesting on the invertebrate fauna of Llanrhidian sands. *Burry Inlet & Loughor Estuary Symposium, March 1995. Part 2.* 111-117. Burry Inlet and Loughor Estuary Liaison Group

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Study Location: Llanrhidian Sands, Burry Inlet. **Reviewed by:** Gubbay and Knapman 1999		**Species:** None	destruction of seabed algal covering, destruction of permanent tube dwellings, mortality of eggs/broods, interference with predator prey relationships or changes in sediment characteristic. Seasonal perturbation eg produced by winter storms produce community changes of greater magnitude than those caused by dredging in unstable high energy environments such as Site B. Site A (stable sediments): Decreased number of *Pygospio elegans* no recovery to pre-dredging numbers by six months. Disappearance of *Scoloplos armiger* from some dredged plots. Distribution of *Nephtys hombergii* disturbed by dredging recovery after six months. Large decline in numbers of *Hydrobia ulvae,* statistical difference between dredged sites and control sites up to six months post-dredging. *Cerastoderma edule* numbers reduced by dredging, significant reduction in numbers compared with the control still apparent up to six months post-dredging. Site B (mobile sediments): Populations of *Bathyporeia pilosa* exhibit greater fluctuations in numbers of individuals post-dredging. Initial reduction in the population densities of *Hydrobia ulvae, Pygospio elegans*, *Cerastoderma edule, Nematoda* spp. and Psammodrilaida after dredging followed by rapid recovery (no difference between control and experimental plots after 14 days). Increase numbers of Nematode attributable to dredging.	
Ref Number: 7 **Year published:** 1992 **Peer reviewed?:** No **Reviewed by:** Gubbay and Knapman 1999	Set nets	**Relevant Habitats:** None **Relevant Species:** Seabirds	Review paper. Coastal net fisheries have been implicated in declines of numerous seabird populations but there are substantial difficulties in establishing cause of a population decline. Synthetic nets have been implicated as a major contributor to the decline of several auk populations. **Species and community effects:** Diving seabirds more vulnerable to entanglement in set nets. Number of birds killed depends on their abundance, diving habits and distribution within the fishery area. Incidental catch of seabirds can be very high around colony sites. Large numbers of shearwaters have been caught in nets. Species of particular importance in European terms known to be caught in nets include: red-throated divers, Leach's petrel, gannet, shag, Brunnich's guillemot and razorbill. In Britain Great northern diver, Slavonian grebe, scaup, common scoter, long-tailed duck and guillemot can be added to the list. Threat to wildlife depends on netting effort and wildlife concentrations. There is temporal and spatial variation in these threats which may be reduced by manipulating where and when fishing takes place. **Further notes:** Species: Red throated diver, Great North diver	Harrison, N. & Robins, M., 1992. *The threat from nets to seabirds., RSPB Conservation Review,* **6**, 51-56.
Ref Number: 8 **Year published:** 1995 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Various (see further notes)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays, Reefs (Subtidal) **Relevant Species:**	Review paper covering many fishing techniques. **Habitat effects:** Subtidal rocky habitats characterised by encrusting communities that are resilient to predation and invasion are extremely vulnerable to mussel dredging as these organisms often have poor dispersal mechanisms and slow growth rates. Desertification of such habitats recorded in Italy following intensive and destructive mussel dredging. Reefs extremely vulnerable to fishing as they often represent islands in seas of soft sediments making recolonisation from surrounding areas unlikely. Intertidal and subtidal soft sediment communities are vulnerable to fishing and as they are often close to areas of population density, heavily fished. Bottom fisheries have resulted in the destruction of *Zostera* beds and saltmarsh vegetation. Calcareous algal bed of maerl destroyed by 8 passes of a dredge in Scotland. Reef building polychaete Sabellaria spinulosa, seagrass *Zostera marina* and oyster beds *Ostera edulis* destroyed by trawling. Hydroid and brozoan habitats lost in English Channel. *Zostera marina* indirectly impacted by increased turbidity, replaced by deposit feeding polychaetes, community composition shifts such as these may resist the recovery of suspension feeding species. Epifauna often play key roles in influencing the structure and stability of benthic communities, modifying benthic boundary flow which further influences	Dayton, P.K., Thrust, D.F., Agardi, M.T. & Hofman, R.J., 1995. Environmental effects of marine fishing. *Aquatic conservation: marine and freshwater ecosystems,* **5**, 2-5-232.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
		Grey seal, Common seal, Harbour porpoise, Bottle-nosed dolphin, Seabirds	sediment characteristics and so the settlement of larvae. Epifauna may also provide a refuge for juvenile species from predators. Organisms which stabilise the seabed can also mitigate the effects of natural disturbances such as storms. Modification of microbial activity induced by bottom fishing, resuspension of pollutants, increased benthic/pelagic nutrient flux. With repeated trawling the intense disturbance may select for species with the appropriate facultative responses, communities will become dominated by juvenile stages, mobile species and rapid colonists. Large amounts of discards falling to the seabed cause anoxia in bottom sediments the discards decay using up oxygen, kills scavenging organism attracted by the discards. Decaying discards may also harbour disease and have caused the elimination of a scallop fishery in Australia. **Species and community effects:** Diving seabirds are more vulnerable to entanglement in set nets. Number of birds killed depends on their abundance, diving habits and distribution within the fishery area. Incidental catch of seabirds can be very high around colony sites. Large numbers of shearwaters have been caught in nets. Species of particular importance in European terms known to be caught in nets include: red-throated divers, Leach's petrel, gannet, shag, Brunnich's guillemot and razorbill. In Britain Great northern diver, Slavonian grebe, scaup, common scoter, long-tailed duck and guillemot can be added to the list. Threat to wildlife depends on netting effort and wildlife concentrations. There is temporal and spatial variation in these threats which may be reduced by manipulating where and when fishing takes place. Longline: Swordfish fishery North Western Atlantic took several times more shark than swordfish resulting in grey seal population rising from 3000 to 45000. Grey seals *Halichoerus grupus* acted as a primary host for parasites which then infected cod. Population density may have increased stress in seals causing a population decline. Gill nets implicated in the extinction of several species. Adult survivorship is extremely important for marine mammals and birds as they have slow reproductive capacity and low fecundity therefore they are high vulnerable to even moderately increased mortality. Incidental by-catch of highly mobile predatory marine mammals likely to be higher than less mobile species as they are efficient foragers and are likely to be attracted to nets laden with fish. Approximately 500-1000 harbour porpoise caught annually in Danish waters. Catch rate of harbour porpoise approximately 0.1 individuals/km of net/day probably an underestimate. Porpoise populations substantially reduced by the Pacific tuna purse seine fishery. Ghost fishing by discarded and lost netting may be significant and persistent, impacting not only on non-target species such as birds and marine mammals but also on fisheries themselves. Complete loss of sessile fauna on rocks and cobbles caused by the action of fishing gear on the seabed. Hydraulic dredging causes complete loss of sessile benthic fauna which are killed by the heat. Otter trawling causes massive amount of by-catch including crab, scallops, starfish. Mortality for some species can range from 10% in starfish to 90% in *Arctica islandica* after a single trawl this may increase drastically with increased trawling intensity. **Further notes:** Fishing types: Longline, Gill nets, Scallop dredging, Mussel dredging, Purse seine, Hydraulic dredging, Otter trawling	

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 9 **Year published:** 1994 **Peer reviewed?:** Yes **Study Location:** North Sea **Reviewed by:** Gubbay and Knapman 1999	Beam trawl, Fixed gill net	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays, Reefs (Biogenic) **Relevant Species:** Grey seal, Common seal, Harbour porpoise, Bottle-nosed dolphin, Seabirds	Review paper. **Habitat effects:** Towed fishing gears such as bottom and beam trawls physically disturb the seabed causing alterations in microbial communities, resuspension of particles, nutrients and pollutants and the relocation of stones and boulders. Inshore fisheries have led to destruction of reefs built by species such as the polychaete worm *Sabellaria* or by calcareous algae. Fishing has led to structural changes in habitat that have resulted in changes in species assemblages **Species and community effects:** Fixed nets such as gill nets are more likely to entangle non-target species. Diving seabirds are especially vulnerable to entanglement in fixed nets such as gill nets. No evidence that mortality due to entanglement has precluded the observed increase in population size of many species of seabirds which has taken place during this century in the North Sea. Harbour porpoises especially vulnerable to entanglement in gill nets. Recent estimate of the by-catch of the Danish gill net fishery in the eastern North Sea gave an annual by-catch of 4629 porpoises. Incidental by-catch could be a significant contributing factor to the overall decline harbour porpoise abundance in European waters. Seal populations have been able to sustain or increase their populations whilst subject to fishery induced mortality. No species exists in isolation, fishery-induced changes in the density of one species will have repercussions on its predators, prey and competitors Heavy towed gears in contact with the sea bed can kill or injure animals living in the top most layers of sediment. The percentage of benthic organisms caught in a beam trawl which die varies from zero for hermit crab, whelks and starfish to 100% for shells such as *Artica islandica*. Beam trawl is the most important fishing gear which penetrates the seabed. General fisheries generated mortality results in reduced abundance of long-lived benthic species and increased abundance of short-lived species. By-catch and offal produced by gutting the fish at sea thrown overboard provides food for seabirds and other scavenging animals. Changes in the amount of discards may affect the relative and absolute abundance of various species of seabirds. Increased abundance of scavenging seabirds since the start of the century. Large or unattractive discard items will fall to the seabed where they can become available to sub-surface scavengers. Fishing produces litter in the form of lost gear and other waste comparable with that produced by shipping in general. Litter from fishing such as lost or discarded nets may entrap seabirds and mammals	Gislason, H., 1994. Ecosystem effects of fishing activities in the North Sea. *Marine Pollution Bulletin,* **29**, 520-527.
Ref Number: 10 **Year published:** 1993 **Peer reviewed?:** No **Study Location:** Cardigan Bay **Reviewed by:** Gubbay and Knapman 1999	Fixed gill net, Tangle net	**Relevant Habitats:** None **Relevant Species:** Grey seal, Harbour porpoise, Seabirds	Notes on recorded entanglement casualties in Cardigan Bay. **Species and community effects:** Potential threat to red-throated divers from gill and tangle nets high. May have knock on effects at the birds breeding grounds. During 14 inspections of beach set nets between September 1991 and December 1992 no seabird by-catch was noted despite red-throated divers observed diving within 20m of nets. Ten harbour porpoises *Phoecoena phocoena* reported as casualties of gill nets in 1991. Author considers that Harbour porpoise is the only cetacean under severe threat of extinction from static fishing gear in Cardigan Bay. 24% of UK deaths of harbour porpoises caused by entanglement in fishing gear. One Grey Seal *Halichoerus grupus* found stranded in 1991 with injuries consummate with gill net entanglement. Net inspected in September 1992 no by-catch recorded despite close proximity of grey seal. Young seals more likely to suffer from entanglement. Juvenile dolphin recorded tangled in net. Author concludes no major entanglement problem in Cardigan Bay. **Further notes:** other species: Red throated diver	Thomas, D., 1993. *Marine wildlife and net fisheries in Cardigan Bay,* RSPB/CCW

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 11 **Year published:** 1994 **Peer reviewed?:** Yes **Study Location:** Off east coast of Anglesey **Reviewed by:** Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Experimental 4m commercial pattern beam trawl fitted with chain matrix and 8cm diamond mesh cod-end. Towing speed 2m s-1. Initially trawl lines fished 3-4x in succession repeated after 2 hours. **Species and community effects:** Gurnards and whiting aggregate over beam tracks to feed on animals damaged by the beam trawl or on other scavengers that are attracted to the trawled area. There was a particularly clear increase in the proportion of the amphipod *Ampelisca spinipes* in their diets and some mobile invertebrate scavengers such as *Pandalus* spp. only occurred in diets after the area was fished. Number of prey items eaten by gurnards and whiting increased after trawling. Dogfish did not increase their intake after trawling but did take *Pandalus* spp. and *Crangon* spp. only after the area had been trawled. Results suggest that fish rapidly migrate into the area to feed. Additional resources such as those made available by trawling, may favour certain species that exhibit opportunistic feeding patterns such as gurnards and whiting. **Further notes:** (Area of coarse sand, gravel and broken shell)	Kaiser, M.J. & Spencer, B.E., 1994. Fish scavenging behaviour in recently trawled areas. *Marine Ecology Progress Series,* **112**, 41-49.
Ref Number: 12 **Year published:** 1993 **Peer reviewed?:** No **Study Location:** Lyme Bay, England **Reviewed by:** Gubbay and Knapman 1999	Oyster dredge, Scallop dredge	**Relevant Habitats:** Large, Shallow inlets and bays, Reefs (Subtidal) **Relevant Species:** None	Pilot survey of reefs subject to bottom trawling/dredging on a variety of seabed types; flint shards; sand, broken shell and dead maerl; sand, gravel, broken shell and dead maerl overlain with cobbles and small rocks; reef of mudstone ledges. **Species and community effects:** Clear differences in epifaunal communities between areas considered to be worked by mobile fishing gear and those not, however different sediment types in these areas is another influence. Reefs highly vulnerable to removal of epifauna and erosion caused by the action of the gear. Reefs with large boulders or severe topography which prohibits the use of fishing gear considered to be self protecting. Complex areas of sandy pockets, cobbles and boulders the size of which do not prohibit the use of rock hopper or spring loaded dredges, which support slow growing and numerous hydroids, anemones and corals, bryozoans, tunicates and echinoderms particularly vulnerable to highly mobile fishing gear. Recolonisation and recovery likely to be slow. **Further notes:** Potential loss of productivity, habitat, and food caused by highly mobile fishing gear, may lead to the direct mortality of commerciality exploitable reef dwelling species	Devon Wildlife Trust, 1993.. *Lyme Bay: A report on the nature conservation importance of the inshore reefs and the effects of mobile fishing gear.* Survey report carried out by the Devon Wildlife Trust.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 13 **Year published:** 1989 **Peer reviewed?:** Yes **Study Location:** North Sea **Reviewed by:** Gubbay and Knapman 1999	Trawling	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide, Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	review **Species and community effects:** Changes in the balance of the benthos, particularly the loss of Sabellaria reefs and oyster beds attributed to over-fishing and trawl damage. Comparable shifts in dominance with certain polychaete species commonly favoured over more vulnerable groups such as echinoderms anticipated at regularly fished sites, and is, in principal, reversible. Recent trend towards the deployment of larger, heavier demersal fishing gear enhances the possibility of benthic changes in intensively fished areas. Shrimp fishery in Wadden Sea observed a long term decline in the number of by-catch species notably *Carcinus* and *Pomatoschistus* spp. Biomass of by-catch remained constant with compensating increase in dab, sprat and cod.	Rees, H.L. & Eleftheriou, A. 1989. North Sea benthos: A review of field investigations into the biological effects of man's activities. *J. Cons. Int. Explor. Mer,* **54**, 284-305.
Ref Number: 14 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** Loch Broom, Bardentarbot Bay, Lyme Bay, Skomer, Pembrokeshire coast., UK **Reviewed by:** Gubbay and Knapman 1999	Pots or creels	**Relevant Habitats:** Large, Shallow inlets and bays, Reefs (Subtidal) **Relevant Species:** None	Experimental study on the effects of Nephrops creels and lobster and crab pots on benthic habitats and communities in a number of locations/habitats. Quantitative effects of one month's fishing using crab and lobster pots. Locations: **Species and community effects:** Sites in Scotland - Descending creels build up a small pressure wave which caused the sea pens *Pennatula phosphorea*, *Virgularia mirabilis* and *Funiculina quadrangularis* to bend before the creel made contact. This removed the tip of the sea pen from damage through impact. After smothering or uprooting all three species reinserted and uprighted themselves when in contact with muddy substrate. No lasting effects on muddy substrates. Devon/Wales - Rocky substrate habitats and communities at a depth no deeper than 23m below chart datum subjected to lobster and crab potting relatively unaffected by fishing activity. Experimental and control plots 30mx12m in Devon and 50mx20m in Wales. *Pentapora foliacea* found broken after hauling although unclear whether this was due to fishing. *Eunicella verucosa* bend under the weight of pots and then return to an upright position afterwards. Slow growing and long lived *Eunicella verucosa* previously considered highly vulnerable to damage. One month's active fishing using crab and lobster pots caused no difference in abundance of species between control and experimental study plots. Abundance of some species increased after potting in comparison with their abundance before potting. Potting did not have a detrimental effect on the abundance of species studied. Experimental simulation of 12 lost parlour pots revealed that they may actively fish for up to 270 days and remain baited for between 8 and 27 days. Catch rates highest during first month. Brown crab catches showed slight temporary decrease after bait depleted and subsequently fairly constant. Spider crab catch declined steadily. In time condition of the catch deteriorate, wrasse showed skin damage and limb loss increased markedly the longer crustaceans remained in the pot. Incidental observations in the vicinity of the pots shows several had moved over and broken *Pentapora* colonies. Pots moved down the gently sloping seabed until constrained by mainline tightening.	Eno, N.C., MacDonald, D.S. & Amos S.C. 1996. A study on the effects of fish (crustacea/mollusc) traps on benthic habitats and species. *A study on the effects of fish (crustacea/mollusc) traps on benthic habitats and species.* Report to the European Commission.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 15 **Year published:** 1995 **Peer reviewed?:** No **Study Location:** Burry Inlet, South Wales **Reviewed by:** Gubbay and Knapman 1999	mechanical cockle dredge	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	Experimental investigation on the effects of cockle dredging on spat settlement using a 71cm mechanical dredge with revolving riddle. **Species and community effects:** A single pass of the dredge reduced both fishable and juvenile stocks of cockles substantially. Adult cockles more damaged by dredge than juveniles. No subsequent difference in cockle mortality between dredged and undredged plots. New spat settlement not affected.	Walker, P., Cotter, A.J.R. & Bannister, R.C.A., 1995. *A preliminary account of the effects of tractor dredging on cockles in Burry Inlet, South Wales.*
Ref Number: 16 **Year published:** 1995 **Peer reviewed?:** No **Study Location:** Firth of Clyde **Reviewed by:** Gubbay and Knapman 1999	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Preliminary findings of experimental investigation of 3x77cm rock hopper scallop dredges with 9x10cm dredge teeth on each dredge, on maerl beds including visual evidence of impacts. **Habitat effects:** Cobbles and boulders up to 1m3 overturned by dredge mouths or towbar. Dredge teeth penetrated the maerl beds up to 10cm. Cloud of suspended sediment created by trawl. **Species and community effects:** Large macroalgae torn up. Large animals including highly mobile species such as plaice either mangled, entrained on the bottom or flicked into the dredge bags. Dredge efficiency in terms of catch thought to be 88% on maerl beds. Fine sediments eroded, maerl crushed and killed through burial compromising habitat integrity and recovery. Fine sediments deposited over adjacent areas smothering photosynthetic organisms and stressing filter feeders. Micotopographical effects clearly visible 8 months post dredging and number and diversity of sessile fauna and flora reduced. May be a long term shift from K-selected species to R-selected species in response to dredging.	Hall-Spencer, J., 1995. The effects of scallop dredging on maerl beds in the Firth of Clyde. *Porcupine Newsletter*. **6**.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 17 **Year published:** 1991 **Peer reviewed?:** No **Reviewed by:** Gubbay and Knapman 1999	Gill nets	**Relevant Habitats:** None **Relevant Species:** Seabirds	A broad overview of the effects of gill nets on seabirds including case studies. **Species and community effects:** Worldwide 60 species of seabird reported as being caught in gill nets. In very few cases was it possible to estimate the level of mortality in specific fisheries but net mortality was implicated as a major contributed to large declines in certain populations. Great northern diver and red throated diver thought to be vulnerable. Average number of great northern divers caught per year 15 780% of great northern divers caught off Newfoundland entangled in salmon gill nets 20% in cod gill nets. Great northern divers caught in nets up to 50m deep. General principles associated with seabird mortality in gill nets: species at greatest risk are predators which (a) pursue their prey underwater (b) aggregate in dense foraging groups. daily catch rates can be very variable greatest by-catch occurs during periods when prey occur in areas frequented by fisheries Magnitude of net mortality for many predators may be a function of prey abundance net mortality decreases with distance from colonies of breeding seabirds vulnerable to entanglement large kills can be caused by nets set at great depths (ie more than 100m) net mesh size may be an important consideration in mortality rates. **Further notes:** Oher species: Great northern diver, Red throated diver	Robins, M., 1991. *Synthetic gill nets and seabirds.* Report to WWF and RSPB
Ref Number: 18 **Year published:** 1991 **Peer reviewed?:** No **Study Location:** Lavan Sands, Wales & Blackshaw Flats, Solway Firth **Reviewed by:** Gubbay and Knapman 1999	Hydraulic dredge	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Control and treatment type experimental investigation with pre and post dredge comparisons. Two spatially separated sites exposed to a single dredge with subsequent benthic sampling. Site A, Lavan Sands NW Wales 3m above chart datum substrate very fine sand, extensively rippled, compact and firm, well oxygenated sediment. Site B, Blackshaw Flats, Solway Firth 5m above chart datum well sorted very fine sand, extensively rippled, compact and firm, well oxygenated sediment. Two experimental regimes. Experiment 1: Effects of a single dredging activity. Experiment 2 at Lavan Sands 80 sampling stations over an area of 400x300m used to assess the effects of a 3 month licensed commercial dredging operation using pre and post dredging data. **Habitat effects:** Experiment 1 - Dredging had no significant impact on the measured sediment characteristics due to the small percentage of fine material and the high degree of sorting. Experiment 2 - No severe erosion of sediments occurred. **Species and community effects:** Experiment 1 - Rapid recovery of benthic infaunal communities as sediment exposed to regular disturbance from water movement - community already adapted to disturbance. *Hydrobia ulvae*, surface grazing gastropod, significantly affected by dredging. Experiment 2 - Impacts appear to be small and for the most part not statistically significant. Significant decrease in the population of tube dwelling polychaete *Pygospio elegans* whose tubes may be destroyed by dredging. *Lanice conchilega* has tough tubes apparently not greatly affected by the dredging operation. Also they can retract into tubes below the maximum depth disturbed by the dredge and can regrow head tentacles. Numbers of *Cerastoderma edule* and *Macoma balthica* reduced significantly resulting in a significant reduction in the total macrofaunal biomass (these molluscs contribute to about 70% of the biomass wet weight). Author concludes hydraulic cockle dredging unlikely to have a significant impact on non-target infaunal species at the site as the sediments are moderately mobile with a low silt content.	Moore, J., 1991. *Studies on the Impact of Hydraulic Cockle Dredging on Intertidal Sediment Flat Communities: Final Report.*

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 19 **Year published:** 1988 **Peer reviewed?:** No **Reviewed by:** Gubbay and Knapman 1999	Gill nets, Longline, Pots or creels, Mariculture (finfish), Fyke nets	**Relevant Habitats:** None **Relevant Species:** Otter, Grey seal, Common seal, Harbour porpoise, Bottle-nosed dolphin	Comprehensive resume of recorded by-catches of marine mammals including dolphins, seals, porpoises and otters. **Species and community effects:** Incidental catches of marine mammals by no means rare and are reported in most fisheries in Britain. Data is still too sparse to enable a robust estimate of marine mammal by-catch. Gill net fisheries likely to account for the majority of marine mammal by-catches. 130 grey seals from the Farne Islands and the Orkneys may drown in fishing gear every year. Young animals more vulnerable to fixed nets. Cetaceans and seals only very rarely affected by long-line fisheries, creel, potting or salmon nets. Otters may be significantly affected by creel and eel fyke nets and the latter may have been a significant factor in the decline of otters in East Anglia. Salmon farming may have a significant effect on seal populations locally, estimates in the region of 100 seals caught in anti-predator nets annually with a further 1,000 seals shot by fish-farm operators. The number of seals caught in anti-predator nets, fishing nets in general or shot by fish farm operators does not seem to have had a deleterious effect on seal stocks. Harbour porpoise most vulnerable to incidental catches. **Further notes:** Possible solutions to conflicts with fishing discussed. Reflective knots at the intersection in netting may help prevent entanglement. Acoustic warning devices on nets may reduce the occurrence of entanglement. Certain nets and locations may precipitate large mammal catches these areas or methods may be avoided. Harbour porpoises more likely to be entangled during storms or at night, modification of fishing methods may reduce incidental by-catch. Comments on the use of a scheme whereby fishermen are asked to land incidentally caught marine mammals for pollution analysis proved to be a successful method of gaining more information on the numbers of animals incidentally caught as fishermen appear more willing to do this than provide information on a written basis especially as pollution has potential ramifications for fish stocks.	Northridge, S., 1988. *Marine Mammals and Fisheries: a study of conflicts with fishing gear in British waters.* Report to Wildlife Link Seals Group
Ref Number: 20 **Year published:** 1994 **Peer reviewed?:** Yes **Study Location:** Whitstable, Kent, England **Reviewed by:** Gubbay and Knapman 1999	Mariculture (Shellfish), Suction dredge	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	Survey of intertidal benthic community and physical characteristics at a site of commercial clam cultivation on a shallow shelving mudflat during clam growth and post harvesting. Underlying sediment composed of London clay interspersed with shell debris and lignin deposits. Surface sediment of fine silt and sand with patches of clay. **Habitat effects:** During clam growth no significant difference in particle size, organic content or photosynthetic pigment between control and clam lay sites. Harvesting by suction dredging removed upper sediment layers exposing clay which is unsuitable for larval settlement. Seven months post harvesting, sedimentation had nearly restored the sediment structure. **Species and community effects:** During clam growth no significant increase in faunal diversity under clam lay but density of benthic species individuals much greater. Community under clam lay significantly different from the control areas. Control area dominated by polychaete *Nephtys hombergii,* area under clam lay dominated by deposit feeding worms *Lanice concilega* and the bivalve *Mysella bidentata*. Nets may change hydrography reducing water flow and increasing sedimentation. This increases food supply and so may promote larval settlement. Adjacent areas may be influenced by commercial clam operation. Suction dredge harvesting had a profound effect on the community structure. Large amounts of sediment and associated animal community (particularly crustaceans and bivalves) removed. Seven months post harvesting density of individuals decreased significantly to the point where there was no difference between control and harvested sites, with *Neptys hombergii* responsible for the similarity between treatment and control. Effects of clam harvesting barely detectable after 7 months. Clam cultivation increases productivity as netting reduces wave action and other disturbances. **Further notes:** Authors conclude that clam cultivation does not have long-term effects on the environment or benthic community at the study site.	Kaiser, M.J., Edwards, D.B. & Spencer, B.E., 1994. Infaunal community changes as a result of commercial clam cultivation and harvesting. *Aquatic Living Resources,* **9**, 57-63.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 21 **Year published:** 1992 **Peer reviewed?:** No **Study Location:** Langstone Harbour **Reviewed by:** Gubbay and Knapman 1999	Clam dredge	**Relevant Habitats:** Estuaries, Large, Shallow inlets and bays **Relevant Species:** None	Treatment and control type dredging experiment, 2 passes of a modified oyster dredge. **Habitat effects:** Sediment removed to a depth of between 15-20cm by dredging and gravel fraction reduced. Sediments may become more anoxic after dredging. Dredge tracks most likely to be filled with fine sediment in low energy conditions therefore discrete habitat variation will be created. Resuspended sediment may have serious survival implications for species unable to deal with heavy suspended sediment loads. **Species and community effects:** Due to the deep penetration of the dredge all fauna, with the exception of bivalves (eg *Abra tenuis, Cerastoderma edule* and *Mya arenaria*) were removed completely in the short term. It is likely that these organisms were dislodged and then redeposited by the dredge or that they migrated or were passively dispersed into the area from adjacent undredged areas. Annelids were most badly affected by the dredge with the exception of *Tubificoides benedeni* and a Phyllodocid. Abundance of bivalves was also greatly reduced but some found in some dredged samples (small specimens thought to have been disturbed by the dredge and re-deposited afterwards). No clear recovery of fauna evident over the 8 day period of study but opportunistic polychaetes (eg *Capitella capitata* and *Tubificoides benedeni*) likely to be early colonisers of disturbed mudflats along with the surviving bivalves. Authors suggest these will be followed by active polychaete species eg *Eteone longa* and more stable habitat species such as *Cirriformia tentaculata*. Continual disturbance will not favour stable habitat species, high biomass communities may occur but are unlikely to contain individuals of high biomass which may be exploited as a food source by birds.	Southern Science, 1992. *An experimental study on the impact of clam dredging on soft sediment macro invertebrates.* Report to English Nature
Ref Number: 22 **Year published:** 1996 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Trawling	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Laboratory based experiment investigating the behaviour of *Buccinium undatum* exposed to different prey items. **Species and community effects:** Less mobile scavengers such as whelks may take several days to arrive at sites of trawl disturbance. Whelks are well suited to exploit fisheries discards as they are very responsive to chemosensory stimuli exuded from damaged or moribund animals. 98% of whelks caught in a beam trawl survive. Whelks are capable of exploiting a wide variety of prey due to their flexible feeding behaviour. In this experiment they ate *Liocarcinus depurator, Spatangus purpureus, Trisopterus minutus* but not *Pleuronectes platessa*. Where whelks are common they have an important capacity in utilising energy from dead or damaged animals. Whelks using this competitive advantage may exhibit local population increases and in areas of intense beam trawling, such as the southern North Sea, dead or moribund animals which result from these activities could make up a considerable proportion of the whelk diet.	Evans, P.L., Kaiser, M.J. & Hughes, R.N., 1996. Behaviour and energetics of whelks, *Buccinium undatum* (L.), feeding on animals killed by beam trawling. *Journal of Experimental Marine Biology and Ecology,* **197**, 51-62.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 23 **Year published:** 1996 **Peer reviewed?:** No Study Dates: August 1990 - September 1995 **Reviewed by:** Gubbay and Knapman 1999	Various (see further notes)	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise, Bottle-nosed dolphin	Record of causes of death in 422 cetaceans of 12 species stranded on the coasts of England and Wales between August 1990 and September 1995 via post-mortem examination. **Species and community effects:** Most frequent cause of death in harbour porpoises and common dolphins was entanglement in fishing gear. 38% of harbour porpoises and 80% of common dolphins diagnosed as being by-caught. The proportion of by-caught harbour porpoises increased from 1990 to 1995. Factors such as changes in fishing effort, technique or location or changes in the abundance or distribution of harbour may account for this. Probably an underestimate of the true incidence of by-catch in cetaceans. Estimates of the number of by-caught harbour porpoises cited as being between 328 and 552 by English fishing fleets on the Celtic shelf. The proportion of starved neonatal harbour porpoises higher than starved common dolphins may relate to the more coastal distribution of harbour porpoises. More coastal distribution of harbour porpoises may also increase their contact with co-factors such as pollutants making them more likely to die from species-specific pathogens than common dolphins. By-catch is a threat to both harbour porpoises and common dolphins around the coast of England and Wales. Of 7 *Tursiops truncatus* studied only one was determined as being by-caught.	Kirkwood, J.K., Bennett, P.M., Jepson, P.D., Kuiken, T., Simpson, V.R. & Baker J.R., 1996. *Entanglement and other causes of death in cetaceans stranded on the coasts of England and Wales.*
Ref Number: 24 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** Southern North Sea **Reviewed by:** Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Side scan sonar investigation into the effects of beam trawling in the southern part of the Danish North Sea. **Habitat effects:** Poorly preserved trawl marks were widely distributed in the study area except in one area of presumably coarse grained sediments where there were numerous extremely well-preserved beam trawl marks. The substrate appears to have altered from coarse grained sand or gravel to fine sand and coarse silt in the trawl marks as shallow scouring and smoothing from beam trawling created conditions favouring fine sand/coarse silt sediment filling the tracks. Effects of beam trawling on sediment may be long-term and in some areas may have resulted in a definitive change of the substrate with implications for the benthic community.	Leth, J.O. & Kuijpers A., 1996. Effects on the seabed sediment from beam trawling in the North Sea. *ICES 1996. Annual Science Conference. Mini-symposium: Ecosystem Effects of Fisheries.* ICES C.M. 1996/Mini 3.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 25 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** Red Wharf Bay and Dulas Bay in Liverpool Bay **Reviewed by:** Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Experimental investigation into changes in sediment structure, in- and epifauna, mortality of by-catch and effects on predators caused by beam trawling with the application of twice-yearly fishing perturbations. **Species and community effects:** Trawling causes changes in the abundance of some in- and epifaunal species. Infaunal diversity reduced by 54%, epifaunal diversity not significantly altered. Mortality of animals retained in the cod-end studied by placing them in tanks. Results varied greatly between taxa. Mortality greatest for fish and animals with brittle skeletal structure such as sea urchins and swimming crabs, and very low for starfish, brittlestars and hermit crabs. Benthic species which are most likely to benefit from the increased scavenging opportunities brought about by trawling were starfish and hermit crabs.	Kaiser, M.J., Ramsay, K. & Spencer, B.E., 1996. *Short-term ecological effects of beam trawl disturbance in the Irish Sea. A review.* ICES C.M. 1996/Mini 5.
Ref Number: 26 **Year published:** 1990 **Peer reviewed?:** Yes **Study Location:** Laboratory **Reviewed by:** Gubbay and Knapman 1999	Clam digging	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Laboratory experiments to see whether non-lethal burial or exposure on the sediment surface could alter the normal living depth of *Mya arenaria* in sand and mud. **Species and community effects:** After 2 weeks those buried under 1-15cm of medium fine sand were buried deeper than controls whereas clams exposed on the sand surface (and had subsequently reburrowed) were able to re-establish their normal living depths. Clams under 1-15cm of mud attained their normal living depth within two weeks but exposed clams reburrowed to abnormally shallow depths. The increased likelihood of predation at shallow sediment depths was compounded by the 60% lower reburrowing speed of exposed clams in mud when compared to sand. Conclusions were that negative impacts of clam digging on *M. arenaria* are not limited to removal of market-size clams and shell breakage of remaining ones. Exposure of prerecruits and depositions of tailings on clams adjacent to harvest sites may increase susceptibility of unharvested clams to predation, dessication or freezing. The effects depend on different substrate types. Mortality will be greater on clam flats having a mud substrate than of medium-fine sand. Management practice should reflect these differences. On sandflats there would be little to be gained from breaking up the clumps of soil turned over since tailing burial will probably not result in mortality. In muddy areas, reducing tailing piles is likely to enhance survival of both buried and exposed clams.	Emerson, C.W., Grant, J. & Rowell, T.W., 1990. Indirect effects of clam digging on the viability of soft-shelled clams *Mya arenaria*. *Netherlands Journal of Sea Research,* **27**, 109-118.
Ref Number: 27 **Year published:** 1990 **Peer reviewed?:** Yes **Study Location:** Loch Gairloch, Scotland	Hydraulic dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Field experiment of impact of fishing for razor clams *Ensis* sp. by hydraulic dredging on the associated infaunal community, 7m depth. **Species and community effects:** Infaunal samples were examined at 1 and 40 days from fished and unfished plots. There were differences in mean number of species and individuals for control and fished sites 1 and 40 days later but only total numbers of individuals significantly lower. After 40 days no detectable difference. No statistically significant differences in the 10 most abundant species *Bathyporeia elegans, Siphonoecetes kroyeranus, Exogene hebes, Spio filicornis, Corophium crassicorne, Streptosyllis websteri, Cochlodesma praetenue, Nephtys cirrosa, Megalorupus agilis* and *Perioculodes longimanus* between treatments after either 1 or 40 days. Suction dredging for *Esnis* had profound immediate effects on benthic community structure with consistent reductions in	Hall, S.J., Basford, D.J. & Roberts, M.R., 1990. The impact of hydraulic dredging for razor clams *Ensis* sp. on an infaunal community. *Netherlands Journal of Sea Research,* **27**, 119-125.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Reviewed by: Gubbay and Knapman 1999			the numbers of many macrofaunal species and the target species. However, despite the relatively large scale nature of the disturbance, these effects appear to persist for only a short period. After 40 days no detectable difference - visually or from macrobenthic community analysis, effects on long-lived bivalves could however be more serious, and action of the dredge is violent enough to often crack shells of adult *Arctica islandica*. Larger polychaetes and crustaceans are also often retained on the conveyer, crushed in the mechanism or fall off the end to fall at random on the seabed. No estimate was made of survivorship of these individuals but many scavenging hermit crabs were active immediately after dredging. Migration and passive translocation play a part in returning the abundance of species to pre-impact levels. Authors suggest that local population reductions due to dredging are only likely to persist in a habitat if one of two conditions are met: (a) macrobenthic populations themselves, or the sediments in which they live, are immobile or (b) the affected area is large relative to the remainder of the habitat such that dilution effect cannot occur. For most habitats where *Ensis* could be fished authors believe that neither of these conditions likely to hold. Current technology restricts this type of fishing to approximately 7m therefore likely to be strongly influenced by wind and tide-induced currents in these areas. Sediments are probably mobile and effects will be diluted rapidly. However they note there is little knowledge of the relative importance of the various processes which contribute to animal movement and whether certain habitats may be more susceptible to persistent damage than others. At most sites the authors believe there will be adequate areas to dilute effects but prior examination of potential fishery sites is warranted. Target species removed in great numbers, long-lived bivalve species often damaged or killed and smaller-bodied infauna either displaced or killed. With the exception of large bivalves, it would appear that effects on macrofaunal community in general are not locally persistent, although in calmer seasons effects may persist for longer than observed here. Another consideration is that if *Ensis* and other large bivalves play an important role in structure of benthic communities, their removal would result in cascading effects over long time scales. But in the high levels of sediment mobility at the study site, this hypothesis was considered unlikely.	
Ref Number: 28 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** North Sea Study Dates: 1999 report no: 28 **Reviewed by:** Gubbay and Knapman 1999	Beam trawl, Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Long term historical record (1945-1981) of by-catch from an area of the North Sea to the Northwest of the Netherlands at Zoological Station in Den Helder. **Species and community effects:** Bottom fisheries have a considerable effect on many by-catch species including demersal fish and invertebrates. Numbers of by-caught fish and invertebrates related to changes in fish gear and effort of bottom trawlers. Catchability of beam trawlers 10x higher than otter trawls. Model of bottom fisheries shows that bottom trawling has reduced the abundance of several demersal fish and invertebrates to very low levels within 35 years.	Philippart, C.J.M., 1996. *Long-term impact of bottom fisheries on several bycatch species of demersal fish and benthic invertebrates in the southeastern North Sea.* ICES C.M. 1996/Mini 6

