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7 Benthic Ecology

7.1 Introduction

The REA benthic ecology study area is located within Guernsey, Herm and Sark's territorial waters to within 3 Nautical Miles of the coastline. This includes all intertidal, sub-tidal and coastal areas within 200 meters of the shore (at MHWS). For the purpose of this REA document, benthic ecology can be described as all species and habitats which are attached on, living in, or near to the seabed within the study areas including areas exposed by daily tidal patterns.

A brief overview of the available benthic ecological data for the REA study area is described, with information regarding areas of current and future ecological conservational areas, priority habitats and species of significant importance.

The chapter outlines the potential effects, significance and likelihood of effects of future marine renewable technology deployment upon the benthic ecological habitats and species within the study area. The final section discusses the mitigation recommendations to reduce these effects and outlines recommended monitoring strategies and further study into gaps in current benthic ecology research knowledge.

7.2 Baseline Environment

Baseline information on the benthic ecology of the REA study area was compiled by performing data gathering exercises from a number of local and regional sources. This included accessing information from online marine biological databases, biological record centres, NGO volunteer research programmes, and regional governmental databanks. Information collected ranged from anecdotal species sightings, past habitat mapping surveys, conservation site reviews and community assemblage surveys.

Sites of special conservational value were also included. Information regarding benthic species and habitats which portray ecological importance status follows guidance from sources such as UK BAP, Marlin, JNCC and EUNIS habitat and species classification systems.

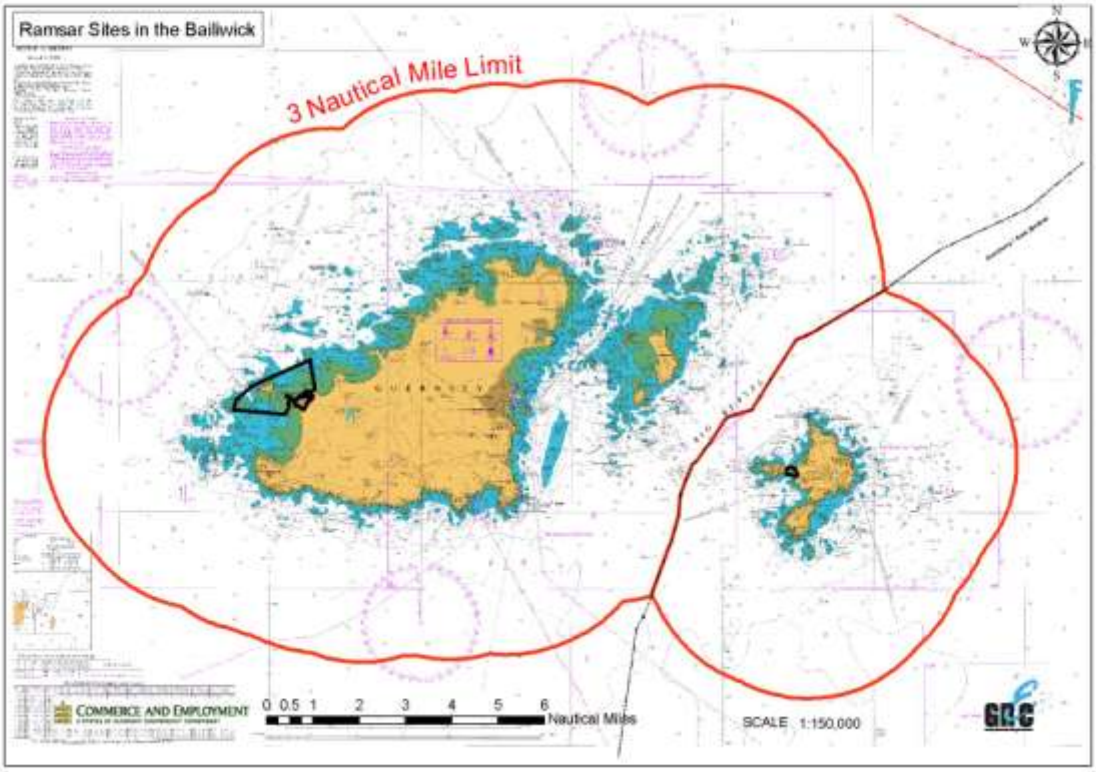
It must noted that a large proportion of the REA study area has not yet been surveyed, with information collected either portraying large gaps in knowledge or low confidence in data quality both quantitatively and qualitatively. This report describes three important aspects that of the benthic ecology within the REA study area: sites of regional importance, benthic habitats and benthic species.

7.2.1 Sites of regional importance

The REA study area contains one site of regional importance in Guernsey and one in Sark, which have been designated as an internationally important Ramsar Site. The site is located on the west coast of Guernsey (049°27.340N, 002°39.430W; figure 7. 2.1) and named the Lihou Island and L'Erée Headland Ramsar Site. The site contains a diverse range of benthic habitats and species which sustain globally or regionally important benthos including eelgrass (*Zostera marina*) habitats and the green ormer (*Haliotis tuberculata*) mollusc species. The site also contains a rich proportion of marine algae, with over 200 species currently recorded supporting a number of intertidal molluscs, echinoderms, crustaceans and fish species.

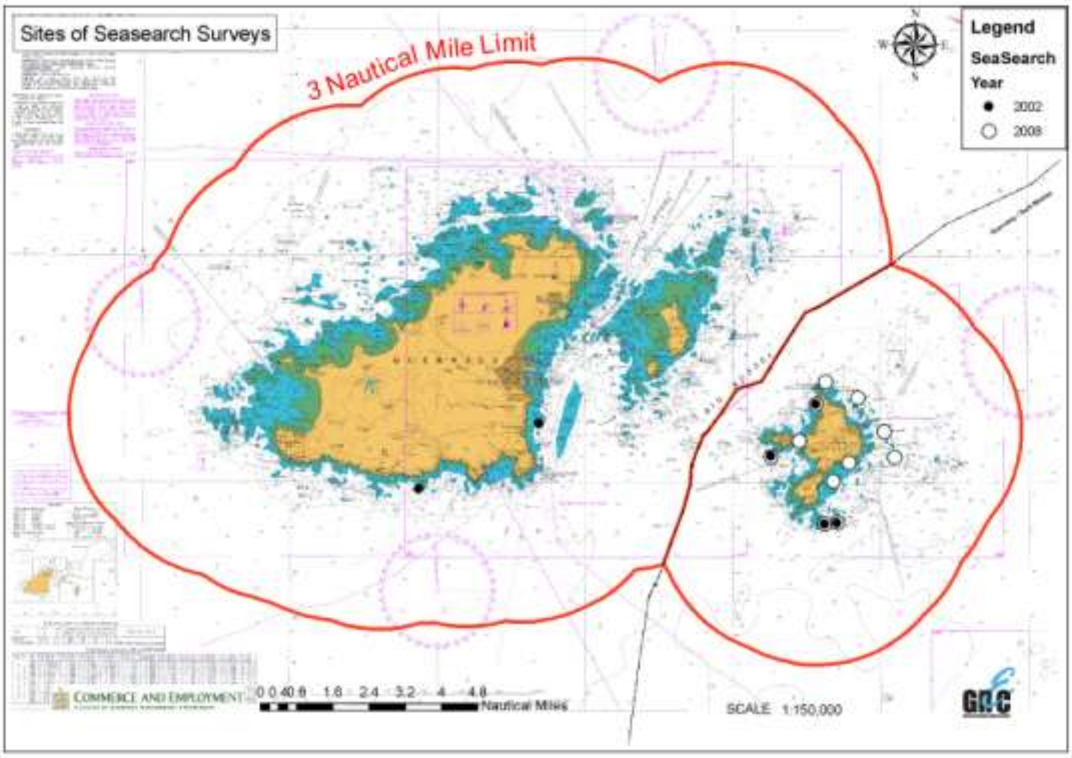
Whilst these are the only sites currently designated within the REA study area, the REA should also take future potential sites of Ramsar Site designation and sites which sustain important benthic ecology communities. Future sites which may gain such status include the area known as the Humps, near Herm located on the east coast of Guernsey. However specific information on future and potential conservation areas is currently unknown for the scope of this report.

