APPENDIX 7

Lockwood, 2005 - A Strategic Environmental Assessment of the Fish & Shellfish Resources with respect to Proposed Offshore Wind Farms in the Eastern Irish Sea

A

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in the

Eastern Irish Sea

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A Strategic Environmental Assessment of the Fish & Shellfish Resources in the Eastern Irish Sea with respect to Proposed Offshore Wind Farms

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Executive Summary

i. In December 2003 the UK Government announced that it was to promote a second round of offshore wind-farm development. After consultation with the wind-energy industry, the Department of Trade and Industry (DTI) identified three strategic areas in which Round 2 developments would take place: the Thames Estuary, the Greater Wash, and the North West - an area of the eastern Irish Sea extending from North Wales to south-west Scotland east of 4º W. Developments on this scale are subject to the provisions of the EU *Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment*, commonly known as the Strategic Environmental Assessment (SEA) Directive. An assessment of the fish and shellfish stocks in the eastern Irish Sea has been undertaken to meet the requirements of this directive.

ii. The report is presented in three parts:

- a review of the fish and shellfish resources in the eastern Irish Sea, describing their distribution and biology;
- a summary of the current status of fish and shellfish stocks exploited in the eastern Irish Sea);
- an initial consideration of the potential effects that developing wind farms may have on fish and shellfish during the pre-construction, construction, operation and decommissioning of wind farms in the eastern Irish Sea.

iii. The report was prepared as a desk study which drew on information provided by the Department of Environment, Food & Rural Affairs (DEFRA) Fisheries Statistical Unit (FSU), research survey data provided by the Centre for Environment, Fisheries & Aquaculture Science (CEFAS), advice from officers of the North Western & North Wales Sea Fisheries Committee (NWNW SFC), published literature, the internet, and the author's personal knowledge of the fish and shellfish resources of the eastern Irish Sea.

iv. Approximately 70 species of marine fish and commercially exploited shellfish are indigenous to the eastern Irish Sea in addition to salmon, sea trout, eels and a variety of fish of nature conservation interests: basking sharks, allis and twaite shad, common and sand goby,

sea and river lamprey, and smelt. The five most abundant species taken in a CEFAS beam-trawl survey were dab, solenette, plaice, common dragonet and Dover sole, but the greatest quantities of fish caught by UK-registered fishing vessels in the eastern Irish Sea were king and queen scallops, nephrops, plaice, cod and whiting. There are also major intertidal fisheries for cockles and mussels centred on, but not limited to, Morecambe Bay.

v. The intertidal shellfisheries are assessed and managed by the North Western and North Wales Sea Fisheries Committee but the finfish stocks are assessed by the International Council for the Exploration of the Sea (ICES) and managed through the European Common Fisheries Policy (CFP). All of the shellfish stocks are currently judged to be in robust condition but most of the commercially important finfish stocks are giving cause for concern and are subject to highly restrictive catch limitations. Salmon, sea trout and eel stocks that run through the eastern Irish Sea to their freshwater spawning or feeding grounds appear to be suffering a prolonged, long-term decline in abundance.

vi. The exact status of the fish of nature conservation interest is not known but there are UK Biodiversity Action Plans in place to safeguard basking shark, shads and lampreys in UK waters. There is no such plan for salmon-related smelt or the gobies; although the smelt is not as numerous as was once the case both goby species are ubiquitous to shallow sandy areas of inshore UK waters.

vii. The greatest single effect that wind farms are likely to have on fish is the change in habitat. Natural habitat will be lost as turbine foundations are put in place and new habitat created by the surface area of wind-farm structures. Although many of the species upon which fish feed live in or on the seabed, only a trivial proportion (<≈0.002%) of the total eastern Irish Sea area would be lost if all proposed wind farms were developed. In mitigation, a much greater area of new habitat would be created by the sub-surface areas of the wind-farm structures. Photographic evidence from the North Hoyle wind farm has already demonstrated that the sub-surface areas are readily colonised by a rich turf of animals, including species upon which fish feed.

viii. The wind-farm structures, and any transmission cables that are surface laid and rock armoured, will create artificial reefs or act as fish aggregation devices. In addition to the new feeding areas that these reef structures offer, they can affect the behaviour and local abundance of fish by causing them to aggregate within the boundary of each wind farm. This localised aggregation will, inevitably, be countered by a drop in local abundance in the area around each wind farm from which the fish are drawn. It is concluded, however, that the physical presence of wind farms in the eastern Irish Sea will not have an adverse effect on fish.

ix. During the construction and cable-laying phase of developing wind farms it is anticipated that there will be increases in the suspended sediment concentrations locally. As the eastern Irish Sea is naturally a relatively turbid environment it is not anticipated that any construction-related increases in turbidity will affect fish adversely with the possible exception of salmon and sea trout. While they too can accommodate high suspended sediment concentrations a persistent plume of suspended sediment in the vicinity of a salmon river-mouth could be sufficient to deter these fish from entering the rivers to spawn. These concerns will need to be considered when scheduling construction or cable-laying activities in sensitive areas.

x. Similar sensitivities will also need to be addressed with respect to certain shellfish species, particularly if modelling indicates that there may be higher than natural settlement rates of resuspended sediments. Intertidal species such as cockles are adapted to the rigours of a highly dynamic environment and mobile habitat but a sustained daily sediment settlement rate of ~5 mm or more may exceed their adaptive capabilities and smother them. For recently settled juvenile cockles the figure could be as low as 1 mm per day. These concerns will be of greatest relevance around Morecambe Bay, the Ribble Estuary and the Dee Estuary. The gills of nephrops (‘scampi’), a species that is found between Cumbria and the Isle of Man, may also be susceptible to clogging from high suspended sediment concentrations.

xi. The preliminary evidence of fish aggregating around North Hoyle suggests that fish are not adversely affected by the noise of an operational wind farm but there may be greater disturbance during the construction phase. At this stage the noises generated are likely to be more variable and allow the fish less time to adapt. The greatest potential concern, however, is during pile-driving when fatal damage could be sustained by fish within 1-2 m of the foundation. This potential risk can be minimised by 'tapping' with the pile-driver to drive fish away from the immediate vicinity before commencing full-force operations.

xii. There remains a degree of uncertainty about the potential effects that electromagnetic fields (EMF) along cable routes may have on fish, particularly elasmobranchs such as dogfish and rays. It is highly unlikely that salmon or sea trout will be affected as their use of EMF is for oceanic migration; in coastal waters they rely on olfaction to detect and recognise their natal river. The elasmobranchs, however, utilise micro-variations in local EMF to detect their prey and any anomaly associated with transmission cables may affect their feeding behaviour or access to preferred spawning grounds. This concern is subject to on-going research.

xiii. At the decommissioning stage the primary concerns would, once more, be with respect to increased suspended sediment concentrations and the loss of habitat as structures, including cable rock-armouring, were removed and the original habitat became re-established.

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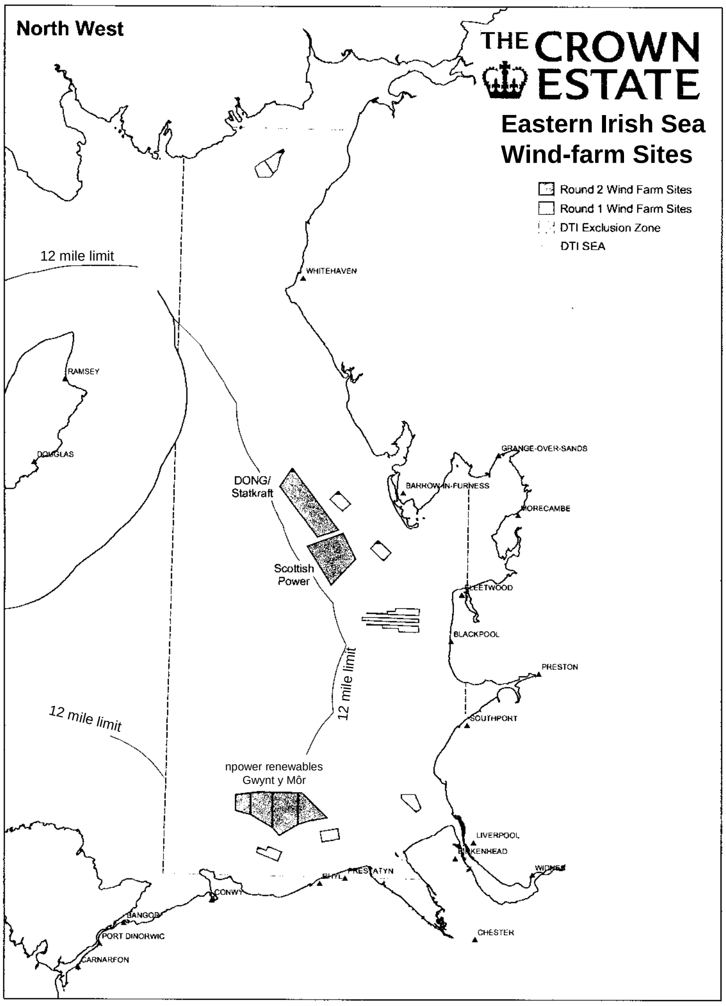
1 Wind Farm Developments in the Eastern Irish Sea

i. In December 2003 the UK Government announced that it was to promote a second round of offshore wind-farm development in pursuit of its policy that 15% of UK electricity demand should be met from renewable resources by 2015. After consultation with the wind-energy industry, and analysis of the national wind-energy database, the Department of Trade and Industry (DTI) identified three strategic areas in which Round 2 developments would take place: the Thames Estuary, the Greater Wash (an area extending from north Norfolk to Flamborough Head), and the North West. The North West area extends from North Wales to south-west Scotland east of 4º W (Figure 1); throughout this report the North West area is referred to as the eastern Irish Sea.

Within the eastern Irish Sea, the DTI has authorised the preparation of environmental statements and development plans for ten 30-turbine offshore wind farms as part of the Round 1 programme (Figure 1). There are two contiguous sites on Robin Rigg Bank (in the Solway Firth), two separate sites off Walney Island, three proximate sites on Shell Flat (Blackpool), and one site each at Burbo Bank (Wirral), North Hoyle (Rhyl-Prestatyn) and Rhyl Flats (NW of Rhyl). Of these ten sites, North Hoyle was built in 2003 and became fully operational in early 2004. The other Round 1 sites are at various stages of the approval procedure but none is yet under construction.

Figure 1: Sites approved by the Crown Estate for investigation as potential offshore wind-farm sites in the eastern Irish Sea or DTI SEA – Dept of Trade & Industry Strategic Environmental Assessment area (www.crownestate.co.uk).



ii. In addition to the Round 1 sites, the DTI has authorised developers to prepare Round 2 proposals for three sites in the eastern Irish Sea, one off the North Wales coast and two off Walney Island-Duddon Estuary (Figure 1). Whereas Round 1 sites were limited to 30 turbines per site, there is no such restriction with Round 2, hence, the sites are significantly larger. However, there is a 10 km coastal exclusion zone that has kept the proposed sites further offshore than the Round 1 sites.

iii. Proposed developments on this scale are subject to the requirements of the EU *Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment*, commonly known as the Strategic Environmental Assessment (SEA) Directive. The aim of this directive is:

"to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development by ensuring that …an environmental assessment is carried out of certain plans and programmes which are likely to have significant effects on the environment".

The SEA Directive was brought into effect in the UK, including the Territorial Sea, through the *Environmental Assessment of Plans and Programmes Regulations*, 2004.

iv. As a first step towards meeting the requirements of the Directive, the DTI commissioned BMT CORDAH Ltd to prepare a Phase 1 SEA of the three strategic Round 2 offshore wind-farm areas – Thames Estuary, Greater Wash and North West (CORDAH, 2003). Subsequently, a consortium of North West SEA wind-farm developers commissioned a more detailed strategic assessment of the eastern Irish Sea. This report contributes to this process by presenting a strategic assessment of the fish and shellfish resources of the eastern Irish Sea.

v. The report is presented in three parts:

- § 2 a review of the fish and shellfish resources in the eastern Irish Sea, describing their distribution and biology;
- § 3 a summary of the current status of fish and shellfish stocks exploited in the eastern Irish Sea);
- § 4 an initial consideration of the potential effects that developing wind farms may have on fish and shellfish during the pre-construction, construction, operation and decommissioning of wind farms in the eastern Irish Sea.

vi. The report was prepared as a desk study which drew on information provided by the Department of Environment, Food & Rural Affairs (DEFRA) Fisheries Statistical Unit (FSU), research survey data provided by the Centre for Environment, Fisheries & Aquaculture Science (CEFAS), advice from officers of the North Western & North Wales Sea Fisheries Committee (NWNW SFC), published literature, the internet, and the author's personal knowledge of the fish and shellfish resources of the eastern Irish Sea. The majority of figures used to illustrate the report are taken or modified from illustrations in published documents;

the source of each is acknowledged in the legend to the figure. Figure 20 showing the distribution of the commercial cockle and mussel beds in Morecambe Bay was prepared by Bill Cook, NWNW SFC Senior Scientist, to whom I am most grateful.

vii. A glossary of technical terms is provided at the end of the report (§ 6).

2 The Marine Fish & Shellfish Fauna of the Eastern Irish Sea

2.1 Introduction

i. Since the early 1970s, the government fishery laboratory at Lowestoft (CEFAS) has maintained a series of trawl surveys in the eastern Irish Sea. Originally the surveys were restricted to an area along the north Wales coast between Anglesey and the Dee Estuary; they were undertaken with two locally-based trawlers using modified commercial otter trawls (see, for example, Innogy, 2002). Since 1992, however, the surveys have covered the greater part of the Irish Sea (Parker-Humpreys, 2004) and sampling has been carried out from the CEFAS research vessel *Corystes* towing a commercial-pattern 4 m beam trawl fitted with a fine mesh cod-end liner (Ellis *et al*, 2000; Parker-Humphreys, 2004). Analyses of these data have been published by Ellis *et al*, (2000) and Parker-Humphreys (2004) but the data were also made available for the assessment presented here and subject to further analysis by Ellis & Parker-Humphreys (2004).

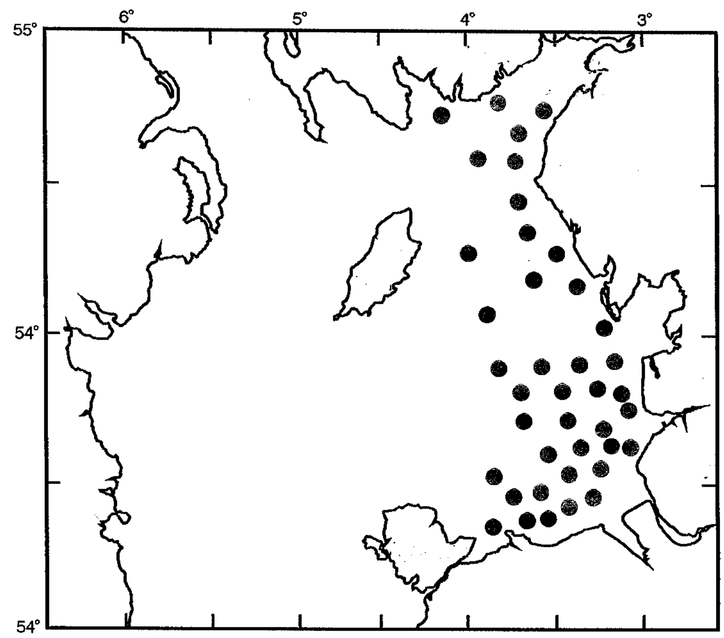


Figure 2: Distribution of CEFAS autumn beam-trawl survey stations in the eastern Irish Sea.

ii. The survey is based on a fixed array of trawl stations (Figure 2) that, weather permitting, are fished every September. At each station the catch is sorted and, whenever possible, the species of each fish and macro-benthic invertebrate – including commercial shellfish – is identified; the total number and combined weight of each species (or higher taxon) is recorded. As the gear is designed primarily for demersal fish species, primarily

Table 1: Marine fish recorded during the CEFAS autumn, 4-m beam-trawl surveys of the eastern Irish Sea (1992-03); common name, scientific name and the average annual number caught (by common name – and listed in order of actual abundance within each integer value).

Common Name	Scientific Name	Average Annual Catch (N)	
Bib or pout whiting	*Trisopterus luscus*	Dab	5327
Brill	*Scophthalmus rhombus*	Solenette	3681
Bull rout	*Myoxocephalus scorpius*	Plaice	3502
Butterfish	*Pholis gunnellus*	Dragonet, common	2298
Butterfly blenny	*Blennius ocellaris*	Dover Sole	2014
Clingfish, two-spot	*Diplecogaster bimaculata*	Scaldfish	984
Cod, Atlantic	*Gadus morhua*	Whiting	962
Cod, poor	*Trisopterus minutus*	Gurnard, grey	833
Conger eel	*Conger conger*	Bib or pout whiting	764
Dab	*Limanda limanda*	Pogge or Hooknose	714
Dogfish, nurse hound or bull huss	*Scyliorhinus stellaris*	Weever, lesser	701
Dogfish, starry	*Mustelus asterias*	Dogfish, lesser spotted	268
Dogfish, starry smooth hound	*Mustellus mustellus*	Gurnard, tub	197
Dogfish, lesser spotted	*Scyliorhinus canicula*	Octopus, northern	144
Dragonet, common	*Callionymus lyra*	Sole, thickback	142
Dragonet, reticulated	*Callionymus reticulata*	Goby, sand/common	93
Dragonet, spotted	*Callionymus maculatus*	Ray, thornback or roker	84
Flounder	*Platichthys flesus*	Sole, lemon	68
Garfish	*Belone belone*	Gurnard, red	66
Goby, sand	*Pomatoschistus minutus*	Wrasse, goldsinney	50
Gurnard, grey	*Eutrigla gurnardus*	Cod, Atlantic	50
Gurnard, red	*Aspitrigla cuculus*	Flounder	33
Gurnard, tub	*Trigla lucerna*	Dragonet, spotted	30
Haddock	*Melanogrammus aeglefinus*	Ray, spotted	29
Hake	*Merluccius merluccius*	Sea scorpion	29
John Dory	*Zeus faber*	Dragonet, reticulated	19
Ling	*Molva molva*	Brill	16
Lumpfish	*Cyclopterus lumpus*	Dogfish, nurse hound or bull huss	16
Mackerel, Atlantic	*Scomber scombrus*	Sprat	16
Monk or anglerfish	*Lophius piscatorius*	Monk or anglerfish	14
Mullet, red	*Mullus surmuletus*	Pipefish, greater	12
Octopus, northern	*Eledone cirrhosa*	Butterfly blenny	9
Pipefish, greater	*Syngnathus acus*	Topknot, Norwegian	8
Pipefish, Nilsson's	*Syngnathus rostellatus*	Turbot	8
Plaice	*Pleuronectes platessa*	Ray, cuckoo	8
Pogge or Hooknose	*Agonus cataphractus*	Scad or horse mackerel	8
Ray, blonde	*Raja brachyura*	Ray, blonde	7
Ray, cuckoo	*Raja naevus*	John Dory	6
Ray, spotted	*Raja montagui*	Butterfish	5
Ray, thornback or roker	*Raja clavata*	Conger eel	3
Rockling, five-bearded	*Ciliata mustela*	Squid	3
Rockling, four-bearded	*Rhinonemus cimbrius*	Sandeel	2
Sandeel, greater	*Hyperoplus lanceolatus*	Squid	2
Sandeel	*Ammodytes tobianus*	Garfish	2
Scad or horse mackerel	*Trachurus trachurus*	Witch	2
Scaldfish	*Arnoglossus laterna*	Rockling, five-bearded	1
Sea scorpion	*Taurulus bubalis*	Haddock	1
Seabass	*Dicentrarchus labrax*	Mackerel, Atlantic	1
Sea urchin, edible	*Echinus esculentus*	Pipefish, Nilsson's	1
Sole, Dover	*Solea solea*	Squid	<1
Sole, lemon	*Microstomus kitt*	Triggerfish	<1
Sole, thickback	*Microchirus variegatus*	Lumpfish	<1
Solenette	*Buglossidium luteum*	Seabass	<1
Sprat	*Sprattus sprattus*	Clingfish, two-spot	<1
Squid	*Alloteuthis subulata*	Tope	<1
Squid	*Loligo vulgaris*	Sandeel, greater	<1
Tope	*Galeorhinus galeus*	Hake	<1
Topknot, Imperial	*Phrynorhombus regius*	Whiting, blue	<1
Topknot, Norwegian	*Phrynorhombus norvegicus*	Ling	<1
Triggerfish	*Balistes carolinensis*	Mullet, red	<1
Turbot	*Psetta maxima*	Dogfish, starry smooth hound	<1
Weever, lesser	*Echiichthys vipera*	Dogfish, starry	<1
Whiting	*Merlangius merlangus*	Bull rout	<1
Whiting, blue	*Micromesistius poutassou*	Topknot, Imperial	<1
Witch	*Glyptocephalus cynoglossus*	Rockling, four-bearded	<1
Wrasse, goldsinney	*Ctenolabus rupestris*	Cod, poor	<1

flatfish, pelagic species are under-represented in the catches, as are the smallest of the non-commercial demersal species, eg gobies (*Pomatoschistus* spp.). Throughout the Irish Sea as a whole, more than 100 species of marine fish were recorded (Parker-Humphreys, 2004) but in the eastern Irish Sea (ie east of 4º W) the number is nearer to 70 (Table 1).

2.2 Marine Fish

i. Numerically, the top dozen species listed in the right hand column of Table 1 account for 95% of the total catch and the top three species – dab (*Limanda limanda*), solenette (*Buglossidium luteum*) and plaice (*Pleuronectes platessa*) – account for over 50%. With the possible exception of pout whiting (*Trisopterus luscus*), which is frequently associated with hard ground and reef features, all of these numerically dominant species are characteristic of relatively shallow soft-sediment areas, such as predominate throughout the eastern Irish Sea (see, for example, Lee & Ramster, 1981; BGS, 1996; Parker-Humphreys, 2004).

ii.

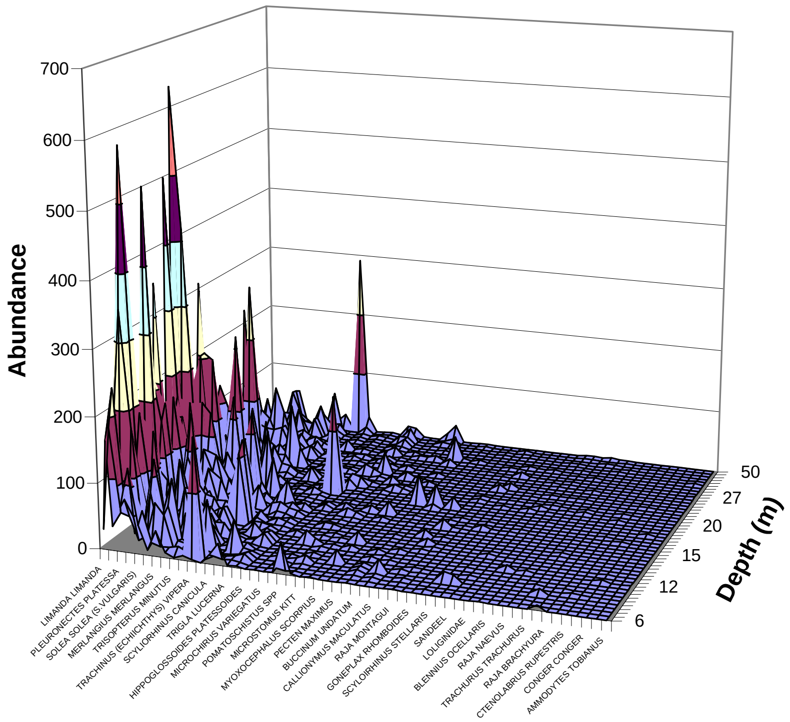


Figure 3: The annual average abundance and distribution by depth of marine finfish taken in the eastern Irish Sea (ie east of 4º W) during the CEFAS autumn 4-m beam-trawl survey (1992-03).

fish species, including Dover sole (*Solea solea*), that is associated with fine, inshore sediments. The predominance of these species and their preference for depths less than 20-25 m can be seen in Figure 3. The overwhelming majority of the other most abundant

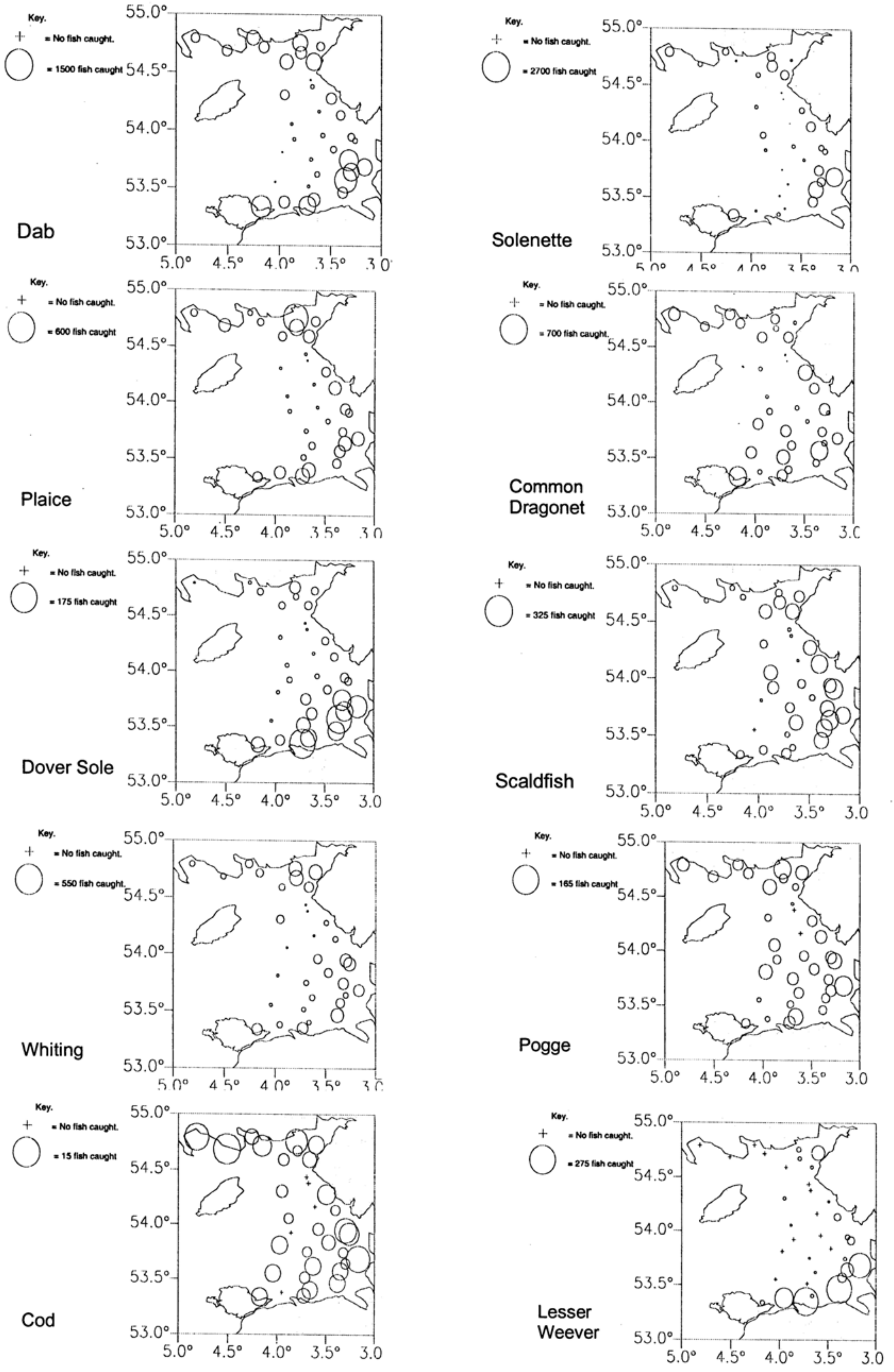
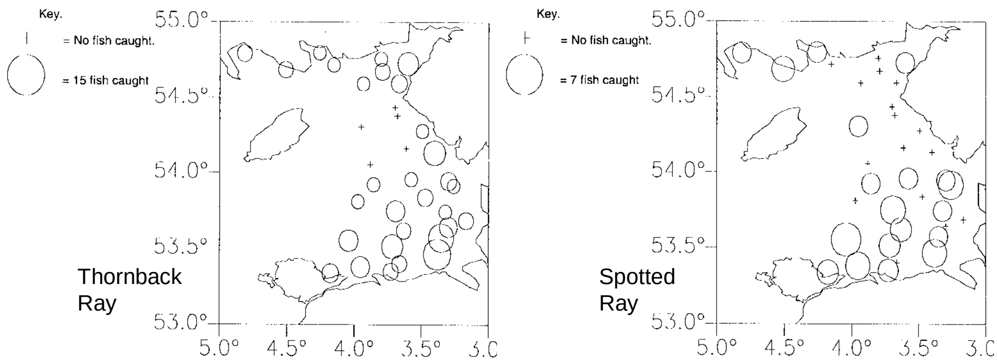


Figure 4: Average distribution and relative abundance (catch per hour's fishing – 1993-2003) of the principal commercial finfish and the five most abundant non-commercial species (from Ellis & Parker-Humphreys, 2004)

10-15 species also prefer these shallow areas although Ellis *et al* (2000) identify a group of fish including thickback sole (*Microchirus variegatus*), Dover sole and common dragonets (*Callionymus lyra*) as characterising waters slightly deeper than the dab-plaice community. The geographic distribution of some of these key species within the eastern Irish Sea, including those of commercial importance, are also shown in Figures 4 & 5; others can be found in Parker-Humphreys (2004). Generally speaking, these distributions indicate the distribution of the exploited population, with the exception of cod (*Gadus morhua*). The majority of cod caught in the CEFAS surveys were juveniles caught in the south-eastern Irish Sea (Parker-Humphreys, 2004) whereas the commercial fishery is concentrated in the northern and north-western Irish Sea.