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 29 **Year published:** 1989 **Peer reviewed?:** Yes **Study Location:** Cruden Bay, NE Scotland **Reviewed by:** Gubbay and Knapman 1999	Salmon net	**Relevant Habitats:** None **Relevant Species:** Seabirds	Investigations by the author into numbers of dead seabirds on the shore in early 1970s at Cruden Bay in NE Scotland in mid summer led to a conclusion that they must have been killed in some of the numerous local fixed salmon nets which were often seen holding dead birds. Most were auks which are known to be killed in fixed salmon nets on a considerable scale around the seabirds colonies on St. Abbs Head and Troup Head in the Moray Firth. Some shags also reported killed in nets set near a roost on the Summer Islands. Off the Scottish Wildlife Trust reserves at Longhaven and on the Dunbuy Rock to the south up to 17 bodies per net were recorded on the 12 or so occasions they were examined during the breeding season over the previous four years.	Bourne, W.R.P., 1989. New evidence for bird losses in fishing nets. *Marine Pollution Bulletin,* **10**, 482.
Ref Number: 30 **Year published:** 1973 **Peer reviewed?:** Yes **Study Location:** Chaleur Bay, Gulf of St Lawrence **Reviewed by:** Gubbay and Knapman 1999	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Trials looking at effects of three types of trawling gear on bottom sediments. Shallow traces made by inshore and offshore scallop dredging could be distinguished from each other. **Habitat effects:** Scallop dredging observed to lift fine sediments into suspension, bury gravel below the sand surface, and overturn large rocks embedded in the sediment, appreciably roughening the bottom. The inshore Alberton dredge was inefficient, dumping its contents back on to the bottom at intervals. Trawl tracks were seen as grooves on the seafloor - considered to be made by otter trawl doors. Suspended sediment in dredge tracks reduced visibility from 4-8m to less than 2m within 20-30m of the track but dispersed within 10-15mins, coating the gravel in the vicinity of the track with a thin layer of fine silt and obscuring Lithothamnion. Offshore dredge - gravel fragments overturned. Depressions left by tow bar of the dredge. Gravel less frequent inside the track. Inshore dredge (Alberton) tracks left, gravel sparser inside and dislodged boulders commonly observed. Tooth marks over sandy bottom. Bottom type and hydrographic regime in the Bay probably allowed marks made by fishing gear to remain recognisable for a long time as tidal currents faster than 1km/hr were not encountered. Even a relatively minor fishery may therefore have a significant cumulative effect on bottom microtopography under these conditions. Scallop and otter tracks could be distinguished, scalloping contributing to an appreciable roughening of the bottom, lifting large boulders and overturning many of them, presumably leading to destruction of the epifauna on their upper surfaces. Under strong tidal flow author considers that intensive dredging will lead to erosion of sediment lifted into suspension by the dredge - this aspect needs more study. **Species and community effects:** Dredging caused appreciable lethal and sublethal damage to scallops left in the track. Damage greatest on rough bottom. Predatory fish and crabs were attracted to dredge tracks within 1hr, and fish were observed in the tracks at densities 3-30 times those observed outside the tracks. There was a pronounced and rapid aggregation of foraging fish - a natural response which also occurs in the absence of fishing operations.	Caddy, J.F., 1973. Underwater observations on tracks of dredges and trawls and some effects of dredging on a scallop ground. *Journal of the Fisheries Research Board of Canada,* **30,** 173-180.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 31 **Year published:** 1988 **Peer reviewed?:** Yes **Study Location:** South-western Bay of Fundy, Canada **Reviewed by:** Gubbay and Knapman 1999	Gill nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise	Study using reports of incidental catch of harbour porpoise. Most are killed in monafilament gill nets set for groundfish or pelagic species. **Species and community effects:** Estimated total catch for the year in the area (based on notifications by fishermen) was 105+10.8 animals. The animals were entangled while nets on the bottom in water depths of 37-96m. They seem to catch certain size classes and not small or large animals. Factors other than fishing effort may also have effected the incidental catch rate of harbour porpoise. In one area it was disproportionately high, perhaps reflecting the high density of porpoises in the region. There were no changes in porpoise density in the region between 1980-86, but two significant changes in length frequencies (increase in length of calves and absence of large porpoises in the recent samples). These changes may be attributed to the fishery which has been operating for 10-15 years. The effects of sustained adult mortality in the gill-net fishery appear to have compressed the size and possibly the age structure of the population perhaps reducing the reproductive lifetime of females. Given the slow reproductive rate authors consider that these incidental catches seriously threaten the population as porpoises in Bay of Fundy and Gulf of Maine apparently form a relatively discrete population unit.	Read, A.J. & Gaskin, D.E., 1988. Incidental catch of Harbour Porpoises by gill nets. *Journal of Wildlife Management,* **52**, 517-523.
Ref Number: 32 **Year published:** 1991 **Peer reviewed?:** Yes **Study Location:** Limfjord, Denmark **Reviewed by:** Gubbay and Knapman 1999	Mussel Dredge, Trawling	**Relevant Habitats:** Large, Shallow inlets and bays **Relevant Species:** None	Effects of mussel dredging and bottom trawling on particulate material, internal nutrient loads and oxygen balance were investigated. **Habitat effects:** Sampling 0, 30 & 60 mins after fishing. Immediately after mussel dredging suspended particulate material increased significantly but 30 mins after the differences had decreased and, after 60 mins, had returned to the start level. Oxygen decreased significantly after mussel dredging and average ammonia content increased but large horizontal variation in the ammonia content prevented detailed interpretation of these increases. Changes in other nutrients were small. Changes in particulate matter and nutrients were also observed at some stations following low wind. Particulate matter and total phosphorus were markedly higher on windy days. Most dredging and trawling in the Limfjord takes place in summer when there is little wind, nutrients and oxygen consumption are low and temperature high. During these periods trawling and particularly dredging reduce the water quality by increasing internal nutrient loads, oxygen consumption and possibly phytoplankton primary production. Immediate increase in particulate matter, oxygen consumption and increase in nutrients particularly ammonia and silicate were a further effect of the fishing activities. Physical effects were scraping and pressure of gear the magnitude depending on depth of penetration, frequency of fishing and structure of sediment. **Species and community effects:** Trawling and dredging can be expected to cause a number of direct and indirect changes in the ecosystem - direct changes in fished populations and the benthos, but also changes in the nutrient level and oxygen budget in the water column. Phytoplankton primary production may increase if nutrients are the controlling factor. During summer when nutrients are generally low in the fjord mixing of sediments will have important consequences for the nutrient regime. It caused the deterioration of the water quality by increasing oxygen consumption and phytoplankton primary production. It was difficult to demarcate trawling and dredging effects versus wind induced effects at this site.	Riemann, B. & Hoffman, E., 1991. Ecological consequences of dredging and bottom trawling in the Limfjord, Denmark. *Marine Ecology Progress Series,* **69**, 171-178.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 33 **Year published:** 1977 **Peer reviewed?:** No **Reviewed by:** Gubbay and Knapman 1999	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Observation of standard and spring-loaded dredges. **Habitat effects:** Bottom deposits settled about 20 mins after hauling. Short teeth of these dredges dug in up to ½ to ¾ of their length and generated a large mound of sediment in front of the toothed bar. Most was deposited around the sides of the dredge and at times completely filled the dredge opening, particularly when large stones or shells blocked some of the gaps between the teeth. Dredge tracks were distinct, ridges of sediment being deposited each side, but path of the spring-loaded dredge less obvious than standard dredge. **Species and community effects:** The dredges caused some damage to benthic organisms. Most hauls had a few crabs *Cancer pagarus*, and starfish eg *Marthasterias glacialis* broken up by the gear. The teeth also dug out several sub-surface animals including heart urchins *Spatangus purpureus* and the mollusc *Laevicardium crassum*. These and other organisms raked up by the teeth appeared to attract several fish and invertebrate predators including juvenile cod adult plaice and dogfish, whelks and hermit crabs.	Chapman, C.J., Mason, J. & Drinkwater, J.A.M., 1977. Diving observations on the efficiency of dredges used in the Scottish fishery for the scallop, *Pecten maximus* (L.).*Scottish Fisheries Research,* 10, 16.
Ref Number: 34 **Year published:** 1994 **Peer reviewed?:** Yes **Study Location:** North Atlantic **Reviewed by:** Gubbay and Knapman 1999	Gill nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise	Global review of porpoise mortality in gill nets **Species and community effects:** Harbour porpoises are taken throughout their range and several populations are in decline, at least partly as a result of gill net entanglement. In the eastern North Atlantic substantial numbers are caught in gill nets in most areas. Highest known takes in Norway, Sweden and Denmark. UK also has substantial takes in gill nets as well as other fisheries. There are reports of harbour porpoise being caught in cod, salmon and whitefish gill nets off the Scottish coast, and in salmon drift nets and inshore set nets off NE England. Gill nets (which include set nets, drift nets and trammel nets) are considered to represent the single most important threat to porpoises as a group. Most porpoises have substantial problems with them. Harbour porpoise, for example, are found primarily in shallow waters, mostly nearshore which is the area where this form of fishing is generally practised.	Jefferson, F.A. & Currey, B.E., 1994. Global review of porpoise. (Cetacea: Phocoenidae) mortality in gill nets. *Biological Conservation,* **76**, 167-183.
Ref Number: 35 **Year published:** 1989 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Gill nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise	Review of interactions between the harbour porpoise and the gill net fishery **Species and community effects:** Harbour porpoise are one of the more vulnerable marine mammals to incidental capture by commercial fishing gear and are particularly prone to entanglement. Nearshore habitats, small size and diet of commercially harvested fish contribute to the magnitude of the incidental and/or directed takes occurring through most of their range.	Polacheck, T., 1989. Harbour porpoises and the gill net fishery. *Oceanus,* **32**, 63-70.
Ref Number: 36 **Year published:** 1993	cockle tractor dredge	**Relevant Habitats:** Estuaries, Mud and sandflats not	Investigated the use of tractor towed cockle harvester on invertebrate fauna. **Species and community effects:** Smaller interstitial forms were not greatly affected in most cases significant reduction in species numbers occurred immediately after dredging with continued decline for at least two weeks subsequently.	Rostron, D., 1993. *The effects of tractor towed cockle dredging on the invertebrate fauna of Llandhidrian Sands, Burry Inlet.*

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Peer reviewed?: No **Study Location:** Burry Inlet - Loughor Estuary (Llandhidrian sands) **Reviewed by:** Gubbay and Knapman 1999		covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** Wildfowl and waders	After that a few species showed signs of some recovery others did not, although seasonal trends were obviously important for several of the latter type. Effects at Site A (more tube dwelling and sedentary species) were obvious for longer than 3 months and the dredged area was still visible after 6 months. At Site B (more mobile fauna) natural winter weather disturbances resulted in changes of greater magnitude than those caused by dredging. Results suggested the importance of a stable environment, including surface microflora, for maintaining certain diverse community types and also revealed interesting patterns. Some types of benthic intertidal communities would be adversely affected by commercial tractor towed cockle harvesting. General conclusions from both this study and a 1990 study at Lavan sands are similar in that effects of dredge. 1. Result in a much decreased biomass of the target species, numerical reductions and likely decreased biomass of non-target species. 2. Are much more pronounced in areas with diverse communities and stable environmental conditions have some effects on certain types of sediment and can change sediment parameters at least in the short term. 3. Depend on the time of year the cockle bed is being exploited will be most severe if sufficient recovery time is not allowed. Results from this study did not agree with the conclusion that recolonisation takes place fully and quickly from nearby areas. Effects were obvious at Site A even at the end of the experiment. General effects on birds. Reductions in *Hydorbia ulvae* populations could affect shelduck, knot, dunlin and redshank. Disturbances to bivalve molluscs could affect oyster catcher, shelduck, knot, curlew and eider ducks, the latter however preferring *M. edulis*. Polychaetes are important in the diet of curlew, dunlin, bar tailed godwit and redshank although the latter prefer Nereis from the upper shore regions. Amphipods figure prominently as food for dunlin, curlew, oystercatcher, knot and shelduck.	*Subsea Survey.* Report to Countryside Council for Wales.
Ref Number: 37 **Year published:** 1991 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Gill nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise, Bottle-nosed dolphin	Incidental capture of cetaceans in gill nets is geographically widespread and considered a severe problem. Most capture dolphins and porpoises although large cetaceans are also vulnerable to entanglement. Large incidental catches can occur in coastal gill net fisheries which can have a greater impact than oceanic fisheries because coastal cetaceans often have more restricted distributions than oceanic relatives. Several proposals to reduce impact are discussed.	Dawson, S.M., 1991. Modifying gill nets to reduce entanglements of cetaceans. 7(3): 274-282. *Marine Mammal Science,* **7**, 274 - 282.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 38 **Year published:** 1993 **Peer reviewed?:** No **Study Location:** French Atlantic coast **Reviewed by:** Gubbay and Knapman 1999	Pelagic Trawl, Trammel-gill bottom net	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise, Bottle-nosed dolphin	Both nets and trawls are involved in the incidental capture of dolphins however accurate estimates of by-catch cannot be made because of lack of relevant data. High opening pelagic trawls towed by pairs of boats and combined trammel-gill bottom nets tied together in a row about the continental shelf are perhaps the most likely cause of large dolphin by-catch.	Charreire, F., 1993. A report for Greenpeace on recent dolphin strandings along the French Atlantic coast. *A report for Greenpeace on recent dolphin strandings along the French Atlantic coast.*
Ref Number: 39 **Year published:** 1995 **Peer reviewed?:** No **Study Location:** Firth of Clyde **Reviewed by:** Gubbay and Knapman 1999	Trammel-gill bottom net, Pelagic Trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Five maerl beds surveyed in the upper parts of the Firth of Clyde. Some information on the impact on maerl habitats obtained from examination of catches during experimental dredge runs. Preliminary findings. Each ground was a focus of high infaunal diversity and biomass consisting primarily of *Phymatolithon calcareum*. **Habitat effects:** Immediate effects a bow wave of fine particulates suspended ahead of the gear. Bobbins usually rolled along the surface but ploughed into the sediment by up to 4cm when the two-bar was skewed on impact with large boulder leaving trenches of crushed maerl. Cobbles and boulders up to a 1m3 were dislodged and overturned when hit by the tow bar or dredge mouths. **Species and community effects:** Dredge teeth projected fully into the maerl deposits. Maerl flicked over dredge mouths creating a cloud of suspended sediment in the wake of the bar. Large macroalgae *L. sacaharina* torn up as dredge dragged through the sediment and large animals *Echinus, Echinocardium, Luidia, Mya, Ensis, Ascidella aspersa* were either mangled or entrained or flicked into the chain mail bags. Even highly motile elements were caught eg butterfish, plaice, *L. depuratur*. The dredging has major repercussions for the structure of maerl habitats and associated biota.	Hall-Spencer, J., 1995. The effects of scallop dredging on maerl beds in the Firth of Clyde.
Ref Number: 40 **Year published:** 1993 **Peer reviewed?:** No **Study Location:** Lyme Bay (Beer Home Ground and Eastern Heads) **Reviewed by:**	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Single pass of full sized scallop dredge (12 spring-loaded dredges, deployed either side in groups of 6 attached to two beams) along 300m transects. Video recordings before and after and survival studies of specimens in laboratory for 14 days. **Habitat effects:** Scallop dredging can alter the substrate composition. Stones and boulders (up to 60cm in length) overturned, small boulders piled against larger boulders, fragments of mudstone reef broken off, sand waves in the dredge path completely obliterated, suspension followed by settlement of fine sediments disturbed by the dredge and displacement of substrate (apart from mudstone, loose rocks brought to the surface and shovelled off the deck once the catch had been sorted). Overall there was a markedly changed appearance the most striking being the covering of all boulders and rocks with a fine coating of sediment. Chipping and movement of cobbles and boulders has implications for the habitat of juvenile crabs, particularly *Cancer pagurus*, which appears to inhabit the areas of soft mudstone. Of the habitats studied, area of sand waves was probably the least vulnerable to scallop dredging in the long term. **Species and community effects:** Changes in species observed before and after dredging due to various factors;	Sea Fish Industry Authority, 1993. *Benthic and ecosystem impacts of dredging for pectinids.* (reference 92/3506) Consultancy Report No.71

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Gubbay and Knapman 1999			revealed by dredge as substrate overturned, dug out of substrate (eg *Pomatocerus triquiter, Pecten maximus*) or dislodged off the interstices eg *Maia squanado*; species hidden Porifera, destroyed *Pentapora foliacea,* injured or killed by action of dredge (adult crustaceans) and attracted by injured specimens in wake of the dredge *Pollachus* spp crustaceans. Survival of dredged specimens in laboratory tanks showed surprising resilience of juvenile *C. pagurus* and *Pholus dactylus* which remained in the honeycomb mudstone, sea squirts died rapidly compared to controls and starfish exhibited comparable survival between experiment and control. No clear cut evidence in the case of *P. foliacea* and *E. verrucosa* but these most likely to suffer from being displaced as unlikely to re-establish themselves so mortality of these species seems likely. Response of the whole system to dredging will depend on resettlement and growth of new stock and whether the substrate is suitable for this. The vulnerability of the system switching to another system would depend on importance of the species affected. If slower growing species with poor recruitment (eg *E. verrucosa* or slow growing but rapidly recruiting (eg *P. foliacea*) hold the system in its present form there is a high risk of complete change. **Further notes:** Substrate types: Mudstone reefs, cobble and bulder seabed, sandy areas with boulders and sandy substrates.	
Ref Number: 41 **Year published:** 1992 **Peer reviewed?:** No **Study Location:** Scottish waters **Reviewed by:** Gubbay and Knapman 1999	Mariculture (finfish), Various (Not listed)	**Relevant Habitats:** None **Relevant Species:** Grey seal, Common seal, Harbour porpoise, Bottle-nosed dolphin	Review paper **Species and community effects:** Seals are still killed around the Scottish coast where they interact with fishing or fish farming interests but it is difficult to assess the impact. Probably localised and limited in extent, but could have a significant effect on some local populations. Seals and cetaceans may be caught accidentally in fishing gear and anti-predator nets around fish farms. Grey and common seals, harbour porpoises and common dolphins are the most commonly caught species in UK waters. Currently the assessment of the significance of the potential threats is hampered by lack of data on the nature of the threats and the dynamics of the populations concerned.	Thompson, P.M., 1992. The conservation of marine mammals in Scottish waters. 100B: 123-140. *Proceedings of the Royal Society of Edinburgh,* **100B**, 123-140.
Ref Number: 42 **Year published:** 1985 **Peer reviewed?:** No **Study Location:** Skomer **Reviewed by:** Gubbay and Knapman 1999	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Pre-dredging surface followed by qualitative and quantitative assessments (although not at the same stations), photographs and sediment samples. **Habitat effects:** Conspicuous tracks on the seabed about 4m wide. At each site a ridge of stones, shells and shell fragments approx. 15cm high and 30cm wide. Inside ridges shallow grooves formed by rubber bobbins at the ends of the towing beam. Examination of tubes of the anemone *Cerianthus lloydii* in the dredge paths suggested top 2-4cm had been removed. Passage of dredge created a thick sediment cloud the heaviest constituents of which settle out rapidly and close by. Fine sediments were carried away by the tide. **Species and community effects:** Dredge bags contained shells and stones most of which supported sponges, hydroids, small anemones, tube-worms, barnacles, ascidians and bryozoans. Remains of several P. folicacea and large numbers of small crustaceans (chiefly *Pilumnus hirtellus*), molluscs (especially *Trivia* spp.) and juvenile echinoderms within the folds of the colonies. Also several sponges (mostly *Suberites* spp.) and a large number of epibenthic echinoderm species in the catch. Predators and tidal currents removed much evidence of killed or injured animals in the	Bullimore, B., 1985. *An investigation into the effects of scallop dredging within the Skomer Marine Reserve.* Skomer Marine Reserve Subtidal Monitoring Project. Report to the Nature Conservation Council.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
			24 hours after dredging but dead or damaged tubeworms, crabs, squat lobsters echinoderms and *P. foliacea* were found. Large numbers of *C. lloydii* present in dredge path. Broken tops of *I. conchilega* tubes were common in dredge paths but large numbers of intact tubes suggested that the worms had survived and rebuilt their tubes. Large mobile.epifauna generally absent from dredge path except for occasional scavenging *A. rubens* although within 48hrs smaller mobile species such as hermit crabs were present. Counts of infauna in and immediately alongside dredge paths showed these species were unaffected by the level of dredging. Sessile species found during presurvey but not seen in dredge paths include "shell fauna", C. celata, *Suberities* spp. *A. digitatum* and *P. foliacea* **Further notes:** Sediment types: Mixed sediment chiefly sand and shell gravel with varying quantities of silt, shells, gravel, stones and cobbles.	
Ref Number: 43 **Year published:** 1991 **Peer reviewed?:** No **Study Location:** European Community waters **Reviewed by:** Gubbay and Knapman 1999	Gill nets, Tangle net, Trammel-gill bottom net	**Relevant Habitats:** Coastal lagoons **Relevant Species:** Grey seal, Common seal, Harbour porpoise, Bottle-nosed dolphin, Turtles, Other cetaceans, Seabirds	Report on the nature and scale of European gill net fisheries and review of accidental catches of non-target species. Incidental catches reported for common dolphins, bottlenose dolphin, striped dolphin, harbour porpoise, common seal, grey seal, sharks (especially blue sharks), loggerhead turtles, guillemot, razorbill, shag and loon. **Species and community effects:** Around the UK catches of grey seals in tangle net fisheries high in the Barra fishery and for Cornwall appeared to be higher than other areas. Catches of common dolphins often reported in southwest fisheries amounting to perhaps some hundreds per year. Bottlenose dolphins rarely recorded but porpoises fairly frequently found in gill net fisheries especially in the North Sea. Drift net fisheries catch most but most of these are released alive. Total drownings in gill nets throughout the country may be in high tens to low hundreds. Impact on porpoise population not known. Bird catches widely reported but little studied. Catches of non-target fish poorly known but crabs are taken in very large numbers. Regarding impact on marine mammals the study clarified importance of North Sea cod fishery and Atlantic hake fishery both already suspected of taking significant number of harbour porpoises and common dolphins respectively. With no populations studies on this species in Europe the impacts of these fisheries and the recently implemented tuna drift net fishery, remain speculative. There are apparently significant catches of birds in the salmon driftnet fisheries in Ireland and Denmark and catches in coastal and lagoon fisheries in Portugal and Italy. It has been estimated that breeding populations of guillemots at two sites in northern Norway have declined by 95% from the early 1960's to 1989 and that this decline could be explained entirely by gill net mortalities based on observed catch rates. Impacts on non-target fish poorly documented, but where examined a wide variety of species recorded. Probably most acutely seen in the swordfish driftnet fishery. May be an impact on benthic communities because of cumulative effect of exposure to netting (including lost netting) on certain seaweeds, seagrass or pedunculate invertebrate communities may be important but little investigated.	Northridge, S., di Natale, A., Kinze, C., Lankester, K., Ortiz de Zarate, V. & Sequeira, M., 1991. *Gill net fisheries in the European Community and their impacts on the marine environment.* MRAG Ltd. A report to the European Commission's Directorate General Environment.
Ref Number: 44 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** Georges Bank, Canada **Reviewed by:**	Scallop dredge, Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Photographic evaluation of the effects of scallop dredging on Georges Bank. **Habitat effects:** small differences in sediment type between dredged and undredged sites with dredged sites having a slightly higher frequency of small pebbles, and the undredged sites having slightly more larger pebbles and cobbles. **Species and community effects:** Samples of benthic megafauna from disturbed and undisturbed sites showed that disturbed sites had lower density of organisms, biomass, and species diversity than undisturbed sites. Many of the species that were absent or less common in dredge sites were small, fragile polychaetes, shrimps and brittlestars. Most apparent difference was the lack of colonial, epifaunal taxa at the disturbed site. This study aimed to give a quantitative assessment of the impact using still photographs. Comparison of deep sites showed that *Filograna implexa* had a high percentage cover at the undredged site and no epifauna and few animals visible at the dredged site. Significant effect between depth and dredging for both *F. implexa*	Collie, J.S., Escanero, G.A. & Hunke, L., 1996. *Scallop dredging on Georges Bank: Photographic evaluation of effects on benthic epifauna*. ICES CM, 1996/Mini: 9

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Gubbay and Knapman 1999			and plant-like animals with effect on percentage cover greater at the deep sites. For plant-like animals the effect was higher at the shallow sites. *Protula tubularia* was significantly more abundant at undredged than dredged sites. There were no differences in the proportion of photographic sampling cells with bryozoans in them, but dredged sites had a significantly higher proportion of cells with abundant bryozoans than undredged sites. *Spirorbis* was more abundant at the deep sites and was in higher frequencies at the dredged sites than undredged sites. Most likely explanation is that the emergent epifauna at undredged sites concealed encrusting bryozoans and *Spirorbis* from view. Depth had the greatest effect on the frequencies of non-colonial animals. Dredging had a lesser, but still significant effect on the frequencies of non-colonial species. Undredged sites had higher frequencies of almost all taxa except burrowing anemones, the earshell *Sinum perspectivum* and hermit crabs. Most of the non-colonial taxa seemed to be negatively affected by dredging but some seemed to profit from dredging. Burrowing anemones were more prevalent at dredged sites for example, perhaps because tentacles easily retracted to safety. Results consistent with the hypothesis that gravel habitats are very sensitive to physical disturbance by bottom fishing and the primary impact is the removal of emergent epifaunal taxa. **Further notes:** Gravel sediment	
Ref Number: 45 **Year published:** 1992 **Peer reviewed?:** No **Study Location:** North East Atlantic, North Sea, Irish Sea **Reviewed by:** Gubbay and Knapman 1999	Various (Not listed)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** Grey seal, Common seal, Harbour porpoise, Bottle-nosed dolphin, Seabirds	Review report describing direct effects of fishing. **Habitat effects:** all towed gears which exploit bottom-living species disturb the sediment and may therefore have an impact on the structure and processes at the seabed. Grain size distribution, sediment porosity and chemical exchange process are properties which may be affected. Another direct consequence is displacement of boulders which would otherwise be a surface for epifauna. A direct consequence of disturbance is an increase in suspended sediment load and the possibility of net transport of finer sediments. Resuspension may also influence uptake or release of contaminants, a shift in sediment-water exchange eg of nutrients. Reworking of sediments may result in burial of organic matter. Gears which disrupt the sediment most are beam trawls and shellfish dredges but method of rigging can have a profound effect on the level of disturbance. **Species and community effects:** Box cores revealed extensive changes to infauna before and after trawling. Significant reduction in burrowing sea urchin and the density of tube-building polychaetes. Survival rates for infauna and epifauna caught in net of beam trawl were high for starfish, many molluscs and crabs but poor for *Arctica islandica*. Trawl-caught whelks and hermit crabs largely unaffected. These results suggested that a relatively high proportion of some benthic species can be killed in the path of a beam trawling. In relation to scallop dredging epibenthic mortalities can be marked. Effects on seabed and benthos depend on substrate type, hydrographic features and community structure as well as the design and operation characteristics of the gears. Seabirds have been killed in gill and other static nets, no comprehensive studies of entanglement in the North Sea but available evidence indicates that it is likely to occur for diving birds in areas with fixed net fisheries. Gill net fisheries in some places have had a high by-catch of diving birds. Seals may be caught in gill nets, fyke nets and fixed nets for salmon. Gill nets killed the most cetaceans, catch rates varying seasonally. Around the British Isles several species of small cetacean have been reported as incidental catches but in the North Sea reported by-catches of species other than harbour porpoise are rare. As well as catch, fishing operations cause incidental mortality of fish which escape from the gear. Gill nets, tangle nets and traps may continue to fish for some time after being lost of discarded. Length of time depends on factors such as current speed and fouling. On the bottom multifilament nets remain tangled, monofilament nets may, once clear of fish remains and crabs, disentangle, return to an upright position and resume fishing. Over time they build up an encrusting layer of marine organisms and become more visible to fish. Fragments of nets of all types may also entrap seabirds and marine mammals.Direct effects of fishing compared with the effects of other anthropogenic influences and natural processes also discussed, along with long-term effects of fishing activities. In the long term there	ICES, 1992. *Report of the study group on ecosystem effects of fishing activities* ICES C.M. 1992/G:11

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
			may be changes in the feeding relationships of organisms, changes in the genetic makeup of populations and other changes such as in the habitat. The mix of direct and indirect effects makes it extremely difficult to establish causal relationships between the amount of fishing and observed long-term population changes. Long-term cascading changes in community structure may occur if 'keystone' populations are adversely affected by fishing, leading to marked changes in the pattern of predation and or competition. One general effect that has been suggested for benthic communities is that overall productivity may increase due to long-lived slow growing taxa being replaced by smaller faster growing taxa whose populations are better able to respond numerically to continued disturbance. Such shifts, it has been suggested, could lead to changes in other community parameters such as species diversity. However, not all levels of disturbance will necessarily result in lower community diversity. Current ecological theory supports the idea that intermediate levels of disturbance would result in an increase in diversity.	
Ref Number: 46 **Year published:** 1994 **Peer reviewed?:** No **Reviewed by:** Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Effects of 4m and 12m beam trawls investigated. **Habitat effects:** sole plate of 4m trawl exerted a force of about 2N/cm^2 at commercial trawling speeds. Trawl marks on coarse sand visible up to 52hrs after fishing. **Species and community effects:** Range of mortalities of discarded, non-target species due to capture and handling. High mortalities for undersized fish discarded, 50% or less for most crabs and molluscs and very little mortality (<10%) for starfish. Overall decrease of 0-85% from initial numbers for different mollusc species (solid-shelled or very small species such as *Chamelea gallina, Corbula gibba, Dosinia lupinus* and *Apporhais pespelicani* not affected. More vulnerable species such as *Abra alba, Mactra corallina, Ensis ensus, Arctica islandica* and *Turritella* communities had mortalities between 12-85%), 4-80% for crustaceans *Corystes cassivelaunus* and *Ebalia* spp. approx. 30%, *Eupagurus bernardus* showed size dependent mortality 15% for large animals and 74% for small animals; *Callinassa* spp. lived too deeply to be disturbed by beam trawling, 0-60% for annelids and 0-45% for echinoderms *A. rubens, A. irregularis, A. filiformis and O. texturata* little affected and *E. cordatum* too deeply buried to be harmed. Considering the high mortality of certain species and the fishing intensity, it can be expected that commercial beam trawling affects the structure and composition of the benthic community in the North Sea. Benthic animals damaged, dislodged or discarded by beam trawls may contribute significantly to the diet of scavengers whose populations may thus become enhanced. Investigations into scavengers showed that dab, gurnard, dogfish and whiting increased intake of prey after fishing. Dab fed largely on bivalves Arctica, Acanthocardium, Donax and Spisula and crustaceans *Upogebia* and *Callianassa* the latter of which are not normally accessible to them. Gurnards and whiting fed on dislodged amphipods and whiting fed on the damaged burrowing heart urchin *Spatangus purpurreus*. Fish rapidly migrated into trawled areas to feed on animals damaged or disturbed by fishing.	De Groot, S.J. & Lindeboom, H.J., 1994. *Environmental impact of bottom gears on benthic fauna in relation to natural resources management and protection of the North Sea*. Netherlands Institute for Sea Research. NIOZ-Rapport 1994-11, RIVO-DLO report CO26/94.
Ref Number: 47 **Year published:** 1983 **Peer reviewed?:** Yes **Study Location:** coast of South Uist **Reviewed by:** Gubbay and	Pots or creels	**Relevant Habitats:** Reefs (Subtidal) **Relevant Species:** Otter	Report of otter mortalities in lobster creels off S. Uist. **Species and community effects:** Most were drowned foraging in depth of 2-5m of water. Greatest depth was 15m, 65% of known status were adult females 15% were juveniles, 10% sub-adult females and 10% adult males. The low number of males perhaps because fewer adult males in the favoured breeding area. Also because of their size the males may not be able to enter the parlour of the creel. Fish such as saithe, small cod and congers swim into the creels and are trapped and it is likely that the otters are attracted to this rather than the lobster bait. The incorporation of a parlour in these pots has greatly increased its ability for holding lobsters as well as otters. Does not appear to be as much a threat from crab creels as they are usually set on sandy bottom in deeper water further offshore rather than the favoured otter foraging areas.	Twelves, J., 1983. Otter *Lutra lutra* mortality in lobster creels. 201: 585-588. *Journal of Zoology, London,* **201**, 588-588.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Knapman 1999				
Ref Number: 48 **Year published:** 1984 **Peer reviewed?:** No **Study Location:** Devon coast, east coast of South Uist, Orkney, Skye, Shetland and west Sutherland **Reviewed by:** Gubbay and Knapman 1999	Pots or creels, Fyke nets	**Relevant Habitats:** Estuaries, Reefs (Subtidal) **Relevant Species:** Otter	Report of catches off Devon coast, off the east coast of South Uist, Orkney, Skye, Shetland and west Sutherland **Species and community effects:** Accidental drowning of otters has occurred in crustacean and fish traps such as lobster pots, crab pots, and eel fyke nets in both freshwater and marine situations. Review of reports shows that this has taken place in parlour creels, single-compartment box creels, single compartment 'inkwell' creels and fyke nets. Work to prevent otter damage to fyke cod-ends suggests that in some cases they attack the nets from the outside and if severing the mesh proves impossible, move to the fyke entrance or directly to the entrance. Uncertain whether otters are attracted to crustacean traps by the bait or the catch -seems that both can occur. In the latter case this is because they tend to contain particularly favoured prey such as eels, crayfish and crabs. Estimates of times otters can submerge are for more than 3-4 mins, normal dive time is far shorter and they run out of time and drown. Sex and status of otters drowned in lobster creels off S. Uist mostly females. Adult males may be less active in the favoured breeding areas and may be unable to enter the parlour of the most widely-used creel. No data to support the view that those otters which drown are young and inexperienced. Some evidence to suggest that they escape more readily from single-compartment creels than double-chamber creels. Family parties are known to have drowned on five occasions. Juvenile casualties have involved animals towards the size where independence is reached, at about 10 months. **Further notes:** Suggestions to alleviate the problem of drowning otters discussed in the paper. These are intermittent operation, size of net, depth, floating cod-ends, opaque covers for traps, excluders over fyke entrances; and ledges in box traps exposed to the air. Satisfactory, preventative measures for a given trap might vary, dependent upon local fishing conditions and the state of the regional otter population.	Jefferies, D.J., Green, J. & Green, R., 1984.*Commercial fish and crustacean traps: a serious cause of otter Lutra lutra (L.) mortality in Britain and Europe.* **31**. Vincent Wildlife Trust, London.
Ref Number: 49 **Year published:** 1988 **Peer reviewed?:** No **Study Location:** the Solway Firth **Reviewed by:** Gubbay and Knapman 1999	Fyke nets, Pots or creels	**Relevant Habitats:** Estuaries, Reefs (Subtidal) **Relevant Species:** Otter	Report of catches in the Solway. A major cause of mortality to otters has been accidental capture and drowning in fish and crustacean traps. Four types of guards for eel fyke nets were constructed and tested - square guard, ring guard, front net guard, grid guard. Effects on catches of eels (total weight, number and catch of saleable eels) were recorded. Techniques other than guards discussed but it was considered that the only safe and continually working otter protection device was a physical barrier at some point near the mouth of the fyke. The Steering Committee set up to look at the problem suggested authorities should consider and adopt most suitable designs for their situation and then consider ways of implementing and ensuring use. **Species and community effects:** Otters investigate eel fyke nets because of the artificially concentrated prey in the cod end. They are unable to bite their way through modern multifilament nylon netting therefore the only way to get the prey is through the fyke entrance and down through the funnels. The time they can submerge is not sufficient in many cases for an otter to negotiate its way back to the entrance so it drowns. Between 1975-1984, 89 otters are known to have been caught in underwater traps (50, 33 and 6 in eel fyke nets, crustacean and fish nets). In the Solway verified data considered by an observer to be only 20-50% of the real total. Fish traps can be effective at reducing otter populations when set for a long period in a single locality.	Vincent Wildlife Trust, 1988. *The effects of otter guards on the fishing efficiency of eel fyke nets.* **47**. Vincent Wildlife Trust, London

