CONTENTS

10 NATURAL FISH RESOURCE

10.1 Introduction

This section presents the existing environment and potential impacts of the marine works associated with the Thanet Offshore Wind Farm (Thanet) project on the natural fish resource in the area. This section should be read in conjunction with **Section 12, Commercial Fisheries**, and **Section 9, Marine Ecology**.

10.2 Assessment Methodology

10.2.1 Data collection and literature review

Information on the fish and shellfish species found within the Thanet study area in the context of the greater Thames Estuary area, the southern North Sea and eastern English Channel is relatively widespread. General descriptions of the range of commercially and non-commercially important species in these areas can be obtained from a number of sources, including English Nature's Marine Natural Area Profiles (e.g. Jones *et al*, 2004), other offshore wind farm development Environmental Statements (ES) such as London Array (RPS, 2005), Gunfleet Sands (Hydrosearch, 2002) and Kentish Flats (EMU, 2002) and survey information obtained from the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) and the Department for Environment, Food and Rural Affairs (Defra) records and other reports (e.g. Swaby and Potts, 1998).

Data made publicly available through the CEFAS Interactive Spatial Explorer and Administrator was used to map spawning and nursery grounds for selected species.

This existing data was supplemented by site specific surveys designed in consultation with CEFAS and based upon the latest CEFAS guidance (CEFAS, 2004), which recommends that when assessing the fish resources of an area, the following should be described and assessed:

- Spawning grounds;
- Nursery grounds;
- Feeding grounds;
- Overwintering areas for crustaceans; and
- Migration routes.

The Environmental Impact Assessment (EIA) determines the extent of the interaction between the planned activity and the resources found at the Thanet site.

10.2.2 Fish surveys

Adult fish surveys

A spring and summer adult fish survey of the Thanet site, export cable routes, inshore area and two control areas was undertaken by Brown & May Marine Ltd and used to inform the existing environment section of this report. Also of specific relevance is the benthic survey, discussed in detail in **Section 9**. Both fish surveys were carried out using a demersal otter trawl and sampled areas within the wind farm site (seven trawls), the two possible export cable routes (six trawls) and two control sites northwest and southeast of the wind farm (three trawls each) (see **Figures 10.1a** and **10.1b**). The survey methodology was agreed, in advance, with CEFAS and is detailed further in **Appendix 10.1**.

Juvenile fish surveys

Juvenile fish species were collected during surveys of the epifaunal assemblage. The survey involved the use of a 2m beam trawl at 27 locations within the study area (see **Figure 9.3** in **Section 9**). Further information on the survey methodology employed is presented in **Section 9**.

Observer trips

Eight observer trips were undertaken on six different Ramsgate vessels during August 2005 and September 2005 to record the target and non-target species captured using the fishing methods employed by the local Ramsgate fleet. The majority of the local commercial fishing fleet are netters, targeting species that may not normally be taken by the survey otter trawl or are caught to a lesser extent (see **Section 12**). Whilst quantitative conclusions cannot be drawn in relation to commercial fisheries, the survey does illustrate the wide variety of species in the area, many of which have some commercial value.

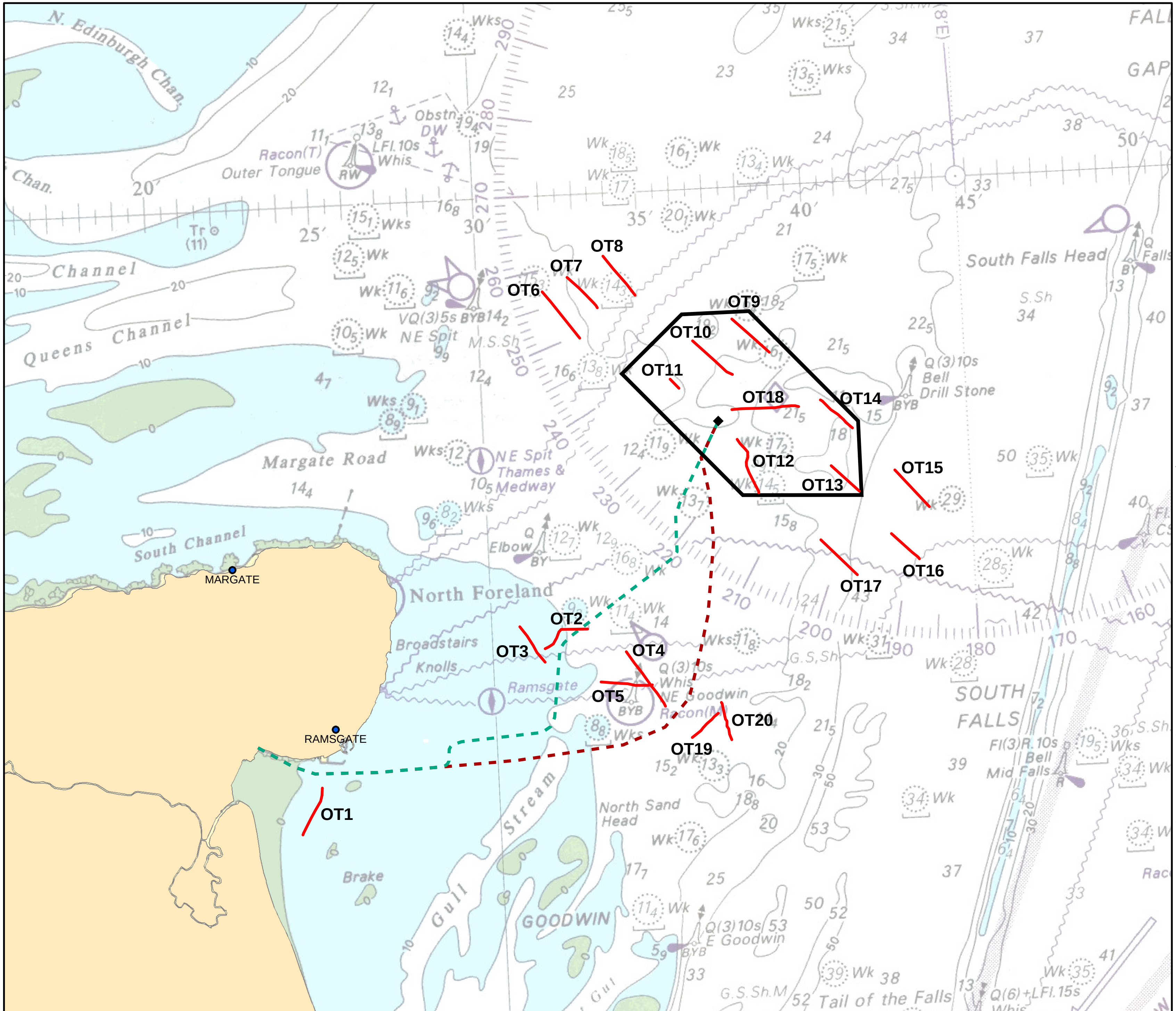
10.3 Existing Environment

10.3.1 Seabed habitats

The Thanet site falls within the sea area that forms a transitional boundary between the southern North Sea and eastern English Channel regions. The seabed within these regions is generally lacking in hard substrata, except where the underlying bedrock comes to the seabed surface, and is dominated by sands and gravels (e.g. Barne *et al*, 1998). In places, the sand forms offshore sandbanks, some of which can rise up to 40m from the seabed. The southeast region is considered to support some 5.8% of the total submerged sandbank habitat in Europe (Jones *et al*, 2004). Such sandbank habitats provide important feeding areas for diving seabirds and predatory fish, as well as spawning and nursery grounds for a range of commercially important fish species.

Section 9 provides a detailed discussion of the seabed geology, sediments and habitat types that are found within the wind farm boundary. Much of the site is dominated by dynamic sandy deposits that form sand waves of up to 5m high in places, interspersed with small areas of gravels and stones. The southern sector of the site is characterised by the emergence of chalk bedrock at the seabed surface, overlain in places by a thin veneer of sandy sediments. The site is not, however, classified as a sandbank.

The nature and extent of available seabed habitat types is a key influencing factor in the development of the benthic assemblage of infaunal and epifaunal species that, in turn provide a food resource for a wide range of fish species. The heterogeneous and dynamic nature of the sediments within the Thanet site has led to the establishment of a benthic assemblage that is highly difficult to classify (see **Section 9**). The macro-infauna of the site is numerically dominated by annelid worms, mainly of the polychaete family.



Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Otter Trawl Locations
- Offshore Substation

Title:

SPRING ADULT FISH SURVEY
OTTER TRAWL LOCATIONS

Project:

THANET OFFSHORE WIND FARM

Source: Main Chart - Not to be used for navigation.

Inset Map -
Derived from MiniScale by Ordnance Survey.

Client:

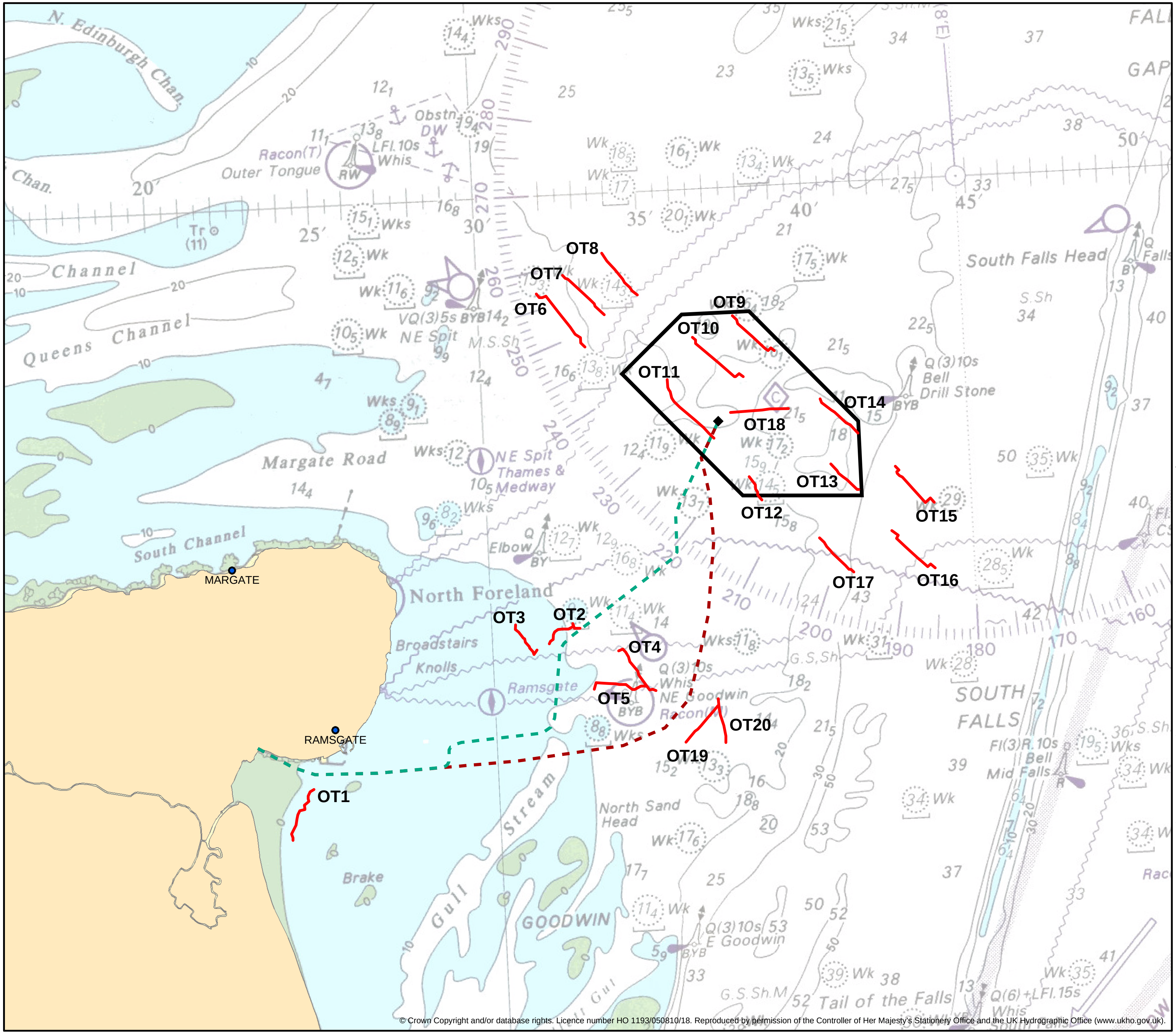
THANET OFFSHORE WIND LTD

Drawn by:	Checked:	Drawing No:
SMG	SDG	9P5164/06/414

Date:	Figure:
01/11/2005	10.1a

Scale:	Revision No:
0 1 2 3 Kilometres	001

ROYAL HASKONING



Legend:

- Wind Farm Site Location
- Proposed Cable Route 1
- Proposed Cable Route 2
- Otter Trawl Locations
- Offshore Substation

Title:

SUMMER ADULT FISH SURVEY
OTTER TRAWL LOCATIONS

Project:

THANET OFFSHORE WIND FARM

Source: Main Chart - Not to be used for navigation.
© Haskoning UK Ltd.
Inset Map -
Derived from MiniScale by Ordnance Survey.
Crown Copyright. All rights reserved.
Licence number AL 100017728

Client:

THANET OFFSHORE WIND LTD

Drawn by:	Checked:	Drawing No:
SMG	SDG	9P5164/06/415

Date:	Figure:
01/11/2005	10.1b

Scale:	Revision No:
0 1 2 3 Kilometres	001

ROYAL HASKONING

There are wide ranging differences between the species assemblages recorded during sampling. In all, 266 species were identified, representing a range of taxa. However, the number of species present in any one area is highly variable, ranging between three and 44 species. The vast majority of samples showed that species numbers are generally low (five to ten species), with just a few samples being represented by high numbers. Statistically, the assemblage across the site has very few characteristics in common, as a direct result of the variability in sediment types and species numbers present. This dissimilarity means that all but a very small number of samples have sufficient characteristics in common with which to form an identifiable 'community', as required for following habitat classification schemes and defining biotopes.

A similar situation was encountered along the export cable routes, where the seabed is characterised by outcropping chalk bedrock and occasional areas of loose sand and sand megaripples.

Benthic species and habitats within a study area have a significant influence on the natural fish resource that is found in the area. The relatively low numbers of species and individuals found within the Thanet study area, combined with the varied nature of the seabed, means it is difficult to relate the habitat type to particular species of fish, which may exploit it for feeding, breeding and nursery grounds. The presence of large areas of sand suggests that the site would be a habitat exploited by demersal fish such as plaice *Pleuronectes platessa.*

The southern sector of the Thanet site is known to support patchy aggregations of low to dense populations of the reef forming polychaete *Sabellaria spinulosa*. The importance of *S. spinulosa* reefs as a habitat and in terms of the species they support is described in **Section 9**. These habitats are also important to the natural fish resource as they provide a degree of stability and complexity in an otherwise dynamic, yet uniform environment. *S. spinulosa* aggregations can increase biodiversity locally (e.g. Jones *et al,* 2000) and have a range of associated epifauna that dwell in the crevices created within the reef structure. These species provide a food resource that would otherwise be absent from the Thanet site and would make a significant contribution to the diet of demersal fish.

10.3.2 Commonly occurring fish species in the outer Thames Estuary

Table 10.1 presents a list of species either commonly encountered in the outer Thames Estuary or considered to be of conservation significance nationally and internationally. The data is based upon the results of the literature review, as previously discussed, and through the site specific surveys described in **Section 10.3.3**.

Table 10.1 Key fish species of the outer Thames Estuary potentially present in the Thanet study area

Common Name	Scientific Name	Commercially Important in Thanet Study Area
Marine Finfish		
Bass	*Dicentrarchus labrax*	●
Bib	***Trisopterus luscus***	
Cod	***Gadus morhua***	●
Dab	***Limanda limanda***	
Dragonet	*Callionymus* sp.	
Five bearded rockling	*Ciliata mustela*	
Greater pipefish	*Sygnathus acus*	
Herring	***Clupea harengus***	
Lemon sole	***Microstomus kitt***	
Mackerel	*Scomber scombrus*	
Nilssons pipefish	*Sygnathus rostellatus*	
Plaice	***Pleuronectes platessa***	●
Pogge	*Agonus cataphractus*	
Poor cod	***Trisopterus minutus***	
Sand gobies	*Pomatoschistus* sp.	
Sandeels	*Ammodytes* spp.	
Sole	***Solea solea***	●
Sprat	*Sprattus sprattus*	
Whiting	***Marlangius merlangus***	●
Elasmobranchs		
Skate and rays	***Raja* sp.**	●
Thornback ray	***Raja clavata***	●
Lesser spotted dogfish	***Scylorhinus canicula***	●
Starry Smoothhound	***Mustelus asterias***	●
Shellfish		
Cockles	*Cerastoderma edule*	
Whelks	*Buccinum undatum*	
Lobster	***Hommarus gammarus***	●
Crabs	*Cancer pagarus* (and others)	●
Species of Conservation Importance in the Thames Estuary area		
Allis shad	*Alosa alosa*	
Angel shark	*Squatina* sp.	
Basking shark	*Cetorhinus maximus*	
Common skate	*Raja batis*	
Salmon	*Salmo salar*	
Sea Lamprey	*Petromyzon marinus*	
Seahorses	*Hippocampus* spp.	
Smelt	*Osmerus eperlanus*	
Sturgeon	*Acipenser sturio*	
Twaite shad	Alosa fallax	

N.B. species in bold text are those recorded during the site specific fisheries surveys.

10.3.3 Fish surveys

Adult fish surveys

Table 10.2 provides data on the combined catch rates (individuals/hr) and the number of individuals caught by species for the four sampling areas comprising the wind farm, export cable route, control and inshore. A total of 465 individuals were caught during the spring sampling and 573 during the summer sampling. A combined total of 19 species were caught during the two sampling periods, which is less than encountered during surveys for Kentish Flats (28 species) and London Array (44 species). This number is low in comparison to the reported number of marine and estuarine species in the greater Thames Estuary (112 species) (Swaby and Potts, 1998). No species of national or local conservation importance or species designated by the Bern convention were caught.

The most prevalent species overall were lesser spotted dogfish *Scyliorhinus canicula*, *Pleuronectes platessa* and dabs *Limanda limanda*. Only five herring *Clupea harengus* were caught during the spring sampling and none during the summer sampling. Only moderate numbers (53) of Dover sole *Solea solea*, the principal species targeted by locally based vessels were caught, with the majority of these being caught during the summer survey. Moderate numbers of starry smoothhounds *Mustelus asterias* and thornback rays *Raja clavata*, which are also targeted by local vessels, were caught.

Figures 10.2 to **10.5** illustrate the relative catch rates of the spring and summer sampling in the four sampling areas. The highest catch rates in both the wind farm site and along the export cable route were for lesser spotted dog fish. The highest catch rates in the control areas were for plaice and dabs.

The spring sampling generally resulted in higher catch rates for lesser spotted dogfish and dabs, whereas in the summer, catch rates where higher for plaice, bib, Dover and lemon sole. Herring catches were negligible within the wind farm site, along the export cable route and at the control sites.

Although the two fish surveys carried out to inform the Environmental Inpact Assessment represent only a brief snapshot of the situation, the results broadly agree with the expected species in the outer Thames Estuary, based on previous studies (Potts and Swaby, 1998; Rogers *et al*, 1998; RPS, 2005; GREP, 2003).

Two species that do not feature strongly in the survey catches were herring and cod, with only one of each caught in the wind farm area in the spring survey. This may be due to the sampling methods employed, however, the local fishing fleet does not target these species.