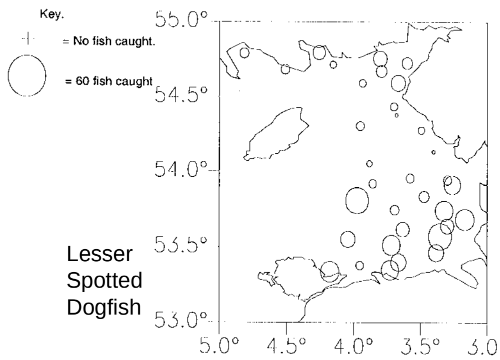


Figure 5: The average relative abundance of thornback ray, spotted ray and lesser spotted dogfish taken during the CEFAS trawl surveys

iii Although sea bass (*Dicentrarchus labrax*) were not caught with sufficient regularity in the CEFAS surveys to feature in Figure 3, they have an iconic status among recreational anglers and, to a lesser extent, among inshore commercial fishermen. In recent decades they appear to have become increasingly abundant in the eastern Irish Sea and now support small-scale seasonal net-fisheries as far north as the Solway Firth.

iv The abundance of all these species, commercial and non-commercial, varies considerably but none is considered 'rare' or 'endangered' (see IUCN web site for definitions - www.redlist.org/info/categories) although triggerfish (*Balistes carolinensis*) are undoubtedly irregular vagrants and species such as red mullet (*Mullus surmuletus*) and John Dory (*Zeus faber*) are at, or close to, the northern limits of their normal geographic distribution. There is concern expressed for the status of some commercial species, notably the cod, but these are given specific consideration below (§ 3.2.1), as are migratory species (§ 3.4), and species of nature conservation interest (§ 3.5).

Table 2: Species of fish and (commercial) shellfish caught at least once during the CEFAS autumn, 4-m beam-trawl survey of the eastern Irish Sea (1992-2003) arranged in the same groupings used to describe the UK commercial landings from the same area (see § 3.2).

Commercial		Non-Commercial	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Gadoids			
Bib or pout whiting	*Trisopterus luscus*	Poor cod	Trisopterus minutus
Cod	*Gadus morhua*		
Hake	*Merluccius merluccius*		
Ling	*Molva molva*		
Whiting	*Merlangius merlangus*		
Whiting, blue	*Micromesistius poutassou*		
Flatfish			
Brill	*Scophthalmus rhombus*	Scaldfish	*Arnoglossus laterna*
Dab	*Limanda limanda*	Solenette	*Buglossidium luteum*
Dover sole	*Solea solea*	Topknot, Imperial	*Phrynorhombus regius*
Flounder	*Platichthys flesus*	Topknot, Norwegian	*Phrynorhombus norvegicus*
Lemon sole	*Microstomus kitt*		
Plaice	*Pleuronectes platessa*		
Thickback sole	*Microchirus variegatus*		
Turbot	*Psetta maxima*		
Witch	*Glyptocephalus cynoglossus*		
Elasmobranchs			
Blonde ray	*Raja brachyura*		
Cuckoo ray	*Raja naevus*		
Lesser spotted dogfish,	*Scyliorhinus canicula*		
Nurse hound or bull huss	*Scyliorhinus stellaris*		
Spotted ray	*Raja montagui*		
Starry dogfish,	*Mustelus asterias*		
Starry smooth hound	*Mustellus mustellus*		
Thornback ray or roker	*Raja clavata*		
Tope	*Galeorhinus galeus*		
Other Demersal			
Conger eel	*Conger conger*	Bull rout	*Myoxocephalus scorpius*
Grey gurnard	*Eutrigla gurnardus*	Butterfish	*Pholis gunnellus*
John Dory	*Zeus faber*	Butterfly blenny	*Blennius ocellaris*
Monk or anglerfish	*Lophius piscatorius*	Clingfish, two-spot	*Diplecogaster bimaculata*
Octopus, northern	*Eledone cirrhosa*	Dragonet, common	*Callionymus lyra*
Red gurnard	*Aspitrigla cuculus*	Dragonet, reticulated	*Callionymus reticulata*
Red mullet	*Mullus surmuletus*	Dragonet, spotted	*Callionymus maculatus*
Seabass	*Dicentrarchus labrax*	Goby, sand	*Pomatoschistus minutus*
Squid	*Alloteuthis subulata*	Lumpfish	*Cyclopterus lumpus*
Squid	*Loligo vulgaris*	Pipefish, greater	*Syngnathus acus*
Triggerfish	*Balistes carolinensis*	Pipefish, Nilsson's	*Syngnathus rostellatus*
Tub gurnard	*Trigla lucerna*	Pogge or Hooknose	*Agonus cataphractus*
		Rockling, five-bearded	*Ciliata mustela*
		Rockling, four-bearded	*Rhinonemus cimbrius*
		Sea scorpion	*Taurulus bubalis*
		Squid	*Sepeiola*
		Weever, lesser	*Echiichthys vipera*
		Wrasse, goldsinney	*Ctenolabus rupestris*
Pelagic			
Garfish	*Belone belone*	Sandeel	*Ammodytes tobianus*
Mackerel, Atlantic	*Scomber scombrus*	Sandeel, greater	*Hyperoplus lanceolatus*
Scad or horse mackerel	*Trachurus trachurus*		
Sprat	*Sprattus sprattus*		
Crustacea			
Crab, brown	*Cancer pagurus*		
Crab, spider	*Maia squinado*		
Lobster, European	*Homarus gammarus*		
Shrimp, brown	*Crangon crangon*		
Molluscs			
Scallop, king	*Pecten maximus*		
Scallop, queen	*Chlamys opercularis*		
Whelk	*Buccinum caudatum*		

2.3 Shellfish

i. The CEFAS beam-trawl survey is not designed to sample commercial shellfish but each of the principal species for which there are fisheries in the eastern Irish Sea were recorded in the catches: king scallop (*Pecten maximus*) and queen scallop (*Chlamys opercularis*), whelks (*Buccinum caudatum*), brown crab (*Cancer pagurus*), lobster (*Homarus gammarus*) and brown shrimp (*Crangon crangon*; Table 2). Brown shrimps are most abundant in very shallow water, particularly adjacent to the major estuaries; hence, there are commercial fisheries in the Solway Firth, Morecambe Bay and the Ribble Estuary (Figure 6). The relatively few brown crab and lobsters that were taken in the trawl survey were widespread and their total distribution probably embraces most of the eastern Irish Sea. However, commercial exploitation (potting) is concentrated in two areas – around the North Wales coast, off Anglesey and the Great Orme, and along the coast of Cumbria (Figure 6).

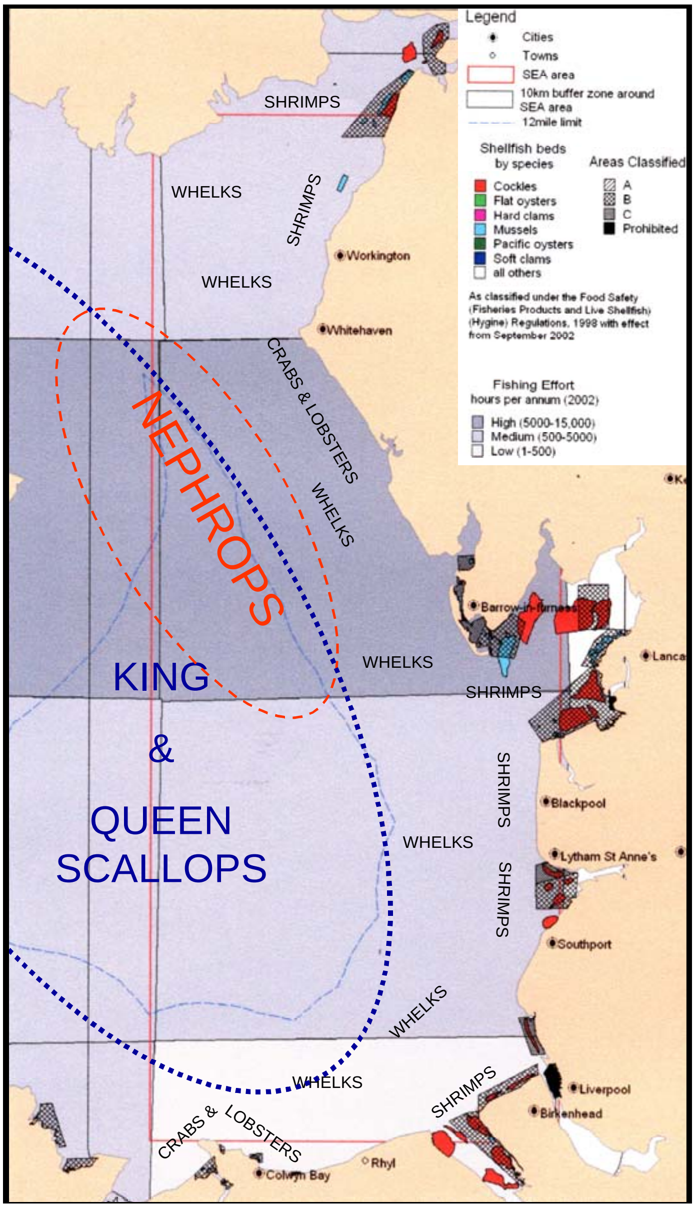


Figure 6: The distribution of major shellfish resources in the eastern Irish Sea (modified from CORDAH,, 2003).

ii. Nephrops (*Nephrops norvegicus*) – Dublin Bay prawns, langoustine, Norway lobster – were not recorded in the trawl survey but are an important shellfish resource throughout the Irish Sea. The principal stock and fishery is between the Isle of Man and Ireland but there is also an exploited stock in an area of mud off the Cumbria coast (see, for example, Figure 6 in Parker-Humphreys, 2004) in depths of 25-40 m from Barrow to Workington (Figure 6).

Occasionally, there are also spider crab (*Maia squinado*) and crawfish (*Palinurus elephas*) recorded from commercial landings but these are vagrant individuals at the northern limits of their normal distribution.

iii. Major cockle (*Cerastoderma edule*) and mussel (*Mytilus edulis*) stocks occur in, or adjacent to, the major estuaries (Figure 6), including Morecambe Bay, but whelks and king and queen scallops are widespread throughout the western half of the eastern Irish Sea. All of these species are subject to commercial exploitation.

iv. None of the commercial shellfish species that are found most frequently, and support specific fisheries is ‘rare’ or ‘endangered’ (see www.iucn.org for definitions), and none is subject to non-fishery management conservation measures.

2.4 Spawning and Nursery Areas

i. The vast majority of fish and shellfish spawn between late winter and early summer which enables the larvae to take advantage of the spring phytoplankton bloom and allows the juveniles time to feed and grow to a size that enables them to survive the winter drop in prey abundance. A similarly high proportion of fish, including the overwhelming majority of commercially exploited fish, have pelagic, ie free-floating, eggs. In contrast, the herring (*Clupea harengus*), sandeels and several of the non-commercial species, eg pogge (*Agonus cataphractus*), gobies and blennies, deposit their eggs on the seabed where they remain until the larvae hatch. These demersal spawners are potentially more sensitive to offshore developments than are the pelagic spawners. The spawning distribution and season for some species listed in Table 1 are shown in Figure 7, others may be found in Fox *et al* (1997).

2.4.1 Marine fish

i. Herring spawn off the east coast of the Isle of Man in August and September (Hillis & Grainger, 1990; Coull *et al*, 1998; Figure 7) but other commercial species spawn more or less ubiquitously throughout the area; some, however, have more defined centres of spawning than others. A centre of plaice spawning, for example, is found (February-April) in the area between the Great Orme and the Isle of Man and a similar area for Dover sole is found (April-May) further to the east in Liverpool Bay. There is another centre of spawning in the outer Solway Firth (Figure 7; Riley *et al*, 1986). Whiting (*Merlangius merlangus*, April-May) and dab (April-May) do not have such clearly defined spawning areas but cod spawning (March-April) is principally in the northern half of the eastern Irish Sea and flounders (*Platichthys flesus*) spawn (April-May) off all the major river estuaries, not least the Solway Firth (Figure 7).

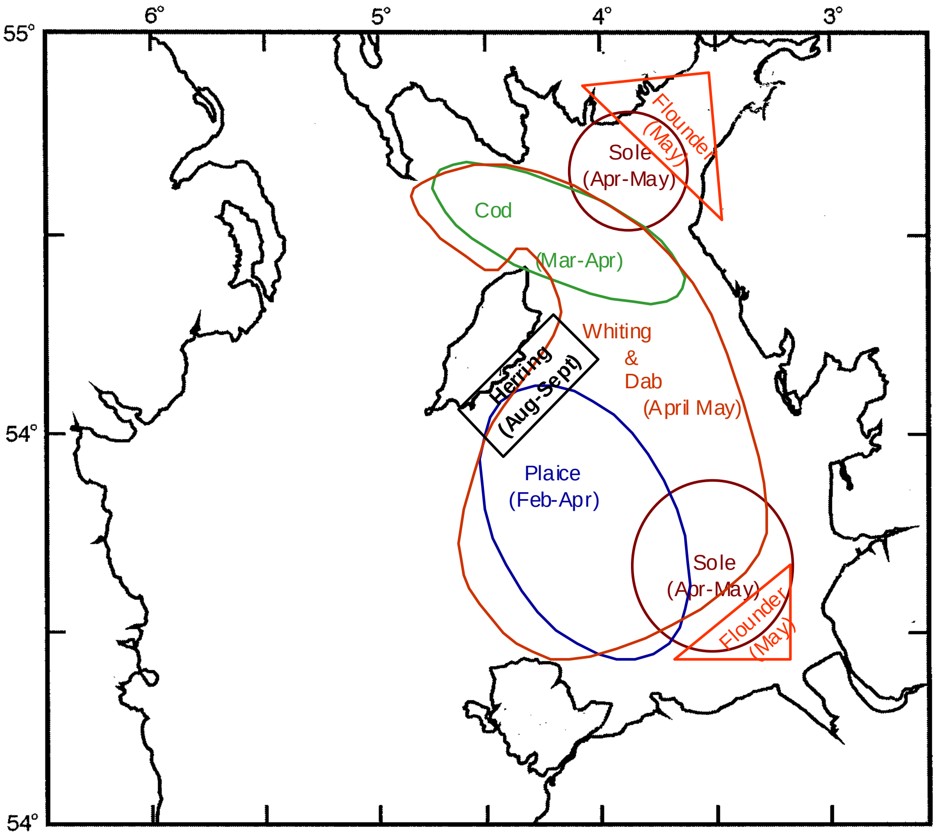


Figure 7: An indication of the spawning distribution of some fish species within the eastern Irish Sea (based on data from Fox *et al*, 1997).

ii. The non-commercial, bottom egg-laying finfish tend to deposit their eggs in close proximity to the area in which the adult population is found, few of these species undertake more than small-scale, seasonal, inshore-offshore migrations and probably maintain relatively discrete, locally-based populations rather than the Irish Sea-wide stocks of the larger species.

iii. The elasmobranchs, rays and dogfish, are found throughout the eastern Irish Sea (Ellis & Parker-Humphreys, 2005); they differ from the finfish in that they have internal fertilisation. With the exception of spur dogs (*Squalus acanthias*) and tope (*Galeorhinus galeus*), both of which are ovo-viviparous, rays and dogfish lay a small number of eggs, each protected within its own horny egg-case – commonly known as a mermaid's purse. The eggs are deposited in spring, in shallow areas of rough ground where the tendrils at each corner of the egg-case help anchor the egg to stones or weed to keep it *in situ*. Although elasmobranch spawning is widespread, not least for the lesser spotted dogfish, thornback ray (roker – *Raja clavata*) are most likely to be found in proximity to the major river estuaries. Hence, the area of rough ground in the vicinity of the North Hoyle wind farm, off the Dee Estuary (Figure 5), is one area in which it seems roker may congregate to spawn.

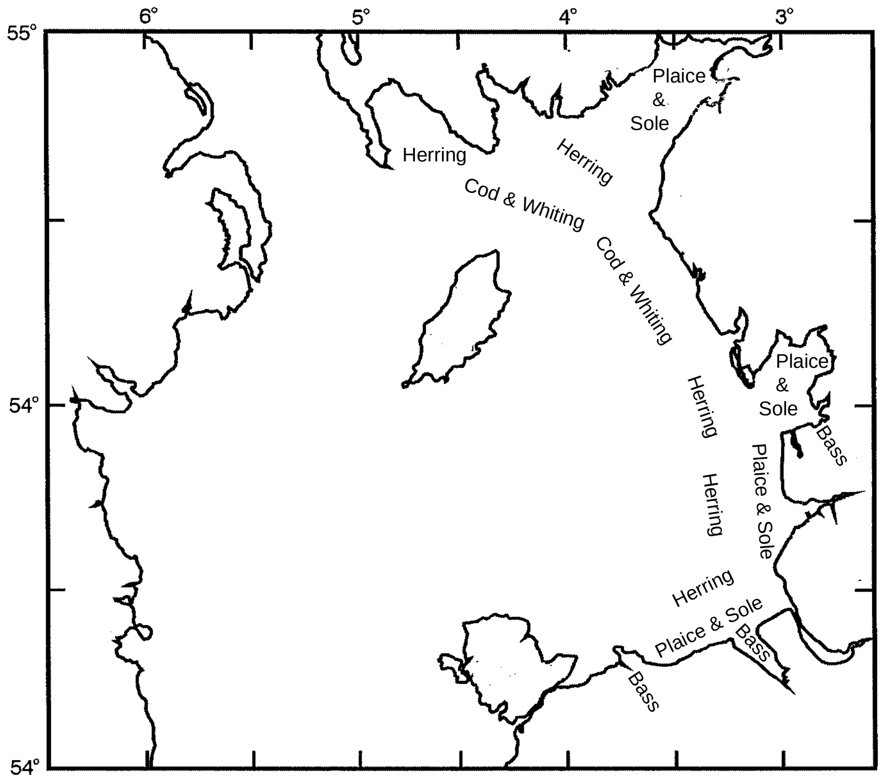


Figure 8: The distribution of juvenile fish and nursery areas around the eastern Irish Sea (After Hillis & Grainger, 1990 and Coull *et al*, 1998).

iv. Planktonic fish eggs and larvae drift wherever the tides and winds take them; for the majority, however, the juvenile stage is spent in shallow coastal waters. Whiting and herring are found more or less throughout the coastal margin of the eastern Irish Sea (Figure 8) while the dogfish and rays remain in close proximity to the areas in which the eggs were laid, as do most small non-commercial species.

v. In contrast to other (commercial) finfish, the distribution of juvenile flatfish is fairly precise and predictable (Figure 8). Post-larval turbot (*Psetta maxima*) and brill (*Scophthalmus rhombus*), for example, settle in the surf zone of exposed shores with relatively coarse sand beaches, eg along the Sefton-Fylde coast. Plaice prefer less exposed environments with somewhat finer sands. Although the juveniles may be found from the surf zone to 10 m depth off any sandy shore in the eastern Irish Sea, they are most abundant in Morecambe Bay (due to its size) but population densities may be no less in other sheltered areas such as the Solway Firth, Ribble Estuary or along the north Wales coast (Rogers, 1993, 1994; Innogy, 2002). Juvenile sole also prefer a sheltered habitat but one that is most often associated with reduced salinity and a higher mud content; hence, they are more likely to be found in the vicinity of estuaries such as the Dee, Ribble, Morecambe Bay and Solway Firth (Figure 9). Dabs are less discriminating; juveniles are found at almost any depth in the eastern Irish Sea.

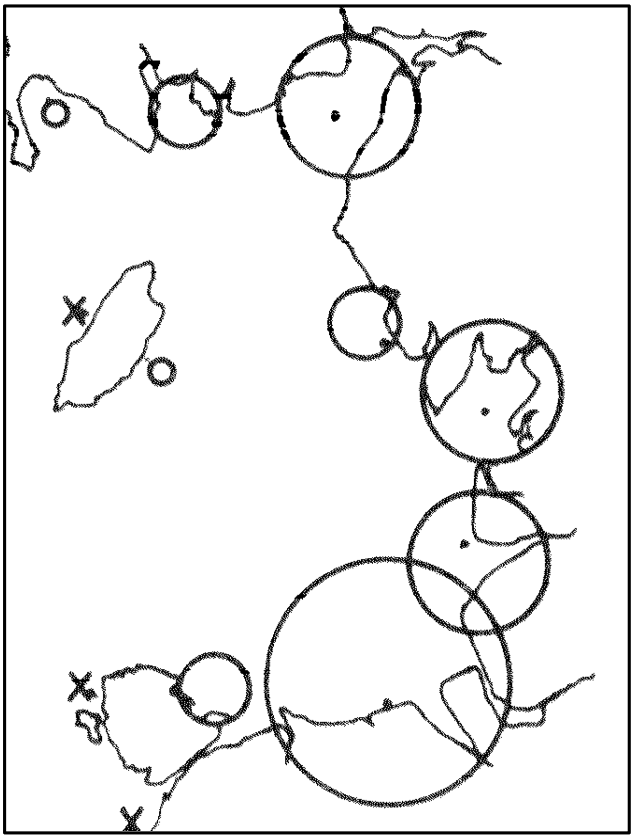


Figure 9: Distribution and relative abundance of 0-group Dover sole in the principal nursery areas in the eastern

vi. ... cket & Pawson, 1994) but there are statutory designated bass nurseries in the Conwy Estuary, Dee Estuary (DEFRA, 1999) and a small area around the cooling water discharge pipe to Heysham nuclear power station in Morecambe Bay (Figure 8). It is reasonable to assume, therefore, that there is some bass spawning in the eastern Irish Sea despite the absence of bass eggs or larvae from the samples analysed by Fox *et al* (1997).

2.4.2 Shellfish

i. Bivalve molluscs such as cockles, mussels and scallops all have planktonic larvae but the principal settlement (spatfall) tends to be in close proximity to the adult (parent) population. Spawning for all these species is from late spring to mid or even late summer. If for any reason the spat do not settle in close proximity to the areas occupied by the parent stock (Figure 5) there is likely to be poor recruitment with concomitant risks to the future wellbeing of the stock.

ii. Of the commercial mollusc species taken in the surveys (Table 2), the whelk does not have pelagic eggs but lays clumps of demersal egg-cases from which miniature, bottom-dwelling whelks hatch and adopt a proto-adult lifestyle. This life history tends to limit the distribution of juveniles to areas very close to, but possibly shallower than, the adult stock.

iii. Crustaceans differ from other shellfish species listed in Table 2 as they carry their fertilised eggs until they hatch. Egg-bearing shrimps undertake seasonal inshore-offshore migrations but the highest abundance of juveniles are found within sandy bays and major estuaries (see, for example, Neal, 2004). Lobster and crabs carry their eggs over winter and they hatch in spring or early summer (see, for example, Wilson, 2004). The larvae are widespread, as are juvenile brown crab (see, for example, Neal & Wilson, 2004) once they settle. Lobster, however, have very specific nursery habitat requirements usually comprising cobble scars over consolidated mud in which the juveniles burrow for the first 2-4 years of demersal life; no lobster nursery areas have yet been identified in the eastern Irish Sea.

iv. Juvenile nephrops also have a specific habitat requirement on which to settle (see, for example, Sabatini & Hill, 2004) – the areas of mud in which the parental stock is found (Figure 6). As with other species that have specific habitat requirements, there is the prospect of poor recruitment to the parent stock with concomitant risks for future brood-stock viability if the planktonic larvae drift away from suitable areas for settlement.

2.5 Migratory Species – Salmon, Sea Trout and Eels

i. The migratory species are diadromous fish, ie they either spawn in freshwater and feed at sea – the anadromous salmon (*Salmo salar*) and sea trout (*Salmo trutta*), or feed in freshwater and spawn at sea – the catadromous European eel (*Anguilla anguilla*). All three are found in virtually all the rivers draining into the eastern Irish Sea (Apprahamian & Apprahamian, 1999; Figure 10) and although the Mersey is not named in this figure, it supports an eel run and even the occasional salmon has been reported as testament to the gradual improvement in Mersey river water-quality.

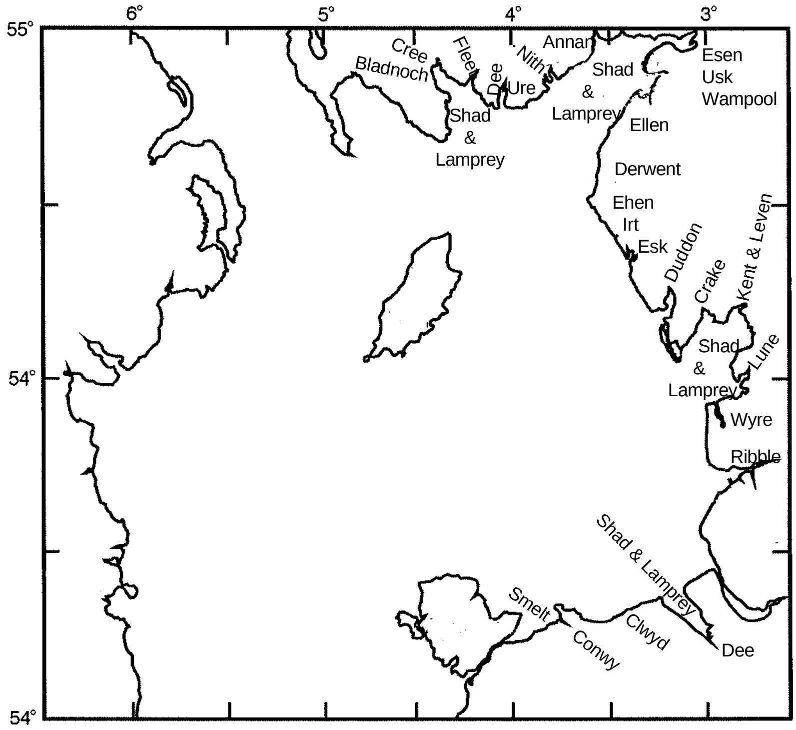


Figure 10: The named rivers known to have spawning salmon and or sea trout runs and estuaries from which shad, lampreys and smelt (species of nature conservation interest) have been recorded (Information from JNCC, 1999).