Figure 7.2.1. Location and boundary of the Lihou Island and L'Erée Headland Ramsar Site situated on the west coast of Guernsey and the Sark Guillot Caves Ramsar Site within the REA study area, outlined in black.



Locations within the REA study area that have been investigated in terms of in-depth quantitative benthic ecological research should also be classed as areas of importance. This is due to the REA study area as a whole lacking extensive benthic ecological information. The studies that exist provide important information on locations within the REA study area to aid applications and site choice decisions for renewable energy developments and/or potential future marine protected areas, i.e. future Ramsar Site designations. Such surveyed locations include the designated Ramsar Site (figure 7. 2.1.) and past sub-littoral scuba diving SeaSearch ecological surveys (figure 7. 2.2) and should therefore be taken into consideration when identifying areas for future renewable energy developments.

Figure 7.2.2. Locations of past 2002 and 2008 benthic ecological surveys conducted by SeaSearch through scuba diving surveying techniques.



7.2.2 Benthic habitats

A small proportion of the apparent benthic habitats located within the REA study area have been described from the available data gathering exercises (table 7. 2.1.). Outlined benthic habitats portray fast tidal current and strong water flowing conditions with circalittoral substrates such as boulders, rock, cobbles, coarse sediments and sands. Faunal community and species descriptions from such habitats predominately display turf (the lowest stratum of erect branching or filiform species covering substratum), mobile and resilient biological qualities that relate to the moderate to high tidal energy levels exhibited, i.e. kelp, bryozoans, sponges and crustaceans.

The databases consulted contained few biological habitat datasets located on the north-north west side of the island. Moreover, these datasets are not current and are based on records from the 1970's and onwards and may not represent the current benthic habitats within the REA study area. Therefore due to patchy and anecdotal information, specific habitat mapping techniques have not been implemented from the existing data sources as this may be biased towards specific mitigation measures, or choice of marine renewable technology.

Recent desk-based studies within the English Channel region have included the REA study area using anecdotal and historical datasets to undertake habitat modelling (figure 7. 2.3). The generalised modelling suggests predominately high energy circalittoral rock and mixed substrata habitats with associated species (table 7. 3.3), corresponding to other past classification systems. Further benthic ecological habitat classification may also be determined based on the local seabed geomorphology/ geology types within the REA study area. Such potential habitats and associated species are described in the Geology chapter (Chapter 4) using BGS information for further reference.

Table 7.2.1. Benthic habitat classifications and descriptions for the REA study area derived from databases and sources.

Classification Scheme	*Habitat Code*	*Habitat Description*	*Database*	*Data Source*	*Year*
EUNIS	A 4.13 A 4.2144 A 4.27 A5. 135	Mixed faunal turf communities on circalittoral rock Brittlestars on faunal and algal encrusted exposed to moderately wave exposed circalittoral rock Faunal communities on deep moderate energy circalittoral rock *Glycera lapidum* in impoverished infralittoral mobile gravel and sand	MESH	IFREMER	1979
EUNIS (modelling)	A 5.27 A 5.14	Deep circalittoral sand Circalittoral coarse sediment	MESH	BGS / JNCC	2007
FOLK		Coarse sediment Rock or reef	MESH	BGS / JNCC	2007
JNCC Biotope	IR. HIR. KFar. LhypR. PK IR. HIR. KFar. Lhyp. Loch IR. MIR. KR. LhypT. Ft	*Laminaria hyperborea* park with dense foliose red seaweeds on exposed lower infralittoral rock Mixed *Laminaria hyperborea* and *Laminaria ochroleuca* forest on exposed infralittoral rock *Laminaria hyperborea* forest, foliose red seaweeds and a diverse fauna on tide-swept upper infralittoral rock	JNCC	SeaSearch	2008

Classification Scheme	*Habitat Code*	*Habitat Description*	*Database*	*Data Source*	*Year*
	IR. MIR. KR. LhypT. Pk	*Laminaria hyperborea* park with hydroids, bryozoans, and sponges on tide-swept lower infralittoral rock			
	IR. FIR. SG	Infralittoral surge gullies and caves			
	CR. HCR. FaT. CTub	*Tubularia indivisa* on tide-swept circalittoral rock			
	CR. HCR. XFa. ByErSp	Bryozoan turf and erect sponges on tide-swept circalittoral rock			
	CR. HCR. XFa. CvirCri	*Corynactis viridis* and a mixed turf of crisiids, bugula, scrupocellaria and cellaria species on tide-swept exposed circalittoral rock			
	CR. HCR. XFa. SpAnVt	Sponges and anemones on vertical circalittoral bedrock			
	SS. SCS. CCS	Circalittoral coarse sediment			
	SS. SSa. IFiSa. IMoSa	Infralittoral mobile clean sand with sparse fauna			

Figure 7.2.3. Modelled EUNIS maps for the English Channel region and REA study area produced by this study, with rock habitats to EUNIS level 3 and sedimentary habitats to EUNIS level 4 (after Coggan & Diesing, 2009). See table 7.2.2 for key to EUNIS habitat codes.

