8 Pelagic Ecology

8.1 Introduction

This report first includes a baseline review of the pelagic ecology in the study area. This comprises the plankton communities and fish communities (including elasmobranchs, especially basking sharks). This first part includes the identification of sensitivities relating to spawning, nursery areas, seasonality, migration and location in the water column.

This report then analyses the potential effects of the development of marine renewable energy in Guernsey on the pelagic ecology. Impacts must be assessed in the context of the baseline conditions within the zone of influence during the lifetime of the development. Cumulative impacts should also be properly addressed. The following parameters are taken into account when assessing the significance of an impact:

- likelihood of occurrence
- positive or negative;
- magnitude;
- extent;
- duration;
- reversibility; and
- timing and frequency.

Mitigation measures and corresponding residual significance are suggested. An indication of the level of confidence in the significance analysis is also provided. The level of confidence is related to the quality/quantity of data available for the pelagic ecology baseline review and to the information available on the potential effects of wave and tidal devices on pelagic components. A summary of data and knowledge gaps is therefore provided at the end of the document to help defining further surveys or research programmes.

8.2 Baseline Environment

Guernsey is situated in the Normano-Breton Gulf between England and France, on the convergence of Boreal (cold temperate) and Lusitanean (warm temperate) marine biogeographical regions. Overlap of these regions promotes increased species richness and allows species to exist at the northern and southern limits of their distributions. This enables the site to support some species which are rare or absent from British coasts as they are normally associated with the warmer waters of southern Europe, as well as species that are normally associated with the colder northern waters of the United Kingdom.

8.2.1 **Plankton**

The English Channel is characterized by a central “river” flowing eastwards from the Atlantic to the North Sea and is bordered with a lot of nested gyres, some of them being cape induced (Barfleur and Antifer along the French coast, Isle of Wight and Dungeness along the British coast), the others being centred on islands; these last gyres can be very strong around the Channel Islands (Ménesguen & Gohin, 2006 – see Figure 8.2.1). Interesting frontal structures are also highlighted in Figure 8.2.2. The influence that these frontal structures may have on the phytoplankton and zooplankton communities (and the overall productivity) is however poorly documented.

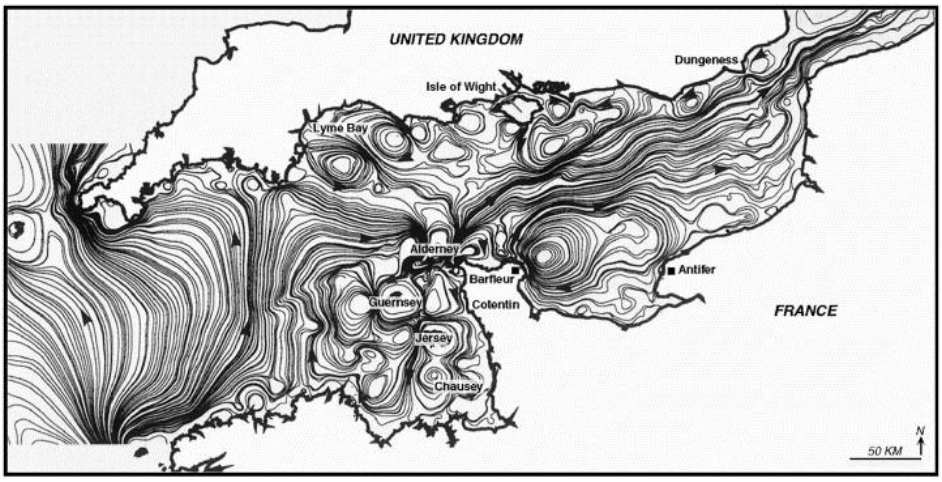


Figure 8.2.1 – Streamlines of tidal residual flow in the English Channel, computed for a constant medium tidal amplitude and without wind (from Salomon and Breton, 1991).

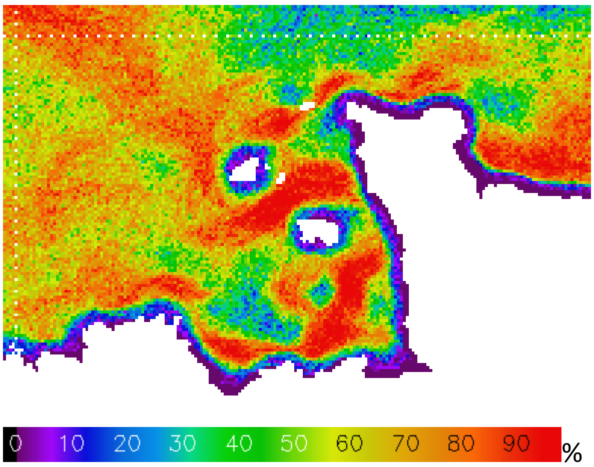


Figure 8.2.2 – Prototype of 'frequent front maps' in summer around the Channel Islands (10-year seasonal analysis), after Miller, 2009
A full analysis can be provided if needed
Note: The low front frequency zones (purple/blue) immediately around the island should be ignored, as the method cannot currently detect fronts right up to the coast.

Regional information on planktonic communities is provided by the SEA 8 report on plankton (Johns, 2008). Unfortunately no local information has been found so far.

Phytoplankton

Data from the Continuous Plankton Recorder (CPR) Survey were analysed by Johns (2008). The aim of the CPR Survey is to monitor the near-surface plankton of the North Atlantic and North Sea on a monthly basis, using Continuous Plankton Recorders on a network of shipping routes that cover the area. In the CPR survey, a visual assessment of 'greeness' is made, this is known as Phytoplankton Colour Index (PCI). It is an estimation of chlorophyll a values (Hays and Lindley 1994).

Guernsey is located at what seems to be a rather productive frontal area (Figure 8.2.3).

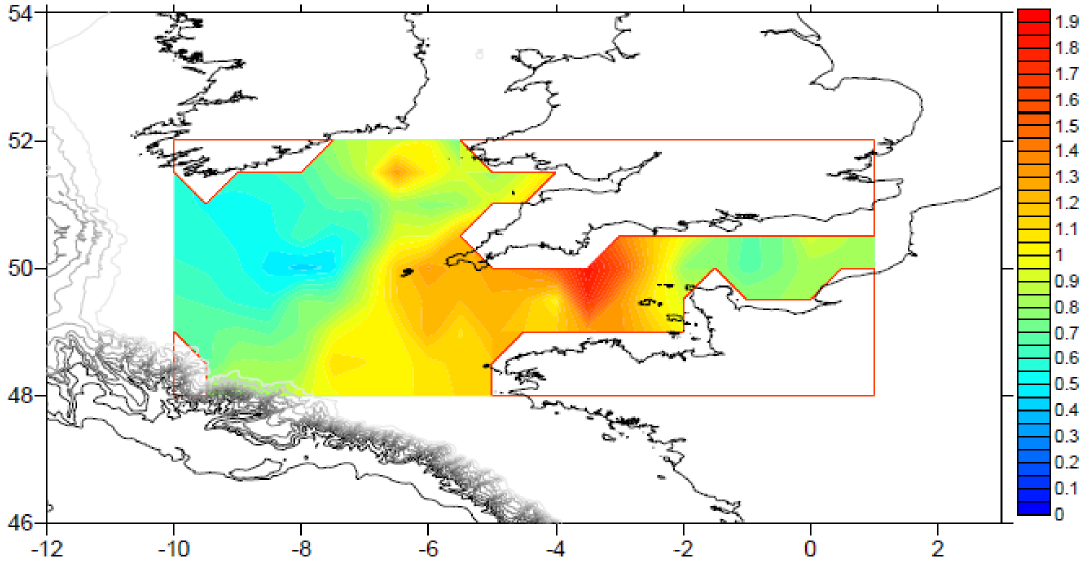


Figure 8.2.3 - Contour map of Phytoplankton Colour Index in the SEA 8 area (Johns, 2008)

Exceptional blooms of phytoplankton take place in summer (July–August) in the western English Channel with chlorophyll concentrations as high as 40 mg m^{-3}(Figure 8.2.4). Blooms of the dinoflagellate *Karenia mikimotoi* (previously called *Gyrodinium aureolum*) are known to have developed in summer in this region.