2.5.1 Salmon

i. Atlantic salmon spend a great part of their life at sea feeding before returning to the specific river of their birth (natal river) to spawn between November and January in the river's headwaters (see, for example, Mills, 1989 or Maitland & Campbell, 1992). Once they have spawned the majority die but a few survive to spawn a second or even a third time. Once hatched, the young fish (parr) spend 2-4 years in the river system before developing into smolts that swim downstream and migrate to sea between late April and early June.

ii. The smolts leave the estuaries in cohorts but whether they remain in shoals or migrate individually to their feeding areas is not known; it is known, however, that they remain relatively close to the surface. During their first year, after entering the eastern Irish Sea, the young salmon appear not to migrate any further than the west coast of Ireland but if they remain at sea for several years, they may migrate as far as the Faeroe Islands or Greenland.

iii. Fish that have spent more than one winter at sea (multi-sea-winter – MSW – fish) tend to arrive off their natal river in the late winter and enter the river system during the spring. These large fish are highly prized by anglers but are currently very scarce throughout Europe. Within the UK there is a policy that anglers must not retain these fish but return them to the river. In the late spring to early summer the smaller, single sea winter (SSW) fish return and move into the rivers.

iv. The route by which they return through the Irish Sea in search of their natal river is not known but it is assumed that they swim along the coast seeking olfactory clues that help identify the correct river. The initial entry into the river is not a smooth, continuous migration. The process may involve the fish waiting off the estuary for a freshet of rainwater to bring stronger clues to them or they may enter and leave more than one estuary before identifying their natal river and moving on into the freshwater river system. Even after identifying the home river some fish may remain within the tidal estuary for a prolonged period and then make a determined late run for the spawning grounds; others may take several weeks for the upstream migration.

2.5.2 Sea trout

i. The life cycle of the migratory sea trout is almost identical to that of salmon (see, for example, Maitland & Campbell, 1992, or Bagliniere & Maiss, 1998) but there are two significant differences. In contrast to the salmon, the majority of sea trout survive spawning and will return to their natal spawning river on numerous occasions during their life time. The other significant difference is that they do not appear to undertake the same sea migration but remain in coastal waters, probably close to their natal river. In addition, sea trout are more likely to enter an estuary and wait there in the pools for conditions to be right for the run up-river rather than remaining at sea off the estuary mouth as salmon tend to do. For all practical purposes, the early life history and emigration of sea trout smolts is the same as for salmon smolts.

2.5.3 European eels

i. Eels spawn in an area of the west-central Atlantic, east of the Caribbean known as the Sargasso Sea (see, for example, Maitland & Campbell, 1992, or Moriarty, 2000). The eggs and larvae – leptocephali – drift with the North Atlantic Drift and arrive in European coastal waters 2-4 years after spawning. Once in coastal waters, the leptocephalus undergoes metamorphosis to an elver or ‘glass’ eel and these young fish enter the estuaries of most UK rivers. The main elver run occurs each spring and although the numbers may never be as great as are found in the Severn Estuary, it is reasonable to assume that elvers will run up all the rivers entering the eastern Irish Sea.

ii. Eels spend many years in upper estuaries or freshwater where they feed and grow as 'yellow eels'. When they are ready to return to the spawning grounds they move downstream and on re-entering an estuary in late summer-early autumn they undergo a process of pigment change to become 'silver eels' ready for the return sea migration. Once at sea it is assumed that they leave coastal waters relatively rapidly.

2.6 Fish of Nature Conservation Interest

i. In addition to the European and national legislation that covers the exploitation of marine fish (eg Common Fisheries Policy) and migratory species (eg UK *Salmon and Freshwater Fisheries Act*, 1975), a number of fish species are subject to a range of national and international conservation measures (Table 3). Species of fish that are resident in, or are migrant visitors to, the eastern Irish Sea are listed in Table 4 alongside the legislation under which they receive protection.

Table 3: A summary of national and international legislation and treaties for the protection of fish of nature conservation interest (summarised from: Costello *et al*, 2002).

	Legislation	Purpose
1 –	*Wildlife and Countryside Act* 1981	Basic UK legislation underpinning nature conservation in the marine environment.
2 –	*Countryside & Rights of Way Act* 2000	UK legislation making stronger provision for nature conservation in the marine environment
3 –	Habitats Directive: *Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna*	Requirement to establish special areas of conservation (SAC) to protect named species and habitats.
3a -	*Conservation (Natural Habitats &c.) Regulations* 1994	UK regulations providing the statutory basis for implementing the Habitats Directive.
4 –	Bern Convention: *Convention on the Conservation of European Wildlife and Natural Habitats*	Particularly for species and habitats which require co-operation between states.
5 –	Bonn Convention: *Convention on the Conservation of Migratory Species of Wild Animals*	Particularly for animals which migrate across national boundaries.
6 –	CITES: *Convention on the International Trade in Endangered Species*	Treaty to prevent the trade in endangered species
7 –	Rio Convention: *Convention on Biodiversity*	Protection of biodiversity at level of genetics, species and ecosystems.
7a -	*Biodiversity Action Plans* 1995	UK mechanism for pursuing convention's objectives.

Table 4: Species of fish recorded from the Irish Sea (Potts & Swaby, 1999) that are covered by one or more of the legislative measures listed in Table 3.

Scheduled Species		Conservation Legislation (listed above)
Common name	**Scientific Name**	
Marine Fish		
Basking shark	*Cetorhinus maximus*	1, 2, 6, 7
Common goby	*Pomatoschistus microps*	4
Sand goby	*Pomatoschistus minutus*	4
Diadromous Fish		
Allis shad	*Alosa alosa*	1, 2, 3, 7
Twaite shad	*Alosa fallax*	1, 2, 3, 7
Salmon (in freshwater)	*Salmo salar*	3
River lamprey	*Lampetra fluviatilis*	2, 3, 7
Sea lamprey	*Petromyzon marinus*	2, 3, 7
Smelt or sparling	*Osmerus eperlanus*	7

2.6.1 Basking shark

i. The basking shark (*Cetorhinus maximus*) is the second largest fish in the world; it is a regular summer migrant to the coastal waters of the Isle of Man and the western Irish Sea but neither a numerous nor regular visitor to the eastern Irish Sea. It is a plankton filter-feeder that is most frequently associated with hydro-thermal fronts or other areas of high plankton production. Little detail is known about its annual life cycle but recent data-logging tag studies (www.cefas.co.uk/sharks) indicate that it overwinters in shelf waters, if not the Irish Sea, rather than migrating to the off-shelf abyss as had previously been thought possible. In common with other large sharks, the basking shark is ovo-viviparous, ie eggs are gestated internally and live young are borne.

2.6.2 Common and sand goby

i. Although the common and sand gobies are scheduled species they are not subject to any specific UK conservation measures; they are ubiquitous and abundant in shallow sandy habitats less than 2-5 m in depth. During spring and early summer they lay demersal eggs, often on the inside of an empty bivalve mollusc shell. The eggs are guarded by the male until they hatch.

2.6.3 Allis and twaite shad

i. The allis (*Alosa alosa*) and twaite (*Alosa fallax*) shad are members of the herring family that spend most of their late juvenile and adult life in coastal waters (see, for example, Maitland & Campbell, 1992). In spring, the mature adults enter estuaries and move upstream to the lower reaches of freshwater where they lay their eggs before returning (May-June) to the sea. The post-larval fish drift downstream in late summer and young-of-the-year reach the estuaries in autumn where they probably remain over winter. Neither species is abundant nor a regularly recorded species in the Irish Sea but there are records of their capture in all of the major estuaries draining into the eastern Irish Sea (Potts & Swaby, 1999; Figure 9). It is more than 70 years since there was any positive record of the allis shad spawning in UK rivers but twaite shad are known to spawn in rivers of the south-west of England and south Wales (Apprahamian & Apprahamian, 1990). The spawning status in rivers draining into the eastern Irish Sea is not certain but relatively regular catches made in salmon nets in and around the Solway Firth suggest that twaite shad may spawn in one or more of the rivers draining into the Solway Firth.

2.6.4 River and sea lamprey

i. The distribution (Figure 10) and life-history of lampreys is not dissimilar to that of the shads (see, for example, Maitland & Campbell, 1992); most of their life is spent in coastal waters and they enter estuaries to spawn in the spring. Sea lampreys (*Petromyzon marinus*) spawn in the lower reaches of rivers before returning to sea in early summer, followed by young-of-the-year in the autumn. River lampreys (*Lampetra fluviatilis*) migrate further upstream and the juveniles remain in the river until spring when they emigrate to the estuaries where they remain for 1-2 years.

2.6.5 Smelt

i. The European smelt (*Osmerus eperlanus*) is a member of the salmon family that, like shad and lamprey, spends most of its adult life in coastal waters but enters estuaries to spawn in the spring (see, for example, Maitland & Campbell, 1992). The adults return to sea once they have spawned; the post-larvae drift downstream and the young-of-the-year reach the lower estuary in autumn. Their distribution and status in the eastern Irish Sea is not known with any certainty but a small spawning population does run into the River Conwy.

3 The Exploited Fish Stocks of the Eastern Irish Sea

3.1 Introduction

i. All fishing within the Irish Sea is subject to EU regulations of the Common Fisheries Policy (CFP). Most commercially exploited species of fish are subject to TAC (total allowable catch) and quota management control with specific quotas being allocated to EU member states that are allowed to fish within an area – in this instance ICES Division VIIa, the Irish Sea. States that have quota to fish in the Irish Sea are: Belgium, France, Ireland, Netherlands and the UK. (Although the Isle of Man is not a member of the EU nor a constituent part of the UK, it fishes against the UK quota.)

ii. UK registered fishing vessels can fish anywhere in the eastern Irish Sea – subject to any local (sea fisheries committee) size-limitation byelaws. Irish-registered vessels have historic rights to fish within 6-12 nautical miles (nmi) of baselines throughout the eastern Irish Sea and French-registered vessels have similar rights from the latitude of Fleetwood around Liverpool Bay to the longitude of Point Lynas (NW Anglesey).

iii. The quantities of fish landed by each EU member state fishing within the Irish Sea (ICES Division VIIa) are published each year but they are not broken down into statistical rectangles (Figure 11). However, these data are available for UK registered fishing vessels from DEFRA Fisheries Statistical Unit and, as UK landings account for the greater part of the Irish Sea TAC, they are used as the basis for assessing the relative importance of commercially exploited species. With the exception of cockle and mussel stocks, however, both of which are assessed locally, the main fish-stock assessments

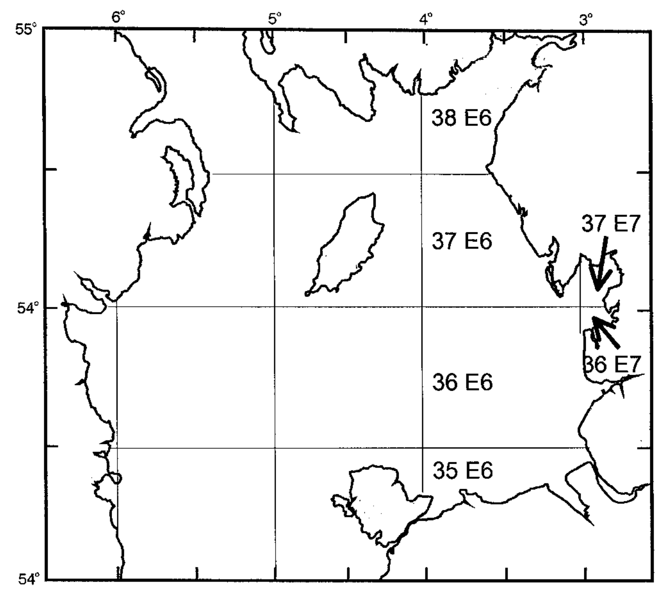


Figure 11: ICES Statistical Rectangles in the eastern Irish Sea covering the area of this review.

are made by ICES for the Irish Sea (Division VIIa) as a whole or for even more extensive areas.

iv. The quantity of fish landed at UK ports is recorded by port-based staff of the government fishery departments. Vessels over 10 m in length are obliged to maintain up-to-date records of when and where they fish and how much of the catch is retained, by species. Vessels under 10 m in length are neither required to keep records nor are they obliged to make any declaration of quantity landed to the fishery departments. Hence, all official landing statistics refer to 'nominal landings', ie they represent a 'best estimate' rather than an absolute figure. Such information that is available is usually provided through vessel owners' catch selling-agents or local sea fishery committee permit schemes, eg for shellfish.

v. The 54 species and categories of finfish and the 13 species and groups of shellfish caught by UK registered vessels in the eastern Irish Sea are summarised in Table 5. The top-ten species of finfish, by weight landed, are: plaice (351 t), skates and rays – predominantly roker (241 t), spurdog, (115 t), cod (102 t), whiting (101 t), gurnard (80 t), Dover sole (58 t), haddock (41 t), flounder (40 t) and brill (25 t). Almost 90% of the crustacean shellfish landings are accounted for by nephrops (414 t) but over 80% of the 9100 t (all species of fish and shellfish combined) landed from the eastern Irish Sea are accounted for by four species of molluscan bivalve shellfish: cockles (2699 t), queen scallops (2151 t), mussels (2119 t), and king scallops (392 t).

vi. The distribution of major groupings of fish catch within the eastern Irish Sea is summarised in Figure 12. This shows that very little finfish is caught within Morecambe Bay (Figure 12A) but there is an appreciable quantity of molluscan shellfish, mostly mussels (Table 5) taken from Morecambe Bay North (Figure 12B). The high quantity of cockles recorded from rectangle 37E6 (Cumbria Coast) are actually from within the northern part of Morecambe Bay as the rectangle straddles the Furness peninsula (Officers of North Western & North Wales SFC, pers comm.). Elsewhere, the greatest quantities of fish are taken in the open-sea area of the eastern Irish Sea (Rectangles 36E6 and 37E6), off the Sefton, Fylde and Cumbria coast. In these areas flatfish, principally plaice, are the resource of greatest interest but rays, dogfish and whiting are also important (Table 5). By

Table 5: The five-year (1999-03) average annual nominal landings (tonnes) from all UK-registered vessels fishing in the eastern Irish Sea: landings less than 1 tonne are shown as zero, a blank space indicates no reported landing.

	Rectangle / Species	35 E6 N Wales Coast	36 E6 Sefton & Fylde	36 E7 Morecambe Bay S	37 E7 Morecam be Bay N	37 E6 Cumbria Coast	38 E6 Solway Firth	Total
Gadoids	Cod	3	32	0	0	55	12	102
	Greater Forkbeard		0				0	0
	Haddock	4	12	0	0	20	5	41
	Hake	1	1		0	4	0	6
	Ling	0	0			1	0	1
	Pollack	0	1	0		4	1	6
	Pout Whiting	0	0	0		0	0	0
	Saithe or Coley	0	1			3	0	4
	Whiting	14	30		0	50	7	101
	Total	**23**	**77**	**0**	**0**	**136**	**25**	**261**
Flatfish	Brill	1	5	0	0	14	6	25
	Dab	0	11	0	0	5	0	16
	Dover Sole	8	28	0	0	16	7	58
	Flounder	1	35	0	0	5	0	40
	Halibut				0	0		0
	Lemon Sole	0	1		0	3	1	5
	Long Rough Dab					0		0
	Megrim	0	0			0	0	0
	Plaice	10	119	0	0	170	53	351
	Sand Sole	0	0			0	0	0
	Turbot	1	2	0	0	8	2	13
	Witch		0			2	0	2
	Total	**20**	**201**	**0**	**0**	**222**	**68**	**511**
Elasmobranchs	Greater Spotted Dogfish	0	0					0
	Lesser Spotted Dogfish	0	0			2	0	2
	Sharks	0	0			0		0
	Skate & Rays	40	87	0	0	78	36	241
	Spurdog	8	17		0	70	20	115
	Tope	0	1			0	0	1
	Unidentified Dogfish	0	1					1
	Total	**48**	**106**	**0**	**0**	**151**	**56**	**360**
Other Demersal	Bass	2	0		1	1	0	4
	Black Sea bream		0					0
	Catfish		0					0
	Conger Eel	0	0	0		1	0	2
	Cuttlefish	0	0			0	0	0
	Eel		0					0
	Greater Weever		0					0
	Grey Mullet	0	0		0	1	0	1
	Gurnards	5	29	0	0	38	8	80
	John Dory	0	0			0	0	0
	Mixed Demersal	0	0	0	0	1	0	1
	Mixed Squid & Octopus	0	0					0
	Monkfish	1	3		0	3	1	8
	Octopus	0	0				0	0
	Red Mullet	0	0				0	0
	Redfish	0						0
	Rockling	0						0
	Salmon				0			0
	Sea Trout				0	0		0
	Sea Breams	0						0
	Squid	1	2		0	7	3	14
	Wrasse	0	0			0		0
	Total	**10**	**34**	**0**	**1**	**53**	**12**	**111**
Pelagic	Herring	0	0			0		0
	Horse Mackerel or Scad						0	0
	Mackerel	0	0			0		0
	Sprats	0						0
	Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Crustacea	Brown Shrimps	0	0		2	1	47	51
	Crabs		0			0	0	0
	Lobsters	2	0			0	0	2
	Nephrops		20	0		377	16	414
	Velvet Crabs	0						
	Total	**2**	**20**	**0**	**2**	**379**	**65**	**467**
Molluscs	Clam (*Venus decussata*)		0			0		0
	Cockles	367			301	2,024	8	2,699
	Mixed Clams		0			0		0
	Mussels	166	5	4	1,043	108	793	2,119
	Periwinkles	0						0
	Queen Scallops	145	1,949		0	26	32	2,151
	Scallops	57	309			18	9	392
	Whelks		3			3	23	29
	Total	**735**	**2,266**	**4**	**1,344**	**2,178**	**864**	**7,390**

comparison, relatively little fish from any group is taken off the North Wales coast or in the Solway Firth (Figure 12).

vii. Of the fish landed from the eastern Irish Sea, only cod, haddock, whiting, plaice, Dover sole, herring and nephrops stocks are subject to analytical assessment by ICES. Many of the other species are subject to EU catch limitations within a broader western area encompassing, but not limited to, the Irish Sea (eg ICES sub-Area VII).

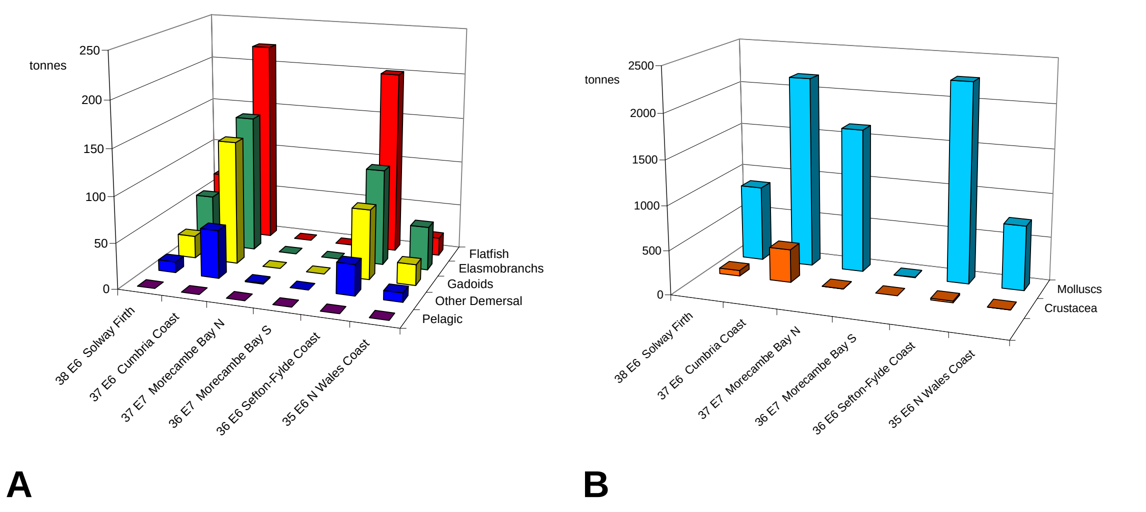
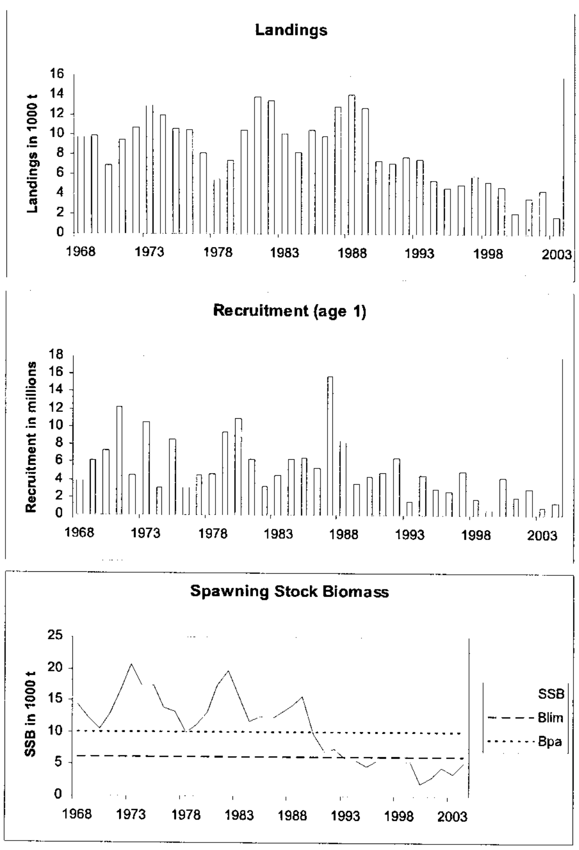


Figure 12: Five-year annual average (1999-03) UK nominal landings (tonnes), all gears combined, from individual ICES Statistical Rectangles in the eastern Irish Sea: A –

3.2 Summary of ICES Stock Assessments for the Irish Sea (ACFM, 2004)



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ii. The EU agreed a total allowable catch for cod from the whole of the Irish Sea in 2003 of 1950 t: ICES estimate of landings was 1810 t, the first time the probable catch had not exceeded the agreed TAC since 1999. To optimise conditions for the recovery of the Irish Sea cod stock ICES advised a closure of all cod fisheries in the Irish Sea. This advice was not adopted by the EU but there are seasonal (spring) closures in the northern Irish Sea and the EU set a TAC for 2005 of 2150 t (UK quota 619 t).

3.2.2 Dover sole

i. Irish Sea sole stock is fully exploited with the current spawning stock biomass at the precautionary long-term minimum, ie $B_{pa} \approx 3800$ t (Figure 14). At this level, there is a heightened risk of reduced reproductive capacity and in recent years recruitment of juvenile fish has been at or below the long-term average.

ii. The ICES estimates of recent catches have been in line with the TAC agreed by the EU Council of Ministers at 1000 t; the TAC set for 2005 is 960 t (UK 213 t).

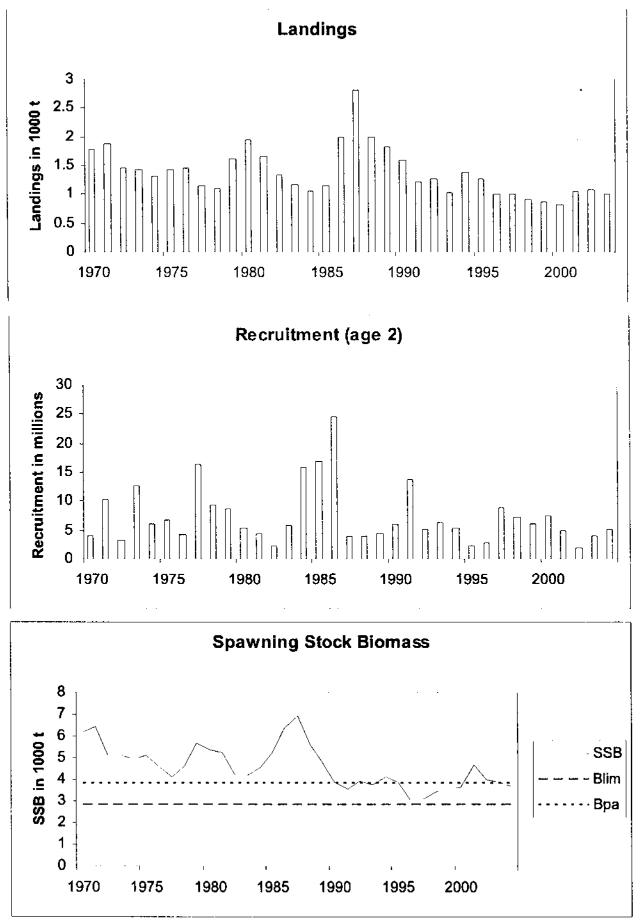

Figure 14: International landings of Dover sole from the Irish Sea and ICES estimates of juvenile recruitment and spawning stock biomass (from ACFM, 2004).

3.2.3 Haddock

i. Haddock in the Irish Sea is assessed as part of a western waters stock, an area extending from the Irish Sea and west of Ireland south through the Celtic Sea, into the Bay of Biscay and the Iberian Peninsula. This stock is being fished unsustainably; the spawning stock biomass in 2004 was estimated to be ≈ 3000 t (Figure 15). In common with other haddock stocks, recruitment of juvenile fish is erratic; there was a relatively strong year class in 2002 but both 2001 and 2003 were among the lowest recorded. There are medium to long-term objectives (ie B_{lim} and B_{pa}) for the management of this stock.

ii. There is little scientific information available for an analytical assessment but the EU set a precautionary TAC for the Irish Sea in 2003 of 600 t; the EU official landing statistics amounted to 410 t. The EU set a TAC for 2005 of 1500 t (UK 718 t).

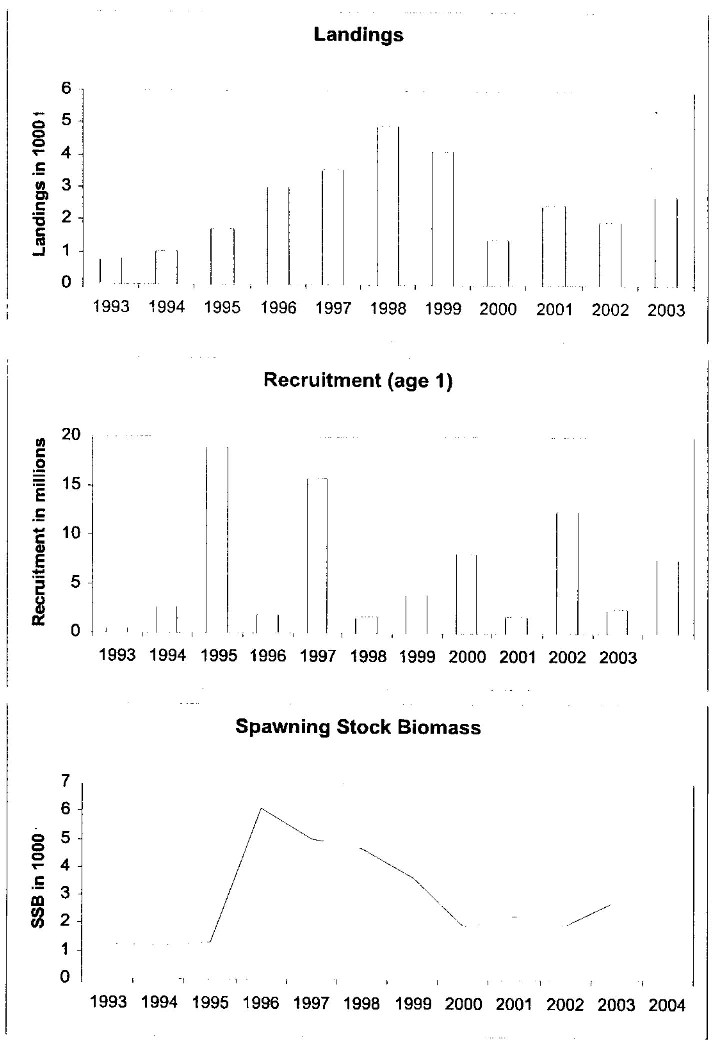

Figure 15: International landings of haddock from the Irish Sea and ICES estimates of juvenile recruitment and spawning stock biomass (from ACFM, 2004).