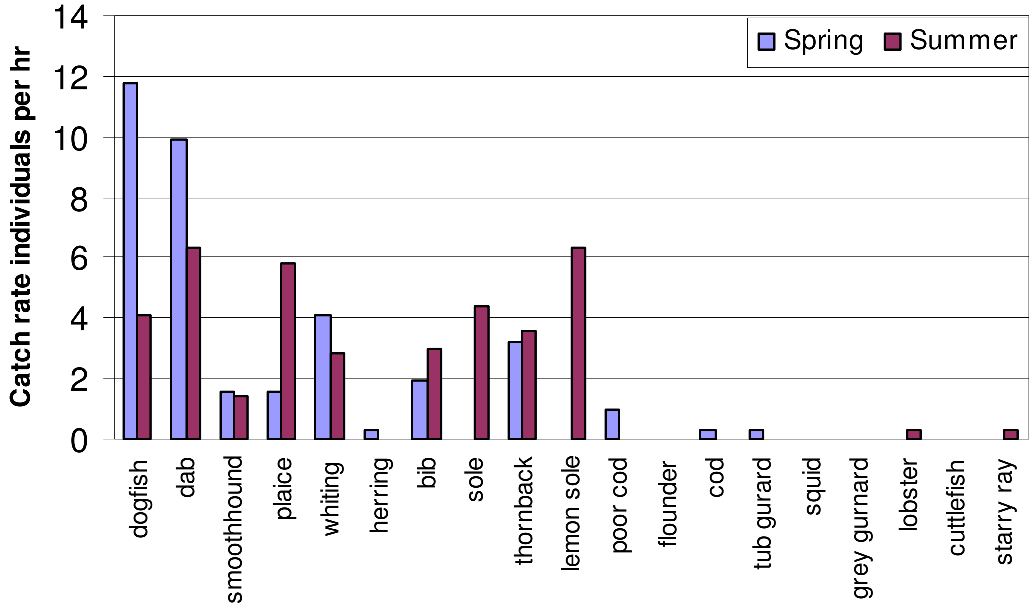
The lesser spotted dogfish was caught in large quantities in the spring surveys and formed a significant proportion of the catch in the summer surveys. This is consistent with surveys carried out for the London Array site (RPS, 2005), but not in line with survey results from Kentish Flats, where no lesser spotted dogfish were recorded (GREP, 2003).

Table 10.2 Combined (all tows) catch rates and total individuals caught by species by sample area

Species		Individuals per Hour								Individuals	
Common Name	Scientific name	Wind Farm		Cable Route		Control		Inshore		Total Numbers Caught	
		Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
Lesser Spotted Dogfish	*Scyliorhinus canicula*	11.8	4.1	36.8	27.6	6.5	6.9	0	6.9	173	134
Dab	*Limanda limanda*	9.9	6.3	3.8	4.4	21.3	5.9	0	0	105	56
Starry Smoothhound	*Mustelus asterias*	1.6	1.4	8.5	4.9	0.3	4.6	0	0	33	36
Plaice	*Pleuronectes platessa*	1.6	5.8	0	0	17.2	31.1	5.2	2.3	57	117
Whiting	*Merlangius merlangus*	4.1	2.8	2.5	5.2	2.1	0.7	2.6	0	28	30
Herring	*Clupea harengus*	0.3	0	0	0	0.7	0	5.2	0	5	0
Bib	*Trisopterus luscus*	1.9	3	1.3	17.7	1.4	1.6	0	0	14	77
Dover Sole	*Solea solea*	0	4.4	0.9	6.7	1	2.6	0	0	6	47
Thornback Ray	*Raja clavata*	3.2	3.6	4.1	1.5	1.4	4.3	0	0	27	31
Lemon Sole	*Microstomus kitt*	0	6.3	0.9	0.6	0	0.3	0	0	3	26
Poor Cod	*Trisopterus minutus*	1	0	0	1.7	0	0.3	0	0	3	7
Flounder	*Platichthys flesus*	0	0	0	0	0.7	0	0	0	2	0
Cod	*Gadus morhua*	0.3	0	0	0	0.3	0	0	0	2	0
Tub Gurard	*Trigla lucerna*	0.3	0	0	0.6	0.7	0	0	6.9	3	5
Common Squid	*Loligo forbesii*	0	0	0.3	0	0.7	0	0	0	3	0
Grey Gurnard	*Eutrigla gurnardus*	0	0	0	0	0.3	0	0	0	1	0
Lobsters	*Homarus gammarus*	0	0.3	0	0	0	0	0	4.6	0	3
Cuttlefish	*Sepia officinalis*	0	0	0	0	0	0	0	6.9	0	3
Starry Ray	*Raja radiata*	0	0.3	0	0	0	0	0	0	0	1

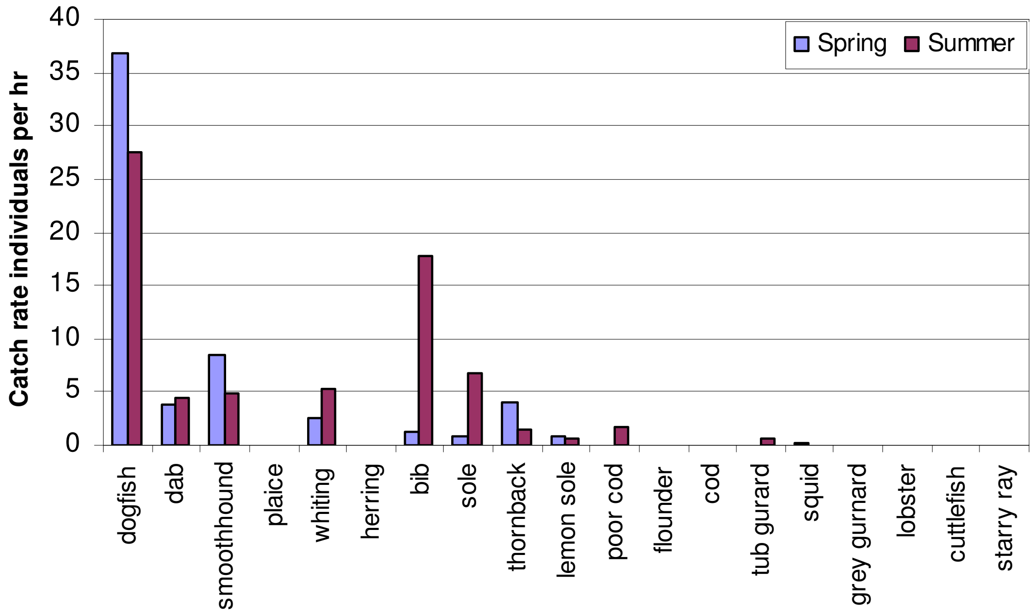
Source: Brown & May Marine Ltd, 2005

Figure 10.2 Relative catch rates of the spring and summer sampling in the wind farm site



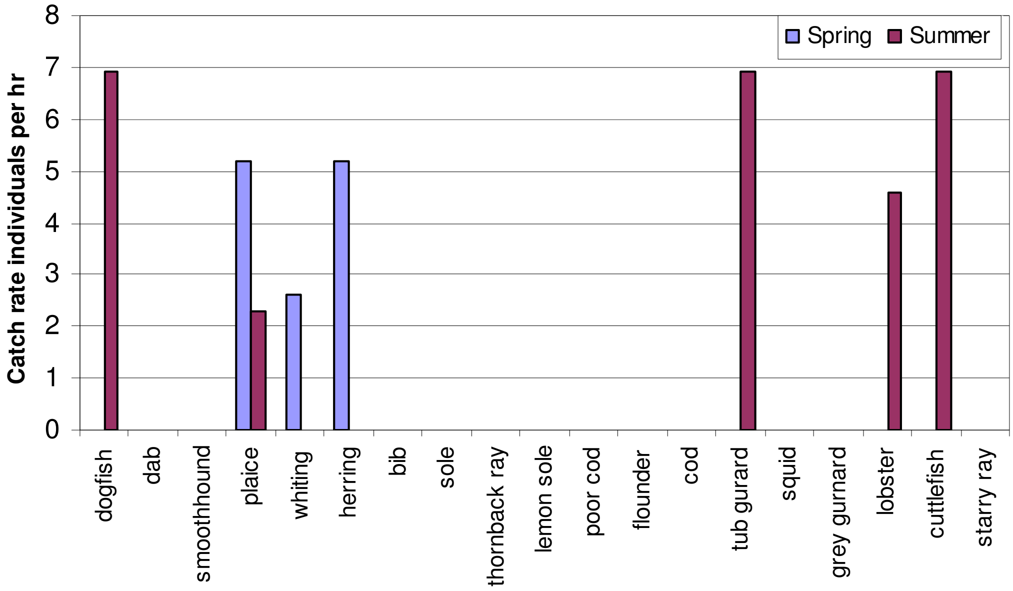
Source: Brown & May Marine Ltd, 2005

Figure 10.3 Relative catch rates of the spring and summer sampling in the cable route areas



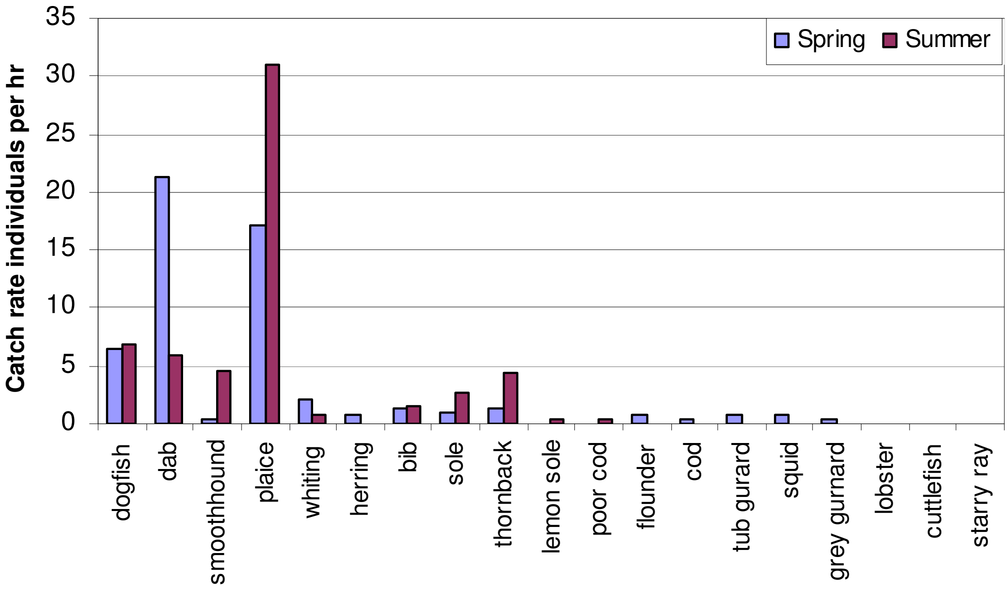
Source: Brown & May Marine Ltd, 2005

Figure 10.4 Relative catch rates of the spring and summer sampling in the inshore areas



Source: Brown & May Marine Ltd, 2005

Figure 10.5 Relative catch rates of the spring and summer sampling in the control areas



Source: Brown & May Marine Ltd, 2005

It is difficult to draw any firm conclusions from the data due to the high fluctuations found in fish populations from year to year. However, it was seen in both surveys that fish numbers are generally highest along the export cable route, due to catches of lesser spotted dogfish and starry smoothhound, with broadly similar numbers in the control and the wind farm areas.