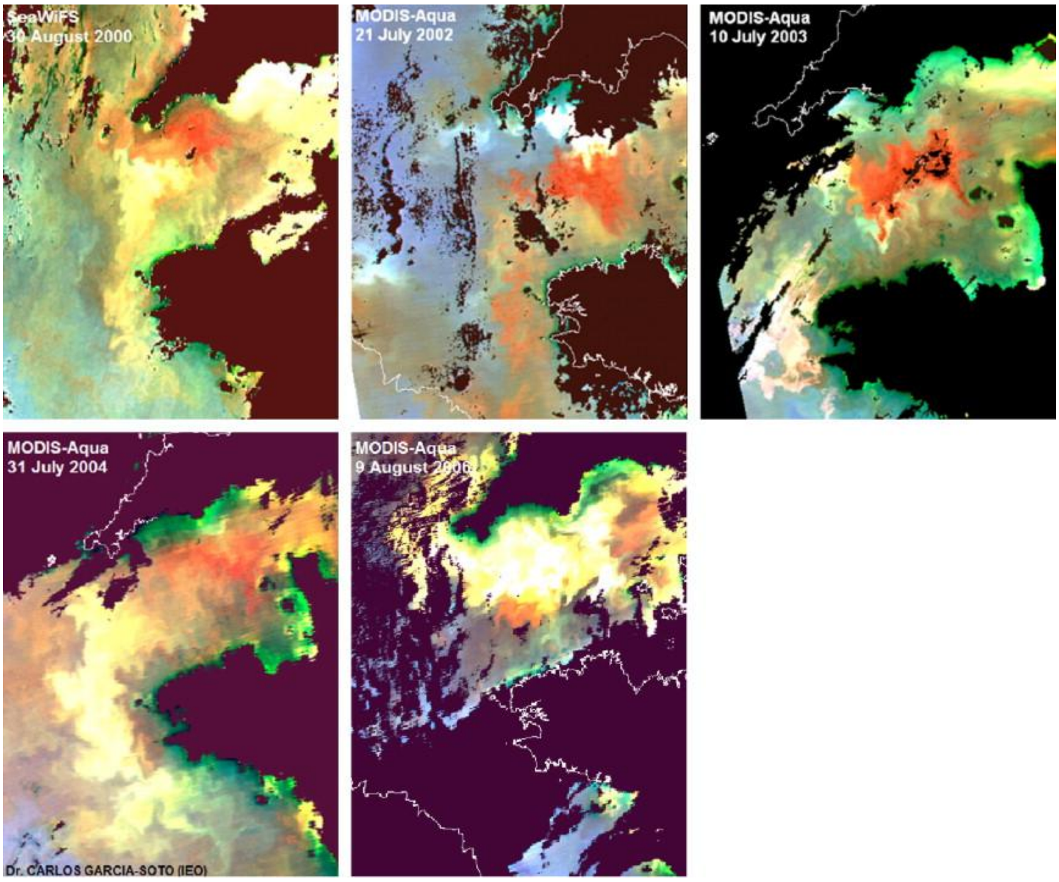


Figure 8.2.4 – Satellite composite images showing the summer blooms of dinoflagellates in the western English Channel on 30 August, 2000: 21 July, 2002; 10 July, 2003; 31 July, 2004; 9 August, 2006. A 200 m depth contour is shown (Garcia-Soto & Pingree, 2009)

Zooplankton:

According to "The Plankton Ecology of the SEA 8 area" (Johns, 2008), the most common species or genus of zooplankton in this part of the Western Channel are *Temora longicornis*, *Calanus helgolandicus*, *Para-pseudocalanus* spp., Decapoda larvae, Chaetognatha, *Acartia* spp. and Cirripede larvae.

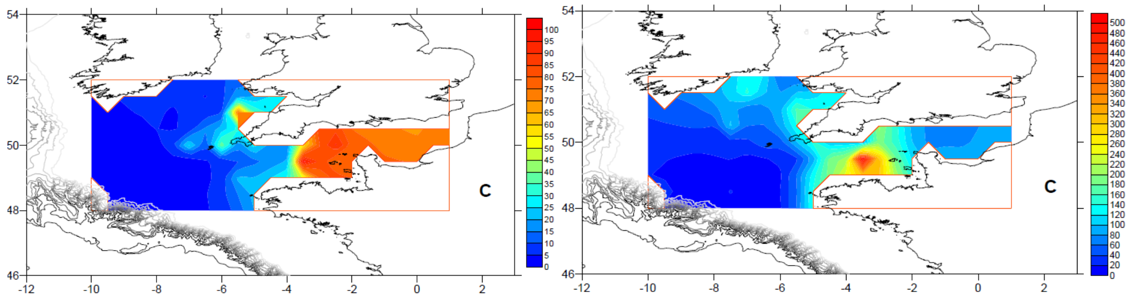


Fig 9 A) *Temora longicornis* long term abundance B) seasonal cycle C) average spatial distribution Fig 7 A) *Acartia* spp. long term abundance B) seasonal cycle C) average spatial distribution

Figure 8.2.5 – Average distribution of *Temora longicornis* and *Acartia* spp.

8.2.2 **Fish**

Information on fish ecology is available at a regional scale, but is more difficult to find for the local scale. The Guernsey Biological Records Centre was contacted and sent a list of references on fish species recorded in the past.

According to data found so far in the literature, along with figures from Guernsey Sea Fisheries (Table 8.2.1), main pelagic species present around the Channel Islands are sea bass (*Dicentrarchus labrax*), black bream (*Spondyliosoma cantharus)*, pollack (*Pollachius pollachius*), sandeel and mackerel (*Scomber* spp.).

Demersal species include brill (*Scophthalmus rhombus*), ray (*Raja* spp.), dogfish (*Scyliorhinus* spp.), tope (*Galeorhinus galeus*) and conger (*Conger conger*).

A survey of Sark undertaken by SeaSearch in June 2008 recorded surprisingly low numbers of such widespread species as pollack and bass. The only species recorded as frequent was ballan wrasse, *Labrus bergylta*.

According to a local charter boat, the main species that can be fished are:

February: Pollack
March: Pollack, Turbot, Brill
April: Pollack, Turbot, Brill, Tope
May: Pollack, Turbot, Brill, Tope, Bass
June: Bass, Pollack, Turbot, Brill, Tope, Cod, Ling
July: Bass, Pollack, Turbot, Brill, Tope, Bream, Cod, Ling...
August: Bass, Pollack, Turbot, Brill, Tope, Bream, Cod, Ling, Conger…
September: Bass, Pollack, Turbot, Brill, Bream, Ling, Conger…
October: Bass, Pollack, Turbot, Brill, Bream, Conger...

Table 8.2.1 – Fish landings in Guernsey. Source: Guernsey fisheries statistics (2009)
Main catches of finfish are highlighted in blue, main catches or shellfish are highlighted in green

Species	Landings 2008 (tonnes)	Landings 2007 (tonnes	Landings 2006 (tonnes)	Landings 2005 (tonnes)	Landings 2004 (tonnes)	Landings 2003 (tonnes)	Average value per tonne (£000,s)
Anglerfish (3)	3.3	2	1.6	2.3	0.9	1.9	3
Bass	123.2	142	162.4	173.0	127.8	49.2	5.5
Black Bream	55	212.5	161.7	158.8	49.9	131.3	1.1
Brill	10.3	8.7	12.7	13.8	9.8	9.4	6
Cod	2.2	1.9	0.9	0.5	1.0	3.0	2
Conger (1)	38.6	38.2	108	58.5	22.4	23.2	1.1
Crayfish	0.7	0.4	0.3	0.3	1.2	1.3	25
Cuttlefish	2	0.7	0.3	2.5	4.5	5	1
Dogfish (1)	16	10.4	20.4	20.6	12.9	45	0.5
Edible Crab	802	933	751	810	899	885	1.2
Grey mullet	1.8	1.2	1.9	1.1	1	1.1	1
John Dory	0.4	0.3	0.4	0.4	0.5	1.1	7
Lobster	67.2	71.5	58.9	59.8	60.5	49	10
Ling	1.6	4.1	3.6	1.8	1.1	No data	1.5
Mackerel	6.5	6.5	6.8	7.1	5.2	No data	0.5
Plaice	1.6	1.5	2	2.9	2.7	1.7	3
Pollack	52 (5)	47.9	42	44.4	35.9	21.4	1.5
Ray	149.8	72.8	117.1	144.6	117.4	163	2.5(3)
Red mullet	8.3	8.2	8.1	12.1	10.1	10.3	5
Sand Sole	1.5	1	0.9	2.0	1.1	1	3
Sandeel (2)	46	60	39.2	45	43.2	37.9	- (4)
King Scallop	102	108	123.4	101.3	107.6	89.2	3.5
Smoothound	19.8	23.1	16.8	18.8	11.3	No data	2
Sole	6.0	3.6	3.5	5.4	6.0	4.8	7
Spider	86.3	59	65	73.3	99	146	1
Squid	0.5	0.5	0.1	0.3	0.4	0.9	5
Turbot	2.5	3.2	5.9	8.1	7.0	4.3	8
Tope	16.2	24.7	10	38.0	26	No data	2
Wrasse (1)	5	4	7.1	4.7	5.5	No data	0.5
Total Weight (tonnes)	**1636**	**1851**	**1728**	**1819**	**1671**	**1688**	
Total Value (£000,s)	**3534**	**3877**	**3825**	**4033**	**3641**	**3159**	

1. Data not including majority of net and pot caught bycatch landed for pot-bait.
2. Not including seine net caught sandeels used for bait (provision for this in 2009 statistics)
3. Whole fish (including ray backs)
4. Value not included as fish re-used for bait.
5. Increased average value for 2008 (£4/ kilo) as large proportion landed directly to France.
* No data (2003) where information is absent, unreliable or incomplete

In the 1960s bass was a rather unusual catch but in recent years over 100 tonnes per annum have been landed (Guernsey Fisheries Statistics, 2007). There also was a big increase in the abundance of black sea bream from 2005 to 2007. However, sea bream populations tend to be cyclical and as a result the return of black sea bream after 30 years (they were last abundant in the 1970s) is not necessarily caused by climate change. Some species which were formerly common, such as red sea bream, are now rarely caught.