3.2.4 Herring

i. There are three separate fisheries in the Irish Sea: southern Irish Sea, western Irish Sea and Isle of Man; the most important of these is the western fishery between the Isle of Man and Ireland. The ICES assessment and the EU fishery management measures focus on this fishery. The TAC for 2005 is 4800 t (UK 3550 t)

ii. The Isle of Man fishery is also outside the strategic eastern Irish Sea wind-farm area as well as being a small fishery. Effectively, there is no exploited herring stock within the strategic eastern Irish Sea wind-farm area even though adult and, particularly, juvenile herring are found throughout the area.

3.2.5 Plaice

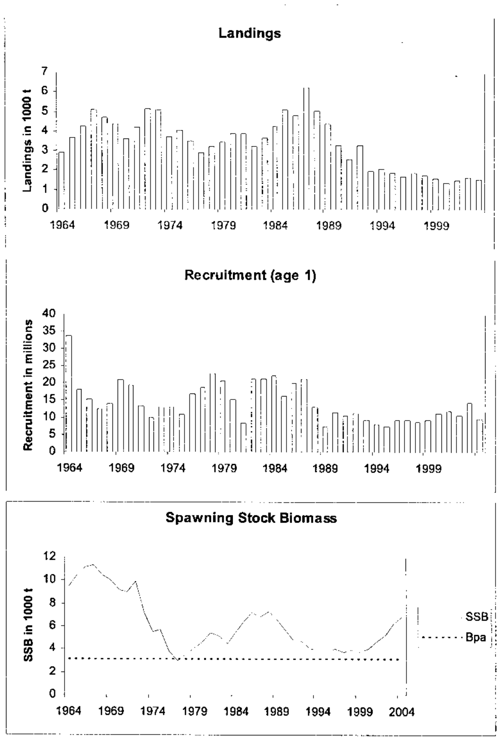

Figure 16: International landings of plaice from the Irish Sea and ICES estimates of juvenile recruitment and spawning stock biomass (from ACFM,

i. This stock is in a relatively robust condition with spawning stock biomass currently 6000 t or double the precautionary long-term minimum – $B_{pa} \approx 3100$ t (Figure 16). The stock has full reproductive potential with recent juvenile recruitment levels running at about the level of the long-term average; the stock is being exploited at a sustainable level.

ii. Irish Sea fisheries are mixed fisheries in which a range of species are caught irrespective of the principal target species. Current EU policy is to manage fishing for plaice so that it minimises the risk to the cod stock rather than what the plaice stock could otherwise support. The TAC for 2005 is 1608 t (UK 485 t).

3.2.6 Whiting

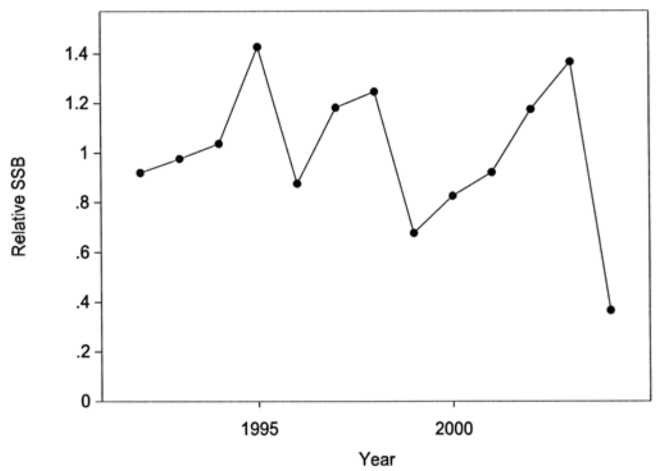

Figure 17: Estimates of relative spawning stock biomass from UK research vessel surveys in the northern Irish Sea (from ACFM, 2004).

i. There is virtually no directed fishing for whiting as it is a low-value species. Most of the whiting landed are taken as by-catch in the nephrops fishery, a fishery in which large numbers of juvenile whiting are caught. The spawning stock biomass is 'low' (Figure 17) with reduced reproductive capacity and is being harvested unsustainably. Although ICES has not specified the size of the current stock it has defined the minimum stock for long-term viability (B_{lim}) as 5000 t but would prefer it to be in excess of 7000 t (B_{pa}). The EU agreed a TAC for 2003 of 500 t but the actual catch is unknown due to the high level of discarding in the nephrops fishery. The EU set a TAC for 2005 of 514 t (UK 199 t).

3.2.7 Nephrops

Although nephrops populations occupy relatively discrete, localised areas of seabed, the EU sets a TAC for all nephrops fisheries throughout ICES Subarea VII (Irish Sea, west of Ireland, Celtic Sea and English Channel); this is currently set at 17 790 t, almost double the 9550 t recommended by ICES. ICES, however, recognises the localised distribution of nephrops and its associated fisheries and assesses 'functional units' (ICES, 2003) within the wider TAC management area; the eastern Irish Sea is one such functional unit (FU 14 - between the Isle of Man and Cumbria).

i.

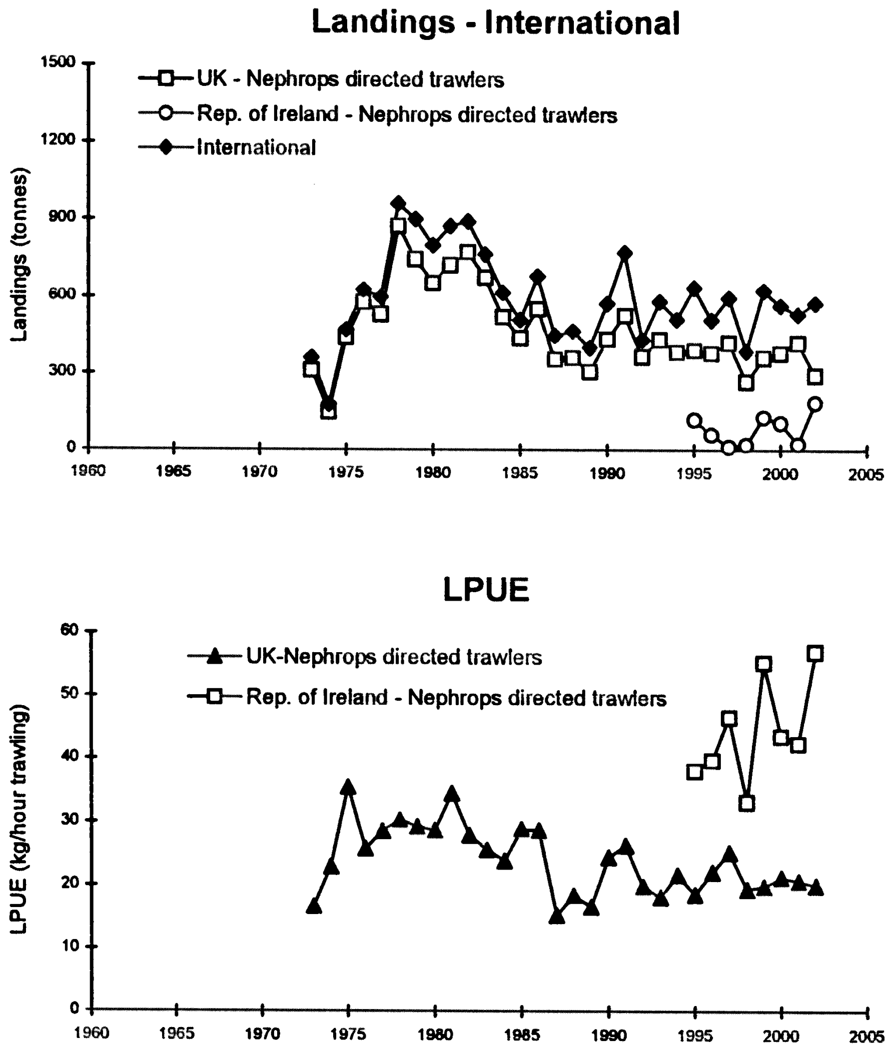

Figure 18: Long-term trend in international landings of nephrops from the Irish Sea and landings per unit of effort, an index of spawning stock biomass (from ACFM, 2003)

ii. Landings from the eastern Irish Sea population of nephrops have been stable since the mid 1980s (Figure 18) and such assessment data as are available indicate that the spawning stock biomass and the recruitment of juveniles are also stable. ICES recommends that nephrops in the Irish Sea should be assessed and managed separately from elsewhere in Subarea VII but, at present, the EU continues to include it in the wider area – TAC for 2005, 19544 t (UK 6411). Landings from the eastern Irish Sea, FU 14, are 5-600 t pa, most of which (400+ t) are landed by UK registered vessels.

3.2.8 Skates, rays and other commercial finfish

i. The EU sets precautionary TAC for a range of other species but they invariably cover wider areas, typically from the west of Scotland southwards to Spain and Portugal, including the Irish Sea. Species in this category for which the UK receives a quota allocation include: hake (*Merluccius merluccius*), horse mackerel (*Trachurus trachurus*), mackerel (*Scomber scombrus*), megrim (*Lepidorhombus whiffiagonis*), monkfish (*Lophius piscatorius*), pollack (*Pollachius virens*) and saithe (coley – *Pollachius pollachius*). There are no directed fisheries for these species in the Irish Sea and none features very strongly in UK landings from the Irish Sea.

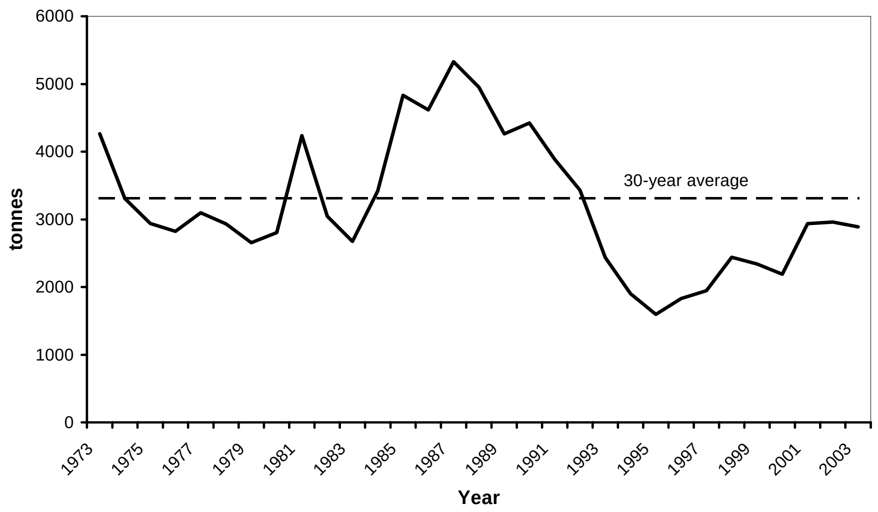

Figure 19: International landings of skates and rays (all species combined) from the Irish Sea 1973-03 (data from ACFM, 2004).

ii. In contrast, there are directed UK fisheries for rays but there is no TAC or quota control. Over the 30-year period to 2003, international landings from the Irish Sea have fluctuated around the long-term average of 3314 t (Figure 19). There was a 35% fall in landings from 1987 to 1997 since when there has been a sustained recovery to a level approaching the long-term average. Nevertheless, there is widespread concern, specifically among the statutory and voluntary nature conservation bodies, that rays are vulnerable to over exploitation and measures should be taken to limit catches.

iii. Bass is another species for which the EU does not yet set a TAC or national quotas and recreational anglers are concerned about the effect commercial catches are having on the stock, particularly in the western English Channel. Some anglers advocate the designation of bass as a 'recreational species' that should not be fished by commercial fishermen but the commercial fishing industry is strongly opposed to any such change in status.

3.3 Shellfish Stocks

3.3.1 Crustaceans

i. The principal fishery for crustacean shellfish in the eastern Irish Sea is the trawl fishery for nephrops (≈ 400 t, Table 5) described above (§ 3.2.7). All other fisheries for crustaceans are undertaken inshore. Very small quantities of brown crab and lobster are landed (Table 5) by under 10 m boats from areas around the Great and Little Orme Heads, North Wales, and along the Cumbria coast, but none of these populations are subject to stock assessment.

ii. In the northern half of the eastern Irish Sea, from the Ribble Estuary to the Solway Firth, there is a regular, shallow-water fishery for brown shrimps (≈ 50 t per year, Table 5). Occasionally the North Western and North Wales Sea Fisheries Committee undertakes a review of shrimp stocks and their management within its district but as this is a short-lived species (≤ 3 years) with potentially very high local and inter-annual variation, regular assessments and catch limits are neither made nor set.

3.3.2 Molluscs

i. ***Scallops*** - Offshore dredge fisheries for both king and queen scallops are widespread throughout the Irish Sea from Cardigan Bay in the south to the outer Firth of Clyde in the north (Hillis & Grainger, 1990). The king scallop fisheries are predominantly in areas west and south of the eastern Irish Sea but relatively small quantities are taken from within this area (= 400 t, Table 5); the quantity of queen scallops taken from the eastern Irish Sea is significantly greater (= 2000 t, Table 5). Neither species is subject to stock assessment beyond the territorial waters of the Isle of Man, nor are there catch limitations other than in Man waters, but there are EU and national minimum landing-sizes and a closed season.

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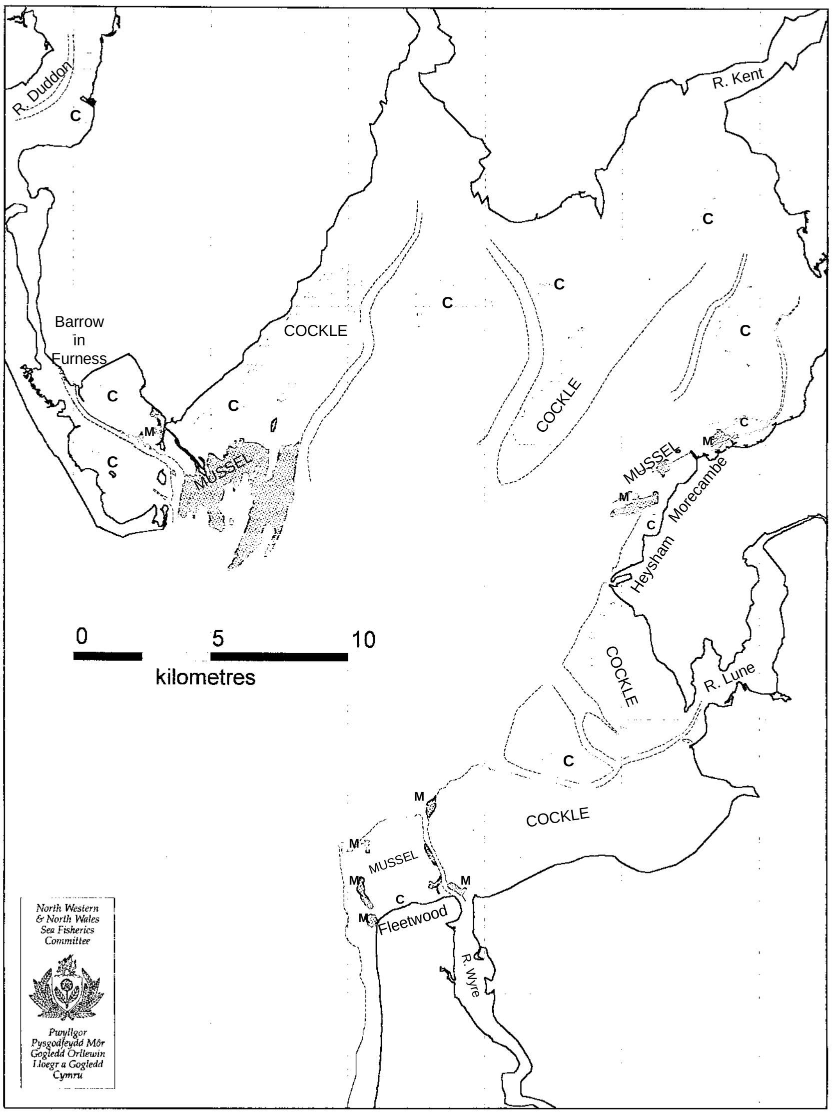

Figure 20: Distribution of exploited cockle and mussel beds in Morecambe Bay (chart provided courtesy of North Western & North Wales Sea Fisheries Committee).

ii.

iii. ***Cockles*** - All cockle fisheries in the eastern Irish Sea are intertidal, wild-stock fisheries, principally hand gathered but occasionally tractor dredging takes place. Stocks in the Dee Estuary are assessed and managed by the Environment Agency under its powers to act as a sea fisheries committee. In the Solway Firth, the principal stock and fishery is on the Scottish side of the estuary where the stock is assessed by Fisheries Research Services, Aberdeen, and managed by the Scottish Executive Environment and Rural Affairs Department (SEERAD) and Cumbria Sea Fisheries Committee. Elsewhere, but principally within Morecambe Bay (Figure 20), the stocks are assessed annually and managed by the North Western and North Wales Sea Fisheries Committee. All of the assessments and management programmes are carried out in consultation with the statutory conservation agencies and individual beds are often shut if stocks are too low to sustain a fishery without putting bird populations at risk.

iv. In recent years, the 5-year average annual yield from the Solway Firth has been trivial (< 10 t, Table 5) but the Dee Estuary fishery yields ≈ 400 t (Table 5), albeit sporadically, as the beds are frequently shut due to low stock levels. The most reliable and prolific fishery (≈ 2300 t, Table 5) is in the northernmost part of Morecambe Bay around the Furness Peninsula but there are also exploited beds in the southern part of Morecambe Bay off Heysham and Morecambe itself. There is also an occasional fishery on the Lavan Sands (eastern Menai Strait, North Wales), immediately to the west of the eastern Irish Sea assessment area.

v. ***Mussels*** - Mussels are harvested from both wild-stock and cultivated (aquaculture) beds in the eastern Irish Sea. Just outside the area defined as the eastern Irish Sea for this review, in the eastern Menai Strait, there is an extensive area of cultivation that typically yields in excess of 2000 t per annum. Elsewhere on the North Wales coast, there is a small-scale traditional, wild-stock fishery in the Conwy Estuary and occasional mussel harvesting in the Dee Estuary off West Kirby; together they have a 5-year annual average yield of 150-200 t (Table 5).

vi. As with cockles, the fisheries are assessed and managed by the sea fisheries committee (Conwy) and the Environment Agency (Dee). There is wild-stock harvesting from a number of beds throughout Morecambe Bay and along the Cumbria coast and into the Solway Firth; all are assessed and managed by the sea fisheries committees. The bulk of the mussel fishery in Morecambe Bay (≈ 1000 t, Table 5), however, is for juvenile mussels that are relayed on cultivation sites elsewhere, eg Menai Strait (NWNWSFC, pers comm).

vii. ***Whelks*** – this species is widely distributed and fished (pots), albeit in relatively small quantities (5-year annual average (≈ 30 t, Table 5) throughout the eastern Irish Sea but excluding the largely intertidal waters of Morecambe Bay. The stocks are subject neither to stock assessment nor catch limitations.

3.4 Migratory Species

i. In this context ‘migratory species’ are the anadromous salmon and sea trout and the catadromous European eel. The status of individual salmonid stocks in UK waters is assessed by the Environment Agency in England and Wales (EA, 2004) and river salmon boards in Scotland (FRS, 2003). The Environment Agency also monitors the state of eel stocks in freshwater. All are subject to international assessment jointly by ICES and EIFAC – the

European Inland Fisheries Advisory Committee, a body sponsored by the Food and Agriculture Organisation of the United Nations (FAO).

ii. Internationally, all three species are giving cause for concern as stocks appear to be subject to a process of long-term decline. Whilst fishing inevitably contributes to this cause for concern, environmental factors are also assumed to be at play. There are no directed offshore sea-fisheries for any of the migratory species in the eastern Irish Sea although there are licensed net fisheries, including stake nets, for salmon and sea trout in the Solway Firth.

3.4.1 Salmon

i. Salmon catches reported to the Environment Agency for 2003 (EA, 2004; Figure 21) from commercial and recreational fisheries in north-west England (6154 fish) were 26% down on the 1998-02 5-year mean (8267 fish). In Wales the 2003 catch (3490 fish) was 36% down on the 5-year mean (5468 fish). However, as the figures from Wales tend to be dominated by catches from the Severn Estuary and south Wales rivers, the data for north-west England are probably a better indication of stocks entering the rivers of North Wales.

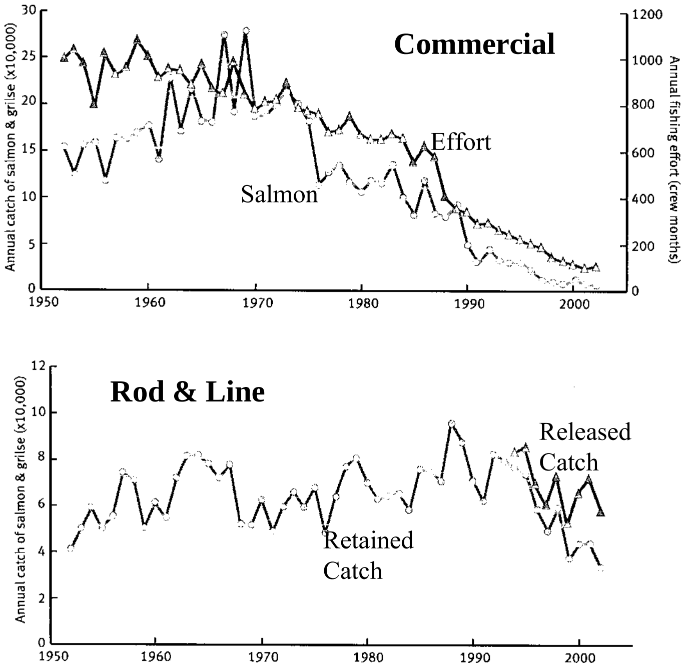

Figure 21: Commercial and recreational catches of salmon reported to the Environment Agency in NW England and Wales (from EA, 2004). The shaded areas in the Rod Catch histograms indicate fish that were released after capture (from EA, 2004).

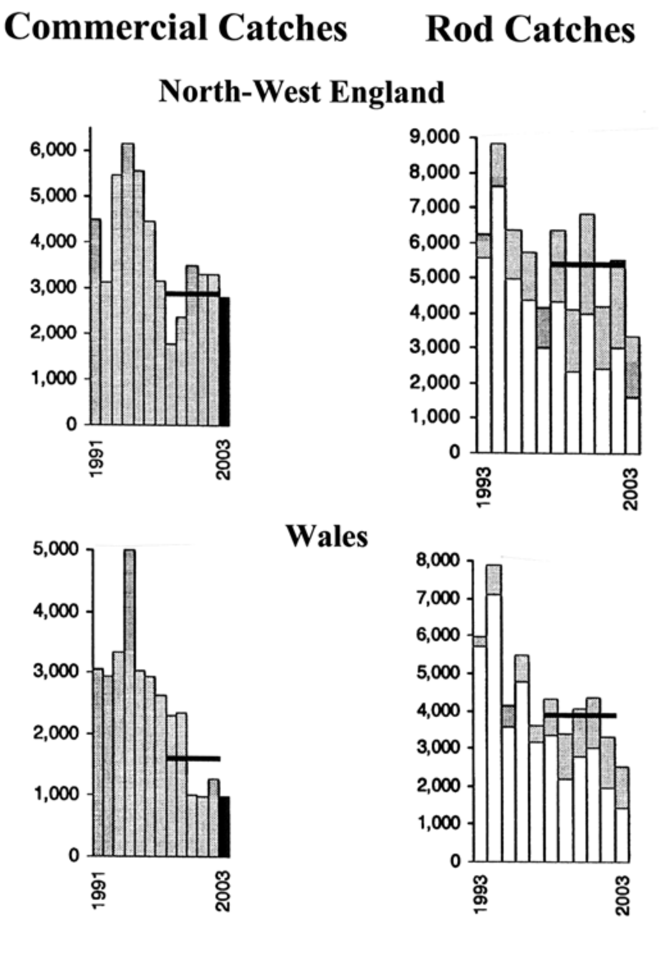

Figure 22: Annual salmon catch, including grilse (one sea-winter fish), and commercial

ii. There are commercial net and fixed engine (hang nets and traps) salmon fisheries in the Scottish Solway Firth as well as recreational fisheries in the rivers draining into the firth. Despite the sustained 40-year decline in Scottish salmon stocks (Figure 22), the 2002 commercial net catches from the Solway catchment (2380 fish) were approximately on a par with the 1997-01 5-year mean (FRS, 2003) while the rod and line catches (2778 fish) were almost 40% higher than the 5-year mean.

3.4.2 Sea trout

i. The Environment Agency does not include sea trout statistics in its annual report on salmon stocks but sea trout data are included in the Scottish report (FRS, 2003; Figure 23). These data show an almost identical picture to the salmon stocks – a sustained 40-year decline in abundance across Scotland (Figure 23). The 2002 rod and line (recreational) catch from the Solway catchment (3239 fish) was almost 20% down, the fixed engine catch (1068 fish) 50% down but the net fishery (398 fish) was almost double the 1997-01 5-year average (FRS, 2003).

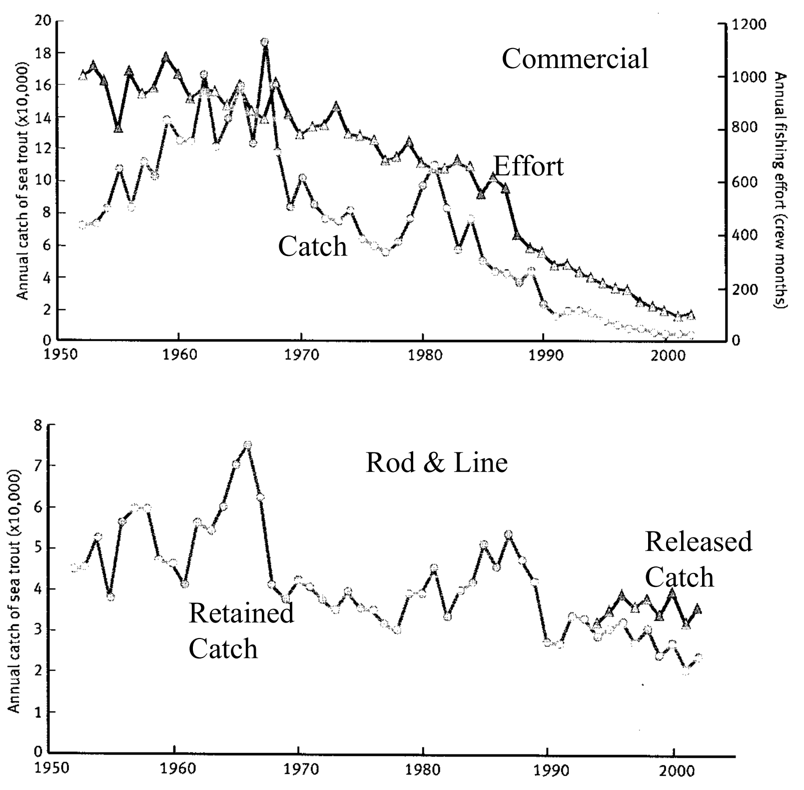

Figure 23: Annual sea trout catch and commercial fishing effort in Scotland (from FRS, 2003).

ii. Just as the pattern of salmon catches shows little variation between NW England and SW Scotland, it is assumed that the data for Scotland give a reliable indication of the state of sea trout stocks throughout the eastern Irish Sea.