Table 10.3 summarises the percentages of individuals of the pressure stock species within the samples that were below the minimum landing sizes.

Table 10.3 Percentages of samples of pressure stock species below minimum landing sizes

Species		% Under Minimum Landing Size (MLS)					
		Wind Farm		Cable Route		Control	
Common	Scientific	Spring	Summer	Spring	Summer	Spring	Summer
Plaice	*Pleuronectes platessa*	80.0%	90.5%	-	-	82.0%	94.7%
Whiting	*Merlangius merlangus*	84.6%	70.0%	0.0%	72.2%	50.0%	100.0%
Dover Sole	*Solea solea*	-	20.0%	0.0%	4.3%	66.7%	12.5%
Thornback Ray	*Raja clavata*	80.0%	76.9%	61.5%	100.0%	75.0%	53.8%
Herring	*Clupea harengus*	0.0%	-	-	-	0.0%	-
Cod	*Gadus morhua*	0.0%	-	-	-	0.0%	-

Source: Brown & May Marine Ltd, 2005

Table 10.3 indicates that, with the exception of Dover sole, the majority of the individuals caught were below the minimum landing size. The numbers of herring and cod were insufficient for comparison, as only one of each species was caught.

10.3.4 Sex ratio and spawning conditions

The summary of the sex ratios given in **Table 10.4** shows generally higher ratios of females amongst the samples taken from the wind farm site during both the spring and summer surveys. This finding is less pronounced in the export cable route and control site samples, although a high proportion of the Dover sole, which were only caught in the summer survey at all three sampling locations were females.

Table 10.4 Distribution of sex ratios

Species	Sex Ratios											
	Wind Farm				Cable				Control			
Common Name	Spring		Summer		Spring		Summer		Spring		Summer	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Lesser Spotted Dogfish	73.0%	27.0%	93.3%	6.7%	18.8%	81.2%	71.6%	28.4%	26.3%	73.7%	95.2%	4.8%
Dab	83.9%	16.1%	91.3%	8.7%	91.7%	8.3%	46.7%	53.3%	82.3%	17.7%	61.1%	38.9%
Smooth-hound	20.0%	80.0%	80.0%	20.0%	33.3%	66.7%	35.3%	64.7%	0%	100%	21.4%	78.6%
Plaice	100%	0.0%	61.9%	38.1%	-	-	-	-	56.0%	44.0%	37.0%	63.0%
Whiting	53.8%	46.2%	80.0%	20.0%	37.5%	62.5%	72.2%	27.8%	83.3%	16.7%	100%	0%
Thornback Ray	40.0%	60.0%	53.8%	46.2%	38.5%	61.5%	80.0%	20.0%	50.0%	50.0%	46.2%	53.8%
Bib	-	-	63.6%	36.4%	-	-	67.2%	32.8%	-	-	-	-
Dover Sole	-	-	75.0%	25.0%	-	-	82.6%	17.4%	-	-	87.5%	12.5%
Lemon Sole	-	-	47.8%	52.2%	-	-	-	-	-	-	-	-

Source: Brown & May Marine Ltd, 2005

The distribution of spawning conditions of the species, where significant numbers of individuals were caught, is given in **Table 10.5**. The majority of the lesser spotted dogfish were found to be mature as were, but to a lesser extent, the bib, smoothhound and Dover sole. High percentages of the plaice and thornback rays were immature.

Table 10.5 Spawning conditions of species caught

Species	Immature*		Mature		Spent	
	Spring	Summer	Spring	Summer	Spring	Summer
Plaice	63.2%	90.7%	12.3%	6.8%	24.6%	2.5%
Dab	23.8%	64.3%	14.4%	0.0%	62.0%	35.7%
Whiting	25.0%	36.7%	39.2%	23.3%	35.7%	40.0%
Lesser Spotted Dog	9.8%	16.4%	90.2%	83.5%	-	-
Bib	35.7%	11.7%	64.3%	2.6%	0.0%	85.7%
Smoothhound	30.3%	55.5%	69.7%	44.5%	-	-
Thornback Ray	81.4%	83.9%	18.6%	16.1%	-	-
Dover sole	16.7%	6.4%	66.6%	19.2%	16.7%	74.4%

Source: Brown & May Marine Ltd, 2005

*Immature includes 'A' category elasmobranchs, as well as fish that were too small to identify. Mature includes all non 'A' category elasmobranchs and all non 'immature' or 'spent' categories.

The spawning condition and maturity of the fish caught provide useful information, however, the numbers of species caught are too low to give any firm indication of whether each area contained spawning or nursery grounds. CEFAS data (Coull *et al*, 1998) has therefore been used to identify such areas in the first instance, as it is not possible to compare the results of the site specific surveys with previous knowledge of the outer Thames Estuary fish resource.

10.3.5 Individual species accounts

There are essentially three important areas for the migration or life cycle circuits for most species namely spawning site, nursery area and adult feeding grounds. These are described for individual finfish and shellfish species in this section.

The Thames Estuary and surrounding coastal waters are recognised as supporting important spawning and nursery areas for a number of commercially valuable species. The location of these, according to CEFAS data, is presented in **Figures 10.6a** to **e** and **10.7**. **Table 10.6** illustrates the seasonality of spawning.

Finfish

Sole *Solea vulgaris*: Sole tend to burrow into sandy and muddy bottoms and feed on worms, molluscs and small crustaceans at night. Sole are found to spawn in a large proportion of the southern North Sea, including the Thanet site and export cable route (**Figure 10.6a**). The spawning season is between March and May, peaking in April. The Thames Estuary is recognised as an important spawning ground for sole, which show seasonal migration, moving from deep water into the Thames Estuary to spawn in spring and early summer, and returning to the deep water in late autumn. There are no recorded sole nursery grounds within the Thanet site. Sole nursery areas are recorded for much of the UK inshore coast, including Pegwell Bay (**Figure 10.7**).

Dab *Limanda limanda*: Dab were found in significant numbers at surveys of the Thanet site and control area, particularly during the spring survey. Dab spawn in the early part of the year, approximately March to May (Gibson *et al*, 2001). They live on sandy seabeds and adults feed on smaller fish and invertebrates.

Cod *Gadus morhua*: Only two cod were taken in total throughout the surveys at all of the sites, reflecting the substantial reduction in abundance in recent years identified by the commercial fishery. Cod are listed as vulnerable under the World Conservation Union (IUCN) Red List, are recognised within the UK Biodiversity Action Plan and are an OSPAR priority species. Historic spawning grounds for cod are defined as specifically offshore and do not include the study area (**Figure 10.6b**). Nursery grounds are present throughout the Thanet site and sections of the export cable route (**Figure 10.7**).

Bass *Dicentrarchus labrax*: Bass generally inhabit the littoral zone on various kinds of substrates and enter coastal waters and river mouths in summer. They migrate offshore in colder weather and occur in deep water during winter in the northern range. Bass feed chiefly on shrimps, molluscs and small fish. Although bass tagged in the English Channel have been found north of the Yorkshire Coast, it is thought most likely that the stocks spawning to the east of the Thanet site migrate south during the winter months. The Thames Estuary is recognised as a nursery for bass, with large numbers of fry moving into the area in the summer months.

Plaice *Pleuronectes platessa*: Plaice live on mixed substrate seabed, feeding mainly on thin-shelled molluscs and polychaetes. They are active at night in very shallow waters and spend the majority of daytime buried in the sand. Plaice are reported to be resident intertidal species with homing behaviour (Gibson, 1999).

Plaice spawning grounds occur throughout the region (**Figure 10.6c**) including areas across the Thanet site. Spawning occurs throughout December to March, peaking in January and February. Tagging experiments have shown that spawning migrations can be long. Nursery grounds are not present within the Thanet site, but do occur closer to shore within the Thames Estuary and other inland areas (**Figure 10.7**), including the export cable route in the vicinity of Pegwell Bay. High proportions of immature plaice within the spring and summer survey catches support this. Plaice are included in the UK Biodiversity Action Plan.

Whiting *Merlangius merlangus*: Whiting inhabit sandy grounds, with large individuals preying on fishes such as gadoids and herring, while smaller ones feed on crustaceans. Whiting exhibit seasonal onshore-offshore migration (Cohen *et al,* 1990). Whiting spawning (**Figure 10.6d**) and nursery grounds (**Figure 10.7**) are present in the region, but not within the Thanet site. Whiting are included in the UK Biodiversity Action Plan.

Herring *Clupea harengus*: Herring are a vital food source to many commercially important species, and are an important resource for many bird species and marine mammals. Herring are facultative zooplanktivorous filter-feeders, i.e. they can switch to filter-feeding if the food density and particle size are appropriate (Blaxter, 1990).

The outer Thames Estuary is known to support an indigenous population of herring (CEFAS data), spawning mainly in the spring. One herring spawning ground is situated close to shore off Herne Bay, but the herring spawning areas illustrated in **Figure 10.6e** are seen to be well away from the Thanet site and export cable route. Herring nursery grounds also occur within the Thames Estuary (**Figure 10.7**) but again, not across the Thanet site. Herring spawn on sandy gravels and gravel and broken shells (CEFAS, 2004). While small gravely areas are found within the Thanet site, they are not considered to be suitable herring spawning habitat.

Herring are included in the UK Biodiversity Action Plan. Other species included in the Grouped Action Plan for Commercial Marine Fish (see: http://www.ukbap.org.uk), but not encountered in surveys of the Thanet area include hake *Merluccius merluccius*, saithe *Pollachius virens* and mackerel *Scomber scombrus*.

Elasmobranchs

The elasmobranch family is made up of sharks, skates and rays and is characterised by a cartilaginous skeleton. This family is known to generally having a low resilience to exploitation and population decline, as low numbers of eggs are laid compared to broadcast spawners. There is also greater potential for them to be affected by changes to the sedimentary environment, as feeding and egg-laying are associated with the benthos.

Rays and skates *Raja sp.*: The most abundant *Raja* species in the study area is the thornback ray, *R. clavata* (Ellis *et al*, 2004). The main mating and spawning period for the thornback ray is throughout summer. Other rays present in the study area include the spotted ray *R. montagui*, cuckoo ray *R. naevis*, and the starry ray *R. radiate*. Although skate, *R. batis*, are present around much of the UK coastline, they were not recorded during the site-specific surveys. It is thought that rays move offshore into deeper waters during winter, possibly to feed (Walker *et al*, 1997).