Landings of edible crab have remained relatively stable since 2002 while spider crab landings have globally decreased over the past decade, and lobster catches have slightly increased. Edible crab remains the main type of landing for Guernsey fisheries (802 tonnes in 2008).

8.2.2.1 Identification of sensitivities for fish

Spawning areas: Guernsey waters are a spawning area for sea bass (Figure 8.2.6, Figure 8.2.8), sprat (Figure 8.2.7), black sea bream (Figure 8.2.11) and, a bit further to the East of Guernsey, sole (Figure 8.2.8).

Black Bream is present around the Channel Islands mainly in April and May. Spawning occurs around the Channel Islands in May.

Local fishermen knowledge indicates that there is a sea bass spawning area west of Guernsey, within the area the 3nm limit. This is confirmed by Pawson et al. (2008), who describe a pre-spawning aggregation at Boue Blondel (Figure 8.2.6). The results of tagging bass at Boue Blondel winter fishery show that most fish disperse in summer along the nearby French Normandy coast or the south east English coast. No tagged fish were reported from the Channel Islands between May and October, and only 4 of 24 recaptures where reported from within 16 km of the Boue between November and April (Pawson et al., 2008). Spawning of sea bass takes place in March, with pre-spawning aggregation starting in November.

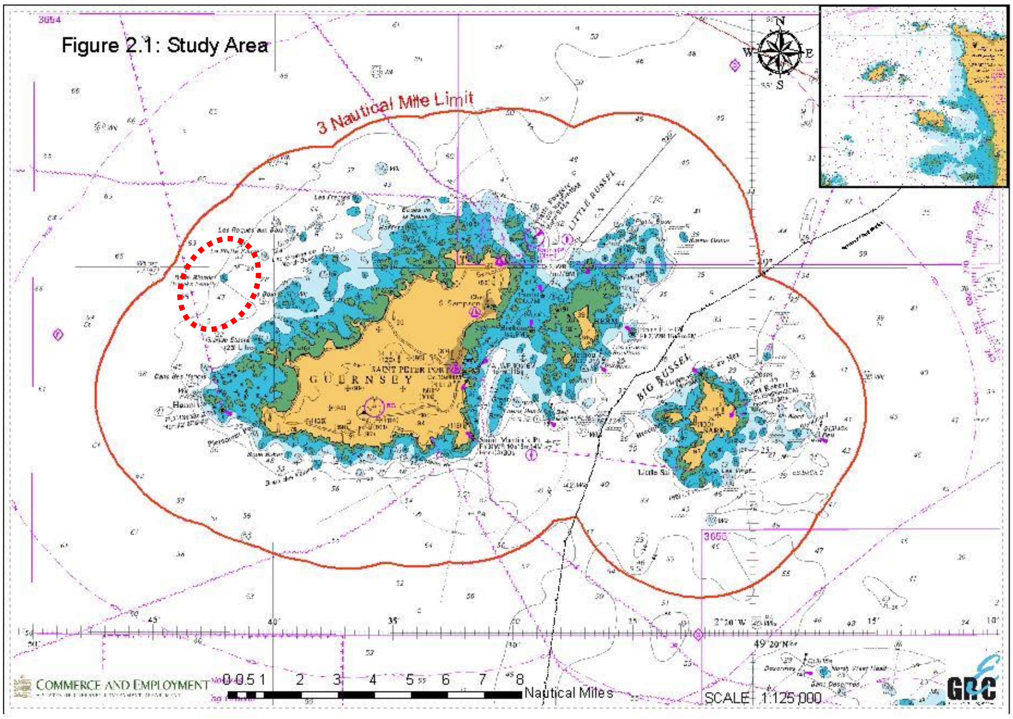


Figure 8.2.6 – Area of pre-spawning aggregation and spawning around Boue Blondel (dotted red circle)

Nursing area: Guernsey waters are a nursing area for mackerel according to Cefas data, however data published by IFREMER do not concur.

Migrations: Migration of sea bass occurs within Guernsey waters. According to Pawson et al. (2007) there is a migratory link between the North Sea and the western Channel.
Guernsey is also located on a migration route for cuttlefish (Figure 8.2.12).

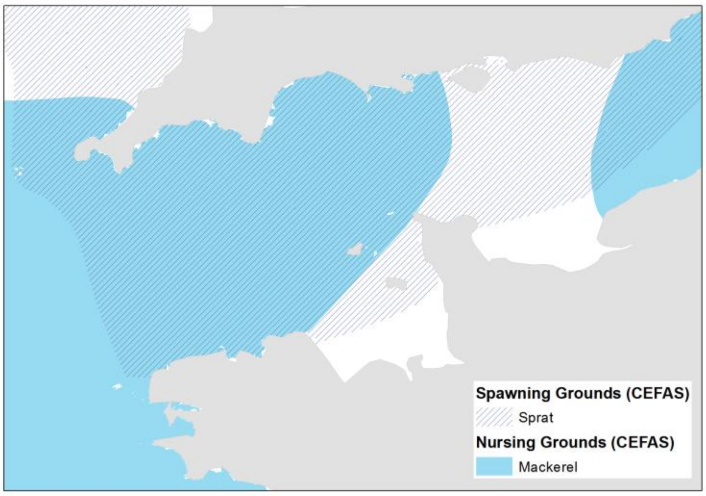


Figure 8.2.7 – Spawning and nursing grounds of Sprat and Mackerel. Source: CEFAS (Coull et al, 1998)

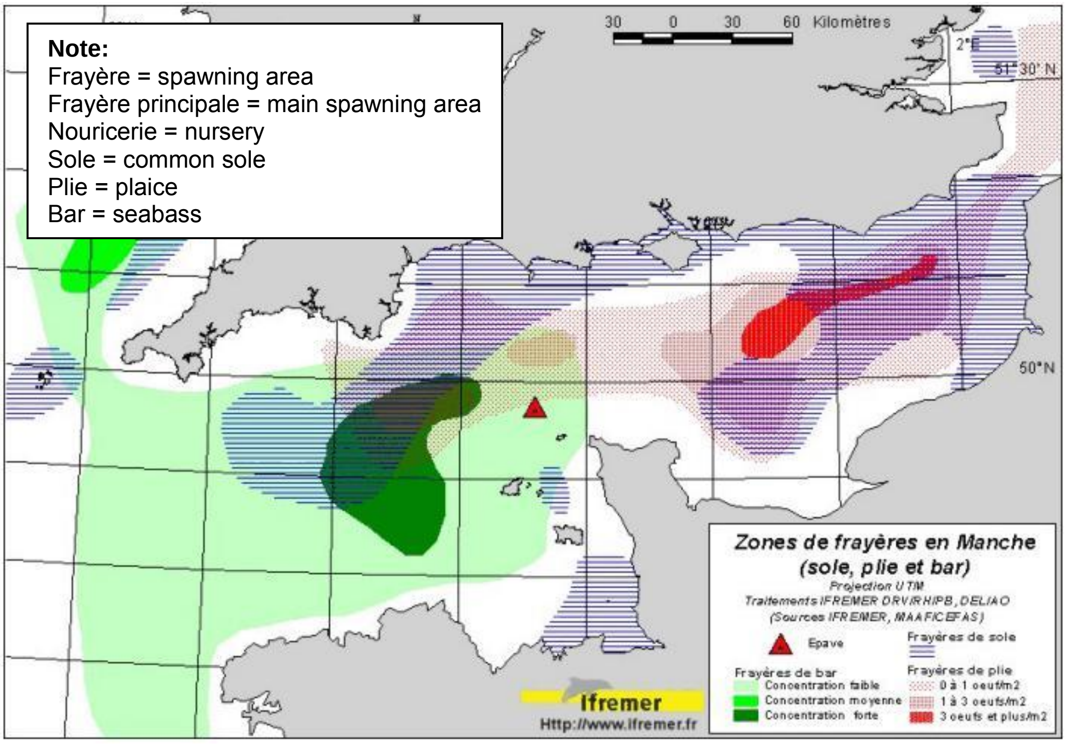


Figure 8.2.8 – Spawning and nursing grounds for Common Sole, Plaice and Sea bass. Source: IFREMER