3.4.3 Eels

i. Fishing for eels in inland and coastal waters of England and Wales is licensed by the Environment Agency. The Agency monitors catches, maintains records and contributes to the ICES-EIFAC assessment of European eel.

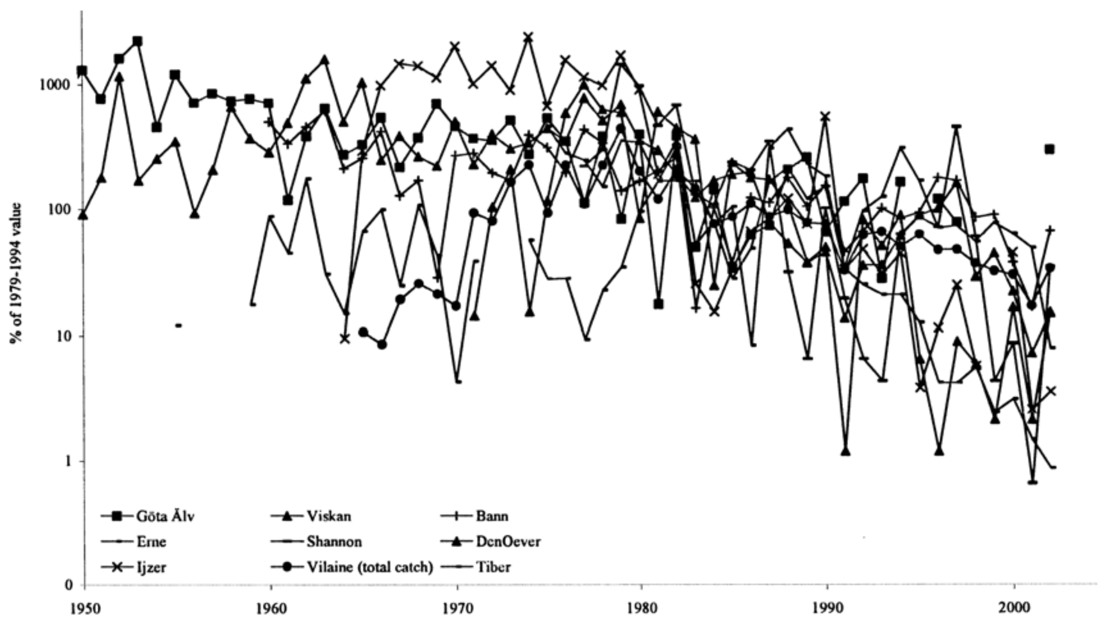

Figure 24: Time series of glass-eel monitoring in European rivers for which data were reported in 2002. Each series is standardised against the 1979-94 average for the river (from ACFM, 2003).

ii. Since the 1970s there has been a steady downward trend in the recruitment of juvenile eels each spring to European rivers (Figure 24), including those in the UK (ACFM, 2003; ICES, 2003). During the 1990s there was some indication that the decline may have begun to stabilise but numbers are still only a fraction of what they were in the period 1950-80. The ICES-EIFAC assessment of European eel fisheries concludes that all are outside safe biological limits (ICES, 2003). In some European countries, including Ireland, glass eels are caught and transported to areas where eel fisheries occur in an effort to enhance stocks locally (Moriarty, 2000) but this is not practised in Britain. It is reasonable to assume, therefore, that eel stocks in Great Britain are at or near a 50-60 year low point with no imminent sign of improvement.

3.5 Fish of Nature Conservation Interest

ii. Fish of nature conservation interest (Table 4, p 20) are rarely, if ever, subject to formal analytical assessment in the way that commercially exploited species are. Their status tends to be assessed in relation to monitored or perceived long-term trends and, where appropriate, non-fishery conservation measures put in place (Costello *et al*, 2002). Some of these measures are based exclusively on UK legislation but more generally they are in response to international treaties or conventions (Table 3, p 20).

3.5.1 Basking shark

ii. General concern for the basking shark relates to its low fecundity (birth rate), high age of maturity and its vulnerability to overexploitation. It is a regular summer migrant to the coastal waters of the Isle of Man and the western Irish Sea where, until recently, it is was fished by Norway under licence from the EU. The EU has ceased issuing a TAC for this species and UK legislation prohibits its exploitation by UK registered fishing vessels. In recent years various organisations have collaborated with sighting-based assessment projects (see, for example, www.mcsuk.org.uk or www.baskingsharks.wildlifetrusts.org) and satellite tracking tags have been used to study basking shark migration (www.cefas.co.uk). Overall, basking sharks are covered by items 1, 2,6 and 7 listed in Table 3 (p 20) but occasional accidental catches are made by trawls and surface-set gill nets.

3.5.2 Common and sand gobies

ii. Although the sand goby is too small to be retained by anything other than the small mesh of a shrimp trawl and it has no commercial value, nor is it targeted by recreational anglers. It is abundant throughout UK coastal waters in sandy environments and is subject to no specific management or conservation measures in UK waters. The species is covered by the Bern Convention (item 4 in the table above).

3.5.3 Allis and twaite shad

ii. The Environment Agency and Scottish Natural Heritage monitor shad numbers as part of a UK Biodiversity Species Action Plan; both species are subject to protection under UK legislation and the EU Habitats Directive (see 1, 2, 3 and 7 in the table above). Twaite shad are recorded most frequently, but not in large numbers, from rivers entering the Solway Firth (www.ukbap.org.uk), particularly the River Cree (Maitland & Lyle, 1995). The allis shad is a rare (vagrant) visitor to the eastern Irish Sea and, again, is most likely to be encountered in the Solway-Cree (Maitland & Lyle, 1995). There are no targeted fisheries, neither commercial nor recreational.

3.5.4 River and sea lampreys

ii. The status of lamprey stocks is not known; they are subject to protection under UK and EU legislation(see 1, 2, 3 and 7 in the table above) and all lamprey species are subject to a UK Biodiversity Action Plan (www.ukbap.org.uk). There are no directed fisheries.

3.5.5 Smelt

ii. There is a run of smelt into the Cree Estuary (Maitland & Lyle, 1995) and another in the Conwy Estuary where it may occasionally be taken by Environment Agency licensed beach-seines (personal observation). However, there is no directed fishery and it is not exploited commercially. The long-term status of the Conwy smelt population is unknown. The species is named under item 7 in the table above.

4 Potential Effects of Wind Farms on Fish and Shellfish in the Eastern Irish Sea

4.1 Introduction

i. Within the eastern Irish Sea the Crown Estate has approved the investigation of 12 sites for possible development of offshore wind farms; ten Round One sites, including three sites aggregated on Shell Flat off the Fylde coast (Blackpool), and three Round Two sites (Figure 25). The principal differences between the Round One and Round Two sites are the constraints on their location and the number of turbines on each site. Round One sites are limited to a maximum of thirty turbines per site but they are close inshore; typically 5-10 km. In contrast, Round Two sites must be located further offshore than the Round One sites but there is no limit on the number of turbines on any one site. Potentially, if all the sites shown in Figure 25 are approved and developed in full, there could be as many as 270 turbines on the Round One sites plus ~ 600 on Round Two sites; a total of 800-900 turbines.

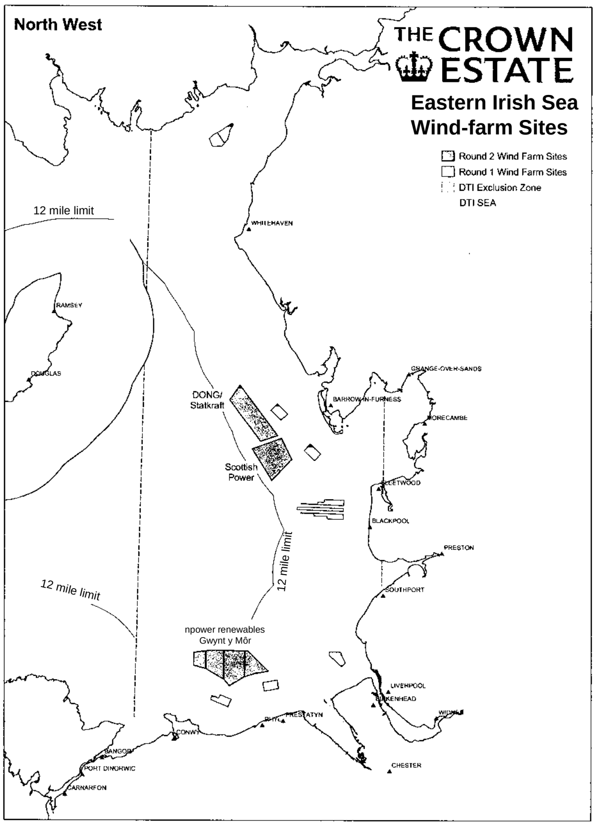

Figure 25: Sites approved by the Crown Estate for investigation as potential offshore wind-farm sites in the eastern Irish Sea or DTI SEA – Dept of Trade & Industry

ii. Each phase of a wind-farm development – pre-construction, construction, operation, decommissioning – has the potential to affect the fish and shellfish stocks of the eastern Irish Sea, either directly or indirectly. A clear example of a direct effect is the immediate loss of natural habitat with the installation of each individual turbine foundation. Indirect effects can be varied and subtle. For example, sudden or progressive changes in seabed characteristics may result in a change in benthic community composition.

iii. Potentially, changes to benthic community structure could affect predatory fish populations if the change results in a decrease (or increase) in benthic prey abundance. Fortunately, although many fish have specialised feeding abilities, eg flatfish have the ability to feed on worms normally buried in the seabed, very few fish in UK coastal waters have diets restricted to a few species. The majority of fish and commercial crustacean shellfish have a relatively broad diet and tend to prey upon the most abundant species present within the broad spectrum of their diet. This propensity for optimising their diet with respect to the prevailing prey available helps mitigate effects that many offshore developments might otherwise have on fish. Nevertheless, the potential for these effects and their significance is considered below.

iv. Each phase of offshore wind-farm development is considered in turn and an assessment made of potential effects: spatially, in duration, intensity and the overall significance of each effect, for fish and shellfish, either in general or with respect to individual species or stocks. They will be assessed relative to the criteria summarised in the Table 6.

Table 6: Matrix of criteria by which a range of construction activities are assessed and their potential environmental effects on fish and shellfish.

	Spatial	**Duration**	**Intensity**	**Significance**
Effect				
Permanent		Permanent effect lasting beyond decommissioning.		
High	National or international in scale.	Long term; 15-50 years.	Large-scale loss of biodiversity, or loss of endangered species or critical habitat.	Significant effects with no possible mitigation.
Medium	Regional – limited to eastern Irish Sea.	Medium term; 5-15 years or reversible within 50 years.	Disturbance of essential fish habitat or loss of productivity.	Significant effect but with potential for effective mitigation.
Low	Within a few km of site boundaries.	Short term; 1-5 years.	Loss or disturbance of non-endangered species or habitat.	Non-significant effects for which mitigation is simple or not required.
Negligible	Within site boundaries.	Reversible in less than 1 year.	No measurable or recognised sensitivity.	No measurable effect.

v. The primary topics of concern are changes in habitat characteristics and the potential effect of the wind farm, including noise, on behaviour and distribution of fish. The broad generality and principals of these effects during each phase of wind-farm construction and operation are described here but the detail of some effects may differ between sites. It is essential, therefore, that all potential effects are given more detailed consideration as each site proposal is developed.

4.2 Potential Effects During Pre-construction

i. The pre-construction phase of wind-farm development comprises two principal elements – a seismic geo-technic survey of the potential construction site and construction of one or more meteorology monitoring masts. The potential effects of erecting met-masts are basically the same as erecting a turbine, albeit on a smaller scale and, therefore, are covered in § 4.3-4.5 below. Seismic surveys are specific to the pre-construction phase and are considered here.

4.2.1 Geo-technic seismic surveys

Potential effect: sound generated by the survey equipment may disturb, physically harm or kill fish.

i. The sea is a noisy environment with many sources of noise propagation, both natural and man-made. This is most evident where waves break onto a shingle beach and redistribute the shingle. Such wave-induced redistribution and associated noise can occur over the whole depth range of the proposed eastern Irish Sea wind farms, albeit rarely and only during the more extreme storms at the greater depths. Waves beating against fixed structures, offshore gas and oil installations for example, also generate noise as does the marine traffic steaming to and from the ports around the eastern Irish Sea.

ii. Very little is known about the effect of noise on the vast majority of individual fish species, and even less about the possible effect on shellfish. Nevertheless, we do know that all fish have the ability to hear. They detect sound waves and low-frequency (infrasonic) vibrations by means of the inner ear (the structure of which is directly comparable with the mammalian ear), the lateral line and cutaneous receptors. As with mammals, the sensitivity and the range of acoustic frequencies that can be detected, or tolerated, differs between species.

iii. The response of fish to sound differs between species and varies with acoustic frequency and intensity. A sudden, low energy noise such as a hammer blow on the hull of a boat, is most likely to generate a startle response. This may entail the fish 'freezing', while it awaits further developments, or a quick, short-scale movement into a less vulnerable position. At the opposite extreme, a sudden high energy noise, such as a pile-driver blow can damage or even kill fish that are in close proximity to the source. Fish with swim-bladders, an internal organ that provides neutral buoyancy in many fish – cod, whiting, herring, bass, for example – are particularly vulnerable, but even fish without swim-bladders – eg all flatfish, dogfish, rays and mackerel – can suffer severe, potentially fatal, bruising. Between these extremes fish either become habituated to noise and accept it as part of their ambient noise environment or they will move away to a distance that places the noise within their limit of tolerance.

iv. Seismic or acoustic surveys entail generating a pulse of energy – sound – that is sufficiently strong to pass through the water column, into the seabed and then be reflected back to the surface where the 'echo' signal can be received and recorded. The acoustic characteristics of the equipment and the potential effect it may have on fish varies with the purpose for which it is intended. Basic information required in shallow water, eg a simple echo-sounder (depth meter), may have a high acoustic frequency but low energy output. Similarly, typical fishing vessel echo-sounders and fish-finders have high frequency (30-300 kHz – kilo Herz or kilo cycles per second) and power output of no more than 3 kW (see, for example, www.furuno.com). By design, this equipment detects fish but it does not appear to have any significant effect on their behaviour or physical wellbeing.

v. At the opposite extreme are the low frequency, high-energy sonar used for trans-oceanic monitoring by the military. There is a growing body of circumstantial evidence that this equipment has physically harmful, if not fatal, effects on cetaceans – and presumably, therefore, fish. At a somewhat less extreme level, the high-energy seismic 'boomers' used by the offshore gas and oil industry to gather information from many kilometres within the Earth's crust are known to drive fish from an area up to 20 miles radius from the survey-vessel source (Dalen & Raknes, 1985; Dalen & Raknes, 1986; Lokkeborg, 1993; Pickett, Eaton, Seabay & Arnold,. 1994; Engas, Lokkenborg, Ona & Soldal, 1996). Such extreme effects are not, however, associated with equipment used for more superficial geo-technic surveys.

vi. Geo-technic surveys for wind-farm sites do not require such powerful equipment as is used for the offshore gas and oil industry. Typically, they need to penetrate the seabed no more than 100 m and, hence, require a fraction of the energy output of gas and oil boomers The risks, therefore, are proportionately less. Wind-farm site surveys also utilise side-scan sonar equipment with characteristics comparable to fishing vessel sonar. Surveys are carried out by towing the equipment along closely-spaced transects to cover an entire wind-farm site.

vii. **Spatial** – There has been no evidence or anecdotal reports of fish being affected by side-scan sonar surveys. Similarly, there have been no reports of low-energy boomer surveys having an effect in the way that has been reported for gas and oil surveys. If fish are disturbed and move away from the source of propagation, the distance is likely to be measured in hundreds of metres rather than miles. The scale of this **effect is Low** (see table above).

viii. **Duration** – Side-scan sonar will have negligible effect and any tendency for the fish to move away from a boomer-survey vessel will be short lived. As the vessel moves over a survey area it may disturb and keep a wider population of fish on the move than if it were stationary. As the fish are unlikely to move more than a few hundred metres from the source of noise (see above) it can reasonably be anticipated that they will return to previously vacated areas relatively quickly – less than one week. The scale of this **effect is Negligible**.

ix. **Intensity** – Side-scan sonar will have negligible effect. Although there may be no long-term or widespread effect from boomer surveys, their timing could be crucial. For most of the year, most of the fish species common to the eastern Irish Sea are not associated with a particular area. The exception to this generalisation, however, is during the spawning season. Even though spawning grounds for individual species may cover much larger areas of the Irish Sea than individual or groups of wind farms, population subsets within the stock as a whole may exercise localised 'spawning site loyalty' within the wider spawning ground. This is even more likely to be the case with small non-commercial species (see Table 2) than with the larger, commercial species. If fish that are aggregating to spawn are disturbed and harried by the passage of a seismic survey vessel they may abort spawning and resorb their eggs and sperm. In mitigation, wherever practicable, seismic surveys should be undertaken in the second half of the year. The scale of this **effect is Low**.

x. **Significance** – Side-scan sonar will have negligible effect. Generally speaking the effects of a geo-technic boomer survey are likely to be ephemeral and limited in scale. There is, however, a small risk of disrupting spawning behaviour with (localised) consequences for productivity. It is possible, therefore that the scale of this **effect is Low**, but **with appropriate mitigation the scale is Negligible**.

4.2.2 In-combination effects

Potential effect: Pre-construction activities will exacerbate the effects of similar or other activities in the eastern Irish Sea affecting the behaviour and distribution of fish and shellfish.

i. As described earlier, the marine environment is inherently noisy and marine traffic adds to this ambient noise. In this context, therefore, the potential effects of a geo-technic seismic survey should be viewed as an independent event and judged by the criteria set out in § 4.2.1. However, there are two circumstances in which there may be additive or synergistic effects: wind-farm seismic surveys undertaken concurrent with gas and oil seismic surveys, and surveys undertaken concurrent with, and in close proximity to, aggregate dredging (Liverpool Bay).

ii. The energy output from boomers used for wind-farm site surveys is a fraction of that used by gas and oil surveys. Wind-farm surveys are unlikely to 'sanitise' an area of fish over distances of more than a few hundreds of metres; in contrast, gas and oil surveys can sanitise areas extending up to 20 miles. Any concurrent wind-farm survey within this radius of a gas and oil survey, is likely to have Negligible additional effect. However, the further the wind-farm survey is from the source of a gas and oil survey vessel, the greater the possibility that it will add to and extend the area of disturbance. Even so, as described above, the overall additional effect would be Negligible/Low compared to the effect of the dominant survey.

iii. If, rather than being concurrent, a wind-farm survey were to follow immediately after a gas and oil survey, it is possible that the fish might be sensitised to acoustic disturbance and be slower to return to the sanitised area than might otherwise be the case. This would be most critical if surveys were undertaken during, or in the run-up to spawning seasons.

iv. The acoustic effect of a marine aggregate dredger is probably not dissimilar to that described above for wind-farm seismic surveys. If the two are undertaken concurrently and the survey area is in acoustic proximity to the dredger their effect is likely to be spatially additive, ie fish will be disturbed and driven from the sum of areas affected by the dredger and the seismic survey. Similarly, if one activity followed immediately after the other any effect on the fish would be extended by a corresponding time. These potential effects would be of greatest concern in the first half of the year when the majority of fish spawn.

4.2.3 Summary of potential effects during pre-construction

§	Effect	Spatial	Duration	Intensity	Significance
	Activity				
	Geo-technic seismic survey				
4.2.1	Side-scan sonar survey	Negligible	Negligible	Negligible	Negligible
4.2.1	'Boomer' survey	Low	Negligible	Low	Jan-June Low July-Dec Negligible
	In-combination with:				
4.2.2	Gas and oil seismic survey	High	Negligible	High	Jan-June High July-Dec Low
	Marine aggregate dredging	Low	Negligible	Low	Jan-June Low July-Dec Negligible

4.3 Potential Effects During Construction

4.3.1 Construction of foundations

Potential effect: Building foundations for wind-farm structures ill cover natural habitat, possibly resulting in the loss of essential fish or shellfish habitat.

i. Although there are large areas of seabed in the eastern Irish Sea that are relatively homogeneous in terms of characteristics and associated seabed fauna (see § 2) some areas can be of greater importance than others. This is most notable in the relatively restricted area in which nephrops are found between the Isle of Man and Cumbria (Figure 6). For other species, certain life stages are more restricted in distribution and are associated with particular habitat types, eg flatfish nursery areas (Figure 8) and possibly nursery areas for some ray (Figure 5) Any species that has a close association with a particular seabed type could be affected by any changes induced by construction work.

ii. **Duration** - From the moment the first foundation is put in place, there is a loss of natural habitat supporting a great variety of bottom-dwelling, benthic organisms, many of which provide the prey upon which commercial species of fish and crustacean shellfish feed. Hence, if a particular benthic item is crucial to the diet of a fish and is restricted in its distribution, there is the potential to decrease the biomass of the prey species and the wellbeing and long-term sustainability of the predator. This effect may be limited locally or, if the prey is of limited distribution but an essential component of a predator's diet, the Irish Sea stock of the predator might be affected. Fortunately very few demersal fish in UK waters have a particularly specialised diet and this is unlikely to prove a problem. Nevertheless, attention will need to be paid to predator-prey relationships if surveys show that some benthic species have a restricted distribution or are noticeably scarce. As this loss of habitat will persist throughout the operational life-time of the wind farm, the **Duration effect is High**.

iii. **Spatial effect -** The sum total of habitat lost will depend on the number and size of individual turbine foundations. Round One sites are most likely to use monopiles of about 4 m diameter, covering 12 m^2. Further offshore, in deeper water, they will be larger ~ 6 m diameter / 28 m^2. Alternative designs that might be used, particularly in deeper water will cover even greater areas of seabed: for example, ~50 m^2 for multi-bases ('tripods'); 80-300 m^2 for suction caissons and up to 3000 m^2 for gravity base foundations. Thus, individually, and at the scale of micro-distribution, the loss of natural habitat appears large but this needs to be put in context of the eastern Irish Sea as a whole.

iv. If, for illustrative purposes, one assumes that all of the ten Round One sites are built and utilise 4 m diameter monopile foundations, the total area of seabed covered might be of the order:

$$10 \text{ sites} \times 30 \text{ turbines} \times 12.6 \text{ m}^2 \text{ seabed} = 3780 \text{ m}^2$$

And if, also for illustrative purposes, the three Round Two sites comprise 200 turbines each with, say, 100 monopiles per site, 50 multi-piles and 50 gravity bases, the total loss of natural habitat would be:

$$3 \text{ sites} \times (100 \times 28 + 50 \times 50 + 50 \times 3000) = 465\,900 \text{ m}^2$$

Thus, the total loss of natural habitat through the development of both Round One and Two sites could be of the order 500 000 m^2, ie 0.5 km^2 or 0.15 nmi^2. If all Round Two turbines were sat on monopiles the figure might be reduced to less than 17 000 m^2 but in the unlikely event that all Round Two turbines required gravity bases the loss of natural seabed habitat could amount to ~1.8 km^2 or ~0.5 nmi^2.

v. Even this extreme proposition where all the turbines cover one half of one square nautical mile of seabed, it represents no more than 0.02 of one percent of the 2300 nmi^2 (~ 5500 km^2) eastern Irish Sea, as defined by the DTI SEA (Figure 26); therefore, the **Spatial effect is Negligible**.

vi. **Intensity** - Although the installation of turbine foundations does not represent a significant environmental effect spatially, its real environmental effect with respect to fish populations is the extent to which it results in a loss of essential fish (or shellfish) habitat – including feeding areas where benthic prey species, upon which fish feed, are lost.

vii. As a very broad generalisation, the eastern Irish Sea has a relatively homogeneous seabed which supports a correspondingly constant fish fauna across the whole area (see § 2). However, there are some areas that differ significantly from this generality. Most notably, around the margins are areas better suited than others to support juvenile flatfish populations (§ 2.4.1), cockle and mussels stocks, and commercial crustaceans such as lobster and crab(§

2.4.2). However, none of the proposed wind-farm sites is within any of these areas, however; consequently, the installation of foundations is unlikely to have an immediate or direct effect upon these species or populations.

viii. Further offshore, the area of most significant difference is the mud 'patch' colonised by nephrops. This is an area mostly at depths greater than 30 m between the Isle of Man and the Cumbria coast. It is possible that the northern and western boundaries of the northernmost proposed wind-farm site off the Duddon Estuary (Figure 26) may border, if not extend into this nephrops habitat.

ix. Both king and queen scallops also have a preferred habitat type, albeit one that is probably more widespread than the mud patch – ie gravel or gravelly sand. The scallop stocks are distributed throughout the eastern Irish Sea, primarily at depths greater than about 20 m, but they are most abundant in the waters beyond the 12 mile limit of the eastern Irish Sea (Figure 6) and around the Isle of Man.

x. Although one of the proposed sites may extend into the specialised nephrops habitat it is unlikely to affect a significant proportion of the total area of habitat; it is doubtful, therefore, that the overall effect is as high as Medium. On the other hand, the affect cannot be discounted as Negligible, not least because scallop habitat could be affected – albeit marginally, as could benthic prey communities. It seems appropriate, therefore, to assess the **Intensity effect as Low**.

xi. **Significance** - Although the loss of habitat would be for the operational life of the wind farm, the loss represents a trivial part of the total habitat available to the fish in the eastern Irish Sea. The only potential area of real concern is the extent to which the nephrops habitat might be affected by one wind-farm proposal; any possible effect might be minimised by careful site selection for individual turbines. Overall, the loss of habitat has **Low Significance** for fish.