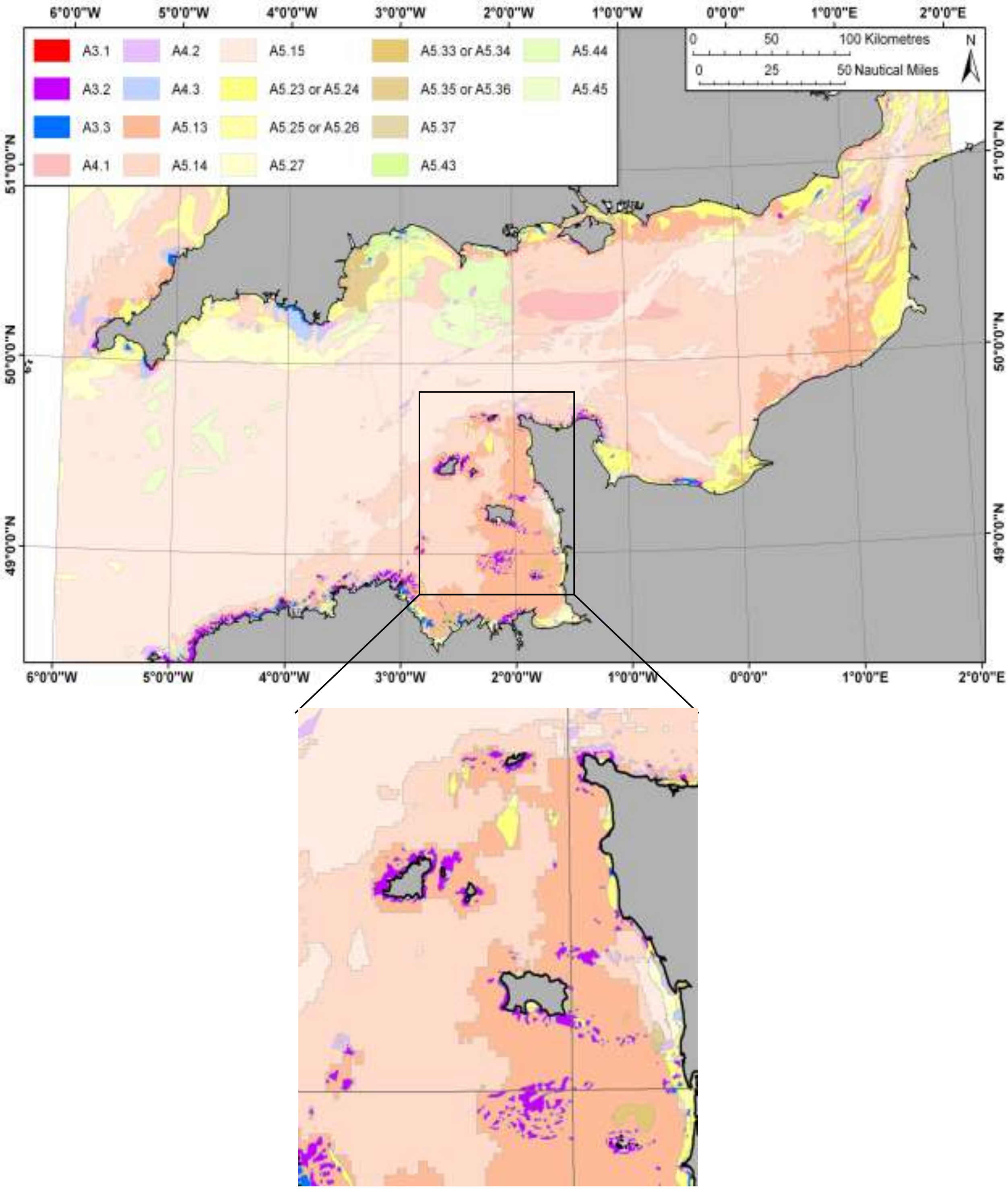


Table 7.2.2. EUNIS biotope codes identified from habitat modelling studies (after Coggan & Diesing, 2009).

EUNIS Biotope Codes	*EUNIS biotope descriptions*
A 3.2	Atlantic and Mediterranean moderate energy infralittoral rock
A 4.12	Sponge communities on deep ciralittoral rock
A 4.131	Bryozoan turf and erect sponges on tide-swept ciralittoral rock
A 4.1312	Mixed turf of bryozoans and erect sponges with *Dysidia fragilis* and *Actinothoe sphyrodeta* on tide-swept wave exposed circalittoral rock
A 4.135	Sparse sponges, Nemertesia species and *Alcyonidium diaphanum* on circalittoral mixed substrates
A 4.1342	*Flustra foliacea,* small solitary and colonial ascidians on tide-swept circalittoral bedrock or boulders
A 4.1343	*Flustra folicacea* and colonial ascidians on tide-swept exposed circalittoral mixed substrata
A 4.213	*Urticina felina* and sand-tolerant fauna on sand scoured or covered circalittoral rock
A 5.131	*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
A 5.444	*Flustra folicacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed substrata

7.2.2.1. Priority Habitats

Several habitats were identified as priority habitats during the data gathering exercises located within the REA study area (table 7. 2.3). These include notable *Zostera marina* eelgrass beds and maerl beds highlighted from existing biological surveys and local sighting records following UK BAP priority habitat information. The new UK BAP priority tidal rapid environments habitat has also been included as a potential future priority habitat to consider following guidance from UK BAP and local sources.

Zostera marina eelgrass beds and maerl beds are described as priority habitats as they are known to sustain high marine biodiversity and act as nursery areas for juvenile marine species including important juvenile commercial species. *Zostera marina* eelgrass sighting records are located throughout the REA study area, highlighting the local population of eelgrass to be a healthy, robust and viable population (figure 7. 2.4) and also the potential for high diversity levels of marine life throughout the REA study area.