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 50 **Year published:** 1988 **Peer reviewed?:** Yes **Study Location:** Isle of Harris **Reviewed by:** Gubbay and Knapman 1999	Discarded gear (ghost fishing)	**Relevant Habitats:** None **Relevant Species:** Otter	The paper describes condition of a dead otter found on the beach near Scarista on the Isle of Harris. It was emaciated and the cause of death strands of monofilament nylon which had become embedded into the flesh around the neck. It was a small section of fishing net (square aperture approximately 50mm). It seems likely that the otter was entangled at an early age (3-5 months) and as it grew the nylon became enclosed in tissues of the neck. Unknown how many are lost in this way and whether it is large enough to be a conservation problem and one of animal welfare. Needs monitoring. This case shows that even a small section of discarded net can be lethal therefore the solution is difficult. **Further notes:** European otters have been caught and drowned in active gear such as wade nets off Pembroke, fyke nets in freshwater and estuaries and parlour creels set for lobsters. Chance encounters with cast-off fragments of plastic netting was not considered a cause of fatality. Otters may be attracted to explore such debris but their dexterity was thought to prevent fatalities. This now appears not to always be the case and could be an increasing problem for coastal otters.	Jefferies, D.J., Johnson, A., Green, R. & Hanson, H.M., 1988. Entanglement with monofilament nylon fishing net: a hazard to otters. *Journal of the Otter Trust,*11-15.
Ref Number: 51 **Year published:** 1989 **Peer reviewed?:** Yes **Study Location:** Ythan Estuary, Scapa Flow, Isle of Arran and off Skye **Reviewed by:** Gubbay and Knapman 1999	Fyke nets, Pots or creels	**Relevant Habitats:** Estuaries, Reefs (Subtidal) **Relevant Species:** Otter	Further reports of otter deaths in fyke nets and creels. These include 2 males in fyke nets in the upper Ythan estuary after nets in the river for only 3 days, indicating the speed at which an eel fyke net will operate as an otter trap in a catchment with normally high otter density. Also reports the release of an otter from a fyke net providing an example of otter surviving capture when in shallow water if struggles bring the cod-end to the surface. **Species and community effects:** Data confirm the potential of eel fyke to attract and kill otters living at very low density. Also appears to be considerable attraction when silver eels begin their seasonal migration - August/September on East Coast, October/November in Severn. This must be one of the last opportunities for otters to feed on eels in quantity before capture becomes too difficult until spring. Overall monthly distribution of all drownings in fykes, creels and fish traps shows a marked concentration in autumn and winter. Partly explained by seasonality of fishing but also when main food may be reduced for seasonal reasons. **Further notes:** Deaths in creels reported from a lobster creel in Scapa Flow, crab creel off Isle of Arran and prawn creel off Skye. Four otter guard test results shows only a significant difference with the square guard but only approximately 17% reduction. This guard is used by the Danes as mandatory on fyke nets. They have been mandatory in some UK regions since the 1980's. Crustacean trap problem still unresolved and an issue on the rocky coasts of NW Scotland, the Northern and Western Isles.	Jefferies, D.J., 1989. Further records of fyke net and creel deaths in British otters *Lutra lutra* with a discussion on the use of guards. *Journal of the Otter Trust,* 13-19.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 52 **Year published:** 1995 **Peer reviewed?:** No **Reviewed by:** Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Review of data on penetration of depth of ticklers and chain arrays of beam trawls. **Habitat effects:** Under normal working conditions beam trawls influence only the top layers of the sea bed up to 30mm on muddy ground and up to 10mm on sandy ground. Summary of results to date suggest average penetration depth 4-7cm. The depth depends on the bottom type and structure of the ticklers and does not always penetrate as the gear moves over the seabed at speeds of 6-7 knots.	de Groot, S.J., 1995. *On the penetration of the beam trawl into the sea bed.* ICES C.M. 1995/B:36
Ref Number: 53 **Year published:** 1996 **Peer reviewed?:** Yes **Study Location:** St Brides Bay, Southwest Wales **Reviewed by:** Gubbay and Knapman 1999	Trammel net, Gill nets, Discarded gear (ghost fishing)	**Relevant Habitats:** None **Relevant Species:** None	90m long gill net (100mm diameter mesh) and trammel net (100mm with 600mm diameter outer mesh) set by commercial fisherman and cut at one end to simulate net loss. Survey of catches by direct observation, still and video photography for the following 9 months. **Species and community effects:** Both nets caught large numbers of elasmobranchs which took about 3 weeks to decompose. Gadoids were eaten within 72hrs therefore not possible to tell how many were caught throughout the observation period and estimates were considered by authors to be conservative. Initially both nets caught more fishes than crustaceans but by 20 days crustacean catch was greater than fishes and was greatest 43 days after initial deployment. Catch per 24hr period declined with time and for fish was nearly zero at 70 days for gill net and 22 days for trammel net. Catch per 24hr for crustaceans remained higher than for fish for both nets throughout the study. Reduction of catch rate probably linked to reduction in net size and degree of entanglement. Overall catch over the 134 day experiment was 261 animals in the gill net and 292 in the trammel net. *Maja squinado* and *Scyliorhinus canicula* were the 2 species most commonly caught in both nets. Other species caught were lobster, brown crab, swimming crab, Nurse hound and Smooth hound. All the crustaceans caught known to scavenge carrion. Other scavengers also aggregated to feed on the animals in the nets included *A. rubens, M. glacialis, O. fragilis* (in large swarms) and *E. esculentus*. Three shags were also caught. When nets retrieved (3 months after last survey) 2 spider crabs, previously marked were still alive after more than 102 days in the net. Towards the end of the experiment the free end of the nets began to roll up reducing the total length of net. Authors conclude that total catch of animals during life of a net may be considerable as in the present study but will depend on local fauna, habitat type and environmental conditions at the site.	Kaiser, M.J., Bullimore, B., Newman, P., Lock, K. & Gilbert, S., 1996. Catches in 'ghost fishing' set nets. *Marine Ecology Progress Series,* **145**, 11-16.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 54 **Year published:** 1995 **Peer reviewed?:** No **Study Location:** Limfjorden, Denmark **Reviewed by:** Gubbay and Knapman 1999	Mussel Dredge	**Relevant Habitats:** Large, Shallow inlets and bays **Relevant Species:** None	Experimental work in situ and in laboratory to evaluate the importance of the upwelling of sediment during dredging and, in particular, the amount of sediment particles, nutrients and oxygen consuming substances released during dredging as these factors can effect macrophyte and phytoplankton growth as well as affecting fish and bivalves. **Habitat effects:** Preliminary results suggest a minimum flux of $2km^2$, corresponding to about 0.9cm penetration of the gear. The release of particles, nutrients and oxygen-consuming substances seems to have little effect on the overall environmental conditions in the fjord. Where 10-15 boats dredge for several days, authors note that this will alter the local concentrations of nutrients and suspended matter directly, but the effect would probably only be visible or significant, during the dredging operations. Total annual release of suspended particles shown to be relatively unimportant compared with total annual wind-induced resuspension and release of nutrients compared to load from land. **Species and community effects:** the effects are probably much more severe on the ecosystem by changing the bottom flora and fauna which may in turn affect water quality. If natural bottom community cannot be established the areas will be characterised by low biodiversity and by opportunistic species dominated by young individuals of small sizes. Overall environmental effects of this disturbance in Limfjorden is not fully understood.	Dyekjaer, S.M., Jensen, J.K. & Hoffman, E., 1995. *Mussel dredging and effects on the marine environment.* ICES C.M. 1995/E:13 ref.K.
Ref Number: 55 **Year published:** 1996 **Peer reviewed?:** Yes **Study Location:** North Sea **Reviewed by:** Gubbay and Knapman 1999	Various (see further notes)	**Relevant Habitats:** None **Relevant Species:** Seabirds	Data from a study of scavenging seabirds in the North Sea and review of literature on quantities of discards. Fishery waste from North Sea fishery is important to seabirds. The sources evaluated here are demersal trawlers and seiners catching gadoids, pelagic trawlers and seiners, and beam trawlers. Authors estimate quantity available amounts to around 62,800t offal, 262,200t roundfish, 299,300t flatfish, 15,000t elasmobranchs and 149,700t benthic invertebrates per year. Beam trawls have the highest rates of discards of fishing fleets in the area. Discard fraction is dominated by flatfish which are less favoured by seabirds potentially supported by fishery waste in the North Sea estimated to be roughly 5.9 million individuals in an average scavenger community. **Species and community effects:** Discards and offal may easily support all scavenging seabirds in southern and southeastern sub-regions of the North Sea for example but only half in the northwest region. **Further notes:** Discards from a number of different fisheries.	Garthe, S, Camphuysen, K.C.J. & Furness, R.W., 1996. Amounts of discards by commercial fisheries and their significance as food for seabirds in the North sea. *Marine Ecology Progress Series,* **136**, 1-11.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 56 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** Southern North Sea Study Dates: 1993 - 1996 **Reviewed by:** Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Large, Shallow inlets and bays, Sandbanks which are slightly covered by seawater **Relevant Species:** None	Study into the micro-scale distribution of beam trawl effort in the southern North Sea between 1993 and 1996 in relation to the trawling frequency of the sea bed and the impact on benthic organisms. **Further notes:** Distribution of fishing effort by 25 Dutch commercial beam trawlers analysed and show that in 8 of the most heavily fished rectangles in the North Sea, 10% of surface area trawled less than once in 5 years, 33% less than once in a year. The surface area of the seabed trawled more than 10 times a year estimated at 3%. Authors note two key parameters to be considered in relation to the impact of beam trawling on benthic fauna; depth of penetration of the beam trawl in relation to sediment type, and spatial distribution of beam trawl effort. They note that the areas of intensive beam trawling have been trawled intensively for several years and still provide profitable fishing grounds and comment that without ample benthic food for plaice and sole, these fishing grounds would have lost their profitability for fishing. However a further comment is that it is not unlikely that the benthic community in intensively trawled areas shifted towards a dominance of highly productive opportunistic species.	Rijnsdorp, A.D., Buijs, A.M., Storbeck, F. & Visser, 1996. *Micro-scale distribution of beam trawl effort in the southern North Sea between 1993 and 1996 in relation to the trawling frequency of the sea bed and the impact on benthic organisms.* ICES C.M. 1996/Mini 11.
Ref Number: 57 **Year published:** 1996 **Peer reviewed?:** Yes **Study Location:** Northern Georges Bank, NW Atlantic Port Erin, Isle of Man **Reviewed by:** Gubbay and Knapman 1999	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Update on studies relating to areas closed to fishing. **Species and community effects:** Comparison of community structure in areas of high and low scallop dredging on northern Georges Bank shows undredged sites had higher densities of shallow burrowing and epibenthic species, more abundant *Modiolus modiolus* and more abundant small fish. Hard-shelled molluscs were equally abundant at dredged and undredged sites as well as scavenger species suggesting that scavenger abundance was not food limited. No consistent differences in mean size and weight of species between dredged and undredged sites. Many polychaete species were only abundant at the undredged sites because of the complex habitat there. Habitat complexity was higher at the undredged sites due to present of Filograna implexa, bushy bryozoans and hydroids. Closed area (from 1989) of scallop ground off Port Erin, Isle of Man is being used to assess environmental impact of scallop dredging. Benthic community and physical habitat has been compared with adjacent areas since 1994 and two plots within the closed area experimentally dredged at 2 month intervals. Results to date show differences in the epifaunal communities including greater species consistently more abundant in undredged areas. Further analysis shows this was due to absence of dredging and not variations in sediment or depth. Overall higher densities of shallow burrowing and epibenthic species at the undredged sites but particular species noted for their vulnerability to dredging eg *A. digitatum, Anseropoda placenta, Luidia sarsi, Cellaria fistulosa* and *E. esculentus*. There was no evidence of longer-lived benthic species at undredged sites but this was not surprising due to relatively short time since effective closure of the area. Scavenger species were common at both dredged and undredged sites with A. rubens consistently more abundant on the dredged sites. Ratio of polychaetes to molluscs was lower at the dredged sites and may be due to greater habitat complexity in the closed area although authors also note that infaunal bivalves were probably not adequately sampled. **Further notes:** Two studies described here. Other studies reported are trawling experiment on the Grand Banks, North Sea Plaice Box, Loch Gareloch (Scotland) and Gullmar Fjord (Sweden).	ICES, 1996. *Report of the Working Group on Ecosystem effects of fishing activities.* ICES C.M. 1996/Assess/ Env:1. Ref: G.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 58 **Year published:** 1984 **Peer reviewed?:** Yes **Study Location:** North Sea **Reviewed by:** Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Review of impacts of bottom trawling **Habitat effects:** Effect of trawls will be influenced by substrate. Visibility of markings depend on substrate and currents and depth of penetration up to 30mm on muddy ground and 10mm on sandy ground. **Species and community effects:** Some groups of animals eg hydrozoans, echinoderms (eg heart urchins) suffer heavy damage by trawling, others escape relatively easily (eg gastropods, hermit crabs). Author speculates that it is not unlikely that in the long-term a shift in species and numbers may occur as has been found in the German Wadden Sea where polychaetes are on the increase and molluscs and crustaceans in decline but that this is unlikely to have a negative effect on fish stocks. Large quantities of benthic animals become available as food source for fishes. Temporary covering due to sand movement is not exceptional and they will survive, and a shift in species distribution from one group or groups of animals to another cannot be ruled out in the long-term. Author comments that as this shift is, in principle, reversible it constitutes no major threat to benthic life.	de Groot, S.J., 1984. The Impact of bottom trawling on benthic fauna of the North Sea. *Ocean Management,***9**, 177-190.
Ref Number: 59 **Year published:** 1988 **Peer reviewed?:** No **Study Location:** Scotland **Reviewed by:** Gubbay and Knapman 1999	Mariculture (finfish)	**Relevant Habitats:** None **Relevant Species:** Grey seal, Common seal, Harbour porpoise, Seabirds	Survey into the effects of predator control measures around aquaculture facilities. **Species and community effects:** Grey seals, common seals, cormorants, shag and mink were the most prevalent predators with most of the fish farms surveyed suffering losses to some or all of them. Eider duck and, on some occasions oyster catchers are known to feed on shellfish farms. Predator control measures can be detrimental to all these species which can get tangled and drown in predator nets. Tangling in fish farm nets, mostly top nets and predator nets, was reported from 68% of the 47 sites visited. The animals reported caught were seals, herons, cormorants, shags but also gulls, eider duck, black guillemot, great northern diver, gannet, dolphins (unspecified), harbour porpoise and even a basking shark. Seals, herons, cormorants and shags have also been shot by fish farm operators to protect the stock. The main impacts of predator control around fish farms are disturbance, displacement and killing both directly and indirectly. More detailed information is needed to assess the significance to local populations but author suggests that it is likely to be acute given the concentration of destructive control measures around individual farms.	Ross, A., 1988. *Controlling nature's predators on fish farms.* **96**. Marine Conservation Society, Ross-on-Wye.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 60 **Year published:** 1990 **Peer reviewed?:** Yes **Study Location:** Europe **Reviewed by:** Gubbay and Knapman 1999	Various (see further notes)	**Relevant Habitats:** None **Relevant Species:** Sturgeon	Life history of 24 species of sturgeon summarised with details of the three different life histories depending on whether the adults remain in fresh water, move into brackish water or finally move into the sea. **Further notes:** Sturgeons are of economic importance as stocks are exploited. Accidental catches in trawls and nets sometimes happen at sea (eg juveniles caught when trawling for clupeid fishes in the Black Sea) but it occurs especially at the mouths of large rivers when fishing for other species. Other impacts, physical obstacles for migrating fish and physical impacts on spawning and nursery areas are also described together with possible mitigating measures. The need to develop techniques for artificially rearing of sturgeon is proposed.	Rochard, E., Castlenaud. & Lepage, M., 1990. Sturgeons (Pisces: *Acipenseridae*); threats and prospects. *Journal of Fish Biology,* 37, 123-132. (Supplement A)
Ref Number: 61 **Year published:** 1993 **Peer reviewed?:** No **Study Location:** UK **Reviewed by:** Gubbay and Knapman 1999	Various (Not listed)	**Relevant Habitats:** None **Relevant Species:** Lampern, Sea Lamprey, Sturgeon, Allis shad, Twaite shad	A review of site based information on these species, life history, distribution, habitat, reproductive biology and sources of threat. Together with recommendations to better assess and implement actions to help with the conservation of each species.	Potts, G.W. & Swaby, S.E., 1993. *Marine Fishes on the EC Habitats and Species Directive.*
Ref Number: 62 **Year published:** (in press) **Peer reviewed?:** No **Study Location:** Various UK sites	Hydraulic dredge, cockle tractor dredge	**Relevant Habitats:** Seagrass beds **Relevant Species:** None	Review. Environmental effects fall into several broad categories the most obvious being (a) direct impacts, mainly on the benthic biotopes and on the discarded undersize by-catch (b) indirect interactions with predators and scavengers, including shorebirds, (c) ancillary disturbance from the vessels and vehicles, including effects at the shore access points. **Habitat effects:** Hydraulic dredge tracks can be seen at low tide days or weeks later, persistence depending on the stability of the sediment surface and the prevailing tide or wave conditions. On areas of cohesive sediment the tracks appeared to act as lines from which erosion of the surface layer spread out therefore appearing to accelerate the erosion phase of a natural cycle of cohesion of the surface sediment by worm tube mats. Where dredging has been carried out in a sheltered area with eel grass (Auchencairn Bay) breaking the sward allowed erosion that produced clearly visible grooves down the shore. Long-term effects on benthic diatoms on and in the surface of intertidal flats were considered unlikely.	Rees, E.S., (in press). *Environmental effects of mechanised cockle fisheries: a review of research data.* A report commissioned by the Ministry of Agriculture Fisheries and Food.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Reviewed by: Gubbay and Knapman 1999			**Species and community effects:** Shell breakage occurs with overall damage rates to cockles and *Macoma baltica* in screen rejects from hydraulic dredgers 12.6% and 5.3% respectively. In experimental plots where damage rates from tractor dredging were determined these were 9.3% in an area of muddy sand and 8.2% in a sandy area but only impinged directly on about 80-85% of the area of the plots. Dredged areas often had a lot more dead shell scattered on the surface, an effect which can persist for several months whereas in undisturbed beds most dead shell is normally under the surface which can create a shell layer limiting the depth to which small drainage channels can normally erode into a cockle flat. Observation on other species include the tendency for some motile species, like the amphipod *Bathyporeia sarsi* to temporarily leave disturbed areas, lugworms producing normal casts in dredge tracks as soon as the tide falls, tubes of the sand mason worm *L. conchilega* still standing, apparently to nearly their full extent in the hydraulic dredge tracks. Results from a study of tractor dredging in the Burry Inlet recorded declines in other invertebrates (particularly *H. ulvae, P. elegans* and *N. hombergii*), the greatest fall being 14 days after dredging for the less mobile species in the muddy areas, and increases in some species *Urothoe* sp., *M. balthica, A. tenuis*. Localised additional bird activity has also been reported in some areas following dredging. In a study on the Solway Firth it was concluded that because natural changes are very large the fishery may not have a significant effect on bird numbers unless a high proportion of the cockles are harvested. On sandy areas the effect on most invertebrate populations was considered to be causing some thinning of stocks rather than persistent patchy defaunation. In muddier, more cohesive sediments tracts may persist for months. Persistent hydraulic dredging has in some cases been reported to have changed the sediment structure which may have medium term consequences for deposit feeding benthic species. The most undesirable effects are where the surface is bound by swards of eel-grasses.	
Ref Number: 63 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** Model tested on Exe estuary **Reviewed by:** Gubbay and Knapman 1999	Various (see further notes)	**Relevant Habitats:** None **Relevant Species:** Wildfowl and waders	Report develops a predictive model to explore the effect of different shellfishery management options on the mortality rates of the migratory shorebirds that feed on shellfish on intertidal wintering grounds in Europe. Effects incorporated include disturbance and reduction of abundance of the shellfish stocks. Application to the Exe estuary was successful in predicting levels of oystercatcher winter mortality in previous years **Species and community effects:** Main conclusions were: Given a number of conditions it is possible to exploit shellfish stocks without increasing the winter mortality of shorebirds. Effects of a given intensity of shellfishing depends crucially on local conditions of the climate and the general abundance of food. Methods of shellfishing which disturb birds can be significantly more damaging to the bird's chances of survival. Numbers of birds using alternative food sources is an early warning that a change in shellfishery practice is beginning to have an effect on the birds. Key factor in determining the impact is the proportion of the shellfish stock that is affected Cumulative effects of small increases in shorebird morality in winter can over a period of years greatly affect stable population size. As fishing effort increases, shorebird mortality may be hardly affected initially but then may suddenly increase dramatically once a threshold level of fishing effort has been reached. **Further notes:** Study into the management of intertidal shellfisheries	Stillman, R.A., Goss-Custard, J.D., McGrorty, S., West, A.D., Durell, S.E.A., le V. dit, Clarke, R.T., Caldow, R.W.G., Norris, K.J., Johnstone, I.G., Ens, B.J., Bunskoeke, E.J., v.d Merwe, A., van der Meer, J., Triplet, P., Odoni, N., Swinfen, R. & Cayford, J.T., 1996. *Models of Shellfish Populations and Shorebirds: Final Report.* Institute of Terrestrial Ecology Report to the Commission of the European Communities, Directorate-General for Fisheries.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 64 **Year published:** 1998 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Mariculture (Shellfish)	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** Wildfowl and waders	Reviews current knowledge of environmental modification or conflicts with other species at seed collection, seed nursery and on-growing, and harvesting stages of the cultivation process. **Species and community effects:** Seed collection - subtidal dredging for seed mussels likely to be confined to relatively small areas of seabed because they occur in dense aggregations in discrete areas. UK licensed areas from unstable beds which are likely to be lost anyway. Non-target species probably adapted to large-scale natural disturbance so likely to recolonise rapidly but in extensive heavily exploited fisheries, such as the Wadden Sea, the entire mussel stock was removed in 1990/1 resulting in increased mortalities for eider duck and reduced breeding success for oyster catchers. May be some effects associated with intertidal collection (trampling, disturbance of foraging birds and removal of winter food source). Few impacts likely from spat collectors, continuous relaying of cultch leads to habitat modification which may increase diversity. There are also risks of introduction of alien species. Ongrowing - effect depends on habitat, type and scale of cultivation. Introduced structures effect local hydrography and provide a settlement surface, high densities increases local oxygen demand and elevates input of organic matter however beds used to be extensive and they fulfil an important role in the retention of phosphorus and nitrogen. May be eutrophication beneath mussel lines if not enough tidal flow to disperse particulate matter. Decreases in abundance of macrofauna and increases in meiofauna beneath oyster trestles been measured. In the USA insecticide is sprayed on intertidal areas and ground may be harrowed prior to cultivation. Addition of gravel or shell, formation of mussel mud anduse of protective netting induces localised changes in benthic community composition. Small-scale culture seems to have only very limited effects on local benthic communities. Cultivation sites may conflict with bird feeding or roosting sites but probably only problematic if cultivation areas cover significant part of the feeding grounds. Harvesting - restriction harvesting to early winter could ameliorate site restoration if main mechanism for recolonisation is by larval settlement. Suction dredging or mechanical rakinking affects the habitats. Recolonisation rates likely to differ between habitat types. Management considerations in light of the reported effects are discussed and potential beneficial effects mentioned such as the proposal that integrated fish/bivalve mariculture systems can ameliorate undesiratal impacc ts of nutrient rich effluents from fish farmining, or for restoration of enclosed, polluted water masses.	Kaiser, M.J., Laing, I., Utting, S.D. & Burnell, G.M., 1998. Environmental impacts of bivalve mariculture. *Journal of Shellfish research,* **17**, 59-66.
Ref Number: 65 **Year published:** 1998 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Various (Not listed)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Study into the influence of fisheries on interspecific competition in sympatric populations of hermit crabs. **Species and community effects:** Starfish and decapod Crustacea are among the most important megaepibenthic scavengers that aggregate in areas of fishing activity but recent work indicates that scavengers are far more selective than presumed previously. They avoid carrion that is phylogenetically similar and may avoid carrion that attracts potential predators. The authors suggest that additional food resources arising from fishing activities are distributed unequally between sympatric populations of hermit crabs as a consequence of differences in their competitive abilities. This may provide a mechanism whereby fishing activities could lead to changes in the structure of crustacean scavenger populations. **Further notes:** This type of effect has been well document for seabirds where fisheries-generated offal and discards have been linked to the increase in populations of larger scavenging seabird species.	Kaiser, M.J., Ramsay, K & Hughes, R.N., 1998. Can fisheries influence interspecific competition in sympatric populations of hermit crabs? *Jounranl of Natural Histor,* **32**, 521-531.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 66 **Year published:** 1998 **Peer reviewed?:** Yes **Study Location:** Area off north east coast of Anglesey, Liverpool Bay. **Reviewed by:** Gubbay and Knapman 1999	Beam trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Experimental beam trawling trials to investigate effects on megafauna immediately after fishing and 6 months later on two seabed types - mobile megaripple structures and stable uniform sediment. Control and fished areas were sampled. **Species and community effects:** Short term changes (within ca. 24hrs) were recorded in the megafaunal community in stable sediments but not in the mobile sediments. There were decreases in the relatively slow moving megafauna eg *Aphrodita aculeata, Macropodia deflexa* and *Asterias rubens*. Some mobile species (eg. *Pagurus bernhardus* and *Ophiura ophiura* increased in the trawled area and are known to migrate into areas of fishing disturbance. There were also increases in some relatively sessile species eg. Mya truncata in the trawled areas but not statistically significant. The effects on the megafaunal community were not uniform, even though the fished areas were completely swept by the gear at least once. Six months later, seasonal changes had occurred in both communities and the effects of the trawling disturbance were no longer evident. No significant change in biomass of hydroids and *Alcyonium digitatum* recorded immediately after fishing although these organisms were the largest proportion of the biomass of beam trawl catches at the study site. Repeated and more intense trawling effort is likely to have a greater effect on these organisms.	Kaiser, M.J., Edwards, D.B., Armstrong, P.J., Radford, K., Lough, N.E.L., Flatt, R.P. & Jones, H.D., 1998. Changes in megafaunal benthic communities in different habitats after trawling disturbance. *ICES Journal of Marine Science,* **55**, 353-361.
Ref Number: 67 **Year published:** 1998 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Bottom trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Author develops a conceptual model of gear impacts across gradients of habitat complexity and levels of fishing effort. Habitats are grouped into 8 general categories and scored according to their complexity. **Habitat effects:** The conceptual model shows the response of the range of seafloor habitat types to increases in fishing effort scored from 0 to 4. It shows a range of changes in habitat complexity based on the effects of fishing grear and predicts reductions in the complexity provided by bedforms from direct smoothing of gear.	Auster, P.J., 1998. A conceptual model of the impacts of fishing gear on the integrity of fish habitats. *Conservation Biology,* **12**, 1198-1203.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 68 **Year published:** 1998 **Peer reviewed?:** Yes **Study Location:** Monterey Bay, USA **Reviewed by:** Gubbay and Knapman 1999	Otter trawl (demersal)	**Relevant Habitats:** Large, Shallow inlets and bays **Relevant Species:** None	Comparison of two fishing areas over a three year period, one of restricted fishing with light levels of trawling and the other with high levels of trawling. **Habitat effects:** Results indicate that intensive trawling significantly decreased habitat heterogeneity. **Species and community effects:** All the epifaunal invertebrates counted were less abundant in the heavily trawled area. No differences were found in the number of infaunal crustacean species but there were more polychaete species in the lightly trawled area every year, implying that high levels of trawling can reduce biodiversity. This also suggests that high-intensity trawling favours opportunistic species. High numbers of ophiuroids and the amphinomid polychaete *Chloeia pinnata* in the highly trawled area may be because they can pass through net mesh unscathed and then benefit from feeding on those organisms that the net crushes or kills. *C.pinnata* was also found to be the most common invertebrate in the diet of several commercially important flatfish species in both areas suggesting that certain prey species and commercially important fish may be enhanced by some level of trawling disturbance.	Engel, J. & Kvitek, R., 1998. Effects of otter trawling on benthic community in Monterey Bay National Marine Sanctuary. *Conservation Biology,* **12**, 1204-1214.
Ref Number: 69 **Year published:** 1998 **Peer reviewed?:** Yes **Study Location:** Grand Banks **Reviewed by:** Gubbay and Knapman 1999	Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Three year study into the effects of otter trawling on a sandy-bottom ecosystem of the Grand Banks. Sediment samples, acoustic measurements and video surveys undertaken. **Habitat effects:** Statistical analysis of seven size fractions gave no evidence that trawling had any immediate effect on sediment grain size. Sidescan sonar showed the persistence of door tracks was variable from several months to a year. Acoustic data suggest that repeated trawling did not affect sediment texture but increased surface relief or roughness. Small-scale biogenic sediment structure down to 4.5cm also changed. Video surveys showed clear differences in the appearance of the seabed. After trawling hummocks were removed or less pronounced, organic floc was either absent or less abundant and mottled appearance of the seabed less pronounced. Sediment grain size data suggest that there may be natural inter-annual changes that are more pronounced than those caused by the experimental trawling. **Species and community effects:** Video imagery showed organisms and shell has organised into linear features in the trawled areas. At times high concentrations of *Strongylocentrotus pallidus* were visible and seemed to be scavenging on dead snow crabs. Biological effects have still to be examined.	Schwinghamer, P., Gordon, D.C. Rowell, T.W., Prena, J., McKeown, D., Sonnichson, G., & Guignes, J.Y., 1998. Effects of experimental otter trawling on surficial sediment properties of a sandy-bottom ecosystem on the Grand Banks of Newfoundland. *Conservation Biology,* **12**, 1215-1222.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 71 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** Gulf of Maine **Reviewed by:** Gubbay and Knapman 1999	Bottom trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Effects of mobile fishing gear at three sites on a variety of bottom types in the Gulf of Maine were investigated. **Habitat effects:** Habitat complexity was reduced by direct removal of biogenic and sedimentary structures and the organisms that create structure eg. reduction of an extensive sponge community to the occasional small colony on large boulders, absence of previously widely distributed ascidian, reduced density of shrimp, dispersal of shell deposits by mobile gear. **Species and community effects:** Authors discuss how this reduction in complexity may lead to increased predation on juveniles of harvested species and ultimately recruitment to harvestable stock especially in the northeast USA, where fish assemblages are part of a system where predation mortality on postlarval and juvenile fishes has a major effect on year-class strength.	Auster, P.J., Malatesta, R.J., Langton, R.W., Watling, L., Valentine, P.C., Donaldson, C.L.S., Longton, E.W., Shephard, A.N. & Babb, I.G., 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (northwest Atlantic): implications for conservation of fish populations. *Reviews in fisheries Science*, **4,** 185-202.
Ref Number: 72 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** Northwest Netherlands **Reviewed by:** Gubbay and Knapman 1999	Bottom trawl, Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Analysis of bycatch of 7 fish and 10 invertebrate species taken in otter and beam trawls in an area north west of the Netherlands which were registered annually between 1945 and 1983. A fisheries catchability model is developed using this data. **Species and community effects:** For species with reliable field data the model results on long-term trends in abundance were in agreement with observations eg. considerable decrease in abundance of Roker and Common skate off Dutch coast between 1951 and 1960. Model also suggests that decline of landings of greater weever in early 1960s often considered to be due to severe winter and/or introduction of beam trawlers should also be attributed to effects of otter trawling. Most differences could be related to changes in gear and fishing effort with otter trawlers catching relatively more fish than invertebrates and beam trawlers catchability ten times higher than that of otters for all species considered. Model estimates suggest that bottom fisheries had a considerable impact on the abundance of several bycatch species even before the Second World War.	Philippart, C., 1996. Long-term impact of bottom fisheries on several bycatch species of demersal fish and benthic invertebrates in the southeastern North Sea. ICES Annual Science Conference. *ICES Annual Science Conference.* ICES