4.3.2 Increased suspended sediment concentration

Potential effect: to drive fish away from areas in which they are normally found and to clog the gills of sessile shellfish causing them to suffocate.

i. The eastern Irish Sea is a relatively turbid environment with seasonal variations in suspended sediment concentrations driven by tidal and storm action on surface sediments of the seabed. In addition, heavy rainfall in the surrounding hinterland can result in significant increases in the suspended sediment concentrations of coastal waters when rivers in spate flow into the sea. The indigenous fish and shellfish species are adapted to these annual and ephemeral variations but any development work that pushes suspended sediment concentrations beyond natural maxima may exceed tolerance thresholds and drive fish away and, or smother shellfish.

ii. **Spatial** – Any disturbance to the sea bed is likely to result in an increase in suspended sediment concentrations above the prevailing ambient levels. The nature of the local seabed will not only influence the extent to which the seabed needs to be disturbed but also the extent to which suspended sediment concentrations increase. Thus, drilling a hard (rock) substrate might result in relatively small quantities of a relatively constant particle size being suspended whereas dredging in areas of mixed sand and gravel would have a variety of size fractions with different characteristics for remaining in suspension – finer particles remaining in suspension longer and, therefore, travelling further before settling once more. Any particle larger than the finest gravel will fall out of suspension almost immediately.

iii. The eastern Irish Sea is a naturally turbid environment that is subject to seasonal, daily and ephemeral variations in ambient suspended sediment concentrations in response to tides and storm-driven wave action. The fish and shellfish populations are adapted to this environment and will only be sensitive to extreme variations relative to the seasonal norms. Where there is a visually identifiable plume, some fish, not only but most notably salmon and sea trout, will move away from a plume or swim out of it if they are entrained within it. This behaviour, therefore, will be influenced by the distance over which a plume persists. In windy conditions or in areas with a highly dynamic tidal regime, dispersion and integration with the ambient levels of suspended sediment concentrations will be rapid. Only in calm conditions, eg at deeper turbine sites, might a sediment plume persist for more than a few hundred metres. Hence, the **Spatial effect is Low**.

iv. **Duration** – Any increase in suspended sediment concentration specifically associated with, and clearly attributable to, construction activity will be ephemeral. Heavier fractions would drop out of suspension within minutes, if not immediately and the fines that contribute to visible sediment plumes are unlikely to last more than one or two tides after the activity has ceased – but will reform as soon as the activity recommences, eg on a new turbine foundation. Even where there are measurable increases in suspended sediment concentrations more or less continuously throughout the construction phase, they would return to ambient levels in considerably less time than one year, therefore, the **Duration effect is Low**.

v. **Intensity** – The extent to which fish and shellfish are affected by suspended and redistributed sediments depends very much on quantity. A persistent suspended sediment plume in close proximity to the mouth of a river might deter salmon from entering the river and thereby prevent them spawning. This extreme prospect, however, would depend on the sediment plume being very significantly more concentrated than ambient conditions and it would have to persist continuously for some time – possibly 6-9 months if it were to deter all fish from entering a river over one spawning season. Any marine fish that were affected by the plume might be expected to do no more than redistribute themselves locally, relative to the sediment plume.

vi. Bivalve molluscan shellfish are filter feeders and their feeding mechanism (and even the respiratory function of their gills) can be clogged by too high a concentration of fine material. Inshore species such as cockles and mussels are less sensitive in this regard than are king and queen scallops but it would take a significant, very persistent increase above seasonal maxima to have a measurable adverse effect on these species. Nevertheless, it is a factor that needs consideration and one for which the sediment modellers must be consulted.

vii. Some crustaceans are also sensitive to excessively high suspended sediment concentrations as it clogs their gills and affects respiration but, generally, they are probably less vulnerable than molluscs because they are rather more mobile and can attempt to move away from the source. An exception might be nephrops that live in deeper water in a habitat – consolidated mud – that implies low current speeds and might, therefore, be an area in which plumes of fine sediments persist, at or near seabed level. Any wind-farm environmental assessment that includes, or is adjacent to, areas occupied by, nephrops will need to take careful note of suspended-sediment modelling results when assessing the potential implications for this species.

viii. Whilst the potential effects of increased suspended sediment concentrations on salmonids and nephrops must not be overlooked, for fish and shellfish as a whole the overall **Intensity effect is Low**.

ix. **Significance** – In all probability, construction-related increases in suspended sediment concentrations and sediment plumes will not prove problematic for fish or shellfish populations over the majority of locations. Only in very specific instances and locations will particular care and attention need to be taken in making site-specific assessments. With this caveat in mind, the **Significance effect is Low**.

4.3.3 Disturbance to seabed structure and topography

Potential effect: altering the grain size or seabed profile in a way that may affect the characteristics of essential fish or shellfish habitat.

i. Fish and shellfish may occupy a particular area for a wide variety of reasons but they are most readily associated with specific stages in the life history – spawning, nursery and feeding areas. If construction activity affects seabed composition or profile significantly it could render an area unsuitable for the needs of one or more of these key life stages.

ii. **Spatial** – Placing a monopile into the seabed has the potential to alter the size composition of surface sediments and disturb the seabed profile (topography), eg due to erosion around the base of turbine towers. The potential for these changes to occur increases if any form of excavation or dredging activity is associated with the preparation of a foundation.

iii. The winnowing of fines from seabed sediments will contribute to suspended sediment concentrations (§ 4.3.2). The remaining sediment will have a different structure that may make the substrate less attractive for some seabed-dwelling species to colonise – but possibly more attractive for others. Similarly, activities that result in changes to the seabed profile may influence the local appeal to a range of species or, indeed, their prey. All such changes might reasonably be expected to be highly localised and within the boundary of the wind farm affected; therefore, the **Spatial effect is Negligible**.

iv. **Duration** – By definition, any winnowing that is specifically associated with construction activity will be ephemeral, at least in the sense that the construction phase is of finite duration. Nevertheless, if all fines from a foundation site are winnowed away, it cannot be assumed that they will re-accumulate once construction work is complete but there probably will be some, if not complete, natural reinstatement during the operational lifetime of a project. Similarly, any gross changes in topography resulting from construction activity would not necessarily 'self-correct' particularly if, for example, a pile of displaced material was left in an area of low tidal or wave action. On completion of construction, therefore, all reasonable efforts should be made to reinstate the seabed profile to that prevailing before construction commenced. (It should be recognised, however, that it may not always be possible to differentiate some of these construction effects from comparable, persistent effects associated with the post construction or operational phase; see § 4.6.) With respect to the biology, ecology and population dynamics of fish and shellfish, therefore, it is anticipated that the **Duration effect is Low**.

v. **Intensity** – Any change in seabed structure (particle size) is likely to influence the composition of the benthic community that inhabits the area of seabed affected. Such changes, however, are likely to be on such a localised, microscale that it is difficult to envisage that they would have any discernible effect on the composition of local fish populations. Similarly, changes in seabed topography might provide more, or less shelter for one or some species of fish but it would be an unrealistic challenge to attempt to demonstrate the change this made to the (local) fish population.

vi. Beyond the immediate field from which fines sediments are winnowed there is the potential effect of these sediments once they settle. As they are lifted into, and integrated with the ambient sediments of a relatively turbid environment it is reasonable to assume that their ultimate fate is to settle in the eastern Irish Sea sediment traps – sheltered bays, estuaries, where cockle and mussel beds may be vulnerable, and the nephrops mud patch. Most of the proposed wind-farm sites (Figure 25) are well away from all of these potentially sensitive areas but the northernmost site might extend into the nephrops area and suspended sediment from Burbo Bank or Rhyl Flat might drift inshore to the Dee Estuary or Llandulas – Rhos-on-Sea shellfish beds. Although it will be necessary to consult the sediment modelling results, it seems probable that any sediment originating from these latter two sites will not elevate sedimentation rates above ambient seasonal maxima and, hence, will remain within limits to which the shellfish are adapted.

vii. The picture may be less clear with respect to the nephrops site, but modelling results should be able to forecast whether any redistributed sediment fraction that might settle there is significantly different from the natural settlement fraction. General dispersion should ensure that the quantity of redistributed sediment that settles is no more than the nephrops can accommodate without smothering, but any significant change in surface sediment composition may render the area less attractive for juvenile nephrops settlement.

viii. These highly localised changes in seabed structure and topography would have **Negligible effect** on fish and shellfish populations.

ix. **Significance** – There is undoubtedly potential for the seabed structure and topography to change and some of these changes may affect the fish and shellfish directly, either, for example, by changing the behaviour of fish or making the seabed less suitable for shellfish settlement. The probability of any of these changes occurring, however, is either extremely low or is unlikely to be more than a highly localised effect of no significance. The overall assessment, therefore is that any disturbance to seabed structure and topography will be of **Low Significance** to fish and shellfish populations.

4.3.4 Noise and vibration

Potential effect: the noise or vibration generated by any activity during the construction phase may disturb, harm or kill fish.

i. The sea, but particularly coastal waters, is a naturally noisy environment to which inshore populations of fish and shellfish are well adapted. Any additional noise, however, has the potential to affect their behaviour ephemerally or, more significantly and in extreme cases, the pressure wave associated with noise can inflict physical harm, including death.

ii. **Spatial effect -** The general responses of fish to noise has been summarised above (S 4.2.1). During the course of wind-farm construction all fish will probably exhibit all the responses at some stage but they will not necessarily all exhibit the same response simultaneously. It is worth noting, for example, that operational offshore gas and oil platforms generate considerable noise yet, on average, there is a higher fish population density within and in close proximity to these structures than there is beyond the immediate platform environment (see, for example, Stanley & Wilson, 2000; Seaman & Sprague, 1991). From this, we might conclude, therefore, that although wind-farm construction will generate a wide variety of noise for a protracted period, it will not necessarily drive all fish away all of the time. Nevertheless, a general expectation might be that the greater the degree of construction activity within a relatively small area (eg if all four sites off Walney-Duddon were under construction simultaneously) the greater is the possibility of noise sanitising a significant area of fish.

iii. The greatest risk of a general disturbance driving fish away the greatest distance will be from high-energy noise generation such as pile-driving foundations. This has the potential to travel greater distances through water than, for example, the noise and vibration propagated by an on-site diesel engine. Although fish may be aware of, and respond to, pile-driving over a greater area than the noise from an engine, pile-driving will be a periodic activity with an intermittent effect whereas an engine generating on-site electricity, for example, will be continuous. Engines such as these are found on gas and oil installations where fish tend to aggregate, consequently, it is reasonable to assume that their effect on fish distribution is negligible. The noise from pile-driving, however, may drive fish away over a distance of some kilometres but the assessment of noise for the potential **Spatial effect is Low**.

iv. **Duration** – A great variety of considerable noise will be generated throughout the duration of each wind-farm construction; ie less than two years for a Round One site, 3-4 years for the larger Round 2 sites, particularly in deeper water. Most of the noise will be relatively low energy, much of it comparable to that generated on working offshore gas and oil installations and least likely, therefore, to have any significant effect on the behaviour or distribution of fish.

v. The activity most likely to have an adverse effect on fish behaviour and distribution is pile-driving. This may drive fish some kilometres from the source of propagation for at least the duration of the pile-driving; ie 2-3 days per monopile foundation. Within hours of the noise ceasing fish will probably begin to move back into a sanitised area but not necessarily at a rate that results in them returning fully before work begins on pile-driving the next foundation. The closer in time that pile-driving a new foundation follows after the previous one the greater the likelihood an area around a wind farm will remain sanitised of fish for the duration of pile-driving operations. Similarly, if pile-driving is concurrent on two wind farms with contiguous acoustic radii, the greater the probability that an area around the wind farms will be sanitised of fish for the duration of the activity. Nevertheless, once the activity ceases, normal fish behaviour and distribution can be expected within a year and the assessment of the **Duration effect is Negligible**.

vi. **Intensity** – The general 'cacophony' of construction work is unlikely to have a very great effect on fish although short-term disturbance associated with a 'new' (ie change in intensity or acoustic frequency) noise may cause fish to take refuge or move away and cease a particular activity (eg feeding or spawning) until the noise ceases or they become acclimatised. Undoubtedly, the most intense effects will be those associated with pile-driving.

vii. Many fish, eg cod-like species, herring, sprats, but not all, eg flatfish, dogfish, rays and mackerel, have a swim-bladder – a gas-filled sac within the main body cavity that is used to control buoyancy. If the swim-bladder is subject to a sudden pressure change it can suffer fatal damage. Fortunately, energy dissipates very rapidly as it radiates from its source through the water column and harmful effects are only experienced in close

proximity to the source of propagation. Hence, sprats or whiting for example, within 1-2 m of a turbine foundation at the instant a pile-driver strikes, can suffer fatal damage but at 2-3 times this range the effect is unlikely to be fatal. If it is just one or two fish that are affected it is unlikely to be noticed or to cause comment. If, however, a shoal of fish has taken position in close proximity to the foundation at the instant a pile-driver strikes there is the prospect of the sea in the immediate area turning silver as dead fish float to the surface.

viii. Although the visible effects will never be so apparent, fish without swim-bladders, possibly including shellfish, are also vulnerable to harm under these conditions. Fatal damage cannot be ruled out but harmful effects are more likely to be non-fatal bruising and contusions to soft tissue resulting from impingement by high-energy pressure waves.

ix. Without appropriate action to minimise these risks the intensity of this effect might be judged 'medium' but mitigation measures are relatively simple. To minimise the risk of killing or otherwise harming fish during pile-driving, or any comparable activity, it is essential that the pile is 'tapped' a few times to drive the fish away before the equipment is used at full force. Providing this is done, the **Intensity effect is Low**.

x. **Significance** – The principal cause for concern with respect to noise and vibration during construction is the lethal effect that unrestrained pile-driving can have on fish in close proximity to the pile. This is an extreme and specific set of circumstances that need not be the norm and one for which appropriate mitigation measures are readily available. Thus, the overall **Significance of noise and vibration is Low**.

4.3.5 In-combination effects

i. The effects of construction activities are discussed in combination with cable laying and other activities below (§ 4.5).

4.3.6 Summary of potential effects during construction

	Effect	Spatial	Duration	Intensity	Significance
§	**Activity**				
4.3	**Site Construction**				
4.3.1	Construction of foundations	Negligible	High	Low	Low
4.3.2	Increased suspended sediment concentration	Low	Low	Low	Low
4.3.3	Disturbance to seabed structure and topography	Negligible	Low	Negligible	Low
4.3.4	Noise & vibration	Low	Negligible	Low	Low

4.4 Cable Laying

i. The effects of cable laying are not significantly different from many of the effects described in § 4.3. Depending on the method used to lay the cables there will be a variety of effects posing potential risks to fish and shellfish populations or to the benthic communities upon which they prey. Any form of dredging trenches in which to lay cables would almost certainly have the greatest potential effect while ploughing a cable into the seabed would be less disruptive and surface laid cables probably have the least (immediate) effect.

ii. The principal difference between the potential effects of cable laying and effects described earlier is that the cables must be brought ashore. This exposes inter-tidal populations such as some juvenile flatfish and molluscan bivalve species (eg cockles) to greater risks than those to which they might be exposed by other construction activities further offshore.

4.4.1 Surface-laid cables

Potential effect: covering essential fish or shellfish habitat.

i. From a purely biological perspective, the best option for cable laying would be to lay them on the surface as a simple cable. This, however, is not a practical option as such cables would be unstable and vulnerable to damage; they would also pose a nuisance or navigational threat to active fishing vessels and vessels that wish to anchor. For this reason the preferred option is to bury all cables in some form of trench; if the seabed is too hard it may be necessary to surface lay and bury them with rock armouring or trawl-over concrete mattresses. Either of these latter options would result in a loss of natural habitat.

ii. **Spatial** – The spatial loss of habitat would be dependent on the total length of cable that could not be buried in the seabed but had to be surface laid. Any section of cable that was surface laid and covered with rock or concrete mat would be no more than 5-10 m wide. A short section, therefore would represent a trivial fraction of the total seabed area of the eastern Irish Sea. However, if some peculiar circumstance meant that all the cables from an offshore windfarm were surface laid and covered there might be, say: 6 cables x 15 km length x 10 m wide cover = 900 000 m^2 or 0.26 $n.mile^2$ loss of natural seabed.

iii. Even in the extreme case that all cables from all offshore sites were surface laid and covered the habitat loss would be less than one $n.mile^2$. This represents a trivial fraction of the total seabed area of the eastern Irish Sea. Overall, the **Spatial effect would be Negligible**.

iv. **Duration** – The loss (or addition) of any habitat along the cable route would be permanent, at least for the operational life of the project. Therefore, the **Duration effect is High**.

v. **Intensity** – Cables need only be surface laid where the seabed is too hard to permit some form of trenching. Hence, any rock or concrete-mat covering is utilising similar material. In some instances, the rock covering might smother indigenous benthic communities but, in mitigation, it would provide a substrate for alternative communities. In many areas, however, where the rock armouring was laid on rock there would be a net increase in surface area suitable for covering by fundamentally the same benthic species and community. In addition, the ridge of rock or concrete formed over the cable would create an artificial reef around which many fish and shellfish would aggregate, shelter or establish new home territory (see, for example, Seaman & Sprague, 1991). Overall, the **Intensity effect would be Negligible**.

vi. **Significance** - Although the effect of surface cable laying has a long duration its negative effects are mitigated, if not eliminated, by the positive contribution that the new substratum offers. Hence, overall it would be difficult to measure any negative effect and the **Significance is Negligible**.

4.4.2 Increased suspended sediment concentration

Potential effect: to drive fish away from areas in which they are normally found and clog the gills of sessile shellfish causing them to suffocate.

i. If cables are surface laid and covered with rock armouring it would be in areas with virtually no soft sediment and, therefore, no likelihood of adding to the ambient suspended sediment concentrations. In the majority of instances, however, it should be possible to bury cables in the seabed by trenching, ploughing, high-pressure water injection or similar methods, any one of which will result in an increase in suspended sediment concentration. The greater the increase in concentration, the greater the potential risk of having an adverse effect on fish or shellfish.

ii. Ploughing is the method that probably generates the least suspended sediment plume while high-pressure water injection probably generates the greatest increase. From the point of view of the potential effects on fish and shellfish, therefore, cables should probably be laid by ploughing in preference to any other method. The comments that follow, however, are made on the assumption that cables will be laid by high-pressure water injection.

iii. **Spatial** – As with the effects during construction, the potential effect of cable laying is highly dependent on the particle sizes of the substratum through which the cable is laid. The finer the particles, the more intense will be the suspended sediment plume and the greater the distance it will travel. In addition, because cable routes cover a corridor from the wind-farm site to the onshore grid connection there is the potential for sediment to affect a far greater area, not least the inter-tidal environment. Nevertheless, detection of any cable-related sediment plume is likely to be limited to a few kilometres; hence, the **Spatial effect is Low**.

iv. **Duration** – The duration of an identifiable sediment plume is dependent on the prevailing levels of turbulence. In areas of dynamic tidal action or during periods of wind-driven turbulence (storms) a plume will be dispersed rapidly and suspended sediment concentrations will merge with ambient conditions. The greatest cause for concern will occur when high concentrations of suspended sediment are generated during calm conditions, particularly if these are close inshore in the vicinity of cockle or mussel beds or near nephrops or scallop beds further offshore. Nevertheless, the mobile nature of this particular operation should limit the duration insofar as it affects one area and ensure that the **Duration effect is Negligible**.

v. **Intensity** - The multiplicity of sites off Walney-Duddon, and in Liverpool Bay means that if all sites receive approval there will be numerous relatively close cable runs coming ashore. If more than one cable is laid simultaneously in either area it might increase the prospect of suspended sediment concentrations exceeding seasonal ambient maxima and, hence, raising the environmental risks associated with suspended sediment. Even if cable laying is undertaken one cable at a time, as is most probable, the process will take longer and increase the possibility of elevated suspended sediment concentrations coinciding with periods when ambient levels might otherwise be low, eg summer time.

vi. All bivalve molluscs, eg scallops, cockles, mussels, are potentially vulnerable to high suspended sediment concentrations as it can block the gills and prevent both feeding and respiration. As the areas close inshore, including the intertidal zone, are generally the most turbid, it will be periods of cable laying in proximity to or across the intertidal zone that could pose the greatest risk. This risk will be greatest to juvenile cockles and mussels just after they have settled – spatfall – in summer and are still very small. For this reason in particular, it will be preferable to avoid cable laying intertidally, or very close inshore, during the summer. The areas that may prove most vulnerable will be Morecambe Bay (see Figure 20) and anywhere in the vicinity of the Ribble or Dee Estuary.

vii. Salmon and sea trout are also vulnerable to suspended sediment concentrations significantly higher than ambient in the vicinity of rivers that support spawning populations (see Figure 10). If a suspended sediment plume persists across a fish's migratory path there is a risk, albeit small, of it abandoning its spawning migrations for that year. Hence the more intense the sediment plume (and the greater its duration) the greater the risk that the total spawning production in a given river might be adversely affected. To minimise the risk of this 'worst case' event, all cable laying in close proximity to the mouth of salmon rivers should take place November-February. This measure would be particularly relevant if high-pressure water injection was the preferred option for burying the cables.

viii. If a salmon or sea trout spawning run was affected to the extent described, or a cohort of cockle spat was smothered, the intensity of this effect might be judged ‘medium’. Even with high-pressure water injection it seems improbable that this ‘worse case’ would occur and a more balanced assessment is that the **Intensity effect is Low**.

ix. **Significance** – If the intensity of the potential effects of increased suspended sediment concentrations reached the extreme levels postulated, the level of this effect would undoubtedly be ‘medium’. If modelling forecasts indicate that persistent high levels of suspended sediment concentrations might be generated in the vicinity of salmon rivers or cockle beds, the potential effects can be mitigated by limiting cable-laying operations to the winter period – November-February. If this is a practical option the **Significance of increased suspended sediment concentrations is Low**.

4.4.3 Disturbance to seabed structure and topography

Potential effect: altering the grain size or seabed profile in a way that may affect the characteristics of essential fish or shellfish habitat.

i. There are a variety of methods by which a cable can be buried in the seabed but the most common are ploughing, trenching and high-pressure water injection. Ploughing a cable into the seabed has the potential to expose but not rebury rocks, boulders and cobbles. This undoubtedly represents a change to the structure and local topography of the seabed surface but it is not a change that would be significant unless it happened every metre of every cable route. Generally speaking, therefore, ploughing a cable will have very ephemeral effects and the seabed would rapidly return to pre-ploughing conditions.

ii. Digging a trench and back-filling to bury a cable will result in fine sediment going into suspension with concomitant change to seabed structure as only larger particles remain. There is also a greater probability of rocks, boulders and cobbles remaining on the surface and the local seabed topography having a different profile once trenching and filling is complete.

iii. High-pressure water injection is unlikely to disturb or expose any large particles – rocks etc, but it would put the greatest quantity of fines into suspension and, hence, probably result in the greatest change in seabed structure (particle composition) as the finer elements are winnowed away leaving only the coarser particles along the cable track. Not only might this make the cable route less suitable for settlement by exploited shellfish species it would alter the benthic community found along the track, including the abundance and distribution of benthic species upon which fish prey. Ultimately, the fine sediments winnowed from the track would settle in the usual places – the nephrops mud patch and estuaries, for example.

iv. **Spatial** – The greatest potential for change to seabed structure and topography would be along the track of each cable laid. The width of locally affected seabed would be less than the area covered by rock-armouring a surface-laid cable (see § 4.4.1) but it is more likely to extend the full length of cable from wind farm to shore. Hence, if the affected cable tack was no more than 5 m wide, the area covered by 6 cables from an offshore site would be of the order 500 000 m^2 or one eighth of one $n.mile^2$ (see § 4.4.1). The extent of the area affected by the redistributed fines might be considerably greater (see § 4.4.2) but more likely to be limited to a few kilometres from the cable track than to extend over the eastern Irish Sea as a whole. Hence, the **Spatial effect is Low**.

v. **Duration** – As high-pressure water-injection cable laying is likely to have the greatest effect on seabed structure, the effects are likely to be of longest duration. The more extreme the sorting and winnowing of the sediments, the longer it is likely to take for the sediment characteristics along the cable track to re-establish the pre-laying composition. In the intertidal, ie most dynamic, zone the effect of cable laying on seabed particle-size composition is unlikely to last longer than a year. As water depth deepens and conditions become more stable, however, there is a greater probability that it will take up to five years or possibly even longer to re-establish the original conditions. Thus, over deep-water sections of cable the effect might be 'medium' but for a cable run as a whole the **Duration effect is Low**.

vi. **Intensity** – High-pressure water injection is most likely to result in the greatest change to the immediate seabed structure and, hence, the structure of the benthic communities that settle along the cable track. While these changes may be significant in terms of species abundance and diversity, the areas affected would be so small relative to the totality of the eastern Irish Sea that the effect these changes might have on predatory fish or shellfish species would be trivial (ie too small to measure). If, however, a cable track were to be taken across an exploited shellfish bed (nephrops, scallop, cockle or mussel) it might represent an appreciable, if not significant, part of the total area of the bed with a consequent risk of affecting the productivity of that bed. It is advisable, therefore, that all efforts are made to avoid a direct crossing of known shellfish beds.

vii. Even if direct crossings are avoided, resettlement of fines suspended during cable-laying operations can affect shellfish. The most vulnerable are sessile species such as cockles and mussels but even these species can accommodate appreciable sediment settlement rates as adults. Mussels might struggle to remain above a sediment settlement rate of 1 mm per day for a protracted period of time but mature cockles could probably maintain themselves in an environment with a rate of the order 5 mm per day.

viii. The real risk of high sedimentation rates is smothering cockle spat. As the newly settled animal is barely 1 mm across it would be hard pressed to survive in an environment where new sediment was settling at the rate of 1 mm per day. If modelling forecasts sediment redistribution and settlement rates of this order or higher it will be advisable to avoid cable laying in the affected area during summer and early autumn. The higher the sediment settlement rate is, the larger the cockle will need to grow before it can survive in the constantly changing environment.

ix. The effect of any cable-laying operation in proximity to commercially exploited cockle beds such as those in Morecambe Bay (see Figure 20), the Ribble or Dee Estuary must be assessed as ‘medium’ unless appropriate mitigation measures are taken. Providing the sensitive areas are avoided in the sensitive period (summer-early autumn) the **Intensity effect is Low**.

x. **Significance** – The significance or resorting substrate and changes to seabed structure and topography along the cable track is ‘low’, not least because the area affected is small relative to the totality of the eastern Irish Sea. Within areas such as Morecambe Bay, however, the **Significance of restructuring seabed characteristics is Medium** but this effect can be reduced by appropriate scheduling of the cable-laying programme in mitigation.

4.4.4 Noise and vibration

i. Cable-laying will involve the use of a barge or other suitable vessel that will generate a range of noises not expected to be significantly different from the noises generated by the variety of numerous other vessels operating throughout the eastern Irish Sea, including fishing vessels. The spatial distribution of the noise will be limited to the immediate environs of the cable-laying vessel, the duration will be limited to the duration of the actual activity and intensity, insofar as it affects fish and shellfish behaviour and distribution is unlikely to drive fish more than a few hundred metres at most. The limited and ephemeral nature of this effect mean that its **Significance is Negligible**.

4.4.5 Summary of potential effects during cable laying

	Effect	Spatial	Duration	Intensity	Significance
§ 4.4	**Activity** Cable Laying				
4.4.1	Surface-laid cables	Negligible	High	Negligible	Negligible
4.4.2	Increased suspended sediment concentration	Low	Negligible	Low	Mar-Oct Medium Nov-Feb Low
4.4.3	Disturbance to seabed structure and topography	Low	Low	Low	Medium
4.4.4	Noise & vibration	Negligible	Negligible	Negligible	Negligible

4.5 In-combination Effects During Construction and Cable Laying

i. In addition to the considerable ship traffic through the eastern Irish Sea there are a variety of other industries: fishing, gas and oil exploration and exploitation, aggregate dredging, military operations. Each of these industries' activities is associated with a variety of environmental effects, any one or all of which could interact with the environmental effects associated with wind-farm construction or cable laying. The more probable or more significant with respect to fish and shellfish are considered here.

4.5.1 Loss of habitat

i. Any offshore development that entails the placing of a structure on the seabed results in the loss of natural habitat. Hitherto, the most widespread development in the eastern Irish Sea has been the gas and oil installations but even in combination they represent a very small area of lost natural habitat. Also, in mitigation, each of these structures offers new habitat albeit in the form of hard substrate in an area that is generally soft substrate.

ii. In addition to the offshore gas and oil installations there are two areas licensed for marine aggregate dredging; an area immediately to the north of the North Hoyle wind farm and another, smaller area, approximately half way between Walney Island and the Isle of Man (www.crownestate.co.uk). By its very nature, this activity results in loss of natural habitat and even when the limit of dredging is reached and the seabed is allowed to recover it can take a number of years (Kenny & Rees, 1994). Nevertheless, the area of eastern Irish Sea subject to active dredging is very small.

iii. If all of the proposed offshore wind farms (Figure 25) are built they will represent the most extensive eastern Irish Sea development to date with the greatest associated loss of natural habitat. Even in combination with the gas and oil installations and aggregate dredging, the potential loss of natural habitat (see § 4.3.1 & 4.4.1) is small relative to the totality of the eastern Irish Sea and the inclusion of the habitat lost or modified by the gas and oil installations would not increase the significance of the assessments made.