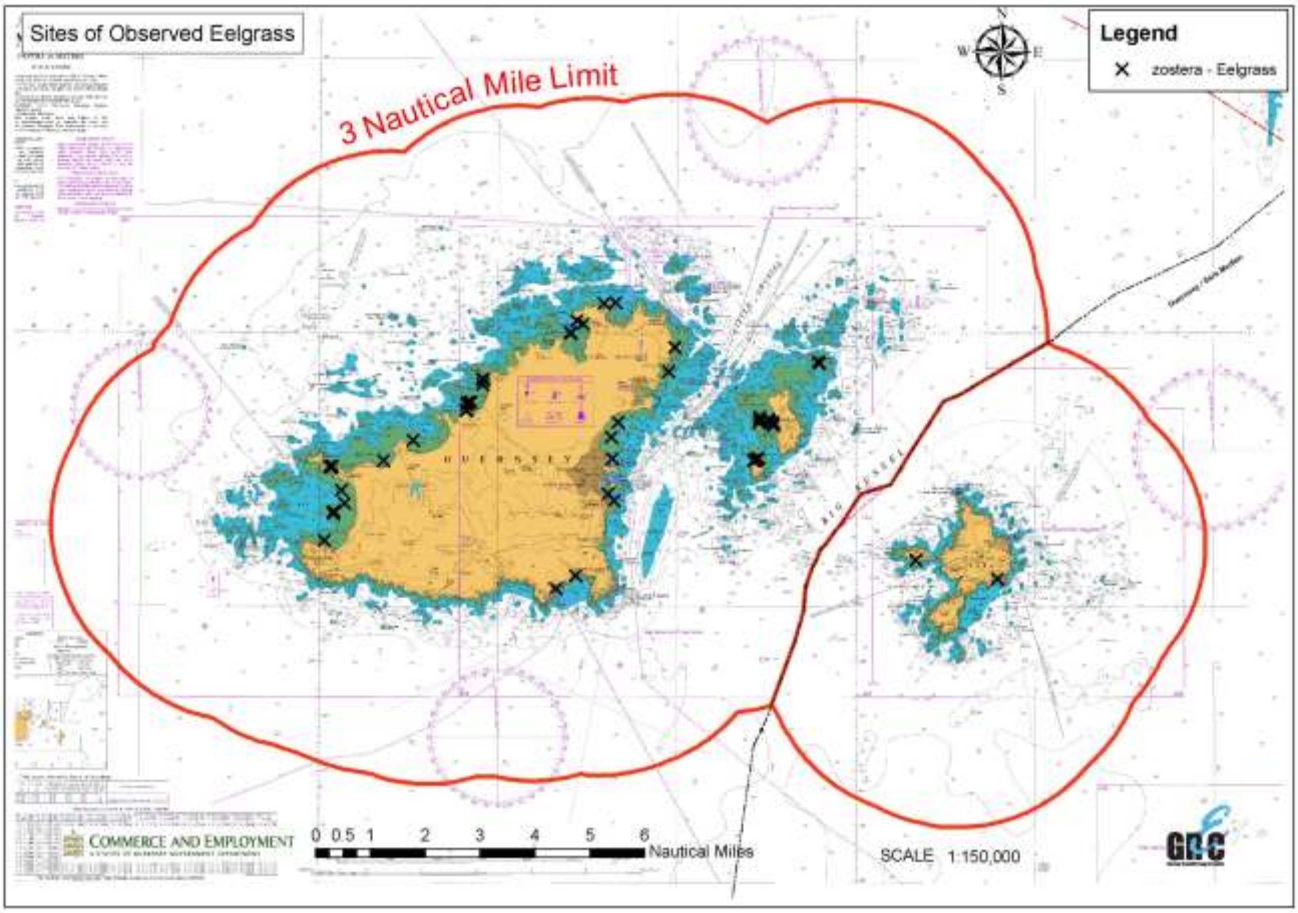
Maerl bed locations within the REA study area are patchily identified, with limited local sightings found in the Big Russel, outside the Vale Castle and located on the east coast of Guernsey. Information regarding the overall distribution, status and population dynamics of maerl beds within the REA study area are unknown but their presence should be acknowledged for possible study and future renewable energy development site choice.

Tidal rapid environment habitats are also portrayed as priority habitats due to their increased interest from renewable energy development. No current information regarding this habitat presence or distribution at present is known within the REA study area but should also be considered for further study and renewable energy development site choice.

Table 7.2.3. Benthic habitat classifications and descriptions for habitats regarded as priority habitats within the REA study area.

Classification	*Habitat Code*	*Habitat Description*	*Database*	*Data Source*	*Year*
JNCC Biotope	SS. SMp. SSgr. Zmar	*Zostera marina* bed on lower shore or infralittoral clean or muddy sand	GBRC / JNCC	SeaSearch	2008
UK BAP		Maerl beds Tidal rapid environments	GBRC / UK BAP UK BAP	N/A N/A	N/A N/A

Figure 7.2.4. Zostera marina eelgrass bed sighting distribution records within the REA study area (from GBRC).



7.2.3. Benthic Species

The data gathering exercises highlighted a wide range of benthic species from records of dense sub-tidal hydroids and sponges to intertidal molluscs and marine algae, particularly mirroring habitat biological qualities that represent fast flowing, opportunistic traits. Data sources are primarily qualitative anecdotal sightings and local records linked with few biological quantitative sources.

7.2.3.1 Priority Benthic Species

Benthic priority species were recognised following the priority habitat exercise through combining data sources and guidance (table 7. 2.4). Species which are designated a priority status exhibit importance status based on their biological traits, rarity or ecological capabilities, i.e., sustaining other important or rare species. Within the British Isles, conservational action plans have been created for certain priority species describing their distributions, current status and anthropogenic threats which are included in this chapter. Other possible priority species may occur within the REA study area that are not included in this chapter but can be found in the relevant chapters of the overall report, i.e., priority commercial species, marine mammals and pelagic species.

Table 7.2.4. Description of marine species designated a priority status from UK BAP and NBN guidelines, excluding cetaceans and bony fish with records located from the GBRC and SeaSearch surveys.

NBN Current Scientific Name	NBN Current Name Authority	Common Name	Grouping	Original UK BAP Status
Adreus fasicularis	(Bowerbank, 1866)	Branching sponge	Porifera	
Alcyonium hibernicum	(McFadden, C.S., 1999)	Pink soft coral	Cnidarian	
Atrina fragilis	(Pennant, 1777)	Fan Mussel	Mollusc	Species Action Plan
Axinella damicornis	(Esper, E.J.C. 1791-1799)	Sponge	Porifera	
Balanophyllia regia	(Cairns *et al* 2001)	Scarlet and gold cup coral	Cnidarian	
Caryophyllia inornata	(Cairns *et al* 2001)	Southern Cup Coral	Cnidarian	
Eunicella verrucosa	(Pallas, 1766)	Pink Sea-fan	Cnidarian	Species Action Plan
Leptopsammia pruvoti	Lacaze-Duthiers, 1897	Sunset Cup Coral	Cnidarian	Species Action Plan
Lucernariopsis campanulata	(Lamouroux, 1815)	a stalked jellyfish	Cnidarian	
Mitella pollicipes	(Gmelin, 1789)	Gooseneck Barnacle	Crustacean	
Ostrea edulis	(Linnaeus, 1758)	Native Oyster	mollusc	Species Action Plan
Padina pavonica	(Linnaeus) Thivy	Peacock's tail	Alga	
Parazoanthus axinellae	(van der Land, J.; den Hartog, J.H., 2001)	Yellow cluster anemone	Cnidarian	
Periclimenes sagittifer	(Türkay, M., 2001)	Anemone shrimp	Crustacean	
Thecacera pennigera	(Gofas, S.; Le Renard, J.; Bouchet, P., 2001)	Spotted sea slug	Mollusc	
Tripterygion deleasi	(Wood 2008)	Black faced blenny	Bony fish	
Tritonia nilsodhneri	(Gofas, S.; Le Renard, J.; Bouchet, P., 2001)	Sea fan sea slug	Mollusc	