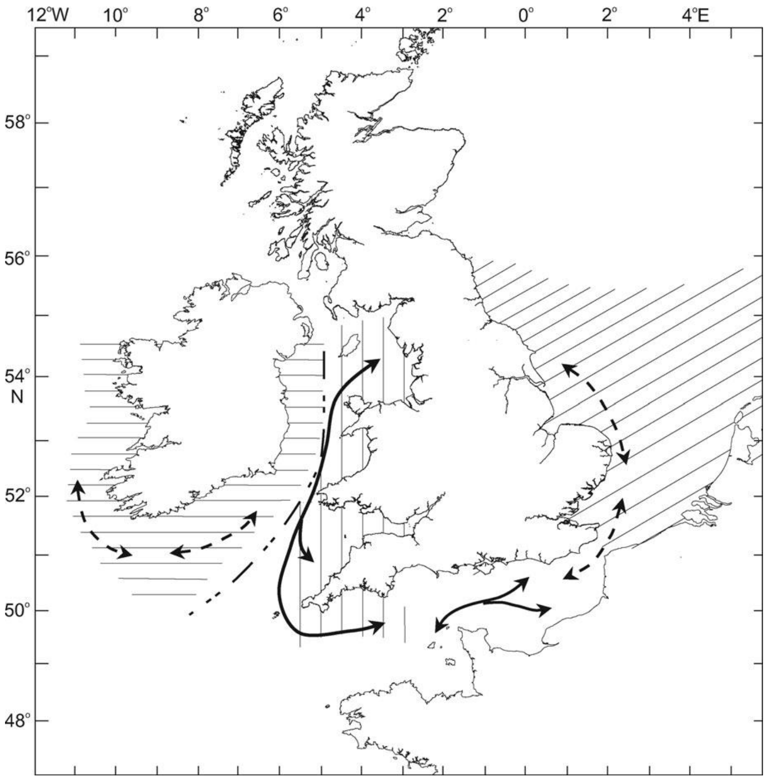


Figure 8.2.9 - Main population movements and putative stock assessment units (hatched) for sea bass in ICES Subareas IV and VII, after Pawson et al. (2007)

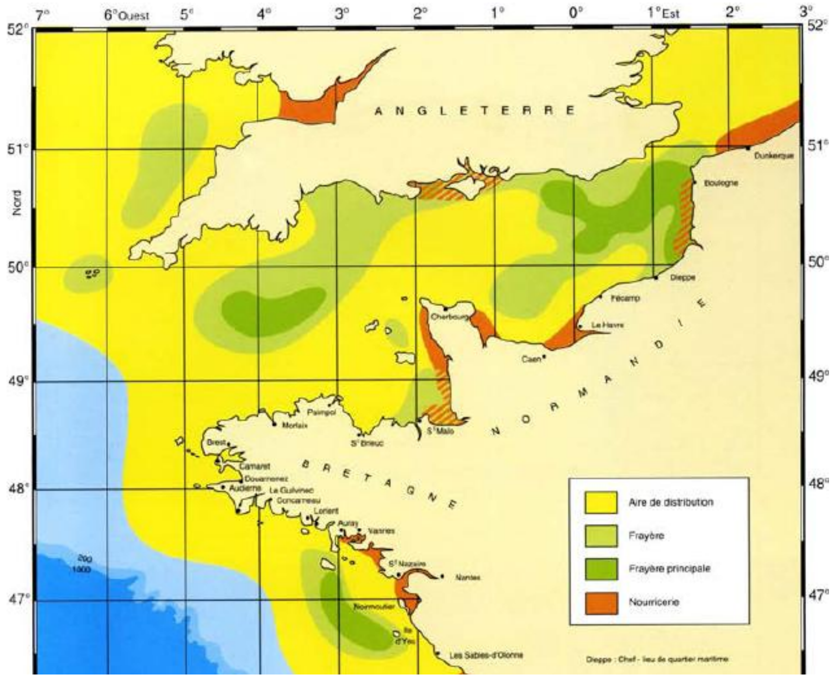
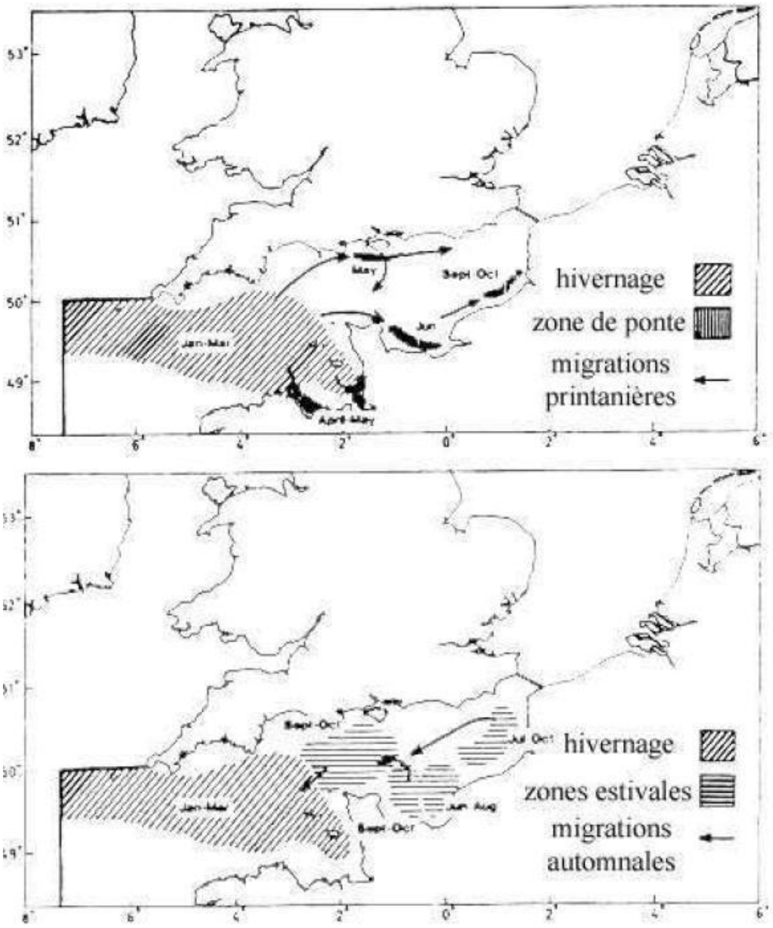


Figure 8.2.10 – Distribution (in yellow), spawning (in green) and nursing (in orange) grounds for Common Sole (*Solea solea*). Source: IFREMER



Migrations du griset en Manche (*in* Soletchnik, 1981).

Figure 8.2.11 – Migrations of Black bream (*Spondyliosoma cantharus*), in Soletchnik, 1981

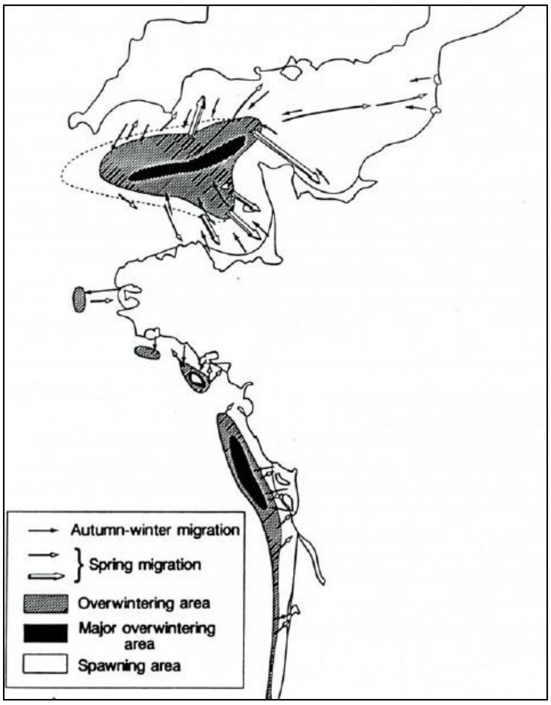


Figure 8.2.12 – Migration, overwintering area and spawning area of Common cuttlefish (*Sepia officinalis*), after Legrand *in* Anonymous, 1993

8.2.3 **Basking sharks**

Basking shark is strictly protected by fisheries regulation around Guernsey. It is also listed in the OSPAR List of Threatened and/or Declining Species and Habitats and is listed in the Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora).

According to an OSPAR report on basking sharks (Martin R.A. et Harvey-Clark, 2004), although Guernsey is not listed as one of the main hotspots for basking shark activity, the entrance to the Casquets traffic separation scheme in the English Channel are sectors with high basking shark activity (Figure 8.2.13 and Figure 8.2.14). In February 2004, Colin Druce reported an estimated 70 basking shark off the Hurd Deep, 3-4 miles northwest of Les Casquets lighthouse.

It is likely that basking sharks visit that area because of the frontal structures previously mentioned: foraging tracks of basking sharks are highly correlated with locations of small-scale fronts containing high densities of large zooplankton (Sims and Quayle, 1998). Priede and Miller (2009), using the *composite front map* technique developed at PML, analysed the track of a shark, presumed to be filter-feeding zooplankton in warm coastal water off the west coast of Scotland, and showed that it was parallel to the line of a thermal front.