4.5.2 Increased sediment concentration

i. The only activities that are routinely undertaken in the eastern Irish Sea that contribute to suspended sediment concentrations are marine aggregate dredging and maintenance dredging of navigation channels. Licensed aggregate dredging is limited to an area immediately to the north of the North Hoyle wind farm and another, smaller area approximately half way between Walney Island and the Isle of Man www.crownestate.co.uk). Navigational dredging occurs, with varying degrees of regularity, in the approaches to all the ports and harbours around the eastern Irish Sea.

ii. Dredge spoil must be disposed of at approved dump sites that have been in use for many decades. Consequently, any periodic increase in suspended sediment concentrations associated with these activities are, effectively, contributing to the seasonal ambient conditions to which the indigenous fauna are adapted either because effects are negligible or because any adverse effects have become part of the norm. Hence, the effect of any increase derived from wind-farm activities are not 'in-combination' but separate, as described above (§ 4.3.2 & 4.4.2).

iii. Marine aggregate dredging in the eastern Irish Sea is a low-level activity compared to, for example, the eastern English Channel and the coastal waters of East Anglia. In these areas the primary concern tends to be with the effect of removing seabed habitat rather than with the effect of sediment plumes. Nevertheless, the effects of a marine-aggregates generated sediment plume on the crab population of Race Bank (off N Norfolk) was undertaken by CEFAS in the 1990s (unpublished). The study found that although a sediment plume could be tracked for several tidal cycles the dredging 'signal' was lost within the far more dominant signal of elevated suspended sediment concentrations originating from the rivers of The Wash following heavy rainfall in eastern England (Dr S Malcolm, CEFAS, pers. comm.).

iv. Thus, although wind-farm activity in Liverpool Bay might act in combination with aggregate dredging from the Liverpool Bay site, or the Walney-Duddon sites might act in combination with aggregate dredging off Cumbria, such effects are unlikely to equal or exceed the sediment effects attributable to rainwater river-discharge from the Dee-Mersey or the rivers of Morecambe Bay. Thus, the in-combination effects are judged to be not significant.

4.5.3 Disturbance to seabed structure and topography

i. Significant changes to seabed structure and topography are most likely to be limited to the near field. It is, therefore, unlikely that there will be any interaction between one wind farm and another nor between a wind farm and, for example, the offshore gas and oil installations. However, if wind farms are established in close proximity to marine aggregate dredging there is the potential for an in-combination effect.

ii. If a wind farm and aggregate dredging do have an in-combination effect on seabed structure and topography, it is reasonable to assume that the wind-farm effect will be trivial compared to that of the dredging activity. Whilst wind farms may influence the near-field nature of the seabed, dredgers physically remove it. It seems doubtful, therefore, that any additional effects stemming from wind-farm construction will have a detectable effect on fish and shellfish compared to any effect that the aggregate dredging may have.

4.5.4 Noise and vibration

i. Apart from passing ship traffic, the greatest source of noise in the Irish Sea is almost certainly the offshore gas and oil installations. Although there have been no specific studies in the eastern Irish Sea we do know that fish are tolerant of the noise generated and they aggregate around such sites at higher than 'natural' densities (eg, see Stanley & Wilson, 2000). Similarly, fish have already been recorded aggregating around the fully operational North Hoyle wind farm (Figure 26). It seems improbable, therefore, that there will be any adverse in-combination effects between wind farms and offshore gas platforms. In contrast, a marine aggregate dredger generates noise that is more likely to drive fish away from the source – the dredger. If the effective radius of this dredger noise overlaps with any wind-farm noise that has a tendency to drive fish away there is the prospect of the two areas merging to create a larger, contiguous non-fish area.

4.5.5 Summary of potential in-combination effects during construction and cable laying

i. There do not appear to be any instances where there is a significant in-combination effect with other industries or activities within the eastern Irish Sea. Either the environmental effects that might be attributable to wind farms are likely to be localised and specific to wind farms or they are small relative to other sources.

4.6 Potential Effects During Wind-farm Operation

i. Once an offshore wind farm is operational many of the effects will be similar to, or variations of, those that occur during the construction phase, eg loss of habitat and effects of noise or vibration. Others are unique to the operational phase, most obviously the fact that electricity is being generated and its transmission along the cables may have an effect on fish and shellfish. As previously, each of these potential effects is identified and the scale of the effect considered relative to the criteria outlined in § 4.1.

4.6.1 Habitat change & the artificial-reef effect

Potential effect: Following the loss of natural habitat during the installation of foundations, sub-surface sections of turbine towers offer new substrate suitable for colonisation and wind-farm structures, both individually and collectively, may act as an artificial reef.

i. **Spatial** – Self-evidently, the spatial distribution of turbine towers will be the same both geographically and numerically as for the foundations upon which they are built and the effects of which were discussed above (§ 4.3.1). In particular the probabilities and uncertainties concerning the style of (foundation) construction apply in this instance no less than they did when considering the construction phase.

ii. Initial monitoring of the North Hoyle wind farm has already demonstrated that a turf community of demersal species is rapidly established. Within 12 months of construction work commencing on the North Hoyle wind-farm site, dense shoals of juvenile whiting were recorded browsing over this turf community (Figure 26). This is evidence that turbines act as very simple artificial reef structures or ‘fish aggregation devices’.

iii. The distance over which fish will be drawn towards and aggregate around turbines, either singly or as a dispersed group, is a matter of conjecture. Nevertheless, if fish are aggregating within each wind farm, thereby increasing local population density, there must be a consequential reduction in fish abundance beyond the wind farms. Whether or not it might prove possible to detect such changes in abundance – local population density or fishing catch rates - would depend in no small measure on fish distribution and behaviour.

Figure 26: Juvenile whiting browsing over a mat of common (blue) mussels settled on the sub-surface mono-piles of North Hoyle wind farm (North Wales) within 12 months of construction (Photograph provided by RWE-Innogy Ltd).

iv. It is reasonable to assume that the fish aggregate from within a relatively small radius around a wind farm relative to the species' total distribution in the Irish Sea. Within this radius of influence it is no less reasonable to anticipate that there will be a fall in fish population density relative to conditions that applied before the windfarm was completed. Hence, around any wind farm will be a zone within which fish population densities are lower than elsewhere in the Irish Sea.

v. The radius of this zone of depleted fish abundance is likely to differ for each species, reflecting, among other things, the extent to which they tend to remain site-loyal. For example, small, relatively 'sessile' species such as gobies, blennies and dragonets, probably remain within a very localised area during their life and might, therefore, only aggregate from within a radius of a few hundred metres. In contrast, aggregations of more mobile species such as cod, plaice, rays and herring, that follow annual migration cycles may be drawn from within a radius of some kilometres. The radius may also be influenced by the extent to which anti-scour material (rock armouring) is used around the base of turbines as this will enhance the artificial-reef characteristics of the structures. Similarly, any rock armouring that is placed over surface-laid transmission cables will also act as an artificial reef or fish aggregation device and tend to attract or hold fish from surrounding areas.

vi. Insofar as this negative aspect to the artificial-reef effect is detectable, it is unlikely to extend beyond perhaps 2-5 km from any wind-farm boundary. The overall negative **Spatial effect on fish is Low**.

vii. **Duration** – The 'artificial-reef' or 'fish-aggregation effect' will exist throughout the existence of any wind farm up to decommissioning and demolition, ie 25-50 years. Therefore, the **Duration effect is High**.

viii. **Intensity** – In one respect, the intensity of any habitat-related effects has been assessed, ie the extent to which fish that might otherwise live beyond the boundary of a wind farm are drawn into or 'held' within a wind farm – the so-called artificial-reef effect. Another, no less important effect is the extent to which the surface of the sub-surface turbine structures offer new habitat for colonisation.

ix. It is anticipated that an average Round 2 monopile foundation will cover 28 m^2 of seabed with concomitant loss of natural habitat. If these turbines stand in an average mean low water depth of 20 m, the subsurface surface area of each monopile turbine will be 375 m^2 and a multi-pile 'tripod' foundation might offer ~1000 m^2 new submerged substrate. Although this new substratum will differ significantly from the natural habitat, even where foundations are built on a rock seabed, it will serve to mitigate the loss of natural habitat at each site.

x. Initial monitoring of the North Hoyle wind farm has already demonstrated that a turf community of benthic species is rapidly established. Early colonisers are common mussels, a key-stone species, that create a new habitat of interstitial spaces occupied by a wide variety of other organisms, many of which are prey items for fish. Indeed, within 12 months of construction work commencing on the North Hoyle wind-farm site, dense shoals of juvenile whiting were recorded browsing over this turf community (Figure 26).

xi. It can reasonably be anticipated that comparable settlement of benthic organisms and aggregation of fish will occur on all wind-farm structures throughout the eastern Irish Sea.

The benthic settlement will represent *de novo* bio-production but the total quantity is a matter of conjecture. Also, it will vary with time as the turf community matures and its composition changes. However, if each turbine is ~6 m in diameter (see § 4.2.1) and mussels settle over half the submerged depth (ie ~10 m), the mussel biomass per monopile might be of the order 1000 kg or possibly 3 tonnes on a multi-pile. Thus, over all the proposed sites in the eastern Irish Sea, total mussel production might be enhanced by 500-1000 t. The quantities could be even higher if conditions conducive to mussel settlement and growth extend to depths greater than 10 m below MLW.

xii. The settlement of mussels is taken purely as an illustration because they have already become established at the North Hoyle site. Other species will also increase in abundance and, as can be inferred from the fish seen in Figure 26, many will offer alternative feeding opportunities for some of the demersal fish predators that might otherwise prey on seabed species.

xiii. Assessing the significance of these changes is difficult because they are positive changes and the general tenor of the assessment criteria (S 4.1) is to assess the status of negative effects. This has been done already in the assessment during construction (S 4.3.1) but there are those that might argue that the introduction of *de novo* production of species not strictly indigenous to the area is an adverse effect. This is an overly narrow interpretation of events and the positive view is that this production mitigates the losses stemming from construction. In terms of negative impacts, therefore, the **Intensity effect is Negligible** on local biodiversity.

xiv. **Significance** – Any changes will last for the lifetime of the wind farm; the greatest effects are those that affect benthic settlement and productivity (positive) and those that affect fish being drawn away from surrounding areas into the wind farm (negative). Although this latter effect may, initially, appear negative it may be balanced by reduced natural mortality rates within the shelter of a wind farm (always assuming fish predators are not also draw into a site) and by potentially enhanced growth rates due to new feeding opportunities. Thus, the overall conclusion is that there are no measurable adverse effects and the **Significance is Negligible**.

4.6.2 Disturbance to seabed structure and topography

Potential effect: Changes to localised currents around the base of turbines may result in erosion and winnowing of sediments resulting in a coarser substratum with an altered profile.

i. Major changes to seabed structure, ie sediment particle composition, and topography are most likely to be encountered during the construction phase (§ 4.3.3) and there is no reason to anticipate any additional loss of habitat (§ 4.3.1). It is possible, however, that winnowing of fines and restructuring of seabed sediment in the near field, as a result of turbine-foundation related current regimes, might be too slight or too subtle to show during the construction phase. Over the prolonged period of wind-farm operation, sustained, low-level winnowing might result in the evolution of new seabed characteristics and associated benthic community.

ii. **Spatial effect -** Any changes that might occur are likely to be limited to a few metres around a turbine base. Probably, the **Spatial effect would be Negligible**.

iii. **Duration** – Winnowing and erosion could be rapid or slow before stabilising but the final effect would last for the duration of the project. The **Duration effect is High**.

iv. **Intensity** - The extent to which such changes might prove significant is entirely a matter of conjecture without the benefit of forecasts from appropriate modelling. Winnowing could result in sufficient change to the remaining seabed particle size so that there is a significant change in the benthic infauna. This might affect the feeding habits of fish locally but as such changes would almost certainly be limited to a very small area around an affected turbine, the significance at the population level would be trivial. Similarly, changes in profile might alter the distribution of fish locally, eg depressions might offer more shelter, but the significance at the population level would be trivial. Overall, the **Intensity effect is Negligible**.

v. **Significance** – The limited scale of these potential changes and their effect is almost certainly very small; the **Significance is Negligible**.

4.6.3 Noise and vibration

Potential effect: The noise of an operational turbine, transmitted to the aquatic environment as vibration of the turbine mounting structure, could drive fish away from the immediate environs of an operational wind farm.

i. Compared with the construction phase (§ 4.3.3), it is anticipated that noise generated during the operational phase would be less variable and unlikely to include sudden loud noises – least of all high-energy percussive sound. The sort of noise that might be expected would be low-energy 'hum' associated with many generators and the 'creaks' and 'groans' of a structure under wind and wave induced stress. Any noise generated by operational wind farms is unlikely to be as great or as variable as that generated by offshore gas and oil installations, all of which are known to harbour higher than average density fish populations (see, for example, Stanley & Wilson, 2000). Furthermore, there is also clear evidence (Figure 26) that juvenile whiting, if no other species, are tolerant of any noise or vibration generated by a fully operational wind turbine.

ii. **Spatial** – As no high-energy noise will be generated, the distance that any noise travels from the source of propagation will depend on its acoustic frequency. Low frequencies that travel the greatest distance would probably merge quite rapidly with the ambient noise of the eastern Irish Sea environment and would not, therefore, affect the behaviour or distribution of fish. If high frequency noise was beyond the tolerance levels of any fish, it would be unlikely to affect them for more than a few hundred metres, ie within the boundary of a wind farm; hence the **Spatial effect would be Negligible**.

iii. **Duration** – Any noise would be generated throughout the lifetime of the wind farm; the **Duration effect would be High**.

iv. **Intensity** – If the noise generated by an operational wind farm influences the behaviour of fish, such an influence is likely to be limited to a few hundred metres at most. The experience with offshore gas and oil installations suggests that such noise is unlikely to drive fish away from a wind-farm site but migrating salmon might possibly maintain a constant radius when passing a site rather than swim through it. At worst, the **Intensity effect is Low**.

v. **Significance** – The effect of noise and vibration on the behaviour and distribution of fish and shellfish around a wind farm is unlikely to be detectable; the **Significance is Negligible**.

4.6.4 Cable routes and electro magnetic fields (EMF)

Potential effect: **Electromagnetic fields around transmission cables will affect the distribution and, or feeding behaviour of elasmobranchs and, or migratory species.**

i. Unless there is 100% effective shielding around each power cable running from wind farm to shore, the passage of current along the cables will induce an electromagnetic field (EMF) around the cable. Most fish are sensitive to electro-magnetic fields but two groups are recognised as giving rise to specific concerns: migratory species – salmon, sea trout and eels, and the elasmobranchs – skates, rays, dogfish and sharks. The potential effect that EMF may have on elasmobranchs is subject to investigation as part of the Crown Estate co-ordinated COWRIE (Collaborative Offshore Wind Research Into the Environment) programme.

ii. **Spatial** - Preliminary studies of EMF suggest that the effect is limited to distances significantly less than 100 m; hence, the **Spatial effect is Negligible**.

iii. **Duration** – Any effect will last for the lifetime of the operational wind farm; the **Duration effect is High**.

iv. **Intensity** – Elasmobranchs have a highly developed sensitivity to EMF and use it to locate their prey, both in mid water (sharks), and on or buried within the seabed (skates, rays and dogfish). The concerns are that if the EMF is above the level of elasmobranch tolerance it will drive fish away; alternatively, a very low induced EMF may be mistaken for buried prey and result in fish vainly digging for food where there is none.

v. If the level of induced EMF is sufficient to drive fish away, the combination of sites in Liverpool Bay may give rise to greatest concern. This is an area in which thornback and spotted rays are known to be more abundant than elsewhere in the eastern Irish Sea (Figure 5; Ellis & Parker-Humphreys, 2003, 2004), not least because it is an area in which they lay their eggs. The relative absence of these species further north in the eastern Irish Sea suggests that there may not be comparable suitable nursery areas should the fish be adversely affected by the Liverpool Bay complex of wind farms.

vi. Although dogfish also tend to be more abundant in Liverpool Bay than elsewhere in the eastern Irish Sea (Figure 5; Ellis & Parker-Humphreys, 2003, 2004) their ubiquity reduces the grounds for concern. If they are driven from one area there appears to be no shortage of alternative areas to which they might move. However, if the EMF signal is comparable to that generated by prey and they aggregate on cables in a futile search for prey, the grounds for concern are no less than for any other elasmobranch. Thus, the current unresolved concerns for elasmobranchs indicate that the **Intensity effect is Medium**.

vii. The concern for the migratory species is based on the knowledge that these species use the Earth's EMF as a reference during their migrations. In particular, there is concern that an induced EMF in coastal waters will interfere with the fishes' navigation and prevent them successfully completing their spawning migration.

viii. There is probably least grounds for concern with eels. The juveniles reach European coastal waters by drifting with the plankton and then migrate contra-natantly (ie against the current) as glass eels to enter fresh water. As emigrating adults they also use currents – selective tidal stream transport – to move away from the coast (McCleave & Arnold, 1999) and probably do not engage fully with EMF as a basis for navigation until they have moved offshore.

ix. Salmon follow a reverse pattern; the prevailing consensus of opinion is that they use EMF as the basis for their oceanic migration, guiding them towards shelf waters in the general vicinity of their natal river. Once in coastal waters, where wind farms are located, it is assumed that they switch primarily, if not exclusively, to olfactory 'navigation'. They move along the coast seeking their natal river by a process akin to trial and error until they recognise the smell of their natal river. This process would not be affected by any local anomalies in EMF.

x. Salmon smolts leave their natal river and migrate to sea each spring in a manner comparable to adult eels. As with eels, it is assumed that not until they are away from coastal waters and migrating towards their oceanic, sub-Arctic feeding areas do they need to engage EMF navigation.

xi. Sea trout remain in coastal waters throughout their adult life and, as with salmon, rely on olfaction to find and identify their natal river.

xii. With the information that is available at present, it seems improbable that the EMF associated with offshore wind-farm cables pose a significant threat to the successful migration of these species, even where there might be a relatively high density of cables in the approaches to rivers with known salmon runs such as off Walney-Duddon and in Liverpool Bay. Hence, for migratory species, the **Intensity effect is Negligible**.

xiii. **Significance** – Pending the outcome of further (COWRIE-funded) research, the true potential effect on elasmobranchs is far from certain; it is advisable, therefore, to assume that for these species the **Significance is Medium**. In contrast, for the migratory species the **Significance is Negligible**.

4.6.5 In-combination effects during operation of wind farm

Potential effect: The operation of a wind farm will exacerbate the effect of similar or other activities in the eastern Irish Sea affecting the behaviour and distribution of fish and shellfish.

i. **Spatial** – The principal aspects of wind-farm operation that have the potential to affect the behaviour and distribution of fish and shellfish tend to be very localised, mainly restricted to the boundary of the wind farm. The principal exception to this is the distance over which the 'reef-effect' might operate. If fish are drawn into a wind-farm area from a distance of 2-3 miles, there is potential for adjacent wind farms and for wind farms and gas and oil installations to interact. Hence, there is potential for the **Spatial effect to be Low**.

ii. **Duration** – Any effect specifically associated with wind-farm operation will last the operational lifetime of the wind farm and, hence, will interact over this period. Interaction with aggregate dredging – noise for example – will be intermittent and short-term whereas interaction with the gas and oil installations in Liverpool Bay – again, possibly noise – will be continuous and permanent. Hence, the **Duration effect is High**.

iii. **Intensity** – The single greatest cause for concern during wind-farm operation is the potential for transmission cable EMF to affect the distribution and feeding behaviour of elasmobranchs. As this is a highly specific concern to wind farms there is no potential for in-combination effects with other industries but, self evidently, cables from adjacent wind farms have the potential to increase any effect, possibly magnifying it if they are laid in relatively close proximity. The intensity effect is generally negligible but for elasmobranchs the **Intensity effect is Medium**.

iv. **Significance** – Overall, the potential for significant interactions between wind farms and other offshore developments is not great; **Significance is Low**.

4.6.6 Summary of potential effects of wind-farm operation on fish and shellfish

	Effect	Spatial	Duration	Intensity	Significance
§	**Activity**				
4.6	**Wind-farm Operation**				
4.6.1	Habitat change & the artificial-reef effect	Low	High	Negligible	Negligible
4.6.2	Disturbance to seabed structure and topography	Negligible	High	Negligible	Negligible
4.6.3	Noise & vibration	Negligible	High	Low	Negligible
4.6.4	Cable Routes and Electro Magnetic Fields	Negligible	High	Elasmobranchs Medium Migratory spp Negligible	Elasmobranchs Medium Migratory spp Negligible
4.6.5	In-combination effects during operation of wind farm	Low	High	Generally Negligible Elasmobranchs Medium	Low

4.7 Potential Effects During Decommissioning

i. At the end of its effective operational life (25-50 years) it is anticipated that offshore wind farms would be decommissioned and demolished. This would entail a number of activities not dissimilar to those employed during construction with comparable effects, others may differ in character but the potential effects might be very similar. Thus, the concerns will be broadly the same: major changes in habitat, suspended sediment concentrations, changes to seabed structure and profile, and noise and vibration.

ii. It is also possible that during the operational life of a wind farm there may be instances of major refit to individual or groups of turbines, the effects of which may comprise a combination of construction and decommissioning effects. No specific consideration of 'refit effects' is given here but it is assumed that any such effects fall within the range of effects – either during the construction phase or the decommissioning phase – that are discussed.

4.7.1 Changes in habitat

Potential effect: Removal of turbines would result in loss of or significant change to habitat type with knock-on effect on fish and shellfish fauna.

i. **Spatial** – By definition, the removal of turbines would be limited to wind-farm sites and any significant effects would be contained within the site boundary. Similarly, the effect of lifting cable, if this option is adopted, will be limited to the immediate area of operation; the **Spatial effect would be Negligible**.

ii. **Duration** – Decommissioning and demolition would be spread over a time scale comparable to that of construction, ie less than 5 years per site and any effects directly attributable to removal should last no longer than this period; **Duration effect would be Negligible**.

iii. **Intensity** – As with the effects discussed earlier (§ 4.5.1) the interpretation of the effect of changing habitat type is very much a value judgement. If, as suggested earlier, the subsurface area of a monopile is ~375 m^2 and the area occupied by the monopile is only 28 m^2, the net loss of ~350 m^2 of heavily colonised substratum represents a significant change. If the monopile turf community has proved a productive feeding area for fish its loss will result in the dispersal of fish, if not a fall in total fish production. This dispersal may be viewed as highly disadvantageous by some, recreational anglers for example, while others with a preference for the natural environment may view a return of 28 m^2 of seabed to the prevailing indigenous fauna preferable. Similar arguments and changes will apply to any lengths of transmission cable that have been surface laid under rock armouring if both rock and cable are recovered. In terms of fish and shellfish distributions and productivity, however, the overall **Intensity effect is Negligible**.

iv. **Significance** – Any effect of wind farms on fish and shellfish distributions will be highly localised and decommissioning is unlikely to have any detectable effect on populations in the eastern Irish Sea. Assuming all structures would be removed at least to seabed level, the **Significance of decommissioning would be Negligible**.

4.7.2 Increased suspended sediment concentration

Potential effect: Fish are driven away from areas where they are normally found and the gills of sessile shellfish become clogged, causing them to suffocate.

i. The scale, duration, intensity and significance of this potential problem will be no different from those which applied during the construction phase (§ 4.3.2). Key concerns will be for raising suspended sediment concentrations in the vicinity of potentially sensitive species such as filter-feeding bivalve molluscs and creating visually dense sediment clouds in the vicinity of river mouths at times when salmon or sea trout may be on their spawning migrations. The levels of concern are**: Spatial – Low, Duration – Low, Intensity – Low, Significance – Low**.

4.7.3 Disturbance to seabed structure and topography

Potential effect: Changes to localised currents around the base of turbines may result in erosion and winnowing of sediments resulting in a coarser substratum with an altered profile.

i. The scale, duration, intensity and significance of this potential problem will not be significantly different from those which applied during the construction phase (§ 4.3.3). There is the risk that some larger rocks, boulders or cobbles may be brought to the surface while removing turbine foundations or ripping up cables but this is likely to be highly localised and of limited effect with negligible cause for concern. Any winnowing or erosion would cease and normal seabed processes would return affected areas to the prevailing ambient condition. The levels of concern during the decommissioning phase would be**: Spatial – Negligible, Duration – Low, Intensity – Negligible, Significance – Low**.

4.7.4 Noise and vibration

Potential effect: The noise or vibration generated by any activity during the decommissioning phase may disturb, harm or kill fish.

i. Any noise or vibration associated with an operational wind farm would cease as soon as the wind farm was taken off-line. All other noise would be limited to what has been described earlier as the general cacophony of a construction site (§ 4.3.4). This effect would be limited in duration to the period of demolition after which noise would return to background, ambient levels. On the assumption that explosives would not be a permitted option for demolition of foundation structures, there would be no high-energy percussive sound propagation with the potential to damage or kill fish as can happen with pile-driving. Overall the levels of sensitivity would be: **Spatial – Low, Duration – Negligible, Intensity, Low, Significance – Negligible**.

4.7.5 Summary of potential effects during decommissioning

	Effect	Spatial	Duration	Intensity	Significance
§ 4.10	**Activity Decommissioning**				
4.10.1	Changes in habitat	Negligible	Negligible	Negligible	Negligible
4.10.2	Increases suspended sediment concentrations	Low	Low	Low	Low
4.10.3	Disturbance to seabed structure and topography	Negligible	Low	Negligible	Low
4.10.4	**Noise & vibration**	Low	Negligible	Low	Negligible

5 References

ACFM, 2003. *Report of the ICES Advisory Committee on Fishery Management*, 2003. www.ices.org.dk

ACFM, 2004. *Report of the ICES Advisory Committee on Fishery Management and Advisory Committee on Ecosystems*, 2004. www.ices.org.dk

Apprahamian, M. & Robson, C.F., 1999. *Fish: salmon, sea trout and eels*. In: JNCC, 1999. *Coasts and Seas of the Untied Kingdom: Region 13*. Coastal Directories, Joint Nature Conservation Committee, Peterborough: CD.

Aprahamian, M W & Aprahamian, C D, 1990. Status of the genus *Alosa* in the British Isles; past and present. *J Fish Biol.* 37 (supplement A): 257-258.

Bagliniere, J.L. & Maiss, G., 1998. *Biology and Ecology of Brown Sea Trout*. John Wiley & Sons, Chichester & New York.

BGS, 1999. Geology. In: JNCC, 1999. *Coasts and Seas of the Untied Kingdom: Region 13*. Coastal Directories, JNCC, Peterborough: CD.

Brand, A.R., Wilson, U.A.W., 1996. *Seismic surveys and scallop fisheries: A report on the impact of a seismic survey on the 1994 Isle of Man queen scallop fishery*. Report to a consortium of oil companies by Port Erin Marine Laboratory, University of Liverpool, Port Erin, Isle of Man.

Cordah, 2003. Offshore Wind Energy Generation: Phase 1 Proposals and Environmental Report. Prepared for the Department of Trade and Industry by BMT CORDAH Ltd, Pennycuik, Midlothian. (www.og.dti.gov.uk/offshore-wind-sea/ process/responses/ EN_030603.pdf).

Costello, M., Elliott, M. & Thiel, R., 2002. *Endangered and Rare Species*, In: Elliott, M & Hemingway, K.L., *Fishes in Estuaries*. Blackwell Science, Oxford: p 217-65.

Coull, K.A., Johnstone, R & Rogers, S.I (1998). *Fisheries Sensitivity Maps in British Waters*. Published and distributed by UKOOA Ltd, Aberdeen: CD & http://www.oilandgas.org.uk/issues

Dalen, J. & Raknes, A., 1985. Scaring effects on fish from 3D seismic surveys. *Institute of Marine Research, Bergen, Norway, Report No. FO 8504.*

Dalen, J. & Raknes, A., 1986. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic exploration. In: Merklinge HM (ed). *Progress in Underwater Acoustics, Plenum Press, London.*

DEFRA, 1999. *The Bass* (Specified Areas) (Prohibition of Fishing) (Variation) *Order* 1999.

EA, 2004. *Annual Assessment of Salmon Stocks and Fisheries in England and Wales*, 2003. CEFAS, Lowestoft, and Environment Agency, Cardiff: www.cefas.co.uk; www.environmentagency.gov.uk.

Elliott, M & Hemingway, K.L., 2002. *Fishes in Estuaries*. Blackwell Science, Oxford.