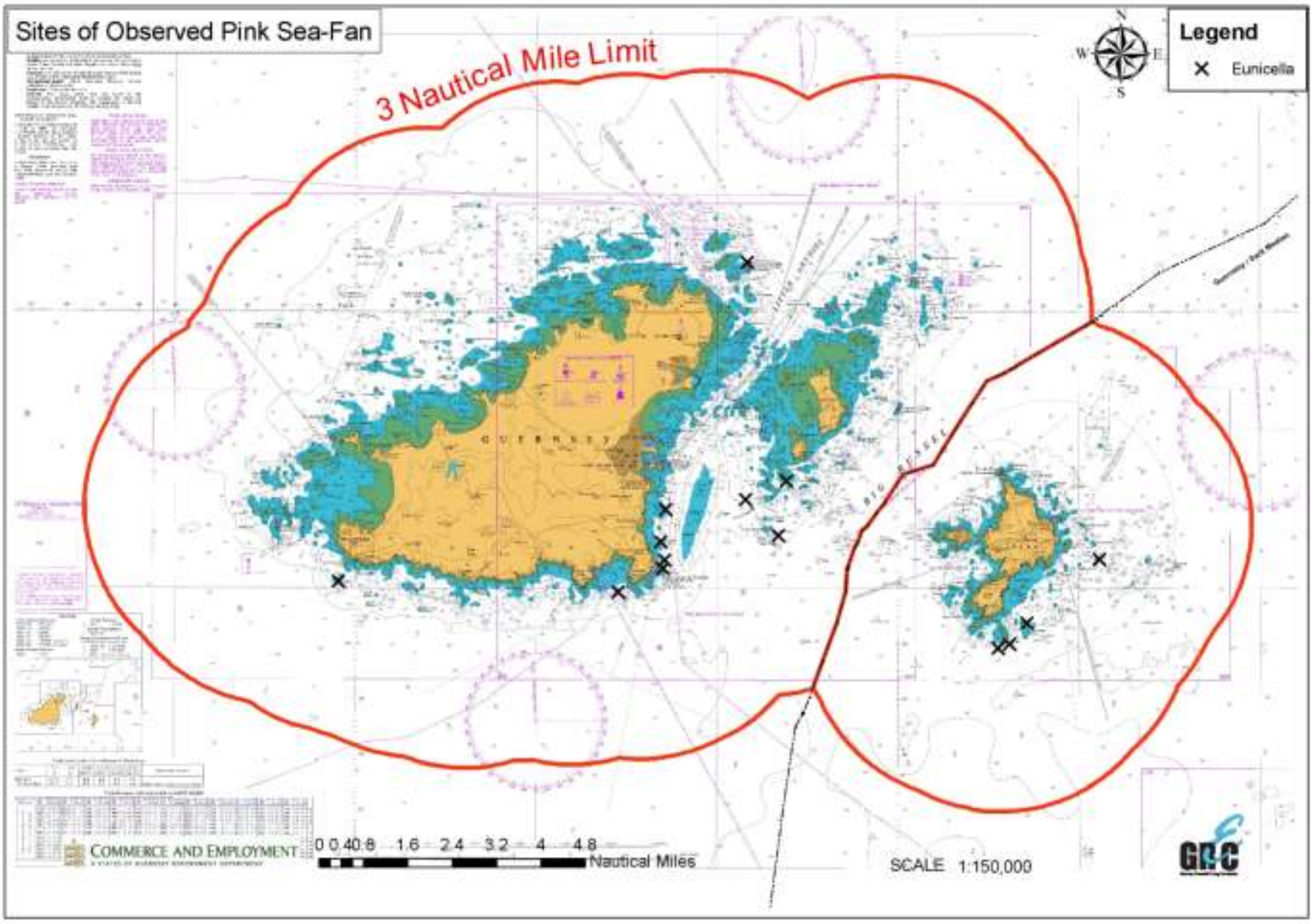
Data sources also outlined regionally important species that are not recognised by UK BAP priority species guidance but deemed important based on other source guidance for the REA study area (table 7. 2.5).

Table 2.5. Description of potential priority species that are excluded from UK BAP guidelines, excluding cetaceans and commercial/ pelagic bony fish. Species records are located from the GBRC and SeaSearch surveys. Zostera marina has also been included as a species which is also recognised as a priority habitat by UK BAP.

NBN Current Scientific Name	NBN Current Name Authority	Common Name	Grouping	Original UK BAP Status
Pachycerianthus indet	(Wood 2008)	Burrowing anemone	Cnidaria	
Echinaster sepositus	(Hansson, H.G., 2001)	Red starfish	Echinodermata	
Haliotis tuberculata	(Linnaeus 1758)	Green ormer	Mollusc	
Zostera marina	(Linnaeus 1753)	Eel grass	Angiosperm	Habitat Action Plan