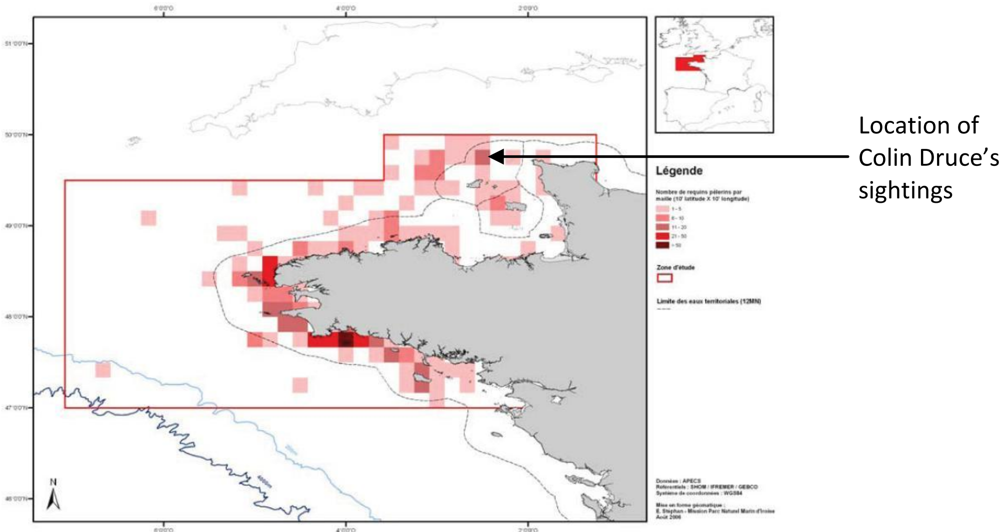


Figure 8.2.13 – Geographic distribution of basking shark sightings reported in Brittany from 1997 to 2005

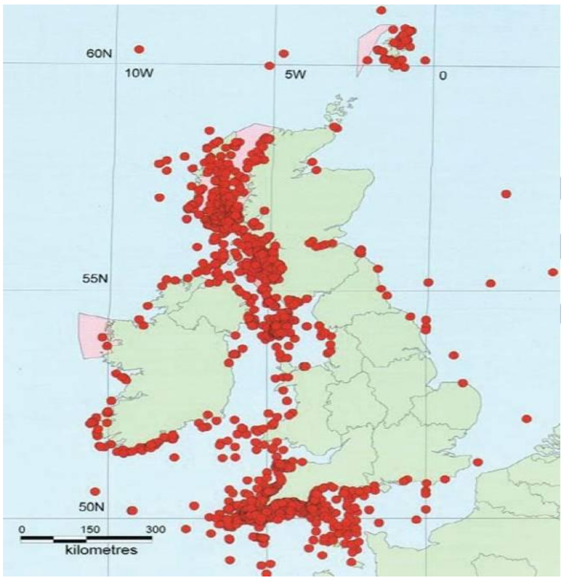


Figure 8.2.14 – Distribution of basking shark sightings around the UK and Ireland (1987-2004) (Source: Marine Conservation Society)

A few basking sharks have also been spotted in inshore waters in 2006 and 2007 (Figure 8.2.15).

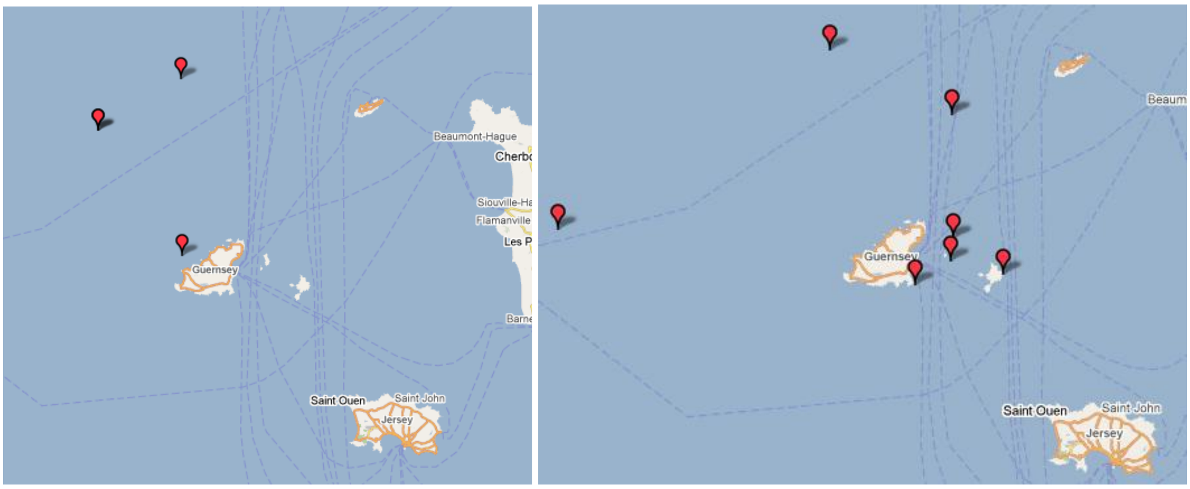


Figure 8.2.15 – Sightings of basking sharks around Guernsey in 2006 (left) and 2007 (right). Source: Guernsey Biological Records Centre

8.2.3 <u>Marine Turtles</u>

The species of sea turtle most likely to occur in the Western Channel is Leatherback Turtle (*Dermochelys coriacea*) as it has a really wide distribution. Leatherback feeding areas are in relatively cold waters where there is an abundance of their jellyfish prey. The Loggerhead Turtle (*Caretta caretta*) could be present as well although very few loggerheads are found along the European Atlantic coastlines.

The distribution of 451 leatherback records, assigned to geographical regions by Pierpoint (2000), is shown in Figure 8.2.16. The majority of records are from the western coasts of the UK and Eire: west of Eire, the west and north coasts of Scotland, the Irish Sea and especially the waters of the Celtic Sea and western English Channel. There are far fewer records from the North Sea coasts of England and east Scotland, and the eastern English Channel. The Channel Islands appear to be at the Eastern limit of leatherback distribution in the English Channel (leatherbacks only occasionally venture into the English Channel according to Pierpoint (2000)).

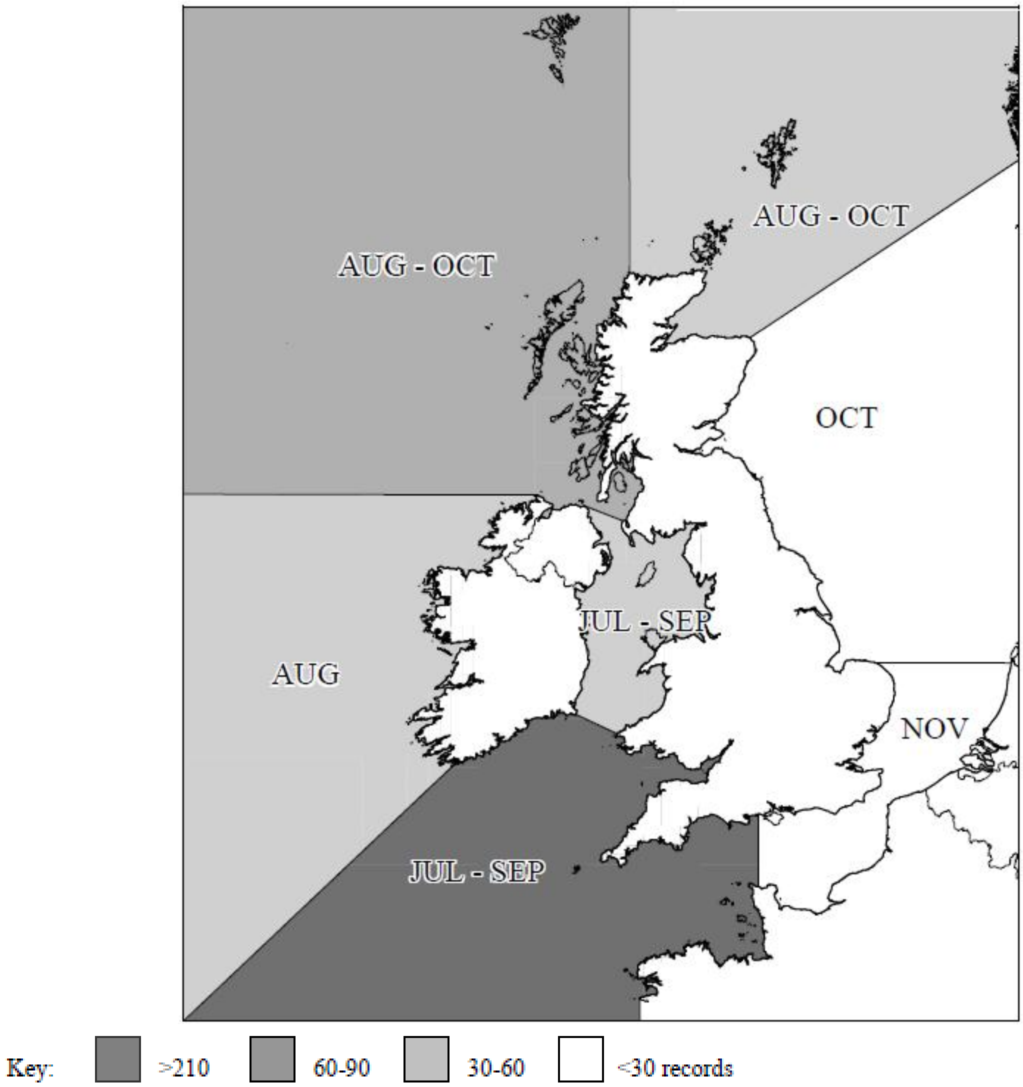


Figure 8.2.16 – Distribution of leatherback turtle records by region. The months in which 75% of have been recorded are also shown (after Pierpoint, 2000)

A Leatherback Turtle was beached dead near Cancale (Brittany, France, south of Jersey) in November 2009. There are however very few sightings in that part of the Channel, which confirms the information found in Pierpoint (2000). As a consequence we have decided to exclude sea turtles from the environmental impact assessment.