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 73 **Year published:** 1998 **Peer reviewed?:** No **Study Location:** Loch Fyne & Loch Sunart **Reviewed by:** Gubbay and Knapman 1999	Mariculture (finfish)	**Relevant Habitats:** Estuaries, Large, Shallow inlets and bays **Relevant Species:** None	Two year study of macrofaunal succession and sedimentary biogeochemical parameters of seabed after intensive fish farming discontinued at 3 sites. **Species and community effects:** All sites had low numbers of taxa at the beginning of the survey which increased in the two years but one site remained impoverished. The increase showed large fluctuations in one case which the authors attribute to a secondary input of organic material to the site which was considered to have set back recovery by at least 6 months. This points to the sensitivity of recovering sediments to additional stress. Improvements in terms of increased numbers of species and increased redox potential were recorded together with decreases in organic carbon, nitrogen and pore-water ammonia.	Nickell, T.D, Black, K.D., Pearson, T.H., Davies, J.M. & Provost, P.G., 1998. *The recovery of the seabed after the cessation of fish farming: benthos and biogeochemistry.* CM 1998/V:1
Ref Number: 74 **Year published:** 1998 **Peer reviewed?:** Yes **Study Location:** Loch Gareloch **Reviewed by:** Gubbay and Knapman 1999	Trawling	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Study of the effects of extensive and repeated trawl disturbance over 18 months followed by 18 months recovery in an area which has been closed to fishing for over 25 years. Reference and treatment areas sampled. **Habitat effects:** The relative differences in roughness between the treatment and reference areas increased during the disturbance programme and declined during the recovery period. The sediment in both areas was poorly sorted fine silt and trawling disturbance did not appear to have any effect on the sediment characteristics but trenches were left in the sediment by the trawl doors. Differences in organic carbon levels were not thought to be ecologically significant. More than 18 months was required before the physical characteristics of the sites became indistinguishable. **Species and community effects:** Changes over time in abundance of individuals occurred at both sites but a treatment effect was also observed. Species numbers were greater at the treatment site after 16 months and remained so throughout the monitored recovery period. Numbers of some individuals were also significantly greater at the treatment site after 10 months disturbance (eg. *Chaetozone setosa* and *Caulleriella zetlandica*) only returning to similar numbers after 18 months recovery. Others declined in density (*Scolopolos armiger* and *Nephtys cirrosa*). There were no detectable effects on infaunal biomass. Community effects extended beyond the 18 month recovery period studied. Such recovery times suggest that even fishing during a restricted period of the year may be sufficient to maintain a community in an altered state.	Tuck, I.D., Hall, S.J., Robertson, M.R., Armstrong, E. & Basford, D.J., 1998. Effects of physical trawling disturbance in a previously unfished sheltered Scottish sea loch. *Marine Ecology Progress Series,* **162,** 227-242.
Ref Number: 75 **Year published:** 1998 **Peer reviewed?:** No **Study Location:** Western Isles	Water jet dredgers	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Experimental dredging in sandy areas swept by strong tidal flow with a paucity of epifauna but openings of numerous larger infaunal animals such as various bivalve species.Tests conducted using single fishing events rather than repeat fishing. **Habitat effects:** Trenches up to 2m wide and 0.15 deep at centre were observed. These started to fill after 5 days and were no-longer visible after 11 weeks but sediment in the tracks remained fluidised under a thin crust of firm sediment. Long term physical effects are less well understood and may be exacerbated by repeated fishing of the same area. **Species and community effects:** Immediate reduction in number of species, individuals and biomass in fished tracks but measures of diversity showed no effects. Abundance of polychaetes reduce and of amphipods increase. Crab species moved into the region to scavenge of material disturbed by the dredge. The results suggest biological effects are	Fisheries Research Services, 1998. *A Study of the effects of water jet dredging for razor clams and a stock survey of the target species in some Western Isles populations.* Marine Laboratory, Aberdeen,. Report No. 8/98

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Reviewed by: Gubbay and Knapman 1999			only short term. No effects were recorded after 11 weeks. Species likely to be damaged (eg.heart urchins and large bivalves) were rare in the samples but present in dredge catches where damage was noted. Most of the animals in the sediments are adapted to a mobile environment so other than being removed or displaced they were not thought to be greatly affected by the dredging. On the basis of this work difficult to comment on areas with more obvious and diverse epifauna. Authors conclude there is little difference between the biological impact of water jet dredges and suction dredging although the latter may have a greater physical effect and fish less selectively.	
Ref Number: 76 **Year published:** 1998 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Bottom trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Review paper. **Habitat effects:** Authors suggest that effects of bottom trawling are the marine equivalent of forest clearcutting, acting as a major threat to biological diversity and economic sustainability, and occurring at a rate two orders of magnitude higher than forest loss worldwide. Reasons include reduction in structural complexity of benthic communities, alternation of biogeochemical cycles, and slow recovery after disturbance. The effects can be large and long-lasting on benthic communities as well as young stages of some commercially important fishes although other species benefit when structural complexity is reduced. Recent experimental studies on trawling and dredging impacts on benthic communities are tabulated. The paper describes the extent and severity of the activity noting that advances in fishing technology have virtually eliminated de facto refuges from trawling, and that frequency of trawling is orders of magnitude higher than other severe seabed disturbances. It calls for the establishment of refuges free of mobile fishing gear, modification of fishing methods and a precautionary approach to management.	Watling, L. & Norse, E.A., 1998. Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. *Coservation Biology,* **12**, 1180-1197.
Ref Number: 77 **Year published:** 1998 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Various (Not listed)	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays, Reefs (Subtidal) **Relevant Species:** None	Review paper describing direct and indirect effects of fishing gears on benthic fauna and habitat, fish community structure and trophic interactions. **Habitat effects:** Effects on habitats and benthic communities most readily identified and last longest in those areas that experience infrequent natural disturbance. Initial effects can be dramatic, additional effects more difficult to detect. Authors concluded that once an ecosystem enters the fished state, diversity, structure and fish production tend to remain relatively stable across a wide range of fishing intensities. Fishing has accelerated and magnified natural declines in abundance of many forage fishes and this has led to reduced reproductive success and abundance in birds and marine mammals. Dramatic and apparently compensatory shifts in the biomass of different species in many fished ecosystems are considered to often be driven by environmental change rather than indirect effects of fishing. When predator or prey fill a key role, fishing can have dramatic indirect effects on community structure **Further notes:** Authors conclude that many marine ecosystems are overfished and that better management is needed. Population-based management, management which minimises the direct and indirect effects of fishing and the case for marine reserves as an adjunct to other management methods are discussed.	Jennings, S. & Kaiser, M.J., 1998. The effects of fishing on marine ecosystems. *Advances in Marine Biology*, **34**, 201-352.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 78 **Year published:** 1998 **Peer reviewed?:** No **Reviewed by:** Gubbay and Knapman 1999	Bottom trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Report on the results of international research project investigating the effects of different types of fisheries on the North Sea and Irish Sea benthic ecosystem. Provides an overview of the effects of bottom trawling on marine communities with chapters on physical impact, direct mortality due to trawling, scavenger response to trawling, comparison of undisturbed and disturbed areas and long term trends in demersal fish and benthic invertebrates. **Further notes:** Recommendations are made for future studies including approaches to management and fishing methods. For more conclusive evidence on the long-term effects of beam trawling on benthic ecosystem authors call for study of relatively large areas closed to fisheries for many years.	Lindeboom, H.J & de Groot, S.J., 1998. *The effects of different types of fisheries on the North Sea and Irish Sea benthic ecosystems.* RIVO-DLO Report C003/98
Ref Number: 79 **Year published:** 1998 **Peer reviewed?:** Yes **Study Location:** Orphir Bay and Bay of Ireland, Orkney Islands **Reviewed by:** Gubbay and Knapman 1999	Razor clam dredging, Suction dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Comparative study of dredged and undredged sites to investigate effects of suction dredging on razor clam. **Species and community effects:** Undredged site was characterised by an absence of small razor clams, contained the largest individuals, and a higher density of razor clams. At the dredged site the population had changed considerable in the 7 years of spasmodic dredging. The most notable differences were the absence of a middle size range of clams and a decline in the number of large razor clams. Shells from the dredged site hand considerably more disturbance marks/damage to the outer shell layer than at the control site with 70% showing the highest level ie. Deep clefts in the outer shell layer embedded with sand grains. Observations of the reburying of razor clams collected by airlift and subsequently released onto the surface of the sediment suggested that they are highly vulnerable to attack from predatory crabs and will experience a high level of mortality after removal.	Robinson, R.F. & Richardson, C.A., 1998. The direct and indirect effects of suction dredging on a razor clam (*Ensis arcuatus*) population.. *ICES Journal of Marine Science,* **55**, 970-977.
Ref Number: 80 **Year published:** 1988 **Peer reviewed?:** No **Study Location:** Gulf of Maine **Reviewed by:** Gubbay and Knapman 1999	Gill nets, Discarded gear (ghost fishing)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Survey of lost gill net over a three year period using submersible. Known ghost net sites at depths between 30m and 127m on a variety of seabed types, surveyed quantitatively by transects. 700m long ghost net on Stellwagen Bank in a boulder field grading to silt-clay substrate was visited on two occasions. **Species and community effects:** Species caught include dogfish, bluefish, lobster, spider crab and edible crab. Hagfish were often seen preying on the dogfish and bluefish. A 470m long ghost net surveyed for two consecutive years had dogfish as the most predominate vertebrate catch. *Cancer* crabs were the most common invertebrate catch. Codfish were not seen in the ghost gillnet, nor were there identifiable remains of cod at the base of the net.	Cooper, R.A., 1988. *Manned submersible and ROV assessment of ghost gillnets on Jeffries and Stellwagen banks, Gulf of Maine.* NOAA Undersea Research Programme Research Report 88-4.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 81 **Year published:** 1997 **Peer reviewed?:** Yes **Study Location:** Celtic Sea **Reviewed by:** Gubbay and Knapman 1999	Gill nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise, Bottle-nosed dolphin	Assessment of cetacean by-catch in the Irish and UK set gill net fisheries for hake in the Celtic Sea over 19 months based on observer programme. **Species and community effects:** Marine mammal by-catch during the sampled trips was 43 porpoises and 4 common dolphins. One porpoise was in a tangle net the rest in the hake nets. No relationships were recorded between by-catch rate and water depth and no significant differences between hake nets with double or single footropes. There were significantly higher by-catch rates during neap tides but no correlation with sea state during net hauling or with hake landings. Observations consistent with porpoise entanglement occurring while net is one the bottom. By-catch rate was 7.7 porpoises per 10,000 km/hr of net immersion. **Further notes:** Authors conclude that although they cannot accurately quantify the impact of the set gill net fishery in the Celtic Sea on harbour porpoises, there is a serious cause for concern about the ability of the populations to which these animals belong to sustain an annual by-catch of the magnitude indicated by their study.	Tregenza, N.J.C., 1997. Harbour porpoise (*Phocoena phocoena* L.) by-catch in set gillnets in the Celtic Sea. 54:896-904. *ICES Journal of Marine Science,* **54**, 896-904.
Ref Number: 82 **Year published:** 1996 **Peer reviewed?:** No **Study Location:** Principally Scottish sea lochs **Reviewed by:** Gubbay and Knapman 1999	Mariculture (finfish)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Symposium report with papers dealing with the physical environment, input of nutrients and chemicals, benthic enrichment, interactions between sea trout and other fish species, seabirds and mammals and aquaculture, the use of wrasse, the consequences of nitrogen enrichment and the possible effects of escapees on wild fish.	Black, K.D., 1996. *Aquaculture and sea lochs.* Scottish Association for Marine Science

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 83 **Year published:** 1998 **Peer reviewed?:** No **Reviewed by:** Gubbay and Knapman 1999	Mariculture (finfish), Mariculture (Shellfish)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Review of environmental issues associated with different types of aquaculture conducted around the world. Describes different systems of aquaculture then covers environmental impact of the facilities (eg. mussel cages and floating cage farming), and of the use of chemicals including antibiotics. Sections on waste minimisation, wastewater treatment systems and environmental management systems for aquaculture.	Midlen, A. & Redding, T., 1998. *Environmental Management for Aquaculture.* 223. Chapman & Hall. London
Ref Number: 84 **Year published:** 1987 **Peer reviewed?:** Yes **Study Location:** British Columbia **Reviewed by:** Gubbay and Knapman 1999	Pots or creels	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Experimental study on catches and mortality and 10 simulated lost traps, left in place for 1 year. **Species and community effects:** During this time 169 crabs (*Cancer magister*) were caught, nearly all males, and about half died. This despite 'escape ports' to allow crabs under the legal minimum to escape. Study revealed that the traps continue to attract crabs long after initial bait has gone, and that catch rates were as high after 1 year as 2 weeks after the start of the study. **Further notes:** Questionnaire survey of crab fishermen in Fraser River estuary led to estimates of an annual trap loss rate of 11% leading to estimate that loss to ghost fishing might be equivalent in weight to 7% of report catch in the Fraser River District.	Breen, P.A., 1987. Mortality of Dungeness crabs caught by lost traps in the Fraser River Estuary, British Columbia. *North-American Journal of Fisheries Management,* **7**, 429-435.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 85 **Year published:** 1984 **Peer reviewed?:** Yes **Study Location:** North Carolina, USA **Reviewed by:** Gubbay and Knapman 1999	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Experimental dredging studies on hard sand and a soft mud compared to an area of no dredging. **Species and community effects:** Experimental dredging studies on hard sand and a soft mud compared to an area of no dredging showed a significantly reduced level of eelgrass biomass and shoot number on both hard and soft seabed. The seagrass was more susceptible to damage (all shoots removed) in the latter case whereas on hard seabed about 15% of the eelgrass per core remained. **Further notes:** The dredges were pulled by hand rather than boat as sometimes done by commercial workers so excluded any effects of propeller scour. Authors conclude that intensive scallop dredging has the potential for immediate as well as long-term reduction of eelgrass nursery habitat. This was based on observation of biological damage which reduces surfaces for attachment for early stage juvenile scallops and other invertebrates.	Fonseca, M.S., Thayer, G.W., Chester, A.J. & Foltz, C., 1984. Impact of scallop harvesting on eelgrass (*Zostera marina*) meadows:implications for management. *North American Journal of Fisheries Management,* **4**, 286-293.
Ref Number: 86 **Year published:** (in press) **Peer reviewed?:** No **Study Location:** Isle of Man **Reviewed by:** Gubbay and Knapman 1999	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Review of study investigating disturbance by scallop dredging from large (fishing grounds) to small-scale (experimental plots) around the Isle of Man **Species and community effects:** Dredging disturbs and may be a factor in structuring benthic communities on gravelly sea bed. Community composition is related to the intensity of commercial dredging effort and effects may differ from that of bottom fishing on other soft sediments due to extreme patchiness of animal distribution, greater abundance of epifauna and to the combined effect of the heavy, toothed scallop gear and the stones caught in the dredges. **Further notes:** [Details from abstract only - full paper in press]	Bradshaw, C., Veale, L.O., Hill, A.S., & Brand, A.R., (in press). Effects of scallop dredging on gravelly seabed communities. *The Effects of Fishing on Non-target Species and Habitats: Biological, Conservation and socio-economic issue.* (ed. M.J. Kaiser & S.J. de Groot)

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 87 **Year published:** (in press) **Peer reviewed?:** Yes **Study Location:** Celtic Sea **Reviewed by:** Gubbay and Knapman 1999	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Comparison of historic (1946-1951) and recent data on benthos in locations some of which have been subject to heavy scallop dredging over the intervening years, some to little dredging. **Species and community effects:** Changes apparent regardless of intensity of dredging. In heavily dredged areas there was extreme physical disturbance, increased polychaete:mollusc ratio, loss of some fragile species and an increase in the predominance of scavenger/predator species. Changes in lightly dredged areas included loss of a number of species including some potentially fragile tube-dwellers. Reasons for these changes not apparent. **Further notes:** [Details from abstract only - full paper was in in press]	Hill, A.S., Veale, L.O., Pennington, D., Whyte, S.G., Brand, A.R. & Hartnoll, R.G., 1999. Changes in Irish Sea benthos: possible effects of forty years of dredging. *Estuarine, Coastal and Shelf Science,* **48**, 739-750.
Ref Number: 88 **Year published:** 1995 **Peer reviewed?:** Yes **Study Location:** Mercury Bay, New Zealand **Reviewed by:** Gubbay and Knapman 1999	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Experimental dredging at two subtidal sandflats (depth around 24m) to identify short-term impacts on macrobenthic communities. Comparison with adjacent reference plots. **Habitat effects:** Natural surface features broken down (eg.emergent tubes, sediment ripples) and teeth on dredge created grooves 2-3cm deep. **Species and community effects:** Density of common macrofauna decreased at dredged sites and some significant differences still apparent after 3 months. At both sites more than 50% of the common taxa showed significant effects. Differences in recovery process likely to relate to differences in initial community composition and to differences in environmental characteristics. Authors consider the effects recorded were conservative as commercial fishermen work over much larger areas and repeatedly dredge the same area in any one fishing trip.	Thrush, S.F., Hewitt, J. E., Cummings, V. J., Dayton, P.K., 1995. The impact of habitat disturbance by scallop dredging on marine benthic communities; what can be predicted from the results of experiments? *Marine Ecology Progress Series,* **129**, 141-150.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 89 **Year published:** 1983 **Peer reviewed?:** Yes **Study Location:** Sweden **Reviewed by:** Gubbay and Knapman 1999	Mariculture (Shellfish)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Changes in sediment composition and benthic community structure under cultures studied over 3 years in a narrow sound, 13-15m deep with generally weak currents.. **Habitat effects:** Faecal material and mussels drop to the seabed. As a consequence a layer of sediment was found to increase at a rate of 10cm/yr. This resulted in the production of H2S in the uppermost layers. Small grain size, high organic content and a negative Redox potential recorded under the cultures and changed with distance from the culture. **Species and community effects:** Benthic fauna initially dominated by *Nucula nitiosa* (numerically), *Echinocardium cordatum* and *Ophiura* spp (biomass). After 6-15 months these disappeared and were replaced by opportunistic polychaetes (*Capitella capitata, Scolelepis fuliginosa* and *Microphthalmus sczelkowii*). **Further notes:** Anaerobic sediments and mass occurrence of opportunistic polychaetes localised 5-20m around the cultures. After harvesting only limited recovery was observed after 6 months.	Mattson, J. & Linden, O., 1983. Benthic macrofauna succession under mussels, Mytilus edulis, cultured on hanging long-lines. *Sarsia.* **68**, 97-102.
Ref Number: 90 **Year published:** 1992 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Shrimp trawling	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Review paper on by-catch associated with shrimp fisheries. **Further notes:** Shrimps tend to live in areas with a great diversity and abundance of other invertebrates and fishes. Many of these caught in trawls. Paper reviews estimates of by-catch, associated mortality of species caught and impacts on ecosystems also discussed. Authors note that there is limited detailed information currently available on this issue.	Andrew, N.L. & Pepperell, J.G., 1992. The by-catch of shrimp trawl fisheries. *Oceanography and Marine Biology. An Annual Review,***30**, 527-565.
Ref Number: 91 **Year published:** 1990 **Peer reviewed?:** No **Study Location:** Waden Sea **Reviewed by:** Gubbay and Knapman 1999	Shrimp trawling	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** Grey seal, Common seal, Seabirds	Investigation into the potential impact of a policy of immediately discarding all by-catch from shrimp fisheries in the North Frisian Wadden Sea. **Species and community effects:** Clearance rate of discards estimated by feeding crabs and shrimps in aquaria. Traps baited with discards used to examine fate in sublittoral and take by birds assessed using combination of counts, photography and video recording. Underwater video revealed grey seals feeding on discarded fish. Authors conclude that 1988 seabird population in the area would have easily been capable of clearing the discards of moribund roundfish. Harbour seals which were most likely to benefit from flatfish discards.	Berghahn, R., 1990. On the potential impact of shrimping on trophic relationships in the Waden Sea. In: Trophic Relationships in the Marine Environment. *Procedings of the 24th European Marine Biology Symposium.* (ed. M. Barnes & R.N. Gibson).

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 92 **Year published:** 1997 **Peer reviewed?:** Yes **Study Location:** River Exe **Reviewed by:** Gubbay and Knapman 1999	Mariculture (Shellfish)	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Study on ecological effects of Manila clam cultivation at the end of the cultivation phase (for all stages see Gubbay and Knapman Reference 64) **Habitat effects:** Organic enrichment in net covered area. Short term sedimentation rates were up to 4 times higher in netted plots than control areas. The increase was localised. Increased organic matter, percentage fines and phaeopigment in the sediment and reduced water flow on the netted plots is likely to have had a major influence on the changes in abundance of some infauna species. **Species and community effects:** Netting encouraged settlement of green macro-algae and in turn *Littorina littorea*. In the first 6 months fauna dominated by opportunistic species *P.elegans*. After 1 year the stabilising effect of netting and sedimentation led to establishment of species such as *Ampharete acutifrons* and *Tubificoides benedii.* **Further notes:** Authors consider biotic and abiotic changes are relatively benign compared to other forms of marine culture.	Spencer, B. E., Kaiser, M. J. & Edwards, D. B., 1997. Ecological effects of intertidal Manila clam cultivation: observations at the end of the cultivation phase. *Journal of Applied Ecology,* **34**, 444-452.
Ref Number: 93 **Year published:** 1997 **Peer reviewed?:** Yes **Study Location:** Auchencairn Bay, Solway Firth **Reviewed by:** Gubbay and Knapman 1999	cockle tractor dredge, Suction dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Three year study into impact and recovery of habitat and marine benthic communities from suction and tractor dredging to harvest cockles. **Species and community effects:** Suction dredging had a statistically significant effect on infauna leading to up to a 30% reduction in number of species and 50% reduction in number of individuals. These effects were not seen with tractor dredging **Further notes:** Authors suggest difference between methods may be due to experimental design and different times of year in which the experiments were done. By day 56 much of the difference between area where suction dredging was used compared to control site was lost but some effects remained.	Hall, S.J. & Harding, M.J.C., 1997. Physical disturbance and marine benthic communities: the effects of mechanical harvesting of cockles on non-target benthic infauna. *Journal of Applied Ecology,* **34**, 497-517.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 94 **Year published:** 1998 **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Trawling	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Simulation in test tank of effects of otter trawl door on infaunal bivalves when moving across a relatively dense, level, sandy seabed. Six species of bivalve were placed in the test bed in typical life positions. **Habitat effects:** A mound of sediment in front of the door formed a single rounded berm with adjacent shallow U-shaped depression which represented the scour furrow. **Species and community effects:** All bivalves within the scour path at the sediment/water interface were displaced but only 5% sustained major damage. Shallow burrowing bivalves in the scour path were redistributed and concentrated along the berm. Exposure on the seabed would make them vulnerable to predation. Increased sediment stress was recorded to depths occupied by deep burrowers but in this experiment the transient elevated stress levels were considered to be of insufficient magnitude to cause shell damage. Possible behavioural or physiological effects on the bivalves unknown.	Gilkinson, K., Paulin, M., Hurley, S., Schwinghamer, P., 1998. Impacts of trawl door scouring on infaunal bivalves: results of a physical trawl door model/dense sand interaction. *Journal of Experimental Marine Biology and Ecology,* **224**, 291-312.
Ref Number: 95 **Year published:** (in press) **Peer reviewed?:** Yes **Reviewed by:** Gubbay and Knapman 1999	Various (Not listed)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays, Reefs (Subtidal) **Relevant Species:** None	Review of fishing effects on habitat. Common themes to emerge included immediate effects on species composition and diversity and reduction in habitat complexity. Recovery variable depending on habitat type, life history of component species and natural disturbance regime. **Further notes:** Authors call for work to predict outcomes of particular management regimes and discuss use of conceptual models to do this as predictive numerical modelling not currently possible. Disturbance theory used to provide the framework for predicting effects of habitat change. Authors call for adaptive and precautionary management practices until empirical data become available for validating model predictions.	Auster, P. J. & Langton, R.W. (in press). The effects of fishing on fish habitat. *American Fisheries Society Symposium.*
Ref Number: 96 **Year published:** 1998 **Peer reviewed?:** No **Reviewed by:** Gubbay and Knapman 1999	Mariculture (Shellfish)	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Papers from working group meeting. Sections on fallowing strategies in coastal cage farming and associate research needs, minimum separation distances between cage farming sites, on coastal management and mariculture and on escapes.	ICES, 1998. *Report of the working group on environmental interactions of mariculture.* ICES CM 1998/F:2. Ref:ACFM+ACME+E

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 97 **Year published:** 1997 **Peer reviewed?:** No Study Dates: 1991-95 **Reviewed by:** Gubbay and Knapman 1999	Mariculture (Shellfish), Hand Raking, Suction dredge	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Experimental study to investigate changes in benthic communities and sediment composition associated with clam cultivation. Trials with four treatments, clams with net covers, net covers only, control plots without clams or net covers and control plats without clams, net covers or human activity. Sediment of the trial area was a stable muddy sand. **Habitat effects:** With net cover, netting and the green alga growing on it caused an increase in sedimentation rate, and slight increase in proporation of silt. Harvesting by hand raking, followed by suction dredge. Suction dredge increased sediment load in the water which dispersed to near background levels within 40m of the device. A trench about 10cm deep was left by the harvester which took about 3-4 months to fill. **Species and community effects:** With net cover, number of worm species increased substantially beneath netted plots irrespective of whether clams were present. Increase occurred within 6 months of placement and still present 2.5 years after seeding when clams were harvested. Harvesting by hand raking, followed by suction dredge. Hand raking caused a reduction of 50% in abundance and diversity of species and suction dredging, a reduction of 80-90%. Regeneration of species diversity and abundance, after harvesting in the winter was completed by the following summer.	MAFF, 1997. Clam cultivation:localised environmental effects. Results of an experiment in the River Exe, Devon. *Clam cultivation:localised environmental effects. Results of an experiment in the River Exe, Devon.* Directorate of Fisheries Research, Conwy
Ref Number: 98 **Year published:** 2004 **Peer reviewed?:** Yes **Study Location:** South Devon coast, English Channel **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge, Pots or creels	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Study examining benthic species assemblages, subjected to four different types of commercial fishing pressure. These were: i) Towed gears only, ii) annual, seasonal towed-gear use, iii) temporary towed-gear use but reverting to static gear use 18 - 24 months before sampling, and iv) static gears only. The survey was undertaken in an IPA (Inshore potting agreement) area, where towed gears had been previously banned, but potting was allowed. Video surveys were used, combined with sampling with towed dredges. **Species and community effects:** Higher biomass and diversity of species was found in sites that had not been trawled in the year prior to sampling, compared to towed gear sites. Untrawled areas had higher biomass, but lower species diversity than 'ex-trawl sites'. The Authors suggest that the most important finding of the study was that very little difference existed between benthic communities in trawled sites and seasonally trawled sites. It was suggested that this indicated that a six month cessation of trawling is insufficient to allow recover of benthic communities. Significantly greater biomass of attached species were found at untrawled sites than all other sites. The authors note that this is important, as many attached species are known to provide settlement sites for other benthic species and shelter for a number of fish species. **Further notes:** The substratum at the study site was mixed, coarse sand.	Blyth, R.E., Kaiser, M.J., Edwards-Jones, G., & Hart, P.J.B., 2004. Implications of a zoned fishery management system for marine benthic communities. *Journal of Applied Ecology,* **41**, 951-961.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 99 **Year published:** 2002 **Peer reviewed?:** Yes **Study Location:** Yaquina Bay, Oregon, USA. Study Dates: 1998 – 2000 **Reviewed by:** Sewell & Hiscock 2005	Hand Raking, Clam digging	**Relevant Habitats:** Seagrass beds, Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	Study comparing the effects of raking and digging for clams in eelgrass beds over one season. The author examined the effect of mimicked, small scale, recreational digging and raking for clams on eelgrass beds and their associated macro and megafauna. **Species and community effects:** In raked treatments, some loss of plant biomass was noted imediately after raking, but no differences were found between treatment and control plots after two weeks indicating that eelgrass beds recovered quickly following this type of disturbance. In contrast, sites where digging had taken place were slower to recover and differences between control and treatment plots were still evident 10 months after disturbance. No significant difference between macrofauna or megafauna was found between treatment and control plots for both raking and digging sites. **Further notes:** The author points out that both raking and digging disturbance were at higher intensities to normal recreational raking and digging. The author concludes that recreational clamming is not a great threat to the eelgrass beds in Yaquina bay, but that differences between the study site and the type of area normally used for clamming mean that these conclusions should be treated with caution.	Boese, B.L., 2002. Effects of recreational clam harvesting on eelgrass (*Zostera marina*) and associated infaunal invertebrates: *in situ* manipulative experiments. *Aquatic Botany,* **73**, 63-74.
Ref Number: 100 **Year published:** 2003 **Peer reviewed?:** Yes **Study Location:** Groninger Wad, Dutch Wadden Sea. Study Dates: 2000 - 2001 **Reviewed by:** Sewell & Hiscock 2005	Suction dredge	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	An oportunistic survey examining how suction dredging for cockles *Cerastoderma edule* effects non-target fauna. Non-dredged locations were compared to heavily commercially fished areas. **Habitat effects:** Dredging tracks were formed and stayed for several months. Sediment was physically removed and dominant sediment type was altered to make it unsuitable for the settlement of mussels *Mytilus edulis*. **Species and community effects:** No significant effect of fishing was found for densities of *Hydrobia ulvae* or 0 - 1 year class *Cerastoderma edule*. No *Mytilus edulis* were found in heavily trawled areas and this was considered to be a direct result of the physical effects of trawling. There was a signifiant negative effect of fishing on young (2000 year class) *Macoma balthica*, but the effects on older individuals could not be tested. **Further notes:** The author concludes that the effects of bottom disturbance by cockle dredging can last more than a year, even in a dynamic ecosystem.	Hiddink, J.G., 2003. Effects of suction-dredging for cockles on non-target fauna in the Wadden sea. *Journal of Sea Research,* **50**, 315-323.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 101 **Year published:** 1992 **Peer reviewed?:** Yes **Study Location:** Firemore, Western shore of Loch Ewe on the west coast of Scotland Study Dates: July 1985 **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Experimental scallop dredging over a sandy bottom, using a modified 1.2 m scallop dredge with a fixed tooth bar, bearing nine 12 cm long and 1 cm wide teeth, separated by 8 cm spaces. The dredge net was removed. The dredge was towed over exactly the same 25 m^2 area a number of times for nine days. Samples and observations were collected after 2, 4, 12 and 25 dredges, to measure the effect of different levels of fishing disturbance. **Habitat effects:** Large, visible furrows were created and all previous bottom features (ripples and irregular topography) were wiped out. Large fragments of shell and stone were dislodged. Grooves and furrows created by the dredge were eliminated shortly after dredging. The time taken for this to happen depended on wave action . **Species and community effects:** Infauna: The infaunal community consisted of bivalves and peracarid crustaceans, Neither taxa showed any significant decrease with dredging disturbance. The biomass of infaunal amphipoda and polychaeta was reduced in all dredged samples, compared to control samples. Epifauna: Insepections of sites following dredges revealed high levels of damage and mortality to large epifauna, including crabs, large bivalves, urchins and sandeels. Overall: The authors conclude that the effect of the dredging experiment was limited to the selective elimination of a fraction of the fragile, sedentary components of the infauna and the destuction of large epifaunal and infaunal organisms. **Further notes:** Sediment at the study site was fine, well sorted sediment with small amounts of silt clay.	Eleftheriou, A., Robertson, M.R., 1992. The effects of experimental scallop dredging on the fauna and physical environment of a shallow sandy community. *Netherlands Journal of Sea Research,* **30**, 289-299.
Ref Number: 102 **Year published:** 1998 **Peer reviewed?:** Yes **Study Location:** Florida, Atlantic Coast. USA. **Reviewed by:** Sewell & Hiscock 2005	angling	**Relevant Habitats:** None **Relevant Species:** Bottle-nosed dolphin	Describes causes of death for two adult (one male and one female) botttle-nosed dolphins found dead in separate locations. **Species and community effects:** lost angling gear was found to have caused mortality in both dolphins. The first dolphin (female) appeared to have eaten a fish, which had been hooked by an angler and still had a length of line attached. This line became wrapped around the base of the larangeal spout, leading to death by asphyxiation. The second dolphin had died following several secondary complications, dirrectly caused by the injestion of a fish with a large amount of line attached	Gorzelany, J.F., 1998. Unusual deaths of two free-ranging Atlantic bottlenose dolphins (*Tursiops truncatus*) related to ingestion of recreational fishing gear. *Marine Mammal Science,* **14**, 614-617.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 103 **Year published:** 2003 **Peer reviewed?:** Yes **Study Location:** North Carolina, USA. **Reviewed by:** Sewell & Hiscock 2005	Gill nets	**Relevant Habitats:** None **Relevant Species:** Bottle-nosed dolphin	Study of bottle-nosed dolphin interactions with gillnets set for Spanish mackerel *Scomberomorus maculatus*. Observations of dolphin behaviour around the net were recorded using a digital video camera suspended directly above the net from a helium balloon. 30 replicate sets were used and observations were later made in a laboratory. **Species and community effects:** Encounters were observed between dolphins and 24 of the 30 nets. Direct interactions were recorded with 19 of the 30 nets. Multiple encounters and interactions were recorded at several of the nets. Dolphins most commonly avoided the nets, but there were several incidences of dolphins 'patrolling' the edge of the nets and occasionally taking fish (depredation). Despite this level of interaction, there were no recorded incidences of dolphin entanglement **Further notes:** The authors note that bottle-nosed dolphins frequently interact with spanish mackerel gill nets, but seldom become entangled.	Read, A.J., Waples, D.M., Urian, K.W. & Swanner, D., 2003. Fine-scale behaviour of bottlenose dolphins around gillnets. *Proceedings of the Royal Society of London,* **270**, S90-S92.
Ref Number: 104 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** North, western Irish Sea Study Dates: 1994 - 1996 **Reviewed by:** Sewell & Hiscock 2005	Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Two studies, examining both the long-, medium- and short -term effects of a *Nephrops* otter trawl in the Irish Sea. To calculate short term effects, two sites were used, a heavily fished offshore site and a less frequently trawled inshore site. Day grab sampling was used to identify initial species assemblage. Each track was trawled twice and a further set of day grab samples were taken within 24 hours to establish direct impacts of the trawl. Long-term effects of fishing were investigated by comparing two unfished shipwrecks, one nearshore and one offshore with nearby fishing areas. **Species and community effects:** Offshore: There was a clear differend between unfished areas and fished areas. The fished site had lower species diversity, number of individuals and biomass compared to the area around the wreck (unfished area). In addition, large specimens of some molluscs and echinoderms were found at the unfished site, but not at fished sites. Inshore: Most species showed a statistically insignificant decrease in numbers immediately after a trawl. Although most species of polychaete increased in numbers (generally small oppertunistic species or large scavangers). Number of individuals and biomass decreased significantly between the wreck site and the fishing ground prior to experimental trawling. In fished areas, number of species, biomass, species-richness and shannon's diversity index decreases significantly following experimental trawling. 49 species were found at the unfished site that were not found at fished sites, whilst 19 were found only at fished sites. **Further notes:** sediment at both short-term effects study sites was fine sand and silt clay. Sediment at long term study sites was muddy, fine sand. Sparsity of fauna in the offshore, fished area made the quantitative assessment of any short term species effects of fishing impossible. Fishing intensity was far greater at the offshore, fished site, compared to the inshore, fished site. As only minor changes were observed at inshore sites, the authors conclude that it is fishing intensity, rather than the direct impact of the passage of fishing gear that is the major factor controlling long-term negative trends in the benthos of the Irish Sea *Nephrops* fishery.	Ball, B.J., Fox, G. & Munday, B.W., 2000. Long- and short-term consequences of a *Nephrops* trawl fishery on the benthos and environment of the Irish Sea. *ICES Journal of Marine Science,* **57**, 1315-1320.
Ref Number: 105 **Year published:** 2000	Water jet dredgers	**Relevant Habitats:** Large, Shallow inlets and bays, Sandbanks which	Experimental dredges were carried out by a commercial water jet, dredging vessel, targetting razor clams (*Ensis* spp.) fishing was conducted for 10min periods. 6 tracks were intensively studied by divers, who observed sites during dredging, collected cores for analysis, made measurements of physical impacts and made observations of epifauna. Video footage of trawls sites was also used.	Tuck, I.D., Bailey, N., Harding, M., Sangster, G., Howell, T., Graham, N. & Breen, M., 2000. The impact of water jet dredging for razor clams, *Ensis* spp., in a