Thornback rays are listed in the IUCN 'Red List of Threatened Species' and in Schedule 5 of the Wildlife and Countryside Act 1981. Skate is classified as being 'endangered' by the IUCN and is subject to its own Species Action Plan, under the UK BAP.

Lesser spotted dogfish *Scyliorhinus canicula*: Lesser spotted dogfish comprised the majority of survey catches in all areas. These are found on sandy, coralline, algal, rocky, gravel or muddy bottoms at depths of a few meters commonly down to 110m. The main breeding season is between November and July. The high numbers found in the surveys are in line with survey results from the London Array (RPS, 2005).

Starry smoothhound *Mustelus asterias*: This species was found in significant numbers in all but the inshore sampling areas. They are, however, found from the intertidal down to 100m, preferring sandy and gravely bottoms to feed primarily on crustaceans.

Other **shark** species that may occur in the area include the porbeagle *Lamna nasus*, the thresher *Alopias vulpinus* and the basking shark *Cetorhinus maximus*. The basking shark is included in the UK Biodiversity Action Plan and is protected under the Wildlife and Countryside Act (1981).

Migratory (diadromous) species

Diadramous species i.e. those which move between fresh and salt waters during their life cycle, are known to migrate in and out of the Thames Estuary and other river estuaries in the area such as the Stour. Many are of high conservation importance and are protected species. None of the species described below were identified in the spring and summer surveys. Their absence from the surveys is not surprising, as most adhere to reasonably specific seasonal migrations. There is the possibility that some may travel across the Thanet site and export cable route, but these are not areas of particular significance.

Sea trout *Salmo trutta*: There is an important sea trout run into the River Stour with most arriving early June.

Salmon *Salmo salar:* A small number of salmon are caught in the Thames Estuary and surrounding rivers and estuaries. It is reported that approximately 50 salmon return to spawn each year (Hart and Hart, 2005). The migratory period for returning salmon is April to November, with the key period being July and August.

Eels *Anguilla anguilla:* Eels inhabit many rivers and estuaries in the area. Spawning takes place in late winter and spring in the Sargasso Sea. The larvae return via the Gulf Stream and enter estuaries as elvers. The main period for elvers returning to the Thames Estuary is April and May.

Smelt *Osmerus eperlanus:* Smelt are present in the Thames Estuary, forming an important prey item for many birds. Smelt enter rivers for spawning between February and May.

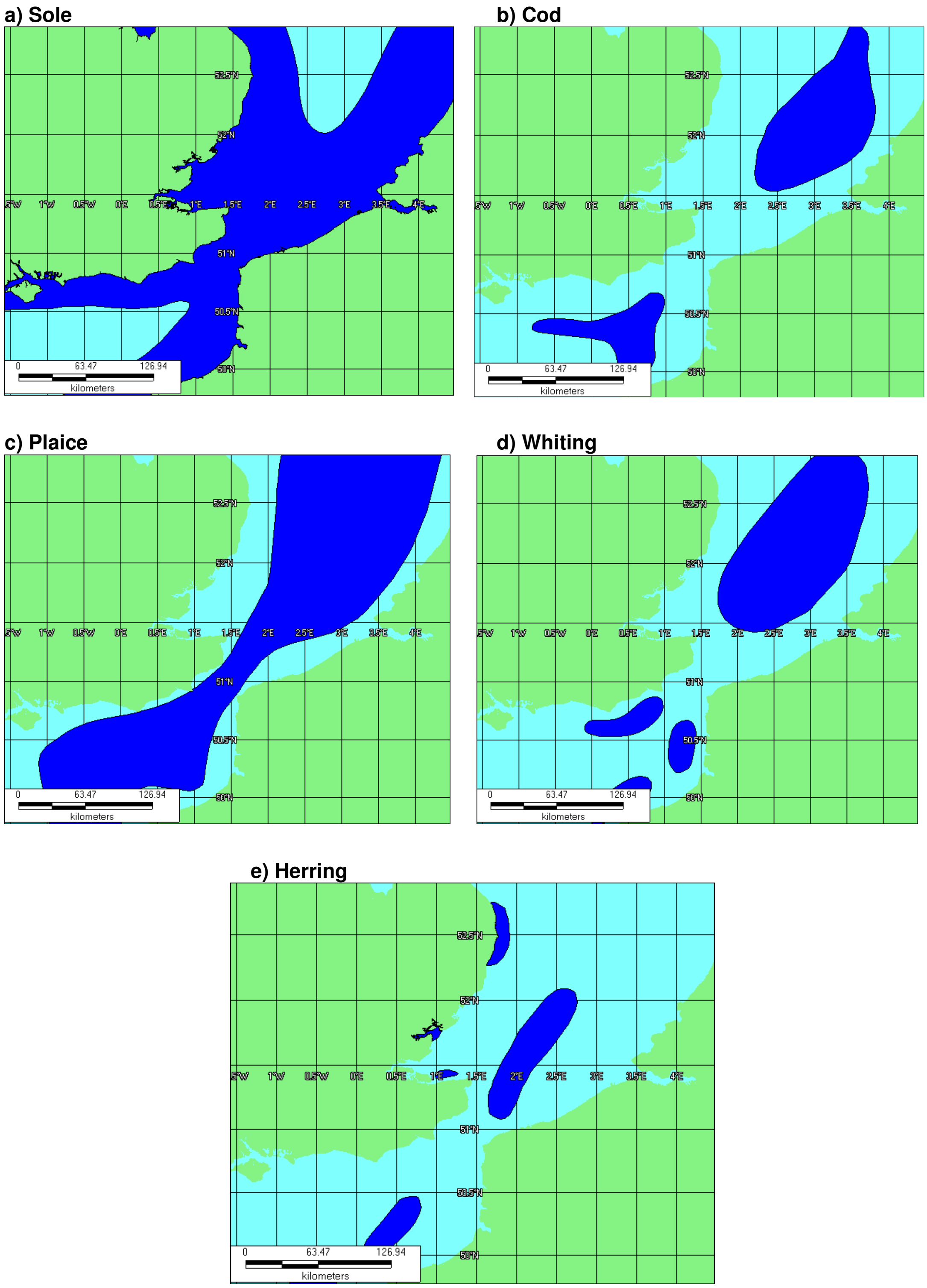
Twaite shad *Alosa fallax* and **Allis shad** *A. alosa:* Shad spawning stocks in the UK are known to occur in specific rivers including the Thames, where spawning occurs between May and July. Both species of shad are listed on Annexes II and V of the Habitats Directive, are UK Biodiversity Action Plan priority species, are listed in the IUCN Red List and are given protection under the Wildlife and Countryside Act 1981.

Sea lamprey *Petromyzon marinus* and **River Lamprey** *Lampetra fluviatilis*: The sea lamprey is considered to be a species of conservation importance (CEFAS, 2004). The sea lamprey has clearly established spawning grounds in the upper Thames Estuary in June and July (Thames Estuary Partnership, undated) and is protected under the EU Habitats Directive. River lamprey spend adulthood at sea, but not as far from the coastline as *P. marinus*, returning to estuaries for spawning in the autumn.

Table 10.6 Main times of spawning activity for key fish species in the Thames Estuary area

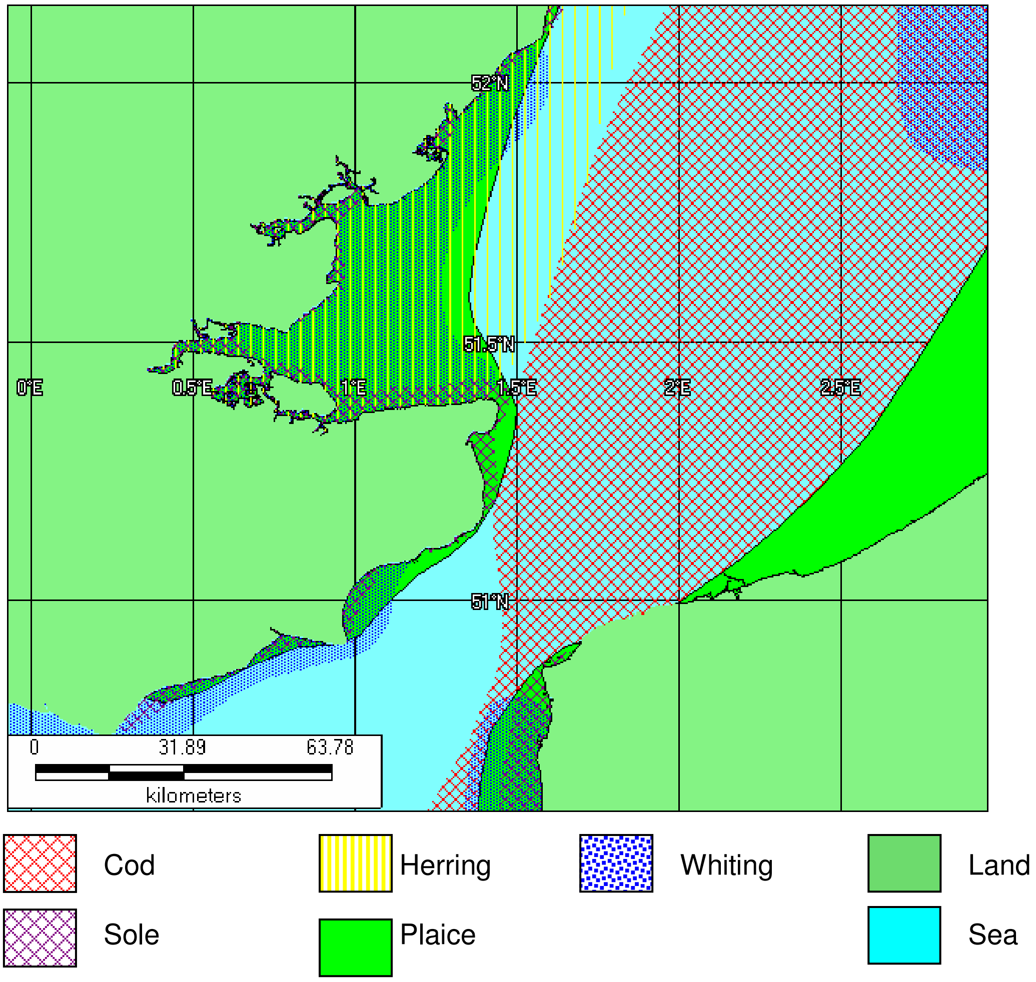
Species	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Bass, *Dicentrarchus labrax*				■	■	■	■	■	■	■	■	
Whiting, *Merlangius merlangus*				■	■	■				■	■	■
Cod, *Gadus morhua*				■								
Sole, *Solea solea*			■	■	■							
Plaice, *Pleuronectes platessa*	■											
Other flatfish			■	■	■	■	■	■	■	■	■	■
Rays, *Raja sp.*		■	■	■	■	■	■	■	■	■	■	
Smoothhound, *Mustelus mustelus*			■	■	■	■	■	■	■	■		
Lobster, *Hommarus gammarus*					■	■	■	■	■	■		
Crabs, *Cancer pagarus*			■	■	■	■	■	■	■	■		
Herring, *Clupea harengus*	■	■										
Sprat, *Sprattus sprattus*												

Figure 10.6 Spawning grounds of species within the study area



Source: CEFAS, Interactive Spatial Explorer and Administrator (http://www.cefas.co.uk/isea)

Figure 10.7 Nursery grounds for species in the study area



Source: CEFAS, Interactive Spatial Explorer and Administrator (http://www.cefas.co.uk/isea)

Shellfish

Shellfish resources of relevance are mainly lobster and crab in the limited hard substrate found at the wind farm site and cockle resources found at Pegwell Bay. Unlike other areas in the Thames Estuary, Native oysters, *Ostrea edulis,* are not found near the Thanet site or the export cable route.