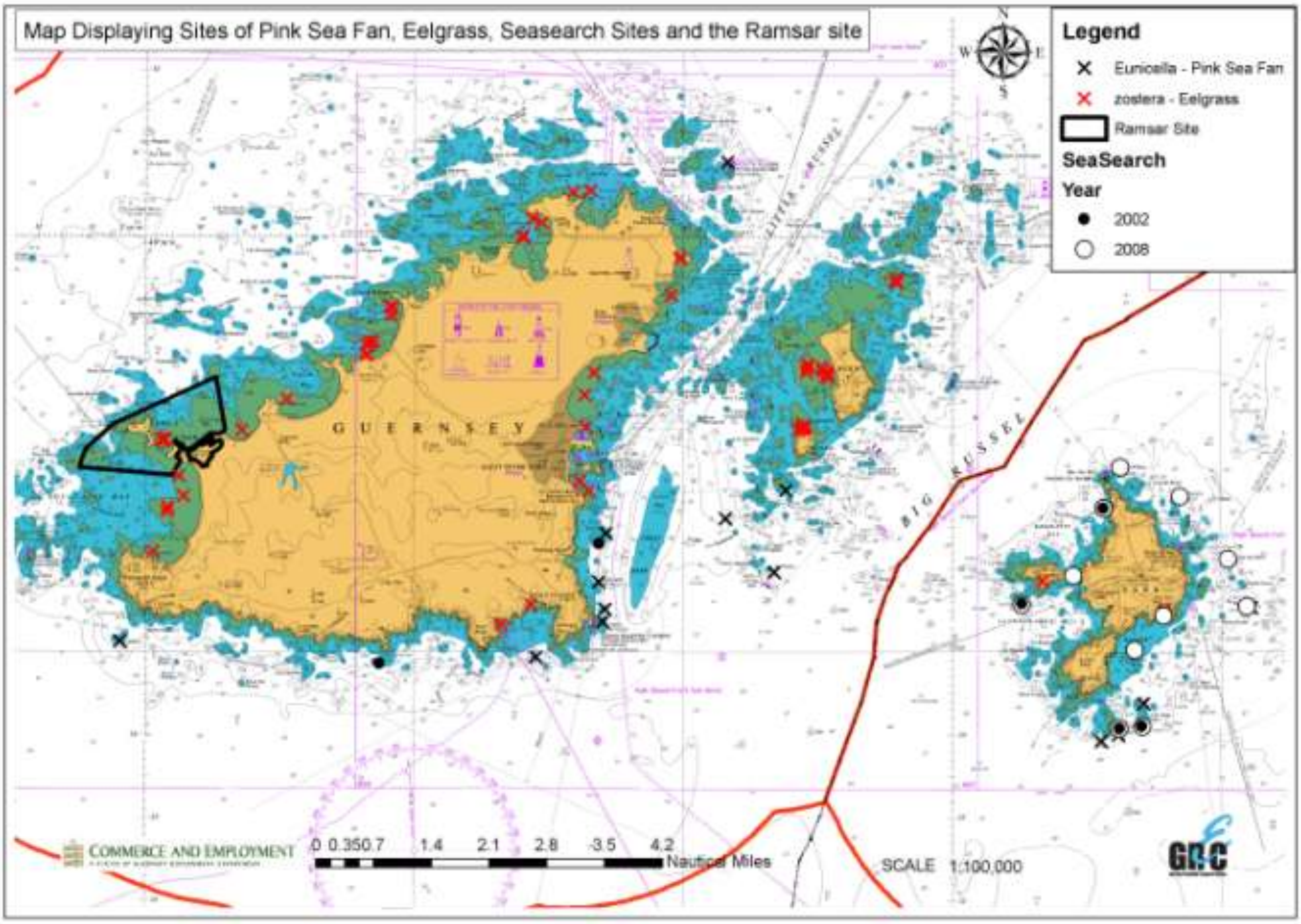
A large proportion of the priority species were recorded through the SeaSearch surveys (figure 7. 2.2) and GBRC sightings records, including the pink sea fan coral *Eunicella verrucosa*. This species is uncommon throughout the British Isles but located at various sites within the REA study area and is classed as an IUCN red listed 'vulnerable' species (figure 2.5). *Eunicella verrucosa*'s importance status is based on its ability to act as a 3-dimensional physical structure, sustaining other species including the endemic species, *Tritonia nilsodhneri*. The sea fan is found in deep fast flowing water conditions, with new studies suggesting it is more robust than previously thought; portraying regeneration and recovery abilities from natural and anthropogenic activities. Due to the sea fan's designated status, vulnerability and enhancement to marine biodiversity as a whole, renewable energy development schemes should acknowledge this species during initial development planning and applications.

Figure 7.2.5. Eunicella verrucosa pink sea fan coral sighting distribution records within the REA study area (from SeaSearch and GBRC).



To summarise, current knowledge of the benthic ecology within the REA study area is largely unknown. However, data sources and past records that are available outline a rich variety of benthic habitats and species located throughout the entire REA study area, including two designated Ramsar Sites (figure 7. 2.6). The available data sources suggest benthic habitats consist of mixed substrates and differing depths, with large proportions of these habitats located within areas of fast flowing tidal currents. A small number of these habitats exhibit ecological importance based on their ability to sustain high diversity of marine life and their sensitivities to natural and anthropogenic impacts. The data sources also describe a rich variety of benthic species located throughout the REA study area, particularly species which represent fast flowing tidal current environments. A proportion of these species are also regarded as important due to their ecological status and sensitivity to impacts.

Figure 7.2.6. Location of the Ramsar Site, SeaSearch surveys and distribution records of Zostera marina eel grass beds and Eunicella verrucosa pink sea fan within the REA study area (from GBRC and SeaSearch).



7.3 Potential Effects

There are a number of conflicting impact predictions from marine renewable energy deployments upon the benthic ecology community from a variety of research sources (table 7. 3.1). Current research predictions suggest direct benthic habitat loss, and/or disturbance impacts during the physical presence of devices during the deployment stages of a renewable energy device deployment project (installation, operation and decommissioning). This can possibly lead to indirect population changes of surrounding local benthic species including marine algae, invertebrates (crustaceans, cnidarians, echinoderms, molluscs) and vertebrates (fish) – see Chapter 11 Commercial Fisheries & Mariculture for more detail. Direct benthic habitat loss and/or disturbance due to scour may also occur from the physical presence of sub- sea cables during all deployment stages.

Conversely there may be also be a possible positive increase in benthic habitats and species within deployment stages, due to devices acting as potential artificial reef structures and attracting colonising marine species. Such artificial reefs may present greater shelter, food availability and reproductive strategies for local habitats and species (Chapter 11).

Re-suspension of sediments during all deployment stages within the water column may also occur, affecting local benthic communities indirectly by influencing reproduction, competition, predation and feeding regimes directly or indirectly. Sediment suspension could occur for short and long term periods during all deployment stages and lead to overall sediment transport pattern and seabed interaction changes. This could then cause detrimental sediment smothering of local and adjacent habitats and species which may have important local, regional and national status or portray ecological keystone characteristics.

The physical presence and energy extractions from renewable devices may also indirectly lead to changes in ecological energy balances and wave/tidal flows thus altering local ecological habitat and species community structures.

Further possible impacts derive from acoustic emissions generated during the installation and operational periods which may disturb and displace local benthic fish species and affect adjacent benthic community patterns.

Water pollution may also occur and impact benthic habitats and species indirectly from devices in terms of toxic leaching from devices i.e. hydraulic fluids, anti-fouling paints and so forth.

It must be recognised that in-depth knowledge relating to benthic ecological interactions, impacts, effects and so forth with renewable energy devices is currently limited. A large proportion of renewable energy device developers are currently at a research and design phase; therefore knowledge of specific commercial device interactions with benthic ecology is unknown. Benthic ecology impacts and effects from renewable energy within the REA study area and this document must therefore be taken lightly, with key research information pending. Guidance of impact status and so forth is derived from local and UK based marine biology scientific research and governmental bodies such as GBRC, Marlin, JNCC and the MBA. This is due to such groups portraying extensive knowledge and expertise in benthic ecology and current application knowledge to offshore renewable energy developments as a whole.

Table 7.3.1. Potential impacts and effects upon benthic ecology from marine renewable technology life stages (installation, operation and decommissioning).