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Peer reviewed?: Yes **Study Location:** Sound of Ronay, near Grimsay, Outer Hebrides Study Dates: March 1998 **Reviewed by:** Sewell & Hiscock 2005		are slightly covered by seawater **Relevant Species:** None	**Habitat effects:** A flat-bottomed 'V' shaped Trench was left, measuring 1.2 m surface width, 0.5 m base width and 0.15 m depth. Track lengths varied between 26 and 122 m. Tracks were still visible but less pronounced after five days. After 11 weeks tracks were no longer visible. However, sediment was still in a state of fluidisation to a depth of 0.2 m. **Species and community effects:** Some short term changes were recorded between infaunal assemblages immediately after and five days after the trawl, but no difference was apparent after 11weeks. Within a day of fishing, the number of infaunal species and number of individuals within trawl tracks had significantly decreased, but no difference was recorded after five days. A reduced biomass in fished areas, compared to control sites was still evident after five days. None of the diversity parameters studied showed significant effects of fishing. Due to the mobile nature of the sediment, epifauna was limited, but there was an increase in large scavangers in trawled areas imediately after each trawl. Several larger organisms where captured as bycatch and many of these showed signs of damage. **Further notes:** Sediment consisted of moderately well-sorted medium or fine sand. The area was swept by strong tidal flow and sediment was mobile. The authors note that in this study, the trawl was only passed through each site once. Commercial vessels would be likely to cross over the area a number of times, with pottentially more profound effects.	shallow sandy subtidal environment. *Journal of Sea Research,* **43**, 65-81.
Ref Number: 106 **Year published:** 1998 **Peer reviewed?:** Yes **Study Location:** Celtic Sea **Reviewed by:** Sewell & Hiscock 2005	Pair trawl	**Relevant Habitats:** None **Relevant Species:** Grey seal, Harbour porpoise	Fishery scientists accompanied Irish, commercial pair trawlers, targeting herring in the Celtic sea. Net openings were 15-20m high and 20-30m wide. Bycatch was examined and the number of large marine mammals present in trawls were counted. During the study, 78 tows took place and a total of 101 hours of towing time was monitored. Nets were towed at depths of 14-55 m in water depths of 24-75 m. **Species and community effects:** Single grey seals, *Halichoerus grypus* were captured and killed in four trawls. This equated to 0.05 seals per tow or one seal per 317.5 tonnes of fish caught. From this, the authors conclude that approximately 60 individual grey seals are captured in the herring pair trawl fishery per year. The authors conclude that due to the timing of the herring fishery in this area, it is not likely to cause a decline in the Irish grey seal population. A group of four harbour porpoises were reported during the study, but none were caught in fishing gear.	Berrow, S.D., O'Neill, M. & Brogan, D., 1998. Discarding Practices and marine mammal by-catch in the Celtic Sea herring fishery. *Biology and Environment: Proceedings of the Royal Irish Academy,* **98B**, 1-8.
Ref Number: 107 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Point of Ayr, River Dee estuary, North Wales. Study Dates: 1996-1998	Hand Raking	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide, Estuaries **Relevant Species:** None	Simulated hand raking for cockles at 18 plots (six control, six small and six large plots), using rakes with 10cm long teeth. Sediment was disturbed in a manner similar to that of commercially deployed hand rakes. Infauna and sediment characteristics were sampled 1, 14, 56 and 503 days after raking once at low tide. The authors examined the effects of the raking disturbance on non-target species, associated with the cockle beds and direct impacts on under-sized cockles. **Species and community effects:** Hand raking led to a three-fold increase in the damage rate of under-sized cockles, compared to control plots. There were community differences between both study plots and the control plots after 14 days. Small plots had recovered after 56 days, but large plots remained in an altered state. The authors concluded that the effects of raking were unlikely to persist beyond a year unless long-lived species where present. **Further notes:** Substratum was predominantly silty sand with a relatively flat and uniform topography. Commercial fishing did not take place at the study sites and the site was chosen specifically because the cockles present were undersize and not commercially targeted.	Kaiser, M.J., Broad, G. & Hall, S.J., 2001. Disturbance of intertidal soft-sediment benthic communities by cockle hand raking. *Journal of Sea Research,* **45**, 119-130.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Reviewed by: Sewell & Hiscock 2005				
Ref Number: 108 **Year published:** 2002 **Peer reviewed?:** Yes **Study Location:** West Ireland Continental Shelf break and 200m off West Norway. Study Dates: Dec1995 - Aug1997 (Ireland) and May1999 (Norway) **Reviewed by:** Sewell & Hiscock 2005	Otter trawl (demersal)	**Relevant Habitats:** Reefs (Biogenic) **Relevant Species:** None	The study examined deep-water coral related bycatch associated with commercial catches taken during a trawl along the continental shelf break, west of Ireland. Some large coral concretions that were taken in trawls were carbon dated. This was combined with observations of trawling impacts on a *Lophelia pertusa* reef in the shelf waters off western Norway. **Habitat effects:** Video footage: There was an obvious difference between trawled areas of *Lophelia pertusa* reef and untrawled areas. Trawled areas were severelly damaged and characterised by coral rubble and sparse living, broken and dislodged colonies of coral. Untrawled sites had far higher habitat complexity and more sessile, filter-feeding macrofauna including sponges. **Species and community effects:** Bycatch study: Large amounts of coral debris and associated coral species were brought up in five out of 229 observed trawls. Coral fragments had a wide diversity of associated epifauna and were up to 1 m 2 in diameter. Based on fragments of the coral species *Desmophyllum cristagalli* found in trawls was estimated to be 4550 years old. **Further notes:** Authors note that the during the trawling survey, skippers of fishing vessels actively avoided trawling rough grounds and coral reef areas as these result in damage to gear and poorer catch quality.	Hall-Spencer, J., Allain, V. &Fossa, J.H., 2002. Trawling damage to Northeast Atlantic ancient coral reefs. *Proceedings of the Royal Society of London,* **269**, 507-511.
Ref Number: 109 **Year published:** 2002 **Peer reviewed?:** Yes **Study Location:** Norway **Reviewed by:** Sewell & Hiscock 2005	Bottom trawl, Discarded gear (ghost fishing), Longline, Gill nets	**Relevant Habitats:** Reefs (Biogenic) **Relevant Species:** None	The report documents the distribution of deep water coral reefs off the coast of Norway and the ways that they are effected by fishing activity. The authors reviewed available published and non-published information, obtained information from fishermen and carried out surveys using ROV equipment. **Habitat effects:** The authors documented extensive physical damage to reefs in all but one survey site caused by trawling activity. Trawl impacts included complete destruction of reef structures, removal or displacement of reefs by trawlers and scouring of reefs and the surrounding seabed by otter boards and the trawl net. Impacts of passive fisheries were also observed. Ghost fishing gill nets, anchors and other fishery related debris were found on several reef areas. The authors estimate that 30 - 50 % of coral reef in this area has been damaged by fishing activity.	Fossa, J.H., Mortensen, P.B. & Furevik, D.M., 2002. The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. *Hydrobiologia,* **471**, 1-12.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 110 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** French Atlantic Coast and the Wadden Sea **Reviewed by:** Sewell & Hiscock 2005	Shrimp trawling, Beam trawl	**Relevant Habitats:** Reefs (Biogenic) **Relevant Species:** None	Direct observations were made of a beam trawl, targeting the brown shrimp *Crangon crangon* passing over a *Sabellaria spinulosa* reef in the Wadden Sea, using a video camera attached to the trawl. A controlled 'before/after' experiment was carried out on a periodically exposed, 30 hectare, *Sabellaria alveolata* reef on the French Atlantic coast, using a 3 m research trawl equiped with ten rollers. The force exerted on the reef by the trawl was calculated as was the load bearing capacity of the reef. **Habitat effects:** The authors conclude that the type of 'light weight' beam trawls used by shrimp fishing vessels cannot cause damage to reef constructions. **Species and community effects:** Following passage of the trawl over the reef, the authors did not notice any signs that the reef structures had been destroyed. Impressions left initially by direct contact from the trawl shoes had disappeared four to five days after the experiment due to rebuilding by the worms. **Further notes:** The authors note, importantly that these findings are based on a once-only disturbance and it is possible, that in the medium to long term, intensive trawling, even with light gears may impare *Sabellaria* reefs.	Vorberg, R., 2000. Effects of shrimp fisheries on reefs of *Sabellaria spinulosa* (Polychaeta). *ICES Journal of Marine Science,* **57**, 1416-1420.
Ref Number: 111 **Year published:** 2000 **Peer reviewed?:** No **Study Location:** South Eastern North Sea **Reviewed by:** Sewell & Hiscock 2005	Beam trawl, Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	For full details of this study, see also: [122]. Mortality in megafaunal benthic population caused by trawl fisheries on the Dutch continental shelf in the North Sea.	Bergman, M.J.N. & Van Santbrink, J.W., 2000. Fishing mortality of populations of megafauna in sandy sediments. In. *The Effects of Fishing on Non-target Species and Habitats: Biological, Conservation and socio-economic issue*. (ed. M.J. Kaiser & S.J. de Groot), pp. 49-78. Oxford: Blackwell Science.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 112 **Year published:** 2000 **Peer reviewed?:** No **Study Location:** Western Irish Sea and Loch Gareloch, Scotland. **Reviewed by:** Sewell & Hiscock 2005	Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Describes the results of two separate surveys. The first is a study of the short-, medium- and long-term effects of otter trawling for the Norwegian lobster in the Irish Sea over inshore and offshore muddy sediments (See [104,] or[112] for full details of survey and results). The second is a study in a sheltered Scottish sea loch. The loch had been closed to fishing for 25 years and experimental trawls were undertaken monthly for 16 months, followed by an 18 month, monitored recovery period. **Habitat effects:** Gareloch study: Trawl marks on the sea bed and changes to sea bed roughness were identifyable for five months after trawling but were almost indistinguishable, but still visible after 18 months. **Species and community effects:** Gareloch study: The number of species and individuals increased throughout the trawling disturbance period, although biomass did not alter significantly. At the same time measure of species diversity and evenness decreased in trawled areas. This change was attributed to an increase in the number of opportunistic species.Large bivalves and polychaetes were identified as being sensitive to trawling disturbance. Community changes occurred between treatment and control sites and were still apparent 18 months after trawling.	Ball, B.,Munday, B. & Tuck, I., 2000. Effects of otter trawling on the benthos and environment in muddy sediments. In. *The Effects of Fishing on Non-target Species and Habitats: Biological, Conservation and socio-economic issues* (ed. M.J. Kaiser & S.J. de Groot), pp. 69-82. Oxford: Blackwell Science.
Ref Number: 113 **Year published:** 2000 **Peer reviewed?:** No **Study Location:** Isle of Man, Irish Sea. **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	The paper reviews the results of a large study, examining the ecological effects of disturbance by scallop dredging at both large and small scales on gravelly seabed communities. **Habitat effects:** Unfished areas were found to be less homogeneous than dredged areas, supporting more diverse species assemblages. Following the onset of the annual closed season **Species and community effects:** Large scale: The composition of species assemblage differed greatly between dredged and un-dredged sites and this was thought to be a direct result of dredging activity. However species diversity and dominance of epifaunal assemblages did not differ greatly between dredged and undredged sites. Dredge disturbance in a previously closed area: Infaunal communities in experimentally dredged sites, within an area that had been closed to fishing for nine years quickly altered and became very similar to survey sites in heavily dredged areas. **Further notes:** The authors believe that the effects of scallop dredging on a gravel bed differs greatly to the impacts on other soft sediments, owing to the extreme patchiness of animal distribution, sediment stability, greater abundance of epifauna and to the combined effect of the heavy, toothed scallop gear and stones caught in dredges.	Bradshaw, C., Veale, L.O., Hill, A.S. & Brand, A.R., 2000. The effects of scallop dredging on gravelly seabed communities. In. *The Effects of Fishing on Non-target Species and Habitats: Biological, Conservation and socio-economic issues.* (ed. M.J. Kaiser & S.J. de Groot), pp. 83-104. Oxford: Blackwell Science.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 114 **Year published:** 2000 **Peer reviewed?:** No **Study Location:** Clyde Sea, Scotland. **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Maerl Beds **Relevant Species:** None	Study examining the effect of dredging for scallops at previously fished and previously unfished maerl beds. Fishing took place using a gang of 3 Newhaven dredges with 77 cm mouth width. The impact on benthic species was measured, as was bycatch in the dredges. The dredge sites were monitored imediately after dredging and four times a year for the following four years. **Habitat effects:** Direct observations showed profound 2.5 m wide tracks were made through the maerl beds, in which, all natural bottom features were erased. Rocks and boulders were overturned, sediment was brought to the surface and live maerl was buried. **Species and community effects:** During the trawl a number of large and fragile species were killed or dammaged by the trawl. This included damage to individuals and nests of the file shell *Limaria hians*. Investigations imediately after the dredge revealed littering of animal fragments and damaged animals across the seabed. This was followed by an influx of opportunistic scavanging species, that began to disperse after three days. Different groups of organisms recovered at different rates over the four years of surveying after dredging. Large, slow-growing bivalves such as the horse mussel *Modiolus modiolus* and the file shell and some sponges and anemones had not recovered after four years. File shells, their nests and diverse associated fauna remained absent for the duration of the surveys. **Further notes:** On each tow, 8-15 kg of bycatch organisms were caught for every 1 kg of scallops.	Hall-Spencer, J.M. & Moore,P.G., 2000. Impact of scallop dredging on maerl grounds. In. *The Effects of Fishing on Non-target Species and Habitats: Biological, Conservation and socio-economic issues.* (ed. M.J. Kaiser & S.J. de Groot), pp. 105-117. Oxford: Blackwell Science.
Ref Number: 115 **Year published:** 2000 **Peer reviewed?:** No **Reviewed by:** Sewell & Hiscock 2005	Drift gill net, Gill nets, Pelagic Trawl, Set nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise, Other cetaceans	Review of incidental by-catch of cetaceans by commercial fisheries. **Species and community effects:** By-catch of *Phocoena phocoena* occurs in all areas where bottom-set gill nets and the harbour porpoise coexist. Levels of bycatch from this industry may be underestimated as individuals often fall out of nets during hauling and may not be counted in surveys. Some harbour porpoise by-catch also occurs in drift net fisheries. Other small cetacean species are captured in pelagic trawls, drift nets, and bottom-set nets.	Tregenza, N.J.C., 2000. Fishing and cetacean by-catches. In. *The Effects of Fishing on Non-target Species and Habitats: Biological, Conservation and socio-economic issues.* (ed. M.J. Kaiser & S.J. de Groot), pp. 105-117. Oxford: Blackwell Science.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 116 **Year published:** 2000 **Peer reviewed?:** No **Study Location:** North Sea **Reviewed by:** Sewell & Hiscock 2005	Gill nets, Set nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise	The paper examines management options to reduce harbour porpoise by-catch from North Sea fisheries, particularly bottom-set gill-net fisheries. The paper included a study of the by-catch associated with UK and Danish, bottom-set gill-net fisheries. The UK section of the study was based on 27 Grimsby gill netters, targeting cod. Interviews were undertaken, along with observations made from on board fishing vessels. The Danish fleet analysis was based on interviews with 30 gill-netters targeting a mixture of species, from various fishing ports in Denmark. **Species and community effects:** Estimates of harbour porpoise bycatch from the Grimsby gill-net fishery ranged from 81 to 193 per year over the period between 1990 and 1997, based on observer data and detailed spatio-temporal analysis of the fishery. Catches ranged from 95 to 202 for 1997 to 1998 based on interviews with skippers. Bycatch from the Danish Gill-net fisheries was estimated at between 3500 and 4500 per year in 1998. **Further notes:** The authors also discuss the presence of 'by-catch hotspots', based on seasonal movements of the harbour porpoise and feeding and calfing aggregations.	McGlade, J.M. & Metuzals, K.I., 2000. Options for the reduction of by-catches of harbour porpoises (*Phocoena phocoena*) in the North Sea. In. *The Effects of Fishing on Non-target Species and Habitats: Biological, onsevation and socio-economic issues.* (ed. M.J. Kaiser & S.J. de Groot), pp. 105-117. Oxford: Blackwell Science.
Ref Number: 117 **Year published:** 1999 **Peer reviewed?:** Yes **Study Location:** ca. 8 Nautical Miles off Anglesey in the eastern Irish Sea. Study Dates: 1993 - 1995 **Reviewed by:** Sewell & Hiscock 2005	Beam trawl	**Relevant Habitats:** Reefs (Subtidal), Sandbanks which are slightly covered by seawater **Relevant Species:** None	Study, reporting the effects of beam trawling on the in- and epifauna associated with the biogenic structures (tube heads) formed by the overlapping tubes of serpulid worms (*Pomatoceros triqueter* and *Pomatoceros lamarcki*). The site was trawled at six monthly intervals for two years. Samples were taken using a quantitative epibenthic dredge. **Species and community effects:** No significant changes to the distribution and number of tubeheads attributable to fishing were detected. No significant changes in community structure associated with the tubeheads was recorded. An additional laboratory study suggested that following disturbance, tube heads are unlikely to return to their original positions on the sea bed. **Further notes:** the study took place in an area of stable sediment at a depth of 26 - 34 metres. Serpulid tube heads were generally attached to rocks and shell fragments.	Kaiser, M.J., Cheney, K., Spence, F.E. Edwards, D.B. & Radford, K., 1999. Fishing effects in northeast Atlantic shelf seas: Patterns in fishing effort, diversity and community structure VII. The effects of trawling disturbance on the fauna associated with the tubeheads of serpulid worms. *Fisheries Research,* **40**, 195-205.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 118 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** West coast of the Isle of Man. Study Dates: July 12 - July 21 2000 **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Study examining the effects of dredging for scallops on megafauna by direct observations of damage in bycatch and in dredge tracks (individuals encountering dredges, but not captured). Authors used two gangs of four 'Newhaven' spring toothed dredges. An identical damage score was used by divers, surveying dredge tracks and scientists on board vessels examining bycatch. The abundance and damage score was recorded for all megafauna. **Species and community effects:** *Asterias rubens* and *Neptunea antiqua* were more severely damaged in bycatch than dredge tracks. *Cancer pagurus* was more severely damaged in the dredge track. For*Cancer pagurus* and *Liocarcinus* spp nearly twice as many crushed or damaged animals were left on the sea bed than were found in bycatch. Some species were little affected by dredging, including *Porania pulvillus* and *Asterias rubens*. The study showed that the majority of fauna to come into contact with the dredge remains on the seafloor and that the majority of megafauna mortality associated with scallop dredges of this type occurs in dredge tracks and not in discarded bycatch. **Further notes:** Sediment ranged from pure sand to gravelly sediments containing mud, sand, shell material and stones.	Jenkins, S.R., Beukers-Stewart, B.D. & Brand, A.R., 2001. Impact of scallop dredging on benthic megafauna: a comparison of damage levels in captured and non-captured organisms. *Marine Ecology Progress Series,* **215**, 287-301.
Ref Number: 119 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Scottish sea loch, West Wales and Lyme Bay. **Reviewed by:** Sewell & Hiscock 2005	Pots or creels	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays, Reefs (Subtidal) **Relevant Species:** None	The study was divided into three sections. The first examined the effects of *Nephrops* creels in a Scottish sea loch, on sea pens. The second examined the immediate effects of hauling pots on the benthos of different habitats, ranging from exposed limestone slabs, to large boulders and rocks interspersed with gravel. The third was a quantitative study into the effects of crab and lobster pots on benthic species on rocky substrata. **Species and community effects:** Sea pens *Penatula phosphorea, Virgularia mirabilis* and *Funiculina quadrangularis* were able to recover from all creel impacts, by bending to avoid the impact of dropped creels and reinserting themselves following uprooting. During observations of pot hauling over rocky substrates, the pink sea fan *Eunicella verrucosa* was observed to bend under the weight of the pot, returning to an upright position afterwards. Quantitative studies revealed that there were few immediate detrimental effects resulting from four weeks of intensive potting over rocky substrata. Damage was however inflicted on large, slow growing ross 'corals' *Pentapora foliacea* [now *Pentapora fascialis*] by pots.	Eno, N.C., MacDonald, D.S., Kinnear, J.A.M., Amos, S.C., Chapman,C.J., Clark, R.A., Bunker, F. St P. & Munro, C., 2001. Effects of crustacean traps on benthic fauna. *ICES Journal of Marine Science,* **58**, 11-20.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 120 **Year published:** 2003 **Peer reviewed?:** Yes **Study Location:** The Stravanan Bay, Isle of Bute and The Caol Scotnish, Loch Sween. Scotland **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Maerl Beds, Large, Shallow inlets and bays **Relevant Species:** None	Comparison of substratum heterogeneity of a dredged site (Stravanan Bay) and an undredged site (Caol Scotnish). **Habitat effects:** Structural heterogeneity was far lower in impacted, dead maerl, which had similar heterogeneity to gravel. Unimpacted maerl had higher structural heterogeneity. **Further notes:** The authors suggest that maerl beds with higher structural heterogeneity will support a wider diversity of associated organisms and will be more important as nursery areas for larger species.	Kamenos, N.A., Moore, P.G. & Hall-Spencer, J.M., 2003. Substratum heterogeneity of dredged vs un-dredged maerl grounds. *Journal of the Marine Biological Association of the United Kingdom,* **83**, 411-413.
Ref Number: 121 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** Clyde Sea area, Scotland. **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Maerl Beds **Relevant Species:** None	The work was a comparison between maerl and associated benthos in regularly fished and unfished areas, both before and after dredging with a 77 cm diameter Newhaven scallop dredge. The study included comparison between maerl thalli collected in the late 1800s and the study date from a separate site, which had been extensively dredged for the prior 40 years. **Habitat effects:** A 2.54 m wide track with three parallel furrows was created at test sites in both areas. All natural, physical bottom features were eliminated and boulders of up to on cubic metre had been dragged along the surface. Sculpted ridges made by the trawl were still apparent after 2.4 years at the previously undredged site and 1.5 years at the previously dredged site. **Species and community effects:** The scallops *Pecten maximus* were more abundant at the unfished site. File shells *Limaria hians* and their nests and the scallop *Aquipecten opercularis* were present at unfished sites, but not at fished sites. Immediately following the trawl, live maerl was buried and biogenic structures were crushed and destroyed. There were no signs of recovery of maerl within the four year study. **Further notes:** Historical comparisons of maerl revealed that in the late 1800s, the average size of maerl thalli was significantly greater and live maerl was far more abundant than following fishing activity.	Hall-Spencer, J.M. & Moore, P.G., 2000. Scallop dredging has profound long-term impacts on maerl habitats. *ICES Journal of Marine Science,* **57**, 1407-1415.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 122 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** South Eastern North Sea **Reviewed by:** Sewell & Hiscock 2005	Beam trawl, Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Study to calculate direct mortality of infaunal and epifaunal species of invertebrates, following otter and beam trawls. The annual fishing mortality for megafaunal invertebrate populations in the Dutch sector of the North Sea was also estimated based on the results of this field study.Three types of commercial beam trawls were tested (12 m wide and 4 m wide with tickler chains and 4 m wide with chain matrices) as well as an otter trawl with a 20 m net width. Mortality was determined by measuring species density before and comparing this with density 12-24 hours after trawling. **Species and community effects:** Single tows of 4 m and 12 m beam trawls, resulted in direct mortality of a number of species, ranging from 5% to 50% and up to 68% for some bivalve species. There were lower levels of mortality associated with otter trawls than beam trawls of all sizes. Mortaliy of organisms was greater in silty sediment than sandy sediment. Most direct mortality took place either as a result of impact by the trawl or disturbance and exposure leading to predation. Only a relatively small percentage of mortality was due to organisms being caught in trawls and discarded.	Bergman, M.J.N. & van Santbrink, J.W. 2000. Mortality in megafaunal benthic population caused by trawl fisheries on the Dutch continental shelf in the North Sea. *ICES Journal of Marine Science,* **57**, 1321-1331.
Ref Number: 123 **Year published:** 1999 **Peer reviewed?:** Yes **Study Location:** Gulf of Venice, Adriatic Sea. **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge, Rapido Trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Experimental tow using one 3 m wide rapido trawl over a relatively undisturbed sandy-bottomed scallop bed. Authors used underwater video before, during and one and 15 hours after trawling and catch analysis to study the effects of the trawl on the benthos. **Habitat effects:** 3 m wide tracks were left, following the trawl. Sediment was flattened, with no worm tubes or burrows that had been there previously. Tracks were littered with animal and shell fragments. **Species and community effects:** Mobile scavenging organisms, particularly spider crabs, hermit crabs and some fish species increased in abundance in trawled areas. Significant decrease in abundance of and obvious damage to the fan shell *Atrina fragilis*. Coralline rhodoliths were smashed and dispaced or buried by the trawl. Large numbers of soft bodied tunicates were killed by the passage of the trawl and/or caught as bycatch. Trawl teeth speared soft bodied invertebrates and large, hard-shelled bivalves. Damage to benthos was limited to organisms living within the top 2 cm of sediment. Large, fragile organisms, generally sustained the highest levels of damage when caught by the trawl, whilst smaller, hard-shelled organisms were fatally damaged only in low proportions.	Hall-Spencer, J.M., Froglia, C., Atkinson, R.J.A. & Moore, P.G., 1999. The impact of rapido trawling for scallops *Pecten jacobaeus* (L.) on the benthos of the Gulf of Venice. *ICES Journal of Marine Science,* **56**, 111-124.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 124 **Year published:** 1998 **Peer reviewed?:** Yes **Study Location:** Walney Island, Anglesey offshore and Red Wharf Bay. The Irish Sea **Reviewed by:** Sewell & Hiscock 2005	Beam trawl, Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Surveys were undertaken of three sites before and after trawling. Site one: Dulas Bay. Sediment was coarse sand with gravel and low commercial fishing activity. Site Two: Red Wharf Bay. Sediment was medium sand, occasionally fished. Site Three: Walney Island. Muddy sediment, heavily fished. 4 m wide beam trawl was used at all sites. Eight 0.75 m wide Newhaven, scallop dredges were used at Site Two only. **Species and community effects:** At Site One, numbers of hermit crab *Pagurus bernhardus* increased following trawls. At Site Two, no increase in scavangers was observed immediately after trawling, however 25 hours after fishing, the abundance of some scavanging starfish and brittle stars increased significantly. At Site Three, the abundance of some previously abundant scavanging species decreased following trawling disturbance. Damage to large, fragile organisms was observed by divers, following trawls.	Ramsay. K., Kaiser. M.J. & Hughes, R.N., 1998. Responses of benthic scavangers to fishing disturbance by towed gears in different habitats. *Journal of Experimental Marine Biology and Ecology,* **224**, 73-89.
Ref Number: 125 **Year published:** 1999 **Peer reviewed?:** Yes **Study Location:** Grand Banks of Newfoundland Study Dates: 1993 - 1995 **Reviewed by:** Sewell & Hiscock 2005	Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Study of effects of trawling with an Engel 145 otter trawl with rockhopper gear and a door spread of 60 m. Trawl catch and remaining epibenthos were analysed. Three experimental sites were trawled 12 times each, with a period of five days once a year for three years. Comparison were made between trawled and untrawled sites. **Species and community effects:** Studies revealed an influx of scavenging snow crabs following trawls. The biomass of benthic organisms was 24 % higher in untrawled sites compared to trawled site. The homogeneity of the sampled macro-invertebrate community was lower in trawled than untrawled sites.The experiment indicated that otter trawling on a sandy bottom ecosystem can produce detectable changes on both benthic habitat and communities, in particular a significant reduction in the biomass of large epibenthic fauna. **Further notes:** The study site was a deep (120 - 146 m) sand bank, with relatively stable, moderately well sorted, fine- to medium-grained sediment.	Prena, J., Schwinghamer, P., Rowell, T.W., Gordon Jr, D.C., Gilkinson, K.D., Vass, W.P. & McKeown, D.L., 1999. Experimental otter trawling on a sandy bottom ecosystem of the Grand Banks of Newfoundland:analysis of trawl bycatch and effects on epifauna. *Marine Ecology Progress Series,* **181**, 107 -124.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 126 **Year published:** 2000 **Peer reviewed?:** yes **Study Location:** north-western Australia **Reviewed by:** Sewell & Hiscock 2005	Otter trawl (demersal), Otter trawl (semi-pelagic)	**Relevant Habitats:** Reefs (Subtidal) **Relevant Species:** None	A study comparing the impact of a benthic otter trawl with a semi-pelagic otter trawl, fished approximately 15 cms above the seabed. Repeated trawls were undertaken in marked areas and the effects on macrobenthos (mainly sponges, soft corals and gorgonians) were recorded, by measuring by-catch and using video survey. **Species and community effects:** No measurable effects were recorded following semi-pelagic trawls, whereas demersal trawls resulted in reductions to the density of benthic organisms growing higher than 20 cm from the seabed of 15.5 % on each tow through the site. **Further notes:** Only four % of the benthos detached by trawls was retained in the net. The semi-pelagic trawl took lower levels of benthos, but also took far less fish.	Moran, M.J. & Stephenson, P.C., 2000. Efects of otter trawling on macrobenthos of demersal scalefish fisheries on the continental shelf of north-western Australia. *ICES Journal of Marine Science,* **57**, 510-516.
Ref Number: 127 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** 20 km east of Venice Lagoon, northern Adriatic Sea. **Reviewed by:** Sewell & Hiscock 2005	Rapido Trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Reefs (Subtidal) **Relevant Species:** None	The study examined the effects of a 3m wide, 120 kg box dredge with 5 - 7 cm long teeth and a net bag, on the benthos of an offshore, sandy, seabed community. The study also included a comparison between a control (unfished) ground and a fishing ground. **Habitat effects:** The upper 6 cm of sediment was disturbed and 50 % of epifaunal organisms were removed along a flattened track with small heaps of sediment running along each side. **Species and community effects:** Experimental trawling induced a modification in the macrobenthic community, that was most evident immediately after the trawl. This included the removal of epifauna and an increase in mobile scavenging species. The authors suggest that recorded changes to the meiobenthic community were probably due to sediment disturbance. These changes were recorded after one week. Comparisons between the control grounds and fishing grounds showed that fishing grounds had significantly fewer species and number of individuals and significantly lower biomass of macrofauna, indicating significant long-term effects of fishing.	Pranovi, F., Raicevich, S., Franceschini, G., Farrace, M.G. & Giovanardi. O., 2000. Rapido trawling in the northern Adriatic Sea: Effects on benthic communities in an experimental area. *ICES Journal of Marine Science,* **57**, 517-524.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 128 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** Heraklion Bay, Crete, Greece. **Reviewed by:** Sewell & Hiscock 2005	Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	A study, examining the impacts of otter-trawling for demersal fish and shrimps at a known fishing site in the Mediterranean. The benthic macrofauna and sediment chemistry was studied at two sites within the trawl lane and two sites outside the known fishing area. Towed video surveys and beam-trawl sampling were used to study seabed conditions and macrofauna. **Habitat effects:** Scrape marks and a 'general flattening of the microtopography' were observed in trawled areas and the resuspension of sediment was apparent. **Species and community effects:** Significantly lower numbers of epifauna were found at unfished sites, particularly large echinoderms. Species number, abundance and biomass were all significantly lower during the trawling season in the trawl lane and there were significant differences in sediment characteristics between fished and unfished sites. The study indicated that the four month closed season currently in place did not allow time for recovery of these factors to pre-trawl levels. **Further notes:** The sediments at the study site were predominantly fine, silty clay.	Smith, C.J., Papadopoulou, K.N. & Diliberto, S., 2000. Impact of otter trawling on an eastern Mediterranean commercial trawl fishing ground. *ICES Journal of Marine Science,* **57**, 1340-1351.
Ref Number: 129 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** Eastern Bering sea **Reviewed by:** Sewell & Hiscock 2005	Bottom trawl	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	The study compares benthic macrofauna between the unfished Crab and Halibut Protection Zone 1 (CHPZ1) and heavily fished areas where bottom trawling is known to take place. Sampling was carried out using otter trawls. **Species and community effects:** Sedentary macrofauna were found to be more abundant in unfished areas. Overall diversity and niche breadth of sedentary taxa was higher at unfished sites. Within groups of motile organisms, a variety of responses were observed and the authors suggest that this may indicate the importance of life history characteristics such as habitat requirements and feeding mode. **Further notes:** The site is relatively shallow (44 - 25 m) with a sand substratum.	McConnaughey, R.A., Mier, K.L. & Dew, C.`B., 2000. An examination of chronic trawling effects on soft-bottom benthos in the eastern Bering Sea. *ICES Journal of Marine Science,* **57**, 1377-1388.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 130 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Damariscotta River estuary, Maine, USA. **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge	**Relevant Habitats:** Estuaries **Relevant Species:** None	Experimental study examining the effects of scallop dredging on the fauna and sedimentary characteristics of a silty sand community. A 2 m wide Bedford-style scallop dredge was dragged 23 times across the study site and this area was compared to an a undisturbed, adjacent site. The two areas were sampled four and five months before, immediately before and after and four and six months after dredging. **Habitat effects:** Passing the dredge over the site removed the surface few centimetres of sediment. Food quality of the sediment was reduced, as was calculated by measuring microbial populations, enzyme hydrolysable amino acids and chlorophyll a levels. This reduced food quality showed relatively complete recovery within four to six months. **Species and community effects:** Immediately after dredging, macrofauna were significantly decreased in overall abundance and assemblage structure was altered at the dredged site. Macrofaunal abundance and assemblage structure at the dredged site did not recover to levels equivilent to the undredged site before six months. **Further notes:** Sediment was characterised by silty sand and the depth was 25 m below mean low water.	Watling, L., Findlay, R.H., Mayer, L.M. & Schink, D.F., 2001. Impact of a scallop drag on the sediment chemistry, microbiota and faunal assemblages of a shallow subtidal marine benthic community. *Journal of Sea Reasearch,* **46**, 309-324.
Ref Number: 131 **Year published:** 2003 **Peer reviewed?:** Yes **Study Location:** Stravanan Bay, Clyde Sea, Scotland **Reviewed by:** Sewell & Hiscock 2005	Hydraulic dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Maerl Beds, Large, Shallow inlets and bays **Relevant Species:** None	This study examined the potential effects of hydraulic dredging on maerl beds. A florescent sediment tracer was used to mark dead maerl, that was laid over the area to be trawled. The maerl was laid on the seabed in a way, that represented the natural maerl bed typical of the area. Following the passage of the hydraulic dredge, dredge track observations, catch analysis, and assessment of maerl catch and sediment resuspension were carried out. **Habitat effects:** Large quantities of dead maerl were caught by the dredge. Only a relatively small proportion of dyed maerl was captured, as the majority was dragged along the dredge track and reburied. A large amount of fine sediment was resuspended by the trawl, when it settled, maerl around the dredged path was blanketed by newly settled silt. This blanketing effect was easily discernable at least 21 m away from the dredged path. **Species and community effects:** A large number and high diversity of benthic organisms were captured in the dredge, including many large, long-lived, deep burying animals. Many larger, more fragile organisms were killed, whilst smaller more robust organisms were largely unharmed. Very few active species were captured, reflecting the slow speed of the dredge. Some live maerl thalli were also caught in the dredge.	Hauton, C., Hall-Spencer, J.M. & Moore, P.G., 2003. An experimental study of the ecological impacts of hydraulic bivalve dredging on maerl. *ICES Journal of Marine Science,* **60**, 381-392.
Ref Number: 132 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:**	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	The paper examines spatial differences in the distribution of bycatch assemblages from scallop fishing grounds. High-resolution fishing effort data was extracted from fishermen's logbooks and used to identify areas with varying levels of disturbance. Species composition of experimental trawls at different sites over time was analysed and compared. **Species and community effects:** Species diversity and richness, total number of species and number of individuals all decreased significantly with increased fishing effort, as did total abundance, biomass and production of most major individual taxa investigated. Species dominance increased with fishing effort. Bycatch assemblage structure was more closely related to fishing effort than any other environmental variable examined.	Veale, L.O., Hill, A.S., Hawkins, S.J. & Brand, A.R., 2000. Effects of long-term physical disturbance by commercial scallop fishing on subtidal epifaunal assemblages and habitats. *Marine Biology,* **137**, 325-337.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
North Irish Sea, around the Isle of Man. Study Dates: 1995 **Reviewed by:** Sewell & Hiscock 2005			**Further notes:** Substratum was generally coarse sand or gravel	
Ref Number: 133 **Year published:** 1995 **Peer reviewed?:** Yes **Study Location:** Dutch Wadden Sea **Reviewed by:** Sewell & Hiscock 2005	Bait collecting	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	Study of the effect of mechanical lugworm dredging on the macrozoobenthos of a large intertidal mudflat. A transect, being used for a long-term sampling programme, established in 1970, was crossed by mechanical lugworm dredgers from 1978, up to and including 1982. Sampling continued during and after this dredging and findings are discussed. **Species and community effects:** A severe reduction in lugworm stock occurred during the dredging period, Total zoobenthic biomass also declined. The population of gaper clams *Mya arenaria* reached almost complete extinction when, prior to dredging, the species had comprised half of the total biomass. Recovery of the biomass of the zoobenthos took several years. Lugworm stocks recovered slowly and reached original levels after three years. The *Mya arenaria* population took five years to recover to original density levels.	Beukema, J.J., 1995. Long-term effects of mechanical harvesting of lugworms *Arenicola marina* on the zoobenthic community of a tidal flat in the Wadden Sea. *Netherlands Journal of Sea Research,* **33**, 219-227.
Ref Number: 134 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** Burry Inlet, South Wales **Reviewed by:** Sewell & Hiscock 2005	cockle tractor dredge	**Relevant Habitats:** Large, Shallow inlets and bays, Estuaries, Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	A tractor-towed cockle dredge was used on both muddy sand and clean sand, intertidal areas to extract cockles. The effects of dredging on invertebrates and their predators were examined. **Habitat effects:** **Species and community effects:** A significant proportion of the most abundant species was lost from both sites. In muddy sand, populations of *Pygospio elegans* and *Hydrobia ulvae* remained significantly depleted for more than 100 days and had not recovered 174 days after harvesting. Some species of polychaete and amphipod remained depleted for more than 50 days. Although bird feeding activity of gulls and waders increased for a short period following dredging due to increased food availability, this was followed by a significant reduction of bird activity compared to control areas. For curlews and gulls, this reduced level of activity continued for 80 days and for oystercatchers, 50 days. In the area of clean sand, invertebrate communities were less dense and recovered more quickly. **Further notes:** The authors conclude that tractor dredging for invertebrates caused sufficiently high mortality of non-target species that harvesters should be excluded from areas of high conservation importance.	Ferns, P.N., Rostron, D.M. & Siman, H.Y., 2000. Effects of mechanical cockle harvesting on intertidal communities. *Journal of Applied Ecology,* **37**, 464-474.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 135 **Year published:** 2002 **Peer reviewed?:** Yes **Study Location:** South Carolina, USA Study Dates: 1992 - 1996 **Reviewed by:** Sewell & Hiscock 2005	Various (Not listed)	**Relevant Habitats:** None **Relevant Species:** Bottle-nosed dolphin	Study of Bottle-nosed dolphin strandings, including examination of cause of death. **Species and community effects:** 153 individuals were examined. sixteen showed signs of fishery related trauma. Five males and eight females were invloved in net entanglements.The majority of these had stomach contents containing shrimp or fish remains, indicating interactions with commercial fisheries. The majority of interactions took place during the summer months.	McFee, W.E. & Hopkins-Murphey, S.R., 2002. Bottlenose dolphin (*Tursiops truncatus*) strandings in South Carolina, 1992-1996. *Fishery Bulletin,* **100**, 258-265.
Ref Number: 136 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Southeastern North Carolina, USA Study Dates: 1997 - 1999 **Reviewed by:** Sewell & Hiscock 2005	Gill nets	**Relevant Habitats:** None **Relevant Species:** Bottle-nosed dolphin	Beach based and aerial surveys were used to quantify gillnets and dolphin numbers in coastal waters. Strandings investigations were used to characterise interactions between bottlenose dolphins and monofilament gill net fisheries. **Species and community effects:** Highest numbers of dolphin mortalities resulting from gill-net interactions were recorded between October and November. During October 1997 four stranded dolphins had been killed as a result of interaction with gill-nets. One individual was captured alive and subsequently released from a gill net and in October and November 1998, six stranded individuals were found to have been killed by gill nets.	Friedlaender, A.S., McLellan, W.A. & Pabst, D.A., 2001. Characterising an interaction between coastal bottlenose dolphins (*Tursiops truncatus*) and the spot gillnet fishery in southeastern North Carolina, USA. *Journal of Cetacean Reseacrh and Management,* **3**, 293-303.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 137 **Year published:** 2003 **Peer reviewed?:** Yes **Study Location:** North Carolina, USA. Study Dates: April 5th - May 10th 2001 **Reviewed by:** Sewell & Hiscock 2005	Gill nets	**Relevant Habitats:** None **Relevant Species:** Bottle-nosed dolphin	Study examining the response of bottle-nosed dolphins to bottom set gill nets with attached, functioning and non-functioning accoustic pingers. Dolphin movements were monitored around commercial gill nets every morning of the study period. Control nets had attached acoustic pingers with no power. **Species and community effects:** 59 groups of dolphins were observed during the study. No dolphins were caught in the nets during the study. The number of dolphins observed per hour and the closest observed approach to the net did not differ between treatments. the number of dolphins entering a 100 m radius of the net varied significantly between treatments and was lower with the active pinger. Most dolphins appeared to be aware of the net irrespective of treatment and some dolphins fed on fish trapped in the net. **Further notes:** The authors conclude that it would be unwise to use pingers in this type of fishery, because, not only would any effects of the pinger deteriorate over time. The pinger may even act as a 'dinner bell' signalling the presence of an easy food supply.	Cox,T.M., Read, A.R., Swanner, D., Urian, K. & Waples, D., 2003. Behavioural responses of bottlenose dolphins, *Tursiops truncatus* to gillnets and acoustic alarms. *Biological Conservation,* **115**, 203-212.
Ref Number: 138 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** (1) Vancouver Island, Canada. (2) Baltic Sea, Germany **Reviewed by:** Sewell & Hiscock 2005	Gill nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise	The Paper reports on two studies. The first examined the effects of an acoustic pinger bearing, bottom set gill net on the movements of harbour porpoise. The second examined the effects of the same type of pinger on herring in the Baltic Sea. The latter study was to explore the hypothesis that pingers deter the harbour porpoise indirectly as a result of prey redistribution. **Species and community effects:** In control studies, harbour porpoise were not affected by the presence of bottom set gill nets. Pinger operation resulted in an exclusion zone around the net ranging from 130 m to 1140 m. Study 2, indicated that herring catches increased with the presence of pingers, indicating that porpoise distribution could not be associated with prey redistribution.	Culick, B.M., Koschenski, S., Tregenza, N. & Ellis, G.M., 2001. Reactions of harbor porpoises *Phocoena phocoena* and herring *Clupea harengus* to accoustic alarms. *Marine Ecology Progress Series,* **211**, 255-260.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 139 **Year published:** 1999 **Peer reviewed?:** Yes **Study Location:** Coconut Island, Oahu, HI, USA. **Reviewed by:** Sewell & Hiscock 2005	Gill nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise, Bottle-nosed dolphin	The detection range of harbour porpoises and the bottle-nosed dolphin for 11 different types of gill net was estimated based on calculated target strength of each type of net and known echolocation abilities of each species. **Species and community effects:** The study suggests that echolocating bottlenose dolphins can detect nets in time to avoid collision, whereas echolocating harbour porpoises cannot in most cases.	Kastelein, R.A., Au, W.W.L. & de Haan, D., 1999. Detection distances of bottom-set gillnets by harbour porpoises (*Phocoena phocoena*) and bottlenose dolphins (*Tursiops truncatus*). *Marine Environmental Research,* **49**, 359-375.
Ref Number: 140 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Bay of Fundy, Nova Scotia, Canada **Reviewed by:** Sewell & Hiscock 2005	Gill nets	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise	Pingers such as those currently used in gill net fisheries to deter cetaceans were set on a mooring and the movements of harbour porpoise were measured over three months. **Species and community effects:** At first, porpoises were displaced 208 m from the pinger. However, this distance reduced by 50 % within four days indicating that porpoises were becoming habituated to the pinger.	Cox, T.M., Read, A.J., Solow, A. & Trengenza, N., 2001. Will harbour porpoises (*Phocoena phocoena*) habituate to pingers? *Journal of Cetacean Research and Management,* **3**, 81-86.
Ref Number: 141 **Year published:** 1998 **Peer reviewed?:** Yes	Hand gathering	**Relevant Habitats:** Estuaries, Large, Shallow inlets and bays, Mud and sandflats not covered by seawater at low	Study examining the relationship between biomass of cockles taken by a small scale, hand gathering fishery, cockle biomass and oyster catcher abundance. The study is based on data covering 11 winters. **Species and community effects:** Winter oyster catcher numbers were not correlated with cockle biomass nor biomass taken by the fishery but with the total number of overintering oystercatchers in the UK overall. Spring oystercatcher numbers were however positively correlated with cockle biomass and negatively correlated with cockle biomass extracted by the fishery. The authors believe that the reason for this is that oystercatchers leave the area earlier in spring when biomass at the start of the winter is small and/or the biomass extracted by the fishery is large.	Norris, K., Bannister, R.C.A. & Walker, P., 1998. Seasonal changes in the number of oystercatchers *Haematopus ostralgus* wintering on the Burry Inlet in relation to the biomass of cockles *Cerastoderma edule* and its commercial exploitation.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Study Location: Burry Inlet, South Wales Study Dates: 1982/83 - 1992/93 **Reviewed by:** Sewell & Hiscock 2005		tide **Relevant Species:** None	**Further notes:** The authors note that the current scale of the cockle fishery is very small, extracting less than 25 % of available stock, using traditional methods such as hand gathering. Even at this level, oyster catcher numbers in spring time were reduced. If more efficient methods of cockle harvesting are employed in the future, resulting in higher catch rates, effects may be even more severe.	*Journal of Applied Ecology,* **35**, 75-85.
Ref Number: 142 **Year published:** 2003 **Peer reviewed?:** Yes **Study Location:** Clyde Sea, Scotland **Reviewed by:** Sewell & Hiscock 2005	Pots or creels, Bottom trawl	**Relevant Habitats:** None **Relevant Species:** Grey seal, Common seal	Results from a consultation exercise involving trawlermen and creel fishers of the Clyde Sea. A questionaire was used to identlify interactions between fishers and common and grey seals. **Species and community effects:** 91 % of Trawlermen reported catching a seal in their towed gear rarely or occasionally. The majority of these were reported as being dead when recovered. This was compared to only nine % of trawlermen reporting damage to their gear by seals. There did not appear to be any reports of seal mortality caused by creel fishermen.	Moore, P.G., 2003. Seals and fisheries in the Clyde Sea area (Scotland): traditional knowledge informs science. *Fisheries Research,* **63**, 51-61.
Ref Number: 143 **Year published:** 1999 **Peer reviewed?:** Yes **Study Location:** North East Atlantic **Reviewed by:** Sewell & Hiscock 2005	Pelagic Trawl	**Relevant Habitats:** None **Relevant Species:** Bottle-nosed dolphin, Other cetaceans, Grey seal	Study of marine mammal bycatch associated with 11 pelagic trawl fisheries operating in the North East Atlantic. Observeres were placed on board vessels to monitor marine mammal bycatch, observations of marine mammals and number of trawls. Some post mortem analysis was also carried out. **Species and community effects:** Four grey seals were landed in the Irish herring fishery operating in the Celtic Sea. Common dolphins, white sided dolphins and possibly one bottle-nosed dolphin (18 total) were caught in the Dutch horse mackerel fishery, French Hake and Tuna fisheries and French Bass fishery. The catch rate of seals in the Irish herring fishery was 0.0513 seals per tow or 0.0396 per hour of tow. The mean +_SD dolphin catch rate for all fisheries combined was 0.048+_0.013 per tow (one dolphin per 20.7 tows), or 0.0185+_0.0019 per hour of towing (one dolphin per 98 h of towing). Cetacean bycatch was highest in the French sea bass fishery and lowest in the French tuna fishery. **Further notes:** No marine mammals were observed by-caught in the UK mackerel or pilchard fisheries or French anchovy, black bream or pilchard fisheries.	Morizur, Y., Berrow,S.D., Tregenza, N.J.C., Couperus, A.S. & Pouvreau, S., 1999. Incidental catches of marine-mammals in pelagic trawl fisheries of the northeast Atlantic. *Fisheries Research,* **41**, 297-307.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 144 **Year published:** (in press) **Peer reviewed?:** Yes **Study Location:** North Bay of Biscay continental shelf. Study Dates: 2001 - 2002 **Reviewed by:** Sewell & Hiscock 2005	Various (Not listed)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	A stratified sampling study was developed to describe the spatial variability of the diversity and structure of macro- and mega-faunal communities in the Bay of Biscay, to identify any changes that appear to have occurred as a result of fishing pressure since the sixties. **Species and community effects:** Three distinct communities were identified. In each community, the epifauna showed less diversity, species abundance and biomass in the areas exposed to higher levels of fishing effort, while endofauna seemed not to be affected. **Further notes:** Three distinct communities were: A *Diptrupa* sand community towards the open sea, *Brissopsis lyrifera* and *Callianassa subterranea* muddy sand community and *Cirratulatus* sp. and *Ninoe armoricana* in the coastal mud.	Le Loc'h, F. & Hily, C., (in press). How does benthic and demersal fishery affect biodiversity, structure and functioning of the 'Grande Vasiere' benthic communities (Bay of Biscay, NE Atlantic)?. *Hydrobiologia (38th European Marine Biology Symposium).* (Ed H, Queiroga)
Ref Number: 145 **Year published:** 2003 **Peer reviewed?:** No **Study Location:** South west of England **Reviewed by:** Sewell & Hiscock 2005	Angling, Trawling, Pair trawl, Salmon net, Drift gill net	**Relevant Habitats:** Estuaries **Relevant Species:** Allis shad, Twaite shad	This report presents the findings from a 2 year project,studying the distribution, biology and ecology of shad (*Alosa* sp) in the Environment Agency's south-west region. The project includes the collection and analysis of various reports of recreational and commercial fishery captures of shads, at sea and from estuaries. **Species and community effects:** Since 1970, in the south west of England, catches of both UK species of shad have been recorded from a number of different fisheries. The most common capture method for shad was trawling, particularly during the winter. Shad catches were recorded by pair, otter and beam trawls, bass nets, drift nets, salmon nets, seine nets and by rod and line. During the summer months, the majority of recorded shad were caught on rod and line from the shore, in estuaries or coastal waters.	Hillman, R., 2003.. *The Distribution, Biology and Ecology of Shad in South-West England.* R&D Technical Report W1-047/TR, Environment Agency, Bristol.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 146 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Skomer MNR, Pembrokeshire, North Wales. **Reviewed by:** Sewell & Hiscock 2005	Pots or creels, Discarded gear (ghost fishing)	**Relevant Habitats:** Reefs (Subtidal) **Relevant Species:** None	Study quantifying the mortality and numbers of animals caught by a fleet of 12 crustacean pots, left on a rocky seabed in " a manner designed to simulte ghost-fishing". Information on the pots was gathered by diver surveys at, 1, 4, 12, 27, 40, 69, 88, 101, 125, 270, 333, 369, and 398 days after initial deployment. **Species and community effects:** During the experiment, seven species were captured in the pots. Crustacean species caught were spider crabs *Maja squinado*, brown crabs *Cancer pagurus*, velvet swimming crabs *Necora puber* and lobsters *Homarus gammarus*. Fish caught in traps were ballan wrasse *Labrus bergylta*, trigger fish *Ballistes carolinensis* and lesser-spotted dogfish *Scyliorhinus canicula*. Spider crabs were captured at a mean catch rate of 7.08 per year and edible crabs at a mean catch rate of 6.06 per year and were the most common species to be caught. The lesser-spotted dogfish and triggerfish were only caught on one occasion each during the study, equating to a mean catch rate of 0.08 per year for these species.	Bullimore, B.A., Newman, P.B., Kaiser, M.J., Gilbert, S.E. & Lock ,K.M., 2001. A study of catches in a fleet of 'ghost fishing' pots. *Fishery Bulletin,* **99**, 247-253.
Ref Number: 147 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** North edge of Georges Bank, North America. **Reviewed by:** Sewell & Hiscock 2005	Otter trawl (demersal), Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Reefs (Subtidal) **Relevant Species:** None	Video and photographic survey of sites with varying degrees of fishing disturbance along transects during two experimental cruises to the area. **Habitat effects:** Emergent colonial epifauna provided a complex habitat for a number of invertebrates and small fish at undisturbed sites. Bottom fishing was found to remove this epifauna, thus reducing the structural complexity and species diversity of the benthic community. **Species and community effects:** For photographed sites, significant differences between disturbed and undisturbed areas were found for; the percentage of the bottom covered by "bushy, plant-like organisms" and colonial worm tubes and the presence or absence of encrusting bryozoa. Colonial epifauna were conspicuously less abundant at disturbed sites. **Further notes:** Sediment types included sand, gravelly sand, pebbles, cobbles and boulders.	Collie, J.S., Escanero, G.A. & Valentine, P.C., 2000. Photographic evidence of the impacts of bottom fishing on benthic epifauna. *ICES Journal of Marine Science,* **57**, 987-1001.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 148 **Year published:** 1999 **Peer reviewed?:** Yes **Study Location:** A brackish, Danish sound **Reviewed by:** Sewell & Hiscock 2005	Mussel dredge	**Relevant Habitats:** Estuaries, Large, Shallow inlets and bays **Relevant Species:** None	Study of benthic species composition in a mussel bed following experimental dredging in a brackish sound. **Habitat effects:** A 2 - 5 cm deep furrow was created in the sediment by the dredge. **Species and community effects:** Fifty percent of mussels were directly removed by the dredge in both dredged areas. Immediately after dredging and for 40 days after dredging, a significantly lower number of species were recorded from the dredged area compared to control areas. Biomass accumulation of mussels in the dredged area was significantly lower, indicating that the disturbance to the mussel bed caused by the dredge reduced the growth rate of mussels. **Further notes:** Abstract of a technical paper presented at International Conference on Shellfish Restoration, September 29-October 2, 1999, Cork, Ireland.	Dolmer, P., Kristensen, T., Christiansen, M.L., Kristenesen, P.S. & Hoffmann, E., 1999. Short-term impact of blue mussel dredging (*mytilus edulis* L.) on a benthic community. *Journal of Shellfish Research,* **18**, 714.
Ref Number: 149 **Year published:** 2003 **Peer reviewed?:** Yes **Study Location:** Clyde Sea, Scotland **Reviewed by:** Sewell & Hiscock 2005	Hydraulic dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Study to quantify impacts of hydraulic blade dredging for razor clams. The study focused on discard generation, damaged caused to the catch and the ability of disturbed organisms to rebury following disturbance. **Species and community effects:** Dredge contents and dislodged fauna were dominated by the heart urchin *Echinocardium cordatum*. Approximately 80 % of these survived the dredge proccess. The majority of heart urchins left in the dredge track that were undamaged were able to rebury following the disturbance. However, none that were brought to the surface after dredging were unable to succesfully rebury within three hours of being returned. The second most common species were the target razor clams *Ensis siliqua* and *Ensis arcuatus*, as well as the otter shell *Lutraria lutraria*. Of these, between 20 and 100 % of those caught suffered severe damage in any one haul. Approximately 85 % of razor clams were able to rebury following disturbance. **Further notes:** The authors calculate that for every 10 kg of marketable razor clams caught by this method, 29 kg of heart urchins would be disturbed, 23.5 kg of which would be brought to the surface and discarded and would be unlikely to rebury.	Hauton, C., Atkinson, R.J.A. & Moore, P.G., 2003. The impact of hydraulic blade dredging on a benthic megafaunal community in the Clyde Sea area, Scotland. *Journal of Sea Research,* **50**, 45-56.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 150 **Year published:** 1987 **Peer reviewed?:** Yes **Reviewed by:** Sewell & Hiscock 2005	Bait collecting, angling	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide, Reefs (intertidal), Estuaries **Relevant Species:** None	Relevant section of the report describes a study to identify the recoverability of *Arenicola marina* populations following depopulation by bait digging anglers. **Species and community effects:** Over a six-month experimental period there was no significant increase in the density of worms in depopulated areas. Control populations remained approximately constant during June and July but decreased in density throughout the remainder of the study, leading to some convergence of treatment and control areas by the end of the experiment.	Cryer, M., Whittle, G.N., Williams, R., 1987. The impact of bait collection by anglers on marine intertidal invertebrates. *Biological Conservation,* **42**, 83-93
Ref Number: 151 **Year published:** 2003 **Peer reviewed?:** Yes **Study Location:** Manai Strait, Wales. **Reviewed by:** Sewell & Hiscock 2005	Mariculture (Shellfish)	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide **Relevant Species:** Wildfowl and waders, Seabirds	An experimental study to quantify the effects of mussel *Mytilus edulis* culture on bird assemblages on an intertidal mudflat. Bird behaviour was monitored over two winters in an area of 4.31 ha, comprising of experimental mussel culture and control plots. **Species and community effects:** Laying of the mussels had no effect on species presence/absence. Although no species were lost from the experimental plots, the bird assemblage in them changed. This reflected variation in the distribution of the 5 most abundant species. However, none of these key species declined in abundance following the laying of mussels. Curlew *Numenius arquata* and redshank *Tringa totanus* increased in abundance, although, oystercatchers *Haematopus ostralegus* did not.	Caldow, R.W.G., Beadman, H.A, S. McGrorty, S., Kaiser, M.J, Goss-Custard, J.D, Mould, K. & Wilson, A., 2003. Effects of intertidal mussel cultivation on bird assemblages. *Marine Ecology Progress Series,* **259**, 173 - 183.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 152 **Year published:** 1997 **Peer reviewed?:** Yes **Study Location:** Lowes Cove, Walpole, Maine, USA **Reviewed by:** Sewell & Hiscock 2005	Bait collecting, Hand Raking	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Study examining the effects of digging for bivalves and worms using a four tined hoe on an intertidal mudflat. Two 1m^2 plots were dug and one 1m^2 plot remained undug as a control plot. The two dug plots were given different digging treatments over the 2.5 month treatment period. The first was dug twice a month (low frequency) and the second was dug twice a week (high density). **Species and community effects:** By the end of the 2.5 month experiment, several species of polychaete showed significantly lower densities and overall total number of taxa was significantly lower at both treatment plots compared to the control plot. However, total number of individuals, total oligochaetes and total densities of *Scoloplos fragilis, Exogone hebes, Hydrobia totteni* , showed no variation between plots.	Brown, B. & Wilson, W.H., 1997. The role of commercial digging of mudflats as an agent for change of infaunal intertidal populations. *Journal of Experimental Marine Biology and Ecology,* **218**, 49-61
Ref Number: 153 **Year published:** 1997 **Peer reviewed?:** Yes **Study Location:** Burry inlet, south Wales Study Dates: October 1992 **Reviewed by:** Sewell & Hiscock 2005	cockle tractor dredge	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Experimental Tractor dredging for cockles was carried out on a cockle bed, previously only harvested by hand raking methods. Six boxes of dredged and control plots were set out in each of two areas, one with high and the other low densities of cockles **Habitat effects:** Approximately 82 % of the dredged area was lifted by the blade of the dredger. **Species and community effects:** Catch consisted almost entirely of adult cockles over 2.5 cm in length. Appreciable losses of smaller cockles and spat were also observed in dredged areas. Spatfall success in 1993 was depressed by 11% on dredged plots compared to that on control plots in the low density area, but was increased slightly in the high density area. Delayed effects of the dredging on cockle stocks were thought to be negligible.	Cotter, A.J.R., Walker, P., Coates, P., Cook, W. & Dare, P.J., 1997. Trial of a tractor dredger for cockles in Burry Inlet, south Wales. *ICES Journal of Marine Science,* **54**, 72-83.
Ref Number: 154 **Year published:** 2003 **Peer reviewed?:**	Hydraulic dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater	Study to examine the long and short term effects of clam fishing with a hydraulic dredge on a deep (70 - 80m) sand bank over a period of three years. The seabed was low relief, with burrows, pits and polychaete tubes. **Habitat effects:** The most obvious effect of dredging was a dramatic change in seabed topography due to the numerous deep (20 cm), wide (4 m) curvilinear furrows that were cut by the dredges. The loss of burrows, tubes, and shells through destruction or burial, and local sedimentation created a smooth surface. After one year, furrows were no longer visible on	Gilkinson, K.D., . Fader, G.B.J., Gordon Jr,D.C., Charron, R., McKeown, D., Roddick, D., Kenchington, E.L.R., MacIsaac, K., Bourbonnais, C., Vass, P., Liu, Q., 2003. Immediate and