Lobster *Hommarus gammarus*: Lobster is found on uneven ground close in to shore and around hard substrate features offshore, including an area on and around Drill Stone Reef.

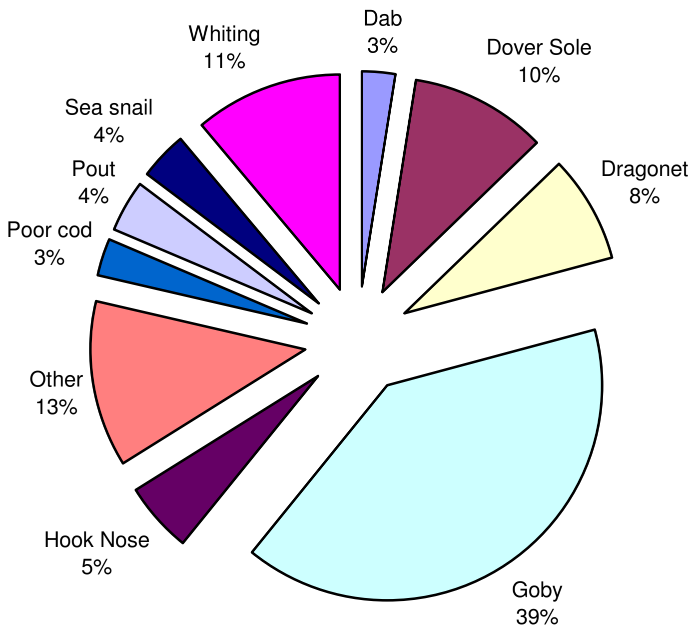
Crab *Cancer pagarus and other sp.*: Found on bedrock including under boulders, mixed coarse grounds, and offshore in muddy sand. Crabs are found extensively in lower shore, shallow sublittoral and offshore environments to about 100m and so are likely to be distributed widely within the study area.

Cockle *Cerastoderma edule*: Cockles are found in the muddy sandflats of Pegwell Bay (see **Section 9**), which is a designated Shellfish Water under the EU Shellfish Waters Directive (79/923/EEC). Cockles inhabit the surface of sediments, burrowing to a depth of about 5cm. They are found on clean sand, muddy sand, mud or muddy gravel from the middle to lower intertidal, sometimes subtidally (Tyler-Walters, 2005) and provide a food source for fish and birds during high and low tide.

Juvenile fish surveys

Twenty-two species were identified in the 27 beam trawls. The catch results are listed in **Appendix 9.2, Table 1** together with the invertebrate epifaunal species. The length distribution of commercial species caught is provided in **Appendix 9.2, Table 2.** Carapace width of edible crab *Cancer pagurus*, is presented in **Appendix 9.2, Table 3**. Percentage distribution of the most numerous fish species caught in the beam trawls is shown in **Figure 10.8**.

Figure 10.8 Percentage distribution of the most numerous species of juvenile species recorded during the beam trawl surveys



Source: Based on Titan Environmental Surveys Limited (2005)

720 juvenile individuals were recorded during the sample analysis. Goby *Gobiidae* indet was the most numerically dominant species (287 individuals), followed by whiting *Merlangius merlangus* (80 individuals) and Dover sole *Solea solea* (74 individuals).

10.4 Impacts during Construction

10.4.1 Impacts due to habitat disturbance

The construction of the Thanet project would result in the direct and permanent loss of areas of seabed in the footprint of the turbine foundations and associated infrastructure. **Section 9** presents the assessment of this impact upon the benthic assemblage within the wind farm boundary. The assessment considers the two potential foundation types that could be used across the site, namely monopiles or gravity based structures (GBS). It has been estimated that the worst case scenario, including an allowance for seabed scour protection, for the footprint of a monopile foundation would be 300m^2. This would be in the region of 1,963m^2 per foundation structure for GBS. Given the greater area of footprint associated with the GBS, the impact assessment is based upon the use of GBS across the entire wind farm site. In the case of the 100 turbine option, this would result in a direct loss of seabed of 0.196km^2, or 0.56% of the total seabed area of 34.99km^2 within the wind farm boundary.

The loss of seabed could have potential knock-on effects to the fish resource through the loss of prey species and/or disturbance to spawning and nursery grounds.

Loss of prey species

The area of seabed lost as a direct result of the placement of foundations and the burial of cables would result in a highly localised decrease in the abundance, diversity and biomass of prey species within the affected area. This, in turn, would result in a decrease in fish productivity, as a percentage of the available prey resource would be lost. However, the analysis of the benthic assemblage in the potentially impacted areas concluded that the species present are widely distributed throughout the study area and beyond. Therefore, while fish may be displaced from the immediate area of loss, they would not have to move far from the disturbance to find an undisturbed prey resource of identical quality, which would be capable of accommodating displaced fish. It is anticipated, therefore, that the impact, during construction would be of **negligible** significance and any localised decrease in fish productivity would not be measurable.

Dense aggregations of *S. spinulosa* have been recorded in the southern sector of the Thanet site (see **Section 9**). Such aggregations can increase the availability of fish prey species locally, by providing a solid, complex structure in an otherwise uniform environment. Thanet Offshore Wind Limited (TOW) is committed to undertaking pre-construction surveys of the *S. spinulosa* aggregations within the wind farm boundary in order to inform the micro-siting of foundations and cabling to avoid areas of high *S. spinulosa* density. By following this mitigation commitment, the potential loss of a valuable habitat in terms of fish prey resource would be **negligible**.

Disturbance of spawning and nursery grounds

As discussed in **Section 10.3**, there are no species of fish within the Thanet study area that have spawning or nursery areas specific to the site. Those species that may utilise seabed habitats in this area are widely distributed around the UK coast. While it is possible that some eggs would be destroyed if located within the footprint of the cables or foundations, on a local, regional and national scale, any such impact is considered to be of **negligible** significance.

10.4.2 Impact due to noise and vibration

Many natural and anthropogenic sources of noise are produced within the marine environment covering a wide range of sound levels. Examples of sources and levels of anthropogenic noise are presented in **Table 9.4** in **Section 9**.

Potential sources of noise and disturbance during the construction of the Thanet project relate to increased vessel traffic, piling, seabed levelling, turbine installation and cable laying. Although there is potential to generate noise from various elements of the project from increased vessel movement and acoustic surveys, it is considered likely that the only significant source would be associated with the installation of monopiles. Previous work (Nedwell *et al*, 2004) has indicated that a level of around 260-270dB per 1μPa @ 1m from source can be expected from the type of piling involved in this project.

In reality, the potential impact of noise and vibration on the fish resource of the study area would be largely dependant upon the 'hearing' sensitivity of the fish species concerned[1]. There are three main types of fish:

- *Hearing specialists:* These species 'hear' sound through their acoustico-lateralis system, which is the collective term for their inner ear and lateral line. They also possess gas-filled swim bladders that are able to detect vibration much like an ear, and increase the ability of the fish to detect the vibrations associated with sound. The proximity of the ear to the swim bladder and the physiology of the swim bladder itself determine how well the fish hears. Hearing specialists include herring and sprat.
- *Hearing-specialists with mid range sensitivity:* These species are hearing specialists, but not to the same extent as true hearing specialists. This is due largely to the fact that they lack a close proximity coupling between the ear and the swim bladder. These species include cod, mackerel and salmon.
- *Non-hearing specialists:* These species do not possess a swim bladder. Non-hearing specialists include flatfish such as dabs, plaice and sole and elasmobranches such as dogfish.

Hearing specialists are most likely to be impacted by construction noise associated with offshore wind farm development. The impact could range from stimulating avoidance reactions through to physiological damage and mortality depending on the proximity of the fish to the source of the noise. Nedwell *et al* (2004) have reported that experiments with caged fish in the vicinity of pile driving activities with a source level of 240-260dB per 1μPa @ 1m showed that fish died instantaneously due to the hyper-expansion and contraction of the swim bladder and that fish exhibited tissue damage resulting in mortality up to 1km away from source.

In a study on the effects of sound from geophysical surveys, Pearson *et al* (1992) found that hearing specialists would observe a strong avoidance reaction at 180dB of received

[1] It should also be noted that, in addition to true 'hearing specialists', the eyes of certain fish species and the gas sacs of some fish larval stages are also sensitive to the vibrations associated with underwater sound. In cases of high intensity sound, these air-filled spaces may be damaged, potentially leading to mortality.

noise. Once disturbed by the noise, the fish, which can detect sound source directions, would increase swimming speeds away from the noise source.

Knudsen (1994) has described the general hearing thresholds for fish in three categories:

- *Absolute hearing threshold:* A laboratory established level, based on strictly controlled conditions with no masking noise. The absolute threshold refers to the minimum sound levels required at a specific frequency for a sound to be heard.
- *Awareness reaction threshold:* The sound level, in the presence of masking noise, at which there is a spontaneous, physiological response, such as increased heart rate, or temporary threshold shift[2] in hearing. This threshold is usually significantly higher than the absolute hearing threshold.
- *Avoidance response threshold:* The threshold at which fish first show an avoidance reaction. This is generally well above the above the absolute threshold.

It is generally accepted that sound levels of between 75 and 85dB above the absolute hearing threshold are generally required for a temporary threshold shift in hearing sensitive species.