Development Stage	*Potential Impact to Benthic Ecology*	*Potential Effects to Benthic Ecology*
Installation	Physical disturbance of installation equipment/ foundations/ cables	Substratum loss/ habitat/ species displacement
	Piling foundations/ grouting/ cementing disturbance	Substratum loss/ habitat/ species displacement
	Disposal of aggregates/ spoils	Contamination/ species mortality
	Minor fuel leaks/ vessel activity wastes	Contamination/ species mortality
	Land based activities/ run- off	Contamination/ species mortality
Operation	Physical structure presence/ habitat loss	Substratum loss/ habitat/ species displacement
	Device rotor/ wave physical movement energy extraction	Decrease in wave exposure/ species displacement
	Energy extraction from tidal environment	Decrease in wave exposure/ species displacement
	Sediment displacement/ smothering	Increased sediment smothering/ turbidity/ habitat alterations/ species displacement
	Routine operations, vessel presence/ maintenance and repair	Contamination/ species mortality
Decommissioning	Physical presence of removal operation activities	Substratum loss/ habitat/ species displacement
	Physical removal of structure	Substratum loss/ habitat/ species displacement
	Disposal of structure, foundations and cables	Contamination/ species mortality
	Minor fuel leaks/ vessel activity waste	Contamination/ species mortality

7.4 Sensitivity of receptors

The likelihood of marine renewable technologies within the REA study area impacting sensitive benthic ecology, specifically priority habitats, is outlined in table 7. 4.1 following key sources such as Marlin, JNCC and other REA guideline sources. Sensitivity is determined using Marlin information from the source's online guidelines and data resources (Appendix F-1). The likelihood of marine renewable technologies affecting commercially sensitive species is covered in detail in chapter 11 – Commercial Fisheries & Mariculture.

Zostera marina eelgrass bed habitats are sensitive to physical disturbance and sediment smothering during all marine renewable technology deployment life stages. However a number of studies suggest recovery of *Zostera marina* can occur, often related to localised population dynamics, distribution and the extent of the impact. *Zostera marina* occurs at several locations throughout the REA study area; therefore their recovery may potentially occur throughout the area following any potential impacts from renewable energy activities.

Tidal rapid environments are potentially sensitive to deployments of physical structures and chemical spillage/ leaching from vessel activities during all life stages. The habitat as a whole is a new designated habitat status; therefore in-depth sensitivity knowledge relating to this habitat within the REA study area is unknown and should be taken lightly.

Maerl bed habitats are extremely sensitive to a number of potential impacts including physical structures, sediment smothering and indirect chemical spillage/ wastage from additional vessel activities. Studies suggest maerl beds are sensitive to a number of natural and anthropogenic impacts; with recoverability relating to localised distribution, percentage of live maerl, and overall size of habitat. However key information regarding specific maerl bed sites and status records and general knowledge within the REA study area is patchy, with more research required for full sensitivity assessment applications.

Table 7.4.1. Potential priority habitat sensitivities to marine renewable technology stages (installation, operation and decommissioning) following guidance and classification from Marlin, JNCC, GBRC and other published records.

Development Stage	*Potential Impact to Benthic Ecology*	*Eelgrass beds*	*Tidal Rapid Environments*	*Maerl Beds*	*Other Habitat*
Installation	Physical disturbance of installation equipment/ foundations/ cables	Moderate	Low	High	Moderate
	Piling foundations/ grouting/ cementing disturbance	Low	Low	Moderate	Low
	Disposal of aggregates/ spoils	Low	Low	Moderate	Low
	Minor fuel leaks/ vessel activity wastes	Low	Low	Unknown	Low
	Land based activities/ run- off	Moderate	Low	Low	Low
Operation	Physical structure presence/ habitat loss	Moderate	Moderate	Very High	Moderate
	Device rotor/ wave physical movement energy extraction	Moderate	Moderate	High	Moderate
	Energy extraction from tidal environment	Unknown	Unknown	Unknown	Unknown
	Sediment displacement/ smothering	High	Moderate	High	Moderate
	Routine operations, vessel presence/ maintenance and repair	Low	Low	Unknown	Low
Decommissioning	Physical presence of removal operation activities	Moderate	Moderate	High	Moderate
	Physical removal of structure	Moderate	Moderate	High	Moderate
	Disposal of structure, foundations and cables	Low	Low	Moderate	Low
	Minor fuel leaks/ vessel activity waste	Low	Low	Moderate	Low

7.5 Potential Significance of Effects

Based on information regarding the REA's benthic habitat data gathering exercises and review guidance, potential significance effects from marine renewable technology upon priority habitats and other recognised habitats can be determined following set criteria (Appendix F-2).

Zostera marina eelgrass bed habitats could potentially be affected by marine renewables throughout all life cycle stages through physical disturbance/ habitat loss and sediment movements.

Tidal rapid environments could be potentially affected by physical disturbance during all marine renewable life stages ranging from minor to major effects.

Potential effects from marine renewable technology upon maerl beds are classed portraying major effects in all life cycles through physical disturbance and sediment smothering.

The potential significance of effects upon other recognised habitats include; physical disturbance and sediment smothering throughout all marine renewable technology life stages.

Table 7.5.1. Potential significant effects of benthic habitats to potential impacts from marine renewable technology deployment stages (installation, operation and decommissioning) following guidance from Marlin, JNCC, GBRC and other published records.

Development Stage	*Potential Impacts to Benthic Ecology*	*Eelgrass beds*	*Tidal Rapid Environments*	*Maerl beds*	*Other habitats*
Installation	Physical disturbance of installation equipment/ foundations/ cables	Moderate	Moderate	Major	Moderate
	Piling foundations/ grouting/ cementing disturbance	Moderate	Moderate	Major	Moderate
	Disposal of aggregates/ spoils	Minor	Minor	Minor	Minor
	Minor fuel leaks/ vessel activity wastes	Minor	Minor	Minor	Minor
	Land based activities/ run- off	Minor	Minor	Minor	Minor
Operation	Physical structure presence/ habitat loss	Moderate	Moderate	Major	Moderate
	Device rotor/ wave physical movement energy extraction	Moderate	Moderate	Major	Moderate
	Energy extraction from tidal environment	Unknown	Unknown	Unknown	Unknown
	Sediment displacement/ smothering	Moderate	Moderate	Major	Moderate
	Routine operations, vessel presence/ maintenance and repair	Minor	Minor	Minor	Minor
Decommissioning	Physical presence of removal operation activities	Moderate	Moderate	Major	Moderate
	Physical removal of structure	Moderate	Moderate	Moderate	Moderate
	Disposal of structure, foundations and cables	Minor	Minor	Minor	Minor
	Minor fuel leaks/ vessel activity waste	Minor	Minor	Minor	Minor

7.6 Likelihood of Occurrence

The likelihood of the potential impacts occurring upon the REA's benthic ecology from marine renewable technology development is described below. Due to the wide geographic range of the benthic ecological zone and location choice by current marine technology device developers, the likelihoods of the occurrence of potential effects within this region range from low, moderate to moderately/high respectively. These likelihoods are determined from a variety of published papers and sources outlined in the REA scoping document and other REA strategic documents published in the literature.