Ellis, J, & Parker-Humphreys, M., 2004. *Fish populations in the eastern Irish Sea*. CEFAS Lowestoft Contract Report (C2150/02) prepared for npower renewables Ltd.

Ellis, J. & Parker-Humphreys, M., 2005. *Rays in the Irish Sea*. CEFAS Lowestoft Contract Report (C2176) prepared for Coastal Fisheries Conservation & Management (on behalf of RWE-Innogy Ltd).

Ellis, J.R., Rogers, S.I. & Freeman, S.M., 2000. Demersal assemblages in the Irish Sea, St Georges Channel and Bristol Channel. Estuarine, *Coastal and Shelf Science*, 51, 299-315.

Engas, A., Lokkenborg, S., Ona, E. & Soldal, A.V., 1996. Effect of seismic shooting on local abundance of cod (*Gadus maohua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Science* 53 2238-2249.

Fox, C J, Dickey-Collas, M, Winpenny, A J, 1997. Spring plankton surveys of the Irish Sea in 1995: the distribution of fish eggs and larvae. *Sci. Ser., Tech. Rep*., CEFAS Lowestoft, 104, 106pp.

FRS, 2003. Scottish Salmon and Sea Trout Catches, 2002. *Fisheries Series Statistical Bulletin* Fis/2003/1. Fisheries Research Services, Aberdeen: www.marlab.ac.uk.

Galbraith, R.D., Rice, A. & Strange, E.S., 2004. An introduction to commercial fishing gear and methods used in Scotland. *Scottish Fish. Inform. Pamphlet* 25, Fisheries Research Services, Aberdeen: 43pp.

Hillis, J.P. & Grainger, R.J.R., 1990. *The Exploited Species*. In: Norton, T.A. & Geffen, A.J., *Irish Sea Study Group Report Part 3 – Exploitable Living resources*. Irish Sea Study Group, Liverpool University Press.

ICES, 2003. Report of the ICES-EIFAC working group on eels. *ICES Council Meeting 2003/ACFM:06*: www.ices.org.dk.

Innogy, 2002. *North Hoyle Offshore Wind Farm: Environmental Statement*. NWP Offshore Ltd., Bourne End.

JNCC, 1999. *Coasts and Seas of the Untied Kingdom: Region 13*. Coastal Directories, JNCC, Peterborough: CD.

Kenny, A.J. & Rees, H.L. (1994). The Effects of Marine Gravel Extraction on the Macrobenthos: Early Post-dredging Recolonisation. Marine Pollution Bulletin, Vol.28, No.7, pp 442-447.

Lee, A.J. & Ramster, J.W., 1981. *Atlas of the Sea around the British Isles*. MAFF Dir. Fish. Res., Lowestoft.

Lokkeborg, S., 1993. Effects of seismic shooting on catch and catch availability of cod and haddock. *Fisken og Havet*, 9.

Maitland, P.S. & Campbell, R.N., 1992. *Freshwater fishes*. The New Naturalist; Harper Collins, London.

Maitland, P.S. & Lyle, A.A., 1995. *Shad and smelt in the Cree Estuary, SW Scotland*. Report to Scottish Natural History, Edinburgh.

McCleave, J.D. & Arnold, G.P., 1999. Movements of yellow- and silver-phase European eels (*Anguilla anguilla* L.) tracked in the western North Sea. *ICES Journal of Marine Science* 56: 510-36.

MCS, 2005. *Basking shark watch*. Marine Conservation Society: www.mcsuk.org.uk.

Mills, D.H., 1989. *Ecology and management of Atlantic salmon*. Chapman and Hall, London.

Moriarty, C., 2000. The European eel. *Buckland Occasional Paper* 6; Buckland Foundation.

Neal, K.J. & Wilson, E., 2004. *Cancer pagurus*. Edible crab. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme*. Plymouth: Marine Biological Association of the United Kingdom: http://www.marlin.ac.uk/species/Cancerpagurus.htm.

Neal, K.J., 2004. *Crangon crangon*. Brown shrimp. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom: http://www.marlin.ac.uk/species/Crangoncrangon.htm.

Parker-Humphreys, M., 2004. Distribution and relative abundance of demersal fishes from beam trawl surveys in the Irish Sea (ICES Division VIIa) 1993-2001. *Sci.Ser.Tech.Rep*., *CEFAS Lowestoft*, 120: 68pp.

Pickett, G D, Eaton, D R, Seabay, R M H & Arnold, G P. 1994. Results of bass tagging in Poole Bay in 1992. Laboratory Leaflet*., MAFF Direct. Fish. Res.*, Lowetoft, (74).

Pickett, G. & Pawson, M.G., 1994. *Sea bass: biology, exploitation and conservation*. Chapman & Hall, London.

Potts, G.W. & Swaby, S.E., 1999. Fish: other species. In: JNCC, 1999. *Coasts and Seas of the Untied Kingdom: Region 13*. Coastal Directories,Joint Nature Conservation Committee, Peterborough: CD.

Rogers, S I, 1993. The dispersion of sole, *Solea solea* and plaice, *Pleuronectes platessa* within and away from a nursery ground in the Irish Sea. *J Fish Biol.* 43 (Supplement A): 275-288.

Rogers, S I, 1994. Species composition and production of sole, *Solea solea* L., in a flatfish nursery ground on the North Wales coast, UK. *Aquaculture & Fisheries Management* (25): 161-177.

Sabatini, M. & Hill, J.M., 2004. *Nephrops norvegicus*. Norway lobster. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme*. Plymouth: Marine Biological Association of the United Kingdom: http://www.marlin.ac.uk/species/Nephropsnorvegicus.htm.

Seaman, W. & Sprague, L. M., 1991 *Artificial Habitats for Marine and Freshwater Fisheries*. Academic Press.

Stanley, D.R. & Wilson, C.A., 2000. Variation in the density and species composition of fishes associated with three petroleum platforms using dual beam hydro-acoustics. *Fisheries Research* 47.

Turnpenny, A & Nedwell, J, 1994. Effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys. *Fawley Aquatic Res. Lab. Ltd. Report*: FCR 089/94.

Wilson, E., 2004. *Homarus gammarus*. Common lobster. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme*. Plymouth: Marine Biological Association of the United Kingdom: http://www.marlin.ac.uk/species/Homarusgammarus.htm

Glossary

The majority of definitions that follow have been taken from:
Lockwood, S.J. (ed.), 2001. *A Glossary of Marine Nature Conservation and Fisheries*. Countryside Council for Wales, Bangor.

Acoustic frequency – the speed with which a surface vibrates to make a sound, usually given in units of Hz (Herz – cycles per second).

Aggregate, marine – marine sand and gravel dredged for the construction industry.

Aggregation, fish – an accumulation of fish in one area, eg around a reef, rather than as a free-swimming (pelagic) shoal.

Anadromous - fish that spawn in freshwater but spend a part of their life at sea, eg salmon, eels and shads. See also catadromous and diadromous

Aquaculture - the artificial rearing and husbandry of aquatic organisms; fish, shellfish and seaweed.

Artificial reef - any man-made structure that is submerged, or partially submerged, at any stage of the tidal cycle. It may be placed by design for a multitude of purposes, eg piers, jetties, coastal defence, fisheries enhancement, or by chance, eg wrecks.

Bass nursery area - 37 designated coastal and estuary sites around the coast of England and Wales in which fishing for bass from boats is either prohibited or restricted. Some areas are restricted throughout the year but the majority are subject to a closed season, eg May – December inclusive.

Beach seine – a relatively simple curtain-like net, typically 50-100 long, that is taken from the beach out in an arc and back to the beach to encircle fish before drawing the net and catch onto the beach.

Beam trawl - bottom trawl that is kept open laterally by a rigid beam. Each end of the beam is attached to the apex of a roughly triangular metal 'trawl head' or 'shoe' *ca* 0.5-0.75m high.

Benthic – relating to benthos or the seabed.

Benthos - all plants (phytobenthos) and invertebrate animals (zoobenthos) that are found in or on seabed habitats, including the intertidal zone.

Biomass - the total weight of living matter, either by species or all species combined. It is sometimes referred to as the standing stock.

Bivalve - molluscs with two hinged shells that encase the soft parts of the animal, eg cockles, mussels, oysters etc.

$\boldsymbol{B}_{\mathbf{lim}}$ - see limit reference points.

Boomer – a high-energy sonar device used by the gas and oil industry to gather information on the geological structure of the Earth's crust below the seabed.

$\boldsymbol{B}_{\mathbf{pa}}$ - see limit reference points.

Broodstock – the mature animals in a population that will breed and generate future year-classes; a term more commonly applied to aquaculture than to wild populations where the term spawning stock biomass (SSB) is more generally applied.

Byelaws – legislation introduced at a local level to meet a specific need. Local authorities, sea fisheries committees (SFC) and ports and harbour authorities, for example, all have the power to introduce and enforce byelaws that can have a bearing on the marine environment and its resources.

Catadromous - species of fish that spawn at sea but spend a large part of their life in freshwaters, eg the European eel and flounder.

Catch - the total quantity of fish that is retained by fishing gear and brought onto the deck or fishing station, ie landings plus discards.

Cetacea - marine mammals that give birth at sea, eg dolphins, porpoises and whales.

Closed season - a period during which fishing for a particular species, often within a specified area, is prohibited. For example, salmon (*Salmo salar*), migratory (sea) trout (*Salmo trutta*), and native oysters (*Ostrea edulis*) may only be taken in UK waters at certain times of year.

Cod-end - the narrow, back end of a trawl into which the catch is funnelled while towing and from which it is released after hauling.

Cod-end liner – a small-mesh insert fitted to the cod-end of a trawl to retain fish smaller than would be retained by normal (commercial-size) meshes.

Cohort - all the fish, or animals in a population that are of the same age, ie all fish spawned in the same year.

Commercial fisheries - any fishery that is undertaken for financial gain but particularly one that generates sufficient revenue to contribute a significant proportion of the total income of those engaged in the fishery.

Common Fisheries Policy – the policy of the European Union by which all European fisheries and fishing vessels are managed.

Community - the grouping of animals and plants that is found living together in a particular place, habitat or environment.

Council of Minister – or Council of the European Union (EU) is one of the main Institutions of the European Union. It is the principal decision-making body of the EU with both executive and legislative powers. The Council is composed of one minister of each member state who is authorised to commit the government of that state. On the basis of Commission (EC) proposals, the Council adopts legislation on its own or jointly with the European Parliament, depending on the legal base.

Crown Estate – A public office charged with the commercial management of UK lands ceded by the Crown to Government in 1760. These lands include 55% of the foreshore, and all subtidal seabed within the Territorial Sea. Surplus revenue is remitted to the Exchequer.

Crustacea - invertebrates with a shell and many legs that are used for walking or swimming. Commercial species include: shrimps, prawns (eg *Nephrops*), crabs, lobsters and crawfish. A very high proportion of the plankton, particularly that part upon which many pelagic fish species feed, are also Crustacea.

Demersal - species of fish that live on, or in close proximity to, the seabed, eg flatfish, cod, haddock. The term also applies to fishing gear that is worked on the seabed.

Demersal trawl - a trawl net that is towed across the seabed rather than through mid water. They are also referred to as a demersal trawls and include both beam trawls and otter trawls.

Diadromous - fish that spend part of their life in freshwater and part in saltwater; eg anadromous salmon and catadromous eels.

Directive, EU – legislation that is binding but leaves individual member states to decide how it should meet its obligations (eg primary legislation, Statutory Instrument, byelaw). If a member state fails to meet its obligations under EU legislation it can be reported to the EU Court of Justice, most probably by the Commission (EC), and fined. (See also Regulation.)

Discards - any fish, or other living matter caught when fishing, that is not retained but returned to the sea - alive or dead.

Doors - a generic name for a wide variety of 'otter boards' that are attached to trawlers' warps (towing wires). They work like a kite, but horizontally, pulling the wings of the trawl out to the side and holding it open laterally.

Dredge fisheries - a method for catching molluscs that live on or in the sea bed, eg clams, native oysters, scallops. Boats tow groups - 'gangs' - of dredges, each dredge rarely more than a metre in width. They are made of a robust steel frame, often with a toothed bar across the lower edge, and a heavily reinforced or chain link bag. (See also French dredge and Newhaven dredge.)

Dredge spoil – the waste material generated by maintaining navigation channels (maintenance dredging) or in preparation of new building work (capital dredging).

Dump sites – designated areas where licensed dredging operators are permitted to dispose of dredge spoil.

Echo-sounder - an instrument mounted in a ship's hull that generates a pressure wave and records the energy reflected back from the seabed or any object in the water column. It records depth or indicates the presence of fish. Echo-sounders are also attached to mid-water trawls to monitor their position in the water column and the catch as it enters the net. Steerable, hull-mounted echo-sounders (sonar) are used to search ahead or around a ship for fish shoals.

Ecology - the study of the inter-relationships between animals, plants and the non-living components of their environment, in their natural surroundings.

Egg case – a horny sac, usually attached to the seabed, that protects the eggs of many elasmobranch species during development; they are commonly known as a mermaid's purse.

Elasmobranch – fish with a skeleton of cartilage, eg sharks and rays. (See also teleost.)

Elver – the juvenile stage of the European eel found in estuaries and lower reaches of rivers in spring and early summer.

Endangered – a species, stock or population is 'endangered' if it is facing a high risk of extinction in the wild in the near future (IUCN).

Environment – the physical surroundings and climatic conditions that influence the behaviour, growth, abundance and overall performance of a population or species.

Essential fish habitat (EFH) – any habitat that is fundamental to the well being of populations or communities of fish. It may be applied to a habitat that a species utilises throughout its life or at a particular time, eg spawning, nursery or feeding areas. The concept was given statutory recognition in the USA (1998) and now forms part of the US national fisheries management programme.

Estuary – the tidal reaches of a river with a tidal variation in salinity.

Exploited stock – any stock of fish that is subject to commercial fishing activity. (See also fishable stock/biomass.)

Fauna – all animal life from microscopic benthos and zooplankton through Crustacea and fish to mankind.

Fecundity – the number of eggs that a female fish produces annually.

Filter feeder – any animal, but typically including bivalve molluscs, that gathers food by filtering organic particles (detritus and living) from the water in which it lives.

Fish stock – scientifically, a population of a species of fish that is isolated from other stocks of the same species and does not interbreed with them and can, therefore, be managed independently of other stocks (*cf* gene pool). However, in EU legislation the term 'stock' is used to mean a species of fish living in a defined sea area, the two are not always synonymous (Holden 1994).

Fixed engines – any fishing gear that is anchored or attached in some other way to the seabed so that it does not drift or move while it is in fishing mode, eg crab pots, long-lines and bottom-set gill nets.

Freshet – a sudden or short-lived increase in river flow rate following rainfall in the river catchment.

gadoid – fish of the cod family, eg cod, haddock, Norway pout, Pollack, saithe (coley), whiting, pout whiting and others.

Gear – an all-embracing term for fishing equipment in total or in part, eg warps, long-line, tickler chains, bridles, dredges etc.

Gill nets – curtains of netting that hang vertically in the water, either in a fixed position (eg surface or seabed) or drifting, that trap fish by their gill covers - operculum – when they try to swim through the net's meshes. (See also drift, tangle and trammel nets.)

Glass eel – a young eel or elver before it has developed any pigmentation and is still translucent.

Habitat – the place where an organism lives, as characterised by the physical features. For example, rocky reefs, sandbanks and mud holes all provide particular habitats that are occupied by animals adapted to live in or on one of them but probably cannot thrive, or even survive in the others.

Hydro-thermal front – the boundary or boundary zone between two water masses with a steep temperature gradient (thermocline) reaches the surface. There is often above-average biological activity in the vicinity of a front including concentrations of plankton, plankton feeders, migratory species.

ICES – the International Council for the Exploration of the Sea, an independent scientific advisory body. It is funded by 19 member states' governments from around the North Atlantic (including Canada and the USA) and Baltic Sea. It was founded in 1902 to encourage research into commercial fish stocks, their biology and all factors (natural and man made) that may affect their abundance. It does not undertake research in its own right but has a secretariat (in Copenhagen) to facilitate and co-ordinate collaboration, including fisheries stock assessments, between member states. Work is carried out through numerous working groups.

ICES Division – statistical area of the Northeast Atlantic comprising a variable number of ICES (fisheries/ statistical) Rectangles, eg Division VIIa, the Irish Sea from the southern end of St George's Channel to the North Channel.

ICES Rectangle – fisheries statistics are collected and collated in 'ICES Rectangles'; these are half degree of latitude by one degree of longitude. The rectangles may be further divided into 'sub-rectangles' (quarter degree latitude by half degree longitude), and exceptionally, may be divided again (one quarter degree of latitude by one quarter degree of longitude).

In-fauna – benthos that lives in rather than on the seabed, eg cockles.

Intertidal – the foreshore or area of seabed between high water mark and low water mark which is exposed each day as the tide rises and falls. Also called the littoral zone.

Invertebrate – any animal lacking a backbone.

Juvenile – an immature fish, ie one that has not reached sexual maturity (but could still be larger than the minimum landing size - MLS).

Keystone species – a species that forms an essential part of a community or assemblage of species without which the rest of the community cannot exist. For example, reef building species such as the colonial worm *Sabellaria* spp or the horse mussel

Modiolus modiolus are keystone species that provide specific habitats within which many other species live.

Landings – that part of the catch which is put ashore. Frequently, landings provide the only record of total catch which is the landings plus discards.

Larvae – the developing animal after it has hatched from its egg but before it has reached the juvenile stage. Many marine larvae drift in the plankton.

Leptocephalus – the planktonic juvenile form of the European eel as it drifts across the Atlantic before it metamorphoses to an elver in coastal or estuarine waters.

Limit reference points – are biological or fishery management indicators that define the point at which precautionary action must be taken to safeguard a fish stock. In order for stocks and fisheries exploiting them to be within safe biological limits, there should be a high probability that: 1 - the spawning stock biomass (SSB = *B*) is above the threshold where recruitment is impaired; 2 - the fishing mortality (*F*) is below that which will drive the spawning stock to the biomass threshold, a condition that must be avoided. Thus:

B_{lim} = minimum acceptable biomass
F_{lim} = maximum acceptable fishing mortality
($_{lim}$ stands for 'limit').

The certainty with which these points can be identified varies with the quality of assessment data available. Therefore, ICES has also identified precautionary reference points that identify higher biomass thresholds than B_{lim} and lower fishing mortality thresholds than F_{lim}:

B_{pa} = precautionary minimum biomass
F_{pa} = precautionary maximum fishing mortality
($_{pa}$ stands for precautionary approach).

In many instances, the value for B_{pa} will be same as the value previously identified as the minimum biologically acceptable limit – MBAL (see: www.ices.org.dk).

Macro-fauna – any animal that is readily visible to the naked eye.

Maturity – the stage that any animal reaches when it is able to breed.

Metamorphosis – the process by which many animals, including fish and shellfish change from a juvenile form to the adult form.

Migration – a positive (ie not passive drifting) movement of fish from one area to another. Migrations can be repeated annually throughout a fish's lifetime or be a one-off lifetime event.

Migratory species – species that undergo significant migrations from one sea area to another; under UK legislation the term applies specifically salmon, sea trout and European eels.

Minimum landing size MLS - minimum landing size, the smallest length at which it is legal to retain a fish or offer it for sale. Ideally, it is the minimum length at which not less than 50% of a given species first reach sexual maturity. In practice it tends to be set at a level influenced by market acceptability and is frequently less than the biological optimum.

Modelling – the numerical analysis of populations and natural processes or environmental events to help understand what has happened, or anticipate what might happen in response to a given set of circumstances.

Molluscs – all animals in the Phylum Mollusca including: gastropods, eg whelks and winkles; bivalves, eg cockles and mussels; cephalopods, eg squid and cuttlefish.

MSW, multi-sea winter – salmon that spend more than one winter at sea before returning to their natal river to spawn.

Natal river – the river in which salmon or sea trout were originally spawned.
Nephrops – *Neprhops norvegicus*, Norway lobster, Dublin Bay prawn, langoustine and in Scotland 'prawn'.
Non-commercial species – species of fish that may be caught but have no commercial value and are, therefore, discarded from the catch and not landed.
North Atlantic Drift – the principal current of the North Atlantic bringing warm water from the tropical SW area to northern Europe; also known as the Gulf Stream.
Nursery area – an area readily identified as one of particular importance, year-on-year, for juvenile fish. For example, many estuaries form bass nursery areas, sandy bays on the east coast of England frequently provide plaice nursery areas, while The Wash and Thames Estuary are important sole nurseries.
Olfactory – relating to the sense of smell.
Otter trawl – a demersal trawl that is held open laterally by otter boards or 'doors'.
Over exploitation or over-fishing – any fishery where the total fishing effort is greater than is required to meet or match a specific management objective.
Ovo-viviparous – animals that incubate their young internally and produce live, free-living offspring, eg many sharks including spur dogs, *Squalus acanthias*.
Parr – the juvenile stage of salmon and sea trout that live in freshwater until they are ready to migrate to sea (age 2-4 years).
Pelagic –relating to mid water, eg herring, sprats and mackerel are all pelagic species that are vulnerable to capture in mid water by pelagic trawls.
Phytoplankton – microscopic plants floating in the water column that drift to-and-fro with the tides.
Phytoplankton bloom - all phytoplankton goes through an annual cycle of abundance. The spring bloom is the normal increase in abundance associated with increasing day length. Abnormal increases in abundance that may be associated with nutrient enrichment (eutrophication), and their subsequent collapse, can result in significant depletion of oxygen content in the water and suffocation of many species.
Plankton – the animals and plants that float in mid water and drift to-and-fro with the tides.
Population dynamics – the sum of interactions involving the rates at which a population increases in size through births, and growth and the rates at which it decreases through senescence and deaths.
Post-larva – the juvenile stage immediately following the (planktonic) larval stage.
pots & potting – a general term to describe traps used to catch crabs, lobsters, larger species of prawns, eg *Nephrops*, and some molluscs, eg whelks and octopus.
Productivity – the total biomass generated by a population, stock or species each year as a result of growth and reproduction – less the quantity lost through mortality.
Proto-adult – a small, juvenile animal that looks identical to the adult and adopts the same habitat and feeding habits but is still immature.
Quota – a fixed proportion of the TAC allocated to each fishing nation. (See also relative stability.) This national quota allocation is further sub-divided into quotas for specific areas, seasons, fisheries or organisations
Quota control or management – a fishery management measure that limits the total quantity of fish that an individual boat, organisation or country is permitted to take in a given period.
Rays – flat, bottom dwelling elasmobranch fish, eg thornback ray, cuckoo ray, blond ray.
Recreational fishery/species – any fishery or fish that is pursued for pleasure rather than financial gain; most frequently it is represented by beach and boat angling.

Recreational sea fishing is not licensed but it is subject to minimum landing size (MLS) regulations and its activities can be curtailed by quota restrictions.

Registered fishing vessel – any European vessel that fishes commercially must be registered with its national fisheries department and display port registration letters and numbers, eg LO 62.

Regulation (EU) - legislation that has immediate, equal and binding effect throughout all member states. The method of implementing the legislation is not left to each member state to decide, as with Directives, but is specified in the Regulation.

Sanitise – clear an area of all fish.

Sea fisheries committee, SFC – Sea Fisheries Committees that operate in 12 'districts' around the coasts of England and Wales: Cumbria, North West and North Wales, South Wales, Isles of Scilly, Cornwall, Devon, Southern, Sussex, Kent and Essex, Eastern, North Eastern, Northumberland. Each committee has responsibilities for representing the local fishing industry, conservation of local fish stocks and fisheries management within its district – out to 6 nautical miles from baselines, including responsibility to manage fisheries with due regard to the environment and wildlife. It has the powers to make byelaws, subject to ratification by DEFRA, and is both a relevant and competent authority with respect to the management of special areas for conservation (SAC). (See also Conservation Regulations). Half the membership of each committee is appointed by the coastal local authorities and the other half by DEFRA. DEFRA appointees are drawn from the local fishing industry, in the broadest sense, and include a representative of the Environment Agency and someone with expertise relevant to nature conservation and environmental protection. The Environment Agency exercises the authority of a sea fisheries committee in the Dee Estuary.

SEA, strategic environmental assessment - EU *Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment.*

Sediment plume – an area of above ambient suspended sediment concentrations, eg as is frequently down-tide from a working aggregate dredger.

Seismic – relating to sound and high-energy sonar surveys.

Sessile – an animal that remains in one place for prolonged periods of time.

Shellfish – molluscs and crustaceans; fish with a hard outer case or shell.

Shoal – a mid-water aggregation of fish that swims as if it was a single unit.

Side-scan sonar – a form of echo-sounder that views the seabed obliquely and has greater power to discriminate detail than a conventional, vertical echo-sounder.

Smolt – a juvenile salmon that has metamorphosed from the freshwater parr stage and is migrating to sea.

Sonar – 'SOund, Navigation And Ranging' equipment; a form of echo-sounder that can be directed to look in a particular direction rather than straight down as with standard echo-sounders.

Spat – juvenile bivalve molluscs.

Spatfall – the process of settling from the planktonic larval stage to become benthic juvenile bivalve molluscs.

Spawn – the process of producing (fish) eggs and sperm; fertilised (fish) eggs.

Spawning ground – an area where fish aggregate to spawn.

Spawning stock biomass – the total live-weight of all mature fish of a single species in a particular area.

Species – a group of animals or plants that are mutually fertile and can breed to produce true (ie non-hybrid) offspring.

SSW, single sea-winter – salmon that spend just a single winter at sea before returning to their natal river to spawn.

Stake nets – a colloquial term for a wide variety of intertidal nets, including salmon traps, that are held in shape and position by stakes driven into the seabed.

Stock assessment – the investigation, analysis and numerical description of the recent history and current state of a fish stock and the fishery that exploits it, ie distribution, abundance, size or age structure, fishing effort, catch rates etc.

Substrate or substratum – the seabed (natural or man-made) but usually used when specifying or implying a specific type or one with characteristic properties.

Surf zone – the shallow sea area in which waves break.

Sustainable fishery – a fishery with an annual catch, including discards, that does not exceed the surplus production of the stock (ie annual growth plus recruitment less the annual natural mortality – *M*). Fisheries can be sustainable at levels of stock significantly below the stock that would support MSY or MEY but only if managers pay full regard to limit reference points.

Swim-bladder – a gas-filled sac within the body cavity of many fish that enables them to maintain neutral buoyancy at any particular depth.

TAC – total allowable catch, the quantity of fish that can be taken from each stock each year. The figure is agreed by the Fisheries Council of Ministers each December for the following year. EU member states are allocated a fixed proportion of the TAC as their national quota.

Taxon – a level in the Linnaean system of nomenclature for animals and plants; eg Kingdom or phylum or family or genus etc.

Territorial Sea – The area of sea over which the coastal state exercises jurisdiction (as permitted by the UN *Convention on the Law of the Sea*), normally 12n.mi from baselines.

Trawl – a large, funnel-shaped net that is towed through the water by single or paired boats. The mouth of the net is held open by a beam (beam trawl) or floats along the headline, weights along the groundrope and is pulled open laterally either by the doors attached to the towing wires (warps) or two boats pulling one warp each.

Turf community – the populations of animals (and plants) that often grow closely together and encrust rocks and other structures in the sea, including barnacles, mussels, corals, sea squirts and seaweeds.

Vagrant species – species that have strayed, by migration or drift with currents, beyond their natural range but have not established self-sustaining populations. Most vagrant species found in UK waters are from warmer waters to the south and west of the British Isles.

Wild stock – usually applied to shellfish stocks where the alternative might be a cultivated (‘farmed’) stock; a stock of fish that maintains itself without any intervention by man.

Year-class - all the fish in a population that were spawned in the same year, eg the ‘1998 year-class’.

Yield – the annual quantity of fish that can be removed from a population without causing long-term risk of the population’s demise.