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Yes **Study Location:** Banquereau, Scotian Shelf, Canada. **Reviewed by:** Sewell & Hiscock 2005		**Relevant Species:** None	video, but still showed up using sidescan sonograms. **Species and community effects:** Densities of large burrows were reduced by up to 90% after dredging with no signs of recovery after 3 years due to the high mortalities of their architect, the propellerclam, *Cyrtodaria siliqua*.	longer-term impacts of hydraulic clam dredging on an offshore sandy seabed: effects on physical habitat and processes of recovery. *Continental Shelf Research,* **23**, 1315-1336.
Ref Number: 155 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Bay of Fundy, Canada. Study Dates: 1993 **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge	**Relevant Habitats:** Reefs (Subtidal) **Relevant Species:** None	Study examining the effects of scallop dredging fo sea urchins and scallops on the proportion of sea urchins damaged during the harvesting operation, the impact on and subsequent recovery time of the associated benthic flora and epifauna, and the impacts on the bottom substrate. Diver surveys were carried out imediately before and imediately and three and six months after the passage of a scallop dredge. Two sites were chosen, with an experimental and control plot at each site. **Habitat effects:** Boulders of varying sizes were dislodged and overturned by the dredge. **Species and community effects:** At both experimental sites, a decrease in urchin numbers and an increase in broken urchin tests was observed following the harvesting operation. As were significant changes in numbers of predators. The breakage rate of kelp was also increased as a result of dredging. **Further notes:** The observable effects on the bottom from the single dragging event were gone in less than 3 months.	Robinson, S.M.C., Bernier, S.& MacIntyre, A., 2001. The impact of scallop drags on sea urchin populations and benthos in the Bay of Fundy, Canada. *Hydrobiologia,* **465**, 103-114.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 156 **Year published:** 1998 **Peer reviewed?:** Yes **Study Location:** The Exe Estuary, South West England. **Reviewed by:** Sewell & Hiscock 2005	Hydraulic dredge, Mariculture (Shellfish)	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	Report of a long term study, looking at the proccess of cultivating and harvesting the intertidal manila clam *Tapes philippinarum* . The study began with the seeding of the clams, then through on growing and harvesting 30 months later. **Species and community effects:** Early studies revealed that the netting used to cover seeded clams encouraged the growth of certain deposit feeding polychaete species. However the immediate effects of harvesting by suction dredging caused a reduction of infaunal species and their abundance by approximately 80 %. Based on comparison with undredged control plots, sediment structure and infaunal communities at netted and dredged and netted but undredged sites had recoverd within 12 months of harvesting.	Spencer, BE., Kaiser, MJ. & Edwards, DB., 1998. Intertidal clam harvesting: benthic community change and recovery. *Aquaculture Research,* **23**, 429-437.
Ref Number: 157 **Year published:** 2004 **Peer reviewed?:** No **Study Location:** Deep sea coral reefs, Worldwide **Reviewed by:** Sewell & Hiscock 2005	Bottom trawl, Scallop dredge, Gill nets, Longline, Pots or creels, Discarded gear (ghost fishing)	**Relevant Habitats:** Reefs (Biogenic) **Relevant Species:** None	Report on deep sea coral reefs. The relevant section, discusses the main threats to coral reefs, including fisheries. The main types of fisheries that operate over deep-water coral reefs and their impacts are discussed. **Habitat effects:** The main conclusions from this section of the report are: Bottom trawls: beam and otter trawls operating over coral reefs can smash, disrupt, tear, break and effectively flatten coral reefs, reducing the structural complexity of the habitat and reducing the number of associated species. Further damage can also be caused by the resuspension of sediments. Dredges: The effects of dredging for bivalves over deep-water corals are similar to those caused by trawls. Bottom-set gillnets: Physical damage can be caused to the reef by anchors and weights and lost nets (ghost fishing) can continue to catch fish for years after they are lost. In Norway, attempts to retrieve these nets have used gear that is damaging to coral reef areas. Bottom-set longlines: Lines can snag and break-off coral heads especially when hauling in. pots and traps: Although some damage can be caused by impact or snagging, the authors state that the degree of damage caused by this method is much lower than is caused by other fishing methods.	Freiwald, A., Fossa, J.H., Grehan, A., Koslow, T. & Roberts, J.M., 2004. *Cold-water coral reefs.* pp. 37 - 39. UNEP - WCMC, Cambridge, UK.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 158 **Year published:** 2004 **Peer reviewed?:** No **Study Location:** Review and investigation covering UK waters Study Dates: 2003 - 2004 **Reviewed by:** Sewell & Hiscock 2005	Gill nets, Pair trawl	**Relevant Habitats:** None **Relevant Species:** Harbour porpoise, Bottle-nosed dolphin, Other cetaceans	Investigation into by-catch of small cetaceans by the fishing industry operating from the UK coast. **Species and community effects:** The harbour porpoise is particularly susceptable to being caught in bottom-set gill nets due to its benthic foraging behaviour. An independent observer on board Celtic gillnet vessels between 1992 and 1994 estimated that vessels in the 15 m and over sector took around 740 harbour porpoises per year during this period. A similar study of gill and tangle net fisheries in the North Sea comencing in 1994 estimated UK vessels took approximately 1000 porpoises during 1995 and 600 in 2000. Another previous study, reviewed in this report estimates that 200 common dolphins are also taken in the Celtic Sea gill net fishery per year. The report also mentions a large level of common dolphin bycatch from the bass pair-trawl fishery particularly during late February and March. Between 2001 and 2003, the average number of dolphins per trawl was four, with a maximum of ten in one trawl. **Further notes:** The authors write that there is currently little evidence of bottle-nosed dolphins being caught as by-catch in the UK although it is likely that they are still at risk from the same fisheries as the harbour porpoise.	House of Commons Environment, Food and Rural Affairs Committee, 2004. *Caught in the net: by-catch of dolphins and porpoises off the UK coast*. 3rd Report of session 2003 - 2004. The House of Commons, London.
Ref Number: 159 **Year published:** 2003 **Peer reviewed?:** No **Study Location:** Strangford Lough, Northern Ireland **Reviewed by:** Sewell & Hiscock 2005	Various (Not listed)	**Relevant Habitats:** Reefs (Biogenic), Large, Shallow inlets and bays **Relevant Species:** None	Preliminary results of a dive survey to examine the status of *Modiolus modiolous* beds in Strangford Lough. One focus of the survey was to assess whether any recovery of the reefs had taken place since conservation measures to reduce fishing activity were introduced in 1993. **Species and community effects:** The survey found no evidence to suggest recovery of the reefs since 1993. The authors conclude that the reefs are 'no longer in favourable conservation status' and that the use of bottom fished gear poses the most immediate threat to the few remaining clumped *Modiolus* beds within the Lough. In a site zoned for trawling for queenies that had previously contained a *Modiolus* with *Chlamys* biotope, no clumped *Modiolus* remained. Divers also observed very few queen scallops remaining in the area.	Roberts, D. 2003. *Work Package 2 - The current status of Strangford* Modiolus. *KA 2.1: Diving Survey 2003.* Strangford Lough Ecological Change Investigation, Queen's University, Belfast