Overall physical disturbance and sediment smothering effects portray a high or moderate likelihood of occurring within the benthic ecology zone throughout all marine renewable technology life stages.

Table. 7.6.1. Likelihood of the occurrence of the potential impacts from marine renewable technology deployment stages (installation, operation and decommissioning) following guidance from Marlin, JNCC, GBRC and other published records.

Development Stage	*Potential Impact to Benthic Ecology*	*Likelihood of Occurrence*
Installation	Physical disturbance of installation equipment/ foundations/ cables	Moderate
	Pilling foundations/ grouting/ cementing disturbance	Moderate
	Disposal of aggregate/ spoils	Low
	Minor fuel leaks/ vessel activity waste	Low
	Land based activities/ run-off	Low
Operation	Physical structure presence	Moderate/ High
	Device/ rotor wave physical movement effects	Moderate
	Energy extraction from tidal environment	Unknown
	Sediment displacement/ smothering	Moderate/ High
	Routine operations, vessel presence/ maintenance and repair	Low
Decommissioning	Physical presence of removal operation activities	Low
	Physical removal of structure	Moderate/ High
	Disposal of structure, foundations and cables	Low
	Minor fuel leaks, vessel activity wastes	Low

7.7 Mitigation Measures

A number of possible mitigation measures are recommended for consideration to reduce the effect from the potential impacts from marine renewable technology development upon the benthic ecology of REA study area. These include:

- Consider geographical avoidance within and surrounding areas of current and future Ramsar Sites and other areas of interest. These include regions that may sustain important species and habitats and promote high diversity when beginning marine renewable technology site selection.

- Consider seasonal (temporal) avoidance to reduce impeding species reproduction/ feeding regimes/ migrations and life cycles within chosen marine renewable technology sites.

- Consider establishing baseline monitoring strategies within the benthic ecology zone at pre, during and post marine renewable technology development (installation, operation and decommissioning stages) utilising key specified sampling techniques (species/ habitat/ environmental specific monitoring surveys) once marine renewable device site locations are chosen. This includes creating collaborating programmes with local and external groups i.e. combining BGS geological mapping data with habitat assessments for more definitive benthic mapping information.

- Consider specific mitigation measures to reducing impacts during each marine renewable device deployment life stage i.e. reducing wastage, fuel and vessel activities during installation, operation and decommissioning stages.

7.8 Confidence and Knowledge Gaps

Due to the marine renewable technology sector still in its infancy coupled with the lack of quantitative benthic ecological data of the REA study area, confidence levels regarding impacts, effects and so forth for this chapter should be recognised as being low.

Knowledge gaps of the region’s benthic ecology are large, not only in terms of basic ecological research but also in general knowledge of marine renewable device interactions within the marine environment. A large proportion of marine renewable technology is still preliminary research and design stages (both in terms of individual device and array designs), therefore potential specific commercial array impact/effect predictions are questionable at this current time. It also should be noted that device types are not only different in terms of their physical structures but also in their power generation, flow dynamic impacts and so forth. Therefore confidence must be considered low as key specific knowledge of interactions from different devices i.e. wave powered, tidal powered and so forth upon benthic ecology is unknown.

7.9 Residual Effects

Following information from the data gathering exercises, reviews and outlined potential effects and sensitivities of the benthic ecology within the REA study area, residual significant effects and the confidence of the effects from data sources can be determined. Residual significance effects range from moderate significance levels outlined in the operational stage to negligible significance levels in routine vessel activities at all development stages.

The confidence levels range from moderate to low levels and are predominately identified as portraying low confidence throughout all development stages. This is due to insufficient knowledge of the effects of marine renewable technology upon benthic ecology and limited sources of information of the REA study area overall. Moderate confidence levels are assigned where information regarding the impacts and effects upon benthic ecology has been identified from other published documents, reviews and guidance criteria.

Table 7.9.1. Potential residual significant effects and confidence of these predictions for potential impacts from marine renewable technology life cycles (installation, operation and decommissioning) upon the benthic ecology following guidance from Marlin, JNCC, GBRC and other published records .

Development Stage	*Potential Impact to Benthic Ecology*	*Residual of Significance Effects*	*Confidence*
Installation	Physical disturbance of installation equipment/ foundations/ cables	Minor	Moderate
	Piling foundations/ grouting/ cementing disturbance	Negligible	Moderate
	Disposal of aggregates/ spoils	Negligible	Moderate
	Minor fuel leaks/ vessel activity waste	Negligible	Moderate
	Land based activities/ run-off	Negligible	Moderate
Operation	Physical structure presence	Moderate	Low
	Device/ rotor/ wave physical movement effects	Moderate	Low
	Energy extraction from tidal environment	Unknown	Unknown
	Sediment displacement/ smothering	Moderate	Low
	Routine operations, vessel presence / maintenance and repair	Negligible	Low
Decommissioning	Physical presence of removal operation effects	Minor	Moderate
	Physical removal of structure	Negligible	Low
	Disposal of structure, foundations and cables	Negligible	Low
	Minor fuel leaks/ vessels activity waste	Negligible	Moderate

7.10 Recommendations for Survey and Monitoring

Benthic ecology information, both qualitative and quantitative data is sparse within the REA study area, potentially leading to numerous recommendations for surveys and monitoring strategies. Unfortunately due to the REA study area size, time constraints, personnel and available funds it was not possible to undertake a comprehensive and detailed survey of the REA study area.

Therefore a number of initial classification surveys researching certain aspects of benthic ecology are recommended to determine baseline scientific information at certain locations throughout the REA study area. However it is envisioned that general monitoring strategies will inherently increase over time following mitigation recommendations for further study at areas allocated for marine renewable devices at pre, during and post deployment life cycles.

7.10.1 Initial classification surveys

Instigating a small proportion of initial classification surveys will allow further introductory information on the benthic ecology within the REA study area, focusing upon potential renewable energy development site choice or relevance to renewable energy research sites as a whole. Survey methodologies include acoustic and video ground-truthing methods linked with ecological scuba diving and intertidal habitat and species assessments. All surveys will require sound methodology designs following robust scientific protocols and survey techniques taking into account the local biological and environmental characteristics i.e. seabed type. This would create additional information regarding the benthic ecology based on a number of potential renewable energy choice sites located in the REA study area.

7.10.2 Baseline and deployment life cycle surveys

Following specific marine renewable technology site choice and development planning within the REA study area, pre, during and post deployment benthic ecological monitoring surveys should be conducted. Surveys should monitor and assess ecological changes between deployment life cycle stages, with further mitigation measures and research considered at each stage and implemented where necessary.

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