8.2.3 Summary and identification of data gaps

	Data found so far	**Data gaps**
Plankton	Interesting frontal structures around Guernsey. Regional information on planktonic communities is provided by the SEA 8 report on plankton	No local information on plankton communities has been found so far.
Fish	Main pelagic species present around the Channel Islands are sea bass (*Dicentrarchus labrax*), back bream (*Spondyliosoma cantharus)*, pollack (*Pollachius pollachius*), sandeel and mackerel (*Scomber* spp.). Demersal species include brill (*Scophthalmus rhombus*), ray (*Raja* spp.), dogfish (*Scyliorhinus* spp.), tope (*Galeorhinus galeus*) and conger (*Conger conger*). Guernsey waters are a spawning area for sea bass, sprat, black sea bream (in May) and, a bit further to the East of Guernsey, sole There is a pre-spawning aggregation and spawning ground for sea bass at Boue Blondel, on the West coast on Guernsey. Spawning of sea bass takes place in March, with pre-spawning aggregation starting in November. Guernsey is also located on a migratory route between the North Sea and the western Channel.	Little information is available on fish of conservation significance in Guernsey waters. It is therefore difficult to assess whether there is any priority species (apart from basking shark – see below) in the areas selected by the States of Guernsey for the development of wave and tidal energy extraction.
Basking sharks	Although Guernsey is not listed as one of the main hotspots for basking shark activity, the entrance to the Casquets traffic separation scheme in the English Channel is a sector with high basking shark activity. A few sightings were recorded by the Guernsey Biological Records Centre.	Additional local observations are recommended.

8.3 Potential Effects

The following section details the potential effects on pelagic communities, the significance of their impacts and suggested mitigation. Effects are listed for each phase of the project (installation/deployment, operation, maintenance, decommissioning) and for potential accidental events

8.3.1 Potential Impacts during Installation/Deployment

Pile driving could disturb mobile fish species and cause hearing damages

Should any piling be required for device installation, the noise generated by this activity is likely to have a greater disturbance impact than for developments where piling is not required.

Studies have indeed found that general noise such as is generated by shipping activity can cause an avoidance or attraction reaction in fish (Thomsen, 2006). Noise from wave and tidal energy projects therefore has the potential to impact fish in the immediate vicinity of operations. Pile driving is anticipated to have the greatest potential effects on marine wildlife, as it generates very high sound pressure levels that are relatively broad-band (20 Hz - > 20 kHz). Physiological impacts of noise are also possible at very close proximity to the noise source

Whilst piling noise would only be produced over a temporary period, for the duration of construction activities, the impacts may continue for longer, as fish may not immediately return to an area, particularly if they have been excluded for lengthy periods. Timing of installation works is also a key factor, as the disturbance effect is likely to be greater during pre-spawning aggregations, as it may affect mating and spawning activity.

The piling of foundations could smother fish spawning habitat

Smothering of fish spawning habitat could occur within the immediate vicinity of the seabed disturbing works, as the coarser fraction of the sediment disturbed is likely to be re-deposited on the seabed within about 50 m of the works. Based on the sensitivity data available from MarLIN, most fish species within the study area are not sensitive to, and therefore not affected by the impacts of smothering. The exceptions however include certain demersal species such as ray and sole, which have a low sensitivity to smothering.

Furthermore, the impact is only expected to be temporary, as excess material deposited will be re-suspended and distributed by natural hydrodynamic processes, and given the strong currents in Guernsey waters, it is likely that any sediment released into the water column will be rapidly dispersed.

The installation of the cable and devices could release contaminated sediments in the water and affect plankton and fish communities

Disturbance of contaminated sediments is also possible during cable and device installation, which may cause potentially detrimental impacts on species that are sensitive to contamination. Areas of potential contamination risk and the associated implications for water quality are assessed in the chapter on water quality.

The presence of the vessels, temporary anchors and installation activity could disturb fish and disrupt their feeding/movement behaviour

The crane barge chartered for the deployment of any wave or tidal device, the safety boat and the multicat vessel laying the cable could have the potential to disturb fish species because of the increased vessel traffic and subsequent noise. However this has to be considered against the 'baseline' boat activity (ca 5000 leisure crafts are registered in Guernsey), but information is currently missing on that topic. In addition to this, the activity would be with short term and temporary effects, although the duration of the mobilisation of vessels will depend on the number of devices being deployed. The safety boat and the other boats would have to abide by the marine code of conduct for the area in terms of speeds to minimise disturbance to the area.

8.3.2 Potential Impacts during Operation and Maintenance

During operation the various aspects of the project which could affect fish communities include the presence of the devices within the water column or at the sea surface, the moving parts and noise emissions from the devices.

Maintenance is expected to involve similar vessel activity to the deployment of the device with the positioning of temporary anchor for the barge, retrieving and re-deploying of the devices after maintenance on board or on the shore and retrieving the barge anchors.

The physical presence of the devices and moorings/sinkers could directly affect fish and planktonic communities by creating a new habitat

The presence of underwater structures, and associated 'artificial reefs', could attract fish species (and their predators). Aggregation of fish around marine structure and man-made objects placed in the sea is indeed a well-known phenomenon. However, the fish are more likely to be seen in more sheltered areas of Guernsey waters. What is more, the small size of the foundations or moorings of wave and tidal devices are unlikely to have much FAD (Fish Aggregating Device) potential. However, with sensitive design wave and tidal installations could potentially form artificial reefs that could have a production role

The presence of structures at the water surface (wave devices) could affect planktonic communities by modifying locally the hydrodynamic: wave field could be disrupted by energy extraction, with consequences for the dynamic balance that currently exists and the associated frontal zone that is crucial to the biological ecosystem. However this research question still needs to be addressed.

Collision risk: The movement of parts underwater of tidal devices could directly affect fish communities

Collision risk is considered to be a key potential effect during tidal device operation, and it is considered, bearing in mind the wide range of devices that may be deployed, that almost all species of marine finfish, and especially pelagic species, are at some risk of collision impacts (Scottish Executive, 2007).

There is however a considerable lack of empirical knowledge on this risk and there are a number of parameters that can be expected to affect the degree of collision risk: size, schooling behaviour, life stage, season (e.g. spawning or migration period), foraging tactics, curiosity, swimming agility, location of devices, tidal flows, turbidity…

Rotation of tidal turbines is generally relatively slow and blades usually have a blunt shape, so even if a small fish is 'trapped' in the flow entering the rotor, it is likely it will swim through without being hit by the blades – however ongoing research and in situ observations have to confirm this hypothesis. Some data are available from hydropower plants, but may not be directly transferable to the marine environment: fish-passage survival for turbine types with large water passages (e.g., Kaplan, Francis, and bulb turbines) is commonly 70% or greater. Among the most "fish-friendly" conventional turbines, e.g., Kaplan and bulb turbines that are used at the Columbia and Snake Rivers dams in the US, survival may range from 88% to as high as 95%.

The Scottish Association for Marine Science (SAMS) undertook some initial modelling of the escape (avoidance and evasion) behaviours by the fish to marine renewable devices, but it was not conclusive and further research is being carried out. Further assessment is also needed for bigger species and basking sharks in particular.

The creation of fishing exclusion areas could have a positive effect on fish resources

Should the wave/tidal array be excluded from fishing activities, this could create spawning grounds and nursery areas that will be able to exist undisturbed by commercial fishing activity.

The extraction of tide and wave energy could cause changes in suspended sediment levels and turbidity

Depending on the specific environmental parameters at a given location this may result in increases or decreases of both sediment suspension and deposition. However, according to the chapter on Sedimentation, it is unlikely that there will be a significant change in sedimentation patterns that could affect the pelagic ecology.

The noise and vibrations from the operating devices could directly affect fish communities

Underwater noise will be generated by the operating rotor of tidal devices, i.e. noise emitted by the generator, gear hub and rotation of blades; or by the moving parts of wave devices. This noise could lead to permanent or temporary hearing damages, or could affect fish behaviour.