It is likely that the driving of monopiles at Thanet would cause a worst case sound level similar to that predicted for London Array of 271dB re 1µPa @ 1 m. Given attenuation over distance, it is likely that a sound level of 180dB, capable of causing temporary threshold shifts, would be received by hearing sensitive fish around 6km from the source. For highly sensitive species such as herring, this could be as much as 8km (RPS, 2005).

It is estimated that physical injury would occur at around 800m from piling operations and high mortality risk would occur at around 200m. It is likely that hearing specialists would be displaced for an area of 6-8km from piling throughout its duration. However, in the 2004 COWRIE report 'The assessment of subsea acoustic noise and vibration from offshore wind turbines', Nedwell *et al* (2004) state, "*In many cases the noise* (from pile driving) *may cause an effect which is of no environmental significance. For instance, a behavioural effect in which fish or mammals are simply displaced from the area of the piling to another area of similar habitat for a limited period may well be unimportant*".

While the validity of this statement may not yet be fully proven, the duration of pile driving and other noise producing activities at Thanet would only occur over a short duration of up to six months, following which, it is anticipated that fish species would readily return to the site as before. In order to reduce the potential for fish mortality to occur during piling, 'soft start' mitigation techniques would be used, where the driving hammer is only lifted a short distance at commencement of the piling activity and gradually increasing in strength over a period of around twenty minutes. This would give

[2] An alteration in hearing level caused by exposure to noise, returning to normal over time. Exposure to greater noise levels can cause a permanent threshold shift, where hearing is considered to be damaged.

sufficient duration within which hearing sensitive species would detect the source of the sound and move away from the area within which physiological damage and mortality could occur. Given this mitigation, the long term impact of displacement due to noise and vibration as a consequence construction activities would be of **negligible** significance.

10.4.3 Impacts due to increased suspended sediment concentrations

Increases in suspended sediments concentrations from construction activities have the potential to adversely impact upon juvenile fish species through the irritation and clogging of gills. Adult fish would normally be able to detect significantly elevated levels of suspended sediment and would move away from the affected area (ABP Research, 1997).

Section 6, Hydrodynamics and Geomorphology presents an assessment of the construction activities of the Thanet project on suspended sediment concentrations within the study area. The assessment concludes that the levels of increased suspended sediment that could be put into suspension as a result of the construction of the Thanet project, both in terms of installing the offshore structures and the export cables, would be small relative to the normal baseline suspended sediment concentrations in the area. The majority of fish species found in the Thanet study area are considered to be tolerant of the relatively high levels of turbidity commonly encountered of up to 60mg/l in the winter and are adapted to the short term variations that are experienced in estuarine environments. As such, the potential impact on the fish resource as a result of a short term increase in suspended sediment of up to 3mg/l is considered to be of **negligible** significance.

10.4.4 Impacts due to release of sediment-bound contaminants

Section 9 and **Section 7, Marine and Coastal Water Quality** have concluded that the impact on the benthos and shellfish water quality as a result of the construction of the Thanet project would have an overall impact of **negligible** significance. As such, it is considered that there would be **no impact** from remobilisation of contaminated sediments on the fish resource of the study area.

10.5 Impacts during Operation

10.5.1 Impacts of electromagnetic fields

The University of Liverpool Centre for Marine and Coastal Studies and Cranfield University (CMACS, 2003a; Gill *et al,* 2005) have undertaken studies, funded through COWRIE, to investigate the modelling and measurement of the electromagnetic field (EMF) emission from typical offshore subsea cables, in the context of the electric (E) and magnetic (B) fields. Initially, a desk and laboratory based study was undertaken, followed by a review of existing information on the impacts of EMF on the marine environment.

The first report of the COWRIE EMF study made the following findings:

For a cable modelled with perfect shielding/earthing:

- There is no direct generation of an E field outside of the cable;
- B-fields generated by the cable created 'induced' E-fields (iE) outside of the cable, irrespective of shielding;
- B-fields are present in close proximity to the cable and the sediment type in which a cable is buried has no effect on the magnitude of the B-filed generated;
- The magnitude of the B-field within millimeters of the cable, referred to as its 'skin', is approximately 1.6µT, which would be superimposed on any other B-fields in the surrounding area e.g. the Earth's geomagnetic field of 50µT; and
- The magnitude of the B-field associated with the cable falls to background levels within 20m.

Considering the results of the modelling in respect of its significance to electrosensitive fish the report found the following:

- That the EMF emitted by an industry standard subsea cable will induce E-fields;
- The cable modelled would produce an E-field of approximately 91µV/m at the seabed adjacent to a cable buried to 1m. An E-field of this magnitude is at the lower limit of emissions that are expected to attract and repel elasmobranchs;
- The iE-fields calculated from the B-field were also within the range of detection by elasmobranchs;
- Changing the permeability or conductivity of the cable may effectively reduce the magnitude of the iE-field;
- To reduce the iE-field such that it is below the level of detection of elasmobranchs would require a material of very high permeability, hence, any reduction in iE-field emission would minimise the potential for avoidance reaction but may still result in an attraction response; and
- The relationship between the amount of cabling present, producing iE-fields and the available habitat of electrosensitive species is an important consideration.

The cabling for the Thanet project would include:

- Interturbine array cables (turbines to offshore substation) – up to 80km of 33kV 3-core copper conductors, insulation/conductor screening and steel wire armoured, buried to a minimum target depth of 1m; and
- Two export cables – up to 53km of 132kV 3-core copper conductors, insulation and conductor screening, steel wire armour and XLPE insulated with a lead sheath, buried to a minimum target depth of between 1m and 3m.

It is not known definitively what the exact magnitude of B and iE-field emissions would be from the cables, but it is considered likely to be in line with the predictions made in the COWRIE report of 1.6µT for the B-field, well below the naturally occurring magnitude of the Earth's geomagnetic field, and 91µV/m for the iE-field. This implies that the B-field would potentially be detectable to magnetically sensitive fish species and that the iE-field would be within the range that could either attract or repel electrosensitive fish species. The impact of the EMF would be highly localised, as the effects would only be detectable within approximately 10-20m either side, or above each cable. However, there would be a similar effect related to each length of cable within the wind farm and along the export cable route.

In order to calculate the potential surface area of seabed affected by EMF, London Array (RPS, 2005) assumed that the entire area of the wind farm array should be classed as being potentially affected by EMF, that the export cables should be calculated as being laid 40m apart for their full length, that the EMF overlaps and that there would be a 50m zone of impact on the outer edge of each outermost export cable. For consistency in calculating impacts, the same calculation is used for Thanet in **Table 10.7**.

Table 10.7 Potential area of seabed affected by EMF emissions

Area of wind farm (km^2)	Length of export cables (km)	Estimated area of impact of export cables (km^2)	Area of greater Thames Estuary (km^2)	% Area of greater Thames Estuary affected
34.99	2 x 26.5	3.71	5,300	0.73

B-fields

Fish species that are likely to be affected by the B-field include species such as eels and diadramous fish such as salmonids. Encounters with a B-field may cause behavioural changes such as a change in swimming direction and could possibly cause a delay in the migration of the species. However, there is currently no available evidence to show whether the magnitude of the B-field produced by a wind farm cable would have a detrimental impact on the normal behaviour of magnetically sensitive fish. The type of cable to be used in the Thanet project would reduce the B-field emission to well below the magnitude of the Earth's geomagnetic field. As such, the impact of B-fields on magnetically sensitive species is considered to be of **negligible** to **minor adverse** significance, dependant upon the outcome of further study.

iE-fields

Electrosensitive species would be expected to be able to detect the iE-field emitted by a shielded cable up to a distance of around 20m from the cable. Exposure to the strongest magnitudes of the iE-field can be reduced by burial, although it is not fully understood whether or not elasmobranchs would be able to detect these fields and further studies are required (Gill *et al,* 2005).

The magnitude of the iE-field falls at the boundary between the likely attraction and repulsion of elasmobranch species. There is currently no evidence to show whether either attraction or repulsion caused by the iE-field would have a detrimental impact upon elasmobranchs. If the iE-field attracted elasmobranchs to the cables, this would reduce their foraging success, as they would be wasting time in the vicinity of the cable. If the iE-field caused repulsion, this could lead to a decrease in the amount of habitat available to the affected species.

The EMF produced by the cables would be at its greatest magnitude while the wind farm is operating at peak capacity. In reality, this would not occur all of the time and would be dependant upon the available wind resource at any given time. There would, in fact, be occasions when EMF emission from the cables would be negligible.

Given the existing level of uncertainty surrounding the true significance of the potential impact upon electrosensitive species, it is considered that the impact of iE-field emission would fall into the range of **negligible** to **moderate adverse** significance. Given the dominance of dogfish in the spring and summer surveys, it is anticipated that further monitoring of the natural fish resource would be required prior to construction and during the operation of the Thanet project, in order to better understand the significance of the impact (see **Section 10.8**).

10.5.2 Impacts due to noise and vibration

Henriksen *et al* (2001) have studied the operational noise produced at the Middlegrunden, Vindeby and Bockstigen-Valar offshore wind farms. Measurements were taken at different wind speeds and when the turbines were and were not operating. **Table 10.8** presents this data (CMACS, 2003b).

Table 10.8 Peak source levels and frequencies of turbines at three Scandinavian offshore wind farms

Wind Farm/Turbine Type	Wind Speed (m/s)	Source Level (dB re: 1 $\mu Pa^2/Hz$)	Noise Frequency (Hz)*
Middlegrunden, Denmark 20 x 2MW 'Bonus' turbines (concrete foundations)	13 6 6	115 101 111	125 125 25
Vindeby, Denmark 5 x 0.55MW 'Windworld' turbines (steel monopile foundations)	8 8	108 108	160 16
Bockstigen – Valar, Sweden 11 x 0.45MW 'Bonus' turbine (concrete foundations)	13 13	113 130	125 25

* Frequencies given are the centre frequencies of 1/3-octave bands

The figures presented in **Table 10.8** are comparable with the sound levels associated with offshore oil and gas drilling platforms, but are significantly less than that produced by most boats and ships (CMACS, 2003b).

The Thanet project would comprise between 60 and 100 turbines ranging between 3.0MW (100 turbines) and 5MW (60 turbines). The worst case for noise produced during the operation of the Thanet project would be in the range of 100-130dB at a frequency of between 25-400Hz, based on estimations made for 3.0MW turbines at London Array (RPS, 2005) and 2.5MW turbines at Burbo Bank (CMACS, 2003).