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 160 **Year published:** 2002 **Peer reviewed?:** Yes **Study Location:** Dutch Wadden Sea **Reviewed by:** Sewell & Hiscock 2005	Mechanical cockle dredge, Mariculture (Shellfish)	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide **Relevant Species:** Wildfowl and waders	Study carried out following unusually high mortality of common eiders in 1999/2000 (approximately 21, 000 birds died). The area surveyed was home to an intense cockle fishery and mussel culture, both reducing the principal food source for the common eider. Dissected eiders showed signs of starvation. **Species and community effects:** Cockle biomass was extremely low during the winter of 1999/2000 , however fishing continued. The remaining cockles were low quality. Stocks of *Spisula* clams in the North Sea (a secondary food source for the common eider) were heavily fished during the end of the summer of 1999 resulting in a loss of 85 % of stock in some areas. The authors conclude that the likely cause of death of the eiders was starvation, resulting in a lack of food caused by overfishing of the eider's principal and secondary food sources.	Camhuysen, C.J., Berrevoets, C.M., Cremers, H.J.W.M., Dekinga, A., Dekker, R., Ens, B.J., van der Have, T.M., Kats, R.K.H., Kuiken, T., Leopold, M.F., van der Meer, J. & Piersema, T., 2002. Mass mortality of common eiders (*Somateria mollissima*) in the Dutch Wadden Sea, winter 1999/2000: starvation in a commercially expoited wetland of international importance. *Biological Conservation,* **106**, 303-317.
Ref Number: 161 **Year published:** 2003 **Peer reviewed?:** No **Study Location:** UK **Reviewed by:** Sewell & Hiscock 2005	Various (Not listed)	**Relevant Habitats:** None **Relevant Species:** Sea Lamprey, Lampern	General review of ecology and conservation of three lamprey species. The review includes very brief explanaitions of threats to the species by exploitation. **Species and community effects:** River lamprey (lampern): Young and adult lampreys are targeted by anglers fo fishing bait where they occur. Young larvae are dug, reducing populations and damaging their habitat. Adults are caught using traps and indiscriminate trapping could damage populations. Sea Lamprey: Similar threats to those described for the river lamprey from anglers are described.	Maitland, P.S., 2003. *Ecology of the river, brook and sea lamprey.* Conserving Natura 2000 Rivers Ecology Series No.5. English Nature, Peterborough.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 162 **Year published:** 1997 **Peer reviewed?:** Yes **Study Location:** Strangford Lough, Northern Ireland Study Dates: 1990 and 1993 **Reviewed by:** Sewell & Hiscock 2005	Otter trawl (demersal), Scallop dredge	**Relevant Habitats:** Reefs (Biogenic), Large, Shallow inlets and bays **Relevant Species:** None	Video surveys (1990) and side scan sonar (1990 and 1993) were used to determine the impact of trawl fisheries on, and epibenthic community associated with *Modiolus modiolus* beds in Strangford Lough. **Habitat effects:** Scars made by otter trawl doors were clearly visible using side-scan sonar. Changes to epibenthos, including evidence of lost mussel beds (broken shells etc) were visible on video surveys. Only one scallop dredge scar was observed, on one occasion during the 1990 survey. Clear evidence was seen that trawling had altered the supperficial structure of sediments in some, heavily trawled areas. Between 1990 and 1993, no evidence was found of temporal change.	Service, M. & Magorrian, B.H., 1997. The extent and temporal variation of disturbance to epibenthic communities in Strangford Lough, Northern Ireland. *Journal of the Marine Biological Association of the United Kingdom,* **77**, 1151-1164.
Ref Number: 163 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Penobscott Bay, Maine, USA **Reviewed by:** Sewell & Hiscock 2005	Shrimp trawling	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Large, Shallow inlets and bays **Relevant Species:** None	Study examining the effects of a trawling disturbance on a soft sediment ecosystem. The study area had not been trawled for 20 years prior to the start of the experiment. Both macrofauna and biogeochemical data was collected quarterly for 1.5 years before experimental dredging. Post trawl samples were taken for a period of 6 months. **Habitat effects:** Sediment porosity reduced significantly imediately after the trawl, but had returned to levels similar to control plots within four months. Chlorophyl *a* content of surface sediments was elevated significantly following the trawl. **Species and community effects:** Immediately after trawling, species abundance, number of species and species diversity decreased significantly in the trawled area. Several species of bivalve and polychaete were found to be particularly sensitive, whilst a species of carnivorous nemertea was found to be resistant, probably on account of its ability to actively seek out freshly dead and dying organisms. **Further notes:** The authors conclude that although the trawling disturbance was low frequency and intensity, compared to commercial operations, the biological variables studied, indicated that succesional proccesses in this habitat had been altered at least for a short period due to trawling disturbance.	Sparks-McConkey, P.J. & Watling, L., 2001. Effects on the ecological integrity of a soft-bottomed habitat from a trawling disturbance. *Hydrobiologia,* **456,** 73-85.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 164 **Year published:** 1992 **Peer reviewed?:** No **Study Location:** Gann Flat, Dale, Pembrokeshire, Wales Study Dates: 1988 **Reviewed by:** Sewell & Hiscock 2005	Bait collecting, angling	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	A survey of the fauna of an intertidal mud/ gravel beach. Distributions of dominant species, which characterised assemblages were compared to similar studies carried out between 1958 and 1959. **Habitat effects:** Based on observations , the authors describe how bait digging brings gravel to the surface, leading to an increase in the gravel content of surface material. Holes dug by bait diggers tend to accumulate fine sediment, resulting in characteristic 'pock marks' surrounded by gravel. The authors note that these decrease in abundance as distance from public access points increases. **Species and community effects:** Several differences were noted between the two surveys. There had been declines in numbers of the polychaetes *Megalomma vesiculosum, Sabella pavonina and Arenicola marina* There had also been a 'dramatic increase' in the abundance of *Nereis virens*. These changes were largely attributed by the authors to an increase in bait digging activity in the area.	Edwards, A. & Garwood, P., 1992. The Gann Flat, Dale: thirty years on. *Field Studiies,* **8**, 59-75.
Ref Number: 165 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** South west coast of the Isle of Man Study Dates: 1995 - 2000 **Reviewed by:** Sewell & Hiscock 2005	Scallop dredge	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	Experimental study, using an area closed to scallop dredgers since 1989. Experimental plots were set up outside the closed area, in an area still exposed to commercial trawling, unfished plots and experimentally trawled plots were also set up inside the closed area. Plots were studied using grab sampling and diver counts of *Pecten maximus*. **Species and community effects:** Benthic communities in experimentally dredged plots became less similar to adjacent undredged sites and more like commercially dredged sites. Since 1989, an increase in numbers of and age of *Pecten maximus* occurred in the closed area.	Bradshaw, C., Veale, L.O., Hill, A.S. & Brand, A.R., 2001., The effect of scallop dredging on Irish Sea benthos: experiments using a closed area. *Hydrobiologia,* **465**, 129-138.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 166 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Saleen estuary, Johnsbrook, SW Ireland. **Reviewed by:** Sewell & Hiscock 2005	Mariculture (Shellfish)	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide **Relevant Species:** Seabirds, Wildfowl and waders	Study examining differences in seabird and wader community composition in an area of oyster cultivation, compared to a control area with no oyster cultivation. Trestles measuring 40cm heigh, 90cm wide and 3m llong were used in an area of one hectare. Of this, an area of 4500 m^2 of trestles was covered with oyster bags. Observations of bird behaviour and counts were carried out. **Species and community effects:** All species observed in the study were seen at both sites. The outcome of the study indicates that oyster structures did not effect the feeding behaviour of the birds and the six species with the most data available did not appear to be affected by the trestles.	Hilgerloh, G., O' Halloran, J.O., Kelly, T.C. & Burnell, G.M., 2001. A preliminary study on the effects of oyster culturing structures on birds in a sheltered Irish estuary. *Hydrobiologia,* **465**, 175-180.
Ref Number: 167 **Year published:** 2000 **Peer reviewed?:** Yes **Study Location:** Review of studies in various locations **Reviewed by:** Sewell & Hiscock 2005	Longline, Gill nets, Discarded gear (ghost fishing), Various (see further notes), Clam dredge, angling	**Relevant Habitats:** Estuaries **Relevant Species:** Wildfowl and waders, Seabirds	Review of direct and indirect threats of fisheries to seabirds, based on existing literature. For the purpose of this review, only issues relevant to species and fishing types used in and around the UK are sumarised here. **Species and community effects:** Long-lines: Due to their feeding behaviour, most surface scavanging sea birds are pre-adapted to follow fishing vessels, feeding on discarded material and steeling bait from hooks. Birds will therefore often become hooked on longlines as they are thrown overboard and drown as the line sinks. North Atlantic cod fisheries using lon-lines are known to take bird bycatch at rates of up to 1.75 birds per 1000 hooks. Although rates may be less if lines are set at night. Gillnets: In the north west Atlantic, a number of species of diving birds, also found in the UK are caught in high numbers by gill nets, while they hunt large shoals of small fish. In Greenland, large numbers of guilemot have been recorded by salmon drift net fisheries. Gillnets set for bass in St Ives Bay, Cornwall have taken an annual by-catch of hundreds, possibly thousand s of razor bill and guillemot. Studies around Wales have shown 'hot spots' of bycatch around bird colonies. **Further notes:** Virtually all types of gear used in bird feeding areas are capable of taking bird bycatch. Birds may become entangled in lost or discarded fishing gear (lines and nets). Studies of dead bird strandings have shown that large numbers of gannets and cormerants are killed by lost fishing gear in the North Sea. Gannets are known to build nests using nylon line. As a result, adults and chicks may become entangled and die of starvation. Studies have shown that sustained disturbance to birds in estuaries by bait diggers can lead to shifts of birds to alternative areas. If there is insufficient food in these location, birds may die. Clam dredgers operating on banks used as feeding grounds by the common scoter in the southern North Sea may have led to disturbance and food depleation of the seaduck species. Overfishing of predatory fish can lead to higher numbers of small forage fish and benefit predatory birds. Conversly, fisheries targetting small forage fish such as herring, sprat and sand eels may reduce the food available for predatory birds, reducing bird numbers and breeding performance. Shellfisheries for mussels and cockles in the Wadden sea have resulted in extra mortalitry of common eiders and oystercatchers. A study also showed that the presence of mussel fishers on a UKmudflat forced oystercatchers away from their prefered food source to feed on earth worms in nearby fields if this switch was unsuccesful the birds died. Some species of bird profit from discards by the fishing industry in the	Tasker, M.J., Camphuysen, C.J., Cooper, J., Garthe, S., Montececchi, W.A. & Blaber, S.J.M., 2000. The impact s of fishing on marine birds. *ICES Journal of Marine Science,* **57**, 531-547.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
			North Sea.	
Ref Number: 168 **Year published:** 2000 **Peer reviewed?:** No **Study Location:** North Sea **Reviewed by:** Sewell & Hiscock 2005	Trawling	**Relevant Habitats:** None **Relevant Species:** Seabirds	The paper examines the provision of discards and offal as a food source for sea birds, Overfishing of large predatory fish and overfishing of small fish by commercial fisheries. The aim was to explore the hypothesis that the recent increased range of many seabirds in the North Sea was influenced by commercial fisheries. **Species and community effects:** *Larus* gulls used discards to a considerable extent. Black-legged kittiwakes largely ignored discards and prefered to feed on small, live fish. Non-breeding birds used discards most frequently. Nesting birds made a greater effort to feed on natural resources this may be related to reduced breeding success resulting from a diet consisting of high amounts of discards. The authors found no evidence that seabirds profited from the removal of predatory fish. Several examples show how overfishing of certain stocks can reduce the reproductive output of some seabirds.	Camphuysen, C.J. & Garthe, S., 2000. Seabirds and commercial fisheries: population trends of piscivorous seabirds explained? *The Effects of Fishing on Non-target Species and Habitats: Biological, onsevation and socio-economic issues.* (ed. M.J. Kaiser & S.J. de Groot), pp. 163-184. Oxford: Blackwell Science.
Ref Number: 169 **Year published:** 2003 **Peer reviewed?:** No **Study Location:** Scottish sea lochs Study Dates: 1999 - 2004 **Reviewed by:** Sewell & Hiscock 2005	Mariculture (finfish)	**Relevant Habitats:** Large, Shallow inlets and bays **Relevant Species:** None	Interim report giving some results of a five year project, examining the ecological effects of some medicines used to control sealice in salmon aquaculture. Aspects measured include settlement of flora and fauna on settlement panels, studies of meiofauna and macrofauna in sediments, phytoplankton and zooplankton sampling and analysis. **Species and community effects:** Although the analysis of samples is not yet complete, preliminary findings indicate that there has not been any catastrophic perturbation of the sea lochs studied. This indicates that if these medicines have ecosystem effects they are either difficult to separate from the natural variability present in such systems or are below the limits of detection of the methods currently available.	Black, K.D., Blackstock, J., Gillibrand, P., Moffat, C., Needham, H., Nickell, T.D., Pearson, T.H., Powell, H., Sammes, P., Somerfield, P. and Willis, K., 2003. *The Ecological Effects of Sealice Medicines, Interim Public Report.* Scottish Association for Marine Science, Aberdeen.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 170 **Year published:** 2003 **Peer reviewed?:** Yes **Study Location:** Cornwall, south west England **Reviewed by:** Sewell & Hiscock 2005	Trawling	**Relevant Habitats:** None **Relevant Species:** Grey seal	Study examining conflicts between grey seals and fishermen in a Cornish trawl fishery. The report examines the 'economic value' of seals and includes analysis of the impact of fishing on the local grey seal population. **Species and community effects:** About 80 individuals belonging to the Cornish Grey Seal population (of about 400 specimens) are killed as a by-catch of trawling annually. **Further notes:** Fishers estimate that grey seals cost the fishery £100 000 annually because of damage to caught fish. The annual non-use value of seals - i.e. value unassociated with actual viewing - was found to be £526 000 in the most conservative estimation. The authors suggest that this income may be used to compensate local fishermen for their losses.	Bosetti, V.. & Pearce, D., 2003. A study of environmental conflict: the economic value of Grey Seals in southwest England. *Biodiversity and Conservation,* **12**, 236-392.
Ref Number: 171 **Year published:** 2000 **Peer reviewed?:** No **Study Location:** UK waters **Reviewed by:** Sewell & Hiscock 2005	Various (see further notes)	**Relevant Habitats:** None **Relevant Species:** Turtles	Review of marine turtle bycatch from UK waters, based primarily on data held in the database 'TURTLE', which contains 712 historic records of turtle sigtings, strandings and bycatch from UK and Irish waters. **Species and community effects:** Five species of marine turtle have been recorded from UK waters (all of these are listed in annex IV of the habitats directive). Occurances of bycatch by various fishing types are discussed. Fixed gears, towed gears, driftnets ropes and lines associated with ot fisheries are all implicated as sources of turtle bycatch throughout the ranges of the turtles. Fishing may effects turtles from coastal waters to deep pelagic waters.	Pierpoint, C., 2000. *Bycatch of marine turtles in UK and Irish waters.* JNCC Report No 310

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 172 **Year published:** 2004 **Peer reviewed?:** No **Study Location:** UK and Eire **Reviewed by:** Sewell & Hiscock 2005	Salmon net	**Relevant Habitats:** None **Relevant Species:** Turtles	Report ducumenting sightings and strandings of marine turtles during 2003. **Species and community effects:** During 2003, only one turtle was reported as bycatch. An individual leatherback turtle was found alive and released unharmed from a salmon net in Eire.	Penrose, R.S., 2004. *UK & Eire marine turtle strandings & sightings annual report 2003.* Marine Environmental Monitoring, Cardigan, West Wales.
Ref Number: 173 **Year published:** 2003 **Peer reviewed?:** No **Study Location:** Wales **Reviewed by:** Sewell & Hiscock 2005	Trawling, angling, Salmon net	**Relevant Habitats:** Estuaries, Large, Shallow inlets and bays **Relevant Species:** Twaite shad, Allis shad, Sea Lamprey, Lampern	Review of ecology and distribution of both species of shad and both species of anadromous lamprey found in Welsh coastal waters. The report includes descriptions of threats to the species and this includes some reference to threats from fishing activities. Species and community effects: Twaite shad and allis shad: Probably the most important fishing related mortalities are from fish traps, particularly putcher net fishermen targeting salmon near Lydney. Fixed net shrimp fishermen also catch occasional fish. Shad are regularly reported in trawl catches and due to the high levels of trawling in some regions, this may cause considerable losses. These species may also be caught as bycatch during bass trawling. The authors note that herring stocks around Wales are improving and should a fishery for this species recomence, it may pose a significant threat to this species. River lamprey: The most important fishing related mortality of this species are caused by fish traps in estuarine waters. Accidental capture by trawling in marine waters appears to be rare. The species is likely to escape through the mesh of commercial nets due to their size and shape. Sea lamprey: The most important fishing related mortality of this species are caused by fish traps in estuarine waters were they concentrate during upstream spawning migrations. Catches in trawls are rare. Reduction in numbers from historical levels may be due to reduced abundance of the favoured prey species including the salmon, sea trout and possibly the shad from coastal waters.	Henderson, P.A., 2003. *Background information on species of shad and lamprey.* Bangor,Countryside Council for Wales Marine Monitoring report no: 7.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 174 **Year published:** 1970 **Peer reviewed?:** No **Reviewed by:** Sewell & Hiscock 2005	Hand gathering	**Relevant Habitats:** Reefs (intertidal), Large, Shallow inlets and bays **Relevant Species:** None	The report includes description of recovery of *Ascophyllum nodosum* following hand gathering. **Species and community effects:** If stumps of harvested *Ascophyllum* are left at 10 - 20 cm, re-sprouting will occur and the plant will be harvestable after 3 - 6 years. If the whole plant is taken, recovery is slow due to slow recolonisation.	Baardseth, E., 1970. Synopsis of the biological data on knotted wrack *Ascophyllum nodosum* (L.) Le Jolis. *FAO Fisheries Synopsis*. 38. Rev. 1.
Ref Number: 175 **Year published:** 1971 **Peer reviewed?:** yes **Reviewed by:** Sewell & Hiscock 2005	Hand Raking	**Relevant Habitats:** Reefs (intertidal) **Relevant Species:** None	Study examining ecology and effects of collection on two species of red seaweed **Species and community effects:** Drag raking for *Chondrus crispus* can cause long-term changes to community structure where it occurs. It may take 18 months for *Chondrus crispus* to recover from this impact.	Mathieson, A.C. & Burns, R.L., 1971. Ecological studies of economic red algae. 1. Photosynthesis and respiration of *Chondrus crispus* (Stackhouse) and *Gigartina stellata* (Stackhouse) Batters. *Journal of Experimental Marine Biology and Ecology*, **7**, 197-206.
Ref Number: 176 **Year published:** 1993 **Peer reviewed?:** yes **Study Location:** Prince Edward Island, Canada **Reviewed by:** Sewell & Hiscock 2005	Hand Raking	**Relevant Habitats:** Reefs (intertidal) **Relevant Species:** None	Study examining the effects of commercially harvesting seaweeds.	Sharp, G.J., Tetu, C., Semple, R. & Jones, D., 1993. Recent changes in the seaweed community of western Prince Edward Island: implications for the seaweed industry. *Hydrobiologia*, **260-261**, 291-296.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 177 **Year published:** 1999 **Peer reviewed?:** No **Study Location:** UK **Reviewed by:** Sewell & Hiscock 2005	Various (see further notes)	**Relevant Habitats:** Coastal lagoons, Reefs (Biogenic), Reefs (Subtidal), Reefs (intertidal), Large, Shallow inlets and bays, Mud and sandflats not covered by seawater at low tide, Seagrass beds, Maerl Beds, Estuaries, Sandbanks which are slightly covered by seawater **Relevant Species:** Harbour porpoise, Bottle-nosed dolphin, Allis shad, Twaite shad, Other cetaceans, Turtles	Biodiversity Action Plans for various UK marine habitats and species. Relevant points are briefly sumarised below. Action Plans are either Grouped Species Action Plans, Species Action Plans, Priority Habitat Action Plans or broad habitat action plans. **Species and community effects:** Species Action Plans: The harbour porpoise *Phocoena phocoena* is vulnerable to incidental capture in fishing gear (unspecified). the pink seafan *Eunicella verrucosa* is sensitive to entanglement in fishing gears and resulting damage to soft tissues sometimes resulting in the death of colonies. The species may also be impacted by intensive potting and netting and direct collection as souvenirs. The fan shell *Atrina fragilis* is extremely vulnerable to mobile fishing methods. There is evidence that the bivalve has been wiped out in areas where scallop dredging takes place. Although they can survive some physical damage to the anterior end of the shell by mobile gears, they cannot survive removal from the sea bed. The native oyster *Ostrea edulis* has been severely impacted by the introduction of non-native species and diseases associated with bivalve mariculture. Over fishing has also severely impacted native oyster populations around the UK. The filamentous red algae *Anotrichium barbatum* found on gravel and pebbles in Cardigan Bay may be vulnerable to bottom trawling. Detached knotted wrack, *Ascophyllum nodosum* is directly collected for alginates and collection has led to the 'decimation' of populations in the Uists. Grouped Species Action Plans: It is likely that commercial fisheries reduce the availability of prey species for piscivorous baleen whales, particularly the minke whale *Balaenoptera acutorostrata* and several species of toothed whale, although demonstrating such effects is extremely difficult. Entanglement in fishing gear (unspecified) is known for some species of baleen whale, but is not considered to be a significant problem in the UK. In the approaches to the English Channel and the Celtic Sea, common and white sided dolphins are caught in substantial numbers in pelagic trawls. Between 1992 and 1993, 1200 striped and 500 common dolphins were caught by French drift-net fisheries between southern Ireland and the Azores. Between 1990 and 1995, post-mortem studies on 138 stranded common dolphins revealed that at least 62 % had been killed as a result of bycatch. Turtles are vulnerable to incidental entanglement in fishing gear and drowning. Damage to deep-water *Lophelia* reefs by various fisheries can reduce the habitat available and adversly affect a range of deep-sea fish species. Habitat action plans: *Sabelaria alveolata* reefs can be damaged by trampling associated with fishing and collection of shore animals. Individual worms are also occasionally extracted and used as fishing bait. Mudflats may be adversly affected by fishing activities and bait collection. Bycatch of juvenille flatfish in shrimp fisheries could be a problem as could bycatch associated with hydraulic dredging for shellfish. Sheltered muddy gravels, found mostly in estuaries, inlets and bays are subjected to bivalve fisheries, which are currently small but may increase in the future. These habitats are also vulnerable to invasion by non-native slipper limpets associated with bivalve mariculture. Dredging for oysters and mussels, trawling for shrimp or fin fish, net fishing and potting can all cause physical damage to erect *Sabellaria spinulosa* reef communities and fisheries are thought to be the most important threat to this type of habitat. In the past, shrimp fishers have been known to actively seek out and fish over reefs for the pink shrimps *Pandalus montagui.* Fishing with mobile gears has been very destructive to horse mussel beds in the past, leading to the destruction of beds in Strangford Lough and of the coast of the Isle of Man. Trawls and dredges can 'flatten' clumps causing fatalities and a loss of associated fauna. Physical disturbance associated with trampling and fishing can be damaging to seagrass beds as can the effects of non native species introduced by bivalve mariculture. Mobile fishing gear, especially scallop dredges can devastate maerl beds by breaking and burying the thin layer of living	UK Biodiversity Group., 1999. *Tranche 2 Action Plans - Volume V: Maritime species and habitats*. UK Biodiversity Group

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
			maerl and have been particularly damaging in the Clyde Sea. Deepwater mud habitats (below 20 - 30 metres deep) are subject to potting and dredging for *Nephrops*. Mobile gears extract non-target organisms and disturb the seabed, whilst pots and creels are far less damaging. Marine fish farms sited above deep mud can affect the seabed by causing smothering and increased biological oxygen demand in mud. The tall sea pen *Funiculina quadrangularis* is susceptible to damage by mobile gears and is not found in *Nephrops* trawling grounds in the North Sea. Serpulid reefs are large and fragile and may be susceptible to damage by mobile fishing gears and anchors. They may also be damaged by direct impact from large pots or creels. Sublittoral sands and gravels are impacted by a wide range of fishing types. Some species occuring in these habitats (e.g scallops) are extracted directly by fisheries, others are removed as bycatch. Large, slow growing species are sensitive to fishing disturbance, whilst species inhabiting already perturbed seabeds are usually more resiliant. The removal of predators and competitors may effect the ecological functions within communities. Demersal trawls can break of larg pieces of *Lophelia* reef and repeated use of heavy 'rock-hopper' gear is known to flatten large areas of reef.	
Ref Number: 178 **Year published:** 2003 **Peer reviewed?:** Yes (see ref 179) **Study Location:** Menai Strait and Conwy Bay, Wales **Reviewed by:** Sewell & Hiscock 2005	Mariculture (Shellfish), Mussel Dredge	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays, Reefs (Subtidal), Sandbanks which are slightly covered by seawater **Relevant Species:** Wildfowl and waders	Review of the known and potential impacts of mussel cultivation, with particular reference to fisheries operating in two candidate SACs in Wales. **Habitat effects:** <u>Mussel seed collection:</u> Seed mussels are dredged from the seabed using small, light-weight dredges. This takes place only when a sufficient amount of mussel mud has developed beneath the mussels to allow easy removal of mussel seed with minimal physical impact on the original substratum. As a result, it is thought that the original substratum is not significantly impacted by this practice. Any effect of seed collection is likely to be limited as the resource is naturally, regularly lost to disturbance events. <u>Effects of faecal and pseudofaecal waste</u>: Bio deposition of these fine sediments leads to build-up of mussel mud to form mussel beds raised from the natural seabed. High organic content of deposits may lead to anoxic conditions and increased sulphate levels, but may represent an important food source for infauna. During harvesting, routine dredging and maintainance of mussel beds, plumes of sediment may be resuspended for up to an hour. This adds nutrients and oxygen consuming substances to the water column and may settle over the surrounding area, potentially having detrimental effects on any species sensitive to smothering. <u>Changes in nutrient flux</u>: Mussels cycle nutrients through their own metabolism and through bacterial decomposition within the mussel bed. This leads to nutrient fluxes within the beds that tend to be higher than sediment without bivalve beds. The ecological consequences of these processes is not yet known. <u>Impacts of harvesting:</u> Because the mussel beds are not natural and are replenished soon after dredging with new seed mussels, direct impacts of dredging are minimal. Resuspended sediment plumes have the potential to effect species sensitive to high sediment loads and may release high levels of nutrients into the surrounding water. Hand gathering instead of mechanical harvesting will reduce this impact. However, access to the sites by foot my effect the site by trampling and increased disturbance to birds. **Species and community effects:** <u>Mussel seed collection</u>: It is possible that the removal of mussel seed will remove a source of food for a number of predatory species, including several bird and fish species. In the Wadden Sea, removal of mussel seed beds has in the past had negative impacts on wild bird populations. <u>Change in benthic communities:</u>Following seeding on a suitable substrate, mussels grow and form a secondary habitat	Beadman, H.A., 2003. *Impact of mussel cultivation with special reference to the Menai Strait and Conwy Bay candidate Special Area of Conservation*. CCW Contract Science Report No: 580. Countryside Council for Wales

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
			composed of layers of mussels with accumulated mud and faeces. This can either enhance or degrade the infauna within or beneath the mussel matrix. The mussels can create a more complex habitat, and an organically enriched sediment capable of supporting a wide diversity of organisms. The mussels themselves may also provide a source of food for a number of predatory animals. Conversly, mussel beds can also reduce the diversity of infanal organisms through smothering, competition, anoxia and removal of larvae from the water by filter feeding. At high levels, these negative impacts of mussel beds can outweigh the positive effects and the impact that that these beds can have is dependant on the biomass of mussels in the bed. Studies in the Menai Strait indicate that impacts may impact surrounding sediments for hundreds of metres. Impacts of mussel beds on phytoplankton: Mussel beds can reduce phytoplankton biomass in the surrounding water column. Non-selective filter feeding can also have the effect of skewing natural communities towards smaller, faster growing species. Mussel beds can also increase phytoplankton growth through the recycling of nutrients into the water culumn. Increased food supply for predators: It is possible that mussel beds have a positive effect on populations of predatory species, including oystercatchers, common starfish and the common shore crab by providing an extra food resource. **Further notes:** This report has also been peer reviewed by Rees *et al* (2004) [179]	
Ref Number: 179 **Year published:** 2004 **Peer reviewed?:** No **Study Location:** Peer review of report based on Menai Strait and Conwy Bay, Wales. **Reviewed by:** Sewell & Hiscock 2005	Mariculture (Shellfish)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater, Estuaries, Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** None	Peer review of a report [178] examining the impacts of mussel seabed-lay bottom cultivation. The authors provide a review of the report, which includes identifying whether the impacts of this activity have been correctly identified and highlighting any potential impacts that may have been omitted from the 2003 report. Relevant points additional to those in Beadman (2003[178]) are included below. **Habitat effects:** During a study in the Netherlands, the hypothesis that mussel seed removal increases the stability of sediments was tested. It was discovered that although increased stability was not observed, fished areas had the same numbers of mussels as unfished reference sites after a winter, indicating that the number of seed mussels taken by fisheries was roughly the same as was removed naturally by winter storms. However, it is also pointed out that studies elswhere indicate that if left, mussel seed is not 'lost' but dispersed to other locations and extraction from these beds may restrict the natural colonisation of other suitable sites. Removal of shell and seed mussels from areas of the seabed may also reduce natural recruitment of mussel in following years. Cultivated mussel beds are removed regularly for harvesting and are therefore different to natural beds as far as long term changes to benthic communities are concerned. Cultivated mussel beds are thought to be effective in controling eutrophication by removing nutrients from the water. The effect that the resuspension of sediment caused by dredging is likely to have on the surrounding benthic community will certainly be influenced by the tidal stage at which dredging takes place. Shellfish re-layed from some locations may act as vectors for the introduction of harmful non-native species.	Rees, E.I.S., Dare, P., Domer, P. & Smaal, A.C., 2004. *Peer review of a CCW commisioned report: Beadman, H. (2003) Impacts of mussel seabed-lay bottom cultivation, with special reference to the Menai Strait and Conwy bay candidate special area of conservation*. CCW Contract Science Report No: 657. Countryside Council for wales.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 180 **Year published:** 2002 **Peer reviewed?:** No **Study Location:** Menai Strait, North Wales. **Reviewed by:** Sewell & Hiscock 2005	Bait collecting	**Relevant Habitats:** Large, Shallow inlets and bays, Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	Study examining the effects of crab tiling on soft sediment, benthic communities. Three treatments were used and the experiment lasted for five months. 'Tile plots' had ridge tiles placed on them and were tended twice weekly to simulate bait collection. 'Trampling plots' Were walked over twice weekly, but had no tiles. And control plots were left untouched. Core samples were taken before treatments and at subsequent 7 week intervals. Tiles were 'fished' for crabs twice weekly and measurements and observations were made of all crabs found. Observations of other flora and fauna within each plot were also made. **Habitat effects:** Sediment composition was not effected by trampling nor the presence of tiles. **Species and community effects:** Core sampling revealed a rapid decrease in number of individuals of all taxa under tiles during the first 45 days. This was attributed directly to the presence of the tiles as overall abundance increased in control and trampling sites during this period. The substantial decrease continued throughout the experiment. Although, abundance of individuals also decreased significantly in trampled sites, this was markedly less than reductions caused by the presence of tiles. The number of taxa present was reduced under tiles, but not significantly in trampled plots. Neither tiles nor trampling effected species richness or diversity over the course of the experiment. Multivariate analysis of community showed that tiles had a greater impact on infaunal community structure than trampling. The presence of mature crabs declined from an average of five crabs per 10 tiles in the first month of the experiment to a much lower level at the end of the experiment. Crab tiles appeared to act as a refuge for juvenille (first year) shore crabs.	Cook, W., Jones, E., Wyn, G. & Sanderson, W.G., 2002. *Experimental studies on the effects of shore crab collection using artificial shelters on an intertidal sandflat habitat*. CCW Contract Science Report No 511. Countryside Council For Wales
Ref Number: 181 **Year published:** 2002 **Peer reviewed?:** No **Study Location:** Burry Inlet, Wales **Reviewed by:** Sewell & Hiscock 2005	Cockle fishery (mixed)	**Relevant Habitats:** Mud and sandflats not covered by seawater at low tide, Large, Shallow inlets and bays **Relevant Species:** Wildfowl and waders	Study using a modelling approach to identify how the removal of 'mussel crumble' from a cockle bed in the Burry Inlet would affect overwintering populations of the *Haematopus ostralegus*. The study aimed to identify whether birds in the inlet are food limited under current conditions and to predict any ornithological implications of changes in shellfishing activity **Species and community effects:** The simulations indicated that removal of 'mussel crumble' and a change to a cockle fishing regime would be unlikely to effect oystercatcher numbers. It was also suggested that fishing practices that reduce shellfish numbers, but do not reduce the area covered by shellfish beds are less likely to have a negative effect on bird populations than fishing practices that reduce the area covered by shellfish. This is due to the increased bird density and interference competition that may occur as a result of reduced shellfish-bed area. **Further notes:** The study was undertaken in response to a request by the cockle fishing industry to remove 'mussel crumble' as it was likely to be reducing their fishing resource by smothering cockle beds.	Rimington, N., 2002. *The relationship between mussel and oystercatcher populations in the Burry Inlet, Part 2*. CCW Contract Science Report No 491

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 182 **Year published:** 2003 **Peer reviewed?:** No **Study Location:** Morecombe Bay, northwest England. **Reviewed by:** Sewell & Hiscock 2005	Hand gathering, Cockle fishery (mixed)	**Relevant Habitats:** Large, Shallow inlets and bays, Mud and sandflats not covered by seawater at low tide **Relevant Species:** Wildfowl and waders	Description of cockle fishing practices in Morecombe Bay. The author describes his observations of changes to the cockle industry, also management response and social issues related to the changing cockle fishery. The report describes how the cockle fishing industry changed from a relatively small scale fishery prior to 2002 to a large scale fishery with over 400 hand gatherers working beds at the peak of activity. Large vessels, usually used for suction dredging were dried out on cockle beds and used to collect and transport large tonne bags of cockles gathered by large numbers of people from the shore. At times, up to four vessels were operating at a time. **Species and community effects:** Although no environmental effects are described in this article, the author notes that the area is designated as an SPA for its important bird life and an SAC for other wildlife and effects that the fishing activity has on these features have implications for fisheries management.	Andrews, J., 2003. Sands of change. Portrait of the cockle fishery in Morecombe Bay: November 2002 - October 2003. *Shellfish News*. **16**. 21-24.
Ref Number: 183 **Year published:** 1997 **Peer reviewed?:** No **Study Location:** Review, British waters **Reviewed by:** Sewell & Hiscock 2005	Mariculture (Shellfish)	**Relevant Habitats:** Reefs (intertidal), Reefs (Subtidal), Large, Shallow inlets and bays, Estuaries, Seagrass beds, Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	A review of non-native marine species found in British waters, including detailed information on each species. The report indicates that the greatest single source of non-native species in British waters (31.4 %) have been by associated unintentional introduction with mariculture. 7.8 % have been introduced by deliberate commercial introduction. Only species introduced by these methods (relevant to this report) and their effects on relevant species and habitats are described. **Species and community effects:** It has been suggested that the phytoplankton species *Coscinodiscus wailesii* may have been introduced to UK waters from the Indian and Pacific oceans with miported oysters. When large numbers are reached, skeletons and minerals can 'blanket the seabed. The red algal species, *Asparagopsis armata, Bonemaisonia hamifera, Grateloupia doryphora, Grateloupia filicina, Agardhiella subulata* and *Antithamnionella spirographidis*, also the brown algae *Colpomenia peregrina* are all thought to have been possibly introduced to European waters unintentionally with shellfish (most often oysters). The impacts, they are likely to have on the environment are however unknown. Another red algae *Polysiphonia harveyi* is known to have been introduced with oysters. It grows quickly on hard substrates and may displace native species. The brown algae *Undaria pinnatifida* may cause the displacement of native species on hard substrates and japweed *Sargassum muticum* is known to cause the displacement of native species including eelgrass and rockpool species. Both species are thought to have been introduced with non-native oysters. The green algae *Codium fragile* is thought to have been introduced with shellfish and displaces the native species *Codium tomentosum.* The gastropod *Crepidula fornicata* was introduced with the American oyster. It competes with native, filter feeding invertebrates for food and space and encuorages the deposition of mud, rendering the substrate unsuitable for the settling of spat oysters. The American oyster drilll *Urosalpinx cenerea* was also introduced with American oysters. It predates native oysters and can consume up to 40 oyster spat per year. Two species of non-native oyster have been deliberately introduced to British waters *Crassostrea gigas* and *Tiostrea lutaria*, however neither are thought to have had a significant environmental impact. In the USA, *C. gigas* is known to have settled in dense agregations and displace native species. The American Hard-shelled clam *Mercenaria mercenaria* was deliberately introduced and now, fishing for the species can have a negative impact on seagrass beds. It is also likely that the presence of this species prevented the reestablishment of the native species *Mya* following a die of caused by cold weather.	Eno, N.C., Clark, R.A. & Sanderson, W.G., 1997. *Non-native marine species in British waters: a review and directory*. Joint Nature Conservation Committee, Peterborough.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 184 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Grand banks, Canada **Reviewed by:** Sewell & Hiscock 2005	Otter trawl (demersal)	**Relevant Habitats:** Sandbanks which are slightly covered by seawater **Relevant Species:** None	A three year study on a deepwater (120 - 146 m), sandy bottom ecosystem that had not been trawled for 12 years. Two 13 km long corridors were trawled 12 times a year within a five day period, using an 'Engel 145' otter trawl. **Species and community effects:** Most prominent feature of the data was a natural decline in the total number of species, the total abundance and biomass of selected species between 1993 and 1995. In 1994 however, the abundance of 13 species, the biomass of 11 species (mostly polychaetes) and the total abundance per grab reduced significantly in trawled areas compared to untrawled areas. The authors found little evidence of trawling effects. **Further notes:** The authors conclude that any trawling disturbance, which was indicated, appeared to mimic natural disturbance, shifting the community in the same direction, when a multidimensional scaling ordination was used. The authors warn against the uncritical extrapolation of the results of this experiment to commercial fishing. They advise that further studies of more extensive commercial scale fishing may reveal substantial impacts, particularly if some of the larger, more fragile species damaged in this experiment prove to have important functions in shapnig community structure.	Kenchington, E.L.R., Prena, J., Gilkinson, K.D., Gordon, Jr, D.C., MacIsaac, K., Bourbonnais, C., Schwinghamer, P.J., Rowell, T.W., McKeown, D.L. & Vass, W.P., 2001. Effects of experimental otter trawling on the macrofauna of a sandy bottom ecosystem on the Grand Banks of Newfounland. *Canadian Journal of Fisheries and Aquatic Sciences,* **58**, 1043-1057.
Ref Number: 185 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Kawau Bay, North Island, New Zealand **Reviewed by:** Sewell & Hiscock 2005	Various (see further notes)	**Relevant Habitats:** Large, Shallow inlets and bays, Sandbanks which are slightly covered by seawater **Relevant Species:** None	Authors studied the relationship between macrobenthic species diversity and habitat complexity at 10 spatially separate sites. Experiments were carried out in a 10 - 20m deep large embayment, composed mainly of simple, soft-sediment habitats, varying in sediment and structure. **Species and community effects:** The findings of the report strongly suggest that biodiversity is directly related to habitat complexity and that human activities (particularly trawling and dredging) that remove epifauna and lead to habitat homogenisation will reduce biodiversity in soft bottomed habitats.	Thrush, S.F., Hewitt, J.E., Funnell, G.A., Cummings, V.J., Ellis, J., Schultz, D., Talley, D. & Norkko, A., 2001. Fishing disturbance and marine biodiversity: role of habitat structure in simple soft-sediment systems. *Marine Ecology Progress Series,* **221**, 255-264.
Ref Number: 186 **Year published:** 2001 **Peer reviewed?:** Yes **Study Location:** Southern Italy **Reviewed by:**	Hand gathering	**Relevant Habitats:** Reefs (Subtidal) **Relevant Species:** None	The study examined the effect of collecting the European date mussel L*ithophaga lithophaga* along a 360 km stretch of coast. **Habitat effects:** Physical damage to rocky substrate was extremely widespread. **Species and community effects:** Based on changes to community structure, damage caused by the collection of the European date mussel was found to be extremely widespread.	Fraschetti, S., Bianchi, C.N., Terlizzi, A., Fanelli, G., Morri, C. & Boero, F., 2001. Spatial variability and human disturbance in shallow subtidal hard substrate assemblages: a regional approach *Marine Ecology Progress Series,* **212**, 1-12.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Sewell & Hiscock 2005				
Ref Number: 187 **Year published:** 1984 **Peer reviewed?:** No **Study Location:** Mumbles Head, Swansea **Reviewed by:** Sewell & Hiscock 2005	Hand gathering, Bait collecting	**Relevant Habitats:** Reefs (intertidal) **Relevant Species:** None	Based on summary in Fowler (1999) (in main references). Study examined the impact of boulder turning when searcing for pealer crabs. **Habitat effects:** Up to 90 % of all boulders along a transect at the study site could be turned over witin a two week period and during the summer, some boulders may be turned 40-60 times. 60 % of boulders are not replaced in their original position. Larger boulders, 'upended' and not over turned completely are most likely to be left as they were found.	Bell, D.V., Odin, N., Austin, A., Hayhow, S., Jones, A., Strong, A. & Torres, E., 1984. *The impact of anglers on wildlife and site amenity.* Department of Applied Biology, UWIST, Cardiff.
Ref Number: 188 **Year published:** 1989 **Peer reviewed?:** No **Study Location:** Mumbles and Oxwich **Reviewed by:** Sewell & Hiscock 2005	Bait collecting, Hand gathering	**Relevant Habitats:** Reefs (intertidal) **Relevant Species:** None	Based on summary in Fowler (1999) (in main references). Study examining the effect of overturning boulders for the collection of peeler crabs etc. **Habitat effects:** During periods of reasonably low tides at both study sites, 3,000 rocks were overturned. An unknown number of these involved repeated turning of the same rocks. No 'serious' collector was seen to replace rocks in their original position. The chief result of this activity was thought to be the loss of habitat stability. **Species and community effects:** The loss of habitat stability due to the turning of boulders was thought to affect the range of species present.	Liddiard, M., Gladwin, D.J., Wege, D.C. & Nelson-Smith, A., 1989. *Impact of boulder-turning on sheltered sea shores.* Report to the Nature Conservancy Council. School of Biological Sciences, University College of Swansea. NCC CSD Report 919.
Ref Number: 189 **Year published:** 1984 **Peer reviewed?:** No **Study Location:**	Hand gathering, angling, Bait collecting	**Relevant Habitats:** Reefs (intertidal) **Relevant Species:** None	A review of the geographical distribution of the *Sabellaria alveolata* including looking at the effects of trampling on *Sabellaria alveolata* reefs. This trampling might be associated with angling, bait collection and gathering intertidal organisms. **Species and community effects:** Following the damaging effects of trampling, worms are often unaffected and may be able to rebuild their tubes rapidly.	Cunningham, P.N., Hawkins, S.J., Jones, H.D. & Burrows, M.T., 1984. *The geographical distribution of* Sabellaria alveolata *(L.) in England, Wales and Scotland, with investigations into the community structure of and the effects of trampling on* Sabellaria alveolata *colonies.* Nature Conservancy Council,

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Reviewed by: Sewell & Hiscock 2005				Peterborough, Contract Report no. HF3/11/22.
Ref Number: 190 **Year published:** 1999 **Peer reviewed?:** Yes **Reviewed by:** Sewell & Hiscock 2005	Trawling	**Relevant Habitats:** Reefs (Subtidal) **Relevant Species:** None	Review of the biology of deep water coral reefs, particularly *Lophelia pertusa*, including an extensive review of impacts from human activities. One section describes the potential and know impacts of deep-sea fishing. **Habitat effects:** Physical damage caused by trawling will damage the three-dimensional structure of the reef resulting in reduced habitat complexity. **Species and community effects:** Deep sea fishing is considered to be one of the main threats to *Lophelia* reefs in the North-east Atlantic and is known to have had significant impacts on reefs in other parts of the world. Many of the deep-sea fish species targeted by fishermen in these areas are also particularly sensitive to overfishing due to their long life-history characteristics. Disturbance to the reef may result in an'alternative low diversity 'disturbance community', particularly following high intensity trawling. Corals are also likely to be damaged by the settlement of resuspended sediments.	Rogers, A.D., 1999. The biology of *Lophelia pertusa* (Linnaeus, 1758) and other deep-water reef-forming corals and impacts from human activities. *International Review of Hydrobiology,* **84**, 315-406.
Ref Number: 191 **Year published:** 2004 **Peer reviewed?:** No **Study Location:** Devon, England Study Dates: 2003-2004 **Reviewed by:** Sewell & Hiscock 2005	Bait collecting	**Relevant Habitats:** Estuaries, Mud and sandflats not covered by seawater at low tide **Relevant Species:** None	Survey of crab tiling activity in a number of South Devon's estuaries. **Further notes:** In 1999-2001, 73,392 crab tiles were counted, however this figure had increased by 3,685 in 2004.	Black, G., 2004. *Report on Surveys in 2003/04 of Crab Tiling Activity on Devon's Estuaries and Comparison with 2000/01 Crab Tile Survey Data,* Devon Biodiversity Records centre, Exeter.