The sensitivity of fishes to noise is however difficult to assess as it is species dependent: the threshold and bandwidth of sound sensitivity is closely related to the presence of specialized structures connecting the swimbladder and the internal ear, which varies from one species to another.

The ambient noise levels must also be taken into account, and these are likely to be broadband and relatively high in tidal stream. There is also a high level of annual variability in noise levels (e.g. by the seasonal tourist boat activity in summer, storms etc.).

A specialist study undertaken for the Scottish SEA (Scottish Executive, 2007) modelled the potential for permanent and temporary hearing damage to result from operating devices. This study was based on the likely noise generated from a single type of tidal and wave device and therefore may not be applicable across all devices, but nevertheless provides an indicative estimate of the levels of noise involved. The study concluded that, for the tidal device, if the most sensitive receptor were to spend 30 minutes within 16 m of tidal device it might suffer permanent hearing damage. The assessment also indicated that 8 hours within 934 m could result in temporary hearing damage. However, the report highlighted that evidence suggests that it is unlikely that an animal would choose to stay in close proximity to the source of a loud noise. Based on the available information, the study also concluded that the noise produced during operation of wave devices was considered to be less than for tidal, and the risk of permanent hearing damage was therefore considered negligible. For temporary hearing damage, the maximum predicted range for an exposure of 8 hours is only 6 metres, so the risk of an animal experiencing Temporary Threshold Shift (TTS) from a single 1 MW wave device of this type is insignificant. The authors noted, however, that their analysis did not include structural noise from the wave device, which is unknown.

The Electromagnetic fields along the cable could directly affect fish communities, especially elasmobranchs

Subsea cables have the potential to generate EMF: a B-field is generated in the local environment by the alternating current in the cable, this in turn, generates an induced E-field close to the cable within the range detectable by electro-sensitive fish species. It is thought that these EMFs can be detected by a variety of fish species, including migratory species such as salmon and elasmobranchs such as sharks and rays. Elasmobranchs, salmonids, eels and plaice are sensitive to both electric and magnetic fields, whilst cod and lampreys may be sensitive to electrical fields. The effects of EMFs are however still unclear.

Most of the studies so far have focussed on the offshore wind industry (COWRIE reports), and cabling strategy across the industry and developers is generally to select three core 33kV cables for intra-array connections and 132 (or possibly 245kV) cables for grid connection to land. However in Guernsey case, the power export cable is likely to be shorter in length and with a lower voltage and amperage. It is therefore expected that the EMFs generated will be considerably lower that those generated by offshore wind farm cables as the induced E-field is related to the current in the cable.

The expected magnetic field from the cable (probably less than a few µT[1]) is therefore very small, with an induced electric field likely to be smaller than a few µV/m at the 'skin' of the cable, and less than 0.5 µV/m at a couple of meters from the cable. This means that the induced E-field is expected to be under the range which may be detectable by elasmobranchs and potentially attractive to such species (0.5 – 100 µV/m, according to COWRIE), although it may be higher in the immediate proximity of the cable.

The leaching of antifoulants from the structures could affect the planktonic communities

Antifoulants may have to be used to limit biofouling that may impair the functioning of the wave and tidal devices. Depending on the paint or material used, these antifoulants may leach and release biocides in the surrounding waters, with potential effects on the surrounding planktonic communities. However, given that Guernsey waters experience a strong tidal mixing and 'flushing', it is unlikely that the pollutant would accumulate in the water column or in the sediments.

The presence of the maintenance vessel could directly affect fish communities

The barge chartered for the maintenance could have the potential to disturb fish species because of the increased vessel traffic and subsequent noise. However this again has to be considered against the 'baseline' boat activity, as discussed for the installation phase.

The lifting and cleaning of devices could directly affect the fish community

It is possible that the structures may need to be cleaned of any encrusting fauna to ensure structural integrity. The process would involve the scraping of the biofouling from the structures, which would damage the encrusting invertebrate fauna, thus forming a source of carrion prey for fish and shellfish species. This would have a short term localised benefit to any fish within the area.

[1] The Earth's geomagnetic field has a strength of approximately 50µT

8.3.3 Decommissioning

The decommissioning of the device will require a lifting process to remove the devices. It is likely that all associated structures will be removed, including the foundations, moorings or sinkers; navigational buoy (if used) and subsea cable.

The presence of the decommissioning vessel could disturb fish and disrupt their feeding/movement behaviour

The crane barge chartered for the removal of the structures and cable could disturb fish species because of the increased vessel traffic and subsequent noise.

The removal of the structures and associated moorings or sinkers could remove habitat available to fish as an artificial reef

The removal of structures would result in the loss of habitat previously available as artificial reef for fish and shellfish species. However it is likely that if several arrays are deployed in Guernsey waters, they would be gradually decommissioned, and this should only result in a dispersal of fish. Any effect of the decommissioning process on fish and shellfish distributions will be localised and unlikely to have any detectable effect on local populations.

8.3.4 Accidental events

Accidental discharge of contaminants from the devices (e.g. lubricants or hydraulic fluids) could adversely affect planktonic or fish communities

The leakage of lubricants and hydraulic fluids could impact planktonic and fish communities. However, given that Guernsey waters experience a strong tidal mixing and ‘flushing’, the pollutants would be quickly diluted and dispersed.

8.4 Sensitivity of receptors

The sensitivity of receptors present in Guernsey waters has been assessed thanks to MarLin data (http://www.marlin.ac.uk/sensitivityrationale.php) and other information available in the literature.

Table 8.4.1 – Sensitivity of receptors

Receptor	Smothering	Change in suspended sediment and increased turbidity	Collision risk	Substratum loss	Decrease in wave exposure	Decrease in water flow	EMF	Contamination	Marine noise
Phytoplankton communities	Not relevant	Medium to High	Not relevant	Not relevant	Unknown	Unknown	Not relevant	Medium	Not relevant
Zooplankton communities	Not relevant	Medium	Not relevant	Not relevant	Unknown	Unknown	Not relevant	Medium	Not relevant
Basking shark	Not sensitive	Low (filter feeder)	Unknown	Not relevant	Not relevant	Not relevant	E, B	Unknown	Unknown
Black Bream	Not sensitive	Unknown	Unknown	Not relevant	Not relevant	Not relevant	Unknown	Unknown	Unknown
Cod	Not sensitive	Medium (larvae)	Unknown	Not relevant	Low (juveniles on rocky coast)	Not relevant	E	Unknown	High
Ling	Not sensitive	Medium (larvae)	Unknown	Not relevant	Not relevant	Not relevant	E	Unknown	High
Mackerel	Not sensitive	Unknown	Unknown	Not relevant	Not relevant	Not relevant	Not sensitive	Unknown	Unknown
Pollack	Not sensitive	Unknown	Unknown	Not relevant	Not relevant	Not relevant	Unknown	Unknown	High
Sea Bass	Not sensitive	Unknown	Unknown	Not relevant	Low	Not relevant	Unknown	Unknown	Medium
Sprat	Not sensitive	Medium (filter feeder)	Unknown	Not relevant	Not relevant	Not relevant	Not sensitive	Unknown	High
Sandeels	High (especially demersal eggs)	Low	Unknown	High (spawning areas)	Not relevant	Medium	Not sensitive	Unknown	Medium to high

8.5 Potential Significance of Effects

Table 8.5.1 Potential Significance of Effects

Receptor	Effect	Potential significance
Fish **Basking shark**	Hearing damages and/or disruption from pile driving noise	High
Fish	Smothering of fish spawning habitat	Minor
Plankton **Fish** **Basking shark**	Contamination (disturbance of contaminated sediment)	Minor
Fish **Basking shark**	Disturbance from presence of vessels and temporary anchors	Moderate
Fish	Creation of new habitat	No impact to positive
Fish	Collision risk	Moderate
Basking shark		Unknown
Fish	No-take zone effect	Positive
Plankton	Changes in suspended sediment levels and turbidity	Moderate to High
Fish		Minor to Moderate
Basking shark		Moderate to High (filter feeder)
Fish **Basking shark**	Hearing damages and/or disruption from noise and vibrations of moving parts	Moderate
Fish **Basking shark**	Disruption to migration and feeding behaviour caused by EMF	No impact (not sensitive fishes) to Moderate (fishes, especially elasmobranchs, sensitive to E and/or B field)
Plankton	Contamination (antifoulants)	Moderate
Fish **Basking shark**	Disruption from cleaning of device	Moderate
Fish	Loss of habitat when the foundations are decommissioned	Moderate
Plankton **Fish** **Basking shark**	Contamination (accidental discharge of hydraulic fluids and pollutants)	Moderate