As previously discussed, the avoidance reaction threshold of hearing specialist fish species is significantly higher than the absolute threshold, which is considered to be 75-80dB. Pearson *et al* (1992) report that noise at a level of 180dB is required to stimulate behavioural changes in hearing specialists. This level is higher than that predicted for the operation of turbines for the Thanet project (100-130dB).

Hearing specialists are known to tolerate, and even be found in the near vicinity of relatively noisy structures, such as oil and gas platforms (Valdermarsen, 1979 cited in CMACS, 2003b). Studies of other offshore wind farms (e.g. Westerberg, 1999) have suggested that fish habituate over time to the noise and vibration of the turbines and that fish numbers actually increase within the wind farm, possibly due to the aggregating effect of the turbine structures.

Hoffman (2000) states that turbines will produce low frequency noise and vibration stimuli in the near-field that fish would perceive as hydrodynamic motion around the turbine structures. However, this motion would not impair the fish's ability to distinguish between the motion generated by the turbine and that produced by other predator and prey organisms.

It is anticipated that the 'start-up' of the turbines would result in an immediate startle response amongst hearing sensitive species, followed by a short period of avoidance. Following this initial reaction, fish would be expected to habituate to the continuous noise produced by the operating turbines and would readily return to the area within a relatively short period of time. As such, the potential impact of operational noise and vibration on the natural fish resource is considered to be **negligible**.

10.5.3 Impacts due to alteration in habitat

The potential for colonisation of the turbine structures is discussed in **Section 9**. Based on past research from a range of sources, it is concluded that the majority of hard surfaces, in the subtidal area of the wind farm, would be readily colonised by a range of benthic invertebrate species and would also facilitate an increase in mobile species that would utilise the increased habitat stability and complexity that would be introduced.

The presence of hard structures, especially if covered in a potential prey resource, is known to promote aggregations of fish in the area surrounding the structure (e.g. Marine Conservation Society, 2000). Aggregations of fish from the surrounding area, however, do not directly equate to increased fish biomass and productivity in the surrounding area.

The fish aggregating potential of a relatively narrow structure, such as a wind turbine, is relatively limited, even with a degree of biofouling. It is anticipated that fish numbers within the Thanet site would increase during the operational phase of the development, particularly amongst species that tend to shoal near reefs, wrecks and other structures, such as gadoids. The provision of scour protection would act to further increase habitat complexity over time and potentially increase the site's attractiveness to fish and shellfish, especially crustaceans such as crabs and lobster.

The presence of an area of hard structures, which provide feeding and refuge potential to fish and shellfish species would be considered as a **minor beneficial** impact of the Thanet project, throughout its operational life. However, the overall impact on the natural fish resource of the study area in terms of biomass and productivity is considered to be of **negligible** significance.

10.6 Impacts during Decommissioning

10.6.1 Impacts due to noise and vibration

The noise and vibration associated with the decommissioning process would be largely similar to that experienced during construction such as increased vessel movement, jack-up operations etc. The major difference, however, would be that decommissioning would not require pile driving and, hence, would not create noise and vibration to the same level as construction. It is anticipated that, on occasion, there would be noise produced above the 180dB level required to cause avoidance reactions in hearing specialist fish. However, such noises would be limited in frequency, duration and extent and would only cause a temporary displacement of fish from the immediately affected area. As such, the potential impact of increased noise and vibration on the natural fish resource is considered to be of **negligible** significance.

10.6.2 Impacts due to disturbance of habitats

Decommissioning would have an impact on seabed habitats of similar, but lower overall magnitude to the construction process. As such, it is anticipated that the impact on fish species in terms of temporary displacement from seabed habitats would be localised and short in duration. Fish would readily return to the area once the decommissioning vessels have moved on. The disturbance of the seabed may even act to attract fish to the impacted area, as it is likely that there would be good foraging opportunities caused by the disturbance.

The loss of the offshore structures and associated fouling communities would mean that the area loses its attraction as a refuge for fish. This decrease in the aggregating potential of the wind farm would lead to a decrease in the number of fish present, and particularly the gadoid species that are the most attracted to upright structures.

This loss of habitat, however, would not act to either increase or decrease overall fish productivity and biomass in the Thames Estuary any more than the operational phase. As such, the loss of habitat associated with decommissioning is considered to be of **negligible** significance to the natural fish resource.

10.7 Cumulative Impacts

10.7.1 Cumulative impact due to noise

In addition to the Thanet project, there are four offshore wind farm proposals in the Thames Estuary area. The locations of these developments are shown in **Figure 1.1**. Of these sites, Kentish Flats and Gunfleet Sands have full consent and are likely to be fully operational during the construction phase of the Thanet project.

If piling activities were carried out simultaneously at London Array, Greater Gabbard and Thanet, it is anticipated that particularly sensitive species i.e. hearing specialists, would be displaced up to 8km from each wind farm for the duration of piling. While the affected areas would not overlap, this displacement would impose a restriction in the available habitat for a range of fish species. This displacement, especially in the case of the piling construction programme for the Thanet project of up to six months, would be short term in duration. Given that noise produced during the construction phase for the Thanet project only has a limited potential for overlap with other wind farm construction it is anticipated that the cumulative impact of noise during construction would be of **negligible** significance.

The operational noise and vibration produced by the wind farms would be highly localised within each array. As it is anticipated that the impact of operational noise for the Thanet project would be of negligible significance within the wind farm, there would be **no impact** in terms of the cumulative effect with the other Thames Estuary wind farms.

10.7.2 Cumulative impact due to EMF emissions

It is clear that further study is required before the effects of EMF on sensitive fish species can be fully understood. For the purposes of this assessment, it has been assumed that all the wind farms will gain consent and that the associated cabling would produce a similar level of EMF over a similar area. The EMF of other seabed cables is not known and, therefore, does not form part of this assessment. However, it is anticipated that cables such as the BritNed Interconnector would emit EMF in a manner similar to that of the export cables. It is possible to say, however, that, given the amount of subsea cabling in this section of the southern North Sea, it is likely that electrosensitive species, such as elasmobranchs, would potentially encounter more than one EMF source on a number of occasions.

The ongoing COWRIE studies and post-construction monitoring for Round One and Round Two offshore wind farms will help further understand the significance of EMF impacts and may show that the significance is considerably less than anticipated. However, at present, a precautionary approach must be adopted. **Table 10.9** predicts the area of potential impact of EMF emissions of the proposed Thames Estuary wind farms. In order to be directly comparable with the predictions made in the London Array ES (RPS, 2005), the same assumptions are made for each wind farm:

- As a precautionary approach, it is assumed that the whole area of the wind farm would be impacted. In reality, this is a significant overestimation, however, there would be potential for sensitive species to encounter cables regularly.
- Export cables are laid 40m apart for their entire length and that there would be a 50m zone of impact on the outside edge of each outer export cable. Again, this is likely to be an overestimation, based on a precautionary approach.

Table 10.9 Comparison of EMF emissions from the Thames Estuary offshore wind farms

Wind farm	Area of array (km^2)	Length (km) x no. of export cables	Area of potential EMF impact (km^2) of export cables	Area of Greater Thames Estuary (km^2)	Potential area affected (%)
Thanet	34.99	26.5 x 2	3.71	5,300	0.73
London Array	233	50 x 6	15.69	5,300	4.69
Kentish Flats	10	8.5 x 4	1.87	5,300	0.22
Greater Gabbard	102	*30 x 3*	5.4	5,300	2.03
Gunfleet Sands	10	7 x 1	0.7	5,300	0.20

N.B. figures in italics are estimates only and would change once design specifications are finalised

In terms of overlap between each wind farm, given that EMF emissions drop to zero within a few metres of the cables, it is concluded that there would be **no impact** on sensitive fish species. The potential impact of sensitive species having repeated encounters with EMF emissions within the Thames Estuary is unknown. However, the potential area affected is small (7.86%), even when adopting a highly precautionary approach to the calculation. Therefore, it is anticipated that the cumulative impact on available habitats for sensitive species would be **negligible**.

10.8 Monitoring Proposals

Monitoring of the natural fish resource within the study area may be of benefit in terms of identifying the actual impacts of the Thanet project. It is anticipated that any such monitoring requirements and methodologies would be agreed in advance with the appropriate authorities, including CEFAS, English Nature and the Kent and Essex Sea Fisheries Committee.

In terms of monitoring for the effects of EMF on elasmobranchs, there is no clearly defined survey method that would be suitable within the wind farm array. It is recommended that the requirement for and methodology of any future monitoring requirements be agreed following the final reporting of the COWRIE EMF study.

10.9 Summary

Information and data on the fish resource within study area was collected from a number of sources including commercial fisheries information, CEFAS and Defra data, published literature and site specific surveys carried out for other offshore wind farms. This overview information was further supplemented by carrying out surveys of the Thanet site, targeting adult fish species during the spring and summer seasons.

A combined total of 19 species were caught during the two sampling periods, which is less than encountered during surveys for Kentish Flats (28 species) and London Array

(44 species) offshore wind farms. This number is especially low in comparison to the reported number of marine and estuarine species in the greater Thames Estuary (112 species). The most common species encountered was dogfish and dabs. Only five herring were caught during the spring sampling and none during the summer sampling. Moderate numbers (53) of Dover sole, the principal species targeted by locally based fishing vessels were caught, with the majority of these being caught during the summer survey. Moderate numbers of starry smoothhounds and thornback rays, which are also targeted by local vessels, were caught.

No species of national or local conservation importance or species designated by the Bern convention were caught.

The Thanet site is not an important spawning or nursery area for commercially important fish species such as herring, as those that may spawn in the wind farm site also spawn widely within the surrounding coastal waters.

Noise created during the construction period, in particular through pile driving, is anticipated to be the source of the greatest potential risk of an impact upon fish species in the form of physiological damage and, in extreme cases, mortality. However, by adopting working practices, such as soft-start piling, these impacts can be effectively reduced and avoided.

Potential impacts during the operation of the wind farm include underwater noise and vibration, the fish aggregating effect of the structures and the influence of EMF. The assessment shows that, overall, the significance of such impacts is considered to be **negligible.**

A precautionary approach to the assessment of the potential impact of EMF emissions has been adopted and worst case scenarios have been assumed, based on current knowledge. However, it is anticipated that, with the outcomes of future COWRIE EMF studies that the overall impact on fish is likely to be **negligible**, over the lifetime of the project.