Reference details	Fishing types	Habitats and species	Description of relevant aspects of the reference	Full reference
Ref Number: 192 **Year published:** 2004 **Peer reviewed?:** No **Study Location:** Solway Firth, Scotland **Reviewed by:** Sewell & Hiscock 2005	cockle tractor dredge, Hand gathering, Hand Raking, Suction dredge	**Relevant Habitats:** Estuaries, Seagrass beds, Mud and sandflats not covered by seawater at low tide **Relevant Species:** Wildfowl and waders	A draft management plan to support regulations that will ensure the sustainable harvesting of cockles and mussels from the Solway Firth. The report includes a review of the pottential impacts of various methods of exploitation of these species. Boat dredging was banned in 1992 and tractor dredging banned in 1994, following this, hand gathering increased in intensity and this too was prohibited in 2002. **Species and community effects:** Following increased catches of cockles that accompanied the introduction of suction dredgers into the Solway Firth there was extremely poor recruitment of cockles and the fishery began to decline. Up to 10 % of hand gathered cockles may be damaged, but the extent to which this occurs depends on the expertise of the gatherer.These rates are likely to be higher for mechanical harvesting techniques. The use of an 'elevator dredge' can vastly increase the survival rate of cockles, including undersized specimens, which can be re-seeded in areas of low spatfall or where they are likely to grow faster.The infauna at exposed sites is less effected by disturbance related to cockle dredging than at undisturbed sites. Hydraulic dredging can potentially result in the complete disapearance of *Zostera marina* beds. All terrain vehicles used by hand gatherers can be extremely damaging in intertidal areas. Particulary if used over *Zostera* beds. Wildfowl can be affected by competition for food (cockles) and by disturbance. Removal of the food source may result in mass mortalities in some species. Fishing method, which require fishers to be present at low water can be significantly more damaging to bird populations that those that take place at high water.	Lancaster, J & Smith, J., 2004. *Solway Firth Regulating Order Draft Management Plan.* Solway Shellfish Management Association, Dumfries

Appendix 2. Biotopes characteristic of Natura 2000 habitats and sensitivity of biotopes to factors associated with fishing. 'Sensitivity' is identified from intolerance and recovery potential. Recovery assumes that the source of damage has been removed, so the table below does not take account of continuous or frequent disturbance. Therefore, the table should be used as an aid to assessing sensitivity of biotopes to different fishing types and not a definitive source of assessment. Biotopes that are: 'Very High' ( ), 'High' ( ) and 'Moderate' ( ) sensitivity are coloured. Biotopes that are unlikely to affected by fishing because of their inaccessibility are indicated NR (Not Relevant).

Natura 2000 habitat	Biotope name	Biotope	Abrasion and physical disturbance				Extraction of key or important characterising species				Extraction of important species			
			Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence
Sandbanks which are slightly covered by seawater all the time, Large shallow inlets and bays and estuaries.	Venerid bivalves in circalittoral coarse sand or gravel	CGS.Ven	Int	H	L	Mod	Ins	NR	Ins	NR	NR	NR	NR	NR
Large shallow inlets and bays	*Abra alba*, *Nucula nitida* and *Corbula gibba* in circalittoral muddy sand or slightly mixed sediment	CMS.AbrNucCor	Int	H	L	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Large shallow inlets and bays	*Amphiura filiformis* and *Echinocardium cordatum* in circalittoral clean or slightly muddy sand	CMS.AfilEcor	Int	H	L	Mod	Int	H	L	Mod	L	H	L	Mod
Large shallow inlets and bays	*Serpula vermicularis* reefs on very sheltered circalittoral muddy sand	CMS.Ser	H	H	Mod	H	Int	H	L	Mod	L	H	L	Mod
Large shallow inlets and bays	*Virgularia mirabilis* and *Ophiura* spp. on circalittoral sandy or shelly mud	CMS.VirOph	L	VH	VL	Mod	NR	NR	NR	L	NR	NR	NR	L
Large shallow inlets and bays and Coastal lagoons	*Beggiatoa* spp. on anoxic sublittoral mud	CMU.Beg	L	Immediate	NS	H	NR	NR	NR	H	NR	NR	NR	H
Large shallow inlets and bays	*Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud	CMU.BriAchi	Int	H	L	H	NR	NR	NR	H	H	Mod	Mod	H
Large shallow inlets and bays	Sea pens and burrowing megafauna in circalittoral soft mud	CMU.SpMeg	Int	H	L	Mod	Int	H	L	H	Int	H	L	L
Reefs	*Lophelia* reefs	COR.Lop	H	VL	VH	H	Int	VL	H	L	H	VL	VH	L
Reefs, Caves and Large shallow inlets and bays	*Bugula* spp. and other bryozoans on vertical moderately exposed circalittoral rock	CR.Bug	Int	H	L	Mod	NR	NR	NR	NR	Int	H	L	L
Submerged or partially submerged sea caves, also Reefs	Caves and overhangs (deep)	CR.Cv	H	VL	VH	H	H	L	H	Mod	L	L	Mod	Mod
Reefs and Large shallow inlets and bays	*Halichondria bowerbanki*, *Eudendrium arbusculum* and *Eucratea loricata* on reduced salinity tide-swept circalittoral mixed substrata	ECR.HbowEud	Int	H	L	H	NR	NR	NR	H	NR	NR	NR	H

Natura 2000 habitat	Biotope name	Biotope	Abrasion and physical disturbance				Extraction of key or important characterising species				Extraction of important species			
			Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence
Reefs	*Pomatoceros triqueter*, *Balanus crenatus* and bryozoan crusts on mobile circalittoral cobbles and pebbles	ECR.PomByC	Tol	NR	NS	H	NR	NR	NR	NR	NR	NR	NR	NR
Reefs	*Alaria esculenta* on exposed sublittoral fringe bedrock (NR)	EIR.Ala (NR)	L	H	L	L	Int	H	L	L	NR	NR	NR	NR
Reefs and Large shallow inlets and bays	Foliose red seaweeds on exposed or moderately exposed lower infralittoral rock	EIR.FoR	Int	H	L	L	Int	H	L	L	NR	NR	NR	NR
Reefs and Large shallow inlets and bays	*Laminaria hyperborea* forest with a faunal cushion (sponges and polyclinids) and foliose red seaweeds on very exposed upper infralittoral rock	EIR.LhypFa	Int	Mod	Mod	Mod	Int	H	L	Mod	Int	H	L	Mod
Reefs and Large shallow inlets and bays.	*Laminaria hyperborea* with dense foliose red seaweeds on exposed infralittoral rock.	EIR.LhypR	Int	Mod	Mod	Mod	Int	Mod	Mod	Mod	H	Mod	Mod	Mod
Reefs	*Laminaria saccharina* and/or *Saccorhiza polyschides* on exposed infralittoral rock	EIR.LsacSac	Int	VH	L	Mod	H	H	Mod	Mod	H	H	Mod	Mod
Reefs, Large shallow inlets and bays and Submerged or partially submerged sea caves	Sponge crusts and anemones on wave-surged vertical infralittoral rock (NR)	EIR.SCAn (NR)	H	H	Mod	H	NR	NR	NR	NR	NR	NR	NR	NR
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	Barnacles and *Patella* spp. on exposed or moderately exposed, or vertical sheltered, eulittoral rock (NR)	ELR.BPat (NR)	H	H	Mod	H	Int	H	L	Mod	L	H	L	Mod
Reefs	*Corallina officinalis* on very exposed lower eulittoral rock (NR)	ELR.Coff (NR)	Int	VH	L	Mod	Int	VH	L	L	NR	NR	NR	NR
Reefs	*Fucus distichus* and *Fucus spiralis* f. *nana* on extremely exposed upper shore rock (NR)	ELR.Fdis (NR)	H	H	Mod	Mod	Int	H	L	Mod	L	H	L	Mod
Reefs and Large,shallow inlets and bays	*Himanthalia elongata* and red seaweeds on exposed lower eulittoral rock (NR)	ELR.Him (NR)	L	H	L	Mod	Int	H	L	Mod	NR	NR	NR	NR
Reefs and Large shallow inlets and bays	*Mytilus edulis* and barnacles on very exposed eulittoral rock (NR)	ELR.MytB (NR)	Int	H	L	Mod	Int	H	L	L	L	VH	VL	L
Sandbanks which are slightly covered by seawater all the time, Large shallow inlets and bays and estuaries	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves in infralittoral compacted fine sand	IGS.FabMag	Int	H	L	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Large shallow inlets and bays	*Halcampa chrysanthellum* and *Edwardsia timida* on sublittoral clean stone gravel	IGS.HalEdw	H	H	Mod	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Sandbanks which are slightly covered by seawater all the time, Large shallow inlets and bays and estuaries	Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand	IGS.Lcon	Int	H	L	Mod	NR	NR	NR	NR	H	VH	L	Mod

Natura 2000 habitat	Biotope name	Biotope	Abrasion and physical disturbance				Extraction of key or important characterising species				Extraction of important species			
			Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence
Sandbanks which are slightly covered by seawater all the time, Large shallow inlets and bays and Coastal lagoons.	*Lithothamnion glaciale* maerl beds in tide-swept variable salinity infralittoral gravel	IGS.Lgla	H	VL	VH	H	H	VL	VH	Mod	H	VL	VH	H
Sandbanks which are slightly covered by seawater all the time, Large shallow inlets and bays and estuaries	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	IGS.NcirBat	L	VH	VL	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Sandbanks which are slightly covered by seawater all the time and estuaries	*Neomysis integer* and *Gammarus* spp. in low salinity infralittoral mobile sand	IGS.NeoGam	Tol	NR	NS	H	NR	NR	NR	NR	NR	NR	NR	NR
Sandbanks which are slightly covered by seawater all the time and Large shallow inlets and bays	*Phymatolithon calcareum* maerl beds with hydroids and echinoderms in deeper infralittoral clean gravel or coarse sand	IGS.Phy.HEc	H	VL	VH	Mod	Int	Mod	Mod	H	Int	Mod	Mod	H
Sandbanks which are slightly covered by seawater all the time, Large shallow inlets and bays, estuaries and Coastal lagoons.	*Capitella capitata* in enriched sublittoral muddy sediments	IMS.Cap	Int	VH	L	Mod	L	VH	VL	L	NR	NR	NR	NR
Mud and sandflats not covered by seawater at low tide and Large shallow inlets and bays	*Echinocardium cordatum* and *Ensis* spp. in lower shore or shallow sublittoral muddy fine sand.	IMS.EcorEns	H	Mod	Mod	Mod	Int	H	L	Mod	L	H	L	L
Sandbanks which are slightly covered by seawater all the time, Large shallow inlets and bays and estuaries	*Macoma balthica* and *Abra alba* in infralittoral muddy sand or mud	IMS.MacAbr	Int	H	L	Mod	Int	H	L	L	NR	NR	NR	NR
Sandbanks which are slightly covered by seawater all the time, Estuaries and Coastal lagoons	*Ruppia maritima* in reduced salinity infralittoral muddy sand (NR)	IMS.Rup (NR)	Int	VH	L	L	Int	VH	L	L	Int	VH	L	L
Mud and sandflats not covered by seawater at low tide and Sandbanks which are slightly covered by seawater all the time, Estuaries, Large shallow inlets and bays and coastal lagoons)	*Zostera marina*/*angustifolia* beds in lower shore or infralittoral clean or muddy sand	IMS.Zmar	Int	Mod	Mod	L	Int	Mod	Mod	L	Int	Mod	Mod	L
Estuaries	*Aphelochaeta marioni* and *Tubificoides* spp. in variable salinity infralittoral mud	IMU.AphTub	Int	VH	L	L	NR	NR	NR	NR	NR	NR	NR	NR
Large, Large shallow inlets and bays and Coastal lagoons	*Arenicola marina* and synaptid holothurians in extremely shallow soft mud (NR)	IMU.AreSyn (NR)	Int	H	L	L	Int	H	L	Mod	NR	NR	NR	NR
Estuaries	*Limnodrilus hoffmeisteri*, *Tubifex tubifex* and *Gammarus* spp. in low salinity infralittoral muddy sediment (NR)	IMU.LimTtub (NR)	Int	VH	L	L	NR	NR	NR	NR	NR	NR	NR	NR
Coastal Lagoons	*Potamogeton pectinatus* community (NR)	IMU.NVC_A12 (NR)	Int	H	L	L	Int	H	L	Mod	NR	NR	NR	NR
Coastal Lagoons	*Phragmites australis* swamp and reed beds (NR)	IMU.NVC_S4 (NR)	Int	H	L	L	Tol	NR	NS	NR	NR	NR	NR	NR
Large shallow inlets and bays	*Ocnus planci* aggregations on sheltered sublittoral muddy sediment	IMU.Ocn	Int	H	L	L	NR	NR	NR	VL	NR	NR	NR	NR

Natura 2000 habitat	Biotope name	Biotope	Abrasion and physical disturbance				Extraction of key or important characterising species				Extraction of important species			
			Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence
Large shallow inlets and bays and Coastal lagoons	*Philine aperta* and *Virgularia mirabilis* in soft stable infralittoral mud	IMU.PhiVir	Int	Mod	Mod	L	Int	H	L	L	Int	H	L	L
Estuaries	*Polydora ciliata* in variable salinity infralittoral firm mud or clay	IMU.PolVS	Int	H	L	Mod	Int	H	L	H	NR	NR	NR	Mod
Large shallow inlets and bays	Semi-permanent tube-building amphipods and polychaetes in sublittoral mud or muddy sand	IMU.TubeAP	Int	H	L	L	NR	NR	NR	NR	NR	NR	NR	NR
Large shallow inlets and bays and estuaries	Burrowing anemones in sublittoral muddy gravel	IMX.An	Int	Mod	Mod	Mod	Int	Mod	Mod	L	NR	NR	NR	NR
Estuaries and Coastal lagoons	*Crepidula fornicata* and *Aphelochaeta marioni* in variable salinity infralittoral mixed sediment	IMX.CreAph	Int	H	L	L	Int	Mod	Mod	H	NR	NR	NR	NR
Estuaries and Coastal Lagoons	Filamentous green seaweeds on low salinity infralittoral mixed sediment or rock	IMX.FiG	Int	VH	L	H	L	VH	VL	H	L	VH	VL	H
Large shallow inlets and bays	*Limaria hians* beds in tide-swept sublittoral muddy mixed sediment	IMX.Lim	H	L	H	H	H	L	H	H	NR	NR	NR	NR
Large shallow inlets and bays, estuaries and coastal lagoons	*Laminaria saccharina*, *Chorda filum* and filamentous red seaweeds on sheltered infralittoral sediment	IMX.LsacX	Int	H	L	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Reefs, Large, shallow inlets and bays and estuaies	*Mytilus edulis* beds on variable salinity infralittoral mixed sediment	IMX.MytV	Int	H	L	Mod	Int	H	L	Mod	NR	NR	NR	L
Large, Shallow inlets and bays and estuaries	*Ostrea edulis* beds on shallow sublittoral muddy sediment	IMX.Ost	Int	Mod	Mod	L	H	VL	VH	H	NR	NR	NR	NR
Estuaries	*Polydora ciliata*, *Mya truncata* and solitary ascidians in variable salinity infralittoral mixed sediment.	IMX.PolMtru	Int	H	L	L	NR	NR	NR	NR	NR	NR	NR	NR
Large shallow inlets and bays, Estuaries and Coastal lagoons	*Venerupis senegalensis* and *Mya truncata* in lower shore or infralittoral muddy gravel	IMX.VsenMtru	Int	H	L	L	Int	H	L	H	NR	NR	NR	NR
Reefs and Large shallow inlets and bays	*Alcyonium digitatum* with a bryozoan, hydroid and ascidian turf on moderately exposed vertical infralittoral rock	IR.AlcByH	H	H	Mod	H	NR	NR	NR	Mod	NR	NR	NR	Mod
Mud and sandflats not covered by seawater at low tide and Large shallow inlets and bays	Burrowing amphipods and *Eurydice pulchra* in well-drained clean sand shores	LGS.AEur	L	VH	VL	Mod	NR	NR	NR	NR	Int	VH	L	H
Mud and sandflats not covered by seawater at low tide, Large shallow inlets and bays and Estuaries	Barren coarse sand shores	LGS.BarSnd	L	VH	VL	H	NR	NR	NR	NR	NR	NR	NR	NR
Mud and sandflats not covered by seawater at low tide, Large shallow inlets and bays and Estuaries	Dense *Lanice conchilega* in tide-swept lower shore sand	LGS.Lan	Int	H	L	Mod	Int	H	L	H	NR	NR	NR	NR
Large shallow inlets and bays	*Pectenogammarus planicrurus* in mid shore well-sorted gravel or coarse sand	LGS.Pec	Tol	NR	Tol	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Mud and sandflats not covered by seawater at low tide, Large shallow inlets and bays, Estuaries and	Muddy sand shores	LMS.MS	Int	H	L	Mod	Int	Mod	Mod	L	Int	Mod	Mod	L

Natura 2000 habitat	Biotope name	Biotope	Abrasion and physical disturbance				Extraction of key or important characterising species				Extraction of important species			
			Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence
Coastal lagoons														
Mud and sandflats not covered by seawater at low tide, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Zostera noltii* beds in upper to mid shore muddy sand	LMS.Znol	Int	Mod	Mod	Mod	Int	H	L	Mod	H	VL	VH	H
Mud and sandflats not covered by seawater at low tide and Estuaries	*Hediste diversicolor* and *Macoma balthica* in sandy mud shores	LMU.HedMac	Int	H	L	L	Int	H	L	VL	NR	NR	NR	NR
Saltmarsh, Estuaries and Coastal lagoons	*Puccinellia maritima* salt marsh community	LMU.NVC_SM13	Int	H	L	L	Tol*	NR	NS*	Mod	NR	NR	NR	NR
Saltmarsh and Estuaries	Pioneer saltmarsh.	LMU.Sm	Int	H	L	VL	Int	H	L	VL	Int	H	L	VL
Reefs, Large shallow inlets and bays and estuaries	*Corallina officinalis* and coralline crusts in shallow eulittoral rockpools.	LR.Cor	Int	H	L	L	Int	VH	L	L	NR	NR	NR	NR
Submerged or partially submerged Sea caves and Reefs	Faunal crusts on wave-surged littoral cave walls	LR.FLR.CVOV.FaCr	Int	H	L	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Reefs, Large shallow inlets and bays and Estuaries.	Green seaweeds (*Ulva* spp. and *Cladophora* spp.) in upper shore rockpools	LR.G	H	VH	L	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Reefs, Large shallow inlets and bays, and Estuaries.	Hydroids, ephemeral seaweeds and Littorina littorea in shallow eulittoral mixed substrata pools	LR.H	Int	VH	L	L	H	VH	L	L	NR	NR	NR	NR
Reefs, Submerged and partially submerged sea caves, Large shallow inlets and bays, and estuaries	Overhangs and caves (NR)	LR.Ov (NR)	H	H	Mod	H	Int	H	L	VL	Int	H	L	VL
Reefs, Submerged and partially submerged sea caves, large, shallow inlets and bays and estuaries	*Rhodothamniella floridula* in upper littoral fringe soft rock caves (NR)	LR.RhoCv (NR)	Int	H	L	Mod	NR	NR	NR	NR	Ins	NR	Ins	NR
Large shallow inlets and bays, and Estuaries	Cirratulids and *Cerastoderma edule* in littoral mixed sediment	LS.LMX.MX.CirCer	Int	H	L	L	Int	H	L	Mod	NR	NR	NR	NR
Reefs and Large shallow inlets and bays.	Erect sponges, *Eunicella verrucosa* and *Pentapora fascialis* on slightly tide-swept moderately exposed circalittoral rock.	MCR.ErSEun	H	VL	VH	Mod	H	VL	VH	L	Int	L	H	L
Reefs and Large shallow inlets and bays	Faunal and algal crusts, *Echinus esculentus*, sparse *Alcyonium digitatum* and grazing-tolerant fauna on moderately exposed circalittoral rock	MCR.FaAlC	H	VH	L	L	Int	H	L	L	NR	NR	NR	NR
Reefs and Large shallow inlets and bays	*Flustra foliacea* and other hydroid/bryozoan turf species on slightly scoured circalittoral rock or mixed substrata	MCR.Flu	Int	H	L	Mod	NR	NR	NR	NR	Int	H	L	L

Natura 2000 habitat	Biotope name	Biotope	Abrasion and physical disturbance				Extraction of key or important characterising species				Extraction of important species			
			Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence
Reefs and Large shallow inlets and bays	*Modiolus modiolus* beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata	MCR.ModT	H	L	H	Mod	H	VL	VH	L	H	VL	VH	L
Reefs and Large shallow inlets and bays	*Molgula manhattensis* and *Polycarpa* spp. with erect sponges on tide-swept moderately exposed circalittoral rock	MCR.MolPol	Int	Mod	Mod	Mod	NR	NR	NR	H	NR	NR	NR	H
Reefs and Large shallow inlets and bays	*Musculus discors* beds on moderately exposed circalittoral rock	MCR.Mus	Int	H	L	L	NR	NR	NR	NR	Int	H	L	L
Reefs, Large shallow inlets and bays and estuaries	*Mytilus edulis* beds with hydroids and ascidians on tide-swept moderately exposed circalittoral rock	MCR.MytHAs	Int	H	L	L	Int	H	L	Mod	NR	NR	NR	NR
Reefs, Sandbanks which are slightly covered by seawater all the time and Large, shallow inlets and bays	*Ophiothrix fragilis* and/or *Ophiocomina nigra* beds on slightly tide-swept circalittoral rock or mixed substrata	MCR.Oph	Int	H	L	Mod	Int	H	L	Mod	Tol*	VH	NS*	Mod
Reefs and Large shallow inlets and bays	*Polydora* sp. tubes on upward-facing circalittoral soft rock	MCR.Pol	Int	H	L	Mod	Int	H	L	H	NR	NR	NR	Mod
Reefs and Large shallow inlets and bays	*Sabellaria spinulosa* crusts on silty turbid circalittoral rock	MCR.Sspi	Int	H	L	L	NR	NR	NR	H	L	VH	VL	L
Reefs, Submerged or partially submerged sea caves, Large shallow inlets and bays and estuaries	*Urticina felina* on sand-affected circalittoral rock	MCR.Urt	Int	H	L	Mod	NR	NR	NR	H	NR	NR	NR	NR
Reefs, Large shallow inlets and bays and Coastal lagoons	*Halidrys siliquosa* and mixed kelps on tide-swept infralittoral rock with coarse sediment.	MIR.HalXK	Int	H	L	L	Tol*	NR	NS*	VL	H	H	Mod	L
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Laminaria digitata* on moderately exposed sublittoral fringe rock (NR)	MIR.Ldig.Ldig (NR)	Int	H	L	Mod	Int	H	L	H	L	H	L	Mod
Reefs, Large shallow inlets and bays and Estuaries	*Laminaria digitata* and piddocks on sublittoral fringe soft rock	MIR.Ldig.Pid	Int	H	L	L	L	H	L	L	L	L	Mod	L
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Laminaria digitata*, ascidians and bryozoans on tide-swept sublittoral fringe rock	MIR.Ldig.T	H	H	Mod	L	Int	H	L	L	Int	H	L	L
Reefs and Large shallow inlets and bays	Grazed *Laminaria hyperborea* with coralline crusts on infralittoral rock	MIR.LhypGz	Int	H	L	Mod	H	Mod	Mod	H	NR	NR	NR	NR
Reefs	*Laminaria saccharina*, *Chorda filum* and dense red seaweeds on shallow unstable infralittoral boulders or cobbles	MIR.LsacChoR	Int	H	L	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Reefs and Large shallow inlets and bays	*Polyides rotundus*, *Ahnfeltia plicata* and *Chondrus crispus* on sand-covered infralittoral rock	MIR.PolAhn	Int	H	L	L	H	Mod	Mod	L	NR	NR	NR	NR
Reefs	*Sabellaria spinulosa* with kelp and red seaweeds on sand-influenced infralittoral rock	MIR.SabKR	Int	H	L	Mod	H	H	Mod	L	L	H	L	Mod

Natura 2000 habitat	Biotope name	Biotope	Abrasion and physical disturbance				Extraction of key or important characterising species				Extraction of important species			
			Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence
Reefs, Large shallow inlets and bays and estuaries	Barnacles and fucoids (moderately exposed shores)	MLR.BF	H	H	Mod	Mod	H	H	Mod	VL	Int	H	L	VL
Reefs, Large shallow inlets and bays and estuaries	Underboulder communities	MLR.Fser.Fser.Bo	H	H	Mod	Mod	L	H	L	L	L	H	L	L
Reefs, Large, shallow inlets and bays and estuaries	*Mytilus edulis* and *Fucus vesiculosus* on moderately exposed mid eulittoral rock	MLR.MytFves	Int	H	L	Mod	Int	H	L	L	Tol	NR	NS	L
Reefs, Large shallow inlets and bays and estuaries	*Mytilus edulis* and piddocks on eulittoral firm clay	MLR.MytPid	Int	Mod	Mod	Mod	Int	H	L	L	NR	NR	NR	NR
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Rhodothamniella floridula* on sand-scoured lower eulittoral rock	MLR.Rho	Int	H	L	Mod	L	H	L	L	Ins	NR	Ins	NR
Reefs, Large shallow inlets and bays and Estuaries	*Ceramium* sp. and piddocks on eulittoral fossilized peat	MLR.RPid	Int	VH	L	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Reefs, Large Shallow inlets and bays and Estuaries	*Sabellaria alveolata* reefs on sand-abraded eulittoral rock	MLR.Salv	Int	H	L	Mod	Int	H	L	Mod	Int	H	L	Mod
Reefs and Large shallow inlets and bays	*Antedon* spp., solitary ascidians and fine hydroids on sheltered circalittoral rock	SCR.AntAsH	H	H	Mod	L	Tol	NR	NS	Mod	NR	NR	NR	NR
Reefs and Large shallow inlets and bays	*Neocrania anomala* and *Protanthea simplex* on very sheltered circalittoral rock	SCR.NeoPro	H	Mod	Mod	H	NR	NR	NR	L	NR	NR	NR	L
Reefs and Large shallow inlets and bays	*Suberites* spp. and other sponges with solitary ascidians on very sheltered circalittoral rock	SCR.SubSoAs	H	Mod	Mod	Mod	NR	NR	NR	NR	NR	NR	NR	NR
Reefs and Coastal lagoons	*Ascophyllum nodosum* with epiphytic sponges and ascidians on variable salinity infralittoral rock	SIR.AscSAs	Int	L	H	Mod	Int	Mod	Mod	Mod	L	H	L	Mod
Reefs and Estuaries	*Cordylophora caspia* and *Electra crustulenta* on reduced salinity infralittoral rock	SIR.CorEle	Int	VH	L	L	NR	NR	NR	NR	Tol*	NR	NS*	NR
Reefs and Coastal lagoons	Mixed fucoids, *Chorda filum* and green seaweeds on reduced salinity infralittoral rock	SIR.FChoG	Int	H	L	Mod	Int	H	L	Mod	L	H	L	L
Reefs and Estuaries	*Hartlaubella gelatinosa* and *Conopeum reticulum* on low salinity infralittoral mixed substrata	SIR.HarCon	Int	VH	L	L	NR	NR	NR	NR	NR	NR	NR	NR
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Laminaria saccharina* park on very sheltered lower infralittoral rock	SIR.Lsac.Pk	Int	H	L	H	L	H	L	Mod	L	H	L	Mod
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Laminaria saccharina*, foliose red seaweeds, sponges and ascidians on tide-swept infralittoral rock	SIR.Lsac.T	H	H	Mod	H	L	H	L	Mod	L	H	L	Mod
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Laminaria saccharina* on reduced or low salinity infralittoral rock	SIR.LsacRS	H	H	Mod	H	H	H	Mod	L	NR	NR	NR	H

Natura 2000 habitat	Biotope name	Biotope	Abrasion and physical disturbance				Extraction of key or important characterising species				Extraction of important species			
			Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence	Intolerance	Recovery	Sensitivity	Confidence
Reefs and Estuaries	*Mytilus edulis* beds on reduced salinity tide-swept infralittoral rock	SIR.MytT	Int	H	L	Mod	Int	H	L	Mod	NR	NR	NR	NR
Reefs and Coastal lagoons	*Polyides rotundus* and/or *Furcellaria lumbricalis* on reduced salinity infralittoral rock	SIR.PolFur	Int	H	L	L	H	Mod	Mod	H	NR	NR	NR	NR
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Ascophyllum nodosum* on very sheltered mid eulittoral rock.	SLR.Asc	H	L	H	H	Int	Mod	Mod	H	L	H	L	Mod
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Ascophyllum nodosum*, sponges and ascidians on tide-swept mid eulittoral rock	SLR.Asc.T	Int	H	L	L	H	L	H	Mod	NR	NR	NR	NR
Reefs, Large shallow inlets and bays and Coastal lagoons	*Ascophyllum nodosum* ecad *mackaii* beds on extremely sheltered mid eulittoral mixed substrata	SLR.AscX.mac	Int	Mod	Mod	H	Int	Mod	Mod	L	Tol	NR	NS	Mod
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	Barnacles and *Littorina littorea* on unstable eulittoral mixed substrata	SLR.BLlit	Int	H	L	Mod	L	H	L	Mod	H	H	Mod	H
Reefs, Estuaries and Coastal lagoons	*Fucus ceranoides* on reduced salinity eulittoral rock	SLR.Fcer	Int	H	L	Mod	NR	NR	NR	NR	H	H	Mod	Mod
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Fucus serratus*, sponges and ascidians on tide-swept lower eulittoral rock	SLR.Fserr.T	Int	H	L	Mod	H	H	Mod	L	NR	NR	NR	NR
Reefs, Large shallow inlets and bays and Estuaries	*Fucus serratus* with sponges, ascidians and red seaweeds on tide-swept lower eulittoral mixed substrata	SLR.FserX.T	Int	H	L	Mod	H	H	Mod	Mod	NR	NR	NR	NR
Reefs, Large shallow inlets and bays, Estuaries and Coastal lagoons	*Fucus vesiculosus* on mid eulittoral mixed substrata	SLR.FvesX	Int	H	L	Mod	Int	H	L	Mod	NR	NR	NR	NR

VH = Very High, H = High, Mod = Moderate, L = Low, VL = Very Low, NS = Not Sensitive, Int = Intermediate, NR = Not Relevant, Ins = Insufficient Information, * The habitat may benefit from the change in an external factor.

Information shown in this table comes from the following sources: Natura 2000 sites were matched to biotope classification based on information in: JNCC, 1999. Relationship between Annex 1 marine habitats of the EC Habitats Directive and the MNCR BioMar marine biotope classification. *Marine information notes*. 8. Joint Nature Conservation Committee, Peterborough, UK.

Biotope sensitivity is based on: *MarLIN,* 2005. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. For details of the methodology used to assess sensitivity for each biotope and for assessment benchmarks, see: www.marlin.ac.uk/glossaries/benchmarks.htm