8.6 Likelihood of Occurrence

Table 8.6.1 Likelihood of Occurrence

Receptor	Effect	Likelihood of Occurrence
Fish Basking shark	Hearing damages and/or disruption from pile driving noise	High if pile driving is undertaken
Fish	Smothering of fish spawning habitat	Moderate
Plankton Fish Basking shark	Contamination (disturbance of contaminated sediment)	Low
Fish Basking shark	Disturbance from presence of vessels and temporary anchors	Moderate
Fish	Creation of new habitat	Moderate
Fish Basking shark	Collision risk	Moderate Low
Fish	No-take zone effect	Moderate
Plankton Fish Basking shark	Changes in suspended sediment levels and turbidity	Low
Fish Basking shark	Hearing damages and/or disruption from noise and vibrations of moving parts	Low (wave devices) to Medium (tidal devices)
Fish Basking shark	Disruption to migration and feeding behaviour caused by EMF	Low
Plankton	Contamination (antifoulants)	Low
Fish Basking shark	Disruption from cleaning of device	Moderate Low
Fish	Loss of habitat when the foundations are decommissioned	Moderate
Plankton Fish Basking shark	Contamination (accidental discharge of hydraulic fluids and pollutants)	Moderate

8.7 Overall significance, Confidence and Mitigation Measures

Confidence: the confidence in the significance analysis is represented using a colour scale (green = high confidence, orange = medium confidence, red = low confidence)

Table 8.7.1 Overall Significance

Phase	Receptor	Potential Effect	Significance	Mitigation	Residual significance
Installation	Fish	Hearing damages and/or disruption from pile driving noise	High	Use gravity foundations	Negligible
	Fish	Smothering of fish spawning habitat	Minor	Avoid spawning season	Negligible
	Fish & plankton	Contamination (disturbance of contaminated sediment)	Minor	None	
	Fish	Disturbance from presence of vessels and temporary anchors	Minor to moderate, depending on size of array	Avoid spawning season	Minor
Operation and Maintenance	Fish	Creation of new habitat	Negligible or positive	None	
	Fish	Collision risk	Fish with no conservation value: Negligible Basking sharks: unknown	None Monitoring	Unknown
	Fish	No-take zone effect	Positive	None	
	Fish	Changes in suspended sediment levels and turbidity	Minor	None	
	Fish	Hearing damages and/or disruption from noise and vibrations of moving parts	Minor to Moderate	Monitoring	Minor to Moderate
	Fish	Disruption to migration and feeding behaviour caused by EMF	Negligible	None	Unknown
	Plankton	Contamination (antifoulants)	Negligible	Use environmental-friendly products	Negligible
	Fish	Disturbance from presence of vessels and temporary anchors	Negligible	None	
	Fish	Disruption from cleaning of device	Negligible or minor positive	None	
Decomm.	Fish	Disturbance from presence of vessels and temporary anchors	Negligible	None	
	Fish	Loss of habitat when the foundations are decommissioned	Minor	Leave foundations in place	Negligible
Accidental Events	Fish & plankton	Contamination (accidental discharge of hydraulic fluids and pollutants)	Minor	Use biodegradable hydraulic fluids	Negligible

8.8 Knowledge Gaps

	Data gaps	Understanding gaps
Plankton	No local information on plankton communities has been found so far.	No data on the influence of wave devices on the surrounding water column, especially plankton communities
Fish	Relatively good information available for commercial species. Little information is available on fish of conservation significance. It is therefore difficult to assess whether there is any priority species (apart from basking shark – see below) in the areas selected by the States of Guernsey for the development of wave and tidal energy extraction.	Fish behaviour (and associated collision risk) in the vicinity of a tidal turbine is for the time being poorly understood. Ongoing research and modelling
Basking sharks	Very few records available. It may be because there are few basking sharks around Guernsey… or because there are too few observers. Additional local observations/sightings effort is recommended.	Behaviour in the vicinity of a tidal turbine unknown.
Noise	No data on soundscape and baseline boat activity in Guernsey waters	The impact of tidal and wave devices on soundscape is poorly understood for the time being. Monitoring will be undertaken at EMEC and WaveHub but this hasn't starting yet.
Cumulative effects		Information on cumulative effects of wave and tidal arrays is for the time being purely speculative as no arrays have been deployed so far (to our knowledge). One of the first tidal arrays to be deployed in the English Channel will probably be the EDF project in Paimpol-Bréhat, Brittany.

8.9 Recommendations for Survey and Monitoring

Surveys:

- Fish: pelagic-trawl sample
- Basking sharks: sightings

Recommended monitoring

- Noise
- Fish collision / change in behaviour for tidal devices

References

References used in Baseline

Coull, K.A., Johnstone, R., and S.I. Rogers. 1998. Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd

Garcia-Soto, C., Pingree, R. D. (2009) Spring and summer blooms of phytoplankton (SeaWiFS/MODIS) along a ferry line in the Bay of Biscay and western English Channel *Continental Shelf Research, Volume 29 (8), pp. 1111-1122*

Johns, D. (2008) SEA8 Plankton - The Plankton Ecology of the SEA 8 area. Report commissioned by DECC

Mahé, K., Delpech, J. P. & Carpentier, A. (2006) Synthèse bibliographique des principales espèces de Manche orientale et du golfe de Gascogne, IFREMER report

Martin R.A. and Harvey-Clark (2004) Background Document for Basking Shark *Cetorhinus maximus*. Prepared by APECS for OSPAR

Ménesguen, A., Gohin, F. (2006) Observation and modelling of natural retention structures in the English Channel. *Journal of Marine Systems*, *Volume 63 (3-4)*, *pp. 244-256*

Miller, P.I. (2009) Composite front maps for improved visibility of dynamic sea-surface features on cloudy SeaWiFS and AVHRR data. Journal of Marine Systems, 78(3), 327-336. doi:10.1016/j.jmarsys.2008.11.019.

Pawson, M. G., Pickett, G. D., Leballeur, J. Brown, M., and Fritsch, M. 2007. Migrations, fishery interactions, and management units of sea bass (*Dicentrarchus labrax*) in Northwest Europe. – ICES Journal of Marine Science, 64: 332–345.

Pawson, M.G., Brown, M., Leballeur, J., Pickett, G.D. (2008). Will philopatry in sea bass, *Dicentrarchus labrax*, facilitate the use of catch-restricted areas for management of recreational fisheries? Fisheries Research, 93 (1-2), pp. 240-243

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

Priede, I.G. and Miller, P.I (2009). A basking shark (*Cetorhinus maximus*) tracked by satellite together with simultaneous remote sensing II: New analysis reveals orientation to a thermal front. Fisheries Research, 95 (2-3), pp. 370-372

Sims, D.W. and Quayle, V.A. (1998). Selective foraging behaviour of basking sharks on zooplankton in a small-scale front, Nature 393, pp. 460–464.

References used in Assessment

Thomsen, F., Ludemann, K., Kafemann, R. and Piper, W. (2006). Effects of offshore wind farm noise on marine mammals and fish. Biola, Hamburg, Germany on behalf of COWRIE Ltd.

Scottish Executive (2007). Scottish Marine Renewables SEA - Environmental Report Section C SEA Assessment: Chapter C7 Fish and Shellfish

Further references not used in this report:

Brehaut, R. N. (1989) Description of the proposed marine conservation area at Rue de la Rocque, St Pierre du Bois, Guernsey. Report & Transactions La Société Guernesiaise, 22 (1988), 385-392 – pdf sent by Guernsey Biological Records Centre

Brehaut, R. N. (1968). Zoological Report 1967. Report and Transactions of La Société Guernesiaise 18 (1967), 159-166. – pdf sent by Guernsey Biological Records Centre

Brehaut, R. N. (1969). Zoology Report. Report and Transactions of La Société Guernesiaise 18 (1968), 283-285 – pdf sent by Guernsey Biological Records Centre

Hoch, T., Garreau, P. (1998) Phytoplankton dynamics in the English Channel: a simplified three-dimensional approach**,** *Journal of Marine Systems, Volume 16 (1-2), Pages 133-150* [held at the NMBL: P.50]

Le Hir, P.; Bassoulet, P.; Erard, E.; Blanchard, D.; Hamon, D.; Jegou, A.M.; Iriec (1986) Etude régionale intégrée du Golfe Normano-Breton. Theme II. Milieu pelagique. DERO Report (IFREMER), DERO-86. 27-EL, 151p. [held at the NMBL: SE.I/FR.17]

Le Sueur, R.F. (1967) The marine fishes of Jersey. 37p. Societe Jersiaise. [held at the NMBL: BL.65/L]

Sinel, J. (1905). The fishes of the Channel Islands. Transactions of the Guernsey Society of Natural Science, 5. [held at the NMBL: P.112]

Southward, A. J., S. J. Hawkins, M. T. Burrows (1995) Seventy years' observations of changes in distribution and abundance of zooplankton and intertidal organisms in the western English Channel in relation to rising sea temperature, *Journal of Thermal Biology*, *Volume 20 (1-2)*, *Pages 127-155* [held at the NMBL: P.30]

Wheeler, A., 1970. Notes on a collection of shore fishes from Guernsey, Channel Islands. Journal of Fish Biology, 2 323-328. [held at the NMBL: SLM.I/GB.2]